DAVID SAUTER

LANDSCAPE CONSTRUCTION

THIRD EDITION

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Landscape Construction, **3rd Edition**
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DEDICATION

To my wife, Lynn

CONTENTS

PREFACE

To change a site from an underdeveloped space to an attractive, functional, outdoor area, sound design and a skilled landscape contractor are needed. Just as the designer must perceive the visual potential and practical concerns that a site offers, the landscape contractor must possess creativity and a wide range of tangible skills to interpret and implement the designer's ideas. Such skills come only through learning and practice. Traditionally, the trade of landscape contracting has relied on apprenticeships and educational programs to teach students the art of implementation. Although both of these methods provide effective hands-on schooling, they have been limited by the lack of written material necessary to form a foundation for experiential learning.

Landscape construction requires knowledge of a broad range of construction techniques. Numerous texts and manufacturer's pamphlets may explain one aspect of landscape construction, but the scattered nature of this information makes it difficult to grasp how one part of construction relates to another. Continuous and holistic learning is hence made difficult, leaving students with a patchy and inconsistent picture of landscape construction. These inconsistencies prevent a design from developing to its fullest potential.

The majority of "complete" landscape texts available are limited in scope or focus on garden projects, rather than on construction techniques. This text attempts to correct those omissions by providing comprehensive, process-oriented coverage of the many facets and phases of landscape construction. Such information will help students develop an understanding of the construction process, as well as sharpen the extensive foundation of skills required before they can become competent specialists. Construction basics are explained and illustrated with numerous photos and diagrams. Fundamental data related to construction techniques and materials are provided.

This text is intended for students of landscape construction and practicing professionals seeking to expand their expertise. It is prepared as a supplement to supervised classroom instruction and is not intended to be a do-it-yourself manual.

The sections of this edition are organized around the logical steps of landscape construction. The first section provides information regarding preconstruction activities, including safety, legal issues, interpretation of construction documents, basic construction math, bidding and estimating, and other basic skills. Following this initial unit are nine sections dedicated to the work typically associated with landscape construction: site preparation; grading, site drainage, and erosion protection; site utilities and irrigation; landscape retaining walls and stairs; landscape paving; wood decks and landscape structures; fences and freestanding walls; landscape amenities; and planting. Chapters within each section detail the steps necessary to install materials covered under the section's title.

THE PROFESSION OF LANDSCAPE CONTRACTING

When considering the importance of landscape contracting in the design and construction process, one should remember the significance of how the site is experienced. Judgments often begin with the first impression a visitor has of a site. People may not even enter a home, yet they develop an opinion of the occupant by how well the exterior environment is presented. People make decisions about whether to shop at a store without ever seeing the merchandise, but by judging the exterior of the business. Landscaping determines the economic or social success of many projects, and the work of the

landscape contractor plays a significant role in determining that success.

As the importance of exterior image and environment has increased, so has the importance of the landscape contracting profession. Public appreciation of an attractive site has been credited with increasing business in certain markets. Advances in technologies for irrigation and issues such as xeriscaping have also contributed to industry growth. What once may have been a sideline to a retail plant sale operation or a small contracting firm has now evolved into a variety of business types and service providers known as *landscape contractors.*

Environmental issues have also widened the role the landscape contractor must play. Concepts such as sustainable landscaping require that contractors think beyond altering the environment and consider the impacts their work has on the environment. Altering sites with sensitivity, reducing needless consumption of resources, selecting ecologically sound materials, and choosing low-impact construction methods are among the concerns facing today's contractor. To concurrently address both the alteration and preservation of the environment, the industry must incorporate new and old philosophies and attitudes.

An increase in the number of landscape contractors and the amount of work available have sparked significant changes in the industry. Basic among the types of landscape companies are the general practitioners who provide their clients a full range of construction services. The growth of the industry has also led to a variety of specialists who concentrate on a single aspect of the construction process. Specialists are common in irrigation, grading, water feature construction, and planting. Depending on the size of the market, contractors who specialize in wall construction, decorative paving, carpentry, and amenity installation can also be found.

The separation of design from construction has been reduced with the growth of design/build firms. Design/build companies prepare a design for the client and follow up with installation of the design. Many design/build firms can also provide separate services, if required, by a bidding situation. In recognition of the value of maintenance contracts for installed landscapes, a growing number of businesses offer a "full-service" approach that includes design, building, and maintenance of a project.

With the landscape contracting industry filling a variety of roles, it is necessary to prepare professionals who can address many aspects of the building trade. This text covers these diverse technical requirements in an attempt to improve the quality of work within the profession of landscape construction. Depending on their choice of specialization, landscape contractors may be required to master one, two, or possibly all of these skills.

The varied opportunities available for practicing in the field of landscape contracting and the specific career choice may determine what education and experience are required to be successful. This text can be used to improve the skills of a student or contracting professional in two ways. When used as a comprehensive text, the entire process of landscape contracting can be viewed. Each section can also be used as a stand-alone teaching unit for introducing specialized construction techniques when appropriate. The author strongly urges you to both read and practice. When addressing a technical topic such as this, few educational techniques work better than the combination of reading, seeing, and doing.

Contractors and Professional Associations

Many contractors receive benefits from joining local and national contractors' associations. Groups such as the Associated Landscape Contractors of America provide valuable support and information to those engaged in the practice of building landscapes. Similar organizations would include the American Nursery and Landscape Association, American Society of Landscape Architects, and the Association of Professional Landscape Designers. Local chapters of each of these organizations can typically be found in many states (see Appendix F).

New to This Edition

Suggestions on how to improve sustainability in landscape construction has been stressed throughout all chapters.

Chapter 1:

- Includes discussion of recycling old materials.
- Added discussion of warranty period.
- Added discussion on virtual design and construction.

Chapter 2:

- Added discussion of the role of the construction manager.

- Added discussion of regulations related to floodplains and restricted areas.
- Added discussion of historic districts.

Chapter 3:

- Added discussion of types of drawings, including CADD, shop drawings, and as-built drawings.

Chapter 4:

- Added discussion of the use of construction calculators.

Chapter 6:

- Added discussion on site inspections and actions and behaviors while on the worksite.
- Added discussion on work in confined spaces.
- Added discussion of electrical lockout procedures.

Chapter 7:

- Added discussion of use of a jackhammer and rototiller in excavation.
- Added discussion of cutting and joining poly drip irrigation pipe.
- Added discussion of the use of power equipment to prepare a site or to fasten materials.

Chapter 8:

- Added discussion of electronic measurement tools, clinomters, and robotic surveying stations.
- Includes discussion on measuring distances and using an electronic measuring tool to measure distances.
- Added discussion of measuring slopes using a clinometer.
- Added discussion of layout of circles using radii and chords.

Chapter 9:

- Added discussion of the preservation of soil on the work site.

Chapter 11:

- Discussion related to how to remove ground cover or topsoil has been provided.
- Discussion of rough grading has been expanded to include discussion of staking, remedying unsuitable subgrade soil conditions, and bulk excavation with use of fill.
- Added discussion of utility installations.

Chapter 12:

- Added discussion of trench drains.
- Added discussion of level spreaders.
- Added discussion of bioswales, cisterns and drywells, soaker trenches, and storage barrels.
- Added discussion on directing runoff to lawns and gardens.

Chapter 13:

- Added discussion of buffer strips and interceptor channels.
- Added discussion of terracing.
- Added discussion of brush mattress and pole planting.

Chapter 14:

This chapter has been completely revamped. Content has been expanded upon, in particular the topics noted below:

- Basics of low-voltage electrical systems, includes discussion of system components, defining electrical terms and concepts, and guidelines for planning a lighting system.
- Added discussion of fixture placement.
- Expansion of discussion of wiring and connections.
- Added discussion of testing and adjusting custom installations.
- Added discussion of low-voltage electrical system kits.

Chapter 15:

- Basic concepts in irrigation systems.
- Added discussion of drip irrigations systems and subsurface drip turf irrigation systems.

Chapter 16:

- Updates related to new materials have been included.
- Discussion of constructing non-structural retaining walls.

Chapter 17:

- Added discussion of recycled plastic landscape timbers.

Chapter 18:

- Added discussion of structural cell walls.

Chapter 19:

- Added discussion of creating visual appeal in stone walls by varying patterns in the placement of the stone.

Chapter 21:

- Added discussion of ADA requirements for stairs in the landscape.

Chapter 22:

- Added discussion of cellular or plastic paving options.

Chapter 23:

- Added discussion of ADA requirements for stairs and ramps.
- Added discussion of staining concrete.
- Added discussion of painting concrete.

Chapter 27:

- Added section on open cellular pavement.

Chapter 28:

- Added discussion of use of bamboo as a wood product.
- Added discussion of the disuse of certain treated products.
- Added discussion of wood cleaners, strippers, and brighteners.
- Added discussion of decorative finishes.

Chapter 29:

- Added discussion of deck post supports and adjustable deck supports.
- Added discussion of bamboo surfacing and composite material surfacing.

Chapter 30:

- Added discussion of ADA requirements for stairs.

Chapter 31:

- Updated and revised coverage of metal roofing.
- Added discussion of tensile fabric structures.

Chapter 32:

- Added discussion of welded wire fencing.
- Added discussion of installation of rail vinyl fence.

Chapter 33:

- Added discussion of rammed earth walls.
- Added discussion of installing utility runs in walls.

Chapter 34:

- Expanded discussion of pond plants.
- Added discussion on installation of decorative fountains.

Chapter 35:

- Added discussion of installation of firepits, patio misters or foggers, and outdoor kitchens.

Chapter 36:

- Added discussion of installation of root barriers.
- New Section on plant material installation, including establishing turf areas.

Chapter 37: Plant Material Installation

- New chapter

Chapter 38: Establishment of Turf and Meadows

- New chapter

Appendix B has been updated.

REGARDING THE USE OF THIS TEXT

- This textbook is intended to supplement supervised classroom instruction. Practice of the profession of landscape construction is filled with safety and health hazards, and use of this book without proper experience or supervision will place the reader at risk. *The reader assumes all risk when engaging in unsupervised activities.*
- Students who will benefit most from this text include those beginning landscape construction programs at secondary and postsecondary institutions or apprenticeships through trade associations. Prerequisite skills necessary to complete the activities outlined in this book include the ability to perform basic math calculations and the ability to lift tools and materials weighing up to 50 pounds or more without assistance. Good physical dexterity and sound critical thinking skills will also be beneficial to the beginning landscape contractor.
- All data and information contained in this text are believed to be reliable; however, no warranty of any kind, express or implied, is made with respect to the data, analysis, information, or applications contained herein; and the use of any such data, analysis, information, or applications is at the user's sole risk and expense. The author assumes no liability and expressly disclaims liability, including without limitation liability for negligence, resulting

from the use of the data, analysis, information, or applications contained in this text.

- It is assumed that the readers of this text possess basic skills necessary to safely perform construction activities and operate construction equipment. Readers who lack skill in these tasks must obtain instruction in these essential areas before attempting to undertake the activities described in this text.
- It is important to understand what aspects of a project should be completed by the landscape contractor and when a professional from another trade should be called in. Throughout the text, reference is made to work tasks that should be completed by related design and construction professionals.
- Design and construction references made within this text do not supersede instructions provided by contract documents. Materials, methods, and performance required by plans and specifications must be followed.
- Historical restorations may require procedures different from those described in this text.
- Manufacturer's instructions or manuals supersede the recommendations made in this text.
- References made to proprietary materials or methods are not endorsements of those materials or methods.
- Practice of the profession varies from region to region. Verify with local building professionals the appropriateness of recommendations made in this text. Local building officials should be contacted to verify legal requirements for the region in which any work is performed.

ABOUT THE AUTHOR

David Sauter is an educator with more than 30 years of teaching, administrative, and practical experience. He has served on the faculties of Foothill College in Los Altos Hills, California, and Kirkwood Community College in Cedar Rapids, Iowa, and worked as a Landscape Architect in the Midwest and on the West Coast. He has taught coursework in landscape design, landscape construction, computer-aided design, computer applications in horticulture, and business management.

David Sauter completed his BS in Landscape Architecture at Iowa State University and received an MA in Higher Education from the University of Iowa. He has presented seminars for the nursery industry, master gardeners, extension service, and public service organizations. He is a registered landscape architect and maintains a landscape architecture practice on the West Coast (http://www.davidpsauter.com). He has participated in the design and construction of landscape projects of all sizes. Mr. Sauter has additional experience in plant maintenance, plant installation, landscape construction, masonry, carpentry, paving, and landscape management.

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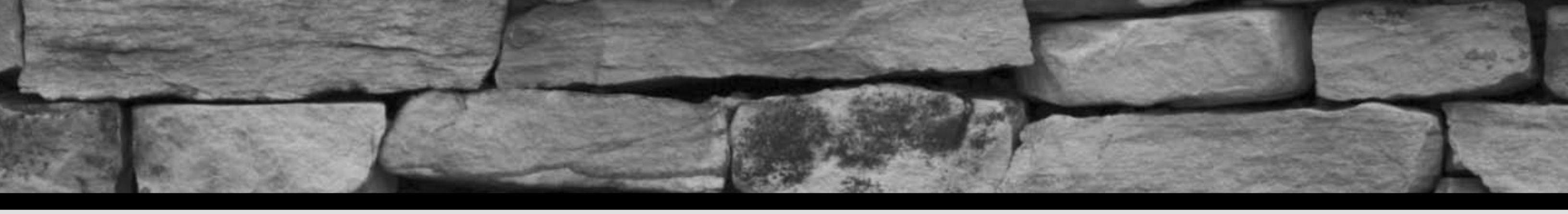
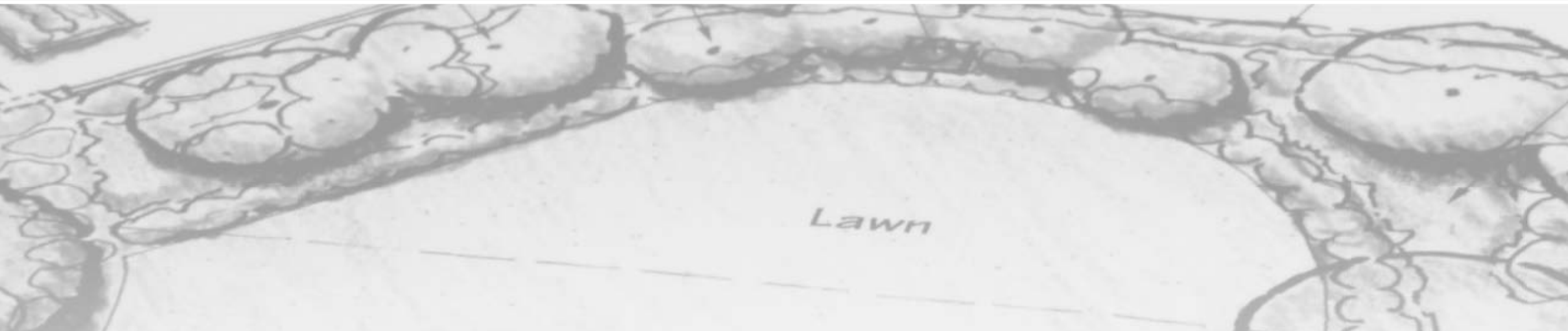


SECTION 1

BEFORE CONSTRUCTION BEGINS

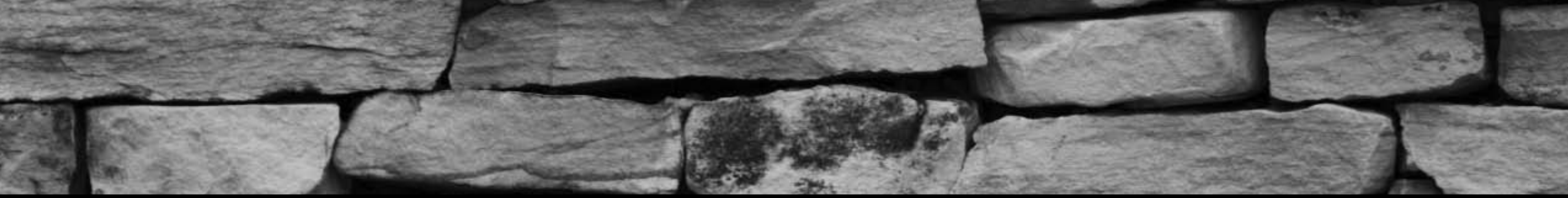


INTRODUCTION

Before beginning any construction project, landscape contractors need to consider the safety, legality, sustainability, and process of the task they are about to undertake. Engaging in a project without knowing the risks involved may bring unnecessary dangers for the contractor, the crew, the public, and even on the site itself. Information presented in this section will detail many activities that landscape contractors should investigate before they begin any physical work.

The steps of the construction process, from preconstruction activities to cleanup, are covered in Chapter 1. Chapter 2 discusses legal complexities that may influence the project, including building codes, contracts, insurance requirements, and the relationship among the designer, client, and contractor. As an assist to those learning to implement design plans, a guide to interpreting construction documents is presented in Chapter 3. Landscape contractors must calculate material needs, estimate costs, and bid construction projects; to do so, they need basic math skills. The essential math formulas and examples presented in Chapter 4 will help students estimate costs of and bid on construction projects. As a corollary, Chapter 5 suggests methods for presenting project estimates and bids. Chapter 6 offers important advice to help a crew reduce its risk of injury during the construction process. Basic construction techniques, including equipment operation, are described in Chapter 7. Explaining the establishment of horizontal and vertical controls, Chapter 8 addresses accurate construction staking.

Although they may be tempted to move quickly into the physical phase of a project, landscape contractors must examine the essential tasks that should precede actual construction. Planning and preparation can reduce the common risks found in, and minimize the potential hazards of, landscape contracting.



CHAPTER 1

THE LANDSCAPE CONSTRUCTION PROCESS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Describe the steps of the construction process.
- Plan construction activities.

The process of landscaping should be efficient yet complementary to other projects in progress at a site. Landscape work has many potential conflicts—e.g., delays in material delivery, tardiness or illness of crew members, periods of inclement weather, numerous contractors at work at the same time—and by being aware of such conflicts, as well as the activities required during construction, landscape contractors can better control the progress of their projects.

This chapter outlines the general process for landscape contracting improvements. Each major step is identified, along with the basic construction activities that will occur during the process, and an explanation is given for why such activities must be performed (Figure 1-1). Timeline alternatives that accommodate variations in the industry are also given. It should be noted that the process outlined in this chapter serves as a guideline; actual construction practices may vary from contractor to contractor, and from region to region, or may change as the size of the project increases or as the weather conditions fluctuate.

The process outline provided in Chapter 1 corresponds chronologically to the numerical sections and chapters of this book. Subsequent chapters will provide more detailed descriptions of what is summarized in this first chapter.

PRECONSTRUCTION ACTIVITIES

Before they can begin work, landscape contractors must first have a project. **Bidding**, or competing with other contractors for a job, is the primary way in which contractors are authorized to work on a site. The general, or prime, contractor will sign a contract with the site owner to conclude the bidding process and to initiate the second phase of a project: preconstruction planning. If the project is large or within the public domain, the owner's representative will give written authorization to signal the beginning of work.

When working as subcontractors, landscape contractors will receive authorization or permission to work from the general contractor; and the two parties may or may not sign a contract. Scheduling of work is critical when landscape contractors operate as subcontractors for larger firms. It is important to verify that other construction activities will not disturb completed work. Restoration work typically does not qualify for additional pay, even if another contractor disturbs or destroys the work already completed. In situations where work has been negotiated directly with a client, signatures by both parties on a legally binding contract is adequate to begin construction.

Prior to beginning any work, landscape contractors should obtain required permits, insurance, and bonding. Orders should be placed in advance for materials that may require lead time for

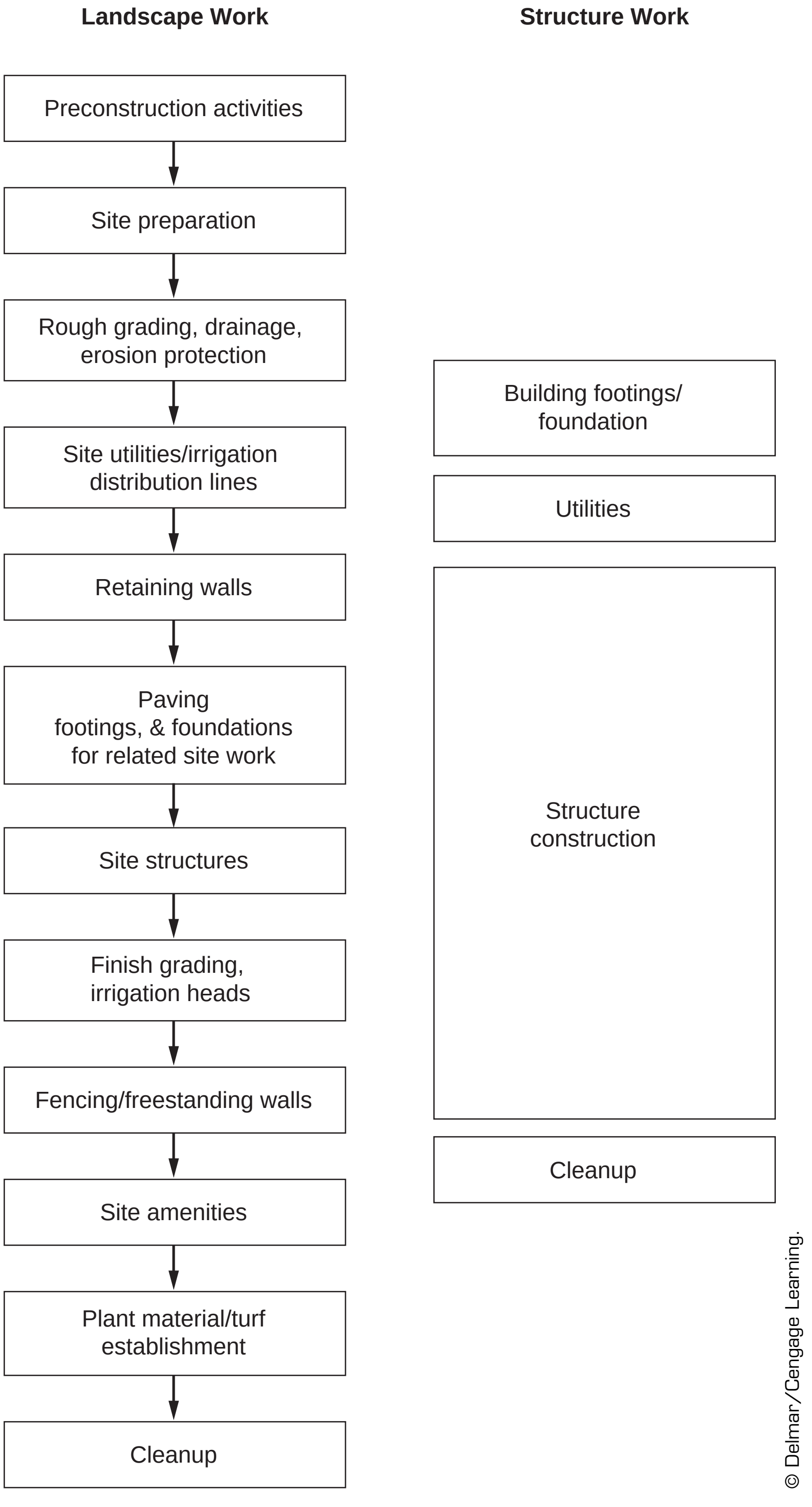


Figure 1-1 Flowchart of the landscape construction process. The right column shows how structure work relates to the landscape process.

manufacturing, such as premanufactured bridges, amenities, lighting, special-dimensioned features, specialty paving, and wall materials. Before construction can proceed, layout of critical dimensions and grades will be required (Figure 1-2). Anyone who is not comfortable doing this work, or is not qualified because of the critical nature of the development, should contact a registered land surveyor to provide construction staking.

SITE PREPARATION

Site preparation can vary significantly, but performing this step typically incorporates two basic tasks: protecting existing site features and demolishing or removing existing site elements that are no longer wanted. Protection and demolition activities are best performed before any other phase of the project begins.

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Figure 1-2 Using a surveyor's transit to stake grades at a landscape project.

Protection of site elements could include defining an access route to construction; fencing the perimeter; stabilizing benchmarks and baselines used to lay out the project; and protecting any plant material, structures, paving, or permanent improvements that will be part of the finished project. Proper protection of existing site features involves the time and effort necessary to reduce significant restoration as a result of construction damage. Construction documents will outline the items to be safeguarded as part of this step. For projects without construction documents, the contractor may have the responsibility of making those judgments.

Site demolition involves the removal of existing site improvements that are not part of the finished project. Disposal of the removed elements is also the contractor's responsibility; and in many cases, recycling or reusing old materials can result in cost savings. Removing old structures, worn pavement, or damaged and misplaced plant material is a common activity before a contractor undertakes new construction. Unlike site protection, demolition is almost impossible to overlook. It can, however, do unnecessary damage to a site if not properly performed; and contractors will need to restore the damage at their own expense. Failing to consider how demolition materials can be recycled also creates a cost to the environment. Old paving, recycled concrete, chipped and composted plant material, and many other products once considered waste could have more productive uses; and the contractor can find ways to recycle these unwanted materials.

ROUGH GRADING, EROSION PROTECTION, AND SITE DRAINAGE

Rough grading to achieve the desired landform and drainage will follow the site preparation activities. A majority of the grading work must be completed before any further steps can be taken. Grading for large projects can be broken down into distinct steps that efficiently sculpt the site and preserve resources such as topsoil. Smaller projects often condense the steps because a small site does not lend itself well to the specialized grading activities of larger projects.

Initial steps in grading include the stripping of sod and vegetative cover from the areas where the grade will be changed. Once the plant material has been removed, the topsoil is scraped from the site

and stockpiled for future use. Subgrade soils are then cut from areas where there is an excess and filled into areas where there are voids (Figure 1-3). Grades established during this phase will be below what is planned for finish grades because paving and topsoil will be placed on top of the subgrade. Grading to facilitate site drainage and to install drainage systems, such as tile or storm sewers, is also performed.

Grading activities are then stopped until all utilities, structures, and paving are put into place. Temporary erosion protection is installed at this time to reduce damage to the site until finish grading can occur.

SITE UTILITIES AND IRRIGATION DISTRIBUTION LINES

Depending on the size of the project, subcontractors who specialize in installation of water, sewer, gas, electric, phone, and other communication utilities will probably be assigned to complete most of the major utility work. Establishment of rough grade prior to beginning this phase is essential to maintain proper cover over utility rough-ins. Trenching and placement of major utility structures, such as manholes and shutoffs, should be performed and then backfilled to avoid disturbing finished elements of the landscape. Placement of conduit and direct burial wire, as well as rough-ins for site lighting, should be completed during this phase. It is also common to place main distribution lines for landscape irrigation systems during this phase of the work. However, valve boxes or irrigation heads should be placed after all heavy traffic has ceased and finish grading has been completed over the site.

Coordination and awareness of utility installation is critical to the landscape contractor. Documentation of utility locations also aids in future construction

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Figure 1-3 Rough grading an athletic field site.

work that requires excavation. Utilities installed in improper or unknown locations may have a significant negative impact on placement of future plantings and landscape walls, as well as on future paving.

LANDSCAPE RETAINING WALLS AND STAIRS

Construction of landscape retaining walls requires a stable finish grade. Once rough grade has been established over a site, construction can begin on landscape walls (Figure 1-4). In areas where utilities must pass near or under a wall, the utility should be completed and the grade above the utility must be compacted prior to placing the wall. Walls that retain the subgrade for paved areas must be in place before the paving activity can begin.

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Figure 1-4 Building a dry-laid, limestone, landscape retaining wall.

LANDSCAPE PAVING

When all rough grades, utilities, and landscape walls that support paved areas are in place and heavy traffic across the site has stopped, landscape paving can begin. Exceptions to this timing occur when asphalt roadways are left unsurfaced, or surfaced only with a base layer, until all construction traffic has ceased. This step includes the installation of concrete paving, brick and concrete paving block, stone, and granular paving used for walks, drives, patios, and other outdoor circulation and use areas (Figure 1-5). Paving edges provide elevation guidelines for lawns and planting beds, allowing topsoil to be redistributed over the site. Final grade should be established after all paving operations are complete. Timing of pavement projects should be coordinated with the completion of structures or paved areas near buildings. Any structure-related pavement should be completed before landscape paving is installed.

Provided future construction will not disturb it, concrete for any fencing or landscape amenities that require footings can also be poured at this time. This facilitates the efficient delivery of materials and reduces the potential for damage to a completed site structure by paving and building activities.

SITE STRUCTURES AND WOOD CONSTRUCTION

Structures related to landscape use can be built at a variety of times during the construction process. Determining the proper time will depend on whether the structure is freestanding, such as a gazebo or trellis, or attached to a building, such as a deck. Once subgrade is established, foundations or slabs for freestanding landscape structures can be placed and erection of the structure can begin. Because structures may require utility connections and site walkways may have a paved connection, pouring of slabs could occur between utility construction and landscape paving. However, a preferred alternative is to pour footings at the same time that landscape paving activities are underway and to finish the structures after paving and buildings are in place.

Although footings, subsurface work, and portions of the site structure that are not connected to a building may be undertaken after site utility work is complete, finish work and connection to the building may have to be delayed. Structures that are

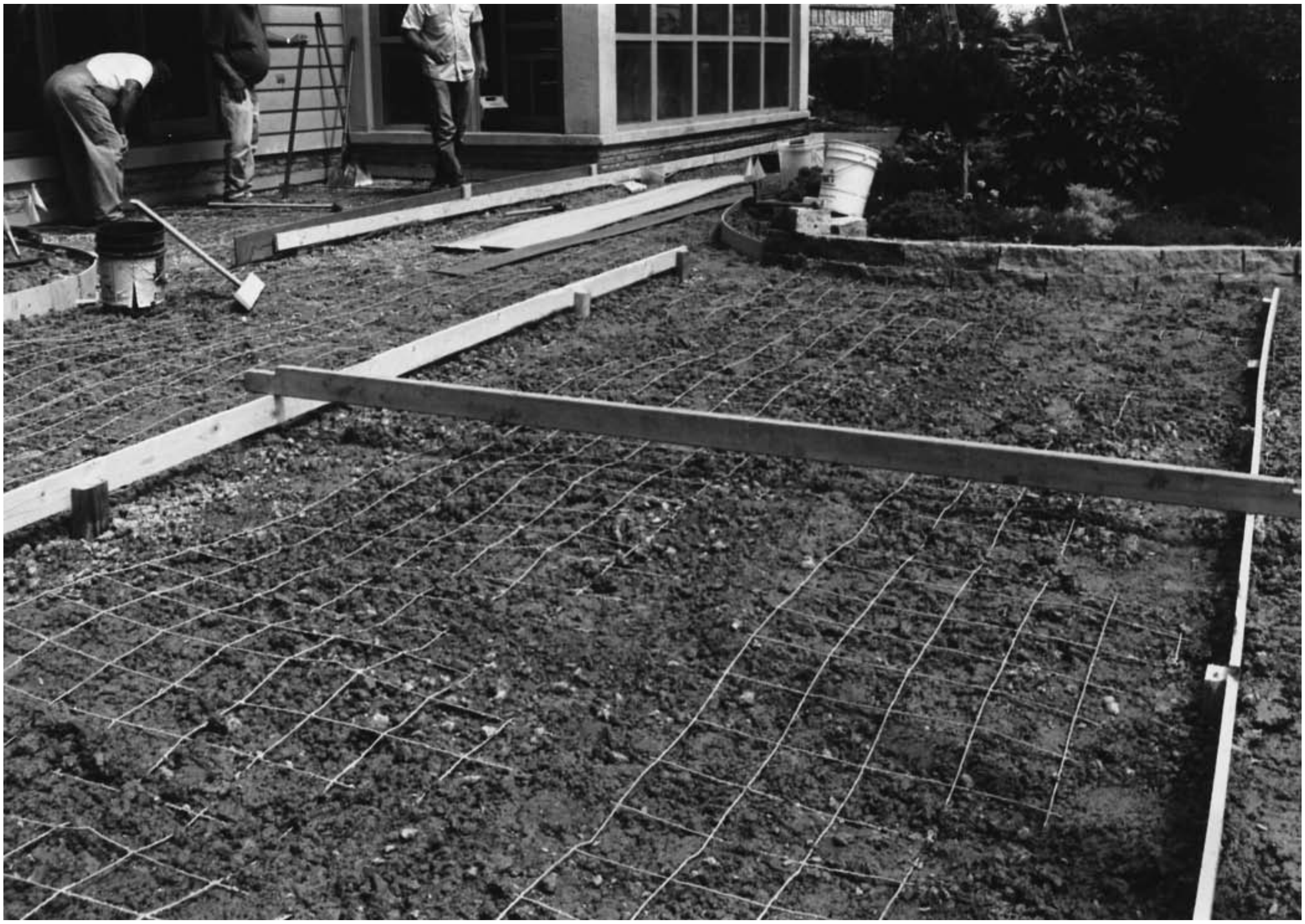

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Figure 1-5 Preparing a site for landscape paving.

attached to buildings will need to have building exterior work underway before construction begins. Most connections for site structures are made to the exterior sheathing or surfacing material, or these connections are designed to integrate with building roofs. Also, because buildings may require a vehicle access route near to where they are planned, material delivery may also influence the timing of this phase. Delivery of materials should be timed to avoid damage to the finished landscape by vehicles traveling to and from a site.

FINISH GRADING AND COMPLETION OF IRRIGATION WORK

Following the completion of other hardscape construction activities, and prior to installation of turf areas and plantings, topsoil is removed from the stockpile and respread over the areas on which turf or plant material is placed. Finish, or fine, grading is performed after the topsoil is respread to achieve the final grades desired by the designer. Installation of irrigation valves and heads can be done after finish grading or after turf areas are installed. The decision on whether to install irrigation valves, boxes, and heads before or after turf installation is a choice between the need for water to irrigate new turf and the prevention of damage to the parts while installing the turf. If the choice is to wait until lawns are installed before completing the irrigation system, arrange for temporary sprinkler systems to care for new turf installations. Once installed, irrigation systems should be operated and spray patterns adjusted to verify that the correct plant material is being watered.

FENCING AND FREESTANDING WALLS

Timing of fence and freestanding wall installation varies from project to project. Footings for freestanding walls should be installed when other

footings are placed and when masonry work is completed before finish grading begins. Chain-link, metal, or wood fences that require posts set in concrete should have that portion of the construction incorporated with pouring of concrete walks and footings for structures or amenities. Surfacing for all types of fencing will need to wait until access traffic for delivery and construction vehicles has ceased. Fence surfacing can be accomplished as portions of the site become available and final grade in the area of the fence is established.

SITE AMENITIES

Amenity installation includes such work as placement of benches, flagpoles, trash receptacles, bike racks, and site lighting. These elements are the finishing touches of the hardscape, and their placement should be postponed as late as possible to protect the finishes and delicate workings. Portions of the work related to amenities, particularly footings and wiring, will need to be addressed during the landscape paving and utility phases of the project. However, final placement of the amenity should occur just before or after plant material is installed. Water elements in the landscape should be completed and their proper operation verified prior to planting. Repairs to pools and fountains require significant disturbance of the surrounding area.

PLANT MATERIAL AND TURF AREAS

Installation or preparation of plant material and turf areas is reserved until the end of a project. Plants and lawns are sensitive, and performing any other task after this step can seriously damage them. Plant installation should begin with large trees and plants in areas that are difficult to access. Smaller trees and shrubs should be installed next, followed by edgers and ground cover plantings. Post-planting care, including mulching, should be accomplished when each plant group is installed. Preparation and installation of turf areas typically begins after plants are installed. However, some landscape contractors practice an alternative method; they prepare all turf areas prior to planting trees and shrubs and then repair any damage to turf areas after they complete the planting.

Timing of plant material installation is important to the plants' survival and the owner's maintenance load. Maintenance of all plants and lawns, particularly watering, consumes a great deal of time. Fall installation of plantings and lawns provides the best chance of survival and minimizes maintenance, but this timing does not always coordinate with the completion of building projects. Completion during the winter, spring, or summer will require a maintenance program that is instituted immediately to ensure plant survival until the owner accepts the project.

CLEANUP

After completing the landscape installation, contractors must clean and touch up exterior areas where work has been completed. The time invested to wash walkways, touch up paint on amenities, and make sure light bulbs are working is worth the effort. Cleanup can be more difficult when the general contractor requires that landscaping be completed before building exteriors or corrective work can be finished. Therefore, contractors should verify that all exterior work on the site is complete before they apply final aesthetic treatments.

WARRANTY PERIOD

The contractor's responsibility may extend beyond completion of a project. Many owners require a warranty period in which the work performed may require replacement or repair. Plant material usually falls under this requirement, but irrigation, lighting, paving, and carpentry work may also have warranty periods. As determined by contract or by mutual agreement between owner and contractor, a warranty typically requires the contractor to repair or replace defective improvements and/or dead plants for the duration of the warranty period.

SCHEDULING CONSTRUCTION ACTIVITIES

Successful management of a landscape business extends beyond recognizing the phases of construction activities. Contractors must also develop skill in effective scheduling of activities. Scheduling must be considered on two levels: individual project scheduling and the integration of schedules for proposed and existing projects. This section addresses in general the techniques for effective scheduling. A full explanation of scheduling techniques would require an in-depth analysis and presentation beyond this text's scope. Literature, coursework, software, and consultation with other contractors can elaborate more extensively on the

details of the techniques introduced in this section. For further information, conduct web searches using the key words presented in boldface here, or contact a local educational institution with a business or construction management department.

The contractor must master the first level of scheduling: individual projects. One common approach to scheduling is performing the work in sequence from start to finish with little more than a starting date and an anticipated completion date. This method is most effective when the project is short in duration (two weeks or less), requires sequential installation (the project involves only one phase and each step of the phase must be completed before the next can begin), or the construction is completed using a small crew. When it exceeds these limits, a project typically requires formal scheduling. Scheduling of more complex construction projects can be accomplished by using a number of techniques, including bar charting and logical graphing.

Bar Charts (Gantt Charts)

A common technique for scheduling construction activities is the bar chart, or **Gantt chart**. The bar chart lists the construction activities, or tasks, that need to be performed down a single column, typically in the order in which they are to be performed (Table 1-1). A second column, indicating the length of time to complete each activity, is often added. At the top of the chart, dates for the construction project are noted in a horizontal row. To the right of each activity, a line, or bar, is drawn from the starting date to the completion date for that activity. All activities in the first column are charted in this manner across the rows of the chart, with the bar for each activity beginning at the earliest possible starting date. Many activities must be completed in sequence, requiring the completion of one activity before the next can be started. Some activities may be completed independently and can be charted when scheduling the work is most convenient.

Although this is a simple bar chart, it represents how a contractor can plan construction activities, including ordering supplies, scheduling subcontractors, and even completing job-related administrative tasks. Charting activities allows the contractor to identify critical points in the construction schedule and to adjust activities to meet schedule demands. Gantt charting is useful for small projects that must be completed in a linear manner, or one step after

Table 1–1 Sample Gantt Chart

Sauter residence construction schedule												
Phase	Task	days to complete	May	June				July				Aug
1	obtain permits and prep work											
	-obtain construction permits	5										
	-order and deliver wall materials	5										
	-order and deliver paving materials	5										
2	rough grade											
	-remove and stockpile topsoil	2										
	-rough grade	5										
	-respread topsoil	2										
	-finish grade	3										
3	wall construction											
	-wall base installation	3										
	-wall material installation	8										
4	paving installation											
	-paving base preparation	4										
	-paving installation	10										
5	cleanup	2										

the other, and for contractors who have small crews and can engage in only one activity at a time.

A contractor can construct a simple Gantt chart by using a pencil and a sheet of graphing paper or can develop more complex charts by using the numerous templates and computer scheduling programs available. Templates list typical construction activities, and the contractor can easily choose from among those activities and then insert the duration of the work to produce a chart. Other scheduling programs can generate an entire chart once the contractor provides information about the duration and sequence of the activities.

Logical Network Scheduling (CPM)

Although the bar chart provides a useful tool for scheduling projects that can follow a general linear path from beginning to end, projects that have several interconnected activities or numerous simultaneous tasks may require a scheduling method that can accommodate these variables. Scheduling methods like **critical path method (CPM)**, or critical path analysis, use logic charts to diagram sequential, or interrelated, tasks and to determine the length of time required to complete a project.

CPM identifies each activity in a sequence. A flowchart is prepared with these activities graphically represented using nodes (circles) connected by arrows showing the logical sequence of completion (Figure 1-6). Times to complete the tasks are added to the chart. Some methods of CPM place the time on the connecting arrows (AOA, or assignment on arrows) or on the nodes (AON, or assignment on nodes). Either method is acceptable as long as it is applied consistently. When all activities and paths are represented, the diagram can be evaluated to find the critical, or longest, path through the project. This critical path identifies activities that, if postponed, will delay completion of the project. CPM not only identifies what activities are critical to the timely completion of the project, but it also improves the understanding of the relationships among various construction activities.

Virtual Design and Construction

Virtual design and construction (VDC) uses computerized models to integrate the aspects of a building project, including the project itself, the organization working on the project, and the process used to implement the project. Although primarily a tool of the architectural and engineering trades, VDC can also be of benefit to the landscape field. VDC uses powerful software that integrates construction by sharing data about the project; this allows anyone who makes changes in the project to see the impact of those changes. One aspect of VDC is the use of Building Information Modeling (BIM), which allows designers to see in advance conflicts in their design by viewing three-dimensional models rather than two-dimensional drawings. The VDC can prepare estimates for construction costs and track changes in the project, including their impact on material orders, schedules, and project costs. As a management tool, VDC has helped firms produce better quality work on tighter schedules and often with smaller budgets.

Additional Scheduling Methods

As projects become even more complex and unpredictable, more complex scheduling methods become more appropriate. Methods such as **program evaluation and review technique (PERT)** combine CPM with probability to identify

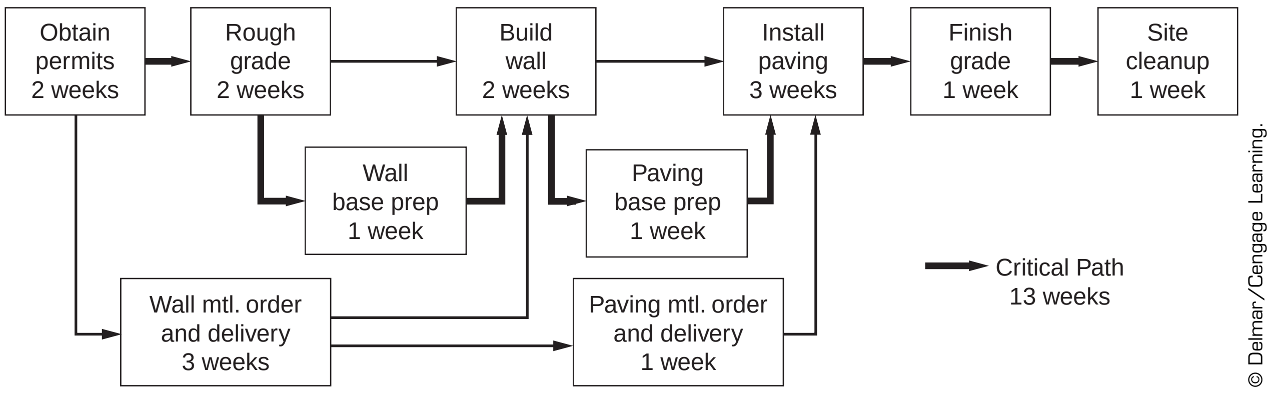

Figure 1-6 CPM charts identify activities in sequence.

completion dates that are optimistic, pessimistic, and most likely. Although not applicable to every project, PERT may be used in large construction projects that are likely to be influenced by nature or human factors. Examples include projects that are to be completed during unseasonable weather conditions or grading in an area that may be delayed because of unknown underground conditions.

Integrating Schedules

The second level of scheduling a contractor must master is integrating the schedules of the many projects being solicited and implemented. Success at this level depends on how well the contractor can plan individual projects without being overbooked with work or being without work for extended periods. Like many businesses, landscape contracting typically requires that multiple projects be contracted simultaneously to keep crews busy and to use equipment and labor efficiently. The activities of multiple projects must be simultaneously integrated to avoid conflicts. Staying in business also requires that new projects be sought while working on current projects. Scheduling at this level involves concurrent marketing of services, bidding on projects, and obtaining permits for future projects while engaging in the construction of existing projects.

CHAPTER 2

LEGAL REQUIREMENTS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Develop relationships with other contractors.
- List the potential legal implications of a construction project.
- Identify sources of information on construction restrictions.

Many legal controls can and often do influence landscape construction work. Few activities that the landscape contractor undertakes will be without some form of standard—either voluntary or involuntary. Although these standards influence the speed and efficiency of a landscape operation, the contractor's attitude toward controls should be tempered with the understanding that most legal requirements protect the health, safety, and welfare of the public and of the contractor.

This chapter covers typical relationships, rules, **contracts**, standards, and entities that govern the profession of landscape contracting in many parts of the nation. National standards, or **codes**, provide guidance in the form of construction standards. Local **ordinances** and building departments provide requirements for location, construction, and, occasionally, style of landscape improvements that can be installed. Local governments may also require that owners or contractors obtain permits and pay fees prior to construction. Contract documents, a legally binding set of instructions, guide projects by placing control over the materials and methods that may be used. In addition, insurance standards, usually expressed in limitations and restrictions incorporated into policies and contracts, also provide some level of control over landscape work.

Before beginning a construction project, the contractor must verify legal requirements. Failure to do so may mean paying fines or removing parts of a project that do not comply with regulations. To verify that the locale has regulations by which the contractor must abide, look in the government section of the phone book for county and city building departments or for a zoning administrator. In some areas, planning departments and forestry departments may be the local regulatory agencies. When you describe the work being done, these officials should be able to provide direction through the appropriate process. Ignorance of legal requirements will not relieve the contractor of liability.

CAUTION

Legal counsel should be obtained for the interpretation of any information described herein.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this

chapter, read the related information in the following chapters:

- Interpreting Construction Documents, Chapter 3
- Project Pricing, Chapter 5

CONTRACTOR/CLIENT RELATIONSHIPS

Entering the world of business requires the contractor to be aware of the many methods for obtaining work, to understand relationships with clients and related parties, and to execute contractual relationships with clients. Because space is limited in this text, this chapter provides an overview of the most common contractor/client relationships. The author suggests supplemental reading to obtain additional information regarding design and construction contracts.

Obtaining Landscape Contracting Work

Obtaining work is essential for the contractor to maintain a business. Methods to obtain, or procure, work in the contracting field range from informal marketing efforts to formal subcontracting arrangements with major builders. Several aspects of the contractor's work may influence the success in obtaining contracts. These aspects include such factors as how the contractor's rates for performing services compare with others in the market area, how efficiently the contractor works, and how quickly the contractor can provide services. Experience in performing similar types of projects and the quality of the contractor's work are also crucial selling points. Depending on the type of procurement method, one or more of these factors may be critical. Three basic methods for obtaining work in the landscape contracting field can be identified: direct procurement, competitive negotiation, and competitive bidding. Chapter 5 explains specific techniques for calculating and presenting costs that these methods require.

Direct Procurement. Direct procurement involves the acquisition of contracts for landscape services directly from a client. The contractor may initiate direct procurement through advertising or marketing of services, by the client through referral from another client, or by what the industry terms "walk-in" business. In any instance, the contractor sells materials and services to the client without direct competition from other parties.

Competitive Negotiation. Many customers prefer to "shop" for landscape services and receive proposals from several service providers. This form of procurement often requires the contractor to submit detailed explanations and itemization to ensure the selection of services based on similar proposals. Competitive projects may be client-originated or solicited from **general contractors** (contractors who hold the prime contract for completion of a large construction project) or from **design professionals** (landscape architects, architects, and engineers) who have projects with private clients. General contractors or specialized contractors, those who perform specific operations for a project, often use competitive negotiation to select subcontractors.

Although negotiation with design professionals and general contractors is standard practice for projects, negotiation directly with a project owner can be challenging. Because most clients are inexperienced in comparing the quality of products and services available, miscommunication is common with this method of obtaining services. The situation is complicated further if the contractor has priced services without the benefit of a design. Slight differences between interpretations of client needs can lead to substantial differences in price. Negotiation is further complicated when the client wants to add or remove elements from the project, begins comparing different design ideas, or places proposing parties in competition with each other on price. The inconsistencies of this process underscore the importance of providing design services as a separate phase from installation services.

Competitive Bidding. Bidding is a formal process practiced by public clients for all but small projects and by private clients for most large projects. Competitive bidding requires that contractors offer, or bid, a sealed project cost based on a specific design. A client will open all proposals at a designated time and place. Selection of a contractor is typically based on the lowest bid submitted by a qualified contractor. A design professional or the client's agent generally determines a qualified contractor. Certain contractors may be disqualified from bidding based on sound legal reasons such as lack of experience, financial insolvency, or government sanction.

Submission of bids is typically restricted to general contractors. In many projects, the landscape contractor will not be the entity submitting the bid. Landscape contractors may submit a bid or negotiated price to a general contractor, who will

add that total to the other subcontractor prices and submit it as part of that contractor's bid. It is not unusual for a landscape contractor to submit prices to several different general contractors for the same project. Bidding opportunities can be obtained by reviewing public notices, contacting plan houses (such as Dodge House, a private publisher who tracks major invitations to bid), prime contractors, and design professionals. Prices prepared for bids may take different forms, as described in Chapter 5.

Relationships Between Contractor and Client

When work is secured, the contractor's relationship with the client is defined as either a general contractor or a subcontractor. Whichever of these positions the contractor holds will have a significant impact on control of the project. Third parties, such as design professionals acting as owner's agents and consulting construction managers, also affect the relationship between contractor and client (Figure 2-1).

General Contractor Relationships. Responsible for completing all aspects of a project, a general contractor holds the prime construction contract with the client, who is typically the project owner or financier. This relationship is framed by the terms of a contract spelling out each party's rights and responsibilities. On complex projects, the general contractor may be responsible for numerous suppliers and subcontractors, including those doing the landscape installation, as well as his or her own workforce (Figure 2-1 A). When subcontractors complete portions of a project, the general contractor assumes responsibility for their work.

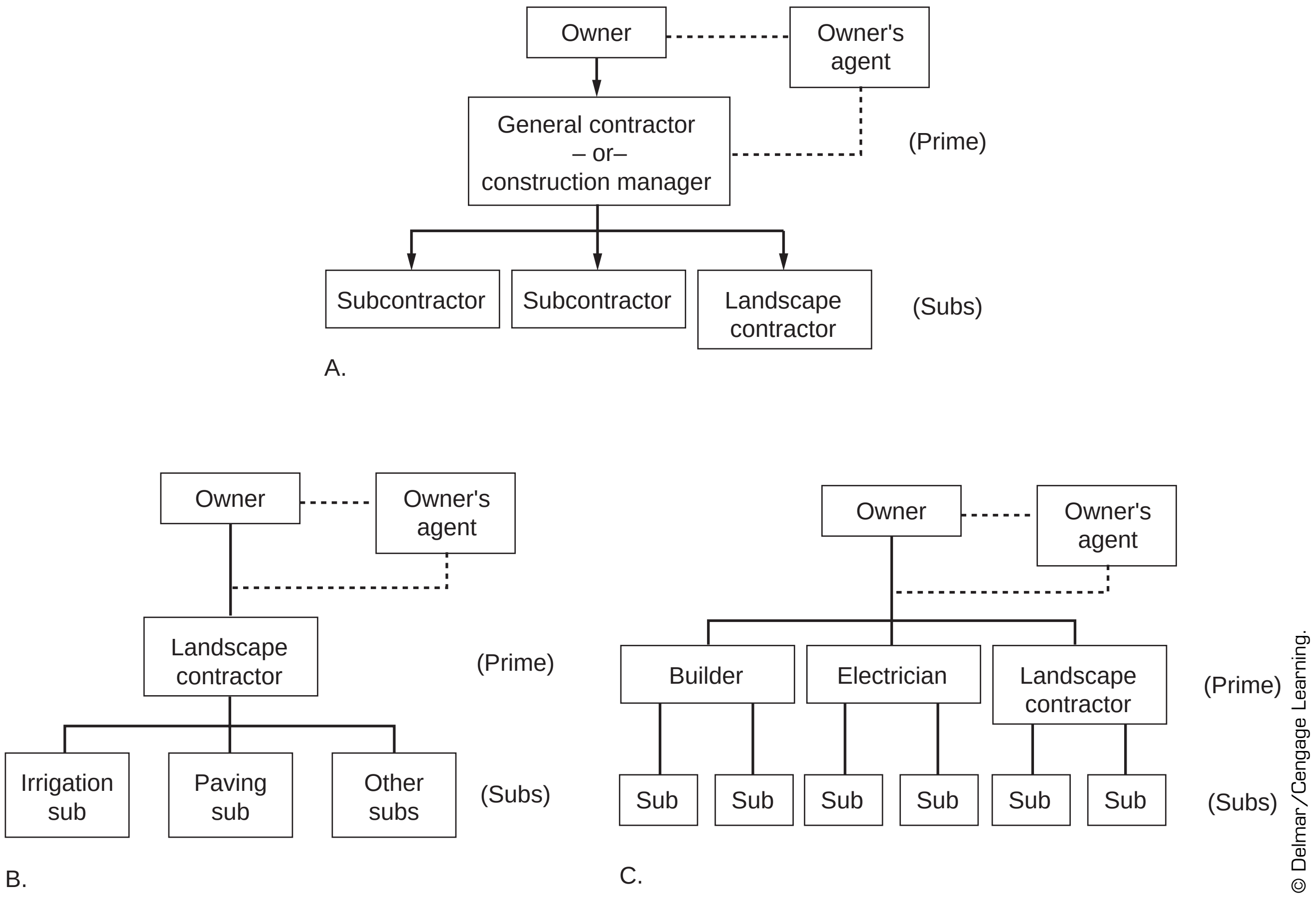

Figure 2-1 Relationship of owner and contractors in the landscape process. (A) Landscape contractor as a subcontractor. (B) Landscape contractor as a general contractor. (C) Landscape contractor as one of several general contractors.

In projects that cover only landscape construction elements, the landscape contractor may serve as a general contractor (Figure 2-1 B). The landscape contractor is then responsible for completion of all work, including those elements that are subcontracted to others.

Another arrangement under the contractual arrangements for a project is the concept of multiple general contractors (Figure 2-1 C). For reasons of timing, cost, or quality control, the client may choose to separate major work areas into separate contracts. Prime contracts will be offered for each of the work areas, with each general contractor being responsible for work within the appropriate trade. The general contractors, owner's agent, and other parties to the work must then coordinate activities among all the contracts.

Subcontractor Relationships. Subcontractors perform specialized work for a project; and although they seldom have a contractual relationship with the project owner or financier, subcontractors maintain a formal or informal relationship with the general contractor. Employing several subcontractors from many building trades for large building projects is a common practice, as is subcontracting landscape elements of a project. Specialization within the landscape contracting field has also increased the possibility of having several landscape-related subcontractors for a single project, such as those who specialize in irrigation, wall construction, plant installation, and turf establishment.

Third Parties to Contractor/Client Relationships. Communications between the prime contractor and owner will typically be referred to the owner's agent (Figure 2-1). In many projects, this will be the design professional. The owner's agent will serve as the clearinghouse for all communications with the owner, accepting and approving submissions and providing instructions to the general contractor. Whether a general contractor performs landscaping work on a small project or a subcontractor performs landscaping work on a large project, any change or deviation from the plans and specifications will require approval from the owner's agent.

Construction Managers

An alternative to completing a project using the typical contractor/subcontractor relationship is to employ a project management firm. The project management firm bridges between design and construction by contracting with the project owner to advise on design and construction and by maintaining the integrity of the project by managing its installation.

The construction management model has three variations. First is the design-build firm, which project owners employ to complete both the design and implementation of a project. Another variation is the agency construction manager who, in exchange for a fee, assists the owner in employing both designers and contractors. Either of these two methods provides advantages to owners. For example, some owners may have too many projects or very complex projects and may need assistance to manage them. Other owners may be novices in the implementation of construction projects and may need an experienced manager. Additional advantages in the form of cost savings are often derived from integrating design and construction. Construction management reduces the adversarial roles often found between designers and contractors and maintains tighter control over the scheduling of activities. Yet a third form of construction management is the at-risk model, in which the manager acts as designer and general contractor for a project, providing the owner a guaranteed maximum price.

Forms of Contracts

A written contract should guide the execution of work in any form. Whether simple or extensive, the contract forms a basis for a relationship between parties and provides a mechanism whereby disputes can be resolved. As mentioned earlier, seek the advice of appropriate legal counsel before preparing and entering into any contract.

Required Conditions of a Contract. Certain conditions must be written into or contained within contracts. They must contain lawful subject matter, must include an offer and exchange (a fee for services rendered), must be negotiated between competent parties, and must not be signed under duress. Contracts must also include agreement and be in proper form for the jurisdiction in which the work will be performed. In addition, the following items should be included in a contract for landscape services:[1]

- Names and addresses of the parties involved
- Date of contract preparation
- Description of the work to be accomplished (also called the scope of services) and the materials or services to be provided, including the location where it is to be accomplished

- The terms of completion, including inspection, the completion date, and the penalty for not completing on time
- The terms of payment
- The signatures of both parties or their legal representatives
- The date of signing

Contract Documents. The documents used to bid and construct large projects are collectively referred to as **contract documents** or **construction drawings**. Included in a full set of contract documents for a large project would be instructions for bidding, contracts for construction, general instructions, and specific technical instructions. These preceding elements are collectively referred to as **specifications**. Also included within the contract document definition would be the set of plans used to guide construction, provisions for change orders if construction is altered, and payment and completion documents to be used during construction. For suggestions on interpreting the drawings and specifications for construction purposes, refer to Chapter 3. All elements of this project documentation are part of a legally binding contract, whether work is performed as a general contractor or as a subcontractor.

Subcontractor/Contractor Agreements. The relationship between a subcontractor and general contractor may be in the form of a contract, an informal letter agreement, or, inadvisably, through oral agreement. Formal and informal agreements should address issues such as recognition of the prime contract, work to be performed by the subcontractor, payments to the subcontractor, timing of the work, insurance and bonding required of the subcontractor, special conditions required by the project, and agreement by the parties.

Two-Party Contracts. Smaller projects may proceed without the benefit of an expansive set of contract documents. Contractors may work from written proposals or landscape drawings that have been presented to, and agreed upon by, the client. Although it varies according to where the contract is prepared and how the proposal is worded, most written proposals are legally binding if both parties sign the document. Proposals lack the type of specific instructions for every element of the project that contract documents provide. Hence, a great deal of communication and understanding by the parties is required to avoid disputes.

BUILDING CODES

Codes are typically prepared by national institutes or organizations that have an interest in advancing the safe application of their trade. Two of the most prominent types of building codes are structure building codes and the National Electrical Code (NEC).

Structure Building Codes

When landscape projects involve the construction of any structure to be occupied, the guidelines of the standardized building codes typically come into play. Building codes provide a wealth of information regarding the safe planning of structures. Information regarding material standards, connectors, area planning, dimensions, and other details of building construction are included in these codes. Examples of building codes used in various areas of the country include ICC (International Code Council, based in Birmingham, Alabama), UBC (Uniform Building Code), and the Standard Building Code. Building codes are adopted on a locality-by-locality basis, so check with the city or county zoning administrator or building office to determine if the codes apply to work being performed.

National Electrical Code (NEC)

Concerns over protection from fire and electrocution led to development of guidelines found in the NEC. Electrical codes guide the planning and installation of electrical systems, including, as safety precautions, circuit load, wire size, connection instructions, material selection, and many other minimum safety standards. Electrical codes are available from building officials or electrical associations.

Related Building Codes

In addition to structure and electrical codes, the Standard Plumbing Code, Uniform Plumbing Code, Standard Gas Code, Uniform Mechanical Code, and BOCA National Plumbing and/or Mechanical Codes may affect the work being performed.

ORDINANCES AND DEED RESTRICTIONS

Local control over construction projects is typically expressed through the use of ordinances that control zoning and building. These regulations place stipulations on the use of land and the

construction of improvements on property that lies within a legal **jurisdiction**. In large communities, these regulations can be extensive and complex; in small communities, they may not exist at all. In absence of an ordinance and permit system, a governmental unit may require adherence to one or more of the codes mentioned in the previous section. Some local government controls are listed in the following section. Contact local building officials, zoning administrators, city foresters, or homeowner association officials to determine if any regulations apply to the work being done.

Zoning Ordinance

Zoning ordinances control how land within a government's jurisdiction may be used. This control may restrict the type of structure one may place on a property, the dimensions of that structure, and the uses of the structure. Also common in a zoning ordinance are requirements for **setbacks**, or distances between improvements and property lines. Elements of a zoning ordinance that may influence landscape construction include provisions that control fence requirements (such as around a swimming pool) and location, fence height and materials, deck location, deck materials and construction, and railing requirements.

Sign Ordinance

Signage controls may be located within a zoning ordinance, but some locales place regulations on signage in a separate ordinance. Controls on sign use, materials, location, lighting, and size are common in developed areas.

Parking Ordinance

Quantity and location of parking spaces, as well as control of access drives, can sometimes be found in an ordinance separate from the zoning ordinance.

Street Tree Ordinance

Many cities have regulations on what type of plants may be placed in city rights-of-way (Figure 2-2). A street tree ordinance will clarify the species that are acceptable for urban planting and may offer guidelines for plant location.

Plant Pruning and Removal Regulations

In communities where plant material is protected from development, permission may be required before trees and shrubs are pruned or removed. In

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Figure 2-2 Street trees along a public boulevard.

selected communities, trees that are of select species or of a certain age or size may be declared heritage or historic trees. Such a designation is intended to protect the plant from damage, particularly from maintenance and construction operations. In addition, the removal of smaller plants or pruning to allow construction may be regulated. Discuss any plans that require major plant pruning or removal of plants with the city forester, parks department, or zoning administrator.

Floodplain and Restricted Area Regulations

Protection of waterways and natural areas has proven beneficial to reducing pollution, enhancing wildlife, and improving overall environmental quality. Many waterways, water bodies, and natural areas are protected from construction activities by entities such as city ordinances, water quality boards, water districts, and the Army Corps of

Engineers. Conducting construction operations within these areas may be prohibited, or at least restricted, and may require special permits. Typical restrictions include requirement of permits, limits on the amount and location of earthmoving, limits on plant material, design control over outfall and discharge structures, and requirement of installation of erosion control protection.

If contractors are not sure of, or are not notified of, work conducted in restricted areas, they should communicate with city or county officials. Indications that restricted areas may exist are the presence of standing or moving water bodies within 100 feet of the construction site or the existence of wetland plants (cattails, rushes, sedges) within your work area.

Disposal of Site Drainage

When construction plans require water to be collected and diverted away from improvements, verify that the planned outlet location is acceptable for dumping. Pollution or flooding regulations may restrict the emptying of drainage into storm sewers, streams, and other waterways. Changing the drainage of runoff in a manner that damages neighboring property could be considered trespassing (see "Tort Issues" later in this chapter). The local water district or city engineer should be able to provide information regarding legal outlets for tiles and drainage swales.

Deed Restrictions

Planned communities, condominium housing complexes, historic districts, and other communities may have restrictions that control what type of exterior improvements can be planned and built. These restrictions are intended to develop uniformity of development or to protect historical authenticity. Review plans with authorities in these situations to verify if construction work must follow established guidelines.

Historic Districts

Neighborhoods with unique and older homes could be designated as historic districts and the homes as historic properties. If the property is on the National Historic Register or within a National Historic District, work on the exterior of a site could be restricted. Even if there is no national historic designation, many jurisdictions have state and local equivalent designations to protect the site. Limitations often include the type and number of changes that can be made to building exteriors, dictation of specific materials, and possibly controls over a wide range of design materials. To verify if the site has such restrictions, contact city or county zoning officials, or check with a state historical society.

In addition to structures on them, sites may also have protection according to their archeological, Native American, or ancient graveyards status. Although the designer is often asked to verify if such restrictions apply, contractors should also be aware of the protected status of the site and be prepared to ask what conditions might apply to their work. During construction, contractors should be observant of any antiquity or artifact unearthed during their work and be prepared to suspend activity until the authorities can clear the site.

Building Permits and Site Plan Reviews

To verify compliance with ordinances, counties and communities often require that a building permit be obtained prior to beginning construction. The process of obtaining a permit may simply involve an official who reviews ideas, or it may require a series of committee meetings in a process called a site plan review. Either method will most likely require preparation of a plan that contains descriptions of the work, along with elevations and dimensions. Building and zoning officials typically supervise the issuance of building permits and submissions for a site plan review.

INSURANCE, BONDING, AND LICENSURE

Insurance, bonding, and licensure are means in which contractors can protect themselves and the business being operated.

Insurance

Considering the risks involved in construction, contractors are advised to obtain necessary insurance to cover the perils faced when building landscapes. Risk in the landscaping industry comes primarily in the form of comprehensive liability from accidental destruction of property, employee accidents, and vehicular accidents. Natural peril coverage and errors in workmanship are also risk areas for which protection may be sought. Other activities that may require insurance protection might include umbrella liability policies, equipment and materials coverage, and crime policies.

Contracted projects typically require that contractors have insurance coverage before work begins, and contractors should not begin any work without securing basic coverage. An insurance agent can best advise about the extent or amount of coverage needed for a particular job.

Bonding

Bonding is a surety tool in which a bonding agency guarantees payment in the event a contractor fails to complete a legal obligation. Common for large projects, bonding is required for licensing in some localities. Bonding protects the project owner from losses, damages, liens, and unpaid bills on the contractor's part. Common bonds used in construction are described in the following section. Bonding agents are typically contacted to obtain proper construction bonding.

Bid Bond. The bid bond protects the owner if a contractor withdraws a bid after opening. Most formal bids require that a bond in the amount of 5%–10% of the total bid be included with the bid. If the low bidder on a project withdraws, the owner may apply the bond against the expense of rebidding the project.

Performance and Payment Bonds. Successful bidders are often required to submit performance and payment bond(s) prior to beginning construction. Performance bonds provide protection to the owner in the event that the contractor fails to complete the conditions of the construction contract. Payment bonds (also known as labor and material payment bonds) guarantee payment of labor and material bills that the contractor incurs in the construction of the contracted project.

Performance and payment bonds that combine these two sureties are available, but many projects require submission of dual bonds—one covering each risk. Typically, bonding for performance and payment is 100% of the contract value. If either of these conditions for which the contractor is bonded occurs, the bonding company may be contacted for assistance in completing the project and/or payments.

Business Licensing

Several states, counties, and cities require that anyone providing products and services to the public obtain a business license to operate in their jurisdiction. The process for obtaining a license may be as simple as filling out an application and paying a fee, or it could include bonding and proof of insurance. The issuing agency may stipulate additional licensure requirements. In some cases, the contractor may be required to obtain a license for every jurisdiction in which the firm works. Contact state departments of commerce, county clerks, and city clerks for information regarding business licenses.

Contractor Licensing

Several states require that landscape or irrigation contractors be licensed to practice their trade. By licensing the professions, states can provide some level of protection for the public's health, safety, and welfare by screening out unqualified practitioners. Licensure procedures vary from state to state and may include completing legal documents, taking exams, or providing evidence of capability to perform work. Bonding and verification of insurance may be additional requirements.

To determine whether a business will require licensure, contact the Department of Commerce or appropriate licensing board in the state where practice is planned. In some jurisdictions, the licensing of contractors may be administered by a county or city government agency. Local zoning and building officials or local landscape association professionals may also be able to assist.

If your company is planning to engage in design/build operations, verify licensure requirements for contracting and designing. Many states require the licensure of landscape architects and, depending on the type of law, may restrict the level of design work that can be performed. Landscape architecture licensure laws are either title or practice laws. Title laws prohibit an unlicensed design professional from using the title *Landscape Architect* in any form, whereas practice laws limit the scope of work that an unlicensed professional may design. In some areas, work on public and commercial projects may legally require the design skills of a licensed landscape architect, rather than the **landscape designer** or contractor.

TORT ISSUES

A contractor will be required to perform activities within the boundaries of the law. Although specific legal requirements vary from region to region, several general requirements are similar without regard to locality. Failure to abide by legal requirements resulting in damage to another's property is considered a **tort** and could result in payment of damages

to the offended party. It is to the contractor's benefit to discuss common legal requirements with industry officials, association members, and insurance and legal advisors before beginning work in the landscaping field. The next section discusses common issues that could lead to legal action.

Trespass

Trespass is an offense committed against another's property. A charge of trespass requires physical entry without permission and the commission of damage. Trespassing is not limited to humans physically entering a site and committing damages. It involves anything under the contractor's control, including equipment, debris, drainage, or other entities, that enters someone else's property and causes damage.

Nuisance

A disruption that causes discomfort to another is considered a nuisance. Working in an unsafe manner or at odd hours may be considered a nuisance. If they meet the legal tests, excessive noise and dust or even disruption caused by construction activities may also be construed as a nuisance.

Negligence

Failure of a professional to act in a reasonable and prudent manner to safeguard the well-being of others leads to negligence. For example, failing to mark construction areas or performing overhead work without any safeguards could lead to legal action if a contractor does not engage in actions or protective measures that would be reasonably expected to protect the public.

Riparian Rights

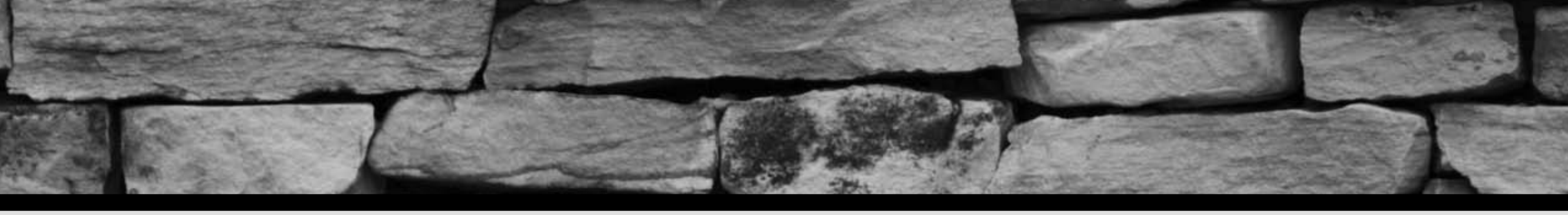
Subject to state and federal laws, landowners have rights regarding access to and use of waterways that run through or abut their properties. Changing the conditions of that waterway, possibly through irrigation or damming, may create a legal violation of those laws.

Lateral and Subjacent Rights

Construction activities that affect the lateral support of neighboring properties may lead to legal action. Landowners are entitled to maintenance of the grade at their property line. For example, if excavation for a parking lot collapses the neighboring grade, lateral support has been denied. Grade change activities must be completed within the boundaries of a project, not outside those boundaries unless neighboring property owners have given prior approval.

ENDNOTE

1. Jack Ingels, *Landscaping Principles and Practices,* 7th ed. (Clifton Park, NY: Delmar Cengage Learning, 2009).



CHAPTER 3

INTERPRETING CONSTRUCTION DOCUMENTS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Measure a construction drawing using a scale.
- Comprehend what construction activities are required from construction plans and specifications.
- Build a landscape project from a set of plans and specifications.

Large and/or complex projects require detailed instructions explaining how the project is to be built. These instructions, called plans and **specifications** (this term is often shortened to "specs"), are prepared by design professionals such as landscape architects, architects, and engineers. Plans and specifications provide the information necessary to ensure that the project is constructed exactly as the owner desires.

This chapter explains the types of construction documents that may be encountered on a project and explains how to interpret the content of key documents. Each plan and specification contains a different type of information, but all plans and specs work in concert to provide necessary information. Even if bidding only landscape work, the landscape contractor should obtain a complete set of construction drawings and specifications at the beginning of the project to verify that other project activities will not change or influence the bid. Because they often receive only their section of the plans and specs, subcontractors encounter problems when they later discover they must perform work that was described in sections they did not review.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Legal Requirements, Chapter 2
- Project Pricing, Chapter 5
- Construction Staking, Chapter 8

READING SPECIFICATIONS

Specifications provide written instructions about most aspects of project construction. Because they address a wide range of topics, specifications are typically organized into sections that cover the nontechnical aspects of the work, often called *general conditions,* and the specific construction procedures, often called *technical specifications.*

General Conditions

General project information is located in the front of the spec manual and includes a wide range of documents. Based on the scope of the project, this information can be quite detailed and extensive. The information contained in these sections pertains to all work, and contractors should familiarize themselves with the details before beginning construction. Special requirements necessitated by laws and regulations

should be explained in this part of the specs. Typical documents found in the general conditions section include:

1. Bidding information
   - Invitation to bidders
   - Instructions for bidders
   - Bid form
   - Noncollusion affidavit
   - Bid bond form
   - Receipt of addenda acknowledgment
2. Sample contract and other forms to be submitted
3. Forms used during construction
   - Notice to proceed
   - Change order form
   - Certificate of payment
   - Certificate of substantial completion
   - Lien releases
4. General conditions
   - Definitions of roles and responsibilities for owner, design professional, contractor, and subcontractors
   - Clauses addressing contract time, payment, completion, retention of fees, changes in work, correction of deficient work, bonding, insurance, royalty payments, related contracts, protection of the work, resolution of disputes, termination of the contract, and miscellaneous provisions
5. Supplemental conditions
   - Government requirements that will govern work, such as anti-kickback regulations, prevailing wage rates, adherence to civil rights, nondiscrimination, and labor legislation
   - Warranties and guarantees
   - Subcontractor approvals
   - Temporary fixtures and utilities
   - Request for material submissions and approval of substitution requirements
   - Other requirements relating specifically to the project

Technical Specifications

Technical specifications include descriptions of the methods, materials, and performance of project components. A variation of technical specifications, typically more common in nonlandscape trade areas, may specify a particular product name or specify how the installation should perform after completion.

To keep the instructions manageable, technical specs are typically grouped according to trade. In large projects, several sections might contain building specifications that have limited impact on landscaping work. Although professionals will use an organizational style with which they are familiar, one standard is a numbering system known as Masterspec®, published by ARCOM, American Institute of Architects (see Appendix B). Under this system, the work for a project is divided into 35 divisions (with nonconsecutive division numbers ranging from 1 to 35; certain sections are left blank for future expansion). Landscaping and sitework are typically found in division 32, but portions of a landscape contractor's work may also be found in divisions 12 (site furnishings), 26 (exterior lighting), 31 (earthmoving), and other sections within the specifications. In addition to Masterspec®, another set of standard specifications can be obtained from Masterformat by CSI (Construction Specifications Institute).

Two basic types of technical specifications are typical to the construction industry. Material and workmanship specifications and performance specifications vary widely in their approach to directing the type of construction used on a project. The wording and manner of the technical specification influence the choices a contractor must make.

Material and Workmanship Specifications. Material and workmanship specifications detail the materials and construction procedures to be used to complete each project component. This type of specification restricts the contractor to use only those elements that the designer has chosen. A typical format for material and workmanship specification begins with a section covering aspects such as warranties, material delivery, and reference standards. A second part indicates what materials are to be used for the project. This description can be written as a closed or an open specification.

- Closed Specifications. Closed specifications limit the contractor's choice of methods and materials. For example, choices may be limited to a single product brand/model (proprietary specification) or to a specific procedure. When closed specifications are used, substitutions are not common.
- Open Specifications. Giving the contractor more choice of materials and methods, open specifications may list two to three

alternative brands/models or list a brand/model and the clause "or equal." The or equal clause allows the contractor to propose brands/models to the owner's agent for approval.

The last part of this type of specification describes the detailed installation methods to be used. An example of a material and workmanship specification is presented in Appendix A.

Performance Specifications. Without providing specific materials or methods, performance specifications prescribe the results that a component of construction must obtain. This type of specification limits the contractor only in producing a product that looks and performs as the designer intended. An example of a performance specification in landscaping is presented in Appendix A.

Reference Standards. Throughout specifications and construction material literature, references can be found to standards that testing agencies, associations, and organizations publish. Design professionals often refer to these specifications and incorporate their parameters as part of legally binding contracts. These organizations spend considerable time preparing standards for the performance and installation of materials, many of which are related to the landscaping industry. A common reference is the American Society for Testing Materials, which prepares standards used throughout all industries. References relating to landscape trade areas include American Association of Nurserymen standards for nursery stock (ANSI Z 60.1), Interlocking Concrete Paving Institute (ICPI), Brick Institute of America, Portland Cement Association, National Electrical Manufacturers Association (NEMA), Asphalt Institute, American Concrete Institute (ACI), California Redwood Association (CRA), and American Institute of Timber Construction. When reference is made to one of these standards, contractors are responsible for obtaining the relevant information and verifying that their work conforms to the standard.

Additional Specification Documents

In addition to those provided by the specifications, other written instructions may be provided during the construction process. Two key documents that affect the process are addenda and change orders. **Addenda** are official notifications of changes in the project, typically revisions of the construction plans or specifications, that occur before the time of bid opening. Addenda modify the project, and these modifications should be reflected in any bid submitted. **Change orders** are revisions to the project that occur after the contracts have been signed. The owner's agent initiates change orders, and the contractor responds by submitting price and/or project scope changes.

READING CONSTRUCTION DRAWINGS

Plans are the graphic communication tools that provide information regarding location, grade, and type of improvements to be placed on the site. To interpret construction plans, contractors need a basic understanding of engineering drafting elements. Following are descriptions for reading drawing scales, dimensions, abbreviations, symbols, and textures. This presentation is an overview and should not be interpreted as a comprehensive explanation of all aspects of engineering graphics. Interpretation of specific plans prepared for landscape construction follows the information for reading drawings.

Drawing Scale

To assist in the interpretation of construction plans, a discussion of the concept of **scale** should precede plan reading. Because most drawings cannot be drawn life-size, the site must be reduced to fit on a sheet of paper that is convenient to carry and read. To reduce the size in a manner that is consistent and measurable for all drawings, the concept of scale is used. Simply put, scale means that a certain measurement on a drawing is equal to a distance on the actual site. Whenever that scaled distance is measured on a plan, the same actual distance should be obtainable on the site.

Scale in landscape construction drawings is typically a reference of 1 inch on the drawing that equals a certain number of feet on the site. Choice of scale depends on the size of the object/site being measured or the stated scale on a drawing. An example would be a scale stated as 1 inch = 20 feet, where 1 inch on a construction drawing equals 20 feet on the actual site. Two types of scales are used for construction drawings: an architect's scale that uses fractional divisions and an engineer's scale that uses multiples of 10 (Figure 3-1).

Special instruments, conveniently termed *scales,* are available for the measuring of plans. Contractors do not have to constantly measure the number of inches and multiply by a conversion number when

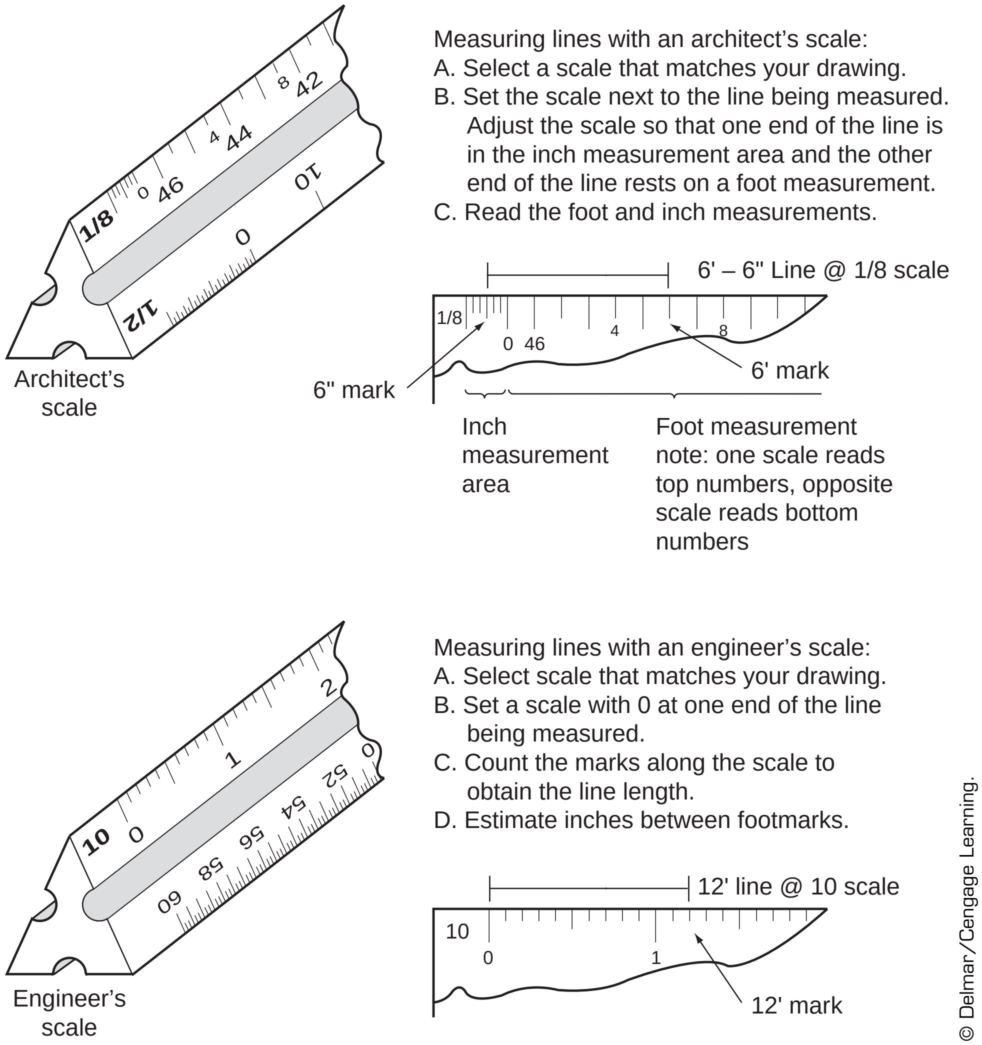


Figure 3-1 An architect's scale with fractional divisions (top) and an engineer's scale with divisions in multiples of 10.

they use scales. Rather, scales indicate the number of actual feet on the instrument. Although the reading of scales, particularly the architect's scales, takes some training and practice, they are useful tools for interpreting construction drawings. Landscape drawings and details relating to landscape work can be drawn in either type of scale. The reader should be able to locate a written scale and a graphic, or bar, scale on each drawing.

Measuring lines with the architect's scale first requires finding the scale that matches the drawing being interpreted. After locating the scale, identify the line to be measured. Set the scale next to the line being measured. Adjust the scale so that one end of the line is in the inch measurement area (this is the finely divided area behind the zero) and the other end rests directly on a foot mark. Read the foot reading and inch reading to obtain the measurement. Use caution when reading both the foot and inch readings on the architect's scale. Architect's scales have two scales running in opposite directions along the same edge of the scale—one reading the top set of numbers and the other reading the bottom set of numbers. Inch markings on the architect's scale may represent inches or fractions of inches, depending on the accuracy of the scale.

Measuring lines with engineer's scales also requires determining drawing scale before measurement. Locate the line to be measured and place the zero mark from the correct scale at one end of the line. Count the marks along the scale to determine line length. Each mark on an engineer's scale represents 1 foot. Helpful numbers

are placed to identify increments along the scale. Inches can only be estimated on an engineer's scale.

A warning is in order when using scales to obtain measurements from construction plans. Because the paper on which a drawing is printed can stretch and shrink, using a scale to determine the dimension of objects shown on a construction plan is not recommended when dimensions are provided. Look for a labeled dimension, which always take precedence over a scaled measurement. Plans that show plant locations may rely on the design professional's field staking or on the contractor's interpretation of the dimensions to accurately locate plants. In addition, plant spacing may be noted elsewhere on the plan. In the absence of labeled dimensions, call the designer for a written verification of missing dimensions or for instructions on interpreting site element locations.

Drawing Types

Three types of drawings are typically used to show improvements for a project—**plan view**, **cross sections**, and **elevations**. Plan view is the primary drawing type used for landscape improvements. Plans show a view looking straight down on the top of a project. Only two dimensions of site elements are visible in a plan view—the length and the width. Cross sections show a side view that cuts vertically through an object, whereas an elevation is a side view that shows the vertical surface of the object. Height and either length or width are the only two dimensions of site elements visible in cross sections and elevations. Cross sections and elevations used for landscape elements are typically used to show details of installations.

Line Types

Construction drawings use a hierarchy of line weights to identify the importance of drawing elements. Lines that are the darkest on the plans typically indicate structures. A second tier of line weights is reserved for hardscape and items to be constructed (object lines). The next level of line width/darkness is used for dimensioning and notations (Figure 3-2). The variation in line weight is to improve readability of the plan and to underscore the importance of drawn elements. Dashed lines are often used to indicate existing contours, subsurface elements, hidden elements, or overhangs.

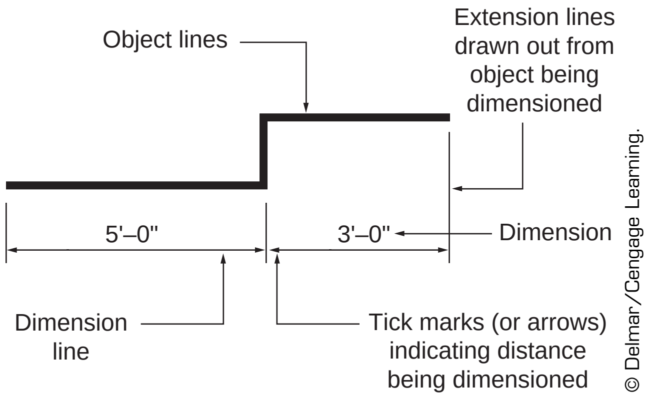


Figure 3-2 Typical line types on construction graphics.

Dimensioning

Items shown on plans for which location is critical have dimensions shown using special lines and labels (Figure 3-2). A typical dimension is located on a line that is slightly separated from and parallel to the object being dimensioned. The object being dimensioned and the dimension line are connected by extension lines that are drawn perpendicular to the object being dimensioned. The extension lines should line up with each end of the object being measured. In instances where several short measurements are provided for an object, an overall dimension may be placed outside the short dimensions.

Dimensions are placed in or above the dimension line and are stated in feet and inches, or feet and tenths for metric measurements. When dimensioning several similarly spaced elements, the designer usually dimensions the first element and adds the abbreviation *typ*. This abbreviation indicates that all following elements along that dimension line have similar measurements. When the dimension line is too small to place the measurement directly on the dimension line, the dimension may be placed to the side with a leader to the dimension line (Figure 3-3).

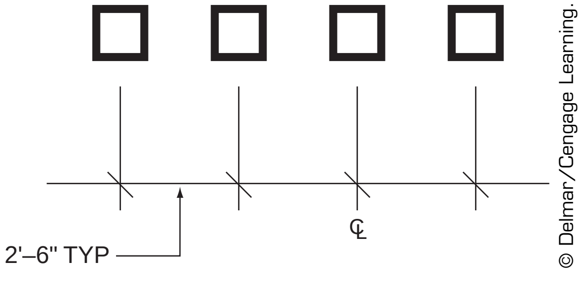


Figure 3-3 Dimensional notations.

Abbreviations, Symbols, and Textures Used on Construction Plans

Adding to the difficulty of interpreting construction plans is the variety of abbreviations (Table 3-1), symbols (Figure 3-4), and textures (Figure 3-5) used to represent construction measures and materials. Many of these items are standardized throughout all construction industries.

COMPUTER GENERATED (CADD) DRAWINGS

Drawings used for construction may be drafted by hand or drafted on a computer using **CADD (computer aided drafting and design)** technology. Drawings produced by either method should be treated in the same manner when reading and interpreting. Only rarely will a drawing be provided as a digital file (no paper drawings, but rather a file that a computer reads). Should you receive such a file, you will need the appropriate software to read it. This may necessitate a purchase of the same CADD program used to create the drawing. Because users can measure with drawing and area calculation tools, CADD drawing files offer the advantage of obtaining accurate project dimensions. Use caution that you do not alter the design when opening and interpreting the drawing.

If the drawing is a *pdf* (portable document format) document, you will need to obtain software called Adobe® Reader® to view the drawing. You can obtain this software for free from Adobe's Web site http://www.adobe.com/products/. Pdf files can be opened and printed but not changed. Use caution when obtaining quantities from pdf files, as the scale of the drawing you are viewing may not be the original scale as prepared by the designer. Other file types may be available to contractors for estimating and installation purposes. Check with the designer providing the documents for instructions on opening and using such files.

SHOP DRAWINGS

Shop drawings are graphic documents provided to an owner by a contractor or material supplier that show the construction details of a project's particular prefabricated or custom fabricated element. Shop drawings represent the contractor's or supplier's interpretation of the designer's requirements from the construction documents. The owner's agent typically approves shop drawings before they are implemented.

AS-BUILT DRAWINGS

As-built drawings, or record drawings, show the way a project was actually built, including any adjustments made as a result of field conditions and change orders.

Table 3-1 Typical construction drawing abbreviations

B&B	Balled and burlap	FG	Finished gradee	Nom	Nominal dimension
BC	Bottom of curb	FH	Fire hydrant	OC	On center
BM	Benchmark	FL	Flow line	OD	Outside diameter
BS	Bottom of slope	Ftg	Footing	PCP	Porous concrete pipe
Cal	Caliper	FT	Foot or feet	ROW	Right-of-way
CB	Catch basin	Ga	Gauge	SI	Storm inlet
CL	Center line	Gal	Gallon	SF	Square feet
CLF	Chain-link fence	HB	Hose bibb	SY	Square yards
CMP	Corrugated metal pipe	HP	High point	TC	Top of curb
Conc	Concrete	ID	Inside diameter	TCP	Terra-cotta pipe
CF	Cubic feet	Inv	Invert	TW	Top of wall
CY	Cubic yards	LP	Low point	TS	Top of slope
Dim	Dimension	Lin	Linear	Typ	Typical
Dia	Diameter	LF	Linear feet	Var	Varies or variable
El	Elevation	Max	Maximum	VCP	Vitrified clay pipe
Exist	Existing	MH	Manhole	WWM	Welded wire mesh
Exp	Expansion	NIC	Not in contract	YD	Yard drain
FFE	Finish floor elevation	NTS	Not to scale		

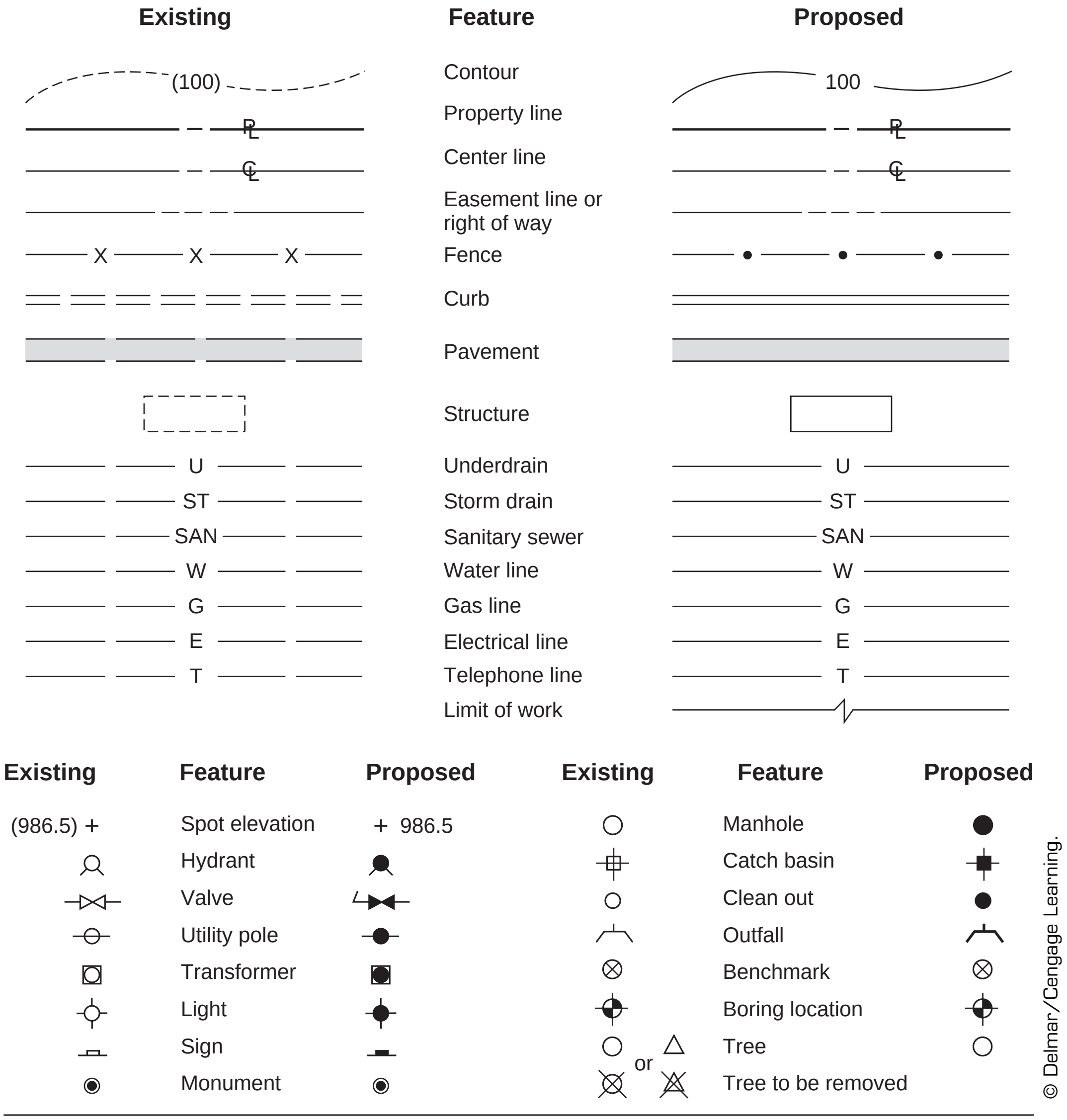


Figure 3-4 Typical symbols used on construction drawings.

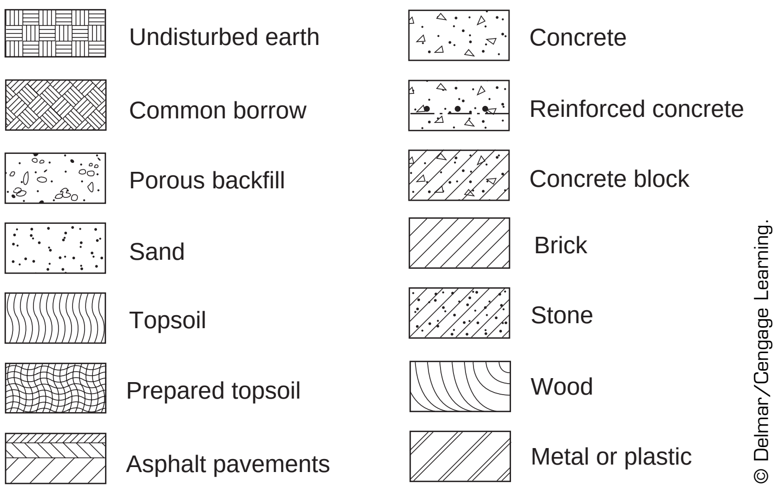


Figure 3-5 Typical plan and section/elevation textures used on construction drawings.

As-built drawings are essentially a set of original construction drawings marked up with the changes that were implemented during construction.

INTERPRETING LANDSCAPE CONSTRUCTION PLANS

Typical landscape construction plans are based on divisions of the work. Without experience in working with construction plans, landscape contractors could misinterpret the information these documents present. Included with each plan description are the types of data it includes, an explanation of how the data are graphically presented, and recommendations for interpreting plan information.

Site Preparation (or Site Demolition)

Site preparation plans show which parts of the existing site are to be removed and which are to be protected. Items that are to be protected or removed are indicated by notations and textures, with boundaries and work areas identified by symbols and lines. Although other contractors may do a majority of the work on this plan, the landscape contractor may occasionally have the responsibility of protecting existing site elements, particularly plant material.

To interpret the information on a site preparation plan, follow these steps:

- Obtain and read all plans and specifications related to site preparation for the project.
- Review the symbols, textures, and abbreviations used on the site preparation plan and locate and read any special notes placed on the plan.
- Become familiar with the drawing layout and locate major improvements such as buildings, roadways, parking lots, and natural features.
- Identify project boundaries and limits of work.
- Identify existing site elements to be preserved.
- Locate plant material to be fenced and the temporary erosion controls to be installed.
- Read notations regarding site elements to be removed.

Site Layout (Construction Staking)

Site construction staking plans show the horizontal location of all proposed improvements. Dimensions of walks, patios, drives, and any other landscape element for which location is critical are indicated on this plan. Design professionals use several formats for locating objects, including grids, **baselines**, and object dimensions. Grid format uses dimensions referenced from two baselines. Measurements are made down both baselines from a single beginning point to locate an object (Figure 3-6). Baseline format measures down a single reference line to provide one dimension for a point and makes a measurement at a right angle to that reference line to obtain the second dimension for a point. Using this format of two measurements, you can locate any point on a project (Figure 3-7). Object dimensioning format uses measurements along an existing object to locate new points. Buildings, roadways, or any other existing object can be used to dimension to new points (Figure 3-8). Dimensions should be carefully marked on a plan to avoid confusion with other numbers and lines.

Detail Keys. Details are identified on construction plans using a symbol termed a **detail key**. Although typically located on the construction staking plan, detail keys may be found on any of the plans. The detail key indicates the sheet number on which the detail is located and the detail number (Figure 3-9). Two numbers are placed inside a circle, with the detail number located on top and the number of the sheet where the detail is located on the bottom. A line that divides the circle will have an arrow, indicating which way the detail is facing.

To interpret the information on a construction staking plan, follow these steps:

- Obtain and read all plans and specifications related to construction staking for the project.
- Review the symbols, textures, and abbreviations used on the construction staking plan and locate and read any special notes placed on the plan.
- Become familiar with the drawing layout and locate major improvements such as buildings, roadways, parking lots, and natural features.
- Determine the layout method used.
- Find the reference point or beginning point used for layout.
- Read and mark overall dimensions for improvements.
- Locate specific dimensions for improvement.
- Identify which improvements have details, and use the keys to locate the details on the appropriate sheet.

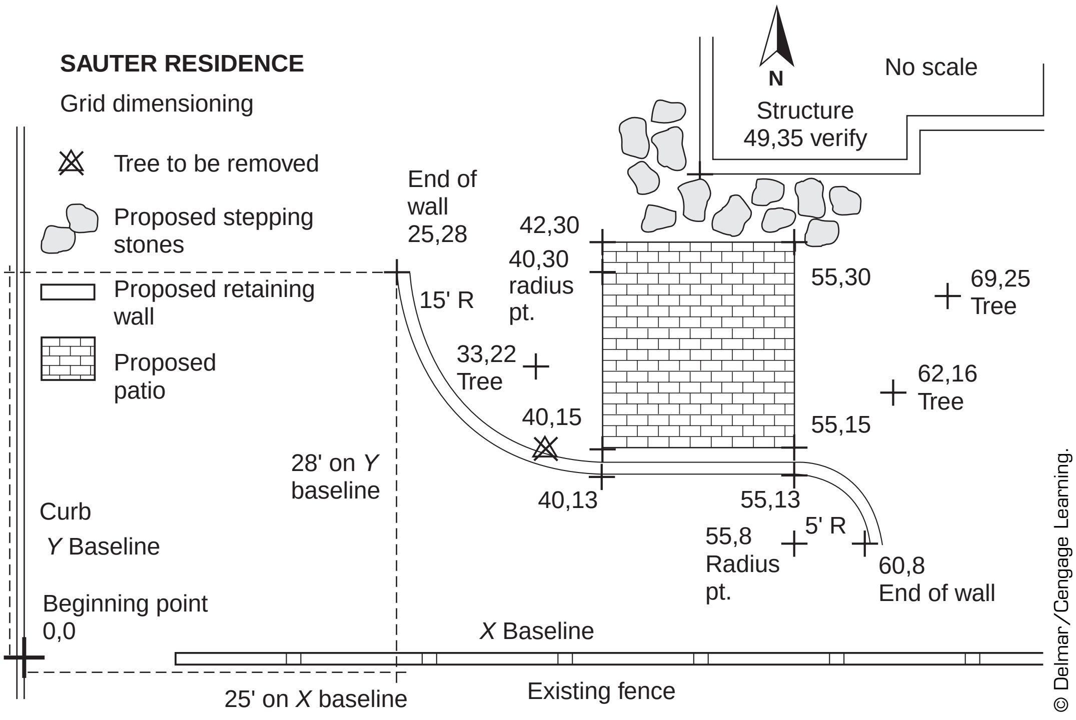


Figure 3-6 Layout plan using grid dimensioning. All points are located using *X* and *Y* coordinates laid out in reference to the beginning point. Dashed lines show example measurements to the first point located at 25 feet down the *X* baseline and 28 feet down the *Y* baseline.

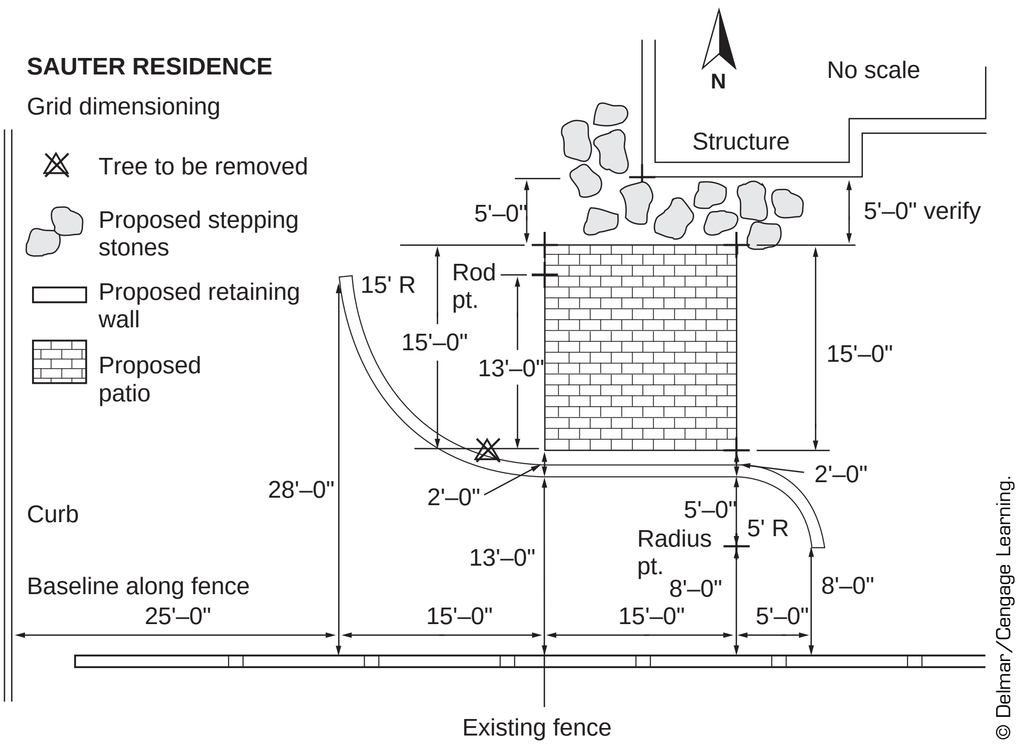


Figure 3-7 Layout plan using baseline dimensions. Points are located measuring off a project baseline.

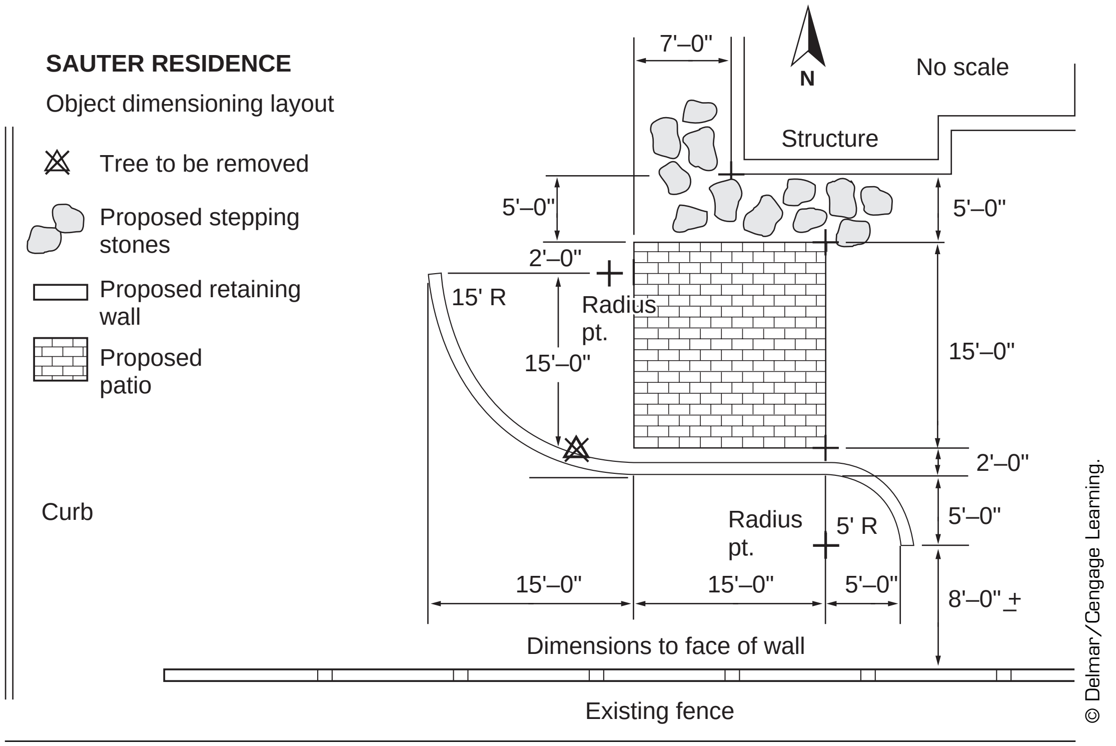


Figure 3-8 Layout plan using object dimensioning. Project elements are located by measuring off other nearby objects that have already been located. In this example, measurements would begin at the structure and continue outward toward the wall.

Grading Plans

Grading plans show the vertical location of all proposed improvements. Grading plans may also include information about water runoff, storm sewer construction, and storm water retention facilities. A key element of a grading plan is the **benchmark** for the site. The benchmark is a set elevation that serves as a reference for all existing and proposed grades for the site. Benchmarks should be placed at a permanent location and should be easily accessible from the site. Using **contour lines** and **spot elevations**, the grading plan indicates the desired height of site elements and the direction of slope. All contours and spot elevations for a grading plan should be set in reference to the benchmark.

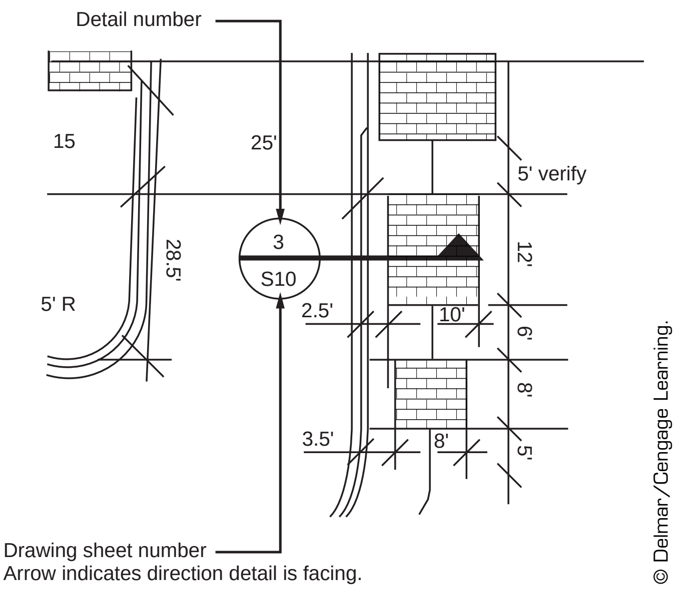


Figure 3-9 Keying details on a construction drawing. This detail key indicates a cross section of paving, with the arrow showing the direction the detail is facing. This detail can be found in Figure 3-14.

Contours are lines that connect points of similar elevation. Although useful for indicating general slope direction and steepness, contours are not sufficient to install improvements at specific grades. Contours are read by locating the elevation number printed in or directly on top of the contour line. Larger numbers indicate elevations that are higher than contours with lower numbers. Grading plans should include existing contours shown as dashed lines and proposed contours shown as solid lines. The closer contour lines are spaced, the steeper the slope. Contours spaced farther apart indicate a shallow, or more level, slope. Landforms used in

landscaping, such as **berms** and drainage swales, have a distinct contour signature (Figure 3-10). When a site is graded, the finish grade must match the direction, slope, and elevation indicated by the contours. To supplement contour interpretation, arrows indicating the existing and/or proposed direction of surface runoff may be added.

Spot elevations indicate elevations of specific points in reference to the benchmark. Permanent improvements such as structures, footings, paving, and walls require specific elevations to build the improvement; and spot elevations provide that data (Figure 3-10). Spot elevations typically include a notation that indicates if the elevation is for the top, bottom, or some other part of the object being measured. Indications of direction and degree of slope can be obtained by calculating the difference between spot elevations.

To interpret the information on a grading plan, Figure 3-11, follow these steps:

- Obtain and read all plans and specifications related to the grading plan for the project.
- Review the symbols, textures, and abbreviations used on the site grading plan and locate and read any special notes placed on the plan.
- Become familiar with the drawing layout and locate major improvements such as buildings, roadways, parking lots, and natural features.
- Locate benchmarks and the range of elevations (high and low points) of the site.
- Identify existing contours and analyze the current "lay of the land."
- Identify proposed contours to determine the proposed changes and areas where significant amounts of cutting or removal of earth, and filling or adding of earth, will be required (color-coding cut and fill areas can be helpful).

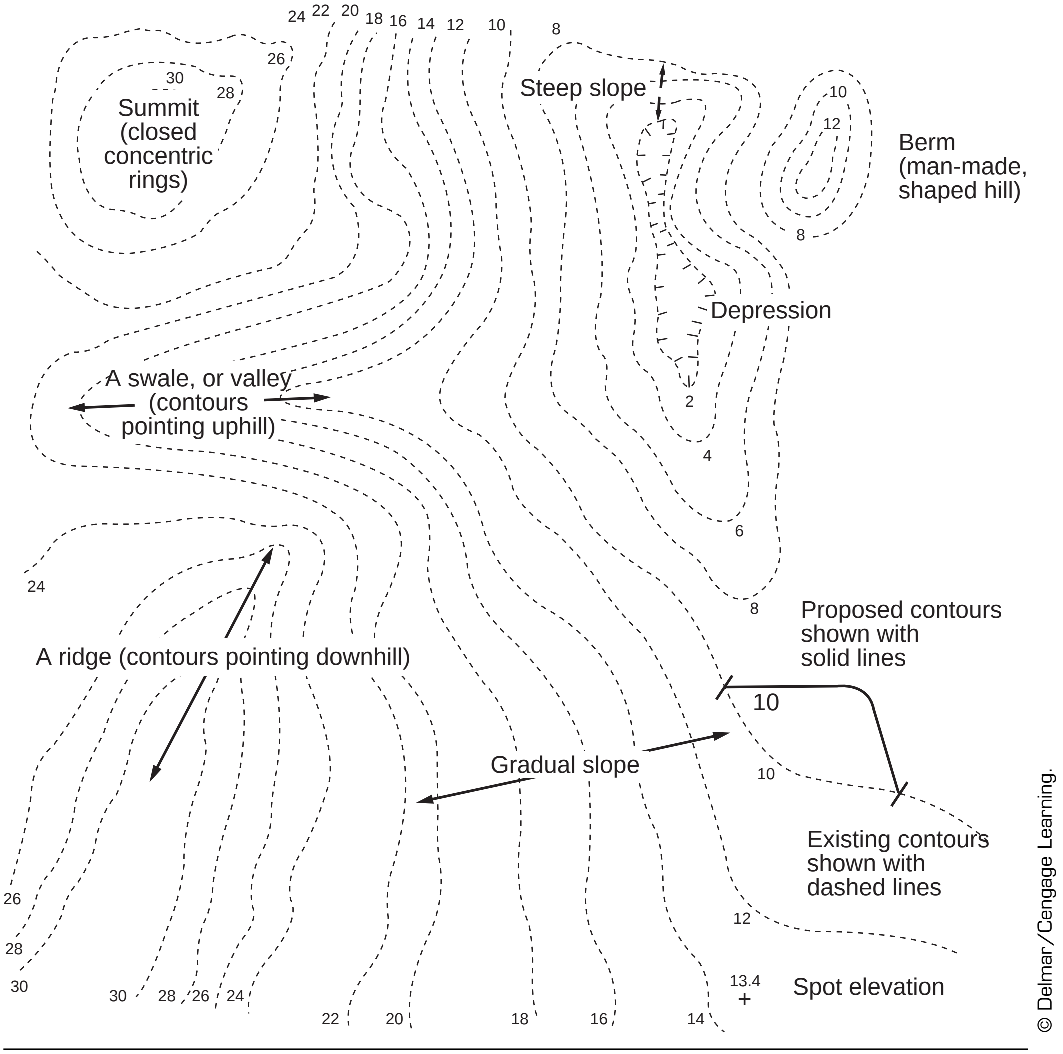


Figure 3-10 Typical topographic landforms and notations.

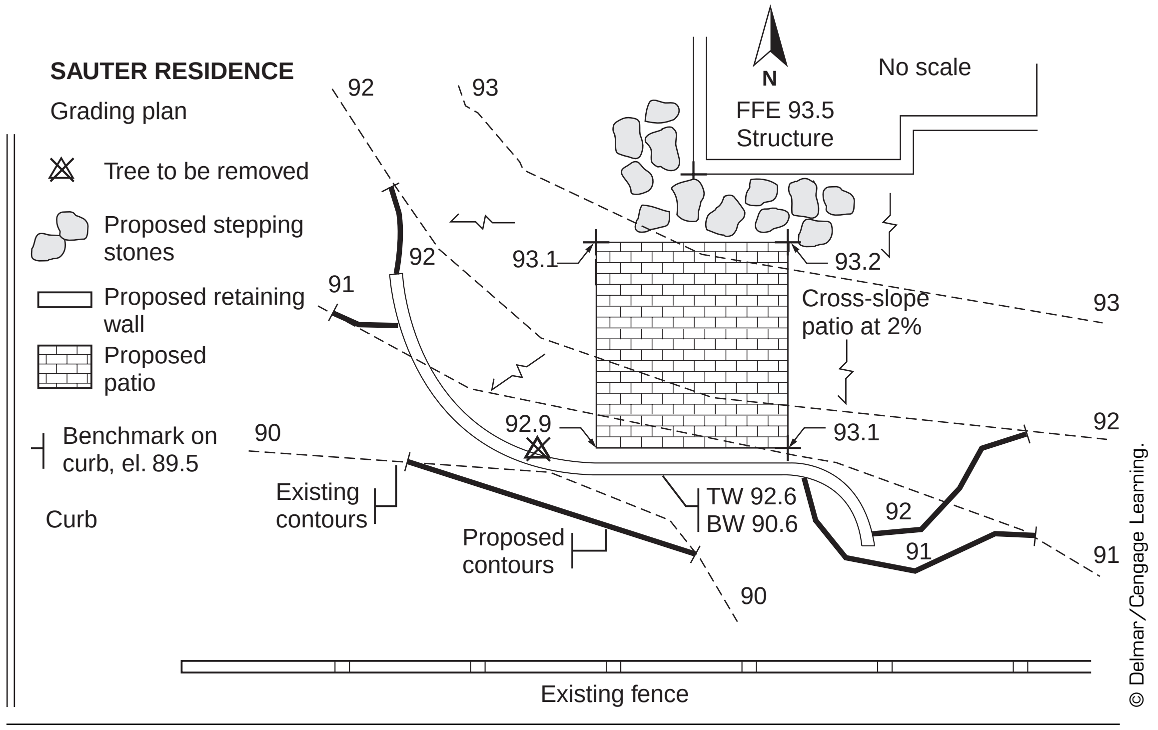


Figure 3-11 Grading plan showing spot elevations and existing and proposed contours.

- Identify major proposed landforms (berms and drainage swales) by their contour signature.
- Locate proposed spot elevations of major structures and compare them to existing grades to determine amounts of cut or fill required.
- Locate proposed spot elevations of other site improvements to determine if cut or fill is required.
- Look for drainage arrows and symbols indicating which direction walks, paved areas, and open areas are to be sloped.

Utility Plans

Utility plans show location, type, size, and depth of proposed utilities. Although other contractors may install many of these utilities, landscape contractors may find irrigation work included in landscape contracts. A separate schedule on this sheet may contain relevant data regarding fixtures, such as pipe sizes and irrigation head model numbers. Irrigation installations are typically indicated by lines on the drawings with notations regarding the type, depth, and size of the utility.

To interpret the information on a utility plan, follow these steps:

- Obtain and read all plans and specifications related to a utility for the project.
- Review the symbols, textures, and abbreviations used on the utility plan and locate and read any special notes placed on the plan.
- Become familiar with the drawing layout and locate major improvements such as buildings, roadways, parking lots, and natural features.
- Find the type, location, and size of utility lines.
- Determine depth of utility lines.
- Locate irrigation components to be installed, including service, controllers, main lines, lateral lines, valves, and heads.
- Locate major utility structures, such as drainage inlets, manholes, utility poles, and light footings, and note their grade (cross-reference the grading plan, if necessary).

Planting Plans

Planting plans indicate the location and type of plant material to be installed. Individual trees and shrubs are shown with circles indicating the approximate spread of the plant, and the location of each plant's center plant is indicated by an *X* or similar

type of mark. The centers of identical plant materials are connected by a line, or leader, that will include a label of the type and number of plants in that "string" (Figure 3-12). Labels may include a key that refers to the plant schedule. Some labels may use multiple naming schemes, such as the plant's common or botanical name. Occasionally, the designer may include on the leader planting information that indicates spacing, planting elevation, or other pertinent data. A planting plan usually includes several of these leaders if several plants are labeled. Alternative methods used to label plants are placing a letter next to the planting location for each plant or using a different symbol for each different type of plant. Both the letter and the symbol should refer to a plant schedule for plant type, size, and details.

Masses of smaller plants, such as ground covers, may be shown using line or dot textures covering the area where plants are to be installed. Leaders for masses of such plants typically include the plant name, quantity of plants in the area labeled, and the spacing of individual plants.

Plant Schedule. Included with the planting plan is a **plant schedule**, which lists all proposed plants with their quantity, size, condition, and special instructions for planting (Figure 3-13). The detail from this schedule should be complete enough to allow ordering of all plant material to be used on the project. Notations may also be included on the planting plan that indicate the amount and type of mulch to be used, spacing of plants, staking or wrapping requirements, and other plant-related instructions. Written technical specifications typically provide other details regarding planting.

To interpret the information on a planting plan, follow these steps:

- Obtain and read all plans and specifications related to the planting plan for the project.
- Review the symbols, textures, and abbreviations used on the planting plan and locate and read any special notes placed on the plan.
- Become familiar with the drawing layout and locate major improvements such as buildings, roadways, parking lots, and natural features.
- Review the plant schedule for special symbols and keys. Plants may use a variety of key types to coordinate the plan and plant schedule. Alpha characters, numbers, symbols, or partial genus and species names are typical keys. Some plants may even be labeled directly on the plan, eliminating the need for plant keys.

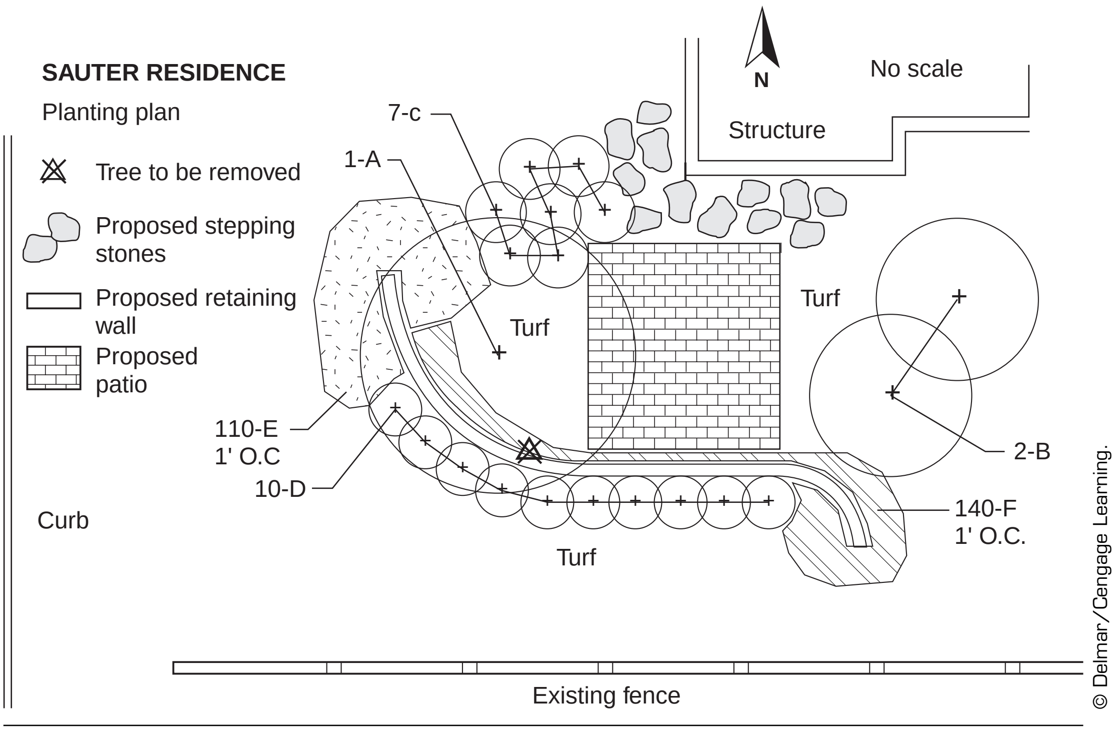


Figure 3-12 Planting plan. The key refers the reader to the plant schedule (Figure 3-13) for details about the plants.

SAUTER RESIDENCE					
PLANT SCHEDULE					
KEY	COMMON NAME	BOTANICAL NAME	QTY.	SIZE/COND.	REMARKS
A	Burr Oak	*Quercus macrocarpa*	1	2″ B&B	specimen quality
B	Shadblow Serviceberery	*Amalenchier canadensis*	2	8′ cont.	
C	Dwarf Compact Yews	*Taxus cuspidata "nana"*	7	7 gal.	
D	Cranberry Cotoneaster	*Cotoneaster apiculata*	10	5 gal.	
E	Purpleleaf Wintercreeper	*Euonymus fortuneii coloratus*	110	flats	space 1′ on center
F	Daylillies	*Hemerocallus sp.*	140	1 gal.	space 1′ on center
					species selected by owner

Figure 3-13 Plant schedule.

- Locate each type of plant material in the order indicated on the plant schedule.
- Identify all plant locations, review the species, quantity, and spacing (if plants are grouped together).
- Note for each plant location the elevation, nearby utilities, and other site improvements in the vicinity.

Construction Details

Construction details provide information about specialized elements that need to be built for the project. Items that are usually detailed include bridges, specialty paving, amenities, stairs, walls, lighting, and other construction items that benefit from being shown in greater detail. Details may show cross sections, elevations, or large-scale plans that illustrate more detail of specialty construction (Figure 3-14). Materials, dimensions, and notes are included to aid in proper construction. Scale for each individual detail is noted below the detail, and detail references, or keys, are typically placed on site construction staking plans.

To interpret the information on a site detail, follow these steps:

- Obtain and read all plans and specifications related to the area of work for the detail.
- Locate the detail on the appropriate detail sheet.
- Identify the type of drawing used for the detail (section, elevation, plan).
- Identify the scale of the drawing.
- Analyze the detail to determine the dimension of the improvement and the materials used for construction.

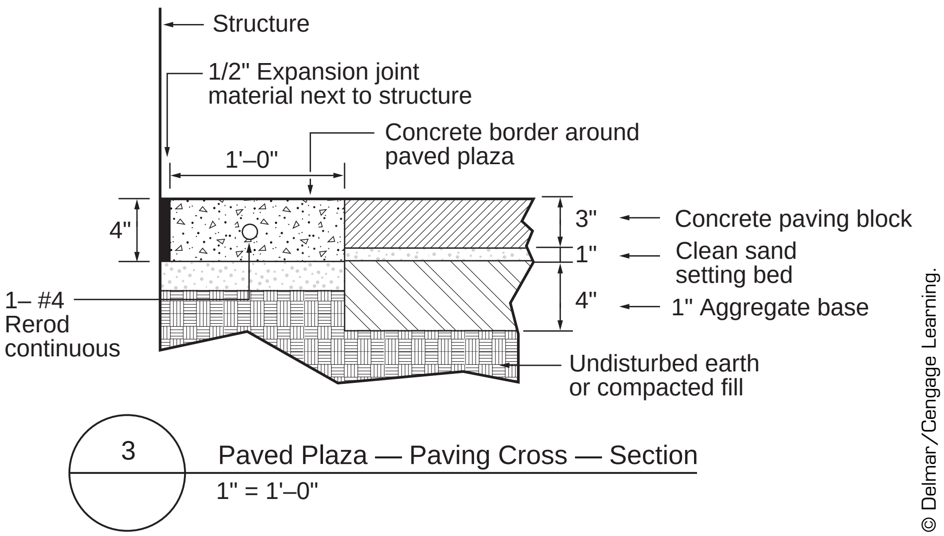
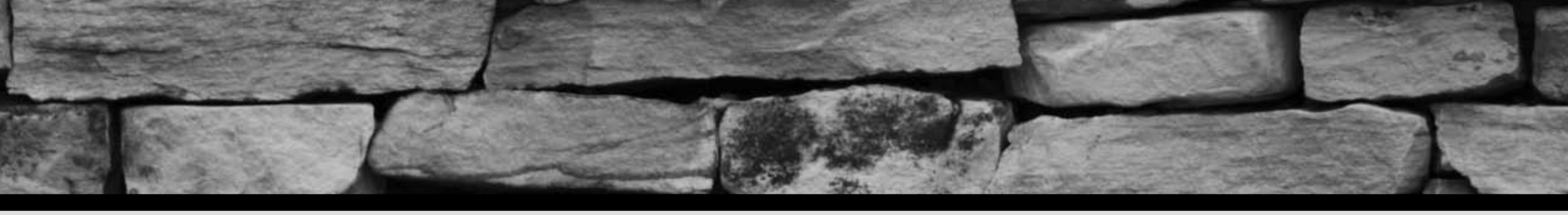


Figure 3-14 Construction detail.



CHAPTER 4

CONSTRUCTION MATH

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Perform basic landscape construction math calculations.
- Calculate material quantities for a landscape construction project.

Whether ordering materials, establishing grades, laying out a walkway, or performing any one of the many activities of landscape construction, the contractor needs to perform basic math operations. In this chapter are the building blocks of math operations for landscape construction. Included as basic calculations are the concepts of item counts; linear, perimeter, area, and volume measurements; and weight conversions. Formulas that use these basic measurements to obtain specialty calculations are also included in this chapter.

Math and project measurements can be made easier if the decimal system is used, rather than measuring in inches and fractions. Most math functions benefit from converting numbers to feet and tenths. Conversions related to construction math can be found in Appendix C.

CONSTRUCTION CALCULATORS

One of the more valuable tools available to the contractor is the construction calculator. Operated much like a typical numerical calculator, the construction calculator uses preprogrammed instructions to perform typical construction-related calculations, saving time doing extensive math calculations in the field. Depending on the manufacturer and model, the construction calculator includes functions that perform dimensioning; conversions of feet/inches to decimals and decimals to feet/inches; calculating center points, area measurements, volume measurements, board feet and block calculations; and geometric calculations, including circles and arc, rise/run calculations, rafter calculations, slope; and trigonometric calculations.

CALCULATING AVERAGES

In construction, calculating the average of several numbers may be required. The formula for calculating an average is:

Sum of all numbers/*N*, where *N* equals the number of numbers added together (Figure 4-1).

$$\frac{A + B + C + D \ldots X}{N} = \text{AVERAGE}$$

N = QUANITITY OF NUMBERS ADDED TOGETHER

EXAMPLE:

$$\frac{5 + 3 + 12 + 17 + 10 + 8}{6} = 9.16$$

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Figure 4-1 Calculating averages.

ITEM COUNT

Items such as benches, lights, plant material, and other amenities are measured and ordered by quantity of each item used. An item count requires only a "head" count of each separate item being used.

LINEAR MEASUREMENTS

Linear measurements are used to calculate quantities for items that are purchased by length, such as edger and fence. Expressed as linear feet (LF), the linear measurement is also the building block for area and volume calculations. Linear measurements are performed by measuring directly from one point to a second point.

Three methods for performing linear measurements are common in the landscaping field. The level of accuracy needed determines the choice of method for making linear measurements. Direct measurement should be selected if an accuracy of 2% is required. **Pacing** can be used if the margin of error can range up to 5%, and estimating is acceptable if the margin of error can be as high as 10%. Actual percentage of error for each measurement technique will vary, depending on how the user applies the technique. Techniques for each method are identified in the following paragraphs.

Direct Measurement

Direct measurement involves the use of a tape measure or measuring wheel to determine the distance between two points. Obstacles or slopes between the two points can affect the accuracy of this method. If obstacles prevent a direct measurement, take the measurement along a route parallel to the one that requires measuring. Use of a screwdriver to anchor the zero end of the tape allows one person, instead of two people, to take measurements. A measuring wheel is easy and convenient to use, but most wheels have an accuracy of 1 foot and provide no increments between feet (inches or tenths).

Slope also affects the accuracy of linear measurements. Horizontal distances are less when measured on a flat surface than when they are measured on a sloped surface. To accurately find a location on a sloped surface, begin by extending a tape measure from the point where the measurement begins. Hold the tape level and along the alignment for the measurement (Figure 4-2). At the correct measurement on the tape, lower a **plumb bob** to obtain the desired location on the ground. Measurements that are longer than one length of the tape can be made by repeating these steps, extending the level tape from each new location found with the plumb bob. Very steep slopes may require several short measurements to maintain accuracy. To accurately measure a point on a slope, hold the measuring tape level and hold the plumb bob directly over the point being measured. Move the tape adjacent to the plumb bob, and read the dimension where the plumb bob line intersects the tape.

Pacing

Pacing can be useful because it requires no special tools and can be adapted to nearly every site or terrain. More than walking, pacing uses the consistency of a person's normal pace to derive a linear measurement for a site. To determine average pace, set up a course that is 100 feet long and walk the course several times, counting the number of steps each time. Divide the distance by the average

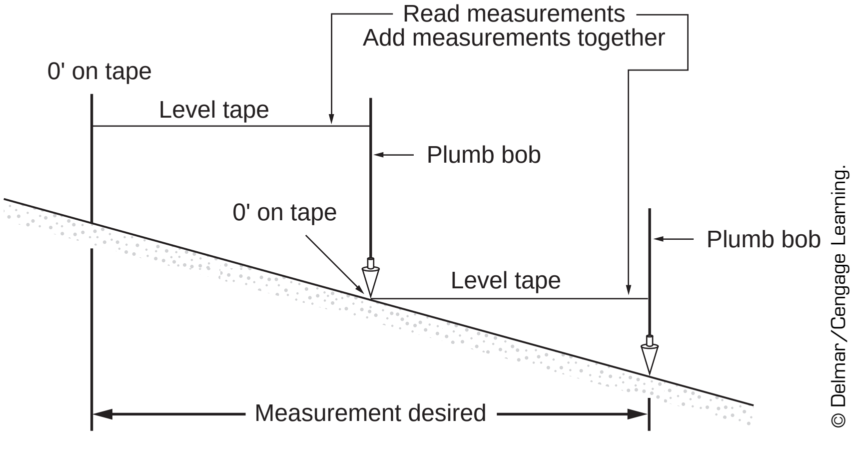


Figure 4-2 Making accurate measurements on a hillside.

number of steps to calculate the average pace (Figure 4-3). It is important, both when calculating average pace and when performing measurements with this method, that you maintain a normal step. Attempting to step an even distance or altering the normal step will result in inconsistent results.

Estimation

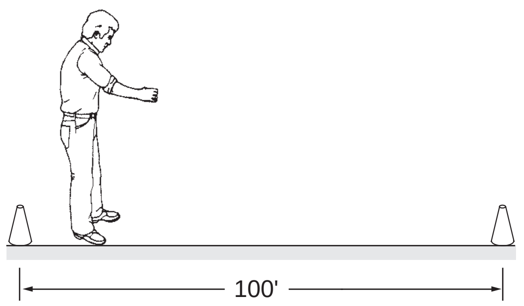
When accuracy is not critical, estimating linear dimensions is a viable option. Estimating requires determining a distance based on visual observation or comparison with a known dimension. Visual determination is developed by experience in working with outdoor spaces, whereas comparison requires visually comparing the distance to be measured with an object of known measurements. Items such as structures, door openings (usually 7 feet high), and sidewalk squares can be used to make comparative measurements.

Perimeter Calculations

Installation of edging or materials placed around a shape requires calculation of the perimeter of an object. To perform perimeter calculations, identify the shape being measured, and then make linear measurements of portions of that shape. If working with an irregular shape, you may find that the fastest method for measuring a perimeter is to pace or to take a direct measurement. If measuring standard geometric shapes, use the formulas identified in Figure 4-4 to obtain perimeter measurements. Figure 4-5 provides sample calculations. Common shapes include:

- Square/Rectangle/Parallelogram: Shapes with two sets of parallel sides. Squares and rectangles have right-angled corners, and parallelograms have no right-angled corners.
- Trapezoid: Shape with one set of parallel sides and two right-angled corners, one adjacent to each parallel side.
- Circle: Round shape with edges equally distant from the center.
- Ellipse: Rounded egg shape with edges at variable distances from center.
- Circle Sectors: Partial segments of a circle. Defined by length of the outside arc or the enclosed angle of circle measured in degrees.
- Triangle (right or equilateral): Shape with three sides. Right triangle has one right angle; equilateral triangle has three sides of equal lengths.
- Irregular Round: Kidney or irregular shaped circles for which a center radius can be located.

1. Set up and pace course three times:



(note: course should be level and free of obstacles)

2. Average the number of paces:

1st pass: ______________

2nd pass: ______________

3rd pass: ______________

Total paces 3 = $\frac{1 + 2 + 3}{3}$ = average number of paces

3. Divide average number of paces into 100' to obtain typical pace:

$\frac{100'}{\text{Average number of paces}}$ = average pace

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Figure 4-3 Calculating your pace.

AREA CALCULATIONS

Materials such as brick, seed, and sod are purchased based on the area of the space they cover. Quantities of materials necessary to cover flat surfaces require area calculations. Expressed as square feet (SF) or square yards (SY), measurement of area requires recognizing the shape (or collection of shapes) of the space to be covered and calculating key dimensions for that shape using linear measurements. Formulas for calculating the area of standard shapes are shown in Figure 4-4. Figure 4-5 provides sample calculations.

Many methods are available for obtaining area calculations. New computer design programs automatically calculate the area of shapes. A **planimeter** is an engineering tool used to measure the area of random shapes. Even with no computer or planimeter, you can break down any shape into a collection of measurable geometric spaces. Once you

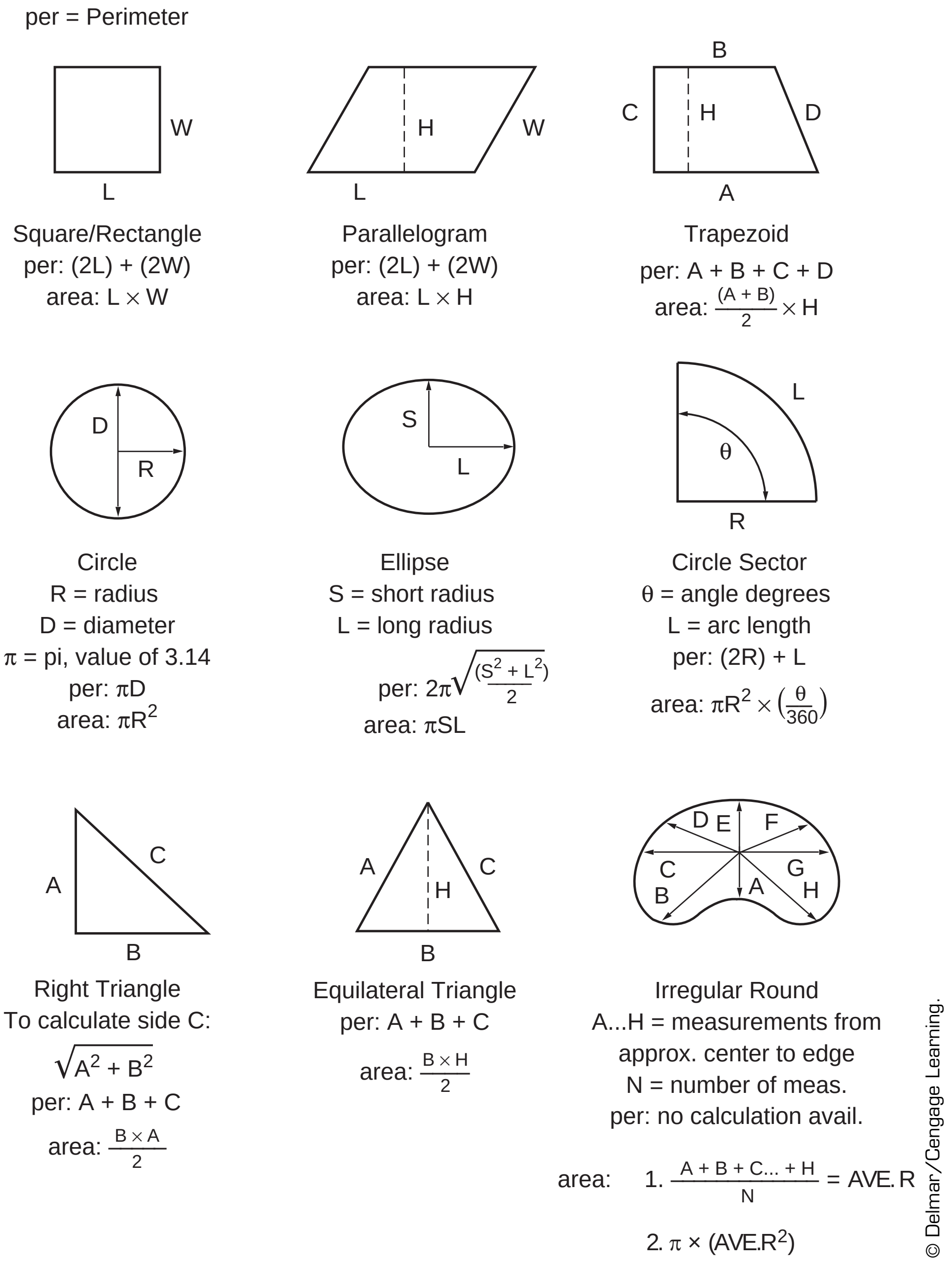


Figure 4-4 Perimeter and area formulas for common shapes.

determine the dimensions of these shapes, you can then calculate the areas and add them to obtain the area of irregular shapes.

To calculate square footages by using the sum of shapes, begin by analyzing the space for which an area measurement is required. Observe if the space is an easily measurable single shape or if one or more of the geometric shapes previously mentioned is recognizable (square/rectangle, parallelogram, circle, or triangle) within the boundaries of the shape. These shapes should closely cover the majority of the area being measured (Figure 4-6). Using the formulas in Figure 4-4, make the measurements and perform the calculations required for each shape; then total the answers to obtain the area for the shape. Be certain all calculations are correct; and if only a portion of the shape is used (such as one-quarter of a circle), reduce the total appropriately. Be forewarned that this method will have a substantial margin of error, so if material orders are critical, a more precise method of measurement should be selected.

Some conversions applicable to area measurements follow. Appendix B includes additional conversions.

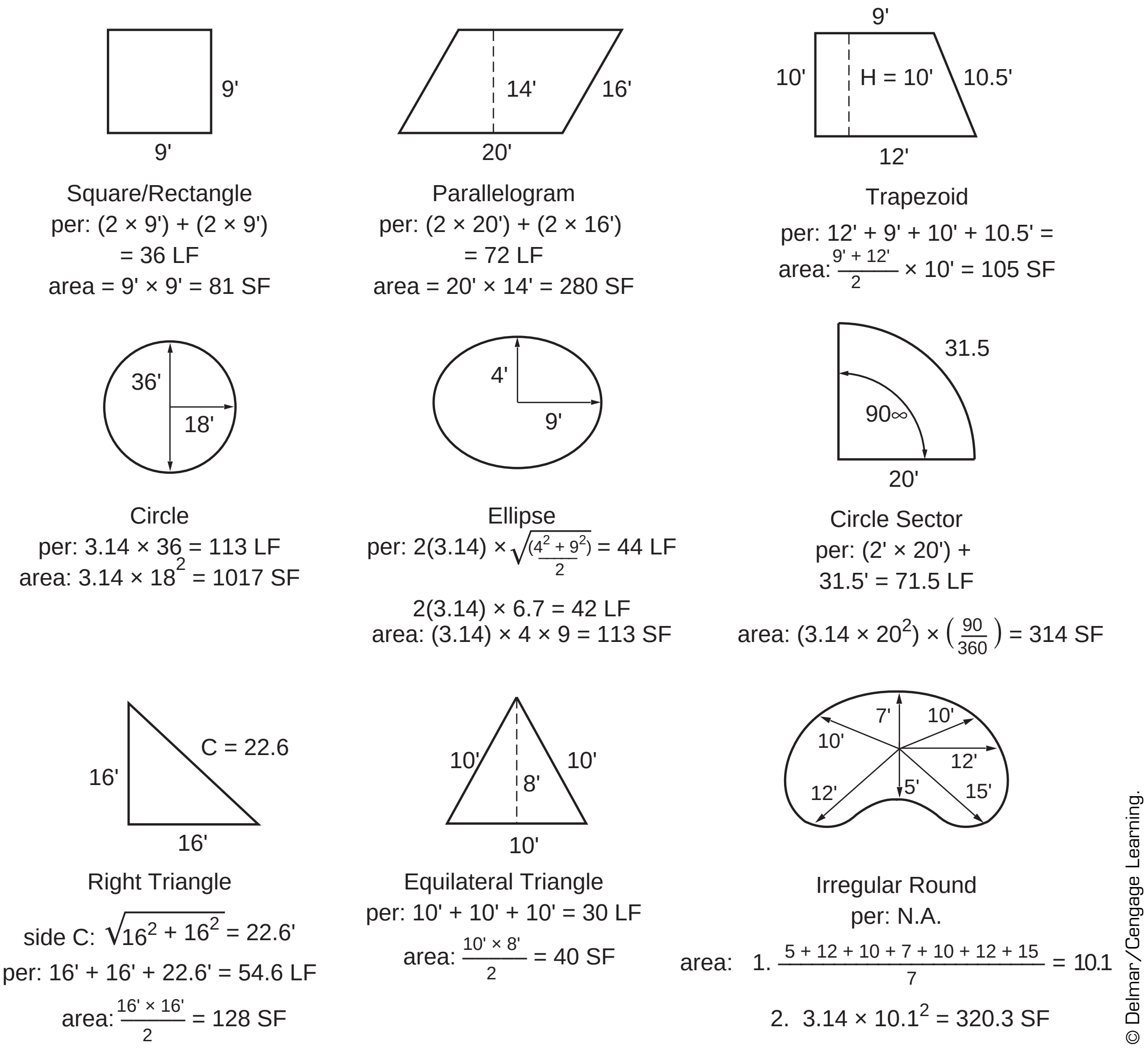


Figure 4-5 Examples of calculating perimeter and area for common shapes.

- If the measurement required must be expressed as square yards, divide the square foot total by 9 to obtain square yards.
- To obtain the number of acres, divide the square foot total by 43,560.
- To obtain squares for sod, divide the square footage by 100.
- To obtain rolls of sod (each sod roll being 1 SY), divide square footage by 9.

VOLUME CALCULATIONS

For materials that are purchased in bulk, a volume measurement is typically required. Bulk measurements are expressed as cubic feet (CF) or cubic yards (CY) and, to be calculated, require an area measurement and knowledge of the depth of the material.

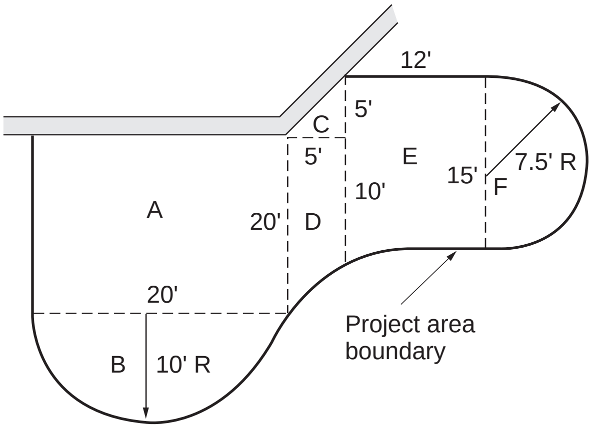
To calculate volumes for landscaping, begin with the square footage of the area that is to be filled. Determine the depth of the layer to be filled and place the numbers in the following formula (Figure 4-7):

$$\text{Area (in SF)} \times \text{Depth (in inches)}/12 = \text{CF}$$

Note that the depth is not converted to feet but is left in inches.

Determining the volume of plant root balls requires a formula used to calculate the volume of a sphere. Once you have calculated the volume, use a weight conversion to convert to pounds. The formula for calculating the volume of a sphere is as follows (Figure 4-8):

1. Identify shapes and measure dimensions of each.



2. Add together areas for each of the shapes identified within the project area boundary (refer to Figure 4-4 for formulas for each shape).

A Square		= 400	SF
B (Half) Circle	314/2	= 157	
C Triangle		= 12.5	
D Trapezoid		= 75	
E Rectangle		= 180	
F (Half) Circle	176/2	= 88	
		± 912.5	SF

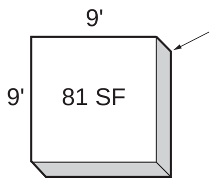
Figure 4-6 Calculating the area and volume of an irregular shape.

Volume formula:

$$\frac{\text{area (in SF)} \times \text{depth (in inches)}}{12} = \text{CF (cubic feet)}$$

Examples from Figure 4-5:

1. 6" layer of topsoil over square shape of 81 SF



$$\frac{81 \times 6}{12} = 40.5 \text{ CF}$$

$$\frac{40.5}{27} = 1.5 \text{ CY (cubic yards)}$$

2. 4" layer of mulch over ellipse shape of 113 SF

$$\frac{113 \times 4}{12} = 37.6 \text{ CF}$$

$$\frac{37.6}{27} = 1.4 \text{ CY}$$

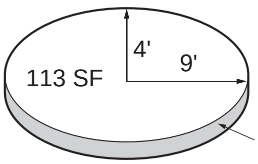
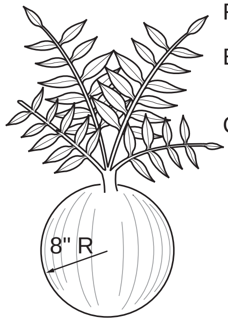


Figure 4-7 Formula and examples of calculating volumes for materials placed in layers.

Volume of Sphere:



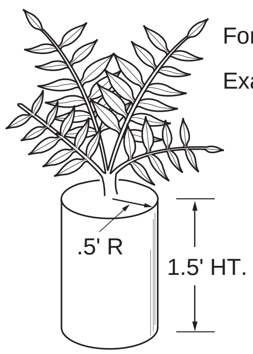
Formula: 4.18 × R × R × R = CI

Example: 4.18 × 8 × 8 × 8 = 2140 CI

Conversion to CF: $\frac{\text{CI}}{1728} = \text{CF}$

$$\frac{2140}{1728} = 1.24 \text{ CF}$$

Volume of Cylinder:



Formula: area of circle × HT. = CF

Example: (.5 × .5 × 3.14) × 1.5 = 1.18 CF

Figure 4-8 Formulas and examples of calculating volumes for spheres and cylinders.

$$4.18 \times R \times R \times R = CI \text{ (cubic inches) when R is expressed as inches.}$$

Expressing *R* as feet (or decimal portions of feet) will provide an answer in CF (cubic feet).

To calculate the volume of a cylinder, use the following formula (Figure 4-8):

$$\text{Area} \times \text{Height} = \text{CF (both area and height must be expressed as feet or decimal portions of feet)}$$

Some conversions applicable to volume measurements include:

- If the measurement required is in cubic inches and must be converted to cubic feet, divide the cubic inches total by 1,728 to obtain cubic feet.
- If the measurement required is in cubic feet and must be expressed as cubic yards, divide the cubic foot total by 27 to obtain cubic yards.

See Figure 4-6 for an example of volume calculations.

WEIGHT CONVERSIONS

Materials purchased in bulk may require a weight, rather than a volume, measurement. In this case, use the following chart to convert volume to weight for each of the following types of materials by multiplying the CY or CF by the conversions:

- 1 CF soil, dry and loose = 90 pounds
- 1 CF soil, moist = 75 to 100 pounds
- 1 CF sand, dry = 100 pounds
- 1 CF limestone, uncrushed = 160 pounds
- 1 CF concrete = 140 pounds
- 1 CY fill dirt, dry and loose = 1.2 tons (2,400 pounds)
- 1 CY concrete sand, dry = 1.5 tons (3,000 pounds)
- 1 CY aggregate (class 5 aggregate, 1 inch roadstone, or equal) = 1.25 tons

SPECIALTY CALCULATIONS

Certain work areas within landscape construction require adaptations of the basic math operations to perform required calculations. These calculations are presented in the sections that follow.

Included are calculations required to determine slope, calculate wall material requirements, determine riser/tread dimensions for stairs, order paving and base materials, and similar specialty calculations. Additional calculations for landscape construction activities can be found in Appendix D.

SLOPE CALCULATIONS

When establishing grades or installing storm water drainage systems, it is critical to maintain downward **slope**. Although many contractors accomplish this task using visual estimation or a level, the ability to calculate slope is a valuable math skill. Slope calculations are presented for two applications: calculating the existing slope between two points and determining the amount of vertical change required to obtain a certain slope over a given distance.

Calculating the Slope Between Two Points

To determine the slope of a uniform grade between two points, use the following steps. Measurements must be in the same units; feet and tenths are recommended (Figure 4-9).

- Measure the vertical difference between the two points (*V*). Use a carpenter's level resting on a straight 2 × 4 or a survey instrument to accomplish this.
- Measure the horizontal distance between the two points (*H*).
- Insert the measurements into the following formula:

$$(V/H)| \times 100 = \% \text{ of slope.}$$

- The answer is the slope percentage.

Calculating the Vertical Change Required to Obtain a Given Slope Between Points

When staking improvements, you may need to construct a slope at a certain percentage from a first point to a second point. To calculate the amount of elevation change, use the following formula. Measurements must be in the same units; feet and tenths are recommended (Figure 4-9).

- Measure or set the elevation of the first point (use 100.0 if the actual elevation is not known) (*X*).
- Measure the horizontal distance between the first point and the second point (*H*).

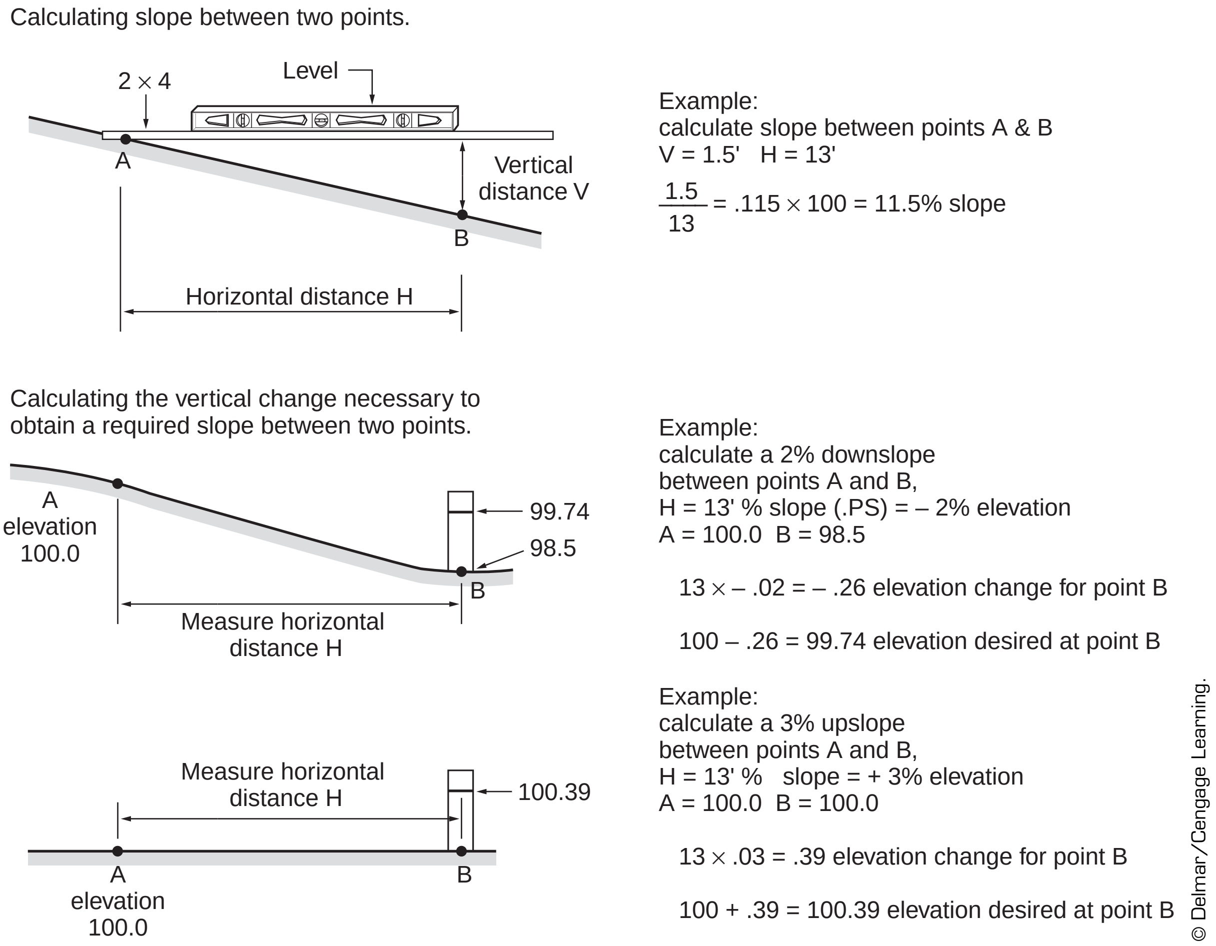


Figure 4-9 Calculating slopes.

- To determine the change in elevation (Change), multiply the horizontal distance times the slope required between points:

$$H \times .PS = \text{Change}$$

(*PS* is the percent slope expressed as a decimal, such as a 2% slope shown as .02).

- If the slope is to go down toward the second point, *subtract* the Change from *A*.

$$A - \text{Change} = \text{Elevation of second point.}$$

- If the slope is to go up toward the second point, *add* the Change to *A*.

$$A + \text{Change} = \text{Elevation of second point.}$$

WALL MATERIAL CALCULATIONS

Determining how much wall material is needed requires calculating the surface area of the wall to be built. To perform this calculation, you will also need information from the manufacturer regarding how much surface area a single unit of wall material covers (Figure 4-10).

To determine the surface area of a wall that has a consistent height (Figure 4-10):

- Perform an area calculation by measuring the height and the length of the wall.
- Add 1 foot to the height measurement to accommodate a buried base, and multiply by the length to obtain square footage of the wall.

If the wall varies in height over its entire length (Figure 4-10):

- Obtain the average height by making multiple measurements at points where the wall is tallest and shortest, adding them, and dividing by the number of measurements taken.

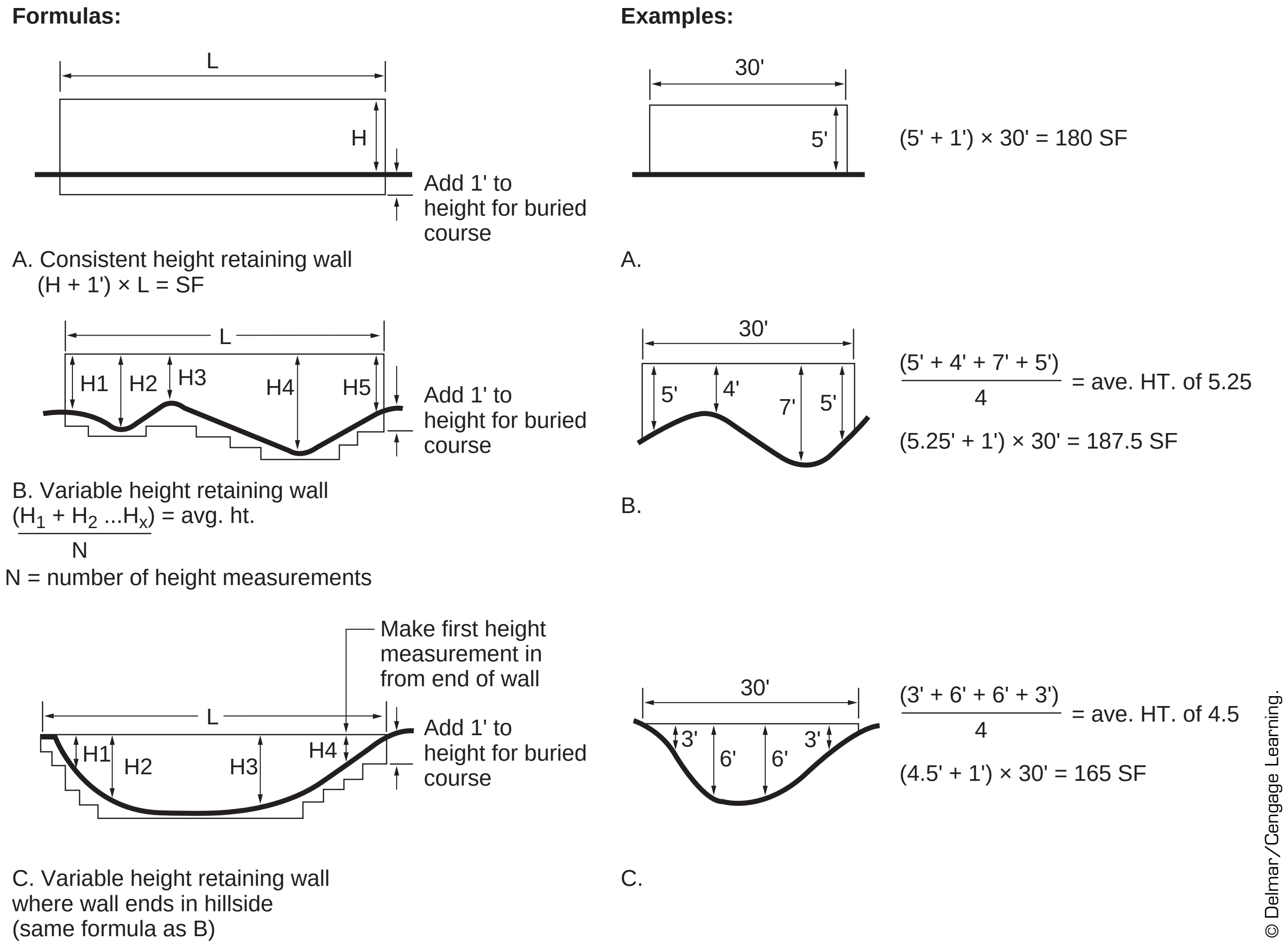


Figure 4-10 Wall material calculations.

- Add 1 foot to the height measurement to accommodate a buried base, and multiply by the length to obtain square footage of the wall.

If the wall is consistent in height except for a few small sections, such as return or cheek walls (Figure 4-10):

- Measure the small sections 5 feet from the ends and several times along the consistent height portion; then calculate as a variable height wall.
- Add 1 foot to the average height measurement.
- Multiply by the length to obtain the square footage of the wall.

If the project contains multiple walls, the square footage of each wall must be measured and added to obtain a total.

Segmental Unit (Precast) Calculations

Add the area of all wall sections when square footage calculations are complete. To determine how many segmental units are required, obtain the square footage of a single unit. Suppliers typically can provide this information, or you can calculate it by performing an area measurement on the surface of one unit (typical areas range from .5 SF to 1.25 SF). Divide the wall square footage by the surface area of one unit to obtain the number of total units required for the wall.

Segmental Unit Capstone Calculations

Capstones are usually ordered by the number of linear feet they will cover. Use a direct measurement of the total linear feet of the wall, and multiply by the conversion number (number of capstones per linear foot) supplied by the manufacturer.

Stone Calculations

To calculate the tonnage of stone required for a wall, divide the square footage of the wall by the number of SF that 1 ton of stone will build. The quarry or supplier can provide this conversion number, typically around 16–25 SF of wall per ton of stone.

Tie/Timber Calculations

Calculations for ties and timbers require the same area calculations just performed. However, the area is divided by conversion numbers to determine the number of ties and timbers to order. Find the material being used in the following list, and then divide the wall SF by the conversion number (Note: Height is the vertical dimension when looking at the side of the material.):

- Railroad tie, 8 feet long by 8 inches in height: divide by 5.0
- Railroad tie, 8 feet long by 7 inches in height: divide by 4.0
- Railroad tie, 8 feet long by 6 inches in height: divide by 3.5
- Timber, 8 feet long by 6 inches in height: divide by 3.7
- Timber 6 feet long by 6 inches height: divide by 2.8

To calculate the number of ties/timbers required for deadmen or verticals, divide the total wall length by 5. Add the wall ties/timbers numbers to the deadmen or vertical numbers to determine the number of ties/timbers to order.

STAIR CALCULATIONS

Calculation of stair dimensions requires an understanding of both slope and stair components. There is a relationship between the dimension of the vertical portion of the stair, or the **riser**, and the horizontal portion of the stair, or the **tread** (Table 4-1). The combination of these two dimensions will determine if the stairs are comfortable to use and fit the space reserved for stair construction. The math presented here applies to exterior stairs constructed of wall materials, concrete, and wood.

Riser/Tread Relationship

The riser/tread relationship, which can be expressed in a formula, maintains dimensions that produce stairs matching a human's normal stride. If one of these two dimensions is beyond the normal standards, the user may have difficulty navigating the stairs. If the sum of these two dimensions is beyond the normal standards, the user may have a difficult time maintaining a normal pace up the stairs. Considering the limitations of many of the materials from which steps are constructed, stairs in landscaping should follow this relationship as closely as possible. A formula for riser/tread relationships and a chart illustrating standard riser heights and tread depths derived from the formula are shown in Table 4-1.

Table 4–1 Relationship Between Riser Height and Tread Depth in Stairs

$2r + t = 26''$ where: r = riser; t = tread

if r is . . .	*then t is . . .*
4 inches	18 inches
5 inches	16 inches
6 inches	14 inches
7 inches	12 inches
8 inches	10 inches

r should not be greater than 8 inches or less than 4 inches
t should not be less than 10 inches

Note: Some formulas use values of 27″ or 28″ to replace the 26″ shown in this formula. Building codes may dictate the dimensions used.

Having no set standard for the maximum depth of a tread provides flexibility, and problems, for stairs constructed in the landscape. It should be noted that using a tread depth greater than those determined by the formulas shown in Table 4-1 will create an uneven, perhaps even dangerous, stepping pattern. Stair dimensions in the landscape are complicated further by the fact that many materials used to construct stairs are materials with dimensions that cannot be adjusted. Riser heights may be limited to wall material thickness, and the corresponding tread depth may be set by the riser dimension.

In addition to these considerations, stairs that serve the public must follow local, state, and national regulations. Specific requirements for access by persons with differing physical abilities may determine the actual stair dimensions. Stairs accessed by the public should be designed by a design professional.

Process for Calculating Risers/Treads

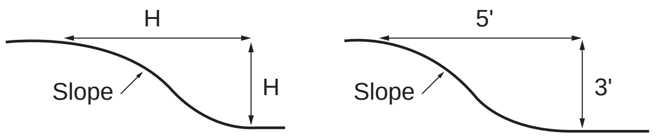
Calculating the number of risers and treads required for a project requires measurements for the thickness of materials from which the stairs will be constructed

(timbers, wall units, wall units plus caps, stone, etc.), the horizontal length of the slope that must be traversed (measured from **top of slope** to **toe of slope**), and the vertical distance that must be covered. To obtain the horizontal and vertical distances, consider using the measuring techniques described in Chapter 8, Construction Staking. These measurements can be used to calculate stair requirements.

Using the following steps and the riser/tread formula, determine how many risers and treads will be required for the project (Figure 4-11):

1. Convert the vertical and horizontal distances into inches.
2. Divide the vertical distance by a selected riser height. This answer will indicate how many risers are required to traverse the slope. Numbers over .5 can be rounded up; numbers under .5 can be rounded down. As mentioned earlier, the thickness of the construction material may dictate the riser height of the stair. If material thickness is not an issue, speed the process by selecting a high riser value if the slope is steep or a low riser value if the slope is shallow.
3. Subtract 1 from the number of risers.
4. Multiply the answer from the previous step by the tread depth required for the selected riser height. Use Table 4-1 to find the corresponding tread depth for the selected riser height. This answer will provide the horizontal distance covered by the stairs.
5. Compare the horizontal distance required for the stairs and the measured distance.
   - If the distances are equal or very close, use that riser/tread combination.
   - If the difference between the measured and required distances is less than the depth of one tread, add the distance to either the top or bottom to create a landing.
   - If the difference exceeds the dimension of one tread depth, choose another riser height and recalculate. If riser height is fixed by materials, add a landing at the top or bottom or consider adding a landing in the center of the stairs.

Formula: **Example 1:** **Example 2:**



Formula	Example 1	Example 2
Convert H and V to inches	5' × 12 = 60" = H 3' × 12 = 36" = V	5' × 12 = 60" = H 3' × 12 = 36" = V
Select riser/tread combination from Table 4-1	R = 6" T = 14"	R = 7" T = 12"
V/riser HT = No. risers	36"/6" = 6 risers	36"/7" = ≈ 5 risers
No. of risers – 1 = No. of treads	6 – 1 = 5 treads	5 – 1 = 4 treads
No. of treads × Tread length = Stair length	5 × 14" = 70" stair length	4 × 12" = 48" stair length
Compare stair length to slope dimensions. Use selected riser and tread numbers or recalculate using new selection.	80" exceeds slope dimensions (H) by 10". Example 2 recalculates same problem with different riser/tread dimensions. For this example use: 6–6" risers 5–14" treads, top one out into hill.	48" is 12" short of slope length. Use the combination from example 1.

*Stairs that do not match slope dimensions with riser/tread combinations in Table 4-1 will require special design considerations. Consult a design professional.

Figure 4-11 Stairs calculations.

6. If horizontal dimensions cannot be matched with adjustments, the stairs will require excavation farther back from the top of the slope to accommodate the longer horizontal distance required.

SETTING BED AND BASE COURSE CALCULATIONS

One or more layers of supporting materials are often placed under paved areas to assure pavement stability. To calculate this quantity, the contractor will need accurate measurements taken from the construction plans and the details, as well as a description of the material from the specifications or plans.

Setting Bed

Setting bed material should be placed in a layer over a compacted base. This material should be ordered by either the cubic yard or ton. To determine the quantity needed, calculate the area to be paved and insert that number in the following equation:

- Area paved (SF) × depth in inches/12 = CF of material required
- CF/27 = CY of material required
- CY × 1.5 = tons of material required

Base Course

Base course material should be placed in a layer over the compacted subgrade at a depth the designer has specified. This material should be ordered by either the cubic yard or ton. To determine the quantity required, calculate the area to be paved and insert that number in the following equation:

- Area paved (SF) × depth in inches (X)/12 = CF of material required
- CF/27 = CY of material required
- CY × 1.25 = tons of material required

PAVING MATERIAL CALCULATIONS

Determining the quantity of paving material required for a project will use the area formulas for a unit paving material, such as brick or limestone, or the volume formulas for concrete or granular paving materials. Extra unit pavers should be ordered to allow for cutting and variation in pallet quantities. Orders increased by 10%–15% typically provide an adequate surplus.

Unit Paving

To calculate unit paver quantities, determine the area of the space to be paved. Obtain from the manufacturer the number of unit pavers per square foot for the style of paving to be used. Most pavers range from 3.5 to 5.0 units per square foot. Standard 4-inch × 8-inch brick requires 4.5 pavers per square foot. Use the following formula to determine material requirements:

- SF of paved area × units per square foot = number of pavers to order

Stone

To calculate stone quantities, calculate the area of the space to be paved in square feet. From the supplier, determine the amount of square footage covered by 1 ton of stone material (standards for stone are typically 40–80 square feet of coverage per ton). Use the following formula to determine material requirements:

- SF of paved area/SF coverage per ton = tons of flagstone to order

Concrete

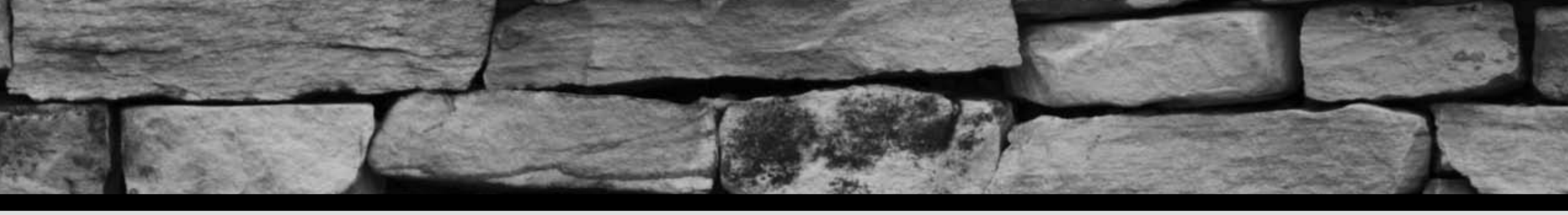
Concrete orders require measurements in cubic yards for the area paved. Concrete is ordered by the CY; so once a volume calculation is complete, no further calculations are needed. The following formula can be used for this calculation:

- Area paved (SF) × depth in inches (X)/12 = CF of material required
- CF/27 = CY of material required

Granular

Although granular paving projects do not require a leveling course, they do require calculations for volume of wearing course material and linear feet of edge stabilization if it is used. To perform volume calculations, use the following formula:

- Area paved (SF) × depth in inches (X)/12 = CF of material required
- CF /27 = CY of material required
- CY × 1.25 = tons of material required



CHAPTER 5

PROJECT PRICING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Identify if a client needs an estimate or a bid.
- Calculate an estimate or a bid for a landscape project.
- Submit a bid to a client.

Determining the price of a project requires a combination of calculating the costs of the various aspects and formatting the costs in one of several ways for presentation to a client. Preparation of costs requires application of many of the formulas and concepts presented in Chapter 4, Construction Math. However, the formulas are not the only variables important to project pricing. Effective preparation of estimates and bids requires input from historical records of a firm's activities, data obtained from textbooks that cover the process of estimating, and judgments from the contractor regarding profit and contingency. Without this external input, the methods presented here create only a framework for calculating project pricing.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Interpreting Construction Documents, Chapter 3
- Construction Math, Chapter 4

ESTIMATES AND BIDDING

Prior to engaging in the preparation of cost estimating, the contractor should determine if the client desires an estimate or a bid. The way the numbers are used affects the level of accuracy in calculating project costs. There is little need to spend hours calculating detailed project costs if the only question a client has is whether the project is within his or her general price range. On the other hand, a rough estimate is risky if a client expects to receive a bid to compare with bids from other contractors. Knowing what stage the project is in and preparing the proper type of cost estimate or bid are essential to an efficient operation.

Estimates

Estimates are exactly what the term implies. When a potential customer wants to know how much a project will cost so that he or she can decide whether to proceed with more detailed work, an estimate may be in order. Preparation of an estimate may be as simple as quoting a range of prices based on similar types of projects. Estimates may also be prepared based on unit costs for general types of materials the customer inquires about, such as deck (SF), plantings (cost per tree), or fill dirt (CY).

Be cautious when asked to prepare an estimate for a client. Misunderstandings can develop when the client is not informed that the estimate is not a

firm price. If an estimate is to be converted into a contract, it is important to qualify the proposal, stating that additional costs may be incurred if the project is changed or if unknown conditions are discovered.

Bidding

Formal proposals to clients in the form of bids serve as a prelude to binding contracts. Prices prepared for bids should be carefully calculated, and the contractor should be prepared to uphold the price if the owner accepts it. Bids are common for all types of projects, public and private. Calculation of a bid requires a design that provides all potential bidders a common document(s) from which to prepare the bid.

The bidding process typically begins with the advertisement, or invitation, to submit a bid. This notice provides instructions that describe the project, client, method of bidding, form of bid, bonding requirements, and the time and place when and where the bid must be submitted. The advertisement typically informs contractors where they may obtain or review contract documents and when bids will be opened and reviewed. After bids are opened, the design professional will canvass the bids to assure there are no irregularities or mistakes in the proposals. If all is in order, a contract is awarded, bonding and insurance documents are submitted to the client's representative, and a notice to proceed is issued.

CALCULATING PROJECT COSTS

Accurately calculating the cost of a project, whether for an estimate or for a bid, is a combination of the science of calculating and the art of estimating. The wide variety of ways that a contractor can arrive at the price of a project requires that numerous skills be developed. These skills include:

- Skill at reading and interpreting specifications and drawing for projects
- Ability to research cost-estimating sources
- Ability to compile, from one's own past projects, what resources were required to complete similar jobs
- An understanding of the abilities of the contractor's workforce to perform the required tasks
- Knowledge of conditions and special requirements for working in a particular geographic region
- Knowledge of the client for whom the work is to be performed. If you do not know prospective clients, check with friends in the business and through normal channels to verify that they are honest and trustworthy.

Even with this skill set, contractors will find that interpersonal relationships with clients, politics, labor disputes, material shortages, and other factors beyond their control may affect their success in obtaining work. Regardless of factors that contractors believe will influence their ability to bid successfully, one element they can control is the calculation of the project prices.

Sources for Preparing Project Costs

Various sources are available to obtain the prices for materials, labor, and overhead needed to prepare an estimate or a bid. The most effective sources are the contractor's own historical records. As contractors gain experience in various aspects of construction, they should maintain records of the time spent on each aspect of the project and costs associated with that aspect. Data that should be compiled include the specific tasks completed (e.g., preparing base for concrete, forming for concrete, pouring concrete, finishing concrete, performing cleanup), the number of worker hours associated with the tasks (include time for all laborers working directly on the task), and the costs for materials used to complete the task. Data should also be collected regarding equipment rented for a specific activity and the amount of time the equipment was used. Special situations, such as delays, site problems, and extenuating circumstances that changed the time and materials originally planned for the project, should also be noted.

Armed with this data, contractors can assemble unit costs. By calculating the labor costs for specific tasks and adding the materials, then dividing by the total units completed (e.g., square feet of concrete walk), contractors can obtain a number that provides detail from which they can generate a bid can. This information also allows contractors to review worker productivity, determine benefits of various construction techniques, and assess differences based on project conditions such as location or client type.

If contractors have limited historical cost records, they can refer to sources that provide cost data. Several landscape construction cost reference guides, including Means©, Sweets©, Kerry© and Dodge©, provide detailed breakdowns of the material, labor, and related costs for a wide variety of landscape construction types. Most are available as textbooks, and newer versions include software applications for estimating. Such sources typically provide this data as unit costs similar to what contractors can calculate based on historical records. Most cost references break the costs down into materials and labor and provide a composite cost. Some provide markups and overhead estimates as well. Keep in mind that any cost data may need to be adjusted based on local conditions. Items such as distance from suppliers, availability of supplies in your area, higher costs for labor or insurance, and availability of utilities all have the potential to influence project costs.

Regulatory Influences on Pricing

Several potential governmental regulations may affect project costs. Visit with local government officials to determine if special conditions apply before preparing your estimate or bid. Factors such as governmental requirements for use of local products, special regulations regarding work hours, and limitations on plant removal and pruning all may increase project costs. If the project involves state or federal funds, a plethora of regulations ranging from antikickback rules to prevailing wage laws will certainly adjust your costs. Such regulations should be noted in project specifications; but before preparing a bid or an estimate, contractors will need to verify with the owner and local government officials whether restrictions or regulations apply to the project.

Several components play key roles in calculating project costs. Accurate take-offs, or calculations, of materials required to build the project must be determined. Labor, or the time spent by employees installing projects, must be estimated. Although materials can be calculated accurately, labor can vary greatly, based on the type of operation and project situation. **Overhead**, or nonlabor or material costs of operating a business, can also range widely among firms of different size and management styles. Overhead can be separated into assignable overhead and unassignable overhead. Providing a percentage of project costs to cover contingency issues is another related project cost. Determining profit is also an essential piece of the pricing scheme. The totals from this list can be combined in many formats to arrive at a project price for presentation to the client.

Materials

Material costs are calculated using the design prepared for the site. Begin by performing a material **take-off**, or a calculation of the quantity of all materials to be used for the project. Organization of a material take-off can take whatever form provides the results required. To develop a method that reduces the potential for missing aspects of the proposed work, thoroughness and consistency from project to project are important when performing take-offs. Using a method that interfaces easily with the system used by the accounting department to track work activities will provide information that is valuable for both current and future projects.

An early step in determining material costs is to review the project plans and specifications to determine what landscape contractors are to provide. A detailed review of the entire set of plans and specifications may reveal that work must be done at certain times, under certain conditions, or in a manner in which contractors have no experience. Because many landscape contractors participate in projects as subcontractors, determining exactly what is included in the scope of each subcontractor's work is critical.

Interpretation of project specifications also requires careful reading to determine the quality and brands of materials that must be provided and whether or where substitutes may be proposed. Typically requiring written approval of the owner's representative, substitution for specified material and products could save contractors money if lower priced brands of identical quality can be substituted for more expensive proprietary brands. Examine the specifications to see if a specific product is listed, if the specifications state "or equal," or if no brand name is listed. These last two clauses open the door to proposing an alternative brand to the owner. Specific examples of where substitutes are common include hardscape materials, irrigation supplies, amenities, and even plant material.

Also important is a review of the plans and specifications for errors and omissions. These mistakes are not opportunities to take advantage of the situation by omitting work or changing materials. Most

specifications include a clause that requires contractors to notify the owner's representative of any errors found in the construction documents. This clause does not relieve contractors of their responsibility.

When performing a material take-off, consider increasing the actual quantity required for certain materials. Landscaping projects typically use many materials that could settle during shipping, be blown away, eroded, or otherwise lose "bulk" from the time they are first loaded to the time they are placed on the site. To accommodate this loss, it is not uncommon to add 10%–15% to bulk material orders to ensure that adequate supplies exist to complete the job. Materials that are typically treated in this manner include soil, sand, base material, and other bulk granular materials.

Bulk materials are not the only material that should be overordered to accommodate construction conditions. Unit pavers and wall materials typically experience waste as high as 5% when the design requires cutting. Concrete is another material that should be overordered by 2%–3% to avoid short load charges (additional fees added to concrete prices when customers order less than a full load). To accommodate plant mortality and waste, ground cover plants and sod are typically overordered by as much as 5%.

Overordering may require hauling excess material from the site, but this expense compares favorably to the cost of additional materials delivered to the site. Excess hauling and material storage adds to the cost of operating a business, so careful review of the project is required to determine which materials should be considered for overordering. Maintaining stockpiles of materials that can be loaded and taken to the site with a work crew can reduce the quantity of overorders required. Items calculated using an item count should not be overordered.

Contractors who stockpile common materials used in construction can also realize some cost savings. Contractors who regularly install similar elements of the design find it more profitable to purchase and store large quantities of base, pavement, wall material, lumber, or other materials rather than to purchase small quantities each time they begin a job. If they stockpile, contractors must have space for storing materials and a means for loading and transporting them to and from a site.

Labor

Calculating the time required to install a project is one of the most difficult tasks. Experienced contractors can calculate with a reasonable degree of accuracy the amount of time employees will require to complete most tasks. However, unusual site conditions and unforeseen problems can challenge even the most experienced contractors.

For purposes of calculating project costs, time is typically presented in an hours-per-unit format. This format presents the number of hours it will take a laborer to complete one unit of a task. Units are typically the measurable elements of a work task, such as square feet of retaining wall or a square of sod, and hours are typically based on one hour of a worker's time. A theoretical example might be a wall construction hour-per-unit rate of 1 hour per square foot of wall. If a project requires 100 square feet of wall, the take-off would calculate 100 hours for construction of the wall. Rates can be calculated for work teams as well as for individual workers.

Hours-per-unit rates are typically determined based on reviews of project designs, the site, and skills and quantity of labor available. Maintaining records that track past projects provides a historical basis for calculating project time and material requirements. When calculating hours, it is important to distinguish among the different types of tasks being tracked. Granular paving and unit paving are both surfacing tasks, but they have significantly different hours-per-unit rates. Businesses can divide the total hours required to complete a particular task for a project by the size of the task to obtain hourly rates-per-unit of work for various types of construction activities. Tracking several projects under different conditions improves the system's accuracy.

Assistance in determining hourly rates is also available in time standards that estimating firms have developed. Time standards provide typical hourly rates-per-unit of construction for most types of landscape work. When using such standards, contractors should compare them to actual costs and make adjustments based on the region and construction methods used.

Overhead

Another cost that can be directly or indirectly associated with the work being done is overhead. For

purposes of calculating project costs, overhead should be split into two categories—assignable overhead and unassignable overhead.

Assignable Overhead. Assignable overhead includes nonlabor and nonmaterial costs that can be directly attributed to a project. Included in this category are special permits, equipment rental, special insurance or bonding requirements, temporary utility costs, and related project activities that do not directly benefit any project but the one currently being bid. These costs should appear as a line item on the take-off for identification purposes. For presentation purposes, assignable overhead may be presented as such or folded into other project costs as required by the proposal format.

Careful review of the specification sections related to temporary facilities, warranties, and care of a project until accepted by the owner may reveal costs that the landscape contractor bears alone or shares with another contractor on the project. Of particular concern are the utility costs for construction. Rental of generators or the cost for watering plants that have been installed before the end of the project are examples of how utilities can significantly increase overhead. Even the rental of portable toilets can upset the delicate balance of bidding. Negotiating with the owner or general contractor regarding who provides such temporary utilities may reduce the landscape contractor's costs, and sharing costs with other contractors may limit the landscape contractor's obligations.

Unassignable Overhead. Unassignable overhead includes the costs of operating a business that cannot be attributed directly to a specific project. Included in this category are the cost of equipment and vehicles, gas, tools, insurance, payroll expenses, debt service, mortgages, office expenses, maintenance, fees, vacation, sick days, benefits, and many other additional expenses. Approaches to recovering these expenses include calculating costs and adding them on a per project basis or establishing an hourly cost for overhead and adding this to hourly labor costs.

This addition to the hourly cost, often called a **multiplier**, is determined by calculating total overhead expenses for the year (or reporting period) and dividing by the number of hours billed to clients for work performed during the year (or reportingperiod). Because not all worker hours are spent working on projects, using billed hours, rather than total hours worked by employees, is essential to obtain an accurate markup. The multiplier may be adjusted up or down based on anticipated changes in upcoming work.

Reducing Overhead. To reduce the high cost of overhead, successful contractors have discovered methods for improving the efficiency of their operations. By crafting procedures, approaches, and relationships, contractors may be able to improve their bidding and/or profit situation in many jobs. Following is a sampling of ideas that may reduce overhead and improve the efficiency of a construction business.

- The timing of the installation of improvements may help improve pricing. Being able to access a site and begin work when crews are in a slow period may even out a busy schedule and reduce overtime costs. Verifying that any work installed before the project is finished will not be damaged or disturbed will save repair time. Overhead costs can increase significantly when the contractor installs plant material as requested but the owner delays accepting the project. During this delay, the landscape contractor is often required to water, prune, mow, and perform other maintenance that should by now be the owner's responsibility. If requested to install perishable improvements, ask the owner to sign a release or maintenance contract for care of these elements should the project's acceptance date be delayed because of another contractor's failure to meet obligations or deadlines.
- Warranties and guarantees can also increase overhead. Most contracted work states the time period for which the contractor will ensure proper performance of project elements, but in some cases that time period will exceed the manufacturer's warranty. Negotiating with the manufacturer to extend the warranties, or alerting the owner to problems with materials that, in past experiences, are unlikely to perform through the warranty period may save both

the contractor and the owner headaches with product replacement.

- Insurance costs comprise a large part of unassignable overhead for many companies. Some insurance underwriters offer premium reductions to companies that institute safety programs, employ drivers with safe records, promote safety on the job, insure multiple vehicles, or have multiple policies with the same carrier. Contractors may also be able to negotiate better rates for engaging in specific sizes and types of jobs or working with specific clients. Higher deductibles are also an option for reducing insurance premiums.
- Contractors are always tempted to buy specialty tools and equipment to complete work tasks, even if they will use the equipment for only a few days per year. Consider sharing such high-cost equipment with other contractors or leasing the equipment for the time needed rather than buying it. When contractors purchase equipment, they should search for quality equipment that will reduce breakdowns and repair time.
- Discussion within the contracting world often focuses on the techniques of construction and dealing with regulatory issues, but little is said about sound business operation. Adherence to acknowledged business practices can often mean the difference between success and failure in any business, and contracting is no exception. Begin by securing the services of a reliable accountant who can structure the business to take advantage of tax regulations.
- Consider adopting regular training programs that improve employees' technical and performance skills. Many schools offer coursework developed specifically for retraining the workforce.

Contingencies

No contractor can accurately determine the extent of weather and material delays, labor shortages, equipment breakdowns, and unknown underground obstructions. Because such conditions are unpredictable, reserve a portion of the project cost as a contingency fund. Typical contingency funds range from 5%–10% of the total project costs to material and to labor costs. When presenting costs, contractors typically include this number in the overhead multiplier to avoid disputes regarding refunds of unused contingencies.

Another method for developing contingency funds is requesting that clients establish one. This method minimizes the issue of unused balances. A dollar amount equal to a fixed percentage of construction costs is then available to contractors when specifically defined conditions arise. The owners retain unused contingencies, and contractors have a method for recovering unforeseen expenses arising from circumstances beyond their control. Definition of this arrangement should be included in the contract.

Profit

Determining what amount of profit is appropriate and knowing how to calculate that amount require insight regarding the market and competition, judgments about income requirements, anticipation of business conditions during the upcoming season(s), and advice from trusted financial advisors. Profit margins are far from standardized in the green industry, and the choice for determining profit remains both a personal and a business decision.

The methods for calculating profit are even wider than the margins expected. Profit is sometimes generalized as a percentage of the cost of materials and labor used in a business. Large projects may operate on a smaller margin, whereas services that are in demand may have a significant markup. Businesses working in the field have materials marked up as much as two to three times their cost to cover overhead and profit. Labor costs are sometimes doubled to provide adequate income for overhead and profit. Profit expressed as a percentage of total project costs ranges from lows of 3%–4% to highs of 25%.

As a technique for calculating profit, some contractors add a minimal amount of profit to the original bid, hoping to use changes in the project to earn additional profit. Most large projects end up with one or more design changes, and these changes are typically negotiated with the firm currently under contract rather than being rebid. When prices are calculated for changes, the full profit factor can be applied; and the owner must either accept or reject that price. Contractors who recognize this fact can prepare their original bid with minimal profit to lower their bid, perhaps enough to capture the project, and then rely on one or more changes to recapture the understated profit. Caution is urged in

relying on this method to make money. The owner can reject all changes and build the project as originally planned, leaving the contractor with the original understated profit. There is also the possibility that a project will require no changes, eliminating any possibility of recapturing that part of the fee.

Profit can be included with overhead when presented to the client as part of the hourly charge for employees or, as in some presentation formats, presented as a separate, negotiable line item in a bid.

Material and Labor Take-Off Form

One format for calculating project costs that includes many of the aspects previously identified is illustrated in Figure 5-1. With the aid of a computer spreadsheet program, this form can be created and modified to suit individual business needs. In this illustration, the work tasks are listed as headings down the left-hand side of the chart, with specific materials used in the task listed below the headings. Quantities of materials required and overages (overorders) from the next two columns are added and multiplied by the current unit cost from the column titled "Unit Cost." The total for materials is then placed in the column titled "Mtl Total." Hours for completing a specific task are calculated and placed on the same row as the task heading. Hours are multiplied by the current hourly rate to obtain the total labor cost. Related construction items, costs, and notes are placed in the far-right column. Rows at the bottom of the form provide space for adding additional billable costs described in previous paragraphs.

Performing the take-off should follow a consistent pattern for each project. Use a standard form formatted to the type of work performed. Check the plans to make sure the scale is accurate and

MATERIAL AND LABOR TAKE-OFF FORM											
Job: Sauter residence				Job No.: 9969		Address: 2852 H. Ave.			Date:6/23/99		
MATERIALS							LABOR			NOTES/RELATED EXPENSES	
Description	Unit	Qty.	Over.	Total	Unit Cost	Mtl. Total	Hrs.	Rate	Labor Total	Description	Related Total
				0		$ —			$ —		
SITE PREPARATION				0		$ —			$ —		
sod removal	SF	700		700	$ —	$ —	4	$ 25.00	$ 100.00		
excavation	CY	10		10		$ —	2	$ 45.00	$ 90.00	skidsteer operator rate	
small tree removal	EA	1		1		$ —	4	$ 20.00	$ 80.00		
WALL INSTALLATION				0		$ —			$ —		
segmental wall material	SF	150	10	160	$ 5.25	$ 840.00	20	$ 25.00	$ 500.00		
4" diameter perf socked tile	LF	50		50	$ 1.50	$ 75.00	1	$ 25.00	$ 25.00		
aggregate backfill	TON	2		2	$ 20.00	$ 40.00	4	$ 25.00	$ 100.00		
clean topsoil backfill	TON	24	5	29	$ 15.00	$ 435.00	4	$ 45.00	$ 180.00	skidsteer operator rate	
PAVING INSTALLATION				0		$ —			$ —		
4" deep aggregate base	TON	3.5	0.5	4	$ 20.00	$ 80.00	6	$ 25.00	$ 150.00		
1" deep sand settling bed	TON	1.5	0.5	2	$ 20.00	$ 40.00	4	$ 25.00	$ 100.00		
interlocking concrete pavers	SF	225	20	245	$ 3.50	$ 857.50	20	$ 25.00	$ 500.00		
plastic paving edger	LF	60	10	70	$ 2.00	$ 140.00	1	$ 25.00	$ 25.00		
flagstone stepping stones	SF	75		75	$ 2.50	$ 187.50	4	$ 25.00	$ 100.00		
PLANT MATERIAL				0		$ —			$ —		
trees	EA	3		3	$ 150.00	$ 450.00	1.5	$ 25.00	$ 37.50		
shrubs	EA	17		17	$ 35.00	$ 595.00	3	$ 25.00	$ 75.00		
ground cover	EA	250	10	260	$ 2.50	$ 650.00	4	$ 25.00	$ 100.00		
mulch	CY	4		4	$ 25.00	$ 100.00	2	$ 25.00	$ 50.00		
staking materials	EA	3		3	$ 20.00	$ 60.00	1	$ 25.00	$ 25.00		
sod	SQ	8		8	$ 28.00	$ 224.00	5	$ 25.00	$ 125.00		
BILLABLE OVERHEAD									$ —	half-day rental of sod cutter	$60.00
ITEM TOTALS						$4,774.00			$2,362.50		$60.00
								PROJECT TOTAL		**$7,196.50**	

Figure 5-1 Sample form used for material and labor take-offs for landscape projects.

has not been reduced or enlarged when printed. When a plan has been estimated, mark it with a large *X* to avoid duplication. Fewer mistakes will result if only one side of the take-off form is used, avoiding missed back pages. Use printed measurements over scaling whenever possible, and look for written notes and notations such as *N.I.C.* (not in contract, so no price is needed), *typ.* (meaning all subsequent elements are similar), and *N.T.S.* (not to scale, so written dimensions must be obtained). Converting to decimals makes take-off calculations easier, but be consistent with your measurements, always using the same unit and measuring in the same manner. When measurements are complete, check your placement of decimal points and math. Round only when calculating the final figure. Consider taking two or three dollars off the price to avoid the angst of matching or being slightly over the bid of someone using similar bidding methods.

PRESENTATION FORMAT FOR PROJECT PRICES

Totals obtained from calculating project costs can be combined in a number of different ways for presentation to clients. The following sections identify methods to arrange the various cost aspects into bid or estimate formats. Selection of an appropriate method will be based on project requirements. Examples of how the material and labor take-off from Figure 5-1 can be presented in the following formats are provided in Figure 5-2. Examples of project bid forms can be found in Appendix E.

Lump Sum

Lump sum is a bid format in which all projects costs are provided to the client in a single number. All components of the project are added together to obtain a lump-sum bid. Although this bid is easy to compare from one contractor to another, it is difficult to change because there are no itemized materials or labor costs. Bids may sometimes include an add or deduct request in which a specific amount is added or deducted from the lump-sum total for the addition or deletion of a project component.

LUMP SUM		
Total project costs:	$ 7,196.50	
ITEMIZED		
Prices would be presented in the same format as **Figure 5-1.**		
TIME AND MATERIALS		
Material costs:		
• walls	$ 1,390.00	
• paving	1,305.00	
• plant material	2,079.00	
Assignable overhead:		
• equip, rental	$ 60.00	
Time (estimate only):		
• 6 hrs. @ $45.00	$ 270.00	skidsteer operator
• 80.5 hrs. @ $25.00	2,012.50	laborer
• 4 hrs. @ $20.00	80.00	assistant
Total estimated project costs:	$ 7,196.50	
Actual costs will be based on hours worked multiplied by above rates.		
COST PLUS FIXED FEE		
Materials:		
• walls	$ 1,251.00	
• paving	1,174.50	
• plant material	1,871.10	
Assigned overhead:		
• equipment rental	$ 60.00	
Labor:	$ 2,126.25	
Fixed fee:	$ $ 713.65	
Total estimated project costs:	$ 7.196.50	
Hourly rates for work beyond estimated hours: $18/hour assistant, $22.50/hour laborer, and $40/hour skidsteer operator (hourly rates minus 10% fee).		
UNIT COSTS		
Site preparation:	$ 270.00	
Walls:	2,195.00	
Paving:	2,180.00	
Plant material:	2,491.50	
Assignable overhead:	60.00	
Total project costs:	$ 7,196.50	
Above costs include materials, labor, and overhead.		

Figure 5-2 Typical presentation formats for landscape pricing. Values are taken from take-offs shown in Figure 5-1.

Itemized

An **itemized bid** or estimate not only provides a total project price, but it also has a detailed listing of project materials or work tasks. This form of bid is easy to compare and adjust if work is changed. Prices can be itemized by unit of work (see following paragraphs) or with lines for each item used in calculating costs. A detailed itemized cost presentation is similar to the format presented in Figure 5-1.

Time and Materials

When either the customer or contractor is wary about the amount of time required to complete a project, a time and materials bid may be the best presentation. This is a form of bid that provides for a set price for materials and assignable overhead, plus an hourly cost for labor. Labor costs on a time and material bid may be represented by an estimated number of hours multiplied by the hourly rate to obtain a general idea of labor costs. Materials and assignable overhead costs do not change significantly during the project, and compensation for labor is based on the rate times the actual hours worked. Unassignable overhead, contingency, and profit are assigned to hourly rates for employees.

Cost Plus Fixed Fee

When uncertainty exists about the amount of time required to complete a project, the cost plus fixed fee form of bid may be useful. The **cost plus fixed fee** bid is a time and materials bid with the profit listed as a fixed line item, rather than being assigned to the employee hourly rate. The contractor is compensated for actual time and materials, but the owner is not responsible for additional profit as a result of delayed completion. Unassignable overhead and contingency costs remain assigned to employees' hourly rate.

Unit Costs

Unit costing is an estimating tool used to provide general project costs. Rather than being itemized by traditional divisions such as materials, labor, etc., costs are presented according to units of work areas, such as square foot of paving.

Development of unit costs requires tracking previous jobs over a variety of installation situations. Calculate unit costs by dividing the total costs associated with a particular aspect of the job by the size of that portion of the job. For example, the total costs for all items associated with the decking for a project totaled $10,000, and the total area of the deck was 500 SF. The unit cost for that project would be decking for $20 per SF. These types of costs can be tracked over several projects to obtain a more accurate picture of actual costs.

Pricing to a General Contractor

Contractors my function as subcontractors for landscape portions of jobs. In this situation, the general contractor will require the subcontractor to provide a price. The process used for this pricing should be formal, with a written proposal or letter of agreement submitted. Typical formats used for pricing to a general contractor include lump-sum and itemized bids.

CHAPTER 6

SAFETY IN THE WORKPLACE

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Identify hazards in the workplace.
- Avoid unnecessary accident and injury.
- Institute practices that minimize workplace hazards.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- The Landscape Construction Process, Chapter 1
- Legal Requirements, Chapter 2

Like most construction occupations, landscape contracting carries with it the risk of disabling or serious injury or death if workers are unaware of the hazards and proper techniques for preventing potential accidents. The many benefits and rewards of landscaping can be quickly erased by a serious or debilitating injury. Fortunately, most of the hazards of the landscape workplace are identifiable. In this chapter, many common on-the-job hazards and strategies for reducing risk are identified.

CAUTION

This textbook is intended to supplement supervised classroom instruction. Practice of the profession of landscape construction is filled with safety and health hazards, and use of this book without proper experience or supervision will place the reader at risk. *The reader assumes all risk when engaging in unsupervised activities.*

PREVENTING ACCIDENTS

Prevention of accidents begins by providing required information to workers regarding hazards in the workplace. Implementation of a safety training program for new and existing employees will assist in improving their awareness of work hazards. Employees should be properly trained before operating equipment or engaging in new construction activities. Signage and postings that warn of health hazards should be present in all areas, including vehicles and structures, that workers frequent. Be certain that warnings and instructions on safety are placed in highly visible spaces and are presented in language(s) that all employees understand. Material Safety and Data Sheet (MSDS) sheets should be read when first received and periodically reviewed and updated.

Material Safety and Data Sheets (MSDS)

Businesses are required to keep on file in the workplace a **Material Safety and Data Sheet** for every

material that poses a potential risk to employees and to others who may come in contact with such materials. These sheets should be kept in a file in a vehicle at each job site and in each shop and structure used for the business.

Site Inspections

Each contracting company should train all employees and contractors on procedures for maintaining a safe work site. In addition, each company or work crew should designate an employee as a safety "officer," who is responsible for verifying that safety rules are observed and practiced. Conducted before and after each work day, regular inspections of a work site will help ensure that conditions are safe for workers and safe when the site is not occupied. Maintaining a record of work site inspections is a valuable tool in documenting problems that could lead to serious consequences.

Actions and Behaviors on a Work Site

Many accidents can be prevented by developing good work habits. Maintaining awareness of safety and keeping focused on the work being performed are initial steps in keeping a workplace safe. Additional preventative actions include not working when overly tired, not running at a work site, and keeping the work site clean. In all cases, using or being under the influence of illegal drugs and alcohol while on the job is prohibited. Also, both employers and employees need to understand and acknowledge how prescribed medications may affect a worker's ability to operate equipment and machinery.

First Aid

Employees who are required to work in a potentially hazardous environment benefit from basic first aid and CPR (cardiopulmonary resuscitation) training. Placing first aid kits in vehicles and structures used in the business and providing means to communicate problems with appropriate officials will aid in addressing emergencies. In addition to first aid kits, **personal protective equipment (PPE)** should be provided. When used properly, this equipment protects workers from blood borne pathogens. PPE should include at a minimum latex gloves and CPR mouthpieces. In addition, all employees should know the location of the nearest hospital or medical center in relation to their current job site. Directions to these facilities should be placed in each vehicle and on each structure.

Medical Conditions

Employers and employees should be familiar with chronic health problems that work conditions may inflame. Dust or pollen from work sites may trigger allergies and asthma attacks, and emergency treatment for such medical conditions should be reviewed prior to beginning work. Employees should also obtain current boosters for tetanus prior to performing landscape construction activities.

REDUCING PERSONAL INJURY

The most important tool in the contractor's repertoire is the human body. Protecting the body from injury is necessary to ensure workers can remain productive throughout their careers. Several potential challenges that landscape contractors face when completing their work tasks are next discussed, along with recommended methods to counter these threats to their safety.

Clothing and Protective Equipment

Protection of the body is a logical starting place when attempting to reduce personal injury. Essential equipment includes proper work boots with steel toe protection, heavy-duty work gloves, and eye protection when using equipment or engaged in activities that create hazardous conditions. In addition, contractors should consider using hard hats for overhead work, appropriate back support for lifting activities, and skin protection for long-term exposure to the sun. Dust masks and ear protection should also be considered when performing landscape construction tasks that involve constant noise and/or dust. When performing tasks that require long periods of kneeling, workers will find that using kneepads provide protection and make doing those tasks more comfortable. Hats or nets that keep hair from becoming entangled in equipment are also recommended.

Heat and Cold Injuries

Because most people think of landscaping as fair-weather work, they give little consideration to protecting themselves from heat and cold injuries. Although the likelihood of suffering a cold injury is quite low, workers need to wear proper clothing and to protect themselves to prevent hypothermia and frostbite when working in extreme temperatures. Threats from heat injuries are more obvious to the landscape contractor. In

addition to protecting their skin from sunburn and excessive exposure, workers need to use caution and protect themselves from heat exhaustion and heat stroke when they plan activities on very hot days. Performing tasks during the cooler hours of the day, taking ample breaks, and drinking water are ways workers can protect themselves when temperatures climb.

Threats from Wildlife

Working outdoors places the worker at potential risk from wildlife. Threats include exposure to insects and smaller animals, such as bees, wasps, snakes, and scorpions, and possible confrontations with hostile, larger animals. Use caution when performing site preparation tasks that require the removal of potential animal habitat. Old structures, brush piles, dead trees, shrubs, wells, ravines, and other secluded areas are generally harbors for potentially dangerous animals. Review the site carefully before beginning work to locate animal habitats. Carry insect spray to repel insects. Examine equipment, tools, and clothing left unattended at the site to determine that wildlife has not adopted these items for shelter.

If wildlife, threatening or not, is discovered, consider contacting animal control, local animal shelters, or wildlife protection centers. Some organizations will relocate animals to new habitats before problems arise.

Hazardous Plants

Workers should be aware of any plants that may trigger dermatitis when contacted. Remove or avoid poisonous plants, or wear proper protective clothing to avoid direct contact with the skin. Some plants should be avoided altogether. Other plants, such as poison ivy, are caustic when burned. Obtain positive identification of all suspected plants and take appropriate precautions.

Back Injuries

If not properly executed, the actions and motions required to complete every task of landscaping have risks of physical injuries, especially to the back. Improper lifting of heavy objects and repetitive improper lifting of light objects produce strain on muscle groups in the back. Too often, workers are tempted to bend over and pick up materials and tools that they need for work. After performing such a motion numerous times without injury, workers give little thought about the potential risk. However, placing undue strain on back muscles over time can accumulate into an injury. Learning how to lift and following simple rules will help reduce back injury from performing the various landscape construction activities. Performing simple stretching exercises before beginning work and following long periods of repetitive motion is also beneficial (Figure 6-1).

Proper lifting technique is designed to direct the strain of lifting to the proper muscle groups:

- Lift by bending at the knees, rather than bending at the waist. This transfers the stress to the thigh muscles, which are better adapted to lifting such weight (Figure 6-2).
- Avoid twisting motions while lifting. Move the feet, rather than twist.
- Hold the load close to the body when lifting. Holding the load at arm's length greatly increases the stress on the back.

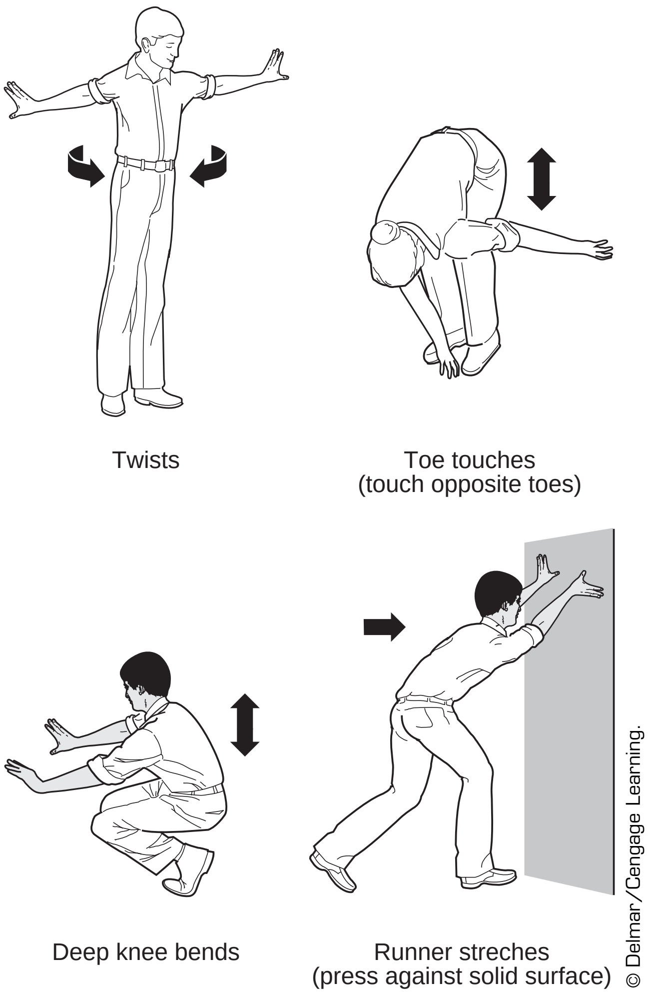


Figure 6-1 Warm-up stretching exercises.

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Figure 6-2 Proper lifting by bending at the knees.

Other techniques that will help reduce back strain are:

- Get help when lifting heavy objects.
- Wear back support braces approved by the Occupational Safety and Health Administration (OSHA) and appropriate health organizations.
- Warm up properly and rest at intervals when engaging in **repetitive motions** such as laying brick or planting ground cover.
- Use labor-saving devices, when available, to lift.

Extended sitting and kneeling can also cause muscle injury. Interrupt periods of sitting that are longer than 20 minutes with a stretching period. Use proper seating and cushioning for back and knees when performing tasks that require long-term sitting and kneeling. Additional suggestions on preventing back injuries are available from injury prevention and rehabilitation organizations.

Confined Spaces

Although not common in landscape work, confined spaces such as manholes, vaults, or cisterns pose risks for contractors. Do not enter confined spaces that are restricted, and avoid entry when conditions of the space are unknown. Also avoid entry into spaces where a person could be trapped or engulfed in hazardous materials or if the spaces have no obvious secondary exit points. Never enter such spaces without a co-worker present in the immediate vicinity.

WORKING AROUND UTILITIES

Cutting through or running into utility lines that serve a site introduces several potential risks to landscape contractors. Personal injury or death can occur from electrocution, explosion, or fire if utility lines are disrupted. Contractors also incur financial risk in the cost of repairing damaged utilities. In addition, the project may suffer immediately or in the future from utility damage and activities required to repair that damage. Particular care should be taken when working with electrical, gas, and communications utilities, which, if damaged during construction, pose the greatest risk to contractors.

CAUTION

Always call for location of utilities lines or cables before performing *any* work at a site.

Public Utilities

Risk can be substantially reduced by calling for location of utility lines or cables prior to beginning your work. Any time plans require disturbing a site, utility companies should be contacted prior to construction. Most utilities require 48–96 hours advance notice for locates and do not charge for locating services. To coordinate the task of locating utilities, many areas of the country have instituted the ONE-CALL service. ONE-CALL is a number that provides a centralized locate service for a portion of the utilities located on a site. ONE-CALL will *not* contact all utilities that are potentially located on a site. You

will still be responsible for verifying which utilities are not contacted by ONE-CALL. To determine which ONE-CALL number is used in the area where you are working, call the nationwide directory at 1-888-258-0808. Suggestions for using this service include:

- Obtain the ONE-CALL number for the area in which work is planned.
- Call 96 hours prior to beginning construction.
- Have the address and specific location of the project ready when you call the service.
- Identify the type and extent of work.
- Indicate who is calling and provide an address.
- Provide construction starting dates and times.
- Provide a phone number the directory service can call with responses and questions.

In certain situations, the utility company may choose to have a representative present while work around its lines is in progress.

Landscape contractors involved in large planting projects or projects that have footings or new utility installation can also mark out their work prior to a utility locate. As long as markings are complete and accurate, this action will aid the utility company in safely identifying its lines. To aid in identification, use white flags or paint to locate landscape improvements to avoid confusion with utility markings. Utility companies have adopted standard colors to identify various types of utilities. This color coding systems is as follows:

- Red: electrical
- Yellow: gas
- Orange: phone, communication, possibly **fiber optics**
- Blue: water
- Green: sewer
- White: proposed excavation
- Pink: temporary survey markings
- Purple: reclaimed water (irrigation)

Once utilities have been located, carefully hand-dig for 2 feet on either side of the utility marking. Should the utility be slightly mismarked, hand-digging reduces the chance of disrupting the line. Certain utilities place a locator tape or cable with or slightly above the actual utility line to aid in its location and to warn that the utility is close. Trenching perpendicular to the marking and gradually working deeper aids in locating lines that are not directly below the mark. Work the soil gently with a shovel and in small amounts. Avoid chopping into compacted soil or using the shovel as a lever to remove large sections of soil.

Private Utilities

Before beginning a project, review the site for utilities that may not have been marked. Lines privately installed do not show up on utility company records and *are not marked* by locators. Look for outbuildings with power, yard lights, wells, gas tanks, septic tanks, or other site facilities that would obviously have some sort of connection to a utility line. Inspect inside buildings, particularly in the basement, for utility lines leaving a structure. Check the buildings on site for electrical breaker panels. Shutting off service at any unknown or unmarked breaker will stop service to areas served by those controls, but this precaution may also reduce the chance of accidental shock. Utility-locating equipment can be rented to help find private lines. Instructions for operating this equipment are critical because connections are often made to the utility line to trace its location. If utilities cannot be located, then contractors may have no choice but to unearth the entire utility line from source to end to find the location.

Locking Out Electrical Circuits

When performing work on electrical circuitry, contractors face the risk of accidental electrocution if they do not use standard electrical lockout procedures. When using a circuit or power cord leading to a task that involves the use of electricity, the contractor performing the task should lock out and tag the circuit or cord; and that same contractor should be the only one to reactivate the circuit or cord.

WORKING BELOW GRADE

If the soil about them is unstable or if they are deep, trenches can collapse. Workers should be aware that any trench poses a hazard when they need to bend down to perform work tasks near the bottom. Special precautions should be taken any time the trench is more than waist deep.

Shoring reduces risk to workers when the trench exceeds a safe working depth. Sheets of plywood separated by 2 × 4s can provide sidewall protection for shallow trenches in unstable soils. Larger trenches will require the use of metal trench shoring. To reduce the possibility of collapse, equipment should not be operated near the edges of open trenches. Always work in pairs when performing trench work. People caught in a trench collapse are often helpless to free themselves; nor are they able to call for help.

OPERATING POWER EQUIPMENT

Personal injury, disability, and death can result from the improper operation and use of power equipment. See Chapter 7 for instructions on performing basic construction activities, including operation of many pieces of equipment. Tractors, **skid-steers**, **chainsaws**, and power tools all pose a risk of serious injury if workers do not follow the rules of operation. Never modify equipment or remove safety guards. Read all manufacturer's safety instructions and heed the safety risk labels found on nearly every tool or piece of equipment used. These labels are the foundation of workplace accident avoidance.

Care should be exercised when using electrical equipment in landscape applications. When strung around a construction site, cords can be easily, if accidentally, severed, creating a potential for shock. Water also poses another potential hazard when using electrical equipment outdoors. Verify that electrical circuits being used have ground fault protection against shock and electrocution.

Operation of tractors, loaders, and skid-steers creates additional hazards for the work site. Use care when backing such equipment because the operator often has no clear vision behind the vehicle. Warning bells or beepers when equipment or vehicles are geared to reverse should be kept in working order, and all workers in the immediate area should be alert when the operator backs the equipment. Potential for tip-over increases when equipment is operated on a slope or when loads become top-heavy. The center of gravity keeps most equipment operating on all four wheels (or on two tracks). When this center of gravity approaches the outside edge of the equipment's operating base (wheels or tracks), instability results. If the center of gravity moves outside the operating base, a tip-over occurs. Most equipment is designed with a low mass, but when equipment is used to carry a load in a bucket or when it is operated on a slope, that center will change (Figure 6-3). Two good rules to follow: Work slopes steeper than 3.5:1 (3½ feet of horizontal distance for each foot of vertical fall) from bottom to top, rather than from side to side, and always carry loads low.

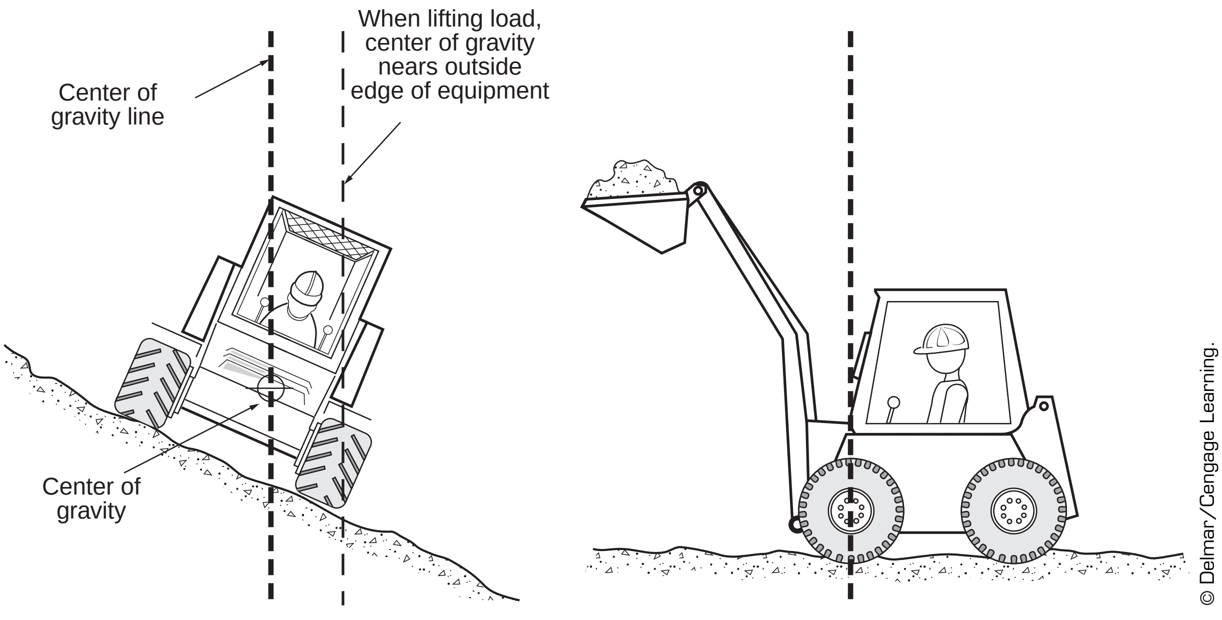


Figure 6-3 When the center of gravity for equipment passes beyond the outside edge, a tip-over may occur. Tip-over may also occur when a load is lifted too high. Use caution when operating equipment on slopes or when lifting a load.

Caution should also be exercised when using power washers, both compressed air and sprayers. Never aim the spray at exposed skin or body parts. Serious damage to the eyes and skin can result from a direct spray at high pressure, including contusion and cutting of skin or the penetration of materials into skin.

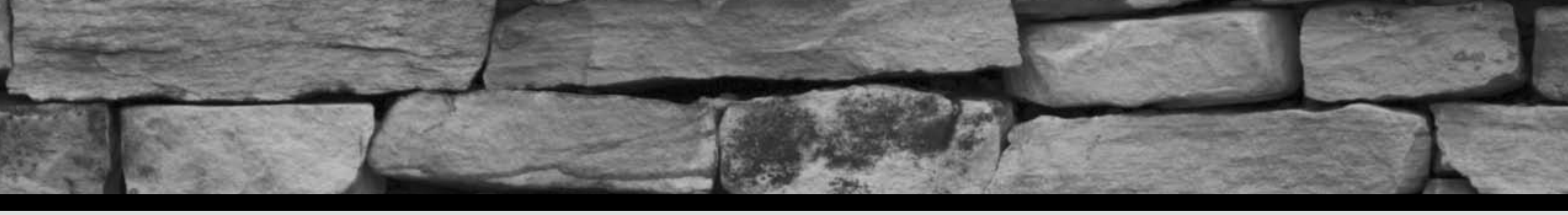
WORKING WITH CHEMICALS

Serious injury, particularly burns, can result from misuse of chemicals associated with landscape construction. Painting, staining, and cleaning masonry work necessitate the practice of safety techniques to reduce chemical injury.

Acids and Volatiles

Acids and volatile chemicals found in exterior finishes can present a risk to landscape contractors. Following a few simple rules when working with muriatic acid, TSP (tri-sodium phosphate), wood preservatives, stains or paints, and other volatiles can reduce the potential risk. Safety rules include:

- To reduce the chance of injury, wear proper protective clothing when mixing and applying volatile chemicals. Eye and face protection, rubber gloves, and complete coverage of body and limbs will afford protection when working with chemicals.
- Mix and use chemicals in open areas with ample ventilation to avoid asphyxiation by high concentrations of fumes.
- When mixing acid and water, always add the acid to the water. Never add water to acid. Adding water to acid will cause the mixture to spray and splatter, creating the potential for burns. Always wear protective clothing, gloves, and eyewear when mixing chemicals.
- Follow the manufacturer's recommended procedures when applying any chemical.



CHAPTER 7

BASIC CONSTRUCTION TECHNIQUES AND EQUIPMENT OPERATION

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Operate basic construction tools in a safe and efficient manner.
- Perform basic landscape construction activities.

Included in this chapter are basic construction techniques and equipment operation instructions that will be referred to in subsequent chapters. Construction techniques that are specific to a particular aspect of landscaping are described in the appropriate chapter.

> **CAUTION**
>
> It is assumed that the reader of this text possesses basic skills necessary to safely perform construction activities and to operate construction equipment. Readers who lack these skills must obtain instruction in these essential areas before attempting to undertake the activities described in this text. Always read and follow manufacturer's instructions when using any piece of equipment.

The process of selecting appropriate construction equipment and techniques starts with understanding the task to be completed and the operator's capabilities. First and foremost among these considerations is safety. The appropriate tool for the work must be selected, and the operator must be familiar with the safe and effective use of the tool. Failure to make the correct selection increases the risk of injury, disability, or even death.

Another important issue is the size and capacity of the tool selected to complete the task. Moving hundreds of cubic yards of soil with a shovel is inefficient, as is installing only two nails with a power nailer. Choosing a tool that is too large wastes energy and is seldom cost-effective. Likewise, choosing equipment that is too small to efficiently complete the task increases the effort and extends the time necessary to finish the work. Carefully evaluate the task and then consider the best tools and equipment available, including hand tools, small power equipment, and large power equipment, to appropriately complete the work.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this

chapter, read the related information in the following chapter:

- Safety in the Workplace, Chapter 6

EXCAVATION

Use of hand tools cannot be avoided in the field of landscape construction. Although working with them is labor-intensive, hand tools can make work easier and more productive when used properly (Figure 7-1). When the work with a particular hand tool is extensive, consider the economy of renting or purchasing the powered alternative. Several powered tools can be substituted for much of the hand labor that is common on landscape jobs. Some common tools include power augers, sod cutters, edging machines, jackhammers (see "Digging" below), trenchers, backhoes, skid-steers, tractors, and dump trucks, including the variety of

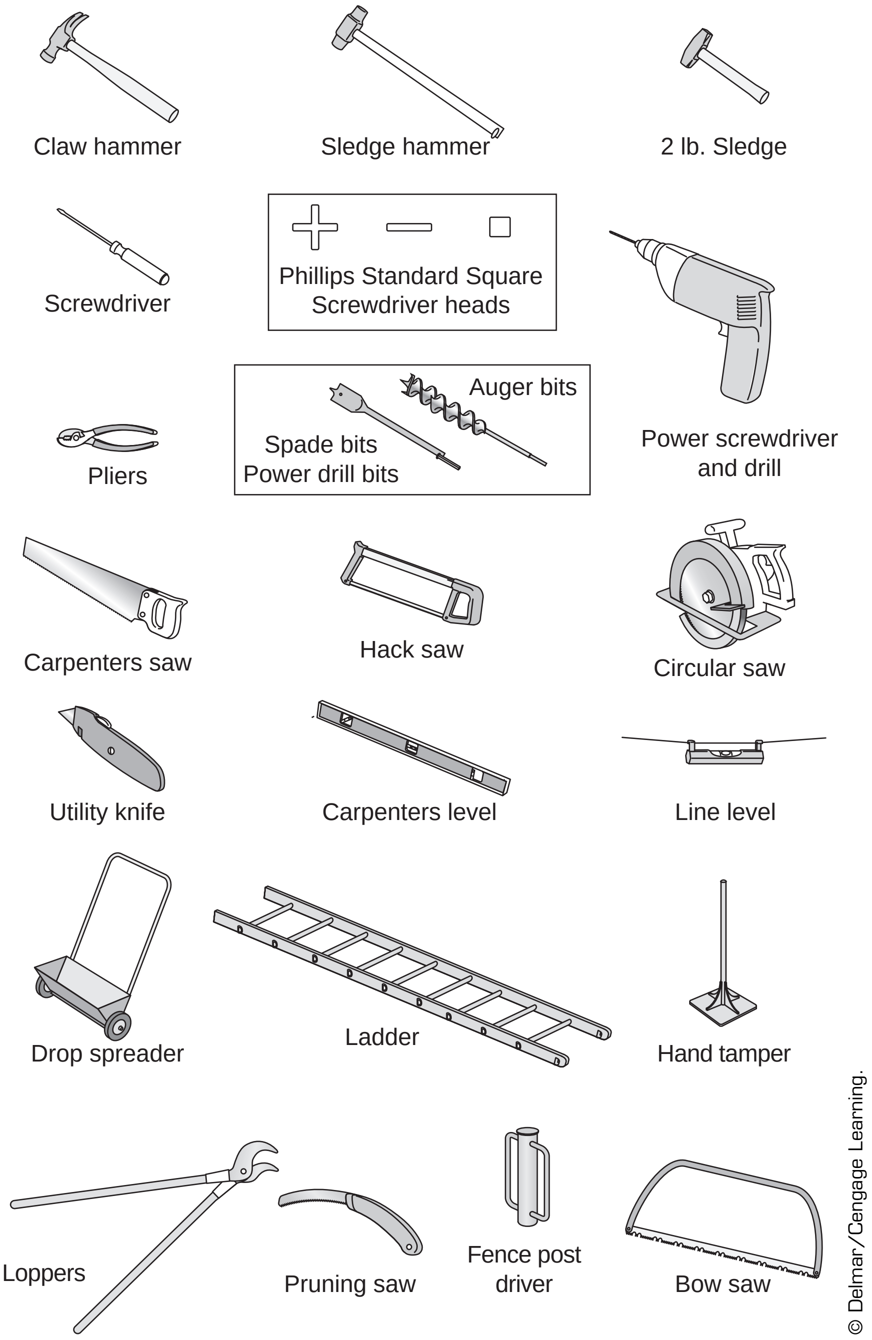


Figure 7-1 Common tools used in landscape construction.

attachments for these pieces of equipment. Operation of most power equipment is embedded with the specific task or is addressed in general in this chapter. Ideally, operation of power equipment should be learned under the supervision of an experienced practitioner.

Digging

Nearly every task in the landscape construction field requires digging in some form. Consider using a skid-steer for excavations of more than 5 CY, but smaller excavations and portions of larger jobs will require hand excavation. Proper selection, use, and care of shovels greatly eases the burden of hand-digging.

Selection begins with determining whether a spade or shovel is required (Figure 7-2). A round-nosed shovel has a curved surface with raised edges and is designed for excavating and scooping material. Scoop shovels have very wide blades (12–18 inches wide) designed for large-scale moving of mulch, rock, and other landscape materials. Square-nosed shovels have a medium width blade with squared corners designed for cleaning out wide base or utility trenches and skimming soil and scooping material. Trenching spades have long, narrow blades (6 inches wide) that are designed for excavating narrow utility trenches. Shovels and spades also come with long handles, which provide more leverage, and short handles, which work better in tight situations. Additional tools that are helpful in moving and removing materials are picks, mattocks, breaker bars, and pitchforks. Identify the type of digging tasks required and select the proper tool to accomplish the task. The experienced contractor carries a variety of tools to accommodate almost any digging chore.

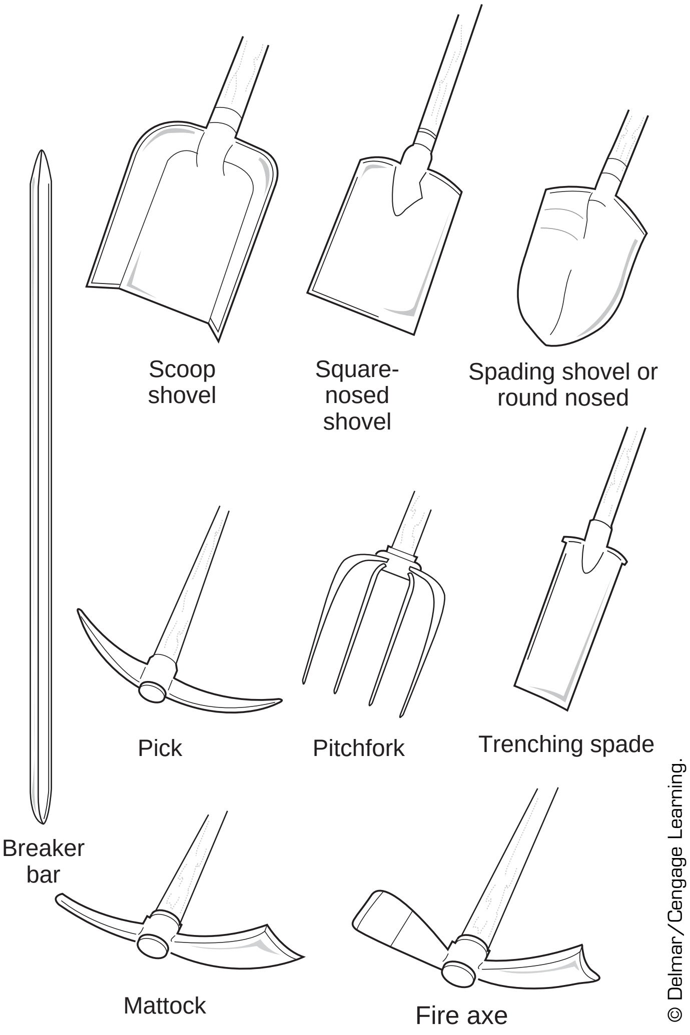


Figure 7-2 Typical landscape construction excavation tools.

To obtain the proper excavation technique, position the digging tool so that the blade is perpendicular with the ground. Place the instep of your foot on the shovel to push the blade completely into the ground and pull back on the handle to leverage material out. Alternate sides and digging positions to avoid overexertion of one muscle group. Use your arms as much as possible in lifting the load of soil. Drop your load using a motion that swings the shovel forward and down, letting the material slide from the shovel blade. If the location for dropping the load is not directly in front of you, pivot on one foot to the correct direction, rather than twisting your back and body (Figure 7-3). Excavate in reasonable amounts that fit onto the spade or shovel without spilling. Proper digging involves many repeated steps, rather than two or three giant shovelfuls. When faced with hard compacted soil that is difficult to excavate, first loosen the soil using a **breaker bar** (also called a *pry bar*), pick, landscape axe, or mattock. The breaker bar is a long, narrow, heavy bar that can be lifted and thrust downward onto hard soil (Figure 7-4). Picks, landscape axes, and mattocks use a chopping motion to loosen compacted earth. Break apart small sections; then excavate using a shovel or posthole excavator.

As an alternative to a breaker bar, use a jackhammer with a spade bit. Make an initial excavation using the jackhammer; then move the equipment back a few inches and work toward the loosened soil (Figure 7-5). Jackhammers are available in electric- and gas-powered models and can often be rented from equipment stores. When operating

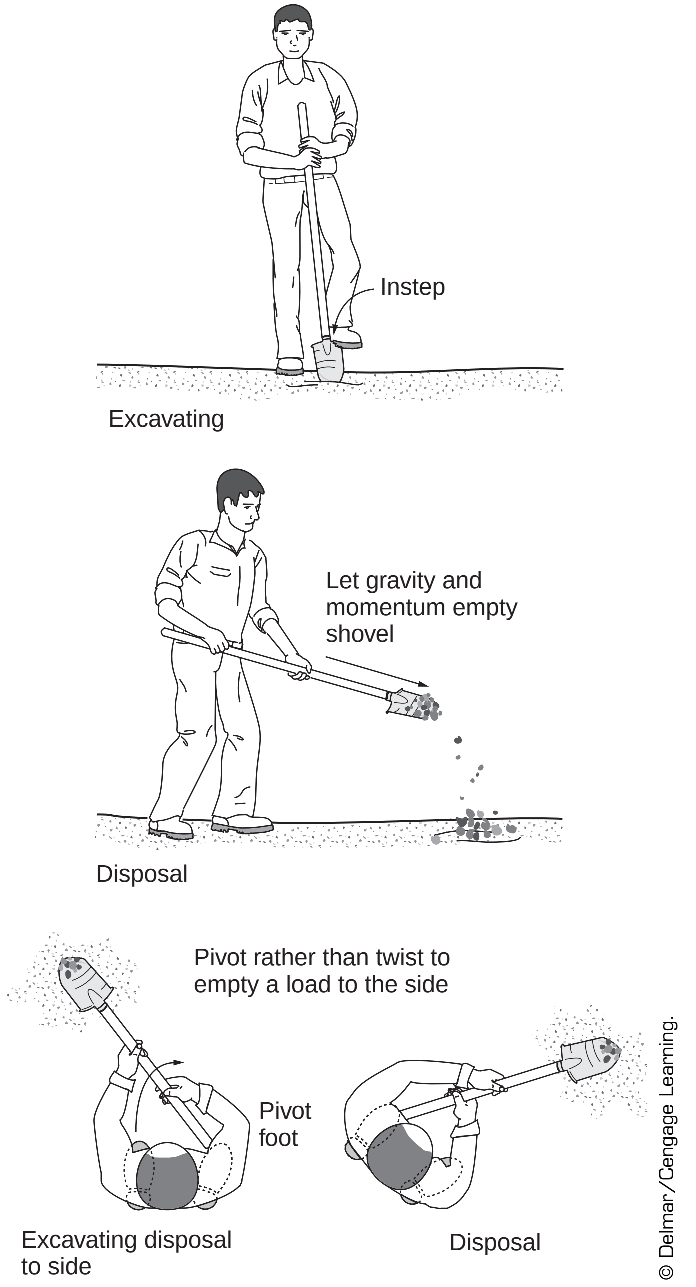


Figure 7-3 Proper spading techniques.

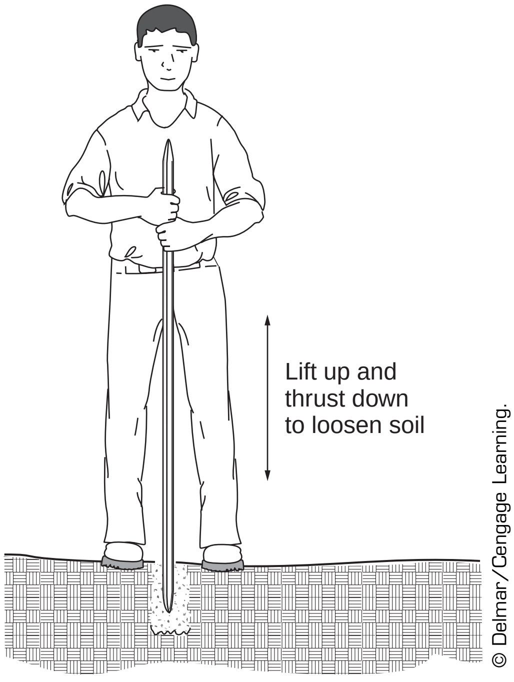


Figure 7-4 Loosen hard soil using a breaker bar.

the jackhammer, the operator should stand squarely on two feet and maintain proper balance. The equipment is heavy, and operators can fall if they lose balance. In addition to the spade bit, point and chisel bits are also available to aid in removing pavement.

If the desired excavation is shallow, use a rototiller to loosen the soil and any existing cover crop (Figure 7-6). Work the rototiller across the site, and then repeat at a right angle to the initial passes. The surface can then be scraped off using square-nosed shovels.

Keep all excavation equipment clean and sharp. Use a file to maintain an edge on the blade of the shovel or spade to ease cutting through tough soils and roots. When not in use, digging tools should be cleaned completely, their surfaces oiled, and then stored in dry locations.

Excavating Postholes

Postholes can be excavated using **clamshell diggers, augers**, and powered augers. Augers work by positioning the tool over the hole location and twisting until the auger is full (Figure 7-7). Lift from the hole and tap on the ground away from the hole to remove the excavated material (Figure 7-8). Continue auguring until you reach the proper depth, checking the hole periodically for depth and plumb. Operate clamshell diggers by holding the handles together and driving the blades into the ground at the hole location by dropping or thrusting the tool downward with the arms (Figure 7-9). Avoid pinching fingers between the handles. Spread the handles to capture a load of material and lift it out of the hole. When working in dry soil, add a small amount of water to the excavation. This will create a soft mud that is easier to remove from the hole than is a loose dry powder. Continue this process until the hole is excavated. Excavating is faster

Figure 7-5 Loosening soil with a jackhammer.

with either tool if depths are marked on the handle (Figure 7-10). If soil in the hole is dry and spills out of the digging tools while you extract it from the hole, add a small amount of water into the hole to create a light mud that you can excavate more easily. Clamshells are difficult to use on deep excavations, whereas augers have difficulty maintaining plumb excavations. Starting an excavation with a clamshell and finishing with an auger will more effectively excavate a hole. Keep a sharpened, long-handled trenching spade or pair of lopping shears handy to cut any roots that disrupt hole excavation.

Excavating a hole can be laborious; so if several holes are planned, consider renting a power auger to perform the work. Power augers have a gas engine that turns a spiral auger to excavate the hole. Two people are required to operate the power auger. The area around the hole must be clear of objects that could block the operators' activities. Begin by marking the location of the center of the hole. Using a round-nosed shovel, excavate a 6-inch deep, cone-shaped centering hole. This small hole will help keep the auger centered on the hole as it starts the excavation. Start the engine and, with each operator firmly grasping the handles, position the auger over the hole. Accelerate the engine and push down on the auger. The auger will bite into the soil and pull the material out of the hole. Maintain the auger in a plumb alignment for the entire depth of the hole (Figure 7-11). Work the auger in an up-and-down motion to periodically clear the blade, but avoid pulling the auger completely out of the hole. Keep a firm grip on the auger. Any solid object encountered while digging will jerk the auger to the side.

Trenching

By using the proper hand trenching method, you can dig larger quantities of trenches that are more stable in shorter amounts of time. Begin with selecting the proper tool. A trenching shovel should be used to dig narrow slit trenches. Using the full


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Figure 7-6 Loosening the surface layer of soil using a rototiller.

length of the shovel blade allows trenches to reach maximum depth. When trenching, turn the spade at a 45-degree angle to the side of the trench, rather than digging perpendicular to the edge. This will limit trench collapse when the soil is levered out.

Leveling

Hand leveling an area typically involves the use of garden or landscape rakes. Using a pulling and pushing motion, you can redistribute soil and other materials into a smooth surface. If a digging action is required to dislodge material, use the tine side of the rake while pushing down with force. When materials are loosened, they can be shifted to the desired location using the tines. For smooth leveling, turn the garden rake upside down and use the bar portion rather than the tines.

Compacting Fill Materials

Compaction of fill materials can be accomplished by hand or mechanical means. All filling activities are more effective if fill material is placed and compacted in layers, also called lifts, 6 inches thick or less. Hand-tamping requires pounding the fill area repeatedly using a hand-tamping plate or the end of a 4 × 4. Mechanical pounding can be accomplished with the use of a **vibratory plate compactor.** The plate compactor operates similarly to a self-propelled lawn mower. Start the compactor and adjust the throttle and settings. With no need for you to push it, the compactor moves forward; and you can steer it using the handle. To turn sharp corners, lift the handle vertically and spin the compactor.

Larger compaction jobs can be accomplished using other mechanical equipment (Figure 7-12). **Rammers,** or **jumping jacks,** are handheld, gas-powered, compaction devices used for compacting trenches, particularly in areas where settling may be a problem. To use a rammer, start the equipment and position it in an upright position. Accelerate the rammer and guide it slowly through the area to be compacted. The rammer will "bounce" up and down to compact. Repeat the process at least twice over the entire area. **Static** and **vibrating rollers** are available as hand-operated or towed equipment for large open areas such as lawns and roadways. Both rollers can typically be weighted down by adding water to the rounded drum, and both should be guided through the area to be compacted at least twice. If possible, make the initial pass over the site with the rollers in one direction and then make a second pass at right angles to the initial compaction.

STAKING AND FENCING

In performing their jobs, landscape contractors often stake perimeters and erect or install fencing. Although fencing the perimeter of a project may not create a physical barrier, it does alert those in the area that construction activity is taking place on a site. For projects where it is imperative that nonauthorized entry be restricted, contractors must rely on chain-link or security fencing to protect the project boundary.

Driving Stakes

Driving, or forcing stakes into the ground, typically requires the use of a small (1–2 pound) or large (4–5 pound) sledgehammer. Position the stake in the proper location and lightly strike the top of the stake to start it into the ground. Stakes may shift location when driven, depending on the size of the stake or its taper, the end being driven into the ground. If the stake shifts when being struck, use your foot to hold it in position. When the stake is

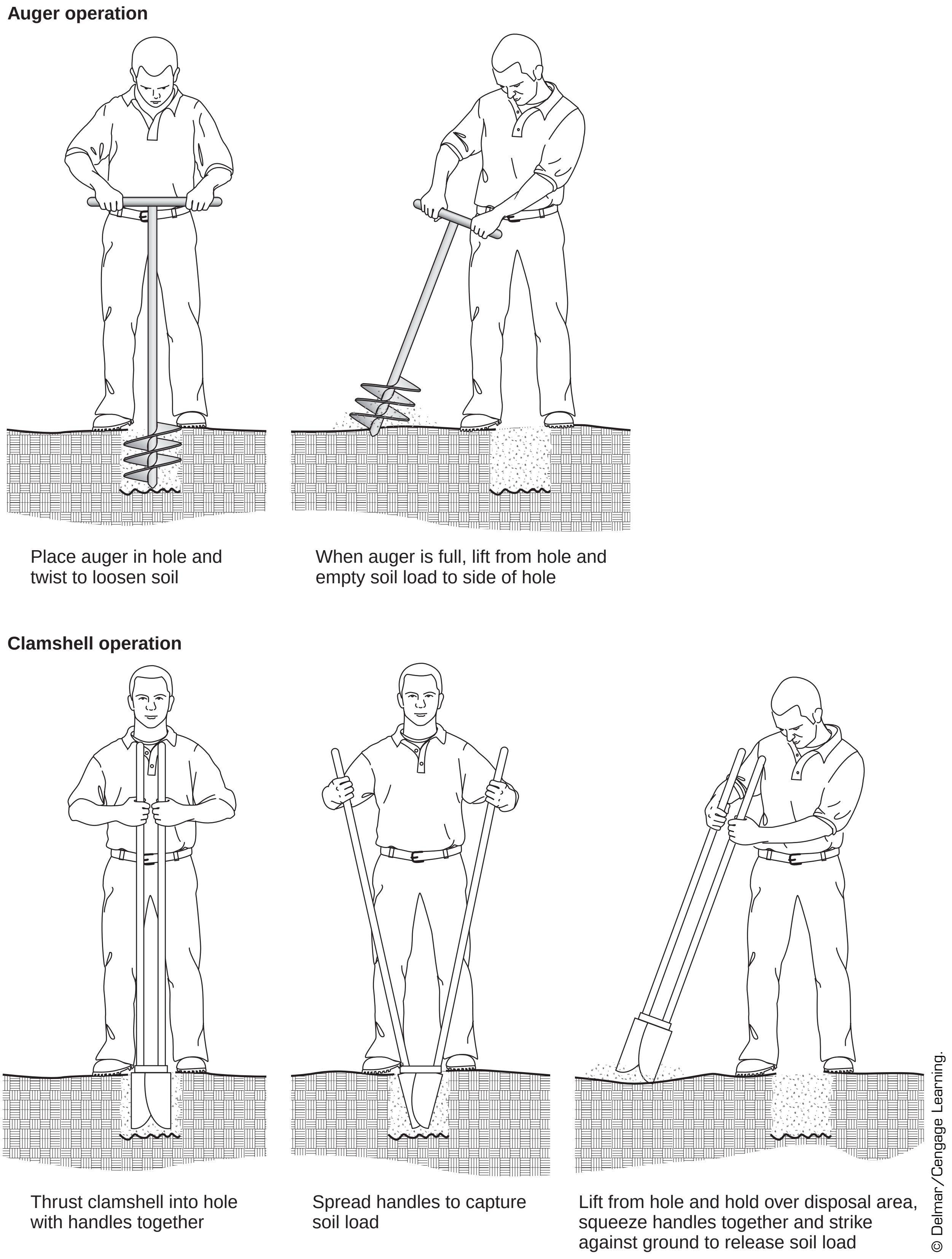

Figure 7-7 Steps for using posthole excavators.

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Figure 7-8 Operating an auger-type posthole excavator.

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Figure 7-10 Excavation depths marked on the handle of an excavation tool.

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Figure 7-9 Operating a clamshell-type posthole excavator.

standing on its own, remove your foot and continue striking, increasing the force of the blows until the stake is driven to the required depth. Maintain eye contact with the top of the stake while striking with the sledgehammer.

Driving Metal Fenceposts

When installing chain-link fence or other fence with metal posts, you will need to drive the posts into the ground. To drive metal posts, place the base of the post at the location where the post is to be set. Lean the post down until the **post driver** can be slipped over the top of the post (Figure 7-13). Check the post to make sure it is in the proper location and oriented properly (notches to the fabric side for fabric fences). Straighten the post and driver to a plumb position, lift the driver, and let it drop on the top of the post. If soil conditions are dry or if driving the post is difficult, apply downward force on the driver to sink the post to the desired depth.

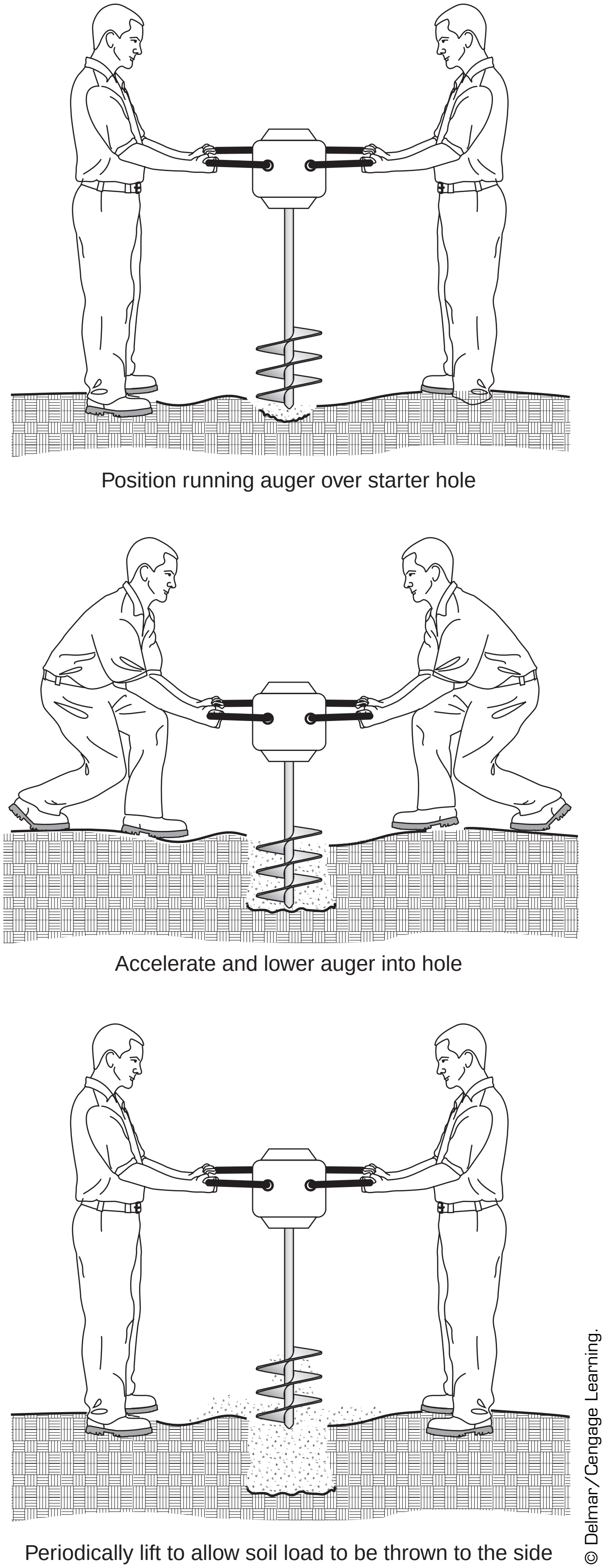

Figure 7-11 Operating a power posthole auger.

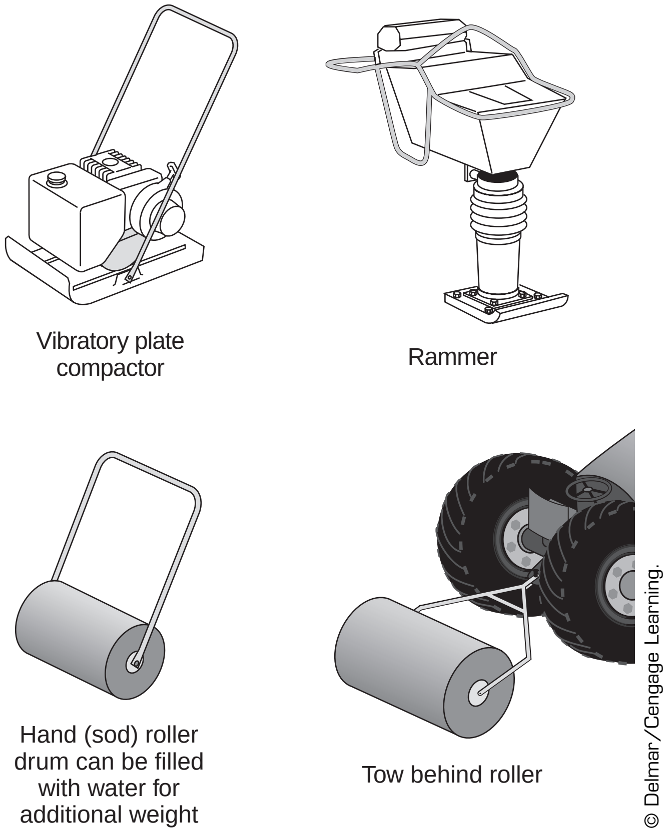

Figure 7-12 Common compaction equipment.

Installing Temporary Fencing

Construction fence may also require that posts be driven and surfacing attached to control traffic at the project boundary. Lean the fence surfacing against the fence, and connect it by passing plastic or wire ties through an opening in the fence, around the post, and back through another opening in the fence. Then fasten the two ends together by twisting or tying.

CUTTING AND JOINING PIPE

Landscape contractors will often have to measure, cut, and join pipe. Whether installing irrigation, plumbing a fountain, or placing drainage pipe, the proper techniques for cutting and joining pipe will be necessary. This section addresses the best practices for working with pipe.

Measuring Pipe Before Cutting

Two methods work best for measuring pipe before cutting. The first is to measure the distance between fittings at either end of a length of pipe and add the length of pipe that will be placed inside the fittings. The second method is to hold the pipe section up to the opening where the pipe will fit and directly

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Figure 7-13 Prepare to drive a fencepost by leaning the post at an angle and inserting the post into the driver. Return the post and driver to plumb and begin driving.

CAUTION

Cutting pipe may create sharp edges. Wear gloves and use care when handling.

mark the location of each end in the fitting at either end of the pipe.

Cutting and Joining Corrugated Plastic Drainage Pipe

Corrugated plastic drainage pipes are manufactured in a variety of types and diameters and include a wide range of drainage fittings and accessories. Drainage pipe is typically manufactured in diameters of 3, 4, 6, 9, and 12 inches and in varying gauges. Lightweight tubing gauges are very flexible and are available in perforated, nonperforated, and socked versions for use in various drainage situations. Heavier piping gauges are very rigid and can be used for subdrains and culverts. Fittings include connectors to downspouts, inlets, sump pump basins, and a variety of Ts, Ys, and elbows.

You can cut corrugated pipe with a utility knife or hacksaw. Place the pipe on a stable surface, mark the cut locations, and make a perpendicular cut (Figure 7-14). Most fittings for drainage pipe are available with snap fittings. These fittings allow the pipe to be slipped into the fitting and held in place with flanges on the fitting (Figure 7-15). Wrap the joint with duct tape (Figure 7-16) to obtain a longer-lasting fit.

Cutting and Joining Poly Pipe

A flexible plastic pipe, **poly pipe** is commonly used for irrigation supply lines. Poly pipe can be cut with a hacksaw or a special ratchet cutting tool that slips over the pipe and slices it. Cutting with the ratchet cutter may require multiple squeezes on the handles to cut through the pipe. Connections are made using automotive tape or specialty hose clamps and ridged plastic fittings.

To cut and join poly pipe, use cutters or a saw to make a square cut at the proper location (Figure 7-17). Slide a clamp over the end and down the pipe a short distance. Fully insert the fitting into the open pipe and slide the clamp back down the pipe until it is resting completely over the fitting (Figure 7-18). Tighten the clamp securely (Figure 7-19).

Cutting and Joining PVC Pipe

Polyvinyl chloride, or **PVC,** pipe is a rigid pipe that comes in a variety of diameters. PVC can be thin-walled or thick-walled (Schedule 40). In addition to the many sizes of piping, PVC offers a full range of fittings, valves, and accessories for exterior applications. PVC is suitable for use as irrigation, water lines, and sewer lines. As part of the installation planning, verify the type of pipe required for the application with local plumbing codes.

PVC pipe can be cut with a pipe cutter or a hacksaw (Figure 7-20). Mark the cut location and make a square cut through the pipe. To use the pipe cutters, slip them over the pipe and squeeze the handle several times, or until the pipe cuts. Use a reaming tool, wire brush, or sandpaper to clean burrs from the inside of the cut pipe.

The outside of the PVC pipe and the inside of all PVC connectors must be cleaned before the pipe can be joined. Wipe dirt and dust from the end of the pipe and liberally brush the primer over the parts to be joined (Figure 7-21). While the primer is still wet, apply PVC joint compound to both the pipe end and the connector, push them firmly

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Figure 7-14 Cutting corrugated plastic drain pipe with a carpet knife.

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Figure 7-15 Joining corrugated plastic drain pipe to a premanufactured elbow fitting. Pipe "snaps" into fitting.

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Figure 7-16 Securing corrugated plastic joints with duct tape.

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Figure 7-17 Making a square cut on a poly pipe.

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Figure 7-18 Joining poly pipe with a plastic fitting.

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Figure 7-19 Clamping poly pipe around the fitting. Each pipe connected to the fitting should be clamped.

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Figure 7-20 Cutting PVC pipe with a hacksaw.

together, and twist one-eighth to one-quarter turn (Figure 7-22). Verify that the alignment of the fitting is correct. The compound will set in approximately 10 seconds, and you cannot correct errors without cutting new sections of pipe.

Cutting and Joining Poly Drip Irrigation Pipe

Drip irrigation line is typically a flexible poly tubing in ¼-inch, ½-inch, and ⅝-inch diameters. Drip irrigation line can be cut using sidecutters, tin snips, or heavy-duty scissors. Smaller diameter poly tubing is joined using barbed fittings that are forced into the end of the tubing (Figure 7-23), whereas larger diameter tubing is connected using compression fittings especially designed for drip irrigation applications (Figure 7-24). The diaphragm inside the fittings prevent leakage when properly joined. To

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Figure 7-21 Cleaning PVC pipe with pipe cleaning solution. Clean both the outside of the pipe and the inside of the fitting. When dry, liberally apply glue in the same manner. Most cleaning and joining solutions provide a swab applicator in the can.

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Figure 7-22 Joining PVC pipe after applying glue. Use a twisting motion to push pipe completely into fitting.

connect compression fittings, push the tubing into the fitting until snug.

Cutting and Joining Copper Pipe

Copper pipe is typically used for supplying water and LP gas to service points within a site. Copper is available as rigid lengths of pipe or as flexible tubing. Each type has a special method for joining. A variety of pipe sizes, fittings, valves, and accessories are available for exterior uses.

Both rigid copper pipe and copper tubing are cut using a pipe cutter. Clamp the pipe cutter onto the pipe at the cut location and rotate the cutter around the pipe. With each successive turn, the clamp tightens until the pipe is cut. Use a reamer to remove burrs from the inside of the pipe after cutting.

CAUTION

Use caution when lighting and operating a torch. The heat zone for a torch extends well beyond the visible flame. Always direct flames away from people and flammable objects. Let all heated items cool before handling.

Rigid copper pipe is joined using sweat fittings, or heated joints into which solder is drawn to seal the joint. To sweat a fitting, begin by cleaning both the end of the pipe and the fitting with sandpaper or wire pipe reamer. Apply a substance called *flux,* which aids in the bonding between pipe and solder, to both the cleaned pipe and connector. Slide the fitting over the end of the pipe and position at the proper angle. Set the joint on a wood block or hold

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Figure 7-23 Using a barbed fitting to join small diameter drip irrigation tubing. Push the tubing firmly onto the fitting over the ridges of the fitting.

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Figure 7-24 A compression fitting to join larger diameter drip irrigation tubing. Push the tubing firmly into the fitting.

the pipe with locking pliers; then heat the fitting using a propane torch. When the joint starts to turn a darker color, remove the heat, touch a piece of solder to the joints, and hold the solder there while it melts and is drawn into the joint. When the solder starts to drip, the joint is filled. Let the joint cool before handling.

Copper tubing is joined using solderless compression fittings. The compression fitting has two parts that sandwich around the end of the tubing and are twisted together using a wrench to complete the joint. Slip the end of the fitting with the open center over the tubing. Insert any washers provided with the fitting. Ream the end of the tubing and insert the part of the fitting with the rounded end. Apply joint compound or joint compound tape over the threads of the second piece. Slide the first part up the tubing to the second part and twist together tightly.

Copper installations should be laid out beginning at the supply point, cutting and joining pipe as the installation moves toward the service point. If placing copper piping in a trench, carefully lay the piping and pressurize the system, checking for leaks. Carefully backfill the trench.

Joining Galvanized and Black Pipe

Galvanized pipe and black pipe are rigid steel pipes. Galvanized pipe is used primarily for water distribution; black pipe, for gas distribution. Both pipe types come in a range of sizes and have a variety of fittings and valves available. Although you can use either pipe in exterior applications, rust resistant galvanized pipe is the better choice.

Because the pipe needs to be rethreaded for joining after each cut, galvanized and black piping are very difficult to trim to appropriate lengths in the field. The best solution is to have a variety of prepared lengths available, or you can measure the piping requirements and take the pipe to a hardware store for cutting and rethreading. Both piping types are joined by applying a joint compound to the threads, threading fittings onto the pipe, and then tightening.

CUTTING PAVING AND WALL MATERIALS

Few landscape materials arrive at a job site ready to install without modification. To complete many of their projects, landscape contractors will need to measure and mark and then cut paving and wall materials. This section addresses the best practices and procedures for accomplishing these tasks.

CAUTION

When cutting any wall material, wear proper clothing and safety equipment. Use cutting equipment according to manufacturer's instructions.

Marking Materials

The simplest way to mark for cutting is to hold the material in position and use a pencil to transcribe the cut location directly onto the material. Measuring can be done if a high degree of accuracy is maintained. Marking with a magic marker or lumber pencil provides better visibility of the mark when you use a wet masonry saw. Make the mark on the scrap side of the cut location so the mark will not be visible when you place the material. Most paving and wall material must be cut to within ⅛-inch of required dimensions to avoid problems with fit. Irregular and angle cuts may take two pieces to get the correct shape. Cutting methods make curved cuts difficult, and notching is difficult to obtain with all cutting tools except a wet masonry saw.

Brick or Stone Set

Clay brick can be cut, or cleaved, with a wide chisel-like tool called a set (also called brick set or **stone set**) (Figure 7-25). Place the brick on sand and align the brick set along the mark for the cut. Lightly tap the set with the hammer to create a weakened joint. Strike the end of the set with a hammer. The brick should cleave along that angle (Figure 7-26). Concrete paving block can be cut in this method with reasonable success, but precast concrete does not cleave well with a set. Stone is cut in a manner similar to that used for clay brick, although there may be some irregularity in the edge of stone after being cleaved. Stone can also be scored along the cut line with a cutoff saw and then struck on the opposite side with a stone set to cleave.

Brick/Stone Hammer

Striking stone with the pointed end of a brick hammer can chip or cleave certain types of stone (Figure 7-27). You can use the blunt end of the hammer to knock off bumps or edges that prevent

Figure 7-25 Cutting paving materials with a brick set. Set the paving material on a flat surface or on sand. Place the blade of the set along the line where you want the stone to cleave; then strike firmly with a hammer.

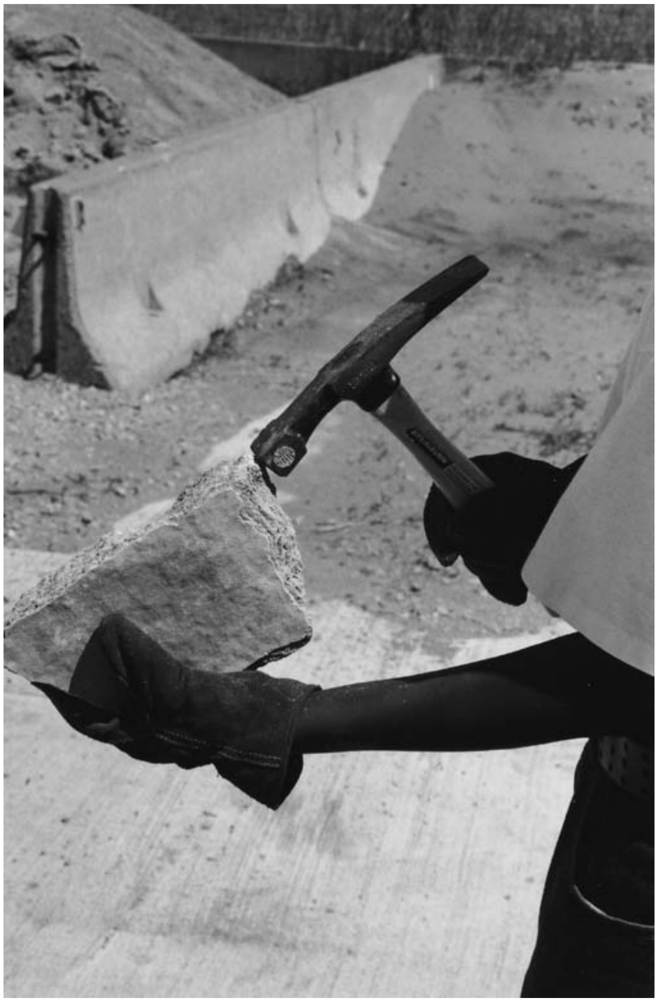

Figure 7-27 Shaping stone edge with brick hammer.

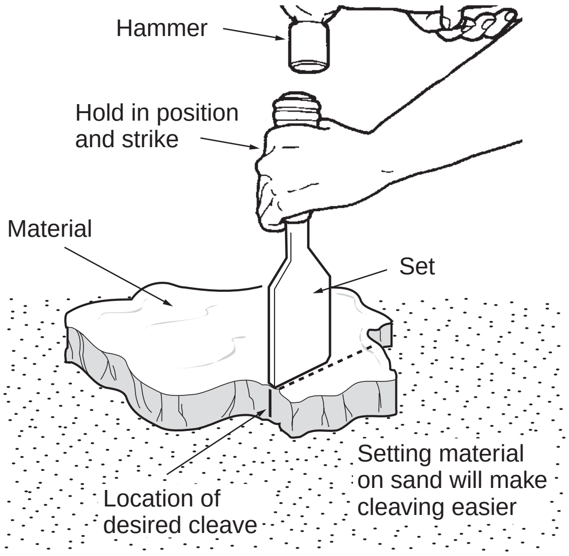

Figure 7-26 Cutting paving material with a set.

a tight fit. To reduce splitting of the stone, strike the offending piece from the side rather than from the top.

Hydraulic Block Splitter

The double blade **hydraulic splitter** is a piece of equipment that will accurately cleave stone, brick, or precast units. Wear gloves and safety glasses when operating a splitter. The material is set on a table with the cleave location directly below a striking bar. The bar is lowered to the stone manually and is tightened. An operator then repeatedly presses a foot pedal that applies pressure to the striking bar through a hydraulic cylinder. When the cylinder reaches the right pressure, the material is cleaved. Although this is a fast way to cleave materials, waste can be excessive when using a hydraulic cutter (Figure 7-28).

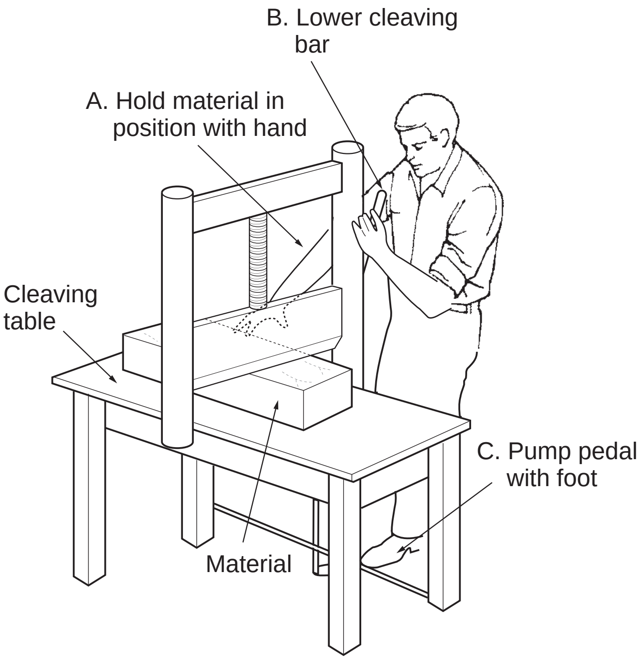

Figure 7-28 Cutting materials using a hydraulic splitter.

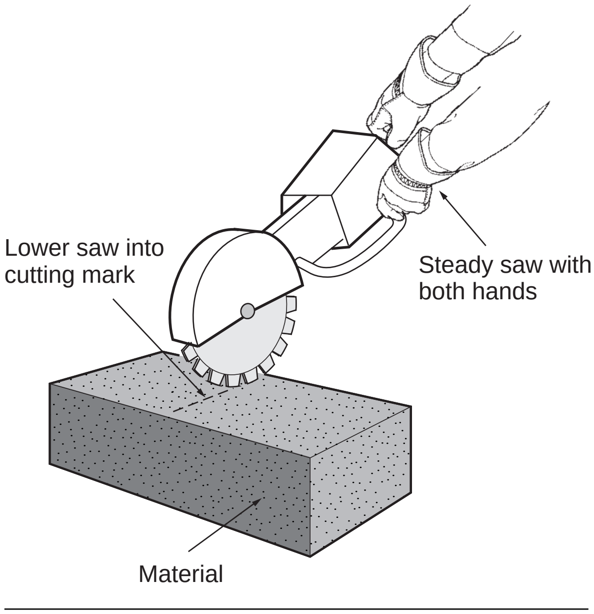

Figure 7-29 Cutting materials using a cutoff saw.

If the splitter is so equipped, the tilting base plate will help improve the cleaving of interlocking concrete pavers. When the bar is lowered, angle paving material downward away from the cut location. This will provide a slightly undercut angled end that will improve the pavers' placement.

Cutoff Saw

A **cutoff saw,** a handheld cutting tool, is powered with a gas motor and has a circular diamond or carborundum blade for cutting. Operated similarly to a chainsaw, the cutoff saw creates a large amount of dust. However, the saw is portable and useful for remote sites without electricity. To cut with a cutoff saw, mark the cut location and anchor the material to avoid movement while cutting. If necessary, place a block underneath the material to avoid cutting into the surface below. In applications where the cut edge cannot show, mark the underside and score, or cut, the material almost halfway through and along the entire length of the mark. Then place a 2 x 4 under the score and apply a heavy downward pressure to one side of the cut to finish the splitting. Wear gloves, safety glasses, dust mask, and ear protection. Start the saw and position it over the material to be cut. Run the saw to full speed and slowly lower it onto the paving material. Let the saw pass completely through the material before removing the blade from the cut (Figure 7-29).

Wet Masonry Saw

A wet masonry saw uses a moving table to pass materials through a fixed diamond blade. A fine spray of water helps remove debris and reduce dust. To cut with a wet masonry saw, mark the cut location and adjust the saw blade to the proper depth. Wear gloves, safety glasses, and ear protection. Start the saw and make sure the water is flowing. Set the paver on the moving cutting table, and align the cut mark on the paver with the saw blade. Slowly pass the paver through the blade (Figure 7-30). If the motor begins to slow (the pitch of the motor will be noticeably lower), back the material up and restart the pass through the blade at a slower pace.

Notching with a Wet Masonry Saw. When cutting unit pavers to fit around objects in the paved surface, notching may be required. This difficult task can be accomplished with varying degrees of success using a wet masonry saw to make the cuts (Figure 7-31). Mark the cuts. Turn the paver over and cut along the long dimension 1 inch beyond the mark. This extra cut length will be on the back side of the paver and hidden when installed. Turn the paver on its side and adjust the saw blade to match the depth of the second cut. Leaving the block on its side, position the block and pass it through the blade. The two cuts should meet and complete the notch.

Figure 7-30 Cutting paving materials with a wet masonry saw. Cutting with a masonry saw is slow but accurate.

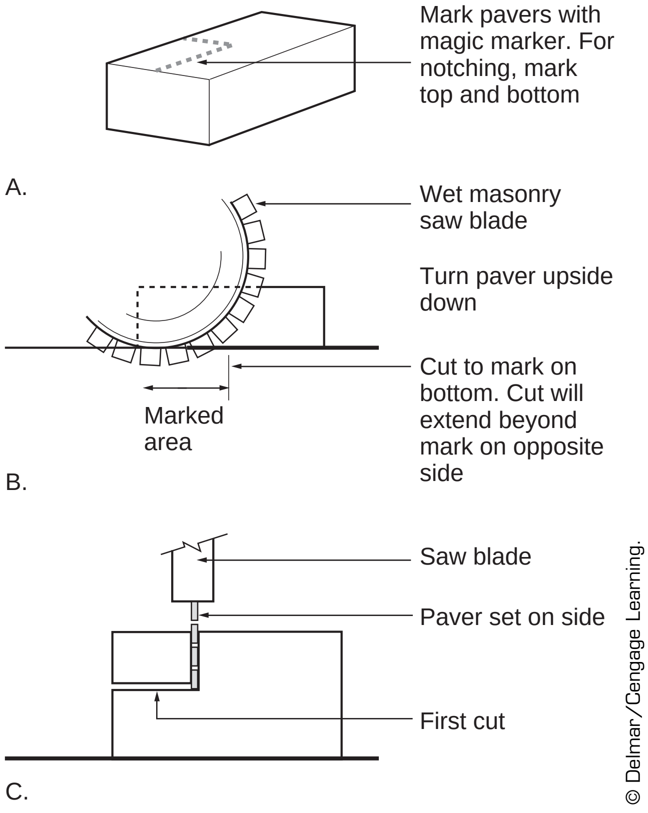

Figure 7-31 Notching pavers. (A) Marking paver. (B) First cut for a notch. (C) Second cut for a notch.

You can also notch pavers by using repeated passes with the wet masonry saw. Position the material and make a first pass that removes a portion of the material. If the notch is on an edge, begin at the outside of that edge. Adjust the material to the side and repeat with another pass of the saw. Continue adjusting and cutting until the entire portion to be notched has been removed (Figure 7-32). Rounded notches can be accomplished in a similar manner if an experienced operator carefully holds or supports the material being notched.

Chainsaw

Wood wall products are best cut with a chainsaw. If the material requires several cuts and if you plan to use a chain saw, bring extra blades, oil, and the maintenance kit for the saw. Mark the tie/timber and place it so that the longer portion will have adequate support. Wear gloves, safety glasses, and ear protection. Use your foot to safely anchor the tie/timber or have a co-worker, standing at a safe distance, hold the piece. Set the saw on the ground to start it. Rev the saw to full speed and then slowly lower it into the material. Cut with the material close to the saw body. Avoid contacting the blade tip with any material. Move the saw with a slight rocking motion as it passes through the material. Make a square cut beginning on the top side, letting the shorter piece fall freely when cut (Figure 7-33).

Cutting Resilient Pavers

Rubber-like resilient pavers are difficult to cut using common cutting methods. Thin-bladed saws and knives work best. A pruning bow saw, hacksaw, or bread knife works best. Mount the paver in a vise to secure it while making cuts.

Alternatives to Cutting Paving Materials

In any unit paving project, the cutting of pavers is inevitable. Few projects are laid out to match the dimensions of unit pavers perfectly. Cutting can be

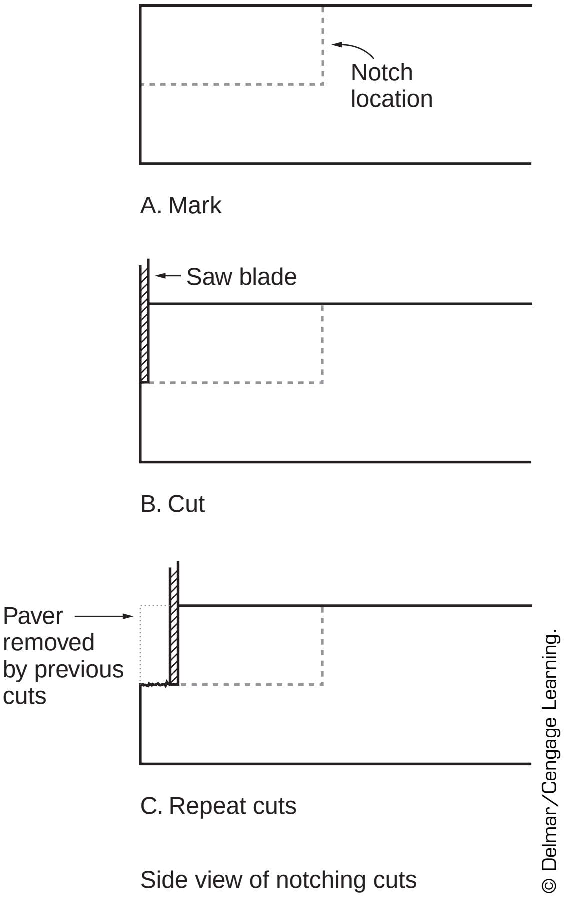

Figure 7-32 Side view of notching cuts.

Figure 7-33 Using a chainsaw.

reduced, however, if factory-produced halves and edging pavers are available.

CUTTING, DRILLING, FASTENING, AND CONNECTING WOOD MATERIALS

When building decks, arbors, trellises, and other landscape elements from wood, the landscape contractor will be required to prepare and assemble a variety of wood components. This section addresses some best practices and procedures to cut, drill, fasten, and connect wood materials.

Cutting Wood Materials

Cutting is one of the basic carpentry techniques that is required to install wood improvements. Proper cutting begins with learning the basic cutting techniques. Four basic cuts are predominantly used in exterior carpentry—the crosscut (or square cut), miter cut, rip cut, and the bevel cut. (Figure 7-34). The square cut, the most common cut for exterior work, can be used for executing most types of joints. This cut requires the contractor to mark and remove a portion of the board at a right angle to the board's edge and face. Used in joining railing, at corners, in rafters, and in other nonsquare portions, and in cuts where the end grain of the lumber is not exposed, the miter cut runs at a right angle to the board's edge but at a predetermined angle across the board's face. The rip cut runs the length of a board parallel to its edge and at a right angle to the board's edge. Any of the three previous cuts can be angled to the board's edge to create a beveled cut. The bevel cut is used when overlapping materials to prevent warping and when placing lumber on edge. Occasionally, usually in rafters, a complicated beveled miter cut may be required. This type of cut makes calculated angles to both the board's face and edge.

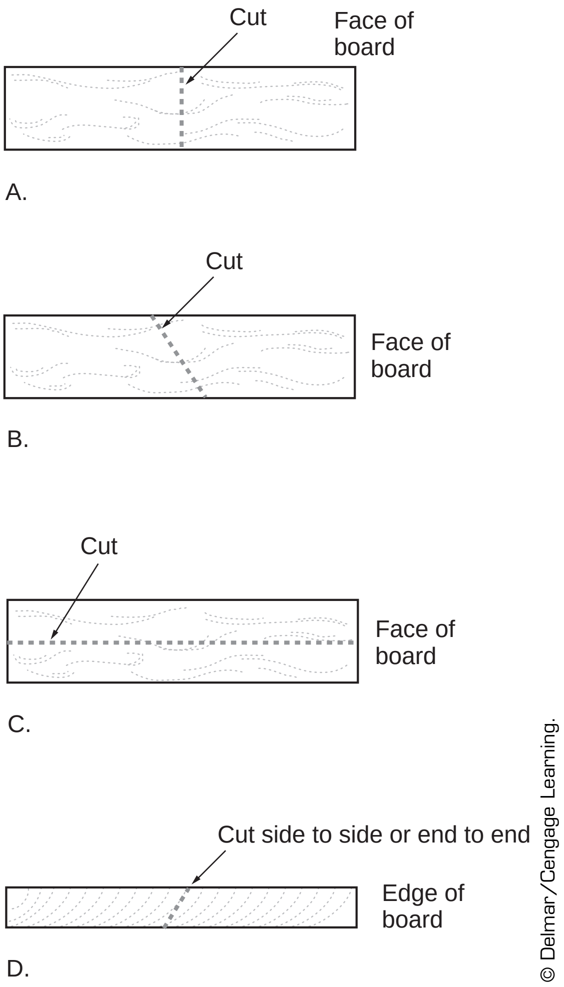

Figure 7-34 Basic lumber cuts. (A) Square crosscut. (B) Miter cut. (C) Rip cut. (D) Bevel cut.

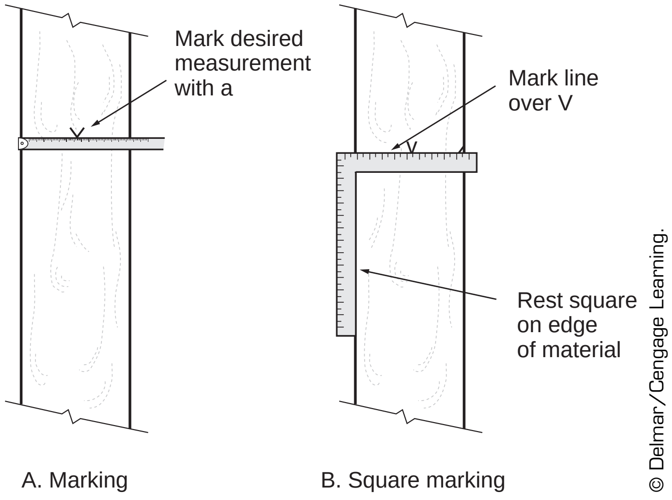

Figure 7-35 Marking dimensions and marking for square cuts.

When marking lumber for cutting, develop the habit of using a *V* mark where the point of the *V* indicates the desired measurement. This avoids confusion as to which end of a single mark is correct. To mark cut lines with a carpenter's square, position the square with one leg resting on the cut mark and the other leg resting flush against the side of the material to be marked. If necessary, adjust the square along the board's side so that the first edge is directly on the cut mark. Hold the square firmly and draw a line along the edge of the square that passes through the mark (Figure 7-35).

Cutting with saws requires support for the piece of lumber. Rest the lumber on a flat, solid surface with the portion to be trimmed extending beyond the edge of the surface. If the trimmed portion is so long that it needs to be supported by hand while cutting, be sure the support does not bind the saw blade. The holder should not grasp the piece of lumber but, instead, should place a hand below the piece and allow the wood to rest lightly. Most short pieces being trimmed can be cut without support and allowed to fall after being cut (Figure 7-36).

CAUTION

Read the manufacturer's instructions before operating power equipment.

Cutting with a Circular Saw. The direction of cut when using a circular saw should place the weight of the saw motor on the supported portion of the lumber. While sawing, position the body so that both the mark and the blade at the point of the cut can be observed. Verify that the power cord is not near the saw blade. The bottom plate of the saw should rest flat on the lumber being cut. Align the blade or directional mark on the guide with the mark on the lumber, start the saw, and run the motor to full speed; then run the saw slowly forward along the mark and through the material (Figure 7-37). When cutting thick materials such as 4 × 4s, you may need to mark both the top and bottom of the lumber. Cut the top, turn the lumber over, and make a second cut aligned with the first cut (Figure 7-38).

Notching wood materials requires using a handsaw or sabre saw to avoid overcutting the

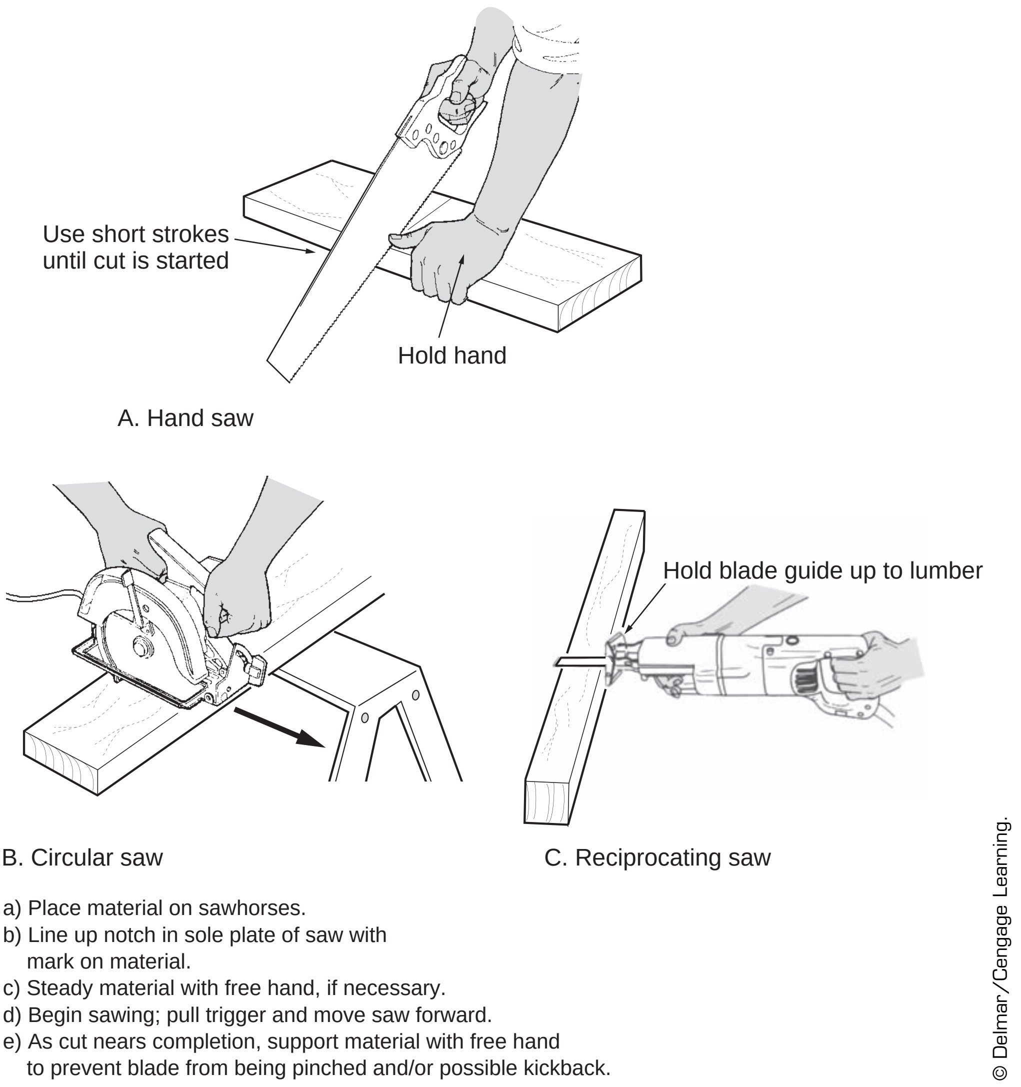

Figure 7-36 Sawing and cutting techniques.

material. Notch by marking and cutting with a circular saw until the tip of the blade reaches the intersecting mark. When the blade stops, remove the circular saw and complete the cut using a sabre saw or a handsaw. Hold handsaws so that the blade is cutting straight up and down when notching.

Combination cuts require additional planning and setup. Combination cuts use two of the basic cuts described earlier, such as a beveled miter cut. Although not common in the landscaping field, the specialty technique is sometimes used when joists, rafters, and trim are placed at angles (Figure 7-39). Before executing the cut, double-check all measurements and angles to verify they are correct.

Cutting with a Sabre or Reciprocating Saw. If the cut involves the use of a **sabre,** or **reciprocating saw,** use the same procedures and precautions as previously described for a circular saw. The reciprocating saw, which works similarly to a large version of a sabre saw, is often used to trim pieces of lumber that have already been installed. Long blades for this saw allow access into tight corners and even allow the blade to bend slightly to saw around corners. To reduce the heavy vibration that

Figure 7-37 Proper cutting technique with a circular saw.

Figure 7-38 Cutting large dimensioned lumber with two cuts.

the reciprocating saw causes, hold the blade guide firmly against the piece being cut (Figure 7-40). Trimming of posts and unanchored wood members is best accomplished with a circular saw to reduce the chance of vibrating the member out of place.

Cutting with a Handsaw. When using a handsaw, position the saw at the mark and hold it in position with your thumb against the saw blade. Begin with short strokes until you cut a groove along the mark that holds the saw blade in position; then pull back your thumb and extend the stroke to the full length of the blade (Figure 7-41). Downward pressure on the saw is not required to cut—let the saw blade do the work. Any piece of lumber less than 1-inch thick, including trim and lattice, should be cut using a hand miter saw or other blade type with very fine teeth.

Drilling Wood Materials

Drills are used for boring holes and driving fasteners. When drilling pilot holes, select a wood bit for small holes or a spade bit for larger diameter holes. Insert the bit into the drill and tighten securely using the chuck key. If the bit penetrates through the wood, place a block of wood under the piece being drilled. Position the bit over the hole location and hold the drill at the same angle as the desired hole. Start the drill, run motor to full speed, and apply downward pressure (Figure 7-42). If drilling deep or wide holes, you may need to pull the bit out of the hole every 2–3 seconds to clear the wood shavings out of the bit.

When using the drill to drive fasteners, install the appropriate bit for the drill. Tighten and secure the bit using the chuck key. Place the fastener on the drill bit and, while holding the fastener, position the tip at the location where the fastener is to be installed. Hold the drill and fastener at the angle desired for driving the fastener. Lightly hold the top portion of the fastener

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Figure 7-39 Bevel/rip cut along length of dimensioned lumber.

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Figure 7-40 Cutting using a reciprocating saw.

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Figure 7-41 Proper handsawing technique.

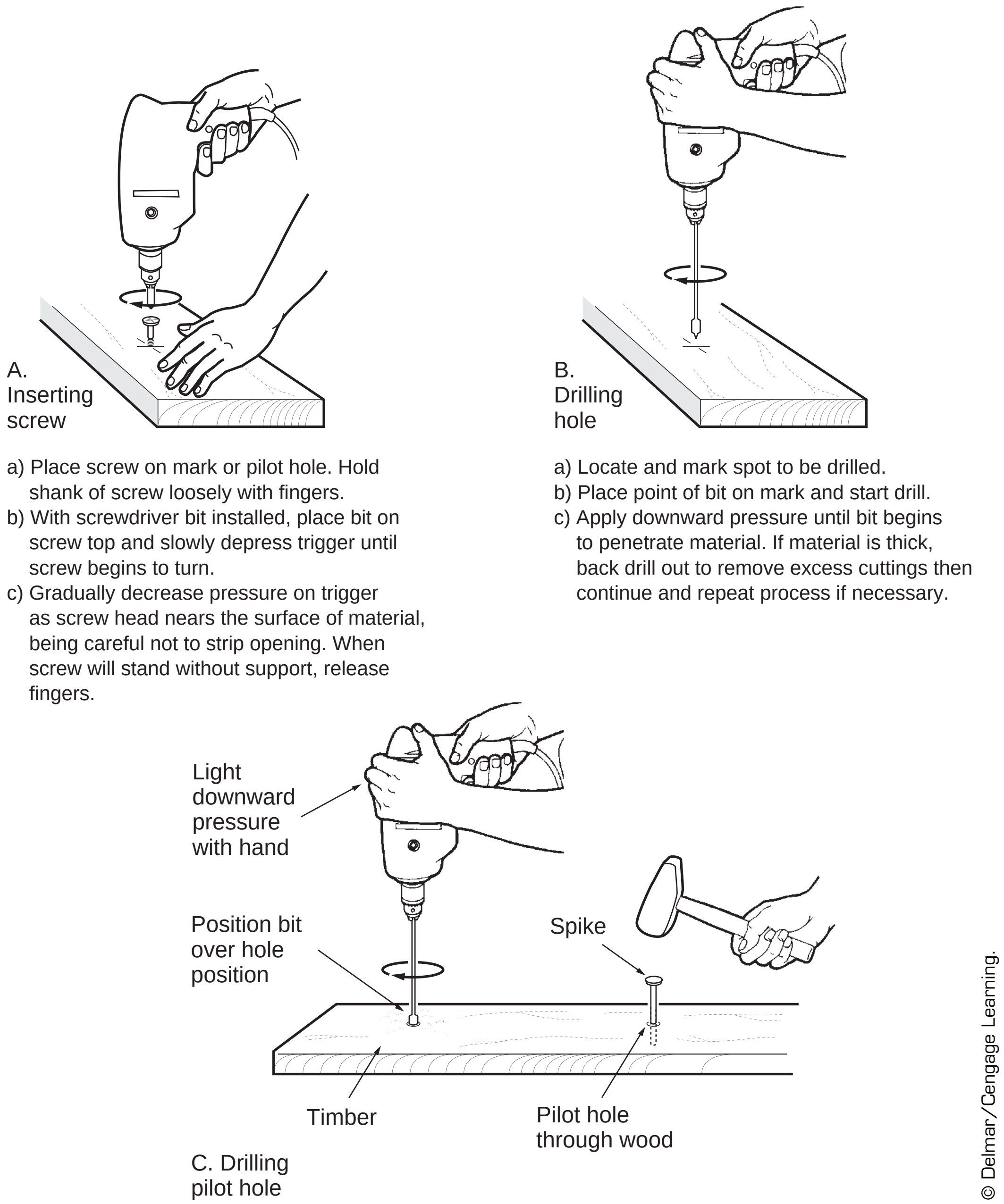

Figure 7-42 Drilling and fastening with a power drill.

shank while slowly starting the drill. When the fastener "bites," or begins to enter into the wood, release the shank. Increase the drill speed, apply increasing downward pressure, and continue driving until the fastener is completely installed. It is important to maintain downward pressure on the drill to assure that the bit remains in contact with the fastener head; otherwise, the bit will slip out and strip the head. Maintain a straight alignment between the drill and fastener to assure solid contact between bit and fastener head (Figure 7-43). When removing fasteners, reverse the drill direction and place the bit on the fastener head. Maintain downward pressure while removing the fastener. The friction may make fasteners hot for a few seconds after removal.

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Figure 7-43 Drilling holes using a cordless drill.

JOINING, SPLICING, AND FASTENING MATERIALS

For work that is stable and long-lasting, the landscape contractor must learn the standard techniques for joining, splicing, and fastening exterior materials. The following section addresses the best practices and procedures for accomplishing these tasks.

Joining Materials

Landscape contractors have several methods for joining materials, with two primary ways for exterior applications (Figure 7-44). Selection of the proper method is based on the appearance and durability required of the joint. Connecting two lumber pieces often involves placing the square ends of pieces of lumber end to end in what is called a **butt joint.** Requiring square cuts on the ends of each piece of lumber being joined, butt joints are acceptable for structural applications and work in situations where the lumber is setting on edge or laying flat and can be executed using direct nailing, **toenailing,** or many of the other connection techniques described in the following sections. The joint formed when cutting pieces of lumber with a miter cut and placing the angled edges together is termed a **mitered joint.** Mitered joints are typically used for appearance and practicality when pieces of lumber meet at a corner or to prevent warping along straight runs. Mitered joints can be executed with the lumber setting on edge or laying flat.

The mortise-and-tenon joint and the dado joint are among other available, but seldom used, lumber joints for exterior carpentry. These joints are seldom used because they tend to hold moisture and work counter to good drainage recommendations in exterior structures.

Splicing

Strengthening joints in structural situations may require a special technique called splicing. When one piece of lumber will not cover the length required and you must connect two pieces to make a structural support, use either the overlap or gusset method of splicing. Good planning of a project will minimize the number of splices required. However,

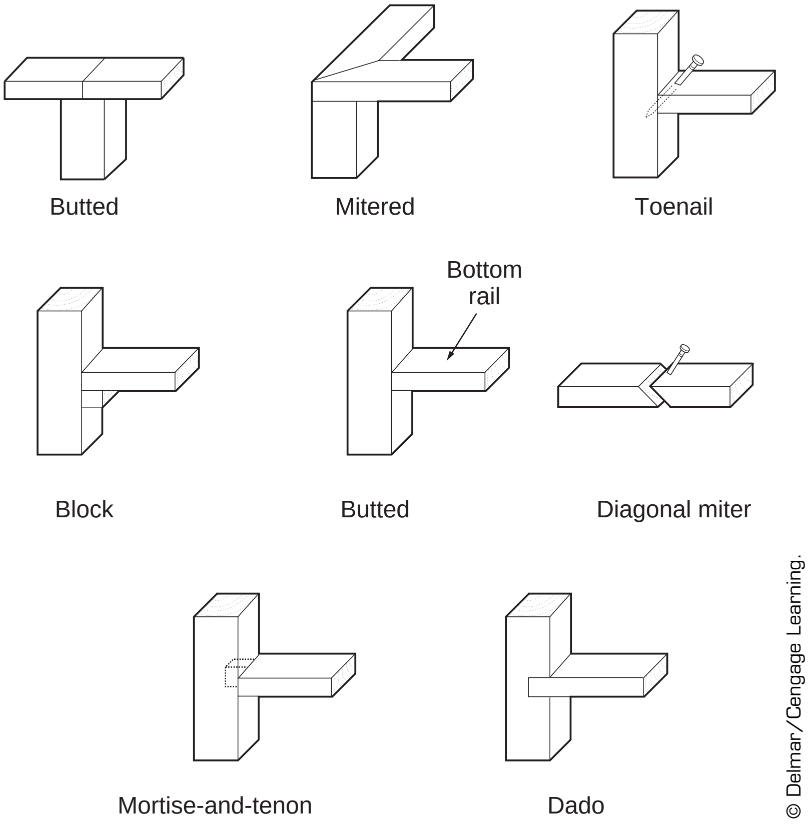

Figure 7-44 Typical lumber joining techniques.

if splicing is required, place the splice over a structural support (Figure 7-45). Unsupported splices can sag over time.

To overlap-splice two pieces of lumber, extend each piece past the end of the other by 1 foot and bolt them together. If the structural member is composed of more than two pieces, the ends of the pieces can be staggered and overlapped. A minimum of four bolts are required to make a connection, and six to eight may be required for longer spans or larger members (Figure 7-46).

If the pieces being spliced must maintain a straight alignment, you may need to install a gusset. A **gusset** is a piece of dimensioned lumber that is bolted alongside the pieces being spliced. To install a gusset, cut a 2-foot length of 2 × treated lumber the same width as the pieces being spliced. Place the gusset flush with the spliced pieces, drill pilot holes, and install a minimum of six bolts—three in each spliced piece (Figure 7-46). Placing eight bolts in a rectangular pattern will provide additional strength.

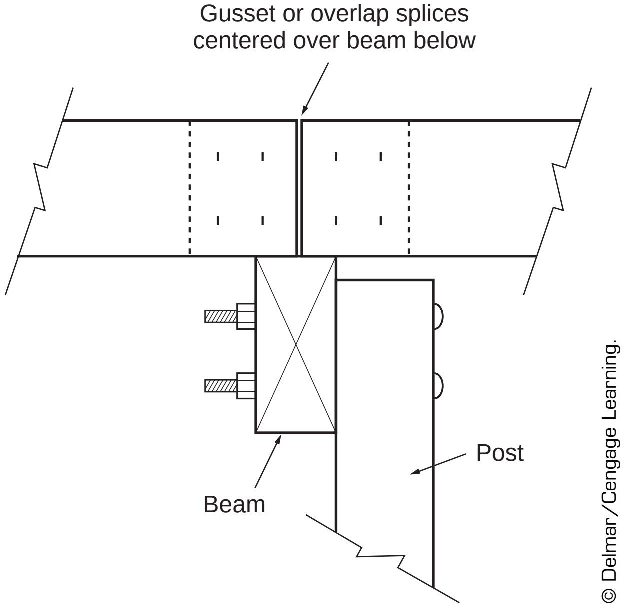

Figure 7-45 Splicing lumber begins over beams.

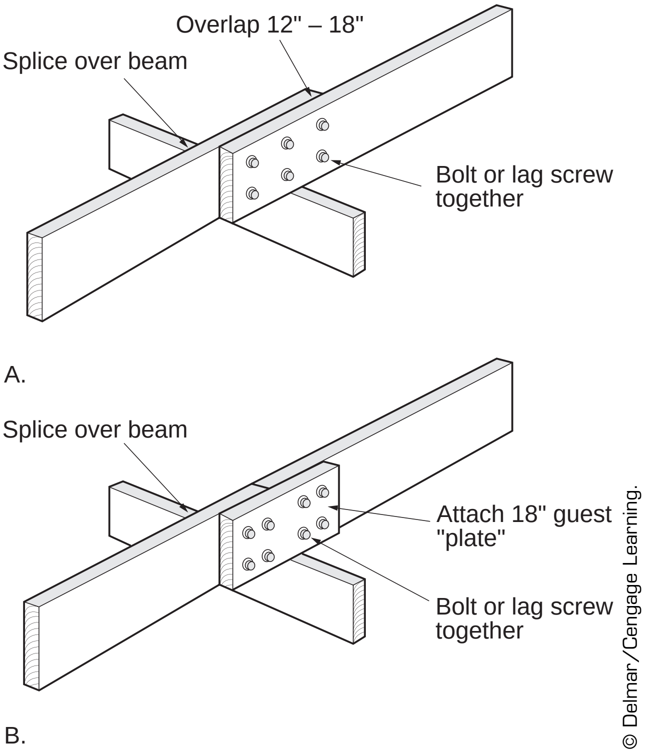

Figure 7-46 Splicing lumber. (A) Overlap splice. (B) Gusset splice.

Fastening Materials

Methods for fastening wood materials continue to evolve. The basic premise for fastening remains one of providing maximum strength with appropriate efficiency. As the use of power equipment increases in the landscape contracting field, quality of workmanship has also entered into the picture. Pneumatic nail guns and screw guns have appeared, adding speed at the expense of (according to many) quality. A contractor's selection of the appropriate fastening method remains a choice based not only on strength, but also on value and workmanship. (See Chapter 28 on materials for exterior carpentry.)

Nailing. The most common fastening method for lumber is nailing. Except for special situations, nails should be driven at a right angle to the face of the lumber. Holding the nail lightly between your thumb and index finger, position it at the location where the nail is to be installed. Grasp the end of the hammer handle and tap the nail until it is driven into the wood far enough that it stands on its own. Continue driving the nail, lightly at first, until the nail begins to enter the wood, and then with full force, until the head is flush with the piece of lumber. Effective use of the hammer's leverage requires that it be grasped at the end of the handle, not near the head (Figure 7-47). To avoid missing or misdriving the nail, focus your eyes on the head of the nail during the entire driving process.

When fastening wood members that butt against each other, use either end nailing or toenailing (Figures 7-47 and 7-48). A warning about connections of this type: End nailing is not a strong connection because the nail enters the lumber parallel to the grain. Review all alternatives for fastening wood members before making your selection. End nailing is accomplished by driving nails through the face of one piece of lumber into the end of the other. Slightly angling the nail will strengthen the connection. When one piece of lumber butts against another piece that is thicker than the length of the nails, toenail the pieces together. Toenailing requires driving the nail at a 45-degree angle through the face of one piece of lumber into the face of the second piece. To toenail properly, position the nail back from the second piece about one-third the length of the nail. Drive the nail lightly into the first piece at a right angle. When the nail bites into the surface of the first piece, tilt the nail to the 45-degree angle and complete driving the nail. Toenailing will require holding the first piece of lumber in proper position so that it does not shift when driving the nail. When improperly done, toenailing can also create a weak connection.

When you are nailing into pieces of unsupported lumber, the wood tends to bounce, which makes driving the nail difficult. If you position another hammer or baby sledgehammer against the wood on the opposite side from which you are hammering, the second hammer's weight will absorb some of the bounce. Start the nail and then drive the nail with one hammer while holding the second hammer with your free hand.

Nailing can easily split thin lumber such as lath and lattice. Examine the end of the nail and observe that the point is diamond shaped. Orient the long dimension of the diamond perpendicular to the wood's grain to reduce splitting (Figure 7-49).

Screwing. Fastening materials with screws provides an extra measure of strength that nails do not offer. As weather and extremes in temperatures move the wood around, nails tend to pull out from the wood pieces they are connecting. Screws remain in position despite minor structure movements. The variety of shapes, materials, and sizes makes screws a practical choice for aesthetic, as well as structural, connections.

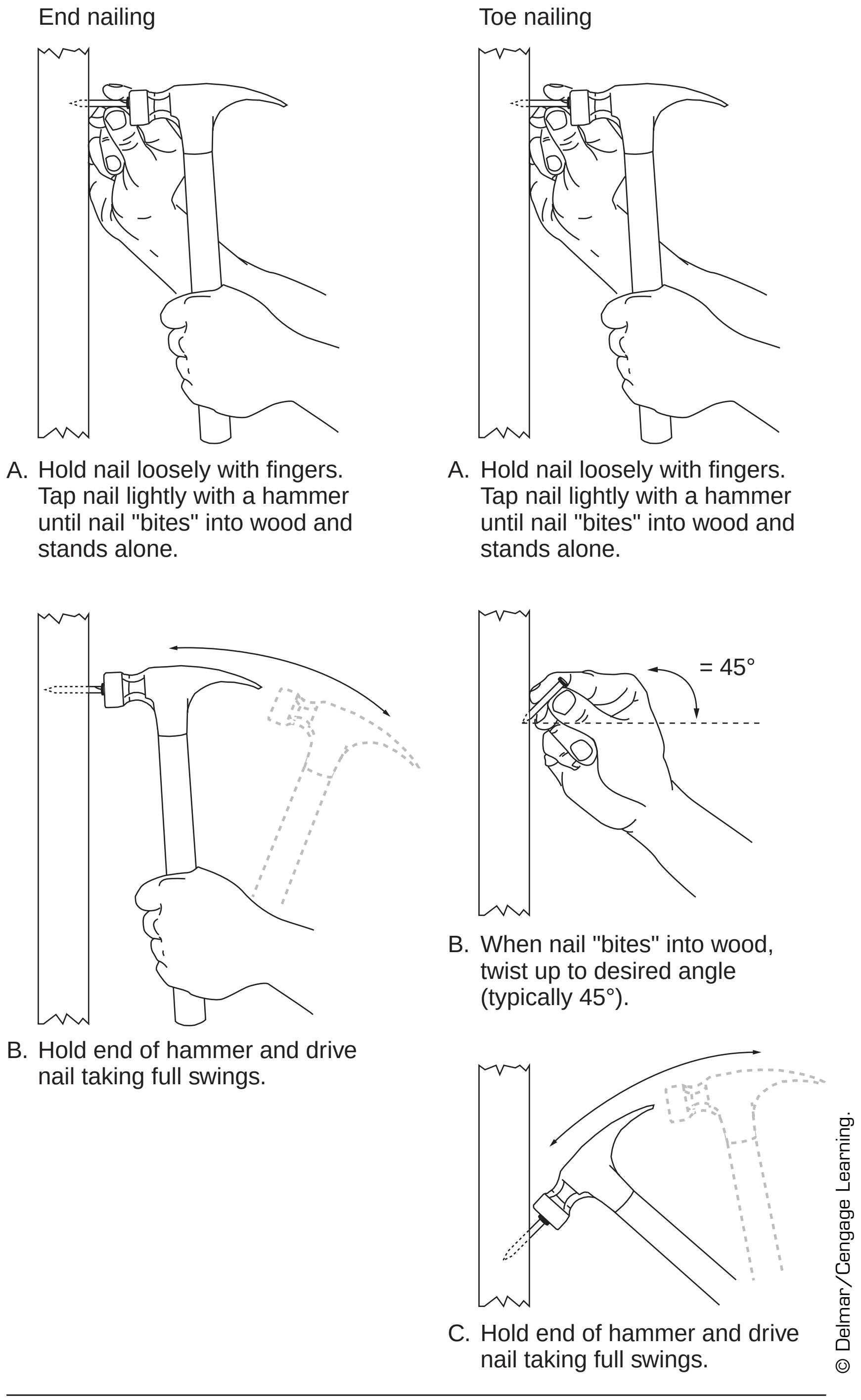

Figure 7-47 Proper hand nailing technique.

Installation of screws is best executed by positioning the piece of lumber, temporarily nailing it if necessary, and drilling a pilot hole. The pilot hole should be slightly smaller than the diameter of the screw shank. The pilot hole and screw installation should be at right angles to the board's face and edge. Some woods are soft enough to be fastened without the pilot hole. Regardless of wood type, drill pilot holes if working within 2 inches of the end of the board or within 1 inch of the board's edge, if using screws with a shank diameter of 1/4 inch or more, or when using any carriage bolt. Holding the screw by the end, hand twist the screw into the pilot hole to start the connection. Continue twisting the

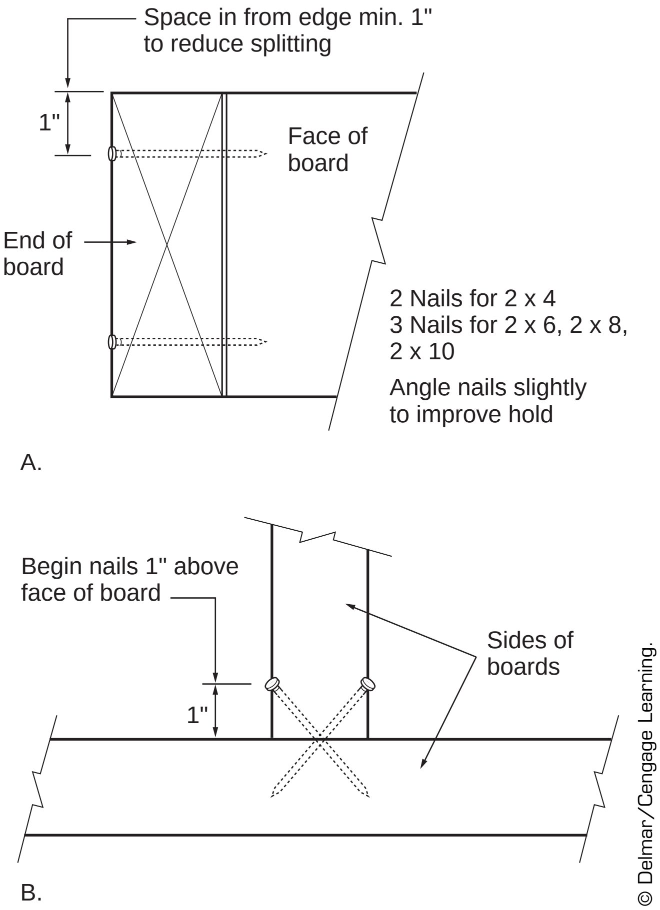

Figure 7-48 Nailing lumber. (A) End nailing. (B) Toenailing.

screw into position using hand or power tools, lightly holding the smooth portion of the shank until the screw can stand in the pilot hole without assistance (Figure 7-50). Screw holders that eliminate the need to handhold the fastener are available. Attach the screw holder in the same manner you would attach a drill bit; then insert screws into the holder.

Bolting. Although they make strong structural connections, bolts are seldom used for surfacing or aesthetic situations. To install bolts, position the piece of lumber, temporarily nailing it in place if necessary. At the location where the bolt is to be located, drill a pilot hole that is slightly larger than the diameter of the bolt though all lumber pieces being connected. Select galvanized carriage bolts that are 1 inch longer than the combined thickness of all lumber pieces being connected. Drive the bolt through the hole (Figure 7-50). Whenever possible, the head of the bolt should be located on the side where the public will view the connection. Install a washer and nut on the opposite side and tighten. Check alignment and elevations before completely tightening the bolt.

Gluing. Gluing exterior connections is limited to locations that will not be exposed to moisture. Use

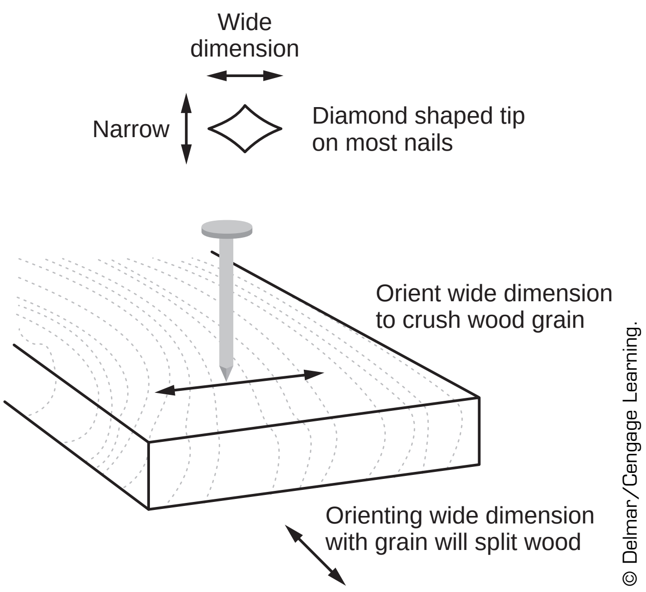

Figure 7-49 Orienting nails to reduce lumber splitting.

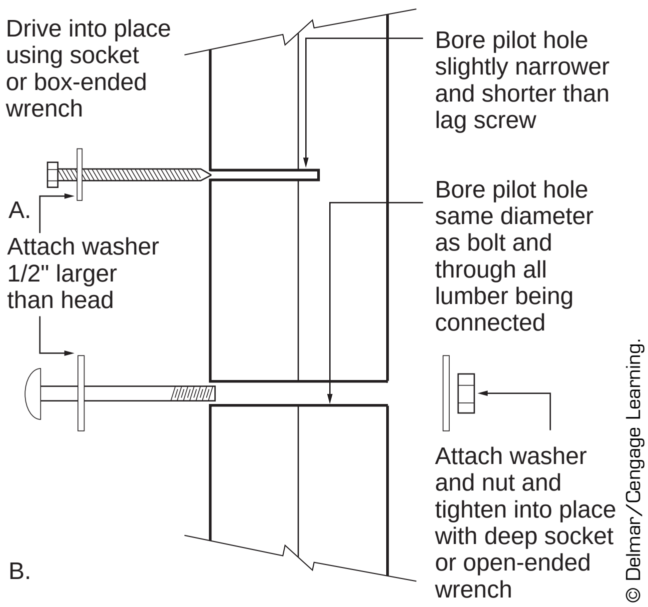

Figure 7-50 Installing lag screws and carriage bolts. (A) Lag screw. (B) Carriage bolt.

CAUTION

Unsafe operation of equipment can cause injury or death. Read the instructions and obtain safety and operation training before operating any equipment. The instructions listed below provide a general overview of each category of equipment. Verify the specific requirements for the specific piece of equipment you plan to operate. Before working on any gas-powered equipment, disconnect the spark plug wire. Always keep all safety guards on equipment, and never place any body part near moving equipment parts. Wear appropriate personal protection equipment.

exterior glues, which are resistant to exposure, for fastening caps and surface trim when other fasteners will not work.

Avoiding Problems with Connections

When making connections, consider alternatives that will reduce damage to the wood or structural failure. When connectors are installed near the ends or edges of boards, the lumber could split. The best solution is to predrill pilot holes slightly smaller than the connector's diameter. Dulling the end of the nail, or turning the nail so that the wide point of the diamond tip is perpendicular to the board's edge, may also help (Figure 7-49).

Structural failure can result from using too few connectors or spacing them improperly in a piece of lumber. Having too few connectors may result in structural failure or instability, whereas improper spacing may weaken the lumber. Figure 7-51 identifies typical nailing and bolting patterns that should provide improved strength.

RELATED POWER EQUIPMENT

To implement their projects, landscape contractors use a variety of equipment, some hand-operated and others powered by other means. Although many pieces of power equipment were described earlier in this section, there are additional tools, including gas- and pneumatic-powered equipment, used to prepare a site and to fasten materials.

General Notes Regarding Gas-Powered Equipment

Many pieces of equipment listed in this section have gas-powered, two-stroke engines. Unlike larger pieces of equipment that have automatic starters and take regular fuel, two-stroke engines often have special requirements for operation. Before operating, verify whether the piece of equipment uses an oil/gas mixture (common in most small engines such as those found on mowers and string trimmers) or whether the equipment has separate tanks for oil and gas. Placing the wrong fuel mixture into the tank can ruin the equipment when operated. When starting a two-stroke engine that is cold (has not been run for a period of time), the operator will typically have to apply the choke lever to enrich the fuel mixture reaching the engine. Apply the choke and attempt to start the equipment; and when it starts or sounds like it is about to start, disengage the choke. For equipment that utilizes pull-cord starting, make sure the equipment is securely anchored before pulling the cord. When pulling the cord, pull the cord lightly out until you feel resistance from the engine; then complete the pull with a sharp snapping motion.

Portable Generator

When working on new construction or remodeling sites, landscape contractors are often without power for all or part of the project duration. To provide power for the job site, many contractors use a

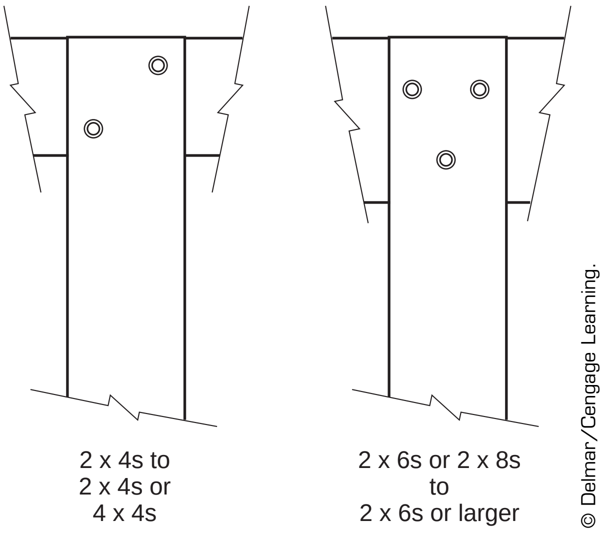

Figure 7-51 Fastening patterns that provide maximum stability.

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Figure 7-52 Portable generator showing outlets for power cords.

portable generator. Portable generators are typically gas-powered motors that turn a generator to provide electrical power through outlets mounted on the equipment (Figure 7-52). Before operating a portable generator, check the piece of equipment to verify that it is in good working condition and that all fluid levels are correct. Turn the engine switch on, choking if necessary. Pull the start cord until the engine engages; then set the throttle to the full setting. You may now plug electrical cords into the outlets on the generator.

Air Compressor

Air compressors are necessary to power pneumatic tools. Most air compressors have an electric motor that places air in a storage tank under high pressure. The pressure from this air tank then passes through pneumatic hoses to the equipment. To operate the typical air compressor, make sure all valves to the compressor tank are closed. Set the pressure release valve for the desired pressure (dictated by the type of equipment). Plug the compressor into a power source and turn on the motor. Compressors typically shut off when the desired range of pressures is reached. Hoses are typically attached using quick-connect fittings that require the user to pull the socket sleeve back, slide the fitting over the plug, then release the socket sleeve to securely connect the hose (Figure 7-53). Perform all regular maintenance required by the compressor manufacturer to maintain proper working order. This may include draining moisture from the pressure tank on a regular basis. Disconnect the equipment from the compressor, and unplug the compressor when not in use. Some pneumatic equipment requires that lubricant be added to the pressure tank.

Pneumatic- and Battery-Powered Nailing and Screwing Tools

For large carpentry projects; using powered nailing and screwing tools is more efficient than using hand tools. Large projects include framing projects, decks of over 500 SF, and installation of deck screws on large decks. Powered nailing and screwing equipment can use air from compressors or from portable cylinders, or they can operate on battery power. Regardless of the power source, most

Figure 7-53 Air compressor fitting. Pull the socket sleeve (on the right) back and slide it over the plug (on the left); then release the sleeve to secure the fitting.

operate in a similar manner. For both types of equipment, load and service the equipment with the power source detached. Nailers deliver nails from a nail cartridge stored in a housing sleeve. Place the delivery tip of the nailer where desired and push down on the tool to depress a trigger in the tip (Figure 7-54). Then squeeze the trigger and the nail is driven into the materials being fastened. A screw gun works in a similar manner. Placing the delivery tip where desired and push down to depress a trigger in the tip. Then depress and hold the trigger until the screw is installed. Use caution when operating any powered nailing and screwing equipment. NEVER aim the tool in a direction where it is not intended to deliver a nail or screw.

Sod Cutter

The sod cutter is invaluable in removing and salvaging large areas of turf from a construction site. A self-propelled, gas-powered motor with an oscillating blade, the sod cutter works by running the equipment over a lawn in a pattern similar to a lawn mower. The blade severs the sod from its roots just below the rhizome level. Before operating the cutter, set the blade to the desired depth of cut and carefully plan the route for removing the sod. When operating the sod cutter on mild slopes, always work perpendicular to the slope. Avoid operating on steep slopes (over 3 feet run to 1 foot rise).

To operate the equipment, place the transmission in neutral and turn off the blade. Start the

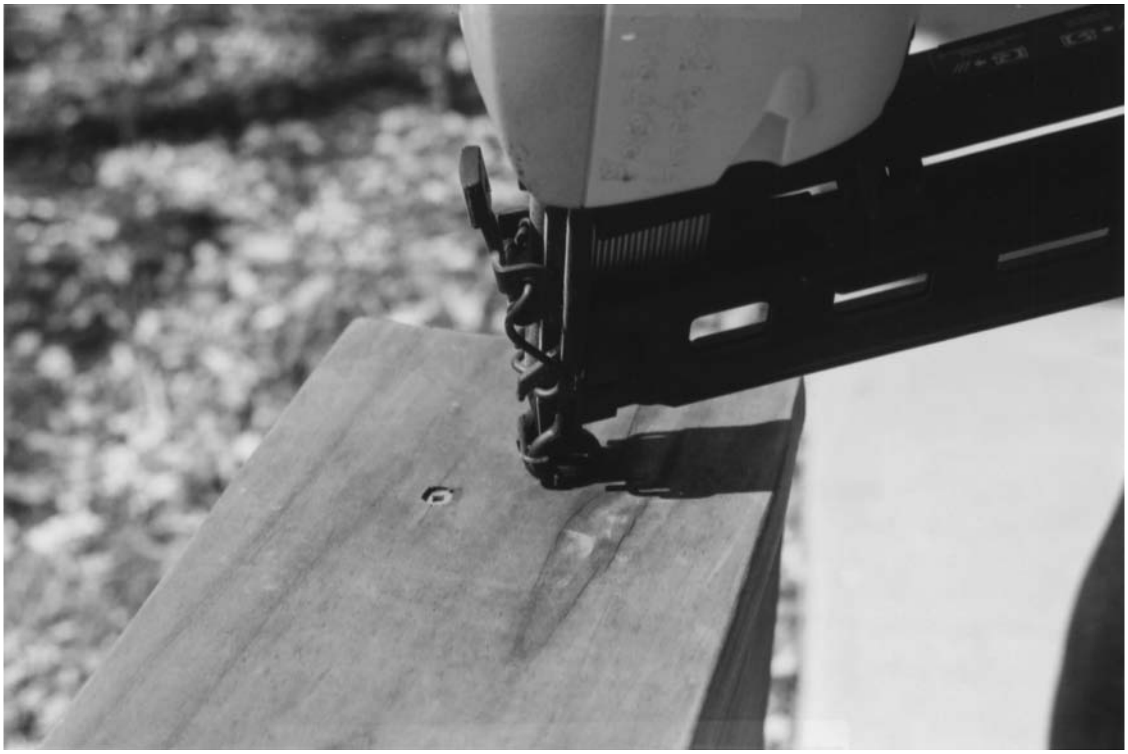

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Figure 7-54 Pneumatic nailer showing the tip where the fastener is discharged.

engine and engage the transmission at low speed. Maneuver the sod cutter to the desired starting point and place the transmission in neutral. Engage the cutting blade and increase the throttle; then place the transmission in gear. Guide the cutter as it moves along the planned route. You may need to exert downward pressure on the handles to force the blade under the sod at the beginning of a pass. Alternately, remove a swath of sod along the ends of each run to make it easier to get the blade under the turf. When reaching the end of a row or finished cutting, place the transmission in neutral and disengage the blade. Place the equipment in gear and move it off the site when finished. The sod may now be rolled or stacked for reuse or composting.

Rototiller

A valuable tool, the rototiller can loosen soil for a gardening project. Most rototillers are self-propelled engines mounted on top of a series of rotating blades. Some rototillers have transmissions with both forward and reverse; others offer only a forward gear. Before operating the equipment, plan the excavation so that you know the boundaries of the tilled area. Operate the equipment perpendicular to slopes and avoid steep slopes (over 3 feet run to 1 foot rise) with tillers.

To operate a rototiller, position the equipment at the location where tilling is to begin. Make sure the transmission is in neutral and the blades are disengaged. Start the engine and engage the blades. Increase the throttle, place the transmission in gear, and guide the tiller along the desired path. Maintain a firm grip on the handles of the tiller to maintain control of the machine. In many cases, you must hold the tiller back to achieve the desired depth of excavation, letting the machine "eat" slowly forward. When finished tilling, put the transmission in neutral and disengage the blades. Place the transmission in gear and move it off site.

Trencher

Installation of irrigation lines often requires extensive trenching. A gas-powered trencher may be appropriate when several linear feet of main and

laterals must be installed. Trenchers use a gas engine to power cutting teeth around a blade, with a screw attachment that throws soil to the side of the trench. Many trenchers have a transmission with forward and reverse gears. Unlike many pieces of equipment, trenchers work by pulling the cutting blades, rather than having the cutting tool on the front. You must work with your back to your work in many situations. Prior to using a trencher, plan the location of all trenches. Verify location of all utilities prior to trenching.

To operate the trencher, position the trencher at the beginning of the excavation. Make sure the transmission is in neutral and start the engine. Increase the throttle, engage the blade, and engage the transmission. Maintain a careful grip on the handles as the equipment slowly cuts along the planned route. When reaching the end of a trench, place the equipment in neutral and disengage the blade. Place the equipment in gear and move to the next trench or off site. Use extreme care when moving and turning the trencher because the blade extends well beyond the piece of equipment. If the blade hits them, improvements or plant material can be severely damaged.

Rotary Concrete Mixer

On the occasions that you need a small amount of concrete for a job, a portable mixer may be more efficient than hand mixing or paying short load charges for ready mix. A portable mixer has an electrical motor turning a rotating drum that has a large opening for adding and removing materials (Figure 7-55). The drum rotates and tilts, usually by hand, using a geared wheel that allows the operator to adjust the speed of the mixing and dumping. Before operating the mixer, verify that it is located on a stable level area and that there is access to the mixer for wheelbarrows or skid-steer. Also make sure that there is a place to clean the mixer without harming existing elements and new improvements to a site.

To operate the mixer, place the angle of the drum at approximately 45 degrees. Add ingredients to be mixed, plug in the mixer, and start the rotation. Add water to the drum as the ingredients mix. If ingredients are not mixing, lower the angle of the drum. When the batch is completely mixed, place a wheelbarrow under the open drum and lower the angle until the mix flows out. When the wheelbarrow is filled, raise the drum and remove the wheelbarrow. Leave the drum rotating until the entire batch has

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Figure 7-55 Emptying the drum of a rotary concrete mixer.

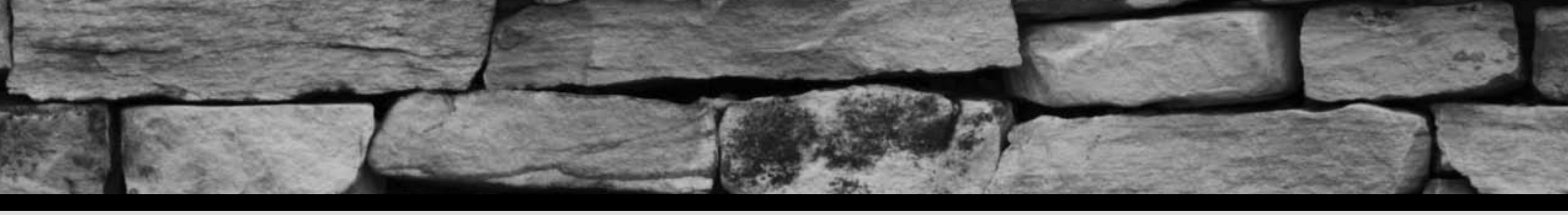
been emptied. Never place any body part or piece of equipment inside the drum while it is rotating. To avoid dumping the load, have a worker positioned to stabilize the wheelbarrow when the batch is emptied. Watch for spatter from the drum while it is mixing and while it empties.

CAUTION

When using a power washer, never aim the equipment at a person, object, or property that is not the target of the washing operation. Mask off all surfaces that may be damaged by the high-powered water stream. Always wear proper personal safety equipment, including eye protection, when operating a power sprayer.

Power Washer

Cleaning decks, concrete surfaces, and paved areas is easier using a portable power washer. Powered with a gas motor, the power washer is a pump that increases the normal water pressure available from a garden hose spigot. Most power washers are portable and come with a range of nozzles that produce concentrated steams to wide fans of spray. The nozzles are attached to a trigger-operated wand. To operate the power washer, verify that you have a hose that will reach the sprayer. Install the nozzle you wish to spray with, and connect the sprayer hose and wand to the outlet side of the pump. Connect a garden hose to the inlet side of the pump, but do not turn the water on until the pump is started. Start the pump and turn on the water from the garden hose. Aim the wand and pull the trigger to begin washing.



CHAPTER 8

CONSTRUCTION STAKING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Locate proposed improvements on a construction site.
- Determine the grade of proposed improvements on a site.

Regardless of a project's size, contractors will need to identify the location and elevation of the landscape elements to be constructed. Determining how to perform construction staking work will require a judgment regarding the complexity of the project and the level of accuracy required. If the project involves only a short walkway, hiring a land surveyor would be inefficient. On the other hand, it would be challenging to measure a large project with only a tape measure. Construction staking addresses techniques used in locating improvements on the site, establishing the elevation of improvements, and locating plant material. Each of these three construction staking requirements uses different approaches and should be performed in a logical order.

Locating improvements in the horizontal plane is typically performed first, followed by establishing the vertical elevation. These first two steps need to be completed before construction begins and may require that improvements be measured and restaked several times during the project. Location of landscape plantings is typically completed later in the construction process, often after finish grading has been completed.

Projects that may require restaking several times benefit from establishing permanent reference points, or control points. Horizontal plane reference points depend on the type of location method used. Typical references are corners of structures, edges of roadways, fence lines, baselines, or other permanent improvements that can be accessed and will not be disturbed by the construction. If existing permanent improvements do not exist on a site, establish reference points by driving fenceposts into the ground and painting them for visibility. Although at least three such reference points are required for most construction staking systems, more locations will be beneficial. Vertical measurements should be controlled by a benchmark, or permanent marker, where the elevation is known. Benchmarks for projects can be set on existing foundations, fire hydrants, manhole covers, or other objects that will remain throughout construction, will not move, and can be seen from locations where a level will be established.

LAYOUT EQUIPMENT

Layout of work requires the use of specialized equipment designed to make the work easier and more accurate. The amount of layout you perform, the accuracy required by the projects, and the cost of the equipment determine the choice of equipment. Typical layout equipment includes the following (Figure 8-1):

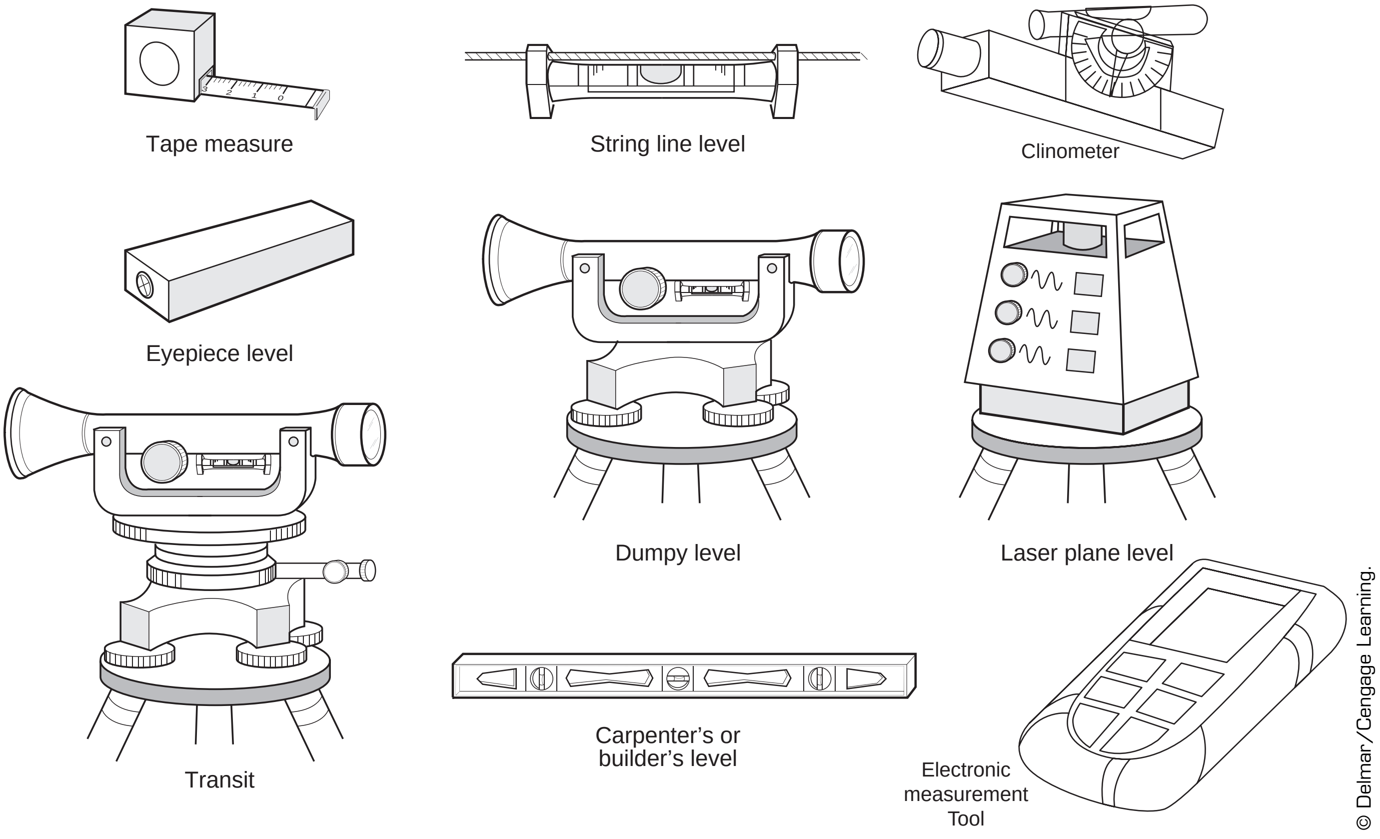


Figure 8-1 Layout equipment and tools.

- Tapes. A tape measure is an essential piece of equipment for all contractors. Useful in measuring horizontal and vertical distances, handy to carry, and marked for levels of accuracy acceptable to almost every building trade, the tape measure remains the one indispensable piece of equipment for layout. Landscape contractors may need tapes that measure in both feet/inches and feet/tenths. Having at least one tape that measures distances of 100 feet or more is also advisable. If only one person measures or marks, having a large screwdriver to anchor the zero end of the tape will be handy.
- Builder's Levels. Builder's levels allow contractors to determine slope, plumb, and, in advanced models, angles with a high degree of accuracy. The effectiveness of a level can be increased by selecting a piece of dimensioned lumber that is straight and resting the level on top of the board. This technique is common for determining grade for walks and paved areas.
- String or Line Levels. A string level is a simple bubble level that hangs from a line stretched between two points. String levels are handy for determining slope or level for paved areas, walks, decks, and other landscape elements that require a consistent grade between two points.
- Electronic Measurement Tools. A single operator can use electronic measurement tools in many exterior applications. Laser measurement devices project a light beam toward the object being measured to obtain a dimension. Depending on the model, exterior laser measurement tools are capable of measuring distances up to 500 feet and will, in addition, measure slopes up to 45 degrees. The battery-operated tools often provide a magnified rangefinder and project a clear light point, making operation by a single operator possible. Many models include calculator functions programmed into the device and come with tripods for more stable operation.

- Clinometer. The **clinometer** (also called inclinometer or tilt sensor) is a visual device used to measure the degree of slope. Looking through a lens, the surveyor can sight along the slope and see the degree of slope reflected in a mirror from a vernier mounted on the instrument.
- Dumpy Level. **Dumpy levels** are tripod-mounted focal instruments that provide a magnified eyepiece for the contractor to look through. The dumpy level has crosshairs that allow accurate measurement at long distances without serious distortion. The level and tripod are also adjustable, allowing contractors to set up on a variety of terrains. A surveyor's rod, a vertical stick with measurements, or a tape measure is required to complete measurements with this level.
- Eyepiece Level. The eyepiece level is a small, handheld version of the dumpy level. Because of its limited accuracy, this tool is used only to establish rough grades for planting or turf areas and rough grading. A rod or tape measure is required to complete measurements with this instrument.
- Laser Plane Level. The **laser plane level** is a technological advancement from the optical level. When properly set up, a laser plane level sends out a rotating beam of high-intensity light in a plane that matches the instrument's height. A receptor mounted on a survey rod then picks up the light beam. The laser plane level allows the measuring and marking of elevations without requiring an operator to focus through the telescope eyepiece, hence improving the speed and accuracy of measurement.
- Robotic Surveying Stations. Robotic surveying stations use laser and servomotor technology to implement site surveying and layout. The surveyor carries a survey pole with a prism that is "tracked," or followed by an unmanned survey instrument. Using a laser or infrared beam, the instrument can calculate the location and elevation of points that the surveyor requests. The information is transferred between survey rod and instrument via radio waves. Robotic stations can be used for layout if adequate control points are established.

CAUTION

Do not look directly at the light beam emitted by the laser plane level, robotic survey instrument, electronic measurement tool, or any tool using laser or infrared for measurement.

- Transit. **Transits** are dumpy levels that provide a means for measuring horizontal and vertical angles. Used by surveyors, such instruments are useful if working on a steep site or when making measurements from a single point. A process called **stadia** uses the eyepiece crosshairs to measure both level and distance in one step.

LAYOUT AND MEASUREMENT TECHNIQUES

Following in this section are suggestions that will make layout work easier and more accurate.

Measuring Distances

Measuring distances in open spaces requires the location of a beginning point, then stretching a measuring tape straight in the desired direction to locate the required dimension. Mark the beginning and ending points to preserve the location until no longer needed.

Using Electronic Measurement Tools. Although extremely accurate, laser measuring devices have limitations. The device selected must be engineered to work in exterior applications, and the maximum measureable distance must be adequate to cover dimensions of your project. Many objects can be measured by aiming the device directly at the object being measured. However, if the measurement is long (typically over 300 feet), the activity may require a second person to hold or position a target plate to reflect the beam. Nontarget items, such as brush or trees, may also affect measurement with a laser device.

To use the laser distance measuring devices, power up the instrument and verify that all settings are correct according to the manufacturer's instructions. Stand at the point where the measurement is to start and aim the instrument at the point where the measurement is to end. Activate the laser and read the measurement on the instrument's digital readout.

Using Global Positioning Systems (GPS). When measuring sites with extreme overgrowth or severe

grade changes, contractors may use a **global positioning system (GPS)** to locate horizontal and vertical dimensions. GPS uses signals from satellites to triangulate the sender's position. Using a hand instrument or backpack-mounted instrument with design data already loaded into it, the person who is staking is guided about the site to key locations. Although GPS has limited accuracy for detailed layout, it can locate general improvements with an acceptable degree of accuracy. One advantage of GPS is that it reduces the need for brashing, or the clearing of brush along a survey line.

Measuring Short Slopes

Select a long, straight 2 × 4 and lay one end at the top of the slope. Place a builder's level on the 2 × 4 and adjust the board up or down until it is level. Using a tape measure, measure the distance from the bottom of the 2 × 4 to the toe of the slope. This distance is the fall of the slope (also referred to as the *V* in some formulas) (Figure 8-2). The run, or horizontal distance, can also be calculated by hooking your tape over the end of the 2 × 4. Holding the 2 × 4 level, measure along the board until directly above the toe of the slope.

Measuring Long Slopes

When slopes exceed lengths of 10 feet, elevation measurements using a straight 2 × 4 and level are difficult. To measure long slopes, use mason's twine anchored at the top of the slope with a screwdriver. Stretch the mason's twine to the bottom of the slope and hang a string level on the twine. Holding the twine level, extend a measuring tape from the twine to the ground to obtain the slope's vertical measurement.

If the slope is steep, you may have to repeat this process several times. For subsequent measurements, always move the screwdriver holding the twine to the location where the measuring tape contacted the ground in the previous measurement. Add all measurements to obtain the slope's vertical dimension.

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Figure 8-2 Determining slope by holding a level board from the high point and measuring from the bottom of the board to the low point.

Measuring Slopes with a Clinometer

The clinometer (discussed above under "Layout Equipment") is a device for measuring angles above and below an artificial horizon. Contractors use the clinometer to measure the angle of slopes for wall and stair construction, as well as for grading, and to calculate the angle/height of vertical objects in the landscape.

Compass Clinometer. Holding the compass clinometer in the vertical position, sight along the instrument with both eyes. One eye reads the scale inside the hole on the clinometer, and the other eye sights along the slope to be measured (or slightly above it to accommodate your height). The horizontal band aligns with the slope, and the slope measurement is read on the scale.

Abney Spirit Level Clinometer. An Abney clinometer is an eyepiece mounted on an adjustable tubular spirit level, which is also connected to a vertical scale (Figure 8-3). To use the Abney, you look through the eyepiece and align the crosshairs (horizontal index line) with the slope being measured. Next to the crosshairs is a reflected image of the spirit level. Adjust the level until the bubble is centered and aligned with the crosshairs. The angle is then read on the vernier scale.

Electronic Clinometers. Available to the industrial, navigation, and aircraft industries, electronic versions of clinometers perform precise measurements of inclination and slope. Although these instruments are highly accurate, they are not directly applicable to landscape operations.

Using Offsets

Another component of project layout is establishing accurate layout markings that do not interfere with the construction. To accomplish this, the construction markings made on a project may use the concept of offset. **Offset** places the stake or identification for the improvement at a consistent, predetermined distance and direction from where the improvement is to be actually installed. Typical offsets may place the construction stakes 5 feet outside of where the improvement should be placed (Figure 8-4). Dictated by project conditions, actual distance and direction should be consistent throughout the project. A common form of offsetting horizontal and vertical markings is the use of **batterboards,** which are ideal for many aspects of landscape construction, especially the building of decks, structures, and paved areas. Construction of batterboards is covered under "Location of Improvements" in this chapter.

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Figure 8-3 Using a clinometer to measure the angle of a slope.

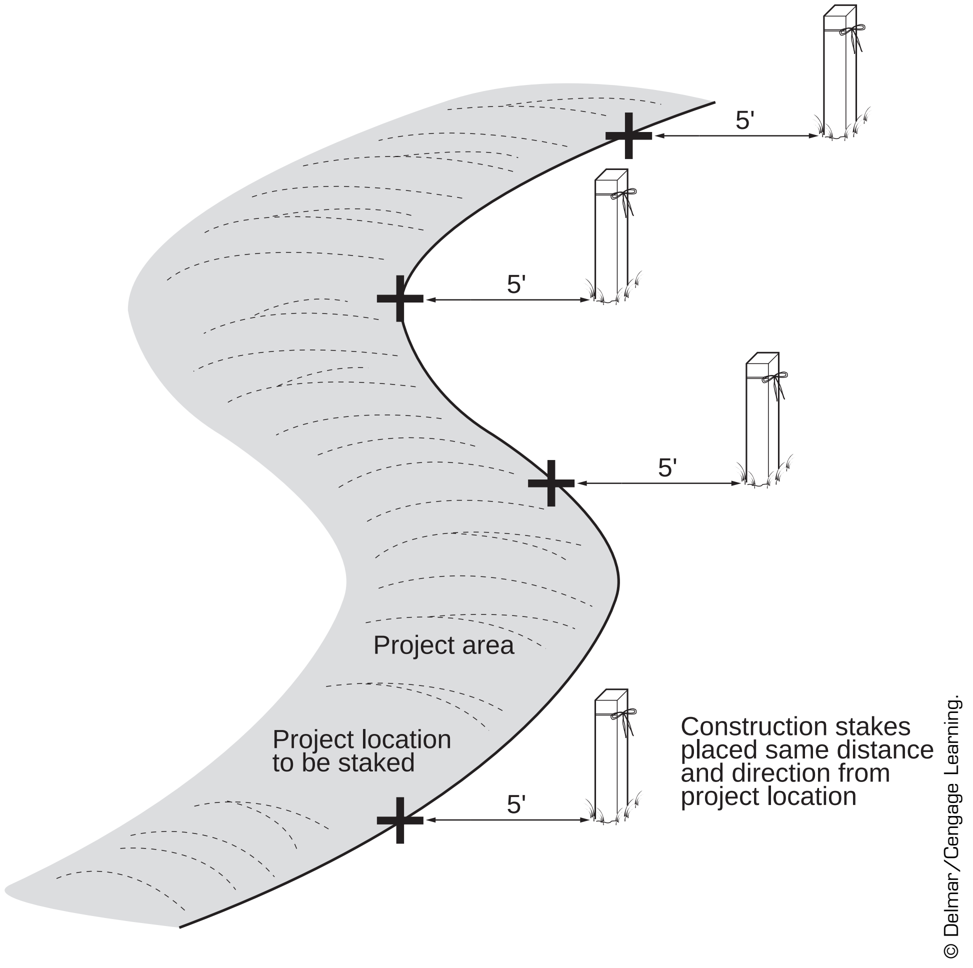

Figure 8-4 Staking with offsets to reduce restaking time.

Floating Dimensions

Dimensions labeled with a plus or minus sign in front of them are considered floating dimensions. Floating dimensions provide flexibility in locating the actual object being measured; that is, they accommodate the lack of accurate existing measurements. An object labeled with floating dimensions may also be located in another manner, such as being aligned with other objects or adjacent to a fixed object.

Locating Points with Triangulation

To locate a single point on a site, you can use the triangulation method. To perform this measurement, locate two known points within a short distance of the object to be located. Measure from each known point to the object to be located. On a plan that shows the two known points, draw an arc from each the distance measured. Where the arcs cross is the location of the unknown point (Figure 8-5). You can reverse this process to locate an object in the field. Measure from two known points on a plan to the object to be located. Find those known points in the field and swing the arc from each the distance measured. Where the arcs cross is the unknown point.

Laying Out Right Angles with the 3,4,5 Triangle

Determining if an angle is exactly 90 degrees can be difficult in field construction. Using a carpenter's square will help for small elements; but when laying out a large paved area, the square may not provide the level of accuracy required. To perform this layout task, use a method known as the 3,4,5 triangle (Figure 8-6). (Math majors will recognize this as an application of the Pythagorean theorem.)

Along the project edge from which you are turning the angle, mark the point from the point where you need the perpendicular, or right-angled, line to begin. (This may also be the corner of the project.)

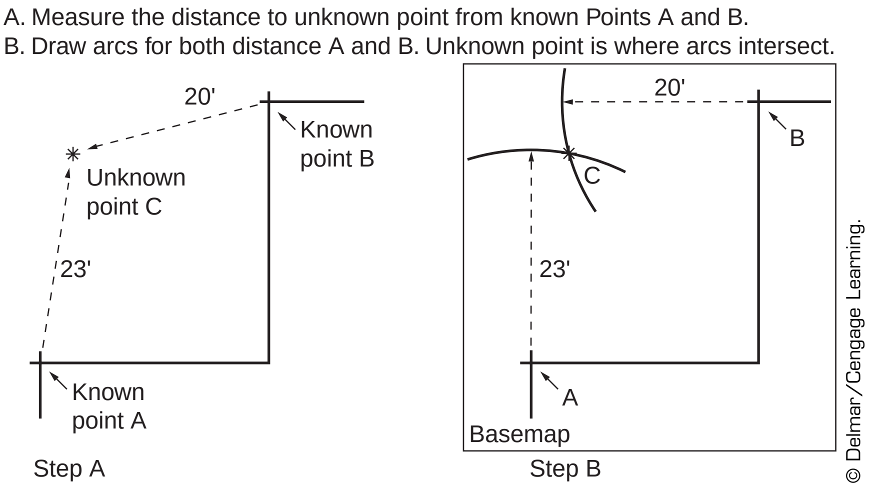

Figure 8-5 Locating objects using triangulation.

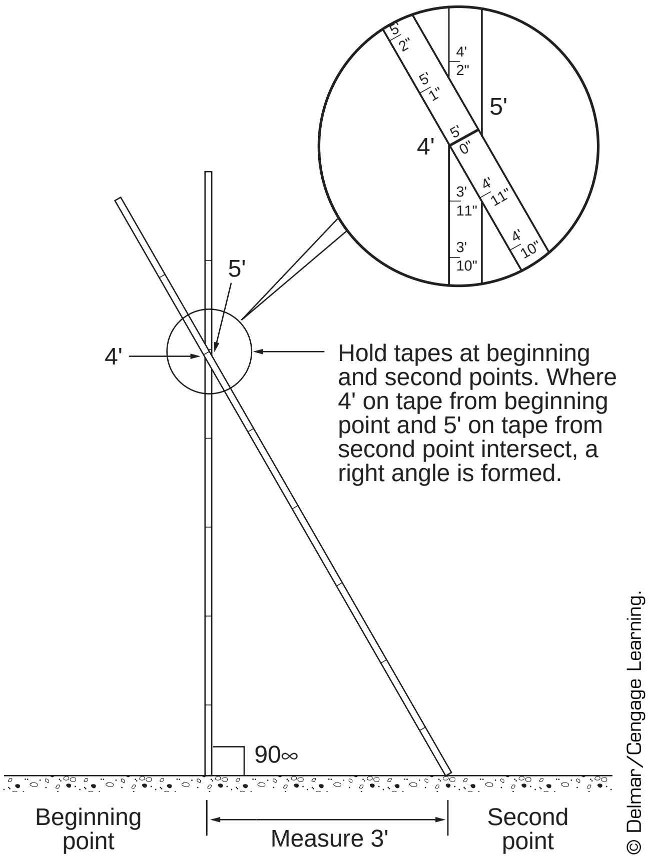

Figure 8-6 Using a 3,4,5 triangle to turn right angles.

From that point, measure 3 feet along the edge you are turning the angle from and make a second mark. From the beginning mark (or corner), stretch a tape in the direction you want the perpendicular line to run. Hold the tape at the 4-foot mark. Place another tape at the second mark and stretch the tape to 5 feet. Adjust both tapes until the 4-foot mark on the first tape and the 5-foot mark on the second tape intersect. Mark directly below that point. A line traveling from the first point marked (or corner) and passing through that third point where the tapes intersect will be at a right angle to the first edge. When **squaring** decks or paving, you may use the 3,4,5 triangle method by marking the 3-foot and 4-foot marks on the joists, then using a single tape to measure the 5-foot mark.

Laying Out a Right Angle Using the Isosceles Triangle Method

Obtaining a perpendicular, or right-angled, line to a baseline or any other straight line can be done using the triangle method (Figure 8-7). Measure two points an equal distance on either side of the point on the baseline from where the perpendicular line is to be located. The distance is not critical as long as it is the same on both sides, but minimum measurements of 3–5 feet are recommended. From each of these two points, stretch the tape measures in the direction of the perpendicular. Select a measurement on one of the tapes and match it with the same measurement on the second tape. Mark the point where these similar measurements intersect. A line laid out from the original starting point through this intersection will be at a right angle to the baseline.

Checking for Square

When laying out a landscape element that must maintain a square (or rectangular) form, check your work using diagonal measurements (Figure 8-8).

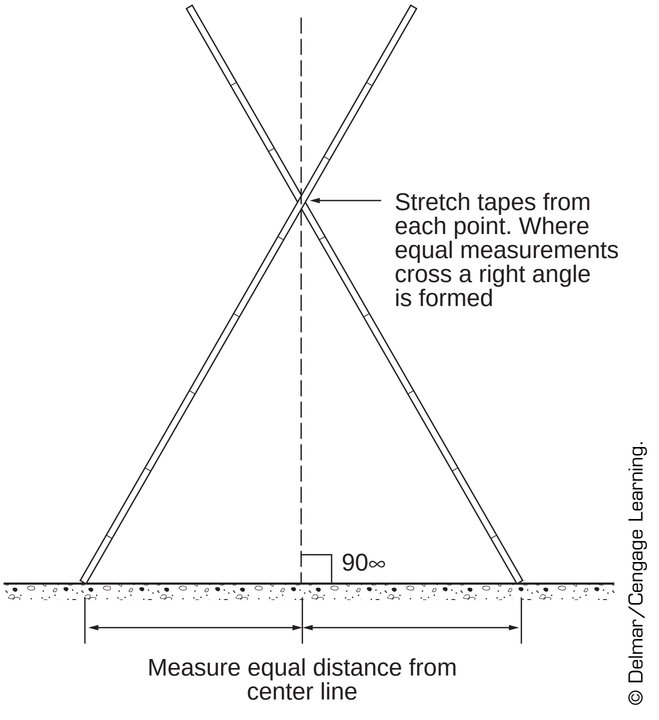

Figure 8-7 Layout of a perpendicular line using the triangler method.

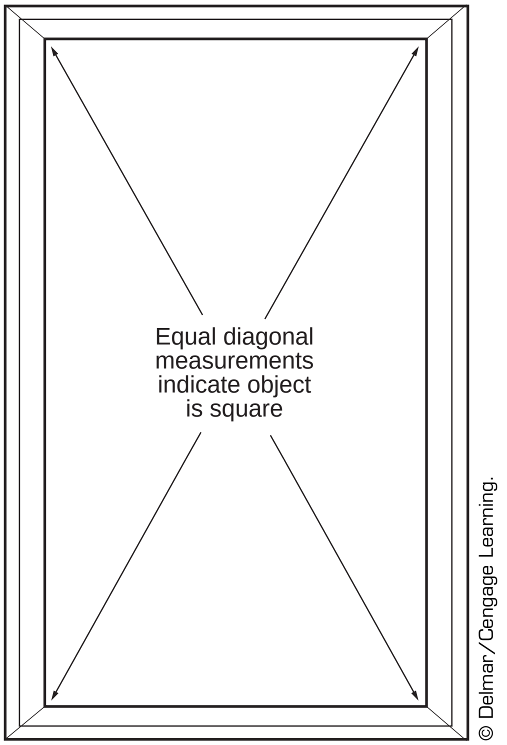

Figure 8-8 Checking for square using diagonal measurements.

Using a tape, measure from diagonal corners and compare measurements. If the measurements are equal, the shape is square. If one measurement is longer than the other, the long corner must be pushed in slightly and the short corner pulled out slightly until the measurements match.

Using Stringlines

When street trees or other improvements are to be laid out in a straight line, using a **stringline** will save time over locating each individual plant. To obtain a straight line, place a stake at each end of the line and stretch a mason's line between the two stakes. Measurements can be made down the line to required improvements. If the line interferes with construction operations, offset it 1–2 feet.

Locating Curves

Curves can be measured by locating three points—the beginning of the curve, the end of the curve, and the radius point. Use baselines or coordinates to locate the beginning and ending points. If the radius of the curve is identified but the radius point is not, locate the radius point by turning a right angle (see the 3,4,5 triangle) from the curve beginning point. Marking as you go, swing a tape anchored at the radius point along the alignment where the curve is to be located (Figure 8-9).

Using a deflection angle and chord length, if that information is provided, you can mark ending points for curves. To use this method for locating curves, you must locate the beginning point of the curve and extend the tangent adjacent to the beginning point beyond the beginning point of the curve for 2 feet. The deflection angle indicates the degrees to the left or right of this

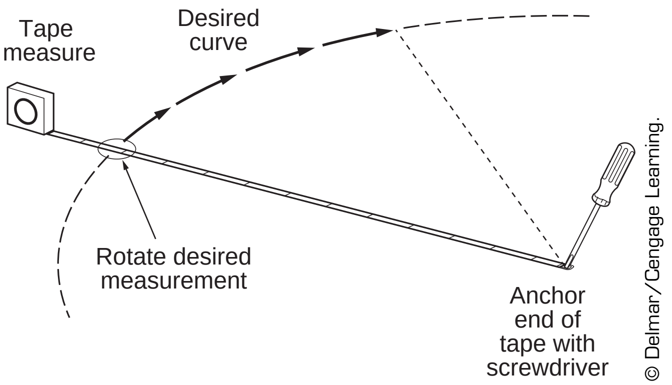

Figure 8-9 Layout of curves using a large screwdriver anchored at the center point and swinging a tape measure to mark the correct radius. Mark the radius as the tape is moved.

extended line where the end of the curve is located. Extend a second line from the beginning point of the curve that is at the noted deflection angle to the first line. Measure the chord distance along this second line to locate the end point of the curve. This method does not locate the radius point for the curve.

Laying Out Arcs and Tangents

Designs that have a series of straight lines (**tangents**) and curves (**arcs**) can be successfully laid out by first locating the tangent sections and then connecting the arcs. If available, use coordinates to find each end of the tangents on the site. To locate the radius point of the curve, turn a right angle at the end of the tangent and measure down the right angle the radius distance as noted previously. This is the radius point from which the curve can be "swung" (Figure 8-10). If your curve does not intersect the end of the next tangent, recheck your measurements for accuracy.

If the layout provided does not give coordinates for the tangent end points, begin the layout using a tangent at the beginning point. Measure this tangent; then measure and turn the radius at the end of the tangent. This method will require measuring the angle of the curve to obtain an accurate layout.

Laying Out Circles Using Radii and Chords

For designs with complex curvilinear layout, you can easily locate the curved element if the design professional has provided the radius and the chord for each segment of the curve. To locate curves using this method, begin at the first curve by locating the beginning of the curve. From this point, turn a right angle and use the radius measurement to locate the radius point. Set up a measuring tape anchored to the radius point (as shown in "Locating Curves"). Set up a second measuring tape anchored

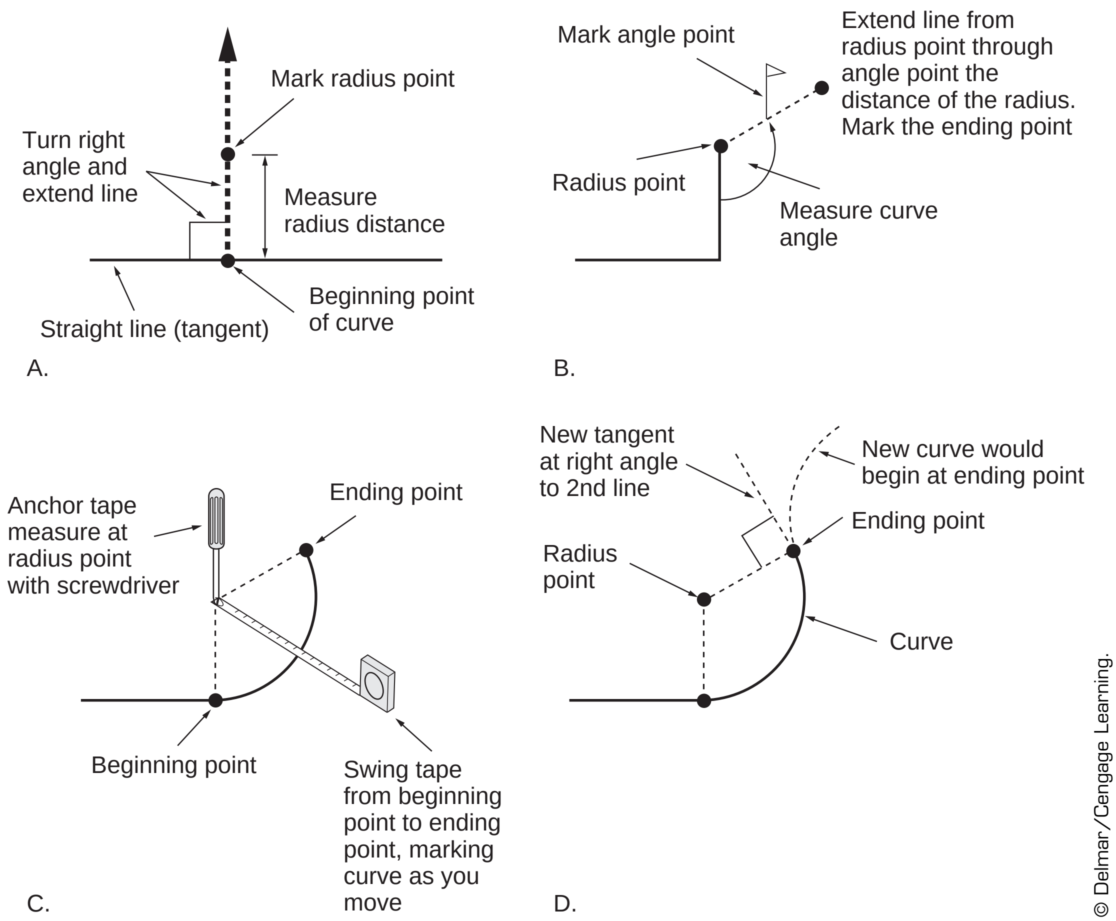

Figure 8-10 Locating radius points and marking a radius for curves.

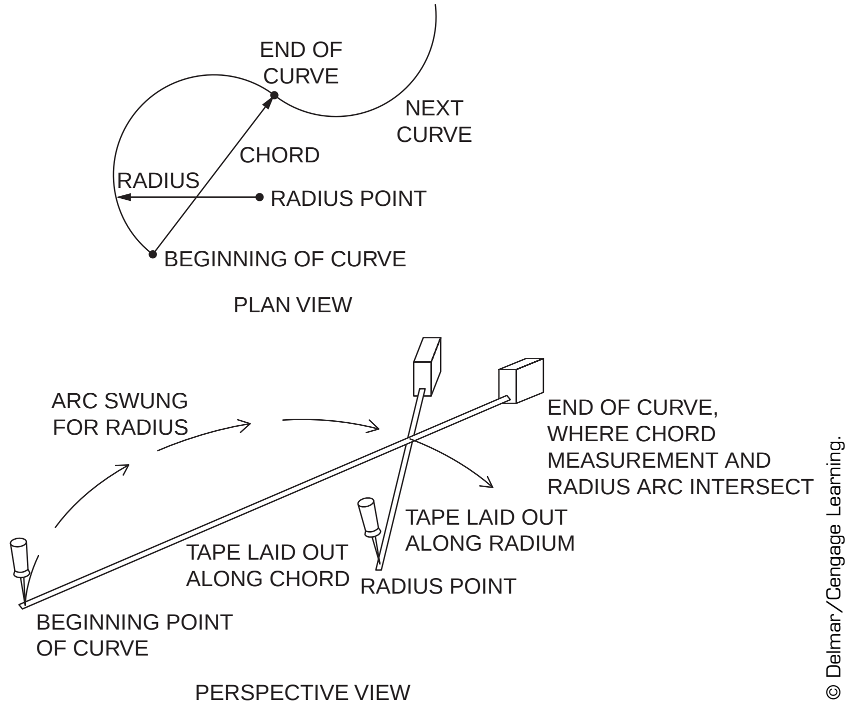

Figure 8-11 Using radii and chords to lay out circles.

to the beginning point of the curve and extend this tape to the length of the chord (Figure 8-11). Adjust the first and second measuring tapes to the point where the radius and the chord intersect. This is the ending point of the curve, and you can now mark the curve from this point back to the beginning point using the radius measuring tape. If the curve continues without a tangent, you can locate the next radius point by aligning the radius point and ending point for the previous curve and extending a line to the new radius point.

Marking

Cutting and joining elements such as lumber, wall stone, and pavers can be simplified by marking the cutting or joining point. This frees one hand to perform the work, rather than having to hold the tape. Using a *V* to mark points eliminates the confusion of determining which end of a mark is the correct measurement. When temporarily locating elements in the field, use white spray paint or basepath chalk to locate edges. You can also use a hose or rope to temporarily locate edges of a curve. Experiment until you are satisfied with the alignment; then replace the hose with permanent markings.

Marking Center Line Locations for Digging

To aid in excavating holes, use paint to mark a large *X*, with the center of the *X* aligned with the center of the hole and the legs of the *X* extended beyond the excavation. If the legs of the mark are extended far enough, reference marks will remain after digging begins. You can use these reference marks to relocate the center of the hole at any time during the excavation.

LOCATING UTILITIES

Chapter 6 addressed the need to locate utilities on a site before construction. The best time to locate utilities, both public and private, is during the layout phase of the project. Contractors may choose to use white flags or stakes to mark the locations of improvement so that their markings do not conflict with those of the color-coded utility markings. Any conflicts between proposed improvements and utilities must be addressed prior to beginning construction.

LOCATING IMPROVEMENTS

Establishing the work area for a project should begin with locating all elements on a horizontal plane.

Among the typical items located during this process are corners of structures, edges of paved and planted areas, center lines for walkways and drives, and locations of points, edges, or center lines for all permanent improvements for a site. Site layout plans typically locate major objects on a plan, leaving specific dimensions to details. On sites that require substantial grading and until major earthmoving has been completed, only key improvements, such as structures and roadways, are located. Waiting until the rough grade has been generally established saves time restaking items that were in areas disturbed by the grading process. Locating elevations of improvements (described below), should be completed after major improvements have been located. Contractors can reuse the stakes for locating improvements to mark any grade change required.

Location of landscape improvements requires a method that provides accuracy and efficiency. Contract projects will typically have a site layout plan, which dictates the location method to use. One of the methods described in the following sections, or a hybrid of these methods, is common on projects that landscape architects or site design professionals design. Projects that have no site layout plan require a method for locating improvements. Four methods—object dimensioning, baseline layout, grid layout, and bearings or survey lines—are typical for locating project improvements. The first three of these methods are the most common.

Complex layout problems should be contracted to a registered land surveyor. By combining the methods described below with the techniques addressed earlier, landscape contractors can accomplish simple layouts. Remember, however, that contractors must correct errors in staking at their expense.

Grid Layout

If a project has buildings and roadways, the grid layout method may be the best choice for accuracy. Grid layout uses a series of **Cartesian coordinates** (*X* and *Y* measurements) to locate improvements on a site. These coordinates can be located with a pair of baselines set at right angles to each other. The beginning points and orientation of these baselines should be located on the layout plan (see Figure 3-6).

For a grid layout, each point to be located will have an *X* and *Y* measurement that corresponds to the distance the point is from the *X* and *Y* baselines. To locate an object, select the point to be located and locate the measurement along the *X* baseline. From that measurement, extend a line perpendicular to the *X* baseline slightly beyond where you estimate the point is located. Locate the measurement along the *Y* baseline and, from that measurement, extend a line perpendicular to the *Y* baseline, which intersects the line extended from the *X* baseline. The intersection of the two lines is the correct location for the point in question. This process is repeated for all points that require location.

Baseline Layout

Baseline layout uses a straight line that runs through the entire site and is measured from a beginning point. Landscape elements are located by making a measurement down the baseline from the beginning point and using a second measurement perpendicular to the left or right off the baseline (Figure 8-12). Baseline layout is common for small-to-medium sized projects that have a great deal of open space on the site. Baselines also work well if a straight curb line, roadway, fence line, or other existing baseline can be used.

Object Dimensioning

Object dimensioning is used when the location of improvements can be measured off existing landmarks such as structures. For most small landscape projects, object dimensioning provides adequate accuracy (Figure 3-8).

Bearings and Survey Lines

The bearings and survey lines method uses lines measured a determined direction (bearing) and distance from a reference point to locate objects on the site. Using an established beginning point such as a property corner, objects are located by providing the bearing and distance from that point. Additional points along a boundary can be located by measuring a second bearing and distance from the previous point. Curves are typically located by interpreting curve data, such as chord and curve length or radius point. Layout of objects described in this manner requires a registered land surveyor to perform the staking.

Batterboards

As related under "Using Offsets," batterboards are an excellent tool for maintaining locations and grades for project corners. When properly constructed, batterboards are the only markings needed throughout the construction of a paved area, a deck, or a structure. Following are instructions for installing a

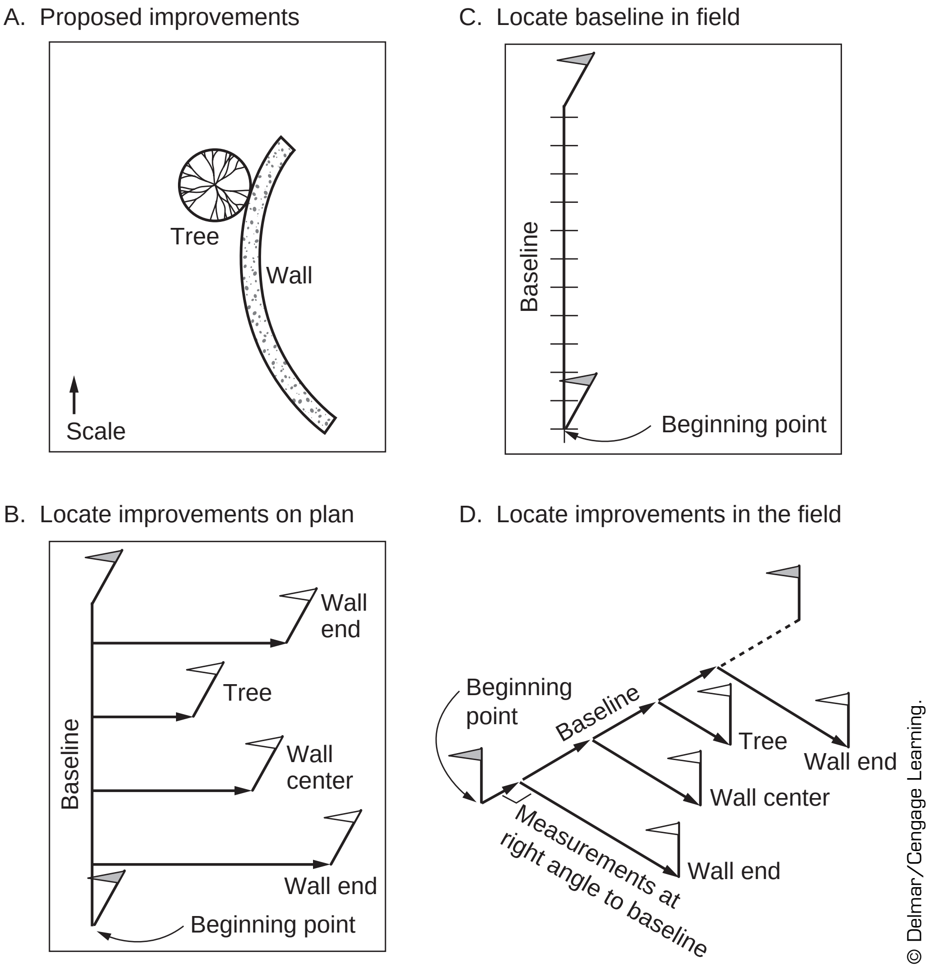

Figure 8-12 Using a baseline to locate improvements in the field.

batterboard for one corner of a project with an offset beyond that corner being staked (Figure 8-13). The actual offset is determined by how much of the area outside the project will be disturbed by construction. Construct a batterboard using the following steps:

- Select three, pointed 2 × 2 stakes that are 4-feet long and two 1 × 6s that are 4-feet long.
- Stretch a stringline along the alignment of each side of the project being staked. Extend the stringlines 4 feet beyond the corners of the project in each direction.
- Drive the three stakes into the ground. The stakes should be in an *L* pattern, with each leg of the *L* paralleling one side of the project. The *L* should be located 2 feet beyond and straddle the stringlines.
- Halfway up each stake along one side of the *L*, connect a 1 × 6 between the two stakes. Using deck screws allows connections to be made with minimal disturbance to the stakes.
- Connect the other 1 × 6 between the two remaining stakes.
- Place a second set of stringlines directly above the first set. Using a small nail, connect the stringlines to the 1 × 6.
- Measure to verify the stringlines are set at the project dimensions. Adjust lines left or right and reset if necessary.

ESTABLISHING ELEVATIONS

Once locations of improvements have been identified, the proposed elevations can be marked. Selection of a method for identifying elevations depends on the accuracy demanded by the project. Projects with no grading plan or with a single layout drawing may state elevations by indicating the direction and percentage of slopes. Another form of identifying elevations is to mark proposed heights of objects by labeling the object with a spot elevation. It is important that drainage from structures

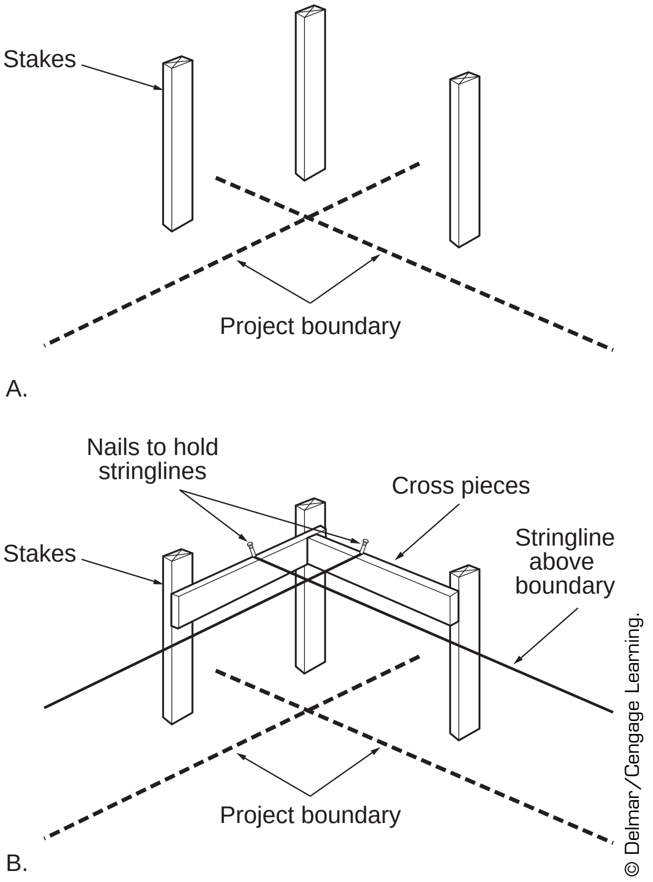

Figure 8-13 Constructing batterboards. (A) Install posts outside the project edges and straddling the boundaries. (B) Attach cross pieces and lines marking project boundaries. Height of the cross pieces can be set to project elevations if you want to locate boundaries and elevations with the same batterboards.

and important improvements be maintained when establishing elevations. If grades are critical, consider hiring a registered land surveyor to perform the staking. As with layout staking, contractors must correct errors at their expense.

Similar to the site's horizontal layout, elevation measurements may require restaking as the project progresses. Often the site is first staked to allow the grading contractor to perform rough grading activities and then restaked or remeasured when areas within the site are built. Individual portions of the project, such as grades for tile inlets, paved areas, and slabs for structures, may be remeasured as they are built. Accuracy for rough grading should be within 2–3 inches. Finish grades should be accurate within 1 inch for lawn and planting areas and under .1 inch (one-tenth inch) for paved surfaces.

Offsets for construction staking of grades are sometimes unnecessary. Rough grading layout typically places a grade stake at the correct location, and the grading contractor adds or removes soil around the stake until the new surface is at the correct level. Cut areas leave the stake on a mound of soil that is removed when the surrounding area is at the correct level. In fill areas, soil is piled around the stake until a mark on the stake is reached.

Batterboards and Stringlines

If the proposed finish elevation of the corner being staked is known, vertical layout functions can be obtained from the batterboards described above. Adjust the height of the 1 × 6 so that the stringline passes over the corner at the proposed elevation. The batterboard can now hold the stringline for the project's edges in the correct location, as well as at the correct elevation.

Slope Direction and Percentage

When a plan indicates no specific spot elevations, contractors must rely on indications of slope direction. Most likely used when defining drainage patterns for lawns, this method may also be used for paved surfaces. Using the slope arrows as a guide, grade the project with a consistent slope in the direction indicated. Set the elevations for structures, paved areas, and utilities first, followed by grades for lawn and planting.

Cross Grades

When plans indicate a slope direction but not a specific percentage, a straight 2 × 4 and carpenter's level can be used to stake the grade. Set the desired grade on one side of the construction area; then lay the 2 × 4 from across the project. Set the level on top and adjust the second side up or down until the level reads the general slope direction required (see Figure 8-2).

Dumpy Level or Laser Plane Level

When specific elevations are indicated for points of a project, contractors must accurately measure and mark each of the points. Staking in this manner requires the use of a level to calculate the precise elevation. The surveyor's rod that is used must match any grading plan measurement increment. If feet and inches are used on the plan, use a rod calibrated in feet and inches; if decimals (feet and tenths) are used, use a rod calibrated in decimals. Math is easier to calculate using decimal measurements, and most

grading plans use decimal markings. A registered land surveyor should stake calculations that require angles and elevations.

Setting Up the Level. Setup for a survey instrument that is leveled manually will be the same for a dumpy level or a laser plane level. A self-leveling instrument requires only the steps through mounting the instrument. For placement of the level, select a location that has good visibility of the benchmark and all locations that will require construction staking. This site should be in an area as level as possible where construction traffic and activity will not disturb the instrument. Set the tripod by first spreading the legs and positioning them with the mounting plate at a comfortable height and as close to level as possible. When mounted, the instrument should be at eye level for ease of operation. Push the legs of the tripod securely into the ground to avoid accidental movement.

Remove the instrument from its case and secure it to the mounting plate. Some levels have a threaded connector that is attached through the mounting plate; others screw directly onto the plate. The telescope is leveled using the four thumbscrews that support the instrument on the mounting plate. A small bubble level below the telescope indicates if the instrument is properly leveled. Begin leveling by turning the screws gently until all four are in contact with the mounting plate. Turn the telescope so it is aligned with one pair of thumbscrews (Figure 8-14). Turn the thumbscrews in opposite directions to center the bubble. If the level bubble needs to move to the left, turn both screws toward the center of the mounting plate. If the level bubble needs to move to the right, turn both screws toward the edge of the mounting plate. With these motions, the screws are actually turning in opposite directions and cause the telescope to tip in one direction or the other. Continue adjusting until the level bubble is centered.

Turn the telescope 90 degrees to the right and repeat the leveling operation with the second pair of screws. When level in that direction, turn the telescope back to the original direction and repeat the leveling process. The telescope should now be level. Test by turning the telescope in all directions and verifying that the bubble stays centered. If the bubble is not centered, repeat the leveling process. The base of the thumbscrews should always remain in contact with the mounting plate. If any screw lifts from the plate, the entire process needs to be redone.

If the survey instrument being used is self-leveling, position the tripod with the level attached and set the instrument for level. Small motors within the instrument will level the telescope.

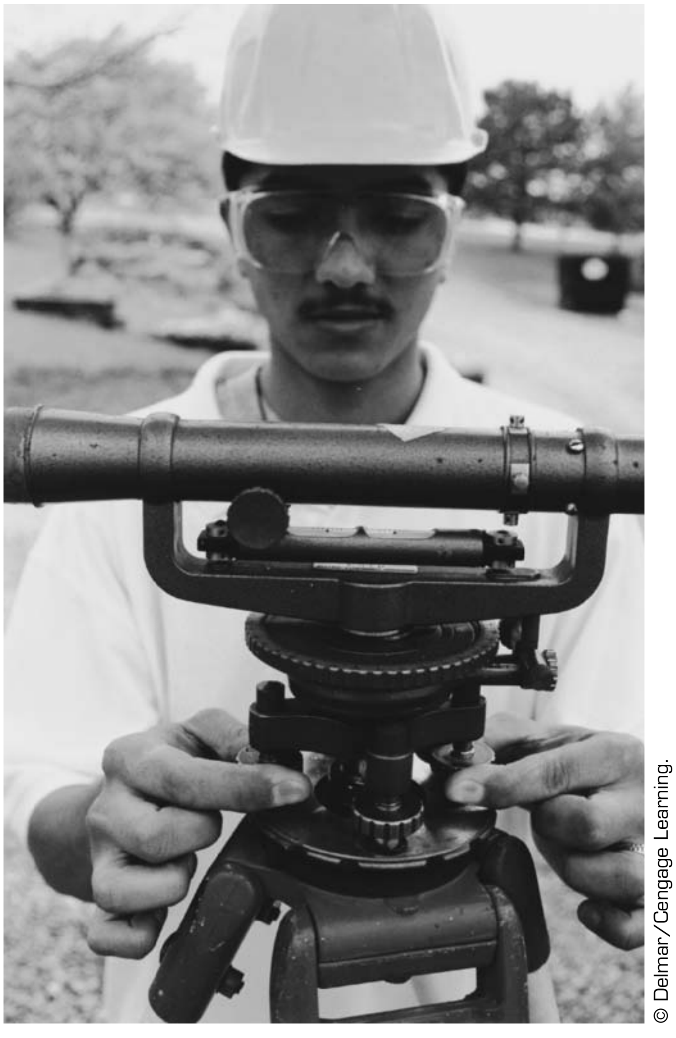

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Figure 8-14 Leveling a survey instrument. Always turn the leveling screws in opposite directions.

Using the Level. When operating the level, use extreme caution not to bump the instrument out of place. Any movement will require resetting the level. Gently aim the telescope in the direction where you will be taking measurements. Look through the telescope using one eye and use the knob on the side to focus (Figure 8-15). When the telescope is properly aimed and focused, you should see the leveling rod (or tape) clearly.

A laser level will send out a level beam in an arc around the construction site. Operators holding rods with laser receptors will position themselves wherever a sighting is required. Do not look directly at the light beam. The operator will raise or lower the receptor until the beam is captured, usually indicated by a beeping noise from the receptor. The

Figure 8-15 Focusing a survey instrument. Use caution not to bump the instrument out of level.

reading is taken from the receptor rod, completing the backsite or foresite.

Taking a Backsite. The first step in calculating elevations is to take a **backsite.** Have a second worker set the surveyor's rod on the benchmark. Look through the telescope, focus, and read the elevation on the rod. If you are unable to read a foot number, the rod operator may need to lift the rod until a foot reading is visible. Add the reading to the elevation of the benchmark to obtain the **height of instrument** (Figure 8-16).

Taking a Foresite. The rod operator may now move to a location where an elevation measurement is needed. Drive a construction stake into the ground at that point (one may already exist from locating the improvements). Look through the telescope, focus, and read the number on the rod. Subtract the reading from the height of the instrument to obtain the elevation of the spot where the surveyor's rod is setting.

Marking and Reading Grade Stakes. Read the grading plan from the construction documents to determine the proposed elevation for the spot where the rod is setting. If the proposed and existing elevations are the same, the stake will be marked *0* (no cut or fill).

If the proposed finish elevation is higher than the existing elevation, subtract the existing elevation from the proposed elevation and mark the stake as a fill, using the difference as the fill amount. Fill stakes are marked *F+ X.X* or *F X.X*, where *X.X* is the amount of fill necessary (1 foot of fill would be marked as *F+ 1.0* or *F 1.0*). To aide the contractor performing the grading work, a dark line can be drawn on the stake that indicates the proper fill level. If the proposed finish elevation is lower than the existing elevation, subtract the proposed elevation from the existing elevation and mark the stake as a cut, using the difference as the cut amount. Cut stakes are marked as *–X.X* or *C X.X*, where *X.X* is the amount of cut necessary (2 feet of cut would be marked as *–2.0* or *C 2.0*). This process is repeated for each spot elevation that must be marked (Figure 8-17).

Moving the Instrument. If the instrument must be moved, take a foresite at a location that is visible from both the existing and new instrument locations. Have the rod operator stay in the same location while the instrument is moved to the new location and leveled. Take a backsite to the same rod location. Calculate the difference between the foresite and backsite. If the backsite is less than the foresite, subtract that difference from

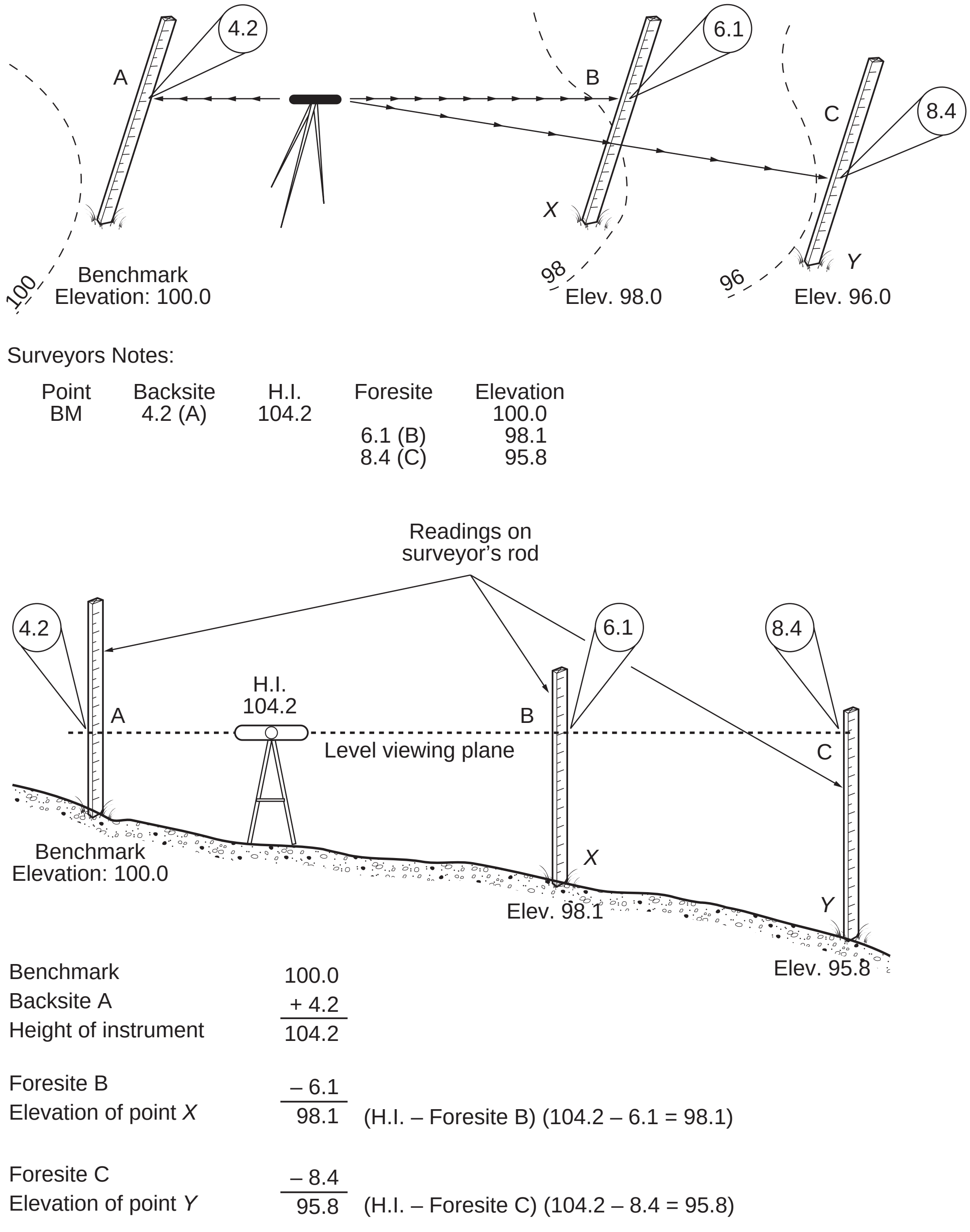


Figure 8-16 Performing elevation calculations. The surveyor's notes and calculations are shown above the figure.

the old height of the instrument to obtain the new height of the instrument. If the backsite is greater than the foresite, add that difference to the old height of the instrument to obtain the new height of the instrument. Continue taking foresites and calculating elevations using the new height of the instrument.

LOCATING PLANT MATERIAL

Locating plant material for a site usually involves marking the boundaries of planting beds and identifying tree and shrub locations. Locating trees and shrubs can be done with construction flags placed at the center point of the proposed planting location (Figure 8-18). Because they are

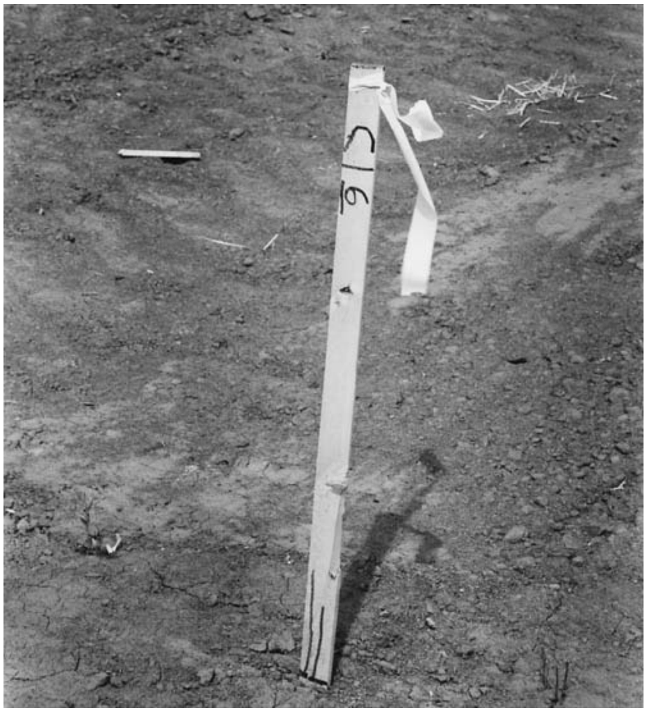


Figure 8-17 Cut markings on a grade stake. This stake shows a cut of 1.6 feet below existing grade (existing grade is indicated by the markings at the bottom of the stake).

Figure 8-18 Flagging of proposed plantings to review placement.

less likely to be confused with standard utility markings, white or green flags are recommended. In projects with many varieties of plants, printing the name of the plant on the flag is beneficial. Planting bed edges can be marked with white paint, indicating the edge between the bed and lawn or other types of plantings. Plantings within a bed may be marked by stringlines or paint lines placed on the ground, or reference markers may be placed along the edges of the planting bed. As with all markings, these indicators may need to be replaced several times during the course of a construction project. Use existing improvements, when available, as references for plant material location.

SECTION 1
SUMMARY

How well contractors prepare for the work often determines the success of a landscape project. Before contractors turn a single shovel of soil, all preconstruction activities should be completed. Section 1 describes the construction process, legal requirements, interpretation of construction documents, construction math, project pricing, safety in the workplace, basic construction techniques, and construction staking activities typically required before undertaking a landscape project.

Landscape construction should be approached as a process with several interlocking steps. To maintain work efficiency, contractors should complete these steps in an orderly and logical fashion that allows current work to build on, rather than disturb, work previously completed. Although contractors may make adjustments to address particular project requirements, the typical steps to complete a landscape project include preconstruction activities, site preparation, rough grading (including drainage and temporary erosion control measures) utility installation, retaining wall installation, paving, site structures and wood construction, finish grading, fencing and freestanding wall construction, amenity installation, and planting.

Landscape contractors must address legal and contractual concerns similar to those that building contractors address. Building codes, ordinances, and legal controls guide the installation of the portions of the project that may put the public at risk. In certain jurisdictions, permits or review of plans may be required before construction can be approved. Work that is bid typically has a set of plans and specifications that bind contractors to the details of the project. Protection for contractors, their clients, and the public is obtained in the form of insurance, bonding, and licensing. In addition to providing quality services, contractors are also required to work within legal boundaries. Before beginning a construction business, contractors should be aware of common torts and activities that may lead to legal action against them.

Occasionally, landscape projects are designed as a general concept or an open-ended project, providing contractors a great deal of flexibility in layout, detailing, and material selection. In many cases, particularly projects that design professionals prepare, contractors must work from a specific set of instructions. Construction plans and specifications (specs) are prepared to guide the location, materials, and installation procedures used in completing landscape improvements. Plans and specs are part of the contract for construction and must be followed to satisfy legal terms of the contract. Various plans may be included, depending on the design professional, but they typically address the preparation (or demolition) of the site, site layout of the improvements, grading and elevations of the improvements, utility installations, plant material installation, and details of critical entities of construction. Specifications provide detailed information regarding the materials and installation methods required for the project, along with general information such as warranties, storage, and other topics related to the work. Interpretation of plans and specs requires that contractors obtain and review a complete set of construction documents. Contractors must also understand the concept of drawing scale and be able to comprehend the variety of graphic standards, symbols, abbreviations, and textures that design professionals use to convey design ideas.

Mathematics is applied to landscape construction in virtually every phase of work. Whether calculating a bid or ordering materials, contractors must master basic measurement and calculation techniques to succeed. Typical math applications that are found in landscaping work include calculating averages, item counts, linear measurements, perimeter measurements, area calculations, volume calculations, and weight conversions. Contractors must understand

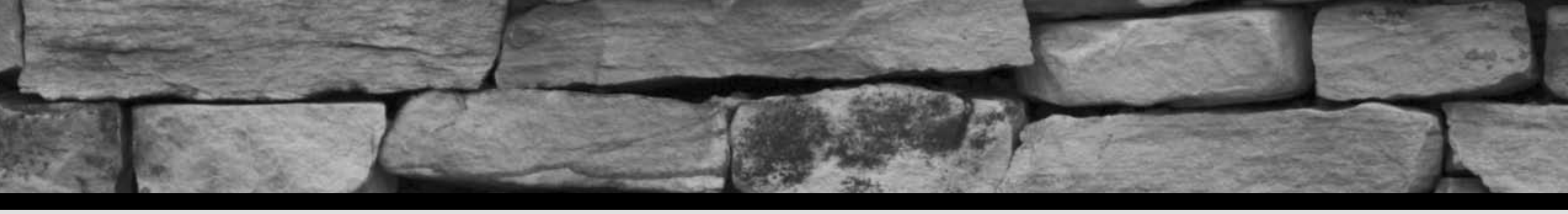
the formulas involved in these calculations and know when they are appropriate to use.

Landscape construction also requires an understanding of the estimating and bidding process and of calculating business operating costs such as labor, overhead, and profit. Understanding the techniques that various types of firms use to calculate and present project costs to potential clients can be equally as important to the success of a business as the work performed.

Safety is an overriding concern in any industry, and landscaping is no exception. Although the risks of the landscaping industry may not be as obvious as those found in other professions, the potential for serious injury or death is just as real. Safety in the workplace should begin with prevention and with education of workers in safety precautions. Wearing proper safety clothing or equipment and being aware of risks on the job will reduce the risk of injury. Proper lifting of the materials used in landscaping is important in reducing muscle injury. Because of the amount of excavation in landscape work, utilities pose a significant risk. Calling for locates before digging is essential. Landscape contractors should also be aware of the potential hazards from working below grade, operating power equipment, and working with the variety of chemicals used in construction.

Basic construction techniques should be practiced and mastered before construction begins. Basic techniques range from digging to mastering essential carpentry skills. Operation of specialized equipment is also required to successfully complete landscape projects.

Proper construction staking of the project begins the project on the right track. Staking the location and elevation of improvements is necessary to install landscape elements in the correct position. Contractors must be prepared to locate improvements for a project or to interpret a site layout plan, which uses object dimensions, baseline layout, grid layout, or batterboards. Establishing proper project grades requires understanding of batterboards, stringlines, contours and spot elevations, and slope calculations. Landscape contractors must also be prepared to locate, or interpret the locations of, plant material and planting beds for a project.



SECTION 2

SITE PREPARATION

INTRODUCTION

The path to improving a site begins with properly preparing for construction operations. Generally, this step can be considered in two steps—preserving existing site elements and removing unwanted elements. Site preparation, or site demolition as this phase is termed in some contract documents, requires the same level of precision in workmanship as does any other phase of work. Failure to properly perform the steps of preparation may lead to reconstruction, hazards and penalties, damage to the environment, or expensive replacement of landscape elements.

The chapters of this section address site preparation in the order in which it should be undertaken—preservation of existing site elements before removal of unwanted elements. Preservation begins with the identification of site access and storage areas, definition of construction limits, and securing of benchmarks and layout baselines. Preservation of existing site elements continues with the fencing or sheltering of plant material, structures, pavement, and utilities. The chapter on removal of unwanted site elements identifies techniques for removing plant material, pavement, minor utilities, and landscape waste.

Landscape contractors should carefully read specifications and discuss the project with their general contractor to determine if any or all of the site preparation work is prescribed in their contract. On large-scale projects, the general contractor or the grading contractor typically undertakes this aspect of the work. Smaller projects may require landscape contractors to complete all site preparation prior to the start of grading and utility work.

PRODUCTIVITY SUGGESTIONS

Activities listed as preconstruction work should be completed at the beginning of site preparation. Some specific suggestions that may be of benefit during this stage are:

- Have any questionable boundaries surveyed before beginning work.
- Early in the project, locate a secure material storage area.
- Before beginning work, review the site for elements scheduled for demolition that may be recycled.

SUSTAINABILITY SUGGESTIONS

To create a more sustainable worksite and work environment, follow these suggestions:

- Minimize the disturbance of the site. Work only in areas necessary and keep to a minimum the footprint of disruption to the natural condition.
- Preserve the existing plant material on site.
- Take efforts to reduce erosion of soil from the site.
- Recycle and reuse any elements that can economically be salvaged, including old piping, paving, lumber, granular materials, soil, and plant material.
- Compost plant material and sod that must be removed.

CHAPTER 9

PRESERVATION OF EXISTING SITE ELEMENTS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Identify elements of a construction site that need protection.
- Effectively protect site elements from damage as a result of construction activities.

Few landscape bids include the price for replacing a 50-year-old oak damaged during construction or replacing a bay window that a skid loader struck. The cost of one construction mishap often exceeds the profit built into a project; hence, proper techniques for preserving existing site elements should be practiced throughout construction.

The concepts of environmental protection and sustainability should be integrated throughout the activities covered in this chapter. Protection begins with a design that considers the impacts of construction and plans mitigation of activities that are detrimental to the site and its environment. Ideally, the design professional provides leadership in protecting valuable resources. The initial physical step to protect a site is to minimize the disturbances when starting construction and to protect portions of the site that are to be preserved throughout the project. During the site preparation phase, establish construction limits and physically protect elements of the site that cannot be disturbed. Beyond avoiding protected areas, search the project for activities that have the potential to damage the site without apparent intrusion, including inappropriate material storage areas, drainage that will foul existing waterways, and temporary access or utility installations that damage plants or disturb soil. Astute contractors will also minimize activities that may introduce unwanted noise, light, dust, or other nuisances into a neighborhood. Consideration must be given to all activities related to construction to appropriately preserve the plants, soil, waterways, and other elements of the site's environment.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Erosion Control, Chapter 13

SITE ACCESS AND STORAGE AREAS

Defining the location of a site access may fall under the design professional's responsibility, but this is sometimes left to the contractor's discretion. Selection of a site access could be as simple as finding a level spot to drive off an adjacent roadway, or selection could be more difficult by a remote, heavily wooded site with steep topography. Considerations for selecting a route to your work should include the following factors:

- Legal Access. Access should not cross another property without the landowner's permission. In certain communities, permanent and temporary access off-public roads must be approved.
- Visibility. Visibility for vehicles entering and exiting the site should not be restricted.
- Traffic. Because unloading may have to take place from streets, traffic should be light during construction hours.
- Level Grades. Level grades make the transitions from street to access easier.
- Size and Type of Vehicles. Verify that openings are large enough for vehicles that will require access to construction areas.
- Utility Locations. Overhead wires and fragile underground utilities should be avoided.
- Construction. Select a route that will not be in the way of present or future construction.
- Minimal Disturbance. Site disturbance should be kept to a minimum.

For sites that require a new permanent access (either walkway or drive), roughing out that new access may provide the best route to the construction site. If a construction site is to be completely disturbed, access may take place at any point until the late stages of construction. Projects that involve only landscaping may require a route across a lawn, which must be restored after construction is complete. Access for pedestrians and small equipment may be accommodated by placing sheets of plywood on the ground to reduce soil compaction and to protect turf. Regardless of the situation, expect your access to create a disturbance that will require some level of restoration, ranging from aerating compacted soil to removing temporary driveways.

Selecting the simplest route that will serve all construction is usually the best choice, even if it involves some work to prepare. Once in place, barricades or a temporary gate should be installed to reduce liability and security problems. The greater the risk, the more secure the perimeter should be. Parking for workers should be located off-site if possible. Finding a street or leasing a parking area near the site reduces the damage that a large number of employees can do with daily trips to and from the site.

Storage areas for work materials require many of the same considerations as site access, along with the following additional concerns:

- Delivery may take place from semitrailers, requiring the storage area to be accessible from both a public street and the construction access.
- Security of stored materials may be a problem in some environments. Fencing may be necessary to protect valuable supplies from theft.
- Temporary utilities may be required if plant material is watered or if materials are prepared (cutting, planing, trimming, etc.) in a storage area.
- Storage for plant material should provide the proper environment for plant health, including access to water and shade, if required.

Similar to construction access, the simplest storage site usually works best for most construction projects (Figure 9-1).

EQUIPMENT CHOICES

Limiting damage to site elements, such as trees and soil, begins with selecting the equipment for performing work on the site. Choosing equipment that is oversized for the job will result in unnecessary site destruction. Equipment that is light and small can pass more easily through wooded areas and causes less compaction than does large, heavy equipment. Choosing appropriate tools and equipment will save both money and time, as well as be less destructive to the environment.

CONSTRUCTION LIMITS

Where you will be performing work is usually not in question. However, areas where you are *not* to work can be confusing. Projects may have limitations on the areas that your construction activities can disturb, and the construction limit line defines these boundaries. Identified in construction documents as a line around the project, limits should be located early in the project and fenced or marked to prevent violations of boundary restrictions. If the project does not have construction limits, verify that the limits are the owner's property. Hire a land surveyor to locate property lines that are in question. If no limits are defined for your project, care should still be taken to avoid and protect sensitive areas. Another concern is how your work may affect

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Figure 9-1 Selecting a simple and accessible storage site.

areas outside your construction area. Chapter 2, Legal Requirements, identifies some of the off-site problems that could arise from your construction activities.

The effort made to lay out the horizontal and vertical controls for your site should be protected by clearly marking benchmarks, grade and layout stakes, and other reference marks that will be referred to often (Figure 9-2). Protection could be as simple as spray painting with a bright fluorescent color to aid in identification. In some cases, however, protection may require setting a fencepost or metal stake. Providing several options for reestablishing destroyed references, multiple reference points ease the pain of an accidental disruption.

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Figure 9-2 Baseline reference markings for project layout.

PLANT MATERIAL PROTECTION

For landscape contractors, the need for providing plant material protection should be obvious. Unfortunately, many tradespeople are not familiar with plant culture and fail to practice proper protection techniques when working around plant material. Construction poses several perils to mature plant species at a site; and, in most cases, the damage does not become apparent until several years after the construction project has been

completed. For this reason, members of the landscape contracting industry must become stewards of the site by practicing sound plant protection techniques. Familiarizing yourself with the identification and cultural requirements of plants helps you recognize which plants are most sensitive to construction and which construction practices pose the greatest risk to plants. Using the philosophy of trying to keep protected plants in their same preconstruction environment throughout construction will help reduce overt and latent construction damage.

Begin the preservation process by judging which plants require the application of preservation techniques. An unfortunate, but necessary, aspect of the process is evaluating plants to determine if they should be afforded the effort of preservation. Although many plants deserve protection, some plants should be removed rather than protected. To make such a judgment, consider the following factors:

- Is the plant in good health? A plant in serious state of decline will probably not survive attempts to preserve it through a construction project. Evaluate the plant to see if it has serious structural flaws, disease, or insect infestations, or is in generally poor health. Do not assume that size is the best determinant of a plant's health. In some cases, the larger plants may be in worse condition than are the smaller, healthier plants. The best philosophy is to protect plants that are currently in good health.
- Is the plant suffering from prior damage? Evaluate the plant's crown, branches, trunk, and roots to see if it is currently suffering from old injury. Significant damage in each of these areas, particularly the root zone, may be reason enough to remove the plant, rather than protecting it.
- Will the plant survive the new environment after construction? Each plant has a set of cultural requirements to ensure its survival. A plant may be able to survive the construction phase only to decline as a result of significant changes in its immediate environment. Although these issues may have been addressed in the planning phase, designers sometimes miss the obvious. A plant that is shade-loving but will now be in full sun, a floodplain plant now in dry conditions, or a plant that has grown in a forest now placed in an unprotected position are examples of a significant environment change. Conditions such as these are likely to lead to the plant's premature decline. In many situations, it is more effective to remove the plant during construction, rather than after project completion.

If you cannot determine whether these conditions exist, consider asking the advice of a certified arborist. ISA (International Society of Arboriculture) certified arborists should be able to judge whether preserving a plant is a cost-effective and environmentally sound option.

Protection techniques vary, depending on the species and maturity of plants and the construction activity taking place. Overstory (shade) and understory (ornamental) trees are at the greatest risk of damage from site construction activities. This risk stems from the errant belief that if the contractor does not damage the trunk or canopy, the tree will not suffer damage. This belief fails in not recognizing that a plant's **root zone** is as equally important as its trunk and canopy. A plant's root zone extends from the trunk to at least the **drip line,** the imaginary line on the ground directly below the outermost foliage. Depending on plant species and environmental situations, many plants have root zones that extend well beyond the drip line. Compaction, trenching, mixing of chemicals, excavation, storage of materials, and related construction activities within a plant's root zone will damage its root system and eventually damage the remainder of the plant. Protection from damage must extend at least to the plant's drip line; and, in some cases, consideration must be given to restricting activities outside the drip line (Figure 9-3). Because of their size and vigor, many shrubs are more durable when exposed to construction activities. However, shrubs should be afforded the same protection given to trees to increase the chances of their survival.

Compaction

Compaction from traffic and material storage within the drip line must be avoided. Fencing a plant at the drip line and leaving the fence in place throughout construction will divert traffic and activities from the plant. If traffic within a drip line

Figure 9-3 Fencing placed at a tree's drip line to protect the root zone.

is necessary, accommodate the need by building a temporary elevated wood boardwalk or placing 6–8 inches of loose, organic mulch over the ground within the drip line. Avoid piling mulch against any plant's trunk. Water the mulch daily. These techniques will only reduce the compaction of root-zone soil.

Root-Zone and Canopy Damage

Because it entirely severs the root structure from the plant, trenching within the drip line should be avoided. Reroute utility lines from the area under the plant's canopy when possible. If utility lines must pass within the drip line, bore the lines 3 feet deep to pass under the plant's root zone. Excavation within the root zone creates the same type of disturbance as trenching, whereas filling within the drip line will suffocate many plants by blocking the path of gases and nutrients to their root zones.

In many cases, aerating the root zone may assist in partially mitigating construction damage from compaction. One method to improve aeration and to reduce compaction is to place 2–4 inches of loose organic mulch over the plant's root zone. When adding mulch, do not place it next to the plant's trunk. The second method of aerating a plant's root zone is to vertical mulch. To perform this activity, drill 12-inch deep by 3-inch diameter holes 3 feet on center throughout the root zone. Fill the holes with pea gravel, peat moss, or mulch to allow air and water to infiltrate the root zone (Figure 9-4). A third technique is to use radial trenching. Select five to seven locations radiating from the tree's trunk, avoiding major roots if possible. Beginning approximately 4 feet from the trunk, excavate a 12-inch deep by 2-inch wide trench to the plant's drip line. Excavate by hand or use a compressed air excavation tool (Airspade®) to reduce damage to roots and utilities in the

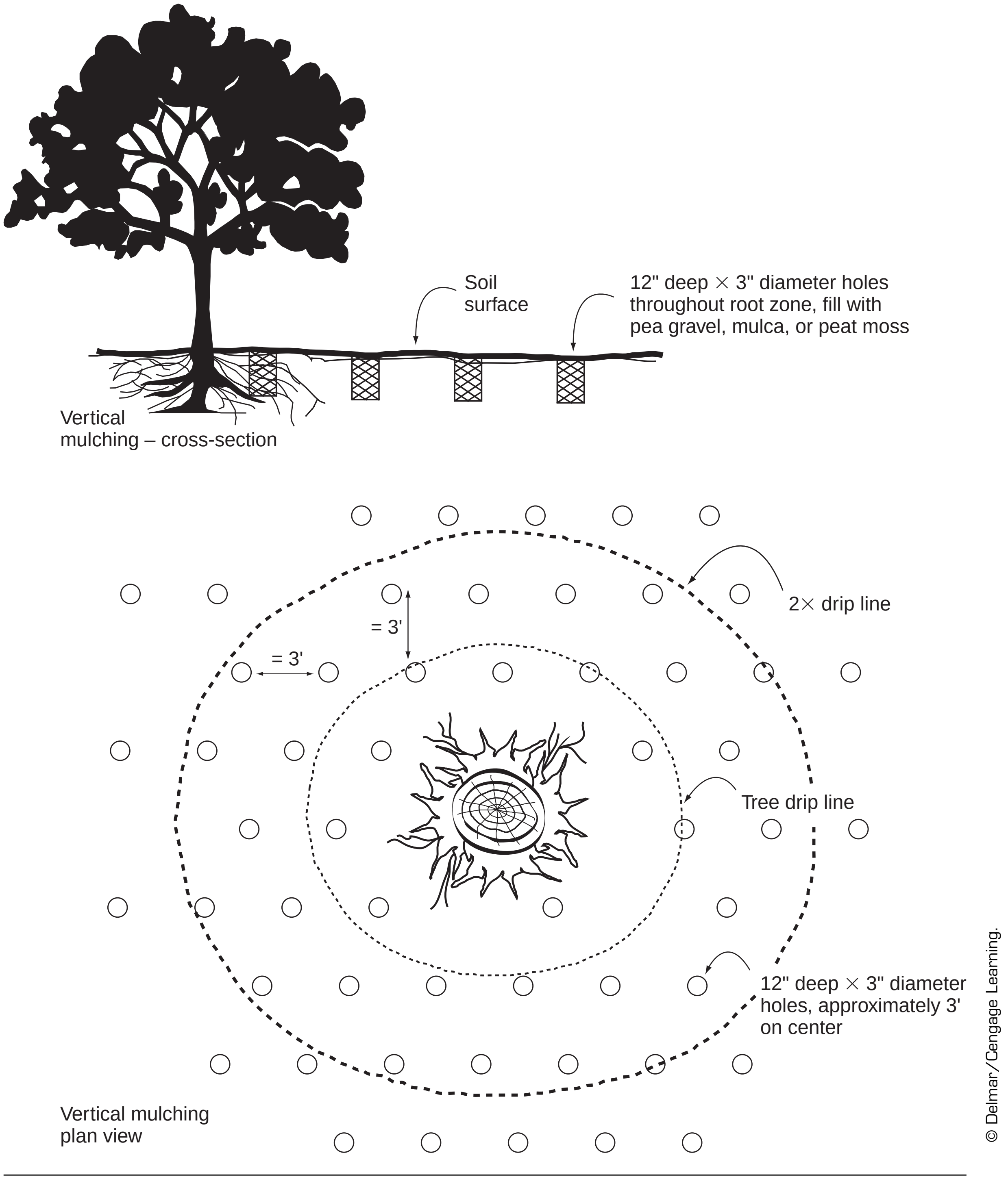


Figure 9-4 Vertical mulching.

excavation area. Backfill the trench with loose soil or compost with mycorrhizal fungi added (Figure 9-5). This technique may encourage new root growth to replace those damaged by construction. Contractors have used both vertical mulching and radial trenching with mixed results in a variety of applications, including root zone soil compacted by construction activities.

Tree wells (Figures 9-6 and 9-7) are recommended where possible to reduce the damage from excavation and filling. Tree wells should be constructed outside the plant's drip line and should be designed to maintain the original grade and drainage patterns.

In locations where fill must be placed over large portions of a tree's root zone, contractors' attempts

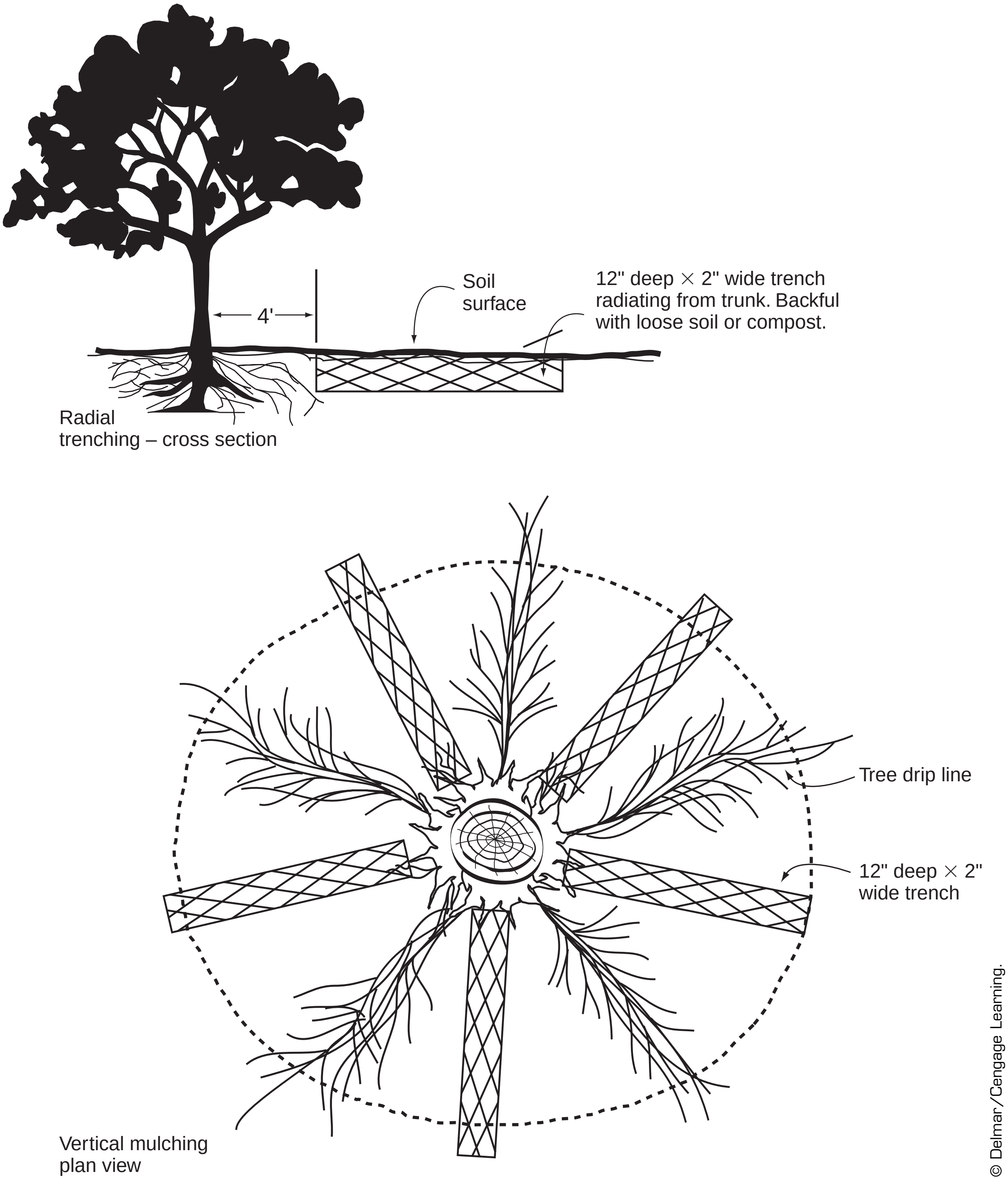


Figure 9-5 Radial trenching.

to construct tree wells and associated aeration systems have had mixed success in preserving plant material. Aeration systems involve placing a large, porous fill and aeration tiles over the original grade to facilitate the exchange of gases in the root zone. Research on the impact of such systems has shown that, in some situations, the systems help plant survival. However, variables such as tree species, type of fill, and percentage of root zone covered all play a part in preserving the plant.

To construct an aeration system, begin by building a retaining wall the height of the fill and at least

Figure 9-6 Tree wells installed to protect existing tree root zone from fill.

2 feet from the tree's trunk. Lay out a tile system of socked perforated 4-inch tile following the tree's drip line in the area that will be filled (Figures 9-8 and 9-9). On the lowest portion of this tile, install a T and a drain tile that outlets beyond the area where the fill is to occur. Every 10 feet along this tile, install a T facing upward. In each T, insert a 4-inch nonperforated drain tile riser that will extend above the fill. Install a stake, and tie the upright tile to the stake for support while filling.

After the tile system is complete, carefully place 4–8 inches of rounded stone in a layer at least 2-feet deep (or to within 6 inches of the surface) over the entire area to be filled. The stone should be free of fine material and create significant amounts of pore space below the fill. Place a geotextile fabric over the stone and complete the fill.

Design for walls and footings around mature plant material should take into consideration protection of the root zone. Avoiding long continuous footings, or installing footings using the grade beam described in the retaining wall unit, will begin the preservation process. Hand-dig in the root zone to the greatest extent possible. When it is unavoidable to remove roots, cut them with a pruning saw, rather than ripping them apart with equipment.

On some construction sites, the source of damage to plant material is well beyond the drip line. Contractors who take advantage of a shade tree to mix caustic chemicals run the risk of damaging plants from spills and leaks. Even changes in drainage patterns from grading activities can lead to plant material damage.

Protection of plant canopies from construction damage can include covering the plant or temporarily tying the branches up/back to keep them out of harm's way. Secure the plants loosely, and do not leave them tied for more than 2–3 days to avoid permanent damage. Placing sheets of plywood over turf will provide temporary protection in an area that may be subject to heavy traffic for a few days. Again, only leave such protection in place for 2–3 days to avoid permanent damage to turf areas.

For locations where occasional traffic will be routed under existing trees, prune the lower branches to a height that is above the equipment's height. When trees must be cut down, direct the tree's fall from plant material to be saved. Limit pruning in stands of trees that are to be protected so that the impact of a sudden change in microclimate is mitigated. Lastly, to make all contractors aware of the concerns regarding protecting the plant zone, post signage that indicates the area to be protected and the prohibited activities within protection zones.

STRUCTURE PROTECTION

Structures are provided a level of protection by their size and their dominance of the landscape. Even with this inherent protection, structures are

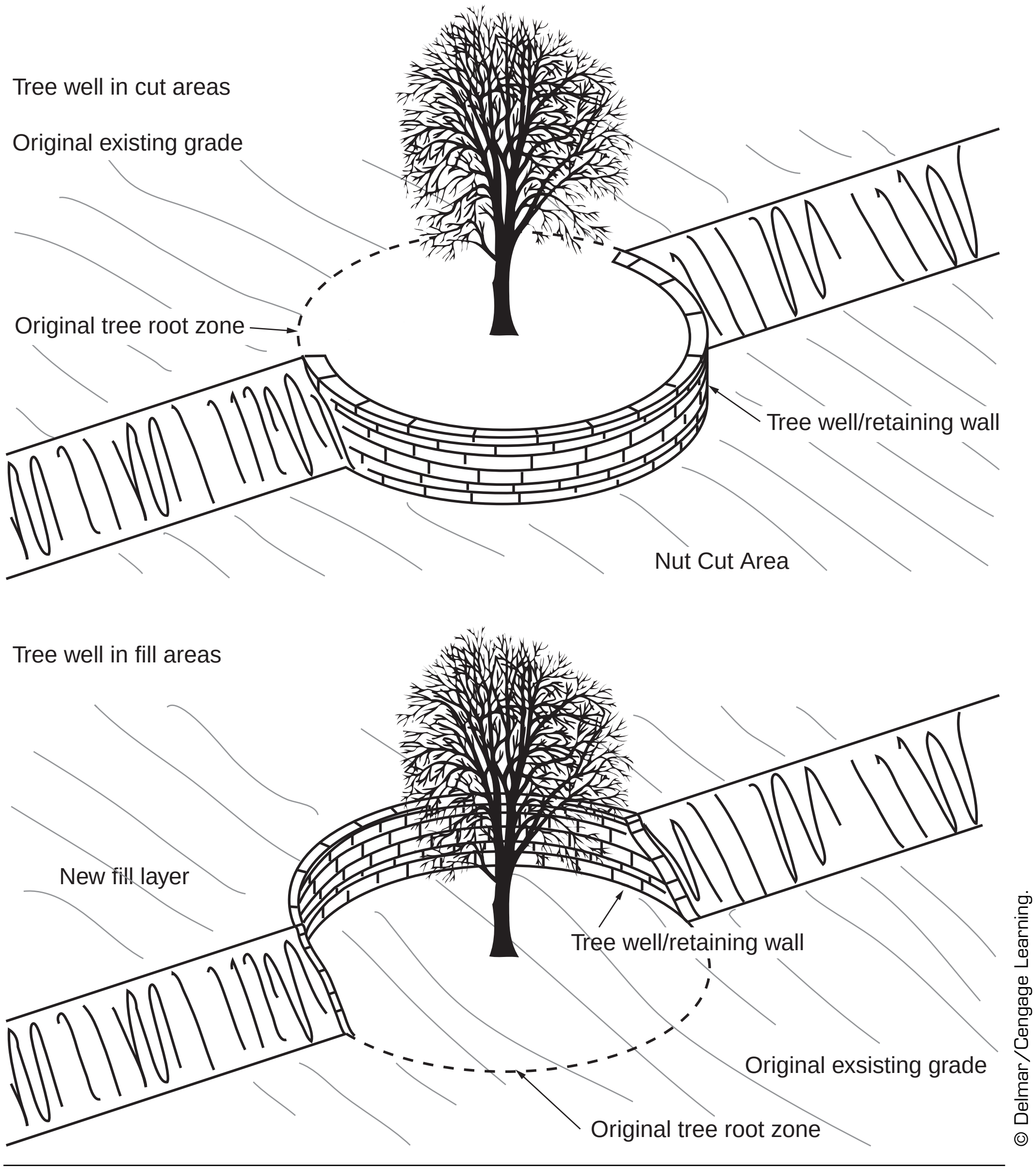


Figure 9-7 Tree well in fill areas.

vulnerable to damage from landscaping operations when care is not taken. Windows can be covered with plywood to protect from shovels, gravel, and other flying objects. Staple or tape sheets of plastic over finished side walls of structures to prevent damage when painting, pouring concrete, cleaning surfaces, or performing any activities likely to splatter materials. Corners of structures can be protected by placing wood fenceposts on either side of the corner, particularly in locations where traffic is routed near a corner. Routing traffic from a structure and placing storage areas apart from buildings also reduce the potential damage from equipment and activities.

PAVEMENT PROTECTION

When a construction project requires that foot or light traffic be routed across existing paved areas, care should be taken not to damage such surfaces. Rubber track equipment will minimize damage to concrete and asphalt surfaces unless the pavement base is already in poor condition. Rubber deposits may be left on concrete after construction and can be removed with water and scrubbing. Unit paved surfaces, such as brick and limestone, may be damaged by any equipment and should be protected using the methods outlined for heavy traffic. Heavy traffic requires protection that will prevent cracking and settling. Simplest among the protection

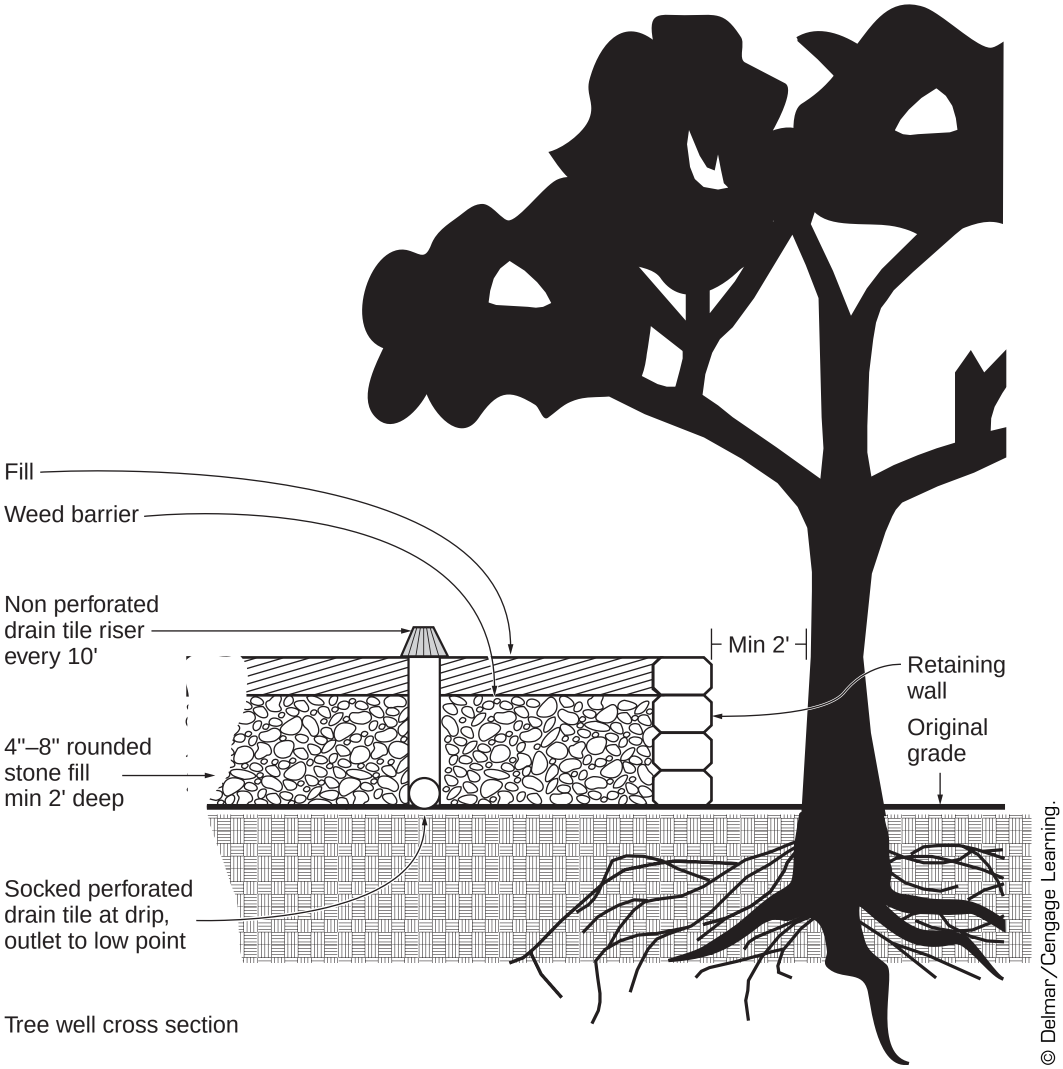


Figure 9-8 Cross section view of a typical tree well.

techniques is to route traffic around the paved area. If rerouting is impossible, mound 12 inches of soil over the pavement in the area where the traffic will be crossing (Figure 9-10). This will redistribute the weight and reduce the stress on the pavement. An alternative is to build a temporary bridge out of 4 × 4s and large-dimensioned (4 × 12, and up) wood planks (Figure 9-11). This method will transfer the weight to the ground surrounding the pavement.

UTILITY PROTECTION

Damage can occur from heavy traffic passing over utility lines buried at a shallow depth. Particular concern should be given to shallow irrigation lines, shallow gas lines in copper or PVC pipe, and PVC or clay drainage tile. Protection can be provided in these instances by increasing the soil depth over the line or by placing 2 × 12 lumber in the tracks of the path over the utilities. Low overhead utilities should be avoided or temporarily relocated to reduce the risk of contact with vehicles and workers.

PERIMETER PROTECTION OF CONSTRUCTION SITE

Temporary fencing should be erected at all construction sites to protect the public from the hazards of an in-progress work area. Broken or removed pavement, open excavations, and unfinished

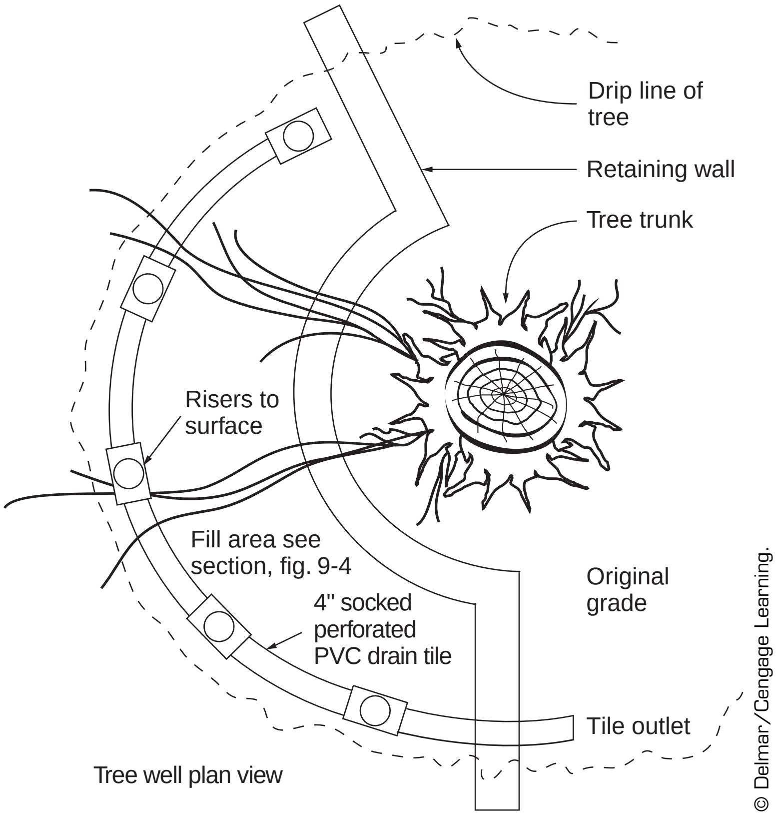


Figure 9-9 Plan view of a typical tree well.

Figure 9-10 Building a temporary bridge during construction.

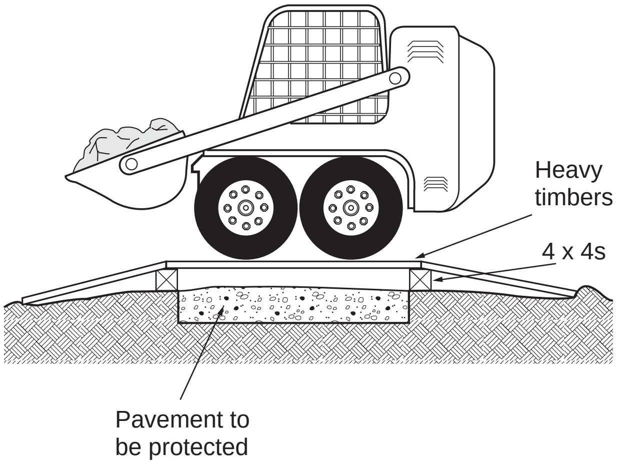


Figure 9-11 Temporary bridging to protect paving from construction traffic.

surfaces are just a few of the potential danger areas from which an unsuspecting public could sustain injuries. Temporary fencing can be brightly colored utility fencing stretched tightly between posts (Figure 9-12) or chain-link fencing temporarily installed or anchored in concrete blocks (Figure 9-13).

PRESERVATION OF SOIL

Soil, like plant material root zones, is often overlooked when providing protection to a construction site. Assumptions are made that soil is a benign element of the site and, if damaged, can be easily replaced. Many contractors do not know that healthy soil is a living organism that, through its many components, provides life for the plant material on which landscape contractors base their livelihoods. Soil is a blend of minerals, organic matter, air, water, and soil organisms that produce the nourishment that plants rely on for growth. Damage to the soil, whether by grading, compaction, or trenching, disrupts this complex organism to the point that it can no longer provide that nourishment. Whenever possible, completely avoid construction activity on healthy soil. If construction is necessary, consider adding a 4–6 inch layer of mulch over the soil to limit compaction. When soil is disturbed, consult a landscape architect or horticulturalist to determine the best way of mitigating the damage. Damage can be compounded when soil repair with inappropriate amendments is implemented.

Figure 9-12 Installing temporary fencing at a construction site to protect the public from hazards.

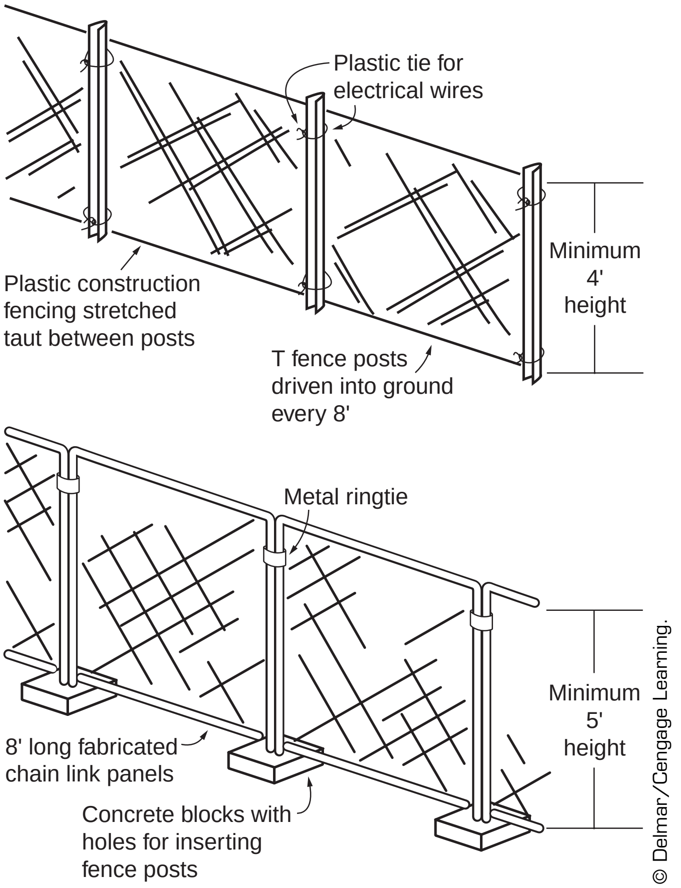


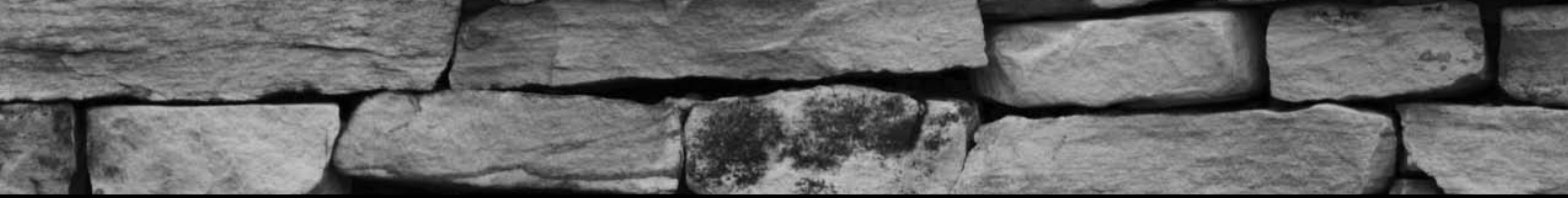
Figure 9-13 Temporary fencing methods used to protect public from construction hazards. Top figure shows plastic fencing on posts, and the bottom figure shows temporary chain-link fencing.

PROTECTION OF ENVIRONMENTALLY SENSITIVE AREAS

Construction activities that deal with exterior environments are likely to have issues regarding protection of sensitive areas. Recognizing the importance of preserving delicate natural environments has led to approaches that mitigate the negative impact of construction on areas such as woodlands, wetlands, prairies, dunes, and wildlife habitats of all types. Probably the most important ingredient in the approach to sensitive areas is the contractor's awareness. As workers who are engaged in the development of the environment, we must be the first to recognize the need to value these areas and to actively engage in preservation activities.

The most effective step in protecting sensitive areas is to avoid direct and indirect construction activities in them. Compaction of soil in a wooded area or even temporary draining of a wetland can do irreparable damage. Even minor changes in the environment around the area can change the characteristics of a wetland or a forest. If construction can avoid the sensitive area, the chances of preservation are improved. Contractors from nonlandscape trades may lack the knowledge to identify and preserve sensitive landscapes; hence, identification is an initial step to preservation. Fencing the area beyond the perimeter will assist in identification. Notifying all workers and inspectors will also aid in protection. Indirect construction can also play a significant role in damaging sensitive areas. Runoff from projects should be redirected if possible. Silt fence (see Figures 13-2 and 13-3) should be installed to prevent eroded soil from passing into a protected area.

In the event that construction must take place within the boundaries of a sensitive area, certain precautions can be taken to minimize the potential damage. Limit disturbing activities such as grading, utility work, and deliveries to a single corridor through sensitive areas. Provide temporary cover such as mulch or planking for the circulation routes through such areas. Suggest boring utilities under protected areas, rather than trenching through them.



CHAPTER 10

REMOVING UNWANTED SITE ELEMENTS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Identify elements of a construction site that need to be removed.
- Effectively remove site elements.

Removing existing landscape elements seems foreign to the concept of landscape construction, but most projects require some level of demolition to make way for new elements.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Preservation of Existing Site Elements, Chapter 9
- Erosion Control, Chapter 13

PLANT MATERIAL REMOVAL

Techniques for removal of plant material differ, depending on the type and size of plants being removed. When removing plants, you must remove the majority of their vegetative parts. Uneven settlement will occur in paving or finish grades if, for example, you leave large portions of stumps in place to decay. Excavating all roots is impractical, but you should remove root crowns and large feeder roots. Also, do not bury plant material waste in areas where finish grade is critical.

Stripping sod and ground cover requires scraping a thin layer of plant growth off a large area. Cut and remove the material by hand or use a sod cutter, and pick up debris with a skid-steer. A technique for larger areas is using a skid-steer with a toothed bucket to peel the sod away from topsoil. This technique requires an experienced operator and more fill because the bucket removes more topsoil with the sod. For very large projects, contractors may use huge earthmoving equipment such as a paddle scraper to successfully peel the ground cover away from the topsoil over large areas.

Removing Shrubs

Shrub removal requires two steps to successfully remove plant debris. Canes or branches of shrubs are cut and removed; then the crowns or roots are dug out and removed. To facilitate the removal of shrub canes, tie twine around the canes and pull them into a bundle; then cut at the base using a chainsaw. This technique works for all but a few spreading and prostrate shrubs and speeds the removal and disposal process. Remove the crowns by hand-digging around and under the crown or by excavating a trench around the roots, hooking a chain around the crown, and pulling the crown out with a tractor. A backhoe will speed the process by excavating the entire crown in one operation. Prostrate shrubs can be removed in a single step by undercutting and lifting them out with a skid-steer.

Removing Trees

Tree removal requires a systematic removal of plant parts, from crown to roots. Begin with the removal of as much of the plant's crown portion as can be removed safely from the ground. Using the steps outlined in the following list, fell the remaining portion of the tree. Remove and dispose of the remaining crown and trunk portions; then remove the stump. To safely cut down trees that do not meet the restrictions outlined in the Caution, follow the steps listed.

CAUTION

Safe felling of a tree requires the operator to be aware that even a small tree carries a great deal of weight and force when falling. Trees over 30 feet in height or 10 inches in diameter and trees located next to structures, utility lines, or other permanent improvements should be professionally removed.

CAUTION

Removal of trees requires use of power equipment. Follow manufacturer's safety instructions for equipment operation.

- Determine the direction for the tree to fall. The direction of fall can be controlled to a certain degree, but gravity will tend to pull the plant in any direction it is leaning.
- Verify that an area twice as long as the tree's height and twice as wide as the tree's spread is clear of any improvements and other large plants.
- Clear an escape path from the tree and from the direction planned for the tree to fall (Figure 10-1).
- At approximately 4 feet above the ground and on the side of the tree facing the direction the tree is planned to fall, cut a *V*-shaped notch one-third of the way through the trunk.
- On the side opposite and slightly above the *V* cut, begin cutting down at an angle toward the point of the *V*. Do not cut all the way to the *V*, and do not stop cutting until the tree begins to fall (Figure 10-1).
- When the tree begins to fall, remove and stop the saw and walk away along the planned escape route. For even a small tree, move 10–15 feet away from the tree to avoid the possibility of the tree "kicking back" toward the operator.

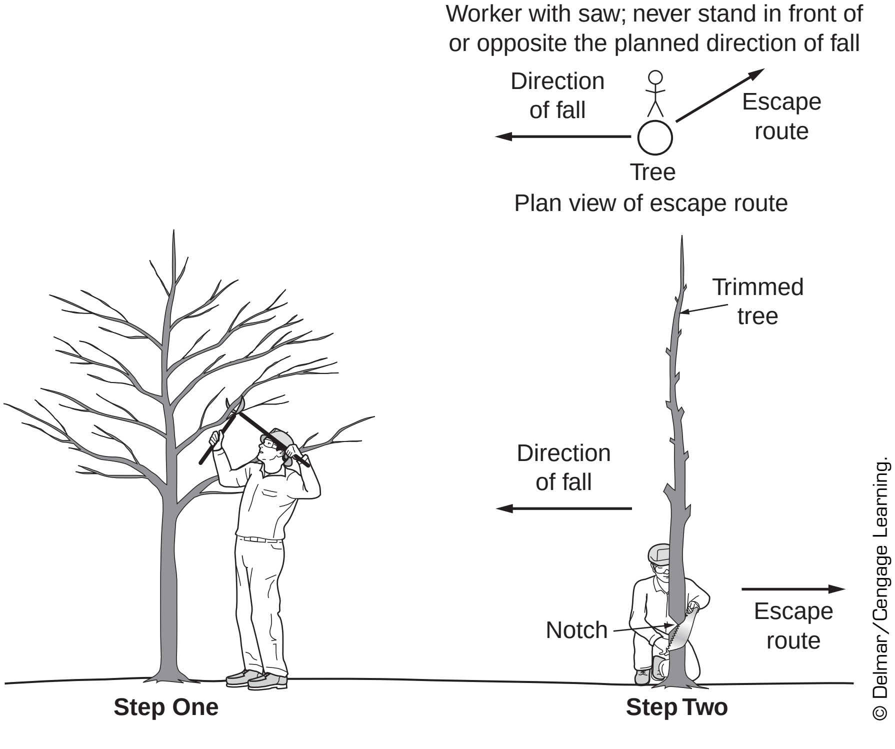


Figure 10-1 Removal of a small tree.

When the tree has been **felled,** cut the side branches off the main trunk. Use caution when completing this operation because the trunk may shift when a supporting branch is removed. Branches may be bent under the tree and snap back when cut. After removing side branches, cut the trunk into manageable pieces that can be hauled away. Grub small stumps using a skid-steer with forks or a backhoe. In some circumstances, you may want to rent a stump grinder to remove the aboveground portion. Large stumps require a great deal of excavating to remove the majority of the roots.

PAVEMENT REMOVAL

Removal of pavement and other permanent improvements is a labor-intensive operation. Rental of specialized demolition equipment for this phase of work is highly recommended if large areas of pavement need removal.

Preparation for removal of pavement varies, depending on the type of pavement being removed. If portions of the pavement are to be saved, cutting with a concrete saw is required before removal can occur. Unit paver surfaces require the removal of edge-restraint material to allow access to the surface. Slab pavement usually requires that the slab be broken into pieces for removal and hauling. For small areas, you can perform this operation by hand with a sledgehammer or jackhammer; but for larger areas, you will need equipment such as a backhoe or excavator.

Portable jackhammers are either air- or pneumatic-powered. To effectively remove pavement using a jackhammer, use a breaker bar to score the concrete into pieces small enough to be hand removed. Start the jackhammer removal by driving shallow indentations every 4 inches along the score line. Have an assistant place a levered bar under the portion you are attempting to remove and lift up on that piece. As you continue working down the score line, the pavement should break (Figure 10-2). You know concrete is fracturing when the tone of the hammering becomes deeper. If the pavement does not fracture after the entire piece has been hammered, repeat the process; but this time drive the point of the hammer completely through the pavement. If the driving point becomes stuck in the pavement, disconnect the jackhammer. Install another point in the jackhammer and drill around the stuck point until the concrete is loosened.

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Figure 10-2 Using a portable jackhammer to break up pavement to be removed from a site.

When larger areas of pavement need to be removed, contractors often use a skid-steer or other large equipment. A skid-steer bucket can lift and drop the pavement, breaking it into more manageable pieces, or contractors can presaw the slab into pieces and then lift them out with the skid-steer bucket. Some contractors rent larger equipment that can remove slab pavement without breaking it into smaller pieces.

After the slab is broken into manageable pieces, locate a spot along the edge where equipment can work under the pavement to begin lifting it out. Excavate soil away from that portion of the slab to allow access under the slab. Work carefully in removing the old surfacing. Caution is advised here; pieces of the pavement should not be forced against structures, footings, or other improvements that need to remain intact. Working at right angles to, rather than toward, structures can reduce damage to existing footings or foundations. Backhoes are used to excavate working areas around footings and foundations that are buried to frost depth. Using the backhoe bucket, the operator can then break and remove these structures.

CAUTION

When removing concrete, always wear protective clothing and gear. Eye wear, gloves, long pants, and ear protection are essential.

UTILITY ABANDONMENT AND REMOVAL

Unearthing and removing old cables and pipes for utilities will reduce confusion for future excavation projects. Abandoned utilities for a site are usually disconnected, capped, and left in place. A certified technician should perform these operations, particularly for gas, electric, fiber optic, potable water, and sanitary sewer lines. If possible, abandoned utilities should be physically removed.

Landscape construction crews sometimes encounter storm water drain lines and tiles. If the lines are active, they should be reconnected or rerouted to avoid new construction. Inactive lines should be capped or plugged to prevent subsurface drainage problems. Such lines can be capped with a PVC cap placed over the end of the pipe, or they can be plugged by placing mortar or **bentonite** into and over the end of the abandoned line. Abandoned utility lines, particularly drainage and sewer lines, may appear inactive during part of the year but then run at capacity during other times. For this reason, removing drainage and sewer lines to their source, rather than capping or plugging them, is often the better option.

BURIAL AND ABANDONMENT OF UNWANTED SITE ELEMENTS

Contractors may be tempted to cover over existing site elements, rather than removing them. This practice is not recommended for the following reasons:

- There is always uncertainty and confusion when utility lines are later uncovered.
- Buried site elements can restrict plant growth. Roots for trees and shrubs may not be able to reach groundwater levels, and sod may dry out faster over an old improvement left in place.
- Future excavation is made more difficult and expensive when old footings or slabs are uncovered.
- Settlement of topsoil will take place at different rates over old site elements left in place.

If on-site burial of waste is planned, be certain that the waste pit is in an area free of any existing or planned structures, pavement, or utilities. Burial pits should be covered with a minimum of 5 feet of soil to provide adequate base for plantings.

RECYCLING AND WASTE DISPOSAL

Methods for waste disposal in landscape construction run the range from using landfills to creative recycling and reusing by-products. Whether environmentally sensitive or insensitive, disposing of landscape waste is an issue for which landscape contractors must prepare. Restrictions on placement of organic waste in landfills and markets for recycled material now counterbalance the temptation to place all waste in a landfill. Because quantities of recyclable materials are generally small for a single project, contractors may find that stockpiling of materials or taking several small loads to the recycling plant is more cost-effective. If contractors make the effort to reuse and recycle, they can use many by-products of site preparation in other aspects of landscaping.

Use caution when removing, transporting, recycling, and disposing of hazardous materials. The

following paragraphs discuss ways to dispose of materials that are removed from the landscape.

Reusing Landscape Materials

Piecemeal adaptive reuse of old landscape materials has been taking place for decades. Following are a few creative suggestions for reusing hardscape material:

- Stone can be reused. This material is timeless and has several applications as walls, paving, steppers, edging, or lining swales.
- Bricks or pavers can be reused as paving, edgings or steppers.
- Concrete pieces can be used for paving and wall material or can be ground and spread as a loose aggregate surfacing. Verify that all reinforcing materials have been removed before reusing concrete pieces as a surfacing material.

Recycling Landscape Materials

Landscape contractors can recycle healthy, woody plant material by using a chipper to create shredded and chipped mulch. The parent material determines the quality and reuse value of this mulch. Material composed primarily of woody plant parts can be used for landscape beds, whereas material with small branches and foliage may be acceptable only for field mulch or **composting** purposes. Diseased or insect-infested plant material should be burned or buried, the choice depending on the disposal technique recommended for the ailing plant. Sod that is stripped from the site can be composted, along with miscellaneous plant waste.

Most landscape materials can be recycled. Many recycling centers accept metals from fences, wood from decks, plastic and metal from edging, concrete and asphalt paving, crushed bricks, wiring and piping, and many other undesired landscape materials. The quantities of waste generated and the time required to separate and deliver the materials often limit the extent to which contractors can engage in recycling.

Using Landscape Waste as Fill Material

When properly placed and compacted, certain waste soils can be used as fill. This filling procedure can be done on-site or transported to an off-site facility. Clean soil of the proper type and without debris is satisfactory for this procedure. Soil contaminated with wood, paving, or other nonsoil material is not suitable for trenching and future underground and should not be used. Soil surfaces become unstable when large quantities of organic material decompose; hence, sod strippings are not suitable as fill material.

Disposing of Material in a Landfill

Placing waste in the local landfill requires a minimum of effort, but this option can be expensive to contractors and the environment. Many localities enact strict regulations on what materials can be placed in landfills, including limitations on plant material. Paying fees based on the tonnage of material disposed, contractors typically haul and place the waste material. Organic materials, including green plant matter, are sometimes composted if the solid waste facility has the processing equipment.

Transporting Waste

When hauling waste over public roadways, contractors must ensure that proper enclosure is provided to prevent spillage. Using vehicles with tailgates or enclosed cargo areas or covering or tying down loose plant waste may be required. Review with municipalities and state transportation departments for regulations regarding proper hauling of waste.

SECTION 2

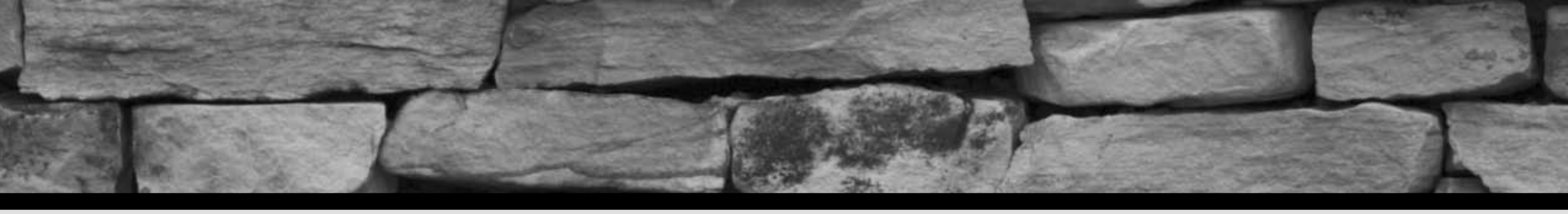
SUMMARY

Initial work for a landscape site includes preparing for the planned construction. Any site elements to remain should be identified and protected, and those elements not incorporated into the design may need to be removed. Section 2 identified construction techniques basic to these steps, along with standard site protection and demolition activities.

For large projects, preservation of existing site elements can cover many activities; for small projects, a simple marking of plant material may be the only activity needed. Typical considerations when preparing a site for construction include identification of a safe, legal access to the site and secure storage of materials. Most projects will also require identification and, in some cases, fencing the limits of the construction. If layout was performed using benchmarks or baselines, those reference points should be clearly marked to avoid future disruption.

Throughout the project, landscape contractors should consider how construction impacts existing plant material. Plants to be preserved should be protected from compaction, trenching, and other construction activities within, at least, the drip line. Permanent improvements such as structures, pavement, and utilities also require protection from construction damage. These preservation techniques may range from marking to fencing the improvement. Environmentally sensitive areas also require special attention when construction activities are in proximity of wetlands, prairies, woodlands, and similarly protected plant and wildlife areas. Avoiding the sensitive area provides the best measure of preservation. However, in cases where avoidance is impossible, contractors may have to provide protected corridors and perimeter protection. Installing tree wells to protect mature plant material is one example.

Removal of unwanted site elements may require cutting out plant material or demolishing old site elements. Attention to safety should be a priority when removing old site features, particularly large plants, structures, and utilities. Because the action impacts future work, burial or abandonment of unused site elements is not recommended. Proper disposal, including reusing and recycling of landscape waste, is required for any demolition project.



SECTION 3

GRADING, SITE DRAINAGE, AND EROSION

INTRODUCTION

Water and soil play leading roles when considering the many elements of the typical landscape. A contractor's ability to properly manipulate these two elements often determines a project's long-term success or failure. Soils vary significantly in terms of composition, texture, stability, and fertility. If the soil is not the right type or not placed in the proper amount using appropriate procedures, improvements may settle prematurely and plants may perform poorly.

Water's role in the landscape is probably more extensive than that of any other element. Controlling water can reduce the impact of such landscape problems as drought, frost heaving, **erosion,** settling, and ponding. The interaction of water and soil can cause erosion, one of the most devastating landscape problems. Improper manipulation and inadequate protection of a site's surface are common problems in landscaping projects of all sizes.

The chapters of this section explore the steps of the grading process, methods for effectively draining water from a site, and protecting a site from common forms of erosion. Included is a review of the grading process, which is often split into rough grading steps that occur during the initial steps of the construction process, and finish grading, which typically occurs near the end of the process. Performed in concert with grading, development of drainage systems must effectively remove unwanted water from a site without flooding, eroding, or otherwise disturbing the site's surface improvements. This challenge is addressed in the development of surface drainage patterns and, if necessary, the addition of subsurface drainage structures.

Techniques are presented for grading surface slopes and swales to provide positive drainage throughout a construction site. Subsurface systems such as tiles, french drains, and storm sewers are also introduced as more comprehensive methods for dealing with large quantities of storm runoff and water problem areas. Erosion protection concentrates on protecting a site's perimeter from runoff, providing surface protection from sheet erosion, and reducing channel problems from gully erosion.

WORKING WITH SOIL

Essential to successful grading and erosion protection is understanding the types of soils on the site and the suitability of those soils to perform the

functions required by the landscape plan. Soil is an amalgam of minerals, organic matter, and living organisms interspersed with voids of varying sizes that are filled with air and/or water. The mineral and organic components determine the physical and chemical properties that allow us to predict if we can build structures or grow plants on a given soil. The parent material that formed the soil and the environment in which the soil was formed determine these properties, which in many cases can be altered with soil amendments or, in the case of structural uses, removed and replaced with a more suitable soil.

A wide variety of living organisms enhance the mineral and organic components of soil. These organisms, which include bacteria, fungi, algae, arthropods, and many species of insects and micro-organisms, are responsible for the decomposition of the mineral and organic component into nutrients that plants use for growth. This living component of the soil also provides the "glue" that holds soil together, makes it resistance to diseases, and enhances the overall performance of plant material. Where soils have been undisturbed, even in poor environments, this rhizosphere (or root zone) is a fragile environment that cannot be recreated by adding amendments or soil replacements. Although some disruption to a site cannot be avoided during construction, making sound judgments about the soil environment and the extent of the disruption will ultimately lead to the best landscape possible.

Soil types have an impact on whether a soil can be reused on the site, whether it must be disposed of off-site, whether structures can be built on it, or how susceptible it is to erosion. It would be impossible to define the characteristics of all soil types in this text, but one basic trait of soil that provides clues to its workability is its composition. Soil is composed of three basic particle types—silt, sand, and clay. Each soil type is a combination of these particle types, and the percentage of each determines the soil's stability and suitability for landscape tasks.

A general rule is that soils high in silt are suitable for planting areas but are undesirable for built areas, whereas clays are suitable for built areas but are undesirable for most planting areas. Based on the percentage of sand they contain, soils may be unsuitable for both. Sandy clays are possible substructure soils, whereas sandy loams, or silts, are suitable for plantings. Soils with high sand or silt content are most susceptible to erosion. Topsoil (dark soil found near the site's surface) is typically rich in organic matter and, in most situations, is capable of supporting plant growth.

Specific information regarding the suitability of site soils can be obtained from a soil survey book, soil conservation service, or, for critical areas, from a soils engineer. Reviewing and understanding this information will improve the success of any landscape project.

SUSTAINABILITY SUGGESTIONS

- Take whatever measures are available to preserve soil on your site. Soil is not just a site commodity to be manipulated solely for the purpose of supporting structures and sculpting the site. Rather, soil should be treated as the complex organism it truly is. Leaving soil undisturbed during construction would be the highest level of protection that can be afforded. Within soil is a complex network of minerals, organic matter, and organisms that, once disturbed by grading equipment, can seldom be recreated. Once soil has been dug, moved, compacted, or altered in other ways, it will take much time to return to its level of original productivity.
- Minimize erosion of soil from a construction site.
- Manage water on your site with conservation in mind. Use technologies that store water for reuse or allow water to be returned to the soil, rather than allowing rain and irrigation excess to run off the site.
- Carefully consider your equipment needs, rather than automatically choosing power equipment over hand labor. In fact, performing tasks with hand tools may be more cost-effective and more environmentally sound than hauling large pieces of gas-powered equipment to the site to perform those tasks.
- Consider alternatives to copper gutter and downspouts. Copper is harmful to certain fish in areas where runoff drains into natural waterways.

PRODUCTIVITY SUGGESTIONS

Grading a site is one of many weather-sensitive landscape activities. Effective completion of construction requires practice of techniques that counter the problems associated with weather. Following are some suggestions for reducing the impact of inclement weather:

- Avoid working soils high in clay or organic matter content when they are wet.
- When working in dry conditions, lightly wet the soil before compacting. Dry soil shifts rather than compacts.
- If rain is anticipated, do not strip sod and surface vegetation. The drying process takes longer if a site has been exposed to the elements.
- Consider how water will drain from the site at all stages of the grading operation. Avoid creating low areas where water will pond and drying will be slow.
- Provide temporary erosion protection throughout the grading process.
- Maintain a covered stockpile of dry topsoil that can be accessed when an exposed site is still wet.

CHAPTER 11

SITE GRADING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Recognize the size and scope of grading required for a project
- Change the grade on a site.

Most landscape projects require moving soil to accomplish design goals. A simple concept of grading could be described as removing soil from where it is not needed and placing it where it is desired. **Grading** a site requires background knowledge about soils and the grading process, the ability to calculate quantities of cut and fill, judgments about the size of the project, and what approach should be taken.

Grading is accomplished through a process called *cutting and filling.* Cutting is the removal of unneeded or undesirable soil from a location, and filling is the placement of appropriate soil where it is needed. Although this concept seems simple, conditions exist that complicate the process. If soil with plant matter, such as turf, is reused when filling, it would later decompose and settle. The desire to save topsoil and place it in the area where it will benefit plants adds complexity to the **cut and fill** process. Respreading topsoil and smoothing the finish grade complicate the idea of cut and fill even further.

The amount of soil moved and the types of landforms required by the landscape plan will determine whether landscape contractors can accomplish the project using typical landscape equipment, or whether the project should be subcontracted to grading contractors who have special equipment and expertise in large earthmoving projects. Determining the size of project that can be effectively graded with a skid-steer and dump truck is a matter of experience. Landscape contractors often undertake projects that require up to 50 CY of earthmoving (roughly enough soil to cover the floor of a two-car garage 3 feet deep). Because heavy equipment can do the job more efficiently, many landscape contractors subcontract larger projects to grading specialists. When considering the grading portion of a project, contractors should base their decision on their equipment and capabilities.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Construction Staking, Chapter 8
- Erosion Control, Chapter 13

STEPS TO GRADING A SITE

When working on small projects, contractors can use a simplified grading approach of pushing the soil and sod away from a project and pushing them back when construction is completed. When major

grade changes are required, however, contractors must use a process that accommodates the orderly completion of all steps (Figure 11-1). Each step of this process is accomplished using specialized grading equipment, ranging from a skid-steer on a small site to bulldozers, scrapers, motor graders, power shovels, backhoes, compaction equipment, and dump trucks on larger sites.

Strip Sod

Because vegetative matter decomposes over time, ground covers such as sod should be removed separately and either disposed of, composted, or stockpiled separately from topsoil for use in noncritical areas. The site should be stripped to a depth of approximately 4 inches to remove the most dense layer of vegetative matter. In some areas, this depth may be decreased or increased based on the type and maturity of the covering plant material. In small grading operations, this step can be completed using a skid-steer with a toothed bucket, passing over the site with the bucket set at a depth just below the root zone of ground cover plantings. On larger sites, a bulldozer will be required, setting the blade at a shallow depth and blading the organic layer into piles that can be loaded into dump trucks by backhoes or endloaders for transport to a disposal area. Areas where tree stumps were located should be excavated with a backhoe to a depth of 24 inches in a 10-foot diameter circle centered on the stump.

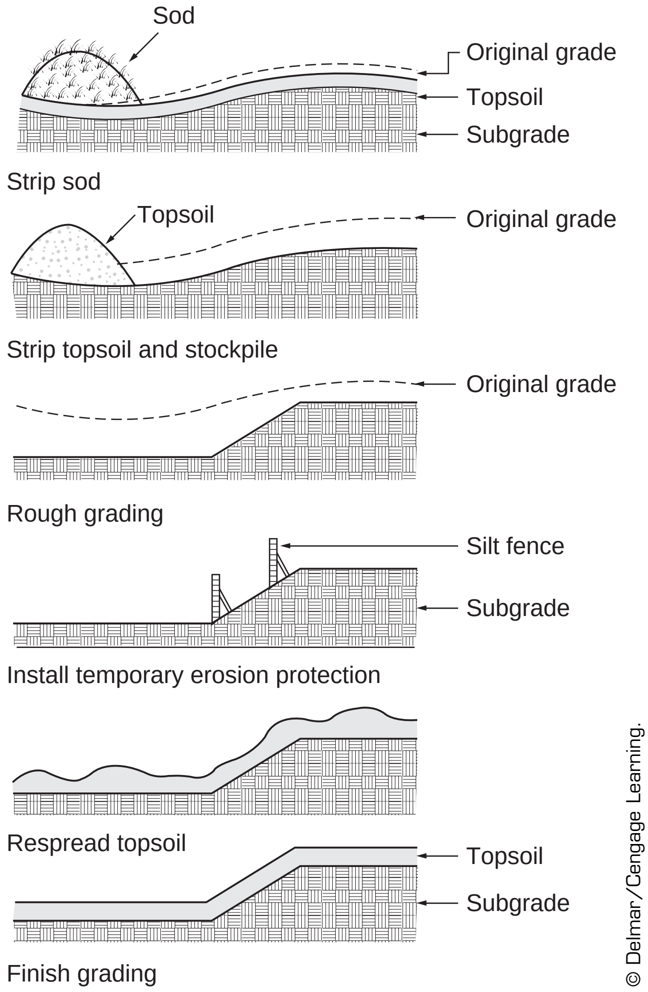


Figure 11-1 Steps of the grading process. A. Strip sod. B. Strip and stockpile topsoil. C. Perform rough grading. D. Install temporary erosion protection. E. Respread topsoil. F. Finish grade.

Strip Topsoil and Stockpile

Following the removal of vegetative matter from the site, strip enough topsoil to cover all areas where topsoil is to be respread in the final grading step. Include an additional 15% in this stockpile to cover settling, erosion, and compaction losses. When calculating areas to receive topsoil, include all turf and ground cover areas, as well as planting beds. A shortage of topsoil indicates that topsoil will need to be imported to cover planting areas. If possible, save all healthy topsoil from areas of a site that are disturbed and avoid disrupting areas where no construction is to take place.

Stripping topsoil on small sites can be done using a skid-steer with a toothed bucket. Set the bucket depth so that it scrapes the topsoil layer to the depth of the subsoil; then transport it to a storage area. Larger sites will require a scraper pass over the site, often using more than a single pass. The scraper blade is set to the depth of the topsoil layer (or the maximum depth), and the topsoil is removed to the depth of the subsoil. The scraper can carry the topsoil to a storage pile and deposit it for storage. Alternatively, a bulldozer can scrape the topsoil layer into piles that are emptied into a dump truck by a backhoe or power shovel for deposition in a storage area. Because of the energy required for hauling and the damage that harvest sites can incur, recycling topsoil from the existing site is preferable to importing topsoil from outside sources. To achieve this goal, contractors may have to request adjustment of the cut and fill areas to balance the soil available. Place this topsoil in a stockpile that is located away from construction areas, yet is easily accessible both for immediate needs and at the end of construction.

Excess topsoil can be stockpiled or, if low in organic matter, used to establish **subgrade** on the site. Most topsoils are stable enough to serve as the subgrade for **berms,** lawn areas, and other areas without permanent improvements. Soils high in organic matter are not recommended as subgrade for paved areas or structures because of the possibility of soil settlement. Soils that are high in sand content or have poor structural qualities, such as high shrink/swell clay, should also be avoided as fill material.

Rough Grade

Rough grading involves cutting and filling the site to establish proper subgrade elevations. This adjustment of grade should always be done on subsoils, rather than by manipulating healthy topsoils. If topsoil still exists in an area where grades are to be changed, strip the topsoil before grading to new elevations. These elevations are obtained by subtracting the required topsoil layer, pavement and pavement base, or other nonsoil subgrade improvements from finish grade.

Within the scope of rough grading are establishing platforms on which paving and structures can be built, establishing turf and landscaped areas, trenching for utilities, and excavating for piers/posts for structures. Staking for rough grading is typically placed slightly offset from the area being graded, with markings on the stake that indicate to the equipment operator the cut or fill required in the area of work. If grading changes are significant, restaking of the site after each step of the grading process may be necessary. Although it does not require the precision of finish grading, subgrading should be as accurate as possible to reduce grading work later in the project.

During this process, contractors should also be aware of area soils that are unsuitable for construction. These areas appear wet or spongy, have a foul smell, or are differently colored. If such areas are encountered, excavate the entire depth of unsuitable soils and replace it with suitable soils. If the depth of unsuitable soils exceeds 24 inches, a soils engineer should be consulted to recommend a solution. Also review the causes of the soil problem in that area. **Tile** installation may be required to remove excess water. Providing stable subsoil is important to the long-term stability of all paved areas and structures. Rock can also pose a problem for rough grading operations. Unless the rock is loose and can be moved with excavation equipment, an expert in blasting may have to be contracted before continuing excavation.

Areas where fill is to be deposited should be first prepared by scarifying the soil's surface. Using a tractor pulling an agricultural disk or using a motor grader with a scarifier attachment, you can accomplish scarifying. In fill areas on steep slopes, you may need to bench, or terrace, the slope before adding fill. Benching can be done either by using bulldozers that scrape away level terraces from a hillside or by using power shovels that excavate soil from hillsides and load it into dump trucks for transport to a storage area.

Cutting will take place in all areas where the current grade is higher than the desired subgrade. Bulk excavation is accomplished on small sites by hand using shovels and wheelbarrows or by using a skid-steer equipped with an excavation bucket. The soil is removed from areas where the grade requires lowering and transported to fill areas and deposited. By loading cut material into a truck and transporting it to fill areas, rather than transporting the soil with a skid-steer, contractors can improve productivity on some sites. When filling, place soil in 6-inch lifts (layers) and compact the lift before adding more fill. This method provides more stability to a fill than when compaction is completed only after placing all fill. To assist compaction, you may need to lightly spray water on the lifts.

Bulk excavation of larger sites is typically accomplished using scrapers or bulldozers. The scraper would make several passes over a cut area, removing soil with each pass to the maximum depth allowed by the equipment. Suitable soil is then transported to storage areas or fill areas and deposited in lifts that can be compacted after placement. As an alternative to a scraper, a bulldozer can push and cut material into piles, and a loader can fill dump trucks for transporting the material to fill or storage areas. During this excavation process, operators are guided by offset grade stakes. As operators pass a stake, they can observe if they need to remove more soil. This excavation process is continued until the platforms on which structures and pavement are to be built have reached the specified grade and slope.

Successful cutting leaves a platform with a consistent and relatively smooth surface on which further work can proceed. If there are irregularities in the surface, a motor grader can provide more detailed grade manipulation. In areas of rolling topography, the motor grader will typically be required to create the desired slope and elevations.

Excavated materials are deposited into fill areas and typically placed in lifts by the scraper, or these materials are emptied into windrows or piles by dump trucks and spread into lifts with a motor grader. Between placement of lifts, the soil is compacted using motorized compaction equipment. Clay or clay-like soils are typically compacted using 10 to 12 passes over the lift with a sheep's foot roller. Granular soils are typically compacted using 5 to 6 passes over the lift with a rubber-tired roller or vibratory steel drum roller. If fill material is dry, water it by using a spray truck to consolidate soil particles before compaction.

To minimize the amount of erosion after rough grading, terrace long slopes, rather than leaving the site as a series of long exposed slopes. Grades can be adjusted to required elevations prior to respreading topsoil.

Following the establishment of rough grade, excavation for utility trenches and pits and for footings, piers, and piles can be started. For deep trenches, excavate by using backhoes; for shallower installations, chain trenchers. Depending on the utility, the alignment is staked and grade stakes may be added. Utilities such as sanitary and storm sewer will require a consistent grade at the bottom of the trench, regardless of the surface grade. This often requires an on-site surveyor to verify that the excavator has attained the necessary trench depth. Soil is excavated from the trench location and placed alongside the trench for future backfill material. Utilities such as irrigation lines typically maintain a consistent depth below the surface grade; therefore, they are better suited to excavation using a chain trencher. The chain trencher can be self-propelled or attached to a tractor or skid-steer. The trencher works backward along the desired alignment, with a screw mechanism that automatically piles soil to the side of the trench to use for future backfilling.

When utility installations are complete, backfill is pushed into the trench using a skid-steer or endloader. In instances where trenches are wide and/or deep, compaction of the backfill using a sheep's foot roller, vibratory plate compactor, or rammer compactor may be required. Unless properly compacted and backfilled, trenches will settle over time and leave a depression running through the site; these depressions are difficult to correct.

Install Temporary Erosion Protection

In most projects, grading work halts after rough grading to allow construction of walls, paving, and other site improvements. Some projects may be small enough to allow the grading process to proceed from beginning to end; but as a project's size and complexity increase, grading must be completed in stages. If grading halts after rough grading, temporary erosion control measures (see Chapter 13) should be installed.

Respread Topsoil

When most heavy traffic over the site has ceased and all walls, pavement, and structures have been installed, grading operations can continue. Topsoil from the stockpile is removed and spread over the site to the required depths. Small areas can be respread using skid-steer equipment with a bucket and grading attachment, whereas larger areas will require the use of a scraper to deposit a lift of topsoil over the entire site. Depths of topsoil vary depending on project specifications, but lawn areas typically require a minimum of 6 inches up to 12 inches. Planting beds may require a minimum of 12 inches up to 24 inches. The topsoil is laid in and roughly spread to the finish grade as specified in the site grading plan.

Finish Grade

The final step prior to seedbed preparation or planting is to smooth the surface to the exact grades stated on the grading plan. This step, called **blue topping** in reference to the color of the project hub grade stakes, is to manipulate the soil to the desired finish grade. For large operations, a motor grader or tractor-mounted blade performs this work; for smaller operations, a skid-steer and shovels. Regardless of project size, performing hand work with shovels and rakes in tight areas is often required to obtain the desired or accurate grades. Begin finish grading by setting hub grade stakes with the top of the stake, typically topped with blue paint or a blue tassel, at finish grade. Place these stakes every 20–30 feet in a grid pattern in large areas to provide adequate reference for soil placement. Existing improvements can also be used as reference points for finish grading, with soil placed a consistent depth around curbs, pavements, and building foundations.

For large projects, finish grading operations are typically implemented using a motor grader. To assure quality in this operation, verify that the grader's tires are matched and in good working condition and that the grader's blade is angled all the way forward to scrape, rather than to cut. The grader should work in sections, windrowing any excess soil out of each section to be picked up by

other equipment. The site should be rough graded and compacted prior to beginning this step. In this operation, it is preferable to make small increments of cuts rather than fill. Make multiple passes if necessary, cleaning the excess off the tops of the grade stakes after each pass.

If no grading plan exists, finish grading will need to maintain proper elevations next to paved areas and permanent improvements and to achieve proper drainage direction and slope. At this stage, soil is often lightly compacted with a drum roller. Further surface manipulation, such as **gilling** or rough leveling, is performed as part of the preparation for turf and areas. Permanent erosion protection should be installed immediately after finish grading to protect the site.

CHAPTER 12

SITE DRAINAGE

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Describe how water impacts a construction site.
- Drain water away from improvements on the surface.
- Drain water away from improvements with a subsurface system.

Much of landscape construction today addresses the issue of water. Irrigation systems combat drought; footings and pavement design strengthen improvements against frost; and grading, tiling, and other drainage work are implemented to reduce flood and water damage. Of all the elements that can cause problems on a site, water is the one element that can single-handedly wreak the most havoc. Whether the problem is an excess of water from flooding or poor drainage, a shortage of water from drought or frozen water that heaves pavement or ices walks, proper management of the many potential impacts that water can have on a site will minimize construction and long-term problems. In this chapter, we examine ways to control water by draining it from improvements on a site.

Two general concepts are incorporated into making site drainage improvements. The first concept is draining water from the site on the surface. Surface drainage consists of shaping the ground to direct runoff where desired. When preparing a site for proper surface drainage, the intention is to slope the ground from important features that water can damage, such as structures, walls, and paved areas. In addition, the contractor attempts to avoid low areas that will collect water and make spaces unusable after rains or irrigation. This method of removing water is typically the most cost-effective and easiest to construct. It is applicable on most sites to some degrees and, on many sites, is the only technique needed for draining.

Basic to surface draining a site is the principle of maintaining a low point, or a series of low points, that is lower than the elevation of structures and important site features. These low points are sometimes referred to as **free outs** or **swale high points.** These low points guarantee that if rains continue and reach flood stage, water will flow away before entering a structure. This principle is easy to maintain on sites with hilly or rolling topography, but it is a challenge on sites that are flat. Sites that limit surface drainage possibilities or make locating low points difficult require drainage systems that are more complex than surface treatments.

When the volumes of water are great or the site's topography is not favorable to effective surface drainage, subsurface drainage systems must be employed to maintain positive drainage. Subsurface systems involve collecting the water on the surface and then allowing gravity to draw it into a piping system for removal. Although more expensive and time-consuming to construct than surface drainage, subsurface systems can be effective in draining problematical sites.

Also discussed at the end of this chapter is the concept of storm water **detention,** dissipation, and mitigating polluted runoff from a site. Many projects incorporate the idea of retaining rainwater for a period after a storm in detention ponds to minimize the impact on downstream areas. Storm water can also be detained and pollutants and sediment can be filtered using a **bioswale.** On selected sites, storm water runoff can be collected and reused or returned to the soil by using drainage structures to dissipate the water into the ground. Construction and finishing of a detention area or bioswale, as well as other storm water management fixtures, may become the responsibility of grading or landscaping contractors.

Regardless of the method they select to drain a site, landscape construction professionals must respect the character of natural waterways that run through and near a site. Development of a site typically diverts, increases, or changes the runoff that passes into the existing drainage network. When this happens, the environment beyond the site is changed, often for the worse. Responsible water management for a site includes protecting downstream waterways from disturbances, such as silt from erosion, contamination from chemicals used in construction, and flooding from diverted runoff.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Site Grading, Chapter 11
- Concrete Paving, Chapter 23

SURFACE DRAINAGE

In any proper grading and drainage scheme, positive surface drainage should be the first consideration. Surface drainage can best be described as draining water from locations where it will be a problem. Drainage is achieved by shaping and sloping surfaces. More specific techniques involve the grading of swales, or shallow ditches, and the use of diversion berms to direct runoff where the designer desires. Surface drainage is the predominant method for sites that are small or have limited amounts of runoff. As a site increases in size, surface drainage may be limited to directing the runoff to more permanent drainage structures such as tile or storm sewers. Another factor that may limit the effectiveness of surface drainage is the amount of runoff. Sites that have many structures and much pavement limit the amount of water that the ground can absorb, leaving large amounts of water that must be removed to protect these improvements. During torrential rains on these sites, surface drainage methods can be quickly overwhelmed.

GRADING SLOPES

Sloping surfaces away from permanent improvements is a simple technique that is also essential to good site drainage. Structures, walkways, patios, walls, and other intensive-use areas of the landscape benefit from having the ground slope away for a short distance, allowing water to drain away from these structures. This shaping process should be addressed during site grading, especially during the rough and finish grading steps.

The percentage of slope graded for a site is dictated by construction drawings or, in the absence of a grading plan, is determined by standards and site conditions. Standards for most sites recommend that a minimum slope of 2%–3% be maintained across turf areas to provide positive drainage. Pavement areas drain well if a 2% slope can be maintained. Athletic fields and sporting surfaces have required slopes recommended by the authority governing that type of activity. Grade around buildings should be maintained 6 inches below the structure's finish elevation, and the ground outside the structure should fall an additional 6 inches in the first 10 feet away from the building.

Grading Drainage Swales

Drainage swales are shallow ditches designed to intermittently carry water through and away from a site. If a site has adequate slope and area to accomplish drainage without swales, none should be used. Although swales are drainage channels, they are typically constructed with side slopes that are gradual enough to mow. As with all surface drainage, the general slope of swales can be completed during rough grading and the detailed slope completed during finish grading steps. The highest point of a swale should be at least 6 inches lower than the finish elevation of any paved area or structure. From that high point, a minimum of 2%

Figure 12-1 Drainage swale constructed to direct runoff away from improvements.

downstream slope should be maintained, with grades of up to 3%–5% allowed for short distances. Although the side slopes are maintained at grades that allow mowing, water volume or occasional steep slopes may require permanent channel erosion protection in some cases.

Swales should be used where they will be most effective. Placement around structures and through low areas of lawns allows the swale to perform the function of collecting water from downspouts and lawns and transporting it away (Figure 12-1). When a hillside with high runoff abuts an improvement, a swale should be placed between the hillside and the improvement to intercept runoff. Water carried in swales can be directed to storm sewer **inlets** or emptied into drainage channels, streams, or unused lawn areas. This latter choice will create wet areas that are unusable for periods of time.

Grading Diversion Berms

Occasionally, a site will have a slope that directs runoff toward structures and other improvements. If a swale cannot be constructed to intercept this runoff, a diversion berm may be an alternative. A swale lowers the surface elevation, whereas a diversion berm mounds soil upward to direct water (Figure 12-2). By mounding soil a short distance from an improvement, and continuing that mounding around the improvement, water can be directed to the point below the improvement.

Diversion berms should be constructed during site grading. To be effective, the berm must create a small swale on the upslope side to carry water, and it must continue around the improvement being protected until the highest point of the berm is level with the improvement's finish elevation. Exercise caution when using diversion berms near structures. The space between the berm and the structure will continue to drain toward the structure; and if water from downspouts, roof drainage, or other large quantities of runoff land in this zone, the structure could flood. If this is the situation, consider using a tile or storm sewer system to handle drainage.

SUBSURFACE DRAINAGE

Although the first consideration for site drainage should be surface drainage, contractors may have to construct subsurface drainage systems on certain sites. Among these sites are those that have

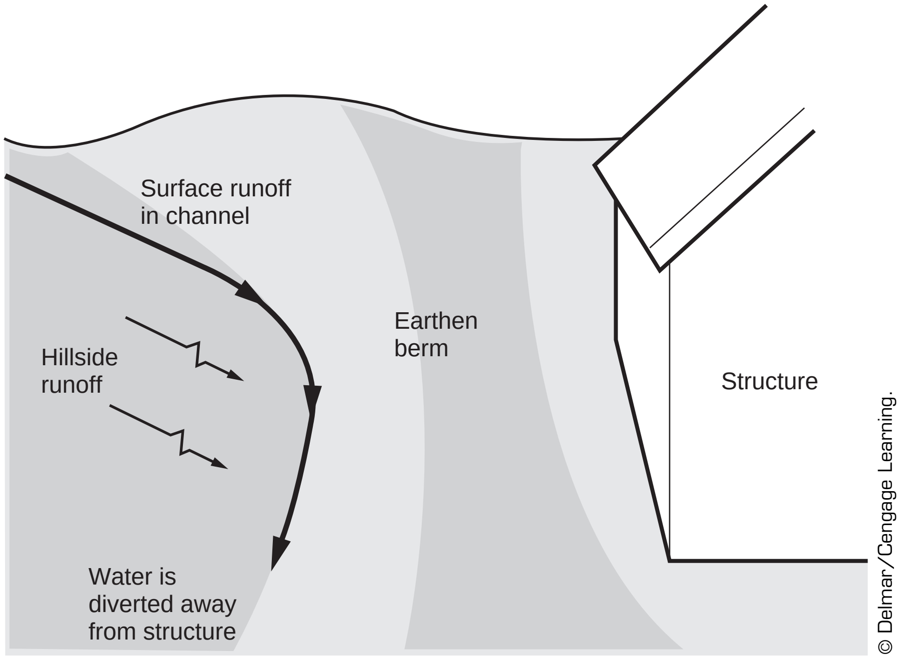


Figure 12-2 Diversion berm to direct surface runoff.

variable grades, are not conducive to the construction of swales, are subject to temporary flooding, have high volumes of runoff, or a high percentage of site coverage by structures and/or paved areas and a critical need to channel runoff away from structures.

Three approaches to subsurface drainage are available, with the first two considered within the scope of the landscape contractor's work. The first approach is using a **french drain** to draw excess water off the surface and to store the runoff until it percolates into the surrounding soil. The second approach is using an underground tile to transport runoff to an outlet point. This system requires that the surface be graded properly to direct water to the system collection points, typically a surface inlet, and then transported to an outlet point through nonperforated pipe. Subsurface water can be removed from a site with the use of a **perforated tile** system, which collects underground water without using surface inlets. The third approach is the construction of storm sewers, a system of drainage structures and underground piping engineered to collect high volumes of runoff at surface low points and carry the water to an outlet point.

CAUTION

Never connect storm drains to sanitary sewer lines.

CAUTION

Verify that the location where you intend to direct water collected in a tile or storm sewer system is a legal location to empty runoff.

Constructing French Drains

French drains are gravel trenches covered with a thin layer of soil and ground cover. The gravel in these trenches stores water in the open spaces between each stone (Figure 12-3). A closed drainage

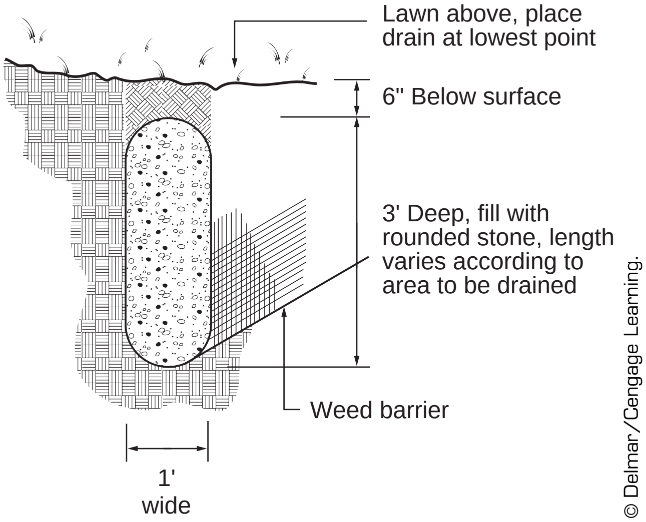


Figure 12-3 Cross section of a french drain.

system that requires no outlet point, a french drain would be properly placed in low areas that collect water or in locations where poor soils slow the percolation of surface water.

Begin by using the formula identified in Appendix D to calculate the length of french drain required. When you have calculated the length of french drain, mark the location of the trench on the site. If the site will not accommodate a single trench, you may split the required length into separate trenches placed at least 36 inches apart. To be effective, the majority of the trench should be located directly under the area that floods. Excavate a trench 12 inches wide and 42 inches deep along the lines marked. In turf areas, remove the sod set it aside for reuse. Save approximately 10% of the soil excavated from the trench for cover.

For each trench, cut two lengths of 48-inch wide landscape fabric 2 feet longer than the trench length. Place the first piece of landscape fabric up one side of the trench. Fold the top over the outside edge of the trench. You do not need to cover the entire bottom of the trench. Repeat the process with the other piece of landscape fabric on the opposite side of the trench. Fill the trench to within 6 inches of the top of the trench with 1–2-inch diameter washed river rock. When filling the trench, use care not to disturb the landscape fabric. Fold the remaining landscape fabric over the top of the river rock. Backfill the trench with the soil set aside earlier and compact. If you saved the sod, replace it over the fill.

The average life of a french drain is approximately 5–10 years. After that time, the storage capacity of the pores between the river rock will be reduced from silt that has worked into the drain. A faster alternative is to construct the french drain without placing landscape fabric around the river rock. However, this alternative has a typical life of fewer than 5 years because silt will form more quickly.

Installing Tile Systems

Tile systems can be used to drain both surface and subsurface water. Surface water is drained away through inlets or trench drains that allow water to drain into a pipe and be carried to an outlet point. Tile also can be used to intercept the water table (subsurface water that is moving up toward the surface) and to reduce damage from frost. Installation of each of these systems is described in the following sections.

Installing Tile Systems with Surface Inlets. Installing a tile system to drain surface areas begins with flagging inlet points and an outlet point. Inlets should be located in paved areas and lawns, near roof downspouts, and in any location where significant runoff is expected. Between inlet locations, a simple network of connecting tile lines should be marked leading to the outlet point. This network should avoid uphill runs.

Beginning at the outlet point, excavate an 8–12-inch wide trench along the entire length of the collection system (Figure 12-4). The trench should be

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Figure 12-4 Trenching and placing plastic drain tile.

deep enough that the grade can fall at a 1% rate from the highest inlet to the outlet point. Excavating the trench 1–2 inches deeper will allow a sand setting bed to be added and make adjusting the trench to keep a downhill grade easier. Add this sand layer before placing the pipe. Beginning at a point just before the highest inlet, lay 4-inch diameter **non-perforated** tile that exits at the surface and drops to the bottom of the trench. At this beginning of the system, cut the tile flush with the surface and install a cap (Figure 12-5). This cap will serve as a cleanout in the event the system becomes plugged with debris. Continue running tile along the bottom of the trench's length. Large numbers of inlets or heavy runoff areas will require increasing the tile size to 6 inches or larger on the lower portions of the drainage system.

At each location where an inlet is planned, cut the tile with a carpet knife and insert a T connection. Insert a vertical tile (**riser**) (Figure 12-6), running from the T to approximately 12 inches above the surface for connection to an inlet. Continue laying tile and inserting Ts until you complete the entire system. Premanufactured Ts, angles, and Ys are available to make branching and connecting systems easier. Apply duct tape around any connections and

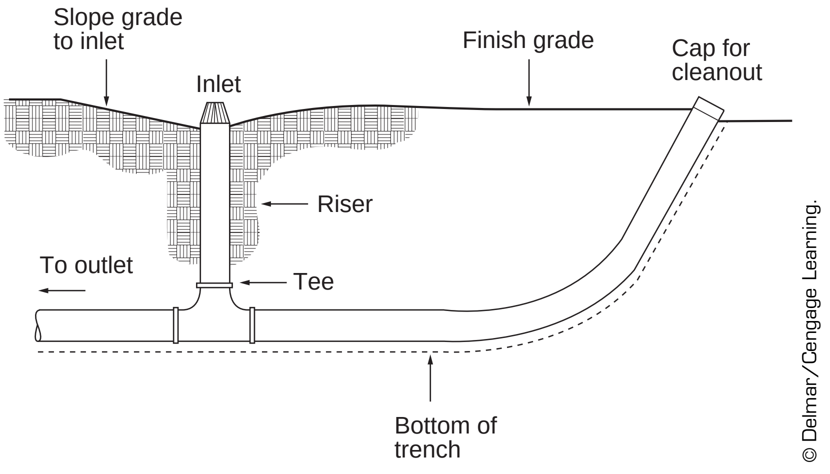

Figure 12-5 Cross section of tile riser and cleanout.

Figure 12-6 Tile riser before being trimmed for inlet installation.

joints to keep them from pulling apart. As you complete tile and fitting installations, add enough soil or granular backfill to fill in on both sides and just cover the pipe before moving to the next fitting. This fill, called **haunching,** will hold the pipe and fitting against movement as you work on other portions of the project. Backfill the system to the surface, lightly compacting the backfill after every 12-inch layer.

Fiberglass inlets with flanges that fit into the risers are premanufactured for tile systems (Figure 12-7). Landscape contractors can choose from a wide variety of sizes and styles, including deep and shallow inlets, square and round inlets, and parabolic grates to reduce plugging from surface debris. To install inlets, excavate the finish grade around each location where a riser was placed. Cut the riser at this elevation and place the inlet into the end of the riser. Position the riser flush with the surrounding ground. Backfill the hole and adjust the finish grade to create a low point at the inlet.

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Figure 12-7 Tile inlet.

Installing Tile Systems and Storm Sewers with Surface Trench Drains. Capturing runoff on sloped pavement and around structures often requires installing a trench drain. The **trench drain** is a formed/molded linear channel with a grate that sets in a frame on top of the channel. This drain is intended to be placed with paving on both sides of the drain or along the edge of a paved surface. Depending on the manufacturer, these channels can be installed in connected links that are approximately 2 feet in length or in longer sloped channels that are up to 10 feet in length. Installation methods will vary as well; depending on whether the channel is being installed before or after the surrounding paving has been completed.

To install the trench drain prior to installing surrounding paving, first mark the drain's location and elevation. If necessary, excavate a trench that is at least 4 inches deeper than the channel's bottom and at least 8 inches wider than the channel's width. Set a stringline along the trench's length at the finish elevation and alignment of the grate. Pour a foundation of concrete along the trench's length. Install the end cap and outlet for the channel's low point. Beginning at the lowest point, insert the channel into the bedding, pushing down or lifting the channel to match the stringline. Adjust the alignment of the channel to match the stringline. Trim the end of the last piece of channel and install the end cap before placing in the bedding (Figure 12-8).

After the channel is in place, mask the grate to protect it from concrete spills or other damage. Install the grate into the frame, and attach the frame to the channel. You may now install the paving material along both sides of the channel, using the frame and grate to hold the top of the channel in proper position. If concrete is placed adjacent to the frame on both sides, you may need to apply expansion joint material along one or both sides of the channel's frame.

An alternative installation method is to install forms alongside the channel and pour the paving on both sides of the channel separate from the pour around the drain. When using this alternative, be certain to install a keyway or reinforcing bar that extends from the drain pour into the paving pour.

To install the trench drain after surrounding paving has been poured, proceed with the paving pour and box out a channel for the trench drain that is at least 8 inches wider than the channel (Figure 12-9). After the surrounding paving has been completed, excavate a trench in the boxout that is at least 4 inches deeper than the assembled drain. Assemble the drain channel and frame. Mask the grate and attach the grate to the center of 2 × 4s that are 2 feet wider than the boxout. Place these 2 × 4s every 4 feet along the length of the drain. Attach expansion joint, if necessary, along one or both sides of the boxout. Assemble the grate to the frame and place the entire assembly into the trench, centering the drain in the boxout. Carefully pour concrete along the entire length of the drain. Use care to tamp the concrete under the channel and to completely fill the voids of the boxout. Finish the concrete and

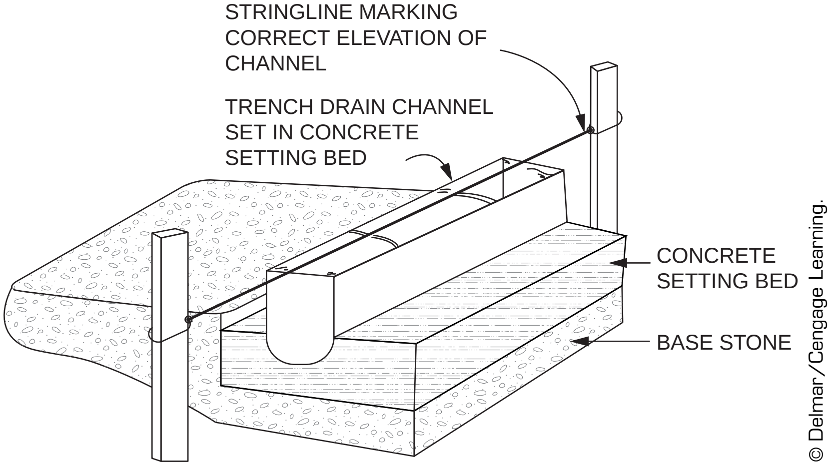

Figure 12-8 Trench drain channel placed in concrete setting bed. Pavement to be placed up to channel.

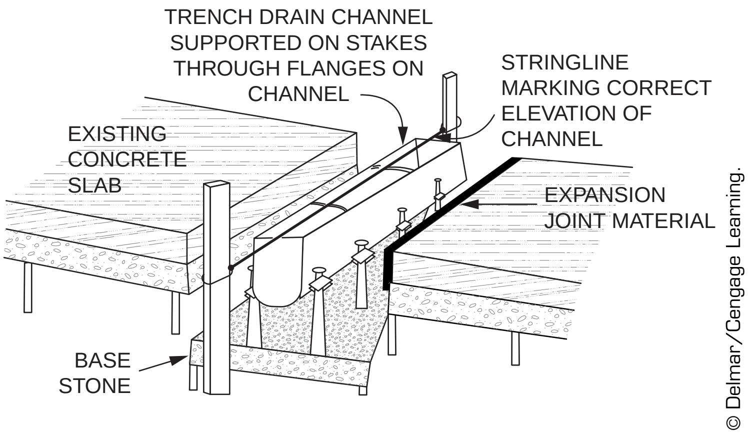

Figure 12-9 Trench drain channel supported on stakes in trench. Channel is installed in a trench through existing pavement. Pavement to be placed around channel.

remove the 2 × 4s. Alternatively, there are drain systems that provide brackets to support the drain assembly in the boxout without using 2 × 4s. These brackets mount on the channel and/or frame and typically are left in the pour; however, provide support for the channel while the concrete is being poured around the drain.

Installing Subsurface Tile Systems. Tile used to intercept subsurface water is laid out in a pattern to cover the entire area that requires drainage (Figure 12-10). Tile line locations are marked out in a parallel line pattern with a connecting tile that runs perpendicular to these lines at the low end. A single tile leads from this connecting tile to the outlet. Soil type, rainfall, and severity of existing water problems determine the spacing of the parallel lines, which may range from 5–40 feet apart, depending on the conditions. The more severe the conditions, the closer the spacing. Consult an engineer if you are uncertain about spacing tiles for a particular application. Inlets are rare on this type of tile system.

Excavate and place tile in the pattern used for surface drainage tile systems, except use *perforated* tile. To prevent silt from filling a perforated tile, backfill with coarse backfill material, such as pea gravel, or use a perforated tile with a **geotextile** sock wrapped around the tile. If intended to protect structure footings from frost, the tile must be slightly deeper than the footing's bottom.

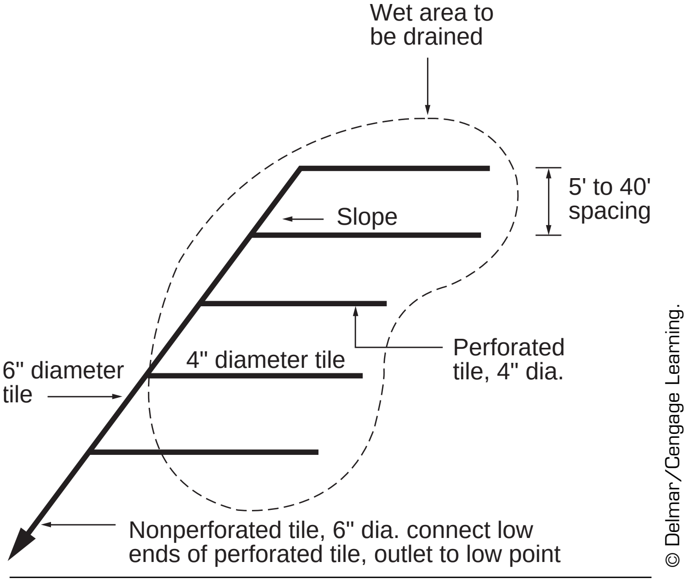

Figure 12-10 Plan view of tile layout for intercepting subsurface water in a wet area.

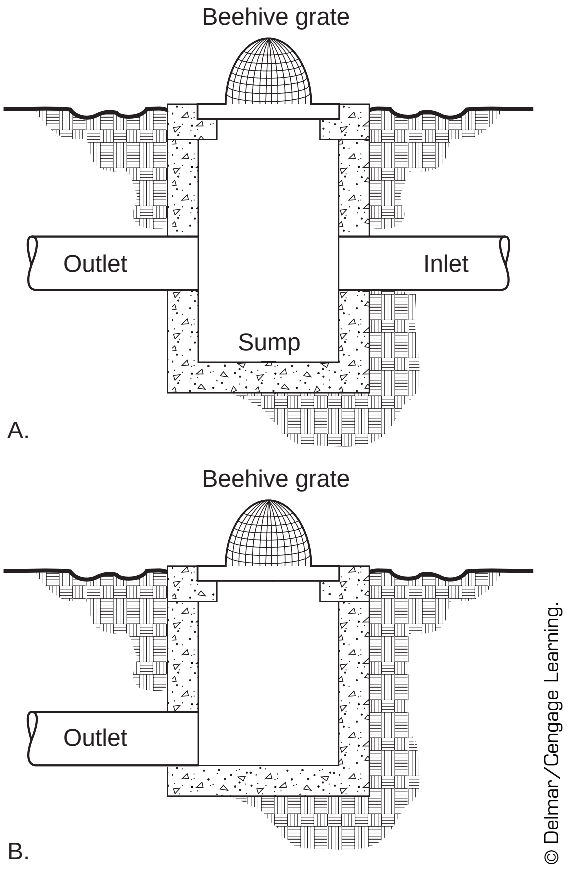

Figure 12-11 A. Cross section of catch basin. B. Drain inlet.

Installing Storm Sewer Systems

Specialized contractors must construct storm sewer systems. Operation of the heavy equipment needed to install storm sewers and the hazardous conditions of trench work place this work beyond the typical landscape contractor's expected scope of responsibility. Landscape contractors will, however, be required to grade surfaces around storm sewer inlets and possibly connect tile systems they install to the storm sewers. Because of this relationship, the components of the storm sewer system will be reviewed.

Storm sewers are permanent subsurface drainage systems composed of two major parts: inlets and piping. Inlets, underground concrete (either precast or cast-in-place) boxes with openings in the top, perform the water collection for a storm sewer. Water is directed to the inlets on the surface and then falls through these openings. Different types of inlets are used, based on where the water is being collected. Having a **sump** in the bottom, **catch basins** are designed to catch debris and sediment that fall into the inlet. **Curb inlets** are concrete boxes with metal frames shaped to match roadway curb lines. Openings along the curb allow water to enter the inlet from the side. Once inside the inlet, water flows into clay or concrete piping and is conducted to outlets at streams or rivers. This pipe is typically laid at a minimum slope of 2% to maintain flow (Figure 12-11). Surface grades that lead to storm sewer inlets should be maintained relatively flat because steep slopes adjacent to the inlet may cause erosion. Also, the adjacent finish grade should be flush with the inlet to avoid water ponding.

With approval from the storm sewer owner, you may connect tile systems to inlets as an outlet point for small drainage systems. To make the connection, knock a hole into the inlet with a sledgehammer and push the tile through the hole into the inlet. The space around the hole should be filled with mortar so that soil does not wash into the inlet (Figure 12-12). When you use this outlet method for tile systems, verify that the tile line can be emptied no lower than halfway down in the inlet. Tile entering near the bottom of the inlet may have surcharge, or water running back up the tile when the inlet is full.

Treating Outlet Areas

Outlet areas for surface and subsurface drainage systems require special treatment to prevent erosion. End points of swales, channels, tile systems, and storm sewers typically carry large volumes collected from the site (or several sites), and the water at these

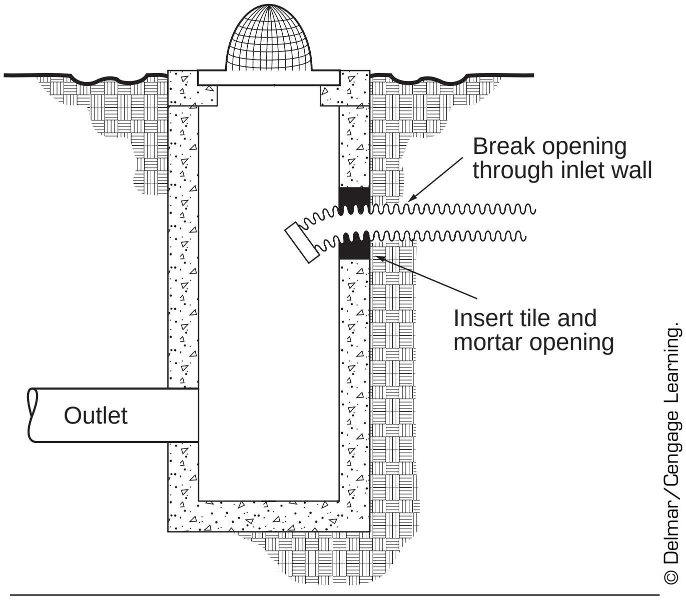

Figure 12-12 Connecting drain tile to existing storm sewer inlets. Perform this connection only with permission from the storm sewer owner.

Figure 12-13 Treatment of drain outlet with 4"–8" rip-rap to reduce erosion.

locations is also moving quickly. The combination of these two factors makes the locations prone to severe soil erosion. To reduce the impact of erosion, treat each of these locations with rip-rap.

Rip-rap, large stone, is used for lining drainage swales to reduce erosion. Composed primarily of 4–8-inch rock, rip-rap reduces erosion by slowing the water as it strikes the rock's surface. The weight of rip-rap holds the surface contour in position so that it is not washed away like soil or smaller stone. The rip-rap at outlets should be placed over geotextile fabric centered on the outlet. The geotextile should be placed in a square with dimensions twice the outlet's width (Figure 12-13). Clients should be advised to monitor this area periodically to watch for erosion problems.

With tile systems, consider covering the outlet opening with landscape fabric to prevent small animals from entering the pipe. Cut a large piece of fabric and wrap it around the pipe end. Secure the fabric with duct tape to prevent water from washing off the fabric.

TEMPORARY STORAGE, DISSIPATION, AND REUSE OF STORM WATER RUNOFF

Previous sections have described methods of managing storm water runoff by directing the water off of the site and into regional water systems. Concerns over flooding and water shortages in highly developed areas have led to development of several methods of addressing storm water runoff before it even leaves the site, including detaining runoff in a basin and slowly releasing it into regional systems, retaining water on-site and letting runoff dissipate into the ground, or even capturing runoff and reusing the water to supplement site irrigation.

Level Spreaders

In areas where large volumes of water need to be channeled and then directed onto the surface for slower discharge, a level spreader can be utilized. A level spreader diverts storm water from a channel and directs it into a holding pond, or forebay. From this forebay, the runoff flows over a level weir, or lip, onto a protected section of surface where it percolates into the ground. Level spreaders are effective at mitigating normal volumes of storm water runoff that would otherwise be directed into regional drainage systems. Engineers or landscape architects should design level spreaders to obtain proper dimensions for storage and dissipation of runoff.

To construct the level spreader, begin by excavating the diversion structure and the forebay. This is typically done by grading the earth to create a detention pond with a diversion berm running to the channel from which water is being diverted. The forebay can be of any shape, but linear dimensions typically match the lip dimensions better than rounded or free-form shapes.

The channel can be emptied directly into the forebay, or a premanufactured diversion "gate" can be inserted into the channel to direct the runoff into the forebay. Line the bottom of the forebay with 3-inch rip-rap. Along one or more sides of the forebay, construct a level lip that will allow water to flow out of the forebay at the same rate at all points along the lip. This lip can be a cast-in-place or precast concrete curbing or a metal gutter that is built with the top perfectly level along its entire length. Alternatively, some designs empty a water channel directly into a precast forebay that is placed at the outlet of the channel. In this design, the precast forebay needs to be placed level on stable base rock (Figure 12-14).

In front of, and along the entire length of the lip, place an area of filter fabric that is covered with 3 inches of rip-rap. The design will determine the dimensions, but this area typically extends no less than 5 feet in front of the lip. The rip-rap area should be constructed at a gradual grade sloping away from the lip, should be a minimum of 4–6 inches below the lip, and should match the natural grade around the outside perimeter. This rip-rapped slope allows the water to dissipate over the site's natural grade, rather than run at high velocity down the original channel. In some designs, this dissipation area is seeded with native grasses that will assist in slowing the runoff's velocity.

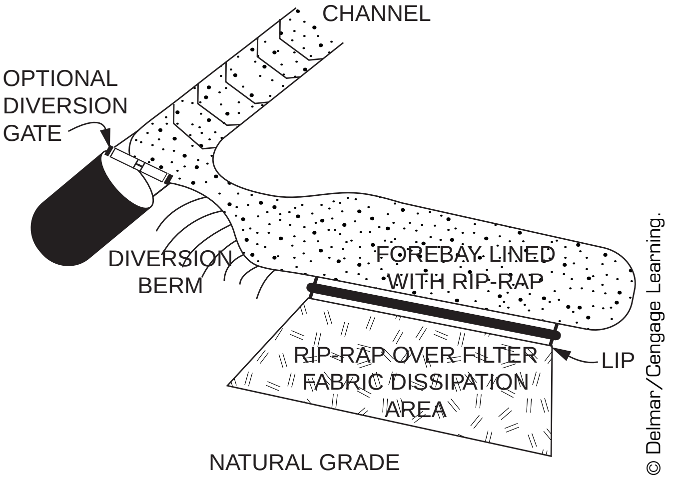

Figure 12-14 Diagram of a level spreader used to dissipate runoff from a drainage channel.

Storm Water Detention Basins

Storm water detention is based on a simple concept. Before a site is developed with paving and structures, most rainwater is absorbed, or percolates, into the surface. After the site is developed, a majority of the water runs off the site instead of percolating into the ground. Storm water detention plans design a pond on the site that will hold storm runoff from a developed site and release it at the same rate as on an undeveloped site. If the detention of storm water is properly practiced in developed areas, flooding that occurs from runoff during heavy storms should be reduced.

Constructing detention areas sometimes falls under the landscape contractor's responsibilities. On-site detention ponds can be placed in turf areas and, when open space is restricted, are occasionally placed on paved parking areas. Turf-lined ponds must be built to exact dimensions to detain the proper amount of water. Rim elevation (elevation where the water will reach its highest level) is critical when grading for a detention pond. Low points in the rim elevation will allow water to exit the detention structure, rather than being retained. Most detention ponds also have an overflow to accommodate rains that exceed design capacities. This overflow may be a grassed or paved channel similar to those discussed in Chapter 13, Erosion Control.

Ponds also require an outflow pipe in which the size of the opening, called an **orifice,** is determined by extensive calculations. Whether plastic or metal, the orifice may require that openings in the surface be covered to reduce the outflow. When sizing the orifice for detention, the most common method is to have a metal plate welded over the required percentage of a metal grate or to glue a covering over plastic grates. Design professionals should calculate the sizes of the detention area and the orifice opening.

Bioswales

Another application of the concept of storm water detention, the bioswale is a gradually sloped drainage channel with shallow sides lined with plant material

and, in certain situations, rip-rap. Used to slow runoff and trap pollutants and sediment, the bioswale allows water to percolate into the soil, rather than running off the site. The bioswale can be used as a decorative landscape element, is typically placed to capture polluted runoff from parking and paved areas, and is most effective in areas where runoff is intermittent, not constant.

To construct a bioswale, grade a channel with side slopes not exceeding 3:1 (3 feet horizontal to 1 foot vertical) and a center line slope that is as gradual as the site will allow (1% is desirable). The bioswale's cross-sectional shape can be either parabolic (curved) or trapezoidal (angled) (Figure 12-15). If the native soil is primarily clay and impervious, the top 12 inches of soil should be amended with approximately 50% sand and compost. Seed or plug the area with grasses native to the area that can tolerate temporary inundation by floodwaters. Place an erosion mat or jute netting over the area to limit erosion while the plant material cover is being established. If the swale experiences high volumes of water, the bottom may be covered with a 4-inch rip-rap.

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Figure 12-15 Bioswale planted with native grasses.

The plant material in the bioswale is only periodically trimmed and is allowed to grow to full height to assist in trapping sediment and slowing the drainage. At the end of the bioswale, place an outlet that is sized to allow drainage from the swale during periods of heavy rains.

Cisterns and Drywells

With cisterns and drywells, storm runoff from roofs and paved areas can be captured and reused or allowed to dissipate back into the ground. Cisterns and drywells are containers of varying volumes, some as small as 5 gallons and others as large as several thousand gallons, that are buried underground on a site. A single large cistern/drywell can manage runoff; also available is a series of small drywells connected to roof drains around a site to accommodate runoff dissipation. Permits are required for most cistern and drywell installations, and specialty contractors will be required for electrical connections and deep underground construction.

Cisterns are typically the term used for containment that stores water for reuse, whereas drywells generally refer to containment that dissipates water back into the ground. Both containers are buried, with the top of the container below ground, and are fed storm water runoff through tiling and piping systems that empty into the top of the container.

Cisterns are often constructed of cast-in-place concrete with a concrete bottom. Precast concrete, plastic, and fiberglass cisterns are also available. To reuse the water stored in a cistern, a submersible pump with a line connected to the irrigation supply system is required. A filtering system is also essential to prevent plugging of the irrigation system with debris from the cistern, and an access to the cistern may also be required to allow maintenance. Drywells can be premanufactured out of plastic or fiberglass, or they can be perforated plastic or concrete panels that are set into a hole excavated in the ground. Drywells can also be constructed of stacked stone with a concrete slab for a cover. A modular open-celled storage system, such as that manufactured by EcoRain®, allows a storage area to be variable in size. Many drywells have perforated walls to allow dissipation of water into the soil, and many also are filled with large drain rock for structural

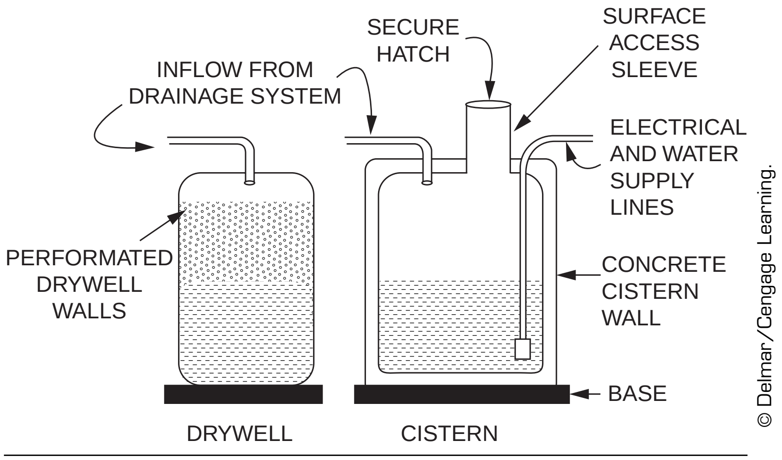

Figure 12-16 Diagram of a cistern and a drywell.

stability. A modular system will require placing the modular units within a jacket of filter fabric to allow percolation of stored water.

Installation of either system requires excavating an area large enough to place the container, placement of base rock to provide a level and stable base for the container, connection of the inlet piping, and backfilling around and over the container (Figure 12-16). If a surface access is required, you can place a sleeve over the opening in the container; then connect a secure hatch at surface level over the sleeve.

CAUTION

Failure to properly install a backflow prevention valve when connecting an irrigation system to a potable water supply may result in contamination of the water supply.

Soaker Trenches

Runoff from roof and surface area drains can be redirected into the soil through soaker trenches. Similar in nature to a shallow french drain and septic leaching fields, the soaker trench is a subsurface trench filled with coarse gravel that holds large volumes of water until it can percolate into the surrounding subsoil. Trenches may also be designed to make use of modular retention cells that are wrapped in filter fabric. In their designs, soil engineers or landscape architects can determine the effective length of the trench, which may also require a permit for construction.

To build the soaker trench, locate the area where the trench is to be installed. Ground that is level is preferable. If on a sloping site, the trench should run perpendicular to the grade. Excavate a trench that is 2–3-feet deep and 2–3-feet wide and slightly sloping from one end to the other. The actual width, depth, and length will be determined by the design of the trench, based on the soil type and the amount of impermeable surface to be drained. General guidelines for a trench in good draining soil would require a 2-foot wide by 3-foot deep trench, with 15 feet of length for every 1,000 SF of surface being drained. Poorly draining soil would generally require a 3-foot wide by 3-foot deep trench, with 25 feet of length for every 1,000 SF of surface being drained. An engineer or landscape architect should verify these dimensions.

Line the bottom and sides of the trench with an 8-foot wide piece of filter fabric. Fold the excess fabric off to the side for later covering of the trench. Fill the trench to within 1 foot of the surface with 1–2½-inch rounded drainage rock. Lay a socked perforated drain tile down the center of the trench for the entire length. Connect the end of this tile located at the higher end of the trench to your drainage system, and cap the tile at the lower end. Fold the remaining filter fabric over the top of the drain tile and backfill the trench (Figure 12-17).

Storage Barrels

One easier method for capturing runoff from roof drains is to empty the drain into a barrel designed for such methods. Disconnected from piping leading to storm sewers, the roof drain is diverted and connected to a large barrel or drum, typically around 50–55 gallons in size. The barrel must be completely enclosed to eliminate mosquito habitat.

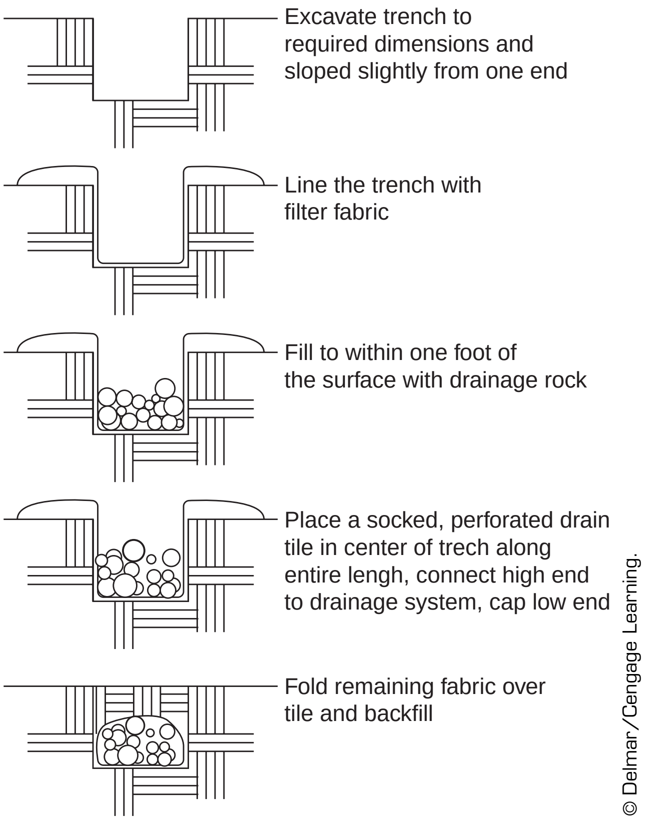

Figure 12-17 Step-by-step construction of a soaker trench.

Position the barrel next to a roof drain. Barrels should be installed on a stable base, preferably one that is a foot or two above ground level. This base can be constructed of wood timbers or concrete block and should have a 4-inch thick layer of base rock below. Cut the roof drain and install elbow pipe to direct the water to the drain barrel. Installing an open wire mesh between the elbows will help capture debris that washes down the drain, or a more elaborate screening system can be constructed or purchased if significant debris is anticipated (Figure 12-18).

Where the drain connects to the barrel, place an overflow valve in the event the barrel fills beyond capacity. This can be a valve inserted into the elbows or a 2-inch diameter, 90-degree elbow installed through a hole drilled in the barrel's side

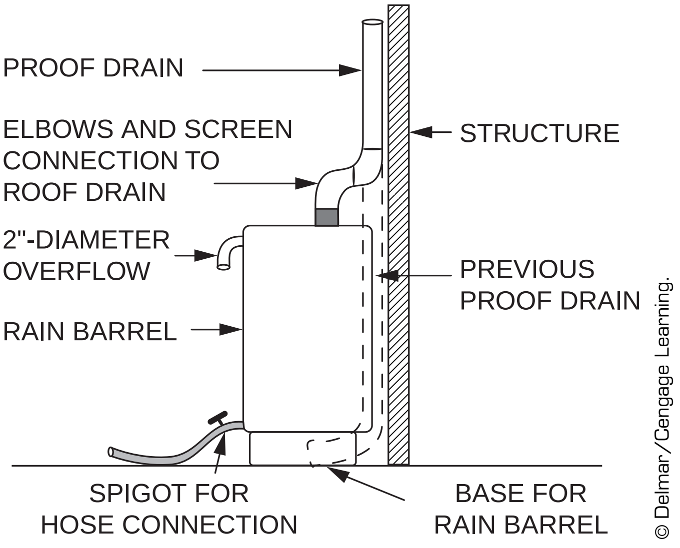

Figure 12-18 Diagram of a rain barrel.

near the top rim. At the bottom of the barrel, a hose spigot should be installed; this allows connection to a garden hose for reuse of the water.

Runoff to Lawns and Gardens

The easiest method to reduce site runoff is to disconnect roof drains from piping that leads to storm sewers and redirect that runoff to lawns and garden areas. This technique is easy to implement but difficult to control. Runoff from roof drains must be directed to planted areas, or the drains should be rerouted to discharge directly above or into the area to be irrigated. Gravity will do the work of directing the runoff downhill. Before implementing this system, verify that runoff will empty into areas that are planted and not into structures or paved areas. Many roof drains are installed to prevent flooding of structures and paved areas, and drains that are performing that function should not be disconnected. To contain the runoff in desired areas, you may have to grade a small berm around the garden to temporarily hold the water. A continuing issue with this method is the runoff's consistency. Often a support irrigation system is required to balance the times when there is no storm runoff.

CHAPTER 13

EROSION CONTROL

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Identify locations on a construction site that require erosion protection.
- Reduce soil erosion from the surface of a construction site.
- Install erosion control measures.

One goal of most landscape designs is to provide positive drainage throughout a site with stable surfacing that will remain in place during all conditions. However, to change a site from its existing conditions to the shapes and forms desired requires various levels of disruption. The period between existing conditions and finished product provides a window for one of the most challenging problems facing the landscape contractor—site erosion. Improvements to sites such as structures and paved areas may increase the amount of water exiting a site, complicating the goal of maintaining stable surfacing. When construction is complete, the potential for erosion still exists on slopes that remain unprotected. Stabilizing these slopes and channels is an important part of the erosion protection concept.

Erosion is the removal of soil from a site as a result of the action of water and wind. Conditions that exist during the landscape construction process, particularly site grading, make most sites vulnerable to erosion. Several factors influence the process of erosion, including soil type, vegetative cover, soil particle size, slope of the site, exposure of the site, and the amount and speed of water and wind over the site. Changing or disrupting these factors is the focus of most erosion protection methods. At each construction site, an important technique for reducing erosion is to cause minimal disturbance to the existing vegetative cover. Additional control methods typically involve covering the soil, reducing or diverting the amount of water and wind passing over disturbed soils, anchoring the soil with plant roots, or slowing the water and wind speed to reduce their capacity to move the soil particles.

Erosion control may be part of a contractual agreement between contractors and clients, or landscape contractors may make their own decisions to provide control measures. Contract documents may specify measures that must be taken to protect the site from erosion, but occasionally they provide only a clause stating "Contractor shall protect site from erosion." Keeping soil on the site protects a valuable resource and reduces cleanup efforts during the project. Erosion protection can also provide protection from liability by preventing the disruption of adjacent properties from out-wash soil. In either situation, whether contracted or through the independent judgment of the contractor, erosion protection provides a valuable preventative service to the landscape project.

The techniques presented in this chapter will use the methods just identified to address erosion on three fronts. Erosion controls are identified for the site's perimeter and exposed surfaces and for drainage channels that carry runoff water from the site.

Techniques are identified as temporary or permanent control methods, with use and installation methods provided for each. The majority of erosion control measures address the problem of water erosion and, unfortunately, have minimal effect on wind erosion patterns.

As with all steps of landscape construction, calculations need to be performed to order materials and complete the steps identified in the following sections. Refer to Chapter 4, Construction Math, to review methods of linear, area, and volume measurements required by this chapter.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Site Grading, Chapter 11
- Site Drainage, Chapter 12

PROTECTING THE SITE FROM PERIMETER EROSION

Protecting the site's perimeter tackles two fronts: preventing eroding soil from washing onto neighboring properties and reducing runoff entering the site. To prevent water from flowing across a site, landscape contractors can install buffer strips around the site in low-volume situations or interceptor channels if the volumes of water are higher.

Installing Buffer Strips

Preserving a buffer of vegetation around the site is an initial step to reducing runoff that enters a site and causes erosion. Existing plant material, including grasses, ground covers, shrubs, and trees, has root systems that can slow and dissipate water that passes into the site. The wider the buffer strip, the better. A minimum of 2–3 feet can have an impact in areas where there is only sheet surface runoff. For areas where greater volumes of runoff are expected, a wider buffer of 10–20 feet would be more appropriate. Channels that direct runoff onto a site will most likely need more structural methods to control the larger volumes of water.

Installing Interceptor Channels

In areas where any amount of runoff can potentially harm a site, a more reliable method of reducing the volume of water entering it is to construct an interceptor channel. The **interceptor channel** is a shallow swale lined with concrete or a heavy-grade vinyl liner (similar to a decorative pool liner) that is placed along the site's perimeter on the high side. This channel is continued along the site's perimeter to an outlet point that is unlikely to compound the erosion (Figure 13-1). Water coming from higher off-site elevations and running into the construction area falls instead into this channel and then flows to the outlet without passing over the areas prone to erosion.

With the aid of trenching or excavating equipment, landscape contractors should install interceptor channels before other construction begins. The sides should be approximately 2:1 slopes with a flat, level surface at the bottom of the channel. Following excavation, a vinyl liner is placed in the channel and secured to the subgrade, or the subgrade is surfaced with a 3–4-inch thick layer of concrete. These channels typically intercept small amounts of runoff. An engineer should size larger interceptor channels to assure proper function for erosion control. A concrete-surfaced channel is a semipermanent structure and can be left in place after construction to deal with long-term irrigation issues, whereas the vinyl-lined channel is only a temporary structure.

Two techniques have been used with varied degrees of success to prevent soil erosion—straw bales and silt fences. An erosion control technique, the silt fence is constructed of **landscape fabric** attached to and suspended vertically between posts or stakes that are driven into the ground. Water strikes the landscape fabric and slows, dropping its load of sediment. Both straw bales and silt fences

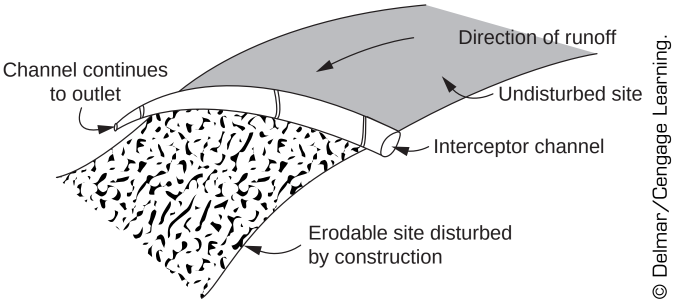

Figure 13-1 An interceptor channel designed to capture runoff before it enters a site.

slow the velocity of water leaving the site, and the sediment is dropped on the upstream side of the protection and stored in 18–24-inch basins. Both techniques are more effective when existing ground cover vegetation is left in place for at least a 10–20-foot strip along the site's entire perimeter. Wattles, covered in "Protecting the Site from Surface Erosion," will also provide some degree of protection on shallow slopes or on surfaces that have been minimally disturbed.

Placing silt fences and straw bales in the proper location greatly increases their effectiveness. Areas to be treated are those below a site's disturbed areas, particularly locations downstream from these areas. Lower areas of sites and channels (see "Protecting the Site from Channel Erosion" later in this chapter) are other potential areas for protection. Both silt fences and straw bales are temporary structures and should be removed after construction ends and when permanent erosion control is functioning properly.

Maintenance of silt fences and straw bales is also critical to proper functioning of the systems. Whichever method they select, contractors should periodically remove the sediment in front of silt fences and straw bales to allow water to run through, and not over, them. Both silt fences and straw bales should be kept in an upright position. Bales that have tipped over and silt fencing that sags reduce the effective area of protection.

Installing Straw Bale Perimeter Protection

Contractors have used straw bales for many years to hold eroded soil on a site. Although inexpensive, bales are prone to washout and have a limited life. Their use should be limited to short-term projects, in which maintenance of bales can be performed. Materials required for straw bale perimeter protection include enough bales (measured along the longest dimension) to cover the perimeter and 2–3-foot wood or metal stakes for each bale placed (Figure 13-2).

Begin installation by marking the locations where you will provide perimeter protection. Clear weeds and debris for a 2-foot wide path along the perimeter identified for protection. Level the surface within this cleared path; the bales must make continuous contact with the surface to prevent leakage under them.

Beginning at the lowest point along the perimeter, place a bale on edge and push stakes into the top of

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Figure 13-2 Surface erosion control measures with straw bales and wattles on the slope.

the bale 12 inches from each end and centered in the bale. Drive these two stakes into the ground until the stakes are flush with the top of the bale. Place a second bale snug with the end of the first bale and repeat the staking procedure. Continue placing and staking bales until the bales line the entire perimeter.

Installing Silt Fence Perimeter Protection

Silt fences are the most effective protection method to reduce washout. Materials required for silt fence perimeter protection include enough premanufactured silt fence and stakes to cover the perimeter to be protected.

Begin installation by marking the locations where you will provide perimeter protection. Clear weeds and debris for a 2-foot wide path along the perimeter identified for protection. In a straight line along the low side of this cleared strip, excavate a 6-inch wide by 12-inch deep trench along the entire perimeter (Figure 13-3). Using a trenching machine for large projects will save both time and labor.

Beginning at the site's low point, place the bottom of the silt fence in the trench. Drive the wood stakes into the ground, leaving 24 inches of stake above the top edge of the trench. With each successive stake, stretch the fabric taut between the stakes. Tuck fabric into the trench and backfill. If more than one length of fabric is required, overlap the first length of fence with the second by 5 feet. Fasten both lengths together using nylon ties. Complete the installation by backfilling and compacting the trench.

An alternative to silt fence with preinstalled stakes is to hang weed barrier from an existing fence at the site's perimeter. The bottom edge of this installation should be buried in the same manner as the silt fence. If using an existing fence for support, excavate a trench along the upstream (high) side of the fence. To fasten to an existing fence, push nylon ties through the silt fence 2 inches from the top of the fabric and wrap them around the fence wires or surfacing. Stretch the fabric taut and place a tie every 2 feet.

PROTECTING THE SITE FROM SURFACE EROSION

Once the plant material cover has been removed from a surface, the process of erosion begins. Water droplets hit the surface and dislodge a particle of soil. Several particles are eroded away and rills, or

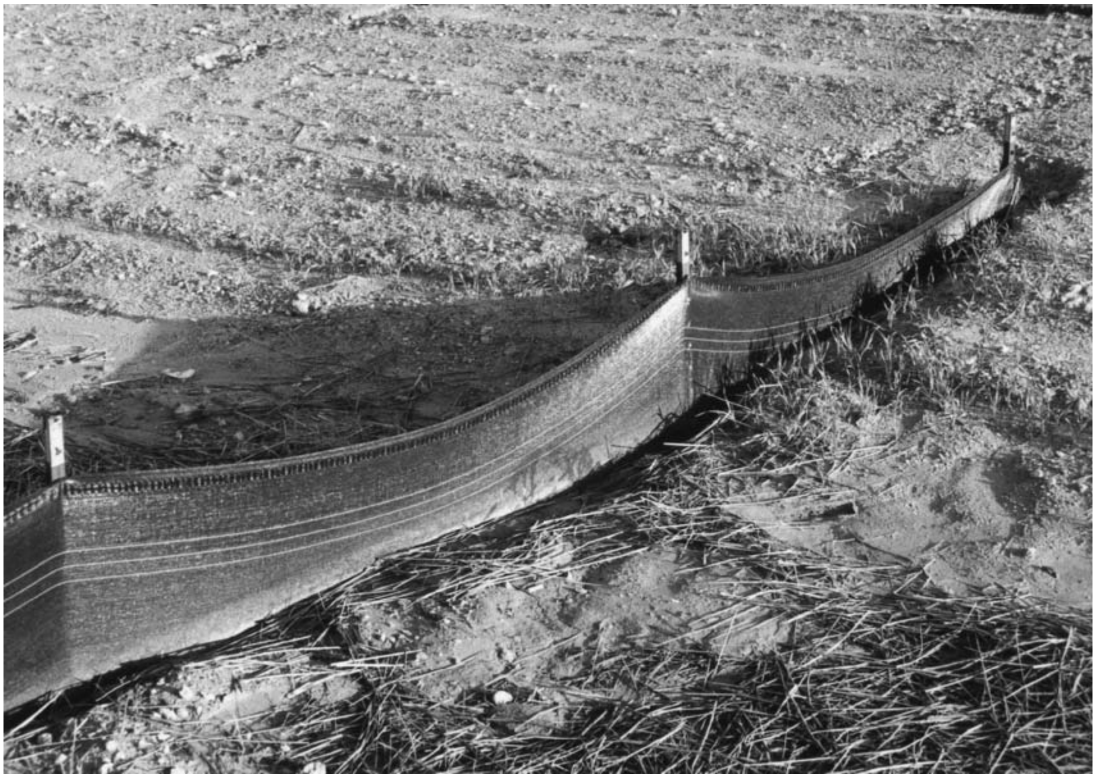

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Figure 13-3 Silt fence installation for perimeter erosion control.

small valleys, are formed. If left unchecked, the rills eventually form a network of gullies, and soil is systematically and continually eroded. Steep slopes and soils highly susceptible to erosion speed the process. To reduce erosion, surface protections are designed to either hold the soil in place with plant roots or cover the soil to limit the dislodging of soil particles. The best protection methods combine both of these techniques.

Protection methods used to reduce surface erosion include terracing, establishing **cover crops**, **mulching**, using wattles, applying soil stabilizers, covering sites with erosion prevention mats, and installing structural coverings on steep slopes. Each of these methods can be used as both temporary and permanent control measures. Most effective among these controls are ones that combine establishment of a cover crop with mulching, **erosion mats**, or permanent structural controls. Areas best suited to these protection methods include any surface that has been disturbed, but particularly disturbed areas with slopes greater than 2% (2 feet of fall in 100 feet of horizontal distance) and soils highly susceptible to erosion.

Applying Soil Stabilizers

The same products that bind aggregate to create a paved trail surface can also be applied to soil to reduce erosion. Although these products bind soil particles, they are only effective on gradual slopes, typically 1% slope and less, and should not be considered a long-term solution. Stabilizers may also reduce or eliminate the germination of cover crops applied before or after stabilization.

Soil stabilizers used for erosion control include polyurethane products, pine tree resin emulsions, bituminous emulsions, and ground seed hulls in powdered form. The liquid polyurethane stabilizer is poured directly over soil and blends into the top 1 inch of the surface. This product is most effective in preventing soil spreading or spilling into surrounding areas and contaminating other surfaces. For example, polyurethane is used in a golf course sand trap to keep the sand and soil separated. Liquid resins and emulsions must be blended into the top 3 inches of the soil by hand or by using mechanical equipment such as tillers or tractor-mounted blades. Once the resins or emulsions are incorporated, use heavy rolling equipment to compact the area. Powdered mixtures are blended into the top 3 inches of soil in the same matter and are moistened before compaction.

Terracing

When landscape contractors have control over grading of the site, they can adapt terracing to reduce erosion. Generally used in agricultural applications, terracing involves sculpting slopes into a series of nearly level, flat areas separated by steeper slopes. Planting cover crops or constructing retaining walls will maintain stability of steep slopes, but the terraced areas are less susceptible to erosion if the grade between the walls is nearly level. Although not appropriate in all areas, and expensive to implement, terracing can make a site more productive, as well as less susceptible to erosion.

To create terraces, "bench" the site during the rough grading phase of construction into a series of flat areas that are a minimum of 8–10-feet wide up to several feet wide. Steep slopes, typically no more than 4 feet high, separate these flat areas. Walls are then constructed to hold back the steep slopes, or the steep slopes are graded at a 2:1 slope and heavily planted and covered with erosion control blankets. After the slopes are completed, the flat areas are then planted with cover crops or permanent vegetation.

Using Cover Crops

Roots of plant material provide an effective method for holding soil in its place. Seeding a disturbed site with a quick-growing crop will both buffer the impact of rain and hold the soil. Selection of a cover crop requires knowledge of locally available crops that germinate quickly. Common selections include oats, wheat, annual ryegrasses, and buckwheat. The most serious limitation of this method is the time required for plant material to germinate. This limitation suggests combining a cover crop with another method that provides immediate abatement of erosion.

Many designs rely on vines, herbaceous ground cover, and woody plant material as a permanent cover to protect slopes from erosion. Because these plants take time to establish, it is necessary to combine their planting with temporary erosion control measures. Suggestions for minimizing the effects of erosion during the establishment period include spacing the plants closer, using erosion mats, and mulching.

Mulching

An inert covering over a disturbed surface reduces the impact of rain on soil particles. Using mulch reduces the energy with which the water strikes the

soil, limiting the disturbance of soil particles and the potential for erosion. A labor-intensive process with limited effectiveness on steep slopes, mulching functions best when combined with seeding of a cover crop under the mulch.

Mulching begins with selecting a suitable mulch material for the project site. Common choices are straw, wood chips, and shredded wood, with straw being a more cost-effective solution for construction protection. Spread the mulch evenly over the entire disturbed area by hand or mechanical means (spreader). Binding the mulch with the surface using a roller or a disk will slightly improve the durability and effectiveness of the mulch. This treatment requires periodic reapplication during construction. Expect some minor erosion and gullying that should be repaired prior to respreading topsoil. If gullying becomes a serious problem, consider channel protection for those affected areas.

A variation of mulching is hydraulic mulching, or **hydromulching**. This process, which requires special equipment, mixes mulch with water and a **tackifier** (sticky substance). The mixture is then sprayed on the site's surface. Hydromulching is typically accomplished by feeding the materials into a trailer-mounted hopper and spraying evenly over a site using a large hose. If desired, seed can also be mixed with the mulch, although the seed's germination and survival rates are reduced when this mixture is used. Hydromulching allows use of more durable mulches and reduces the labor required to evenly spread the mulch over the site.

Hydromulch formulas, called *bonded fiber matrices* (BFMs), chemically bond the materials and provide a durable, papier-máché-like coating over an exposed area. Water, starch, or a guar-based tackifier, and either cellulose (recycled paper) or wood fibers are blended and sprayed on the exposed surface. In some applications, synthetic fibers are added to increase bonding capabilities, and dyes are added to simulate vegetation colors. A few products have introduced water-absorbing gels into the mix to assist in holding water. Application of BFMs is best accomplished if the mixture can be sprayed so that it descends in an almost vertical angle similar to rainfall. Applying the material from opposing directions will improve coverage. BFMs require a drying time of up to 48 hours to be effective, and any rainfall or irrigation that occurs prior to curing may erode the surface.

Caution should be used in selecting BFMs if you plan to establish vegetative cover. The materials used to bond the product and the hard covering created after it is applied may restrict the germination and growth of cover crops. If combining seeding with BFMs, prepare the seedbed and sow or drill the seed prior to applying the matrix.

Installing Wattles

Wattles are tubular-shaped nylon nettings filled with straw fibers or small sapling branches such as willow. Installed on a slope perpendicular to water flow, wattles slow the water and force sediment to drop (Figure 13-4). Wattles are also used around the rims of storm drains and in locations where it is desirable to reduce sedimentation. Wattles are measured for length by laying out the material near the location of installation. Cut the wattle using tin snips or a knife and reseal the cut end of the netting using a twist tie. Along the alignment where the wattle is to be placed, excavate a shallow, concave trench approximately 2 inches deep. Place the wattle in this trench and stake it into place using 12-inch long 2 × 2 wood stakes spaced every 5 feet (Figure 13-5). Although wattles degrade over time, they are not intended to be left after permanent cover or erosion control is in place.

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Figure 13-4 Wattle installation.

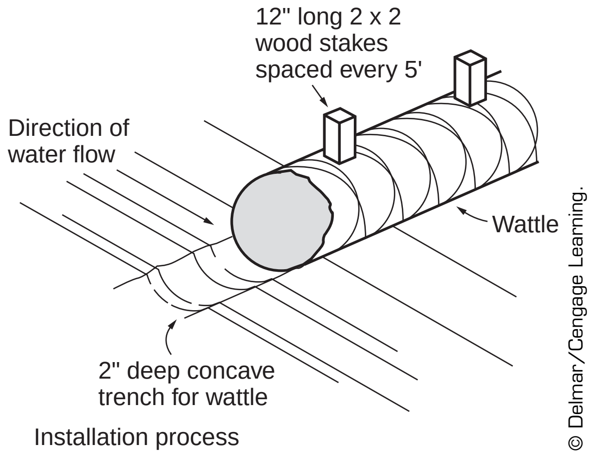

Figure 13-5 Trenching and staking of wattles.

Installing Brush Mattresses and Pole Plantings

For lakefronts, channels, and streambanks in areas where fast-growing plant material can be harvested, brush mattresses and pole plantings can be used to reduce streambank and channel erosion. Brush mattresses are 6-inch thick layers of thin-diameter brush branches and stems that are arranged vertically along an embankment or channel side. Willow or other fast-growing plant material are preferred for this application. At the top and bottom of the smaller branches, horizontally lay 2–3-inch diameter cross branches. Drive stakes 2–3 feet into the embankment; wire the stakes to the cross branches to hold the branches in place. Then place soil over the mattress to encourage rooting (Figure 13-6). In moist environments, pole plantings, or stakes of fast-growing plant material such as willow and dogwood, can be driven into the embankment and allowed to sprout. These poles should be at least 2 inches in diameter and 4 feet in length and driven at least 2 feet into the embankment. With the buds of the poles facing upward, space the poles every 2 feet horizontally and vertically.

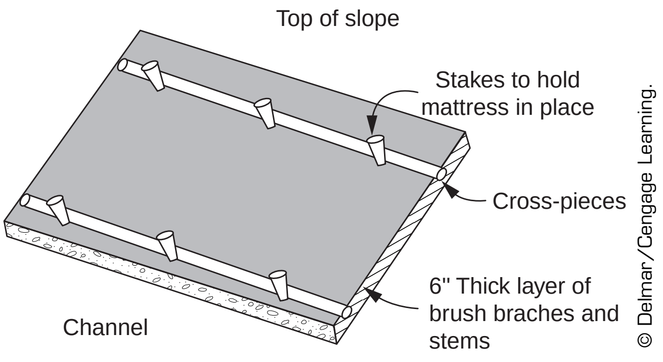

Figure 13-6 Diagram of a brush mattress.

Installing Erosion Control Blankets (Erosion Mats)

Erosion control blankets (ECBs), or erosion mats, are a layer of biodegradable materials sandwiched between two layers of lightweight netting. Materials commonly used for netting are slowly photodegradable, and some manufacturers produce nettings that slowly biodegrade. Mats are intended to be anchored to a disturbed surface that has been seeded, either below or on top of the mat, and left to degrade over time. The lightweight netting is ground up by mowers or imbedded into the ground cover, which eventually covers the site. The mat material, often wood fibers, excelsior, coir (coconut husks), straw stems, or other wood by-products, degrades over one to two seasons and allows any seeded ground covers below the mats to grow.

Not all ECBs are biodegradable. Some use nonbiodegradable synthetics and plastics for the netting or core, and the products do not break down as readily as the natural or lightweight products. Some erosion mats are intended to remain in place for long periods and are sold as turf reinforcement mats, or TRMs. These and similar products, which are difficult to remove once vegetative cover is established, will remain in or under the plant material cover for long periods of time. This variety of material choices requires that the selection of a product be based on careful review of the situation for which the material is being used. Although they are more costly than mulching, mats provide better cover and a more stable form of protection for slopes up to 5%.

Installation begins with identifying the area to be covered. Prepare the entire seedbed below the area where the mat is to be placed. Starter fertilizer and seed may be placed on top of the mat, but placement below the mat provides better success for seed germination rate. Beginning at the site's high side, excavate a trench 6 inches deep and bury the top edge of the mat. Staple the fabric to the bottom of the trench (Figure 13-7). Backfill and compact the trench. For improved stability of installation, the mat can be wrapped around a ½-inch wood dowel or piece of #3 rerod, with the stakes placed straddling the dowel or rerod (Figure 13-8).

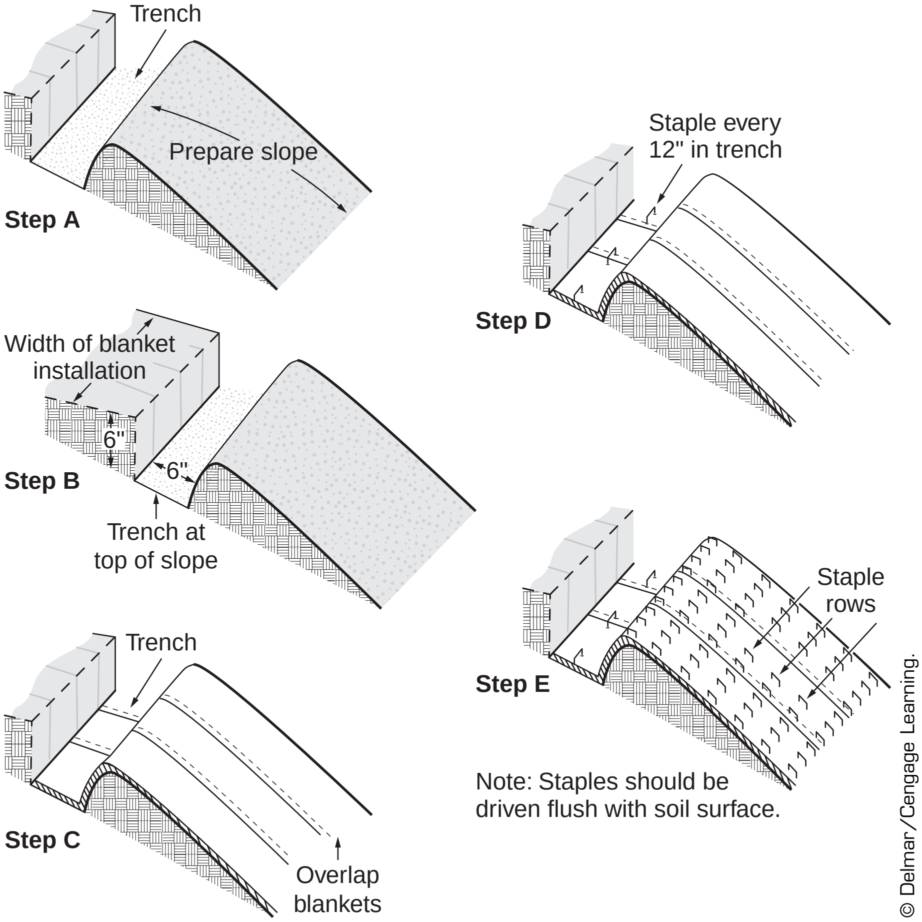

Figure 13-7 Installation of an erosion control blanket. The blankets are oriented with the long dimension running in the same direction as surface runoff.

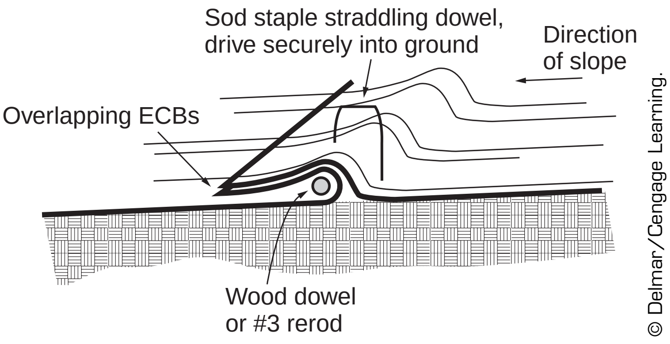

Figure 13-8 Using a dowel or rerod to improve stability of ECB installation.

Roll out the mats in the same direction that water will run across the surface (top to bottom). Verify that there is good mat-to-soil contact. Where two mats are adjacent to one another, overlap the mats 12 inches. Mats can also be overlapped if there is excess material in odd-shaped areas. If mats are placed on a sloped surface, overlap them by placing the mat from the higher side over the mat on the lower side. Using metal staples or stakes (usually provided by the mat manufacturer), secure the mat every 12 inches around all edges and at overlap joints (Figure 13-9). Place staples in staggered rows every 18 inches for the length of the mat. For installations where the slope length is more than 20 feet top to bottom, install an additional row of stakes across the width of the mat every 10 feet (Figure 13-10).

In applications where the possibility of water running under the mat is high, "check slots (Figure 13-11), or two closely spaced rows of anchors may be used transverse to flows at intermittent points down a slope or along a channel."[1] Construct a check slot by excavating a 6-inch deep by 6-inch wide trench along the entire width of the slope. Roll the blanket into the trench and staple at the bottom; then fold the blanket

Figure 13-9 Anchoring an erosion mat using metal staples. Photo shows overlapping ECBs and stapling before installation.

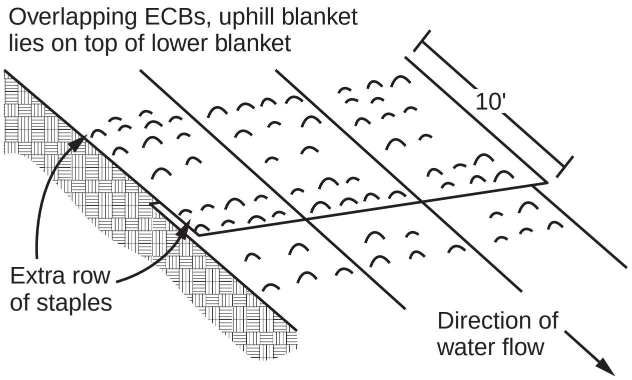

Figure 13-10 Overlap of ECBs secured with a double row of staples.

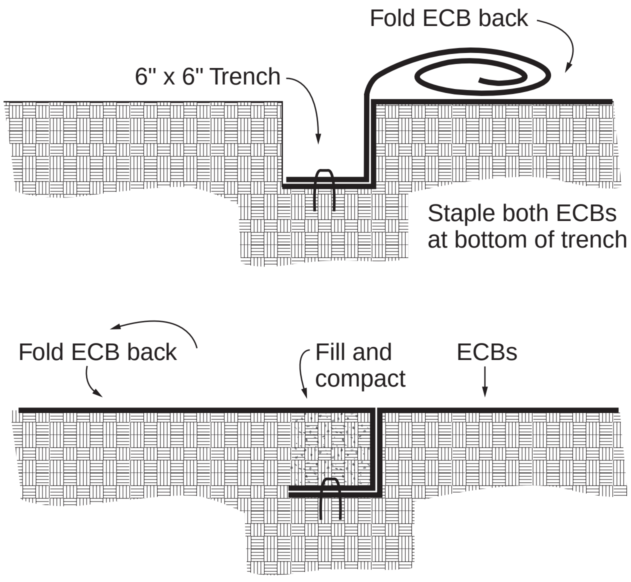

Figure 13-11 Securing ECBs with a check slot.

uphill on top of itself and fill the trench. When the trench is filled and compacted, continue rolling the blanket down the hill. After the ground cover is established and prior to the first mowing, remove all stakes and staples that can be located. This will reduce the chance of mowers "throwing" loose stakes as projectiles and will protect mowing equipment from damage.

Controlling Structural Erosion on Steep Slopes

Steep slopes may need a more durable installation alternative for reducing surface erosion. Three choices of structural controls are available for a variety of situations—cellular confinement systems, slope retaining blocks, and rip-rap.

Cellular Confinement Systems. Cellular confinement systems use a web of geotextile pockets spaced down a slope to hold surface materials in place against erosion forces. These pockets function similarly to small dams that hold back material while slowing the water running down a hillside (Figure 13-12). Materials perforated with holes approximately ¼-inch in diameter are used for most installations, but nonperforated cells are available when filling with fine aggregates that may wash through the openings. When properly installed, the cellular confinement system stabilizes steep slopes and can be used for soil and granular fill, as well as for concrete.

Before installing a cellular confinement system, remove all debris and surface irregularities; the slope must be smoothed. Excavate a 12-inch wide by 12-inch deep trench along the entire top edge of the slope. Place a geotextile cover over the entire

Figure 13-12 Cellular confinement system.

slope and fold the cover into the trench (Figure 13-13). Geotextile should be placed with the long dimension running down the slope the same direction as runoff. Staple the geotextile into the soil surface every 12 inches along all seams and edges and every 18 inches throughout the center of the material.

Supporting lines, or tendons, are anchored in the trench at the top of the slope using rerod, stakes, ATRA©, or DUCKBILL© anchors. These tendons should be spaced to match the openings in the cellular confinement system. Place an unexpanded section of the confinement system fabric next to the trench on the slope side. Using a tube or a hook placed through the openings, thread the tendons through the openings in the unexpanded cellular confinement system. Pull the tendons down the slope and space them parallel to each other. Expand the cellular confinement system down the slope. If the slope is irregular, the cells can be compressed or tapered to match the slope direction. Secure the bottom of the cellular confinement system by knotting the tendon just past the last cell and anchoring the tendon just beyond the last cell. Fasten runs of cellular material to each other by stapling cells along the edge of the material. Anchor the installation internally by staking the tendons at 5-foot intervals down the slope.

Fill the cellular confinement system from the top of the slope working downward. Gently place fill material by hand or, if using excavation equipment, dropping the load from under 3 feet above the material. Evenly distribute the material throughout the cells.

Slope Retaining Blocks. Interlocking precast concrete block can be used to structurally stabilize a steep slope. Although similar to retaining wall block, these blocks are installed with a steeper **batter**, or backward lean, and with open voids between units. Slope retaining blocks anchor a slope by creating a loose wall that holds the soil at its natural **angle of repose** and allows plant material to establish in the voids.

To install slope retaining block, excavate a 12-inch wide by 6-inch deep trench along the entire length of the slope. Place the base course in this trench. The base course is laid by leveling the blocks side to side in the trench. Slope the base toward the hillside

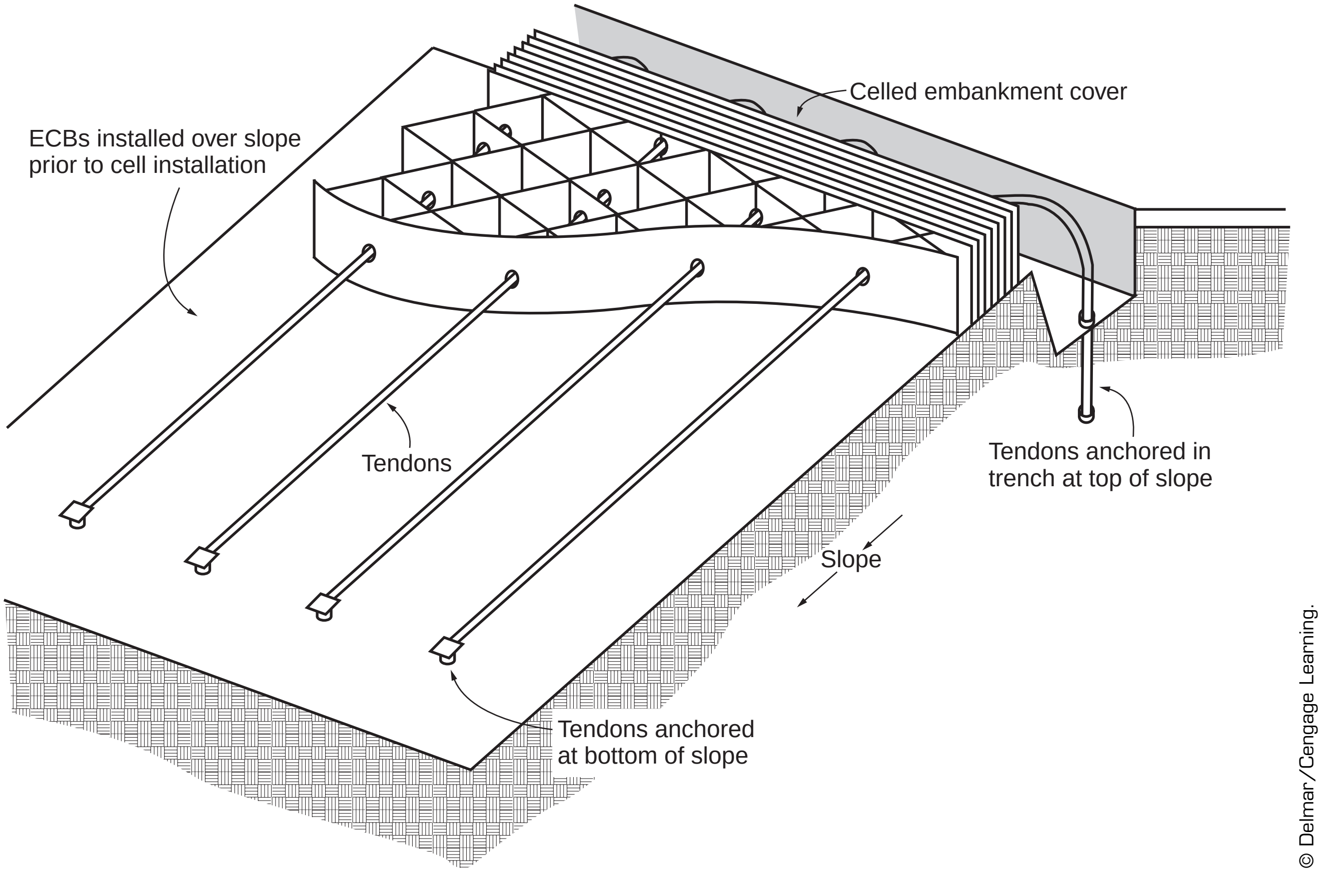

Figure 13-13 Installation of cellular confinement system.

to provide the batter recommended by the manufacturer (typically 2-inch batter for every 1 foot height of wall). Blocks in subsequent courses should be placed straddling the two blocks below. Backfill with soil and continue adding courses until you reach the top of the slope. As you construct the wall or after you complete the installation, you may add ground cover plants in the voids.

Rip-Rap. In cases where plant material is not a reliable or practical choice for protecting embankments from erosion, permanent protection can be obtained by placing rip-rap (loose rock surfacing) over landscape fabric. Install the landscape fabric running in the same direction as the slope, and staple the fabric in place with sod or fabric staples. In instances where significant water is running onto the slope from above, excavate a 6-inch deep trench along the top of the slope, and bury the top edge of the fabric in this trench. Staple the fabric to the bottom of this trench, backfill, and compact. Beginning at the bottom of the slope, place rip-rap of at least 4–8-inch diameter over the fabric. Material choices may include rounded or angled stone or other locally available stone. Rip-rap must be large enough and heavy enough to counter the force of water washing down the slope. Carry the rip-rap 18 inches beyond the fabric's edges at the top and sides to help hold the fabric in place.

PROTECTING THE SITE FROM CHANNEL EROSION

Unless a site is extremely flat, water will collect in lower areas to drain away. This runoff is often heavy enough to form channels in areas with high volumes of runoff. If the channels are disturbed or have no protection, severe erosion can result. To provide temporary protection from erosion, techniques such as silt fences are used to slow down the runoff and to trap soil washed from higher elevations. Erosion mats can provide longer term protection because they help establish well-rooted ground covers on the channel's surface. In locations where water volumes and speeds are high, paved surfaces or rip-rap is used.

Determining the proper technique to use, as well as the proper location of the treatment, varies greatly from site to site. If the site is still under construction and more grading or construction activities are planned in the channel area or in those areas more susceptible to erosion located above the channel, temporary silt fences along the entire channel route are recommended. Spacing of silt fences depends on the slope and volume of water. However, a standard is to place the fences 50 feet apart for a channel that has a slope of 2–3% or drains an area that is primarily covered by impermeable surfaces. Steeper slopes and greater permanent coverage will require closer spacing. In channels with a flat slope, it is possible to place the erosion mats as described in "Protecting the Site from Surface Erosion" above.

Channels in areas where all construction is completed may be addressed with one of the permanent solutions. A ground cover is acceptable if the flow in the channel is intermittent enough to allow seeding to germinate. Maximum slopes of 2–3% and drainage areas that are less than 50% permanent cover approach the upper limits of channel erosion control using living plants. Channels above these limits should have rip-rap installed or be paved to limit erosion.

Installing Silt Fences

Silt fence for channel protection is installed in a manner similar to silt fence installation for perimeter protection. Materials required for channel silt fence will include lengths of the premanufactured silt fence with stakes that are 50% longer than the channel width (e.g., 10-foot wide channel requires 15-foot fence lengths). Begin installation by marking the locations where fences are to be located. Silt fence should be placed across the channel perpendicular to the direction of the water flow. Position the silt fence in a *V* configuration with the point of the *V* at the channel's low point and facing downstream (Figure 13-14). Clear weeds and debris for a 2-foot wide path along the path identified for the silt fence. Excavate a 6-inch wide by 12-inch deep trench along the path.

Beginning at the edge of the channel, drive in place at the bottom of the trench the first stake of one of the previously cut silt fence lengths. Leave half of the stake/fabric above the top edge of the trench, and place with the fabric on the upstream side. Stretch the silt fence out along the length of the trench, driving wood stakes into the ground. With each successive stake, stretch the fabric taut between the stakes. The silt fence should be completed using a single piece of material. Complete the installation by backfilling and compacting the trench (Figure 13-14).

Similar to the procedure for perimeter protection, the silt fence must be maintained by periodically digging the trapped soil out of the reservoir. Failure to clean out in front of the fence may allow water to flow

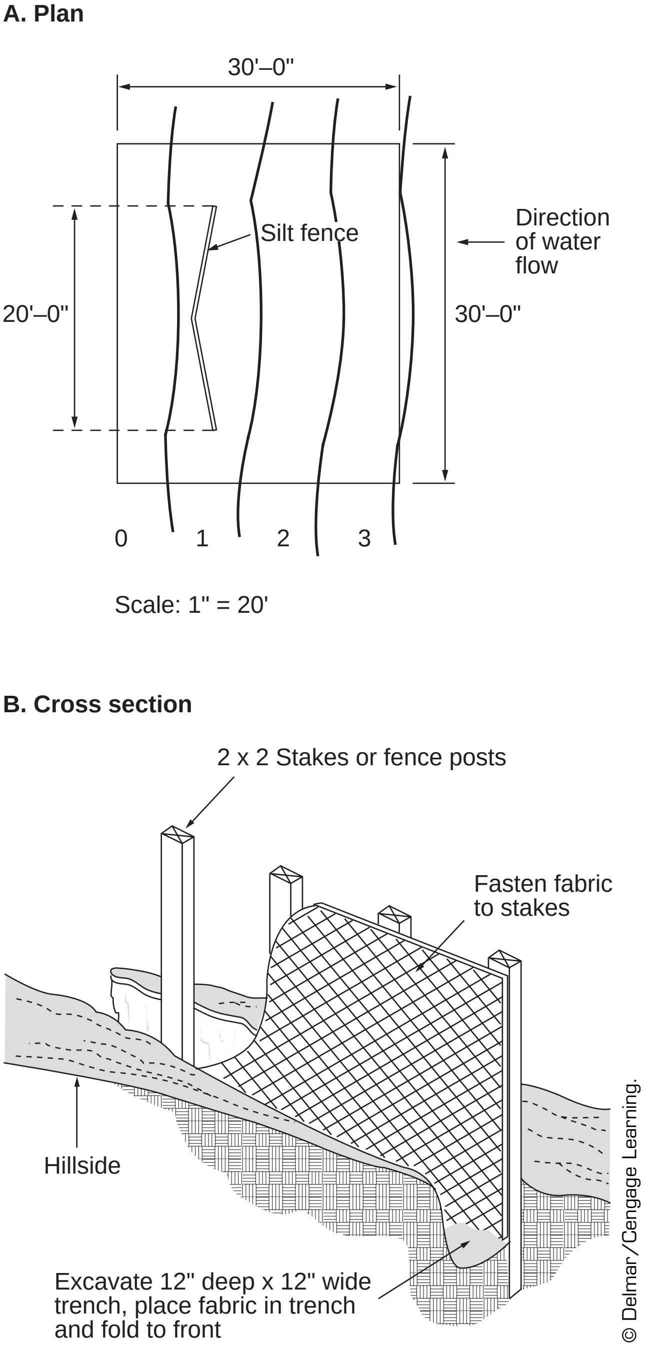

Figure 13-14 Silt fence. A. Layout. B. Installation.

over the fence, making it nonfunctional. If the reservoir fills up rapidly, consider placing more fencing between existing installations or addressing surface erosion above the channel with a temporary control.

Installing Erosion Mats

Erosion mats can also be used for protection of channel surfaces. Installation is the same as that described in the previous paragraph, with the following exceptions. Beginning at the channel's low end, roll out the mats in the same alignment that water will flow in the channel (Figure 13-15). Where two mats are adjacent to one another, make certain the mats overlap 12 inches. Overlap by placing the mat from the higher side over the mat on the lower side and securing them with staples. Using metal staples or stakes (usually provided by the mat manufacturer), secure the mat every 12 inches around all its edges and across its center. Place staples in staggered rows every 12 inches for the length of the mat. In instances where significant water is running into the channel from above, excavate a 6-inch deep trench along the top of the slope and fold the edge of the mat in this trench. Staple the mat to the bottom of the trench, backfill, and compact. After ground cover is established or prior to the first mowing, remove all stakes and staples that can be located. Place rip-rap at either end of erosion mats in areas of high water volumes.

Installing Rip-Rap

Rip-rap erosion protection is accomplished by lining a channel with large, loose stone that water, when passing through the channel, cannot pick up and wash away. This permanent installation performs the functions of slowing the water as it strikes the stone and holding the soil beneath the stone in place. Some contractors use a variation of this application by laying landscape fabric below the rip-rap before placing it.

The success of rip-rapping is entirely based on selecting the proper size of stone. For most small channels, 4–8-inch stone will provide adequate weight to slow the water and to hold the soil. Larger channels may require larger stone to perform this same function. Consult a design professional if you are uncertain about what size of stone to select. Place the stone beginning at the lower end of the

Figure 13-15 Placement of erosion mat along length of a channel. Note that the mat is placed with its long dimension running the same direction as the water flow.

channel and evenly cover all surfaces (Figure 13-16). To be effective, the stone must extend from the bottom of the channel to the top, with no gaps in coverage.

The owner must periodically maintain the rip-rap. Sediment dropped in the channel creates an ideal environment for grasses and weeds to germinate. Manual, mechanical, or chemical weed control will be needed to control growth in the channel.

Installing Paved Channels

Paved channels provide the most reliable protection against channel erosion. Unfortunately, they are also the most expensive and difficult to construct. The reader is referred to Chapter 23, Concrete Paving, for details regarding preparation, forming, and pouring cast-in-place concrete. Following are some special considerations for review before selecting and pouring paved channels as a permanent erosion protection.

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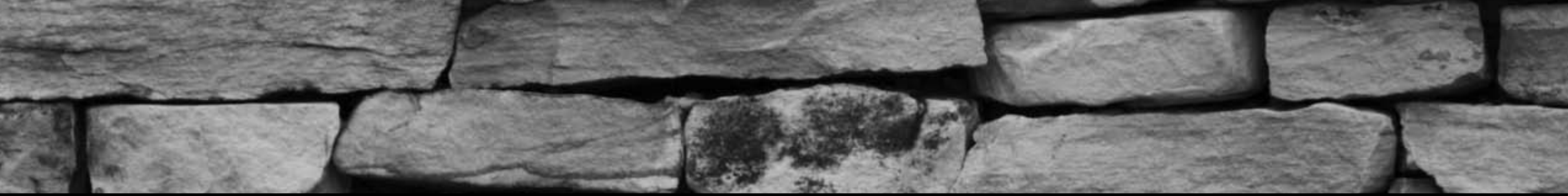
Figure 13-16 Swale protected with 4–8-inch rip-rap.

Pouring slabs for channels that will carry large volumes of water requires special preparation and finishing to ensure an effective installation. First consider whether the channel can be paved without being disturbed by the amount of drainage through it. If flows through the channel are not intermittent, explore other methods to divert or stop the water to allow construction. Because the slabs that form the channel may not be completed in a single pour, contractors will need to provide joints that are solid and impermeable. Any water that works under the slab will cause erosion, resulting in failure of the channel. The channel's surface should be "distressed," or textured, to slow the water as it moves through the channel. To distress the surface, drag a rake across the finished concrete perpendicular to the direction of water flow or embed 4–6-inch diameter angular rock into the concrete, leaving half of the rock exposed. Other methods of distressing the surface are available; however, these methods may require that the slab be thickened by 1–2 inches to avoid weak areas.

Treatment of outflow areas should be considered when providing channel protection. The area where water passes out of a channel is a potential area for significant erosion. The grade in this area should be flattened and covered with rip-rap to prevent the installed channel protection from being undermined (see "Treating Outlet Systems" in Chapter 12).

ENDNOTE

1. Greenfix America, Technical Data, http://www.greenfix.com.



SECTION 3

SUMMARY

Creating attractive landforms and effective site drainage requires grading the soil on the site and protecting it from erosion. Section 3 discussed the process for grading a site, installation of basic drainage structures, and temporary and permanent erosion protection measures. Each of these components works together to create interesting site features, to effectively remove unwanted water from a site, and to keep valuable soil in place.

Grading is a logical process of removing, sculpting, and replacing the layers of soil on a site. Initial steps in grading include stripping sod and vegetative matter from the surface, stripping and stockpiling topsoil, rough grading to approximate elevations desired, and placing of or installing temporary erosion control. At the conclusion of rough grading, the process is suspended until drainage systems, utilities, irrigation piping, walls, paving, and structures are in place. When intermediate construction activities are completed, the grading process resumes with the respreading of topsoil and grading to desired finish elevations. Additional smoothing and shaping of the finish grade may be undertaken before establishing turf areas. Permanent erosion control measures follow either finish grading or completion of turf areas.

Managing the amount of water that drains from the site can be addressed by surface drainage or subsurface drainage systems. Surface drainage involves the shaping of grade to direct water to desired locations. On sites with little existing topography, the construction of drainage swales or diversion berms may be required to direct surface runoff. When surface techniques do not provide effective drainage, subsurface systems such as french drains, tiles, and storm sewers may be required. French drains are temporary storage trenches that drain and hold small amounts of water in low, undrainable areas. Tile systems involve the trenching and laying of pipe that will intercept water and carry it to an outlet point. Storm sewers work in the same manner as tile systems, with the exception that water is collected at concrete structures set at low points throughout the site and carried in large, nonperforated concrete pipes. In areas where flooding is a problem, temporary storage, reuse, or dissipation of storm water runoff in detention ponds, bioswales, cisterns, soaker trenches, and rain barrels may be required. With outlets sized to slowly release detained water, detention ponds are open basins into which storm water is directed, whereas bioswales filter water that is moving along a channel. Soaker trenches allow the slow percolation of runoff from underground trenches into the surrounding soil. Cisterns and rain barrels allow the storage of rainwater runoff until it can be used for other purposes.

Keeping valuable soil on the site is the function of erosion protection measures. Erosion can be addressed at the perimeter of the site, over surfaces in areas more susceptible to erosion, and along channels that carry runoff. Perimeter protection is accomplished by burying straw bales or silt fences at the construction boundaries and other required locations. Measures typically used over surface areas include terracing, establishing fast-germinating cover crops, mulching, placing wattles, brush mattresses, erosion mats, cellular protection, and rip-rapping of steep embankments. Channel erosion protection ranges from installation of erosion mats and silt fencing to the rip-rapping and paving of high-volume channels.

SECTION 4

SITE UTILITIES

INTRODUCTION

Drainage systems are not the only utility systems for which the landscape contractor may have responsibility. Preparation of the site for an electrical contractor's work, kit installation of direct current (DC) or low-voltage lighting systems, and custom installation of DC lighting systems are the most likely utility systems that landscape contractors may also need to address. Installing pipes, valves, and heads for irrigation systems are also common tasks for landscape contractors or specialized irrigation contractors. Because general contractors or project owners often retain separate utility contractors to perform related utility work, only reference information is provided for other utilities.

Whether engaging in a simple or complex utility installation for a site, landscape contractors must exercise caution when working with underground utilities. Call the local utility companies for location of lines or cables before digging, and use extreme caution when using equipment and digging trenches for utility work.

SUSTAINABILITY SUGGESTIONS

When working on a project, landscape contractors should follow these suggestions for sustainability:

- Select lighting components, particularly lamps, that are high efficiency. Light emitting diode (LED) lamps provide maximum lighting for the energy input and are preferred over incandescent lamps.
- Place lighting circuits on photocells and timers to limit energy consumption to the times when lighting is needed rather than having circuits that are on all the time.
- Utilize the most efficient irrigation equipment available. Select controllers that use smart technologies, such as ET (evapotranspiration) control of the irrigation times, and sensors that limit overirrigation after rain. If a choice is allowed by the construction documents, drip irrigation systems are more efficient than spray systems.

- If permitted by project documents, use of recycled water (gray water) can be maximized for site irrigation.
- Choose materials that have reduced toxicity, including those that are toxic in their manufacturing processes and uses. Minimize use of polyvinyl chloride (PVC) products, pesticides, synthetic fertilizers, and wood preservatives.

PHONE, TV, AND TELECOMMUNICATIONS SYSTEMS

Most people underestimate the impact of phone, TV, and telecommunications systems on the landscape. Any deck or gazebo can be "wired" for technology with simple preparation during the construction phase of landscaping. Installing a phone line communications wiring or coaxial cable to an outdoor structure expands the idea of the virtual office into the virtual garden. Specialized contractors must install private phone or TV lines; however, installation of empty conduit is recommended even if service lines are not initially placed.

Please note that utilities may regulate who makes the connections to their service lines and may charge for additional outlets connected to a single service. Inform clients that there is also a security issue with phone and TV connections in exterior applications. If access points have no locking covers or security measures, then anyone could plug a phone into the client's line and make unauthorized calls.

GAS SYSTEMS

Gas systems can be either natural gas or liquid propane (LP). Gas used in exterior applications is typically reserved to supply lines to outlying structures for outdoor cooking and occasionally for lighting or for firepits. As with other utility systems that pose health and safety risks, gas systems require specialized contractors for installation and connection.

PLACEMENT OF CONDUITS FOR FUTURE USE

When installing permanent landscape features, particularly those adjacent to buildings, it is advisable to install empty conduit under the feature. Conduit can be placed under walks, patios, decks, and similar structures to avoid the necessity of digging up these elements at a later date to install utilities. Consider placing two oversized Schedule 40 conduits (4–6 inch) through which electrical, gas, water, and other lines can be pulled in the future. Conduit can be placed through a basement wall or left just outside the wall if there are concerns about moisture or insects entering the structure. The conduit should be capped to prevent moisture from filling the pipe and possibly flowing back into the structure. Sloping the conduit away from a structure is also advisable.

CHAPTER 14

DC SITE LIGHTING AND RELATED ELECTRICAL WORK

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Install a custom low-voltage site lighting system.
- Install low-voltage lighting kits.
- Install footings for alternating current (AC) lighting installations.

In this chapter, the installation of a low-voltage **direct current (DC)** electrical systems is presented, along with a summary of site-related **alternating current (AC)** electrical installations that may become the landscape contractor's responsibility.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Related Site Utility Work, Chapter 15
- Site Amenities, Chapter 35

CUSTOM LOW-VOLTAGE ELECTRICAL SYSTEMS

When the needs of the project require exterior illumination for aesthetic or safety purposes, landscape contractors can craft custom low-voltage lighting installations from the many components available. Lighting of many styles can be designed using the variety of fixtures, lamps, transformers, controllers, and wiring available to the competent lighting installer. Among the choices available with custom lighting installations are (Figure 14-1):

- lighting along paths and stairs
- uplights that shine into plant material
- downlights that cast an evening-like light down from the upper reaches of a plant
- backlighting that enhances the silhouette of a plant
- spot lighting that focuses on specific landscape features from one or more directions
- lighting that grazes the front features of an object
- flood lighting that fills larger open areas with light

Accomplishing each of these lighting styles requires specialized circuits, fixtures, and lamps that direct the proper amount of light to the correct location.

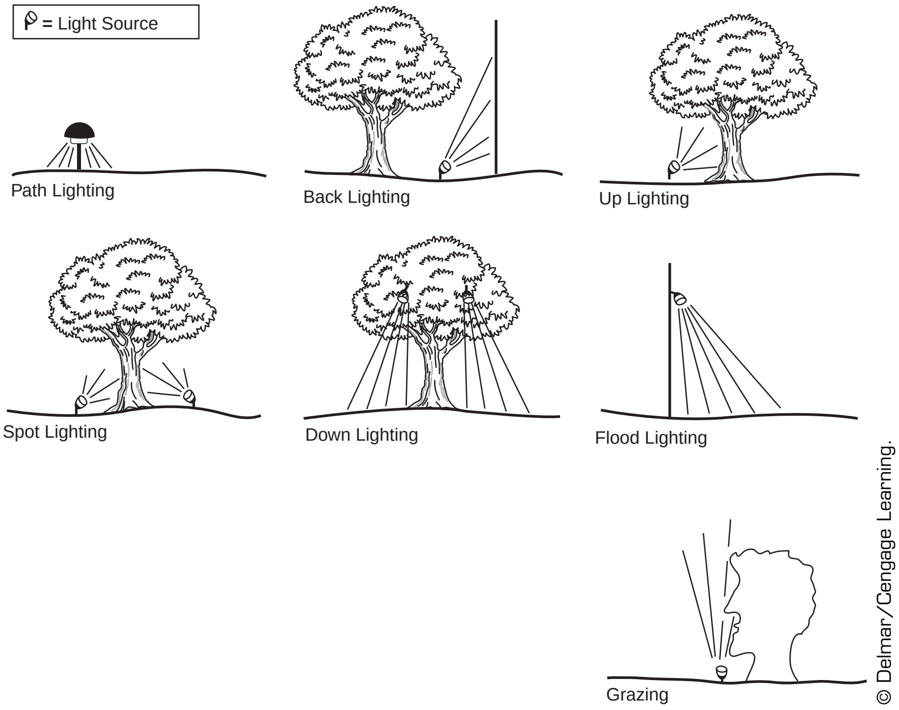


Figure 14-1 Decorative lighting styles.

LOW-VOLTAGE ELECTRICAL BASICS

Low-voltage lighting is so named because the electrical power used is reduced from a high level (typically 110–120 volts) to a lower level (typically 10–12 volts) to operate the lights installed in the system. Although the concept is simple, the parameters of designing a low-voltage DC lighting system can often confuse the typical layperson and even the occasional contractor. For simplicity sake, one can visualize the low-voltage lighting system as being a collection of components that produce decorative effects for the landscape. An electrical source provides the power to operate the system, a transformer reduces the voltage to a level that matches the fixtures on the system, electrical **controllers** such as timers and photocells turn the system on and off based on desired conditions for light, fixtures with lamps provide the illumination, and wire distributes the electrical current from the transformer to the fixtures.

The effective operation of this system is based on mathematical relationships among a defined set of electrical parameters that are standards throughout the electrical industry. Although more concerned with system installation, contractors can improve their work and understand why systems are laid out in a particular manner by learning some of the basic components, terms, and guidelines of lighting design.

Components of Low-Voltage Lighting Systems

The components of low-voltage lighting systems are very simple in nature but diverse in choices. These components are described below.

Transformers. Transformers reduce voltage so that low-voltage systems can work. Transformers are electrical boxes that are either wired directly to a household circuit or plugged into a household outlet. Inside the transformer is special circuitry that reduces the voltage from 110 or 120 volts to circuits that carry from 10 to 15 volts. This lower voltage is typically adequate for powering a run of light fixtures for the landscape. Although some transformers only supply a single circuit (tap), more complex transformers may offer multiple circuits (taps) with varying voltages. This provides flexibility for adding timers or photocells. Timers turn a circuit on and off based on time, whereas photocells allow a circuit to be turned on and off based on the amount of light present on a site.

Wiring. Similar to that used to operate household appliances, wiring for low-voltage systems has some important differences. Within most exterior wires

are two multistranded copper wires. These wires allow the electricity to be conducted to, and returned from, the fixtures on the system. The coating of most low-voltage wires is thicker than household wires to minimize damage from landscaping activities and is treated to withstand ultraviolet (UV) light deterioration.

Fixtures. The luminaires used in custom low-voltage systems are primarily made of cast metals with heavy-duty housings that can withstand the abuse of an exterior application (Figure 14-2). Most **fixtures** provide a sealed chamber, where the bulb is located, and a secure method of anchoring the fixture. All fixtures should provide two wire leads that are spliced into the wiring system with weatherproof connections.

Lamps. Several lamp types are available for exterior illumination. Incandescent, Halogen, Xenon, and LED are typical types of bulbs available in low-voltage lighting systems. Once the standard for lighting, incandescent lamps are being phased out because of their inefficiency and short lives. **Halogen**, an advanced form of incandescent lighting, provides a bulb with a longer life, brighter light, and higher efficiency of operation. Yet another form of high-intensity discharge lighting for low-voltage systems are **Xenon** lamps. In Xenon lamps, electrodes replace the filament of the incandescent lamps and produce light that mimics natural light with a high level of efficiency. Light emitting diodes (**LEDs**) use diodes to produce a light that is extremely efficient with no compromise on quality. Specialized manufacturing of LEDs provides greater flexibility in the design of low-voltage circuits for exterior illumination, allowing many more fixtures on a single circuit with lamps that are less sensitive to changes in voltage. Selection of the proper lamp will be based on factors such as initial cost, life cycle costs, quality of light, and the desired durability of the product.

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Figure 14-2 A low-voltage luminaire showing the two leads connected to the supply wire using waterproof nuts.

Basic Electrical Terms and Concepts

If a design professional plans a system, contractors do not necessarily need to know the specifics of low-voltage electricity to complete their work; but they can become more knowledgeable by understanding basic electrical terms and concepts. The terms *voltage, amps, watts*, and *ohms* are common to the design of electrical circuits, and the following explanations can help relate these terms to low-voltage lighting systems.

Voltage. Voltage is the electrical potential of a circuit, or the circuit's ability to do work. To use an analogy from irrigation, voltage is similar to pressure. An irrigation line that has pressure can operate irrigation heads, whereas a circuit with voltage can illuminate lights. Voltage is provided throughout a household using electrical circuits with circuit breakers or, in the case of low-voltage systems, transformers. Voltage is slowly lost over the length of the system through resistance from the wire and by fixtures in use on the circuit. This loss of voltage is termed voltage drop and is one of the factors that controls the length of a wire run, the size of the wire, the size (or wattage) of lamps on a circuit, and the number of lamps that can be placed on a circuit.

Amps. Amps are the "flow rate" of electricity in a circuit. Using the same irrigation analogy, if volts represent the pressure of an irrigation line, amps

represent the gallons per minute that the line can deliver. Higher amperages for a circuit increase the amount of electricity that can flow to the lights connected to the circuit. Amperages for circuits are controlled by circuit breakers, which limit the amount of flow based on the size of the wire. If too much amperage is drawn into or available to a circuit with a wire that is too small, heat will build up and the potential for fire or circuit failure is increased.

Watts and Ohms. The watt is a measure of the amount of electricity being used, whereas an ohm is a measure of electrical resistance. Wattage will typically be listed on electrical appliances and also on lamps of a low-voltage lighting system. This wattage rating tells the designer how much of the electrical current that lamp will use. The wattage allowed by a circuit will depend on the type of lamps used, how bright the lamp needs to be, how much wire is in the circuit, and the size of the wire. Each of these factors consumes electrical current and must be balanced by the correct voltage and amperage of a circuit. Again, using the irrigation analogy, just as irrigation heads discharge water, using up the pressure and gallons per minute, lamps on an electric circuit discharge heat (in the form of light), using up the voltage and amperage.

The maximum wattage of lamps that can be placed on a circuit is based on the size of the wire and the distance from the transformer. Each manufacturer will have a table with recommendations. As an example, using 12-gauge wire, a lighting run of up to 40 feet could have 150 watts of lamps, whereas a lighting run of up to 100 feet could have 80 watts of lamps. If the wire is larger, the wattage allowed increases; and if the distance decreases, the wattage allowed increases. Figure 14-3 shows the relationships among wire sizes, length of wire runs, and the amount of wattage that can be installed on a circuit. As noted above, when using LED lights, the number of fixtures on a run can be significantly increased, and the voltage can have a wider range.

Guidelines for Planning a Lighting System

When planning a lighting system, the designer uses some standard guidelines and mathematical formulas to determine the parameters of a lighting circuit. These guidelines will help the designer determine how long the lighting run can be, how many lights can be placed on a circuit, and whether the lights will function properly. Add these factors to the decisions about the style of fixture and esthetic function of the lighting, and the design of a system can become a challenge. Some of the common guidelines used for low-voltage lighting systems are identified below and in Figure 14-4.

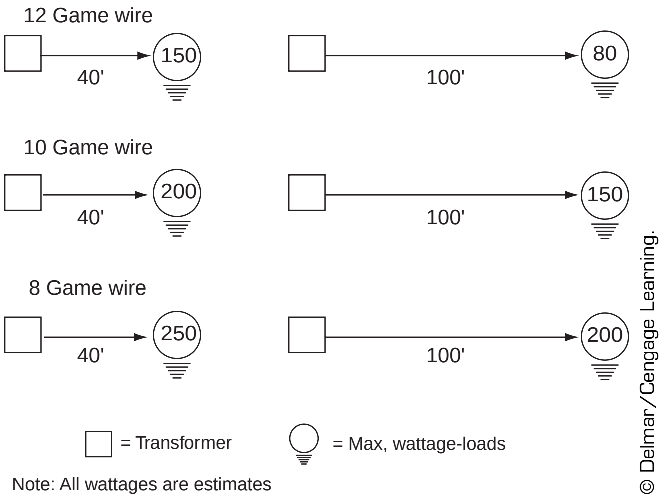

Figure 14-3 Approximate relationships among wire sizes, length of wire runs, and wattage loads.

- Unless the lighting needs are small enough to warrant a single circuit, lights that perform similar functions work best on separate individual circuits. For example, path lights are best on the same circuit, rather than being grouped with several different lighting styles.
- Lights are grouped in zones that are about the same distance from the transformer. Instead of being on the wire supplying the circuit, lights are placed on a branch line that is then connected in the center of that branch line to the wire supplying power to the circuit. This evens out the voltage drop among all of the fixtures on a circuit.
- To achieve maximum and even light and to maintain maximum bulb life for a low-voltage system, each circuit should deliver between 10.5 and 11.5 volts to each lamp, with the exception of LEDs. LED circuit voltage can have a much wider range, often between a maximum of 14 volts and a minimum of 6 volts per circuit, without losing lighting quality or lamp life. LEDs also allow many

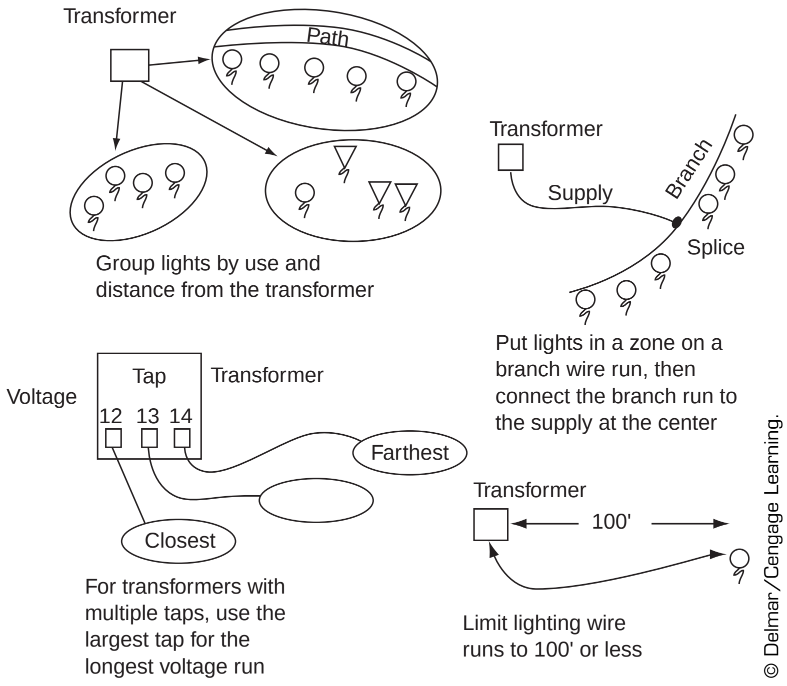

Figure 14-4 Low-voltage lighting guidelines.

more fixtures to be placed on a circuit than do traditional lamps.

- Because of voltage drop on long circuits, wire run lengths are typically limited to 100 feet. This keeps the lights on the circuit from dimming because of the lack of voltage. Unlike other lamp types, many LED lights can be placed on a longer circuit because of their low wattage and compensation for voltage differences.
- When using transformers that have taps with different voltages, use higher voltage taps for the longer wire runs and lower voltage taps for shorter runs.
- The interrelationship among volts, amps, and watts determines how many lights can be placed on a circuit in low-voltage lighting. To determine how many watts of lighting can be placed on a circuit, use the formula Watts = Volts × Amps. For example, a 10-volt circuit at 15 amps would support 150 watts of lighting, or 15, 10-watt bulbs. The actual number of lamps on a circuit would be even fewer when the loss of voltage for every foot of the wire run is subtracted. Although this is a simple example, calculating the size of a more complex low-voltage lighting circuit follows the same basic tenets of this formula.

Installation

One primary difference between the packaged kit lighting systems and custom low-voltage DC electrical systems is product quality. A custom installation offers a better quality product and more satisfaction with that product. Another difference is the piece by piece installation required for a custom system. Beginning with a dedicated power supply, rather than an electrical outlet, and ending with fixtures that are set either with heavy-duty anchors or in footings and wired with waterproof connections, completion of a custom lighting job requires far more effort than does the installation of a packaged kit system. The result of this extra effort, however, is a lighting system that is more durable, far more effective, and more aesthetically pleasing than the less expensive system.

Electrical Source. For a custom DC electrical system, a licensed electrician must provide a 115–120-volt circuit to the location where the transformer(s) will be located. This supply line should be on a separate ground-fault circuit interrupt (GFCI). GFCI circuits are designed to shut off electrical power to the circuit when voltage fluctuations from short circuits are sensed, providing protection from accidental shock. When routing the electrical supply to an exterior location, the contractor should

place all components in conduit a minimum of 18 inches deep and ensure that all components are waterproofed and grounded. This circuit, which may have multiple subcircuits, depending on the scope of the project, should have a dedicated circuit breaker on the electrical panel. This circuit can have a switch, but it is often best to avoid switches, photocells, timers, and other control devices on this circuit and place such controls on the individual circuits coming out of the transformer.

CAUTION

Working with electrical systems poses serious risk of shock, burns, or electrocution. Only a licensed electrician should perform electrical connections.

Transformers and Hubs. Electrical sources for custom low-voltage systems typically follow one of three distribution methods. The first is mounting a single transformer and wiring each circuit from that transformer. Requiring the positioning of only one control point, this method can suffer from poor lighting performance because long runs of cable must serve the fixtures. The second method is to mount a single transformer that feeds a number of hubs positioned around the site (Figure 14-5). Multiple hubs allow shorter runs of cable to the lighting fixtures, thereby reducing voltage drop and improving lighting performance. Hubs can also equalize voltage among lighting runs or for feeding to other hubs. The third method is to run separate electrical circuits to multiple low-voltage transformers located close to the lighting fixtures the transformer will serve. Although this method increases the cost because AC circuits are running to various locations throughout the site, lighting quality is typically better because wiring runs for each low-voltage circuit are shorter.

Any of these three methods will require a transformer sized to handle the electrical demands of the system. Transformers are typically available in a range of wattages and with varying numbers of circuits that can be installed. Because of the variability of lighting fixtures, number of fixtures, and length of lighting runs, installation of a transformer that has multiple circuits (or voltage taps) will aid in providing adequate power to multiple wire runs (Figure 14-6). Multiple taps can also aid in programming different operating systems such as

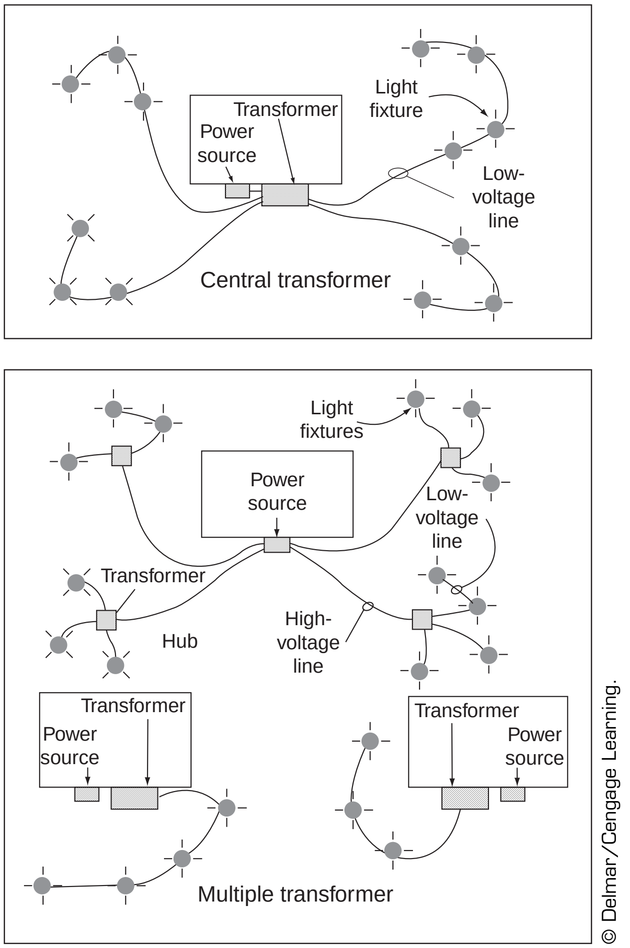

Figure 14-5 Transformer and wiring options for DC lighting.

photocells, timers, and remote controls to specific lighting circuits. When mounting the transformer and controller, position the equipment in a location that is accessible but not visible to the public. Transformers should be mounted a minimum of 1 foot above grade, with higher installations making wiring and connections easier. If space within the transformer has been allowed for adding timers or photocell controls, install those features at the beginning of the circuit. Separate weatherproof boxes may be necessary for installing circuit control features.

Fixture Placement. The wide range of lighting types suggests a variety of fixture types and installation methods. However, most decorative lighting is accomplished by using either an appropriately placed spot or flood fixture. Spot fixtures focus a narrow beam of concentrated light at an object, whereas flood fixtures cast a wide beam of diffused

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Figure 14-6 An FX PotenzaX low-voltage transformer with multiple wire taps and timer.

light. Placement will require an understanding of the lighting's purpose. In most applications, the light being cast, not the fixture, should be the focal point. This suggests that the contractor locate the fixture so that it is hidden from view without compromising the beam of light. Placement behind plants, signage, and site structures and on the backside of plant branches and trunks are common ways to hide the fixtures. The intensity and spread of the light beam for each fixture is controlled by a reflector installed inside the fixture behind the bulb. Bulb and lens choices will also determine beam intensity and spread. These light fixtures are typically used to accomplish decorative lighting effects:

- Uplighting. Spot or flood fixtures; place fixture on ground and aim up into plant or object to be featured.
- Downlighting. Spot light; place fixture above head height in plant and aim toward ground; hide fixture in branches, if possible; place wire in dark conduit and embed in bark fissures to hide wiring.
- Backlighting. Flood light; place below and directly behind object to be silhouetted; aim at surface behind object.
- Spotlighting. Spot light; place in front of, beside, or above object to be highlighted; aim at object to be lighted.
- Floodlighting. Flood light; place above area or object to be lighted; aim at center of area or object.
- Grazing. Spot light; place in front of, almost adjacent to, object being lit; aim directly upwards.

In addition to installations where the light source is to be hidden, a wide array of fixture choices are available for lighting where the fixture's character is as important as the light. These fixtures, often path and decorative lighting, should be placed in highly visible areas, such as along walkways and patios.

Anchoring the fixture to the ground and the cable to the fixture is another factor that will influence the success of the installation. Some fixtures have direct burial stems that are inserted into the ground to stabilize them. Other fixtures may require the pouring of a small concrete base, or even a concrete footing, to properly anchor them. Installing fixtures so that frost, erosion, soil settling, and other disturbances do not shift the fixture (and the resulting light) should dictate the anchoring method.

Still other connection methods include those that bolt directly to fences, walls, and other permanent objects that can provide support. Routing cable to fixtures can often be accomplished underground or on the surface as described below; but in some installations, the wire needs to be routed behind walls, across the tops of structures, or even up the trunks of plant material. Regardless of the cable routing choice, consider a location and method that will protect the cable from damage and hide the cable from view.

Wiring and Connections. For most custom low-voltage electrical installations, the wiring and connection components are significantly upgraded from kit installations. Wire gauges for kits are often 18-gauge; whereas for custom applications, the installer may choose 14-gauge or 12-gauge to reduce voltage drop. Wire for low-voltage lighting can be placed underground in conduit, directly buried into the ground, or placed on top of the ground and hidden under mulch. Although using conduit is preferable to protect the installation and to reduce maintenance problems, direct burial is often used for low-voltage systems. When laying out wire runs, leave slack line along each run to allow

for adjustment of fixture and cable locations. Unless you are using conduit, do not bury the wire until the system has been completely laid out and tested. Place the cable runs from fixture to fixture. Determine where the cable from the transformer should be spliced into the fixture run. When positioning splicing locations, less voltage drop will occur if the splice is placed in the middle of a string of fixtures, rather than connecting the line to one end. Locate that midpoint and place the cable run back to the transformer.

For conduit installations, the conduit and fixture installation require coordination, as listed below, to place each fixture properly.

1. Excavate an 18-inch deep by 4-inch wide trench from the supply to the first fixture in the run.
2. Lay out a lightweight metal or plastic electrical conduit and fittings along the trench location. At each fixture a curved piece of conduit should turn toward the surface at the fixture location. A separate curved piece of conduit should lead back down into the trench to start the conduit run to the next fixture.
3. Cut the conduit to fit between fixtures and join.
4. Place the conduit in the trench and backfill.
5. Install light fixture bases, if required. If no base is required, mount a waterproof junction box on top of the two curved conduits. Install the light fixture either on the installed base or, as direct burial, next to the junction box (Figure 14-7).
6. Pull the wire from the source to the first fixture using a lubricated wire snake fed through the conduit. Leave extra wire at the fixture location to make connections and slight adjustments. Continue to pull cable for all fixtures in the run.
7. Make connections at the fixtures, and then make connections at the power source. Connections for DC fixtures are often accomplished within the fixture, either in the bulb housing, a built-in junction box, or a base. When making connections, even inside a junction box, use the guidelines noted below to reduce connection problems and failure.

Exterior connections of fixtures to wiring and between wiring runs should be made with waterproof wire nuts, splicing gel, or heat-shrink connectors to reduce moisture problems. The **waterproof wire nut** is a wire nut filled with a waterproofing compound that holds the wire connection in a moisture-resistant seal (Figure 14-8). Installation is similar to other wire nuts: Simply strip the last half inch of each wire to be joined, give the two wires a slight twist together, then slip the nut on and turn in a clockwise direction until snug. Making connections within a waterproof junction box also helps reduce future maintenance problems. When installing bulbs or making other friction type connections, coat the tabs or threads of the bulb with a light coat of Vaseline to reduce corrosion problems with connections.

To make a more permanent waterproof connection using a splice gel connector, begin the process by cutting and stripping the wires in a manner similar to using waterproof nuts. Fully insert the wires to be spliced into each side of the connector until they reach the stop. Squeeze down on the connector with pliers until gel runs into the connector stem. An alternative way to use splicing gel

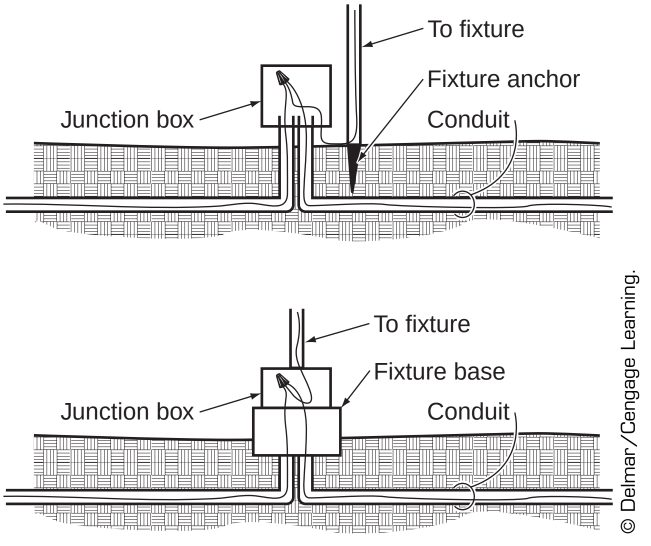

Figure 14-7 Connections for a DC lighting fixture.

Figure 14-8 Joining wires in a waterproof wire nut.

is to cut and strip the wire and make the connections using a wire nut. Then squeeze about 3 fluid ounces of splicing gel from a dispenser tube into a small plastic sandwich bag. Pull the bag over the wire nuts and squeeze the gel into and around the wire nuts. With either method, the gel will set in a few days, making a permanent connection. Cover the connection with waterproof tape for even more protection from the elements.

Heat-shrink connectors are another way to provide a weatherproof connection. Select a connector that is large enough to fit over the cables and the splice, typically ½-inch flat or diameter. Begin by cutting and stripping the cables in a manner similar to using waterproof nuts. Slide the piece of tubing lined with adhesive over one of the wires. Either insert the wires into the splice connector and tighten the set screws (for solid copper wire) or slide both ends into a butt end connector and crimp the connection. An alternative is to solder the wires before finishing the heat shrinking process. Once the wires are spliced, slide the tubing back so it is centered over the splice. Using a heat gun, butane torch, or propane torch (Figure 14-9), carefully shrink the tubing. Hold the flame a safe distance from the fitting and ensure that the heat does not burn the wire, splice, or tubing.

Testing and Adjusting the Custom Installation

Testing and adjusting the custom installation will require multiple steps. Initial tests should come when the wiring runs are established in the form of voltage checks at the splicing points and ends of runs. After the wires have been connected to the transformer and to the fixtures, use a digital voltmeter. Touch each of the two leads with the voltmeter to measure the voltage at the splicing points, where a minimum of 11.5 volts should be registered (with the exception of LED lighting that can be up to 15 volts), and at the end of the fixture run, where a minimum of 10.5 volts should be registered (again, with the exception of LED lighting that can be as

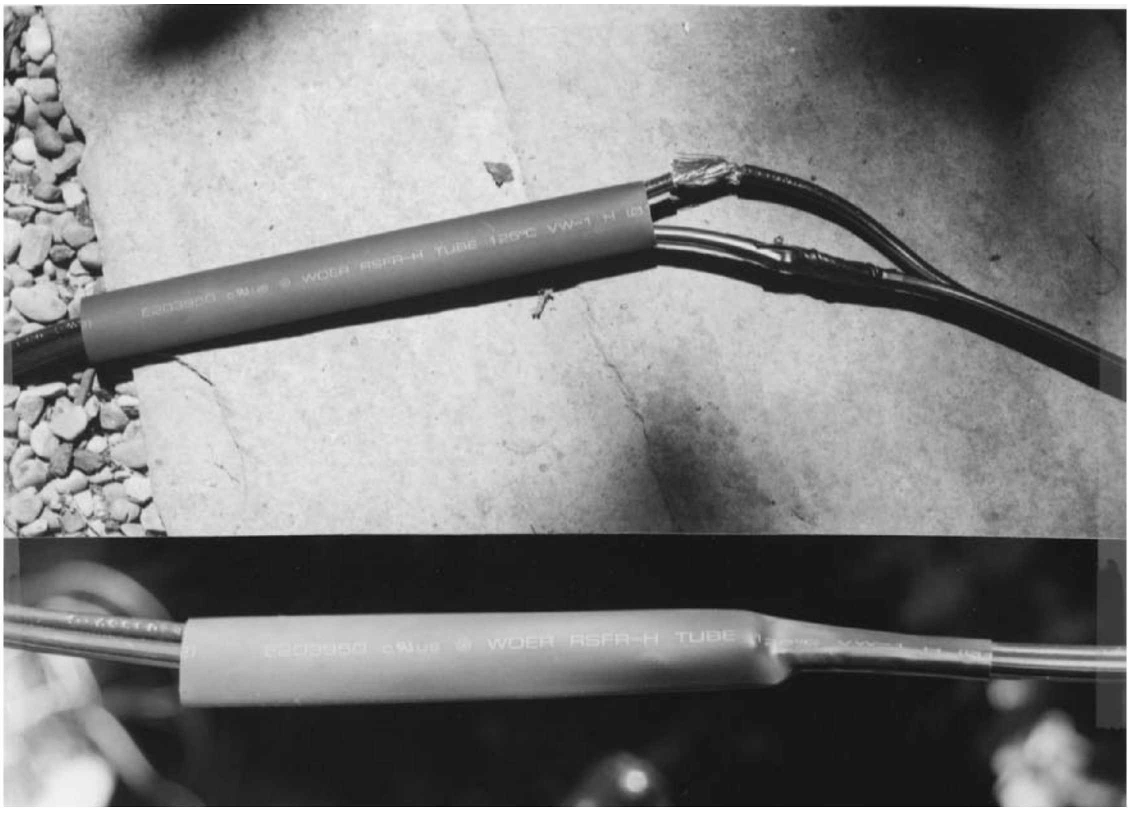

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Figure 14-9 Using heat-shrink connectors to protect an electrical splice. In the top half of the photo, the lower wire is spliced and taped, the top wire is ready to be spliced, and the heat-shrink connector is pulled to the left. In the bottom photo, the heat-shrink connector has been pulled over the splice and is being formed using a butane torch.

low as 6 volts). Voltages above 11.5 at the beginning of the run create the risk of burning out lamps prematurely, and voltages below 10.5 anywhere along the circuit create problems with obtaining even lighting along the entire run of fixtures. Should voltages exceed these limits, adjustments can be made to the length of the wire run, the size of the wire, or the number of fixtures on a circuit. In addition to checking voltages, perform a nighttime check of fixture placement to assure that the desired effect is being obtained. Fixtures that are not creating the lighting patterns desired should be adjusted.

LOW-VOLTAGE ELECTRICAL SYSTEM KITS

Exterior low-voltage electrical system kits are used primarily for powering small-scale decorative lighting schemes. Spotlights, stair lights, low-level walk lights, uplights, and downlights in plant material are examples of low-voltage direct current (DC) lighting applications that the landscape contractor can install. Installation of basic DC lighting fixtures may vary slightly from manufacturer to manufacturer, but the steps undertaken for system assembly are similar.

Locating Electrical Sources and Controllers

DC electrical systems require an AC outlet to provide power. Typical AC sources are 120-volt outlets located in garages, basements, or exterior locations. Identify an outlet in a weatherproof location where a transformer can be placed. It is necessary to select an outlet that is a GFCI circuit.

Most transformers are designed so they can be mounted on a post or wall with a grounded plug for an outlet. The transformer, typically supplied with a single or double tap, reduces the AC current so that the low-voltage system may use that current. A low-voltage electrical cable plugs into the transformer and must be fed to the locations where lights are located. If the transformer is inside, drill a hole through an exterior wall and feed the lighting cable through to the outside. Plug the hole with insulation or steel wool and fasten the cable to a nearby stud with a wire staple.

Some DC lighting systems have controllers that turn on lights at dusk or allow the user to control the on and off times. These controllers may be built in with the transformers or may be separate units placed along the cable. Either method requires that the controllers be located where the owner can gain access to the equipment. In the case of photocells, controllers must be located in an area that receives ample sunlight. Therefore, transformers with built-in controllers must be located outside a structure, and the cord that connects to the AC outlet must be fed through the wall to the outlet.

Fixture Installation and Cable Connection

Fixtures require some level of assembly according to the manufacturer's instructions. Locate the fixtures in the areas where they are to be placed before stringing the cable. Lay the cable from the transformer to where the first fixtures are located. Provide ample cable to allow for adjusting the fixture locations after they are connected. Typical fixture assembly and connections are performed as follows:

1. Insert bulb into lamp base socket (Figure 14-10).
2. Attach lens to lamp base. Lenses will snap or twist into the base (Figure 14-11).

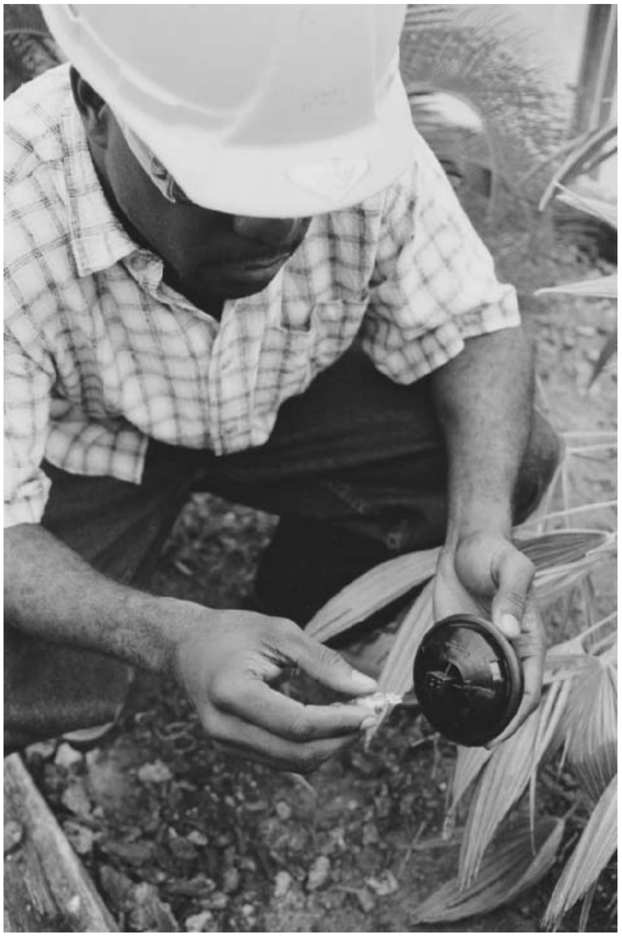

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Figure 14-10 Inserting bulb into lamp base socket.

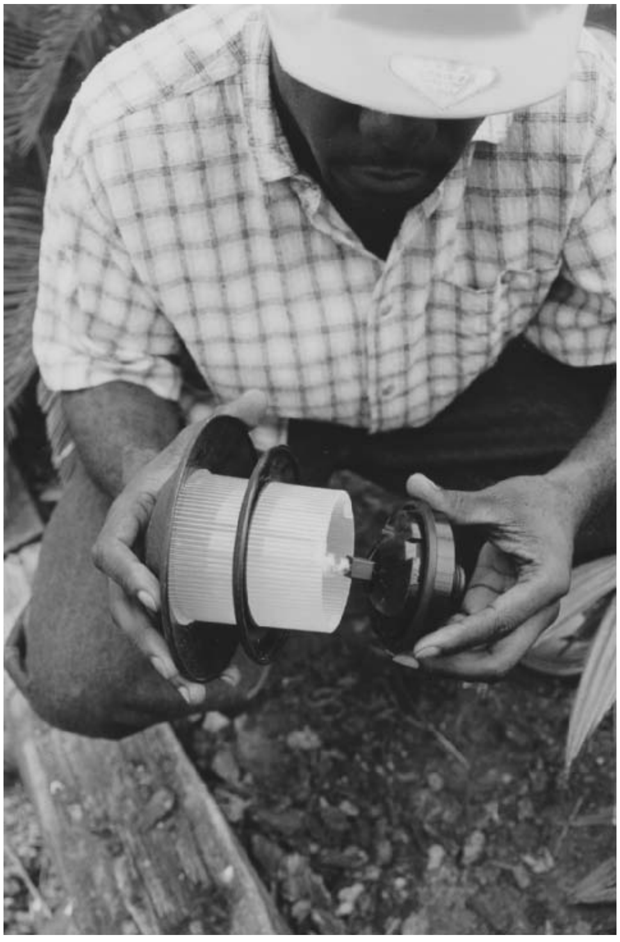

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Figure 14-11 Attaching lens to lamp base.

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Figure 14-12 Running loop of cable through mounting stem.

3. Run a loop of cable through the mounting stem bracket (Figure 14-12).
4. Connect the lamp base to the cable by pressing the cable onto the metal prongs projecting from the lamp base (Figure 14-13). These prongs puncture the cable and make contact with each conductor in the wire. One metal prong must make contact with the wire inside each side of cable. Use care not to bend the prongs.
5. Attach a threaded cap, which will hold the cable in place (Figure 14-14).
6. Slide the mounting stem bracket into place over the threaded cap (Figure 14-15).
7. Insert the mounting stem into the mounting stem bracket (Figure 14-16).
8. Gently push the fixture into the ground (Figure 14-17).

(Note: This assembly procedure is general and may not apply to every style and manufacturer of light fixtures. Review manufacturer's instructions before assembling any light system.)

Ground-level lights may have the stem and fixture in a single unit, allowing the installer to connect the light and insert the mounting stem into the ground in a single operation. Mounted lights may require that the fixture be snapped or bolted to a mounting base.

Continue installation of fixtures at each location along the cable where a light is planned. DC cables can be placed directly on the ground. Typical installations place the cables through planting beds covered by mulch. Danger of shock is reduced if the cable is cut, but this shallow installation does create more opportunity for the cable to be severed by construction and gardening activities. If the cable is severed, or if additional cable length is required, splicing kits are available that clamp the ends of two cables together to complete circuits. After all the fixtures have been installed, plug in the transformer and test the system.

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Figure 14-13 Connecting cable to lamp base. A metal prong must penetrate each side of the cable for light to work. Do not bend metal prongs.

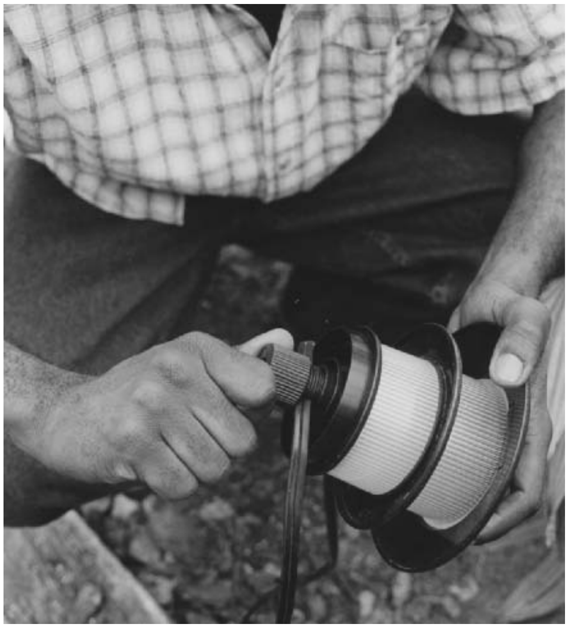

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Figure 14-14 Attaching threaded cap to lamp base.

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Figure 14-15 Sliding mounting stem over threaded cap.

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Figure 14-16 Inserting mounting stem.

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Figure 14-17 Gently pushing fixture into ground.

CAUTION

Working with electrical systems pose serious risk of shock, burns, and electrocution. Only a licensed electrician should perform electrical connections.

ALTERNATING CURRENT ELECTRICAL SYSTEMS

High-voltage electricity is used to power exterior lighting systems used for decoration, safety, and security. In addition, exterior electrical systems are used to power pumps, fountains, and other landscape systems that use motorized equipment.

Exterior lighting systems can be as simple as a security light mounted on a pole or as complex as systems using numerous lights and multiple lighting styles. Although low-voltage DC lighting is limited to small areas and simple uses, AC electrical systems are capable of illuminating large areas such as parking lots, walkways, and building facades. AC lighting also uses a variety of lighting types such as mercury vapor, metal halide, and high-pressure sodium to accomplish lighting tasks.

Common lighting uses associated with site AC systems include pedestrian walkway lighting, area lighting, decorative lighting, and utility lighting. Pedestrian walkway lighting includes low- and medium-height lights used for illuminating walkways and entries. Area lights are pole mounted and used for filling parking lots and open areas with light. Similar to low-voltage DC light systems, AC lighting can also perform decorative functions. Floodlights for buildings, uplights and downlights for plants, and spotlights for signs require high-voltage systems when high light levels are required.

Installation of AC electrical systems is a task for a licensed electrician. The scope of the landscape contractor's responsibility is limited to site preparation. Landscape contractors should not be required to complete AC electrical tasks such as pulling cables, supplying power, making electrical connections, or performing related circuitry work. Preparation of footings for light fixtures and installation of fixture standards or empty conduit for future use are tasks that may fall under the landscape contractor's scope of responsibility.

Light Fixture Footing Installation

Preparation of the site for AC landscape lighting applications may require installation of footings for **light standards**, or posts on which light fixtures are mounted. Properly installed exterior lighting requires frost footings to prevent damage to the fixtures from heaving (Figure 14-18). Installation of footings requires expertise in excavating and forming footings and placing internal conduit. Manufacturers prepare extensive instructions for both the completion of footings and installation of standards, which should be reviewed prior to beginning such work. Chapter 35, Site Amenities, covers footing preparation for common types of amenities that require electrical service.

Installing Lighting Standards

Standards are placed over the anchor bolts inserted into the footing. They are then plumbed and connected with lock washers and nuts. Caps may be provided to cover the bolted connections, or connections may be completed inside the handhold at the base of the fixture (Figure 14-19).

Figure 14-19 Handhold at the base of a lighting standard. Electrical connections are made inside this handhold after the fixture has been installed.

Installing Conduit for Future Use

Placement of empty conduit that the electrician, irrigation contractor, or other utility installer may later use is another task that may be assigned to the landscape contractor. Conduit installation requires the trenching and placement of weatherproof PVC or metal conduit to locations where future utility service is planned and to unserviced areas that could require future irrigation or electrical service.

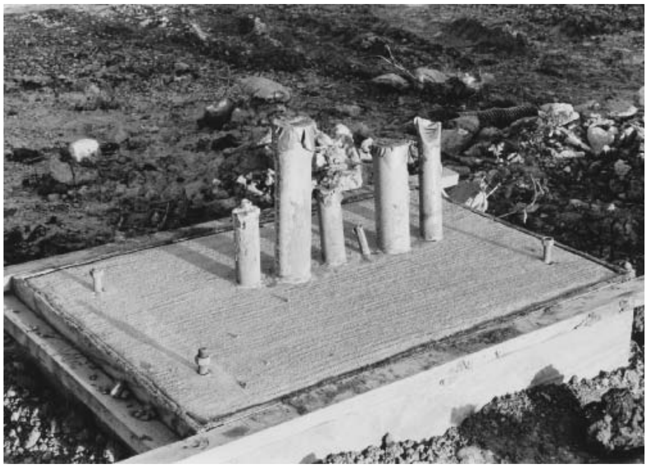

Figure 14-18 Poured concrete footing to which site light fixture will be bolted.

When determining empty conduit locations, consider running conduit from structures with utility service under paved terraces and walks, from open lawn areas to smaller planting beds that are isolated by hardscape or property lines, and at regular intervals under paved pathways. Additional areas where empty conduit may be beneficial are isolated side yards and areas that link front yards to back yards.

Check construction documents or local codes for allowable types of conduit and proper burial depths. If no plans or codes are applicable, bury **Schedule 40** conduit a minimum of 18 inches deep. Installing two conduits that are either 2 inches or 3 inches in diameter should provide adequate dimension to route future irrigation mains, controller wires, low-voltage or AC electric, or gas lines. For locations where only electrical or irrigation is anticipated, a single 2-inch diameter conduit should suffice. Trenching for conduit and piping of all types should be executed after the rough grade has been established and deep utilities such as drainage, water, irrigation, and sewer

service have been completed. Trenching before paving and finish grade have been established reduces disturbance of completed parts of the project.

Leave a stub of conduit projecting 6 inches beyond the edge of any hardscape. If surface connections are desired, extend the conduit to finish grade at each location where a fixture or other electrical service is located. Cap or place duct tape over the open end, and mark the location with a colored flag for visibility. It is also helpful to mark the location of empty conduit on a plan to make future location of the conduit easier. Although it is not recommended to extend empty conduit through foundations at the time of installation, if it is necessary to do so, such installations should be securely capped and sloped so that any moisture trapped in the conduit runs away from the structure. Leave additional length on the end extended through the foundation so the cap can be cut off and still leave room to install a fitting.

CHAPTER 15

WATER AND IRRIGATION SYSTEM INSTALLATION

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activity:

- Install major components of an irrigation system.

Although what they can undertake as part of their scope of work is often limited by codes, labor unions, and safety issues, landscape contractors must be aware of the process and procedures necessary for the successful installation of water and irrigation systems. Only the most tropical of sites can exist without supplemental water. Public parks often have drinking fountains and restrooms, and many landscapes require water supplies to fill and refresh fountains and ponds. Cleaning a site usually requires a water spigot to which a hose can be connected. Keeping the plant material alive on a site requires the location of water hydrants or the installation of an irrigation system that can deliver adequate amounts of water to the correct locations at the correct times. Whether simple or complex, landscapes require plumbing systems that can deliver adequate water when necessary. In many projects, landscape contractors may be responsible for installing the irrigation system. Whatever the conditions or reasons, contractors need to be familiar with the basics of plumbing and the process for installing water systems to a site.

CAUTION

Most areas restrict installation of many utilities to licensed specialists. Landscape contractors should engage only in the utility installations for which they are qualified and certified. Significant health and safety hazards may result from the improper installation of utilities listed in this section.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- DC Site Lighting and Related Electrical Work, Chapter 14

WATER SYSTEMS

Exterior water systems can include irrigation, external **hydrants**, and other supplies of potable water to outdoor living areas. In many projects, plumbers or irrigation specialists complete the types of work covered in this section. However, landscape

contractors may be contracted to install a hydrant or a water supply line.

CAUTION

Improper installation of water fixtures can contaminate public and private water systems. The health department must inspect the installation before the system is operated.

Installing Hydrants

Exterior hydrants provide convenient sources of water for landscape maintenance. Freeze-proof hydrants that can be connected to threaded PVC, copper, or galvanized pipe fittings are available. Unless they learn otherwise before or during installation, contractors assume that the water supply line is buried below frost depth; otherwise, the installation will not function properly in cold weather.

Install by first turning off the water that supplies the line on which the hydrant will be connected (Figure 15-1). Excavate a 3-foot diameter pit over the water line where the hydrant is to be located. Excavate around and 1 foot below the water pipe and place pea gravel backfill at the bottom of the pit up to the water pipe level. Cut out a section of pipe and insert a T connection. Run a short supply line from the T and connect the hydrant to this supply. Using a flexible pipe, rather than a rigid pipe, may reduce breakage in the water supply line. Turn the water back on and check the system for leaks and proper function. Fill around the connection with another 6 inches of pea gravel and backfill the pit.

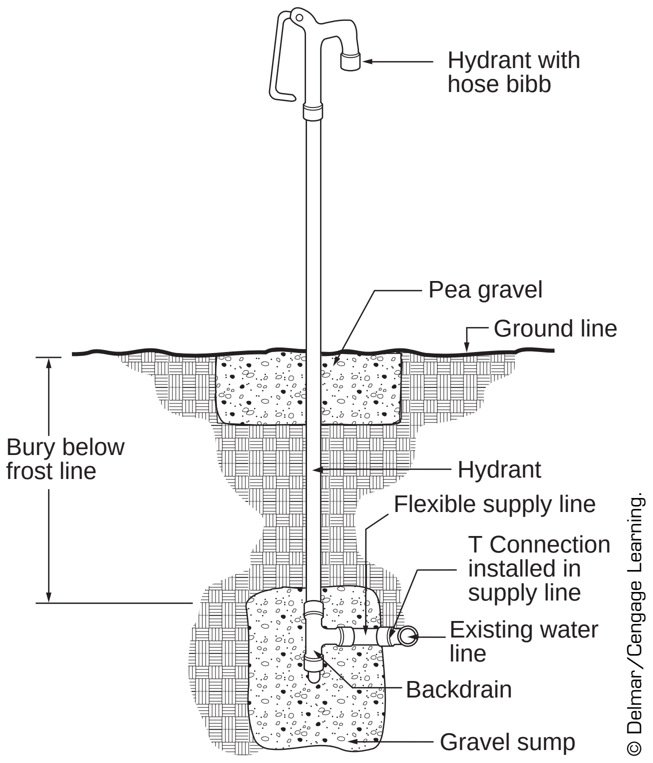

Figure 15-1 Elevation of freeze-proof hydrant installation.

On the surface directly below the hydrant spigot, or opening, place an 18 × 18-inch precast concrete block or 2 CF of pea gravel. This provides a "splash block" for the hydrant and allows access across a mud-free surface.

SPRAY IRRIGATION SYSTEMS

Maintaining a green, lush landscape is not entirely a result of good weather. Keeping the landscape growing often is a function of a properly planned, installed, and operated **irrigation** system. Historically, the concept of irrigation has been to flood a site with water from a heavy-duty system of pipes and sprinklers, but that scenario has changed. Irrigation systems now have the capability to deliver as little or as much water as needed through systems constructed of lightweight, easy-to-assemble components (Figure 15-2). With this drastic change in philosophies toward irrigation and the availability of easy-to-assemble components, the number of systems installed has dramatically increased. With that increase comes a greater need for contractors who can successfully install these systems.

Basic Irrigation Concepts

If an irrigation system is to function properly, the installer must be familiar with basic plumbing concepts and the basic operation of standard watering systems. Plumbing will differ from electricity when it comes to terminology and mathematics, but planning a successful irrigation system still requires knowledge of water pressure, or the force that delivers the water, and volume measurement, typically given in gallons per minute or gallons per hour. These two factors work together to assure that adequate water is delivered to the heads and emitters used in irrigation equipment. If there is too little pressure, water will not move through the piping and out of the fixtures; too much pressure, and the equipment will be damaged. If water is not available in adequate volumes, irrigation systems will not deliver what is required to keep plants alive.

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Figure 15-2 Spray irrigation equipment. A valve box at the top, a swing L with a rotor head in the center, a rotor head at the bottom, and a pop-up shrub head on the right.

Managing and delivering adequate amounts of water at the correct pressure is the function of the irrigation equipment when correctly installed.

To provide a simple overview of an irrigation system, water is delivered from a water supply through a valve that keeps it from flowing back into the supply system. From that supply, a water main routes the water to valves located throughout the site. A controller that is wired to the valves turns different parts of the system on and off at required times, balancing the pressure and volume needed to operate the system. From the valves, piping, called laterals, carries the water to irrigation fixtures, typically spray heads or low-volume drip emitters, that deliver the water directly to the plants (Figure 15-3). When all factors are considered, however, installation of an irrigation system can be far more complex than this simple overview.

Planning the Installation

Irrigation systems require more planning than most landscape installation projects. In addition to the work involved in installing the system, contractors can spend countless hours in properly designing the system to efficiently deliver water to the landscape. For contractors, planning includes such key elements as verifying the connections to power and water, locating system components, and preparing the site for installation.

System Design. Effective irrigation installations have a common beginning point: a sound design. Although the procedures of design and installation often integrate during a construction project, understanding

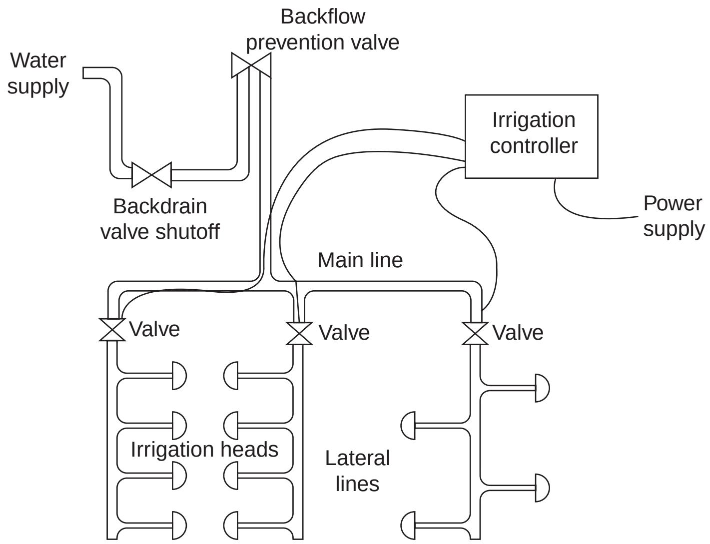

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Figure 15-3 Simplified diagram of an irrigation system.

the site's water demands and the delivery of that water by sophisticated equipment requires more than a random approach to system design.

Properly providing water to plant material requires dividing the site into zones of matched water needs, both in the volume and application time. When they identify these zones, contractors can then determine the correct method for delivering water. Water can be delivered over an area using spray heads, rotor heads, or impact sprinklers, or delivered specifically to plant root zones using drip heads. Depending on the size of the area, the type of soil, or quantity of plants, the zones may need to be further subdivided to match available water pressure and flow. The delivery of water to the various zones must be controlled using equipment that manages the sequence and duration of irrigation times. To ensure that each of these components work properly, a professional should review the data for the project and prepare an irrigation design that effectively uses this precious resource.

Supply and Connection Locations. Establishing an irrigation system requires an adequate, available water supply. Water for an irrigation system can be supplied through a municipal system, a well, or other water source such as a pond or river. For most residential systems, the water source will be a supply line that also provides water to the residence. In some circumstances, a separate metered line or branch line may be available for irrigation water. To ensure that adequate water is available for an irrigation system, contractors must verify the pressure (measured in pounds per square inch, or PSI) and volume (measured in gallons per minute). Contractors can make these measurements by attaching a pressure and volume gauge to a hose bib at or near the water source and turning on the valve.

Selecting and Siting Controllers and System Management Systems

In managing the sequence and timing of watering cycles, irrigation controllers are typically mechanical or electromechanical devices that turn valves on and off according to the times the owner programs. These devices can be as simple as an on/off switch, or they can be more complex in design. Most controllers can manage several irrigation zones, or stations, and can be operated in person or by remote signals. Sensors connected to the controller can override the programmed system based on the weather conditions or system problems. Owners can remotely operate irrigation controllers through phone and radio signals sent from a computer or handheld unit. Today's advanced controllers use information from weather centers or local weather sensors to adjust irrigation timing based on evapotranspiration, rainfall, and seasonal conditions.

Controllers require siting near electrical connections and in a location where the operator will have access for programming. Unless the design dictates a location, search for a location that meets these requirements. Often a garage or basement can accommodate a controller. Sensors that operate with the controller will also need siting in a location where they can collect data, such as buried in a lawn to detect moisture or in open areas to access weather stations.

Marking Component Locations. Lay out the irrigation system components using spray paint to locate the **main** and **lateral lines** and flags to indicate the location of **valves** and irrigation **heads**. Verify that the layout will cover the area for which it was designed and that no conflicts with existing utilities exist. Layout and installation of irrigation systems are best accomplished after rough grading of the site has been completed, hence avoiding damaging or exposing lines. Head and sensor installation can often be delayed until shortly before the planting phase starts.

Plumbing and Electrical Connections. Review the information in Chapter 7 about cutting and joining pipe for irrigation installations. When cutting pipe, make clean cuts and remove all burrs from inside the pipe. Join threaded pipe with a heavy application of threading compound or at least two to three wraps of threading tape. Piping for most irrigation systems is Schedule 40 or Schedule 80 PVC or poly pipe; some systems use lightweight class piping, although durability issues remain with class piping and lightweight poly piping. Fittings are also predominantly PVC slip or threaded. When making connections that need to remain flexible, such as risers, use Marlex HDPE fittings. Always tighten PVC pipe by hand because wrenches may damage or crack the piping. PVC pipe degrades when exposed to sunlight; so, in the event a PVC pipe runs above the surface, wrap it with dark tape or spray paint it with metallic paint.

CAUTION

PVC piping, solvents, and primers are highly flammable. Use caution when joining pipe with these materials. Keep away from open flame and work in a well-ventilated area when using these materials.

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Figure 15-4 Irrigation controller.

Wiring connections should be made using waterproof nuts or heat-shrink connections to reduce the chances of system failure as a result of corrosion. Most wiring installations for irrigation are 18-gauge, but 14- or 12-gauge will carry more voltage. Taping multiple wires together and taping wires to the valve nipple when entering the valve box will reduce damage to wires.

Installing Electrical and Plumbing Tie-ins

Making power and water connections is a critical initial step in system installation. Without power and water, no irrigation system can function. Although a licensed electrician and plumber must make electrical and water connections, landscape contractors will be closely involved during these installations.

Installing Electrical Circuits for Controllers. A licensed electrician must install a 115–120V electrical service to the controller. If mounted inside, the service can be romex or conduit routed directly from the electrical panel to the box. If located outside, the service should be in conduit. The circuit should have a dedicated GFCI circuit. After installing the piping and wiring and when the system is ready for a test, have a licensed electrician complete the electrical connections inside the controller and electrical panel. Most controllers also have a location in which to install a battery backup that stores settings in memory in the event of a power failure.

Installing Controllers. Mount the controller securely on an interior wall or exterior wall using anchor screws through the back plate of the controller box (Figure 15-4). If no wall is available, mount the controller in a weatherproof box slightly larger than the controller box. This weatherproof box should be mounted on a treated 4 × 4 framework attached to a treated post set to frost depth or a minimum of 3 feet deep. Electrical conduit routed to the weatherproof box should be secured at the box entry point. A 10-gauge copper ground should be connected from the controller box to an approved grounding rod. Wiring to the valves is addressed later in this chapter.

Connecting the Water Source. If no separate line is available, the water supply line should be cut or disassembled and a T connection installed that branches to the irrigation system. This T should match the supply line's piping material and diameter. If it runs outside the structure and is less than 18 inches deep, the supply line to the backflow valve must be metal. At a point along the supply line between the supply and backflow valve, install an isolation valve to allow the irrigation system to be turned off in the event of a repair or emergency.

Installing Backflow Prevention. For sanitary reasons, connections to potable water supplies must be protected from contamination as a result of siphoning of water back through the irrigation system. To provide this protection, install a backflow prevention valve between the water supply and the valves. This device can take many forms, including antisiphon valves, vacuum breakers, check valves, and pressure vacuum breakers. The height of the backflow prevention device is critical to prevent siphoning. All devices require the valve's mounting height be above the highest irrigation head, with most plumbing codes requiring a minimum of 1–2 feet above the highest head. Install the valve by connecting it to the water supply and adding any riser necessary to achieve the required height. The main serving the valves should be connected to the other side of the valve.

CAUTION

Failure to properly install a backflow prevention valve when connecting an irrigation system to a potable water supply may result in contamination of the water supply.

Trenching

Trenching for irrigation projects can be completed by hand or by using rented trenching machines. If the trench is more than 100 feet long and has primarily long straight runs, excavation by machine (Figure 15-5), provided the site allows machine access, will be more efficient. If the weather is forecast to be inclement, excavate only the amount of trench that you can work on before the weather turns. Excavation depths will vary based on the design, type of line, and location of the installation. Plumbing codes typically require that pressurized lines, such as main lines to valves, that are buried less than 18 inches deep be a metal (typically galvanized iron) pipe, rather than PVC. For this reason, the mains will be buried 18 inches deep or more, especially in locales that experience cold temperatures, to protect them from freezing damage. In other installations, the burial depth of nonpressurized lines can vary from 10 to 14 inches.

To make trenching easier on hard ground, operate a sprinkler over the area for a couple days prior to trenching. Trenches should be at least 4–6 inches wide with a smooth bottom. Free the trench of debris and large clods of earth before laying the pipe.

If trenched before the paving is installed, place two to three 3-inch diameter metal conduit in locations where the trench will pass under pavement. When installing irrigation under existing pavement, hand-dig or bore a trench under the slab (Figure 15-6). Contractors who specialize in boring operations can accomplish long excavations, whereas shorter bores can be dug by hand or by using a high-pressure water nozzle.

An alternative to hand or machine trenching pipe runs is to “pull” pipe. For very long runs through soft soil, flexible heavy-walled poly pipe can be pulled using a special vibrating plow. Although typically reserved for commercial and recreational applications, “pulling” the pipe in this manner offers the advantages of faster installation and fewer disturbances to existing sod. Pipe that is pulled is anchored to the front of the vibrating plow. The plow is lowered into a starter hole; and as the plow moves forward, it vibrates a narrow slit trench that the pipe slides through, pulling behind it a continuous run of pipe. After pulling runs of pipe, excavate

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Figure 15-5 Irrigation trenching.

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Figure 15-6 Trench excavated under pavement.

locations for valves and heads, cut the pipe, and install the fittings.

Installing Wiring and Piping

Following completion of trenching, install the control wiring, piping, valves, and risers. When making connections, use caution to avoid damaging wiring and piping. Making pipe connections outside the trench will make easier work and reduce the possibility of getting foreign materials into the pipe.

Installing Control Wires. Control wires should be run from the controller to the valve manifold or each individual valve. A harness of wires is run from the controller to the valve manifold or where the main branches to the various lateral lines (Figure 15-7). The wires should be 2–4 inches away from the main line piping and preferably below the pipe. This position will provide some protection for the wiring when repairs are required. Tape loose wiring together every 5 feet with electrical tape, or place all wires in a 1-inch diameter or larger conduit placed in the trench. Leave ample wire to make connections at the manifold or valve box locations. Alternatively, two-wire controllers are available that require only a pair of leads be run from the control in a series to every valve. At each valve is a decoder that "reads" a signal from the controller, telling the valve when to open and close. This system requires far less wire than running separate pairs of wire from the controller to each valve. Two-wire systems also are easier to change and expand if necessary.

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Figure 15-7 Wires from controller to valves.

Installing Sensors. Any sensors designed into the irrigation system should be installed as the wiring and piping is prepared. Sensor locations will be determined by design and may require excavation of separate trenches to lay the wire between the controller and sensor. If near a main line or lateral trench, the sensor wire can be placed in the line trench. Install the sensor and lay the wire back to the controller, leaving ample wire to make connections at both ends. Certain sensors, particularly moisture sensors, may require installation after the landscape work has been completed. In these cases, lay the wire and leave a stub to the surface that is marked by a piece of PVC (Figure 15-8).

Installing the Main Line. Beginning at the water source, lay out piping along the route from the backflow prevention valve to the valve manifold or valve locations. Trim the pipe to proper lengths, and complete fitting connections out of the trench. Using caution not to get dirt or debris into the lines, gently place them into the trench.

Installing Manifolds and Valves. Plastic or brass valves are used to turn the supply of water on and off to each irrigation zone. Systems may be designed to use a valve manifold in one location or several valves that are distributed at various locations around the site. Most manifolds are a series of valves mounted on risers extending upward from the supply main. Lines then return to ground from each valve as laterals to supply the irrigation heads. If using a manifold, assemble the manifold in a clean location and carry it to the site. Transport the manifold to the installation location and place it in the trench. Connect the manifold to the supply main; then bring the control wires up the manifold risers and connect them to the valves.

If valves are distributed throughout the site, they function most effectively when placed in valve

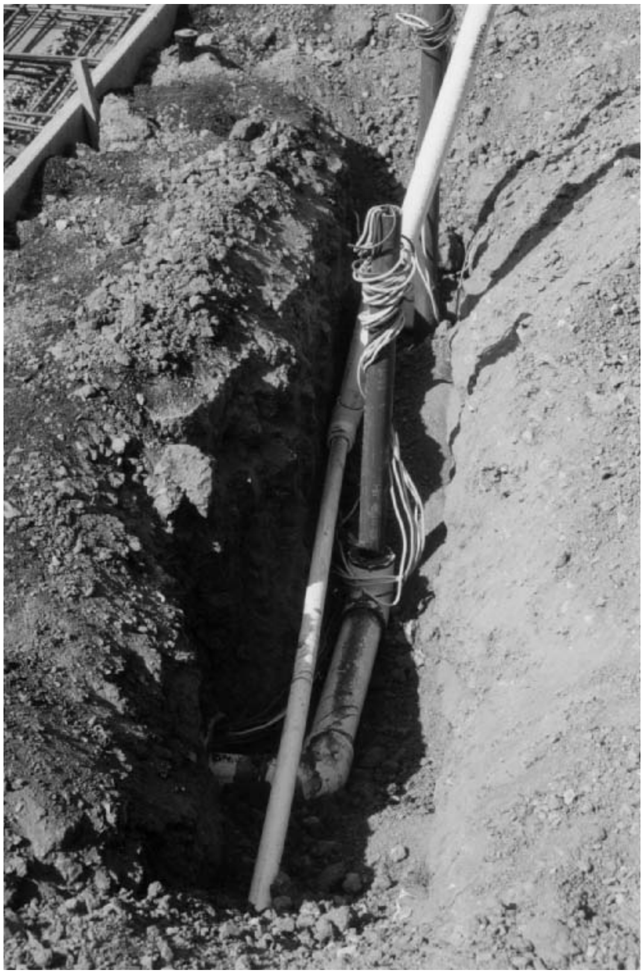

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Figure 15-8 Stub out for irrigation system sensors.

boxes (Figure 15-9). Select valve boxes that will provide at least 2–4 inches of clearance around the valve and piping inside. At each location where a valve is to be located, excavate an opening the size of the valve box, plus 6 inches on each side and 4 inches deeper. The excavation should be centered on the valve location straddling the main. If the piping from the main to the valve is entering from below, center the box location on this pipe. Use caution not to damage the controller wires and main line already installed. Place 4 inches of free-draining angular fill in the bottom of the excavation and install the valve. Connect the lateral to the valve and continue installing piping. Valve boxes can be set now or after completion of lateral and riser installation.

Installing Laterals and Risers. A network of piping, called **laterals**, extends from each valve location and connects the valves to each irrigation head location (Figure 15-10). At each irrigation

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Figure 15-9 Irrigation valve box.

head location, a connecting pipe, called a **riser**, runs from the lateral to the irrigation head. Each lateral in an irrigation system typically has several riser locations. To install the laterals, lay out piping for each lateral next to the trenches. Trim the pipe to the proper length and make all fitting connections out of the trench if possible. Begin the connections starting at the valve, moving outward toward the last riser location. When you encounter

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Figure 15-10 Lateral line installation.

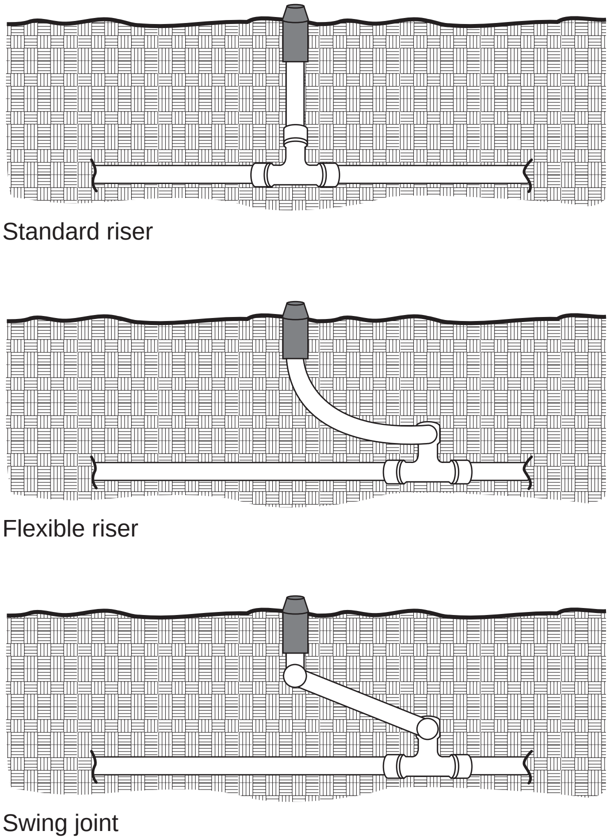

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Figure 15-11 Riser types.

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Figure 15-12 Nipple riser before irrigation head installation.

a riser location, install the riser but not the irrigation head.

Risers for the irrigation installation can be preassembled and stored for immediate or future use. Riser types (Figure 15-11) include: straight risers that use a **nipple** to connect a T in the lateral with the irrigation head (Figure 15-12); risers that use flexible pipe to connect from a T in the lateral to the irrigation head; or risers called **swing joints** or **swing ells** constructed of four ells and a straight nipple that joins the lateral and head with a shock-absorbing connection (Figure 15-13). Regardless of the riser type used, verify that the riser's placement will position the irrigation head in the correct location without twisting or bending the riser. Temporarily cap the riser and continue installing the lateral.

Installing Quick Couplers. Quick couplers are locations where hoses can be connected to the irrigation system to supply supplemental water. To install quick couplers, install a T connection in the main. At the T, install a swing joint connected to a quick coupler valve. Anchor the quick coupler using a 3-foot long rerod driven into the ground

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Figure 15-13 Swing ell riser.

next to the quick coupler. Using two auto hose clamps, attach the rerod to the quick coupler.

Installing Valve Boxes and Valve Wiring. After installing all laterals and risers, return and place the valve box over the valve and securely seat the box on the granular base. Adjust the box's height until it is level with adjacent finish grades. Use duct tape to secure heavy plastic pieces to the outside of the box to cover any openings. To keep excess wire out of the way, coil the control wire around a half-inch dowel. After you completely wind the wire, slide it off the dowel to create a spring-like coil. Complete the control wire connections to the valve by connecting the "hot," or colored, lead to the colored lead on the valve and the "common" lead (typically white or green) to the common lead on the valve. The common leads for all valves can be connected at one point and then continued on to the next valve box, whereas the hot leads must be matched with the correct wire from the controller. Because wiring schemes may differ, verify the correct connections on the wiring diagram.

Installing Backdrains. In locations where temperatures reach freezing or below, a backdrain can be installed at key locations in the system. Under each planned backdrain valve location, dig an 8-inch diameter by 2-feet deep sump hole and fill it with pea gravel. Directly over the sump, install a T connected to a ball valve drain in the main or lateral. Set a valve box over this installation. Sloping the pipe from the heads to the sump will aid in draining lines. An alternative to installing backdrains is to install a compressed air fitting before the valves and after the isolation valve. Compressed air introduced into each zone through an opened valve will blow out the water.

Backfilling and Flushing

Flushing debris out of the piping and valves is a critical step in an irrigation system installation. Prior to and during installation, sand and dirt can enter the irrigation lines. Only a small amount of debris will plug or damage a sprinkler; so, flush the system before installing heads.

Begin this step by carefully backfilling the irrigation lines to half to two-thirds full. Do not backfill around riser locations. Do not compact the backfill at this time and avoid stepping on the lines. When you complete the partial backfilling, uncap the risers, turn the irrigation system on, and flush each valve zone for approximately 5 minutes. Keep the open end of the risers out of the soil to prevent washing debris back into the lines. Water that enters the trenches will help settle the soil around the piping. Recap the risers and begin a second flushing, this time going zone to zone and removing one riser cap at a time. In each zone, first remove the cap on the riser closest to the valve and flush for 2 minutes; then recap the riser and repeat for the next riser in line. Continue the flushing until you have cleaned all risers. After performing this second flushing. finish backfilling the trenches.

Installing Heads

Once you have cleared the lines of debris and backfilled, you can attach the heads and distribution lines. These elements distribute water to the plants. When installing them, use caution not to bend or kink the risers or damage the equipment.

Installing Rotor, Spray, and Impact Heads. Install appropriate heads at the riser locations. Most heads are threaded onto the risers and set at finish grade (Figures 15–14 and 15–15). When installing shrub heads or other riser-mounted heads that project out of the ground, place a post or #4 rerod next to the riser for stability. Bury the post or rerod at least 2 feet into the ground. Use auto hose clamps to connect the riser to the post or rerod.

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Figure 15-14 Irrigation head installation.

Figure 15-15 Setting irrigation head at proper elevation.

Testing the System

When all components are installed, the system can be tested. Verify that all valves and zones are working and that head and distribution lines are delivering the required amounts of water. If necessary, adjust head spray patterns and distances to match the design requirements. Also adjust the timing and cycling of the controller. When all components are correctly working, mark a set of plans showing the location of lines and valves, including which heads are in which zone. This document will be invaluable when changes or repairs are required in the future.

DRIP IRRIGATION SYSTEMS

A drip irrigation system, an alternative to a spray system, more efficiently utilizes water for irrigation. Drip systems are low-pressure systems that precisely distribute water directly to the plants' root zone, rather than distributing water over an entire planting zone. Drip irrigation uses a variety of water distribution techniques ranging from emitters that slowly drip small amounts of water to microsprays and soaker hoses. Water in drip systems is typically distributed by poly tubing that is laid on the surface and covered with mulch; however, spray systems can also have separate zones that use the drip fixtures.

Cheaper and easier to install, drip irrigation is often chosen as a low-water alternative to spray; however, drip systems have their drawbacks. Drip systems are less suitable in colder climates where protecting them from freezing temperatures is difficult, and drip systems are more prone to plugging and failure than are sturdier spray systems. Unless placed below the surface (see later in this chapter), drip systems are not effective at watering turf areas. Despite these limitations, drip irrigation is often chosen for sustainability reasons and as a way to reduce water consumption.

Installing the Water Supply and Irrigation Head

A hose bibb, threaded riser from a spray irrigation system, or dedicated water line with a threaded fitting

can supply water to a drip irrigation. All systems will require a backflow preventer and pressure regulator. A timer, usually battery-operated, will be necessary if the drip system is not on a spray system valve or the owner does not want to manually operate the system. Each of these fixtures is typically supplied with threaded fittings that connect to the hose bibb/water line and each other using typical plumbing connections (Figure 15-16). Also available for drip systems are fertilizer injectors and filters that further enhance the system. Create the irrigation supply head by connecting each of the desired fixtures in line; and at the end of this supply head, install a tubing adapter. The distribution line will slip into the compression end of this tubing adaptor to create the supply line to the plant material.

Installing Distribution Lines

In a drip irrigation system, water is distributed using one or more distribution lines of ⅝-inch, ½-inch, or ⅜-inch poly tubing and compression fittings. The distribution line is laid out along the paths that will best serve the plant material being irrigated. For areas where the distribution line does not come in contact with every plant, branch lines of ¼-inch connector tubing can supply water to additional plants. For smaller sites (utilizing 50–75 emitters), a single distribution line can be split into branch lines to better access the plant material. Large sites may require additional irrigation heads and distribution systems to serve significant numbers of emitters.

Cut the tubing with pruning shears or tin snips, and lay lengths of tubing along the desired route. Leave extra tubing to allow for adjustments in alignment. After laying out the distribution line and beginning at the irrigation head, connect the line to the tubing adapter. Using T, Y, and elbow fittings, complete the routing of the distribution line (Figure 15-17). If a system is installed on a sloping site, you may need to install additional pressure regulators in the distribution tube midway down

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Figure 15-16 A drip irrigation supply head with the hose bibb on the left and with the backflow preventer, pressure reducer (not visible), battery-powered controller, and a drip tubing adaptor on the right.

Figure 15-17 Drip irrigation fittings. An elbow at the top with a T just below.

the slope to prevent excess water pressure at its bottom half. Connect the line to the irrigation head and turn on the water to flush the pipe for at least 2 minutes. When you finish flushing, cap or crimp all open ends to the distribution system.

Installing Emitters

In a drip system, getting water to the plants requires choosing from a variety of methods designed for use with varying types of plant material. Some of the choices available in irrigation equipment include the following (Figure 15-18):

- Emitters. Emitters are small, plastic, disk-shaped irrigation heads that deliver a measured amount of water over a given period of time. Typical emitters provide ½, 1, or 2 gallons of water per hour. Emitters are placed directly into the distribution tube or as a series of in-line emitters that can be connected to the distribution tube using smaller tubing.
- Emitters Placed within the Distribution Tube. If the distribution tubing can be routed next to or through the plants being irrigated, distribution tubes that have low-volume emitters placed directly into the tube are available.
- Flag Emitters. Similar to the emitters listed above, flag emitters also have an adjustable valve that can vary the rate of water flow. Flag emitters are valuable additions in containers and annual beds where plant material may change periodically.
- Microsprays. If a large number of low-growing plants require irrigation and if it is impractical to route an emitter to each plant, microsprays can distribute a low-volume spray similar to the heads used in spray systems. Although microsprays have a limited volume and radius of spray, they can be useful in small areas of ground covers and planting beds.
- Bubblers. For planting areas that are best irrigated by flooding, bubblers can discharge

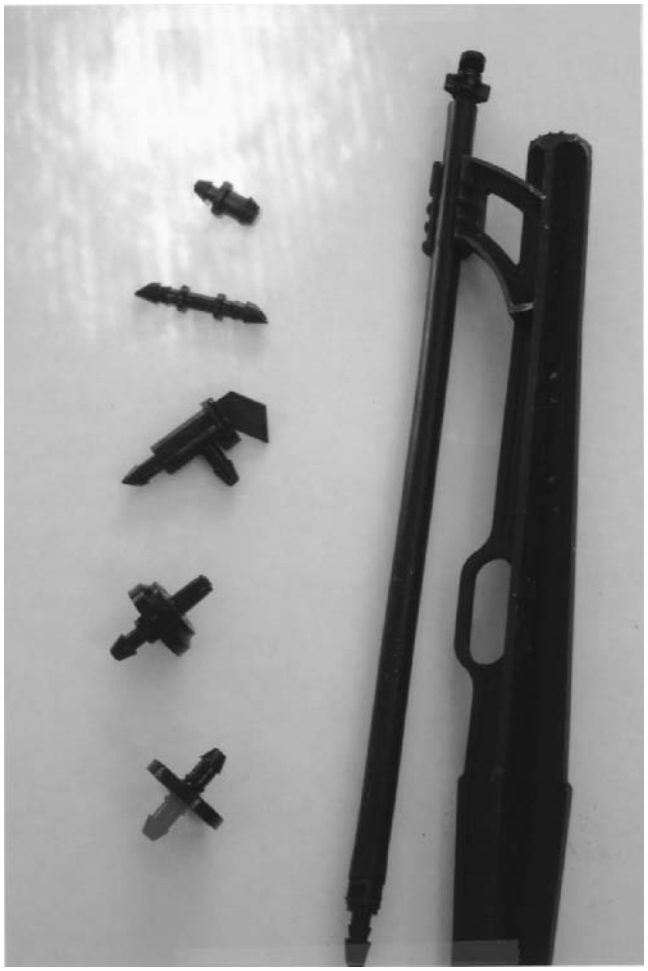
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Figure 15-18 Drip irrigation emitters. On the left from the top, a "goof" plug, a barbed connector, an adjustable flag emitter, an emitter, and an in-line emitter. On the right is a microspray head with an attached stake.

low volumes of water that flows over the surface to plants.

- Soaker Hoses. A small-diameter hose that slowly emits water through laser drilled holes or directly through the hose wall can be used to drip irrigate planting beds. Because they emit water along their entire length, soaker hoses can address beds with large numbers of plants or irregularly spaced plants.

Most of the above emitters can be installed directly into the distribution line or separated from the distribution line by ¼-inch tubing.

Installation of emitters and ¼-inch connection tubes requires the use of a special tool termed a **punch**, a small diameter awl that punches a hole through the distribution tube. Place the distribution tube on a solid surface and position the punch where the connection is desired. Apply pressure and twist the punch to create a small hole in the distribution tube. A characteristic "pop" is heard when the punch has cut through the tube (Figure 15-19). Use caution not to apply so much pressure that the punch goes through the back of the tubing. After punching the hole, hold the distribution tube with your fingers and firmly push the barbed end of the fixture into the hole. If you punch a hole in an incorrect location, push a "goof" plug into the hole to close the opening.

Using ¼-inch tubing to connect fixtures to the distribution tube will require the insertion of a barbed connector to supply the tubing. Place the distribution tube on a solid surface and hold a barbed connector with a pair of pliers. Use a twisting motion to push the connector through the hole made by the punch (Figure 15-20). Once firmly inserted, ¼-inch tubing can be pushed over the connector's open end and run to the fixtures on that line. Pushing tubing over the barbed end connects emitters. If using in-line emitters, push another piece of ¼-inch tubing over the barbed fitting on the emitter's opposite side and run to the next emitter. At the end of an in-line emitter run, install a short piece of ¼-inch tubing and clamp or crimp it to close off the end of the run (Figure 15-21).

Emitters should be placed on the uphill side of a plant within its root zone. This placement allows gravity to evenly distribute the water. If a plant is large or if there is no slope, consider installing two or more emitters with lower volumes and placing them around the plant perimeter to avoid watering only one side of the plant. When the line and emitters are laid out correctly, use small wire stakes to hold the line in place and cover the tubing with mulch. Flag emitters will need to be adjusted to achieve the desired flow rate, and microsprays will need to be adjusted to aim the spray in the proper direction.

Installing Drip Fixtures on a Spray System

Drip systems do not need to be exclusive from traditional spray irrigation systems. Spray systems can include zones dedicated to drip fixtures, and existing spray systems can be retrofitted to include drip components. When mixing drip and spray irrigation on a single system, ensure that all drip fixtures are on a separately controlled valve from spray fixtures and that pressure reduction is provided at the

Figure 15-19 Using a punch to create a hole in drip tubing. A barbed connector will then be inserted into the hole.

Figure 15-20 Holding the connection barb with a pair of pliers, gently push the barb into the hole made by the punch.

Figure 15-21 Crimping the end of an in-line emitter run.

beginning of drip zones. The mixture of water pressures and irrigation times does not allow these two forms of irrigation to be placed on the same valve.

To install drip components in a spray system, begin by identifying where the drip features would best serve the plant material and which zones a separate valve can control. When you identify this zone, find the best location for a water supply to an irrigation distribution line. At that point, install a riser with a pressure reducer and tubing adapter. If an irrigation head is already at that location, remove the head and install a sprinkler body retrofit (that includes a pressure reducer) and a tubing adapter. If there are other spray heads within this zone, remove those heads and cap the risers. From the supply point, install the distribution line and emitters as described above in this section. An alternative to converting an existing system to drip is to replace all spray heads with a sprinkler body retrofit and add a multioutlet emitter (Figure 15-22). This allows ¼-inch tubing with emitters to be routed to plants from each location where a sprinkler head was formerly located. When converting zones or entire systems from spray to drip, remember to adjust the timing on your controller.

SUBSURFACE DRIP TURF IRRIGATION

Although surface drip irrigation systems offer advantages to ornamental plants, subsurface drip irrigation creates similar benefits for turf areas. Subsurface drip irrigation is essentially a grid of in-pipe emitters placed in the turf's root zone. Water spreads by capillary action between the points of the grid to reach the roots. By placing the water in the root zone, rather than distribution by spray head, water loss is minimized. As with surface drip irrigation systems, subsurface systems have issues. Root growth into emitters, pipe failure, and uneven water distribution as a result of poor planning or installation can offset the value of more efficient turf irrigation.

Installing the System

Installation of subsurface turf irrigation begins with examining the soil type, topography, and shape of the area to be irrigated. Each of these factors influences the location and spacing of the irrigation grid. Identify how a turf area can be generally divided into roughly linear, preferably square or rectangular, zones. Each of these zones will have a header pipe placed at each end with laterals that have embedded emitters running between the headers. This creates the grid that supplies the water to the turf

Figure 15-22 A multioutlet adapter used to convert spray irrigation to drip.

roots and allows for supply and drainage of the system. Clay soils will have emitters spaced on an 18-inch grid, whereas loamy soils will have a grid of 12 inches. Slopes will require spacing further apart and berms require closer spacing. Lateral layout should be no further than 4 inches from hardscape.

For new installations, prepare a smooth and even subgrade 4–6 inches below the desired finish grade. Piping can be laid on top of this subgrade, and finish grade can be established by carefully placing topsoil over the piping. For existing turf areas, the location of the piping must be trenched 4–6 inches deep by hand or by using a trencher. Large installations may have pipe installed using a multiblade pipe puller, which will trench and install several laterals simultaneously. For clay soils, spacing of both the laterals and emitters should be 18 inches; for loamy soils, 12 inches. Adjustments in spacing may be required for topography.

At either end of the grid, install a Schedule 40 header pipe connected to the water supply and with T fittings at each location where a lateral is to be run. The water should be supplied to the highest point of the grid to facilitate flushing each time the system is charged. Grade changes of over 4 inches may require check valves be installed in headers. For laterals, use poly piping that has the emitters installed within the pipe (Figure 15-23). To minimize issues with root growth into the emitters, use either Netafim® techline® pulse irrigation line or Toro® DL2000 Rootguard® irrigation line. Connect the laterals to the header at each T location. The former provides irrigation in slow pulses to reduce root intrusion, whereas the latter has small amounts of herbicide infused into the emitters to achieve the same results. At the highest point of the grid, insert either an antisiphon valve or air vent in a valve box. This will supply air when draining the system. At the low point of the grid, install an automatic flush valve in a valve box with a 6–8 inch layer of pea gravel below the box. This will be used when draining the system.

After you place all headers, laterals, air vents, and flush valves, you may cover the trenches (or entire

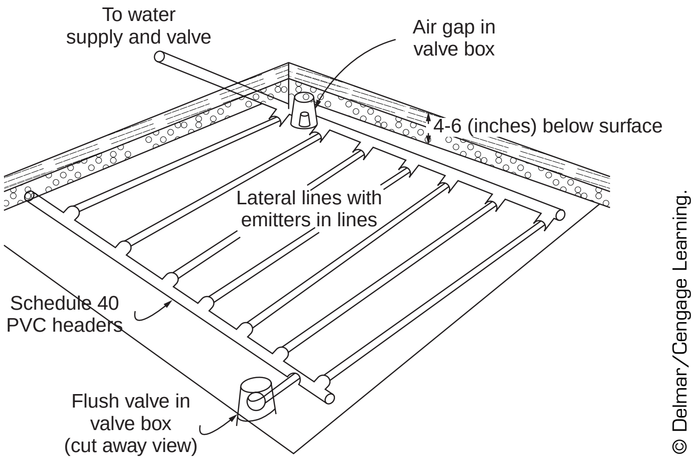


Figure 15-23 Cut-away diagram of a subsurface drip turf irrigation installation.

grid). Completely compact the soil in filled trenches for even water distribution. When using equipment to fill over irrigation lines, staple the equipment in place, always fill in front of the equipment, and avoid operating equipment over piping that has not been covered. Work equipment parallel to the laterals to avoid moving pipe out of position. For new turf, the finish grade may be seeded or sodded. Sod should have a layer of soil between the irrigation grid and the grass. Supplemental irrigation may be required for new turf areas until the root zone is established.

SECTION 4

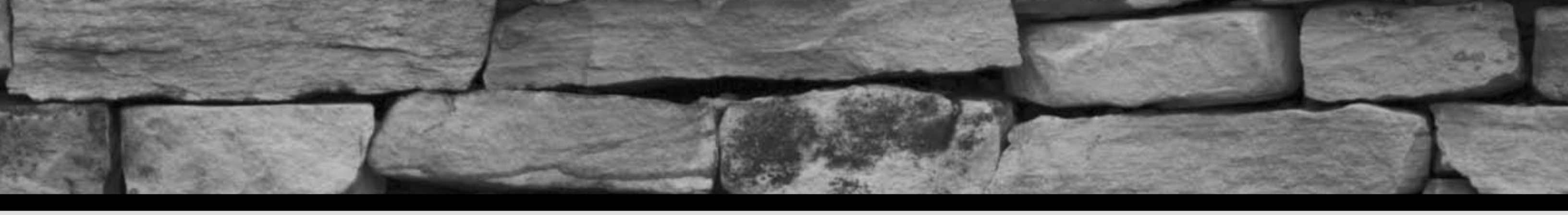
SUMMARY

Although specialized contractors install a majority of the utilities designed to serve a site, landscape contractors may be asked to perform minor utility tasks and coordinate activities with other utility installers. Section 4 described those utility tasks related to landscape work.

Low-voltage DC lighting systems are one utility element often assigned to landscape contractors. Installation of the DC system requires identifying a suitable electrical source, connecting any controllers, laying cable, and connecting fixtures. Because of their versatility and reduced risk, low-voltage DC electrical currents can be used to serve several decorative lighting purposes. Custom low-voltage DC electrical systems are available for clients who desire a more extensive and durable installation. Hubbed distribution points supplied with AC current and controllers can manage safety and decorative lighting for a large site. AC electrical work is limited to laying empty conduit, pouring footings for exterior lights, and installing lighting standards.

Water installations prepared by landscape contractors are limited to the installation of yard hydrants and irrigation systems. Yard hydrants are often buried to frost depth so they can be used during cold weather, whereas irrigation systems are placed at shallower depths and winterized prior to the onset of cold weather. Irrigation system design and installation require knowledge of water dynamics, construction techniques, and plant physiology. System setup begins with the installation of a safe, reliable water service, installing the distribution mains and valves, and providing the correct piping and irrigation heads to deliver adequate water to specific locations. Irrigation systems may be spray systems designed to deliver water through irrigation heads that provide spray over large areas or drip systems that provide small, measured amounts of water directly to plants. Several options are available at each step, and contractors must be aware of the circumstances when selecting from the many options.

Specialized contractors, with assistance from landscape contractors on smaller projects, may install wiring for the various communication mediums available. Although landscape workers can place conduit, cables, and service entries to landscape structures, plumbing professionals must install gas service connections because of the safety risks involved.



SECTION 5

LANDSCAPE RETAINING WALLS AND STAIRS

INTRODUCTION

One of the most dominating functional and visual elements of the landscape is the **retaining wall**. Whether a single wall or several walls grouped together in **terraces**, this vertical element creates an immediate and significant change in a landscape. Walls also serve a variety of functional purposes for the homeowner, from mitigating erosion to creating space. Primary among the functions of the retaining wall is the leveling of grades to create more usable areas in the landscape. On sites that have a significant slope, normal use of open areas for lawns, gardens, play areas, or circulation routes may be restricted because of the steep grade. Retaining walls can create level areas to accommodate these activities.

Large-scale wall installations, like those seen along roadsides, may rely on techniques such as soil nailing and anchoring or building cantilever walls, but most residential and smaller commercial projects rely on what is termed gravity walls. Contemporary construction materials and techniques make walls a versatile and effective landscape element. Walls of almost any form, color, and material can be blended with other landscape elements to accomplish design goals. Despite these innovations, walls are still an expensive and time-consuming landscape element to construct; so, landscape contractors must consider all possible solutions when addressing grade problems.

The chapters of this section cover construction techniques for building walls with several common materials available to landscape contractors. Also included in the materials chapter, Chapter 16, is a section on building retaining walls for nonstructural applications and for sustainable materials. Chapters cover the installation techniques used for timber wall construction, segmental wall unit (precast concrete) and structural cell construction, dry-laid stone wall construction, and gabions. Not included are retaining walls constructed of cast-in-place concrete, rammed earth, or mortared veneer materials. Both cast-in-place concrete and mortared masonry veneer retaining walls are impermeable materials that require stabilizing designs and specialized drainage systems placed behind the wall to protect them against water pressure.

In addition, the skills required and risks involved in forming and pouring large installations typically place these walls beyond the landscape contractor's scope. Specialty contractors are also required for cantilever walls and for soil nailing and anchoring, as well as for walls used in situations with dynamic water such as

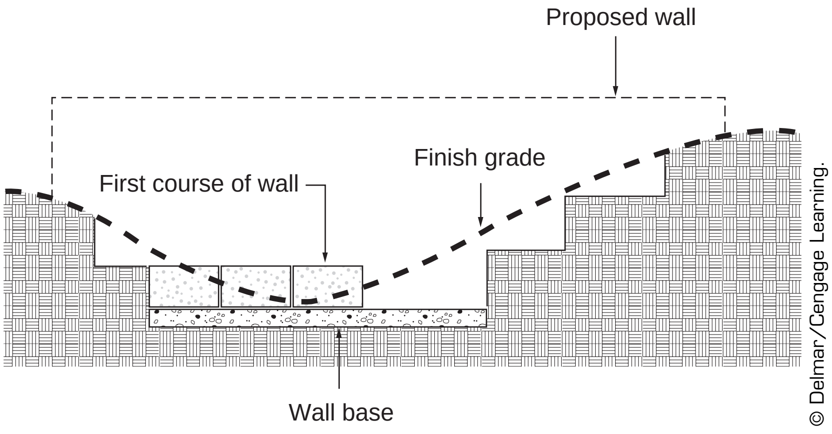


Figure S5-1 Beginning wall at low point.

river or marine revetments. Nonretaining, freestanding wall construction, including mortared walls, cast-in-place concrete, stucco, rammed earth, and veneered walls, are discussed in Chapter 33.

SUSTAINABILITY SUGGESTIONS

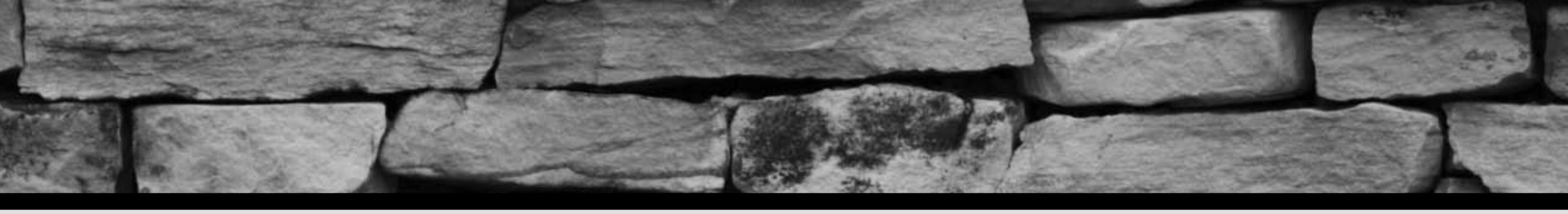
Incorporating the following actions into your project can make your work more sustainable:

- When you have control over such choices, give careful consideration to the materials used in your project. Choose local materials before selecting materials that must be transported great distances to your site, and choose renewable materials, rather than products that cannot easily be reused.
- Select toxin-free, environmentally friendly materials. Avoid plastic materials that use harmful chemicals in their manufacturing process. When using wall materials to create planters and other areas in which consumable food is grown, do not use wall materials treated with chemicals that prevent decomposition.

PRODUCTIVITY SUGGESTIONS

The process for constructing walls and stairs can be approached a number of ways. The following suggestions may provide general ideas from which a project can be started:

- Always begin wall construction at the lowest point (Figure S5–1).
- Work from lower walls to upper walls when terracing.
- Build cast-in-place concrete stairs first and then build the wall up to the stairs.
- Locate stair and/or corner locations and plan material layout to end evenly at these points.
- To avoid delays caused by weather, install base courses for several projects, rather than beginning and completing one project at a time. Bad weather interferes with base construction but has minimal impact on stacking of subsequent courses or horizontal layers of wall material.
- The bottom course of all walls should be buried below grade. This will enhance the wall's stability. There are accepted manufacturer's and engineering standards for bottom course burial depths.
- Excavation of a wide trench along the wall alignment will ease access problems, allow use of a skid-steer for excavation, and provide more room for working.
- Never use pea gravel as a base, infill, or backfill materials for walls. It does not create enough friction between stones to maintain stability.



CHAPTER 16

MATERIALS AND INSTALLATION TECHNIQUES FOR RETAINING WALLS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Choose appropriate materials for a retaining wall.
- Plan the installation of a retaining wall.
- Install a sound base for a retaining wall.
- Drain water from behind a retaining wall.
- Stabilize a retaining wall.

Wall material selection is dictated by the construction documents prepared for a project. If the contractor or the client makes the choice, a review of available materials will help with proper selection. Regardless of the type of wall material selected, site preparation is similar. Preparing the proper base, providing for drainage behind the wall, and planning wall stabilization are required for all walls, especially for those that are taller than 1 foot.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Concrete Paving, Chapter 23

SELECTION OF WALL MATERIALS

In many construction projects, the designer bases the choice of wall material on engineering and aesthetic considerations. Should the contractor have the opportunity to recommend wall materials to clients, review with them the positive and negative aspects of the many materials available. Among the variables to consider are material performance and stability, cost, appearance, ease of installation, and durability.

Although the material evaluation often focuses on new products, contractors should also consider recycled materials and those materials and techniques that reduce impact on the environment. Many of the best wall materials, including most stone and some woods, can be reused from previous applications. Old concrete paving can be reused as a dry-laid wall material. The cellular confinement material introduced in Chapter 13 for erosion control can be stacked

Figure 16-1 A stacked wood timber retaining wall with vertical anchors.

horizontally and filled with crushed stone to create a short retaining wall. A selection that withstands the forces of nature without compromising the environment benefits all. The following sections identify several common retaining wall materials that are available to landscape contractors.

Railroad Ties and Treated Wood Landscape Timbers

Wood railroad ties are often the least expensive wall material, but availability of quality ties has been limited since the late 1980s. Ties provide a gray to dark brown color for the wall and blend well with naturalistic design themes. However, poor quality ties provide an inconsistent look to the wall surface. Workability of the ties can be difficult, considering their weight, irregular lengths, and irregular dimensions. Consistent wall building requires modular materials, and railroad ties require a great deal of sorting to match dimensions. Using either a chainsaw or cutoff saw is the most efficient way to trim ties, but the creosote, wood hardness, and buried nails and metal end ties are extremely hard on this equipment.

A more costly substitute for railroad ties is treated wood **landscape timbers** (Figure 16-1). Manufactured to consistent dimensions and lengths, timbers overcome the inconsistency problems that ties present. Timbers also have a consistent wall surface color and texture. Timber weight is slightly less than that of ties, and the cost for timbers is significantly more than the cost of ties. Do not confuse landscape timbers with the small edging and planter timbers sold in lumber centers. Landscape timbers are typically sold in 6-inch × 6-inch or 8-inch × 8-inch dimensions, in 6–8-foot lengths, and have squared edges. The much smaller edging timber has rounded edges and is not suitable for walls. Ties and timbers treated with wood preservatives are not acceptable for use adjacent to areas where edible crops are grown. Adding sustainability to the timber and tie arena are landscape timbers manufactured with recycled plastics. Similar in workability but with an extended life

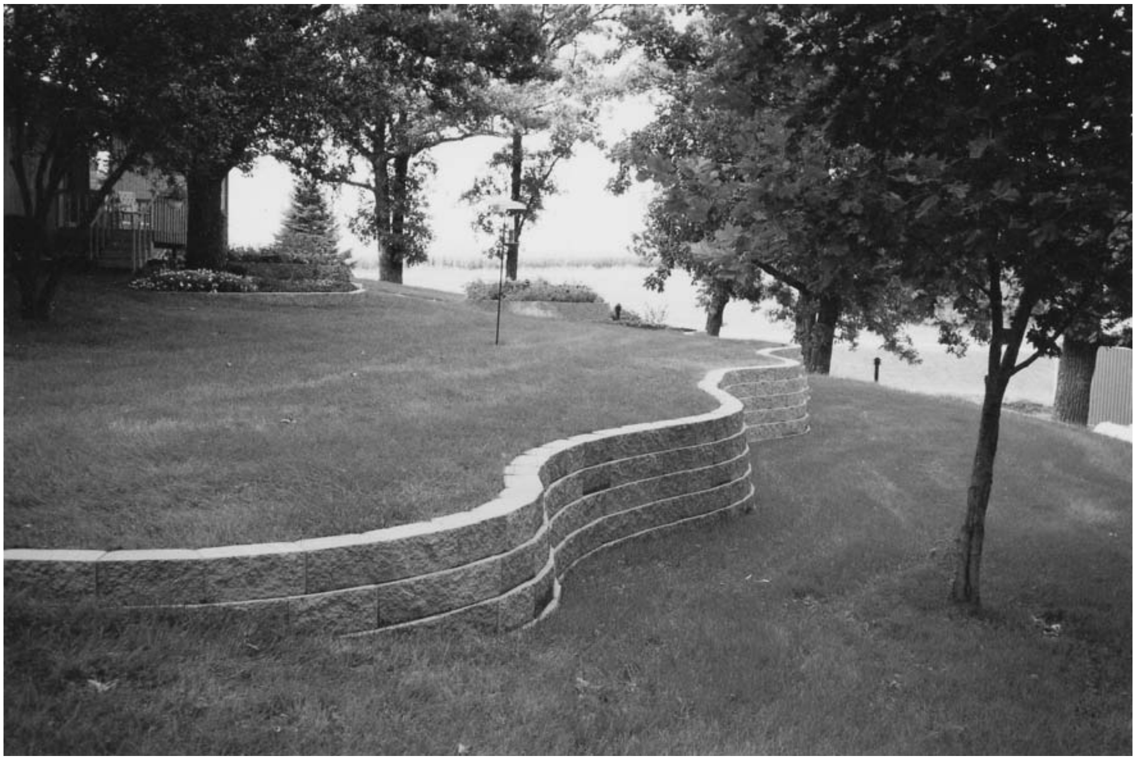


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Figure 16-2 Segmental precast concrete unit retaining wall.

expectancy, recycled plastic timbers can be used in many of the same situations as wood.

Segmental Wall Units

Many manufacturers now produce **segmental precast concrete units** used for constructing walls (Figure 16-2). Similar in surface area to a concrete block, these wall units come in a variety of forms, shapes, and installation methods. Segmental units create an appearance of a rough-surfaced stone wall and, combined with the variety of colors, provide an attractive and consistent wall surface. Wall units can be heavy, ranging from 30–80 pounds per unit, but they weigh less than timbers and most workers can handle them. Installation requires careful layout and base course preparation, and most subsequent layers are stacked. Corners and stair incorporation can be difficult. Cost is in the mid- to slightly high range when compared to other wall materials. Two common types of segmental units are **pinned wall units**, which use metal or fiberglass rods to stabilize layers, or **lipped wall units**, which use a protrusion on the top or bottom of the unit to integrate layers. Anchored units, or thin concrete fascia blocks with precast anchors placed into the hillside and pinned together, are also available.An additional material that is installed using many of the same techniques as segmental precast concrete is structural cell wall units manufactured by Millenia® Wall Solutions. Manufactured from preconsumer recycled polymeric products, the structural cell units offer a variety of surface patterns and a lightweight wall construction material. Providing similar surface appearances as precast concrete segmental units, the structural units are placed in a running bond pattern on a granular base. One primary difference between the two materials is that the structural cells will form an almost vertical wall with minimal batter.

Dry-Laid Stone

Used for years, **dry-laid stone** is considered a classic wall material (Figure 16-3). As the name suggests, this natural wall material is installed without mortar between the stones. Considered a highly aesthetic wall surface, the stone wall can be constructed of regular or random thickness material and with a variety of stone types. Costs vary but are typically high as a result of availability and quarrying costs, high demand in construction, and intensive labor for preparation and installation. Stone is a workable material because most cut stone weights are within

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Figure 16-3 Dry-laid stone retaining wall.

a worker's lifting abilities and are available in reasonably consistent dimensions. However, stability of the material may be a concern for high walls.

Gabions

An alternative to small, single-unit materials for retaining walls is the use of **gabions** (Figure 16-4), or heavy-duty rectangular wire baskets placed in position and filled with large stones. The size and weight of the gabions make a stable wall installation. Varying the size and type of stone inside the gabion produces different aesthetic effects, but the presence of the wire basket will always be a detraction. Because of their size, gabions require special equipment to place and fill. However, the cost is in the lower range of wall materials.

Alternative Materials

As society searches for ways to reduce consumption of materials, the efforts to find adaptive reuses for old materials has increased. One such material is old concrete paving in retaining walls. Not every old paving can be reused, but if the old concrete has consistent thickness and has no reinforcement, then it can be reused successfully. With artistic application,

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Figure 16-4 Gabion retaining wall one course high.

the appearance is similar in texture and form to dry-laid stone, although close inspection will reveal the source material. From a strictly visual perspective, reused concrete paving is best when limited to applications in background locations where appearance is not the primary concern. Installation techniques are similar to dry-laid stone, with wider pieces providing more stability but more difficulty in placement. Costs for this material are primarily related to the labor involved in sorting, preparing, and installing it, hence making it a cost-effective choice.

Another alternative material that makes use of recycled products are old tires. The limitations of tires as a wall material mimic those of the recycled concrete, but the impact on the environment can be substantial and there is no shortage of available material.

When structural strength is not critical to a retaining wall, materials such as cellular confinement systems, irregular natural stone, and bags of concrete mix can be used to create installations that will serve specific purposes. These alternative materials will vary widely in their cost to install, with some ranging from minimal cost to those that are as expensive as a highly detailed wall. Although not always as efficient or attractive as other wall material choices, these alternatives may be the best choice in particular situations.

WALL LAYOUT

Prior to construction, identify the location of the front of the wall. Placing stakes and a stringline, or painting the ground along the alignment, will help in identifying potential starting points and any problems that may be encountered. Also, identify locations of stairs and corners. This layout will guide the location of the rough trenching necessary to establish an approximate grade for the wall. Offset temporary markers away from the excavation so that the wall location can be reset after rough trenching.

EXCAVATION

Excavation may be required in locations where walls are to be constructed. Sod and topsoil should be excavated from an area 2 feet in front of and 2 feet behind the entire wall alignment. Excavate to a depth that is approximately 8 inches lower than the desired finish grade along the base of the wall (Figure 16-5). This depth is necessary because the bottom, or base, course in any wall is placed below the finished grade. When excavating, remove any unstable materials encountered and replace them with **granular base**.

BASE PREPARATION

Wall construction begins at the lowest point of the wall (Figure S5–1). After you complete the rough trenching, replace the stringline that identifies the front of the wall. In the rough trench and along the wall alignment, excavate a trench to be filled with **base material** that is 6 inches deep and 12 inches wider than the wall material (Figure 16-6). The bottom of this trench should be level from end to end. When the depth of this level trench exceeds the

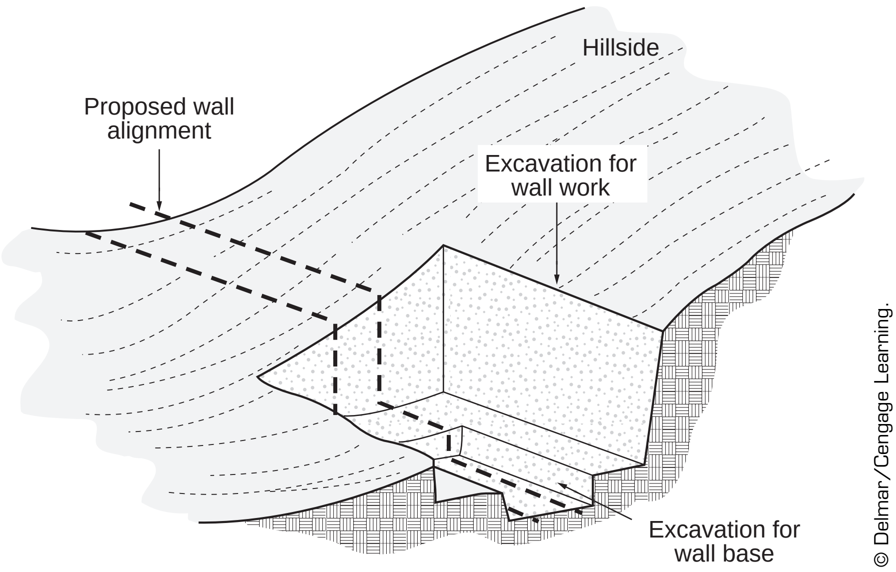

Figure 16-5 Preparing an excavation for retaining walls.

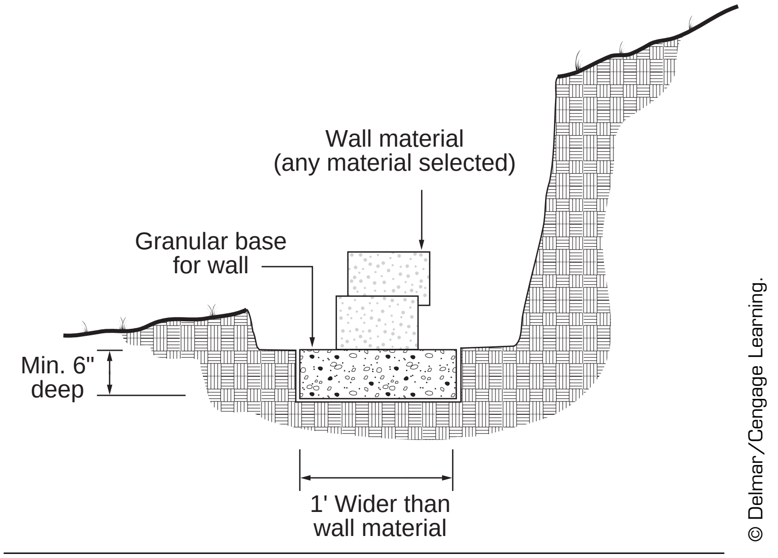

Figure 16-6 Granular base material for wall. Trench should be 12 inches wider than the wall.

thickness of the wall material, the wall should step up one level. When walls encounter embankments, this stepping may occur rapidly. Walls should never step up more than one course at a time, and the course on the bottom should always be covered by grade in front of the wall.

Fill this trench with free-draining angular ¾–1-inch crushed stone. Level the base material and compact using a **vibratory plate compactor**. Placement of a ½–1-inch layer of finer granular material on top of the crushed stone will ease the leveling of the base course of wall material. Crushed stone that passes a ⅜-inch sieve is suitable for this second layer.

Flowable Fill

A stable alternative to compacted granular base material is a medium-grade **flowable fill**, a thin concrete mixed with fly ash that will flow throughout a prepared trench. Consult premixed concrete suppliers for a suitable flowable fill formulation. To install flowable fill, excavate a base trench a minimum of 24 inches wide and 12 inches deep along the alignment of the proposed wall. Place a grade stake in the trench and mark the elevation desired for the top of the base material. Begin pouring flowable fill at one location along the trench and allow the material to fill the trench to the desired grade. Flowable fill is liquid enough that it will seek its own level without screeding or finishing. Allow the flowable fill to harden before you begin to install the wall material.

Grade Beams

A design professional may require that walls in areas with highly unstable soils be placed on a **grade beam**, a reinforced concrete footing supported by concrete piers sunk to stable subgrade (Figure 16-7). Although uncommon and expensive, this application is an effective way to support a wall. Construction of grade beams begins with excavation and pouring of piers in locations and dimensions determined by the design professional. Reinforcing rod should be extended out of the top of the piers to anchor the footings. Under the alignment of the footings, excavate and place a minimum of 2 inches of sand (or whatever depth the design professional states). This will accommodate frost pushing up against the bottom of the footing. Form the footing and place steel reinforcement that is tied to the stubs projecting from the piers. A typical grade beam is 1-foot square, but dimensions vary depending on the situation. Verify that the tops of the forms are level and at the correct subgrade elevation. Pour the footing and remove the forms when hardened. Place drainage tile behind the wall as described in the following section, backfill with **free-draining angular backfill**, and proceed with wall construction.

DRAINAGE BEHIND WALLS

Wall failure can often be traced to a buildup of **hydrostatic** (water) **pressure** behind the wall. The forces exerted by water behind a wall are strong

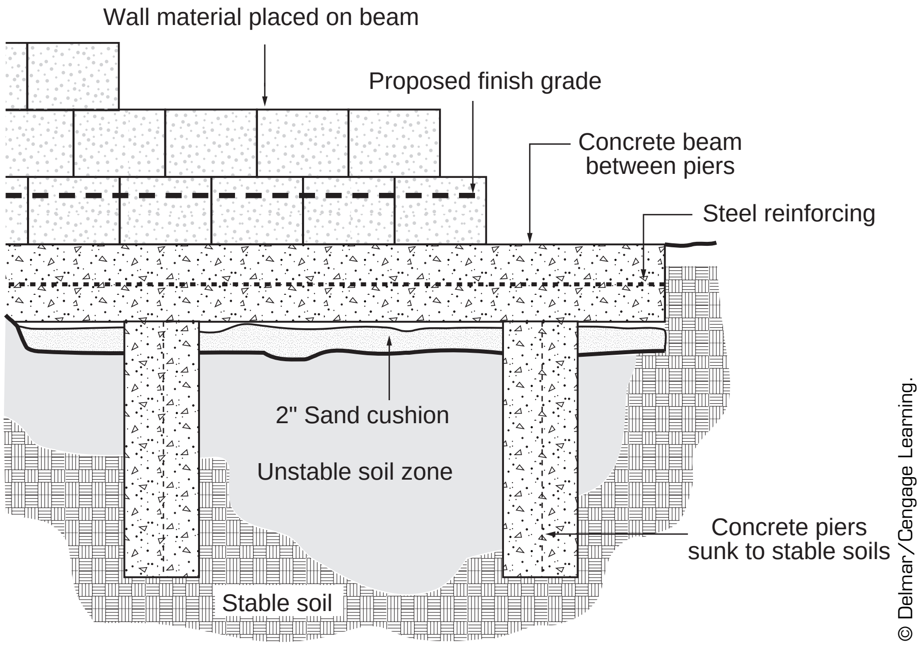

Figure 16-7 Cross section of grade beam used to support walls in poor soils.

enough to collapse even reinforced installations. If you encounter significant moisture or flowing water while preparing the wall base for construction, consult an engineer to eliminate the water problem before continuing the project. Drainage systems described in this section are proposed to handle occasional water buildup behind a retaining wall. Water problems associated with springs, high water tables, or similar types of situations may exceed the capacity of the drainage systems described in this section and lead to failure of the retaining wall.

Release of water from behind a wall is partially accomplished by placing 1–2-inch diameter Schedule 40 PVC pipes running completely through the base course of the wall every 6–8 feet. These openings, called **weepholes**, allow water to drain from behind the wall and may require respacing or notching of wall material to accommodate the pipe. Weepholes can also be installed by drilling a ½-inch diameter hole through the base course every 6–8 feet. A small amount of water will also pass naturally through the wall in open-joint wall materials. Weepholes and natural drainage are not acceptable substitutes for installation of proper drainage.

Although weepholes and open wall joints are beneficial, supplemental drainage is recommended in any type of wall that exceeds 2 feet in height. This is typically accomplished through the use of drainage tile placed behind the base course of the wall (Figure 16-8). A 4-inch perforated **geotextile socked tile** placed in this location along the

Figure 16-8 Placement of socked drain tile behind retaining walls.

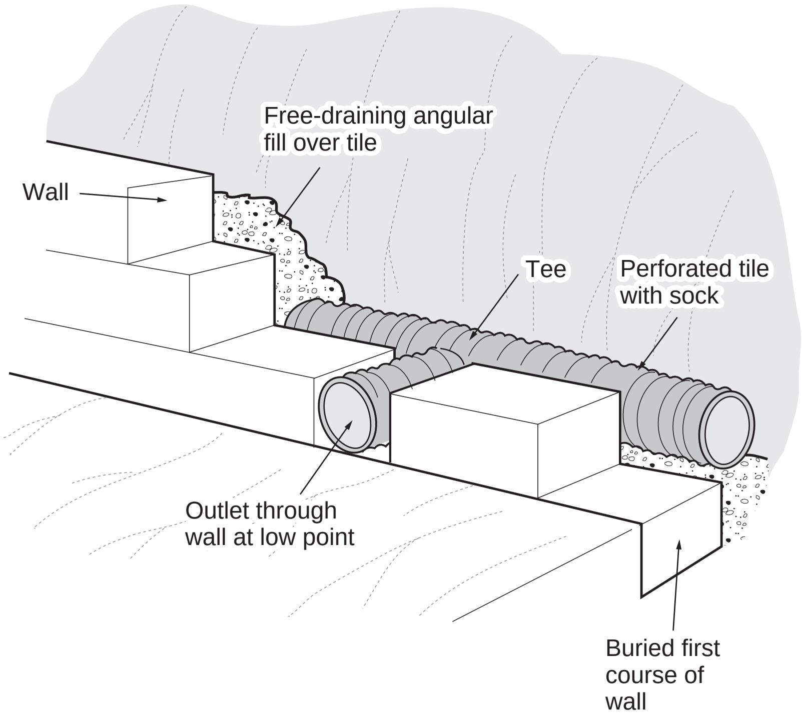

Figure 16-9 Placement of drain tile through an opening at the low point of the wall.

entire length of the wall should aid in the removal of excess water. For the tile to work properly, free-draining angular backfill should be placed above the tile to allow water to seep down to it.

Proper material selection for backfill behind the walls is critical in reducing hydrostatic pressure. A 12-inch zone directly behind the wall should be backfilled with a ¾–½-inch clean, free-draining angular granular material (also called class 57 rock or washed class 2 in some locations). This material will provide adequate compaction without disrupting water movement downward to the drainage tile. The tile must be sloped to the wall's low point. If the low point does not allow the tile to run around an end of the wall, you will need to cut or notch the wall material to allow the tile to pass through the wall and empty the collected water (Figures 16-9 and 16-10). Engineered walls that exceed 4 feet in height may have additional layers of tile along the wall's length to expedite collection of water.

Figure 16-10 Drainage tile exiting through opening cut in wall.

Landscape Fabric

Certain wall materials may have open joints large enough to allow backfill material to pass through the wall. Designers may opt for a solution that places landscape fabric behind the compacted fill material to reduce the movement of soil through the wall openings. In most wall construction projects, this approach is not recommended because it can increase the hydrostatic pressure behind the wall and counter the benefits gained from drain tile

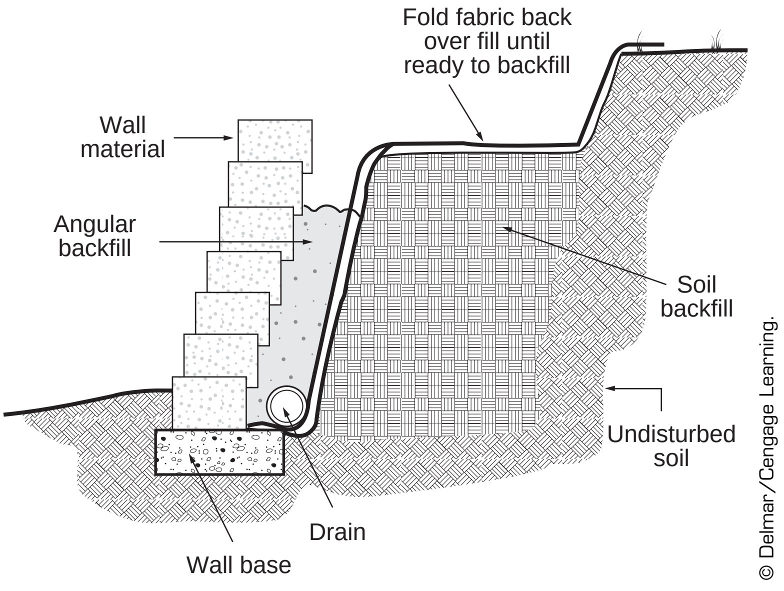

Figure 16-11 Placement of landscape fabric behind retaining walls. Note: Not all wall material manufacturers and designers recommend installation of landscape fabric behind walls.

and free-draining backfill. For precast unit walls, this material is not recommended because it also disrupts any wall stabilization material placement (see following paragraphs).

If required by landscape plans and specifications, landscape fabric placed behind the wall should run from the base to the second-from-the-top course of the wall (Figure 16-11). Run the fabric in the long direction along the wall and place it in the trench behind the wall material before doing the first backfill. Drape the fabric over the backside of the trench until the backfill behind the wall reaches the top. Fold the fabric back over the backfill and tuck it under the top course of wall material. Then complete wall construction and backfilling.

COMPACTION BEHIND WALLS

Remaining backfill beyond the first 12 inches directly behind the wall may be original or imported soil. Backfill material should be placed in **lifts**, or layers, of no more than 6 inches before compaction. Compaction methods should be selected carefully to reduce the chance of wall collapse. For a distance of 5 feet behind the wall, compaction should be performed with a vibratory plate compactor (Figure 16-12). Beyond 5 feet, the compaction may be performed by heavier equipment. Avoid over compaction immediately behind the wall to prevent displacing wall material.

WALL HEIGHTS AND STABILIZATION

As a wall increases in height, its potential of failure also increases. Gravity and hydrostatic pressure can topple a wall, and these forces must be countered by measures that will support the wall. Typical measures used to prevent wall failure include burying or pinning the base course, **battering** the wall, placing **buttresses** in front of timber walls, installing wall anchors, and **terracing**. Detailed techniques of anchoring are explained in the chapters on specific wall materials.

Burying of First Course

Burying the base of the wall provides the first measure of stability. Actual burial depth depends on engineered specifications that the design professional or manufacturer provides. At a minimum, the first course of the wall is buried; and in shorter height wall applications, the depth of one course may be adequate. With all wall materials, excavate the base trench low enough to place at least one full course of material below the finish grade on the wall's front side. Another formula used for calculating burial depth is to bury the base course 1 inch below grade for every foot of wall height, with a minimum of one course below grade. Many of the wall materials, particularly the unit wall materials, can be pinned to the subgrade using 24-inch rebars driven through holes in the material and into the base. Both of

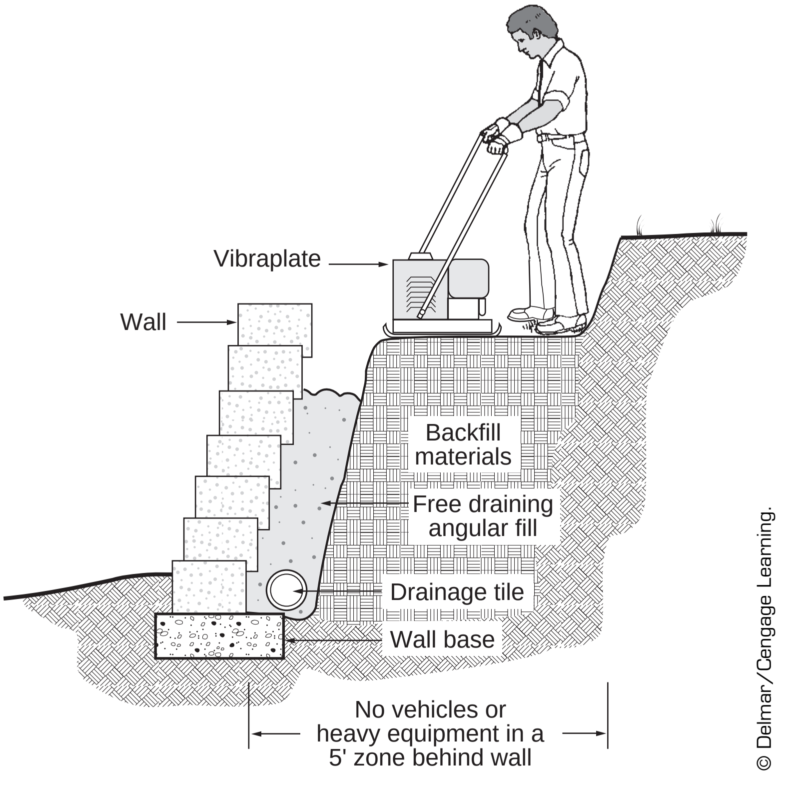

Figure 16-12 Compaction of fill behind retaining walls.

these measures anchor the base of the wall and counter pressures pushing out at the base.

Battering

Batter is the backward leaning or stepping of a wall (Figure 16-13). Batter can be built into a wall by tilting the base course slightly backward (approximately ¼-inch fall from front to back). This will cause all subsequent courses to lean in the same direction when placed. Batter can also be built into the wall by setting the front of each subsequent course back from the front of the previous course a small amount. This process, called **step-back or stairstep batter**, helps anchor the wall but keeps the materials level. Standards for step-back batter range from 1–2 inches for each foot of wall height. Most walls incorporate one of these two types of batter, particularly along a wall's straight sections and outside curves. A few wall materials may have a nonbattered vertical face on inside curves as a result of the materials from which they are constructed.

Anchoring

In addition to batter, many wall systems incorporate some sort of anchor to combat overturning.

Verticals. One type of anchor used in timber or tie wall construction is **vertical** timbers, or buttresses, which are placed in front of a wall (Figure 16-14). These verticals are buried to frost depth and placed at joints in the wall to hold back the wall materials.

Deadmen. Another type of anchor used in timber and tie wall construction and occasionally in stone walls is a **deadman**, a horizontal anchor connected to the wall face and run back into the hillside. The friction from contact between deadmen and the soil behind the wall counters the forward pressures.

Deadmen can be constructed by placing a timber with a crosspiece into the hillside or by using rods or cables that are run through the wall face to an anchor in the hillside. Timber deadmen are typically nailed to the wall face, whereas rods or cables are connected to metal plates attached to the wall face.

Geogrid. Similar in principle to the deadman and commonly used in segmental unit wall construction, the geogrid is a newer alternative for anchoring. **Geogrid** is a gridded polyethylene or polyester fabric that is laid in contact with backfill behind a wall (Figure 16-15). The front edge of the geogrid is

© Courtesy of Gary Pribyl, Kings Materials

Figure 16-13 Retaining wall showing step-back batter.

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Figure 16-14 Vertical timber anchor for a stacked timber retaining wall. Note the vertical is placed at the joint between wall sections.

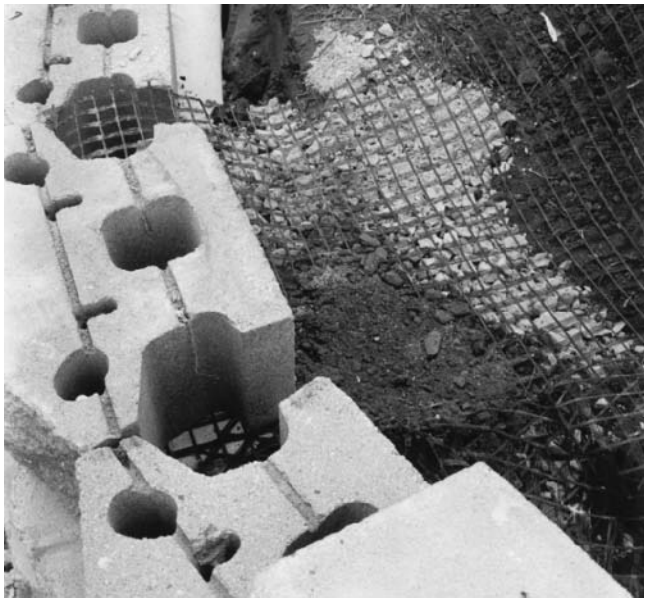

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Figure 16-15 Installation of geogrid anchoring behind precast concrete retaining wall.

laid between courses of a wall or hooked over the wall pins and spread out in a flat sheet behind the wall (Figure 16-16). The friction between the backfill and fabric provides similar results to those of a deadman. Geogrid is rated according to the strength and direction of resistance. 2T geogrid, which can be laid in either direction, is adequate for most short wall applications. Stronger geogrids typically have a higher number (e.g., 5T) and must be placed with proper orientation to have maximum design strength. Proper orientation places the loose strands of the geogrid parallel to the wall face and the bonded solid bands perpendicular to the wall face.

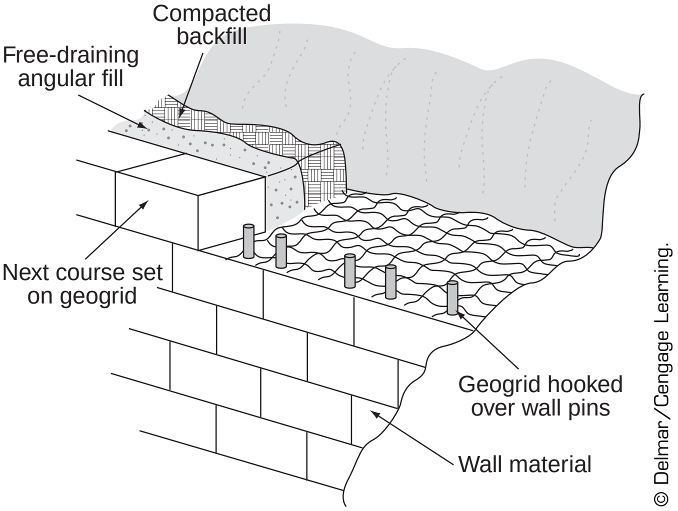

Figure 16-16 Hooking geogrid over pins in a pinned wall system.

Terracing

One effective technique for reducing wall failure is to limit the wall's height. Although design professionals can design walls of extreme heights, without the benefit of their expertise, landscape contractors should construct walls of no more than 4 feet (or 3 feet in the case of alternative materials such as loose stone, tires, etc.). In many landscape situations, this wall height is ample for accomplishing design goals. If there is a need for higher walls, either terrace the site or consult an engineer. Terracing is the construction of a series of short walls, each stepped back a calculated distance from the previous wall (Figure 16-17). By using terracing, you can construct a 12-foot wall as three 4-foot walls without extensive engineering. Terracing is not that useful in areas where there is extensive fill or in locations that have limited space.

Terracing should be constructed beginning with the lower wall first, then grading an area behind

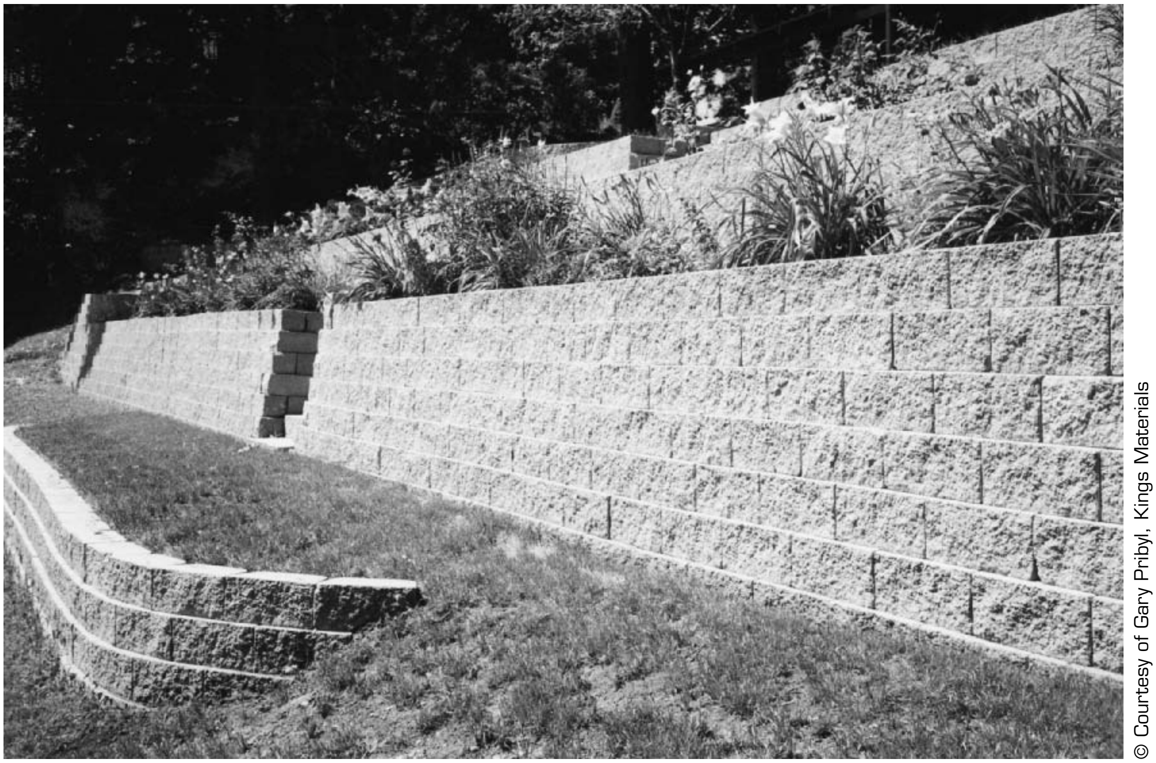

Figure 16-17 Terracing of precast concrete retaining walls for stability.

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Figure 16-18 Lower wall of a terrace under construction while excavation for the next higher wall of the terrace is underway.

the wall and constructing the next higher wall (Figure 16-18). The grade between the walls should slope forward with a fall of 6–12 inches. Spacing between the walls depends on whether the area leveled to create the second wall is above a slope. Generally, the spacing between the walls should be no less than twice the height of the taller wall. If the wall is built on fill or has heavy traffic above, consult a design professional to determine the proper method for stabilization.

ENDING WALLS

Ending retaining walls without an abrupt stop requires some method of transitioning the grade. Methods used range from tapering the grade in front of a wall to stair-stepping the top of the wall to meet the grade (Figure 16-19). Choosing the best method depends on whether the grade behind the wall is falling or moving upward behind the wall.

Tapering Grade

The easiest method for transitioning grade is to construct the retaining wall, backfill behind it, and slope the grade from the higher elevation to the lower elevation in front of the wall at each end. Select the

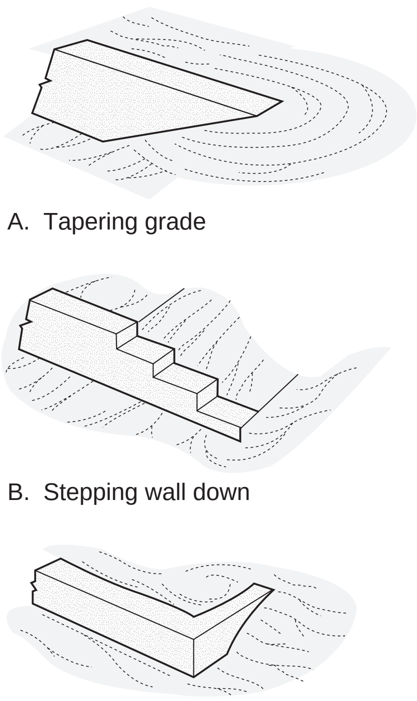

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Figure 16-19 Ending retaining walls. A. Tapering grade. B. Stepping the top of a retaining wall down. C. Return walls.

steepest slope possible that will allow maintenance and minimize erosion. For a wall 4 feet in height, use 10 feet of horizontal distance in front of the wall to bring the grade down is common. Place fill carefully so that the wall is not disturbed. Taper the slope in front of the wall to accommodate grade change.

Stepping Wall Down

When the grade behind the wall is dropping, the transition to ending the wall can be accomplished by gradually stepping the top of the wall down. Execute this transition by ending the top course and extending lower courses a few units beyond that ending point. Continue stepping down until the wall matches grade or can be ended in an existing grade.

Building Return Walls

If grade cannot be used for a transition, then construct a small section of perpendicular wall. This **return wall** should carry the full height of the wall until it can be stepped down or ended in an existing grade.

PREVENTION OF EXCESS RUNOFF

When a wall is constructed near the base of a slope or near a paved area, the potential for excessive runoff passing over the wall can be a problem. To reduce the potential for wall failure from this runoff, grade a shallow swale above the top of the wall that runs the entire length of the wall (Figure 16-20). This swale should empty water out at a storm sewer inlet or carry the water around to the wall's front side. An alternative to a drainage swale for paved areas is to install a curb that directs water to a location away from the wall.

CONSTRUCTION OF NONSTRUCTURAL RETAINING WALLS

If it retains soil, almost any material can be considered for a retaining wall. However, materials that make the best walls are products that have the ability to stay upright and to support structural loads. If properly constructed, precast concrete, timbers and ties, segmental unit, dry-laid stone, and gabion walls will support calculated loads. When selecting materials for a wall that must support soil in critical situations, limit the choices to those noted above. If a short wall need not support a structural load, then you can use alternative materials to save time and money. Described below are the construction techniques associated with several types of nonstructural retaining walls for those purposes.

Recycled Concrete Installation

To install recycled concrete, use the steps for placing, leveling, and backfilling described previously

CAUTION

Wall construction techniques listed in this section should be limited to walls under 3 feet in height and without a structural load above or below the wall. An engineer should design wall heights beyond this height. Technologies for building the walls in this section are fluid; and before constructing one of these walls, search to see if new techniques have been developed.

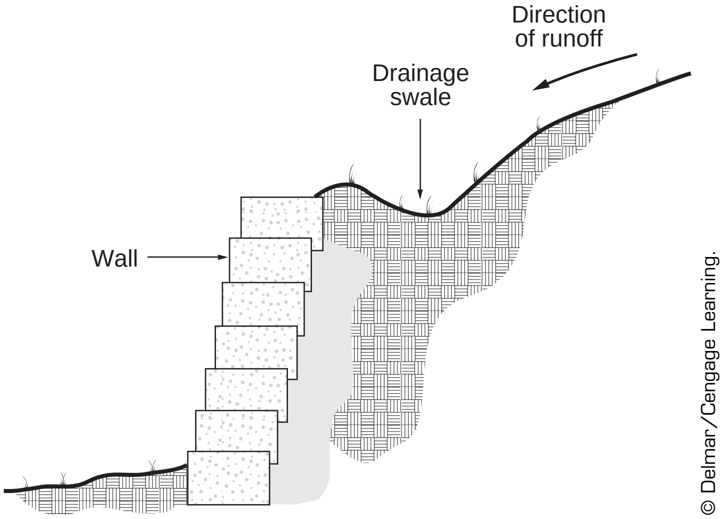

Figure 16-20 Drainage trench at top of retaining wall to intercept runoff before it can run over top and face of wall.

for dry-laid stone. One variation in the process would be sorting the material before placement because of its irregular shape. Find the larger pieces to use for the lower courses of a wall; and for each piece, orient the flattest edge toward the front of the wall. Even with careful sorting, you will find it difficult to obtain perfection in material placement. In addition to the irregular horizontal dimensions, recycled concrete may also have inconsistent thickness. This characteristic will require shimming with pieces of stone or crushed rock to achieve stability. As with all walls, proper base and behind-the-wall drainage should be provided (Figure 16-21).

Cellular Confinement Wall Installation

If a wall that can support plant growth is required, cellular confinement material (see Chapter 13, Erosion Control) can be placed in horizontal layers to create an installation. The structural stability of this material requires continued research; so, this technique is only recommended for walls under 3 feet in height and without a structural load. To create a planted wall, cut a piece of confinement material that is the length of the wall with an expanded width that is at least two times the height of the wall. Steeper batters can be used, but stability will be reduced. Sizing the cut sections for a 1-foot batter with a minimum of a 1-foot wide top course provides the best stability and area for planting. Cellular materials will vary, but most will create 6-inch high wall courses after installation.

Stretch the confinement material out on a granular base and, using sod staples, anchor at the front and back edge. Fill all but the front two rows of cells with granular material. Fill the front two rows of cells with planting soil. Cut a second length of confinement material two cells, or 1 foot, narrower than the base layer. Stretch out over the base layer and anchor the front and back edges. Repeat the filling process used for the base layer, placing planting soil in the front two rows of cells and granular base in the remaining rows (Figure 16-22). Repeat laying horizontal layers of cellular material until the top course is set. Fill all cells of the top course with planting soil. Plants can be installed in voids filled with soil, eventually providing a cascade of green rather than a visually harsh wall material. Planting will be limited to ground covers, perennials, and vines because of the small planting pockets between cells.

Loose Stone Wall Installation

Using a simplified version of "piling up stone," you can use rounded and irregular shaped natural stone to create retaining walls of limited height. Unlike dry-laid stone with flat surfaces and more precise dimensions, irregularly shaped stone will require a shallower batter and a wider base to maintain stability while also retaining soil. For rounded and irregular stone, retaining wall heights should not exceed 3 feet, and stones should be a minimum dimension of 8 inches. The stability of these techniques relies on stone that is large and heavy enough to stay as placed, but they should not be used in critical situations or to protect valuable site elements. Occasional stones may break

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Figure 16-21 Recycled concrete used for short retaining wall.

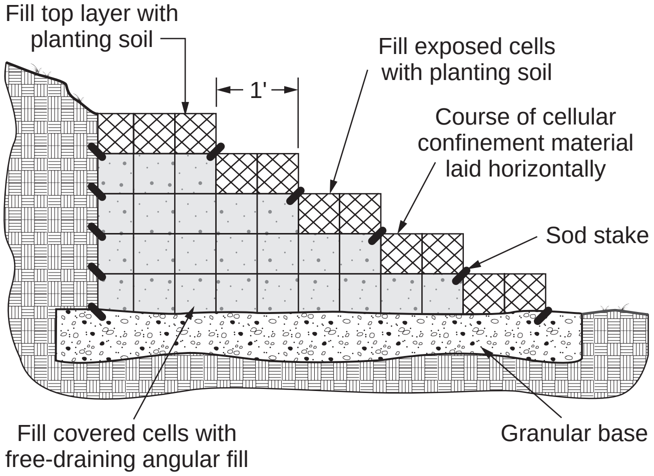

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Figure 16-22 Cellular confinement wall installation.

loose from the wall's surface and roll down the face into whatever improvements are placed below the wall. One significant benefit to this type of wall construction is that skill requirements are minimal. Because irregular stone cannot be fitted without a great deal of manipulation, contractors often use endloaders or skid-steers to place material.

To construct a retaining wall using irregular stone, excavate a base pad that is 1-foot deep and one and one-half times as wide as the wall's height. Place 6 inches of angular base rock into the base pad and compact using a vibratory plate compactor. Using a wheelbarrow, skid-steer, or endloader, place an initial layer of stone on top of the base pad. Spread the stone until it covers the entire base pad. The bottom layer should be partially buried along the front of the wall. Add a second layer of stone over the base layer, placing or dropping the stone near the center of the first layer. Let the stone settle to its natural angle of repose. Add additional loads of material to the top of the wall until the settled height is the desired height of the wall (Figure 16-23).

If the desired height cannot be attained without stone spreading beyond the base pad, widen the base pad. The wall's depth can be shortened if the contractor takes the additional time to hand stack the stone, rather than freely piling the stone and letting it fall to its natural angle of repose. If hand stacked, the stone should be fit together tightly. If the desired height is attained and the stone has not "spread" to the front of the base pad, remove excess stone for use elsewhere. Fill this void in the base pad with compacted soil. Although optional, drainage tile can be placed at the base of the wall on the uphill side at this time. Place a layer of filter fabric over the backside of the wall to reduce the migration of soil into the voids in the wall. Backfill the backside of the wall with soil and compact.

By hand or using small tools such as a brick set, check the stability of stone on the wall's surface. Remove any stones that are loose or could fall if disturbed by nearby soil vibrations. If aesthetics is not an issue, anchor a layer of hardware cloth at the bottom of the wall, place it over the face of the wall, and anchor it again at the top of the wall to reduce the hazard of loose material falling from the wall face.

Recycled Tire Retaining Walls

Using old tires is a retaining wall solution that assists in recycling society's waste. Issues regarding this construction material still remain. The chemicals in tires, rigorously testing the structural stability of tire walls, recommended construction techniques, and the legality of such walls are among the issues in several jurisdictions. Because of structural issues, retaining walls of recycled tires should be limited in height to 3 feet and should not be used in any situation where they support a structural load above or below the wall. The aesthetics of recycled tire walls is an additional issue, but this can be mitigated by planting vine-like ground covers in the soil-filled voids of the tires. Because of the potential of cadmium leakage, food crops should not be planted in tire retaining walls.

To create a short retaining wall of old tires, begin by sorting materials so that tires used in construction are of a similar tread width and diameter on each course. Removing the upper sidewall will make filling easier, but an alternative to the connection method described below will need to be found. Create a stable and level base for placement of the first course. As with other walls, burying the base

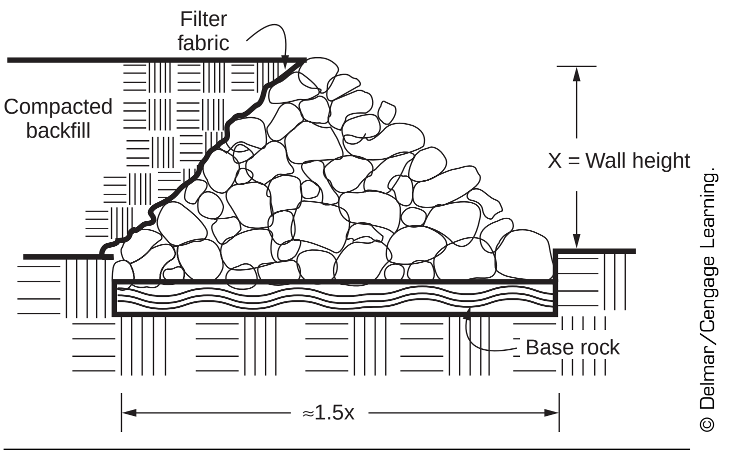

Figure 16-23 Cross section of loose fit retaining wall with irregular shaped natural stones.

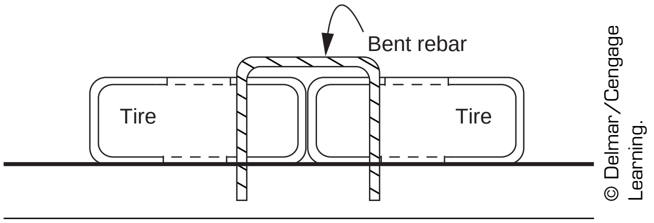

Figure 16-24 Bent rebar used to anchor tires. One method of securing retaining wall tires.

course will aid in stabilizing the wall. Place a row of tires along this base, making sure that the tires are level front to back and side to side. Each tire should abut the adjacent tire and be at the same level. Connect each new tire to the adjacent tire using a bent rebar tie (Figure 16-24). Fill the tires with earth and compact tightly (95% standard proctor density) using a tamper or sledge. At the center back of the tire, drive a 2-foot long #3 rebar into the ground flush with the tire. Backfill behind the base course and compact using a vibratory plate compactor.

For subsequent courses, batter the course back 50% of the tire diameter and stagger the tires in a running bond pattern (Figure 16-25A). Connect

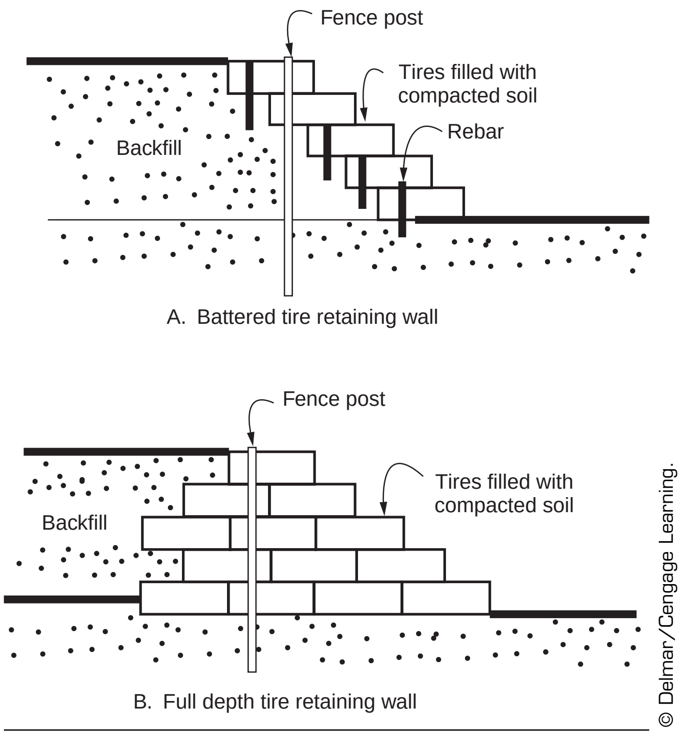

Figure 16-25 Cross sections of recycled tire retaining walls. A. Battered tire retaining wall. B. Full depth tire retaining wall.

adjacent tires and repeat the filling and staking operation. After you have obtained a height of 3 feet, drive a steel fencepost through all courses and into stable ground. Place the fenceposts every 5 feet along the length of the wall. An alternate method for obtaining stability is to create the base course and each subsequent courses of rows of tires that extend behind the back of the wall for the full depth of the wall (Figure 16-25B).

Concrete Bag Retaining Walls

For locations where the wall's appearance is not critical but time and budget are, you can use stacked bags of concrete mix to create short retaining walls. Not for locations where there are structural issues, such walls can be used as heads for drainage outlets or for short space separators in natural gardens. For structural purposes, the maximum height for such walls should be approximately 3 feet.

To create a concrete bag retaining wall, excavate a trench 6 inches deep and 2-feet wide. Place 4 inches of angular base rock in this trench and compact using a vibratory plate compactor. Smaller bags (approximately 60 lbs.) that include a mix of cement, sand, and aggregate make the wall project stronger and the work faster. Begin the wall by placing bags of concrete at the wall's low point. Lay the bags snugly end to end along the entire length of the wall. Using a garden fork, poke several holes in the tops of each bag and soak the entire row of bags using a garden hose. Place a socked drainage tile at the back of this base course, and route it to an open discharge area.

Subsequent courses should be constructed by stacking concrete bags in a running bond pattern along the entire wall. Adjust the bags if necessary to obtain a tight fit. Repeat poking holes and soaking the bags every course. Backfill the void behind the wall with free-draining angular fill rock. Continue laying courses until you attain the top of the wall. To add strength to a concrete bag wall, you can drive a #3 rebar vertically through the bags every 2 feet along the length of the wall. The rebar should extend from top to bottom of the wall and 8 inches into the base and should be placed so that it avoids the joints between bags. Over time the concrete will harden and the bags will decompose, leaving a rounded stone-like appearance.

CHAPTER 17

TIMBER RETAINING WALLS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Install a vertical timber retaining wall.
- Install a timber retaining wall.
- Anchor a timber retaining wall.

Retaining walls made of wood have long been a standard in home landscaping. Such walls are versatile in performing functional duties and in adding a natural look to the landscape. A former standard for wall construction, railroad ties are now difficult to locate and many people now consider them a poor environmental choice. However, newer timber materials have been introduced that produce similar aesthetic effects. A more recent addition to the "timber" family is recycled plastic formed to simulate the size and look of wood timbers. Whichever material the homeowner or contractor chooses, proper installation should produce a wall that will serve the dual purpose of retaining hillsides and adding a natural feel to the landscape.

A variety of wall types are available for wood retaining walls, with the primary types being vertical placement, horizontally stacked timbers, or horizontally staggered timbers.

CAUTION

Many timber and tie walls are lasting fewer years than originally anticipated. Review the cautions in Chapter 28 regarding use, handling, and construction with treated woods. Do not construct planters that are used to grow food for consumption with treated lumbers.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials and Installation Techniques for Retaining Walls, Chapter 16
- Stairs, Chapter 21

PLANNING THE PROJECT

Additional preparations are required when using railroad ties as building material. Ties need to be separated according to thickness and trimmed to a consistent length. Matching the ties by thickness eases construction by allowing rows of a similar thickness. Layout of the wall location, including locating stairs, corners, and ending points, allows planning the project for minimal cutting.

VERTICAL POST OR TIMBER WALL CONSTRUCTION

For walls under 4 feet in height, timbers and even round posts can be placed vertically in a trench and reinforced to create a retaining wall (Figure 17-1). Contractors consider this method easier to construct than horizontally placed wall systems, but vertically placed timbers or posts lack stability over the long term.

Preparing the Site

Initial layout and rough trench excavation are similar to the methods described in Chapter 16. Rather than excavating a trench for base material, dig a trench 12-inches wide with a depth equal to the wall's height along the entire length of the alignment. A maximum trench depth of 4 feet and maximum wall height of 4 feet should be used for this installation technique. Placement of 4 inches of granular fill in the bottom of the trench is optional.

Figure 17-1 Timber retaining wall with all timbers buried vertically. Elevation of tops are staggered for interest.

Installing the Wall Material

Place the first segment of selected wall material into the trench. The wider trench should allow the vertical to be placed with a backward lean that will serve as the batter. Continue placing vertical segments, making sure each fits snugly against the previous segment. After installing several segments, verify that the batter is the same for all pieces; then partially backfill the trench in the front of the wall.

On the backside of the wall, anchor a treated 2 × 6 with galvanized lag screws to each vertical near the top of the timber. This 2 × 6 should be placed horizontally and connected to each of the vertical segments. When constructing curved walls, you can substitute a strip of rust-resistant metal for treated wood. Select a metal such as steel or aluminum edger and drill holes at each timber location. Connect with 4-inch lag screws as just described. As a vertical wall approaches an inside or outside corner, the batter will have to be reduced gradually until the corners are vertical. Corners may be secured using 16-inch galvanized angle brackets and lag screws on the backside of the wall (Figure 17-2).

Place drainage tile at grade level at the backside of the wall; then backfill the back and front sides of the wall. If the top of the wall is irregular, trim the tops of the wall material to the proper height. For decorative purposes, the tops can also be left with varied heights. For a more stable installation, consider backfilling the trench at the base of the timbers with concrete, rather than granular material or compacted soil. Anchoring a vertical wall is accomplished by the batter and burial of the base of the wall. Additional anchoring typically proves ineffective.

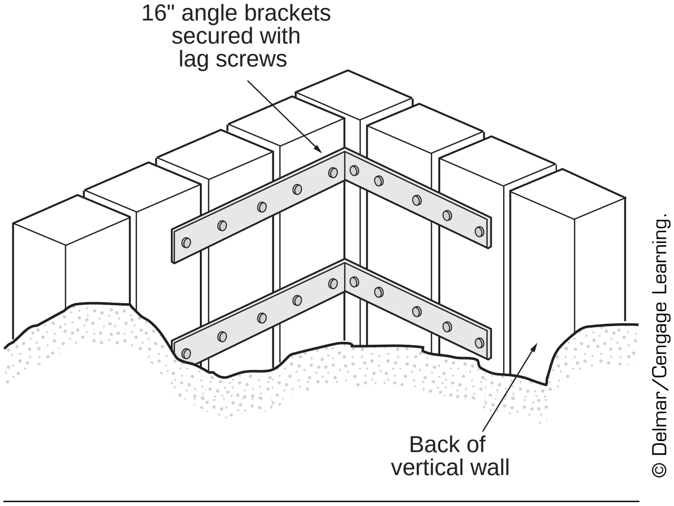

Figure 17-2 Corner connection on back of vertical timber wall.

Interlocking stairs cannot be constructed with vertical timber walls. If stairs are necessary, consult the **butt stair** installation instructions or consider pouring concrete stairs before the wall is built.

STACKED TIMBER WALL CONSTRUCTION

Stacked timber walls use the construction material placed in courses stacked directly on each other to form panels with a single vertical joint between each panel. Vertical timbers or buttresses are placed in front of this common joint, overlapping ties in each panel. Stacked walls are typically built using a tilted base course batter. This type of wall also requires trimming timbers to a consistent length.

Placing and Leveling the First Course

Installation of timbers begins with site preparation as described in Chapter 16. The first course of timbers is placed on the compacted base material in the trench. Place a timber in the trench and, using a carpenter's level, check the timber for level end to end, and for a half bubble batter toward the back of the wall. If the batter or level is not correct, lift the timber and remove or add base material as necessary. Level ties and timbers by placing small piles of granular base near each end of the timber. Once grade is established, you can gently force granular base material under the timber using a shovel. Recheck the timber and repeat until correct in both directions. If the project requires exact elevations for the bottom and top of the wall, use a survey instrument to verify elevations at this point. If the elevation is incorrect, add or remove base to adjust to the correct elevation.

Continue placing timbers the length of the first course, making sure that each timber has the same level and batter as the previous one. All timbers in the first course should be similarly placed. If you encounter a corner, trim a timber to the correct length (Figure 17-3). If an opening is placed in the wall for stairs or for other reasons, level across the opening to ensure that the wall is level on both sides of the opening. Place drainage tile behind the wall at this point and, if the tile does not outlet at the ends of the wall, leave an opening at the low point for the tile to pass through the wall (Figure 16-9).

Placing, Connecting, and Backfilling Subsequent Courses

Subsequent courses are stacked on top of the first course and backfill is placed behind the course (Figure 17-4). In instances where the lower course of the wall steps up, complete the lower course to

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Figure 17-3 First course installation for stacked timber wall.

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Figure 17-4 Placement of subsequent courses for timber wall.

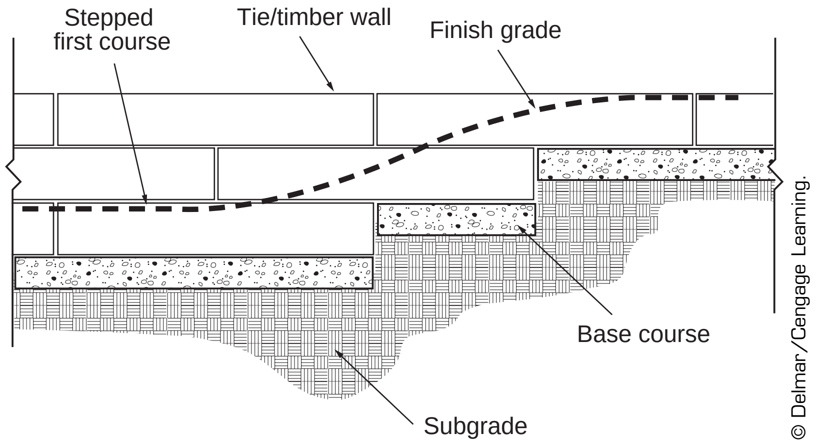


Figure 17-5 Stepping wall first course up a hill.

where the step occurs. Prepare the granular base for the upper course so that it is level with the top of the lower timber. Set a second course of timbers straddling this base and the lower course (Figure 17-5). Timbers are anchored to the course below by drilling three, ⅜-inch pilot holes through the top timber and driving a 12-inch spike or 12-inch piece of #3 **rebar** through each hole. The three pilot holes should be located 12 inches in from each end and in the center of the timber. All holes should be centered between the front and back of the timber. Use a heavy-duty drill with a long bit to auger the holes and a sledge to drive the nails. Compact the backfill every course after you connect the courses.

When turning corners, trim the end of each tie to match the batter of the adjacent wall section. Corners of stacked walls require butting one panel against the adjacent panel. Wall panels butted together require vertical timbers on each side of the corner for stability (Figure 17-6).

Placing Vertical Timbers

Following completion of the second or third course, auger 1-foot diameter holes in the ground in front of the wall centered on the joints between timbers. The recommended depth for the holes is frost depth, but they should be at least two-thirds the wall's height. (Note that this will limit the wall's height to the length of the timber minus the amount buried.) Use caution not to disturb the courses when auguring the holes. When you have placed all courses of timbers, set the vertical ties in the holes and lean them back against the wall overlapping the joint. Backfill and tamp around the vertical. For a decorative effect, you may trim the tops of the verticals at an angle.

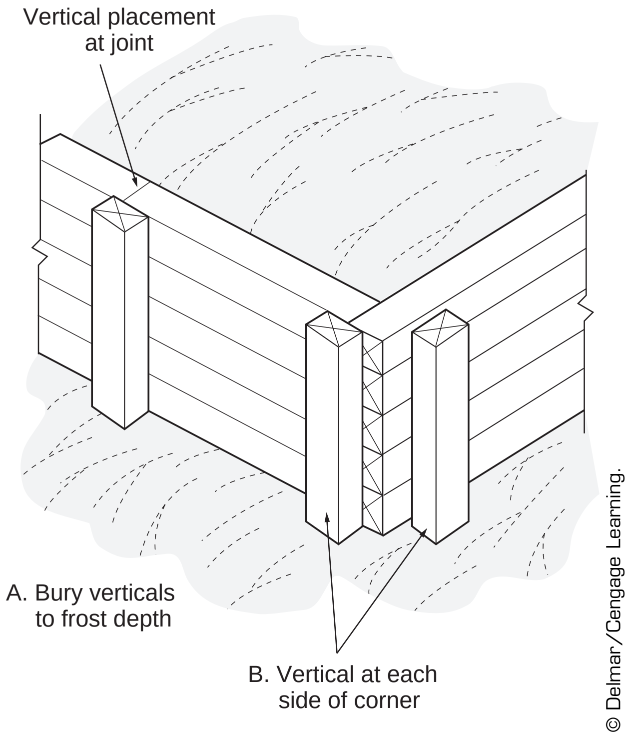


Figure 17-6 Vertical supports for stacked timber wall. A. Vertical support placement for stacked timber wall. B. Placement of vertical timber to reinforce corners.

STAGGERED TIMBER WALL CONSTRUCTION

Staggered timber walls differ from stacked walls in that the courses are staggered so that the vertical joints do not line up (Figure 17-7). Whereas stacked walls rely on batter and vertical members for anchoring, staggered walls can be built with a step-back batter and deadmen for anchoring. The step-back approach allows the corners of this wall system to be easily overlapped.

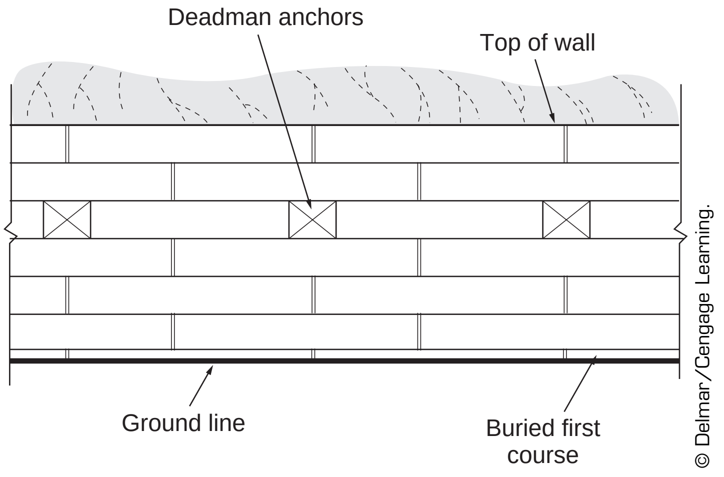


Figure 17-7 Staggered wall pattern for timber walls.

Placing and Leveling the First Course

Installation of timbers begins with preparation of the base trench as described in Chapter 16. Place the first course of timbers on the compacted base material placed in the trench. Place a timber at one end of the trench and, using a carpenter's level, check it for level end to end and front to back. If the level is not correct, lift the timber and remove or add base material as necessary. If the project requires exact elevations for the bottom and top of the wall, use a survey instrument to verify elevations at this point. If the elevation is incorrect, add or remove base to adjust to the correct elevation. Recheck the timber and repeat until correct in both directions. Continue placing timbers the length of the base course, making sure that the next timber is flush with the previous one and has the same level. If you encounter a corner, trim the timber to the correct length. Place drainage tile behind the wall at this point; and if the tile does not outlet at the ends of the wall, leave an opening at the low point for the tile to pass through the wall (Figure 16-9).

Placing, Connecting, and Backfilling Subsequent Courses

Subsequent courses are placed on top of the first course by centering the top tie over the joint between the two timbers below. Backfill is placed behind the course and compacted after each course. In instances where the wall steps up, complete the lower course of wall to the point where the step occurs. Prepare the granular base for the upper course so that it is level with the top of the lower timber. Set a second course of timbers straddling the base and the lower course. Do not interrupt the staggered pattern when the wall steps up. If necessary, trim a timber to maintain a consistent pattern.

Timbers are anchored to the course below by drilling four, ⅜-inch pilot holes through the top timber and driving a 12-inch spike or 12-inch piece of #3 rebar through each hole (Figures 17–8 and 17–9).

Figure 17-8 Drilling holes in timber with a cordless drill for 3/8" × 10" spikes.

Figure 17-9 Driving spikes in timber with a 2-lb. sledge.

The pilot holes should be located 12 inches from each end and 36 inches from each end (Figure 17-10). All holes should be centered between the front and back of the timber. Use a heavy-duty drill with a long bit to auger the holes and a sledge to drive the nails. Compact the backfill every course after you connect the courses.

When you encounter a corner in a staggered wall, overlap each new course over the previous course (Figure 17-11). Drill a pilot hole in the center of the overlap area and drive a 12-inch nail or rebar through the pilot hole.

Installing Deadmen

Deadmen should be installed every fourth course of a timber wall. Measuring from the end of the wall, install the deadmen every 8 feet (Figure 17-12). To install a deadman, cut an opening in the appropriate course of the wall equal to the width of the deadman. In this opening, set the end of a timber running perpendicular to the face of the wall. The length of the deadman should extend back into the hill between 4 feet and 8 feet. If you encounter an obstacle behind the wall, you will need to trim the deadman. Excavating a trench for placing the deadman is also sometimes necessary. At the hill end of the deadman, place a 3-foot timber cross-piece parallel to the face of the wall and under

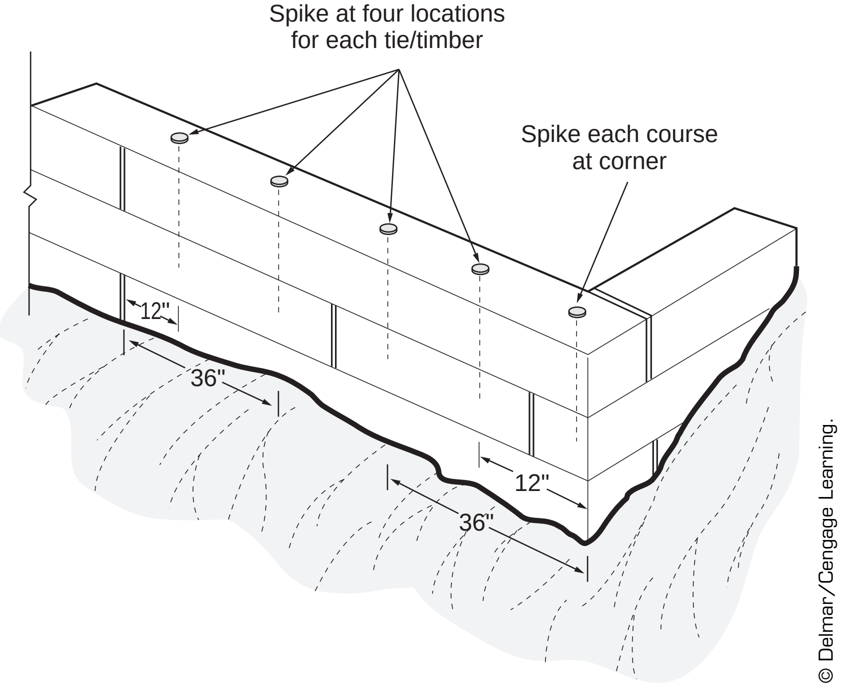


Figure 17-10 Spiking pattern for staggered timber walls.

Figure 17-11 Interlocked square corners with a stacked timber wall.

the deadman. Connect the deadman to both the wall and crosspiece by drilling a ⅜-inch pilot hole and driving a 12-inch nail through the pilot hole into the timber below. When you place the subsequent course over the deadman, fasten that timber to the deadman using a 12-inch spike through a pilot hole.

Instead of using timber deadmen, you can use the drilled cable deadman system noted in Chapter 16. This system requires less work than that required for the wood deadmen, but it leaves a visible metal plate or connector on the wall face. Anchoring a vertical wall is best accomplished using a drilled deadman placed every 6 feet horizontally. Deadmen should be placed two-thirds up the wall's height. Threaded bars or flanged wall anchors make acceptable deadmen. Drill a 1-inch diameter hole through the wall and slide a bar or cable through the hole. Anchor the bar or cable in the hillside and to the wall with 12-inch diameter plates threaded into both ends of the bar. Manufactured flanges can be used to anchor the bar into the hill.

Because it is difficult to anchor to wood materials, geogrid has limited uses in timber wall applications. Some attempts have been made to drive nails through the bonded strands to anchor the geogrid or to place the grid forward far enough so it will catch on the spikes holding the timbers. However, effective results with geogrid depend on the application.

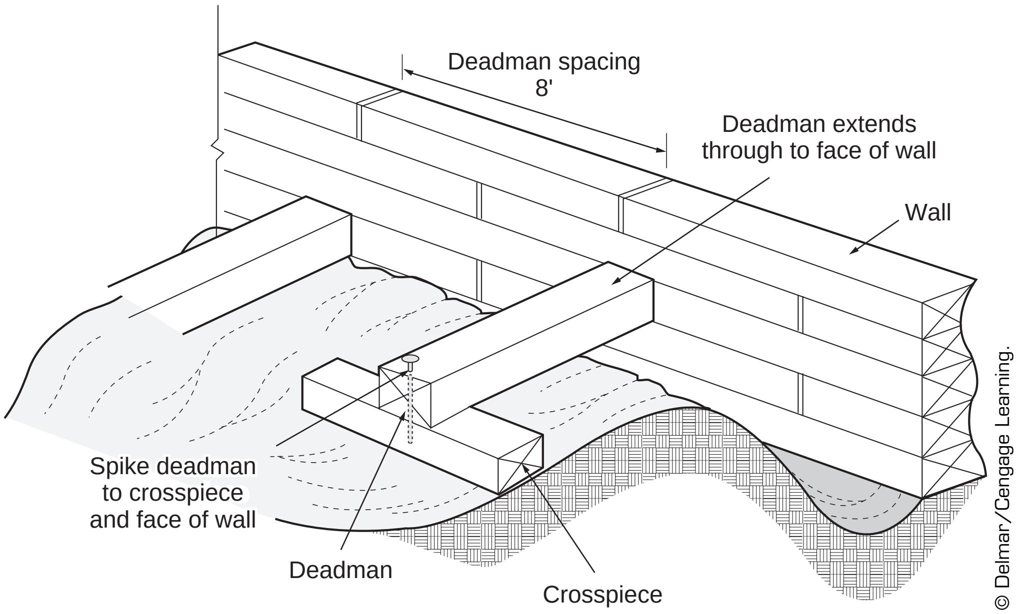


Figure 17-12 Rear view of deadman location and installation for timber walls.

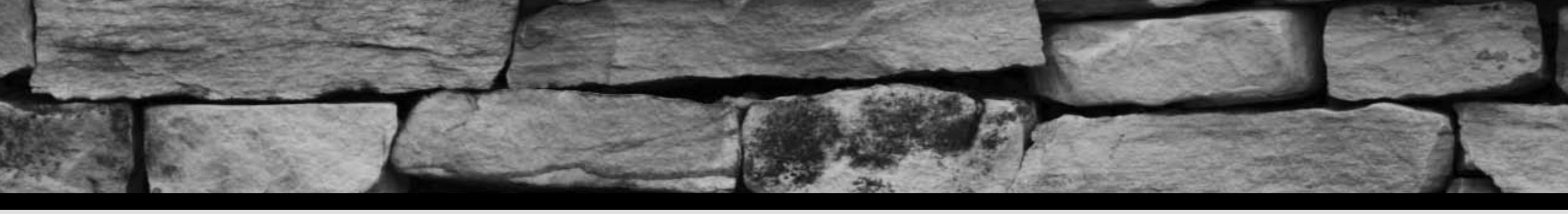
RECYCLED PLASTIC LANDSCAPE TIMBERS

Recycled plastic landscape timbers can be used as a nonstructural alternative to wood timbers for retaining walls and planters. Most plastic timbers are made of 100% recycled plastic and typically come in 8-foot by 5½-inch or 6-inch square dimensions. Because no preservatives are used in their manufacture and because they do not decompose, the timbers provide a long-term alternative to treated wood products. Most plastic timbers are treated for UV resistance to deter decomposition as a result of sunlight. Several product forms are on the market, but those considered typical replacement for wood are limited in color choices to earth tones and black, with additional cost for custom colors. Among recycled timber manufacturers, you will find those that add interlocking edges, predrilled holes for rebar fasteners, fitted and stackable ends, and a variety of surface textures intended to mimic wood or stone. Certain products can also be painted.

Construction techniques to install recycled plastic timbers, including base preparation, anchoring, and placement, should be the same as with wood timbers. Timbers can be cut using circular, reciprocating, or cutoff saws. Drilling should be done using a heavy-duty drill with an auger drill bit. Because this product is made of recycled content, safety equipment should be worn when working with the materials. Limited data are available regarding the strength properties of recycled plastic timbers. However, for nonstructural applications and low walls, the product seems to have performed well.

CONSTRUCTION OF STAIRS WITH TIMBER WALLS

Selection of a stair construction method is based on the type of wall constructed. Stacked and vertical wall construction methods require solid cheek walls, which will not accommodate the overlap of wall material necessary for interlocking stairs. Hence, only the butt stair method may be used for those wall types. Staggered timber walls can accommodate either interlocking stairs or butt stairs. See Chapter 21 for directions on installing butt and interlocking stairs.



CHAPTER 18

SEGMENTAL PRECAST UNIT RETAINING WALLS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Build a segmental precast unit retaining wall.
- Anchor a segmental precast unit retaining wall.

Use of segmental precast unit walls has increased dramatically in the landscape construction industry. Experimentation with concrete wall blocks has grown into an industry standard for construction of attractive, stable wall systems. Precast concrete units are one of the few wall materials that can be engineered for placement in vertical installations. In addition to the product's stability, its variety of surfaces and colors has enhanced the aesthetic qualities of the wall material. This chapter presents the installation of segmental wall units that use pins, lips, and anchors as stabilizing and battering systems.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials and Installation Techniques for Retaining Walls, Chapter 16
- Stairs, Chapter 21

PINNED AND LIPPED SEGMENTAL WALL CONSTRUCTION

Pinned wall units rely on metal or fiberglass pins to tie one course of segmental units to the next. Pins provide a strong connection between courses that will not slip or be dislodged by pressures behind the wall. Pins also provide a strong connection between the wall and geogrid anchoring. Lipped wall units rely on a thickened segment on the bottom or top of the block to position the subsequent courses behind units on lower courses. Although lipped units are faster to place, they do not provide as strong a connection between courses. Both solid- and hollow-core lipped units also provide a weaker connection to geogrid anchoring (Figure 18-1).

Most manufacturers recommend a level placement of segmental wall units because a setback batter is designed into the systems. In many pinned wall systems, the pins provide a means of automatically determining the setback from one course to the next. In most lipped units, the lip creates an automatic setback from the lower course. A few manufacturers may recommend that the blocks be tilted backward to create a batter for the wall. Review the literature provided by a wall material supplier to determine what method is recommended for installation.

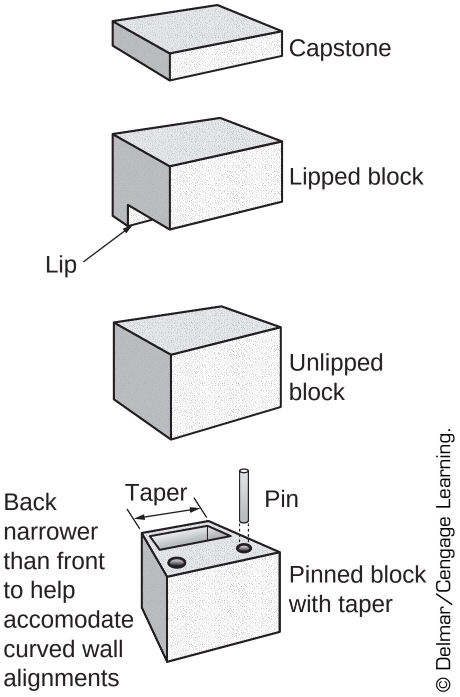


Figure 18-1 Common segmental unit types.

Figure 18-2 Leveling and placing first units for precast concrete wall.

Placing and Leveling the First Course

Chapter 16 provides important information about the preparation of the base for unit placement. As with all walls, first course installation should begin at the wall's lowest point. To minimize cutting, measure the distance between the beginning point and corners or ending points to allow for slight adjustment of the unit placement. Once you have compacted and leveled the base, set the first block. Verify which side of the block is the top side. For pinned units, the top side should have openings for placing pins, and the bottom should have openings to receive pins. For units with the lip on the bottom units, the bottom has a thickened ridge of concrete. Using a hammer, break off this lip for all blocks used on the base course. For some block types, instead of knocking off the lip, you can turn the bottom course upside down and backward for the base only. This will place the lip up and at the front of the base course. For units with the lip on the top of the block (typically on top in the front), the unit's bottom is smooth and requires no special preparation before installation.

One of the more difficult tasks in constructing walls is the setting and leveling of base stones. To speed the leveling process, place a ½–1-inch layer of fine granular material (select stone that passes a ⅜-inch sieve) over the compacted granular base. This layer provides a more workable material when making fine leveling adjustments. Place the block and check for level front to back and side to side with a carpenter's level (Figure 18-2).

If the block is not level, make minor changes by tapping it lightly with a rubber mallet. You may also make adjustments to level by tipping the block and using your fingertips to scratch away base material, if the block is high, or sprinkling handfuls of base material under the block, if it is low. These methods allow minor height adjustments and create less disturbance than striking the block with a rubber mallet. You can also adjust units by twisting the block. Major adjustments require lifting the block and adding or removing base material as required.

After setting the first block, place the second block next to it and verify that the edges are in contact and the tops are flush. Check the second block for level in both directions and adjust as necessary. Use caution not to disturb adjacent blocks that you have already set, and verify that the edges of the blocks are still in contact with each other after adjustment. Repeat this process along the entire length of the wall first course, checking periodically using a level long enough to cover three blocks. It is imperative that the first course be flush and level because any irregularity will be compounded as you add later courses. Place any drain tile behind the first course, and cut or leave an opening for the tile through the wall if drain tile is not routed around the ends of the wall. Backfill and compact the void behind the wall with a free-draining angular material. If you are using a landscape fabric, install it at this time (see Chapter 16 for instructions.) Fill the openings of hollow-core blocks with the same material used for backfilling behind the wall. Place backfill and compact.

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Figure 18-3 Fiberglass pin placement in precast concrete wall.

Placing, Connecting, and Backfilling Subsequent Courses

After backfilling and filling cores, sweep any base material and debris from the tops of the blocks. Prior to placing further courses for pinned units, insert pins in the openings on the top of the base course blocks. Review manufacturer's instructions to determine into which holes the pins should be placed. Some block styles have pinhole locations that will create vertical walls, and others that will create a setback batter (Figures 18-3 and 18-4). Set pins along the entire length of the wall. Lipped units do not require pinning. Place blocks for subsequent courses straddling the joint between the two lower blocks, with half on one block and half on the other.

For units with the lip on the back, set the upper unit on a unit below with the lip positioned behind the lower unit. Slide the upper unit forward until its lip contacts the back of the lower unit (Figure 18-5). For units with the lip on the front, set the upper unit on a unit below behind the lip on the lower unit. Slide the upper unit forward until its lip contacts the

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Figure 18-4 Unit placement for precast segmental pinned units.

Figure 18-5 Placement for precast segmental unit with lip located at the back of the unit.

Figure 18-6 Placement for precast segmental unit with lip located at the front of the unit.

back of the lower unit (Figure 18-6). Continue placing blocks until you have set the entire course (Figure 18-7). Backfill behind the wall and compact; then repeat for each course until you reach the top of the wall (Figure 18-8). If geogrid is required, place it between courses.

In locations where the base of the wall must step up, fill the void beyond the end of the last block with base material and compact. This base will continue under all blocks on the upper courses, similar to the base below the lower course. Level the base flush with the top of the lower course, and place a pin in the last block (for pinned units) on the lower course. Place a block straddling on the lower block (over the pin) and the base for the upper course. Check for level and adjust if necessary.

Different types of corners require different treatments. **Concave**, or inside, curved **corners** can typically be built by keeping the front edges of the blocks in contact and fanning out the back of the units. **Convex**, or outside, curved **corners** will also require that the block edges be in contact but may require trimming of back portions of units with a cutoff or wet masonry saw to fit the required curve (Figure 18-9). Units with the lip on the bottom side may require removal of a portion of the

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Figure 18-7 Back of a wall built with lipped units showing lips protruding behind wall.

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Figure 18-8 Section of segmental precast concrete wall showing backfill and drain tile.

lip to accommodate a tight radius. On long curvatures, you may need to cut a block to maintain the running bond pattern for a course (Figure 18-10). Most manufacturers have technical publications that indicate the minimum curve at which radii can be built without serious modification of blocks. Expect major cutting with radii smaller than 5 feet.

Inside and outside angled corners can be difficult to construct with segmental wall units. To construct outside angled corners, begin by laying the base course so that two full units meet at the corner. If full units are not at the corner, trim an amount from units that are one or two units back from the corner so that full units are at the corner. From the two corner units, trim half of the corner angle from each block (e.g., for a 90° corner, trim 45° from each block). Set the second course using the running bond pattern with the desired batter (Figure 18-11). From the two corner units on the second course, trim half the corner angle from each block. Because the batter makes these units smaller than those in lower courses, use concrete adhesive to assist in securing them to the lower course. Continue the placement and trimming until the corner blocks are smaller than half a unit. At that point, repeat the process of trimming an amount from units that are one or two units back so that full units are again at

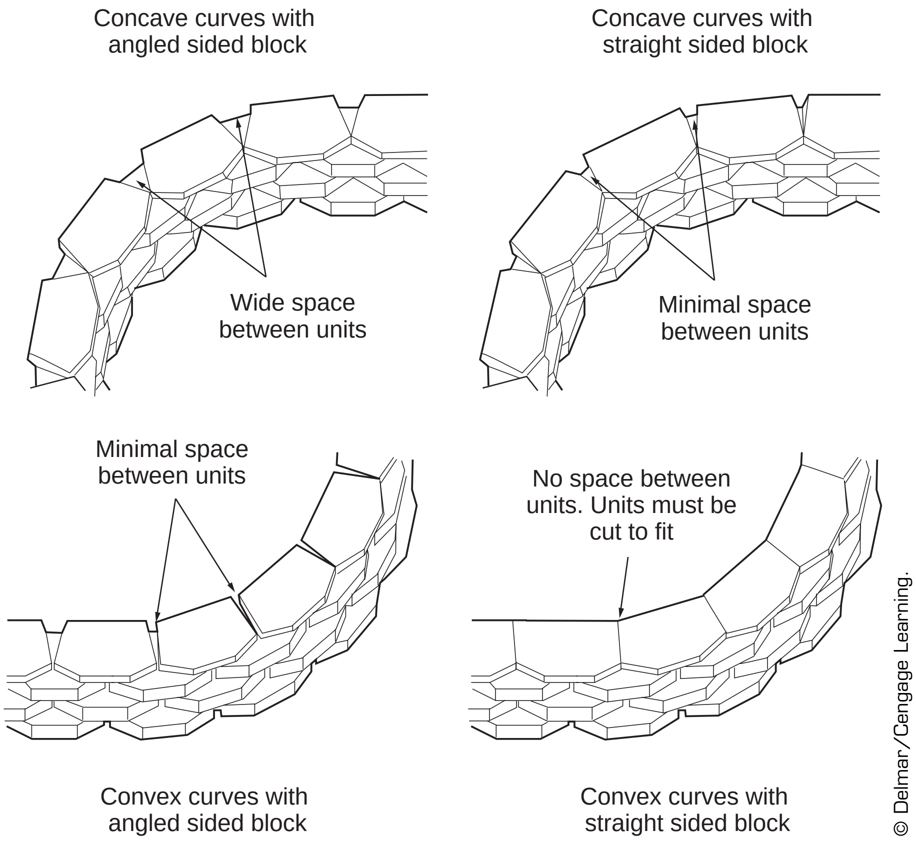

Figure 18-9 Rounded corner construction with segmental precast wall units.

Figure 18-10 Wall unit trimmed and placed on a curved section of wall to maintain running bond pattern.

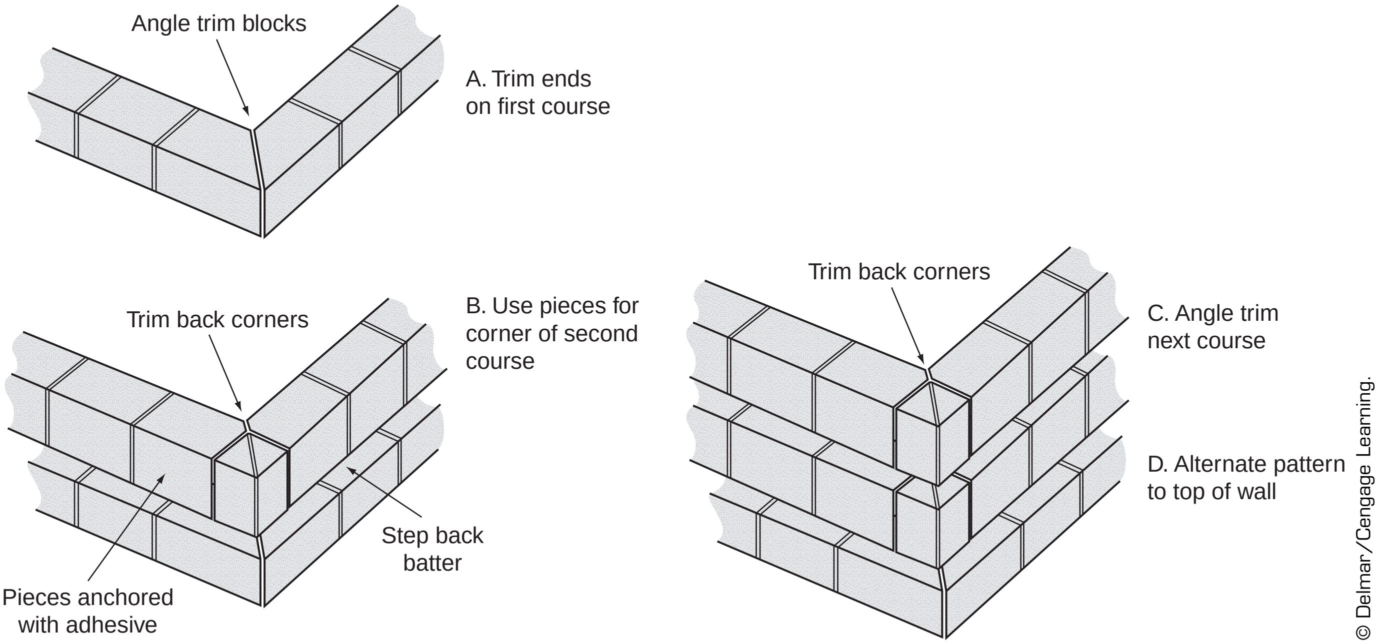

Figure 18-11 Outside angled corners with segmental units.

the corner. This process of trimming should continue until you reach the top of the wall. Trim the caps as required.

Inside angled corners are built by constructing base course on the left side (or whichever side you prefer) of the corner running past the right side. If necessary, trim the unit on the right side to fit flush with the left side. On the second course, reverse the order of which course runs past the other (Figure 18-12). If necessary, trim a unit so the courses fit flush (Figure 18-13). As you build the wall, continue the batter on each course. A support piece may be necessary if the passing course is not long enough to support the block placed in the next higher course. Trim the cap for the course that is passing to match the alignment of the back of the wall. Split solid units by hand, hydraulic block cutter, or cutoff saw with partial units placed in the wall. Hollow units can be split, but placement at a corner may expose the inside of the unit. Some manufacturers produce special corner units to address the exposure and trimming problems encountered at right-angle corners. If hollow cores must be exposed, mix mortar to match the wall color and fill the open cavity. Use concrete adhesive between courses at the corner, especially when partial units disrupt the normal placement of pins or interlocking lips.

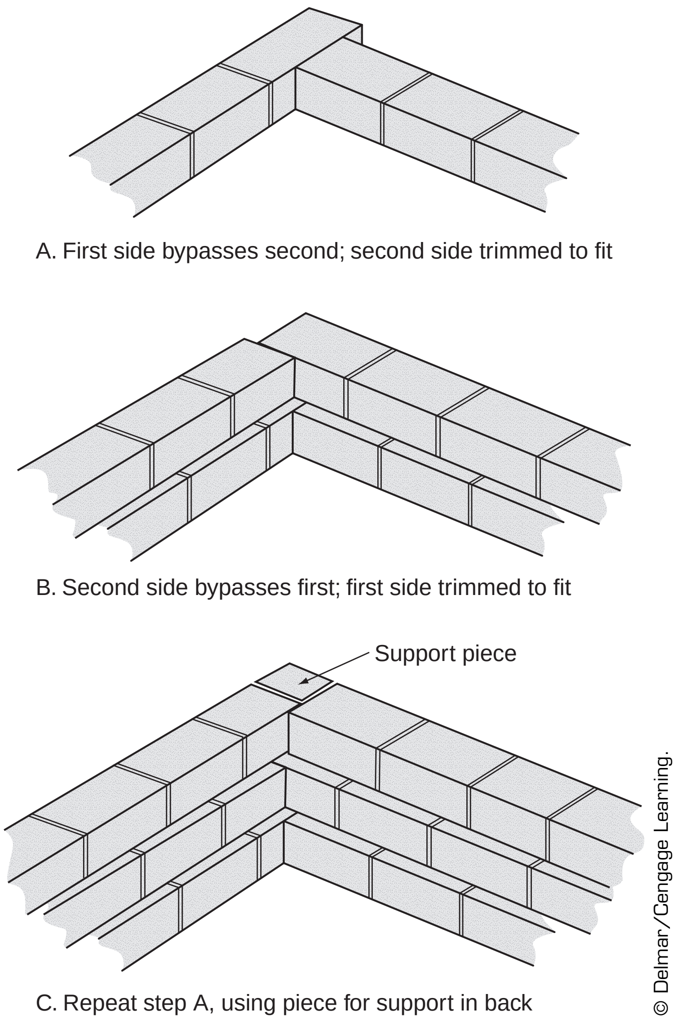

Figure 18-12 Inside angled corners with segmental units.

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Figure 18-13 Wall units trimmed to create an outside angled corner.

Placing Geogrid

Manufacturers or design professionals must calculate if a wall requires anchoring with geogrid fabric. These specifications should indicate the course in which the geogrid should be placed, as well as the width of the fabric behind the wall. If the wall is tall enough to require geogrid, you will need to place it between the appropriate courses before you can build the wall any higher. Because geogrid comes in rolls, you can easily cut it to the width required by using a knife or fine-toothed saw. The required orientation must be maintained for various types of geogrid to obtain the designed strength. The direction of the geogrid's bonded and loose strands determines its proper orientation. Bonded strands are load bearing and should be placed perpendicular to the wall face. Loose strands should run parallel to the wall face.

After compacting the backfill for the course below the geogrid, roll the geogrid out flat behind the wall along the entire length of the area to be reinforced. You may need to widen the backfill area to accommodate the geogrid's width. Slide the geogrid to within 2 inches of the front of the wall units. Pull the material back slightly if any will be exposed when you add later courses. For pinned units, place the pins for the next course so that they pass through one of the grids (Figure 18-14). Lipped units are set in place with the geogrid resting between courses. Unpinned walls rely on the weight of the wall material, plus friction between the geogrid and the aggregate fill in the unit cores, to hold the geogrid in place. Place the next course of blocks and then stretch the geogrid away from the wall to remove any slack. Backfill and compact over the geogrid.

Capping the Wall

Most segmental units require a cap to cover open voids and spaces between the block (Figure 18-15). All cap units should be installed with pins or adhesive. Clean the top of the wall and apply

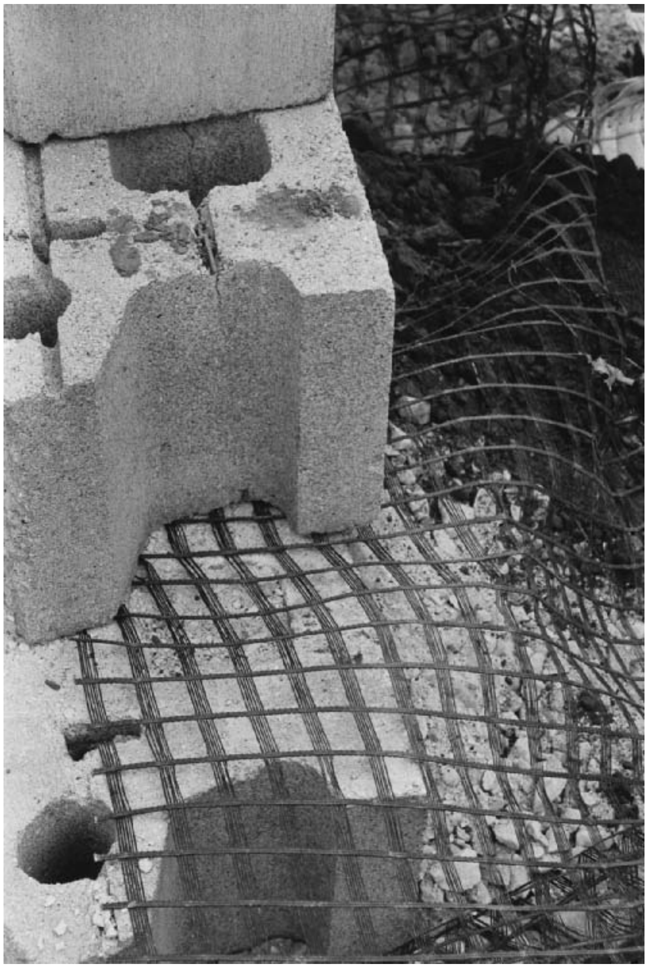


Figure 18-14 Geogrid placement between courses of precast wall units. Geogrid is oriented with the wide separated strands paralleling the wall face.

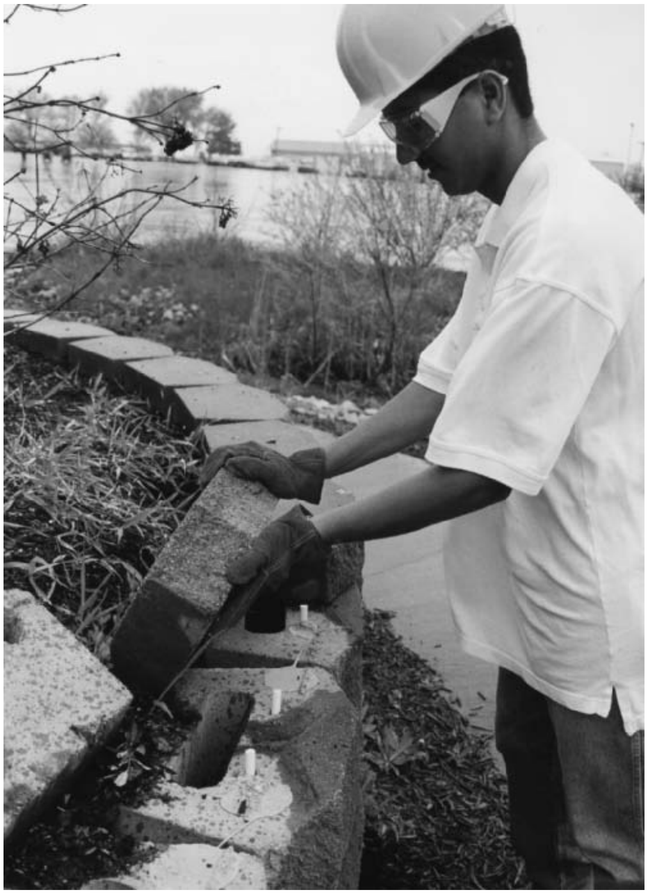


Figure 18-15 Cap installation for precast concrete unit walls.

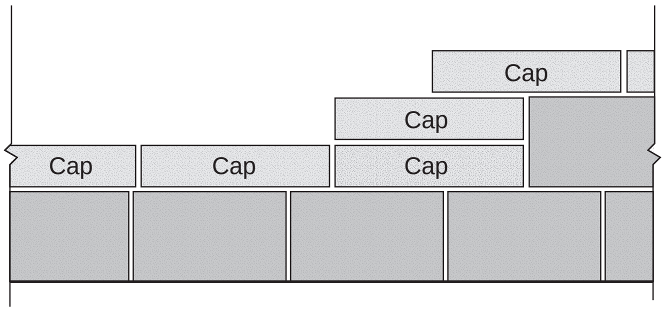


Figure 18-16 Using caps to transition a step in a wall. The caps hide any open cores or tapered backs.

adhesive generously prior to placing the caps. Pinned units require short pins to secure the cap. Push down on the cap after placement to ensure good contact with the adhesive. Some systems provide caps with angled ends that can be alternated for straight wall sections or placed with all angles facing in or out to cap curved walls. If a cap must be trimmed to accommodate an angle or curve in the wall, trim half the material from each side of the cap, rather than trimming all of the material from one side. Although this will require two cuts, trimming both sides will blend the cut with the wall angle.

To avoid exposing open cavities at the top of a wall that steps down, either cut a cap to fit the step or replace the unit on which the voids are exposed with two cap units stacked vertically (Figure 18-16). Bond the cut cap or stacked caps with adhesive.

Adhering and Bonding Precast Concrete Wall Materials

When wall capstones or corner units require bonding to maintain stability, thoroughly clean all surfaces to be bonded. Generously apply a flexible adhesive and place the two pieces together. Scrape any excess adhesive from the joint. Because it

maintains its flexibility, a one-part urethane sealer is better to use than subfloor or construction adhesives.

ANCHORED UNIT WALL CONSTRUCTION

In addition to pinned and lipped segmental wall systems, some manufacturers produce a wall unit that uses precast anchors connected to a face piece and protruding back into the hillside. These anchors are covered with backfill and provide stability for the wall. Although anchored units are lighter in weight, they require more labor to assemble. The thin face piece provides a thinner profile for the wall, and the reduced anchors for the top course make planting behind the wall easier. Geogrid is installed in the same manner with anchored walls as it is for pinned wall systems.

Installation of anchor units is similar to pinned units in most aspects, except that each face piece has two rectangular precast anchors that are connected to the front with metal U pins. These anchors protrude from the back of the face piece and form a *V* shape. Pin the anchors together with a third U pin, and fill and compact the cavity. Anchors for subsequent courses rest on the anchors for previous courses (Figure 18-17). As the wall approaches the top courses, the number of anchors is reduced. The top and second-from-the-top course have only one anchor per face piece. Pin a cap to the top course to provide a finished appearance.

© Courtesy of Lucy Hershberger, Forevergreen Landscaping

Figure 18-17 Anchored precast units showing anchors in place. Openings on tops of anchors are for U-shaped pins that hold anchors and face blocks together.

STRUCTURAL CELL WALLS

Placement of structural cell wall units is similar to placement of precast segmental units. A stable level base of base rock is prepared prior to installation, with the minimum dimensions established by the product manufacturer. Typically an 8-inch deep by 2-foot wide trench will be required. Place 4 inches of angular base rock in the trench and compact using a vibratory plate compactor. The wall's base course will be buried a minimum of 4 inches to improve wall stability. Any unit on the base course will require cutting the hooks off the lower back of the wall using a circular saw or reciprocating saw.

Begin placing the base course of units at the wall's lowest point. Place the first unit and level it front to back and side to side. Place the second unit and slide it against the first unit until the tabs on the side lock together. Level the second unit and continue this process for the entire base course. Place a drainage tile behind the wall and route the tile to a low point for discharge. Openings in the units for drainage or pipe outlets can be cut with a reciprocating saw. Fill the cells and an 8-inch zone behind the wall with free-draining angular stone and compact using a vibratory plate compactor. Units are designed for straight wall runs and for corners not exceeding the manufacturer's design criteria.

Subsequent courses are staggered in a running bond pattern on top of the lower courses, with each subsequent course interlocked into the course below. To place the upper courses, hold the units at an angle to lock the hooks in the back of the unit into the lower units; then lower the unit down and slide to the side to lock with an adjacent unit (Figure 18-18). After placing each course, fill and compact the cells and drainage zone behind the wall, and backfill the wall with soil and compact. If

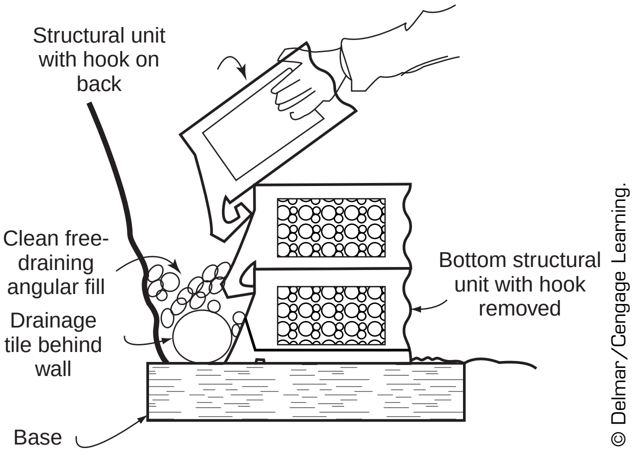


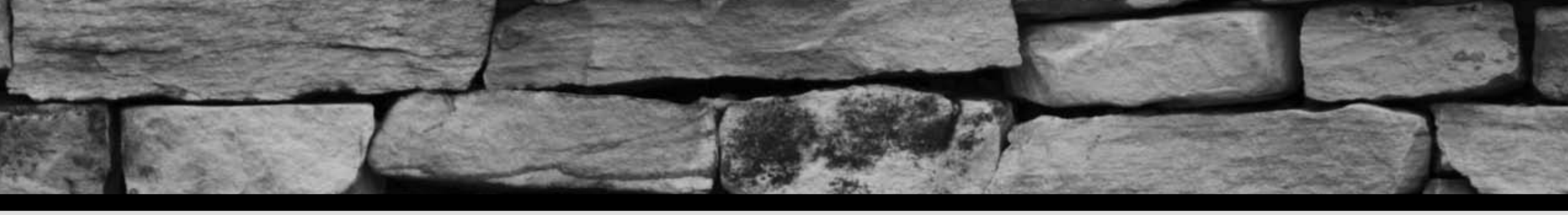
Figure 18-18 Installation of structural cell wall units.

the wall exceeds 3 feet in height, you will need to place geogrid reinforcement between courses. Adjust the geogrid to one side to avoid interfering with the locking mechanism at the rear of the unit.

When corners or wall abutments are required, cut the cellular unit to fit and fill with expanded polystyrene foam for structural strength. Premanufactured end units are available that can be locked in place by setting the panel in position and striking it with a rubber mallet. To complete the structural cell wall, install capstones that are available from the manufacturer. Apply construction adhesive to the top of the unit below the capstone, set the capstone in place, and slide it forward to lock in position. Secure the rear of the unit using screws that anchor the capstone to the unit below.

STAIR CONSTRUCTION WITH SEGMENTAL WALLS

Stair construction with segmental units is accomplished in a variety of ways. Most manufacturers have engineered a solution to the stair issue by designing special stair units, producing a combination of base unit and cap units, or using standard wall units for stair construction. Most stair solutions use the butt method of placing stairs between cheek walls, but some stairs interlock with cheek walls. Stair solutions with precast units typically work best when the stair width is a multiple of the units used to construct the stairs. This requires careful spacing between cheek walls to ensure that an even number of units will fit. See Chapter 21 for directions on installing butt and interlocking stairs.



CHAPTER 19

DRY-LAID STONE RETAINING WALLS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Build a dry-laid stone retaining wall.
- Build a dry-laid recycled concrete retaining wall.

Successful installation of a dry-laid stone wall is as much a skilled craft as it is a construction technique. In laying the varied types of stone available to them, landscape contractors must acquire patience and vision to arrange stone in structurally sound and attractive patterns. **Ashlar** refers to stone that has been cut, or cleaved, in modular lengths and widths with consistent thicknesses to aid in placement. An alternative to ashlar is **rubble,** a stone that has natural, untrimmed edges. Techniques for laying stone are discussed in this chapter, and Chapter 33 covers the construction of freestanding walls.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials and Installation Techniques for Retaining Walls, Chapter 16
- Stairs, Chapter 21

PLANNING THE PROJECT

Stability of dry-laid stone walls is a primary concern. Most stone used today is quarried and cut into widths of 4–8 inches. This narrow width limits the weight and surface area between courses, and these two factors help in countering forces that can push the wall forward. As a result, dry-laid stone walls sometimes need both leaning batter and setback batter to provide stability. Placement of geogrid is also difficult, and using verticals in front is both unattractive and impractical. Stone deadmen can be placed, but they are of limited value because they cannot be attached to the wall or to a crosspiece in the hillside. All these factors combine to limit the effective structural height of dry-laid stone walls without a design professional's engineering expertise.

Sorting stone prior to placement speeds the process and enhances the stability of the construction. Laying several pieces out so that length can be quickly observed allows for a fast sort and selection of stone. Preparation of the site and laying of the first course is similar to that of other wall materials, but the courses above the first one require a different approach.

Following are suggestions that add to the quality of a dry-laid stone wall:

- Use larger and longer stones for the base course and stairs for increased stability.
- Avoid vertical joints that run more than two courses. One of the strengths of dry-laid

Figure 19-1 Staggering of vertical joints in stone walls improves stability.

stone comes from the overlapping of joints (Figure 19-1).

- Maintain spacing between vertical joints that is at least as wide as the thickness of the stone.
- Interlock all corners when possible.
- Avoid using short or small pieces of stone near corners. Larger pieces space the joints farther apart and improve stability.
- Cut or match stone pieces a consistent thickness to eliminate one variable that makes laying a stone wall such a challenge. This practice allows the worker to concentrate on length and joint placement, not with matching both the thickness and length dimensions of the stones.

DRY-LAID STONE WALL CONSTRUCTION

The following paragraphs provide instructions on the best practices when laying a dry-laid stone wall.

Placing and Leveling the First Course

Prepare for installation using the instructions from Chapter 16. As with all walls, laying of the first course should begin at the wall's lowest point. Setting a stringline aids in keeping the front of the wall aligned (Figure 19-2). Once you have compacted and leveled the base, you can then set the first stone. Place the stone and check with a carpenter's level for level side to side and a slight batter toward the back of the wall. A quarter bubble is often used as a standard batter. An alternative to placing a leaning batter on a stone wall is to use a step-back batter similar to that used in precast units (Figure 19-3). Although stone is not a manufactured product with built-in safeguards, a step-back batter for walls under 2 feet tall should provide enough stability to reduce the potential for failure. You can also combine both batters for increased wall stability.

If stones are not setting correctly, make minor changes by tapping with a rubber mallet. A twisting

Figure 19-2 Dry-laid stone wall first course installations.

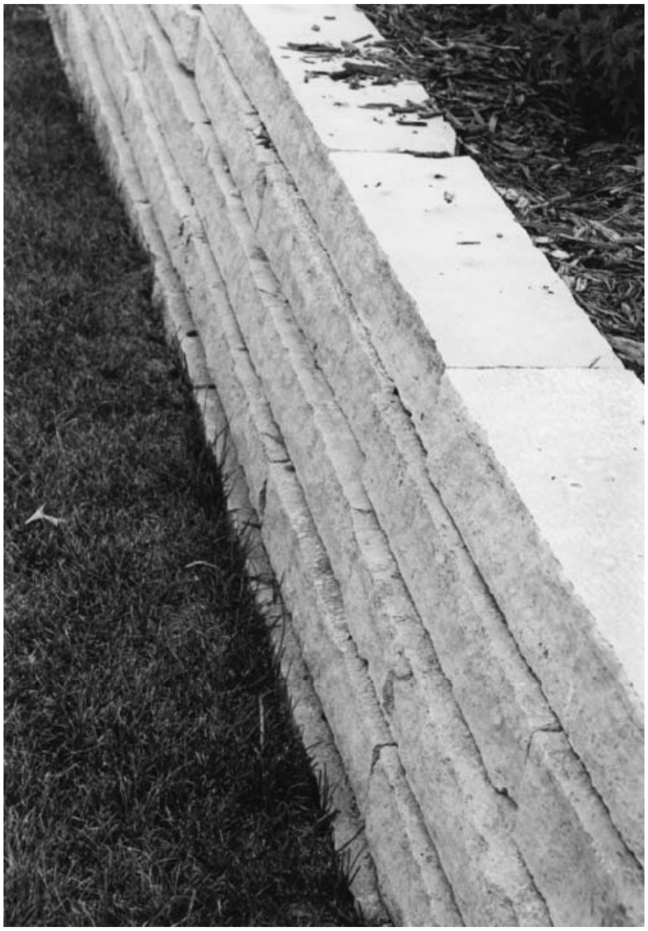


Figure 19-3 Dry-laid stone wall showing setback batter of 1 inch with each higher course.

motion will also adjust the level of stones. Major adjustments require lifting the stone and adding or removing base material as required. After setting the first stone, place the second block next to it and verify that the edges are in contact and the tops are flush. Check the second block for level and batter and adjust as necessary. Repeat this process along the entire length of the wall base. It is imperative that the base course stones be flush and consistently placed because any irregularity will be visible as later courses are added. Place drain tile behind the base course, and leave an opening for the tile through the wall if you do not route the drain tile around the ends of the wall. Backfill the void behind the wall with a free-draining angular material and compact.

Placing, Connecting, and Backfilling Subsequent Courses

Stones for subsequent courses should be placed so that the joints are staggered. Set one course at a time (Figure 19-4). Place backfill and compact.

Figure 19-4 Placement of dry-laid stone wall material.

Repeat for each course until you reach the top of the wall. If you use a setback batter, move the front of each subsequent course back 1 inch from the course below.

In locations where the base of the wall must step up, fill the void beyond the end of the last block with base material and compact. This base must extend under all blocks on upper courses in the same manner as the base below the lower course. Level the base material flush with the top of the lower course. Place a block straddling the lower block and the base for the upper course. Check for level and batter and adjust if necessary. Continue placing stones for the base along the wall alignment.

Square corners should be interlocked between courses (Figure 19-5). If you use leaning batter to lay the wall, butt, rather than overlap, square corners. Concave and convex corners are typically built using shorter stones and stones that have angled ends that can be turned over to create a tight-fitting radius (Figure 19-6). For concave corners, place the shorter face of the stone toward the front of the wall. For convex corners, place the longer face of the stone toward the front of the wall. Trim stone as necessary to maintain tight joints. Maintain batter around corners. Geogrid is of limited effectiveness on dry-laid stones walls. If you use wider or larger stones, you may place the geogrid between courses

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Figure 19-5 Dry-laid stone wall showing interlocking courses at corner.

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Figure 19-6 Rounded corners with dry-laid limestone walls. Shorter pieces are used to turn tighter corners. Stairs were in place before wall was built.

and anchor it into the hillside. However, if walls are laid with narrower or smaller stone, the surface area between courses is insufficient to securely anchor the grid.

The artistry of building a stone wall often comes from the pattern in which the stone is placed. It is possible to create dry-laid walls where each course is of a consistent thickness if stone of similar dimensions is available. Although this creates a stable wall, the visual interest may be lacking. To create a more aesthetically pleasing pattern with the surface of the wall, consider some of the following techniques for variation (Figure 19-7).

- Vary the thickness of the courses. Sort stone by thickness so you can insert a course that is thinner than the typical course being installed (A).
- Substitute two stones of a smaller thickness but similar length for a typical stone in the course (B).
- Occasionally insert a stone that may bridge two vertical courses (C).
- Occasionally place a collection of smaller stones in place of a typical stone on a course. The smaller stones should fill the space and may require a stone in the course above that bridges over all of the smaller stones (D).
- Insert occasional shims below the stone to raise it to a typical course height (E).
- Forego courses altogether. If your material allows you to structurally build walls without identifiable courses, begin with a bottom row of larger material; then work left to right building the wall to full height.

Utilize the full list of techniques described above. This will take longer and require you to verify the structural stability of each stone placed. The rules about avoiding long vertical and horizontal joints should be followed, with very few identifiable joints being visible when the wall is complete (F).

It is the artistic blend of solid forms and line, along with the added dimension of varying colors, that makes the difference between a wall that simply retains soil and a wall that is a work of art. Attractive

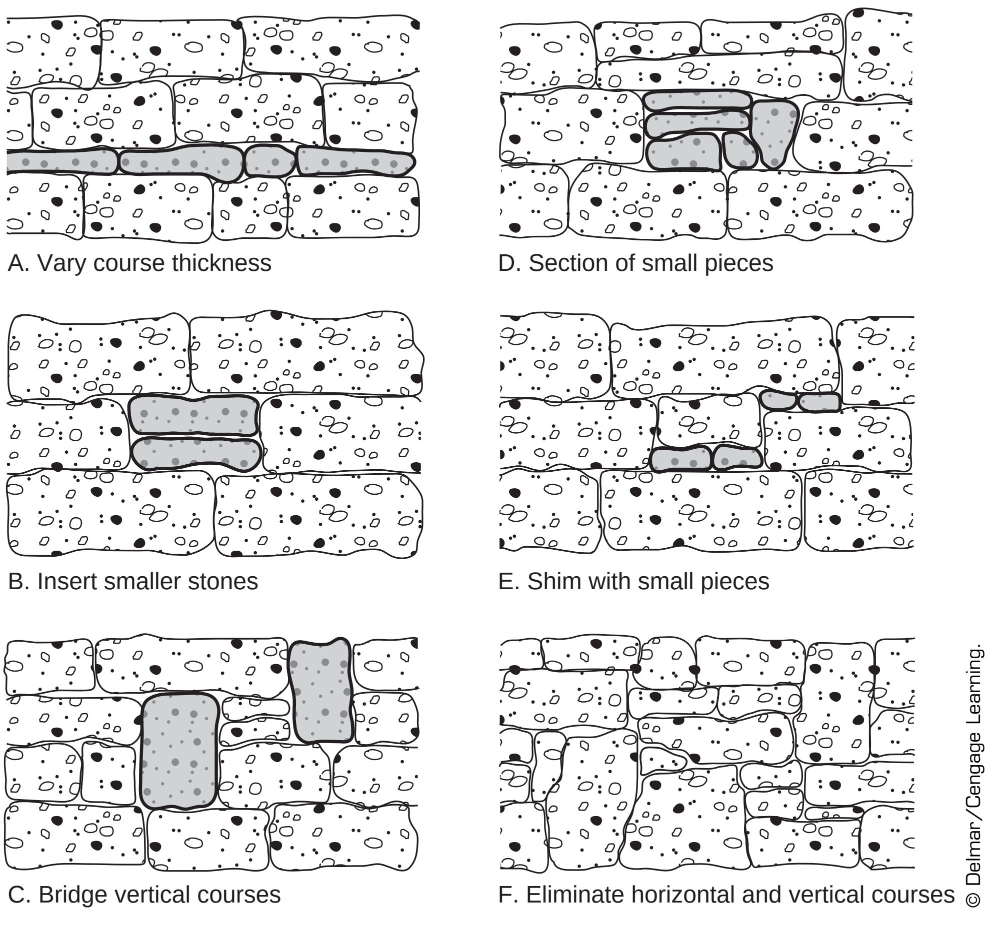


Figure 19-7 Stone pattern variations.

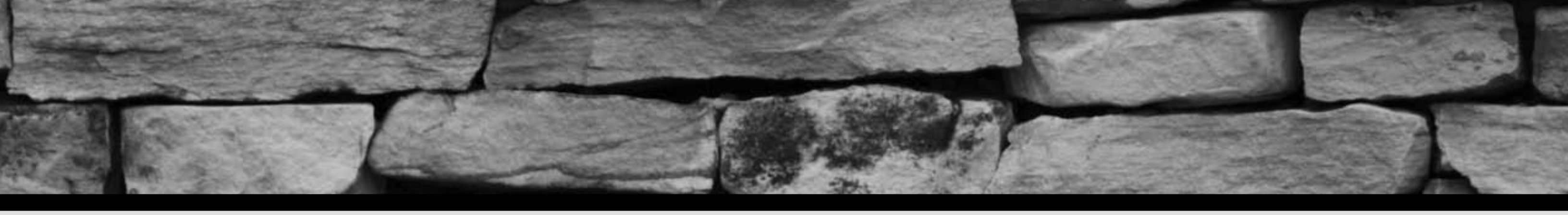
walls are built with a balance of large massive stones and smaller filler stones, all surrounded by a range of more consistent sized stones, that creates the framework. Attaining mastery of stone masonry as an art form requires both an understanding of form composition and extensive practice.

Anchoring Using a Top Course

To cap a dry-laid stone wall, an anchoring course may be installed. At the top of the wall, lay a course of block with the long dimension perpendicular to the wall face. Align an end of the stone with the front of the wall and extend the long dimension beyond the back of the wall.

STAIR CONSTRUCTION WITH DRY-LAID STONE WALLS

Stair construction with stone is accomplished by using precut stair pieces or by selecting wider stones that can be used for treads. Both butt stairs and interlocking stairs are suitable for stone. See Chapter 21 for directions on installing butt and interlocking stairs.



CHAPTER 20

GABION RETAINING WALLS

OBJECTIVE

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activity:

- Install gabions.

Gabions are an effective material for landscape walls when stability is paramount. Usually confined to large road and grading projects, the gabion is also ideal for addressing large-scale wall projects. With their wide base and heavy weight, gabions are quite stable and can be stacked three or four units high. The open nature of the material also makes hydrostatic pressure less of a problem when a wall is laid with gabions.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Materials and Installation Techniques for Retaining Walls, Chapter 16

PLANNING THE PROJECT

Preparation for gabion construction requires that the alignment be staked and the rough grading be prepared in the same manner as described in Chapter 16. Grade preparation for gabions can be a shallow trench slightly wider than the gabion cage. Gabions are buried only 6–12 inches, rather than the depth of an entire first course.

Although they require less craftsmanship than other types of retaining walls, gabion walls do require special equipment to aid in wall construction. Caution should be used when working with gabions because of their significant weight. Although they are typically stable, gabions can slide or shift, resulting in serious injury to a worker.

GABION WALL CONSTRUCTION

The following paragraphs give instruction on the best practices when laying a gabion retaining wall.

Placing and Leveling the First Course

Leveling should be accomplished by adjusting the grade below the cages before they are placed. Mark the alignment of the first course, and place gabion cages along the alignment. Gabions should be installed with the long dimension parallel to the wall face. Note the top of the gabion and orient so that the opening edge faces the side from which material will be installed (Figure 20-1).

Carefully fill each of the cages with a consistent selection of stone that has a diameter larger than the cage openings. Stone selection should be based on availability and aesthetics. Either angular or washed river stone is acceptable. Filling operations for the first course should not dislocate the cages from their alignment. When you have filled the cages, close the tops and wire them shut (Figure 20-2). At this time, place any drainage behind the cages and fill and

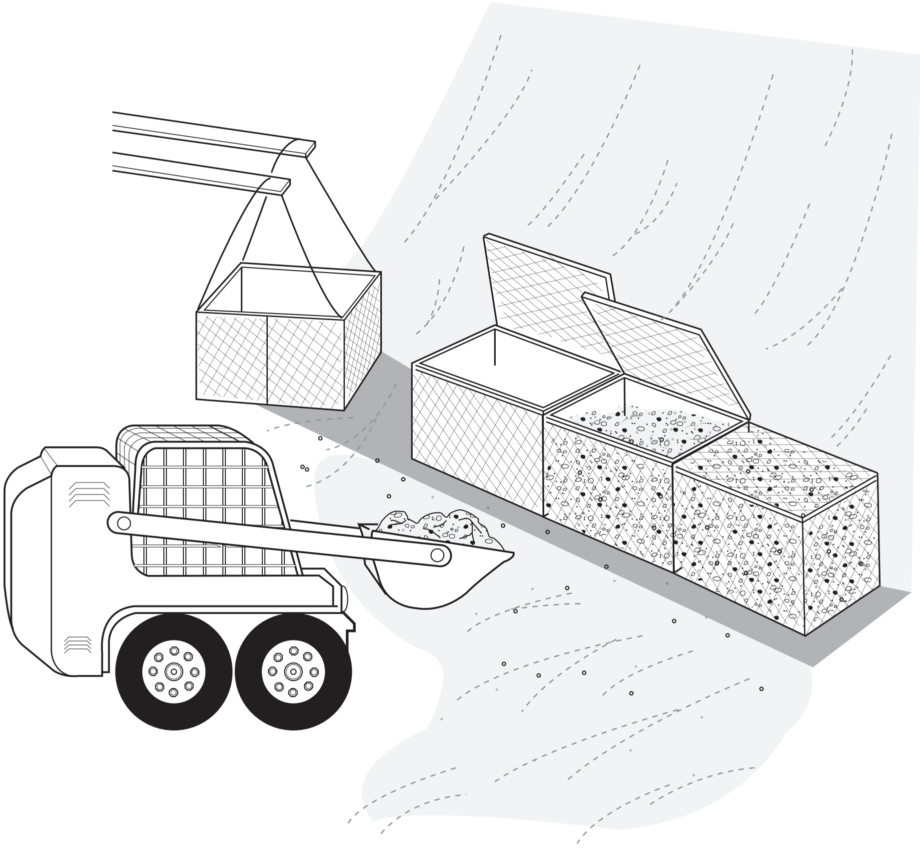


Figure 20-1 Cage placement and filling for gabions.

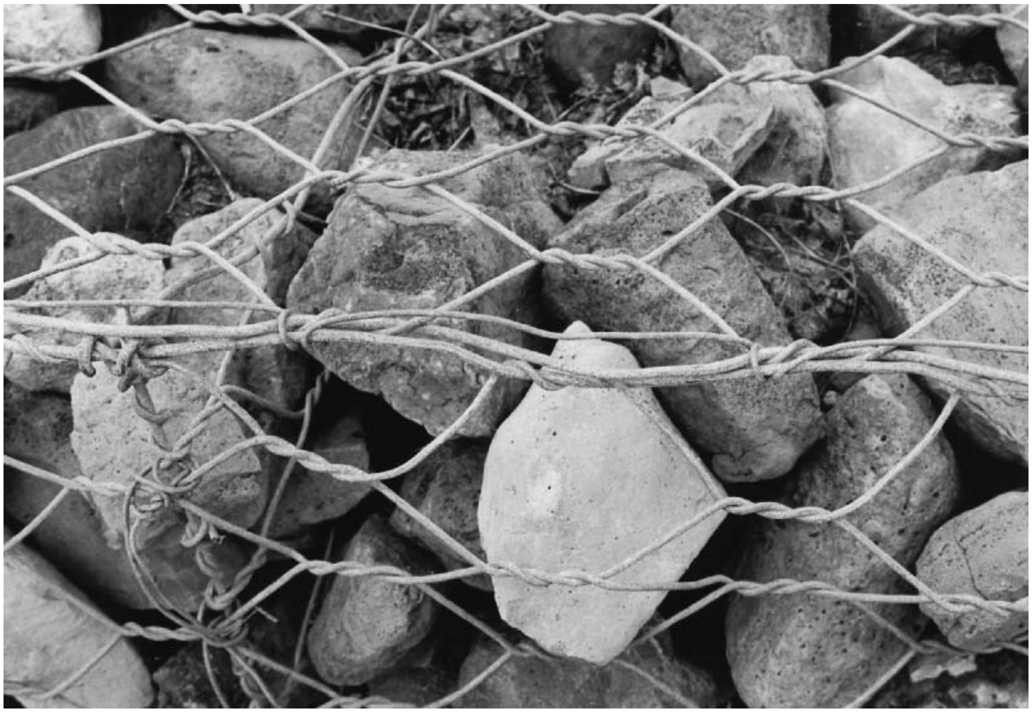


Figure 20-2 Gabion cages are filled with stone larger than the diameter of the cage openings. Cages are wired shut using 12-gauge galvanized wire.

compact the void behind the wall with free-draining angular material.

Placing, Connecting, and Backfilling Subsequent Courses

After placing and compacting the backfill for the first course, place the cages for the second course. Place subsequent courses straddling the joint between the two gabions below. You may use a slight setback batter of 4–12 inches for each course (Figure 20-3). Fill the cages, close, and wire them shut with 12-gauge wire. Backfill behind the wall and compact; then repeat for each course until the you reach the top of the wall. Turn gradual corners by fanning the gabions along the proposed alignment, and overlap right-angle corners on subsequent courses.

In locations where the base of the wall must step up, fill the void beyond the end of the last gabion in the lower course with base material and compact. Level the base with the top of the lower course, and place a gabion cage straddling the lower gabion and the base for the upper course. Fill the cage and continue placing cages along the wall alignment.

STAIR CONSTRUCTION WITH GABION WALLS

Stairs used with gabion walls need to be constructed separately out of an alternative material. Although cast-in-place concrete makes a durable step, any wall material described in this section makes a suitable step for gabion applications. See Chapter 23 for forming and pouring concrete stairs and Chapter 21 for butt stair installation.

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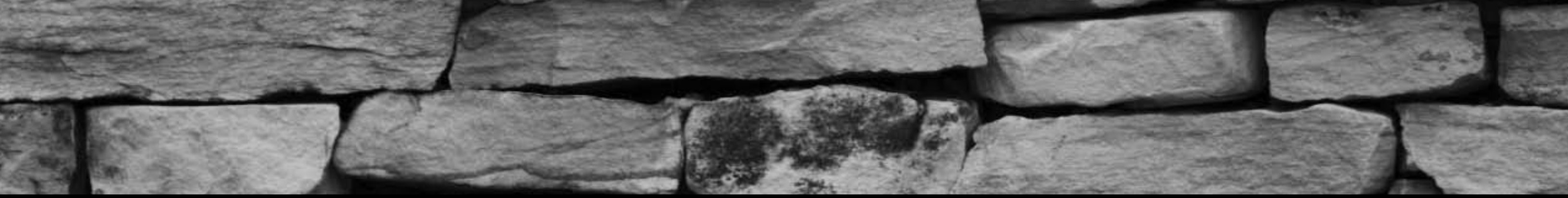
Figure 20-3 Stacking gabion cages.



CHAPTER 21

STAIRS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Identify appropriate stair style for a project.
- Install stairs that abut a retaining wall.
- Install stairs that interlock with a retaining wall.
- Install freestanding stairs.

When walls are used to create levels on a sloping site, stairs are often required to traverse the different levels. Stairs are addressed as part of this section because of their relationship to walls and because many stair projects are incorporated into wall projects. Planning information presented in this chapter applies not only to stairs as part of a wall project, but also to cast-in-place concrete stairs and wood stairs built as part of a landscape structure. Specific construction techniques for cast-in-place concrete and wood stairs are presented in Chapters 23 and 30, respectively.

The landscape also presents situations where a slope needs to be navigated with stairs even though no wall is planned. Such instances require the construction of freestanding stairs. Because the side slopes are so gradual, freestanding stairs are constructed without the benefit of retaining or cheek walls. Stairs in this situation are typically constructed with riser/tread dimensions that match the slope, rather than matching the ideal mathematical relationships for steps. This chapter also outlines the methods of planning and installing various types of materials used for freestanding stairs.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7

PLANNING THE PROJECT

The range of construction difficulty for stairs can be quite wide, depending on the materials used and slope on which the stairs are being constructed. Prior to beginning the project, develop a plan for materials desired and the number of risers and treads needed.

Building Codes Governing Stairs

Before beginning your project, check with local building officials to verify regulations for stairs as part of a landscape. Many communities have regulations on stair **tread** and **riser** dimensions, railing requirements, stair widths, and other stair-related attributes. Access up/down grades may also have to be accompanied by a ramp as well as stairs. Check

with building officials for rules or requirements that might supersede techniques described here.

If stairs are accessible to the public, ADA (Americans with Disabilities Act) requirements will play a role in the design and construction of the project. To meet these requirements, exterior stairs must be stable, slip resistant, and noncombustible. In addition, no open risers are allowed, protection for snow and ice will be necessary, and any set of stairs with more than two treads will require handrails flanking the stairs. Other specific requirements for ADA are listed in Chapter 23 under "ADA Stair and Ramp Requirements." To meet the many requirements of ADA, exterior stairs are often constructed of cast-in-place concrete to overcome the limitations of natural materials. If the stairs are accessible to the public and if a licensed professional did not design them, seek advice to assure compliance.

Types of Stairs

Stairs can be constructed as part of wall systems (Figure 21-1) or be independent of walls, such as freestanding stairs traveling up a gradual slope (Figure 21-2). In certain cases, stairs may be replaced by gradual sloping ramps. The type of construction selected depends on the steepness of the slope, the distance covered, and the mobility of the user. Whenever possible, select a ramped walkway over stairs because of the ease of construction and the diverse age and physical condition of the people who will use the ramps. Building codes and access regulations may also require installation of ramps rather than stairs. When grades begin to exceed 4% longitudinal (over 4 feet of fall in 100 feet end to end), stairs should be considered as part of the project. If the slope to be traversed does not require a wall, incorporate freestanding steps to assist the client over the slope.

Cheek Walls

Stairs constructed as part of a wall require that **cheek walls** be built on either side of the area where stairs are desired. Cheek walls are short walls that run into the hillside the stairs traverse. Perpendicular to the retaining wall, cheek walls should be the same height as the retaining wall and should extend into the hillside at least as far as the stairs will extend. Timing of

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Figure 21-1 Stairs built as part of a wood timber retaining wall installation.

Figure 21-2 Freestanding stairs in a gradual slope.

cheek wall construction depends on whether stairs will be interlocked with the cheek wall or built independently and butt into cheek walls.

Material Selection for Stairs Built as Part of a Wall

A preferred choice for stair materials is the same materials used for wall construction. This provides continuity in design and dimension from the wall into the stairs. In some cases, the same material may not be possible or desirable. One popular choice for stairs is cast-in-place concrete. This material, when properly formed, can be set at any riser and tread dimension and can be poured to fit snugly with any cheek walls. Forming for stairs is covered in Chapter 23. Freestanding steps can be constructed of any wall material just identified, as well as from cast-in-place or precast concrete.

Material Selection for Freestanding Stairs

Freestanding stairs can be built of almost any material. To organize the presentation of choices and installation, materials are grouped into four categories as follows:

- Concrete Stairs. Concrete can be formed with any riser height and tread depth and can be built without the benefit of retaining walls alongside (Figure 21-3). See Chapter 23 for forming and paring concrete stairs.

Figure 21-3 Freestanding concrete steps formed and poured as part of this entry construction.

- Timber Framing with Treads of Concrete, Brick, or Loose Material. Stairs along a hillside can be framed on the front and two sides with ties, timbers, or heavy-dimensioned lumber with the tread portion surfaced with a variety of materials. The front portion for each higher step rests on the sides of the lower step. For informal stairs, a tie or timber can be placed across the front of each step with the tread behind left untreated or covered with loose fill (Figure 21-4).
- Stacked Slab Materials. For informal stairs, large slab-like materials can be placed level in the ground and serve as both a riser and a tread. Each subsequent step rests on the back edge of the lower step. Materials that might be used for this type of step include precast concrete, large flat stones, tree sections, or other materials with thickness and large dimensions (Figure 21-5).

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Figure 21-4 Freestanding stairs using timbers to create risers with a loose granular material for the treads.

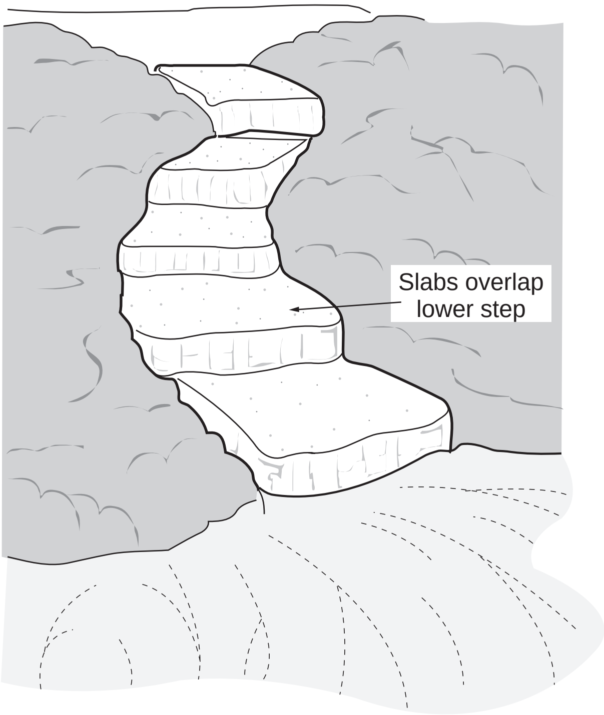

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Figure 21-5 Freestanding stairs constructed from slab materials.

- Stone or Segmental Precast Concrete Wall Units. Both of these wall materials can be interlocked or butted against cheek walls to create stairs. In some precast units, the caps are necessary to cover hollow voids in the blocks.

Riser/Tread Calculations for Freestanding Stairs

Unlike those constructed as part of a deck or wall, freestanding stairs are adjusted to match the slope that is being covered. It will be a fortunate coincidence if the slope where the freestanding stairs are to be constructed matches the mathematical formula for riser/tread dimensions. Landings or cheek walls will usually have to be added to accommodate the mismatch length of the slope. To determine the number of risers and treads in a set of freestanding stairs, use the following abbreviated formula:

- Measure the length and height of the slope.
- Convert the measurements to inches.
- Divide the height (in inches) by the thickness (in inches) of the material selected for stairs. The answer will indicate how many risers are needed.

- Divide the length of the slope (in inches) by the number of risers. The answer will indicate the depth of each tread. If the tread depth is less than 12 inches, the tread depth will not accommodate a normal step pattern, creating potential safety concerns. Consider routing the stairs diagonally across the slope or extending the stairs beyond the top or bottom of the slope to provide more length for calculating tread depth.

When constructing the stairs, use the tread depth measurement to determine the placement of the front of each subsequent stair.

Building Freestanding Stairs on Irregular Slopes

When placing freestanding stairs on irregular slopes, adjusting the tread depth may be required to avoid significant excavation. If the slope is steep, shorten the tread depth to no less than 12 inches. The length cut from these treads can then be added to treads on the flatter portion of a slope. It is best to group at least three steps with short treads together. Avoid alternating a short tread depth with a long tread depth if possible. If the adjustment of treads is not acceptable, cutting and filling to create a more even slope is an alternative.

Interlocking Stair Installation

Interlocking stairs should be constructed as the wall is being erected, with the first course of the stairs installed with the first course of the wall and continuing for each subsequent course. The following steps outline how to install interlocking stairs for timbers (Figure 21-6), segmental units (Figure 21-7), and dry-laid stone (Figure 21-8). These instructions are prepared for stair treads that are approximately 12 inches in depth. For deeper stair treads, additional stair materials are required. If special precast or one-piece stone treads are available, use those materials for stair construction.

1. Widen the granular base trench at the stair location 24 inches in back of the entire width of the stair opening. This trench should be the same elevation as the base trench for the wall. Because the first course of the wall will be buried for stability purposes, this level will serve only as a landing and not as a riser (Figures 21-6A, 21-7A, 21-8A).
2. Route any tile around the back of the widened trench.
3. Fill this widened trench with base material and compact.
4. Place the first course of the wall up to the opening for the stairs, keeping the wall front aligned. Place the first tread behind the first wall course. This tread may be composed of multiple ties, wall units, or stones, or may be a single-piece tread. The tread should be approximately 24 inches wider than the stair opening (12 inches on each side), providing enough extra material to allow the tread to extend behind the wall on both sides of the stair opening (Figures 21-6B, 21-7B, 21-8B).
5. Construct the second course for the wall and stop short of the stair opening on each side of the stair.
6. Excavate a base trench behind the first tread for the second tread. This trench should be 18 inches wide by the length of the tread and 6 inches deep. Fill the trench with base material and compact. If a tile is present, fill over the tile without disturbing its level. Smooth the base material so that it is flush with the top of the previous tread.
7. Place the second tread across the opening for the stairs. The second tread should be 24 inches wider than the stair opening. The second tread should also overlap the back of the first tread enough to create the desired tread dimension for the first step. If using timber treads, pin the second tread to the first (Figures 21-6C, 21-7C, 21-8C).
8. Build the cheek wall between the front wall and the tread. Trim wall material as required to fit between the front wall and tread. If building the wall with wood or stone, remember that the cheek wall must interlock with the wall face at the corner and that alternate courses of the cheek wall will run to the face of the wall.
9. Backfill and compact behind the wall and tread.
10. Repeat steps 5 through 9 for each subsequent course of the wall until stairs are complete (Figure 21-9).
11. If tread coverings are used, place them for all treads.

BUTT STAIR INSTALLATION

Although easier to construct, butt stairs have less stability than interlocking stairs. Because butt stairs are not interlocked into the cheek wall, they

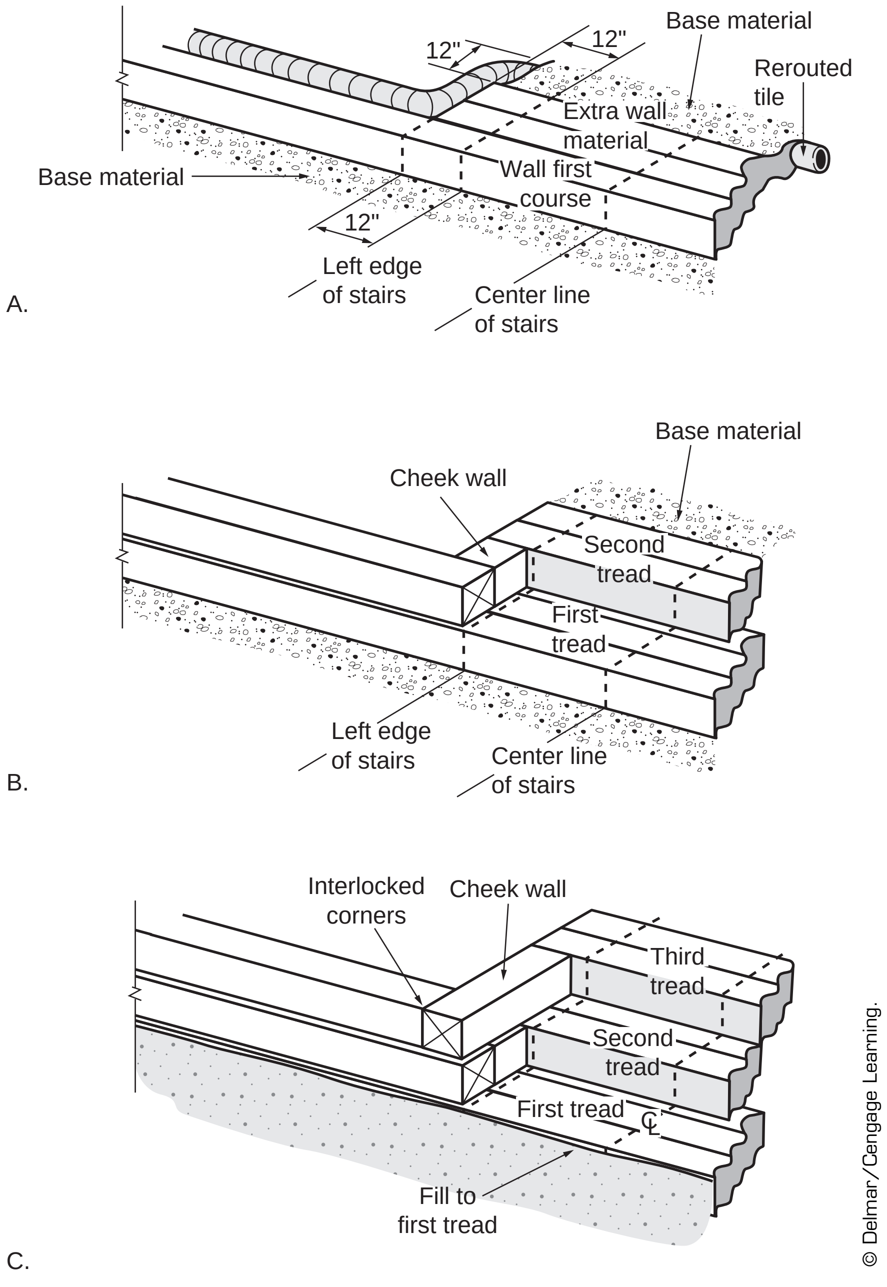

Figure 21-6 Interlocking stair construction for timber walls. A. Base trench and first course for interlock stairs. B. Second course for interlock stairs. C. Subsequent courses for interlock stairs. (Note: First course will be completely or partially buried.)

may move up or down at a different rate than the walls next to them, causing unevenness or irregularity. Construct butt stairs using the following steps for timbers (Figure 21-10), segmental units (Figure 21-11), and dry-laid stone (Figure 21-12). The instructions are prepared for stair treads that are approximately 12 inches in depth. For deeper stair treads, additional stair materials are required. Precast or one-piece stone treads will simplify tread installation.

1. With butt stair construction, walls and cheek walls can be built prior to the stair installation or concurrently as the walls are assembled. If

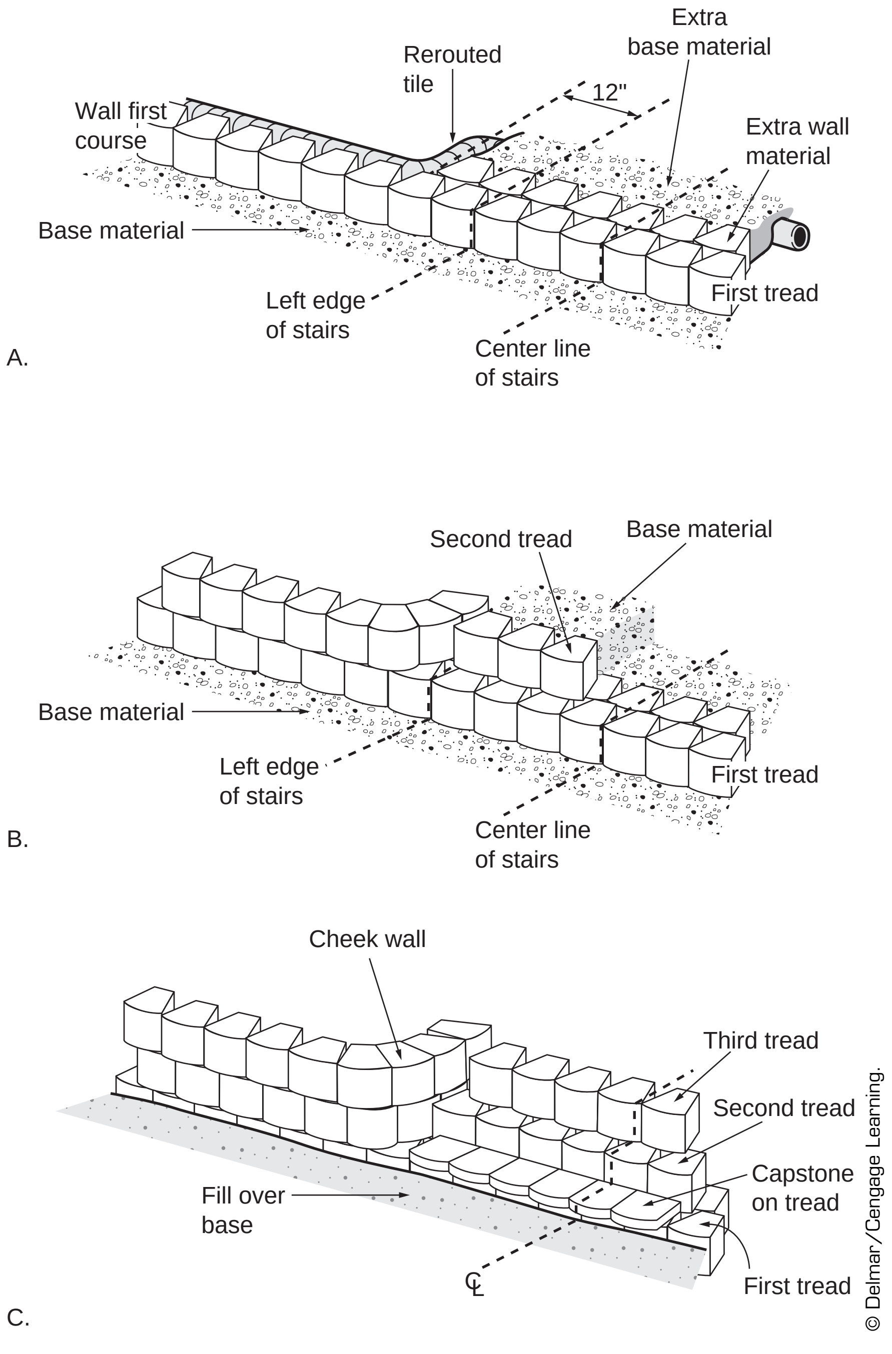

Figure 21-7 Interlocking stair construction with segmental precast units. A. Base trench and first course for interlock stairs. B. Second course for interlock stairs. C. Subsequent courses for interlock stairs. (Note: First course will be completely or partially buried.)

installing the walls first, leave an opening for stairs when constructing the wall and verify that the walls on each side of the opening are level and aligned. Adjusting the width of the opening to match tread material dimensions is also desirable, although use of a step-back batter on cheek walls requires cutting tread materials to fit.

2. Widen the granular base trench at the stair location 24 inches in back of the entire width of the stair opening. This trench should be at the same elevation as the base trench for the wall. Because the first course of the wall will be buried for stability purposes, this level will serve only as a landing and not as a riser (Figures 21-10A, 21-11A, 21-12A).

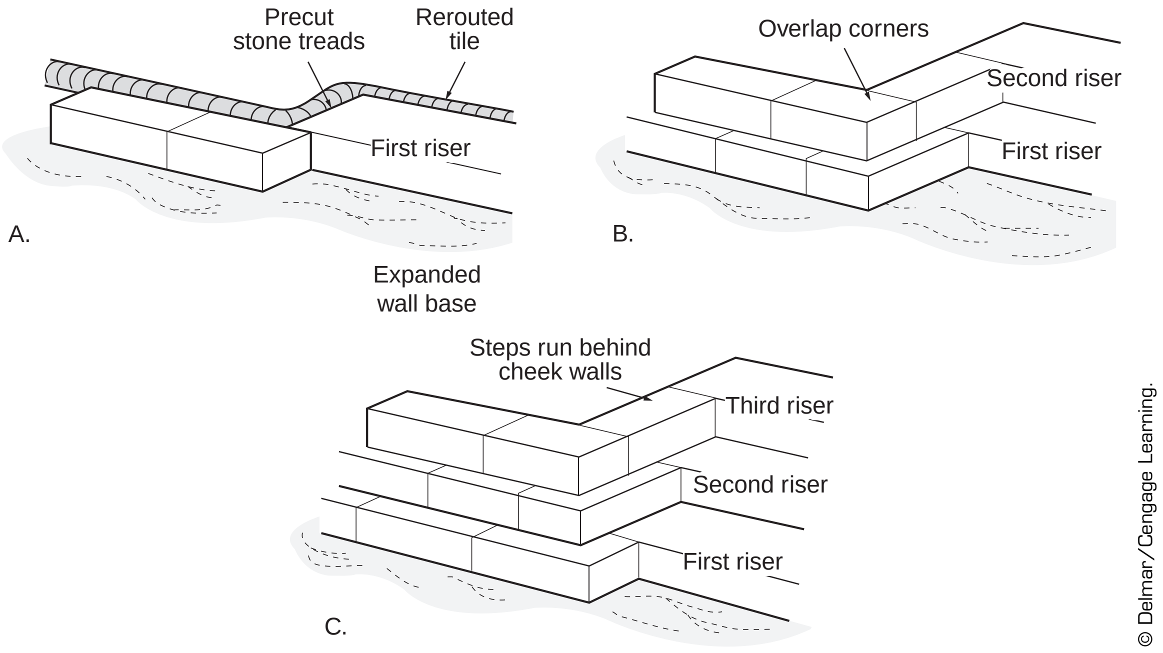

Figure 21-8 Interlocking stair construction with stone. A. Base trench and first course for interlock stairs. B. Second course for interlock stairs. C. Subsequent courses for interlock stairs. (Note: First course will be completely or partially buried.)

Figure 21-9 Completed interlocking stairs with precast units.

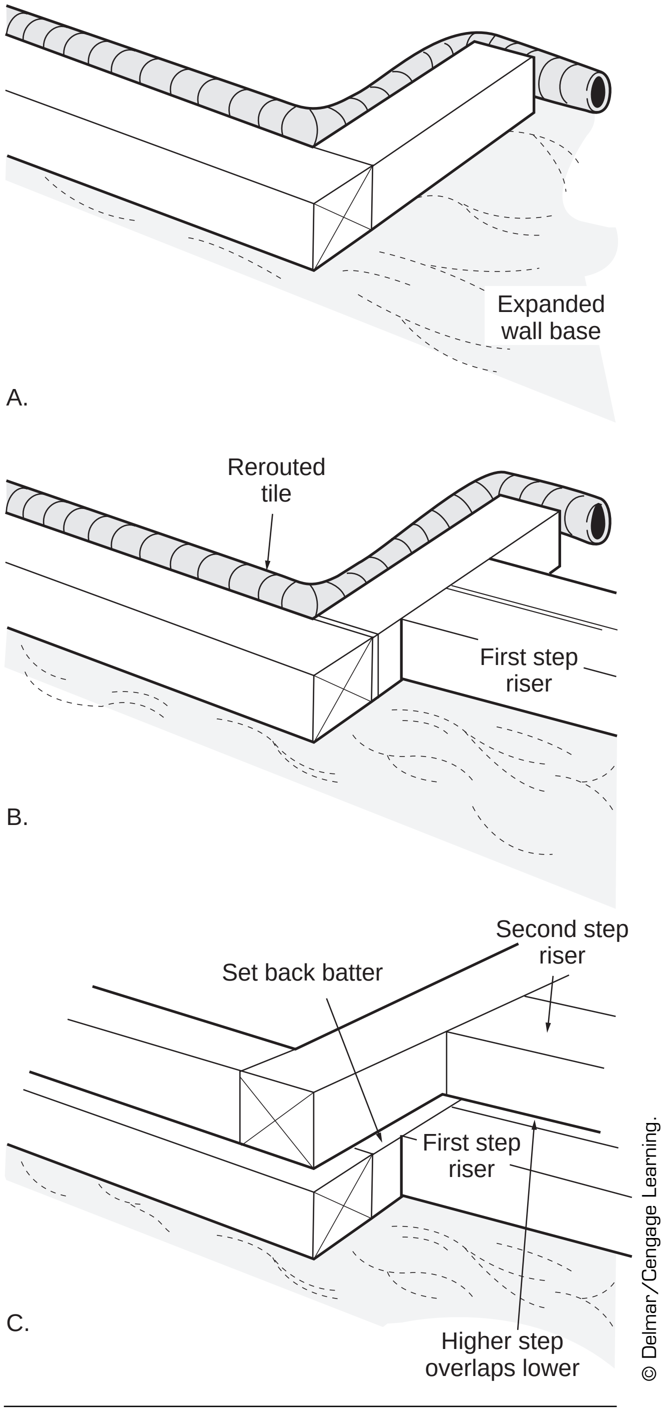

Figure 21-10 Butt stair construction for timber walls. A. First course of wall and cheek wall for butt stairs. B. First step riser for butt stairs. C. Second course for butt stairs. (Note: First course will be completely or partially buried.)

3. Route any tile around the back of the trench where the treads will be placed.
4. Fill this widened trench with base materials and compact.
5. Place tread materials between the cheek walls flush with the first wall course. Level treads side to side and front to back. A slight (¼ inch or less) fall toward the front is desirable if it does not disrupt the riser installation. Cut and fit partial tread materials along the sides if required (Figures 21-10B, 21-11B, 21-12B).
6. If building the walls and stairs concurrently, continue construction of the second course of the wall and cheek wall before installing the second tread. With wood and stone wall materials, the wall and cheek wall must interlock at the corners. Excavate a base trench behind the first tread. This trench should be 18 inches wide by the length of the tread and 6 inches deep. Fill the trench with base material and compact. If a tile is present, fill over the tile without disturbing its level. Smooth the base material so that it is flush with the top of the previous tread.
7. Place tread materials for the second tread across the opening for the stairs. The second tread should overlap the back of the first tread enough to create the desired tread dimension on the first step. If a wall cap is used for the tread, the overlap should equal the wall unit width minus the cap width (Figures 21-10C, 21-11C, 21-12C).
8. Backfill and compact behind the tread.
9. Repeat steps 6 and 8 for each subsequent course until the wall has been completed (Figure 21-13).
10. If cap stones or tread coverings are used, place them.

FREESTANDING STAIR CONSTRUCTION

Site preparation is similar for all of the following types of stairs if placed on an even slope.

Site Preparation

Mark the location for the stairs along the slope. Cut and remove any vegetative cover and excess soil in the stair right-of-way. Add 4 inches of granular base. Except for concrete stairs, begin placement of stair material with the base step.

Concrete Stair Installation

Concrete stairs can be formed and poured similar to stairs that are built as part of a wall. After excavating the area for the stairs, fill with 4 inches of granular base material. Construct the forms and pour the stairs according to the instructions given in Chapter 23, Concrete Paving, for independent forming of stairs.

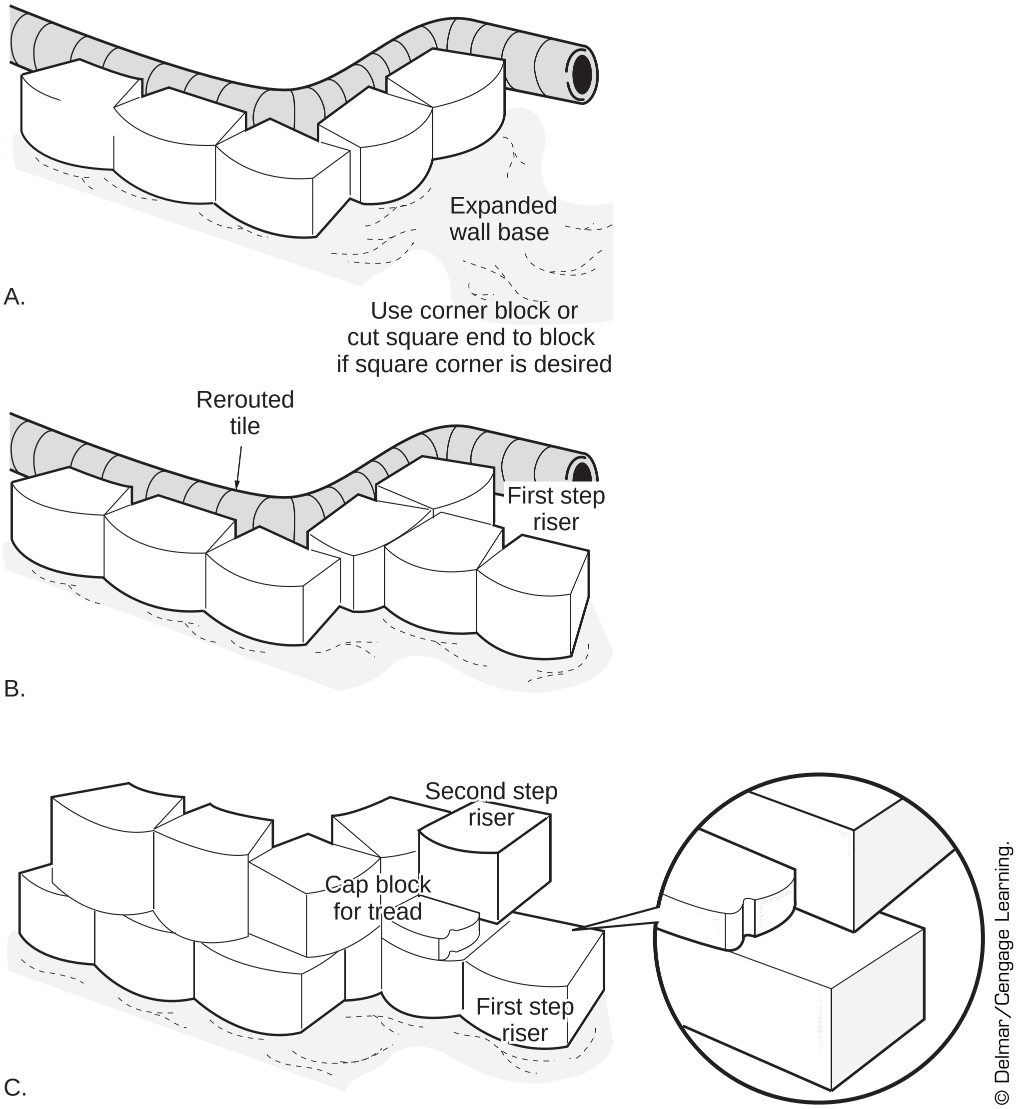

Figure 21-11 Butt stair construction with segmental precast units. A. First course of wall and a cheek wall for butt stairs. B. First step riser for butt stairs. C. Second course for butt stairs with optional tread surfacing. (Note: First course will be completely or partially buried.)

Wood-Framed Stair Installation

Stairs that have a wood framework on the front and both sides should be installed beginning with the base step. Add a small amount of granular material in the area excavated for the first stair. Cut the front piece the width of the stair. Cut two side pieces, each 1 foot longer than the depth of the tread. Place the front and two side pieces on the base material (Figure 21-14). Connect the side pieces to the front using galvanized lag screws or spikes. Level all three pieces by adjusting the base material. Fill the voids along the outside edge of the stairs with soil. Fill the tread area between the three pieces with material selected for the tread.

Cut the next set of step boards. Place the front board on the two side pieces for the step below. Position the front board so the distance to the front of the first riser creates the desired tread depth. Anchor the front board for the upper step to the side pieces for the lower step by drilling a ⅜-inch diameter pilot hole through the front board. Drive 12-inch spikes through the pilot holes into the side

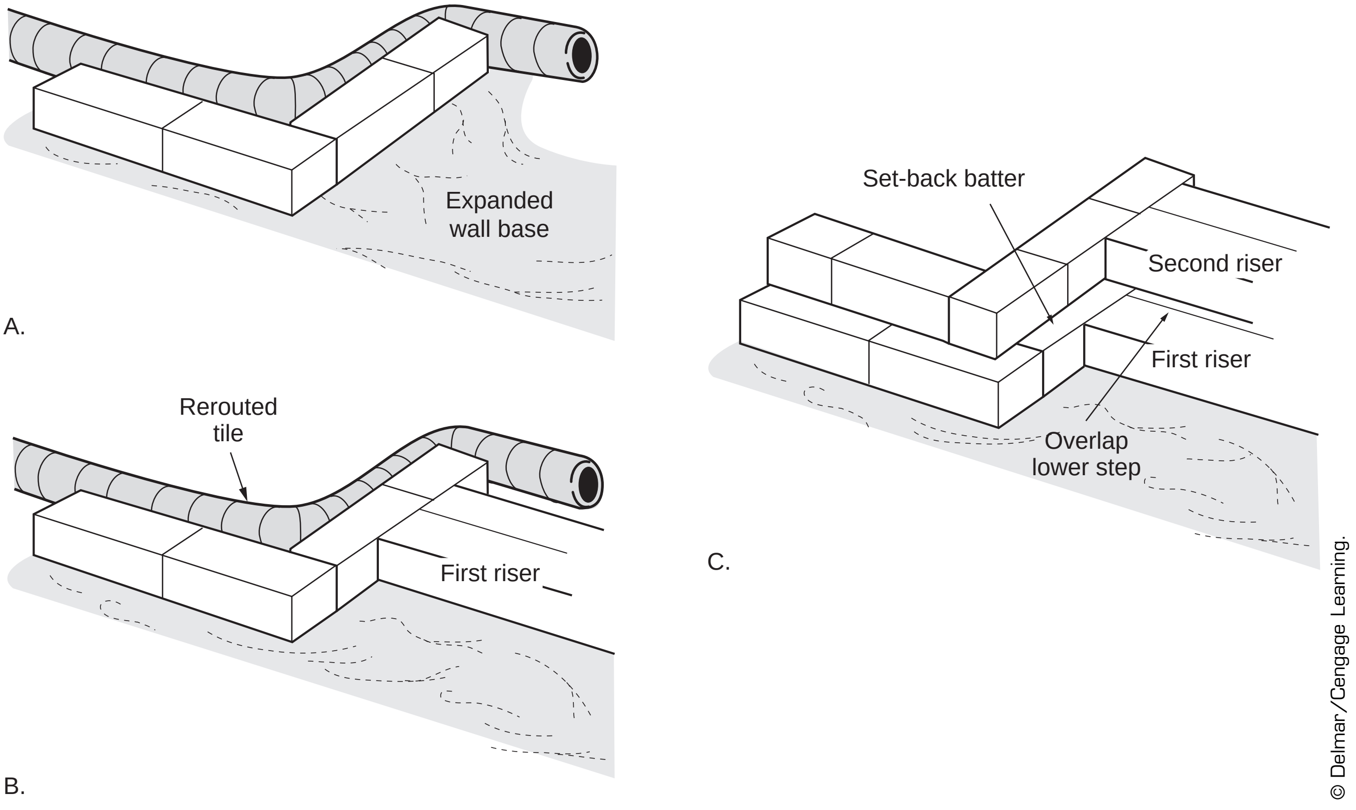

Figure 21-12 Butt stair construction with dry-laid stone. A. First course of wall and cheek wall for butt stairs. B. First step riser for butt stairs. C. Second course for butt stairs. (Note: First course will be completely or partially buried.)

Figure 21-13 Completed butt stairs with precut stone steps.

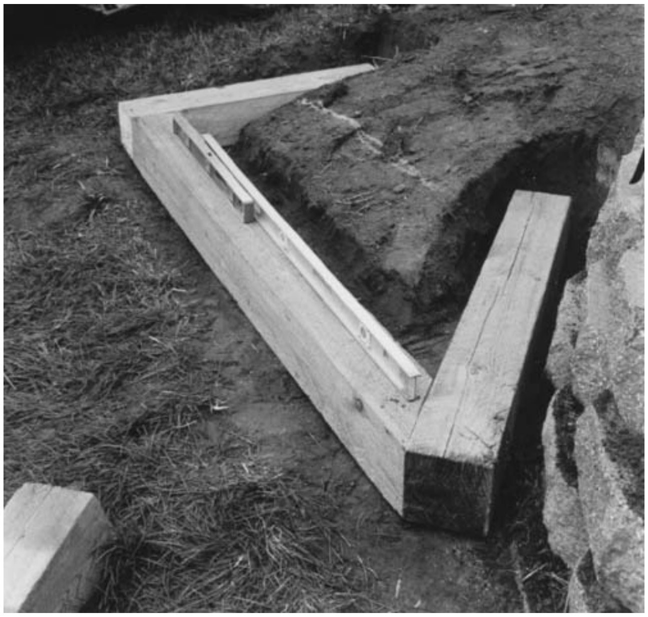

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Figure 21-14 Building the base step of a freestanding wood timber installation.

pieces. Connect the side board to the front pieces and repeat the filling procedure. Repeat these steps until the top of the stairs has been reached (Figure 21-15). The top stair may require an additional board opposite the front board to hold the tread surfacing material in place.

Wood Riser Stair Installation

Install a small amount of granular base material in the area excavated for the first stair. Cut the first riser piece the width of the stair. Place the riser piece on the base material and level. Fill the void behind the riser with the material selected for the tread. Fill the area along the sides of the tread with soil. Cut a second riser piece. Place the second riser

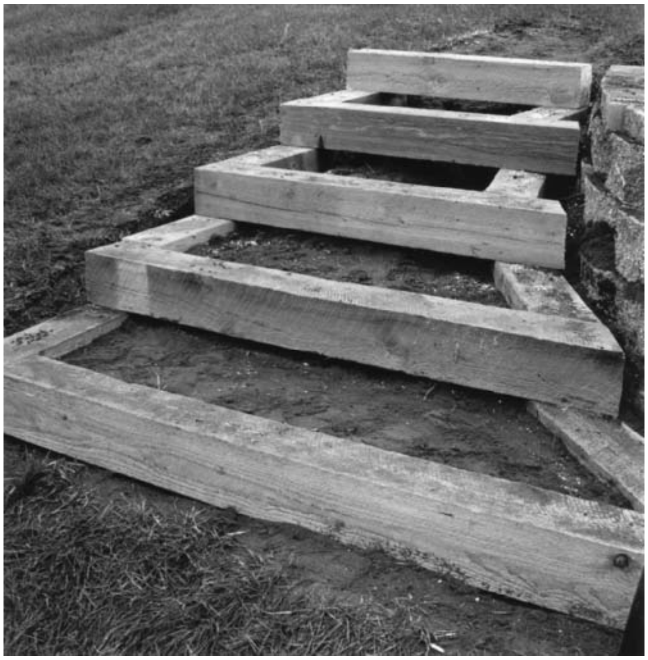

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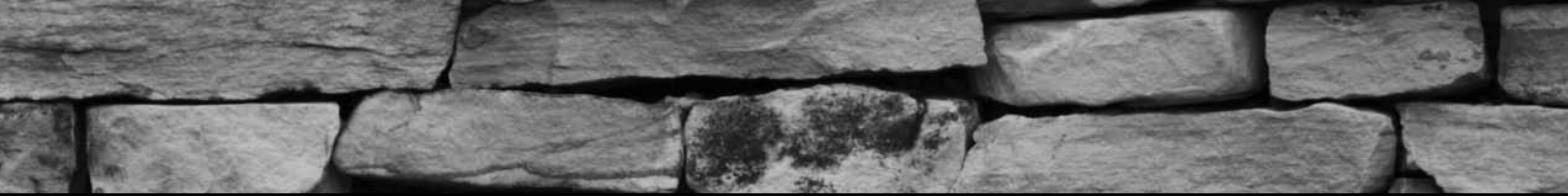
Figure 21-15 Subsequent steps of this freestanding wood timber stair installation rest on the sides of the lower stair. Treads will be filled with granular material.

piece on the tread material for the lower stair at the correct distance from the front of the first riser to create the desired tread depth. Repeat the filling operation and continue with the remaining steps.

Stacked Slab Material Installation

Place a small amount of granular base material in the area excavated for the first slab. Place the first slab on the base and level. Fill around the edges of the slab. Place the second slab with an overlap on the first slab that provides the correct tread depth. Fill around the edges of the second slab. Continue this process with the remaining slabs.



SECTION 5
SUMMARY

Construction of retaining walls is one of the major jobs of most landscape contracting businesses. Section 5 discussed the preparation for wall projects and installation of nonstructural walls, timber, segmental precast and structural cell walls, dry-laid stone, and gabion retaining walls. Also covered were the installation of stairs as part of a wall project and construction of freestanding stairs built without being incorporated into stairs. Cast-in-place concrete walls and freestanding walls are covered in Section 8.

Preparation for a retaining wall project begins with the selection of the proper wall construction material. Many choices are available, with timbers, precast concrete units, and dry-laid stone being the most popular choices. A seldom-used but appropriate wall material for short walls is the gabion. When choosing wall materials, consideration should be given to aesthetics, ease of installation, and cost. Retaining walls that are cast-in-place with concrete, with or without stone veneers, are also a popular choice for walls but require special expertise to construct. Several choices are available for short walls that are not retaining any heavy structural loads. Recycled concrete, recycled tires, concrete bags, cellular confinement material, and loosely stacked irregular stone can hold back limited amounts of soil and create needed space.

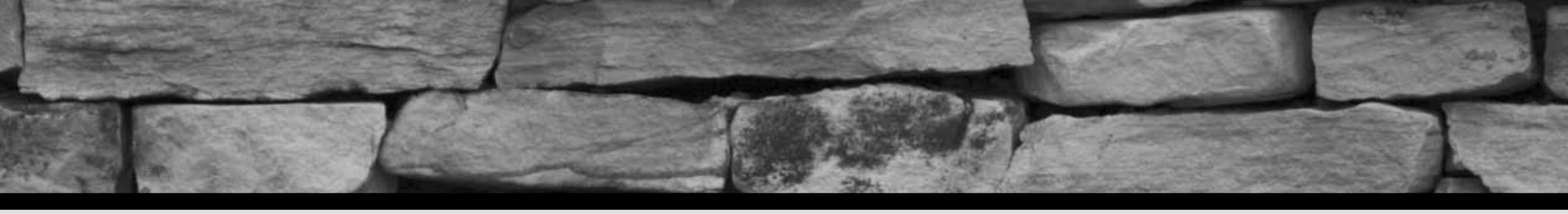
Construction of all wall types requires the preparation of a sound base. Long-term stability of any wall relies on installation of the first course on solid support and with the proper level. First courses for most wall installations are buried to provide extra stability, and proper drainage is provided behind the wall to reduce hydrostatic pressure. This buildup of water is drained away from the wall using a tile placed behind and at the base with a zone of free-draining fill directly behind the wall. Stability of the wall is also maintained by building the wall with a batter, by anchoring the wall, or by doing both. Batter is the backward lean of a wall to counter the effects of gravity and hydrostatic pressure. Anchoring the wall can be accomplished using vertical buttresses, deadmen, or geogrid to secure the wall to the hillside behind. Taller wall installations can be accomplished by terracing (using a series of shorter walls).

Installation techniques vary, depending on the type of wall materials selected. Wood products such as ties and timbers can be placed vertically or horizontally in stacked or staggered patterns. Vertical timbers are anchored by placing them in a trench and backfilling. Horizontal ties are placed level with a leaning batter or step-back batter. Stacked timbers are secured using verticals buried in front of the wall at the joints. Staggered timbers walls are secured between courses using nails or pins and anchored into the hillside using deadmen. Segmental (precast concrete) wall units are placed individually and stacked in courses. Precast units can be placed in a straight line or turn radius or angled corners. Courses are stabilized using blocks with lips, pins, or blocks with special precast and pinned anchors. Most precast unit walls are stabilized using geogrid placed between courses and buried horizontally in the hill behind the wall.

Dry-laid stone walls use natural materials cut to standard or random dimensions and stacked without mortar. Stone walls rely on a batter for stability and cannot be reliably anchored with other available technologies. Because of this, the height of stone walls is limited. Gabions are metal cages filled with large aggregate and stacked to create retaining walls. Although not common in residential landscape projects, gabions are a viable alternative to other wall materials in locations where aesthetics are not a prime concern. With their similarity in size and form, the use of pieces of recycled concrete to construct retaining walls employs the techniques presented in Chapter 19.

When addressing slopes on a site, walls are usually considered; and as part of traversing those slopes, stairs are a landscape element commonly

built into retaining walls. Stairs constructed as part of a wall project can be built with the tread interlocking into the cheek walls or butting against the cheek walls. Stair material would preferably be the same material as the wall, but stairs may also be formed and poured from concrete as independent units from the wall. Special calculations are required for stair construction to obtain the ideal dimensions for risers and treads and to determine the number of risers and treads the slope requires. Freestanding stairs can also be constructed without walls from a variety of materials.



SECTION 6

LANDSCAPE PAVING

INTRODUCTION

Most landscapes rely on paving to create usable outdoor areas. By providing hard surfacing, we can create drives, walkways, patios, entry areas, and a variety of functional spaces that property owners can use in all weather conditions. In many projects, the paved area is also a source of aesthetics, introducing color, texture, and materials that enhance the overall design of a project. A paving material will work if it performs the essential function of separating your feet from the mud, but the variety of excellent paving material choices provides aesthetics as well as functionality. More recent emphasis has been placed on paving materials that reduce resource consumption and help retain water on site. Once a novelty, the desire to reuse and recycle paving materials has added a new dimension to material choices.

The chapters of this section review material selection and installation techniques for common paving materials used in today's landscape. Emphasis is on selecting a material, preparing the site, and installing the pavement. Specific paving topics covered in this section include concrete paving installation, unit paver installation, dry-laid stone paving installation, recycled concrete paving, mortared stone paving installation, granular paving, and porous paving installation. Although asphalt paving is an important paving material for many landscapes, it is not presented in this text because asphalt paving requires special equipment and contractors with paving expertise to perform this portion of the work.

SUSTAINABILITY SUGGESTIONS

- Consider paving that provides drainage through the surface instead of paving materials that are impervious or direct water off the paving surface. Permeable concrete, asphalt, pavers, and granular materials will all increase percolation of water, rather than contributing to erosion and drainage problems by increasing runoff.
- When you have control over such choices, give careful consideration to the material choices used in your project. Choose local materials before selecting materials that will need to be transported great distances to your site; choose renewable materials, rather than products that cannot easily be recycled.

Examine materials carefully to understand the full life cycle cost, including the cost of production, transportation, installation, use, and disposal.

- Carefully consider your equipment needs, rather than automatically choosing power equipment over hand labor. In certain cases, it may be more cost-effective and better for the environment to perform a task using hand tools instead of hauling large pieces of gas-powered equipment to the site to perform a task.

CHAPTER 22

MATERIALS AND SITE PREPARATION FOR PAVING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Choose a paving material appropriate for a project.
- Prepare a project for paving.
- Install edge restraint for a paving installation.

With only minor variations, project preparation is similar for all types of **paving.** Considerations such as selection of materials, access to the site, and layout of a project should precede the start of a project. A successful paving installation, whatever the surface material used, requires a well-prepared, stable **base.** Surfacing is no better than the base on which it rests; and if the base settles or heaves, the paving will usually follow. Identified in this section are methods to prepare base and to correct drainage and soil problems that might lead to future problems.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7

SELECTION OF PAVING MATERIAL

Paving material types are identified on the design documents or through discussion with clients regarding standard criteria used in determining which material will best suit the project's needs. Although selection of paving type is best done during the design phase of a project, applicable construction-related criteria should also be reviewed. The following sections identify several choices for paving materials and include a description of the pros and cons of each choice. By using this information and the installation instructions in the chapters that follow, contractors can make wise decisions about which paving material is best for a project.

Concrete

An excellent choice for surfacing outdoor spaces (Figure 22-1), **concrete** is moderate in cost and is extremely versatile in finishes and shapes. Because forms are custom-built to match the design, almost any shape of surface is possible. A variety of finishes are available, from **exposed aggregates** to **colored, impressioned** walks that mitigate the aesthetic problem of "plain" concrete. As the complexity of the forming or surface increases, concrete becomes more expensive. Yet, concrete is still one of the most cost-effective surfacing materials available. For both new and existing concrete surfaces, options of painting and staining to create a colorful decorative surface create a cost-effective alternative to new paving. Properly installed concrete is excellent in durability and safety and is regularly used in areas with vehicular traffic and in commercial and public use areas. Maintenance is typically performed

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Figure 22-1 Concrete paving. Shown here in an urban plaza, concrete paving is versatile and easily adapted to various settings.

without problems unless the installation is old or cracks have formed from improper installation. Most concrete pours can be installed with moderate difficulty if installers are experienced in preparing and completing pours.

The need for stable paved surfaces that do not aggravate excessive runoff problems has led to attempts to create porous paving surfaces. Both asphalt and concrete have been modified in selected applications to create pavement that will allow water to percolate through the surface, rather than being shed from the surface. In both material formulations, the high porosity has been created by decreasing the percentage of sand and fine aggregates in the mix, creating a pavement with continuous voids throughout the thickness of the slab. In addition to changing the formulation of the paving material, for a porous paving to have maximum effectiveness, the base layer should function as a reservoir or transport mechanism for water. In these situations, the standard base of compacted graded base stone is replaced with an 8–36-inch deep base of clean, uniform graded aggregate ranging from 1–2½ inches in diameter. This base layer is lined with a nonwoven geotextile on the bottom and sides. Applications for such surfaces range from lining drainage channels for stability to installing minor roadways, parking areas, and paths. Although effective in managing water, such surfaces also have limitations. Concrete applications in cold climates are subject to freeze/thaw damage; asphalt installations are subject to compaction in high traffic areas; and both require specialized techniques for an effective installation.

Unit Pavers

Unit paver is a collective term that includes clay **bricks, interlocking concrete paving blocks,** adobe pavers, precast concrete units, open-cell grass pavers, permeable pavers, and modular resilient pavers. Because of their aesthetic surfaces, unit pavers have been among the most desirable and requested types of paving materials (Figures 22-2 and 22-3). This attractiveness is not without its price because unit pavers are costly and require expertise and effort to install. Strength for properly installed unit paver surfaces is good, but failure of base/subgrade under unit pavers can create potential safety problems, breakage, and definite maintenance problems. All unit paved surfaces have numerous joints between the pavers; and even with a perfect installation, these joints can hinder snow removal. Concrete paving block with a heavy-duty base is often used in areas where vehicular traffic is expected or for commercial and public use areas. If installed on a proper base, brick can be used in these circumstances. To create an antique appearance, particularly with concrete paving block, pavers are tumbled in large drums to break off corners and sharp edges. This look gives the appearance of paving that is aged or has been in place for many years. Permeable unit pavers are standard units that have either truncated corners or wider spacers to create a wide but stable joint between units. Compared to traditional unit pavers, permeable pavers significantly increase the infiltration of water through the surface of the paving.

Typically used in turf locations where compaction from foot or vehicle traffic is a problem, open-cell pavers can be constructed of precast concrete

Figure 22-2 Interlocking concrete paving block is an excellent choice for both pedestrian and vehicular traffic.

Figure 22-3 Brick paving provides rich colors and textures.

or plastic rings attached to a mesh. Resilient pavers are manufactured from recycled materials, and the installation techniques are similar to those for precast concrete pavers. Resilient pavers have applications where softer surfacing is required, such as on playgrounds. Although priced higher than other unit paving choices, resilient pavers can be used to provide a surface with a "softer" feel. This type of pavement would be appropriate for certain walkways and play courts (see Chapter 35, "Resilient Playground Surfaces").

Stone

Patios of limestone, bluestone, sandstone, granite, porphyry, cantera, or slate are an aesthetically pleasing paving surface (Figure 22-4). The intricacy of shape, form, and pattern suggests a high level of craftsmanship. Concurrent with increased aesthetics for stone paving are higher costs and higher skill requirements for installation. Material availability has an impact on price, with lower costs in areas where stone is commercially quarried and available. To reduce the high cost of natural stone, designers are also relying on recycled stone and manufactured substitutes that provide the appearance of stone. Some of these products include manufactured bluestone, recycled cobbles, recycled granite, and other stone reclaimed from construction and building demolitions.

Balancing the high costs just mentioned are moderate levels of strength and concerns about safety, particularly for stone paving in public areas. Maintenance and safety issues are similar to those for unit pavers. Stone paving has joints that can be irregular, creating safety hazards for pedestrians and making snow removal difficult. Any base failure or water below the paving can force the stone out of position, amplifying the problems. Only under certain circumstances (some granite units and cut stone placed on permanent base) is stone paving

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Figure 22-4 Dry-laid stone paving provides texture and a natural feel.

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Figure 22-5 Recycled concrete may be reused as a dry-laid paving surface.

recommended for vehicular traffic or paving in commercial projects and public areas.

Although the material for stepping stones can be selected from any paving choice, **flagstone** is used most often for informal walkway applications. Unmortared stepping stones placed on earthen or thin, granular bases are inexpensive; however, these are suitable only for private uses.

Recycled Concrete Paving

Concrete that has been broken into random-sized chunks and removed from a site can be reused as a dry-laid paving surface (Figure 22-5). For concrete to be recycled, it must be broken into pieces that are the correct size. Pieces less than 8 inches across in the smallest dimension will be difficult to place and to walk on, whereas pieces larger than 2 feet in the largest dimension will require at least two people to lift them. The larger pieces pose the greatest challenge to accurately set and adjust. If recycled concrete has steel reinforcement, that reinforcement will need to be trimmed flush with the paver's edge and the irregular edges will need to be smoothed with a sledgehammer. In preparation for recycling, trim pieces so that they are the correct size and have edges split as close to vertical as possible.

Mortared Paving

Mortared paving has a cement/sand mixture, called mortar, that spaces and supports the paving materials (Figure 22-6). Mortar in the joints between materials provides even spacing and prevents water penetration. Paving materials that can be installed as a mortared surface include tile, brick, and stone, particularly random-shaped stone. Mortared paving can be durable if properly installed and maintained. If allowed to penetrate the joints of the surface, water will eventually damage the paved surface. This problem is far more damaging in areas of the country that experience freezing temperatures. Aesthetics of mortared surfaces are good, but installation is difficult and costly when compared to other paved surfaces. With proper maintenance, a

Figure 22-6 Mortared stone provides a rich, stable stone paving.

mortared surface has a strength rating in the fair range. Surfaces that are improperly installed or poorly maintained or that use improper base materials may suffer from durability problems. A maintained surface is typically safe, but surfaces that are not maintained can cause those who walk on them to trip.

Granular Paving

Typically found in drives, walkways, trails, and, occasionally, outdoor living areas (Figure 22-7), granular paving includes such materials as crushed stone, crushed brick, pea gravel, and other permanent materials available as small pieces. In certain applications, soil and finely ground aggregate are bound using soil stabilizers to create paved surfaces. A variation of the soil stabilizers are epoxy resins that are blended with a variety of aggregate types and then installed using hot-mix asphalt equipment to form pathways and parking areas. Depending on the geographic region, granular materials sold as decomposed granite (or D.G.) fines, blue fines, gold fines, ¼ minus, granite sand,

Figure 22-7 Granular paving provides functional walkways.

and similar headings that include pieces of crushed stone ⅜-inch in size or smaller can be used for granular paving surfaces. For decorative areas, a wide selection of pebbles and smaller stone up to ½-inch can be placed to create a flexible yet attractive surface.

Selection of such materials requires a careful review of use and placement. Thin applications of granular paving make the installation less durable. Although they provide consistent texture and color for aesthetic applications, granulars do not suggest a high level of craftsmanship. Installation is easy and costs are typically low, and these are reasons why granular materials are often used in residential settings. Granulars with permanent edgings such as stone, brick, or concrete balance cost and aesthetics for walkways and outdoor living areas. Safety problems such as washouts, poor traction, and sharp edges exist for some materials. Maintenance is moderate to high for granulars, with the constant refurbishing of surface materials, edging upkeep, leveling, and cleanup after materials that track inside. Durability of fine granular surfaces can be improved by adding soil stabilizers. Granulars are typically not suitable in areas where erosion and public safety are concerns.

To improve permeability of water without compromising the ability to support heavy traffic, a wide range of cellular (or plastic grid) paving options have been created. Typical application of cellular paving would be service access points, emergency access, and overflow parking areas. Although it requires base preparation similar to other paving options, cellular paving places a layer of plastic rings or grids over the base and fills the voids with granular materials or turf. These plastic cells provide adequate strength to support vehicles while allowing surface runoff to filter through the paving surface.

Asphalt

Hot mix **asphalt** paving is used for roadways, drives, walks, and trails in the landscape. Versatile installation also makes asphalt useful as a base material for unit pavers. Composed of bituminous materials mixed with aggregate and sand, asphalt is heated to high temperatures to improve its workability and bonding. Installed while hot, using special spreading and compaction equipment, asphalt provides a functional wearing surface for foot and vehicular traffic. When properly installed over a stable base, asphalt can be relatively free from maintenance. Because of the limited aesthetics of the surface, asphalt is seldom used when a high level of craftsmanship is desired. Cost for asphalt depends on labor and material prices. Installation requires the use of highly specialized equipment and experienced crews. A variation of asphalt, cold mix has a similar composition but is used for patching potholes in paved surfaces. Because of the specialized equipment and installation procedures required, asphalt installation is not covered in this text.

ACCESS TO SITE AND DELIVERY OF MATERIALS

Once the project has begun, workers will need access to the site, and materials must be delivered to the site. Ideally, this access route will not cross over the prepared base of paving surface. Plan a route that provides access to the site by equipment as large as a concrete truck and as small as wheelbarrows and foot traffic. Unit pavers and granular paving material typically require delivery by large vehicles, flatbed trucks with loading cranes and, dump trucks. Skid-steer loaders and other moving equipment must have a route and room to operate as they deliver the materials or move those materials from stockpiles.

Labor and time can be saved if installation is planned for effective delivery, pick up, and removal of pavers and granular materials. “Effective” here means that the delivery, pick up, and removal of pavers and granular materials will not disturb completed installations, will not unduly delay the installation process, and can be completed without repeatedly returning for partial loads. For example, to speed the selection process when laying stone, contractors can designate a staging area where they can lay out several pieces of stone. Also, having a stockpile of granular material delivered to the site will save labor and time to have extra material picked up and removed. Locating an area to stockpile additional granular material may also benefit the client who could use the material for future refurbishing. On sites where access is difficult, it may be more cost-effective to have the concrete pumped to the delivery location. A pumping rig is positioned on the site where delivery equipment can access it. Concrete is then pumped through ground or overhead tubes to where it is needed. This adds costs for pumping but saves in labor and

allows concrete to be placed in locations that could otherwise not be paved.

PROJECT LAYOUT

Measure and place project location stakes and stringlines to guide the initial excavation. Painting or "chalking" (pouring a line of base path chalk) the limits is often easier than fighting with strings. Mark and excavate an area that goes 1–2 feet beyond the actual paved area to create an apron that can be used for construction and later used to gradually match the new paving to the existing grade.

Once paving has begun, you can achieve the highest quality and efficiency by moving through the project without pause. This requires that materials be delivered and prepared for installation. Any equipment that will be necessary for site preparation or cutting should be present at the proper time.

STRIPPING SOD

Remove sod from the entire construction area and recycle it to bare areas of the yard or compost the sod. Once you strip the sod, remark the project edges and identify project elevations, typically with grade stakes.

MATCHING EXISTING CONCRETE AND ASPHALT SLABS

When new paving abuts old cast-in-place concrete slabs or asphalt paving, it is beneficial to prepare a straight edge against which new paving is placed. To prepare the edge of existing pavement, mark and cut a straight line using a cutoff saw or mobile concrete saw. A dry diamond or carborundum blade is required to cut most paving materials. The cut should be vertical and through the pavement. Chip away rough edges with a chisel. Excavate old pavement and prepare the edge for new pavement. Concrete paving may also require joining old paving to new paving (see Chapter 23). If asphalt is cut, you may apply a spray tack coat to improve adhesion of new pavement.

EXCAVATING

Using the most efficient means available, dig out excess soil until you achieve a uniform depth over the entire paved area (Figure 22-8). For paving with an edging, the base excavation should extend 1 foot beyond the finished edge to support the edging. Check the depth and cross-slope, often by running a string between grade stakes and measuring down with a tape measure. To avoid a less stable fill area, avoid over-excavation. Stockpile the excess topsoil for use in backfilling edges (Figure 22-9).

Actual depth of the excavation depends on which surface material is used, the subgrade soil conditions, and the weight of the traffic on the surface. Table 22-1 suggests appropriate base depths based on the type of paving material and the type of traffic on the surface. To determine excavation depth, add the paver dimension, the thickness of any sand or mortar setting bed, and the thickness of the base. If the paving material is designed to be seated, or vibrated into the **setting bed,** as is the case with

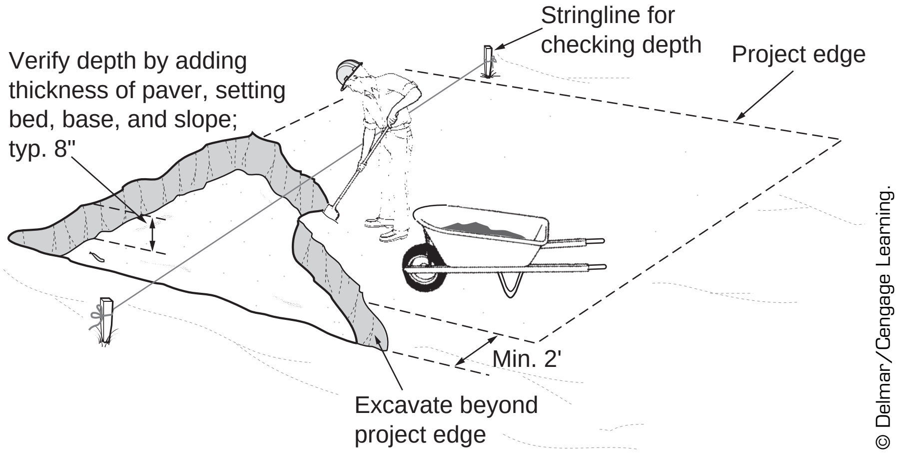

Figure 22-8 Excavating a site for paving.

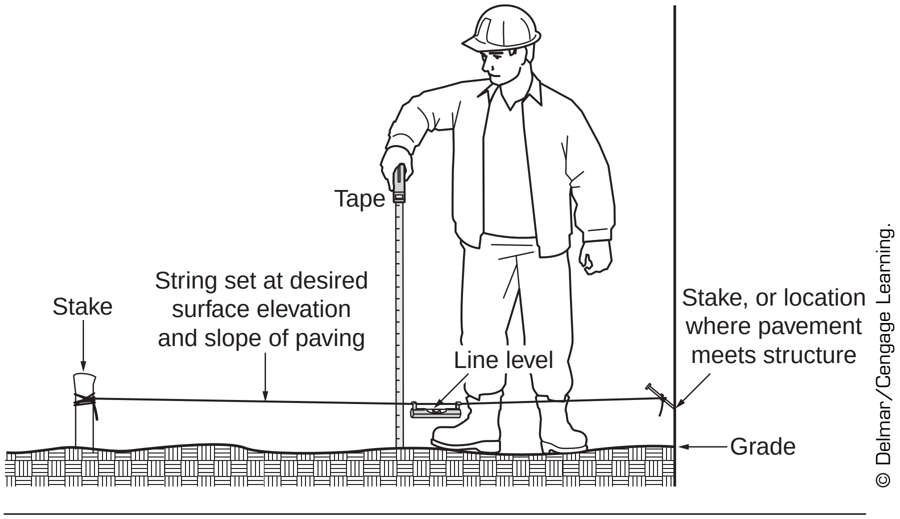

Figure 22-9 Checking the cross-slope and depth of pavement excavation.

some unit pavers, subtract the manufacturer's recommended seating dimension (typically ¼ inch) from the excavation depth. Verify base requirements with a design professional or manufacturer for the situation. Poor soils require additional depth or alternative base treatments as noted in Chapter 11 and the following paragraphs.

Rough Grade Preparation

Because paving creates relatively flat surfaces with slight slopes introduced for drainage, creating the proper grade is important. Attempting to accommodate slopes that are too steep leads to difficult installation and surface slippage. On such slopes, you may have to install retaining walls to create a slope that is stable and flat enough to pave. On the other hand, slopes that are too flat result in future problems with water drainage. Grade also directs surface runoff away from structures. A slope of 2% (¼ inch fall for every 1 foot of horizontal distance) is recommended for most paving. Although flat cross-slopes (even sloping the entire surface one direction) are the easiest to construct and the best for drainage, you may have to occasionally introduce variable cross-slopes, or warping, in the pavement to accommodate drainage and to match existing elevations. Warping makes installation difficult, but warping is preferable to poor drainage.

Subsurface Utility Work

Paving is not easily changed; hence, other work that might affect an installation should be completed

Table 22-1 General base thickness chart for various paving materials

Paving Type	Pedestrian Traffic	Occasional Vehicles	Auto Traffic	Heavy Traffic
4-inch concrete slab	3 inches	4 inches	6 inches	8 inches
Interlocking paving block with 1-inch sand setting bed	4 inches	8 inches	8 inches	16 inches
Clay paving brick with 1-inch sand setting bed	4 inches	8 inches	8 inches	Not recommended
2-inch unmortared stone with 1-inch sand setting bed	4 inches	Not recommended for this traffic type		
2-inch mortared stone with 1-inch mortar base	4 inches	Not recommended for this traffic type		
3-inch granular paving	3 inches	4 inches	Not recommended	

The depths are general recommendations from manufacturers. Verify actual base depths required for a project with an engineer.

before paving begins. All underground utilities in the area should be in place, and trenches below the paving should be backfilled and compacted. Empty conduit can be placed if future utilities are anticipated. See Section 4 for a discussion of related utility work.

Subgrade Problems

The best subgrade is undisturbed, sandy-clay soil. Placing base on topsoil or unconsolidated soils can expose paving to subgrade movement. Therefore, consider removing unsuitable materials and backfilling with base material. Consult a soils engineer when there is uncertainty about the subgrade's condition.

Soil Problems. Occasionally, subgrade soil problems must be corrected. Identify problem soils by looking for areas that are wet, spongy, or sink under foot traffic. Also look for soils that have leaf and twig debris or a foul smell. If these signs are present, excavate these soils and replace them with base material. If the depth exceeds 1 foot, special subgrade restoration will need to be designed by the soils engineer.

Drainage Problems. If water stands in an area or seeps into the area excavated for the base from any direction, chances are the site has subgrade drainage problems. Sloping the subgrade the same direction as the surface assists in removing water. During dry seasons, there may be no indication of water; however, mucky, gray soils that smell like sewage indicate drainage problems. Water that percolates through the paving surface is usually minimal and is expected to be absorbed into subgrade soils. If you suspect subsurface drainage problems, the most effective solution is to install subgrade drainage tile in the wet area. Place a 4-inch perforated plastic drain tile wrapped in a geotextile sock in 1-foot deep trenches spaced 5 feet apart (Figure 22-10). Run the trenches the length of the paved area from the high side to the low side. Connect each tile to a collector tile at the paved area's low end and outlet this tile to a drain, storm sewer, or swale. Backfill and compact each trench with base material.

Grade Preparation and Subgrade/ Base Compaction

Undisturbed earth is preferable for subgrade. If a paving installation is constructed in an area where the subgrade has been disturbed, proper compaction is necessary. If required to create a flat surface for paving, walls should be constructed in advance and the backfill compacted to meet base specifications. Also, all heavy traffic (deliveries of building materials, etc.) through the area should have ceased, or alternative routes should be established to protect the paving from traffic for which it was not intended.

Compacting subgrade in most small landscape operations is typically done using a vibratory plate compactor. Alternatives to a plate compactor include

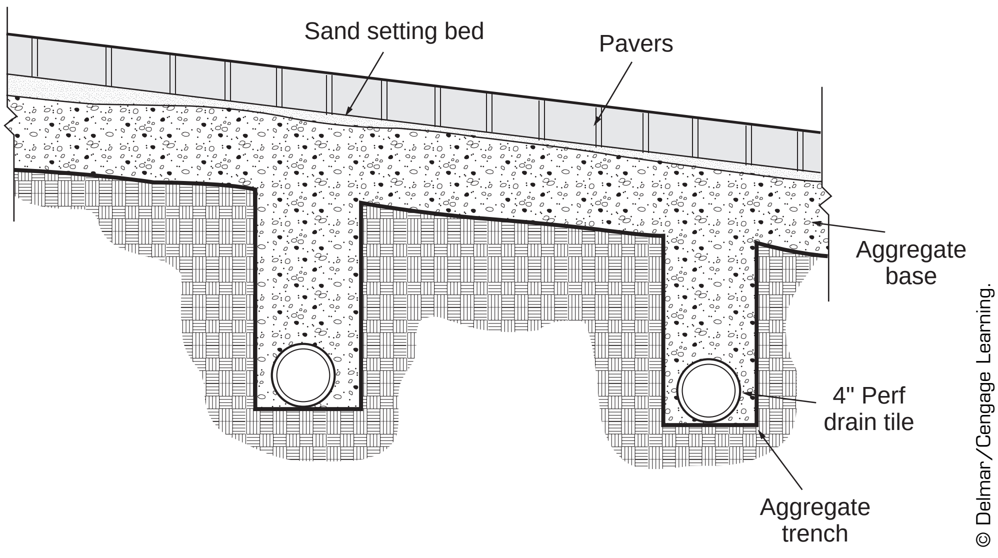

Figure 22-10 Cross section of tile placement to drain paved area base.

a rammer or vibratory roller. For best compaction results, select a plate compactor that has a compactive force of 5,000 pounds at 75–90 cycles per second. A vibratory plate compactor operates similarly to a self-propelled lawn mower. Start the engine and steer using the handles. To work tight corners, lift the handles vertically and twist the plate compactor to change direction. If the plate compactor has multiple operation settings, use the high-force/low-frequency setting for subgrade and base compaction. Always run the plate compactor at full throttle. Utility trenches under paved areas should be compacted in layers, or lifts, of 6 inches as the trench is backfilled. Small areas that cannot be accessed by a plate compactor should be hand-tamped.

To verify that the paving's foundation is stable, testing the compaction of subgrade and base is recommended. Engineers use measuring standards for determining if a material has been compacted to its maximum density, and the most commonly used standard is modified Proctor density. Projects performed under contract may require lab testing of soil and base samples to verify proper compaction. For projects without construction documents, obtaining Proctor test results may be cost-prohibitive. However, contractors can perform an informal test of base firmness. They can observe if heavy equipment operated over the surface leaves any rutting or depressions, which indicate incomplete or improper compaction, or an unstable subgrade.

INSTALLING GEOTEXTILE

Unit pavement, dry-laid stone, and granular paving projects may be designed for placement of a geotextile below the base to assist in maintaining separation between the base and subgrade soils. Select appropriate geotextiles with thermal spunbond or woven construction. Do not use weed barrier or geogrid to substitute for geotextiles. Place the geotextile on the subgrade and extend the material up the sides of the excavation and any structures around the entire perimeter of the project. To keep it out of the way during construction, staple the geotextile to a structure and then trim the excess after placing the pavement. If the area requires more than one piece of geotextile, overlap the joints by at least 18 inches.

INSTALLING BASE MATERIAL

Choice of base material varies from one geographic region to another; however, in most areas, a base of granular crushed stone ranging in size from dust to pieces that pass a ¾-inch sieve is preferred. In some areas of the country, this material is called ¾-inch roadstone or 57 rock. A more formal description is National Stone Association Class 2 aggregate. When compacted, this blend usually provides adequate support for residential paving projects. Base material should have enough moisture that a handful of it holds together when squeezed. Dry material requires wetting during installation to compact properly.

Spread base material in 2-inch lifts over the paving area and level the lift with a rake or **screed** (Figures 22-11 and 22-12). Remove all clumps of soil or other debris and compact with a plate compactor. Make two compaction passes with the plate compactor at different angles. You obtain the best compaction results by working from the outside edge to the center, from a lower side to a higher side, or by working up and down slopes.

Check the elevation of the base after you install each lift. The slope should not have deviations of more than ⅜ inch from desired grade and should reflect the slope desired for the surface. To level the base for an evenly sloped area, first check along a structure or existing edge for proper elevation. From that edge, check the sides of the base installation for proper grade. Between the sides, use a stringline or straight board to check for high or low spots across the center. You can also check the base by rolling a pipe over the surface and looking for bumps or depressions. Mark any unleveled areas with paint. Add a thin layer of base if low, or scratch out excess base with a rake if high. Recompact and verify for proper base grade. Repeat the process until you complete the base. Most unit pavers, dry-laid stone, and granular pavers will require that some material be placed along the edge to hold the pavement in place. This edge restraint can also serve as a decorative treatment for concrete and mortared paving material.

INSTALLING EDGE RESTRAINTS FOR PAVED SURFACES

Depending on the choice of paving, some edging materials should be placed after the base has been installed and before the setting bed is installed. Many edgings require special construction techniques and will seriously disrupt the pavers that have been installed. Other edgings work better when

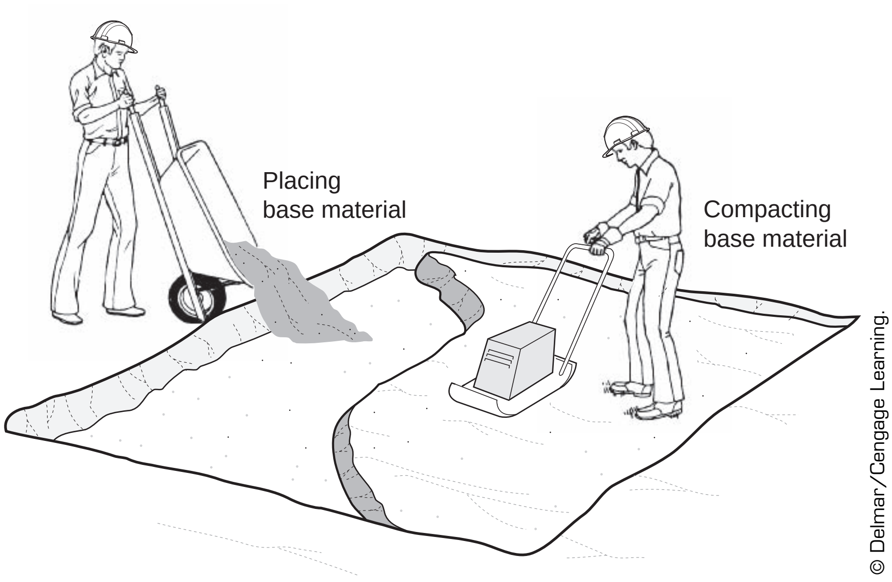

Figure 22-11 Placement and compaction of granular base.

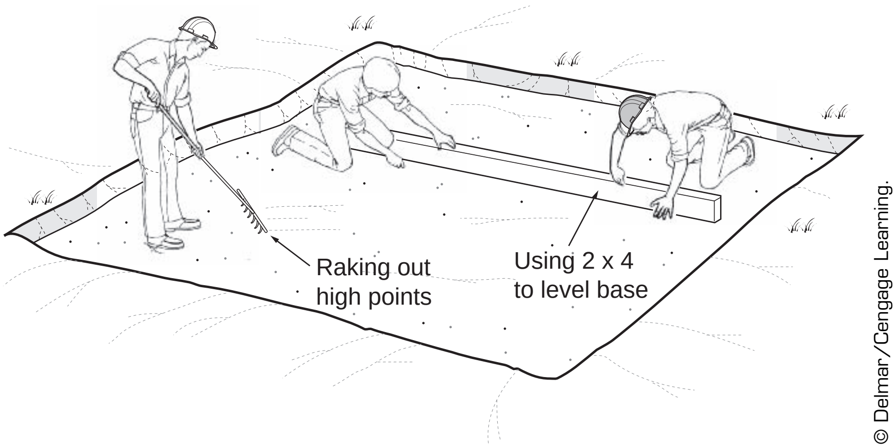

Figure 22-12 Leveling the base.

installed after the majority of the pavement has been placed. These edgings work best when installed before the partial pavers have been cut and installed. The common types of edgings in landscape pavement and their installation techniques are identified in the following paragraphs (Figure 22-13).

Stone (Pre- or Postpaving Placement)

Wall stone makes an acceptable edging for dry-laid stone and clay brick. If used elsewhere in the project, the stone carries the design into the paved areas. Unless buried at least 8 inches, stone edging is not recommended for surfaces where the pavers must be seated. To install stone, select a heavy wall stone material, typically 4–8-inches wide. Longer stones make a more stable installation, with shorter stones used to turn corners. Excavate a trench around the area to be paved, and set the stone level with the desired finish grade for the patio. If desired, a strip of landscape fabric can be placed under the stone to reduce weed growth between blocks. After placing the stone, backfill and compact around the outside edge and build paving layers up on the inside (Figure 22-13A).

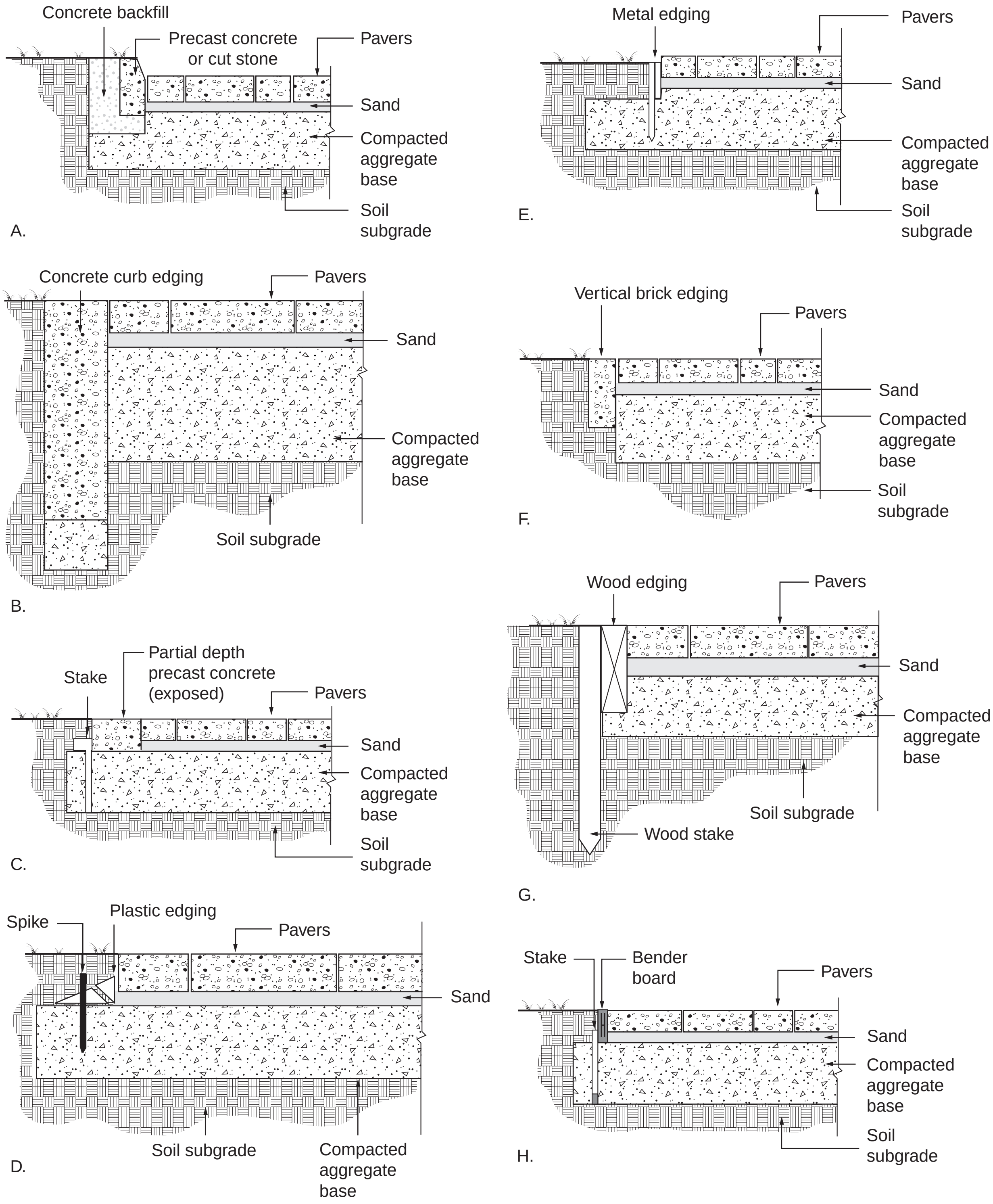

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Figure 22-13 Pavement edge restraints.

Concrete Curbing (Prepaving Installation)

Concrete curbing makes a durable and long-lasting edging for a paved area. To install curbing, begin by excavating a trench along the perimeter where the curb is to be placed. Make sure the depth is correct for the thickness of the curbing selected. If the trench is too deep, fill with a granular backfill. Construct forms (see Chapter 23, Concrete Paving) with the top of the forms set at the finish elevation of the paved area. Fill with concrete and finish (Figure 22-13B).

Precast Concrete (Prepaving Installation)

Precast concrete edging units can be used to secure most unit pavements. Install prior to installation of the setting bed and paving but after the base has been installed. Mark the alignment of the edging and set the blocks in place directly on the prepared base. If openings for spikes are available, secure into the base using 10-inch spikes. Fill any voids between paver and edging with base material. Backfill and compact the area outside the paved area prior to placing the pavers (Figure 22-13C).

Composite Materials and Bender Board (Prepaving Installation)

Several composite materials can be used as edge restraints in applications that are straight or have large radius curves. Having a limitation to bend, many composite materials will not bend at all or, if shaped into radii tighter than 20 feet, will break. If a wood look is desired but the installation is designed with curves and radii, **bender board** may be an appropriate edge restraint. Manufactured of thin overlapping strips of lumber, bender board allows installation in radii as small as 5 feet.

To install composites or bender board, excavate a 6-inch wide trench slightly deeper than the edge restraint width along the entire alignment of the pavement edge. After excavating the trench, remark the exact pavement edge using marking paint. Install treated 12-inch long 1 × 2 stakes every 18 inches along the alignment of the edge restraint. Drive the top of the stakes at least 1 inch below the top of the desired elevation of the pavement surface. Beginning at one end, hold the restraint to the stakes and drive galvanized 10d nails through the edger into the stake. You can substitute 2-inch, rust-resistant screws for nails to minimize disturbance of the stake. If necessary, adjust the elevation of the stake before fastening. Trim the edge restraint to the proper length before installing the final section. When sections require joining, drive stakes at each end of abutting pieces of restraint. Some composites are manufactured with interlocking joints. Fill pavement base against the inside of the restraint and place pavement. When you have installed the pavement, fill and compact the outside of the edge restraint before seating pavers (Figure 22-13H).

Plastic (Pre- or Postpaving Installation)

The current standard for concrete paving block is the use of flexible plastic **edge restraint** specifically designed for this application. This edging is notched so that it can be bent to very tight radii, is installed with metal stakes or spikes, and is not visible after installation. Install this edging either before placing the setting bed or after completing installation of full pavers and before cutting and placing edge pavers.

Prepaving installation requires marking the alignment of the pavement edge. Place the edging firmly on the base and secure using stakes or 10-inch spikes. Trim edging to fit. Joints should be as tight as possible, with gaps covered with geotextile to prevent setting bed sand from seeping. Use this edging as a screeding guide for setting bed placement.

Postpaving placement should begin by using a steel trowel to cut a vertical edge down from the pavers, through the setting bed sand, to the base. Scrape away this sand. Beginning at a structure or a corner, take a length of the edging and, with minimal disturbance to the paved surface, tuck the notched side of the edging under the setting bed. Placing the edging directly under the setting bed and on top of the base will assure that enough of the paver is covered to hold it in place. Slowly work the edging under and tightly against the pavers along the length of the side (Figure 22-14). If necessary, tap edging lightly with a hammer to force it under the pavers. Verify that at least half the length and thickness of each paver is covered with edging, and then trim off extra edge restraint. Place and drive metal edging stakes or 10-inch spikes through the openings and into the pavement base at 1-foot increments along the edge. Driving the stake or spike at a slight angle toward the pavement base will draw the edging in tighter against the pavement. Fill any voids between the edging and paver

Figure 22-14 Installation of plastic edging after placement of pavers.

with base material. Backfill and compact outside the edging before seating pavers (Figure 22-13D).

Metal (Postpaving Installation)

Metal landscape edging can be used to hold the pavers in place. Install metal edging after all pavers are cut and placed. Measure and precut pieces of edging for each side of the paved area so that the entire perimeter is covered. Using a steel trowel, cut the setting bed sand away in a vertical edging along the pavers to the base. Starting at a corner, hold the metal edging 1 inch below the top of, and against, the sides of the pavers. Through the notches in the edging, drive edging stakes into the base at 1-foot increments along the edge. Backfill outside the edging and compact before seating pavers (Figure 22-13E).

Vertical Bricks (Postpaving Installation)

This method provides limited stability and works best with brick pavement and pavements that are not seated. Vertical brick edging should be installed after all bricks have been placed, including half and partial brick. To install vertical brick edging, carefully excavate a 9-inch deep trench along the entire perimeter of the paved area. The trench must form a vertical edge going straight down along the outside of the pavement. Place a small amount of granular material in the trench and place brick vertically against the pavement. By adding or removing granular material, adjust the height of the edging so that it is flush with the paved surface. Backfill outside the edging and compact immediately after placement. Using a small amount of mortar instead of soil for backfill will make the installation more stable. When the mortar hardens, cover it with soil (Figure 22-13F).

Wood (Pre- or Postpaving Installation)

Although a wood edging provides restraint, it warps, decays, and heaves and, hence, should be considered only a short-term option. Cutting and filling of partial pavers should be completed after this edging is installed. To install wood edging, select a decay-resistant, dimensioned lumber and cut it to length for each side of the paved area. Larger-dimensioned lumber, such as 4 × 4 or 6 × 6, reduces problems with warping, but you may also use a 2 × 6 for short-term installations. Re-treat cut ends with a wood preservative. Excavate a vertical trench 6 inches deep along the outside edge of the paved surface. Place the wood edging in the trench tightly against the pavers. Drive treated 2 × 2 stakes every 2 feet along the outside of the edging. Fasten stakes to the edging using galvanized nails or 2½-inch, rust-resistant screws. Backfill outside the edging and compact (Figure 22-13G).

CHAPTER 23

CONCRETE PAVING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Form a concrete pour.
- Form concrete stairs.
- Install joints in a concrete pour.
- Pour a concrete slab and stairs.
- Finish a concrete slab and stairs.

Concrete can be placed in any shape or form, can be colored or stamped to look like another material, is cost-effective, and is durable as a paving surface. For these many reasons, concrete is a staple in the world of landscaping. Countering the versatility of concrete is the challenge of installing it. Although competing paving materials also have their challenges, the preliminary work required to ensure a successful concrete pour is unmatched by that of other paving types. This chapter describes the forming, pouring, and finishing of a typical concrete installation. Included in this chapter are instructions for forming both flatwork and stairs, along with information about typical finishes available for concrete.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials and Site Preparation for Paving, Chapter 22

PLANNING THE PROJECT

Preparation of base for concrete projects should be completed according to the instructions provided in Chapter 22.

Concrete Finishes

Several choices are available for concrete finish textures, and their procedures and timing differ depending on the choice. The following list explains common choices for finishes. Instructions for creating each finish are listed in the "Surface Texturing and Finishing" section of this chapter.

- **Float** Finish. Using the float as a finish produces a slightly rough surface that provides adequate traction. The float finish can be applied parallel to edges of the slab or joints or applied in an arcing swirl texture.
- Broom Finish. A stiff-bristled shop broom texture provides an excellent nonslip surface. When combined with the bordered segment approach described for a float finish, the broom finish creates an attractive appearance (Figure 23-1).
- Colored, Impressioned Finish. Concrete can be colored and stamped with special forms to create a surface that looks like stone, granite, or brick. Color can be added to the concrete while it is mixed or sprinkled dry on fresh concrete and troweled into the surface.


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Figure 23-1 Broom finish for concrete walkway.

Expert concrete finishers can also add color as a mortared topcoat over a slab.

- Seeded Exposed Aggregate. Exposed aggregate surfacing can be installed by sprinkling pea gravel or other fancy stone on a smoothed, wet concrete surface and using a trowel to embed stone in the top of the slab (Figure 23-2). After the concrete begins to dry, it is "scrubbed" with a hose and broom to remove the top film of concrete to "expose" the aggregate that was embedded earlier. One recurring maintenance problem with an exposed aggregate surface is that moisture can work under the aggregate and break it from the surface.
- Integral Exposed Aggregate. A variation on the previously described aggregate surface is an integral exposed aggregate. The problem of surface deterioration is minimized by mixing the special aggregate right into the concrete at the plant. Instead of being a weak addition to the surface, the aggregate is mixed completely into the full slab. The finished product of this surfacing is obtained by scrubbing the slab before it sets or sandblasting the slab after it dries.
- Rock Salt. This pockmarked surface is created by sprinkling rock salt on a finished surface and rinsing it after the curing process begins. This finish provides a rustic texture that looks interesting with colored concrete. Rock salt finish is not recommended in areas where the surface can be damaged from water that freezes in the indentations (Figure 23-3).
- Acid Etch. This slightly roughened surface is created by acid eating away the smooth


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Figure 23-2 Seeded exposed aggregate concrete finish.

Figure 23-3 Rock salt concrete finish.

trowel finish on a slab. Although a good surface for traction, acid tech requires treatment of the entire surface because the acid is difficult to spot apply.

- Cobbled Concrete (Traffic Medians). To warn drivers of improper entry, large rounded stone can be imbedded into concrete to create a rough cobbled surface (Figure 23-4). This finish would not be appropriate for pedestrian walkways.

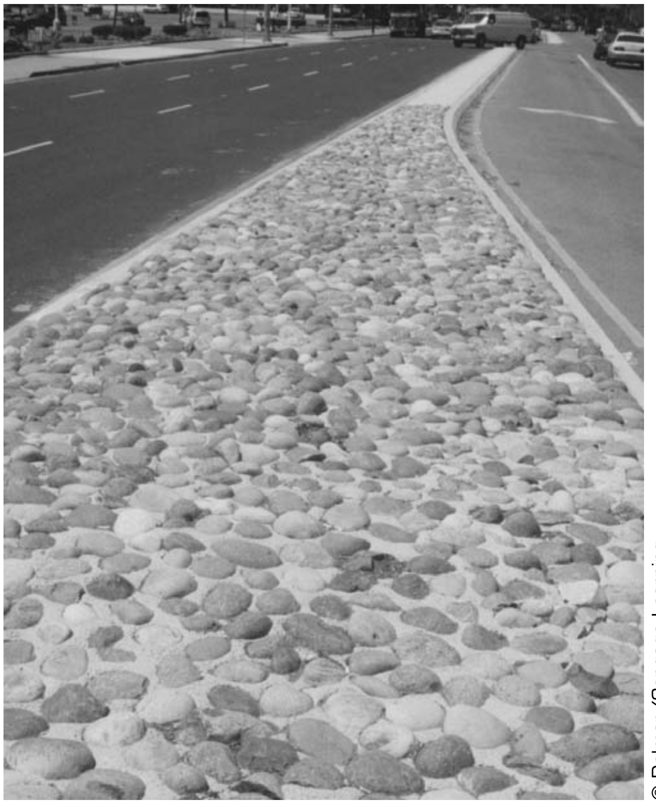

Figure 23-4 Cobbled concrete surface for traffic medians.

Planning Concrete Delivery and Pouring

Concrete pours require extensive route planning. When preparing for a pour, consider how the mixer will gain entry to the site, where the pour should begin and end, and how access will be gained to finish the surface.

CAUTION

It is imperative that the route for the mixer will not cause it to contact overhead utility lines or damage underground installations or valuable plant material.

If the mixer can access the entire pour, then the need to transport concrete by wheelbarrow is eliminated. At times, it may be beneficial to leave a section of forms out and have the mixer drive across the base to access a remote corner. The many extensions that a mixer carries and the experience of a driver will save a great deal of labor. If route problems are too difficult to overcome, consider pumping the concrete. If access or pumping is not possible, use wheelbarrows. A wheelbarrow can carry 2–3 CF of concrete at a time to the necessary locations. Plan the pour so that an open area at the end of the pour allows screeding beyond the forms. Allow open areas along both sides of a pour to provide space for floating, finishing, and edging. Working against a wall and in corners creates problems finishing the slab from the edge. Verify that the **forms** and base are completely prepared before the concrete arrives.

It is best to order the concrete ahead of time. Even in small communities, concrete suppliers may need a day or two lead time to reserve concrete. Do not expect concrete suppliers to give priority to small orders, especially if you call them at the last minute. Well in advance of the pour, inform the concrete supplier of any special colors, aggregates, fibermesh, or other additives that need to be in the concrete mix. Suppliers may not stock some of these items and may have to order them, adding more time for delivery.

For most landscaping pours, order 4,000 **PSI** (sometimes termed *7 bag mix*) concrete with a 3-inch **slump,** which is a measure of the amount of water in concrete. Water directly affects the strength of concrete—the more water in the mixture, the weaker the slab. Table 23-1 shows the relationship between water/cement ratios and strength for concrete. When placing your order, specify a drier concrete than actually desired. You can add water at the site before placement. Check the consistency when the mixer arrives to see if more water is needed (consistency checks are described in "Placement of Concrete" later in this chapter).

Occasionally, concrete must be mixed in small batches by hand. This operation requires a mixing tub or wheelbarrow that will accommodate approximately 3 CF of material. Mix 1 part cement (one-half bag, approximately 47 pounds), 2 parts sand, and 3 parts aggregate together with approximately 3–4 gallons of water. Work the materials back and forth with a mortar hoe or shovel until thoroughly mixed. A chopping motion works well when attempting to incorporate moisture into dry materials. If additional water is necessary, add it in small amounts and remix until the concrete is of proper consistency.

Table 23-1 Water/cement ratio effect on compressive strength of concrete

	Water/Cement Ratio by Weight			
	0.4	0.5	0.6	0.7
Days after pour	Compressive Strength in PSI (pounds per square inch)			
28	5,800	4,700	3,700	3,000
7	4,000	3,100	2,400	1,700
3	2,500	1,900	1,500	1,000
1	1,000	700	480	250

Notes:

1. Compressive strengths shown are ±200 pounds per square inch (PSI).
2. Data shown is for air-entrained Type 1 Portland cement with moist curing at 70° F.
3. Flexural strength is approximately 79% of compressive strength.
4. Ratio example: 0.4 indicates approximately 1 pound of water (approximately 1 pint) for every 2.5 pounds of cement in a concrete mixture. This ratio will vary with cement and aggregate type.

Source: Adapted from *Design and Control of Concrete Mixtures,* 12th ed., Portland Cement Association.

FORM CONSTRUCTION FOR SLAB POURS

Concrete pours depend on reliable forms. Properly installed forms should be anchored to withstand the force of several dozen pounds of wet material being dumped into them at high rates of speed. Stable enough to maintain the proper grade at the perimeter of the project, forms must also be strong enough to withstand the **screeding** and finishing work that will be performed upon them.

Selection of materials for forms depends on the thickness and shape of the pour, with 2 × 4s providing the most common method of pouring a 4-inch thick, straight-edged slab (a 2 × 4 produces a slab that is 3½ inches thick). Thicker pours may require dimensioned lumber that is wider (2 × 6s or 2 × 8s) or rental of metal forms. Curved sections of a pour can be constructed with forms of ¼-inch masonite siding cut into strips that match the slab's thickness. Additional materials that can be used to form curved sections include ⅜-inch plywood cut into strips the same width as the pour's thickness and bender board edge restraint. Easiest forming is accomplished with metal forming stakes

(Figure 23-5). The stakes are approximately ½-inch round metal with holes along the entire length of the stake. Wood stakes should be 2 × 2 or 1 × 4 material and 8 inches longer than the slab is thick (e.g., 12-inch stakes for a 4-inch slab). Because their double heads make them easy to remove, **form nails** are the best choice for nailing dimensioned lumber forms; however, using deck screws to connect forms reduces the disruption of forms as a result of hammering.

Begin form installation by selecting a starting point at the project's highest corner or next to a structure. Set form material on edge along the outside of the project edge (Figure 23-6). Forming should match any existing pavement grades that abut the new slab (Figure 23-7). At the high end of the form, drive one of the stakes along the outside edge of the form material. Metal stakes should be driven below the top of the form, whereas wood stakes can be left above the form and trimmed later. Drive a form nail through the stake and into the form material, holding the top of the form at the desired elevation for the top of the slab. Placing the head of a sledgehammer on the inside of the form opposite the nail will make driving the nails easier. Repeat this process at the other end of the form, and then adjust the elevation by tapping the stakes down or prying the form up. Adjust until the entire form follows the required grade along the project's outside edge. Add additional stakes along the form every 2 feet, driving and nailing carefully so that you do not disturb the elevation. Once you have the form in place, move to the next form and repeat the process. Be sure the forms butt together tightly. Add an extra 1 × 4 stake behind the joint for stability. Forms work best if the sections are at least 2-feet long, but use whatever length is required to make a continuous connection. Continue forming around the entire project.

Curved forms should be set up in a similar manner. Nail from the inside of the form into the stake because the nail will project into the concrete if nailed from the stake side (Figure 23-8). If using masonite forms, use nursery nails to fasten forms to the stake. Stake curved forms every 1 foot for additional support. In some installations, it may be easier to complete all the straight forms before

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Figure 23-5 Metal stakes for concrete forming.

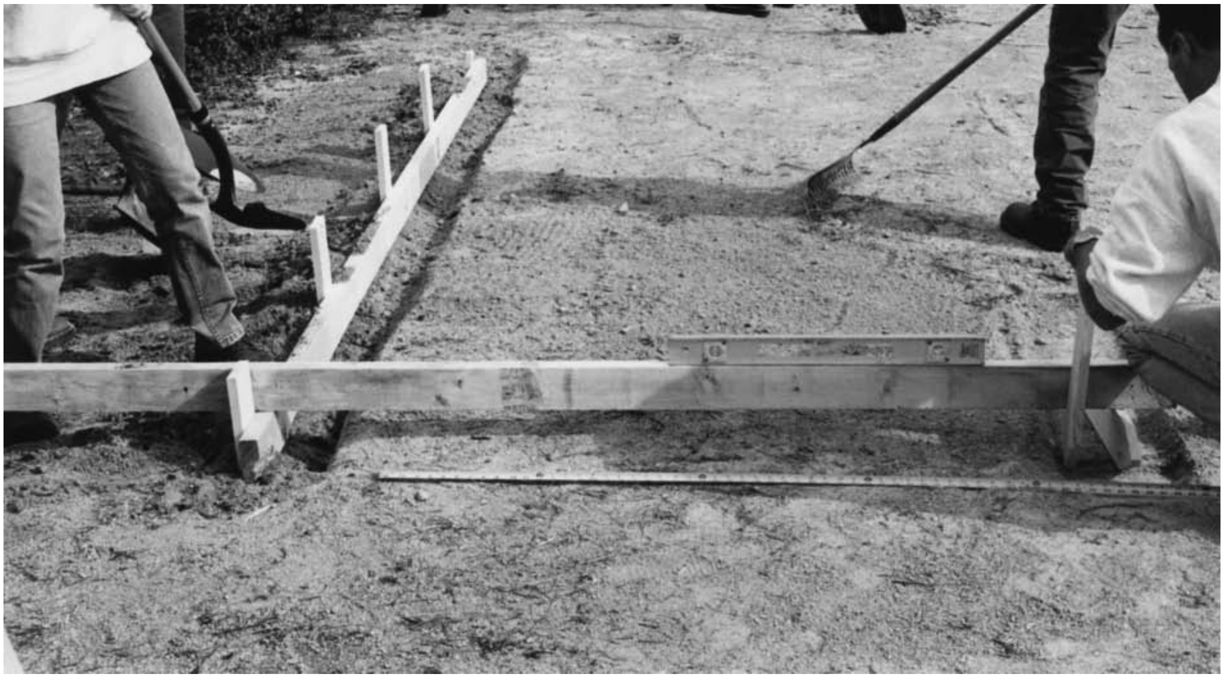

Figure 23-6 Installing and leveling forms for a concrete pour.

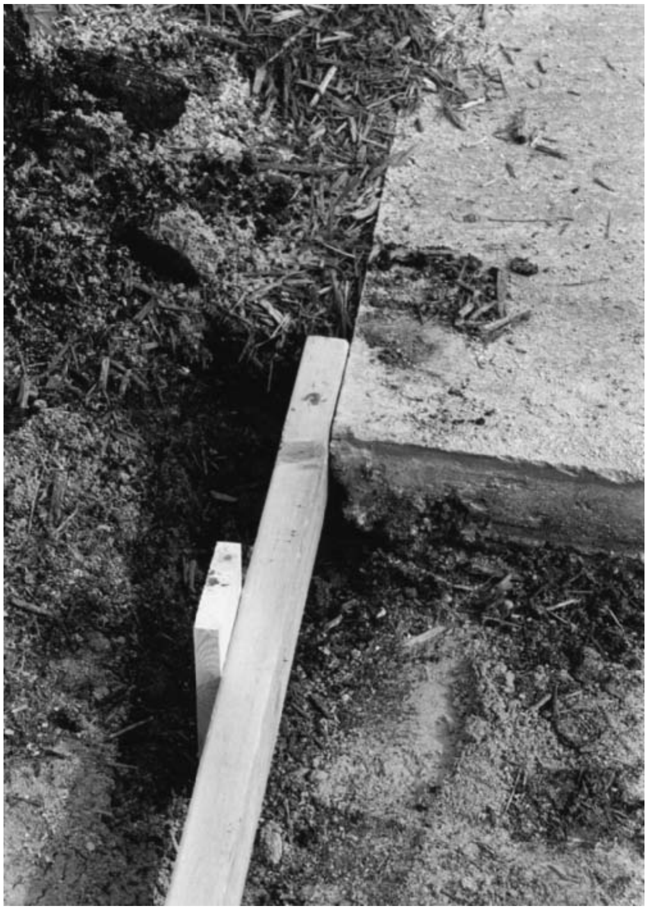

Figure 23-7 Installing form flush with top of adjacent slab.

preparing the curved sections. Because curved forms are a challenge to maintain in correct alignment and elevation during installation, reinforce them at several locations along the form.

At locations where posts or other improvements will penetrate the surface of the concrete pour, an opening, or boxout, must be formed. A boxout will frame this opening and provide identification of an area where concrete should not be placed (Figure 23-9). Frame the opening with form material that matches the slab thickness. Position the box in the correct location and drive stakes into the base on the inside of the boxout. You can determine the correct elevation of the boxout forms by using a string level resting on side forms. Place the string level on the side forms passing over the boxout. Adjust the boxout until the correct elevation is obtained and fasten it to the stakes.

Forming Curbs

When used as edge restraint for paving or as edging for planting beds, **curbs** are formed independently before installation of the project. To install curb forming, cut ½-inch plywood in strips the same width as the curb's thickness. At the back of the curb, drive 2 × 2 stakes every 18 inches along the alignment of the pour. These stakes should extend at least 8 inches into the ground and 8 inches above the top of the proposed curb. Hold the plywood forms against

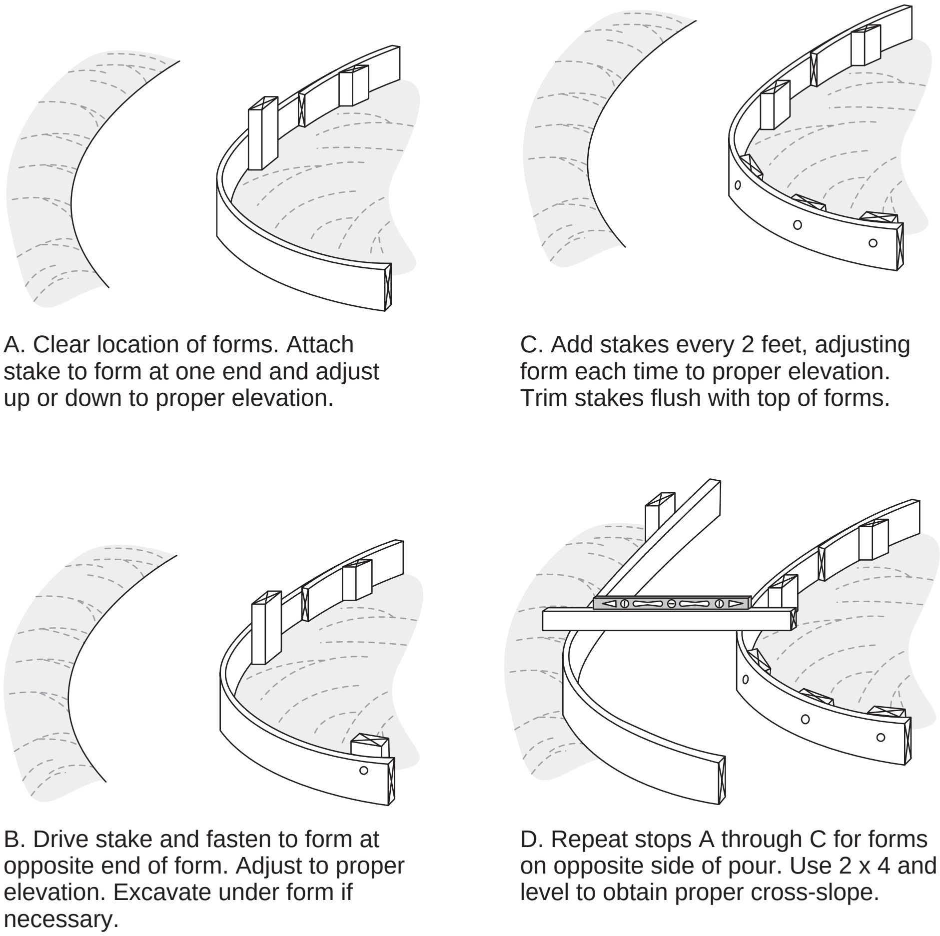

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Figure 23-8 Curved form installation.

the stakes, adjust the forms to the correct height, and fasten them to the stakes using deck screws or form nails installed from the inside of the form through the stake. Place two fasteners at each stake, one at the top and one at the bottom of the form. Repeat the process for staking and placing the form along the front side of the curb. Locate the stakes for the front forms directly across from the stakes for the back side. It will be easier to fasten this side from the outside, through the stake and into the form.

To maintain spacing of the forms, fasten a 1 × 2 spreader between each pair of front and back stakes 6 inches above the top of the forms (Figure 23-10). This will reduce the chances of the forms being pushed apart when the pour begins. Spacers may also be placed inside the forms to hold them in position during the pour. These spacers can be metal flanges or blocks of 2 × 4 cut to the exact width of the pour. Because these interior spacers will remain in the pour, verify that the location does not impact the pour's aesthetics or structure. If any

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Figure 23-9 Boxout to identify area where concrete should not be poured.

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Figure 23-10 Forms for pouring curb.

wiring or irrigation lines need to pass through the curb, cut a piece of 1-inch diameter (or whatever size is needed to accommodate the passing material) Schedule 40 pipe to the exact width of the curb. Position the pipe where the passage is to be located. Drive a nail through the form into the center of the pipe from both the outside of the front and back form to hold it in position.

You can make the forms more stable by driving #4 rebar behind the forms between each pair of stakes. If you need to provide additional stability at the top of the form to obtain a straight edge on the pour, fasten a 2 × 4 set on edge along the form's top and bottom outside edge before it is placed. This will require that the trench for the pour be widened and the stakes placed back 3½ inches from the front and back of the curb (Figure 23-11).

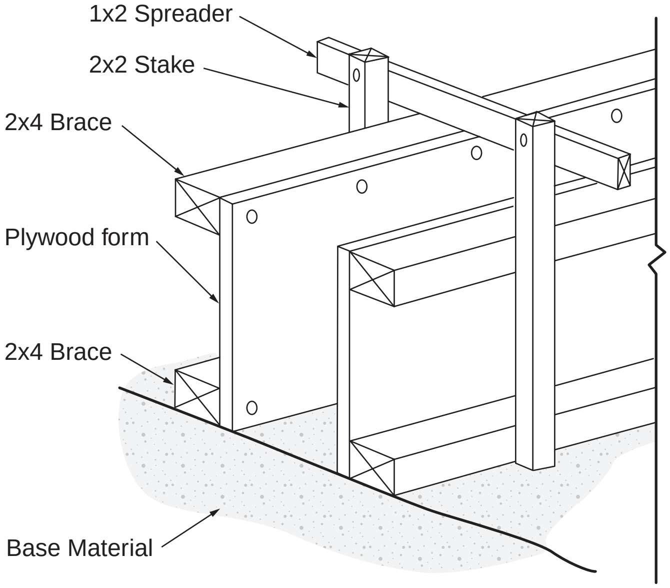

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Figure 23-11 Forming for concrete curb.

Using Wood Headers

Instead of constructing forms that are removed following a pour, contractors can construct forms that remain and serve as expansion joints and decorative edging to the concrete surface (Figure 23-12). These permanent forms, called **headers,** must be constructed with a decay-resistant lumber. Kiln-dried redwood, dried-treated lumber (wet-treated lumber may shrink), and composite materials are available choices. Although wood headers offer aesthetic advantages, many older installations have maintenance problems as the wood decomposes.

Construct wood header forms in the same manner as that used for the previously described temporary forms. In each location where a contraction joint or header is planned, cut forming material, set it on edge, place it flush with the top of the forms, and connect. Every foot along both sides of the header, drive galvanized 16d nails halfway into the header. These nails will project into the concrete and, when the concrete sets, will anchor the header to the slab. When all forming is complete, place wide masking tape over the tops of all headers to protect the lumber from scuffing during concrete placement and finishing. Remove the tape when the pour is complete.

Checking Forms

After forming is complete, check the grade around the perimeter to be certain the elevations are correct. Cross-slopes can be checked by placing a 2 × 4 on edge from the form on one side to the form on the other. A level placed on top should show a slight

Figure 23-12 Wood header between paved slabs.

drop between the sides. Backfill to the top of the outside of the forms and add base material to just below the bottom on the inside. Fill any gaps or openings of ½ inch or less with an expanding spray foam insulation from an aerosol can. Spray the foam in the opening and let the foam expand and harden. Trim any excess to match the form's surface. To keep them from interfering with screeding and finishing, the tops of any stakes that stick above the forms should be cut with a saw.

Leveling Base

Make a **base screed** by cutting a 2 × 4 (or the dimension of lumber selected for forms) 10 inches shorter than the width between the forms. To serve as a handle, at each end of this screed nail a 1 × 4 laid flat, on top, that extends 8 inches beyond the end of the screed. Set the flat handles of this screed on top of the forms and, using a sawing motion, move it from one end of the pour to the other to check the depth of the formed area. Add additional base material and screed inside the forms to ensure a uniform slab thickness (Figure 23-13). Sprinkle a fine granular base material (stone screenings that pass a ⅜-inch sieve) into the areas that look low, and rake material away from any area that appears high. This screed should move easily from one end to the other with the compacted base just below the bottom of the screed. Compact the base using a vibratory plate compactor.

Figure 23-13 Screeding 3/8s minus granular base to a consistent depth. Base will be compacted after screeding.

FORM CONSTRUCTION FOR STAIR POURS

One of the most difficult forming and pouring jobs is the placement of stairs in landscapes. Not only must the setup hold concrete horizontally between forms, but it must also hold concrete vertically. This situation is often compounded by the existence of walls, structures, or other landscape elements that do not provide an open work area. Landscape contractors can construct stairs in the range of 6–10-feet wide and 5 risers, but longer or wider stairs may require special construction techniques beyond most landscape contractors' expertise. Form construction for three types of stair pours are: (1) independent forming, or pours that allow forming the stairs before other improvements are installed; (2) suspended forming, or pours that require forming after improvements such as wall structures are installed and that require hanging forms between the improvements; and (3) a method in which forms are wedged into place.

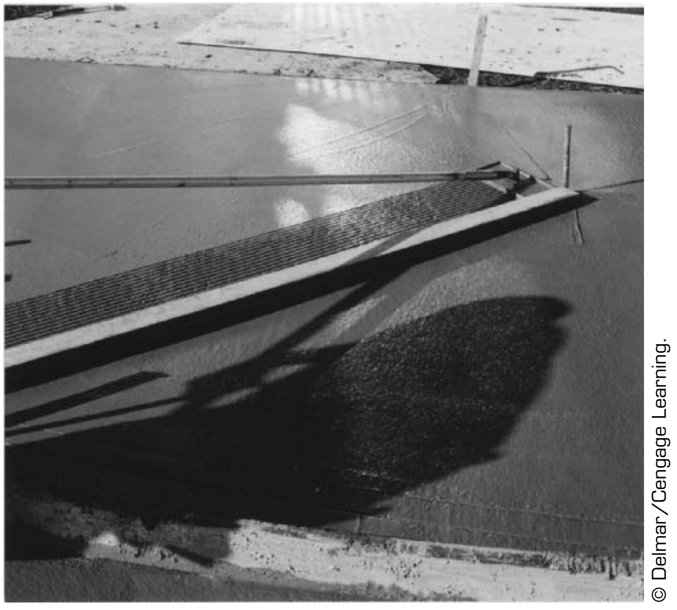

Figure 23-15 Tool used for creating safety markings at the top of a poured concrete ramp.

ADA Stair and Ramp Requirements

A designer will integrate requirements of the Americans with Disabilities Act (ADA) into many projects. When forming and pouring concrete stairs and ramps, contractors will be impacted by these ADA requirements. Among the work impacted is forming the face of the risers, finishing the nosing on stairs, and providing safety markings at the top of each riser or ramp (Figure 23-14).

For example, in compliance with ADA requirements, no open risers are allowed; and the riser cannot be vertical, but angled back at the bottom. Detailed drawings will specify the dimension of this angle, typically 1 inch. When finishing the stair, round the nose of the riser to avoid an abrupt change. Edge a radius as specified by the designer at the nosing of each stair. At the top of risers and ramps, edge a safety detection strip into the surface. A special edging tool with multiple grooves is available to perform this task (Figure 23-15). When the concrete has dried, paint the top and bottom safety strips with yellow safety paint; all other strips, with black safety paint. Additional issues that relate to the design include handrails of specific dimensions on each side of stairs, stairs with even riser and tread lengths, and pavement sloped to avoid water pooling on the stairs and the approaches to the stairs.

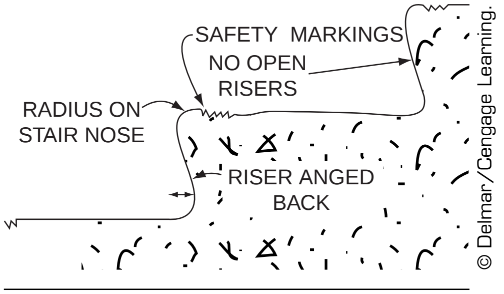

Figure 23-14 ADA finishing requirements for poured concrete stairs.

Independent Forming of Stair Pours

Pouring stairs before any of the surrounding landscape improvements have been installed often provides the opportunity to independently form a set of stairs. This allows contractors to form all parts of the stair, including sides and risers. Be certain the location and elevation of stairs match other improvements before forming. Independent pouring can be completed in four steps, as illustrated in Figure 23-16.

Begin the form construction by preparing forms for the sides of the pour. Use a ¾-inch plywood for side forms. Mark the alignment of risers and treads for one side of the entire stair run on the lumber.

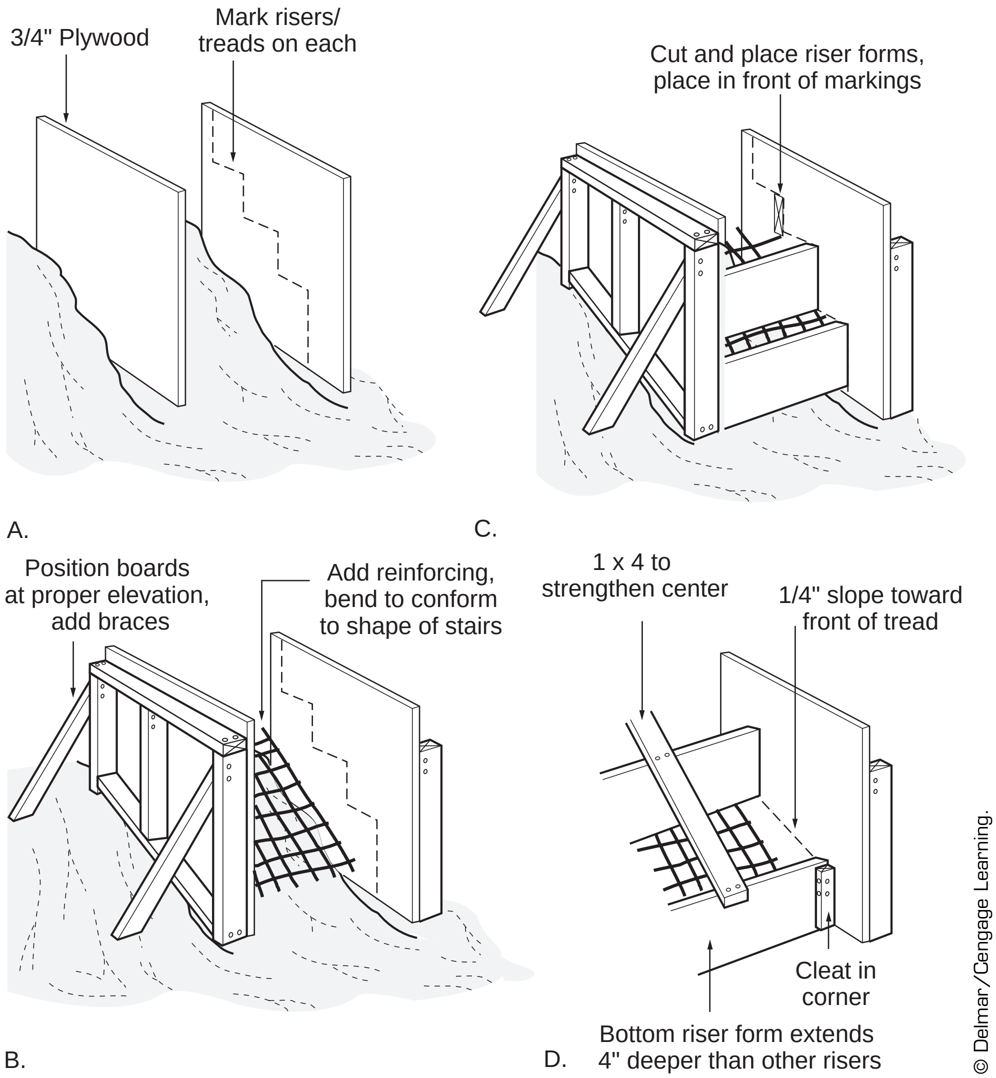

Figure 23-16 Independent forming of concrete stairs. A. Marking side forms. B. Securing side forms and installing reinforcement. C. Installing riser forms. D. Bracing the forms.

Repeat this marking for the other side of the stairs. Side forms do not need to be cut.

Excavate the pour site and place one side form, verifying that the treads are at the correct location and level. Drive 2 × 4 stakes behind the form, and anchor them in a manner similar to that used in anchoring forms for flat work. Repeat this process with forms on the opposite side of the pour, verifying that this side is positioned at the same level as the first side. Some contractors install riser forms first and then use the riser to set the second side form. Prior to constructing and installing riser forms, place any reinforcing along the ground in the pour area. If using **welded wire mesh** (WWM), bend the mesh to conform closely to the stair contour. An alternative to WWM is fibermesh, which is added to concrete for stair pours.

Using 2-inch dimensioned lumber that is wider than the calculated riser height, measure and cut risers to match the width of the stair opening. Any gap larger than 1/16-inch at either end will allow concrete to seep through when pouring. If the stairs are not a constant width, mark and measure each stair in its location to verify the correct length. After trimming the length, cut the lumber the long dimension (rip cut) to the correct height for the riser. Rip cutting at a 45° bevel will provide room at the

bottom of the riser form for finishing the tread with a trowel (Figure 23-17). The riser for the bottom stair should be 4 inches deeper than the others to provide the depth necessary for paving that will abut the stairs. The bottom riser form does not need the bevel cut.

Beginning with the bottom riser, nail the riser form in position using form nails driven through the outside of the side forms. Check for level side to side across the top of the riser form and plumb down the front; then secure using deck screws placed from the outside of the side forms into the end of the riser form. Repeat this process for each of the risers. Before completing connections for each subsequent riser, check for a slight fall between the bottom of the upper riser form to the top of the lower riser form. Properly calculated and constructed stairs should have a tread that tilts ¼ inch per foot toward the front of the stair to prevent standing water. Fasten 2 × 4 bracing to the outside of the form for additional strength.

To brace the form, add cleats in the corner formed by the back of the riser form and the side form. Forms wider than 3 feet may require additional bracing to prevent bowing after concrete placement. Near the center of the stairs, screw a 1 × 4 to the tops of all the riser forms.

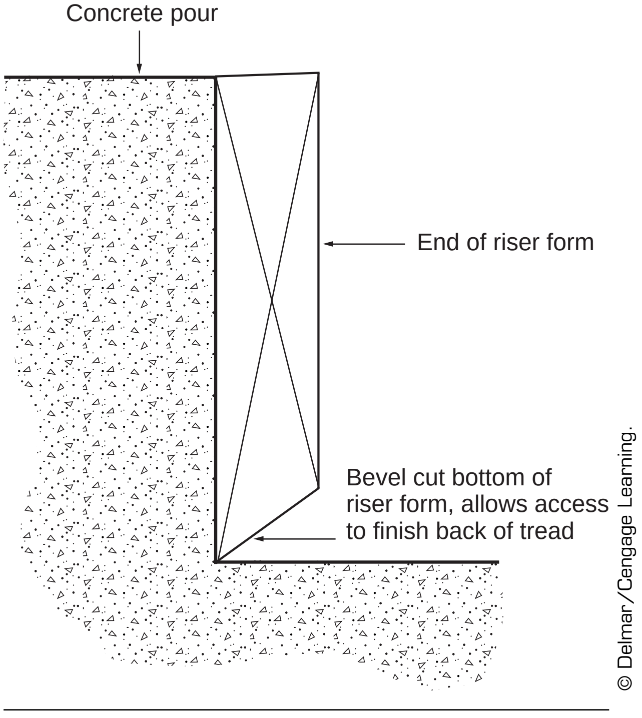

Figure 23-17 Bevel cutting the bottom of riser forms.

Suspended Forming of Stair Pours

Occasionally, landscape contractors construct forms for poured concrete stairs that must fit between existing walls and structures. Use of walls or structures as the "sides" to the forms saves a step in construction, but it also eliminates the support for the riser forms. To accommodate this lack of support, cut and hang, or suspend, the riser forms from beams that run over the top of the pour. This type of pour should be completed before any paving is done above or below the stairs to allow anchoring support beams.

Before constructing this type of form, place any required expansion material against structural objects against which the stairs will make contact. Concrete stairs expand and contract, creating pressure against a structure foundation. If expansion joint material is not installed, damage to the structure may occur. Also place any reinforcing along the ground in the pour area. If using WWM, bend the mesh to conform closely to the stair contour. An alternative to WWM is fibermesh for stair pours.

Installing an anchor that connects the stairs and a building foundation or concrete wall may also be required. Foundations and concrete walls have surfaces that allow stairs to rise or settle over time. To anchor the stair to the sides, drill ⅜-inch diameter holes 2 inches into the wall. Cut 6-inch long pieces of ⅜-inch (#3) steel reinforcing rods and drive them into the holes. Leave the 4-inch stub projecting into the stair pour area. Place one anchor per riser.

Constructing suspended forms begins by marking the riser and tread locations on the sides of the pour. Select a piece of 2-inch dimensioned lumber that is wider than the riser's height. Measure the length for the first riser and cut the lumber to the correct length. Rip cut the lumber to the riser height using the 45° angle described in "Independent Forming of Stair Pours." Repeat for each riser. The riser for the bottom stair should be 4 inches deeper than the others and does not need the bevel cut.

Beams mounted on stakes running from the top to the bottom of the pour will be used for support of the riser forms. Support beams must be spaced close enough and braced well enough to hold the weight of the riser forms, the concrete, and the workers who will lean on them when finishing. Place a beam 1 foot in from each side of the stairs, with an additional beam in the center,

and one for every 3 feet of width for the stairs. At the top and bottom of the stair location, and in alignment with each of the beam locations, drive 4-foot long 2 × 4 stakes with sharpened points 18 inches into the ground. Between the pair of stakes at each side of the pour, attach a 2 × 4 that sets just above the height of the planned risers. If a stair run has more than five risers, these beams should be constructed of 2 × 6s. Once installed, the stakes may need to be braced to prevent movement. The two outside beams will be used to initially hang the riser forms, with the center beams added after you secure and level the riser forms (Figure 23-18).

Beginning with the bottom riser, attach 18-inch long 2 × 4 extensions on edge to the back of the riser form at locations under where the beams will pass. Using the riser markings on the side walls as guidelines, place the precut riser form in the correct position under the support beams and tack the 2 × 4 extensions onto the beam. Adjust the riser form to level along its length and plumb down the face; then securely connect the riser form extensions to the beam at both ends. To further brace the riser form, connect angled braces from the beam to the base of the riser form. This will prevent the concrete from pushing out at the bottom of the riser. Repeat this process for each riser form to the top of the stairs. Before completing connections for each riser, check for a ¼ inch per foot downward slope between the bottom of the upper riser form and the top of the lower riser form.

When you secure the risers to the beams at each edge of the stairs, you may install center beams and riser connections. Use caution not to disturb the level previously established for the risers. Additional bracing may be added to secure the forms, but leave access to the inside of the forms for placing and finishing the concrete. Placement of concrete by hand reduces the chance of form failure. Figure 23-19 shows a suspended form in place for a pour. In this diagram, the verticals supporting the riser forms also serve as a brace for the next higher riser form. A 2 × 8 has also been used to hold the center of the riser forms in place during the pour.

Wedge Forming

When a stair pour is located between two existing flat, solid, well-anchored objects such as building walls, stairs may be formed by wedging a riser form between the two objects (Figure 23-20). Although this method saves time-consuming construction of form supports, wedging also has the risk of form failure if the riser form cannot be tightly wedged between walls.

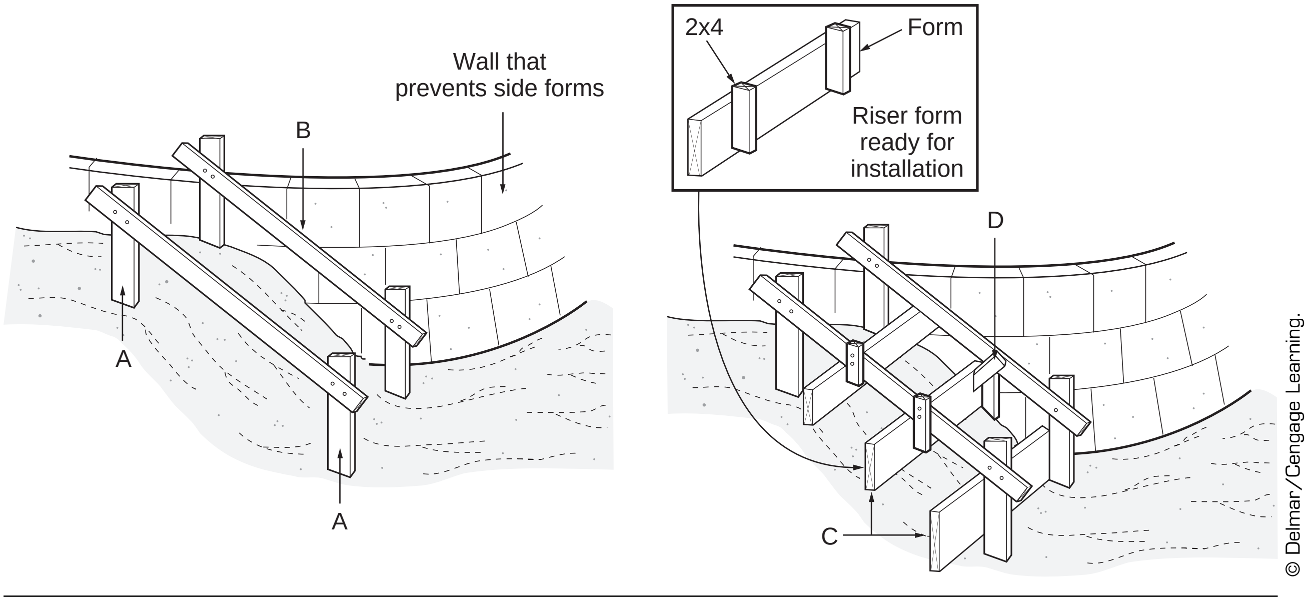

Figure 23-18 Suspended form construction. A. Stake installation at top and bottom. B. Support beam installation. C. Riser form attachment. D. Bracing riser form.

Figure 23-19 Suspended forming for pouring a concrete stair. Riser forms are supported by verticals along the side. The centers of the riser are held in place with a 2 × 8.

Place any reinforcing material and expansion joint material before installing the form. On the surfaces at each side of the stairs, mark the location for the stair treads and risers. Measure the length between the marks for the first riser form. Cut a piece of 2-inch dimensioned lumber ⅛ inch shorter than this measurement. Rip cut the length of the lumber to match the riser's height. Rip with a beveled bottom similar to the riser forms for independent and suspended pours.

Position the riser form and drive a shim between the form and wall to wedge the form tightly into position. If necessary, adjust the location using a hammer. Fill gaps of ¼ inch or less with expanding foam insulation or caulking. Let the foam expand and harden; then trim away any excess. Repeat for each riser. When pouring concrete, carefully hand shovel concrete into the stair behind the wedge forms to reduce the chance of form failure.

JOINTING AND REINFORCING

After finishing the forming, prepare any joints and reinforcing that can be done before pouring. This work includes installation of any **expansion joints** next to fixed objects, preparation of **construction joints,** and installation of wire mesh for reinforcement. **Contraction,** or **control, jointing** is performed after the pour is complete and is covered later in this chapter.

Using Reinforcement

Reinforcement material is a subject of much discussion in concrete circles. Some say wire mesh does

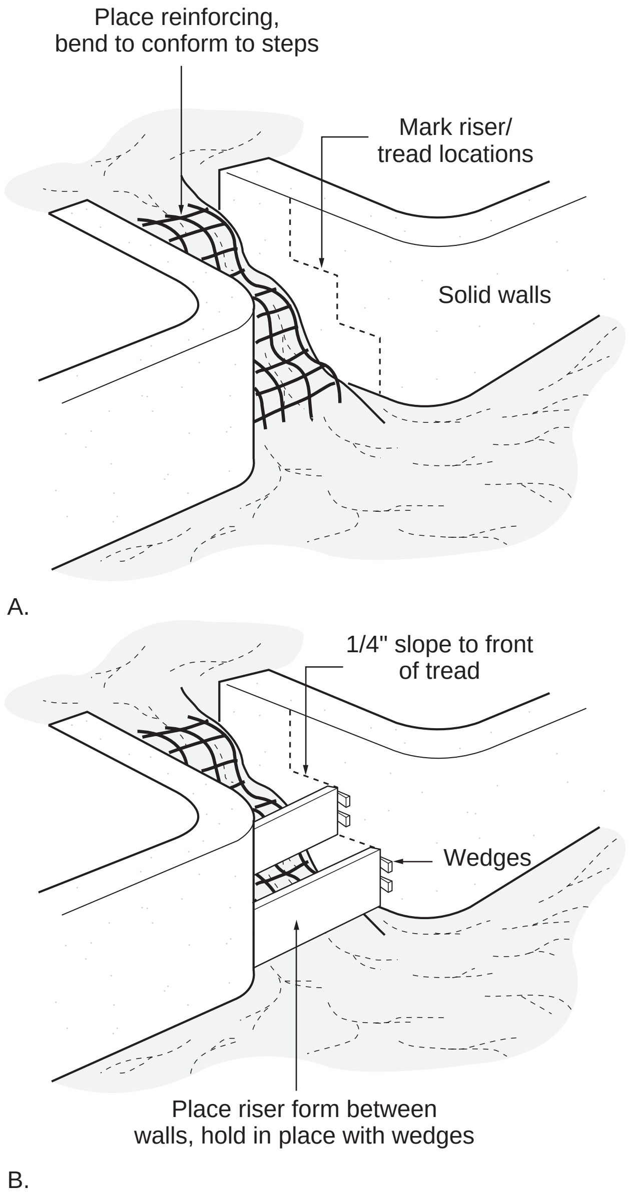

Figure 23-20 Wedge forming stair risers. A. Marking riser/tread locations and placing reinforcement. B. Installing and securing riser forms.

little to help strengthen concrete, especially if it is improperly installed. Others still insist on the value of WWM to reduce the effects of contractive cracking and to strengthen the slab. Welded wire mesh is a 10-gauge wire that is welded in 6-inch squares. If using WWM, roll it out across the entire area of the pour and flatten it (Figure 23-21). Overlapping the joints slightly provides seamless reinforcement. Hold the mesh back a few inches from the edges in case it moves when the pour begins. Use a fencing tool to cut WWM when required.

CAUTION

WWM is typically supplied in rolls that must be unrolled and flattened before they can be used. When unrolling WWM, hold the end in place to prevent recoiling and injury.

Cut holes around objects that are in the middle of the slab. Keeping the mesh flat requires significant bending and shaping, but this is necessary because bows will cause the WWM to protrude above the slab.

Fibermesh is an alternative to WWM that requires no preparation, but using fibermesh can be a problem in the finishing stage. Fibermesh, which is tiny strands of fiberglass, is added to the concrete while it is being mixed. The strands bond to the concrete and form an integral reinforcement. Finishing is slower because the strands of fiberglass drag on the equipment. The finished look of the slab with fibermesh can have a “fuzzy” appearance until the strands wear. The fine fiberglass strands of this reinforcement appear to add a great deal of strength to

Figure 23-21 Welded wire mesh reinforcing cut and placed before pour.

the slab and may serve as an adequate strength replacement for WWM.

Another reinforcing material is deformed steel reinforcing rod, also termed **rerod,** a rigid bar used to strengthen concrete in pours. The surface of rerod has tiny ridges, or deformations, that keys with the concrete hardened around them. Cut rerod using a hacksaw, heavy-duty bolt cutter, or cutting torch. Rerod can be placed in a grid network inside thick slabs or placed along the edge of a slab to add strength. Rerod is purchased in lengths and is specified by fractional diameter. This diameter is typically stated in eighths—for example, a #3 rerod is ⅜-inch in diameter. Diameters are available up to 2 inches, but most landscape work requires #3 or #4 rerod.

When rerod is to be positioned inside the concrete slab, it needs to be supported in place during the pour. Two materials, chairs and dobies, are available to hold the rerod slightly above the base during the pour. Chairs are short metal baskets with indentations that hold the rerod above the base surface. Place chairs directly on the base, and place the rerod in the indentation. Wrap wire ties around the chair and rerod to anchor the rerod during the pour. Dobies are short, precast concrete blocks with wire ties protruding from the top. Set the dobies directly on the base with the rerod positioned on top. Twist the wire tie around the rerod to hold it in position during the pour (Figure 23-22).

Installing Construction Joints and Anchoring Adjacent Pours

If plans are to complete the pour in more than one session, a construction joint, or a clean vertical joint from which future work can be started, will need to be formed (Figure 23-23). This joint is created by installing a 2 × 4 form staked into place where the pour stopped. If using wood joints in the pour, you can use any of the wood headers as a construction joint for the project.

When pouring slabs at different times, one of several joining methods should be used to hold both slabs in the same position. An existing concrete slab may be undercut to help join slabs. Underexcavate the existing slab 4 inches deeper and back 4 inches from the edge. When pouring the new slab, be certain to tamp concrete into this void. Another method for joining slabs is to drill ½-inch diameter holes 4 inches into the edge of first slab and insert ½-inch (#4) rerod into the holes. The rerod should extend

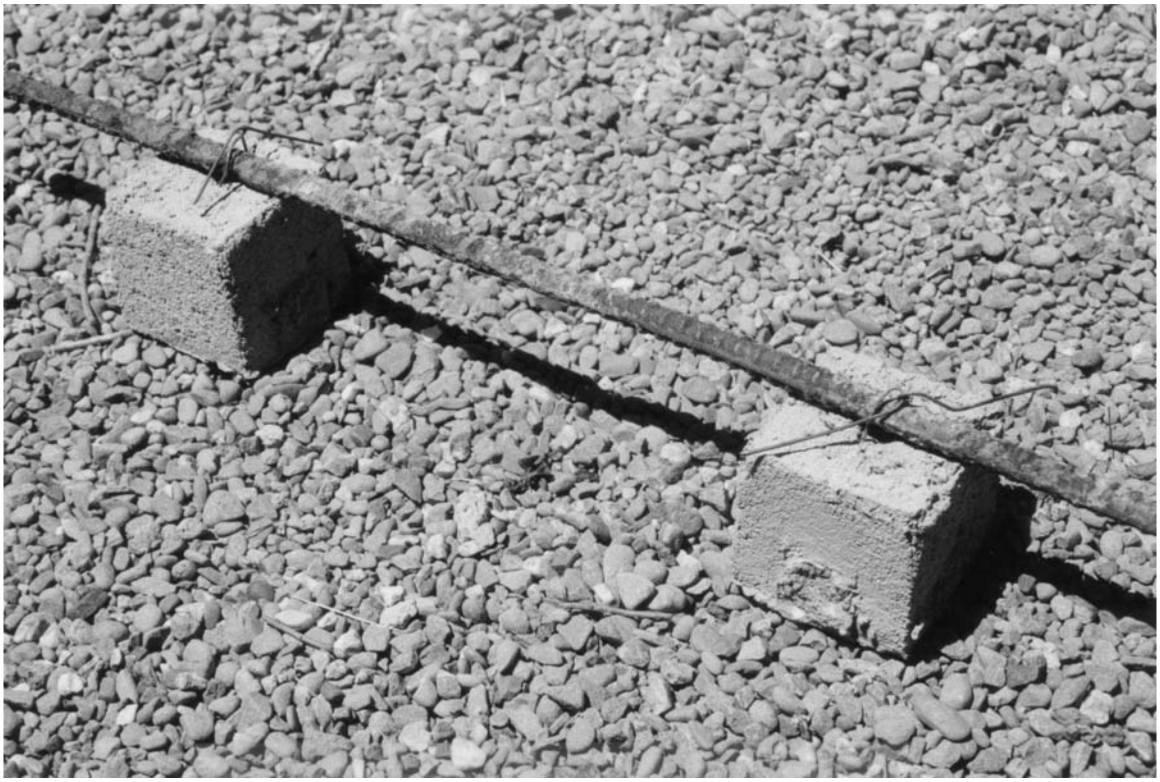
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Figure 23-22 Dobies hold rerod in place during concrete pours.

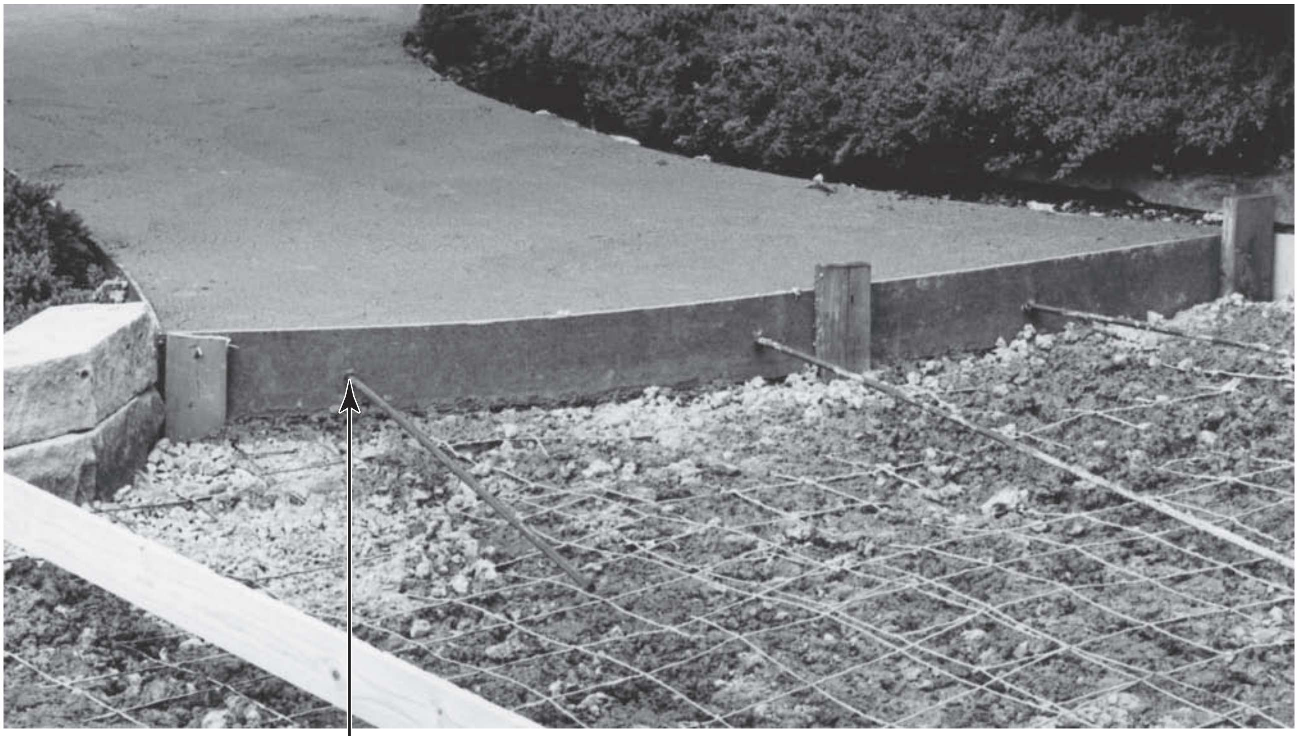

Figure 23-23 Construction joint set at a breaking point in pour.

into the new slab area 12 inches (Figure 23-24). Space these rerod connectors every 2 feet along the length of a slab's edge. A third way to joint slabs is to use a keyway joint. A **keyway** is a metal channel that is nailed to the pour side of the board forming the construction joint (Figure 23-21). Keyway channels form an indentation into the slab, creating a lip into which concrete from the next pour will flow and interlock the slabs.

Attempting to join two, 4-inch slabs with rerod or a keyway joint results in only 1–1½ inches of concrete above the rerod/keyway that is weak and prone to cracking. If the keyway or rerod joining is desired, the slab should be thickened to 8 inches at construction joints to provide more concrete above and below the rerod/keyway. To thicken a slab at a joint or edge of a pavement pour, excavate the base to 8 inches deep in an area 8 inches back from the slab edge or joint location. This extra depth should extend across the entire width of the slab, or along the entire edge where the thickened slab is desired. The transition from the thickened base to the normal base should be tapered at a 45° angle from the lower depth to the normal depth (Figure 23-25).

Installing Expansion Joints

Expansion joints absorb the expansion of concrete when temperatures warm the material. **Expansion joint material** should be placed between a slab/stair and any permanent object in or adjacent to a pour. This list typically includes buildings, curbs, deck posts, light posts, hydrants, foundations, and any other object that can be moved as the slab expands.

Materials used for expansion joints include a premanufactured, ½-inch thick plastic that comes precut in 4-inch and 6-inch widths in varying length rolls, or a ½-inch thick by 4-inch wide asphalt-impregnated fiberboard that comes in 8-foot lengths. The plastic material is very flexible and fits most installations, whereas the fiberboard is rigid and works best in straight installations. In certain applications, expansion joint material must be installed as the paving is poured.

This expansion joint leaves a gap in the continuous run of concrete. The placement of an expansion joint in the pour requires that the joint material be supported while the pour is executed. To join the slabs, thicken the pour to a minimum of 8 inches for 1 foot on either side of the pour. Cut and place a piece of

Figure 23-24 Rebar placement along edge of pour to anchor new slab to existing concrete.

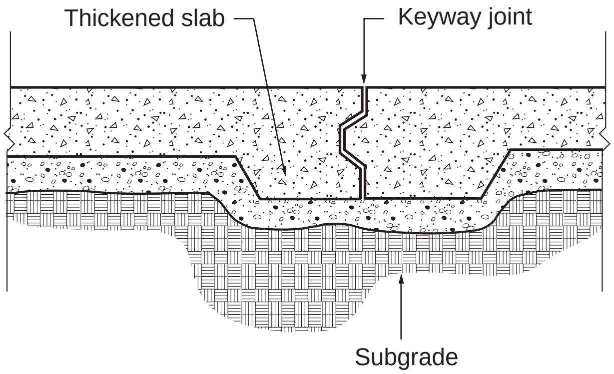

Figure 23-25 Keyway joints and thickened slabs.

expansion joint material the full thickness and width of the slab. Bore ½-inch holes 4 inches down from the top edge and at every foot along the length of the material. Place the expansion joint material in the center of the thickened portion of the slab at the correct location for the expansion joint. Cut 1-foot lengths of deformed #4 rerod and center them in every bored hole in the expansion joint material. Position the expansion joint upright and support the rerod on both sides of the expansion joint using chairs or dobies. When pouring the slab, hand shovel concrete on either side of the joint to hold it in position. Verify that the expansion joint has not moved and is not covered by concrete while the pour is being placed and finished. Verify the rerod is not protruding through the slab surface. If rebar extends above the surface, push it back into the slab with a shovel. After the slab has cured, a sealant may be applied over the expansion joint (Figure 23-26).

To attach expansion joint material to structures, mark the top of the slab with a chalk line and use concrete nails to fasten the joint material along that line. If the object does not accept nails, try wrapping the joint material around the object and taping it in place, or attach it using a construction adhesive.

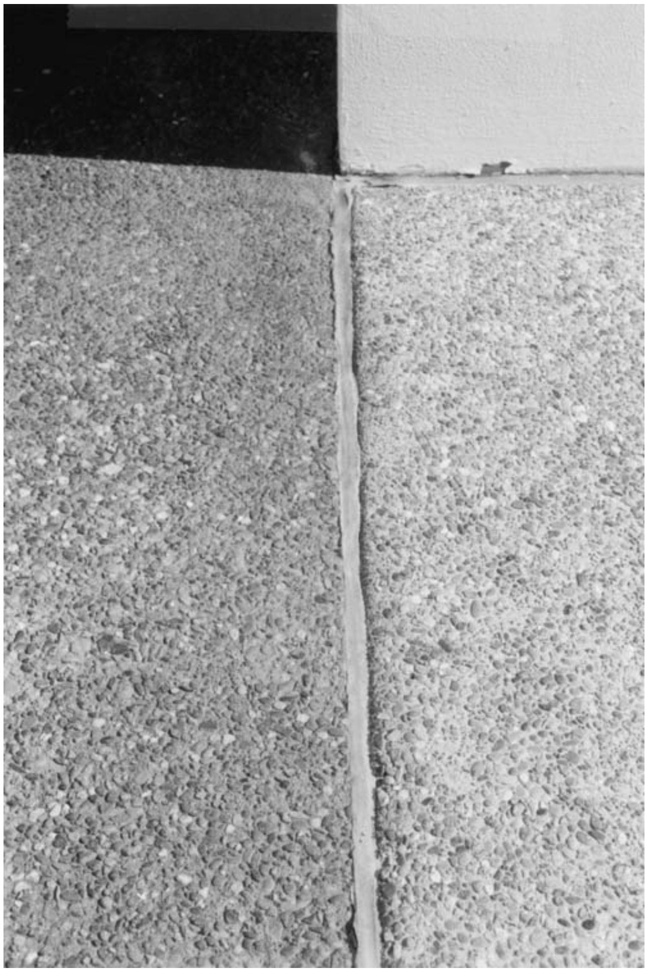

Figure 23-26 A sealed expansion joint between two exposed aggregate concrete slabs.

PREPARATION BEFORE POURING

Between the forming and the pouring, a few steps may be required to assure the success of the project. Although minor in scope, these steps cannot easily be completed when concrete is flowing into the forms.

Temporary Screeding Rails

Screeding of concrete is an important step in the pouring process. Screeding uses a long, straight piece of lumber or metal to smooth the rough concrete into a surface that can be finished. Occasionally, pours may have slabs that are wider than available screeds or no forms on one side, such as next to a building. If this is the case, consider a temporary screeding rail as a solution. A temporary screeding rail is a rigid metal conduit placed parallel to forms and supported on short stakes. This rail supports the screed and is slid to a new position as the screeding progresses. As you move the screed, shovel concrete into the void left by the rail and smooth the concrete by following the steps of the concrete finishing process. Leave the stakes that supported the screed in the slab. Failing to slide the pipe every 2 feet or so will make reaching the void more difficult. At the end of the pour, remove the rail.

Stakes that support the temporary screeding rails are made of 1 × 4s, driven into the base to within 2 inches of the finish grade. Two nails spaced the width of the conduit are driven into the top of the 1 × 4. Leave only 1 inch of the length of the nails sticking up so they will not project above the concrete surface when finished (Figure 23-27). Adjust stake height to place the top of the temporary screed rail at the desired height (Figure 23-28). A typical screed rail is a 2-inch diameter, galvanized, Schedule 40 electrical conduit. An alternative is to set up temporary wood forms that are removed and to fill the void after screeding.

Form Break Compound

Spray the inside of the forms with a form break compound or light kerosene. These chemicals reduce the bonding of concrete to the forms, making removal of forms an easier chore and causing less damage to the concrete.

Final Check

Go through the checklist again before the concrete arrives. Included in the checklist are some last-minute steps to prepare for the pour:

- On hot days, sprinkle the base with a light shower of water before pouring to slow the curing process.
- Make sure all necessary tools are easily accessible.
- Prepare ahead of time for bad weather. Have a cover ready for the surface.
- Make sure any routes for access are free of debris to avoid accidents.
- Have preselected locations for excess concrete and mixer cleanout.


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Figure 23-27 Support stakes for temporary screeding bars. These stakes will be buried in the slab. Verify that nails do not project above screed bars.


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Figure 23-28 Temporary screeding rails used for screeding wide pours. The top of the rail should be set at the desired thickness of the slab.

PLACEMENT OF CONCRETE

Begin the pour by checking the slump of the concrete. Correctly checking the slump requires filling a 12 tapered cone and tamping the concrete inside. Invert the cone on a solid surface, remove the cone, and measure the amount the concrete "slumps" below the top of the cone. A 3-inch slump is standard for slabs. If you cannot make a formal slump check, you can use other methods to determine concrete preparation. In a visual check, concrete with proper consistency should look like a thick stew. If the concrete fails to move down a wetted chute, it is probably too dry; if it pushes water out along the sides of the chute, it is probably too wet. Another check is to chop through a pile of concrete and see if ridges remain. If ridges crumble, the concrete is too dry; if ridges slump, the concrete is too wet. It is better to add water to concrete that is too dry than to have concrete that is too wet. If the concrete pour is on a slope, a low slump will be necessary to keep it in place when working from the top of the slope to the bottom.

CAUTION

Concrete contains caustic materials that can cause burns after prolonged contact with the skin. Avoid contact between bare skin and wet concrete, and wash thoroughly after working with concrete.

Placing and Screeding

Once you have prepared the concrete for pouring, position workers to make the task efficient. Placing one worker in rubber boots in the middle of the pour to push concrete and to help pull the screed with a rake is an effective use of labor. Position two workers on either side of the pour, one to operate the end of the screed and the other to shovel concrete to the locations required.

When the concrete has reached the proper consistency, place it in piles, working the chute from one side of the forms to the other. Using rakes and shovels, spread the concrete in front of the screed. If using WWM, use the rake to hook the mesh and pull up gently to seat it in the center of the slab. If the WWM rises above the surface during the pour and cannot be forced back down, lift the mesh up and cut out the offending section with a fencing tool, bending the edges back down into the slab.

When approximately 2 linear feet of the pour has been leveled with rakes and shovels, begin screeding. Using a 2 × 4 that is cut 2 feet longer than the width of the pour, rest the screed on the forms. With a side-to-side sawing motion, gradually pull the screed forward until the concrete is leveled and the aggregate is pushed down into slab (Figure 23-29). Be certain to keep the screed resting on the forms to ensure the proper thickness of the slab. If the screed is difficult to move, try dragging the screed forward 1–2 feet without the sawing motion to rough level the concrete; then go back and rescreed using the sawing motion. Tilting the top of the screed forward can also make the screeding process easier. It is typically easier to pull, rather than to push, the screed. If large pours are planned, the work may benefit from renting a power screed. The power screed is a flat, horizontal plate mounted on a framework. A motor vibrates the screed, and workers push the machine forward across the forms.

In corners or areas where both ends of the screed cannot rest on a form or temporary screeding rail, you can use a technique termed **wet screeding.** Perform wet screeding by resting one end of the screed on a form, holding the unsupported end of the screed at the approximate finish elevation, and

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Figure 23-29 Placing and screeding concrete.

performing the sawing action of screeding. Although this technique is not recommended for large areas, small spaces or short runs can be successfully leveled using the previously screeded area as a guide for the elevation of the area being wet screeded.

If low spots or honeycombing voids appear after screeding, workers with shovels should sprinkle concrete on the spot and repeat the screeding. Screeding should be completed in as few passes as possible. When finished, the surface should be level, have no holes, and should resemble a sheet of rough-sawn plywood.

Bull Floating

Almost immediately after the screed passes, workers can begin floating the surface with the **bull float,** a wide, flat metal blade with a long handle that is pushed and pulled over the surface several times. This process further smoothes the surface and embeds the aggregate in the slab; it may not be practical in tight areas or on small pours. Most bull float handles are adjustable, allowing a person of any height to operate it on any reasonable width of slab. Because the float handle is long, watch out for power lines and windows behind and above its path.

> **CAUTION**
>
> Review the area before bull floating. If the handle comes into contact with power lines, a worker could be electrocuted. Also, if it strikes them, the handle can cause damage to structures and injury to people.

The long-handled bull float is set on the near side of the slab and slowly pushed across the slab, keeping the leading edge of the float off the concrete by holding the handle low. When the float reaches the other side, lift the handle up and slowly pull back along the same path, keeping the leading edge high by holding the handle high (Figure 23-30). If the

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Figure 23-30 Bull floating a concrete slab.

float sinks into the concrete surface, remove the float and wait a few minutes before continuing. If the float digs into the concrete, you are holding the front edge too low. Using a repetitive jerking motion may help the float move easier on the first pass. Float the surface as many times as necessary to create a smooth, glasslike surface without holes or voids; then pick up the float, move it down one width, and continue. Between sections where you move the float, tiny ridges will exist but can be troweled out later. If the float becomes coated with chunks of concrete or debris, stop and rinse the surface.

Darby Floating

A **darby float** may be used in areas that are too tight to reach with a bull float. The darby is a narrow, 4-foot long float made of wood or metal, with handles on top. Operate the darby by lifting the leading edge when moving the float across the surface. Make several arcing passes with the darby, exerting slight pressure on the trailing edge. This pressure will bring moisture and the fine particles of concrete to the surface to fill any small voids or holes.

Floating and Troweling

Floating and troweling is the laborious step of working the surface with flat-bladed tools that push the aggregate farther down into the pour and cause water and fine particles to move up to the surface. Two troweling steps are recommended for concrete slabs: (1) floating, performed with a wood or metal float, and (2) steel troweling, performed with thin steel trowels. Exterior slabs may need only the first step, as is the case when planning a rough, broom texture for the surface; but smoother surfaces and interior slabs may require both steps to prepare the surface properly for finishing. Floating and troweling works best starting at the point where the pour began and working in the same direction that the pour progressed. This finishes the surface in approximately the same order in which it will harden. Watch for portions of the pour that are in direct sunlight or in areas where the concrete may harden more quickly. These areas may need to be floated or troweled sooner.

Floating can be done with wood or **magnesium floats,** also known as *mag floats.* Begin once the surface has begun to lose the wet sheen left from bull floating. Test the surface before finishing. If the tool sinks easily into the surface when pushed straight down, wait a bit longer. Working quickly, move the float in a sweeping, arcing motion across the concrete surface to remove any ridges, holes, or other irregularities. Pushing down hard with the back edge of the float while holding the leading edge above the surface makes floating easier and more productive (Figure 23-31). Floating is done while the concrete is just beginning to dry, so the majority of this step is completed with the worker standing to the edge of the slab. Reach as far inward as possible; then move to the other side of the slab or use kneeboards as described in the next paragraph.

If the slab is too wide to reach from outside the pour, use a pair of 24-inch × 24-inch sheets of ½-inch plywood, termed **kneeboards,** to reach the center. Gently position the first kneeboard and step onto it; then place the second kneeboard within a step from the first. If the board sinks completely into the surface from your weight, delay until the concrete hardens a bit more. If the board does not sink at all, move quickly.

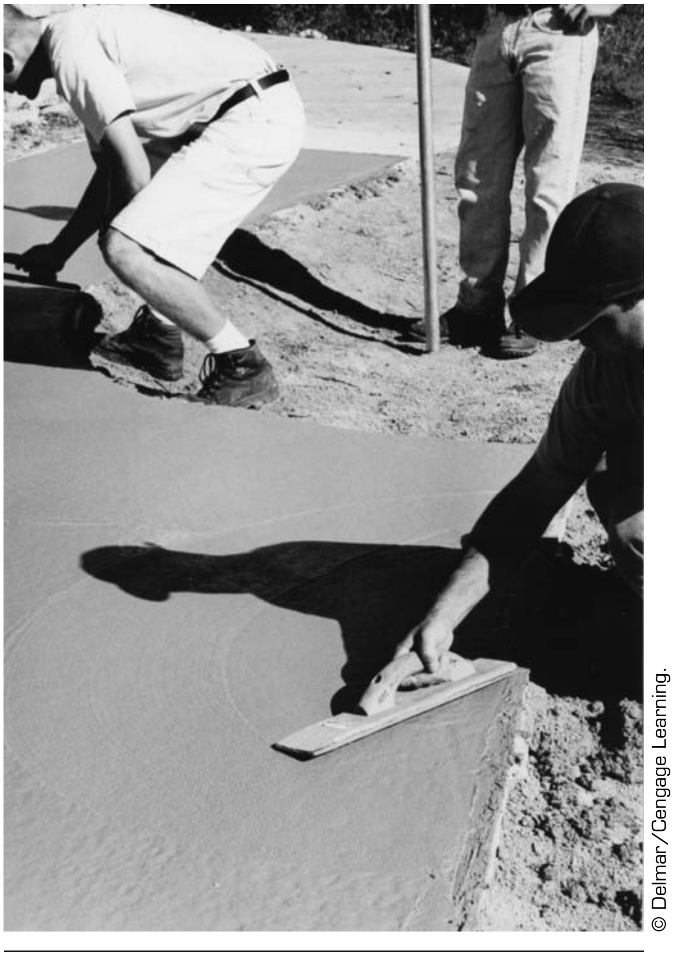

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Figure 23-31 Floating a concrete slab from the edge.

Kneeboards should be spaced close enough to step from the first board to the second. If unable to reach the center of the pour, then reach back and pick up the first kneeboard and move it closer to the center. Repeat this process as many times as necessary. When you are positioned, float/trowel the area around and up to the kneeboard. Step back to the kneeboard closer to the edge (Figure 23-32). Peel up the vacated board and reverse the placement process used to get to the center. Weight on the board will cause it to stick to the concrete surface, requiring it to be "peeled" from the concrete.

Once you remove the board, you can float/trowel out any indentation. If the concrete is hardening quickly, you may need to make several passes over the surface while exerting pressure on the float to bring moisture back up to the surface. Extra concrete may be placed by the shovelful to fill low areas or to repair serious damage. Properly floated/troweled surfaces appear smooth and wet and will have no holes, ridges, or irregularities. The surface should look prepared enough that it could be left in that condition if no other finishing were to take place.

If a smooth surface is planned or if the surface is still rough after floating, you need to perform steel troweling. Begin troweling after the sheen has disappeared from the surface, and use the same process outlined in the floating description. When done properly, steel troweling creates a very smooth surface that is slick in exterior applications. Consider renting a power trowel to save a lot of labor on surfaces that are intended to be smooth. The power trowel is a large piece of walk-behind equipment that uses a motor to drive a fan of trowels. Used primarily for interior slab finishing, the power trowel has limited applications in exterior use.

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Figure 23-32 Using kneeboards to reach center of a concrete slab for floating. Concrete must begin to set before boards can be placed on the slab.

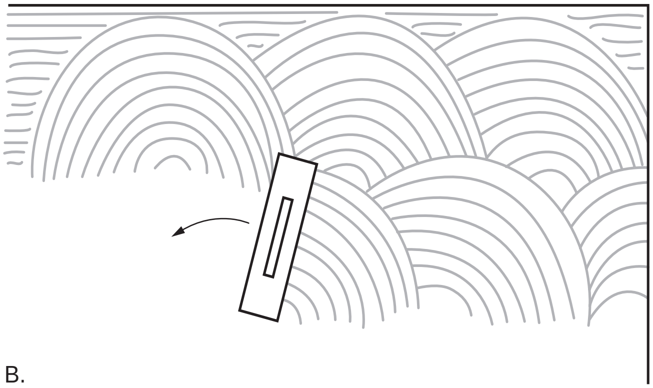
SURFACE TEXTURING AND FINISHING

When the concrete has begun to set, you can begin surfacing and texturing. Instructions for obtaining the finishes described in the chapter introduction are described here. Proper timing of each operation is also identified.

- Float Finish. Floating for a finish should be done after the surface has begun to harden; the intention here is different than that of the first floating operation. Use a back-and-forth motion that eliminates a pattern and provides uniform results. You may need to apply extra pressure on the float to get a rough surface. Jointing the slab into squares, rectangles, or other geometric segments creates an interesting surface out of what could otherwise be a very dull finish. Using the edger around each segment creates a border that highlights the finish inside. To obtain a swirl float finish, press hard to work a large quantity of soft material to the surface. Work the surface in horizontal rows of arcing swirls that slightly overlap each preceding row. Along the slab edges, float a single. horizontal swath. On the next horizontal row, begin applying arcing half-circle swirls evenly across the row (Figure 23-33). Overlap the horizontal swath of the slab edge with the swirls. In the next horizontal row, continue the swirls, slightly overlapping the previous row and offsetting by one-half pattern. Continue this pattern across the entire surface to be finished.
- Broom Finish. Brooming should be done when the surface is firm to the touch but not dry. The broom will create a ridged pattern that should be perpendicular to the direction of traffic but parallel to the direction of drainage off the slab. Extend the broom to

A.

Figure 23-33 Swirl finish on concrete slab. A. Finish. B. Technique.



B.

Figure 23-33 Swirl finish on concrete slab. A. Finish. B. Technique.

the far edge of the slab or to a location where a joint will be placed, set the broom down lightly, and pull with a single, smooth motion to the near edge of the slab (Figure 23-34). Repeat this motion the full length of the slab, using a slight overlap from one pull to the next. If the broom becomes plugged with wet concrete or begins to drop small "kernels" of concrete, set the broom head on end to the side of the slab and tap it a few times to dislodge the debris. You can use small hand brooms to surface tight areas.

- Colored, Impressioned Finish. (Using some versions of this process may be restricted to contractors who hold licenses from manufacturers.) This process involves two steps: (1) coloring the concrete and (2) impressioning, or stamping; the surface. The first step is accomplished by adding a powdered color to the concrete while it is mixed or by sprinkling powder on the wet, screeded surface and floating it into the concrete. Manufacturer's instructions recommend the best method for adding color. The powder must be mixed thoroughly and evenly into the surface of the concrete. Finishing proceeds in the same manner as that for plain concrete until after troweling. When the sheen from troweling has disappeared, stamps are carefully placed on the slab surface and are either pounded down with a rubber mallet or forced down by the weight of a person standing on them. If the stamps sink into the surface, postpone the operation until the concrete has hardened a bit more. When

Figure 23-34 Broom finishing a concrete slab.

one area has been successfully impressioned, pull up the stamp and place it on the slab adjacent to the first area stamped. Repeat this process until you have impressioned the entire surface. Small areas and irregular spaces will not allow stamping. However, you can hand finish these areas by pushing the blade of a brick set into the wet concrete. When hand finishing areas, follow the same pattern made by the stamp. Work quickly with the stamping operation; otherwise, the concrete could harden before you complete the impressioning work. This type of surface is not edged or jointed as described for float and broom finishes.

- Seeded Exposed Aggregate. Broadcast the special aggregate over the surface after bull floating and, using a trowel, embed it into the top of the slab. Float the surface just until the aggregate disappears. Floating too long will bury the aggregate too deep. After the concrete begins to harden enough to support a person's weight—in approximately 2 hours—lightly "scrub" with a hose and broom to remove the top film of concrete and "expose" the embedded aggregate. If the scrubbing operation gouges the surface and dislodges aggregate, stop immediately and repair the holes; then wait for the slab to harden further. Six to seven days later, wash the surface with a mixture of 9 parts water and 1 part muriatic acid or trisodium phosphate (TSP).
- Integral Exposed Aggregate. Pouring and finishing proceeds in the same manner as that for plain concrete until just before the slab is nearly hardened. When the slab supports a person's weight—in approximately 2 hours—begin a light "scrubbing" of the surface with water and a broom. Scrub only enough to wash the top film of concrete off the surface and expose the aggregate near the surface. An alternative to scrubbing the surface is to lightly sandblast the concrete 2–3 days after the pour to expose the aggregate. Because you can easily gouge the surface or dislodge the aggregate, work carefully when exposing the aggregate and when jointing and edging this type of surface.
- Rock Salt. To create rock salt texturing, first finish the surface with the desired texture. Colored or plain concrete with a float or broom finish is the best surface. Before the concrete hardens, or when your thumb leaves about a ¼-inch deep impression, sprinkle ¼–⅜-inch grains of rock salt over the finished surface in the desired pattern. A random pattern, with some heavy concentrations interspersed among lightly textured areas, provides an attractive surface. Trowel or roll the salt into the surface so only the tops of the grains are visible (Figure 23-35). You can use a special salt roller to provide the correct pressure for embedding the salt crystals. Use caution not to leave marks when rolling or finishing, and do not embed the salt crystals too deep into the concrete. Cover and cure the concrete for 2–5 days. Uncover the slab and rinse it, brushing the remaining salt from the surface.

- Acid Etch. Complete the pour and allow the surface to cure for 2 weeks or longer. Mix 9 parts water with 1 part muriatic acid and apply evenly over the surface. Let the water/acid mix work at the surface until the desired texture is achieved. At that point, rinse the surface thoroughly, scrubbing with a broom to remove material.

CAUTION

Muriatic acid and trisodium phosphate (TSP) can cause severe burns. Follow manufacturer's instructions for mixing and applying these chemicals. Wear protective clothing, avoid contact with skin, and do not inhale the fumes.

CAUTION

When mixing acid and water, always add the acid to the water. Never add water to acid. Adding water to acid will cause the mixture to spray and splatter, creating the potential for burns. Always wear protective clothing, gloves, and eyewear when mixing chemicals.

- Cobbled Concrete. After completing the floating and while the concrete is still workable, embed 4–6-inch rounded stone into the soft concrete surface. Stone, or cobbles, can be placed closely or in any pattern that the designer or contractor selects.

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Figure 23-35 Using a mag float to embed rock salt crystals for a rock salt finish.

Contraction Jointing

Before the concrete has lost all workability, you should complete the edging and contraction joints. Although these two operations use similar tools and methods, the purpose for each method is quite different. Edging rounds and smoothes the slab's edge corners to reduce chipping of the edge and to help separate the slab from the forms. Edging also provides an aesthetic function by providing a contrasting surface texture when compared to the finish of the slab's interior. Jointing controls cracking as the slab dries and the concrete contracts. Contraction shows up as cracks in the slab's surface; and to control where cracking will occur, contraction (or control) joints are placed in the slab's surface. Without these joints, cracking would occur at random weak points in the slab, and seldom in aesthetically pleasing patterns. Contraction jointing may be done with a jointing tool while the slab is still wet, or the jointing can be done 1–2 days after the pour with a saw. Commercial installers typically use saws, but the equipment and blades are expensive. Similar to edging, jointing also provides a contrasting surface texture and helps define squares or other geometric forms created in the slab.

Planning joint locations requires the application of the mathematical formula presented in Appendix D. When spacing the joints, you want to avoid joints that create acute angles. Acute angles are weak points where the slab will crack without a joint. Space joints wider to avoid an acute angle. Consult an engineer or design professional with questions regarding joint placement.

Jointing with a hand tool requires a guide to keep the joint straight across the slab. This is usually provided by laying a piece of dimensioned lumber on the forms from one side to the other, parallel to where the joint is desired (Figure 23-36). A 2 × 8 should be adequate for this. Gently lay the 2 × 8 in place and step halfway across the slab. Begin at the center and press the **jointer** into the concrete. Work the jointer forward and backward, always holding the tool tight against the 2 × 8. You obtain the best results by lifting the leading edge of the tool while pressing down on its back edge. If the slab is drying quickly, the jointer may work up pieces of aggregate.

Figure 23-36 Jointing a concrete slab using a jointing tool run alongside a 2 × 4 guide.

Use the flat part of the tool to push them back into the slab, and then work back and forth over the aggregate with the jointer's back edge until smooth. Going back and forth several times over the surface will usually work up enough moisture to rework the surface. Continue the jointing until you reach the slab's edge.

Move to the other side of the slab and repeat this process from where the previous joint began. Carefully lift the guide board and move it to the next joint location. If necessary, retouch the surface texture when you remove the board. Installing joints down the center of a long slab with a jointing tool is a difficult process. You must set the guide in the correct location and access it using kneeboards. When completed, jointing provides a ⅜-inch deep joint; this is the weak area in which contraction cracking will occur.

You can complete jointing after the concrete has dried. You will need a cutoff saw or walk-behind concrete saw equipped with a carborundum or concrete blade. After the concrete has hardened enough to walk on (2–3 days), use a chalk line to snap the location of all joints. Start the saw and slowly run the blade along each mark. Use caution to make the cuts only ⅜-inch deep and straight. Using a 2 × 4 guide may help you keep the sawed joints straight.

CAUTION

When cutting concrete, always wear long-legged pants, hard hat, ear protection, safety glasses, dust mask, and gloves to protect yourself from the dust, noise, and debris.

Edging

Edging should be done following the completion of surface texturing (colored, impressioned concrete is not edged) and may require additional work with the tools because the slab may be nearly dry (Figure 23-37). Dip the edging tool in a bucket of water to make working the surface easier. Use the **edger** in the same manner as the jointer, pushing the edger along the form with the leading edge lifted and putting downward pressure on the trailing edge. Work around all edges that need to be finished. If it is difficult working corners, start the edger in the corner and work outward; then work back toward the corner to cover any marks left in the surface.

COMPLETING THE POUR

The final steps to a successful concrete pour involve protecting the concrete from curing too rapidly and removing the formwork placed to contain the pour.

Curing

After you complete all finishing operations, cover the work with a plastic sheet or wet burlap or spray on a **curing** compound. Covering retains heat and moisture as the slab cures, improving the slab's strength and reducing surface cracking by slowing the drying process. The cover should lie flat on the surface to avoid discoloring. A cover also provides some protection from rain and sunlight and identifies the project site as a construction zone. If you

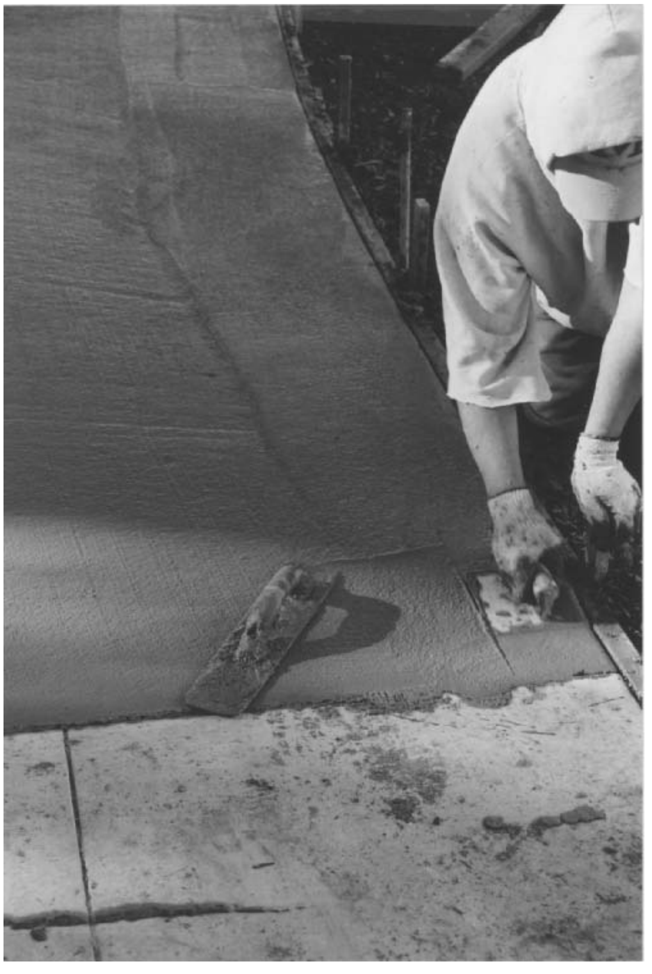

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Figure 23-37 Edging a concrete slab.

have concerns about traffic passing over a new slab, erect a temporary fence around the project to further protect the work. Leave the cover in place a minimum of 24 hours. Coverage for 3–7 days is ideal. Remove the covering when moisture no longer condenses on the its underside.

Removing Forms

Approximately 2–4 days after the pour is completed, you can remove the forms. Uncover the slab and use a claw hammer to remove the form nails from the stakes. Using a careful, prying motion with a shovel or pry bar, gently work the stakes up and away from the forms. When you have removed all stakes, gently work the shovel or pry bar between the slab and the forms and pry outward. Use great care during this step so that the edges of the slab do not chip. A finished slab will still be "green" (the color is actually a dark gray that will dry to a light gray over a few weeks), but it is ready for backfilling the edges. Keep foot traffic off the slab for 2–3 days, and keep any vehicle traffic off the slab for 1–2 weeks.

STAINING CONCRETE

You can add color and interest to new or existing concrete using exterior concrete stains and paints. To revive or renovate older concrete surfaces without having to replace them, use a colored stain to provide almost immediate change. On new concrete installations, use staining to obtain desired design effects. Painting, although not as versatile as staining, is often used to surface athletic facilities such as tennis and basketball courts.

General Information

Several variations of stains and paints are available for exterior use, with most falling into one of two categories: (1) acid-based stains that etch the surface and allow metallic salts to bond color to the concrete and (2) water-based acrylic stains that either penetrate the surface to color the concrete or bond a color to the existing surface. Both types of stain produce permanent opaque coloration, with acid-based stains providing a range of earth tones and water-based acrylics providing a wide range of colors. When choosing stain to alter a concrete surface, please note that stains are not intended to hide imperfections in a surface such as cracks, spalling, or patches. Stains will, in many cases, highlight these imperfections. Note that the information provided by most stain manufacturers are only guidelines, and the only way to preview the end result is to test an area. Many factors will alter the actual color and finish, including the age of the concrete, the amount of cement in the mix, the finish of the surface, and the type of aggregate used.

CAUTION

Stain should be handled and applied with care. Follow manufacturer's recommendations for safety when using coloring products. Protect valuable surfaces and elements adjacent to the area being treated from damage as a result of runoff and overspray.

Concrete Preparation

The beginning step in preparing concrete for staining is to verify if the concrete can be successfully stained. Sealers previously applied to older concrete surfaces will prevent the stain from penetrating the concrete. To test for sealers, sprinkle water on the surface and verify that the water does not stand on the surface but penetrates the concrete. New concrete surfaces must cure the proper amount of time to achieve the correct pH and moisture levels. At a minimum, new surfaces should set for 14–28 days before staining, and some stain manufacturers recommend a curing period of up to 60 days. To test for pH, apply a paper test strip to the surface. A desirable pH is between 9 and 10. To test for moisture content, tape a 1-foot square sheet of plastic over the concrete's surface for 24 hours and see if moisture accumulates on the underside of the plastic. If so, wait until no moisture is evaporating out of the slab. Some manufacturers recommend immediate staining of the concrete; so, verify the requirements of the product you are using.

Depending on the type of stain and the age of the concrete, further surface preparation may be required. New concrete should be ready to stain unless a smooth finish was applied. If the surface is smooth, etch the concrete with a mixture of 1 part muriatic acid and 20 parts water. An alternative would be a stronger mix of citric acid with water. Sprinkle this mixture over the surface with a plastic sprayer or watering can and allow 1 hour for the etching to work. Follow with a thorough rinse with clean water. If staining existing concrete, you will need to clean and perhaps etch the surface. To prevent irregular staining, remove all foreign material from the surface.

Cleaning methods include scrubbing, sanding, and grinding. Scrubbing is for mildly dirty surfaces and should be accomplished by mixing an organic degreaser with water and vigorously scrubbing the surface with a nylon bristle brush. Power washing is an alternative that can speed the scrubbing process. For surfaces with paint or heavy staining, clean by sanding or grinding. Sand using a floor buffer with #80 grit sandpaper, or grind using a floor grinder with a fine grit diamond pad. For both sanding and grinding, attempt to maintain an even surface finish without patterns that will cause irregular staining. Areas that are heavily sanded/ground will absorb more stain and appear darker than lightly sanded/ground surfaces. Final preparation would include masking any areas not to be stained. Use a heavy-duty paint masking tape to protect these surfaces.

Stain Application

To apply stain, first mist the prepared surface lightly with water. Using a plastic sprayer, apply stain with a circular pattern nozzle in an even pattern. Overlap small areas to maintain a consistent appearance. To create a more consistent pattern, follow the spraying with a circular brushing with a medium-bristle brush. Avoid excessive overlap or brushstrokes when applying the stain. You can also use a medium-bristle paintbrush or roller to apply stain. For acid-based stains, a "fizzing" of the surface indicates that the stain is properly reacting with the concrete. Remove any residue and excess stain by mopping the pools or lightly rinsing the surface.

Leave the stain on the surface for approximately 4 hours (unless manufacturer's recommendations are different). If possible, avoid walking on the surface until it is dry. The surface must be dry before you apply additional coats of stain or sealer. For acid-based stains, rinse the surface with a mixture of clean water and 2 tablespoons of baking soda to neutralize the acid.

Sealant Application

When the stained surface has dried, you can apply sealer. Apply a light coat of sealer using a brush or roller; avoid leaving brush marks. Allow the sealer to dry and apply a second coat. To achieve the desired effects, you may have to apply additional coats. Most sealers are acrylic urethane, polyurethane, or epoxy products, with the choice determined by the manufacturer's recommendation.

PAINTING CONCRETE

Concrete stains create an opaque coloration of the surface, whereas paints provide solid color for outdoor surfaces. Painting, rather than staining, concrete has advantages; namely, painting can hide patchwork and patterns can be stenciled onto the surface. Typically epoxy-based, paint for concrete can be tinted a wide range of colors, and silica sand can be added to create a slip-resistant surface.

Concrete Preparation

Before you can paint concrete, its surface must be dry and free of any residue. Prepare the surface by power washing with water and a mild detergent.

After cleaning the surface, patch broken areas and fill cracks. Select nonshrink material that will bond well with the surrounding concrete. When the surface is dry, etch the concrete with a mixture of 1 part muriatic acid with 20 parts water. Sprinkle this mixture over the surface using a plastic sprayer or watering can and allow 1 hour for the etching to work. Follow with a thorough rinse, using one gallon of clean water mixed with 2 tablespoons of baking soda to neutralize the acid.

Paint Application

When the surface is clean and dry, apply paint using a brush or roller.

INSTALLING POROUS CONCRETE

Porous concrete, offered by the concrete industry under names such as Pervious® or Permeable® concrete, is a Portland cement concrete that allows water to percolate through the finished surface. Although similar to concrete in structural characteristics, porous concrete differs in composition and installation procedures.

Porous concrete is installed using many of the basic techniques described in this chapter, with a few significant exceptions. The initial difference is in form preparation, where an additional ½-inch shim is required on top of the forms to keep the screeded surface high enough for compaction to the desired finish elevation. A second difference is that the material is placed, screeded, compacted, cured, and jointed. To reduce filling the voids in the material, the steps of bull floating, wood floating, and steel troweling are not used for porous surfaces. Because this is a specialized finishing, the installer should have or should develop skills in working with porous concrete before attempting a contracted installation.

Ordering Material

Porous concrete is formulated differently from typical nonporous concrete. To obtain the open voids in the material, the percentage of fine aggregates is greatly reduced. This reduction in fine particles, typically to around 3 CF per CY of concrete, prevents the filling of all pore space between the aggregate. One manufacturer recommends smooth ⅜-inch aggregate to create a mix with approximately 15% voids. To ensure that the concrete maintains workability and stability, it should be mixed with a slump of 1½–3 inches. A water-to-cement ratio of 0.30 is typically recommended. A hydration stabilizer is often added to slow curing.[1]

Installing Porous Concrete

For a porous surface, the subgrade can be either a lightly compacted subgrade for erosion control installations or a layer of granular base for surfaces that will support traffic. If the surface supports only light traffic, the success in percolating water into the subgrade can be improved by using an 8–36-inch base of clean angular crushed stone of 1–2½-inch diameter. Placing a nonwoven filter fabric below and along the sides of the washed angular base creates a holding basin similar to a french drain below the pavement. This allows water to slowly percolate into the subgrade (Figure 23-38).

Form preparation follows the steps outlined for concrete, with the addition of a ½-inch shim on top of all forms to increase the pour depth. This additional depth will be required to accommodate compaction during finishing. Ground surfaces may require additional thickness to accommodate the grinding dimension. Jointing with neighboring slabs should be accomplished using fiberglass-reinforced plastic rods. Porous concrete mix is placed using wheelbarrows or a ready-mix chute directly on the base. Using shovels and rakes, distribute the concrete as evenly as possible between the forms in front of the screed. The low slump of the concrete makes it more difficult to evenly distribute the concrete. Screeding with a single pass from an adjustable mechanical vibrating screed is recommended. Following screeding, remove the shims on top of the forms to allow finishing.

Accomplish the finishing of the porous surface by using a 10–15-inch diameter steel drum roller that you will pass over the surface only enough to compress the slab to the finish elevation. No work with

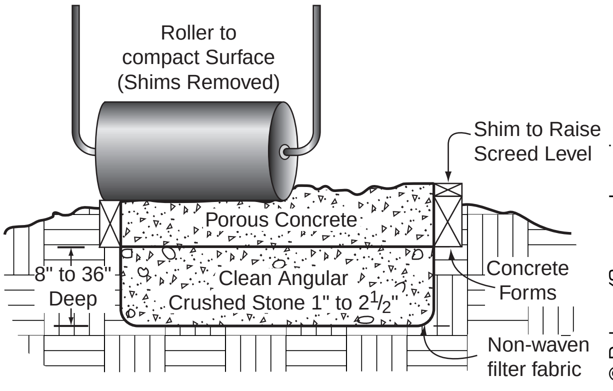

Figure 23-38 Cross section of a porous concrete installation.

bull floats or trowels is required. To avoid sealing the pores in the concrete, excessive working of the surface is discouraged.[2] Correct low spots in the surface by sprinkling loose concrete into the spot and hand-tamping. Contraction joints can be installed either before curing, using a ridged drum "pizza" roller that you pull from one side to the other, or following curing, by sawing or grinding to achieve uniformity. Curing of the surface is critical and begins by misting the surface to prevent drying after compaction. Then cover the surface with heavy (6 mil) plastic sheeting for 7–10 days.

ENDNOTES

1. U.S. Concrete, *Previous Concrete Sample Specification,* February 2003, 3–7.
2. Ibid.

CHAPTER 24

UNIT PAVERS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Install unit pavers in a recognizable pattern.
- Prepare the site for installation of unit pavers.
- Lay unit pavers.
- Finish a unit paver installation.

Including manufactured paving material that is laid by hand, unit paving provides opportunities for color, texture, and pattern unique to the landscape industry. This chapter covers the installation basics used for unit paving materials such as brick, interlocking concrete pavers, asphalt block, and adobe. Included in the information are descriptions of paving patterns and specific installation techniques. Open-cell paving installation is described at the end of the chapter.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Construction Staking, Chapter 8
- Materials and Site Preparation for Paving, Chapter 22
- Site Furniture, Signage, and Prefabricated Playground Equipment, Chapter 35

PLANNING THE PROJECT

Construction of unit paver surfaces can be a time-consuming project. To avoid problems, plan the installation before beginning any work. Following are some considerations for planning a unit paver installation. For techniques on installing resilient surfacing tiles, see Chapter 35.

Paving Patterns

Examples of common paving patterns are identified in Figure 24-1. Because of the special shapes in

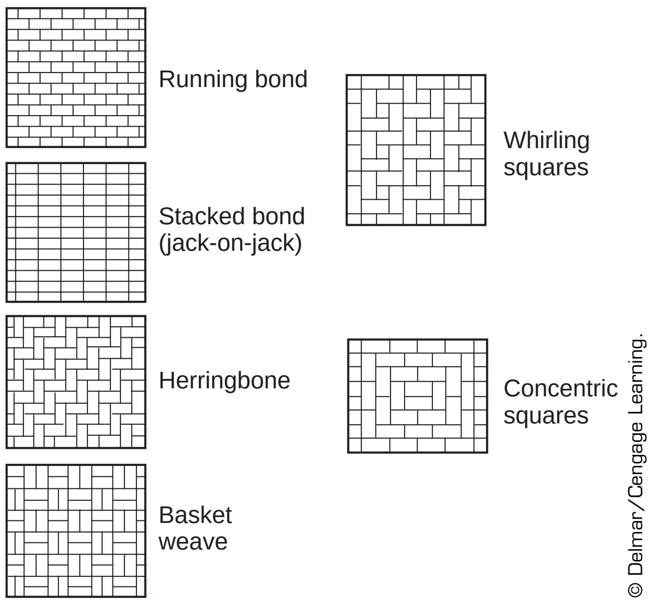

Figure 24-1 Common unit paving patterns.

which they are manufactured, certain paving materials may allow only one pattern. Use caution when purchasing brick pavers. If the units are not modular (length twice as long as width), patterns such as herringbone and basket weave will not work. Placement order for each pavement pattern is shown in accompanying figures. Paving brick should be solid and without any cores or surface openings.

- Running Bond. Running bond is a pattern in which pavers are placed in staggered, horizontal rows. Pavers are placed end to end in one row; and in the next row, they are set end to end but are offset by one-half paver. Pavers that work in this pattern include most interlocking concrete pavers, all brick, and any paver that is not modular. Old roadway bricks can often be used only in this pattern (Figure 24-2).
- Stacked Bond (also called Jack-on-Jack). Stacked bond is a pattern in which pavers are placed side by side in even horizontal and vertical rows. Pavers that work in this pattern include many interlocking concrete pavers (all sizes), most brick, adobe, and any modular paver (Figure 24-3).
- Herringbone. Herringbone is a pattern that places horizontal and vertical blocks in a diagonal pattern across the paved area. The finished pattern leaves a zigzag, or herringbone, appearance. Halves are required for starting this pattern. Any modular paver can be used in this pattern (Figure 24-4).
- Basket Weave. Basket weave places two pavers vertically, and then two pavers horizontally. This alternating pattern is repeated across the entire paved area. Any modular paver can be used in this pattern (Figure 24-5).
- Whirling Squares. Whirling squares place four pavers in a square pattern around a half-brick center. This pattern can be offset to

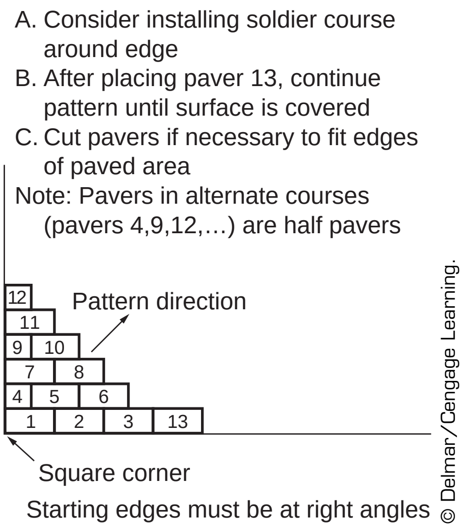

Figure 24-2 Running bond pattern installation.

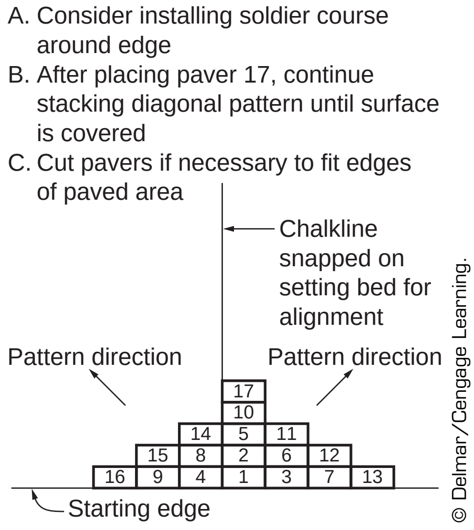

Figure 24-3 Stacked bond pattern installation.

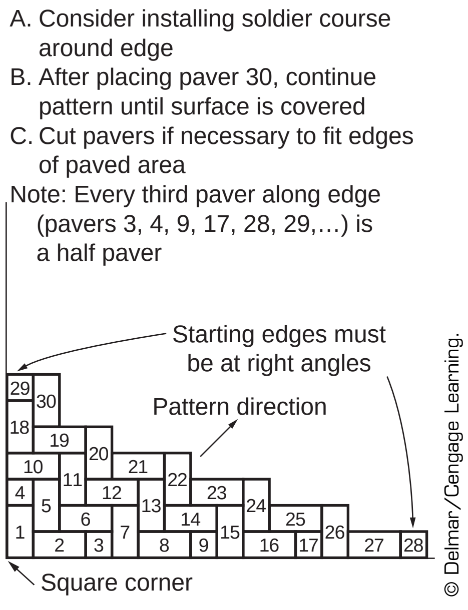

Figure 24-4 Herringbone pattern installation.

create an even more interesting pattern. Halves are required for this pattern. Any modular paver can be used in this pattern (Figure 24-6).

- Modified Basket Weave. Variations of the basket weave are possible. A common variation includes placing an extra vertical between the vertical and horizontal pairs in every other row. Any modular paver can be used in this pattern (Figure 24-7).

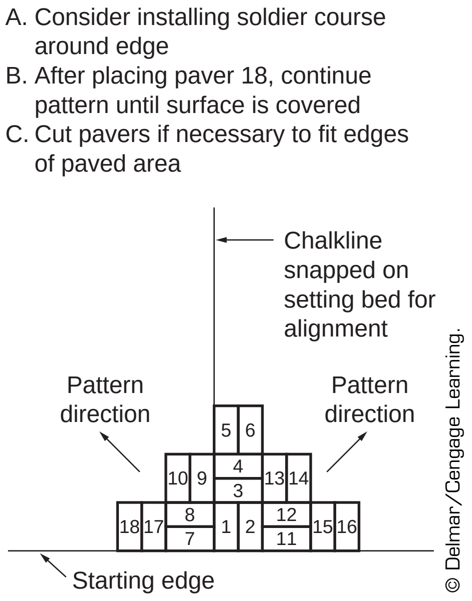

Figure 24-5 Basket weave pattern installation.

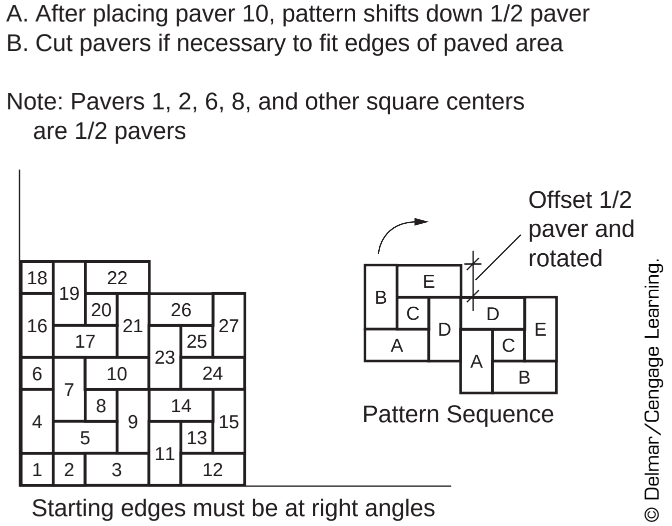

Figure 24-6 Whirling squares pattern installation.

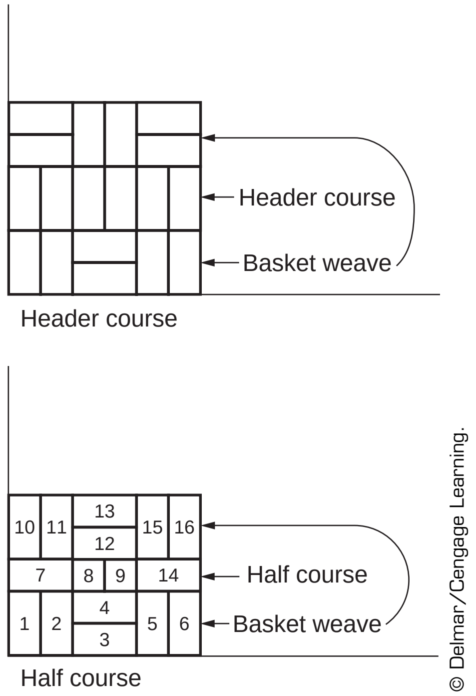

Figure 24-7 Basket weave pattern variations.

Interlocking Pavers

Interlocking concrete pavers are also available in a variety of shapes that create patterns when installed in stacked or running bond. Some common shapes of interlocking pavers include (Figure 24-8):

- Rectangle. Modular rectangular paver.
- Double Score Rectangle. Modular rectangular paver with a score line in the center to create an impression of two halves.
- Octagonal. Paver with an octagonal body and interlocking tab.
- Dentated. Paver with an interlocking angled edge.
- Cobble. Combination of modular rectangular and square stones.
- H Block, I Paver, or Dogbone. Paver with an interlocking H shape.
- Permeable Pavers. Block with truncated corners or wider side spacers.
- Porous Pavers. Precast blocks with porous surfaces to allow drainage through the material.
- Circle Pavers. Wedge-shaped stones to form various radii circles.
- Euro-Cobble®. Combination of modular rectangular stones. Also named Villa®.

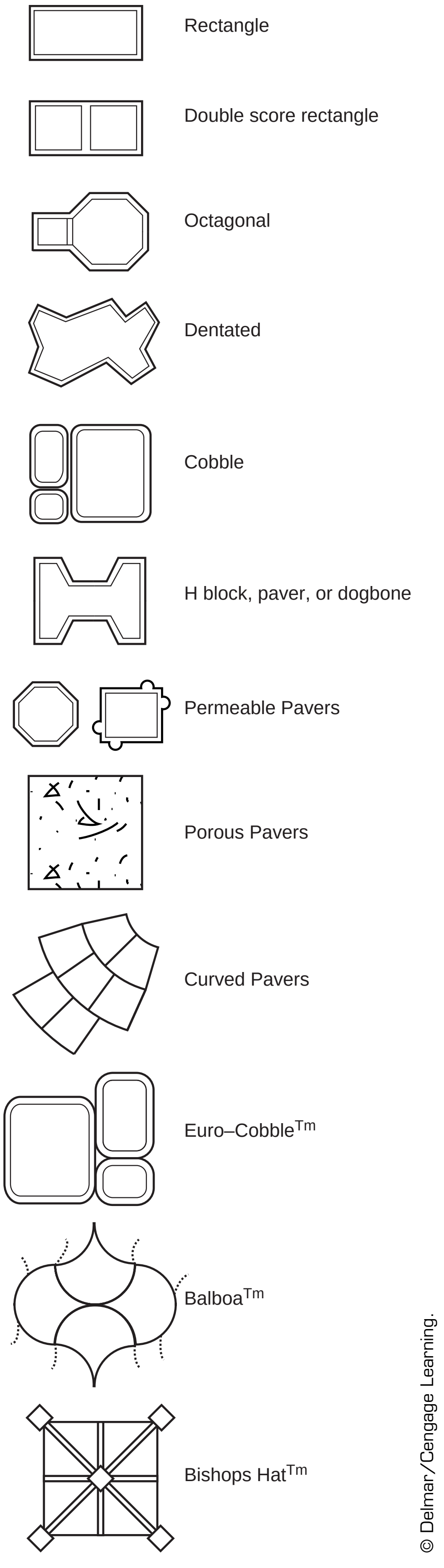

Figure 24-8 Interlocking concrete paver shapes.

- Balboa Pavers®. Arced edges that interlock in patterns of four stones.
- Bishop's Hat®. A combination of triangular stones with small square center blocks.
- Custom Pavers. Molded stones in the shapes of animals and custom designed shapes. ®Pavestone Manufacturers and ®Gecktostone.

BASE MATERIAL

Base preparation for most unit paving installations is similar to the process described in Chapter 22. However, for some pavement types, there are alternatives for using an aggregate base with a setting bed. Installation over a previously paved surface, or pavement that must carry heavy traffic loads, may require an alternative to a crushed stone pavement base. Regardless of material, the base under the entire paved area should be consistent. Differential settlement can occur in areas where the unit pavers move from one type of base onto another. Valleys and ridges typically develop over time where base materials change. Some alternative treatments are:

- Concrete or Asphalt Base. Placement of brick or concrete pavers on a sand setting bed over concrete or asphalt is possible if the base is level and has no cracks or serious surface disruptions. If the proposed base surface has broken joints or other disruptions, paving is not recommended. The installation may suffer long-term deterioration if placed on a base that does not drain properly. If pavers are placed on an impervious base that has no drainage, holes should be drilled at the low edges of the subpaving to allow moisture that has passed through the pavers to drain through the base.
- Mortar Base. For some applications, brick or stone paving is placed on a mortar base. See Chapter 26 to review the situations and methods for this type of paving.

EDGE RESTRAINTS FOR PAVED SURFACES

All unit pavers require some sort of edge restraint to prevent the outer courses from wandering. The methods and timing of the placement vary, depending on the design of the project, but several choices are described in Chapter 22.

ADHERING PAVERS TO STEPS

When pavers are to be placed on step treads or edges of stoops, pavers must be set in a thin bed of mortar or an adhesive must be applied to bond the paver to the material below. Mortared installations should be completed according to the instructions provided in Chapter 21. Pavers bonded to stairs should be cut with joints of 1/16 inch or less. Use a one-part urethane or similar type of adhesive to bond the pavers to the outer edge of the stoops.

PLACEMENT OF SETTING BED

A thin layer of material on which the pavers will be set should be placed over the compacted base. The setting bed should be screeded to a consistent 1–1½-inch thickness across the compacted base. Because the pavers are resting directly on this material, the setting bed must be sloped in the proper direction and be set at the proper elevation. Clean, coarse, concrete sand is the preferred material for a setting bed. Stone dust, fines, limestone screenings, and other materials provide inconsistent compaction after pavers are set. Setting bed sand should contain enough moisture that it forms a ball when squeezed in the palm of the hand. Sand that is too dry will need to be wetted slightly prior to screeding.

Precise screeding of the setting bed can be accomplished using a board notched to fit adjacent pavement or preplaced edge restraint. If using a paved edge for screeding, be certain the base screed is notched to accommodate the thickness of the paver minus ¼ inch (Figure 24-9). Screeding can also be accomplished by working off 1-inch diameter screed rails that are set directly on the base. Screed only the area of the setting bed that will be paved immediately. Screed perpendicular to the rails when possible. To match existing grades, small sections may need to be screeded in areas where the pavement cross-slopes, or warps. Screed the setting bed and lift out the temporary screed rails, filling the voids left by the rails with additional sand and smoothing with a steel trowel.

Headers

Similar to those discussed in Chapter 23 for concrete paving, headers can separate brick paved surfaces into smaller paved areas. Typically, decay-resistant wood headers are installed prior to the placement and screeding of the setting bed. The headers are then used as a screed support for leveling the bedding sand.

UNIT PAVER PLACEMENT

Placing unit pavers requires craftsmanship that is created through planning, patience, and creativity in completing an installation. Unlike bulk paving materials that are placed and finished, the placement of each paving unit must be considered.

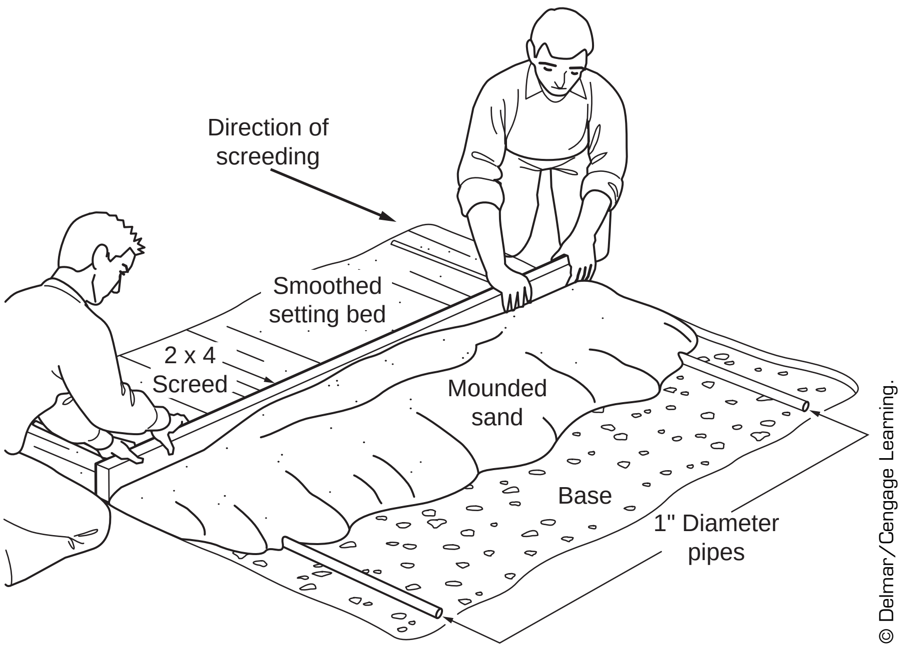

Figure 24-9 Screeding setting bed for unit pavers. The 2 × 4 slides across the 1-inch diameter pipe leaving a smooth surface.

Patterns and Edge Course

Before beginning a project, lay a test area large enough to see how the pavers will fit together. For each of the patterns, place a soldier course of full pavers around the entire perimeter (Figure 24-10). This course eliminates placement of cut and partial pavers adjacent to the edge restraint; it also reduces breakage and movement problems.

Beginning Placement

To obtain a tight, uniform pattern across the paved area, always work from a line that is perpendicular to the edge from which paving begins. Beginning in the wrong place or starting on two sides may lead to a "pinching" or "spreading" of the pattern near the center of the paved area. To correct this error, you may have to cut or relay additional pavement.

One method commonly used for paver placement is the T method, which begins paver placement in a line perpendicular to one of the project's straight edges. The straight edge often used for alignment is a structure or existing paved surface that the paved area abuts. For patios with sight lines through the doors and into the paved surface, consider centering the T layout on the door to ensure a full pattern in front of the door. Near the center of this straight edge, lay out a line at a 90° angle to the straight edge that runs through the center of the paved area. Snapping a chalk line on the screeded bedding sand along this alignment will help maintain the pattern. Extend the pattern along this line for four or five courses, and then fill the area between the straight and perpendicular lines (Figure 24-11). This method works well for rectangular-shaped areas where minor variations from perfect horizontal and vertical lines will be noticed. Most patterns can be laid with this method.

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Figure 24-10 Soldier course at edge of pavement.

Another method for placement is to begin at a structure or wall and work out one row at a time. This method works well for curved walkways and irregular shaped areas where minor variations from perfect vertical and horizontal alignment will not be noticed. This method is also easier for placing herringbone patterns. Without a structure or paved area against which to align paver placement, snap a chalk line across the screeded bedding sand for alignment.

When using the herringbone pattern for placement, you may find that beginning in the corner of a project, rather than using the T or horizontal method, to be more beneficial. With a corner beginning point, you can more easily place this complex pattern and continue the placement in one direction across the project. Problems will be encountered with either method if the paved area is between walls that are not at right angles. If you encounter this situation, expect to do a great deal of cutting along one or both walls.

To speed the work, stack several piles of pavers near where you will begin placing them. Become familiar with the paving units. Note that interlocking concrete paving block and precast pavers have a top side with a beveled edge. Other pavers may have patterns or textures on the upper side. Pavers placed upside-down will need to be removed and reinstalled with the wearing surface facing up. When paving large areas, you may need several pallets of material. To avoid problems with minor color variations between pallets, select pavers randomly from each of the pallets provided.

Laying Pavers

Begin laying pavers according to one of the placement methods and patterns previously described. When placing the pavers, set them straight down onto the setting bed. Avoid dropping, angling, or twisting the paver. Allow the paver's weight to set it

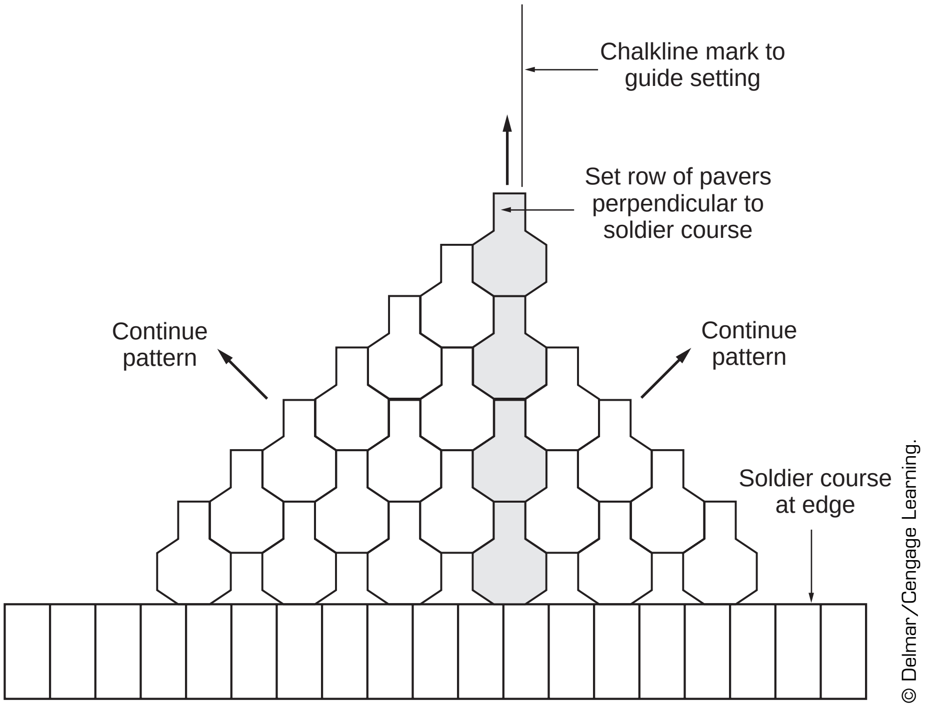

Figure 24-11 T pattern for placement of unit pavers.

onto the sand bed. The paver should be placed with joints of approximately 1/16 inch (Figure 24-12). Some paver varieties have spacers cast into the sides of the paver; these spacers hold the pavers the correct distance apart. Set clay brick and other pavers with sides and ends touching.

If a paver pushes too far down into the setting bed, it may leave a small ridge of sand around the bottom edge. This ridge will prevent tight placement of the next pavers. Lift the paver out and lightly smooth the setting bed with a steel trowel. Use caution not to compact or vary the surface level when resmoothing the setting bed.

Check paver alignment often as you lay the pavers. Verify that the joints are straight and that the pattern is correct. Place a stringline along the pavers' joint lines and check paver alignment every 10 courses. Adjust pavers using a pry bar. Avoid stepping near or adjusting pavers within 1 foot of an unrestrained edge. Continue laying pavers up to the edge restraint that is in place or to the edge marking. If you cannot complete laying pavers in a single session, temporarily restrain them with a piece of edging. Before continuing paving operations, remove the edging and repair the surface.

Figure 24-12 Beginning placement of interlocking concrete pavers.

CUTTING AND FINISHING EDGES

Few unit paving jobs can be completed without cutting and placing partial pavers. Planning and selecting simple pavement patterns may reduce the number of cuts that have to be made; but anytime you encounter an irregular shape or structure, you can expect to do some cutting. To improve aesthetics and to avoid breakage and movement of pavers, place full pavers in areas where visibility and traffic is high. Marking and cutting paving materials is described in Chapter 7. As an alternative to cutting half or partial pavers while installing the pattern, place all full pavers first; then mark, cut, and place partial pavers to complete the surface. This will concentrate cutting into a single activity. Use caution not to alter the pattern when placing all full pavers.

Placing Cut Pavers

Placing cut pavers into position may require tapping the paver with a rubber mallet or shifting the pavers with a mason's trowel. Pavers should fit precisely into the opening (Figure 24-13). If the fit is too snug, trim a bit more off the paver. If the paver can be removed without contacting any adjacent pavers, the cut was too extreme and should be redone using a new paver.

SEATING AND FINISHING THE SURFACE

After you have placed all pavers and edging, apply the final steps to a paved surface. This process may vary, depending on manufacturer's requirements, but most processes require the pavers to be "set" into the setting bed and to sweep sand on the surface.

Seating Pavers

Concrete paving blocks require a mechanical seating of the paving units (Figure 24-14) using a vibratory plate compactor. The seating of pavers vibrates them into the setting bed and forces the setting bed sand up into the joints between pavers. When seating clay brick pavers, use a plate compactor with a rubber mat on the plate to avoid chipping the units. Sweep all debris from the paved surface. Make two passes in this initial seating operation.

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Figure 24-13 Setting cut pavers.

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Figure 24-14 Seating pavers using a plate compactor.

If the plate compactor has multiple settings, use the high-frequency/low-force setting. Place the plate compactor on the surface, start the equipment, and work the surface from the outside edge into the center. Operate the plate compactor at least 3 feet away from unrestrained edges. This mechanical seating will push blocks down into the sand, leveling course as much as ¼ inch. When working against existing paving or a preset edging, run the plate compactor on both surfaces at the same time. Placing the plate compactor only on the new pavers may cause them to settle below the existing surface. Examine the surface for any damaged paving units. Use a paving puller or two screwdrivers to lift damaged units out of the surface. Replace damaged or broken units with new pavers.

Sweeping Joints

Filling the joints between the pavers helps create interlock and contributes to the waterproofing and stabilization of the surface. This is accomplished by shoveling dry, coarse sand onto the surface of the pavers and sweeping it into the joints. Sweeping diagonally to the joints in two different directions is most effective in working the sand down (Figure 24-15).

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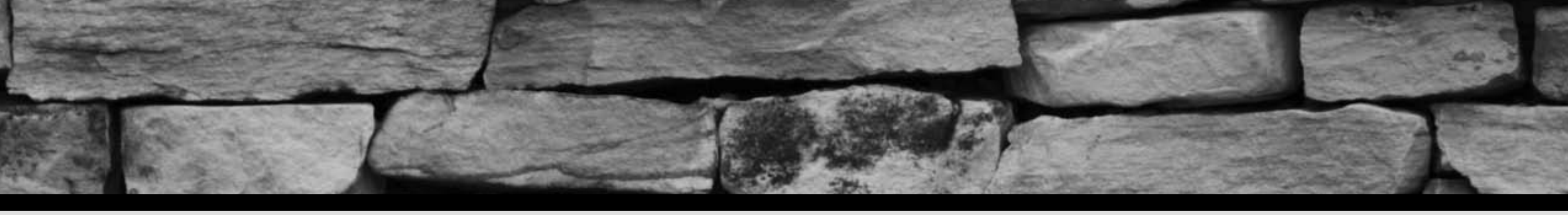
Figure 24-15 Sweeping dry sand into paver joints.

Repeating Compacting and Sweeping Operations

Repeat the plate compaction and sweeping of joints until all joints are full.

SEALING UNIT PAVER SURFACES

Some unit paved surfaces can be sealed to protect them from stains and soiling. Pavement sealing is a specialized operation that involves washing the surface and applying formulated sealers. Contact paving manufacturers or distributors for their recommendations on sealing procedures for unit pavers.



CHAPTER 25

DRY-LAID STONE PAVING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Install dry-laid stone in a recognizable pattern.
- Prepare the site for installation of dry-laid stone paving.
- Lay dry-laid stone.
- Finish a dry-laid stone installation.
- Install a dry-laid recycled concrete paved surface.

Stone paving combines craftsmanship with technique in creating one of the most aesthetic paved surfaces. This chapter covers the techniques of dry-laid stone paving using limestone, slate, and other regionally available flagstone materials. Techniques for base preparation and laying also support the installation of modular paving materials such as granite and cut stone. In addition to dry-laid base materials, stone paving can be effectively laid in a mortar base. Mortar base stone paving is covered in Chapter 26, whereas this chapter covers stone paving laid on a granular base. Also included at the end of this chapter are techniques for placing dry-laid stones informally as stepping stones.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Construction Staking, Chapter 8
- Materials and Site Preparation for Paving, Chapter 22

PAVING PATTERNS

Selecting a pattern for stone pavement is based on the type of stone chosen for the construction project. Pavement patterns are generally identified as either modular patterns, for stone that is cut into square and/or rectangular shapes, or random patterns, for stone that is left in natural, uncut shapes. Examples of common paving patterns and the stone that works best in those patterns are listed below (Figure 25-1). Placement order for each pavement pattern is shown in accompanying figures.

- Random-Irregular. Pattern using irregularsized stone. Stone should be placed with small and large pieces evenly intermixed (Figure 25-2). This pattern requires an artistic eye to develop an attractive pattern throughout the installation. Intermix large pieces, rather than concentrating them in one area of the installation. Use the smaller pieces to create patterns that fan out from each side of the installation.

- Random-Fitted. Pattern using irregular-sized stone to create horizontal and vertical joints. Although stone sizes are intermixed, joint arrangement is maintained (Figure 25-3).
- Modular-Irregular. Pattern using stone of varying sizes with straight-cut edges. Widths are typically in multiples of 2, 3, or 4 inches so stone can be fit with horizontal and vertical joints (Figure 25-4). The intermixing of stone sizes and colors creates the richness of this pattern. Large stones should be interspersed throughout the design and placed with only minimal overlap with each other. When laid as separators between the largest pieces, the smaller pieces of stone appear like veins running from end to end and side to side in an installation.
- Modular-Running Bond. Pattern using stone of same size with straight-cut edges. Stone is placed in staggered pattern similar to that found in brick installations (Figure 25-5).

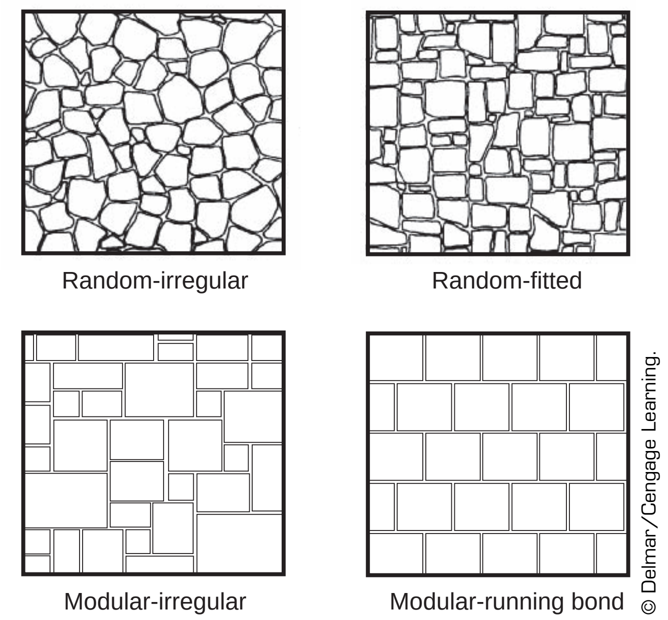


Figure 25-1 Common stone paving patterns.

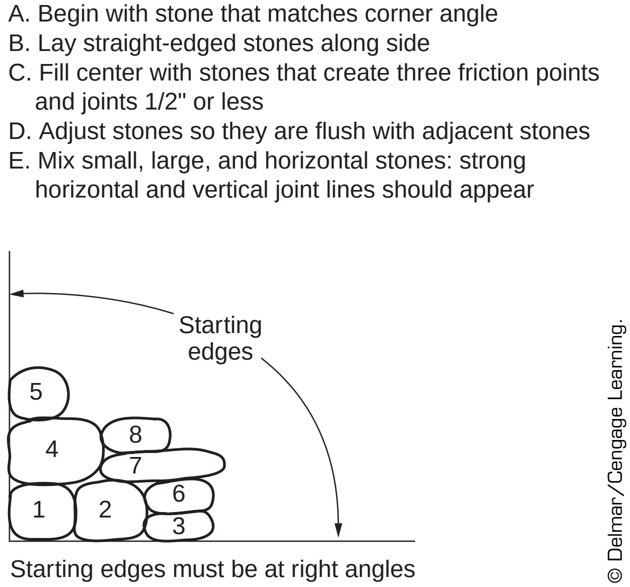


Figure 25-3 Random-fitted pattern installation.

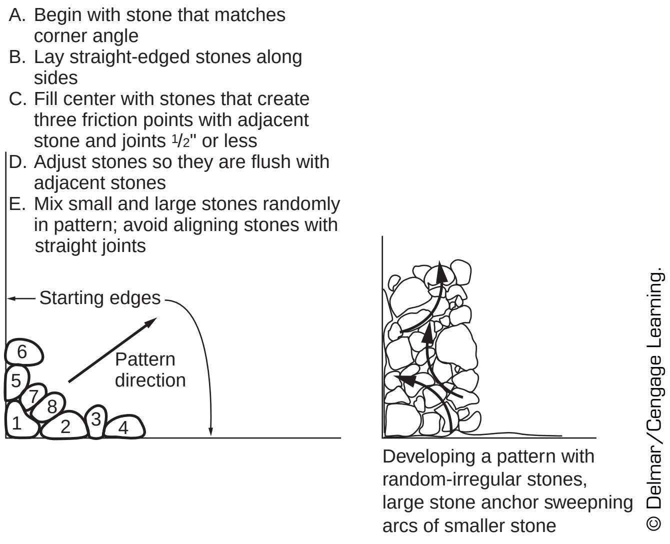


Figure 25-2 Random-irregular paving patterns.

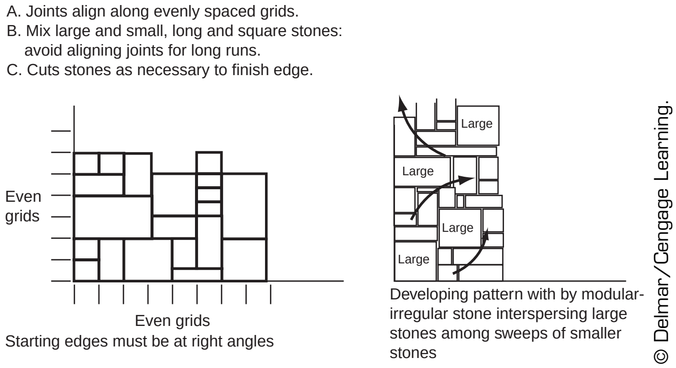


Figure 25-4 Modular-irregular pattern installation.

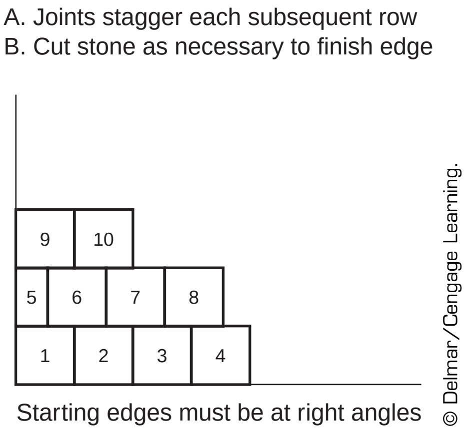


Figure 25-5 Modular-running bond pattern installation.

CHOOSING BASE MATERIAL

Base preparation for most dry-laid stone paving installations is similar to the process described in Chapter 22. Alternatives to a granular base with setting bed are:

- Undisturbed Soil. There is always a temptation to place stone directly on a soil base. This can be done if the base is undisturbed and the expectations for a long-term, level surface are not high. The amount of work in preparation and placement is somewhat less than that for a proper base preparation, but the time and labor required for long-term maintenance offset the short-term time savings. It is not recommended in any area where public safety or heavy traffic will be an issue.
- Mortar Base. In addition to being dry-laid, flagstone may be set on a bed of mortar. See Chapter 26 to review the situations and methods for mortared stone paving.
- Concrete or Asphalt. Concrete or asphalt will substitute for granular base material if the surface is level and stable. Surfaces with deep depressions or ridges should be removed and replaced with a new granular base. If paving over an existing slab, place a setting bed of 2 inches to accommodate base variations.

INSTALLING EDGE RESTRAINT

If the project requires a permanent edge restraint such as a concrete curb, walk, or cut stone, install this edge before placing and screeding the setting bed (Figure 25-6). This minimizes disturbance of the paving after it has been placed and ensures that the finish grade of the stone matches the edging material. Edge restraints are described in Chapter 22.

PLACING THE SETTING BED

Because it often varies in thickness, stone requires a thin setting bed of fine granular material to maintain a level surface. Depending on the region, concrete sand or stone dust makes a good setting bed. Each is placed over the base and screeded smooth. Setting beds should not be less than 1 inch or more than 2 inches in thickness. Maintaining the 1-inch course provides the most stability for an installation. Because the stones are resting directly on this material, the setting bed must be sloped in the proper direction and be set at the exact elevation below the

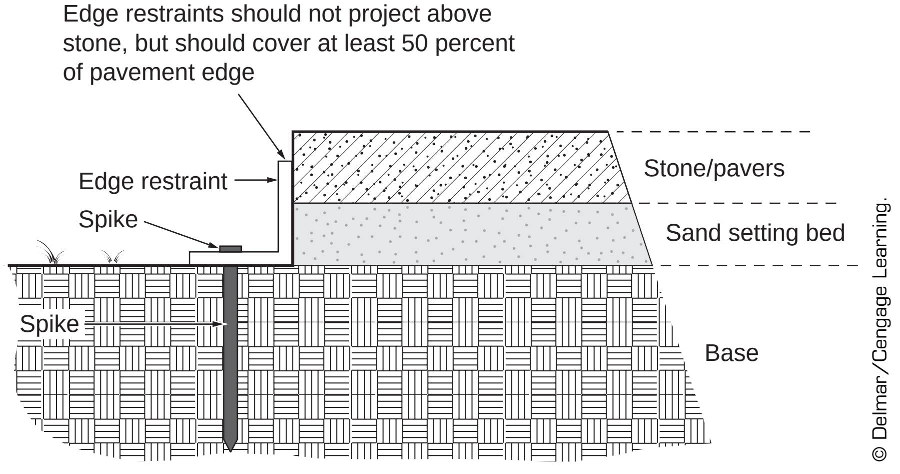


Figure 25-6 Edge restraint for stone paving.

finish grade required. The proper elevation for the top of a setting bed is the finish elevation minus the average thickness of the stone.

Screed the setting bed using preinstalled edge restraint or temporary screeding rails. If using a paved edge for screeding, be certain the base screed is adjusted to accommodate the thickness of the stone. In installations where it is only important to maintain a positive slope, screed from stringlines stretched between grade stakes. This will create a surface with some minor variations, but this method is a much faster way to prepare for paving.

You may screed small amounts of the setting bed as the work progresses, or you may screed the entire area before laying any stone. If an edger has not been preplaced, use a stringline or paint line to mark the edge of the paved area. If the surface of the setting bed has dried out before you begin laying stone, wet the surface with a light mist from a hose attachment. Do not soak the surface, and do not disturb the setting bed during the wetting process.

PLACING STONE

Laying stone requires a great deal of placement and rearrangement of materials, particularly when you use random patterns. Lay a test pattern large enough to see how the stone fits together. One technique that helps with stone selection is to lean several stones against a fence or railing (assuming it will support the weight) so you can observe their shape, color, and other characteristics. Regardless of the pattern selected for the body of the paved surface, full stone with square edges should be placed around the entire perimeter. This placement reduces stability problems when small stone is placed adjacent to the edge. When transporting stone to the placement area, use available tools to make lifting and transporting easier. For example, if you place heavy stone in a wheelbarrow or on a two-wheeled cart (Figure 25-7), you can easily move it.

Beginning Placement

The objective of laying stone is to maintain a tight and uniform pattern across the paved area. Stone should have joints of less than ½ inch, and adjacent stones should touch. Stone that is placed in random patterns is best laid in a fan shape. Begin in one corner of the paved area and work along the edges; then fill the space between (Figure 25-8). Use a structure or corner as the straight edge(s) against which the first fan of stone is aligned. You may move outer edges slightly, or you can trim the stones to create a tight fit.


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Figure 25-7 Transporting heavy stone using a two-wheeled cart.

Another method for placement is to begin at a structure or wall and work out one row at a time. Select pieces with straight edges to use in placement next to structures or other restraints. This method works well for irregular-shaped areas where minor variations from perfect vertical and horizontal alignment will not be noticed. Snapping a chalk line on the setting bed will aid in maintaining alignment for patterns with straight joints.

Stone Laying

Begin laying stone according to one of the placement methods previously described. Have a mag float handy to smooth out any variations in the setting bed. Tapping the stone with a rubber mallet will also help fit it into tight locations. Before placing a stone, examine the edges for bevel. Bevels should be placed down when setting stone, reducing open joints in the surface (Figure 25-9). When placing the

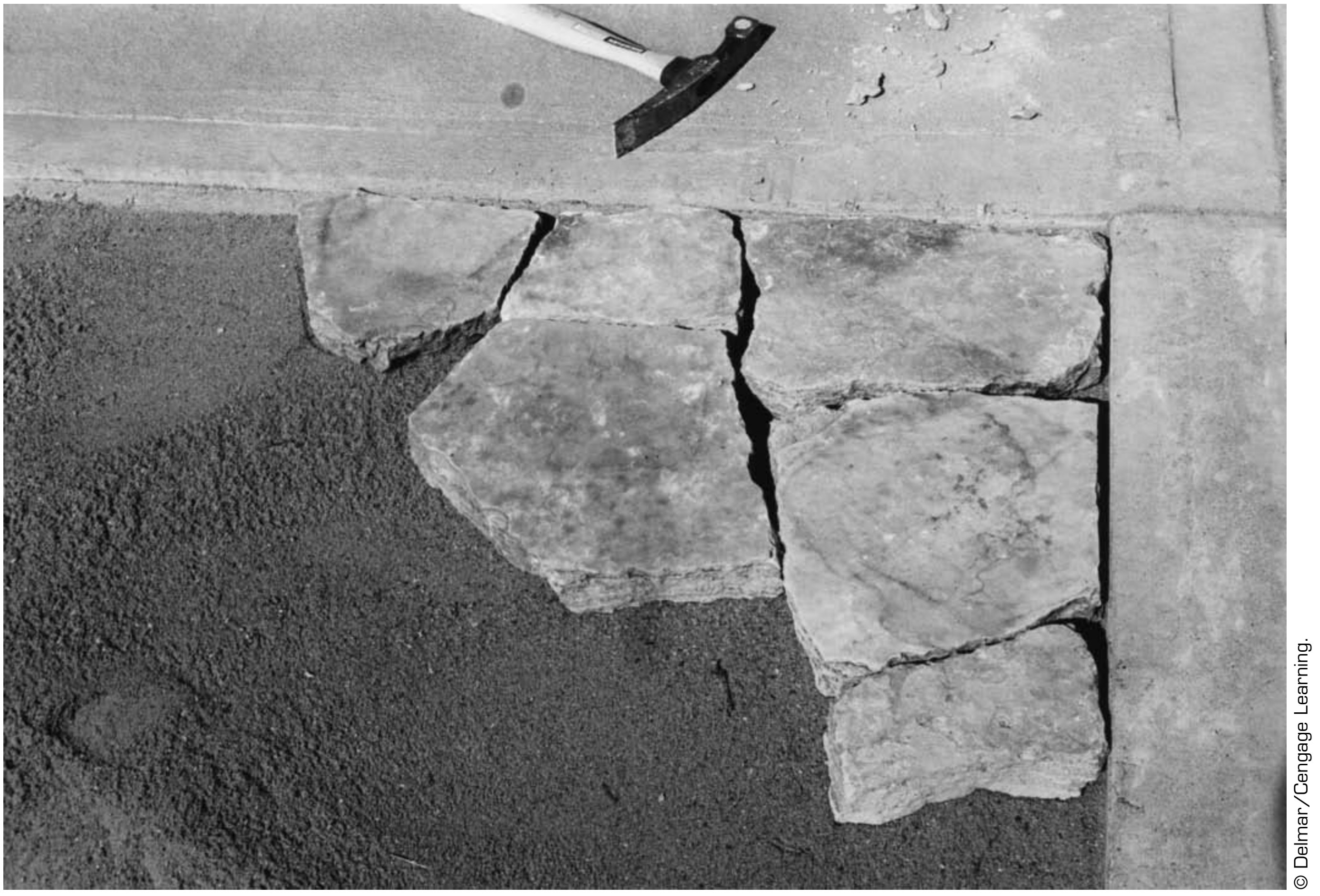

Figure 25-8 Proper placement of dry-laid stone. Note that surfaces are flush with surrounding stone and each stone makes contact with adjacent material. Joints are ½ inch or less.

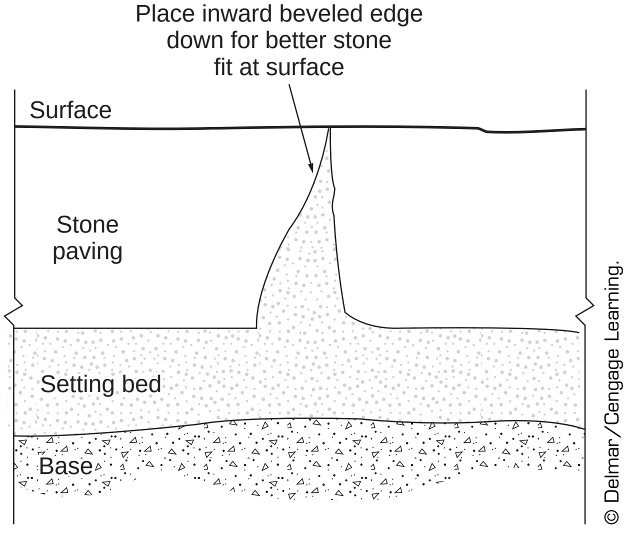

Figure 25-9 Proper orientation of stone with beveled edge.

stone, set it straight down onto the setting bed and twist it slightly to seat. Modular stone must fit tightly against any adjacent stones already in place.

Irregular-shaped stone should make contact with adjacent stones at a minimum of three points to provide stability. Random patterns should have minimal joints. Although some joint space is expected, any stone that has fewer than three contact points or joints over ½ inch should be set aside, and a new stone should be placed (Figure 25-10). A flush surface must be maintained, requiring that stone height be adjusted as necessary by adding or removing setting bed material below the stone. Adjust the height and position of small stone by lifting and adding or removing setting bed material. Larger stone may require the use of a lever or tool to perform the lifting and movement. You can use a pry bar to temporarily lift a stone for adjustment (Figure 25-11).

Check pattern alignment often as you continue laying stone. For modular stone, verify that the alignment is straight and that the pattern is correct. Make

Figure 25-10 Placement of dry-laid stone in pattern.

corrections by relaying stone or by gently tapping the sides with the rubber mallet. Continue laying stone up to the edger that is in place or to the stringline or paint marker at the edge. You can cut modular stone to complete edges, whereas you should fit and/or trim random stone to fill all voids up to the edging.

CUTTING AND FINISHING EDGES

Planning and selecting certain pavement patterns may reduce the number of cuts you have to make; but anytime an irregular-shaped stone or structure is involved, you can expect a certain amount of cutting. To the greatest extent possible, avoid the use of small stone pieces along the pavement edges. Methods for marking and cutting stone for the project are described in Chapter 7.

FINISHING THE SURFACE

Following placement of all stone and edgers, apply the finishing steps to a paved surface. This process varies, depending on the type of stone, but most processes require that material be swept into the joints of the surface.

Filling joints between the stones helps hold them in position. To fill the joints, shovel concrete sand onto the surface of the pavers and sweep it into the joints. Sweeping in several different directions is most effective in working the sand into joints. Sand can be mixed at the rate of 2 parts sand to 1 part Type N mortar mix to create a weak mortar for flagstone paving. Sweep the mixture into joints and lightly wash the surface with water. This mix hardens after the surface is washed and performs the role of a spacing material. Expect this weak mortar joint treatment to crack soon after placement because it is not a full-strength mortar placed on a stable base. Repeat the sweeping operation twice more within a week on all types of surfaces.

Joints of ½ inch or less can also be loosely sealed using a mixture of 1 part white glue mixed with 4 parts water. Blend the mixture and apply it directly

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Figure 25-11 Adjusting the position of a stone using a pry bar as a lever.

to loose sand or aggregate in joints. This formula can stain paving material; so, apply it only to the joints. Apply by pouring out of a paper milk carton or through a funnel. For additional protection from staining, mask the edges of the pavement with masking tape prior to application.

USING RECYCLED CONCRETE AS DRY-LAID PAVING SURFACE

Preparation and setting of **recycled concrete** follow the same steps as setting dry-laid stone, with only minor adjustments in the process. Prepare the base as you would for dry-laid stone. Edge restraint can be installed if desired. When placing recycled concrete, select and place pieces so that they fit aesthetically and structurally according to the same rules as dry-laid stone. Pieces should have joints of no more than 1 inch and should contact adjacent pieces in no less than three places. The surface should be flush with adjacent pieces.

Complicating the setting of recycled concrete are irregularities on the lower surface if the concrete was poured on an uneven base. To counter this problem, place a 1-inch setting bed of crushed fines or sand on top of your prepared base to provide a material that can be adjusted to match the profile of the lower surface. Round the sharp edges on concrete pieces by striking them lightly with a brick hammer. Several attempts at lifting and resetting may be necessary to level set recycled concrete (Figure 25-12). To speed the process, set the material on the base and slightly twist it; then tilt it up. Look for the impressions on the setting bed that indicate high points to be lowered. If you are setting large pieces of concrete (minimum dimensions of 18 inches), an exception to the 1-inch joint and adjacent stone contact requirements is possible. Properly set large pieces of concrete are unlikely to shift; so, you can set them with joints up to 2 inches wide. Fill these joints with granular material or pea gravel, rather than sand.

Joints for recycled concrete are finished in a manner similar to dry-laid stone. If no edge restraint is placed, the material swept into joints should be larger than sand to reduce joint erosion. The surface of recycled concrete may also benefit from

Figure 25-12 Level setting recycled concrete.

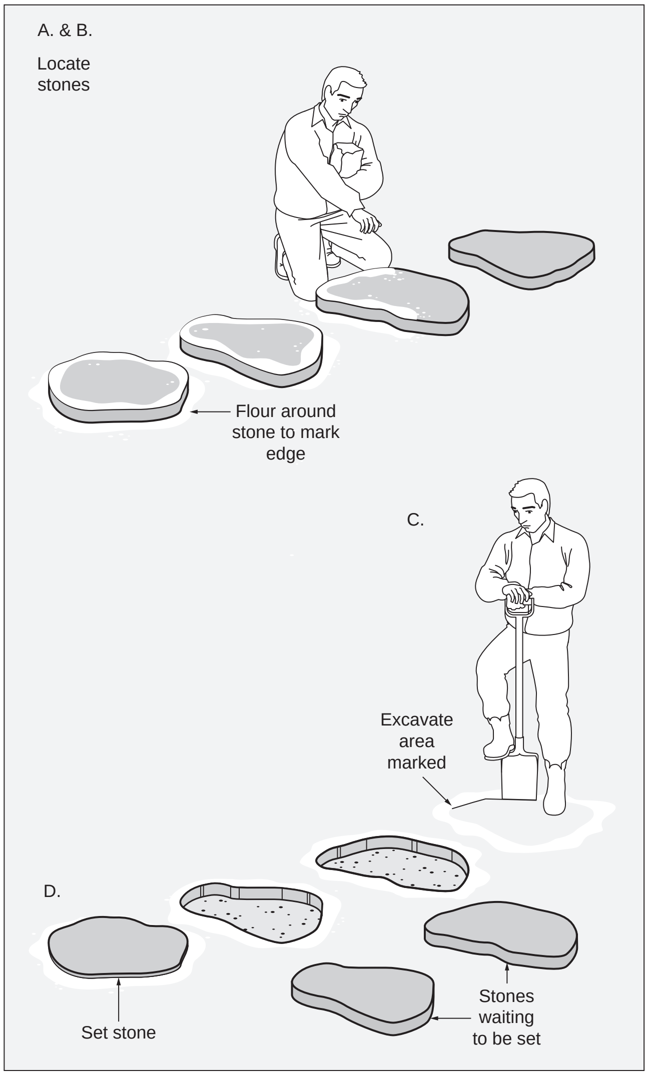

Figure 25-13 Installing stepping stones.

a light sandblasting to clean the material and to remove irregular textures.

SETTING STEPPING STONES

For informal paths, paving materials can be placed directly on an earth surface. Place stepping stones in locations where the path is desired. Arrange as necessary to accommodate a comfortable stepping pattern.

For a more stable installation, place the paving material and mark the material location by sprinkling base path chalk, floor, or lime around the edge of the paving material (Figure 25-13 A & B). Lift the paving material and excavate a shallow, level area at the location of the markings. The excavation should not be deeper than the thickness of the paving material and should extend slightly outside the markings (Figure 25-13 C & D). Replace the paving material and check for stability. If paving material rocks, lift and place a small amount of sand in low areas. Twist back into the excavation and recheck for level. Backfill around the material with soil to complete the installation.

An alternative method for setting stepping stones can be used in areas where the pavement can be flooded. This method requires a subgrade that will allow water to eventually drain away from the project. Excavate a 2-inch deep base below the stone. Place a 3-inch deep layer of fine sand over the entire area to be paved. Place the stone on the base and flood the area with water. While the sand is saturated, twist the stone down into the base until set at the proper elevation. Continue saturating the base and setting the stone until you have set all paving. Let the area dry and fill in joints with sand.

CHAPTER 26

MORTARED PAVING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Prepare the base for a mortared paved surface.
- Prepare mortar.
- Install paving on a mortar base.
- Finish a mortared paved surface.

Mortared paving is a surface in which bricks, stone, tile, or other paving materials are set in a bed of **mortar** with mortar-filled joints. When improperly installed, mortared paving will have durability problems in areas of the country where temperatures fluctuate above and below freezing. With proper installation, however, applications are appropriate in many situations. Choice of materials for mortared pavement is almost as great as the choice for dry-laid and unit pavements. Stone pavement, brick, and tile are common choices. This chapter provides the basic techniques required to set appropriate pavement types in a mortar base. Included are instructions on base and mortar preparation and on placement of paving material and finishing its surface.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials and Site Preparation for Paving, Chapter 22
- Concrete Paving, Chapter 23

PLANNING THE PROJECT

Preparation for a mortared paving project requires examining the work situation and making choices regarding base, base preparation, paving pattern, and when half brick may be required. Complete the project planning by considering each of these situations before beginning installation.

Base Material

Base preparation for mortared pavement typically requires a solid base on which to place a mortar setting bed. This base is typically a concrete slab because of concrete's rigid nature. In some random stone applications, a compacted base similar to that described in Chapter 22 is prepared, and mortar is applied to that base. The possibilities of cracks developing in that type of surface are high.

Base Preparation

If a concrete base is being used, prepare the surface in the manner described in Chapter 23, stopping after the screeding operation. The

surface needs to be level and slightly rough so that the mortar will adhere to the base. When pouring a base for a slab or stairs that will have a mortared surface, verify that the elevation is lowered to leave an allowance for the mortar bed thickness and pavement material thickness. See Chapter 22 if a compacted granular base is selected.

Paving Patterns

The pavement patterns available for unit pavers can also be accomplished as a mortared pattern by spacing the pavers to create mortar joints. Examples of common paving patterns and the materials that work best in those patterns are located in Chapters 24 and 25.

Use of Half Brick

Stair locations may require application of half brick on mortar to maintain proper riser dimensions. Half bricks are paving bricks with full length and width dimensions but half the thickness. This narrow paver can set on a mortar bed with minimal increase in stair riser dimensions.

PREPARING FOR PAVING

Mortared paving requires preparation to avoid delays and problems when the actual paving begins. Practicing the patterns before performing an on-the-job installation speeds the work. Working small areas limits the amount of mortar that must be mixed. Observing weather conditions is also important. Unlike how it affects other unit paved surfaces, rain destroys an incomplete mortared project if the mortar has not set. By establishing a staging area close to the project, you can more conveniently mix mortar and prepare paving materials to speed the construction process (Figure 26-1).

Test patterns by laying a test area large enough to see how the paving material fits together. On small projects and stairs, lay out the entire paved area and precut the material. This test layout will save time during placement of pavement and will avoid placement of cut materials in locations that are unstable or highly visible. When placing unit pavers such as brick in mortar, place a soldier course of full pavers around the edge of the project. The soldier course will reduce small pieces of paving material adjacent to the edge and will improve the surface's durability.

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Figure 26-1 Preparing for placement of mortared limestone.

CUTTING PAVEMENT MATERIALS

Methods for marking and cutting paving materials are discussed in Chapter 7. Stone and unit pavers that are set on mortar should be cut using a hydraulic splitter or wet masonry saw. Cleaving with a set may slow the process and leave uneven edges. You may need to hand shape stone with a mason's hammer to improve fit of irregular-shaped pieces.

MIXING AND PLACING MORTAR

As the setting bed that holds the paving material at the proper elevation, mortar is also used between the paving materials to hold them in position and to help create a surface impermeable to water. Mortar types vary from project to project

and may be custom mixed or purchased in premixed bags.

When purchasing premixed mortar, type M or spec mix is typically used for flat, exterior applications. Table 26-1 identifies common mortar types and suggested mix ratios. When custom mixing, use a ratio of 3 parts **Portland cement**, 1 part hydrated lime, and 9 parts sand. Small mortar quantities can be mixed in a clean wheelbarrow, in a wood box, or even on a sheet of plywood; but large jobs may require rental of a portable mixer. Blend the dry ingredients and mound in a pile using a shovel or mortar hoe. Make a depression, similar to a volcano's crater, in the top of the pile. Slowly add water in the depression and mix, using a pushing and pulling motion at first,

Table 26-1 Mortar mixes.

United States-ASTM C270

Parts by Volume

Mortar Type	Portland Cement or Blended Cement	Masonry Cement Type M	Masonry Cement Type S	Masonry Cement Type N	Hydrated Lime or Lime Putty	Aggregate*
	1	—	—	1	—	4½ to 6
M	—	1	—	—	—	2¼ to 3
	1	—	—	—	¼	2 13/18 to 3¼
	½	—	—	1	—	3⅜ to 4½
S	—	—	1	—	—	2¼ to 3
	1	—	—	—	Over ¼ to ½	•
	—	—	—	1	—	2¼ to 3
N	1	—	—	—	Over ½ to 1¼	•
	—	—	—	1	—	2¼ to 3
O	1	—	—	—	Over 1/14 to 2½	•

Canada—CSA A179M

Parts by Volume

Mortar Type	Portland Cement	Masonry Cement Type S	Masonry Cement Type N	Hydrated Lime or Lime Putty	Aggregate*
S	—	—	1	—	2¼ to 3
	½	—	1	—	3½ to 4½
	1	—	—	½	3½ to 4½
N	—	—	1	—	2¼ to 3
	1	—	—	1	4½ to 6

*The total aggregate shall be equal to not less than 2¼ and not more than 3 times the sum of the volumes of the cement and lime used.

Notes: 1. Under both ASTM C270, Standard Specification for Mortar for Unit Masonry, and CSA A179, Mortar and Grout for Unit Masonry, aggregate is measured in a damp, loose condition and 1 CF of masonry sand by damp, loose volume is considered equal to 80 lb. of dry sand (in SI units 1 CM of damp, loose sand is considered equal to 1,280 kg of dry sand).

2. Mortar should not contain more than one air-entraining material.

Courtesy Portland Cement Association and the Canadian Standards Association. Canadian material presented with the permission of the Canadian Standards Association; material is reproduced from CSA Standard A179-94 (Mortar and Grout for Unit Masonry), which is copyrighted by CSA, 178 Rexdale Blvd., Etobicoke, Ontario M9W 1R3. Although use of this material has been authorized, CSA shall not be responsible for the manner in which the information is presented, nor for any interpretations thereof. This material may not be updated to reflect amendments made to the original content. For up-to-date information, contact CSA.

then a chopping motion while pulling the mortar forward and backward (Figure 26-2). Pick up shovels of the mortar and slap them down to break up clumps.

Mix the mortar in workable batches. When working with a small crew, mixing several small batches is better than mixing a large batch that may harden before it is used. Deliver the mortar to the work area on a rigid material. If you place 18 × 18-inch squares of ¾-inch plywood in convenient locations around the pavement surface, then you can use this plywood for storing delivered mortar. If mortar begins to harden before it can be used, temper, or rewet, it. Sprinkle a small amount of water over the mortar and remix with a trowel. Use a chopping motion, occasionally picking up small amounts of the mortar and slapping them back on the board.

Laying mortared pavement requires working from a kneeling position on the base. Begin work in a corner that will allow exit without walking over newly laid material. Lay the pavement working backward, away from the beginning point. Shovel or trowel the mortar onto the base in a layer over about 2 SF of a corner of the work area (Figure 26-3). With a trowel or rake, spread the mortar in a rough layer over this area. This layer should be approximately ½-inch thick for brick and ¾–1-inch thick for stone.

PLACING PAVEMENT

Placement of paving material requires proper alignment and elevation for all materials. For materials that are placed in a modular pattern, use a stringline or snap a chalk line on the base to maintain alignment. Random patterns typically have enough flexibility that aides are not required to maintain the pattern.

If there is no structure or paved area to begin placement of pavement, lay a stringline across the

Figure 26-2 Mixing mortar with mortar hoe.

Figure 26-3 Mortar placement.

area and begin the first row by placing stone lightly against the string. Setting a stringline slightly above the finish grade will help ensure the paving material follows the desired alignment and will assist in maintaining the proper elevation (Figure 26-4). You may encounter problems with modular patterns if the paved area covers a corner between walls that are not at right angles. If you encounter this situation, you may need to cut pavers along the wall.

Placement of pavement is similar for all materials. Placement requires that the paving units be set into the mortar bed and the joint filled separately. Before placing stone, examine the edges for bevel. Bevels should be placed down when setting stone, reducing the irregularity of the surface. Stone should be placed with joints of ½–1-inch. Tile and brick should have uniform edges and a typical joint spacing of ½ inch. Push stone or tile into the mortar bed with a twisting motion, and use the trowel's handle to tap the material into alignment. Check for level and correct as necessary (Figure 26-5). You may need to remove material that is significantly out of level or at an incorrect elevation and add or remove mortar. Replace the material and recheck for level and elevation.

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Figure 26-4 Placement of stone using stringline to maintain proper elevation.

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Figure 26-5 Leveling individual stones when placed.

Check pattern alignment often as you lay the material. Verify that the alignment is straight and that the pattern is correct. To make corrections, relay the stone or gently tap it sideways with the trowel.

JOINTING AND FINISHING THE SURFACE

After you have set a few paving units, fill the joints. Pick up a small amount of mortar on a small trowel and, holding the trowel at an angle next to the joint, push the mortar into the joint using a pointing tool. Joints can also be filled using a mortar bag filled with mortar that is squeezed into

joints for finishing. Fill the joint and scrape away the excess with the trowel. Using a jointer or small trowel, press down on the mortar that was placed in the joints between paving units. This pressure will smooth the joint surface, press the mortar into voids in the joint, and compact the mortar surface (Figure 26-6). Refill with mortar and smooth all voids between edges of stone. Joints that are flat or concave are the best for horizontal paving.

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Figure 26-6 Finishing joints using a mortar trowel.

CLEANING SURFACES

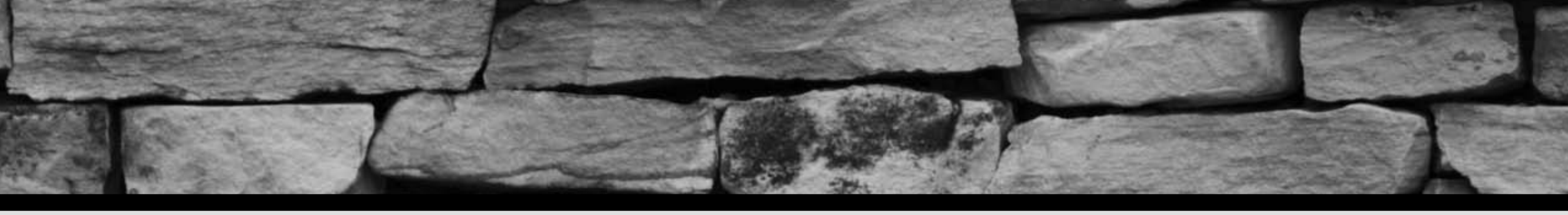
After the mortar has hardened, clean the paved surface of any excess mortar and scrub it with a solution of 9 parts water and 1 part **muriatic acid** or **trisodium phosphate** (TSP). Rinse surfaces thoroughly. Remove difficult stains or deposits with a wire brush or trowel.

CAUTION

When cleaning pavement with acid and caustic cleaners, follow all safety precautions identified on the product label. Wear proper safety clothing. Contact and exposure to acids and caustic cleaners can cause personal injury and can harm plants.

CAUTION

When mixing acid and water, always add the acid to the water. Never add water to acid. Adding water to acid will cause the mixture to spray and splatter, creating the potential for burns. Always wear protective clothing, gloves, and eyewear when mixing chemicals.



CHAPTER 27

GRANULAR AND OPEN CELLULAR PAVING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Prepare a site for granular paving.
- Install granular paving.

Although granular paving materials are typically not considered a primary landscape paving surface, there are several applications for this type of surfacing in today's landscape. Loose, granular materials are found on private patios, historical paving surfaces, and playgrounds. Each of these paving surfaces must be installed to ensure its durability and compliance with safety and design goals. The following sections provide information specific to the applications of granular paving surfaces to the landscape.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials and Site Preparation for Paving, Chapter 22

INSTALLATION OF GRANULAR PAVING

As with all previous paving projects, advance planning improves the effectiveness and efficiency of the work operation.

Preparing the Base

Base preparation for most **granular paving** installations is similar to the process described in the section introduction. Because the wearing course is resting directly on it, the base course must be sloped in the proper direction and set at the exact elevation below the finish grade required.

Some alternative base treatments include:

- Undisturbed Soil. If the base is undisturbed and the expectations for a long-term level wearing surface are not high, granulars can be placed directly on a soil base. The amount of work in preparation and placement is somewhat less than that for a proper base preparation, but the instability of the surface and ongoing maintenance, especially refreshing of the surface, will offset the initial time savings. If using a very fine, granular wearing surface, the material could be "pumped" into the base by traffic. Pumping occurs in wet conditions when traffic pushes the granular material down and forces moisture and subsoil up. Eventually, the granular material will be completely embedded in the subsoil. Granular materials work their way into a soil base much faster than they do into a prepared base, requiring refurbishing of the surface sooner than if

a prepared base is installed. Placement directly over soil is not recommended in any area where public safety or heavy traffic will be an issue.

- Concrete or Asphalt. Granular paving should *not* be placed over existing concrete or asphalt bases. Granulars will not bond with a solid paving base and will erode or wear very quickly over such bases. Slipping of the granular material will compromise safety. The best solution is to remove existing pavement below where granulars are to be placed.

Using Landscape Fabric or Geotextile

If desired, landscape fabric or geotextile may be placed on top of the base material and under the granular paving. Installation of landscape fabric or geotextile reduces the loss of granular paving by separating the base from the granular material. Although the landscape fabric will initially reduce the growth of weeds, this benefit will lessen over time. Landscape fabric can create problems if areas of high wear expose the fabric. Once exposed, the fabric can create a tripping hazard and be pulled up, disrupting the surface of the paved area. If fabric is used, lay the fabric or geotextile flat over the entire base and fasten by driving sod staples through the fabric into the base. Trim the material at the edge restraint (Figure 27-1). Overlap any joints by 18 inches.

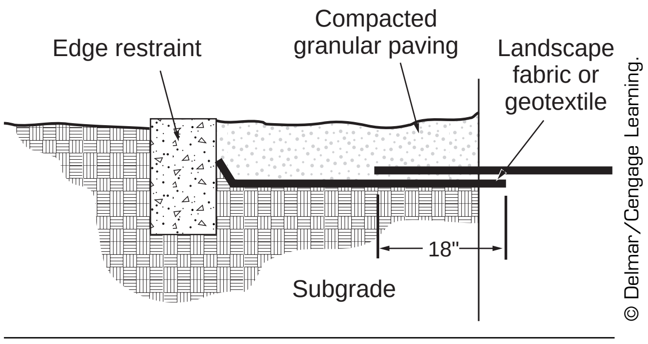


Figure 27-1 Proper placement of landscape fabric below granular paving.

Installing Edge Restraint

All granular paving installations require edge restraint to prevent migration and settling at the outer edge of the paved area. The methods used to edge vary, depending on the design of the project; however, some choices are described in Chapter 22. Do not select plastic landscape edge restraint for granular paving. Any edge restraint selected must cover the entire perimeter of the project to prevent granular paving from washing through open joints between edging pieces.

Preplacing Edge Restraint

Edge restraint material should be preplaced to provide a screeding guide for wearing course material. Install all edge restraint at the finish elevations desired around the entire area to be paved. Edge restraint may be temporarily left out of an area where access to the site is necessary and then placed as the paving reaches that segment of the project.

Adding Soil Stabilizers

Soil stabilizers can provide two benefits to fine-grained granular paving installations. First, they reduce the need for a geotextile fabric below the surfacing to protect the paving. Second, they bind the surface materials to reduce loss of pavement surface. To reduce soil working up into granular paving, use a urethane stabilizer. Pour the liquid over the subgrade to bind the soil and prevent dislocation. To reduce the erosion of fine or granulated particles such as ⅜s minus, fines, granite, or stone dust, blend liquid resins and emulsions into the surface course as it is installed. Mix dry products into the surface material before placement and wet them before compaction. Soil stabilizers provide few benefits for larger granular paving such as crushed brick or pea gravel. Epoxy resin soil stabilizers can also be blended with aggregate and placed using asphalt paving equipment for large installations.

Placing the Granular Wearing Course

Installation of a granular paving surface is similar to the placement of concrete. Granulars are dry and can be moved with most common landscape

equipment and tools. If the correct equipment is available, a small crew may place a great deal of this material in a short time.

Beginning Placement. Using the most efficient means available, deliver the granular material to the area to be paved. Provide an access point that will not disturb any of the preplaced edging. Begin placement at a point opposite the access point, and fill hard-to-reach corners first (Figure 27-2). Spread the granular material in a layer that is slightly thicker than the desired grade.

Leveling the Wearing Course. To develop a level draining surface, screed or level the placed material. For large granular materials, leveling with a garden rake can usually produce a suitable wearing course (Figure 27-3). For fine materials, screeding will produce better results. To screed, select a long, straight 2 × 4 and nail pieces of lath to the bottom of the screed at locations where it will rest on edging. This will leave the screeded surface slightly higher than the surrounding paved areas to allow for compaction. Screed the paved area using the preplaced edging material as a screed support. To provide precise screeding of the open areas in the center, use temporary screed rails as described in Chapter 23. Dissimilar to the procedure for concrete applications, remove the stakes used to support the temporary screeding rails and repair the course around the disturbed area by raking material into the opening.

Figure 27-2 Placement of granular paving material.

Finishing and Compacting the Surface

Following placement and screeding of all granular material, apply the finishing steps to a paved surface. This process varies, depending on the type of stone, but most processes require raking the material and compacting the surface.

Raking. Adjust the surface elevation of the granular material by lightly raking with a garden rake. Most granular materials require continual maintenance of this type to maintain worn areas. Loose granulars should be raked along the adjacent existing pavement to ensure that the two surfaces are flush.

Compacting. Large granular materials such as pebbles or loose stone will not require compaction. Compact fine granular materials with a vibratory plate compactor or sod roller to create a tight, drainable surface (Figure 27-4). The surface should be dry to prevent material sticking to the compaction equipment. Work from the low end to the high end, compacting and adjusting the level as required. If you encounter a high area, use the teeth of a garden rake to loosen the surface and the top of the rake to drag out material. Loosen low areas with a rake and sprinkle material over the depression. Recompact all adjusted areas. Most loose granular materials benefit from a light compacting; however, some materials may well up under the equipment and prevent even compaction. Hand tamp those materials that do not accept rolling.

Figure 27-3 Spreading large granular materials with a rake.

Figure 27-4 Leveling and compacting paving installation.

INSTALLATION OF OPEN CELLULAR PAVEMENT

To reduce the problems associated with compaction of turf by pedestrian and vehicular traffic and to improve the permeability of paved surfaces, a variety of cellular paving options are available to landscape contractors. Among the choices for cellular pavement are PVC rings attached to a fiber mesh, plastic grids with open structural networks, or precast unit pavers with an open-cell design (Figure 27-5). Each of these cellular pavers not only provides support for traffic, but also allows water to pass through the pavement into the subgrade, rather than running off the site. These types of pavement can be filled with granular paving materials, soil, or even with turf. Typical applications include service entries, emergency access points, and overflow parking areas. With proper installation, some cellular pavers can also be used in areas with light traffic.

Preparing the Base

Depending on the design and purpose for the paving, several options for base preparation are available for cellular pavement (Figure 27-6). For a

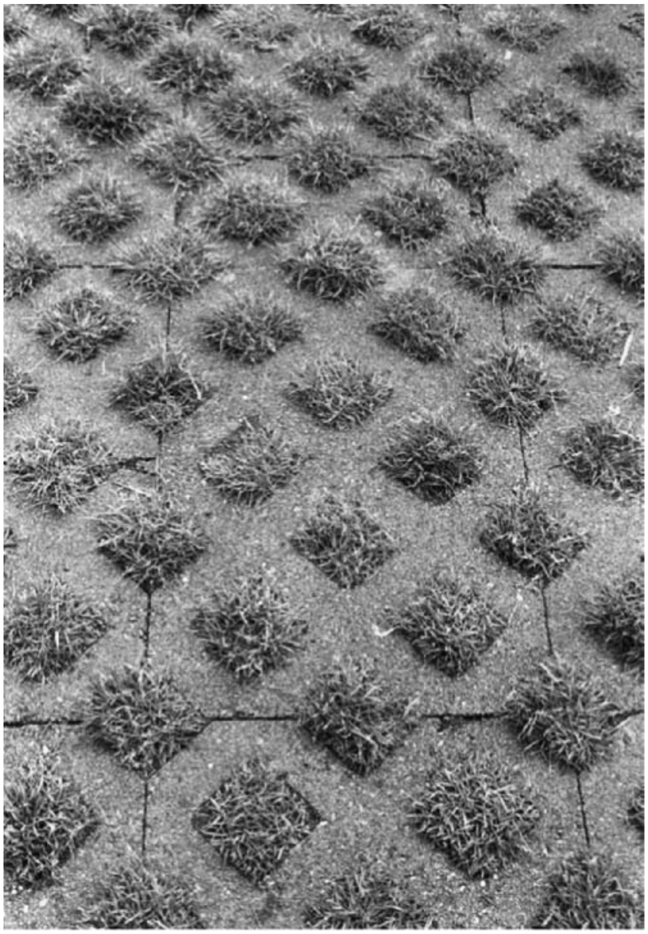


Figure 27-5 Precast concrete open cellular paving with grass growing in cells.

simple installation, the pavers can be placed directly on a prepared subgrade. Excavate the area where the paving is to be placed to the paver's depth, correct any subgrade soil problems, level, and compact using a vibratory plate compactor. Lay a filter fabric, if desired, over the subgrade. A slightly more durable installation can be attained if you place 1–2 inches of granular base over the subgrade before leveling and compacting. If the paved area is to support vehicular traffic, install a compacted granular base as described in the section introduction.

If the installation is to retain runoff, a base of 8–36 inches of clean angular aggregate will be required based on the design for the pavement. Excavate the entire base area to the required depth and fill with aggregate. The fill should range in size from 1–2½ inches in diameter. Place a nonwoven filter fabric over the entire bottom and sides of the base area.

Placing Cellular Pavers

Begin placing cellular paving at the lowest end of the installation. Lay the pavers across the grade, interlocking the units if necessary. The pavers should be in firm contact with the base and set level and flush with adjacent pavers (Figure 27-7). Install cellular pavers level and flush with adjacent pavement, adjusting the base height if necessary. Cut around irrigation heads and vertical elements that

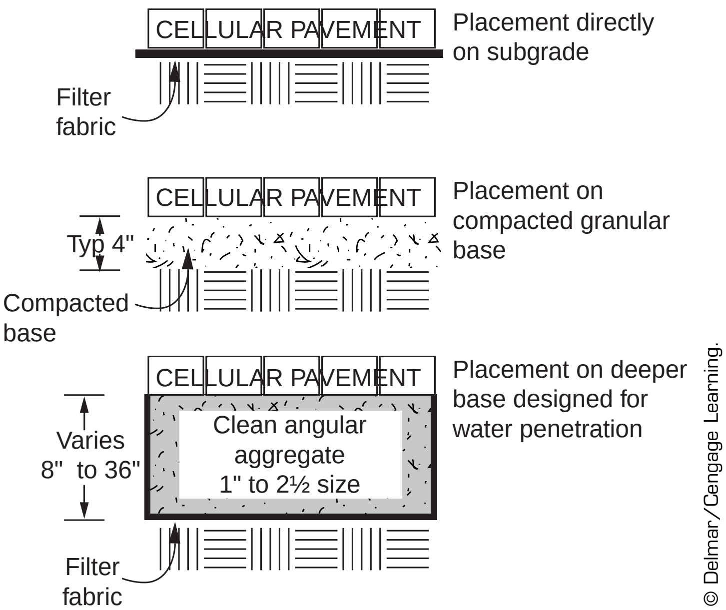


Figure 27-6 Base options for open cellular pavement.

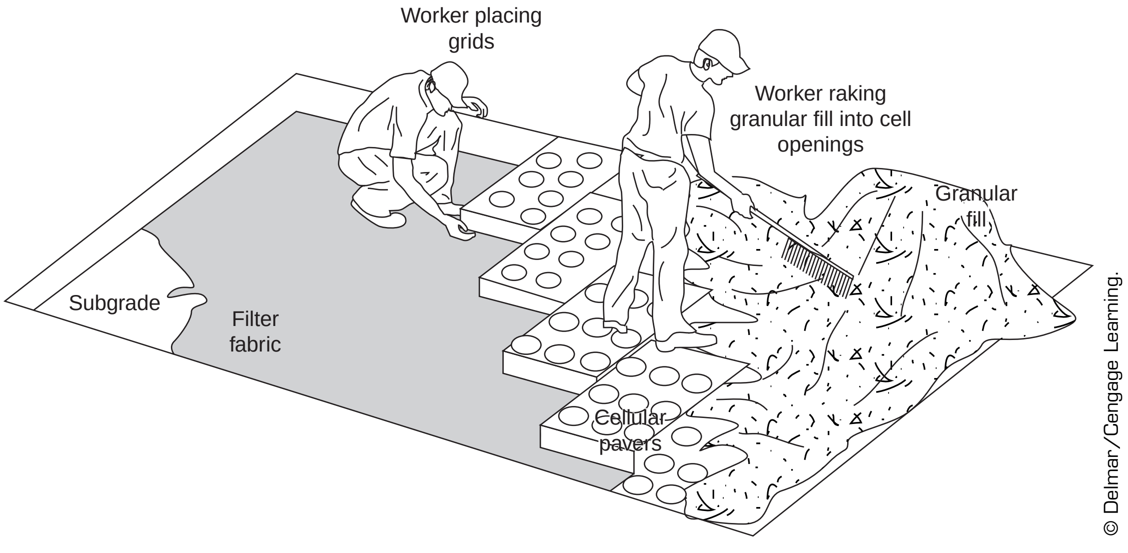


Figure 27-7 Placement of open cellular pavement units and filling with granular material.

project through the pavers. Make any cuts in the pavers using a reciprocating saw (for plastic products) or a wet masonry saw (for precast concrete products).

Finishing the Surface

Cellular paving can be filled with a variety of materials. Granular paving, pebbles, stabilized soil, or soil with seed can be used to complete the surface of the paved area. To use granulars, pebbles, or stabilized soil, place backfill over the entire area by hand or by using hand equipment. Once you place the backfill, rake the surface level and compact using a drum roller. Fill any low areas or voids. To create a surface with turf, backfill with 1 inch of coarse concrete sand, followed by topsoil, to within ½ inch of the top of the pavers and apply turf seed over the surface. Keep the area thoroughly watered until the first mowing; then scale back watering to a normal schedule.

SECTION 6

SUMMARY

Specialty paving of outdoor areas is a basic skill required of most landscape contractors. Section 6 covered the selection of materials and the preparation of base for most paving types. Specific instructions were provided for installation of concrete paving, including the forming for flatwork and stairs, unit paving, dry-laid stone paving, mortared paving, and granular paving.

When choosing a paving material for a project, consider the durability, safety, maintenance, aesthetics, cost, permeability, sustainability, and installation characteristics of each material available. With the variety of paving materials to choose from, you can select at least one that meets the demands of the project. One of the more common paving materials for landscape projects is concrete. Whether left “plain” or treated with one of several surface textures and colors, concrete is a durable choice. Unit pavers are also widely used for landscape applications. Interlocking concrete paving block, asphalt pavers, brick, cut stone, adobe, and pavers from recycled materials create a look of craftsmanship. You can also obtain an aesthetically pleasing surface by using a variety of locally available stone paving materials. If placed in a bed of mortar with mortar joints, many of the unit materials and stone can be given added stability. Stone and other paving materials can be used for stepping stones. Granular paving is an inexpensive way to cover flat walkways and outdoor use areas. Compacted turf areas can be treated using open-cell pavers, which have openings filled with soil and seed or granular materials.

Preparing for paving requires a stable subgrade. In most situations, this will involve excavating to the proper depth and examining the subgrade for any moisture or soil problems. If you encounter any unstable areas or problems with drainage, address these problems before installing a paving base. Any compaction and/or utility work required below the paved area should also be completed before base installation proceeds. Undisturbed earth provides the most stable subgrade, and fill areas require special compaction techniques to avoid settling problems. Base material is then placed over the subgrade and compacted in preparation for the various types of paving. If edge restraint is required for a paving material, verify whether the restraint should be placed before or after paving installation.

Concrete paving installation requires extensive preparation prior to the actual paving activities. You must prepare the forms, level the base material, install reinforcement, and plan joints before the concrete arrives. Form materials are typically dimensioned lumber for straight sections and flexible masonite for curved edges. Forms must be securely anchored with staking and backfill to prevent failure during the pour. Stairs can be formed in open areas by building forms for sides and risers; in enclosed areas, by suspending riser forms from beams running over the top of the stairs. For all forms, check their stability carefully before concrete arrives to reduce the chance for failure.

Concrete pours begin with the placement of concrete directly from the truck or transported by equipment to remote areas. The material is leveled initially using a hand or mechanical screed. Smoothing of the surface with a bull float and hand float follows. In locations where a very smooth surface is desired, an additional floating with a steel trowel follows. Each of these steps is intended to embed the aggregate into the slab and bring the fine materials to the surface. Before the slab hardens, special surface finishes are applied and the surface is edged and jointed. The new pour is sprayed with a curing compound, or covered for 3–7 days for curing. Forms are removed after 2–4 days. If control

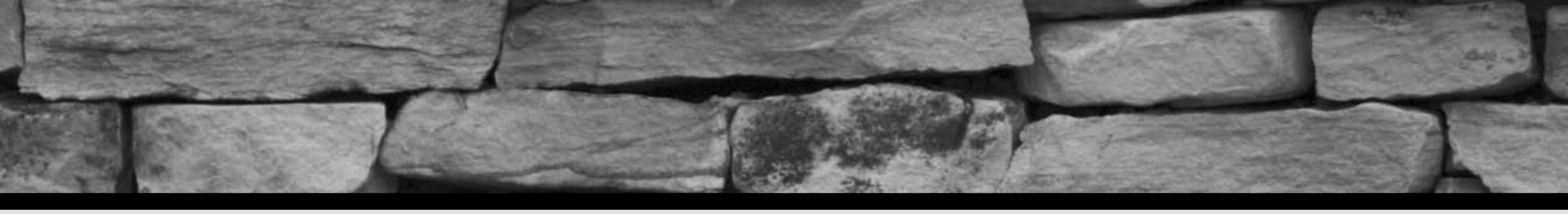
joints are to be cut with a saw, it is done at this time. Both new and existing concrete can be stained or painted to achieve various decorative effects.

Installation of unit pavers requires a setting bed over the base course. Composed of sand, this course is placed approximately 1-inch thick and screeded to obtain a level surface that mirrors the desired finish surface. One of the variety of patterns is selected for the project, and pavers are placed beginning with a *T* or horizontal pattern, working out from a wall or straight edge. Pavers are individually placed across the entire area to be paved and, if not already in place, edge restraint is installed. Working with unit pavers requires special edging to hold the pavers in place. Many choices are available, based on aesthetics and requirements of the paving installation. Unit pavers require cutting and placing of partial pavers to fill voids along edges and around corners. Pavers are seated into the setting bed using a plate compactor, and the joints are swept with dry sand to lock the pavers into place.

Dry-laid stone paving and recycled concrete are installed in a manner similar to that of unit pavers, with the exception that some stone choices have no formal pattern to guide placement. A setting bed is installed and screeded, and individual stones are placed beginning in a corner or along a straight edge. Random stone must be carefully selected for fit, whereas cut stone may be placed in patterns similar to those of unit pavers or in special patterns developed by the designer. After placement, edge restraint is placed and joints are swept with fine granular material. Stepping stones are marked and the base excavated and leveled. Steppers are then replaced and leveled. Although it requires little for a setting bed and no edge restraint, recycled concrete can be difficult to move and place because of its weight.

Stone and most unit pavers can be installed on a mortar bed with mortared joints if the design requires. For a more durable installation, a concrete base is recommended instead of a granular base. Patterns for installation are the same as those used with unit pavers and dry-laid stone, with the exception that allowance must be made for mortar joints between paving units. After the base has been installed, mortar is mixed and placed in a thick layer over the base. Paving materials are set in the mortar bed and adjusted to the correct elevation using a trowel. Placement continues with the installer backing across the base while laying pavement. Edges and corners require cutting of materials, but edge restraint is not required. When the setting bed has begun to harden, the joints are filled using a mason's bag or a trowel and pointing tool. Joints are smoothed with a joining tool. When all mortar is set, the surface can be cleaned with a weak acid mixture if necessary.

Granular pavement can be installed with or without base material. Consideration may be given to placing landscape fabric under the granular material to reduce weeds and prevent the paving material from being pumped into the base. Edge restraint is required and must be placed before granular material is installed. Place the paving material over the base, and screed or level with a rake to the appropriate depth across the entire paved area. Some materials require compacting the surface, whereas other materials are ready for use immediately after placement. To address concerns with routing excess water off sites via paving, materials that allow water to percolate into the ground have gained importance. These materials include a wide range of open cell pavements and products that reduce runoff by allowing infiltration of water through the paving surface.



SECTION 7

WOOD LANDSCAPE STRUCTURES

INTRODUCTION

Wood structures provide practical, usable space in the landscape. Whether a multilevel deck or a simple trellis, the structure adds warmth and interest to the design. When incorporated into a landscape concept, structures instantly change the dynamics of the design. Compared to lawns and spaces defined by plant material, structures are precise in their definition of space. Because of their "instant" nature, they tend to dominate the vistas of the landscape until plant material matures. Structures are also labor- and cost-intensive aspects of the design.

Construction of wood elements for the landscape requires a level of craftsmanship not typically associated with the landscape industry. Because the structure dominates a landscape, the quality of the craftsmanship is obvious to the client and visitor. Many consider outdoor construction as being rough and approximate; yet, building decks, gazebos, or other landscape elements requires as precise a level of workmanship as does any structure.

This section approaches wood structures and carpentry by describing the construction techniques for the basic components of typical structures, rather than describing how to build each specific structure. The information in this section addresses constructing foundations and platforms for decks; adding railings, stairs, seating, and skirting to a structure; and building structure roofs. This approach allows the carpenter to mix and match components required to build a variety of structures. This section also introduces the basic types of structures and describes the variety of materials used in exterior carpentry. The text does not attempt to cover every aspect of carpentry nor every possible design available to landscape contractors. The approach uses basic construction techniques to help contractors become familiar with building with wood and to provide a foundation for exploring advanced construction methods. Enclosed porches with footings that are integral with a building may be beyond the scope of landscape contractors because of the structural and building code implications related to their construction.

TYPES OF STRUCTURES

Landscape structures can be loosely classified as deck structures, open-roofed structures, or freestanding solid-roofed structures. Although this may be an oversimplification of structure classification, most wood landscape elements include one or more of these characteristics. An expanded definition of each follows.

Decks

A deck is a surfaced, structural platform that can serve as a landing for an entryway, an outdoor use area, or a walkway between points in a design. Many decks are constructed to accommodate a severe change in grade between use points, but some are constructed simply because the client prefers the use of wood for outdoor use areas (Figure S7-1). Decks consist of a foundation that is supported on an existing building or by a structural system anchored in the earth, a framework of structural lumber, and surfacing on which one can safely walk. Further components often associated with decks include railings for safety, stairs for access, and possible seating for convenience. Decks can be combined easily with various types of roofing and fencing to create even more useful and interesting outdoor areas.

Open-Roofed Structures

Arbors are open-roofed structures that typically accent entry points in the landscape. Composed of posts that support a framework of open roofing materials, arbors are one of the simplest structural ways to introduce overhead enclosure into the landscape. Not intended to be weatherproof, the roof can be composed of any number of creative patterns or materials (Figure S7-2). The designer may consider adding plant material that vines as a natural enhancement of the arbor landscape structure. Designs may have the arbor arcing over a walkway, or the arbor may be enclosed on one or both sides along a walkway.

Although similar to arbors in construction, shade structures are typically used to reduce light intensity over patios, decks, or other outdoor areas. Clearance under shade structures (also called sunscreens) and placement for maximum shading potential may alter the construction slightly from that of arbors, but the use of creative patterns and plant material as part of the structure is the same. A shade structure most often has two or three sides open to the landscape, but partial enclosure of the sides is sometimes introduced to restrict further access by sun. Trellises are wall-mounted or overhead structures with an

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Figure S7-1 Wood decks create functional outdoor spaces.

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Figure S7-2 A landscape arbor creates space without complete enclosure.

open framework (Figure S7-3). Many landscapes use a trellis to support plants that vine.

Freestanding Solid-Roofed Structures

Gazebos and other freestanding structures are closed-roof structures typically used as outdoor facilities and focal points (Figure S7-4). Components of the typical gazebo include flooring created by a deck or concrete platform, railings and/or sidewalls, support posts for the roof, and an enclosed, weatherproof roof. Gazebos are built in a variety of sizes and shapes and can have enclosed sides to further weatherproof the structure. Used to articulate historical landscape themes, many gazebos have intricate details and ornamental embellishments.

SUSTAINABILITY SUGGESTIONS

Suggestions for making work more sustainable include:

- Use sustainable wood products. If using tropical woods, select wood that is FSC (Forest Stewardship Council) certified.
- Choose materials that reduce the toxicity of our environment. Using anchoring techniques and woods with natural decay resistance will decrease soil pollution caused by wood treated with toxic chemicals.

PRODUCTIVITY SUGGESTIONS

Suggestions for making work more productive include:

- Double-check measurements to avoid cutting twice or wasting lumber.
- Square the ends of boards before measuring. Factory cuts are often not square.
- Mark dimensions with a *V*, where the point of the *V* is the desired dimension.
- To mark the location of pilot holes for bolts or connectors that are already in place, hold the piece of lumber in correct position and tap slightly with a hammer opposite the bolt location. This leaves a small indentation at the exact location for pilot holes.

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Figure S7-3 Landscape trellis supporting grape vines.

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Figure S7-4 Gazebos add form and interest to a landscape.

- To mark the center of a square or rectangular piece of lumber, draw diagonal lines from opposite corners. The lines cross at the center of the square or rectangle.
- Tie the ends of power cords in a loose knot to prevent annoying unplugging while moving around a construction site. Cords can then be moved by "whipping" them over piles rather than hand moving.
- Rent a power auger if the project requires digging several holes.
- Make sure framing is square before attempting to build any roof. A small error from square will amplify in the roof structure.
- To keep rafters level, install both end rafters and run a stringline from one to the other that rests on the top side of the rafters. New rafters should not push the stringline up or have a gap between the rafter and string. Use stringline at both the top and bottom.
- To determine the trim angle for stair posts, place a board on top of two or more stairs next to a post. Place a speed square between the board and the post and set the angle.
- Establish a consistent procedure for marking that takes into account the width of the saw blade.
- Locate the elevation of interior floors by making measurements down from windows and doors. Establish elevations on the outside of a building by measuring down on the exterior side of the same windows or doors.
- Go to the basement and check the perimeter of the structure in the area where work will be taking place. This may aid in locating rim joists and spotting potential problems such as utilities running around the perimeter of the interior.
- Premanufacture sections of railing on a flat surface; then position in place and fasten.
- In locations where holding the lumber to start a nail or screw is difficult, start the nail or screw on a flat surface and hold into position to connect. Marking the position of the lumber before connecting also makes work easier.

CHAPTER 28

MATERIALS FOR EXTERIOR CARPENTRY

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Choose wood or construction materials appropriate for intended use.
- Identify the quality of wood and wood products.
- Choose fasteners appropriate for intended use.
- Select finishes for exterior wood.

Landscape contractors must make many material choices when performing carpentry tasks. Selections include wood products, connectors, fasteners and hardware types, finish choices, and a wide variety of premanufactured materials made from wood, metal, and vinyl. With the rapidly changing nature of carpentry products and construction methods, visit the lumberyard often to explore new products.

WOOD PRODUCTS

Wood for landscape use is available in a variety of species, characteristics, and qualities. Selecting the correct wood product for an exterior project requires consideration of a variety of factors, ranging from the type and grade of wood to the material's finish. In this section, these many facets of wood will be explored.

Wood Types for Exterior Use

In selecting the proper wood for a project, landscape contractors must consider the characteristics of available wood products and the proper application of those products. Primary choices for wood products used in exterior carpentry include treated or naturally decay-resistant hardwoods and softwoods milled into boards or dimensioned lumber. In certain applications, plywoods and other engineered panels may also be used.

The terms **hardwood** and **softwood** refer to the type of tree used in the milling and manufacture of lumber. Softwoods are milled from coniferous, or cone-bearing, trees such as pine, spruce, and fir, and are the dominant wood used in the framing and structural segments of construction. Hardwoods are milled from deciduous, or broad-leafed, trees such as oak, maple, and walnut, and are predominantly used in cabinetry and finish carpentry. Engineered panels such as plywood and sheathing can be manufactured from either hardwoods or softwoods.

Treated Softwoods. Treated woods include a variety of pines, firs, and spruces that are treated by one of several methods to resist decay and insects. See the information on lumber treatment later in this chapter.

CAUTION

Avoid prolonged skin contact with treated lumbers. When working with treated lumbers, wear gloves and long-sleeve shirts to prevent exposure to chemicals used to treat wood. Wear a dust mask when cutting treated lumbers, and wash your hands thoroughly after handling treated lumbers. Wash clothes worn when handling treated lumbers separately from other clothes. Do not let treated lumbers come in contact with food or the roots of food-producing plants. Do not burn treated lumbers.

Treated lumber is a common choice for structural members and any part of the construction that will not be visible. Most treated woods are durable and strong enough to use for posts, beams, joists, and decking materials. Treated lumbers can also be used for finished components, provided potential contact between lumber and skin is restricted and the client does not mind the colored cast left from many treatment methods. This discoloration can remain for several years, but eventually most treated lumber will weather to a light gray.

Western Red Cedar. Cedar heartwood is a soft, naturally decay-resistant lumber that makes excellent surfacing and trim material. Cedar is usually not cut in structural dimensions (e.g., 2 × 8s, 2 × 10s), but is available as 1 × dimensioned lumber and deck surfacing in a form called 5/4s, which has a nominal, or actual, thickness of 1 inch and various widths and lengths. The edges of 5/4s cedar are eased, or rounded, to reduce splintering. Cedar deck surfacing is soft enough that it can be installed with limited predrilling. Cedar can be left to weather to a medium gray or stained as desired. Rough-sawn cedars are often used as trims for exterior work.

Redwood. Redwood heartwood is a soft, naturally decay-resistant lumber that is excellent for decking and trim material. Available in limited quantities, all heart redwood can also be used for structural members in exterior conditions. Redwood deck surfacing is soft enough to fasten without drilling pilot holes. If it is not finished, redwood weathers to a warm, dark gray.

Bamboo. Bamboo, while not a tree lumber, has been introduced as a deck surfacing, primarily in milder climates. Sold as surfacing only with a specialty fastening system, bamboo uses a quickly renewable resource that does not compromise on strength.

Imported Woods. Several choices of imported lumber may be available from suppliers in your area. Included in this group are purpleheart and greenheart, ipe, jarrah, Phillipine Mahogany, and other woods. Purpleheart and greenheart are hard lumbers that provide natural decay resistance and good workability, but they must be dry to avoid shrinkage problems. Jarrah is a red-brown lumber that is hard and offers good strength. Ipe, also known as Brazilian walnut, is an extremely dense wood with a dark color that naturally resists decay and fire. Although the density makes the wood durable, it also necessitates predrilling holes for fastening and using carbide tip blades for cutting.

Composite and Nonwood Products. Many products are composed of wood by-products, plastic, recycled materials, natural fibers, or combinations of these products. Most products in this category are limited to surfacing and trim applications, with few providing structural components. Most cut and install in a manner similar to wood and provide a surface with an appearance like opaque stained lumber. Use caution when choosing from the available products. Verify the structural capabilities and durability of each, and confirm that the choice matches your environmental perspective. Common names for products from this market segment include Trex®, TimberTech®, Evergrain®, Carefree Decks®, and Nexwood®.

Plywood and Wood Panels. An engineered lumber product of thin layers, or plies, of wood glued together to create a sheet of wood, plywood has applications in exterior carpentry such as sheathing for roofs and siding for structures. Typically, plywood is available in sheets with 4-foot × 8-foot dimensions and can be cut and nailed like boards. Most plywoods require staining or painting to improve aesthetics and to protect and preserve the material. Also included in the wood panel classification is a variety of exterior siding treatments that are manufactured as surfaced and textured panels.

Selection of Appropriate Materials

When a project is performed under the direction of construction documents, a design professional will make the material choices. When contractors have that responsibility, factors that influence their material choices range from how the product will be used to how that product will affect the ecology. Primary considerations in selection include a wood's strength, appearance, and resistance to decay and insects. Additional considerations include workability and availability. The following sections and Table 28-1 discuss several of the common selection criteria.

Strength and Related Structural Properties

Selecting lumber types and dimensions that will support the loads expected requires an understanding of structural properties of lumber. Natural properties make most lumbers highly resistant to breaking when exposed to weight pushing down on the member, or compression forces. Working

Table 28-1 Softwoods

Kind	Color	Grain	Hardness	Strength	Workability	Elasticity	Decay Resistance	Uses	Other
Red cedar	Dark reddish brown	Close medium	Soft	Low	Easy	Poor	Very high	Exterior	Cedar odor
Cypress	Orange tan	Close medium	Soft to medium	Medium	Medium	Medium	Very high	Exterior	
Fir	Yellow to orange brown	Close coarse	Medium to hard	High	Hard	Medium	Medium	Framing, Ponderosa	White millwork, plywood
Ponderosa pine	White with brown grain	Close coarse	Medium	Medium	Medium	Poor	Low	Millwork, trim	Pine odor
Sugar pine	Creamy white	Close fine	Soft	Low	Easy	Poor	Low	Pattern-making, millwork	Large clear pieces
Western white pine	Brownish white	Close medium	Soft to medium	Low	Medium	Poor	Low	Millwork, trim	
Southern yellow pine	Yellow brown	Close coarse	Soft to hard	High	Hard	Medium	Medium	Framing, plywood	Much pitch
Redwood	Reddish Brown	Close medium	Soft	Low	Easy	Poor	Very high	Exterior	Light sapwood
Spruce	Cream to tan	Close medium	Medium	Medium	Medium	Poor	Low	Siding, subflooring	Spruce odor

opposite the compression forces are tension forces, or forces attempting to pull the wood apart. Resistance to failure from these forces determines a wood's strength. Woods such as southern yellow pine and fir rank high in strength, whereas cedar and redwood are ranked low in strength. Strength is typically measured in pounds of weight that can be placed on every square inch of the board. Wood also has a structural quality of stiffness, or elasticity, which plays a part in how much "bounce" a deck platform may exhibit. Southern yellow pine and fir are moderate in elasticity, whereas cedar and redwood are very flexible.

Each of these structural properties can be calculated if factors such as type of lumber, orientation of the wood fibers, thickness of the member, and spacing between supports are provided. Other factors that enter into strength calculations are live and dead loading. Live load is the weight, or load, placed on a piece of lumber while dead load is the weight of the lumber without a load. Both live and dead loads need to be determined when calculating the strength of lumber. The complexity of these variables underscores the importance of having a qualified design professional determine the types and sizes of wood members used in construction.

CAUTION

To prevent structural failure of wood, a registered design professional should perform calculations for wood members.

Lumber Grades. Grading is a process wood processors use to classify the strength, source, moisture content, and related aspects of lumber. In the United States, associations such as West Coast Lumber Inspection Bureau, Western Wood Products Association, Southern Pine Inspection Bureau, Northeast Lumber Manufacturers Association, Northern Softwood Lumber Bureau, and Redwood Inspection Service grade the products harvested in their geographic region (see Appendix F). Grading

varies from organization to organization, but criteria typically separate wood into classes of structural grades and appearance grades. Structural grades indicate that the woods are structurally sound; however, these woods may have visual defects that make the lumber undesirable for finish work. Structural grades may also be further subdivided into classes based on their strength or severity of appearance defects. Appearance grades indicate that the woods are typically structurally and visually sound. Some organizations also include a factory grade, which is for lumber intended for further processing.

Grades are usually stamped on the lumber piece, and the grading criteria typically include an indication of the following wood characteristics:

- Bending Strength Ratio. Higher grades are rated for more stress and heavier loads. Terms such as "select" and "No. 1" indicate higher grades. Larger numbers, such as "No. 2," indicate lower grades. To accurately compare stress rating nomenclature, review each association's standards.
- Moisture Content. Lumber that has been dried to less than 19% moisture content is stamped "Dry." Surfacing of the lumber may take place before the lumber has dried, indicated by an "S-Grn" label, or after the lumber has been dried, indicated by an "S-Dry" label. Moisture contents below 19% are important in reducing problems with insects and lumber warping.
- Mill. The location of milling is indicated.
- Grading Association. Initials or name of grading association is included on the stamp.
- Species. If not inferred by the association name, the species may be indicated.
- Method of Rating. Machine-rated lumber may also have the strength stamped on the board.

Typical grades for exterior carpentry include southern pine No. 2 structural grade for structural work, and southern pine appearance or finish grade for visible surfaces such as trim. Douglas fir ratings from the Western Wood Products Association include the grades of structural, appearance, and factory. "Structural" is wood that may have defects but has sound strength properties and is suitable for use in structural applications. "Appearance", further subdivided into select, finish, and common, is based on the lumber's surface characteristics and indicates its suitability for finish applications. Redwood grades differ in that they include a group of classes based primarily on appearance and are further subdivided based on the presence of sapwood. If a piece of redwood lumber is composed completely of heartwood, the decay-resistant, red lumber, it is labeled "heart." If not labeled "heart," it contains a percentage of white sapwood and may be subject to decay. Common redwood grades include the following:

- Clear all heart, for finish and surfacing work, all heartwood and free of knots.
- Clear, similar to clear all heart but with sapwood.
- Heart B, similar to clear all heart but with limited knots or defects.
- B grade, similar to heart B but with sapwood.
- Construction heart/deck heart, for deck structures and surfacing, contains some knots and no sapwood.
- Construction common/deck common, for deck structure and surfacing above grade, similar to construction heart but with sapwood.
- Merchantable heart, less expensive heartwood for retaining walls, fences, and utility structures, typically has some larger knots.
- Merchantable, same as merchantable heart but with sapwood.

Plywood Grades. Plywood that will be exposed to moisture should be classified as "Exterior" grade by the American Plywood Association (APA). Strength of panels is identified by the span rating stamped on the sheet. Typical plywood panels used in exterior carpentry include sheathing-rated plywood and composite sheets.

Resistance to Decay and Insects. Most of the landscape contractor's work is exposed to exterior conditions and moisture. Although no wood is truly permanent, these exposure conditions necessitate the selection of materials that are either naturally resistant to decay and insects or are treated to obtain the same properties. Selecting woods with these characteristics will prolong the life of exterior projects. Woods such as cedar and redwood are naturally resistant; and as long as their heartwoods are used, they need not be further treated. Most other softwoods are susceptible to decay and insects

if not treated by one of several methods and materials. Each treatment method is used to reduce potential damage from insects and decay, and most treatments are registered pesticides, restricting their use and application. Look for treated woods indicating “Ground Contact” to ensure use in exterior structural projects. See the cautions listed under “Treated Softwoods” earlier in this chapter before using chemical treatments.

Caution is also urged when selecting any wood product that has been treated to resist decay. The chemical compounds in all treatments can cause injury when improperly used or handled in an unsafe manner. Most preservatives are highly toxic. Several treatments common to the industry during the past decade are now no longer used for landscape applications. Products no longer appropriate for residential use because of environmental concerns or voluntary bans include creosote treated products, penta, and chromated arsenic (CC, CCA, ACZA). Never use these treatments in applications where human contact or food production is anticipated, and wood treated with these products should be removed and disposed of as hazardous wastes to prevent contamination of the environment. Builders will still find woods treated with a variety of preservatives available for industrial and agricultural uses, but users are advised to review information available from manufacturers and the Environmental Protection Agency before making a preservative choice.

Most current preservatives fall into two classes, water-based or oil-based. Water-based preservatives are induced deeply into the wood and then dried to leave a paintable surface. Many water-based treatments remain in the wood for the life of the wood, whereas others may be leached by groundwater or rain. When using woods treated with water-based preservatives, all fasteners should be hot-dipped galvanized or stainless steel to reduce corrosion. Water-based treatment methods available for exterior wood applications include the following:

- ACQ. Alkaline copper quarternary is a mixture of copper and quarternary ammonium to create a preservative that resists insects and fungi. Two forms are available: ACQ-B, which weathers to a greenish brown color and is used for denser woods, and ACQ-D, which weathers to a light brown and is used for softer woods. Both can be stained or painted.
- CBA. Copper azole contains copper, boric acid, and tebuconazole. A newer preservative, CBA is effective on several southern softwoods. It is a greenish brown color and can be stained or painted.
- Borates. Several sodium borate products are being used to treat a variety of wood products. Although borates are effective as a preservative, they remain water-soluble after application and should be used only in applications where the wood will not be in contact with groundwater, rain, irrigation, or any source of water that will leach the material.
- For treatment of woods that are not in contact with the ground, Cyproconazole and Propiconazole can be used.

Oil-based preservatives are common for posts, pilings, and marine applications where there is little human contact with the wood surface. The oil in the preservative creates a finish that is greasy to the touch and makes the surfaces difficult to stain or paint. It is unlikely that wood preserved with oil-based products would be recommended for a finish application.

Most of these treatment materials can be applied to lumber using the following methods:

- Pressure Treatment. Pressure treatment uses special chambers to place lumber under high atmospheric pressures. This forces preservatives deeper into the wood than other methods of treatment achieve.
- Nonpressure Treatments. Nonpressure treatments expose the surfaces of the wood to preservatives under normal atmospheric pressures. Nonpressure treatments cover the surface of the lumber, but the penetration into the wood is limited. Methods included in this category include brushing, dipping, and soaking. When dipping or soaking wood into copper-based treatments, immerse the wood for a minimum of 3 minutes for aboveground applications and for a minimum of 48 hours for applications that will be in contact with the ground. Let the lumber dry for 24 hours before installing. Other processes, such as thermal treatment and vacuum processes, are combined to improve the effectiveness of nonpressure methods.

When treated wood is cut, the cut ends must be retreated. A hand-applicable or dippable treatment method is the most efficient method for retreating. Failure to retreat cut ends will result in a condition known as end rot, where the wood will decay on the interior and lose its structural integrity (Figure 28-1).

Surface Finish. Lumbers have a range of surface finishes. Wood pieces may be rough sawn, left with the initial saw cut surface, or planed to a smooth finish. When the lumber is planed, its grade stamp or order may note the number of planed sides. This designation would appear as a number indicating the number of smooth sides and the letter S. An example would be 4S for lumber that is smooth on all sides. When ordering lumber, note if you need rough-sawn lumber; otherwise, you will probably receive planed lumber.

Cost and Availability. Which material is available at a reasonable cost often dictates the selection of a wood product. Influences such as markets, transportation costs, and production schedules are beyond the contractor's control and may necessitate use of whatever acceptable material is available. The factors of cost and availability are typically interrelated. The more available a product, the lower the cost. Products that are in short supply tend to be more expensive.

Many treated woods, such as southern yellow pine and fir, are harvested from large stands and are typically available in greater quantities than woods such as redwood and cedar. Dwindling supplies of redwood have also interjected ecological issues, causing some design professionals to select alternatives, particularly for structural components, to reduce the demand for harvesting redwood.

Quality of Wood Products

Quality of the products being used has a direct relationship to the quality of the product produced by the carpenter. Awareness of common wood defects improves selection and installation of wood products.

Defects. Many defects are reason to reject a piece of lumber. Some, such as cupping, can be corrected by reorienting the lumber if the defect is not severe. Others require trimming the defective portion from the lumber to make it usable. See Figure 28-2 for illustrations of common wood defects.

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Figure 28-1 Post end rotting from failure to retreat with preservative after cutting.

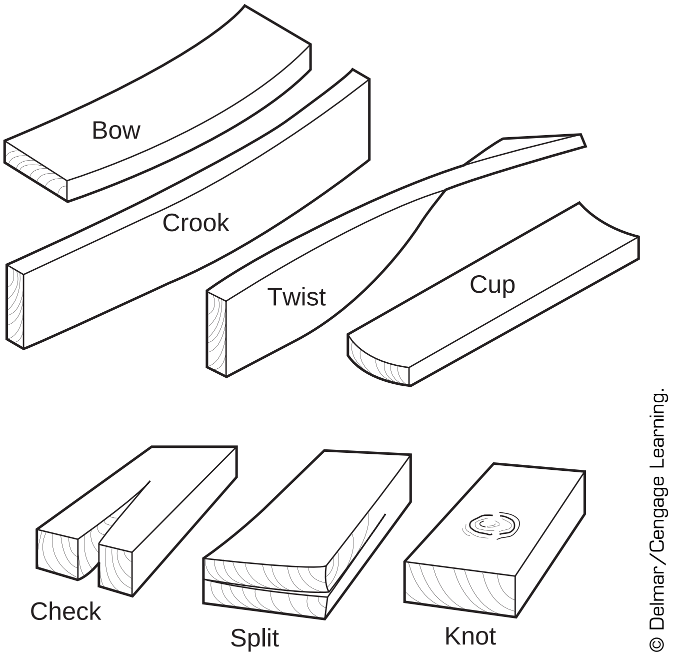


Figure 28-2 Common wood defects.

- Warping. Twisting and deforming of the board shape caused by drying too quickly and improper storage (among other things) is referred to as warping. Several types of warps can be present in lumber, including:
  - Bow, or curving of the ends of the lumber.
  - Crook, a curving of the edge of the lumber along its length.
  - Twist (or wind), an end-to-end twisting of the lumber.
  - Cup, or curving of the edges of the lumber from side to side.
- Checks. Splits in the end of the lumber.
- Splits. Cracks between and parallel to annual rings.
- Knots. Branch cross sections. Knots are a problem if the defect is large and/or loose.

Aesthetic Appearance. The aesthetic appearance of wood products can be referred to, in part, by the characteristic of color. Generally, color can be further described as the initial color of the lumber when installed and the weathered color of the lumber after extended exposure to the elements. Exterior woods have distinctive initial colors, with most weathering to various shades of gray if left unfinished. Cedar is initially a light tan and redwood is a reddish brown. Treated woods begin with either a light green or brown cast.

Table 28-2 Plywood veneer grades

Veneer Grade	Description of Surface Quality
A	Smooth, paintable. Not more than 18 neatly made repairs
B	Solid surface. Repairs and tight knots of up to 1 inch across. Some minor splits permitted.
C	Splits of up to ⅛ inch, defects limited to ¼ inch × ½ inch. Plugged. Broken grain and wood/synthetic repairs permitted.
C	Tight knots up to 1½ inches with limits. Defects that do not impair strength.
D	Knots and knotholes up to 2½ inches. Limited exposure.

Plywood appearance is graded using the letters A, B, C, and D, corresponding to its surface veneer quality, with A being the best and D being the poorest. Table 28-2 describes the letter grades.

Lumber Dimensioning

When working with wood, contractors may be confused by the nominal terminology for lumber dimensions. When a 2 × 4 is first cut, its nominal dimensions are actually 2 inches thick by 4 inches wide. After drying and planing, boards are reduced to their actual thickness and width. Using the **nominal dimensions**, rather than the actual dimensions, when measuring and cutting will cause errors. To avoid this problem, memorize and use the dimensions listed in Table 28-3. Length is not affected by this same issue; however, you should verify the length of any board before installing it.

Table 28-3 Nominal and actual dimensions for stick lumber

Nominal Dimension	Actual Dimension
1 inch	¾ inch
2 inches	1½ inches
4 inches	3½ inches
6 inches	5½ inches
8 inches	7¼ inches
10 inches	9¼ inches
12 inches	11¼ inches

CONNECTORS, FASTENERS, AND HARDWARE

Connectors and construction hardware offer an almost endless variety of ways to attach and support landscape projects. Specific selection depends on the project's application situation.

Connectors, fasteners, and related hardware for exterior projects should be made of materials that resist rust naturally or are treated to resist rust. **Galvanized** materials are made of steel that has been coated with zinc to reduce rust when exposed to moisture. Coating is done through an electrogalvanizing or hot-dipping. Although suitable for use with any type of treated lumber, galvanized materials may stain if the coating is damaged. Polymer-coated, ceramic-coated, and epoxy fasteners are made of steel that has been coated with a thin polymer, typically applied over an electrogalvanized zinc coating. Coated fasteners resist rust, typically do not corrode with newer preservatives, and ease installation because of their slick coating. When working with cedar or redwood, select stainless-steel connectors for a finish free of stains. Stainless-steel fasteners are strong and rust-resistant, but they are expensive and should be considered in areas where both structure and appearance are critical. Although rust-resistant, brass fasteners are weaker than most connectors and can corrode when they contact certain woods and metals. Brass would be used primarily for trim and finish purposes. Brass-plated fasteners are stronger than pure brass, but the plating can be damaged, leading to rust. Nails labeled *brite finish,* or *plated finish,* should only be used where there is no weather exposure. The coating for these nails is cadmium plating and is not rust-resistant.

Fasteners

Fasteners include the variety of nails, screws, and bolts used to fasten construction components together. Terms used when discussing fasteners include the head, or the flattened portion used to drive the connector into the wood, and the **shank**, or the long shaft of the fastener. Nails have either a smooth shank or a deformed shank, and screws and bolts have a threaded shaft.

Nails. Of all the variety of connectors, the nail is the most common fastener used in exterior applications. Nails are pieces of hardened wire of varying diameters that are cut to length and flattened on one end to facilitate driving into the wood. Nail sizes are determined using a measurement called "penny" and symbolized using a number and the small letter "d" (a 16-penny nail is labeled 16d). Several types of nails are available for use in specialty situations (Figure 28-3). Common nails are used for general-purpose applications. **Truss** nails, or **joist hanger** nails, are short, stubby nails used to connect galvanized hangers. Box nails are thin nails with flat heads used for nailing trim. Roofing nails have large diameter heads to reduce tearing of roofing materials.

Wood Screws. Similar in length to nails, screws have tapered shanks that are threaded at one end so they can be twisted into the materials. Recommended for fastening deck surfacing and most trim, the screw provides stronger holding characteristics when compared to the nail (Figure 28-3). Most common among the screws used in exterior applications is the deck screw, which is similar in length to the 16d nail. Deck screws can be driven with hand or power screwdrivers using **slotted, phillips,** or **square-headed** drives (Figure 28-3). Pilot holes one half or the fractional equivalent the diameter of the shank should be used for installing screws into most woods. Screws should always be torqued, or twisted, into the wood and never driven using a hammer.

Lag Screws. A heavier and longer screw used for anchoring structural members, lag screws come in a variety of shank diameters and are available in lengths from 2–8 inches and larger (Figure 28-3). Lag screws require pilot holes that are drilled to the same diameter of and two-thirds the length the shank. To determine the proper diameter of a lag screw pilot hole, hold a drill bit in front of the lag screw. The proper diameter drill bit will cover the solid portion of the shank, but the threads will be visible. Lag screws are always torqued in place using wrenches and never driven using a hammer.

Carriage Bolts. Carriage bolts are large-diameter bolts with a rounded head used for connecting structural pieces. The strength of the carriage bolt far exceeds the strength of the other connectors discussed previously. Carriage bolts come in diameters from ¼–¾ inch and in lengths of 3–10 inches and larger (Figure 28-3). Carriage bolts require a nut and washer at the end opposite the head to complete the connection. A washer is not required under the head. Carriage bolts require a hole the same

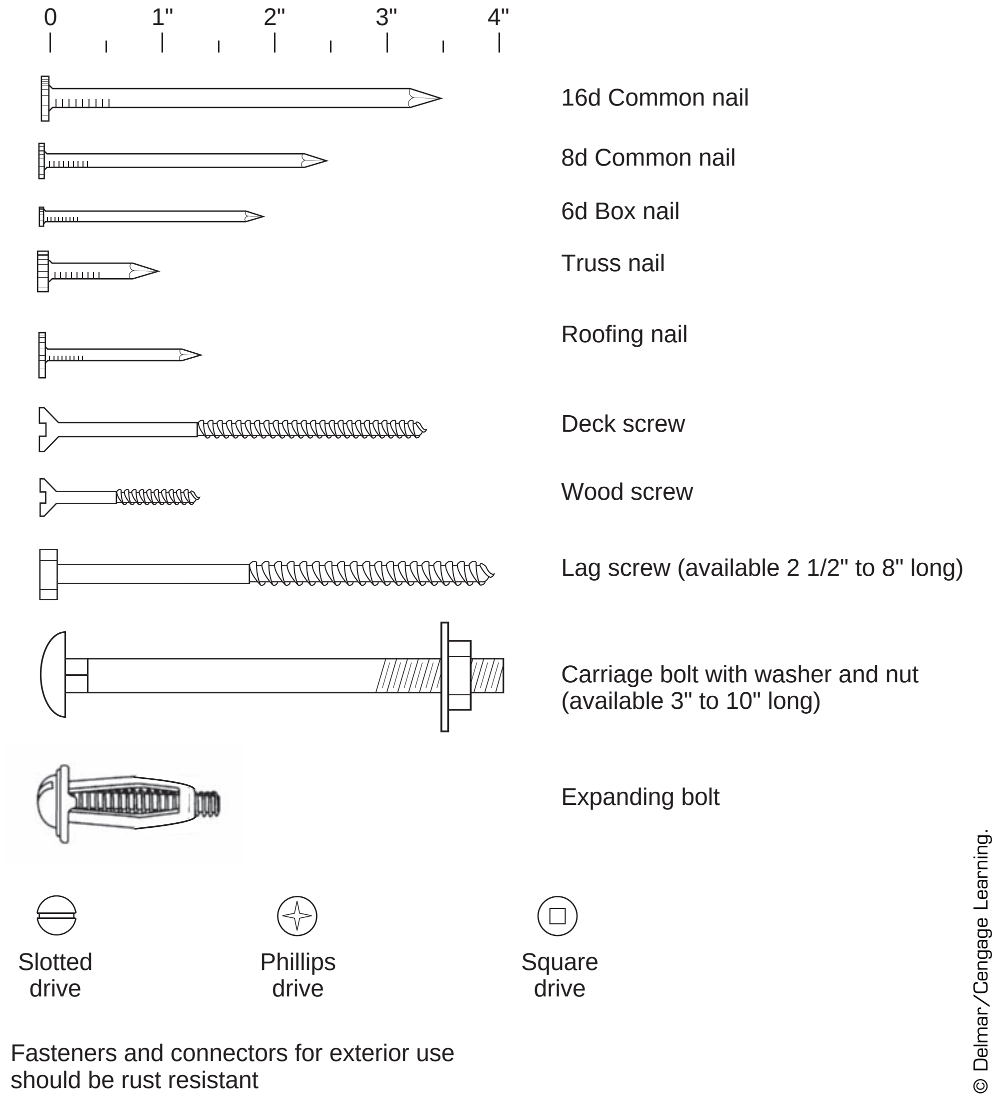


Figure 28-3 Common landscape carpentry fasteners and connectors.

diameter as the bolt, drilled completely through all pieces of lumber being connected. The bolt must be tightened using a box or open-end wrench.

Specialty Bolts. Many types of specialty bolts are available for applications in appropriate situations. One common bolt used in landscape applications is the **expanding bolt**, or molly bolt (Figure 28-3). When connecting to brick, block, concrete, or other hard material, insert expanding bolts into a pre-drilled pilot hole. Expanding bolts have a flange that enlarges when the bolt is tightened. The flange pushes against the side of the pilot hole and holds the bolt in place. The expanding bolt leaves a threaded bolt extended above the surface over which connectors can be set and fastened.

Toggle Bolts. When a surface has no structural backing for fastening, consider using a **toggle bolt**, a threaded bolt with a spring-loaded flange at one end. Installation of a toggle bolt requires a pilot hole the same diameter as the closed flange through all materials being connected. To install a toggle bolt, mark the location of the bolt and drill a pilot hole. Verify that the flange is threaded down near the end of the toggle bolt. Squeeze the flange together and push the flange and bolt through the pilot hole into the cavity behind the surface. When free in the

cavity, the flange will expand, making extraction difficult. Pull the bolt outward and begin turning the bolt with a screwdriver. Turn until the flange is tight against the inside of the surface. Please note that toggle bolt connections are not as strong as connections made into a structural piece and, therefore, are limited in what this connection can support.

Specialty Connectors and Hardware

To aid in connecting posts to footings, posts to beams, and other structural connections, a wide selection of galvanized hardware is available (Figure 28-4). Post supports can be set into a concrete footing to support the post for a structure. Post supports hold the end of the post above the footing to reduce the potential for contact with moisture. Joist hangers are U-shaped metal pieces that aid in connecting joists to **ledgers**, or end joists. These hangers improve the strength of joist/beam connections and make the work easier. Joist hangers can be purchased at standard angles or various other angles necessary to complete connections at corners and other points. Saddle connectors are available for joining 4 × 4 and 2 × lumber.

Numerous galvanized metal fasteners are available to make or supplement wood connections. Straps, Ts, stair supports, angle braces, and post caps are all examples of metal connectors that can be used to make connections that are otherwise difficult to nail, screw, or bolt. Most connectors can be installed using galvanized nails or rust-resistant screws whose length is two-thirds the thickness of the wood piece being connected. When nailing a connector, hold the piece in proper position and, with the same hand, hold a nail that can be driven to "hang" the piece. Drive nails into the remaining opening to stabilize the connector. When using screws, hold the connector in position and mark the openings. Remove the pieces and drill pilot holes for each screw location. Replace the piece and install the screws to stabilize the connector. Specialty connectors achieve rated strength only when all fasteners have been installed. Nailing in only half the openings provided or improper installation will reduce the strength of the connection.

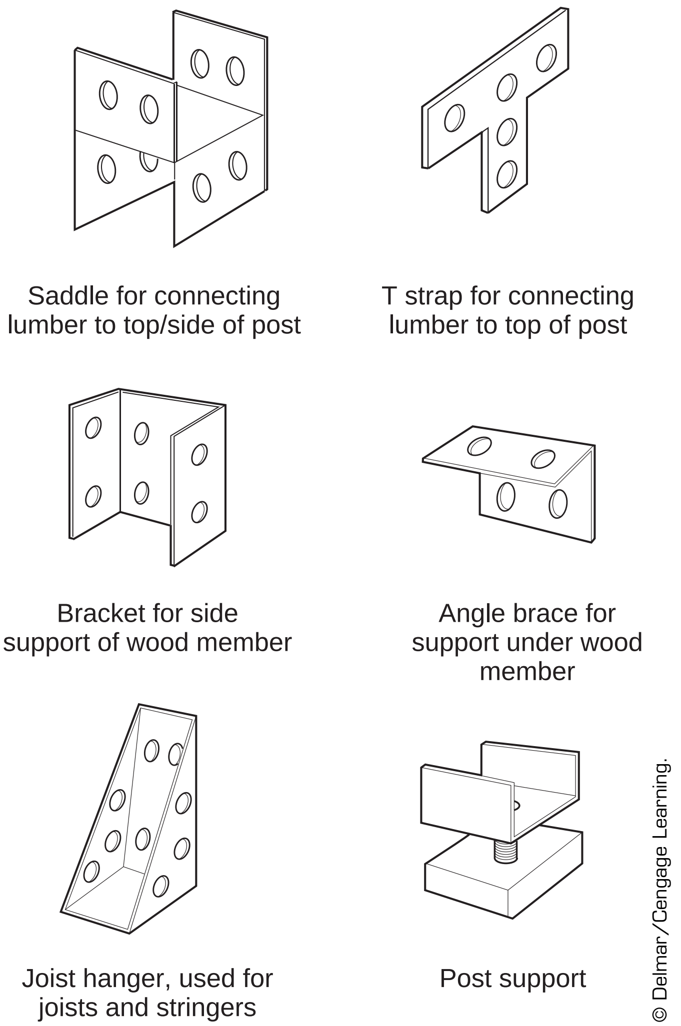


Figure 28-4 Specialty connectors used in landscaping.

EXTERIOR FINISHES FOR WOOD

Wood used in exterior conditions is exposed to conditions that will age the materials, change their color, and possibly begin the process of decay. During the design phase of the project, the designer or owner should decide if the wood selected for construction is to be treated to deter the effects of weathering or if the lumber will be allowed to age naturally. A common misconception is that woods suitable for exterior use must be treated to avoid decay. If a wood is properly selected and prepared for exterior use, preservatives and finishes may contribute to extending the wood's life. The primary reason to finish-treat such woods is to maintain the new look of the lumber or to change the wood's natural color. Once selected for exterior woods, finish treating should continue for the life of the project. Wood that is finished and then allowed to weather will become unattractive; the natural, untreated finish will eventually blend with the remaining treated finish.

All exterior use woods can be allowed to weather to their natural color with minimal structural damage to the wood. Wood that is in contact with soil, and over time all wood that contacts the elements that deposit organic debris on the surface, can benefit from stain or paint treatment. Pressure-treated southern yellow pine begins with a light green color and takes 1–2 years to weather to a natural gray. Western red cedar begins as a white color and takes 1–2 years to weather to a mottled gray in an unprotected location and a consistent gray in protected locations. All heart redwood begins as a rich, red color and takes 2–3 years to weather to a consistent medium to dark gray color. To extend the natural color of a wood, a water repellent with an ultraviolet light inhibitor must be applied to slow the weathering process. Water repellents eventually wear off and must be reapplied periodically to maintain protection.

To change the wood's natural color, its surface must be **stained** or painted. Stains enter the wood's surface and temporarily bond a new color to the surface. Three different types of stains commonly used with exterior applications include opaque stains, which provide a painted coating over the wood; semi-transparent stains, which provide coloring to the surface while allowing the grain of the underlying wood to show through; and transparent stains, which allow the grain to show without adding color. Solid stains are seldom recommended for exterior surfaces. As with water repellents, stains must be reapplied periodically to maintain a consistent surface color.

Two bases for exterior stains are latex and oil. Latex stains should be applied using brushes with synthetic bristles or rollers with a short nap. Cleanup is with soap and warm water. Oil-based stains should be applied with natural bristle brushes or rollers with a short nap. Cleanup for oil-based products will require solvents. Paints for exterior uses also come as acrylic latex and oil-based, with application tools and cleanup similar to those for stains. Many paints will require application of a primer with a chemical formulation matched to the paint base.

Application of all surface treatments should be completed according to the manufacturer's instructions. To apply exterior finishes, begin by providing protection for all existing improvements, including structures, paving, amenities, and plant material, before applying surface treatments. Clean the surface that is to be painted or stained. Remove dirt and mildew from the old surface using a 9:1 water/bleach mixture. In extreme cases, use a formulated wood cleaner instead of the bleach mix. Scrape or strip old paint from the surface, and sand the rough surfaces, particularly if you will use a transparent stain. Test the stain or paint in a hidden area for color correctness. Stains and paints are best applied on warm and dry days with low humidity. If possible, avoid applying stain to surfaces that are in direct sunlight. Begin application of the stain from the top to the bottom of the surface. Brush in the direction of the grain, lapping into the areas wet from earlier brushstrokes. Allow the surface to dry 24 hours and recoat if necessary.

Wood Cleaners, Strippers, and Brighteners

Much of the naturally occurring discoloration and dirt on wood can be removed by using a wood cleaner; and in applying a deck stripper as a second step, the wood can often be lightened to improve the conditions for applying stain. Always follow any specific instructions provided by the product manufacturers. Before cleaning the wood, mask off any surfaces that these products can damage or discolor.

To use cleansers, first remove any large debris from the surface. Mist the surface and apply the cleaner with a sprayer or by hand using brushes and rollers, allowing it to stand for 10–15 minutes. Do not let the surface dry during this period, misting it if necessary. Following the time allowed, pressure wash the deck. Use approximately 1,200 psi of pressure, and use a fan spray head operated in a sweeping motion. If the surface color is uneven after cleaning, consider a second cleaning using a deck stripper. If the surface color and consistency is acceptable, a deck brightener may be applied. Before the surface has dried from the cleaning/stripping operations, apply the lightener using a sprayer or by hand using brushes and rollers. Allow the brightener to stand for 5–15 minutes on the deck; the longer wait typically results in a lighter finish. When the desired color has been achieved, thoroughly rinse the deck. Allow the deck to dry completely, typically a minimum of 48 hours, before applying any stains or finishes.

Decorative Finishes

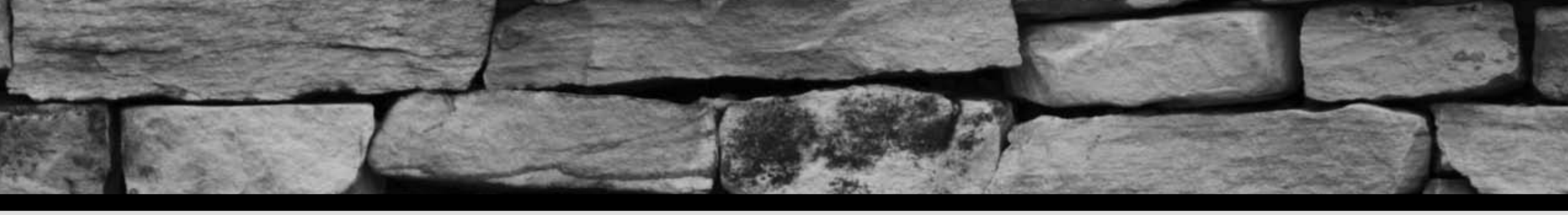
For projects that call for metal, stone, and other decorative finishes, painting faux finishes over wood may provide a viable alternative. Manufacturers such as Modern Masters® have developed paint products that allow contractors to turn a wood post

or panel into a variety of metal, stone, plaster, and other decorative elements. Each decorative paint has a different process, but most begin with a surface coating of primer or base. Top coats are painted or troweled onto the base and treated to achieve the desired effects.

PREFABRICATED MATERIALS

To speed the construction of landscape structures, contractors can purchase many prefabricated pieces. Available in a variety of natural and artificial materials, contractors can find **lattice**, stair **stringers**, rail posts, and many other commonly used parts that are cut and ready for installation. These exterior building components are often available:

- Screening Materials. **Screening** materials are valuable for insect barriers on decks, screened porches, and gazebos. Screening is available in sheets or rolls that are 36-inches or 48-inches wide. Contractors can choose from inexpensive polyester or the more durable aluminum screening materials.
- Lattice. Lattice is thin strips of wood fastened together at right (or more acute) angles in an evenly spaced gridwork pattern. Precut and nailed lattice is available in 4 × 8-foot sheets. Lattice is available in treated and naturally decay-resistant woods in both **lath** or 1 × 2 lumber. Diagonal and gridded lattice patterns, as well as paintable vinyl lattice, can be found in some locations.
- Stair Carriages. Stair carriages are the notched, dimensioned lumber that supports the stairs. Pressure-treated stair carriages are available precut to standard riser/tread dimensions.
- Columns and Posts. Precut and routed columns and railing posts are available in a variety of materials; 4 × 4 posts in treated and naturally decay-resistant woods have a variety of designs. Stainable porch columns are available in wood and vinyl.
- Post Caps. Protective and decorative caps for posts are available in metal, vinyl, and lathed wood. Metal and vinyl are manufactured with integral color, and wood can be stained or painted.
- Railing and Fence Sections. Preassembled railing and fence sections are available in a variety of lumber types and designs. Fencing panels are also available in vinyl materials that are ready for assembly.



CHAPTER 29

WOOD DECKS AND PLATFORMS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Build foundations for wood structures.
- Frame the substructure of a wood structure.
- Apply surface materials to a wood deck.

The concept of a deck is an open-air space, often with railings and stairs. Although this is one version of a deck, another is the platform from which many of the landscape structures are derived. Stoops at the entry to a building are actually small decks with stairs and railings attached. Gazebos are decks with roofs and side railings. The deck is the basic structure that, with a few additions or modifications, supports the diversity of landscape structures available.

This chapter covers the site preparation, the construction of the foundation and substructure, and the surfacing, trimming, and finishing for a deck. Construction of railings, stairs, benches, and roofs for a deck or other structures is covered in Chapters 30 and 31. The integral nature of wood construction may require the review of all chapters in this section to gain an understanding of how the components relate to each other and fit together. Although one piece may be constructed as a stand-alone, many wood projects require the combination of all three components. While reviewing this chapter, bear in mind that any construction documents prepared for a project would supersede the methods and techniques covered here.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Construction Staking, Chapter 8
- Materials for Exterior Carpentry, Chapter 28
- Wood Steps, Railings, Seating, and Skirting, Chapter 30
- Overhead Structures, Chapter 31

SITE PREPARATION FOR WOOD STRUCTURES

As with all other aspects of landscape construction, beginning a new phase of work requires preparation. Before building any structure, the contractor will need to verify site conditions and details of the work to assure the work progresses.

Structure Layout

Before building any structure, first lay out the foundation and post locations. Proper placement of these elements will save time removing and relocating misplaced elements. Preparation of a plan that precisely calculates the location of footings and posts will aid in proper placement. Measuring these elements to the center line will also avoid mistakes common with adding and subtracting lumber

dimensions. If the site has a slope, you may have difficulty in accurately placing elements that are above or below each other. Place tall stakes just beyond the edges of the structure, and then run level stringlines at the finish elevation of the structure to obtain an accurate picture of how the structure will be positioned. When the stringline network is set square and at the proper dimensions, use a plumb bob to locate the proper center position of postholes and foundation locations. Batterboards (Chapter 8) provide an effective means of locating improvements throughout a project.

Ground Preparation below Structures

Decks, gazebos, and other structures are often positioned slightly above finish grades. Structures that are positioned with a crawl space underneath require preparation of the ground below to prevent erosion and weed growth. One common treatment of this area includes removing all vegetative growth within the perimeter of the structure, positioning landscape fabric over the exposed soil, and covering with a nondecomposing material such as washed river rock, pea gravel, or field stone. This treatment will hold the soil in place and reduce the weed growth in an area that is difficult to access.

FOUNDATIONS FOR WOOD LANDSCAPE STRUCTURES

All landscape structures require some form of anchoring, either to a building or to the ground, for stability. Most structures also require that this anchoring be prepared in a manner that provides adequate protection from frost heaving and soil movement and provides lateral support to prevent the structure from leaning or twisting. Anchoring can be accomplished by attaching structures to an existing building through the use of a **ledger** plate; supporting structures on existing **slabs**, **footings**, or foundations; or supporting structures on **posts** anchored in the ground.

> **CAUTION**
>
> Obtain the assistance of a design professional for designing wood structural systems. Serious injury or death can occur with structural failure of any wood structures described in Chapters 29, 30, and 31.

Attachment to an Existing Building

A ledger plate provides adequate anchor for structures that can be attached to a building, an attachment that also protects the landscape structure from differential movement. In the unlikely event the building goes up or down, so will the structure. The ledger provides lateral support only for structural members attached to it; structure away from the building requires additional support and perhaps even bracing.

Using a ledger plate requires preparation of the building where the ledger is to be installed. The building is marked at the location where the landscape structure will be attached. Construction drawings should note the proper location for attachment. In many installations, the connection is placed about ¼–½ inch below the threshold to any exterior door. If the structure has no door, calculate the elevation by measuring down to the interior floor elevation from a window sill, then repeating that measurement on the outside of the structure. Verify the location is correct before removing any exterior siding or sheathing. Mark the building on the exterior surfacing with a pencil or chalk line, including the dimensions of any surfacing, railing, and trim that will be attached. Verify that the markings are level and match the elevations of any doorways that the structure must serve.

If the building is new construction and siding has not yet been installed, proceed directly to the installation of the ledger. If the building is an existing wood structure, remove the exterior surfacing until sheathing or the foundation is exposed. Use a circular saw set at the depth of the exterior surfacing material to cut along the markings. Carefully remove the surfacing with a pry bar, using caution not to damage remaining materials in the building's exterior surfacing. When you have removed the surfacing, remark this exposed surface with the location of the ledger, again verifying for level and proper elevation.

Holding the ledger in the correct place, **tack** the ledger to the building using galvanized 16d nails. Use the nailing pattern on the sheathing as a guide to locate building joists and studs behind the sheathing. Connecting to the building **rim joist** is preferred. If possible, avoid connecting to the wall studs and floor joists to avoid future problems in the event the building is remodeled. At the location where the rim joist is positioned behind the **sheathing**, drill ¼-inch diameter pilot holes every 16 inches through the ledger and into the sheathing

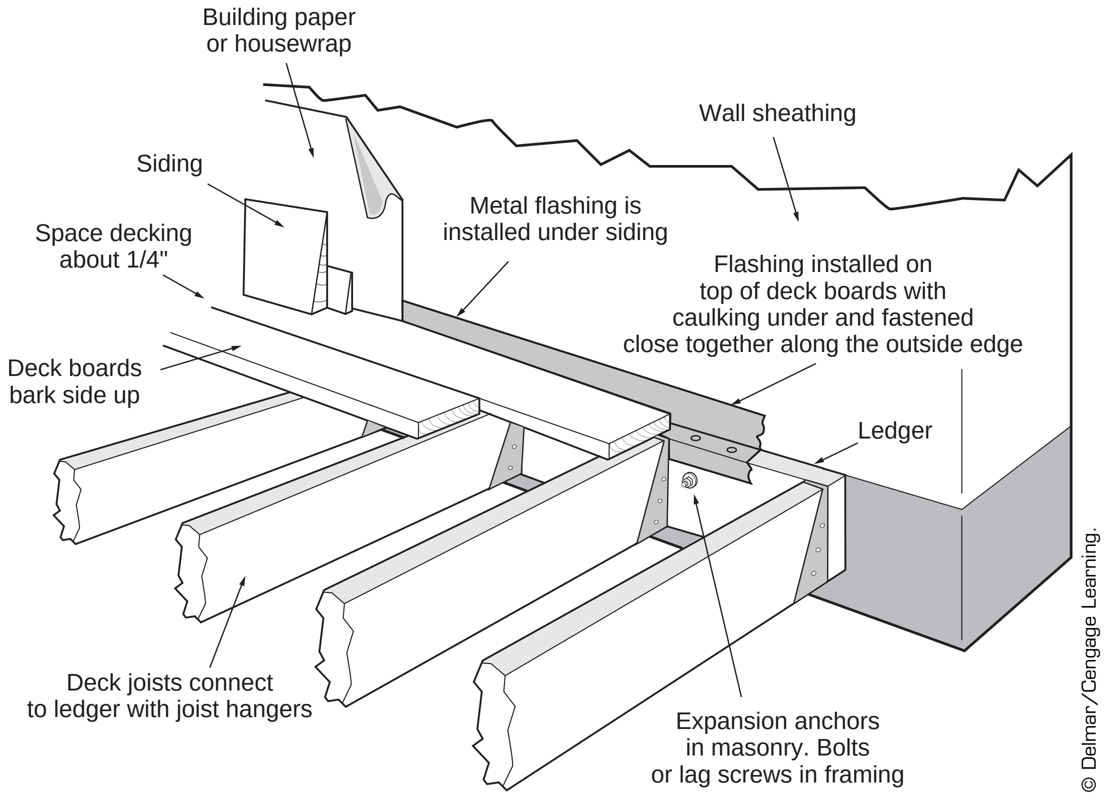


Figure 29-1 A ledger is used where the deck joins the building.

and building rim joist. Insert galvanized ⅜-inch diameter by 3-inch lag screws with washers into the pilot holes and screw into the building until the ledger is held snugly against the building (Figure 29-1).

If the ledger is to be attached to concrete block, concrete foundation, or masonry veneer, use a masonry bit to prepare ⅜-inch pilot holes every 16 inches. Anchoring must be done using galvanized expanding bolts rather than lag screws. When fastening to materials with hollow cores, toggle bolts will be required. In every connection situation, use the connector that will provide maximum anchoring. If you can use carriage bolts, a stronger connection will be obtained.

Attachment to an Existing Slab or Footing

Connecting a structure to an existing slab requires either drilling and setting an expanding anchor bolt with a galvanized post anchor (Figure 29-2) or connecting to the slab using an angle brace (Figure 29-3). In cases where wind may lift the structure, consider using both techniques. Setting an **anchor** bolt requires marking the center line location of the post

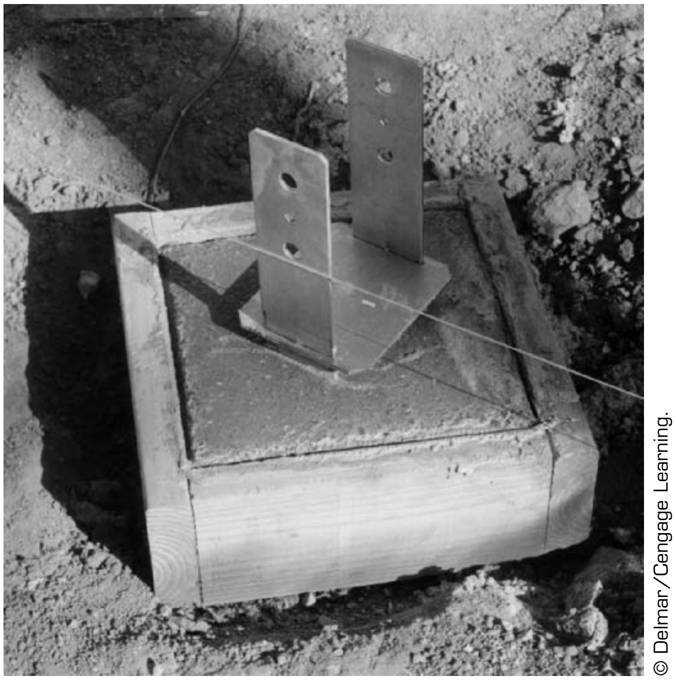


Figure 29-2 Galvanized post anchor placed in concrete footing. Note the boxout for the footing, which was poured separate from the slab.

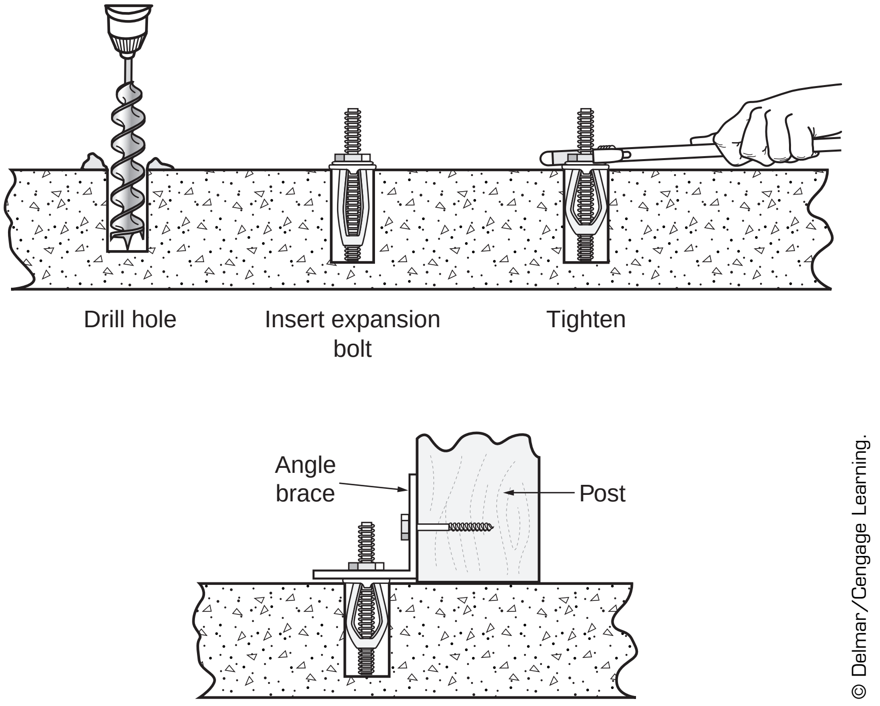


Figure 29-3 Installing an expanding anchor bolt and angle brace in concrete.

or beam connection. Using a **hammer drill** with a **masonry bit**, drill a hole the same width and depth as the expanding bolt. Connect a galvanized post anchor to the top of the expanding bolt. Drive the anchor bolt into the hole and, using a wrench, twist until the bolt fits securely in the concrete. The expanding bolt provides a threaded end over which an anchor can be placed and then secured with a washer and nut. Set the post or beam in the post anchor and fasten it to the anchor.

Angle braces also use expanding bolts in the concrete with lag screws into the post or beam. Angle braces are installed by placing the post or beam in position and marking the location of the brace on the post or beam and concrete surface. Remove the brace and drill pilot holes in the post or beam for the lag screws. Drill the pilot holes in the concrete the same depth and diameter as the expanding anchor bolt. Place the angle brace over the expanding bolts and attach the washers and nuts loosely. Install expanding anchor bolts in the concrete and twist with a wrench until the bolt fits securely in the concrete. Install and tighten the lag screws into the post or beam. Tighten the nuts on the expanding bolts.

Cast-in-Place Concrete Footings

Cast-in-place concrete footings sunk below **frost depth** provide a stable support for most structures with a substructure framework. Structures are anchored to this footing using a galvanized post anchor set in the top of the footing. Structures that rely on the footing for lateral stability do not work with this type of support (Figure 29-4). This type of

Figure 29-4 Post supported by a round concrete footing.

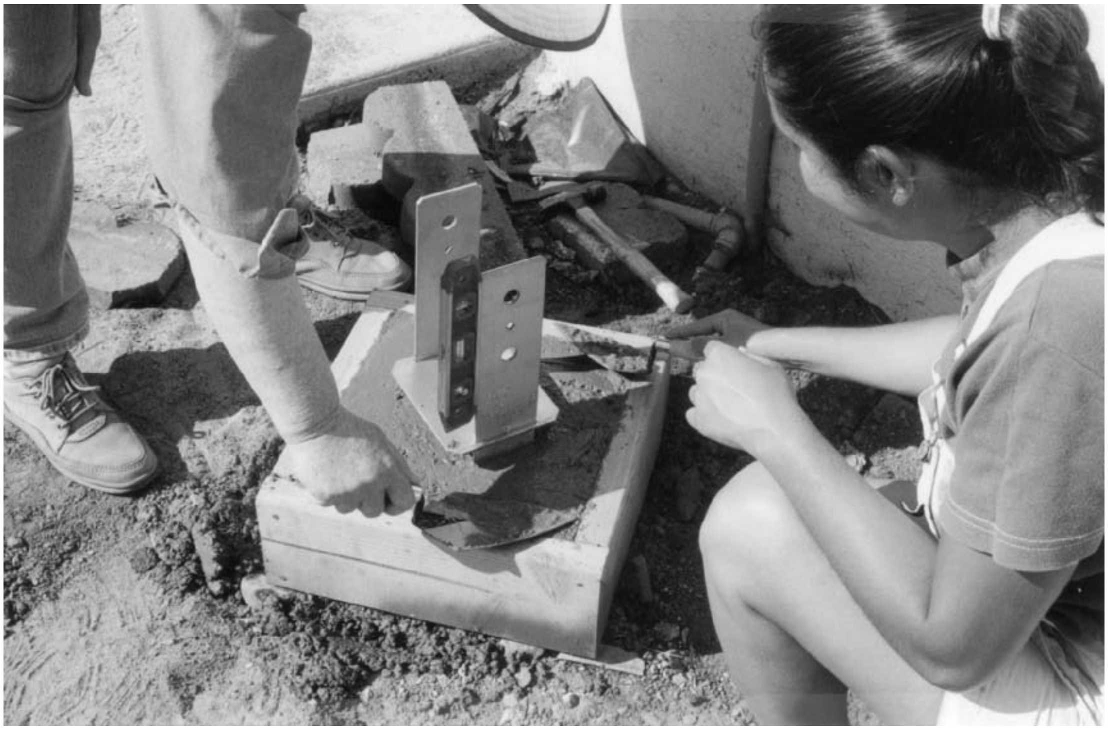


Figure 29-5 Using a box form to shape the top of a concrete footing pour.

footing works primarily for structures that have multiple posts with bracing between the posts that will hold the structure square.

To construct a concrete footing for posts up to 6 × 6, excavate a 12-inch diameter round hole to frost depth centered on the footing location marking. The hole should be as vertical as possible with straight sides. A properly excavated hole does not require forms; but if desired, install a piece of tubular paper form in the hole. For installations that require a neat appearance at grade level, use a piece of paper form or a box form constructed from 2 × 6s to form the top 6 inches of the pour (Figure 29-5). Before pouring, recheck measurements to verify that the footing is located in the proper position and elevation. If not, expand the hole to cover the location required or fill the hole and move to the proper location. If you overexcavate the hole, install a paper form in the proper location and backfill the hole around the form.

If reinforcing is desired, cut two, #4 rerods 8 inches longer than the hole's depth. Insert the rerods into the hole, pushing the extra length into the ground at the bottom of the hole until the top ends of the rerods are below the top of footing. Place 2–3 inches of gravel into the bottom of the hole for drainage. Mix and pour concrete into the hole and tamp gently until settled. Adjust the rerod so that it does not rest against the sides of the pour. Fill to the top of the hole and smooth the top with a wood float. Slightly dome the top of the pour to drain water off the footing. Before the concrete hardens, insert a galvanized post anchor into the center of the footing. When the concrete is hard, remove the forming material used for the top (Figure 29-6).

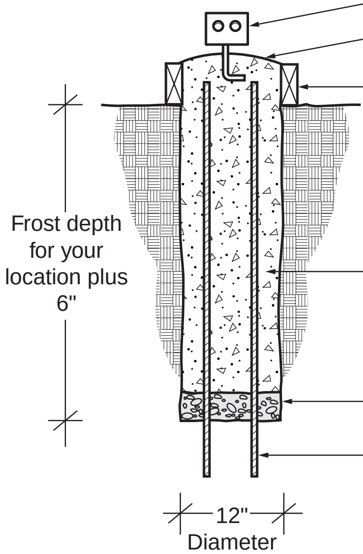


Figure 29-6 Cast-in-place concrete footing.

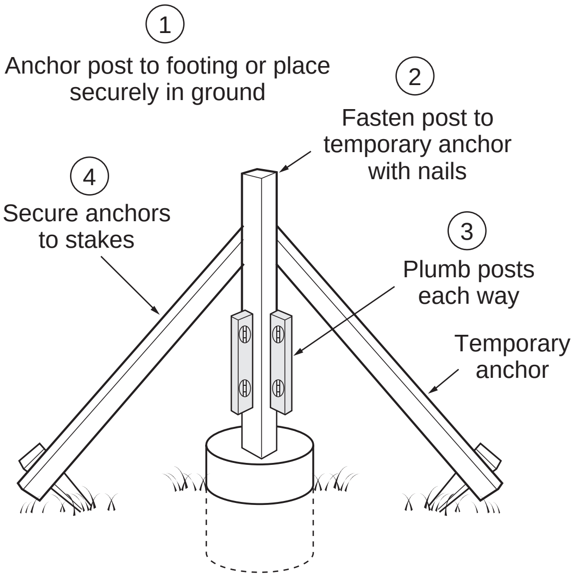


Figure 29-7 Temporary bracing for posts.

Figure 29-8 Stapling roofing felt around a direct burial post. Felt extends 6 inches above and 9 inches below the ground line.

If placed on footings or piers, posts should be braced and held in correct position until beams and joists are installed. Tack two 1 × 6s, placed at right angles to each other, to a post. Connect each 1 × 6 to stakes anchored in the ground (Figure 29-7). Each subsequent post can be braced in two directions in a similar manner or braced against posts anchored previously. Verify that the installation is square before placing any beams or joists.

Direct Burial of Posts

For residential applications in locations with stable subsoils, treated support posts may be buried directly into the ground to provide adequate support for landscape structures. This type of support provides both structural and lateral support and, if prepared to the proper depth, can provide frost heave protection. To extend the life of a direct burial post, wrap the post with asphalt building paper (roofing felt) to prevent contact with soil at the ground line. Extend the **building paper** 6 inches above and 9 inches below finish grade (Figure 29-8). As an alternative to wrapping a post, use a plastic post sleeve (Figure 29-9). Excavation is the same as direct burial of the post; but before inserting the post into the hole, slide a sleeve over the post. Adjust this sleeve up or down to cover the critical area at grade, tack the sleeve into position, and fill the hole. If there is excess sleeve, cut it with a hacksaw to fit.

To execute direct burial of a post up to a 4 × 4, excavate an 8-inch diameter hole to frost depth centered directly on the footing location marking. The hole should be as vertical as possible with straight sides. Place 2–3 inches of gravel at the bottom of the hole for drainage. Place the post in the hole, backfill half of the hole, and tamp (Figure 29-10). Verify that the posts are plumb and square. Complete backfilling and tamping. Brace the post to maintain its correct position until framing begins (Figure 29-11).

You can backfill the hole with several materials. Backfilling with soil excavated from the hole provides stable support of the post if the hole has not been oversized. Compact the soil with the handle of a shovel after placing every 8 inches of fill. Although you can use it for backfill, crushed aggregate does not provide as much stability as other choices. Place

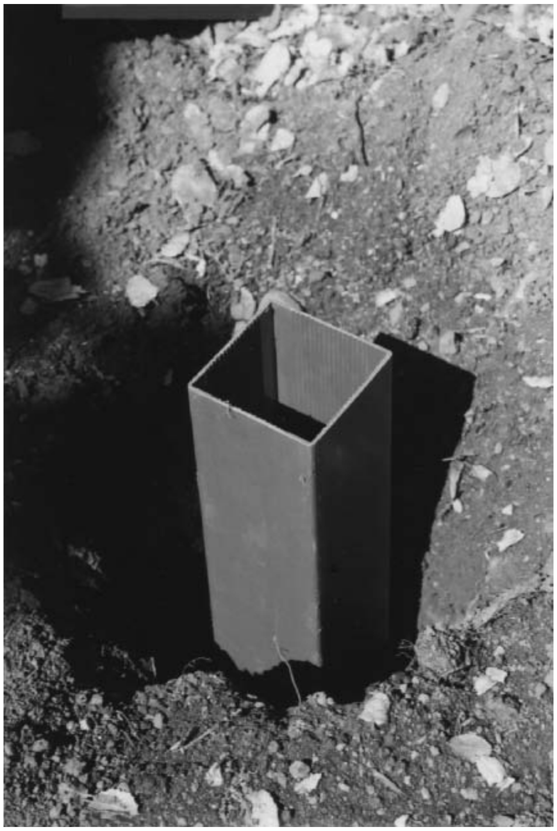


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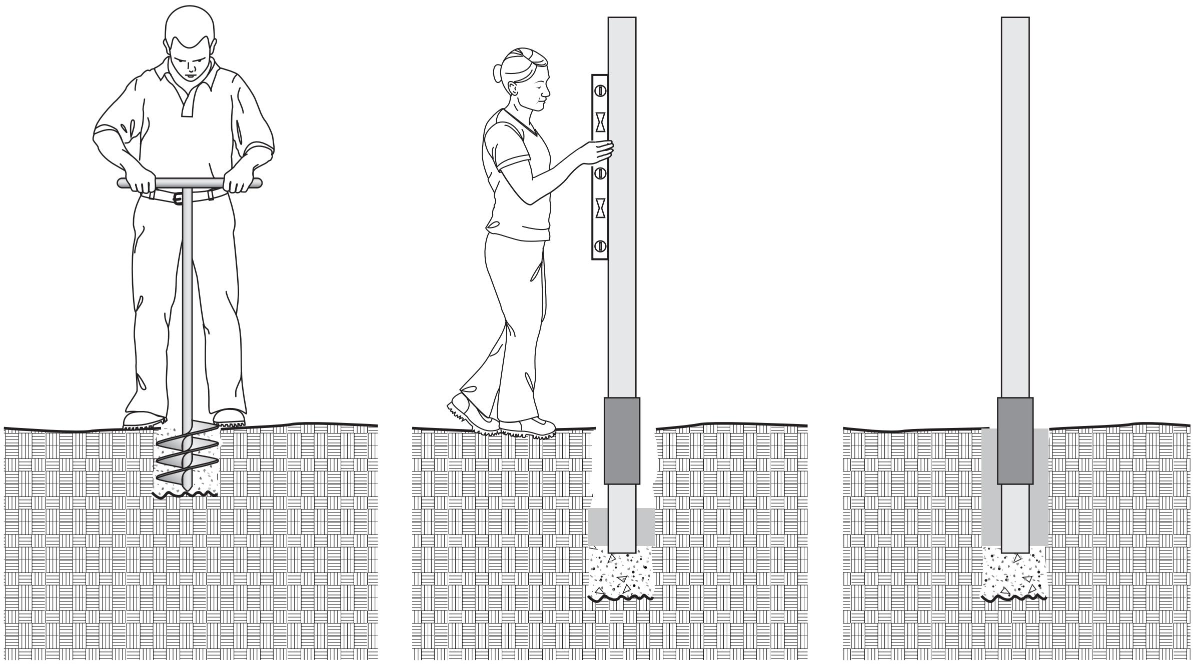
Figure 29-9 Plastic sleeve to protect post from decay at ground line.

aggregate and compact after placing every 8 inches of gravel. Another choice for filling around a post is concrete. Although concrete provides a stable installation, research has shown that post replacement is extremely difficult. A fourth choice is dry, premixed concrete for backfill. When the hole is nearly full, soak the dry concrete mix with water and stir using a long piece of rerod in a churning motion. This creates a "soft" concrete backfill that has stability slightly better than that of soil.

Whichever backfill material you select, constantly check the post for plumb as you fill the hole. Correct leaning posts by wiggling the post and applying pressure in the direction the post needs to move. Recompact after alignment is corrected. If you selected concrete for backfill, smooth the surface of the hole with a wood float, tapering the surface down and away from the post so that water will drain.

Deck Post Supports

For deck structures, fences, and site improvements that are not supporting heavy loads, you can use metal post supports to separate the post from the ground. These supports should not be used in structural situations or for decks and other improvements



A. Excavate vertical hole to proper depth

B. Place granular material and post in hole. Plumb in all directions while backfilling

C. Backfill and compact around post. Verify post is plumb

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Figure 29-10 Steps for post installation.

Figure 29-11 Setting and leveling posts for deck construction.

that people will occupy. Using a heavy sledge, drive metal supports into the ground; then fasten the post to the support using lag screws or bolting hardware (Figure 29-12). The elevation should be set before the post is inserted. If any type of loads will be applied to the support, drive the support further into the ground than the original elevation.

Adjustable Deck Supports

Almost any type of wood or modular decking material can be installed over old paving, compacted grade, and roofs using adjustable deck supports. Adjustable deck supports are plastic levelers that can be adjusted from 2–12 inches, depending on the model. Supports are installed by laying out the location of deck supports based on structural requirements. Typically, place supports anywhere from 1–2 feet on center to support surfaces. Place the supports at either end of a row with a level line run between them. Using an adaptor, adjust the other supports along the line for height and slope, if necessary. When you have adjusted all supports to desired height, set surfacing or structural pieces in place on top of the supports.

Figure 29-12 Metal post support.

Precast Pier Blocks

If frost protection is not an issue, precast **pier blocks** are a good choice for support. These units are tapered, concrete blocks with a square opening in the top designed for the placement of a treated 4 × 4 post (Figure 29-13). Because they provide no lateral support for a structure, pier blocks are recommended only for supporting decks or freestanding structures where frost and stability are not concerns.

To install precast pier blocks, locate the center of the post location. In a 12 × 12 inch square centered on the post location, clear away all vegetative growth. If the topsoil is unstable, excavate any unsuitable soil until you reach a solid subgrade. Replace the excavated area with granular base material, compacting in 6-inch layers. Place the block under the center of the post location and level in both directions. The pier block may be moved

Figure 29-13 Precast concrete pier block holding a support post.

slightly to accommodate any errors in layout. Place the posts in the blocks and extend the posts up to the deck structure. Attach posts to the structure using carriage bolts and trim flush with deck joists. Provide temporary bracing for the posts until the deck structure is installed.

Wood Sleepers

When deck material is to rest directly on grade, install wood **sleepers** to provide a connecting point for surfacing. Wood sleepers are decay-resistant, dimensioned lumber, typically 4 × 4s or 6 × 6s, that are placed level on a compacted base material. Position sleepers under all edges of the surfaced area and space them no more than 2 feet apart. Use granular material to fill between and to the tops of the sleepers to hold them in place. Attach deck structure or surfacing directly to the sleepers in the same manner you would attach them to wood structural framing.

SUBSTRUCTURE CONSTRUCTION

When building the substructure for a deck, contractors have two basic choices available—traditional **post and beam framing** (also called drop beam or plank and beam) (Figure 29-14) or **platform framing** (also termed box or flush beam) (Figure 29-15). Post and beam uses a system of posts to support heavy construction **beams**. These beams in turn support structural **joists** onto which the surfacing material is applied. Although durable and time-tested, the post and beam construction methods require enough clearance between the surfacing and ground to accommodate the structural components. Sites that are relatively flat may be difficult to adapt to a post and beam construction method.

Platform framing consists of a rim joist box that runs around the outside of a structure inside of which the joists are hung. This platform is connected directly to the posts, bypassing the requirement for beams. Platform framing requires fewer structural members to complete the substructure; but because those joists are carrying the same loads as would a beam, the members must be larger and/or spaced closer together. From a structural soundness standpoint, each method can provide adequate support if properly designed; so, the choice may depend on space and clearance.

Post and Beam (Plank and Beam or Drop Beam) Framing

If the deck is connected to a building, install a ledger plate at the correct location and elevation. Allow space for surfacing material between the finish elevation and top of the ledger. No beam needs to be installed at the ledger location because the ledger carries the load typically carried by a joist and beam. Fasten hangers for joists directly to the ledger (see Figure 29-1). Locate post locations and install as directed in previous paragraphs. Post and beam framing requires that all posts be installed and stabilized before beams are connected.

Beams may rest on top of posts or be attached to the sides of posts as single or **grab beams** (double beams, one attached to each side of the post). If the beam is to rest on top of the posts, the posts must be trimmed to the correct height before installing the beams. If beams are attached to the side, the posts must be marked but may be trimmed after the beams are connected.

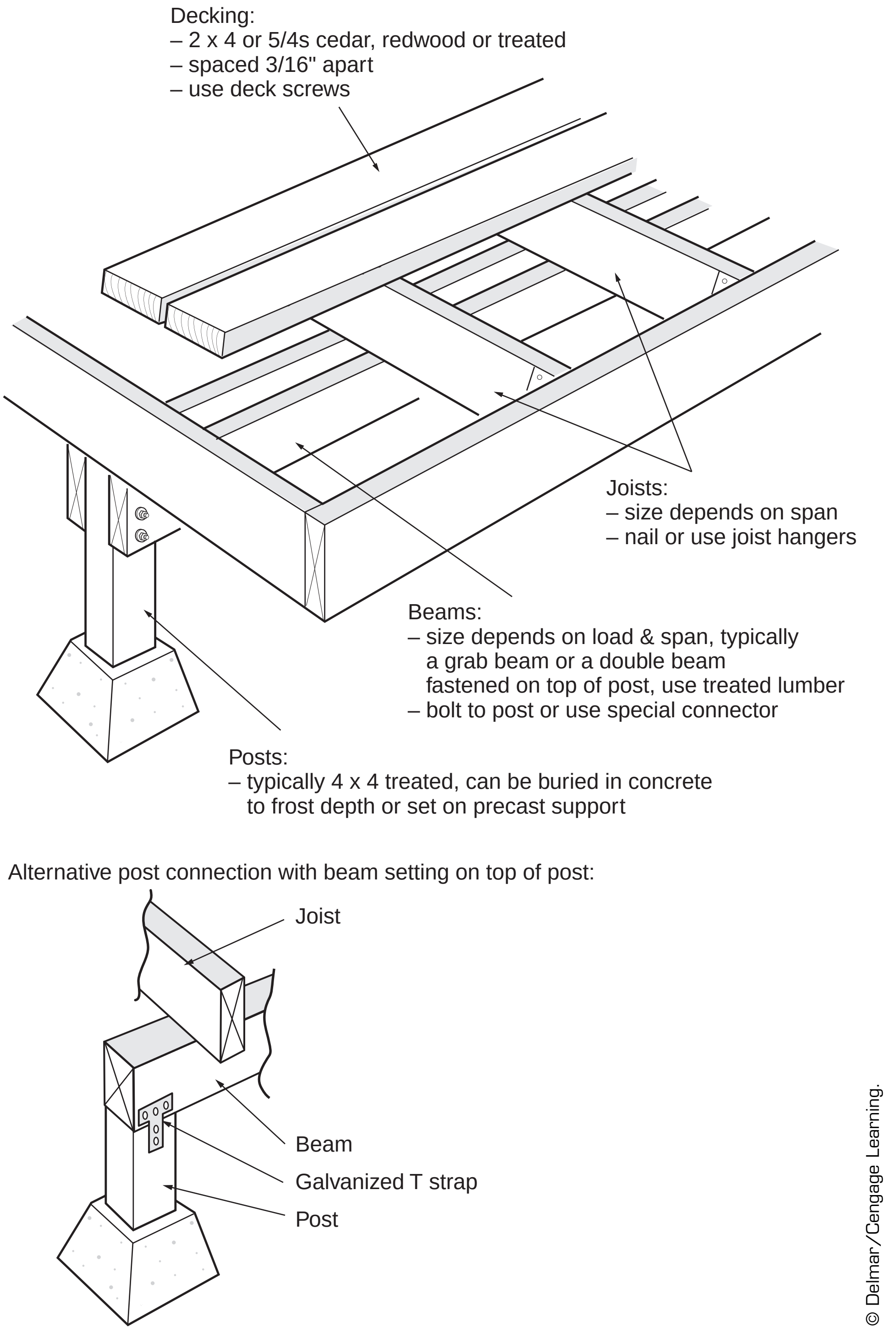

Figure 29-14 Post and beam (drop beam or plank and beam) framing diagram.

Post and Beam Framing with a Ledger Plate. To set the post heights when using a ledger plate, extend a level stringline from the top of the ledger to a post on the edge of the project. The ledger plate functions as a rim joist, and the position of all structural members must be set in accordance with this stringline. From the stringline elevation, subtract any cross-slope desired for the deck (typically a ¼-inch per foot fall away from structures or less), the depth of the joist material, and, if the beam is to rest on top of the post, the depth of the beam (Figure 29-16).

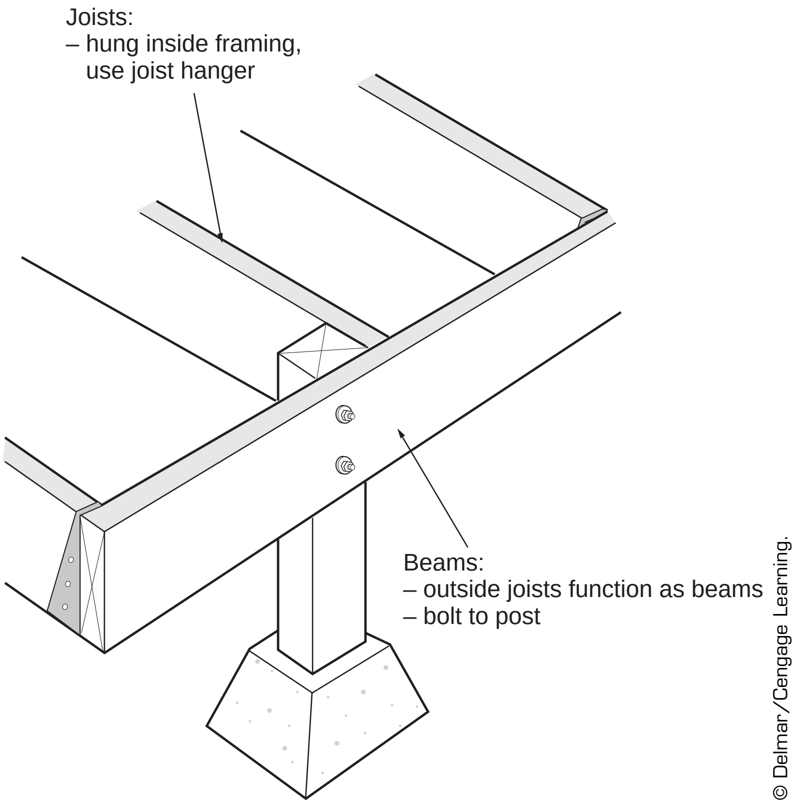

Figure 29-15 Platform (box or flush beam) framing diagram.

Use a **speed square** to mark the post. If placing the beam on top of the post, trim the post using a circular saw. The cut must be square and level for the beam to be positioned properly. Position and attach the beam using a saddle or metal T connector on both sides of the beam (Figure 29-17).

Attaching the beams to sides of the post also provides a stable installation. This also allows the use of grab beams, constructed of two smaller pieces of lumber, rather than one large piece (two 2 × 10s rather than one 4 × 10) (Figure 29-18). Attach one section of the beam to each side of the post. This provides the same structural support as one large beam but makes construction more cost-effective. Run the stringline as described in the previous paragraphs, and mark the proper location for the top of the beam. Be certain to include the depth of the joists and slope of the deck in the measurement. Because the beams will be attached to the sides of the post, this mark indicates where the top of the beam(s) should set. Attach the beam(s) by drilling and inserting at least two ½-inch diameter bolts (Figure 29-19). Based on the design specifications, larger structural installations may require more or heavier bolts. After you have installed the beams, trim the top of the post flush with the top of the beams using a reciprocating saw.

Post and Beam Framing without a Ledger Plate. If no ledger plate is used, mark the desired **finish floor elevation** on one post. From that mark, subtract the floor surfacing and joist dimension to determine the top of beam elevation. Re-mark the post with this top of beam elevation. Use this elevation to establish the elevations on other posts by extending a stringline with a line level to the other posts. Subtract any desired slope on the deck surface from markings on other posts.

Joist Installation. Joists on top of the beams are set on edge and are hung from the ledger using joist hangers, regardless of the method used for beam/post connection. Recheck the installation to ensure level and square before placing any joists. Mark the locations of all joists along the outside beam and the ledger. Install joist hangers along the ledger at each location (Figure 29-20). Beginning at one side

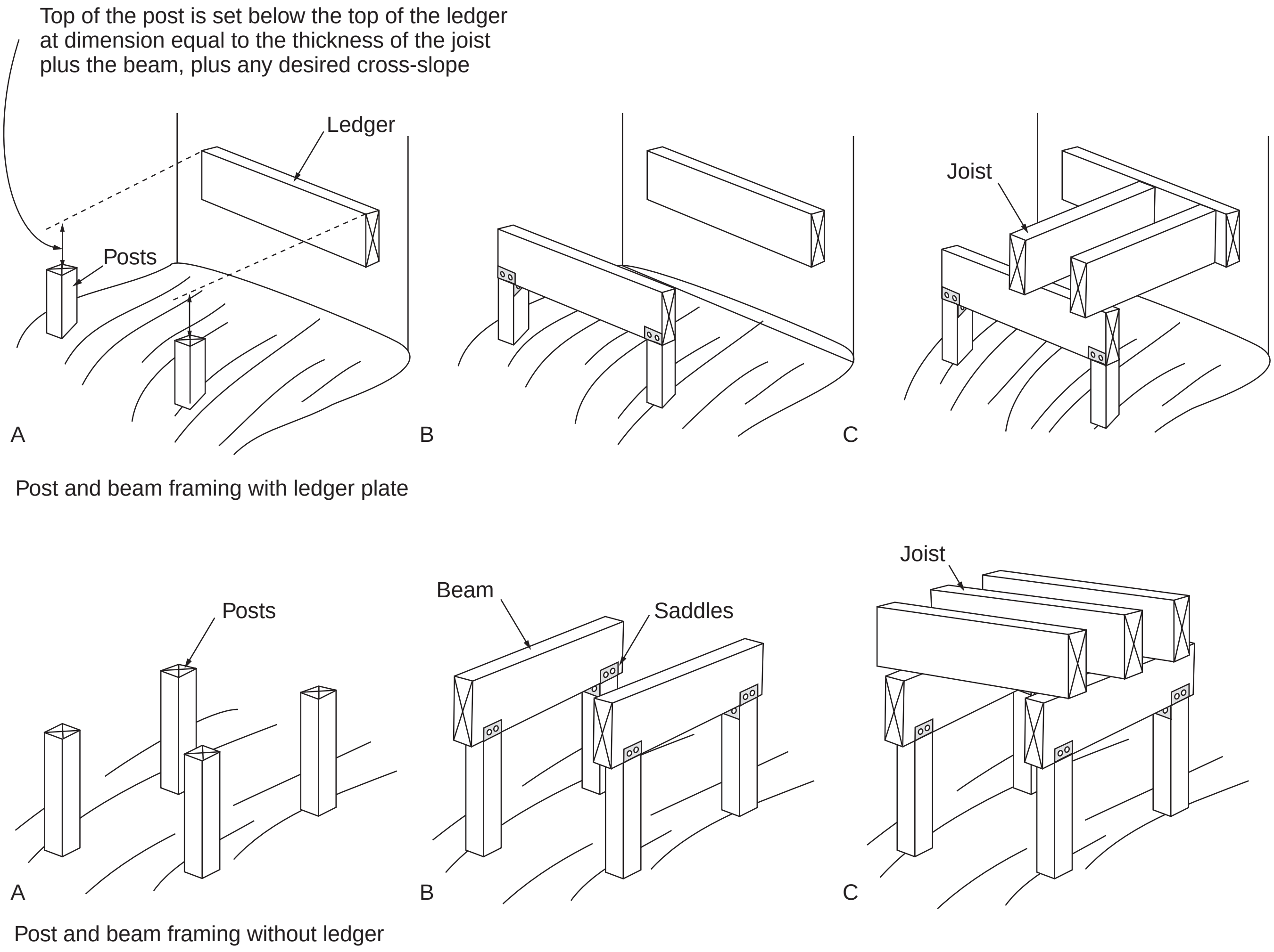

Figure 29-16 Steps in post and beam framing.

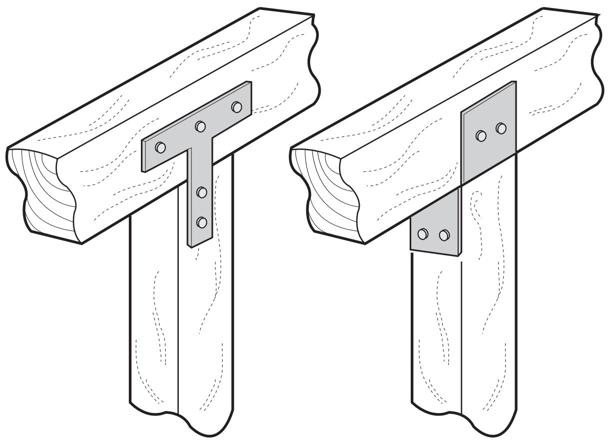

Figure 29-17 Common post to beam connectors.

Figure 29-18 Grab beam connections used for seating framing.

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Figure 29-19 Post to joist connection using carriage bolts. At this corner, bolts are installed from both sides.

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Figure 29-20 Installing joist hangers. The block positions the hanger at the correct height. The prepunched tabs are driven in to hold the hanger until nails can be installed.

of the deck, place the first joist in the joist hanger and on the beam at the correct marking. If a joist is too high, notch it at the end or move the hanger down. If the joist is too low, move the hanger up or place cedar shims placed under the joist to raise its level. Attach the joist to the joist hanger using joist hanger nails.

Secure the joist to the beam by toenailing (see Chapter 7) with 16d galvanized nails. Proceed with placement of joists along the entire length of the deck. If joists do not extend to the outside edge of the deck and splicing is required, attempt to center the splices over a beam. Trim beams that extend beyond the joists. Using a chalk line, mark the correct lengths for all joists that extend beyond the edge of the deck. From that chalk line, mark a vertical line using a speed square and trim with a circular saw. Nail a 2 × 4 diagonally across the surface to hold the joists in position until surfacing is installed.

Platform (Box or Flush Beam) Framing

Platform framing also begins with the placement of ledger plate and posts for the deck. Install a ledger plate at the correct location and elevation, remembering to allow space for surfacing material between the finish elevation and top of the ledger. The top of the ledger sets the elevation for the top of the posts and joists. If posts are direct buried, verify that they are straight, plumb, and square and proceed with connecting the rim joist. If placed on footings or piers, posts should be braced and held in position until all the joists are installed. Verify that the installation is square before placing any joists.

The outside, or rim, joist performs the same support function as the beams in post and beam construction. Begin platform framing by using a joist hanger to connect a rim joist at one side of the deck to the ledger plate. Holding the joist against an outside post, use a carpenter's level to adjust the joist until any required slope away from the ledger is reached (Figure 29-21). Connect the joist to the post using two ½-inch diameter bolts. Repeat this process for the rim joist at the opposite side of the deck. Note that if the posts are not set at the outside edges of the platform, you may need to install two interior joists and the end rim joist before installing the side rim joists. After these initial joists are in place, install the rim joist across the end by end nailing into the perpendicular joists. Angle connectors provide a stronger connection than does end nailing. Trim posts that extend above the platform frame

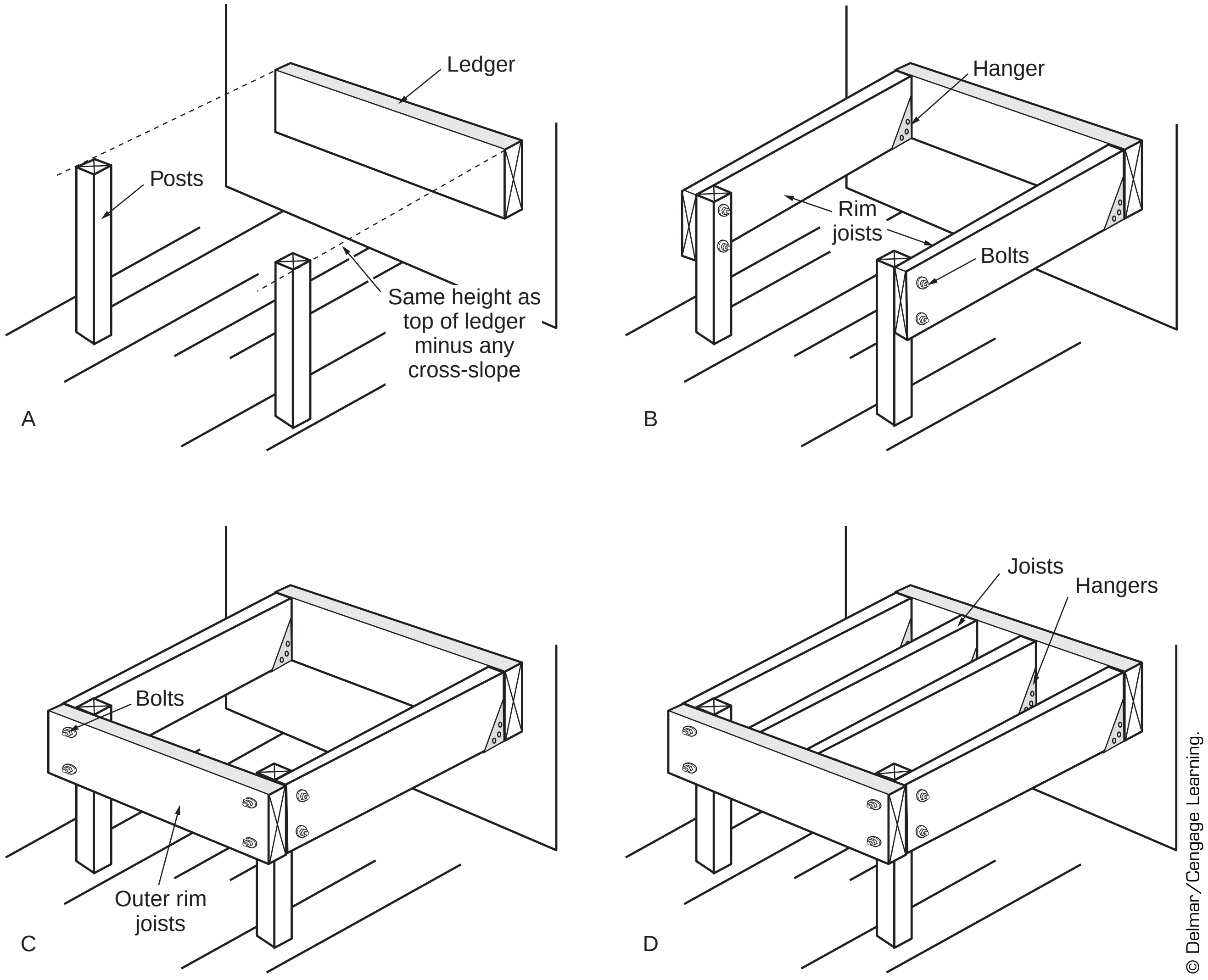

Figure 29-21 Steps in platform framing.

with a reciprocating saw to the same elevation as the top of the beams.

After you have framed the platform rim joists and securely attached them to the posts, place the interior joists. Check the level and square of the platform before proceeding. Mark the location of all interior joists and install hangers for connections at both ends of all joists. Measure and cut joists, install in the hangers, and nail them in place.

Cantilever

Joists from post and beam framing and platform framing may be designed to extend beyond outside support posts (Figure 29-22). This concept, called **cantilever**, requires extensive calculations by a design professional to determine how far beyond the posts structural members can be extended. When framing post and beam structures with a cantilever, no special construction techniques need to be employed. Cantilevers with platform framing are constructed in the same manner as structures without cantilevers, except that posts are located back from the edge of the deck substructure. Actual location of the posts is determined by the cantilever's design.

Multilevel Deck Structural Preparation

When decks are designed as multilevel structures, dramatic aesthetic effects can be achieved with little additional structural preparation. Multilevel decks can be constructed as separate platforms, each standing as a separate raised deck, or as shared structures.

Figure 29-22 Cantilever of deck platform 4 feet beyond outside support post.

Shared structures create a single network of posts on which deck platforms are constructed at different elevations. Connecting the different deck levels of either method with broad stairs improves the usability of the outdoor space.

When multilevel decks are constructed, bracing should be installed connecting the structural members between levels. Angle or cross bracing, described in the following paragraphs, prevents structural problems that can occur from shifting platforms.

Additional Structural Preparation

With each of these framing methods, it is beneficial to complete additional structural preparation before the surfacing is installed. Additional structural preparation may be necessary for stairs, railings, seating, and skirting. Although these structural items can be added later, installation at this point will save cutting and notching surface material and will provide easier access to connections.

Bracing

Wood construction may require bracing to supplement the stability of the structure. Depending on the circumstances, several types of bracing are available. Typical uses include bracing posts for installations that have a high clearance above grade or between joists to maintain spacing and straightness. Cross or angle bracing is recommended if the deck structure is more than 4 feet above finish grade or is carrying loads heavier than pedestrian traffic and deck furniture. When bracing the structure, select a system that applies braces in two directions at right angles to each other.

Cross bracing is used in post applications where lateral stability is required. Most decks or structures that have tall supporting posts require cross bracing to prevent collapse. Although cross bracing is effective, it is not particularly attractive. Locating bracing under decks will minimize the visual impact, but it will be difficult to hide in above-grade situations such as roof supports.

Cross bracing is installed by selecting sound boards, usually 2 × 6s or larger, and securely attaching them to posts in a diagonal manner (Figure 29-23). When bracing two posts, one brace connects from near the bottom of one and near the top of the second. The second brace runs the opposite diagonal direction between the two posts. Connect the braces in the center to strengthen the brace. Set braces flush against the surface of the post being braced and fasten them with at least two bolts at each post connection point. If the braces are on opposite sides of the post in order to obtain a flush fit, place blocking between the two braces at the crossing point. This type of bracing should be placed between each pair of posts to stabilize an installation. Angle and W bracing are installed in a similar manner to cross bracing, with the exception that only one brace runs between each pair of posts.

Bridging, Blocking, and Cleats

Bridging or blocking helps maintain spacing between joists and rafters. When joist or rafter span length exceeds 10 feet, bridging or blocking should be considered at the midpoint of the span. **Bridging** is constructed with treated 1 × 4s placed diagonally between each pair of joists/rafters from the top of one joist/rafter to the bottom of the other. To install bridging, measure the diagonal distance from the top of one joist/rafter to the bottom of the next. Bevel cut two 1 × 4s and nail into position using 5d box nails. Bridging should be placed in pairs running in opposite directions.

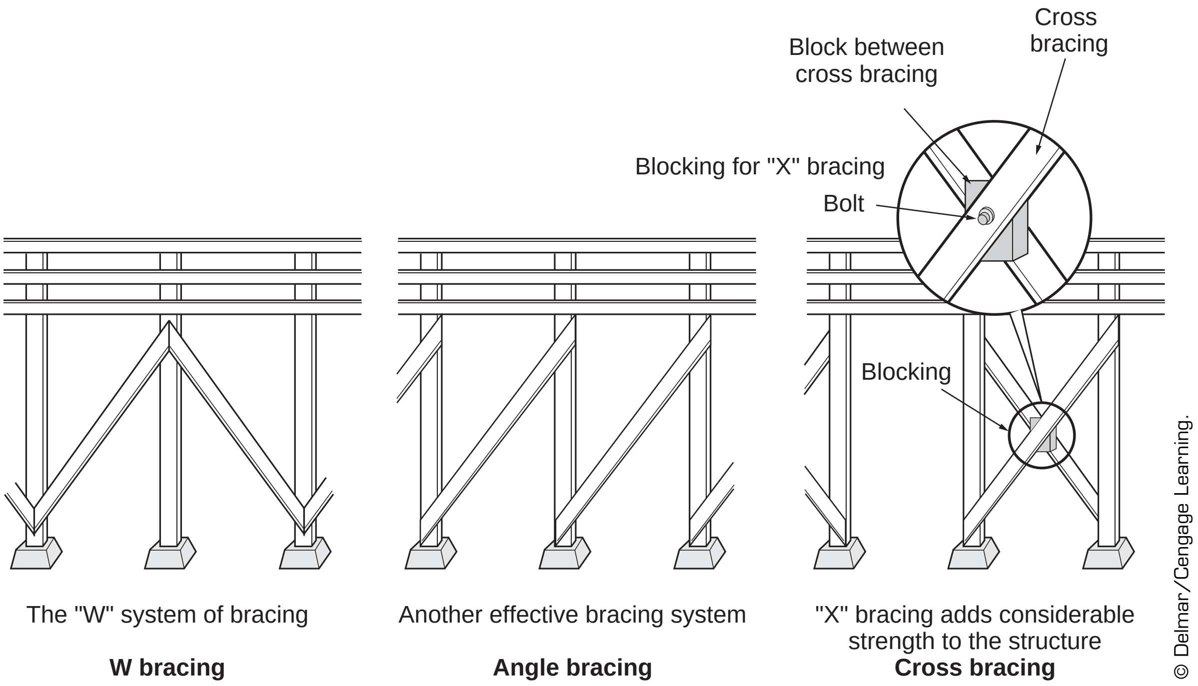

Figure 29-23 Cross bracing for stabilizing below structures.

Blocking is the placement of solid wood blocks between joists/rafters to maintain spacing. Select blocking material of treated lumber with the same dimensions as the joist/rafter. Measure the distance between joists/rafters and square cut the blocking material. Place between the joists/rafters and end nail in place (Figure 29-24). Stagger every other piece of blocking to allow the material to be end nailed. Locate blocking on top of a beam or in any location where the joist/rafter is twisted. If located in the rafters, consider spacing blocking or bracing so it looks like a design element.

Cleats are small pieces of dimensioned lumber that are attached to the structural framework in locations where posts interrupt the joist/rafter pattern. Cleats provide support for surfacing that runs into posts. To install cleats, cut a piece of treated lumber the same width as the post and nail to the post where necessary (Figure 29-25). Verify that the top of the cleat is the same elevation as the joist/rafter. Pilot holes may be necessary to prevent cleats from splitting. Temporary cleats can also be installed for supporting structural pieces that are being installed. Cut a piece of dimensioned lumber and tack to a post at the proper elevation. Rest the structural piece on top of the cleat while attaching and then remove the cleat when connections are completed.

Figure 29-24 Blocking between joists for stability and to anchor vertical post.

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Figure 29-25 Cleat on which decking material will be fastened. Drill pilot holes through cleat before fastening.

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Figure 29-26 Post extensions through deck platform for seating supports.

Extending Supports for Overhead Roofs, Railings, and Seating

Decks that are designed to include overhead canopies, railings, or built-in seating require posts that extend above the surface to support these elements (Figure 29-26). When ordering materials and installing the foundations and substructure, be certain to take this extra dimension and load into consideration. Extending posts that support the deck upward to support the overhead structure provides the best lateral stability. Carefully select the posts that will perform this function for straightness, minimal knots, and no twisting.

An alternative choice is to attach posts for roof framing to the substructure constructed for the deck. This method requires temporary bracing until the roof is complete and should have permanent bracing to prevent lateral movement. Positioning posts at the intersection of two joists will provide additional strength. This allows the post to be bolted in two directions.

Insect Screening

Before surfacing the deck, install any desired insect screening over the structural framework to prepare the deck for future enclosure. If you do not install screening material at this point, you will need to remove the deck surfacing to attach screen if enclosure is ever considered. Roll screen material over the joists and staple into the top of the joists. Overlap where necessary to avoid gaps in coverage. Trim excess screening material at the outside edges of the deck.

DECK SURFACING

Covering the surface of the deck can be accomplished with a variety of patterns and materials. Before selecting a covering, review the project's structural and aesthetic requirements.

Deck surfacing must be applied at an angle to the joists for maximum support. Right angles provide

maximum support, but angles up to 45° are structurally possible. Selecting a beginning point for installing deck materials depends on the pattern and desired edge treatments. If you begin at the outer edge and work inward, you will not have to install a partial piece of surfacing at the outer edge; however, you may need to rip cut the last piece next to the building to fit the space left.

Begin attaching surfacing at the selected location and work toward the opposite edge of the deck. Examine the cross section of each piece of decking before installation. Orientation of the grain to prevent cupping will be necessary to prevent water retention on the deck surface. Decking must be installed with the bark side up (Figure 29-27). If one piece of decking material will not cover the entire deck length, butt a second piece against the first, straddling one of the joists (Figure 29-28). You can trim deck material that hangs over the outside edge when you complete the surfacing. Align the deck material and fasten it to the joists (Figure 29-29).

Continue placing material using a shim or nail as a tool to keep spacing consistent throughout the surfacing. Typical spacing for 2 × 4s is 3/16 inch, but 2 × 4s that are still wet from preservative treatment and 5/4s cedar should be spaced closer to allow for shrinkage. Periodically measure the distance from the installed surfacing to the unfinished edge at two or more points to verify that one end of the surfacing is not being spaced greater than the other end. Correct variations by respacing the surfacing. To reduce the chances of unequal spacing, snap parallel chalk lines on top of the joists across the entire area to be surfaced. By keeping the edges of surfacing parallel with these chalk lines, you will have visual guides during the installation (Figure 29-30).

Figure 29-28 Deck surfacing is installed with end joints staggered.

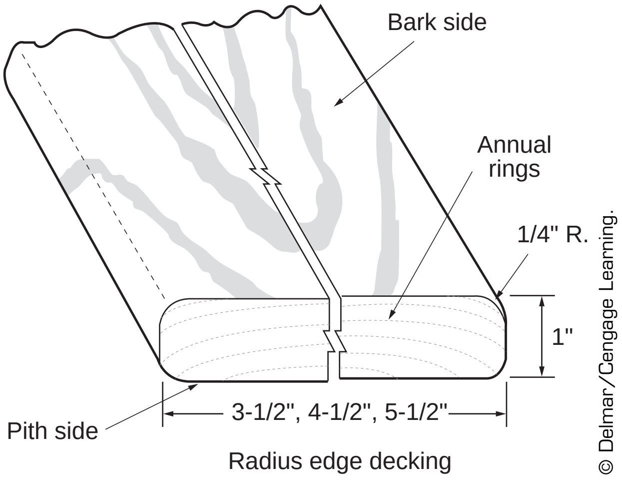

Figure 29-27 Placing deck boards with bark side up to avoid cupping.

Most surfacing materials require two nails or deck screws at each joist location placed 1 inch in from each edge of the surfacing (Figure 29-31). Place one fastener per joist while you initially lay the material, and install the rest of the connectors after all surfacing is in place. At edges where the decking was left overhanging the structure, snap a chalk line at the location of the outside edge of the structure and trim by running a circular saw from one end to the other. For a straighter edge, attach a trimming jig, or guide, which will hold the saw in the proper location along the entire cut.

A more attractive, but time-consuming alternative to nailing or screwing fasteners through the top of the surfacing is to use deck clips that allow the surface to be fastened without exposed nails or screws. Two forms of fasteners are available, and both work best with lumber that has been adequately dried or with composite materials.

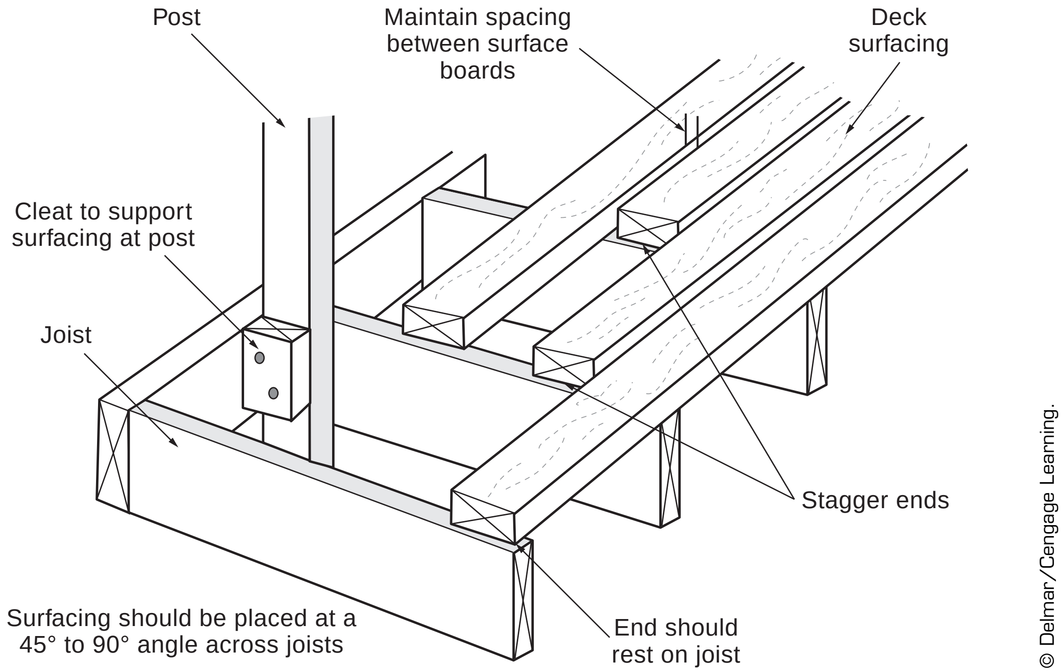

Figure 29-29 Deck surfacing.

The first connector is a galvanized clip that rests on top of the joists and is connected using 10d galvanized nails. The first piece of deck surfacing is installed using surface nailing or by toe-nailing through the side. On the open side of the deck (facing the unsurfaced joists), slide a clip under that deck board and fasten it to the joist. The clip is fastened to the deck surfacing by nailing through an opening in the clip into the side of the surfacing. If using 5/4s deck surfacing, predrill the nail holes into the side of the decking. Slide the next piece of deck surfacing over the connector up to the first

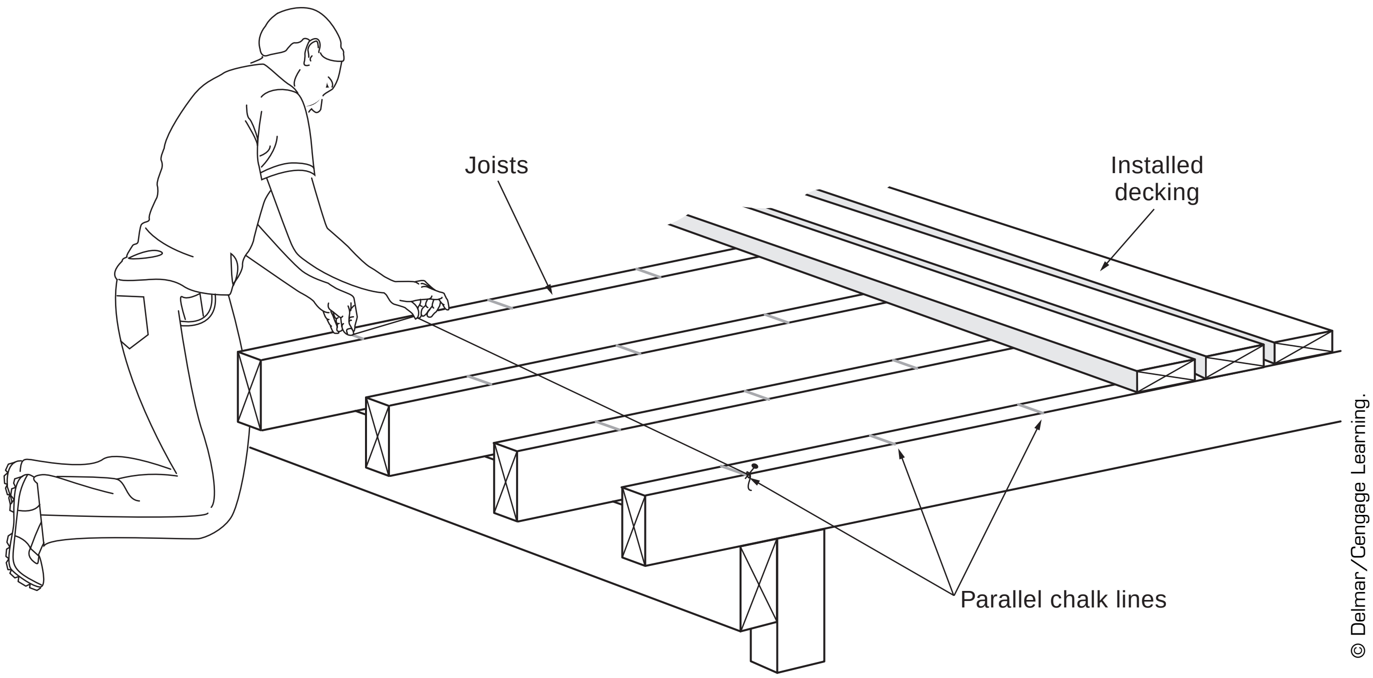

Figure 29-30 Snapping parallel chalk lines to guide deck surfacing installation.

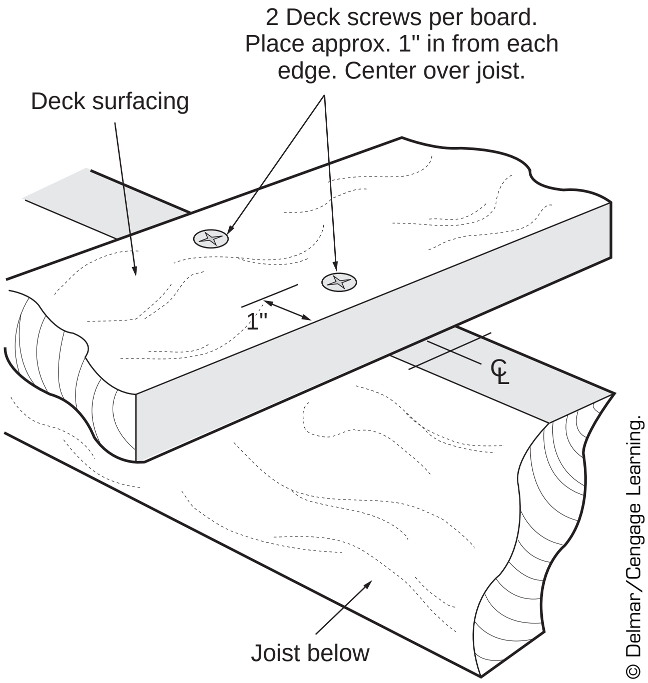

Figure 29-31 Deck surfacing connecting locations.

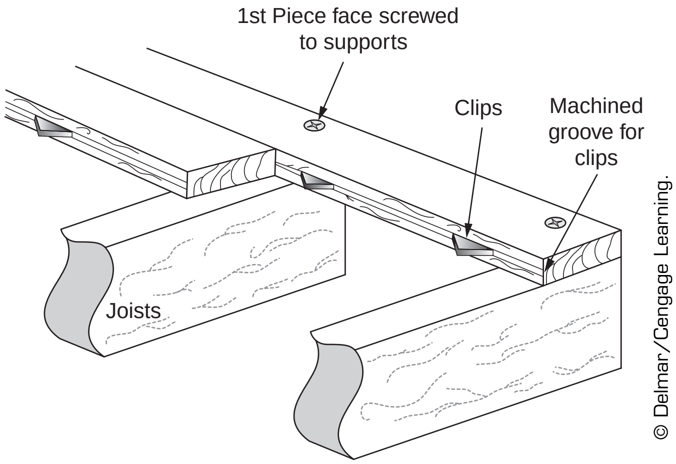

Figure 29-32 Installation of bamboo deck surfacing using clips inserted into machined groove on decking.

piece. Sharp prongs on the side of the connector anchor the second piece to the first piece. Slide another connector under the open side of the second piece. Repeat the process. Continue installing decking and clips until you have surfaced the deck.

A second hidden fastener technique using Eb-Ty® deck clips requires that slots be cut or routed into the sides of the deck surfacing at each location where the surfacing passes over a joist. Apply construction adhesive to the joist and place the first piece of surfacing material. Insert a deck clip into the slot on the side of the surfacing and position a #7 stainless-steel screw at a 45° angle toward the surfacing at the opening in the clip. Drive the screw into the joist. Repeat the process with each subsequent piece of surfacing.

If the deck is attached to a building, protection from moisture must be provided. To prevent moisture from entering between the ledger and the sheathing, insert a piece of galvanized Z **flashing** under the building siding material and attach it on the top of the ledger. When you have completed the surfacing, restore the building exterior surfacing over the structure (see Figure 29-1).

Bamboo Surfacing

Before installing bamboo deck surfacing, verify with the manufacturer that this product is suited to the installation and climate where the deck is being installed. Bamboo deck surfacing materials come in variable lengths and widths, all with a typical 4/5-inch thickness. The bamboo planks are machined along the edges of the board to accept specialized clips that hold the surfacing in place. To install bamboo surfacing, snap a chalk line at a right angle to the joists and adjacent to a suitable beginning surface such as a structure or wall. Place the first piece of planking and face screw the bamboo into position. Install clips every 12 inches along the edge of the plank facing the next plank. Set the second bamboo plank adjacent to the first, and tap the plank onto the clips using a rubber mallet (Figure 29-32). Continue to place clips and planks until you reach the edge of the platform. When it is necessary to join two pieces where a single plank will not reach the edge of the platform, center all joints over a joist. After all planks are in position, face screw the outer edges to hold the surfacing in place.

Composite Material Surfacing

Composite materials can be used to create a stone-like surface using deck framing. These materials are manufactured with a composite backing adhered to a stone, or cultured stone, surface in dimensions that fit the spacing and thickness of typical wood deck surfacing. Available in many colors and stone types, composite materials fasten using polyethylene connectors fastened to existing or new joist structures. Also available are panels that are fastened to plastic trays that attach to the surface of deck framing. Surfaces have small gaps to allow drainage and provide similar strength characteristics as wood. Note

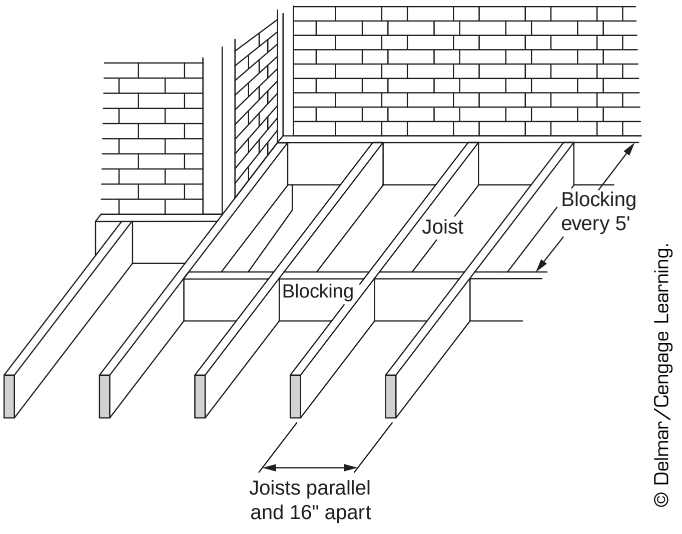

Figure 29-33 Installation of additional blocking every 5 feet for composite deck surfacing.

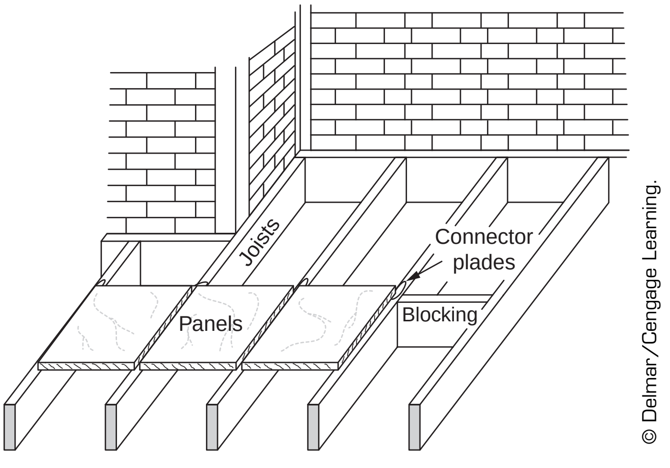

Figure 29-34 Beginning installation of composite deck surfacing panels.

that installations vary in many aspects; so, verify with the product manufacturer the details for installation.

Prior to installation, verify that the deck framing is set square, with all joists running parallel and spaced 16 inches apart. Add blocking every 5 feet to secure the framework from twisting and moving (Figure 29-33). Shim any low points in the framing and trim any ridges in joists. Where joist spacing is less than 16 inches on center, fasten 2 × 4 cleats flush with the joists using deck screws to provide an installation surface for the connector plates.

To install composite deck surfacing panels, begin with marking out locations for connector plates. Select a beginning location away from structures or irregular edges. Snap a chalk line perpendicular to the joists across the deck surface at this location. The installation will first work out from this point toward the outer edge of the deck, then back toward the structure to make any cuts to fit irregular edges.

Fasten down the first row of connector plates on this chalk line, working from the center toward the outside edge. Slide the panels into the connector plates, with each edge of the panel fitting into a connector on a joist (Figure 29-34). When using panels with ribbed backs (such as StoneDeck®), orient the ribs to run perpendicular to joists. Continue laying panels to the edge of the deck. If a partial panel is required, cut a panel using a wet masonry saw or circular saw with a diamond blade. After cutting, remove any residue immediately to avoid staining surface. Return to the center of the deck and install connector plates between each pair of panels. Tap a connector plate under the two panels using a rubber mallet; then fasten to joist using deck screws (Figure 29-35). Screws must be fully inserted for a stable connection.

Continue to place panels and connectors working toward the outside edge of the deck. When working back toward a structure or irregular edge, you may need a cut panel and connector to fit an opening. Cut the connector to use just the vertical spacer portion of the connector; then fasten it to the joist

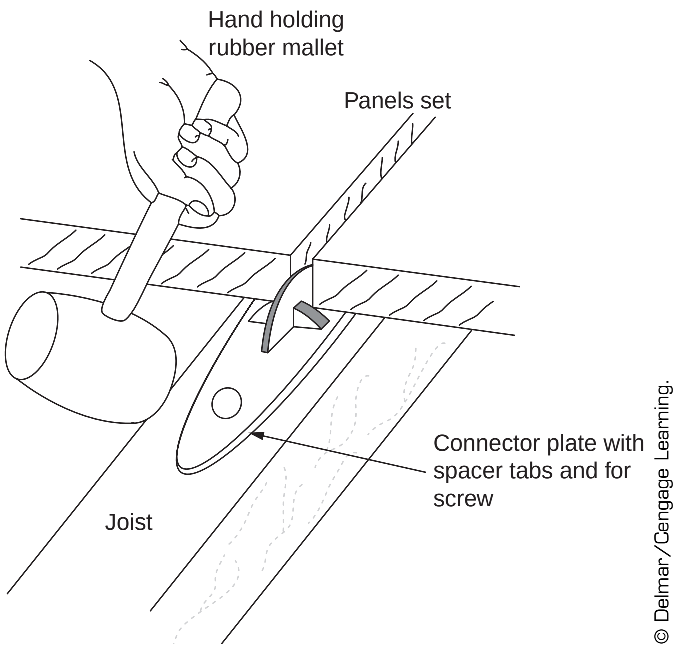

Figure 29-35 Using a rubber mallet to carefully tap connector plates between composite panels.

next to the structure and apply construction adhesive to the top. Cut a panel and fit it into the full connector away from the building; then lower it onto the construction adhesive on the cut connector (Figure 29-36). When you have installed all panels, trim the outer edge (Figure 29-37).

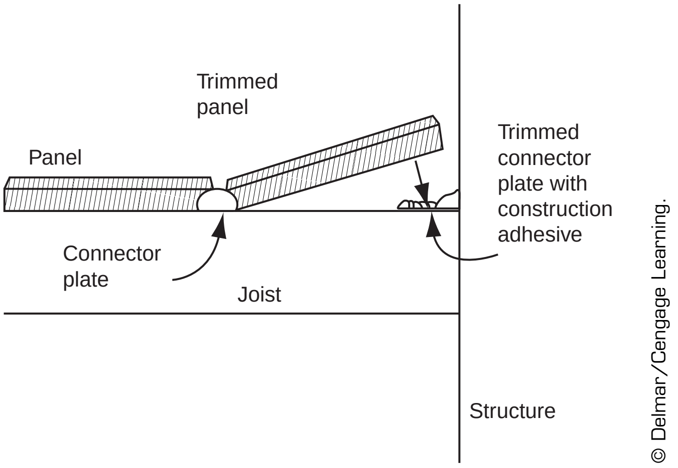

Figure 29-36 Installation of a trimmed composite panel at structure.

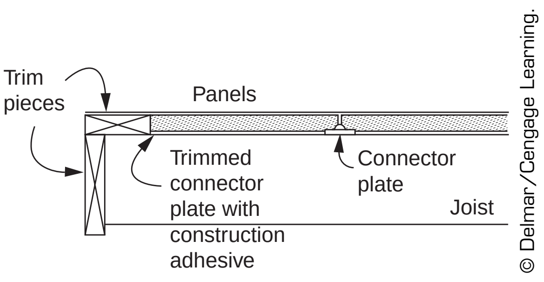

Figure 29-37 Trim at edges of composite panels.

TRIMMING

Provide the finishing touch to a deck by trimming unsightly structural pieces and connections. Trimming should wait until all carpentry work, including roofing, railing, and seating, is in place. Trimming is usually done using 1 × lumber that is wider than the structural piece being covered. Bevel cut at any trim pieces that abut and attach, using 8d galvanized box nails. Nailing in a consistent pattern improves the finished appearance. Space fasteners 1 foot apart or less to combat the high potential for warping in 1 × trim boards. Using 2-inch wood screws also reduces the potential for warping.

Particular areas that benefit from trim pieces include the front and back sides of railing caps, posts that are exposed above the deck surface, edges between two sheets of material (such as skirting), rim joists, stair risers, and the edges of seating (Figure 29-38).

Figure 29-38 Trimming of deck railing.

CHAPTER 30

WOOD STAIRS, RAILINGS, SEATING, AND SKIRTING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Build wood benches as part of a deck.
- Construct railing for a wood deck.
- Apply skirting to a wood deck.

Decks and exterior wood projects often include a variety of related amenities that aid in the safe use and enjoyment of the project. Although these additions require construction techniques similar to those of other wood components, each addition has special approaches and requirements, which are outlined in this chapter. Special techniques are described here for wood stairs, railings, seating, and **skirting**. Any construction documents prepared for a project would supersede the methods and techniques described in this chapter.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials for Exterior Carpentry, Chapter 28
- Wood Decks and Platforms, Chapter 29
- Overhead Structures, Chapter 31

FOUNDATIONS AND STRUCTURAL SUPPORTS

The material in Chapter 29 presented typical methods for preparing ledgers, footings, posts, and piers for a wood deck. Although most of the items listed in this chapter do not require separate foundation support, the support posts used for decks may be part of the structural system. Review of the framing methods used for wood decks will provide valuable information regarding installation and connection of support mechanisms for deck elements. The actual method for support should be implemented based on the design for the project.

STAIRS

In most instances, it is necessary to construct some type of stairs to access a deck. Basic components of a stair system include the **carriages**, or the large lumber pieces, usually notched, which support the stairs; the risers, or the vertical portion of the stair; and the tread, or the horizontal portion of the stair on which we step.

Stairs can be constructed in a straight run or in segments separated by a landing or small deck. Complex stair installations may include several sets of stairs with landings between each set. Construction of landings is similar to that in building decks, with platform framing the easiest method to use on landings placed between stair runs. When constructing projects with complex stairs, construct and surface all platforms before installing stairs.

Stairs and Code/ADA Requirements

Before planning the installation of stairs, review any local codes and requirements, as well as ADA requirements. If stairs are professionally designed, the designer should have incorporated these laws when preparing the details of the stair installation. If stairs are not professionally designed, whether intended for public or private use, construction requirements will most likely fall under one of these sets of regulations. If so, design issues such as the number of stairs before a required landing, width and depth of treads, no open risers, marking the nose of steps, and installing handrails on each side may supersede the instructions outlined in this section. Contact local building officials to review requirements for wood stairs. Additional comments regarding ADA requirements can be found in Chapter 21 under "Building Codes Governing Stairs" and in Chapter 23 under "ADA Stair and Ramp Requirements" (see, in particular, Figures 23-14 and 23-15).

Stair Supports

Locations where stairs are attached can be heavy stress points for decks. To increase the strength of these areas, double the rim joist or add bridging or blocking between the rim joist and the first interior joist. In locations where the rim joist of the deck is used as the top riser in a set of stairs, the structure left for attaching the stringer may be limited. In these situations, the substructure must be modified to provide adequate support for the stair carriage. To effect additional structural support, add a second joist directly below the rim joist at the location where stair carriages are to be attached (Figure 30-1).

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Figure 30-1 Extra stair supports. The bottom 2 ×10 provides a solid surface to nail to, and the 2 × 4 assists in supporting the bottoms of the stair carriages.

Landing Area Support

Stairs that land at ground level require a stable support for the ends of the carriages. Placement of a small footing or paved area provides stability against settling and prevents erosion of the landing area at the bottom of the stairs (Figure 30-2). When the ground support is poured concrete, attach the stairs to the landing area using galvanized angle brackets or galvanized supports. If using precast slab, anchor the supports with expanding bolts placed in pilot holes.

Stair Framing

Stairs are supported by joist-like structural members called **carriages**. Carriages are 2 × lumber that are either notched and placed under the treads of the stairs or placed along the sides of stairs with supports connected for the treads to sit upon. Side carriages are adequate for straight, narrow runs of stairs, whereas notched carriages work for straight run stairs and are the only structural method for stairs that wrap around corners. Stairs may combine side carriages with notched carriages in the center.

The tread material applied determines the spacing of carriages. Treads that are constructed of 2 × lumber should have carriages spaced no more than 2 feet apart. Treads constructed of 5/4s decking material should have carriages spaced 16 inches on center. Closer spacing of carriages may be required in special situations such as heavy loads, commercial settings, long runs of stairs, or unstable installations.

Figure 30-2 Stair landing is excavated and precast blocks are placed to support the bottom of the carriages. The stake in the front left is marked with the level required for the top of the precast blocks.

Notched Carriages

Review the section of Chapter 4 related to stair calculations before constructing stair carriages. If construction drawings exist for a project, use the dimensions provided. Precut carriages can also be purchased to fit many standard projects. Construction of notched carriages requires selection of lumber that is approximately 2 feet longer than the diagonal measurement that the stairs must cover. 2 × 12s are a typical choice for runs with 5–10 stairs (Figure 30-3). Larger dimensioned lumber or strengthening may be required for notched stairs because notching reduces the effective thickness of the lumber that supports the load on the stairs.

Long carriages (for stairs with several risers) have a significant amount of flexibility that can be reduced by attaching a 2 × 4 along the carriage's length below the treads. Attach this 2 × 4 with the face flat against the carriage and the bottom edges flush. Place rust-resistant deck screws every 8 inches as connectors.

Marking and Cutting Stair Carriages

Use the following steps to mark carriages for side or notched stairs (Figure 30-4):

1. Place the lumber on a stable surface.
2. On the outside rulers of a carpenter's square, locate the riser dimension of the short side and the tread dimension on the long side (Figure 30-4, step A).
3. Beginning near one end of the board, place the square with the corner off the lumber and the riser and tread marks on the rulers setting on the edge of the lumber (Figure 30-4, step B).
4. Trace along the long side of the square to locate the top tread location.
5. Measure along the line the dimension of the top tread.
6. From the back edge of the tread, draw a perpendicular line down (Figure 30-4, step C).
7. Flip the square so the corner is on the lumber (Figure 30-4, step D).
8. Position the square with both the riser and tread marks on the edge of the lumber. Adjust the position of the square along the edge so the riser mark aligns with the outside mark for the top tread.
9. Along both sides of the square, trace the riser and tread locations.
10. Slide the square down the lumber and set the riser and tread marks with the riser mark aligned with the previous tread mark.
11. Along both sides of the square, trace the next riser and tread locations.
12. Continue this process for the number of risers and treads required.
13. At the bottom of the lowest riser, use the square to mark the bottom of the carriage. This line will be parallel to the lowest tread and perpendicular to the lowest riser.

Corner Stair Carriages

Notched carriages at the corner of stairs are placed at an angle to the other carriages and require special calculations because of their length. The riser height remains the same for corners, but the tread length is longer because of the angled placement (Figure 30-5). If stairs turn a 90° corner and the

Figure 30-3 Elevation view of stair carriage supported at the top by a 2 × 10 and at the bottom by a concrete footing.

treads are the same width on both sides of the corner, multiply the calculated tread length by 1.41 to obtain a quick measurement of the tread length for an angled carriage. You may need to fasten intermediate carriages to this angled carriage to support the upper treads.

Side Carriages

Review Chapter 4 for instructions on calculating stair dimensions. If construction drawings exist, use the dimensions provided. On stairs that are narrow, carriages can be placed along the outside of the treads. Construction of side carriages, also called rough stringers, requires selection of lumber approximately 2 feet longer than the diagonal measurement that the stairs must cover. 2 × 12s are a typical choice for runs with 5–10 stairs. Mark the location of each riser and tread as described in the steps for marking and cutting stair carriages. Cut only the scrap at the back portion of the top and lower portion of the bottom of the carriage. Removal of these scrap pieces are necessary to allow the carriage to fit flat against supporting surfaces. Subtract the thickness of the material used for the tread; attach a 1 × 3 cleat below the mark using three rust-resistant deck screws. You may need pilot holes to prevent the wood from splitting. Treads are cut to fit between the two carriages, resting on top of the cleats. Mark and cut the carriages as described in the previous section.

Attaching Carriages

Attach carriages to the rim joists and/or deck framing by toenailing or by using joist hangers. Hangers are the preferred method because of their increased support capacity and ease of installation. Mark the top of the carriage locations with a chalk line to ensure proper placement. Mark the location for each carriage and install the

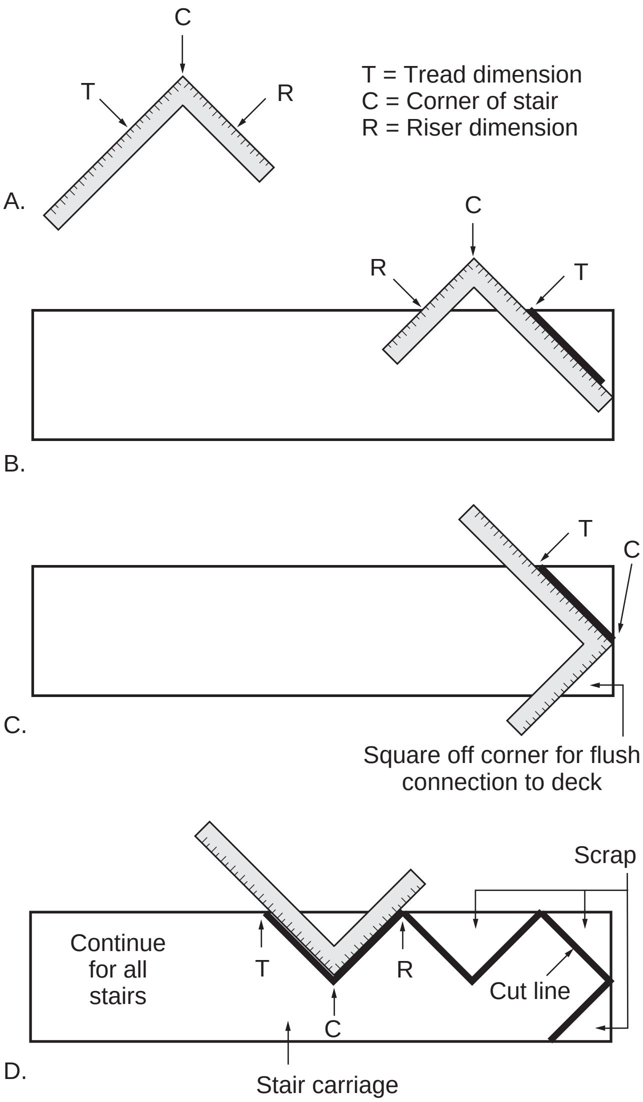

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Figure 30-4 Marking stair carriage for cutting.

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Figure 30-5 Framing for stairs with corners.

hanger. Place the carriage and check for plumb and level; then connect to the hanger. If toenailing is used, mark each location and hold the carriage in the proper position. Toenail from each side and from the top.

Stair Surfacing

Surfacing the stair treads can be done using 2 × lumber or 5/4s surfacing, depending on the spacing of the carriages. Risers can be surfaced with 1 × lumber regardless of the carriage spacing. If there are no concerns about people tripping on the stairs, no legal requirements for riser surfacing, or if acceptable to see under the deck, risers can also be left open on any carriage arrangement.

Begin tread surfacing from the front edge of the tread and work to the back. Measure and cut the first tread board the correct length. Place the first tread board overhanging the front edge of the riser by ¼ inch. If risers are to be surfaced, the tread will need to project out farther. Connect to the carriage using two rust-resistant deck screws at each carriage. Miter cut to fit the carriage for corners on wrapped stairs. Place the next tread board with a ¼-inch gap between the first tread board and connect. Continue surfacing toward the back until you have covered the entire tread. If a partial board is required at the back of the tread, rip the dimension required and place it in the back of the tread (Figure 30-6).

Install riser surfacing after installing tread surfacing. Measure and cut risers to fit the riser dimension marked on the stairs. Rip cut the riser surface, if necessary, to match the stair riser height. Attach to the carriage with two 8d box nails at each carriage. If using side carriages, place a cleat behind each end of the riser surfacing (Figure 30-7).

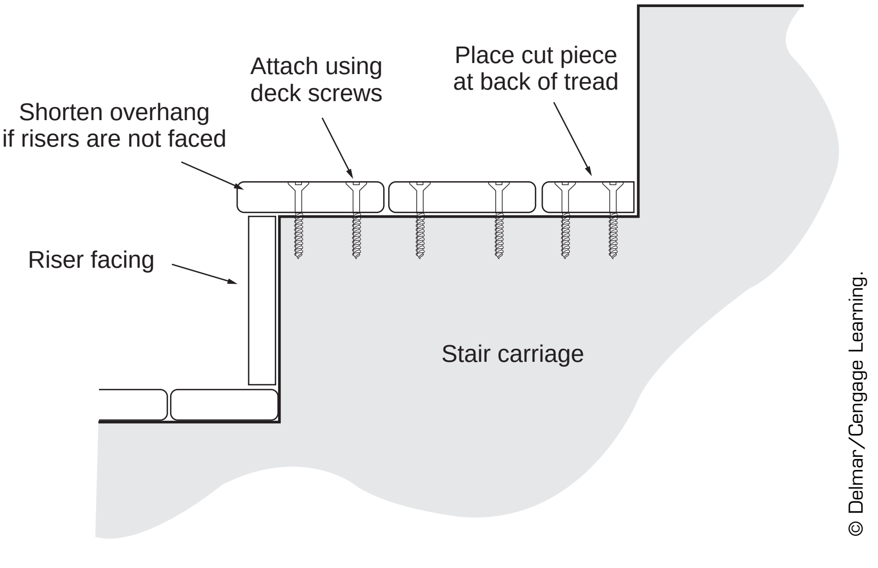

Figure 30-6 Attaching stair tread material.

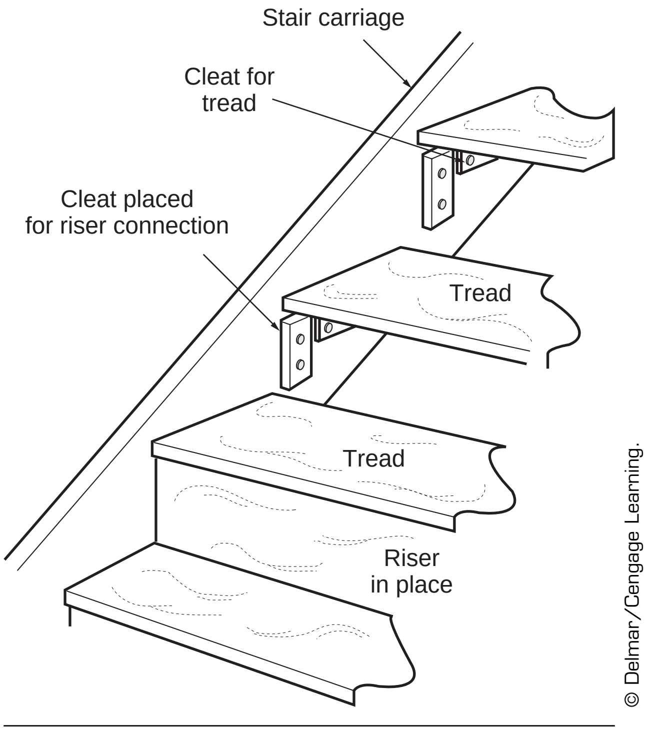

Figure 30-7 Cleats to support riser surfacing.

RAILINGS

Railings provide decks with important safety and aesthetic qualities. Decks that are above grade 12 inches or more need railings to prevent accidental falls. Minimum railing heights are stated in codes, with 42 inches between the deck surfacing and the top of the railing a typical required railing height. Verify the railing height required with local building officials. Railings can be constructed in a variety of ways and surfaced with an even greater variety of patterns. Railings can rise up out of the deck structure, be attached to the outside of the structure, or be incorporated into seating. Horizontal boards, vertical boards, and **balusters** can all be used to create the fence's surface.

Railing Supports

Railing placed around the edge of the deck requires some form of structural support posts. The initial framework for railing is best installed when building the deck's substructure. Rail posts can be attached either inside or outside the rim joist (Figures 30-8 and 30-9). Space the posts according to the design. If no design exists, space the posts no farther apart than the structural strength of the surfacing will permit. Consult a design professional to determine the correct spacing.

Mark the location of the posts and use a level when attaching to ensure the posts are plumb. If attached inside the rim joist, cleats are required to support deck surfacing that abuts the post. Attach posts to the deck substructure using two ½-inch bolts (Figure 30-10). If posts move out of plumb when tightening, insert cedar shims between posts and joists to position the post correctly. Seating that is incorporated into decks can have structural components integrated into the substructure in the same manner. After you apply the deck surfacing, complete the remaining structure and facing for seating and railings.

Railing Stringers

Although designs may vary, typical railing structures include a horizontal top and bottom support, called a **stringer**, to support facing. Stringers run

Figure 30-8 Railing support bolted to outside of deck framing.

Figure 30-9 Seating support bolted inside deck framing.

from post to post in all locations where railing is planned. Stringer material is typically a 4 × 4, if installed between posts, or a 2 × 4 or 2 × 6, if fastened to the face of the post (Figure 30-11). If railing surfacing material is placed vertically, these will likely be the only supports holding the surfacing. Railing surfacing material that is placed horizontally may require only the top stringer.

Measure and install the stringers level between the posts. If a stringer is placed on top of or in front of post, fasten with two deck screws. Connections on the top or face may run for several posts. If a stringer is placed between posts, use specialty connectors or angle brackets to fasten. Stringers that support railing facing should be soundly connected to rail posts using specialty fasteners. Avoid making such connections using only end nailing or toenailing or any of the joining techniques.

Railing Facing

Most facing material is constructed using 1 × lumber or 2 × 2s attached horizontally or vertically using either 8d box nails or rust-resistant deck screws. Carefully plan the pattern for facing material to avoid inconsistent spacing at posts and corners. Marking the facing material location on the stringers will help in visualizing how the installation should occur. Several arrangements and combinations of facing material patterns are possible (Figure 30-12), with the three most common methods described here. Each of these methods can be modified and combined with other methods. Review openings in railing facing carefully to ensure compliance with codes and standards that prevent injury to children from falling through railings or placing their heads into the openings.

Use the playground entrapment prevention standards from the Consumer Product Safety Commission to calculate openings and spacing in railings. According to these playground regulations, openings should be less than 3½ inches or greater than 9 inches to avoid dangerous entrapment for children. Because railings can pose serious safety hazards, have designs reviewed by building officials and a design professional.

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Figure 30-10 Railing post installation. Decking material has been marked and cut to place posts through deck surface to structure below.

Horizontal facing material (Figure 30-12A–B) can be attached to posts on the front (for the strongest railing), on the back, or on both the front and back. Mark horizontal members and cut them to proper length to cover the distance between posts. One board may cover several posts, with joints bevel cut and centered on a post. At corners, vertical cleats of 2 × 2s or 2 × 4s are required to provide a nailing location for the surfacing (Figure 30-13). Bevel cut the surfacing at the corner.

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Figure 30-11 A 2 × 4 stringer has been placed across the top of the posts. Balusters are then hung from the stringer. Surfacing of 1 × 2s is being installed beginning at the bottom of the balusters.

Beginning at the top of the posts, place and connect the facing material to each post with two deck screws.

Vertical boards should be marked out along the top stringer before installation to determine spacing and to plan how posts will be covered. If a partial board is required to maintain even spacing for facing, place the partial board at an inside corner. Cut vertical boards to proper length and begin placing them at a corner, working outward. Fasten to the top stringer with one fastener. Holding the board plumb, install two fasteners in the bottom stringer and the final fastener at the top stringer. As with all facing, the nail or screw pattern should be consistent in placement and spacing.

Baluster, or **spindle**, railings are 2 × 2 posts spaced closely together along the inside of the

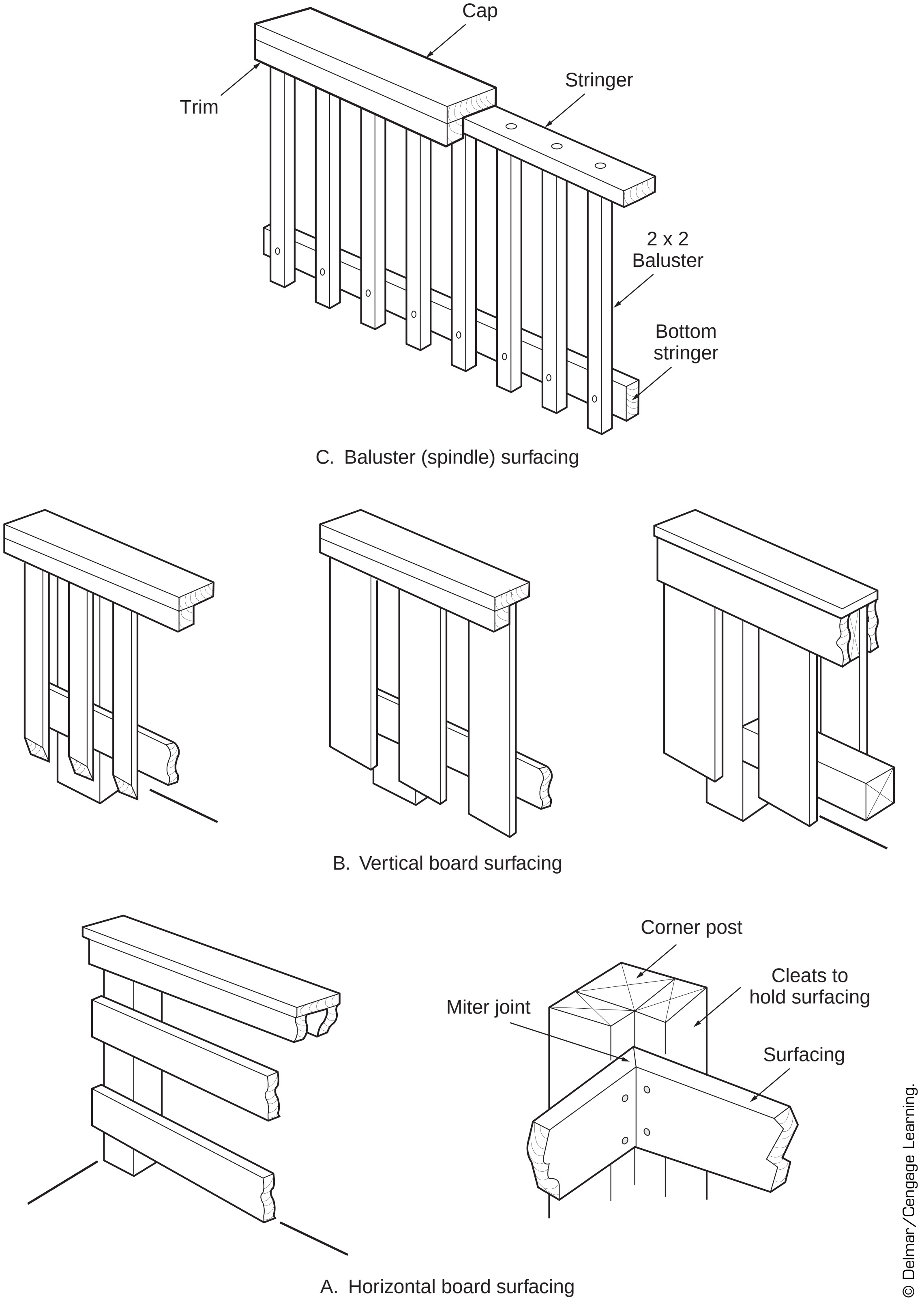

Figure 30-12 Railing facing materials. A. Horizontal board surfacing. B. Vertical board surfacing. C. Baluster (spindle) surfacing.

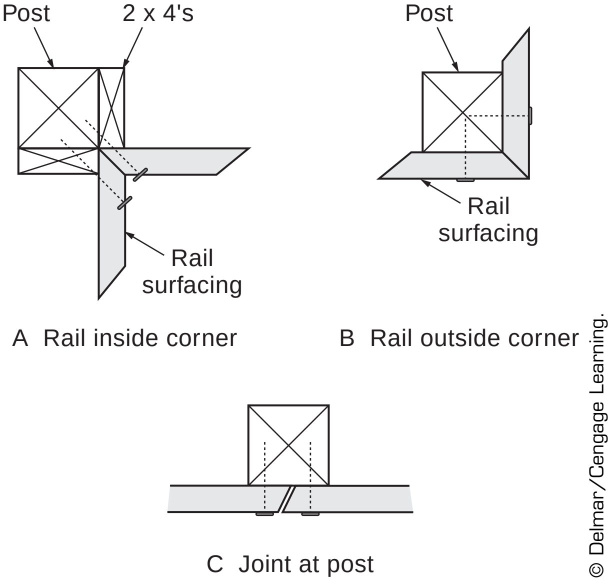

Figure 30-13 Railing corner installation details.

stringers (Figure 30-12C). Begin placement of balusters at an outside corner by connecting the top of baluster. Holding the baluster plumb, fasten to the bottom stringer. Use the top stringer to align the tops of all balusters. Continue installation of balusters until reaching a corner. If spacing is uneven at an inside corner, use a 2 × 4 to complete one run of stringers with a 2 × 2 flush against it to start the other side.

Trimming Railings

Railings require a cap and possibly other trim to maintain a finished appearance. Rail caps should be 1 × lumber wider than the post facing and any fascia trim planned for the inside and outside. Add ½–1 inch to the width to create a small overhang on both the front and back for appearance. Connect the rail cap to the top of the posts and top stringers using rust-resistant deck screws placed in pairs every 12 inches. Miter cut corners where the railing turns.

Fascia trim can be placed at the top of the facing material where it meets the rail cap. This trim piece is useful in covering the intersection of balusters and rail cap. Cut pieces of 1 × 3 or 1 × 4 and, using 8d box nails or deck screws, fasten on top of the facing material directly under the rail cap. The same installation can be done to the outside edge of the facing, as well as to the inside and outside of the bottom of the railing facing (Figure 30-14).

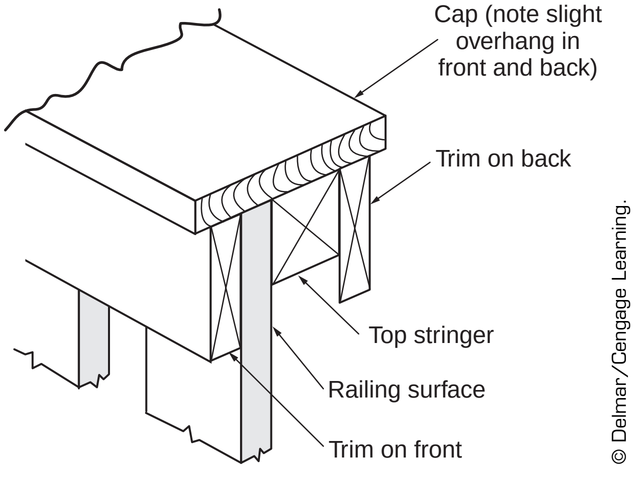

Figure 30-14 Trim and cap for railing.

Exposed posts can be covered by calculating the spacing of facing material so that a piece of facing material is positioned directly over all posts. If the material or spacing does not create this effect, a piece of 1 × material can be fastened over the post using 8d box nails or deck screws. The material should be at least 1 inch wider than the post. Install the facing so it is centered on the post. Trim exposed corners using two pieces of 1 × material jointed along the corner. Miter cut the edges of the trim that will be placed together and connect using 8d box nails.

SEATING

Providing seating for decks saves space, adds convenience, and provides delineation of the edge. Seating has as many possible shapes and patterns as do railings; so, it is impossible to describe the construction of every type of seat option. Covered in this section are the most common types of seating that use basic structural and surfacing techniques.

Seating Supports

Seating supports consist primarily of posts that project up through the deck surfacing or are attached to the outside of the deck structure. (See earlier section on railing supports.) Framing is then attached to these posts to support the seat surfacing. When 2 × lumber is used for seat surfacing, posts can be located up to 3 feet apart. When 5/4s surfacing is used, posts should be spaced no farther than 16 inches apart. Installing a structural frame-

work under the surfacing may allow the wider spacing of posts.

Seating Framing

Common types of structural frameworks include seating that is supported by two posts (see Figure 30-20), by grab beams sandwiched around a single post, by long beams running between posts, and by a triangle of structural pieces attached to deck framing (see Figure 30-21). Benches that have backrests require support to the backrest surfacing. All posts used to support seating and backrests are connected to the deck substructure.

Beam Framing between Posts (Long Dimension). Begin construction of beam supports by measuring and cutting 2 × dimensioned treated lumber that will run between each post on both the front and back side (Figure 30-15). On each post, mark the proper height for connecting the beams by subtracting the surfacing thickness from the finished seat height (e.g., 18-inch seat height minus 1½ inches for a seat using 2 × 8 lumber). Tack the beams in position and drill 2½-inch diameter pilot holes through both beams and the post. Insert ½-inch diameter carriage bolts through the holes and connect. Repeat for each post. Where two beams meet at a post, use a butt joint centered on the post and connect each beam with two bolts. Trim the tops of the posts flush with the beams.

Grab Beam Framing (Short Dimensions). Grab beams should be constructed of 2 × 8 or 2 × 10 treated lumber (Figure 30-16). Measure and cut two pieces for each post. The measurement should consider the width of the bench, including any extension necessary to hold a backrest support. Subtract the dimension of any trim planned for the front and back. On each post, mark the proper height for connecting the beams, remembering to subtract the surfacing thickness from the finished seat height. Tack the beams in position, level, and drill 2½-inch diameter pilot holes through both beams and the post. Insert ½-inch diameter carriage bolts through the holes and connect. Repeat for each post. To maintain a straight front to the seat, properly position a beam at either end of the seat and stretch a

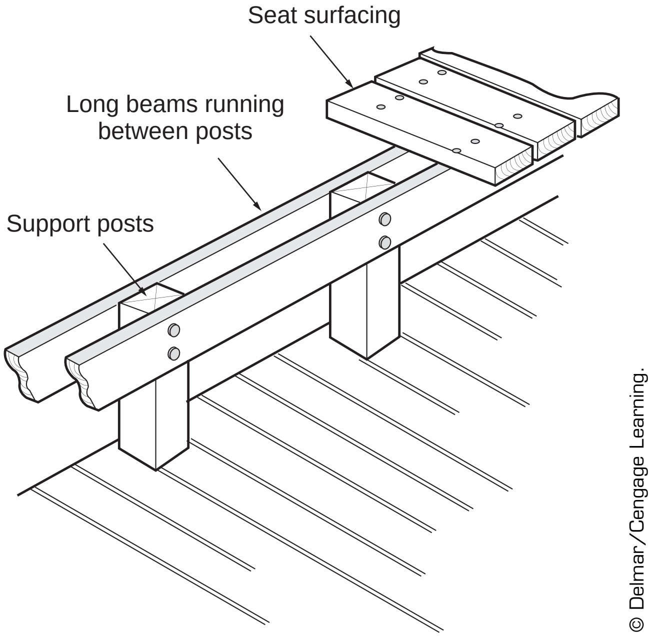

Figure 30-15 Seating framing with beams between posts.

Figure 30-16 Seating framing with grab beams.

stringline along the front between these two beams (Figure 30-17). Each subsequent beam can be positioned so that it is just touching the stringline. Trim posts to the height of the grab beams.

If a backrest support is required, cut a piece of post lumber the height of the support plus the grab beam dimension. Position the lumber between the grab beams and place at the desired angle for the backrest (Figure 30-18). Tack the support in place and drill two ½-inch pilot holes through the support and the grab beams. Insert ½-inch carriage bolts and connect.

Grab beam supports can be further strengthened by adding box framing in front and/or in back of the grab beams (Figure 30-19). Before calculating the proper height for installing the front and back framing, determine whether the seat surfacing will overlap the framing or whether the surfacing will be "inset," with the seat surfacing flush with the top of the framing (see "Seating Surfacing" in this chapter).

Figure 30-17 Layout and leveling of grab beams for seating supports. Stringlines are stretched from the end supports for the bench. Remaining supports are aligned with the stringlines.

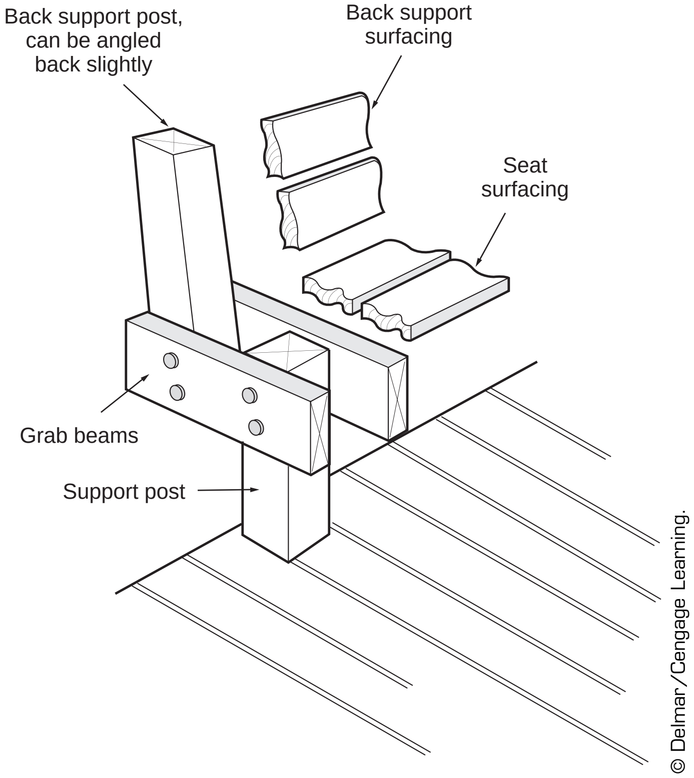

Figure 30-18 Seating framing with integral back support.

Install the front and back framing along the entire length of the seat. Attach the framing to the grab beams using two deck screws at each beam. If two joists intersect at a grab beam, use a bevel cut on the front and use two deck screws on each beam. Once you have connected the framing to the grab beams, you can install additional beams between the front and back joists every 16 inches.

Double Post Framing. Seating framework that is supported by multiple posts (e.g., double posts projecting through the deck surfacing or posts supporting a roof structure) can use the same framing techniques described for grab beams (Figure 30-20).

Triangle Framing. Another popular version of structural support for deck benches is the triangle frame technique. Consult a design professional for sizing and positioning of materials and fasteners for this framing method. The design professional should also determine spacing. Triangle framing attaches a 2 × 4 backrest support on the outside edge of the deck rim joist (Figure 30-21). This support is attached with the 2 × 4 flush against the rim joist, and at least three ½-inch bolts inserted through pilot holes, pulling the support tight against

Figure 30-19 Box framing of seating.

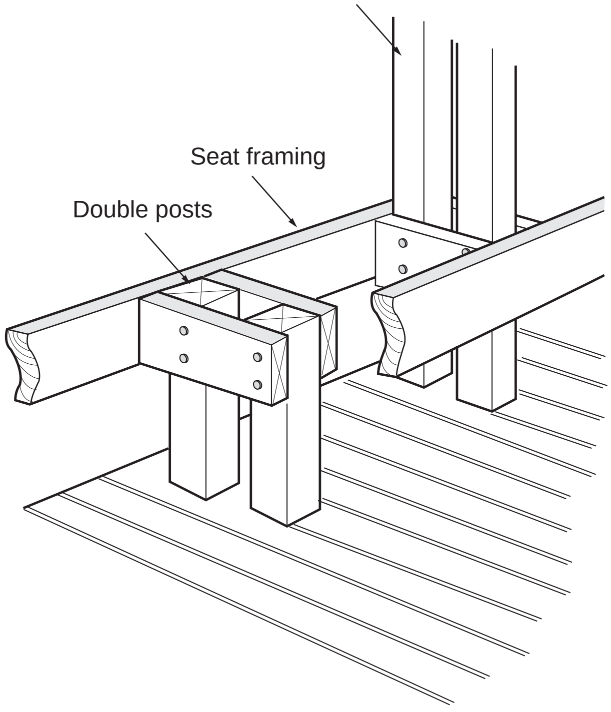

Figure 30-20 Double post support of seating.

the joist. At seat height, a horizontal 2 × 6 is attached to this back support, extending toward the deck. Attach the support using two ½-inch bolts. A vertical 2 × 4 support piece is attached to the front edge of the 2 × 6 through the deck surfacing to a joist below. Both connections for this support should be made with two ½-inch bolts. This forms a triangular-shaped support structure with backrest incorporated. An additional diagonal support should be added between the front corner of the seat and the angled backrest to provide additional stability. Connect the support using the same bolts that fasten the horizontal and vertical. Triangle framing is typically spaced 3 feet or closer and uses 2 × lumber for seating.

Seating Surfacing

Surfacing choices for seating range from wide 2 × lumber placed flat on the surface, 2 × 4s placed on edge, or 5/4s decking material. Benches without a structural framework between posts require 2 ×

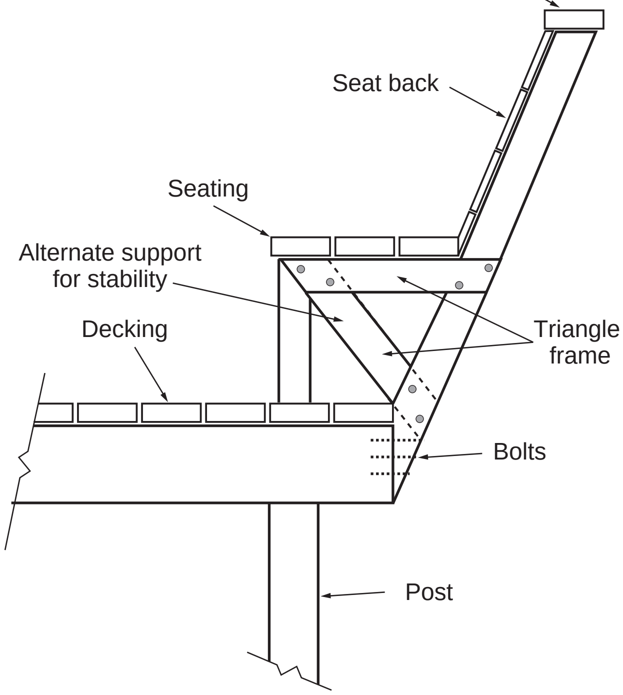

Figure 30-21 Triangle framing for seating.

dimensioned lumber such as 2 × 6s, 2 × 8s, or wider, or 2 × 4s placed on edge. The orientation and size of this lumber provide the strength required to support loads without the structural support. Lumber that is placed flat on the surface should be applied beginning at the outer edge of the bench (Figure 30-22). Overhang the front edge 1 inch. Attach with at least two deck screws per joist and space ¼ inch between boards. If 2 × 4s are placed on edge, place only one connector per joist. Recess the top of the fastener, drill a pilot hole through the board, and insert one 5-inch lag screw per board.

Smaller dimension lumber, such as 5/4s decking, should be applied flat over seating with a framed structural support system. This lumber will not support a load between posts without structure. If the surfacing materials run the long direction between posts, begin attaching these boards at the outside edge of the bench. Attach with two deck screws per joist (Figure 30-23). If these seating materials run the short dimension—front to back—over grab beams between posts, center and install the boards at each end of the bench. Stretch a stringline between the outer edges of these two boards and align the other surfacing with the stringline. Fasten using two deck screws per joist.

Trimming Seating

Trimming can perform two important functions for seating. It can cover unsightly structural work below the seats, and it can provide a safety edge that protects the legs of those who sit on the bench. Trim is typically used along the front edge of the seat, the back edge of seats that do not have a backrest, and as a cap for backrests. Typical lumber used for trim is 1 × dimensioned lumber wide enough to cover the structural pieces to which it is attached. Attach trim pieces using deck screws installed in a pattern matching that of the seat surfacing.

Before applying finishes to seating sand all surfaces and edges that will potentially come in contact with occupants. Corners such as the front edge

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Figure 30-22 Seat surfacing inset at edges. Framing is set higher than beams to accommodate thickness of surfacing material. A cleat supports the framing at the end.

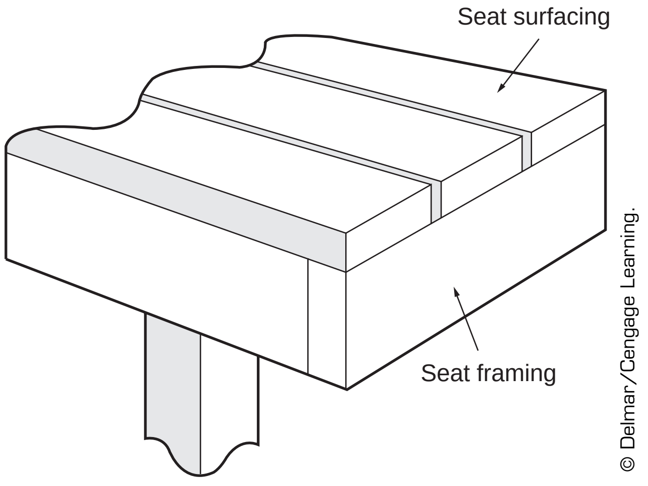


Figure 30-23 Seat surfacing overlapping framing material.

of the bench, edges of backrests, and the seat itself can have sharp edges or splinters that should be removed by sanding.

SKIRTING

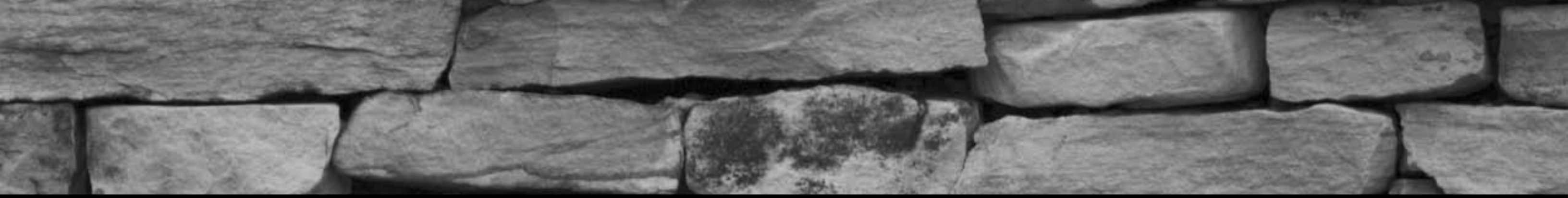
Skirting is the screening placed under deck structures to hide structural components. Many decks are low enough that skirting is not required, but if the deck is 3–4 feet off the ground, the underside may be unattractive. Decks that are viewed from a lower vantage point may also require skirting, regardless of their height.

Skirting Framing

The skirting placed under decks requires minimal framing. Skirting can usually be hung from 2 × 4 framing nailed between posts or attached directly to posts and bracing. When framing the skirting, consider framing openings that will allow future access to the space below the deck. This opening can be framed with hinges to create a doorway for spaces that require occasional access.

Skirting Facing

Materials and patterns selected for skirting should match or complement any railing pattern used on the deck. In instances where there is no dominant pattern, premanufactured lattice makes an adequate skirting material. Measure the framework openings and cut the sheets of material to fit. Attach premanufactured sheets using 5d galvanized box nails. To provide a finished look, trim the tops where skirting pieces meet.



CHAPTER 31

OVERHEAD STRUCTURES

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Construct supporting framework for a wood structure.
- Surface the roof of a structure.

Installing a roofed space creates a strong visual element with instant impact. Plants may take several years to provide shade for a patio, but a properly designed canopy provides immediate cover and gives a strong sense of space. Overhead structures are also an effective way of "extending" the interior spaces outdoors. Porches, sunshades, and other open or closed roofs near a house can create the feel of an additional room.

Building a roof for a landscape structure can be treated as an integral part of the construction of a porch, deck, or gazebo, or it can be a completely independent element in the landscape. This chapter explains the techniques for framing, sheathing, and surfacing roofs used for exterior structures. Any construction documents prepared for a project would, of course, supersede the methods and techniques described in this chapter. A licensed carpenter may have to connect roofs to existing buildings, and may be required for all wood construction. Consult building officials for requirements. For information on green roofs and living walls, see Chapter 38.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials for Exterior Carpentry, Chapter 28
- Wood Decks and Platforms, Chapter 29
- Wood Stairs, Railings, Seating, and Skirting, Chapter 30

CAUTION

Use proper ladder safety and climbing techniques when working overhead and on roofs.

CAUTION

When constructing green roofs, additional structural and waterproofing requirements must be considered. Seek advice from a design professional before installing a green roof.

FOUNDATION AND STRUCTURAL SUPPORTS

Support systems perform the important functions of holding the roof up—and holding the roof down. In roof systems composed of open framing with lightweight coverings, the most serious problem can be providing an anchor against wind. For this reason, all roofs must be securely anchored and not just rest on top of a support. Providing a roof for a landscape structure requires support from an existing structure, wall, or fence or the installation of a support system of posts or a framework. Chapter 29 includes directions for footing and post installation.

Supporting the Roof on an Existing Wall or Fence

A simple way to support a landscape structure roof is to place it on an existing fence or landscape wall (Figure 31-1). The fence or wall must have enough structural strength and enough height to support the roof and to provide clearance for it. The wall's or fence's strength may be difficult to determine without knowing how it was originally constructed, but if the wall or fence is constructed of 4 × 4 posts sunk to frost depth or of masonry materials with a footing, it may be strong enough to hold up the roof. If the height is not adequate, short posts can be installed on top of the wall/fence to provide clearance. Roof support posts can be installed on fences and walls by anchoring a post support to the fence or wall. This support can be nailed directly to the top of the fence or fastened to a concrete or masonry structure by drilling a pilot hole, inserting an expanding bolt, and fastening the anchor to the expanding bolt. Posts can then be inserted into the support. These support posts work best if aligned with existing posts on a fence and fastened using specialty connectors. Consult a design professional if you have questions whether the wall or fence can support a roof.

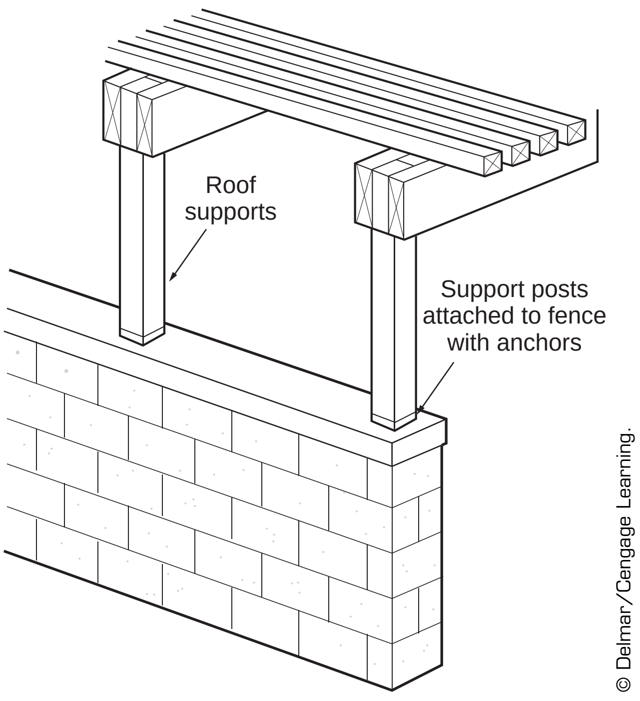


Figure 31-1 Supporting roof structure with fence framework.

Supporting the Roof from an Existing Building

In some designs, the roof may have to connect to an existing building. If the roof is to be installed flush to a building wall, follow the instructions provided in Chapter 29 for attaching a ledger plate. If an eave provides adequate vertical clearance for both the building's occupants and the roof structure, connection below the eave is possible. Connecting the roof below the eave does not affect roof drainage and minimizes future problems when reroofing. This attachment can be accomplished by hanging the roof framing under the eave using galvanized strapping that is lag screwed into the building rafters.

Another alternative provides a more stable and attractive connection. This involves removing the **soffit**, or flat panel that covers the underside of the eave, and using gusset plates to bolt the roof framing directly to the building rafters (Figure 31-2). Install the new soffit panel and the trim to cover the connections, open eave area, and spaces between rafters. To reinstall the soffit, install cleats along the old rafters on both sides of each opening. Cut and attach the soffit to these cleats. If the original soffit had a vent, you must also install an equal size vent in the new soffit.

Supporting the Roof from Posts and Frameworks

Frameworks that independently support landscape structure roofs require some form of post structural network. Many small posts or a few large posts perform the dual functions of support and anchoring. Post installation, either as part of

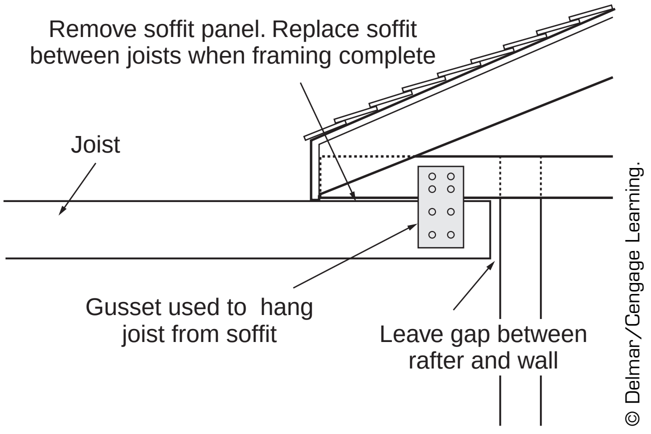


Figure 31-2 Connecting roof structure to building below soffit.

a deck structure or as an independent roof system, is described in Chapter 29. When installing a roof support as part of a deck structural system, use 4 × 4s or larger posts.

Techniques that make structural support more attractive include using multiple posts, building up the posts, or trimming the posts. Multiple post techniques use two, three, or four posts at each corner to support the roof. All of these supports do not need to be placed on a footing because, typically, only one is providing structural support. The space between the posts can be filled with lattice work, seating, or shelves for plants. Built-up posts add 2 × lumber to the sides of the posts to create a bulkier aesthetic and structural look. Attach 2 × 6s to opposite sides of each post with deck screws to improve the post's appearance. Trim by **cladding**, or completely covering, all four sides of each post with 1 × lumber attached with 5d box nails or 2-inch screws. This also creates a bulkier look with a more aesthetically pleasing appearance. By combining these techniques, landscape contractors have an endless variety of treatments from which to choose.

Unless you are limited by an existing structural system, the choice for posts does not need to be limited to 4 × 4s. You can use built-up posts, structural timbers (6 × 6s and larger), round posts, prefabricated columns, masonry columns, or metal framework to hold up the roof. Notching a flush connection area for rafters and beams on round posts makes a stronger structure. If you choose prefabricated components, follow the manufacturer's recommendations for connectors.

ROOF BEAMS/RIDGE PLATES

Rafters used in the roof substructure need supports and can be supported directly on a ledger plate or hung from an eave as described in the previous section. You can also attach rafters to a beam that is supported on posts (Figure 31-3). Attach beams to posts using two ½-inch bolts, if attached to the side, or a saddle, if attached on top. Verify that the system supporting the rafter and/or beams/ledger plates is square and level. Minor variations from square will make cutting rafters difficult. Adjust beams and ledgers as necessary before installing rafters.

Ridge plates, the structural pieces supporting the high end of rafters in peaked roofs, require support to hold them in position. The ridge plate can be supported by being connected directly to a building with a joist hanger, set on top of a post, or built into the structure framing (Figure 31-4). Long structures may have several such supports on which the ridge plate is to rest. You will need to install the structural support method before setting the ridge plate.

To install the ridge plate, cut a 2 × 10, or larger dimensioned lumber, the length of the roof and attach it to the support. The position and level of this ridge plate must be accurate. Fasten securely using hangers, metal straps, or anchors at each support location.

ROOF SUBSTRUCTURE

Roof substructures perform the same functions as the deck substructure performs—supporting the loads applied to the structure. One major

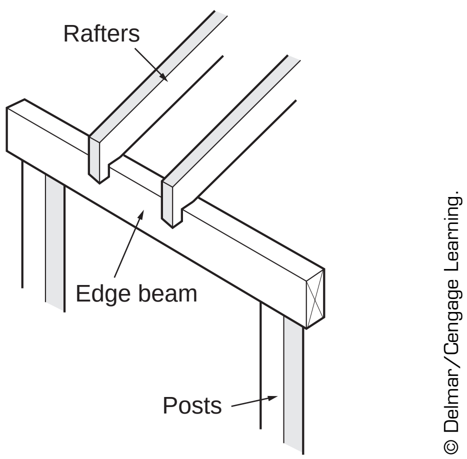


Figure 31-3 Supporting structure roof beams.

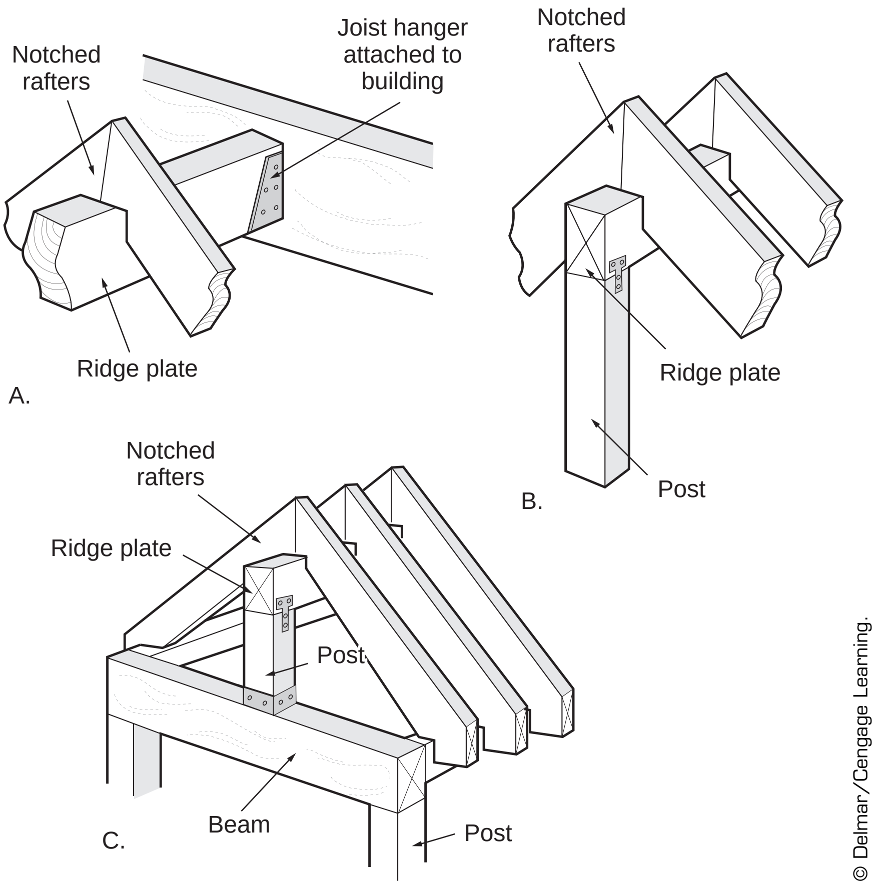


Figure 31-4 Roof beam at edge.

difference exists in structural design between the roof and deck: the roof seldom carries as heavy a live load as does the deck. The only live loads on a roof occur during construction and repair and dead loads are typically limited to snow, ice, organic materials, and equipment; hence, the sizes of rafters are slightly smaller than those used as normal floor joists.

Roof design can also be classified according to whether the surfacing is open or closed and by roof styles such as shed, gabled, or hubbed. Open-surfaced roofs have no permanent, solid surfacings to protect whatever they cover from the elements. Generally covered with lath, lattice, louvers, or dimensioned lumber with open spacing, open roofs are prime candidates for covering with vines or fabric. Built with a weather-impermeable covering such as shingles, metal panels, or fiberglass panels, closed roofs require more materials and labor but provide whatever they cover more protection from the elements.

Roof styles for exterior structures typically fall into three categories. Shed roofs have a single-sloped surface running from a high point on one edge to a low point on the other. Gabled roofs have dual slopes, each running down from a central high point. The gable is the ridge that divides the two sloped sections. Hubbed roofs are a gabled roof with several facets coming together at a single high point in the center. Commonly used in freestanding structures such as gazebos, hubbed roofs can have anywhere from four to eight or more sloped sections. Although hubbed roofs are the most difficult of this group to construct, they provide a high level of aesthetics.

Shed Roof Framing

Shed roofs are framed by cutting and placing rafters along the length of the roof between supports located at both ends of the rafter, typically two beams or a beam and ledger (Figure 31-5). Before cutting rafters, verify that the supports for the roof are level and square.

To make a pattern for a shed rafter that abuts a building, select a piece of rafter lumber and place it on top of the supports. Mark the angle at the top by placing a block of lumber against the building wall and transferring the angle to the rafter (Figure 31-6).

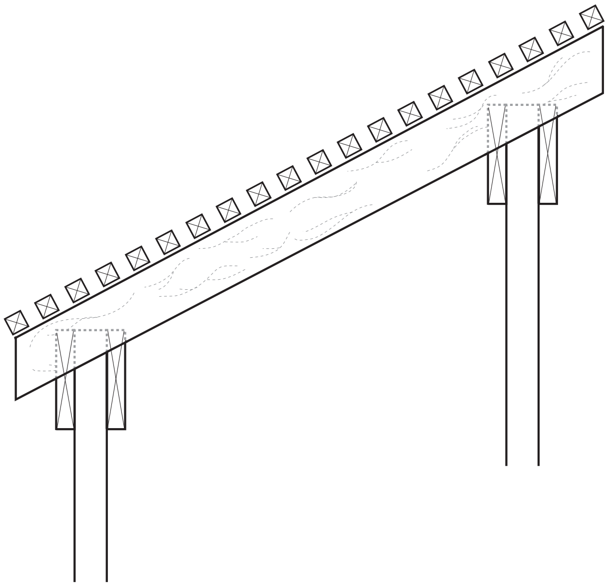


Figure 31-5 Shed roof slopes in a single direction.

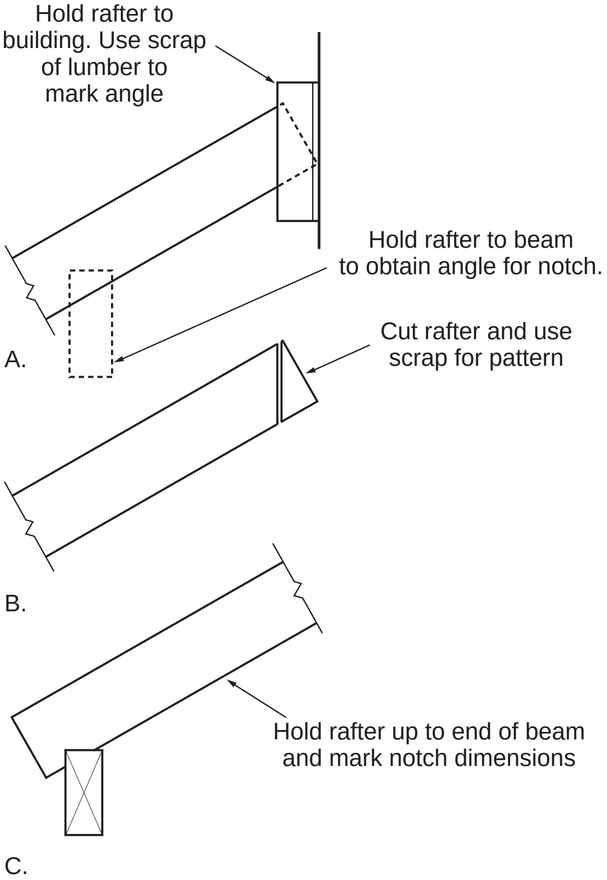


Figure 31-6 Marking, cutting, and notching rafters.

Cut the angle from the rafter and use the scrap to mark and cut the same angle at the bottom of the rafter. When no building is available as a guide, use a carpenter's level to plumb a line from the top corner of the rafter. Return the rafter to the supports and hold it against the ends of the supports. Mark the location for a notch where the rafter will set on the support. The bottom will always be notched if resting on a beam, and occasionally the top will also be notched. Cut out this notch and check the rafter for fit at each location where a rafter will be located. If cut properly, use this rafter as a pattern for all others required for this section of the roof.

Begin installing rafters at spacing determined by design or calculation. Connect the rafters to the supports by toenailing with 16d nails. If attaching to a ledger, use joist hangers. For roofs that are designed with exposed rafters, blocking and bracing may be required to maintain spacing and/or to prevent twisting or toppling of rafters. For roofs that have covered ends, attach a piece of 1 × fascia across the end of the rafters at the bottom edge of the roof (and the top if not attached to an existing building). This lumber should be wide enough to cover the ends of the rafters and should be connected by endnailing with three 8d nails or two 2-inch screws per rafter.

Gabled Roof Framing

Gabled roof framing relies on rafters that are attached to both sides of a ridge plate at the top of the **gable** and resting on beams at the bottom (Figure 31-7). Mark and cut rafters in a manner similar to that used for shed roofs. Check the rafter for fit and, if properly cut, use it as a pattern for all others in this section of the roof.

Begin installing rafters at spacing determined by design or calculation (Figure 31-8). Connect the rafters to the ridge plate using joist hangers or a lag screw on the top and by toenailing with 16d nails on each side. Attach to the beams by toenailing with 16d nails. For roofs that are designed with exposed rafters, blocking and bracing may be required. For roofs that have covered ends, attach a piece of 1 × fascia across the end of the rafters at the bottom edges of the roof. This lumber should be wide enough to cover the ends of the rafters and should be connected by endnailing with three 8d nails or 2–inch deck screws per rafter.

Hubbed Roof Framing

Roofs that have multifaceted roof segments require a central point at the top to which rafters can be connected (Figure 31-9). Depending on the number of facets the roof contains, this connection can be accomplished with a 4 × 4 block, a

Figure 31-7 Gabled roof has a long peak and two sloped sections.

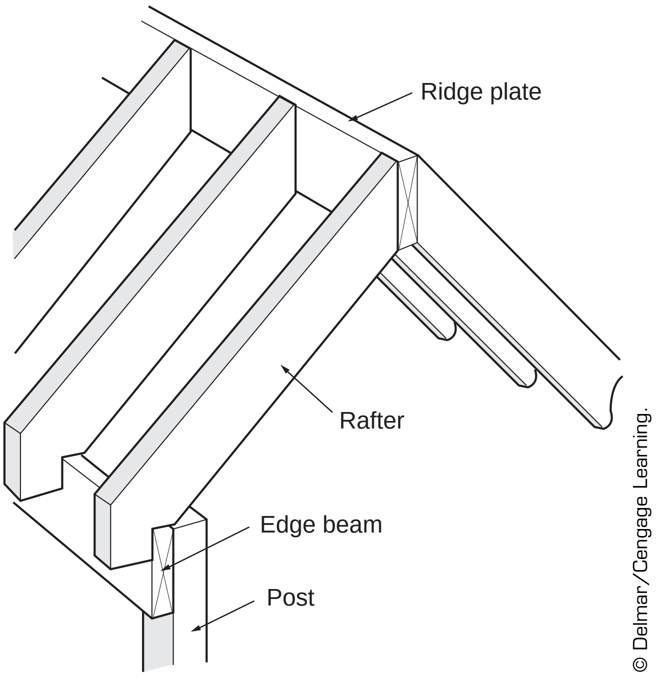


Figure 31-8 Framing gabled roof.

Figure 31-9 Hubbed roof has a high point with several sloped sections, or facets.

special six- or eight-sided hub block, or a metal hub kit. For each side of the hub, a rafter will run down from the hub to rest on the beams (Figure 31-10). Each rafter supports the roof surfacing for two adjacent facets. Roof support is provided by the downward pressure of all of the

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Figure 31-10 Close-up showing six rafters connected to hexagonal hub.

rafters on this hub and the support beams around the perimeter of the roof.

Angles and notching for hubbed roof rafters must be calculated and marked from designs or measurements that a hub manufacturer provides. Mark and cut two rafters and tack to opposite sides of the hub; then hold in place to check for fit in all directions. If the rafters are properly cut, use as patterns and cut all rafters for the project. Rafters for hubbed roofs may have angles to provide a more interesting roofline. Measure and cut each section of the angled rafter; then fasten the sections using plywood gussets screwed to each side (Figure 31-10). Rafters should be connected to a wood hub using a lag screw on top and by toenailing with 16d nails on both sides. Rafters connected to metal hubs are bolted or fastened through each side of the hub flanges. Use fasteners that the hub manufacturer recommends. To support this hub during construction, cut three rafters and attach to the hub. Place the rafters and hub on the support beams and tack in place. With the hub temporarily supported, you can attach and fasten other rafters.

For roofs that are designed with exposed rafters, block or brace them as required to maintain spacing. For roofs that have covered ends, attach a piece of 1 × fascia across the end of the rafters at the bottom edges of the roof. This lumber should be wide enough to cover the ends of the rafters and should be bevel cut to match the angle between roof facets. Connect by endnailing with three 8d nails per rafter.

Additional Structural Preparation

Because of their height, exposure to wind, and snow loads, roofed structures need bracing for lateral stability to keep them upright and square. Methods commonly used to strengthen roofed structures include bracing between the posts and beams, using railings, or using interior joists.

Bracing between roof posts and roof support beams is typically short blocks of wood securely fastened at an angle between these two structural members (Figure 31-11). These braces should be 1–2 feet long and fastened with ⅜-inch bolts or lag screws. Gazebos often make use of decorative trim braces for this function. Installation of railings can provide some additional structural stability to a roof structure. Securely fasten the stringers of the railing between the posts supporting the roof.

ROOF SURFACING

Choices for covering a roof include a wide range of open and closed surfacing materials. The material installations described in this section represent the basic coverings used in the industry.

Open-Roof Surfacing

Open-roof surfacing involves the placement of strips of surfacing material, such as grape stakes, lath, 1 × 3s, 1 × 4s, 2 × 2s, or 2 × 4s, with an open space between strips. Open-roof surfacing can be nailed or deck-screwed directly to the structure in most applications (Figure 31-12). Begin application of surfacing materials at the top or one edge of the structure by installing the first piece and using a spacer to maintain even distances between subsequent pieces (Figure 31-13). When approaching the end of the installation, adjust the spacing slightly, if necessary, to accommodate any shortage or extra space left. Lattice work can also be directly nailed to the top surface of the structure. Cut lattice pieces so

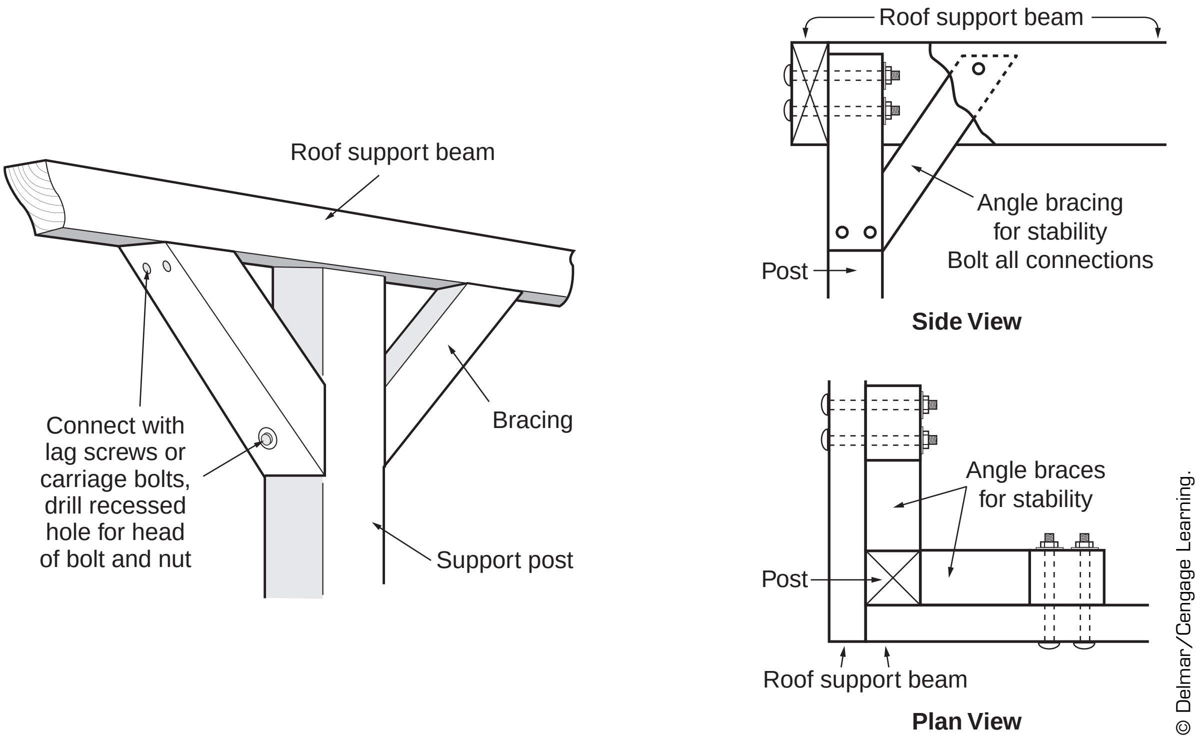

Figure 31-11 Angle bracing of hubbed roof beams.

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Figure 31-12 Open roof shade structure.

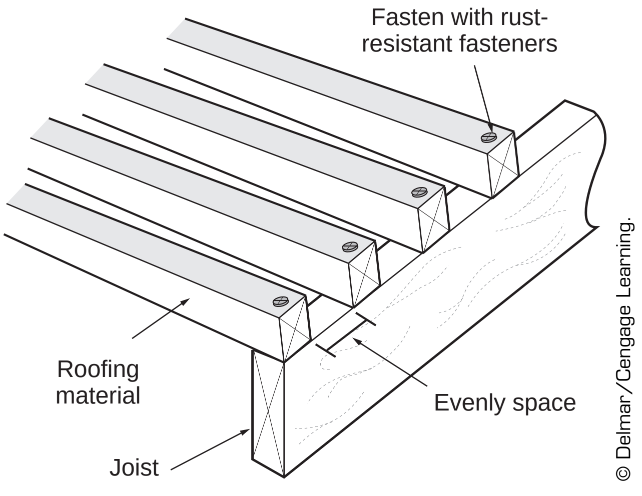

Figure 31-13 Open roof connections.

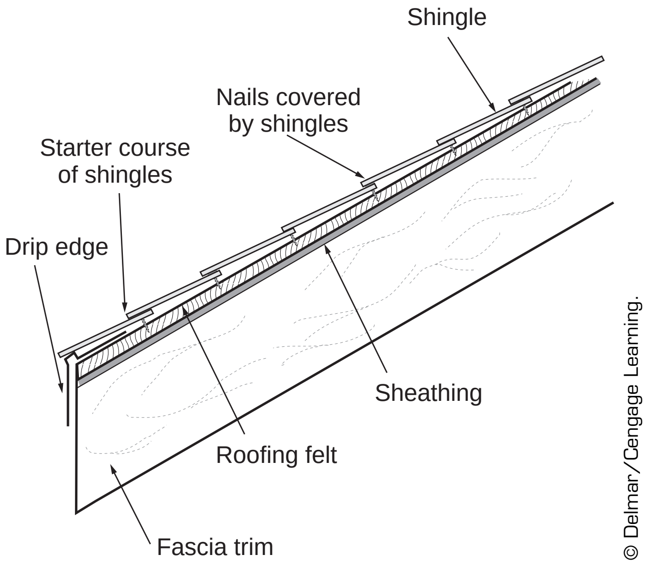

Figure 31-14 Shingled roof cross section.

the joints butt directly over a joist and the pattern matches from one piece to the next. Secure lattice installations by nailing 1 × 2 strips above all structural supports.

Open-surfacing materials can also be preassembled in panels that are connected to the joists. Cut and assemble panels with a 1 × 2 frame around the outside edges. These panels are then fastened to the roof framework. Materials such as lattice or louvers can also be installed directly on cleats already installed inside the joists. Connect materials using deck screws or 8d box nails.

Open-roof surfacing may require trimming out the structure before or after surfacing is applied. Trim structural grade lumbers with 1 × stock for a more finished appearance, and cover joints in lattice work with 1 × stock trim.

Asphalt Shingle Surfacing

Three-tab asphalt shingles are a common and durable roof surfacing for many landscape structures. Available in a variety of colors and relatively easy to install, asphalt shingles are a versatile way to weatherproof an outdoor space. Shingled roofs are composed of many components installed in a particular order to maintain waterproof conditions (Figure 31-14).

Special Materials, Nails, and Techniques for Shingle Roofs. Cutting and nailing shingle roof materials require special tools and fasteners. Both roofing felt and shingles can be cut using a carpet or utility knife. You can cut roofing felt completely through, whereas you must score shingles along a straightedge and bend them to break through the surface. Nailing shingles requires the use of 1¼-inch roofing nails. Drive nails snugly into the surface without puncturing or breaking the surface of the shingle. Use four nails to fasten each shingle—spaced 1 inch in at each end and one at each shingle notch placed slightly above the black asphalt tack strip.

Sheathing. Surfacing begins with the installation of roof sheathing material. Common choices for sheathing include ½-inch exterior grade plywood, or **OSB**. Measure and cut sheathing material to fit the rafter spacing for the structure. Center joints on rafters, and place each piece of sheathing so that it covers at least three rafters. Begin installation by placing the first piece of sheathing flush with the bottom and one edge of the roof. Nail in place with 8d ring shank box nails every 8 inches along each rafter. As the application of sheathing moves up the roof, stagger the vertical joints as much as possible. Space horizontal joints for roof sheathing ¼ inch. Special spacing clips are available.

Subroofing. Fifteen pound roofing felt is installed next over the sheathing. Align the first piece horizontally and flush with the bottom edge of the roof and fasten using ⅜-inch staples. Overlap each subsequent piece of roofing felt 6 inches over the lower piece. Continue installing felt to the peak of the roof. At the peak of a gabled roof, install one piece of felt that overlaps both sides of the roof. Beginning at the bottom edge, install aluminum drip edge along all edges of the roof. Drip edge can be cut with tin snips and should be installed with 5d box nails.

Marking the roof with horizontal chalk lines will help in maintaining straight shingle application. If you install roofing felt horizontally, lines that are printed on the felt will help keep shingle application straight and horizontal.

Flashing. Flashing is required to prevent moisture leakage at valleys and in each location where items such as vents or fireplaces penetrate a closed-roof system. Apply flashing to valleys after placing any roofing felt and before installing shingles or surfacing materials. Use roll aluminum or galvanized metal to straddle the valley and extend 6 inches up each side of the roof. When a valley is adjacent to a vertical wall, run the flashing 6 inches onto the roof and 6 inches up the adjacent wall. Attach using a weatherproof glue. Metal flashing should also be installed around each roof penetration. For vents, use the premade flashing with a rubber boot that fits around the vent pipe. For other installations, use pieces of metal step flashing. Begin installation of step flashing at the bottom of the penetration, with a row of flashing placed over roofing felt and under shingles. Alternate flashing and shingles while moving up the roof, with the flashing always placed under the shingle. Attach flashing using a weatherproof glue.

Shingling. Shingle application begins with the installation of the starter course. First cut the colored coated tab off the bottom of enough shingles to run the entire length of the roof. Leave the black tack strip on these shingles. Cut the left 6 inches (½ tab) off the first starter shingle, place it so the tack strip is flush along the edge and bottom of the roof, and nail it in place (Figure 31-15). Continue placing starter shingles until you cover the entire bottom edge. Nail the first course using a full shingle placed with a ½-inch overhang over the left and bottom edges of the roof. Continue placing full shingles with a 1/16-inch gap between shingles along the length of the roof.

To install the second course, cut 6 inches (½tab) off the left-hand side of a shingle and install that shingle flush with the left edge of the roof. Follow that shingle with full shingles along the entire length of the roof, trimming any excess at the end. Place each subsequent course so that 5 inches of the course below is exposed and the centers of the tabs in the second row are aligned with the gaps in the row below. To begin each subsequent row, cut an additional 6 inches off each first shingle (6 inches from the first, 12 inches from the second, 18 inches from the third, and so on), then continue with a full shingle (Figure 31-16). This will stagger the joints

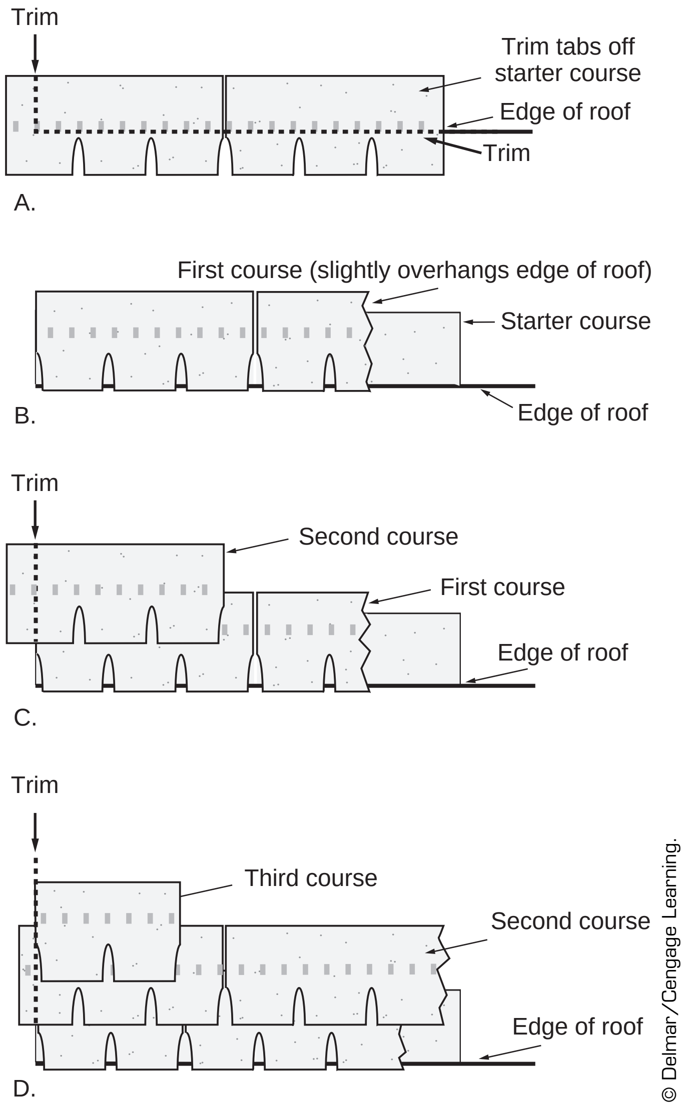

Figure 31-15 Shingle installation pattern.

across the roof. Continue shingle placement until you reach the roof ridge.

Ridge Treatment. Completing the shingling at the top, or ridge, requires cutting shingles and following special installation techniques. If the roof has a ridge, cut several shingles into thirds by scoring and breaking at the tab. Bend the shingle and place, straddling the ridge with the coated tab on the left. Nail the shingle into place and lay the next shingle overlapping all but the coated tab portion of the first ridge shingle. Nail in place and continue along the entire ridge. The last shingle will require cutting off all but the coated tab. Nail this last tab over the previous shingle and caulk around the exposed nail holes. If the roof is a shed roof against a building or has no ridge, use the same process with a single row of

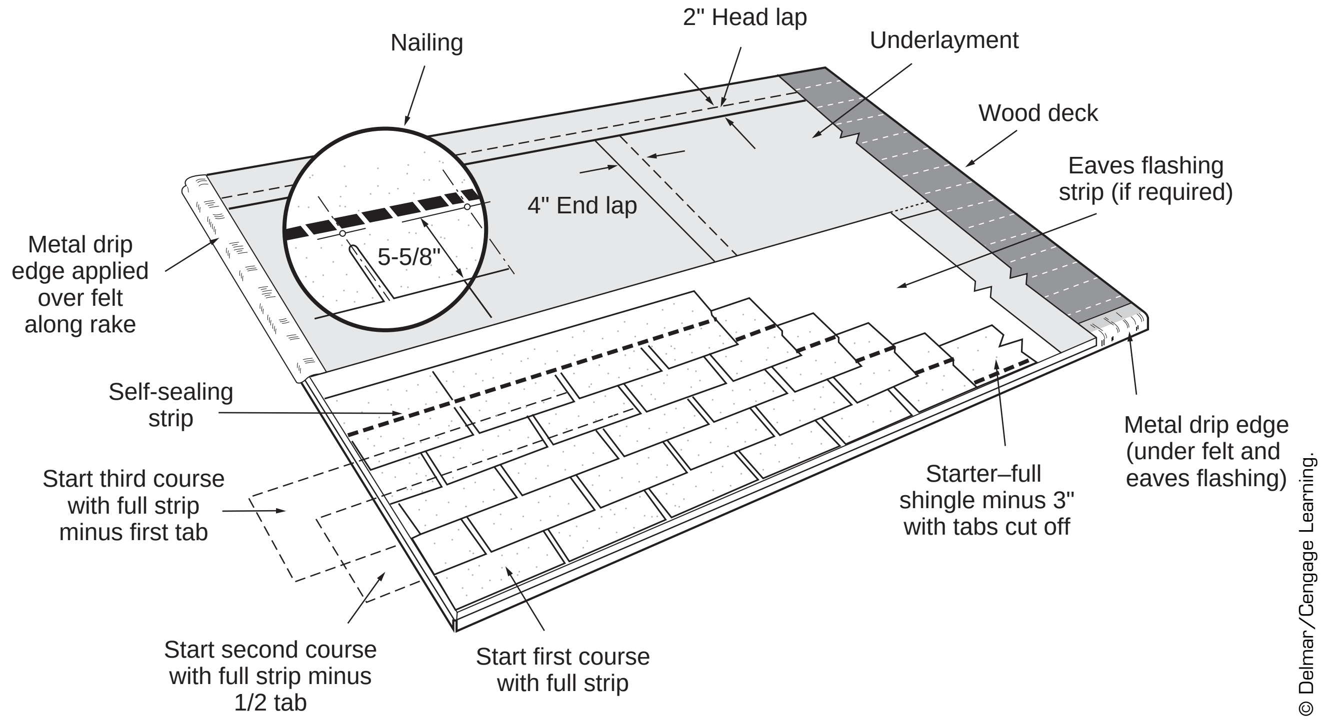

Figure 31-16 Shingle roof components.

shingles placed against the building over a piece of flashing installed against the building. Roofs that are surfaced on the underside will require leaving a gap in the sheathing, installing a premanufactured vent, installing ridge shingles over this vent (Figure 31-17), and installing a vent in the roof's soffit or fascia.

Wood Shingle Surfacing

Wood shingles provide one of the most attractive roof surfacings available for landscape structures. Different in surface texture than wood shakes, wood shingles are sawn from red cedar, whereas shakes are split. Wood shingles for landscape structures are

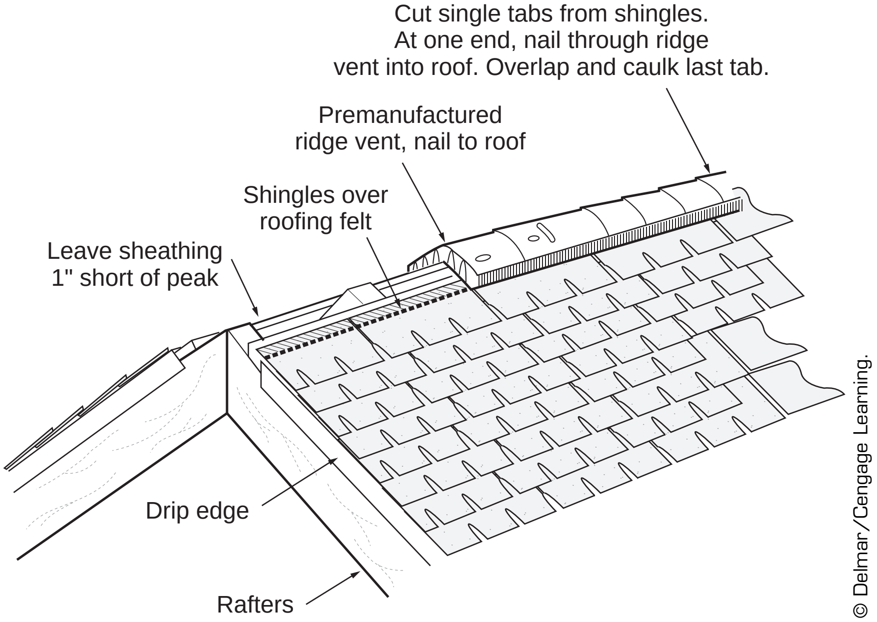

Figure 31-17 Shingled roof ridge treatment.

best installed over sheathing base, similar to the installation of asphalt shingles. Like asphalt shingled roofs, wood shingled roofs are built of many materials installed in sequence (Figure 31-18).

Special Materials, Tools, and Techniques for Wood Shingles. Wood shingles can be sawn using a circular saw or split lengthwise using a roofing hatchet. Fasteners used should be 1¼–2-inch, 14d galvanized nails. Insert two nails per wood shingle, ¾ inch from each side, and 1 inch up from the exposure line. The exposure line is the location where the bottom edge of the shingle placed above will rest. The exposure line varies from one-quarter to one-third the length of the shingle. The steeper the roof pitch, the greater the exposure. Nail the wood shingle firmly, but do not countersink the nails into the surface of the wood shingle.

Sheathing. Follow the same sheathing installation process described for asphalt shingles. Fifteen-pound roofing felt is installed over the sheathing. Align the first piece horizontally and flush with the bottom edge of the roof and fasten using ⅜-inch staples. Cut subsequent courses of roofing felt to an 18-inch width and install it between courses of wood shingles.

An alternative to solid sheathing is to install wood **purlins**, the wood members that run perpendicular to rafters and provide support and a nailing surface for roofing materials. Purlin attachment requires installing 1 × 4s horizontally across the roof, spaced twice the width of the shingle exposure. For wood shingle roofs, purlins should be solid for the first three courses at the bottom and the outer 1 foot at the **rakes** (Figure 31-19). Fasten the purlins with two 10d common nails per rafter. Roofing felt is not used if installing wood shingles on purlins.

Wood Shingle Installation. Wood shingle installation begins by trimming 2 inches off the top edge of enough wood shingles to install one course the

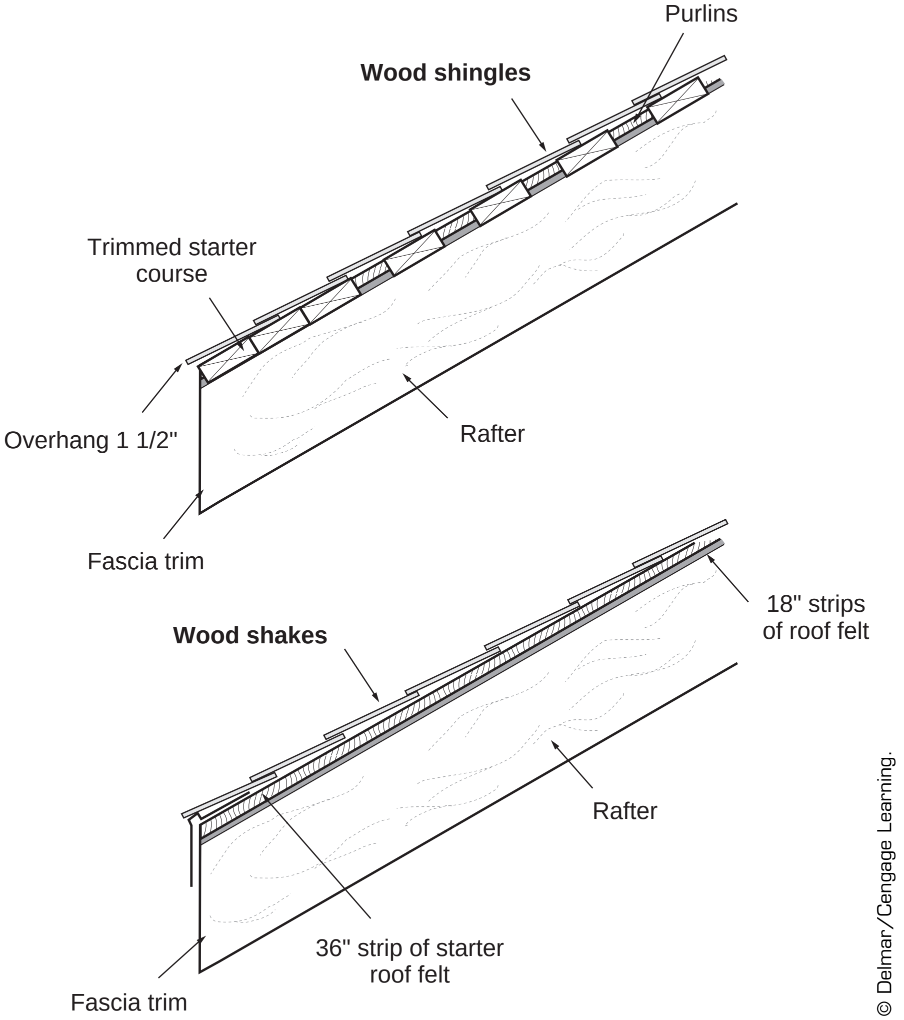

Figure 31-18 Wood shake or shingle roof cross section.

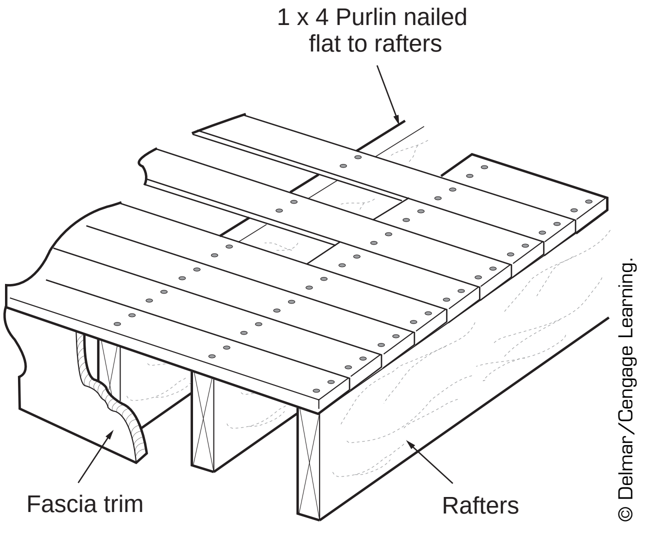

Figure 31-19 Purlin installation.

length of the roof. Nail this shorter starter course in place with a 1½-inch overhang at the bottom edge and ½-inch spacing between wood shingles. Install the first course of wood shingles directly on top of the starter course with the same overhang and spacing, offsetting joints between courses 1½ inches to cover the gap below. This may require splitting a wood shingle to begin and to finish the course. Overlap each subsequent course over the first so that the proper exposure is obtained (Figure 31-20). With shakes, between each subsequent course, install an 18-inch wide piece of builder's felt, with the lower edge of the felt halfway between the next exposure line and the end of the wood shingle. Continue installing courses until reaching the ridge.

Ridge Treatment. The top or ridge finishing course is laid perpendicular to the direction of roof wood shingles. Finish the top by splitting one shingle and placing it on one side of the ridge, butted against a split shingle on the opposite side of the ridge. Fasten with two nails for each wood shingle. Install a second pair of split shingles that completely cover the first pair to create a double starter (Figure 31-21). Continue to overlap by half to cover the nails in the lower shingle along the entire ridge. Caulk around the final exposed nails. If the roof is a shed roof against a building or has no ridge, use the same process with a single row of wood shingles placed against the building.

Metal Roof Surfacing

Metal roofing provides both inexpensive and high-end choices as cover for an outdoor shelter. Available in a variety of forms, metals, and colors, metal roofing is installed over 2 × 4 purlins attached to the roof framing or installed over a sheathed roof (Figure 31-22). The two most common forms are wide rib and standing seam (Figure 31-23).

The wide rib is typically used for agricultural and service buildings and has a ridge that is up to 1-inch wide with nails driven from the top through the seam to hold the metal in place. Wide rib is available in a number of cross sections and colors. Standing seam is used for garden structures and has a narrow vertical seam where sections of roofing overlap. Wide rib is typically purchased, with all of the flashing and trip pieces, precut and ready to assemble. Standing seam can be purchased precut or can be fabricated on site. Most metal roofing has the disadvantage of being a rather unattractive surface when viewed from below and susceptible to damage from high winds and hail. However, standing seam metal roofs provide a higher degree of aesthetics for even the most simple garden structure and are durable if properly installed.

Special Materials, Tools, and Techniques for Metal Roofing. Wide rib metal roofing is attached using 2-inch ring shank roofing nails with a rubber washer around the shank, whereas standing seam is installed with pancake head screws. Wide rib metal roofing can be cut using tin snips or a circular saw with the blade installed backward. The reversed blade "grinds" a clean cut through the metal. When using a circular saw, use an old blade or buy an inexpensive blade. Standing seam is best when cut by a hydraulic cutter, but you can also trim it using tin snips. For most metal roofing, nails must be placed along the ridges of roofing rather than in the valleys. However, with standing seam roofs, the nails are placed in a nailing flange running alongside the seam or through clips that snap over the seam. Drill pilot holes or directly drive nails through the material. Install nails at each purlin location.

CAUTION

Support metal and fiberglass under both sides of the cut. Wear gloves and safety glasses. Use caution when handling metal and fiberglass, particularly after it has been cut. The edges are very sharp, and small metal slivers and fiberglass shards are exposed after cutting.

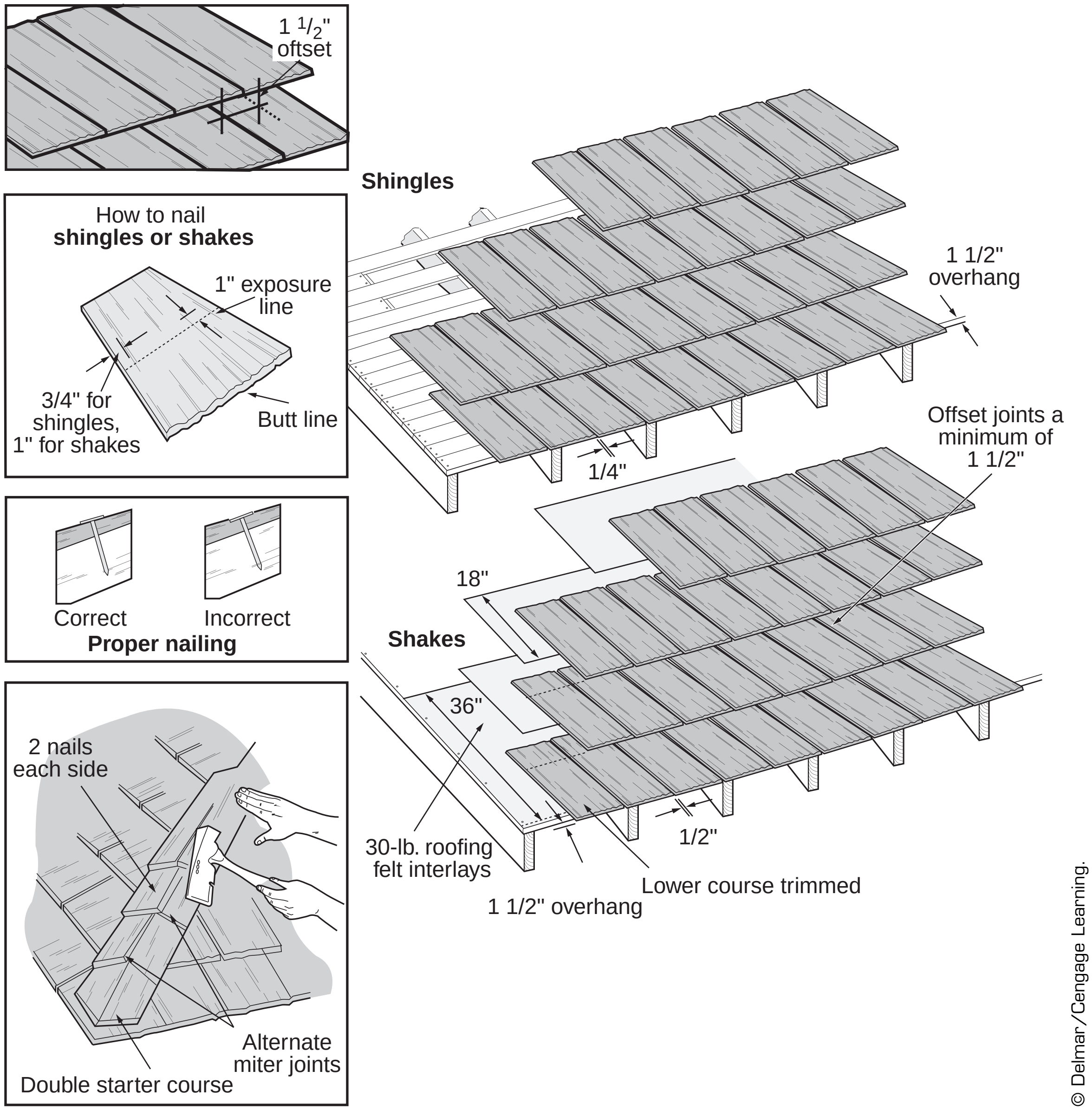

Figure 31-20 Shake installation pattern.

Purlin Installation/Sheathing. Purlins are attached to the rafters by placing horizontal 2 × 4s on edge every 2 feet up the rafters. Drill pilot holes and attach the purlins to the rafters using 5-inch ring shank nails. For standing seam metal roofs, install sheathing and roofing paper in a manner similar to a shingled roof.

Trim and Flashing. To finish edges and cover exposed rough cuts, premade metal trim is available that covers corners and ridges. Most trim and flashing pieces are installed before surface material is attached (Figure 31-24). The exception would be any ridge cap, which is installed after the surfacing has been completed. Measure the areas that need to be trimmed or flashed, cut pieces with tin snips, and install with ring shank nails or pancake head screws.

Surfacing Attachment. For wide rib roofs, begin at the outside edge and place the first piece of steel over the purlins aligned with the bottom and the edge and nail it in place. Most steel pieces have one edge formed to overlap and one edge formed to accept another piece. The pieces should be placed in order so each one properly overlaps the previous piece. If the pieces are not long enough to extend to the top of the roof, place the lower pieces first and overlap the bottom piece with the top by 6 inches. Fit the pieces into the previously installed trim.

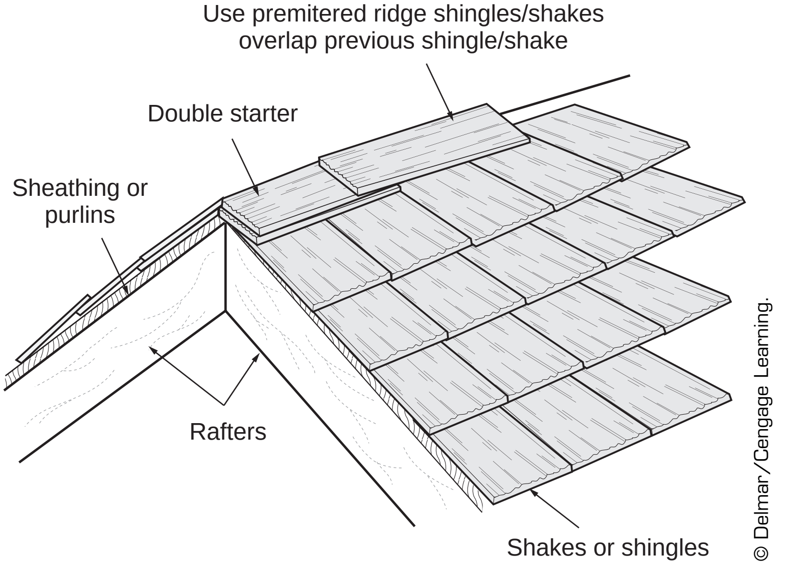

Figure 31-21 Shake roof ridge treatment.

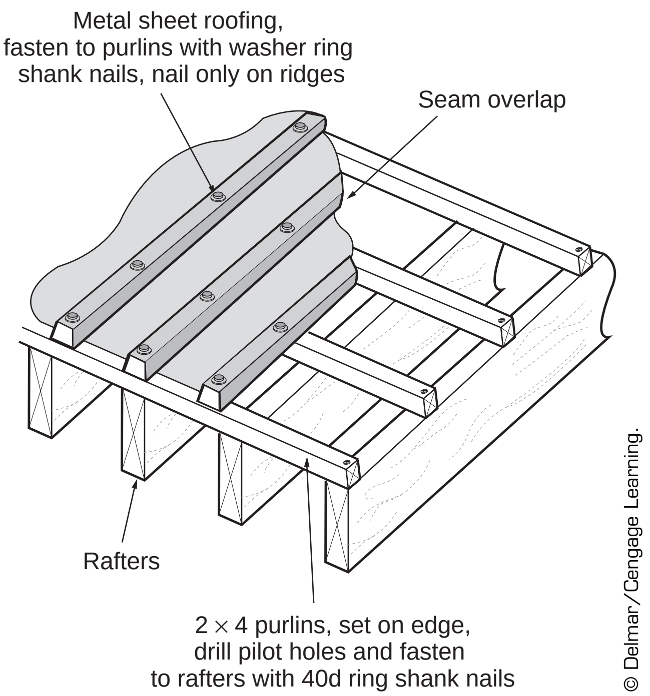

Figure 31-22 Metal roof installation cutaway.

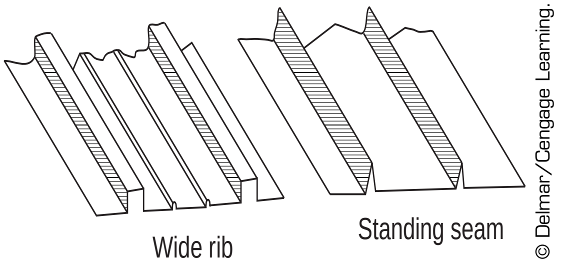

Figure 31-23 Styles of metal roof materials.

Standing seam metal roofs hide the fasteners with the next overlapping piece of roofing. Install the initial piece and screw into place with pancake head screws. The metal sheet should overhang at the eave and slide into the ridge cap at the top. Some forms of roofing have clips that fit over the seam and are screwed into the roof; other forms have a nailing flange with predrilled holes that runs next to the seam. After screwing the piece of roofing to the sheathing, fit the seam of the next piece over the seam of the first piece beginning at the eave side of the roof. Screw the second piece of roofing into place. Return to the first overlapped seam and crimp the seam from eave to ridge using a roof crimping tool (Figure 31-25).

Corrugated Fiberglass Surfacing

Fiberglass surfacing comes in a variety of colors and translucencies that make an inexpensive roofing choice. Less expensive than other roofing materials, fiberglass is also less durable and requires a specialized structural system to match the material sizes (Figure 31-26).

Special Materials, Tools, and Techniques for Fiberglass Roofing. Fiberglass roofing is attached using 2-inch roofing nails with a rubber washer around the shank. Nails must be placed along the ridges of roofing and not in the valleys. Pilot holes must be drilled using a backing block to avoid fracturing the fiberglass. Fiberglass roofing can be cut with a circular saw using an abrasive or plywood blade. Support the fiberglass on both sides of the cut and observe the safety precautions stated earlier.

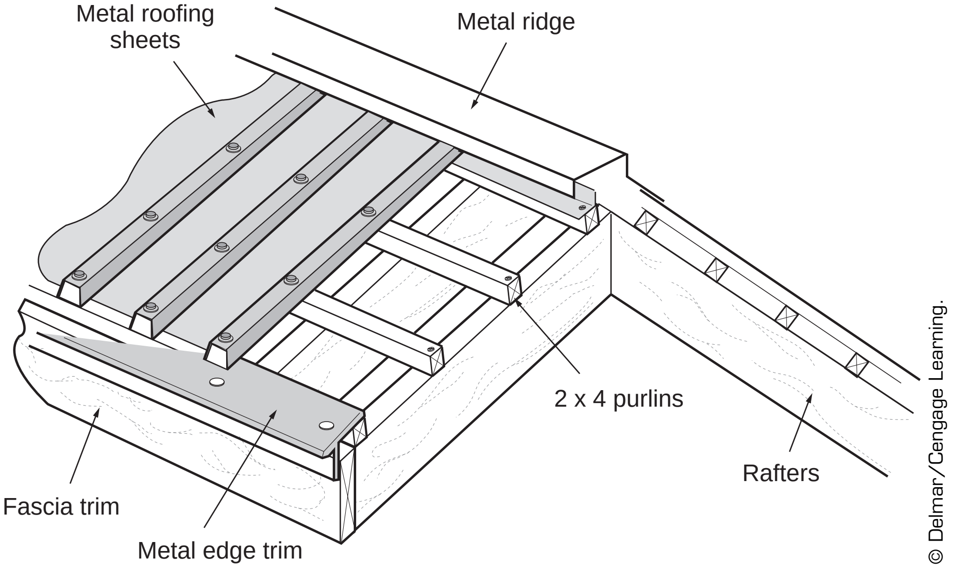

Figure 31-24 Metal roof trim installation.

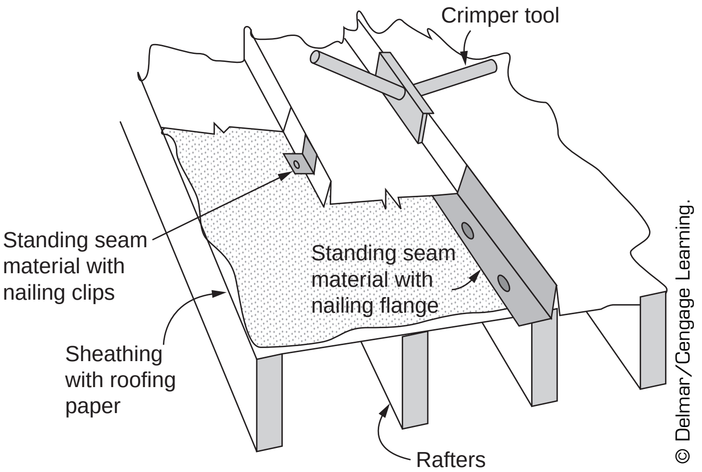

Figure 31-25 Standing seam metal roof installation.

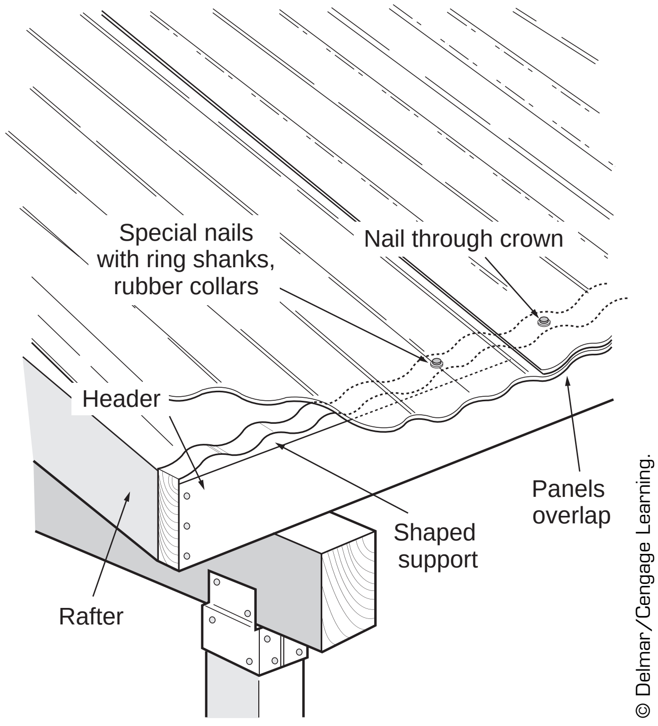

Figure 31-26 Corrugated fiberglass roof cross section.

Structural Support. Fiberglass sheets should be placed and nailed directly to the rafters or to 2 × 4 purlins installed in a manner similar to metal roofing. Blocking is placed between rafters every 2 feet to provide support for the sheets. A special formed trim is available to match the shape of the top of the blocking to the corrugated sheets. For this reason, the rafters must be spaced the same width as the sheets of fiberglass, typically 16 or 24 inches. The pieces should be placed so each one

CAUTION

Support fiberglass under both sides of the cut. Wear gloves and safety glasses. Use caution when handling fiberglass, particularly after it has been cut. The edges are very sharp, and fiberglass shards will be exposed after you cut the material.

overlaps the previous piece directly above a rafter. Place a bead of caulk along the ridge at the overlap to reduce the possibility of leakage. If the pieces are not long enough to extend to the top of the roof, place the lower pieces first and overlap the bottom piece with the top by 6 inches. Place trim at the ridge and around each of the roof's edges.

Fabric Roof Surfacing

Covering an outdoor roof with fabric can range in complexity, based on what the fabric is expected to do. Duck and vinyl drop cloths come in standard sizes, or an awning company can produce a custom covering. An additional fabric that can be used is greenhouse shade cloth, available in different degrees of shading. Durable materials can be **grommeted** around the edges of the fabric so they can be held in place using lag screws through the grommet holes or using catches anchored to the roof framework. Movable fabric roofing requires specialized framing and a retraction system that the manufacturer should install. The framework placed under the fabric is important to proper functioning of the covering. The framework should not be constructed of materials that will catch or rip the fabric, and the framework should hold the fabric taut so that moisture can drain from the roof.

TENSILE FABRIC STRUCTURES

Beyond simply covering a wood structure, fabric with a support system can be used to create an outdoor room. Tensile fabric structures, also called shade structures, stretch fabric between supports to create a covering that can protect whatever it covers from the sun and falling debris (Figure 31-27). Although not suitable for every situation, waterproof tensile fabric structures have been successfully used to cover stadiums, events, and activities while providing color and an "airy" feel while porous structures create a non-waterproof covering for patios and decks. With optional sides installed with the overhead canopy, the structure provides an "all-weather" tent for outdoor functions.

Site Preparation

Unlike many fabrics used in construction, most tensile fabric structures are heavy duck canvas or

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Figure 31-27 A tensile fabric structure.

HDPE (high density polyethylene) treated with a fire retardant and UV (ultra violet light) protection. Supported from structures or posts and drawn into a variety of configurations, this tent-like covering can be adapted to many uses. Installation will begin with correctly evaluating the support mechanisms for the covering. Landscape contractors can install posts that meet specifications to support the fabric; however, if the structure is to be fastened to other objects, contractors must evaluate the structural integrity of the support. Because extreme pressure can be exerted on the support during windy periods, an engineer should evaluate the structural worthiness of the structures and plant material expected to hold the fabric. Most manufacturers recommend strengthening fascias, reinforcing walls, or bracing posts if typical construction methods were used to build these elements. Manufacturers recommend posts no less than 4 inches square/diameter or larger for support. Because it is so variable as a means of support, plant material is not recommended as an anchor.

If supports are deemed acceptable, contractors must make careful measurement to correctly order the cover. Tensile fabrics are available in a variety of sizes and shapes; and for the installation to function properly, the dimensions must match the area to be covered minus the support connections. The elevation of the fabric corners is also an important consideration. Tensile fabrics are typically not installed flat, but with corners or edges that create slope across the fabric. This requires verification that the connection height planned will not interfere with traffic, utilities, or other activities in the area and that any moisture that drains off the structure is directed to appropriate locations. All hardware that is used in the installation should be galvanized or rust-resistant.

Support System Installation

When providing support for a small tensile fabric structure (less than a 15 foot square), contractors have two basic choices available: use existing support objects or install new posts with footings. Verify with each manufacturer the minimum dimensions recommended for post size, connector sizes, connection method, and footing depth before making connections.

Installing Supports on Existing Elements. Fastening to existing walls, posts, or trees typically requires installing a ½-inch diameter galvanized eyebolt through the support or securely mounting a pad eye to the surface (Figure 31-28). Locate where the support is to be fastened. Verify that there are no electrical or other utility lines or critical structural elements that could be damaged by drilling a hole in that location. If you find no obstructions, drill a ⅝-inch hole through the support. Insert the threaded end of the eyebolt through the hole and fasten securely using a lock washer between two nuts. Alternatively, fasten the pad eye to the surface of the support using ⅜-inch × 3-inch lag screw in each hole.

Installing Support Posts. Identify the location of the support posts and excavate a hole that is deep enough for the burial depth of the post plus approximately 4 inches. The hole should be large enough in diameter that the post can be leaned away from the center of the fabric between 10–20 degrees, yet still have a minimum of 4 inches of concrete surrounding the post's perimeter (Figure 31-29). Post burial depths are typically one-third the pole height (for example, a post that is to be 10 feet tall should be purchased 15 feet long with 5 feet being buried). Add 4 inches of crushed stone to the bottom of the hole, treat the end of any wood post with a preservative, and place the post in the hole at the correct location and angle. Brace to hold in position if necessary.

Completely fill the hole with concrete and finish the top of the footing with a float. Slope concrete away from the post's base to deter water from setting around the post. An alternative is to use a post sleeve (Chapter 29, "Direct Burial of Posts") to protect the post from water. Allow the concrete to completely cure before installing fabric. Drill a ⅝-inch diameter hole near the top of each post and insert a ½-inch eyebolt in each hole. Insert the threaded end through the hole facing away from the center of

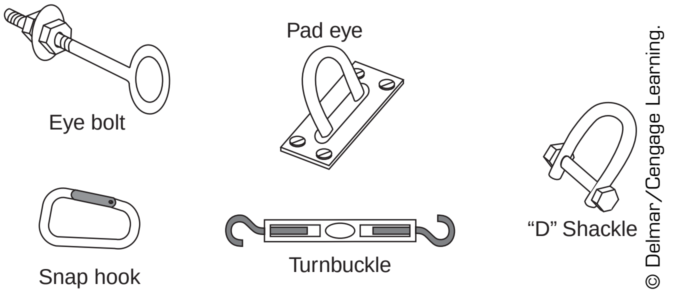


Figure 31-28 Hardware typically used to install residential tensile fabric structures.

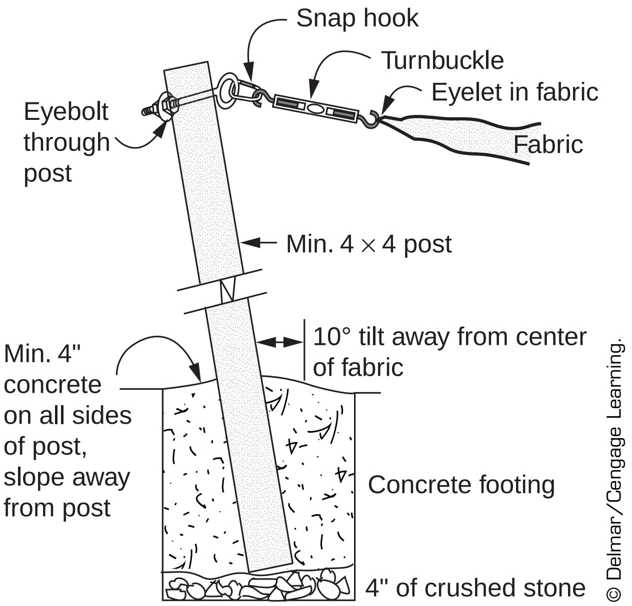


Figure 31-29 Cross section of typical post installation for tensile fabric structure.

the fabric and secure tightly using a lock washer between two nuts. If posts are to be painted or stained, complete this step before installing fabric. To make the installation easier to adjust for height and tension, drill a line of ⅝-inch holes spaced 4 inches apart starting at the top of the pole.

Fabric Installation. Once you have completed the support connection/post installation, lay the fabric out with the topside facing up. If the fabric is not equipped with metal rings, insert a heavy-duty snap hook at each connection point on the fabric. Beginning at a mid-level connection point, raise the fabric to the support point. Between the eyebolt/pad eye on the support and the fabric hook, place a heavy-duty turnbuckle and expand to the turnbuckle's maximum spread. Carefully lower the fabric so that it drapes down to the ground from the turnbuckle connection. Repeat this process at the corner of the fabric opposite the first connection; then at each of the other support points around the fabric. When you have fastened all corners of the fabric to the connection points, tighten the turnbuckles evenly at all corners until the fabric is taut. If a corner does not reach its connection point, bridge small gaps with snap hooks (Figure 31-30). Large gaps will require installation of a second turnbuckle or possibly a short length of metal cable with D shackles installed at either end.

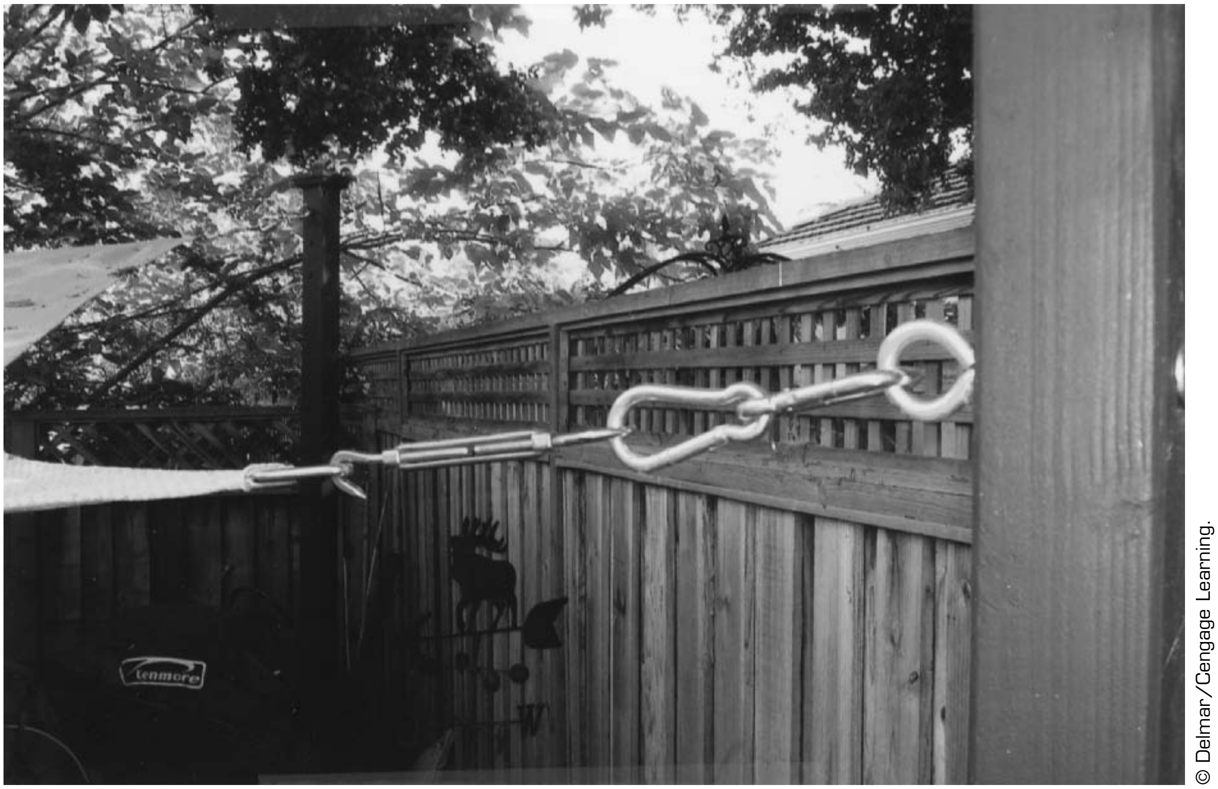
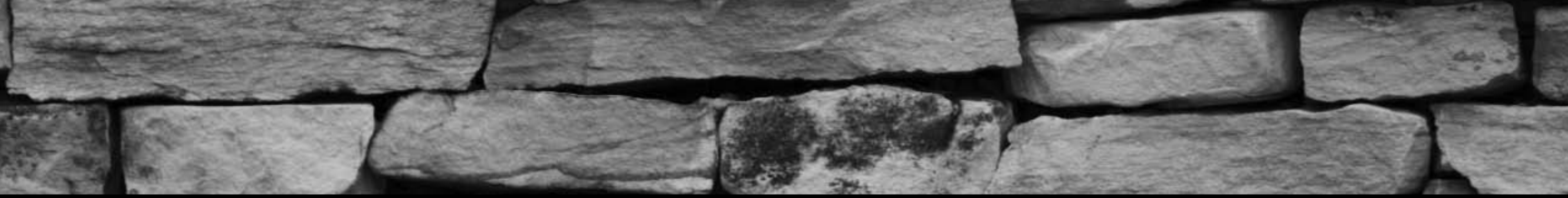


Figure 31-30 Hardware connection for tensile fabric structure showing fabric on the left, turnbuckle, two snap hoods, and eyebolt threaded through post.



SECTION 7

SUMMARY

A variety of wood structures are available for entertaining, for establishing functional uses, and simply for creating space in the landscape. To address this variety of structure types, Section 7 presented carpentry and the construction of wood decks and landscape structures by describing the components of the construction. Covered in this section were discussions of the basic materials, preparing foundations and footings that support structures, building decks and platforms, installing functional additions such as railings, stairs, seating, and skirting, and, if the structure requires, constructing roofing and coverings. This approach allows the contractor to select à la carte from the components of wood landscape construction to fabricate any type of structure desired.

Wood structures can take many forms in the landscape. A standard for exterior use areas is the deck, but overhead structures such as screened porches, sunscreens, and arbors are also common in the industry. Gazebos combine the elements of several structure types to create a stand-alone space. Contractors can also create open-aired structures by suspending fabric from support posts.

When planning exterior structures, contractors must first give consideration to selection of proper materials. Because of their exposure to the elements, components must be resistant to decay, rust, and other hazards of exterior use. Additional considerations for selection of wood products include strength, grade, availability, cost, and aesthetics. The quality of the products used affects the quality of wood construction. Awareness of problems with warping, checks, shakes, and knots will help contractors select appropriate materials for building. Availability of a wide range of wood products, fasteners, connectors, and premanufactured materials makes the carpenter's work more stable and more productive.

Preparation of the site and installation of support mechanisms for wood structures are necessary for long-term improvements. Landscape structures can be anchored to existing structures, anchored to existing slabs or footings, or installed on separate supporting posts. Posts installed to support a structure can be anchored to the top of a frost footing or buried directly. In climates where freezing occurs, these supports should extend to frost depth. For structures where movement is not a problem, or where freezing conditions seldom occur, precast pier supports can be used to support structures. Using leveling deck supports, contractors can support deck structures and surfacing directly on grade or on paved surfaces.

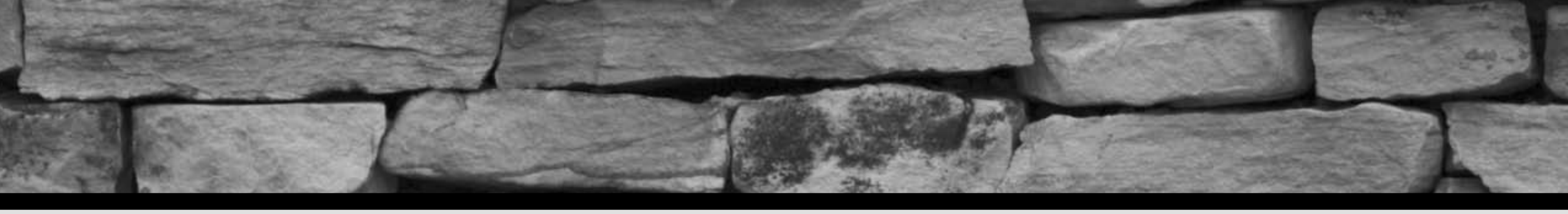
Construction of decks and platforms involves the framing of a substructure on which a surfacing material is placed. Two choices for substructure are considered for landscape work—post and beam (also called plank and beam or drop beam) framing or platform (also called box or flush beam) framing. Post and beam involves the installation of posts (or other support method), attachment of beams to the posts, and installation of joists on top of the beams to support the deck surfacing. Platform framing involves the installation of posts (or other support method), attachment of a frame of joists to the posts, and installation of joists inside the box. Surfacing is then applied over this framework. Each method has benefits and drawbacks, but proper

sizing and spacing of materials will make each structurally sound. When constructing the framework, contractors can employ variations such as multilevel decks and cantilevered decks. Support for benches, railings, and roofing must be considered before surfacing proceeds. Surfacing the framework can be accomplished using specialty decking lumber or standard dimensioned lumber. Trimming the structural components provides a finished look to the structure.

To make exterior structures more safe for and convenient to users, contractors may consider adding stairs, railings, seating, and skirting to a platform. Although it can take almost any form, stair configuration requires landing space and framing similar to that for the deck's platform. Supports are carefully measured, cut, spaced, and attached; and surfacing is added to provide a walking surface. Railings require the installation of structural supports that will hold the load of people leaning against them. Supports may be attached to the outside edge or inside of the platform framing and may be extensions of the posts that support the platform. Stringers are connected between supports; and surfacing is applied, which creates a barrier to accidental falls from the platform. Seating for decks can be framed using supports similar to railings or specialty framing such as grab beams or triangle frames. Surfacing is applied; and, if required, backrests are installed. Skirting to hide the underside of a structure is framed between posts, and surface screening such as lattice is applied to the framework.

Overhead roofing requires the contractor to determine the type of roof and the materials from which that roof will be constructed. Simple roof styles such as shed, gabled, and hubbed are common for landscape structures. Material selections can include open-style lattice or wood, fabric, asphalt or wood shingles, metal, and corrugated fiberglass. Once contractors have made the choices for style and material, they can install support for the roof. Support can be from an existing structure or from posts extending up from the ground or a platform. Roof framing includes installation of support beams around the perimeter of the roof that will support rafters. Special measuring and cutting techniques are required for roof framing because of the angles and dimensions common in each of these roof styles.

When framing is complete, the selected surface material is installed. Open-roofing materials are spaced and attached according to the desired pattern. Although fabric roofs may require less support, they still require sound attachment to anchor the fabric. Asphalt shingle roofs require the installation of sheathing and roofing felt over the rafters and special treatment of the edges and ridge to prevent moisture problems. Wood shingles also require sheathing or wood purlins and special ridge treatment. Both asphalt and wood shingles require starting and placing shingles in a specific pattern to ensure watertight installations. Metal roofs require the installation of purlins or sheathing onto which metal sheets are attached. Special edge and ridge treatments are necessary to prevent leakage and exposure of sharp metal. Framing for corrugated fiberglass requires spacing rafters to support the edges of fiberglass sheets and placing additional supports under the sheets. All roofing materials have specialty fasteners designed to effectively connect the material to the support framework.



SECTION 8

FENCES AND FREESTANDING WALLS

INTRODUCTION

The chapters of this section describe the construction materials and installation techniques for a variety of fences and freestanding walls. Chapter 32 covers fences made of prefabricated wood panels, wood rails, wood surfacing mounted on stringers (horizontal supports), chain-link, welded wire, decorative metal, and vinyl. Chapter 33 discusses freestanding walls that are made of basic materials: those that are stacked dry, such as fieldstone; those that are mortared together, such as stone, brick, concrete block, and cast-in-place concrete; those with stucco or veneered finishes; and those constructed of rammed earth.

PRECONSTRUCTION CONSIDERATIONS

Before installing any fence or freestanding wall, first locate the property lines. Do not rely on recollection or on the property owner's descriptions for boundary locations. You can more easily locate the property line than relocate the fence. Nor would the property owner wish to deed away the small strip of land the fence rests on after an error has been made. Property lines are based on legal descriptions, and a surveyor's expertise may be needed to locate the actual corner. Also, consider constructing the fence slightly inside the property lines to maintain a margin of error. Flagging the locations of all posts, gates, and openings before surveying will allow adjustments to be made before posts are installed.

When constructing fences and walls, the contractor must obtain permission from adjacent property owners for access to their land during construction. Minimal space is required to construct most fence or wall projects, but even a small encroachment may create problems. Always leave adjacent property clean and in good condition.

When construction documents do not dictate which surfacing must be selected for a fence, consider using a material that is finished on both sides. A fence that is visually attractive to all affected parties will be more readily accepted than one that pleases only the property owner.

SUSTAINABILITY SUGGESTION

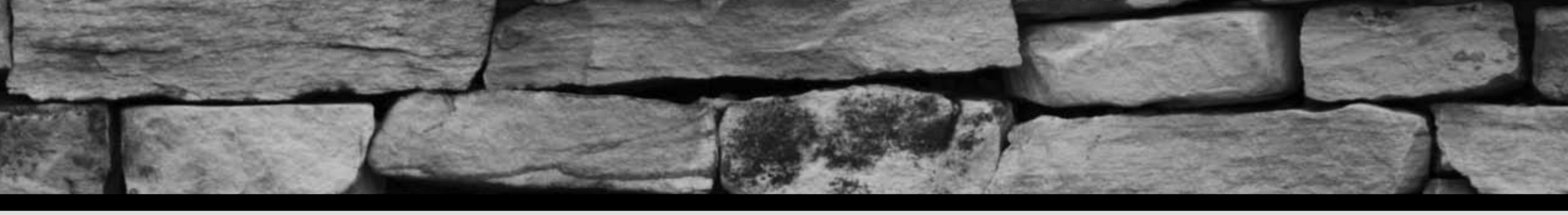
- Make use of recycled and reused materials before purchasing newly manufactured products. Recycled concrete, rammed earth, and recycled wood can create landscape features. These materials lend a natural look

of antiquity without using toxic chemicals to treat them or importing other materials from great distances.

PRODUCTIVITY SUGGESTIONS

The following suggestions may provide general ideas from which project productivity can be improved:

- With masonry, lay out the base course to verify the number of units required for a wall. Begin work by building opposite corners and stretch mason's line between corners to maintain alignment and elevation.
- Measure and flag post and gate locations before auguring holes.
- To improve the stability of chain-link fencing placed in areas exposed to high wind, replace a line post every 50 feet with an end post set in concrete.
- Before building custom gates, check the opening for square and accurate dimensions.
- Both sides of gates should be at the same level for the gate to function properly. Adjust the grade before installing posts.
- If you encounter permanent obstructions when installing posts for fences, trim the post bottom to match the hole depth. This approach should be used only for single posts over obstructions that will not move with frost or freeze upheaval. A minimum burial depth of 18 inches should be maintained.



CHAPTER 32
FENCING

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Plan the successful fence installation.
- Build a wood panel fence.
- Build a wood rail fence.
- Construct a chain-link or welded wire fence.
- Assemble a vinyl rail fence.

Because there is such a variety of fence types available, describing fence construction is a difficult task. Rather than explaining every possible fence pattern and facing material, this chapter discusses fence construction in general terms for the basic materials and methods available. Although this chapter does not cover every possible fencing material, it does provide information about the basic choices being used in the industry today.

Wood fencing offers the widest variety of options, with prefabricated panel fences, rail fences, fences with horizontal or vertical surfacing, and combinations of each of these styles. The first section of this chapter describes how to install posts and attach surfacing for prefabricated panel fencing. The second section covers wood fences constructed of horizontal rails. Horizontal rails are often left unsurfaced to create an open style of fence. Rail fences can also be modified by adding surfacing, such as **pickets,** boards, and other forms of vertical decoration to create a more opaque fence. The third section describes the installation of custom-built, wood-surfaced stringer fences with opaque surfacing. This surfacing requires the installation of stringers, or horizontal supports between the posts, for support. Chain-link, welded wire, decorative metal, and vinyl fencing are described in the fourth section of the chapter. Because its construction involves a specialized technique, chain-link fencing is a topic by itself. Welded wire, decorative metal, and vinyl fencing are also specialized applications that have unique installation techniques.

In projects guided by construction documents, the design will dictate surfacing patterns and installation procedures. The installation for every pattern of fencing is not described in this text, but close review of the design details will most likely reveal similar techniques used in the construction of most patterns.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Safety in the Workplace, Chapter 6
- Construction Math, Chapter 4
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Materials for Exterior Carpentry, Chapter 28
- Wood Decks and Platforms, Chapter 29

MATERIALS FOR FENCING

This section of the chapter covers the more commonly used materials for fencing. When the choice for materials is left open, the contractor should consult with the client regarding the pros and cons of each type of material.

Wood Prefabricated Panel Fencing

Wood prefabricated panel fencing creates an attractive perimeter for a lawn enclosure. Panel screen surfacing can be either horizontal or vertical or composed of both patterns to reduce monotony. Surface panels can also be custom-manufactured to tailor an environment visually or structurally. Compared to other fencing materials, wood panel is moderately priced and ranks as average in maintenance, requiring periodic refinishing and repairs. Installation requires basic carpentry skills and good planning. When creatively used, wood panels can traverse any slope and perform any function expected of fencing material.

Wood Rail Fencing

Because they are transparent and open, rail fences are typically used to define boundaries (Figure 32-1). Most rail fences are composed of two or three horizontal rails mounted into posts. Typical examples include **split rail,** woven board, and three-board fences. Variations of the rail fence include picket fences and other types, which add an open, vertical surfacing to improve the enclosure properties of the fence. Most rail fences are easy to install and the material is inexpensive. Based on the design style selected, aesthetics vary. Maintenance includes repair and resurfacing, with periodic restraightening of posts in frost-prone areas.

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Figure 32-1 Wood rail fencing.

Wood-Surfaced Stringer Fencing

Wood-surfaced fences are used primarily for privacy and screening. Although similar in appearance to prefabricated panel fencing, wood-surfaced fences differ in that they are custom-constructed using a design. The surfacing for stringer fences is spaced close together, rendering it more opaque than its rail counterpart (Figure 32-2). Usually taller than rail fencing, surfaced stringer fences are more expensive than panel or rail fences and require more carpentry skills to install. Maintenance and durability are similar to those of panel fencing.

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Figure 32-2 Wood stringer fencing.

Chain-Link Fencing

With its woven metal fabric stretched between a metal post framework (Figure 32-3), chain-link is a durable choice for securing the site's perimeter. However chain-link fencing typically requires some modification to make it more attractive. The components of chain-link can now be colored, and decorative slattings provide some aesthetic quality. Chain-link is available in a variety of heights, can be installed on flat and moderately sloped sites with minimal difficulty, and is relatively maintenance-free.

Welded Wire Fencing

Welded wire fencing has panels of heavy-gauge steel wire welded together in a grid pattern. These panels, along with the posts and hardware, are galvanized and either painted or powder-coated to provide color and durability. This produces an attractive fence that will survive for many years in exterior applications. Built of 0- to 6-gauge wire with squares that are 2 inches × 2 inches up to 4 inches × 8 inches, welded wire fences come in heights ranging from 4 to 8 feet. To help maintain rigidity, some panels have one or more angles or *V* shapes stamped into the cross section; and for sites that require additional security, the horizontal or vertical components of the fence can be doubled (Figure 32-4).

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Figure 32-4 Welded wire fencing.

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Figure 32-3 Chain-link fencing.

Decorative Metal Fencing

Decorative metal fencing plays an important role in historic and thematic landscape design. Metal fencing is manufactured of wrought iron or welded tubular metals such as aluminum and is constructed by installing panels between preset posts or standards (Figure 32-5). Decorative metal fencing requires a high level of effort and expertise for installation and may also require field painting. Considered high in aesthetic value, the fencing is also high in cost when compared to other fencing materials. Although decorative metal fencing separates spaces, it does little to screen unless covered by plantings. Metal fencing is average in maintenance, requiring periodic repainting.

Vinyl Fencing

A plastic product, vinyl fencing is available in simple residential patterns that mimic wood rail fencing (Figure 32-6). Functions performed by vinyl fencing are limited to boundary identification and

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Figure 32-5 Decorative metal fencing.

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Figure 32-6 Vinyl fencing.

possible enclosure. Costs are moderate but installation is relatively easy. Because it has limited patterns and colors, vinyl fencing offers little visual appeal; and some people consider the fencing unattractive. Maintenance is, however, very low.

PLANNING THE PROJECT

Patterns

Fence design is limited only by the contractor's imagination and by the materials used. Figures 32-7 and 32-8 illustrate some of the common fence patterns available.

Fence Alignment and Wind Resistance

As you might suspect, fences with solid panels are wind-resistant and can collapse during periods of high winds. Adding variations in alignment to a solid-panel fence increases its resistance to wind. For example, designing the fence with **niches,** or corners, in a serpentine alignment (Figure 32-9) and avoiding long, straight runs of fence will make these fences more wind-resistant. While building the fence, provide temporary bracing for support.

Layout

Begin a fence project by installing a stringline at the fence alignment (Figure 32-10). Using flags or paint markings, locate all posts along this alignment. Posts should be marked center to center. Locate any slopes where post pattern or length may have to be adjusted to step up the grade. Once you have set end posts, run a stringline from one end post to the next. This will provide a guide for setting the depth of posts between corners.

Fencing on Slopes

Although many fence types can follow moderate slopes without losing function and aesthetic appeal, other types require special planning and construction techniques when traversing hills. Wood rail and vinyl fences are typically installed with the posts vertical and the railing parallel to the ground line. On most grades, this requires little adaptation of construction techniques.

Chain-link fence is installed on slopes with an end post in concrete at both the bottom and top of the slope. This sloped section of the fence can be stretched separately from other fence sections. When installed on grades over 1:3 (1 foot of rise for every 3 feet of run), chain-link fence can be

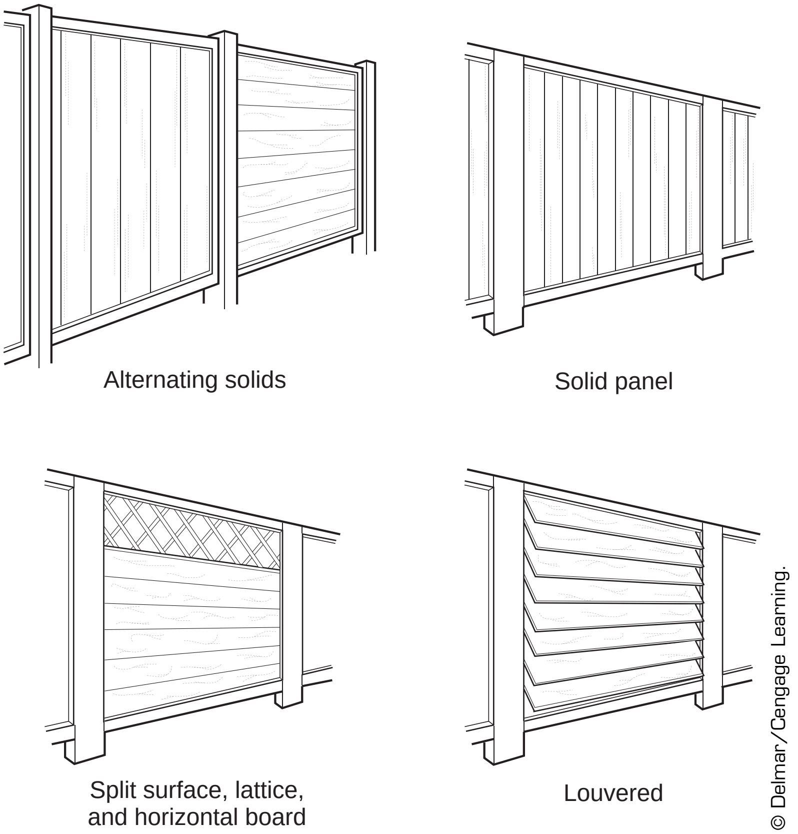

Figure 32-7 Common panel fence patterns.

"stepped" up slopes using techniques similar to wood panel fencing. To do this requires a great deal of special construction. Stepping chain-link up a slope requires end posts sunk in concrete along the rise of the slope to create horizontal panels. Depending on the steepness of the grade, the fence may have several short panels.

Wood panel and decorative metal fencing typically "step" along slopes of all degrees. Wood panel and metal fences are constructed with panels suspended between each pair of posts. To cover slopes, the posts are extended upward and the panels shifted up or down to match the grade. Wood-surfaced stringer fences are also constructed with stepped panels between posts. Stringers can be constructed level on shallow slopes or parallel to the grade on steep slopes (Figure 32-11). To keep children or animals from crawling under the panels, the surfacing for each of these fence types must be extended down to meet the ground.

Posts on a hillside should also be installed plumb and should have extra height. Do the measurements for extra height before setting any posts (Figure 32-12). To determine how much extra height is required, extend a level line from the ground line on the higher post to the lower post. From that point on the lower post, measure to the ground line. Add that distance to the normal height of the lower post. Use this process for each pair of posts on a slope until you have traversed the slope.

Maintenance Edges for Fences

Maintenance around fence installations can be a time-consuming chore for the homeowner or groundskeeper. When installing fences, consider adding a **maintenance edge** under the length of the fence to reduce the time and effort required to trim and weed. The maintenance edge is a 4-inch thick by 1-foot wide strip of concrete or stone over a weed barrier (Figure 32-13). After determining the fence alignment, use a sod cutter to remove a single strip of turf along the entire route. Install the maintenance strip surfacing after you have set the posts.

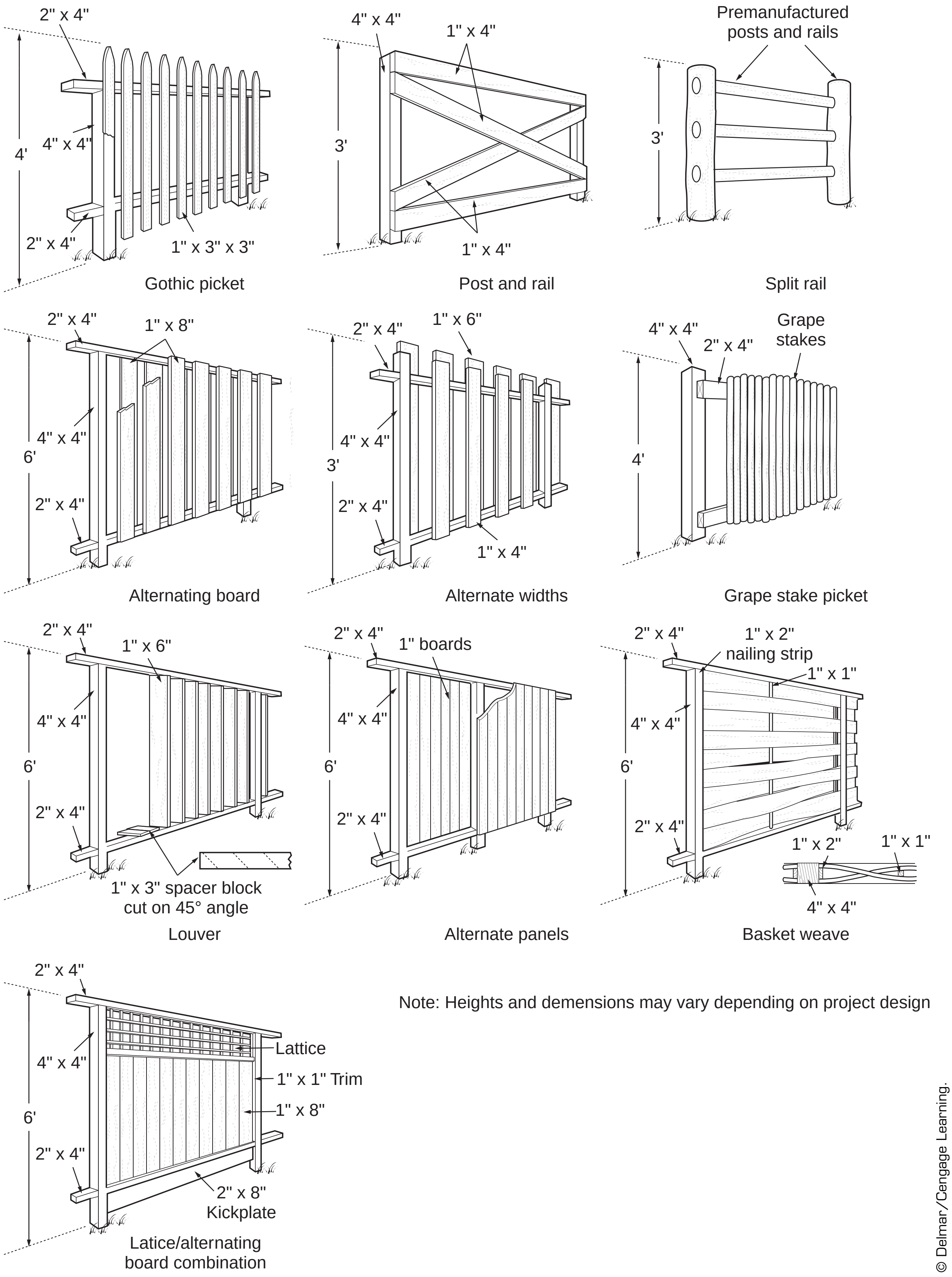

Figure 32-8 Common rail and stringer fence patterns.

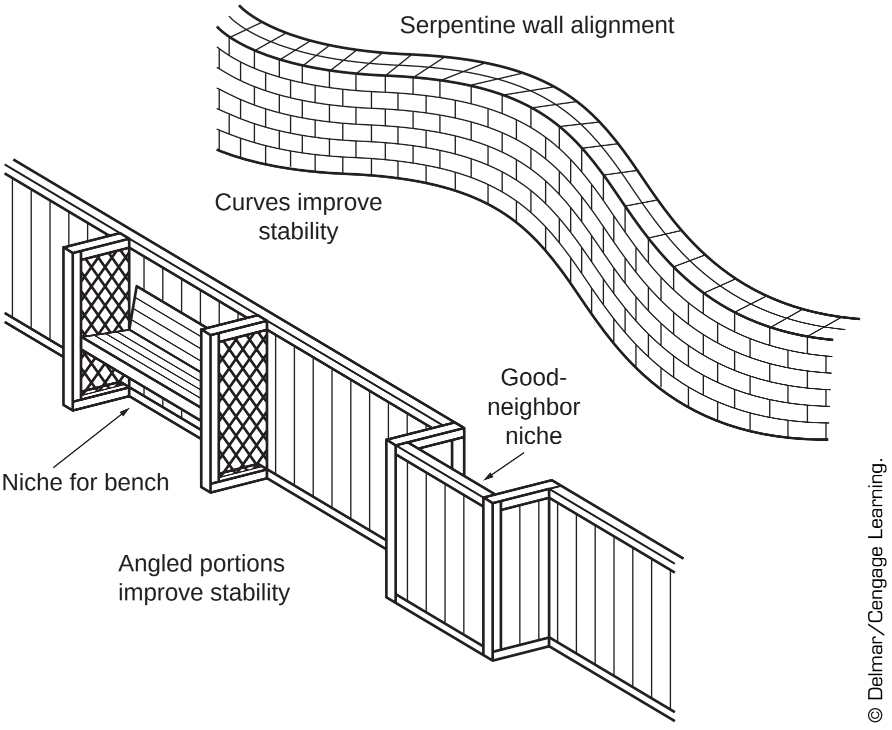

Figure 32-9 Fence alignment alternatives.

WOOD PREFABRICATED PANEL FENCE INSTALLATION

Wood prefabricated panel fences are constructed by installing posts and mounting the panels between the posts. Panels can be solid, opaque, or a combination of designs. Most panels are set in a framework that can be fastened to the face of posts or hung between the posts.

Post Installation

The spacing of posts for panel fences depends on the panel design and how the panel is to be attached. Face attachment requires different post spacing than hanging; review "Panel Installation" below before locating posts. Mark each post location carefully so minimal adjustment of panel length will be required during construction. Regular spacing along the entire length of the fence makes installation of the panels easier, but it may be necessary to install one smaller panel to accommodate any irregular distance left over. Although this small panel can be placed at any location, placement is less obvious at either end.

In the center of every post location, dig or auger a hole twice the diameter of the post and 6 inches deeper than the typical frost depth for your region, but a minimum of 2 feet for a 6-foot high fence. Install ground line protection for direct burial posts as described in Chapter 29 under "Foundations for Wood Landscape Structures." Post sleeves (Figure 29-9) can also be used for wood fencing if the sleeve is tacked or screwed to the post after setting.

Using a marker, draw a line near the base of the post that indicates the proper burial depth. Place crushed aggregate to the bottom of the hole and set posts in the holes. Adjust the post by adding aggregate until the mark is at finish grade. Begin placing backfill in the hole and tamp with a shovel handle. Recheck for height, plumb, and spacing between the posts when the hole is half filled and then completely filled. An alternate method for anchoring is to attach braces to hold the posts upright until all posts are set, then backfill with concrete. To save time with height adjustments, mark and set corner posts first; then stretch a stringline between the tops of corner posts to use as a guide for line posts (see Figure 32-10). If posts are too tall, trim with a circular saw. Refer to Figures 32-11 and 32-12 for placing posts on a hillside. You can also anchor posts on top of concrete footings or slabs, but you will need to provide additional lateral support to hold the fence upright.

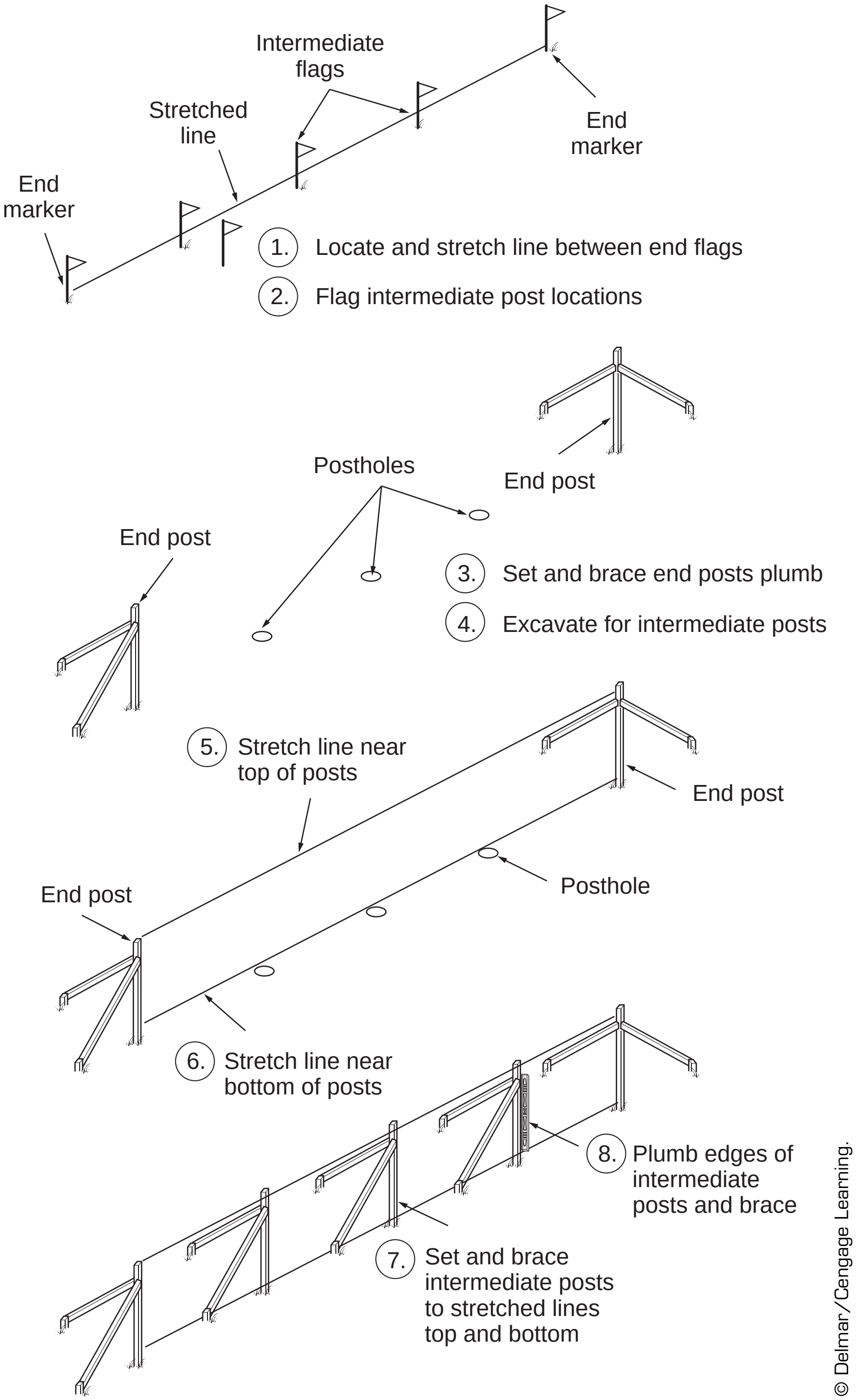

Figure 32-10 Post layout.

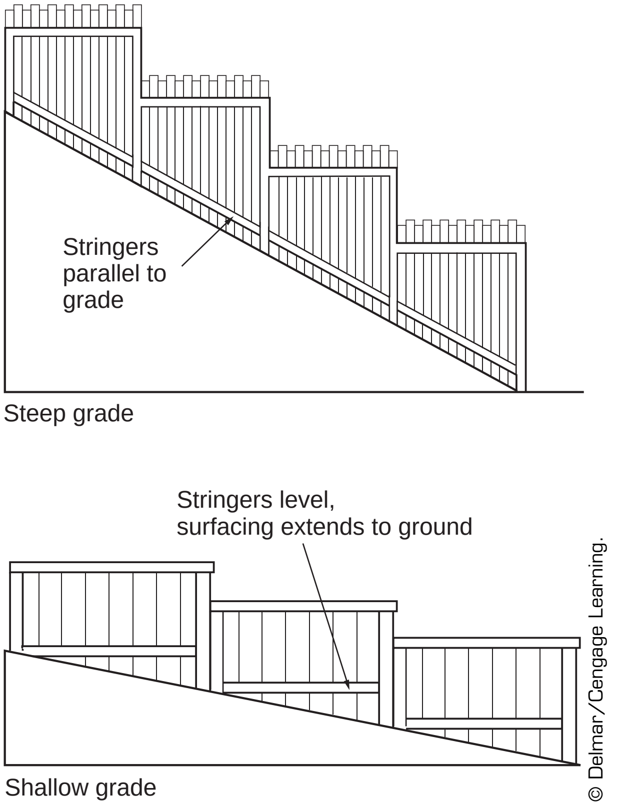

Figure 32-11 Stepping panel or stringer fence up hillsides.

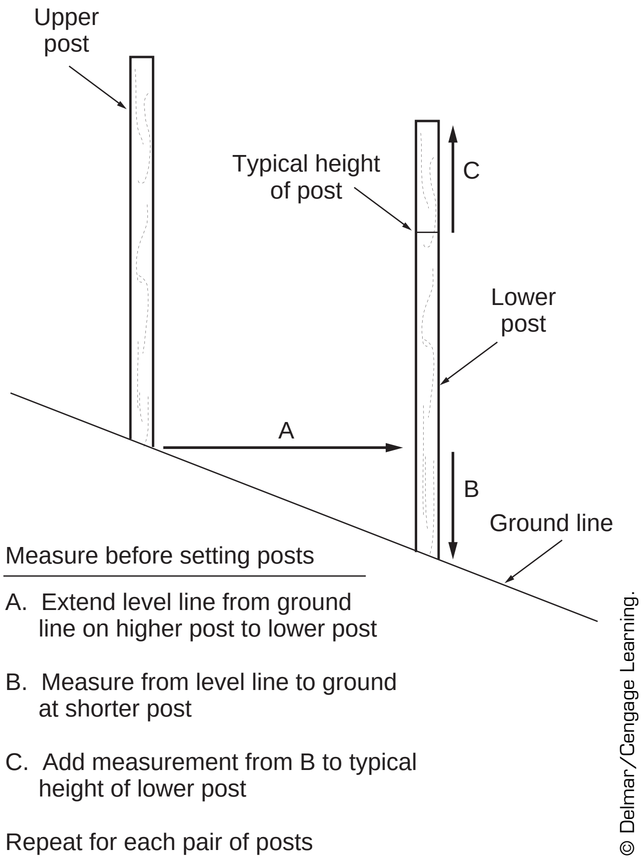

Figure 32-12 Determining post height for stepped fence panels.

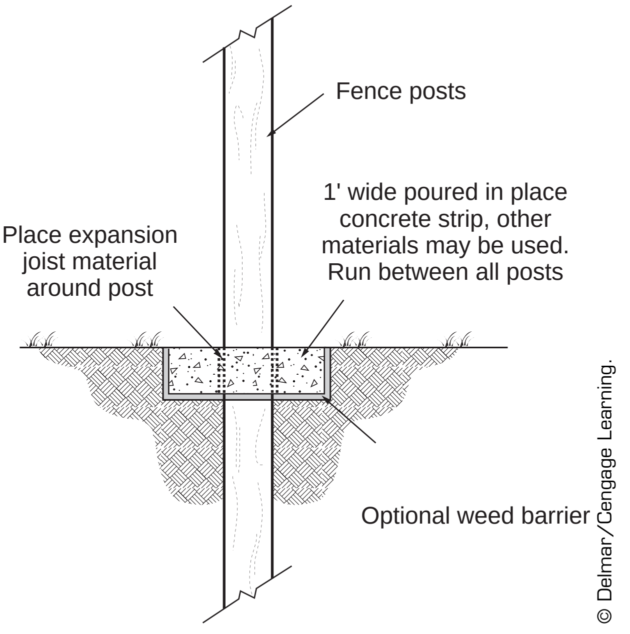

Figure 32-13 Fence maintenance edge.

Panel Installation

The preconstructed panels for this style of fence are typically attached between posts using metal hangers. Hold the panel in position to check for fit. If too wide, trim a small amount off the side of the panel using a circular saw. Mark the top location of all panels using a **chalk line.** Mark the location of the hangers on the sides of the posts. Install the hangers using 2-inch screws or 8d galvanized box nails. Slide the panel down between the hanger flanges. While holding the panel in the proper position and elevation, attach it to the hangers using screws or galvanized box nails slightly shorter than the thickness of the panels (Figure 32-14).

Another method for installing panels is to attach them to the front of the posts. This method requires spacing posts closer together during the initial phase of construction. To install the panels, hold them at proper height and attach them to the face of the posts using four deck screws per side.

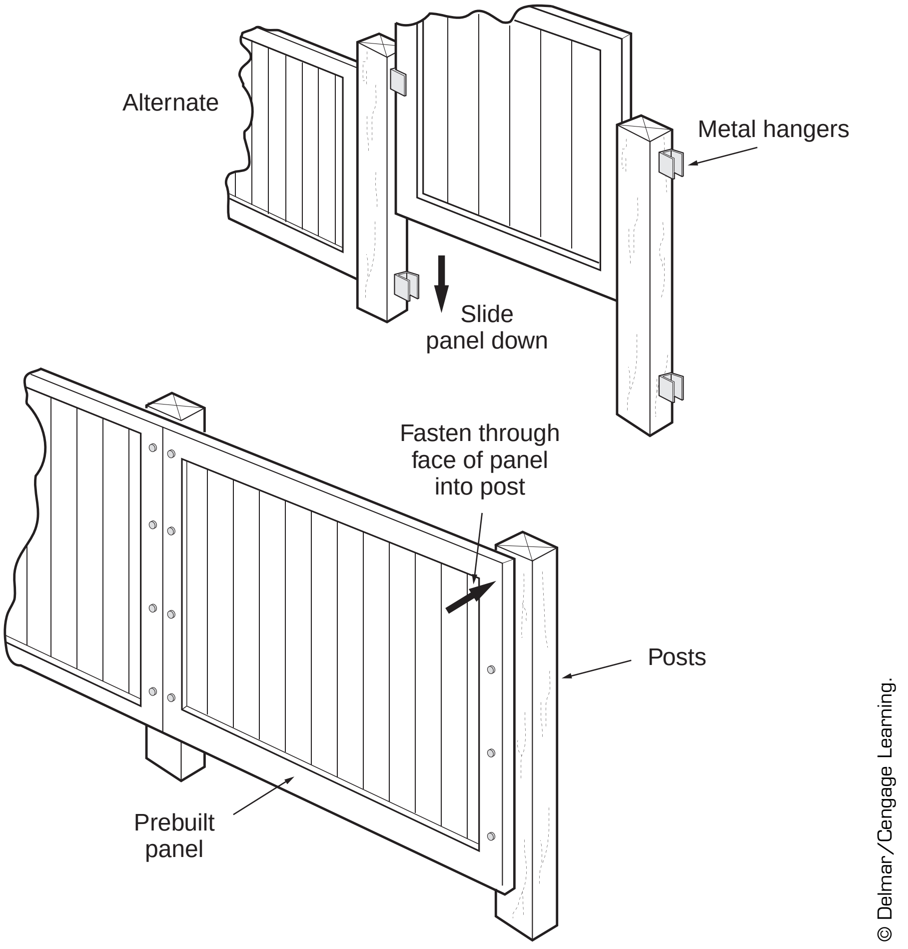

Figure 32-14 Prefabricated panel fencing, panel installation.

Trim

Trimming with panel fencing is usually not required. If panels are attached to the faces of posts, rather than mounted between posts, a piece of 1 × 4 trim with 8d box nails can be attached over the joint between panels to screen the post. Capping fences with 1 × or 2 × lumber that is slightly wider than the post and panels can hide the connections at the top. Bevel cut the caps and center them on the top of the post. Fasten using 8d nails or 2-inch screws for 1 × lumber or 16d nails or deck screws for 2 × lumber.

Gates

Gates are typically premanufactured for panel fences, leaving only the hardware attachment to complete. Attach the hinges and latch hardware to the gate panel and prop it in position in the gate opening. Connect the hinges to one post and check the gate for proper swing. Attach the latch hardware to the other post and adjust for proper closing. To hybridize between premanufactured and custom-built, metal frameworks to which custom surfacing materials can be attached are available for creating gates (Figure 32-15). Build a wood panel that matches the fence surfacing, then screw the panel to the gate hardware, and complete the installation with hinges and bracing.

For custom-built gates, measure the gate opening and check for square. From these dimensions, subtract hinge and latch dimensions plus an additional ¼ inch for a clearance margin. Construct a gate framework out of 2 × 4 material that matches the calculated dimensions. Add corner bracing or a diagonal brace made from 2 × 4s. Apply surfacing that matches the surfacing used for the fence. Attach the hinges and latch hardware to the gate panel and prop it in position in the gate opening (Figures 32-16 and 32-17). Connect the hinges to one post and check the gate for proper swing. Attach the latch hardware to the other post and adjust for proper closing.

Figure 32-15 Premanufactured metal framework for wood gates.

WOOD RAIL FENCE INSTALLATION

Wood rail fences are composed of posts with horizontal railings, such as split rail or board. Unlike prefabricated panel fences, rail fences must be custom-built with each component attached separately. Although this requires more labor during construction, it allows you to adjust the fence as the installation progresses.

Post Installation

The design and the material's strength determine the spacing of rail fence sections. Regular spacing along the entire length of the fence will make construction of the fence easier. If equal sections are not possible, you can use one small section to finish a run. With preengineered fence systems, the spacing is determined by the length of the rails provided.

Install posts in a manner similar to that used in panel fencing. Verify that posts are plumb (Figure 32-18). If posts are too tall, trim them with a circular saw. Except for split rail fencing, install posts along the entire fence perimeter. For split rail fencing, set only the end post and leave the remaining posts loose in the hole until you have attached the rails.

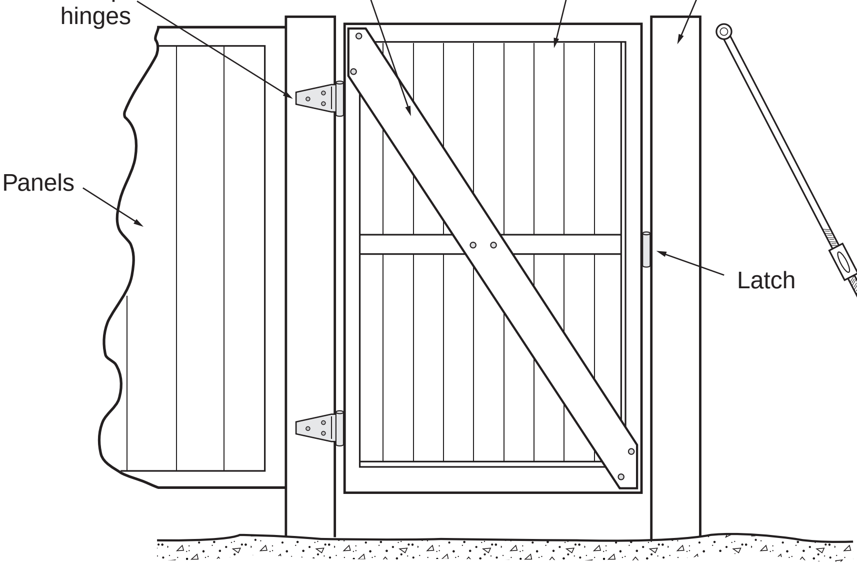

Figure 32-16 Prefabricated panel fencing, gate installation.

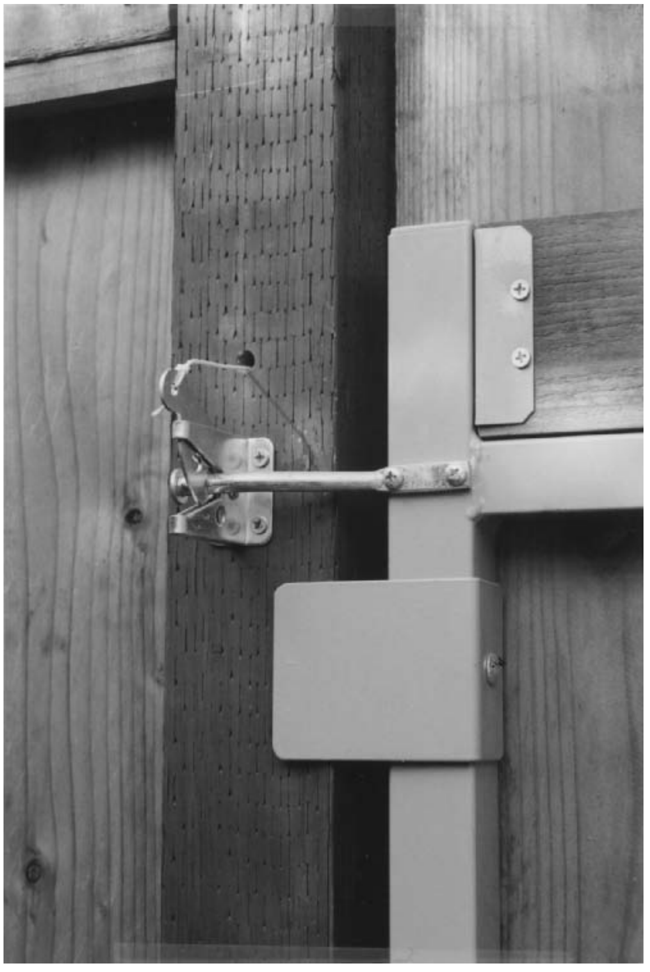

Figure 32-17 Gate latch hardware.

Figure 32-18 Rail/stringer fence post installation.

Posts installed on a hillside for split rail and three-board fences should be installed plumb and at the same height above grade as posts on level ground. Railings or face boards are placed at an angle between posts parallel to the slope. Determine the correct hole location by holding one of the rails between an installed post and the next post to be dug. Posts for other rail fences installed on a hillside should be installed plumb and have extra height similar to panel fences. The surfacing on this type of fence will be installed level between posts.

Attachment of Horizontal Rails and Surfacing

The variety of surfacing options for horizontal board fencing means that special techniques will be required based on the style selected. This section covers a variety of surfacing techniques suitable for wood rail fencing.

Split Rail. Split rail fencing has rails with tenons on the ends that fit into notches in the posts. Rails are installed parallel to the ground line. To install split rail fencing, one post should be firmly anchored and the second post left loose so that it can be moved, allowing the rail to be installed. Holding the second post at a slight angle away from the first post, slide the bottom rail into both posts. With the rail in place, pull the top of the second post toward the first post and insert the middle rail (Figure 32-19). Again, pull the top of the second post toward the first post and insert the top rail. When all rails are secure, pull the second post into a plumb position. Backfill and tamp around the second post. Repeat this process for the next set of rails and posts in line until you have set all posts et. To improve appearance in tapered rail fences, when the rail ends inserted on one side of the post are wide, match the rail ends on the other side of post with wide ends.

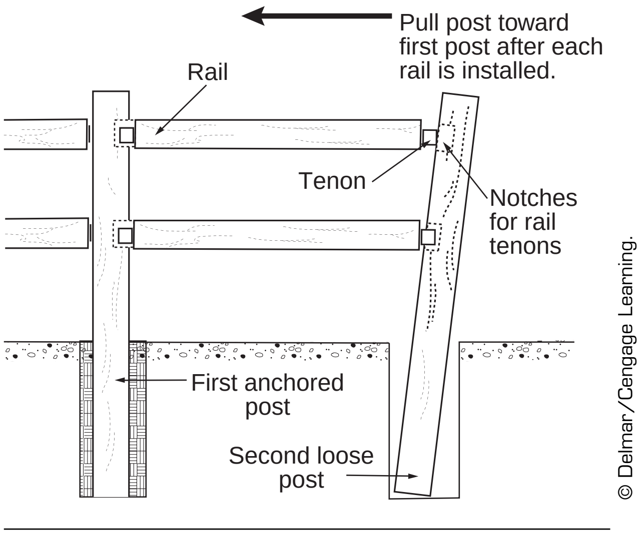

Figure 32-19 Split rail fence installation.

Board Surfacing. A traditional board fence has three or more boards installed parallel to the ground. Board fence surfacing is typically applied to the face of the post. All posts should be installed and secured before attaching face boards. Mark the location of the tops of each board using a chalk line stretched between end posts. Space the boards so that the top board is flush with the top of the posts and the other boards are spaced evenly down the rest of the post. Attach the boards to the face of the posts using two deck screws per board. Butt the boards together with a joint centered on each post. For installations on hillsides, you may need to trim the board ends to match the plumb of the post. Fences with a face board located flush with the top of the posts may require a cap that overhangs the front of the face board slightly.

Woven Board. Woven board fencing is installed level between posts. This surfacing requires lengthening posts on hillsides (see Figure 32-12). Woven board surfacing should begin at the top of the fence. Measure from the center front of one post to the center back of the next post. Cut a surface board (typically a 1 × 6 or 1 × 8, but other 1 × lumber can be used for variation) the proper length and set in front of one post and behind the next. Lift the board into a level position and tack it in place. Attach one end to the front of the post using two deck screws and the other end to the back of the next post in the same manner. For the next lower board, reverse the location, measuring and attaching from the back of the first post to the front of the second post. These locations are also reversed for each subsequent section along the fence run (Figure 32-20). Rounded posts make attachment easier. If square posts are used, consider attaching surfacing to a cleat attached to the post.

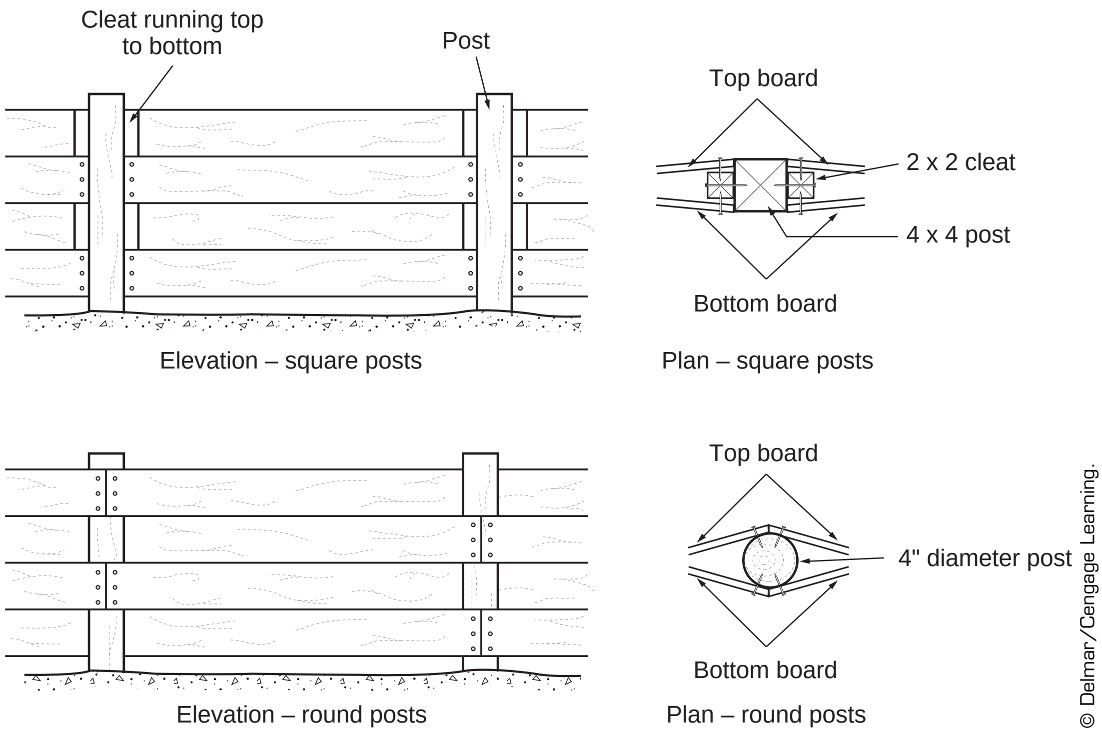

Figure 32-20 Fencing weave pattern attachment.

Pickets. Picket fencing is created by installing stringers between posts or to the face of posts, then attaching vertical boards, or pickets, evenly spaced along the surface with equal spaces between the pickets. Common materials used for pickets include 1 × 4s, 1 × 6s, 2 × 2s, and other dimensioned lumber and grape stakes or natural wood pieces (Figure 32-21). Construct the framework for the fence and install a stringline to mark the location of the top of the pickets. Use a spacer to maintain an equal gap between pickets. Attach the picket to the top stringer with one nail or screw, plumb the picket, and then fasten the bottom (Figure 32-22).

Balusters. Balusters are thin pickets installed on the face of the fence or hung from a top stringer. Typical balusters are 2 × 2s, often with at least one end bevel cut. To install balusters to the face of a fence, construct the fence framework and attach the balusters to the front. The alignment of the top may match the stringer or may extend above the top of the fence. Fasten at the top, plumb, and then the bottom. Maintain an even gap between balusters using a spacer.

Figure 32-21 Grape stake pickets.

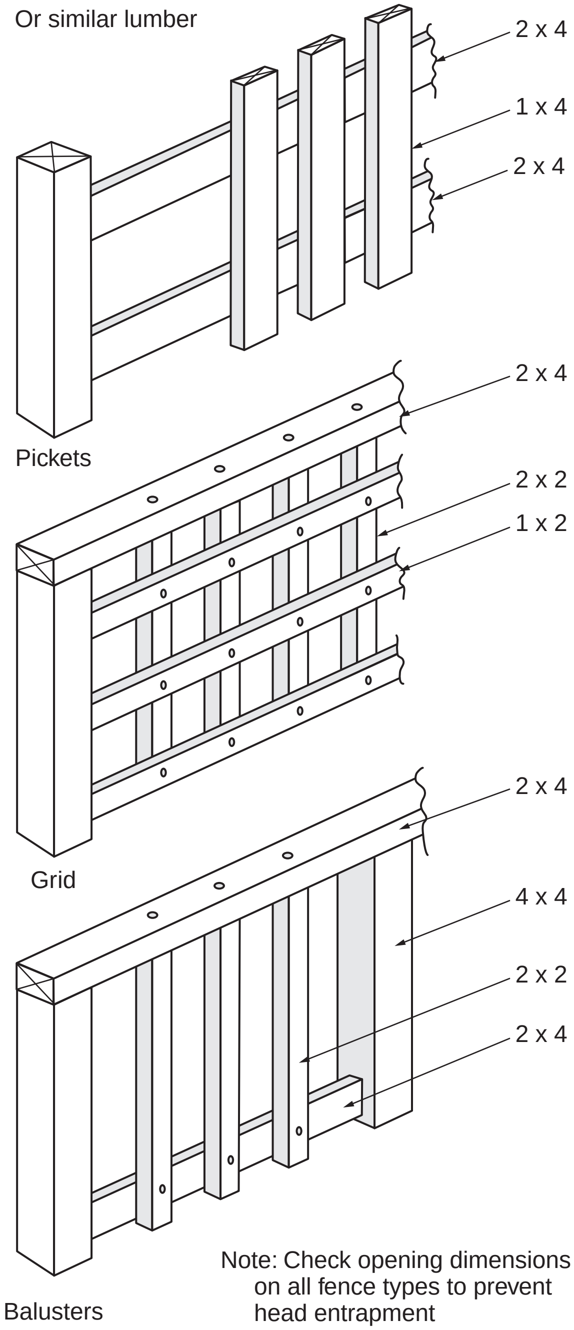

Figure 32-22 Stringer fence surfacing options.

When balusters are hung from the top stringer, mark the location of each baluster and insert a deck screw through the stringer into the top of the baluster. Plumb the baluster and fasten to the bottom stringer. Calculate the spacing of the balusters so they are evenly spaced between the posts. Hung balusters are typically trimmed at the top with a front trim and cap to hide the connection point (Figure 32-22).

Gridded Pattern. A gridded pattern can be attained by installing vertical balusters hung from stringers as described previously, then enhancing the look by

adding horizontal cross pieces. Install the balusters, and then fasten 1 × 2s or 2 × 2s horizontally across the face of the balusters using 2-inch screws. Space the horizontals evenly up the fence surface. You can install horizontal pieces across the face of the posts to add more interest, and you can trim the top to hide the connections (Figure 32-22).

WOOD-SURFACED STRINGER FENCING

Wood-surfaced stringer fences require the installation of horizontal structural members to support the surfacing. Post installation for this type of fencing should be completed in the same manner as that for panel fencing. Following completion of post installation, proceed with installation of the stringers and surfacing.

Attaching Stringers for Vertical Surfacing

Fences that have vertical surfacing require stringers between posts to support the facing at the top and the bottom. Fences over 4 feet tall may also require a stringer placed midway between the top and the bottom. Stringers attached to the face of the posts, as is the case with picket fences, use 2 × 4s or 2 × 6s attached flat to the posts. When stringers are hung between posts, use 4 × 4s. If a **kickplate** is installed, use 2 × 4s for the stringers (Figure 32-23).

To install stringers on the face of the posts, mark level lines between the posts using a chalk line. The top stringer should be placed at or near the top of the posts and the bottom stringer within 1 foot of the bottom. A middle stringer should be halfway between these locations. For each segment of the fence, measure the distance from the center of one post to the next. Stringers may run between several posts. Cut a stringer the measured length and attach it to the posts using two deck screws per post. Center joints over posts using butt joints. Install kickplates by cutting a piece of 2 × 8 (or wider) lumber the length of the fence panel. Mark the location for the top of the kickplate and toenail the piece into the posts. Use angle brackets to install the kickplate if the nailing locations are difficult to reach. Cut the 2 × 4 stringer the width of the fence panel, place it flat on top of the kickplate, and nail it into the kickplate and post.

Stringers can also be hung between posts as an alternative to attaching them to the face (Figure 32-24). To hang stringers, mark level lines for top, bottom, and, if necessary, middle stringers, on the posts. Install metal hangers on these marks, making allowance for the thickness of the lumber

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Figure 32-23 Kickplate for a wooden fence.

that will rest on the hanger. Hold a 4 × 4 up to one of the level lines and mark the distance between the posts. Cut the stringers to this length and set them on the hangers. Fasten at all locations (Figure 32-25). Although you can toenail the stringers to the posts, toenailing creates a weaker connection than using hangers.

Attaching Vertical Surfacing

Place a stringline along the fence run at the height of the top of the fencing material. Measure and cut surface material for the fence. If placed on the face of the stringers, attach the surfacing at the top using a deck screw and check for plumb. Finish attaching the surfacing at the top and at the bottom using two deck screws per stringer (Figure 32-26). Vertical surfacing on the face can be extended up to 1 foot above or below the stringers, but extensions longer than this tend to warp. If vertical surfacing is designed with spaces

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Figure 32-24 Angle brackets used to support fence stringer.

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Figure 32-25 Fence stringer attachment for vertical surfacing.

between boards (such as alternating board or picket fences), use a **spacer** to maintain consistent spacing along the entire fence run. Plan the spacing so that a board or picket is placed over the support posts.

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Figure 32-26 Fencing vertical surfacing attachment.

Alternative vertical surfacing may require different preparation before attaching materials. **Grape stake** surfacing should have pilot holes drilled at each location where surfacing will contact a stringer. Use deck screws to attach grape stakes. Stockade fencing is typically attached without a space between surfacing pieces. Vertical louvered fencing is constructed with only a top and bottom stringer. The location and angle of each louver is marked on both the top and bottom stringers, then a spacer block of 2 × decay-resistant wood is attached with deck screws along each mark. Trim any portion of this block that extends beyond the stringers. Attach the louvers to the block at the top and the bottom with two 2-inch deck screws at each location.

Lattice surfacing should be trimmed to match the opening of the panel and attached to the stringers and support posts using 6d galvanized nails. Trim must be placed over the lattice to prevent wind from dislodging the surfacing. To provide proper support for lattice, space horizontal and vertical supports no more than 2 feet in each direction. If lattice is to be

inserted from the face of the fence, rip cut stringers to a narrower width.

Trimming

To improve its appearance, 1 × trimming material can be installed at the top, on posts, and at corners of a fence. Measure and cut the trim using bevel cuts and attach using 8d box nails (Figure 32-27).

Installing Gates

Gates for wood rail fences should be constructed using the same procedures described in the "Wood Prefabricated Panel Fence Installation" procedures.

CHAIN-LINK FENCING

Because of its increasing popularity, chain link fencing has a wide range of easy-to-install parts, fixtures, and accessories. These ready-made components have made the construction of chain-link fencing a task that landscape contractors can perform (Figure 32-28).

Figure 32-27 Wood fence trimming.

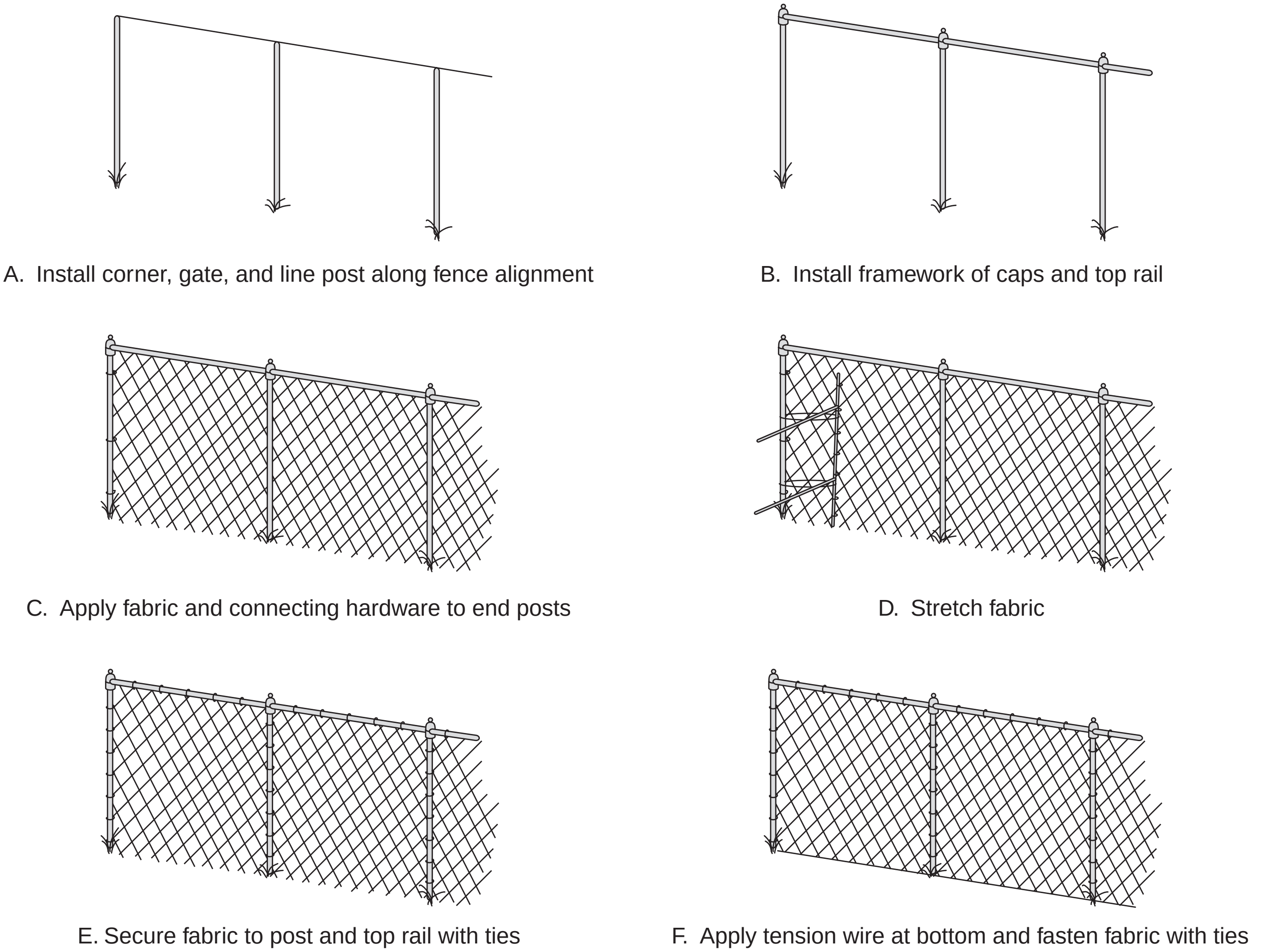

Figure 32-28 Chain-link fence installation.

Corner/End/Gate Post Installation

Excavate an 8-inch diameter hole to frost depth, or a minimum of 2 feet for a 6-foot high fence, at each corner and gate post location. Use an auger or dig by hand. Mark the correct burial depth on posts using a permanent marker (Figure 32-29). Fill the holes with a stiff concrete mix and set the corner/gate posts in the hole. If the posts sink, remove them and wait 15 minutes. When the concrete has hardened enough, the post will set in the footing and will not sink. Bounce the post down to the mark and check for plumb. Repeat for all corner and gate posts. Recheck for depth and plumb every 15 minutes for the next hour, adjusting the posts if necessary. You can also brace the post in position using a support system of 1 × 4s (Figure 32-30). Wait 48 hours for the concrete to completely set before continuing fence construction. At locations where posts are set in a slab, box out the post location while you form the slab (Figure 32-31).

Line Posts

Between the tops and the bottoms of corner posts, connect a stringline for the alignment of the fence. Using a fence post driver, drive a **line post** at each location marked along the alignment (Figure 32-32). Check often for plumb and alignment. Typical spacing for panels is 10 feet, but spacing can be reduced to maintain even panel dimensions.

An alternative to driving the line posts is to dig or auger 6-inch diameter holes and place the posts in the holes. Partially backfill the holes with gravel and

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Figure 32-29 Marking on corner post indicates proper setting depth.

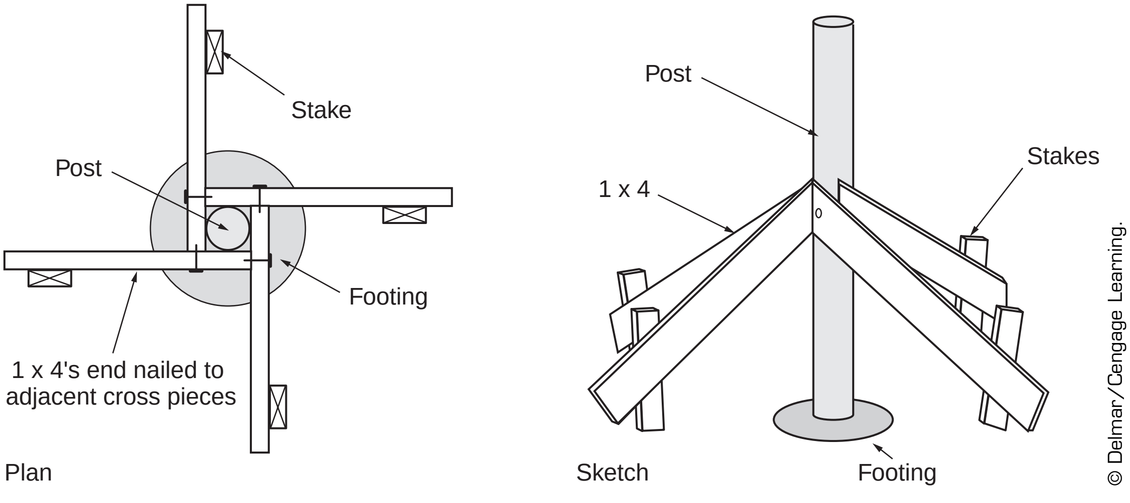

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Figure 32-30 Supporting fence posts installed in concrete footings.

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Figure 32-31 Chain-link fence post set in concrete. Concrete slab was poured earlier and a box out left in which the fence post and footing could be placed.

adjust the height to match the stringline. Check for level in each direction and continue to backfill with soil. Compact the soil after every 6 inches of fill. Line posts can also be set if concrete in a manner similar to end and corner posts.

Framework

The framework of the fence includes the railing that runs across the tops of the posts, a **tension wire** that runs across the bottom of the fence, and, in some cases, a **mid rail** for reinforcing. The **top rail** is installed using special caps, whereas the mid rail and tension wire are installed using brackets with special hardware that bolt to the posts.

Install the special caps on each corner, gate, and line post. Corner post caps, which fit on top of the end posts, have openings that accommodate the end of a railing, whereas the line caps slip on top of line posts and have an opening through which the railing runs. Top rail has a tapered end designed to join with additional sections of top rail. Beginning at one end of the fence, slide a section of top rail through the line post caps and place the nontapered end into one corner post cap (Figure 32-33). Place a second section of top railing through the next line post caps and join with the first section. Continue

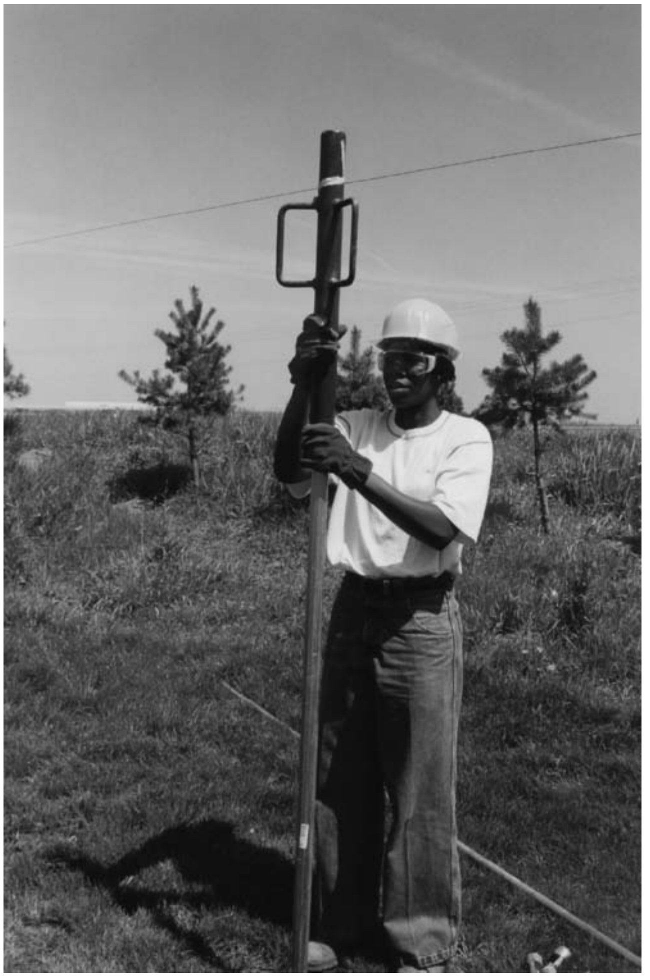

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Figure 32-32 Chain-link fencing line post driving.

placing top rail until a section passes over the corner post at the other end of the run. Hold the top rail against the corner post cap and mark where the end of the rail will meet the back of the opening in the cap. Using a reciprocating saw with a metal cutting blade, cut the top rail at the mark. Lift the corner post cap and insert the cut end of the top rail in the opening. Lower the cap back on the corner post. Continue installing the top rail on all fencing runs.

A mid rail is installed on tall fences for stability and at each panel adjacent to corners and gates for any fence over 4 feet tall. Begin mid rail installation by loosely bolting the rail holder fitting around the corner post at approximately mid-level. Measure and cut a piece of top rail that will fit between the corner and first rail posts. The measurement must take into account the fitting on each end. Insert the cut rail into the first fitting and slip a second fitting over the other end. Clamp this second fitting around the first line post. Tighten the rail holder fitting at the first post. Repeat this process for every panel that requires a mid rail.

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Figure 32-33 Chain-link fencing top rail installation.

Fabric Application

Surfacing is installed by stretching chain-link fabric between the corner posts and bolting it to the posts. The maximum run for stretching fabric by hand is approximately 100 feet. Fabric that is stretched by hand can be pulled between 1 and 1½ feet over this distance. Hand-pulled fabric will fit loosely and sag slightly over time. It is not uncommon for fabric that is stretched tightly by hand to be stretched another 1–2 feet using jacks or mechanical **stretchers.** Stretch fabric from either side of the fence posts over straight runs; at curves, stretch the fabric around the outside of the posts along the curve. If the fence runs up a slope, set the corner posts at the top and bottom of the slope and stretch separately for this section.

Begin surfacing installation by rolling the fabric out along the fencing run. Lean the fabric against the posts to roughly determine the length needed (Figure 32-34). At one end of the run, insert a stretcher bar through the first loop of the fence. Fasten clamps around this stretcher bar and the corner post. Install one clamp for each foot of fence height. Stretch the fabric as tightly as possible by hand along the entire run. Mark the link 2 inches back from the end post. For hand-stretched fabric, this is where you will disconnect links to create the fabric end. For mechanically stretched fabric, add an additional 2 inches for every 10 feet of fence being stretched to locate the new end of the fabric.

Return the fabric to the ground to disconnect a link at the point where you determined the new fabric end. To disconnect, straighten the bend at the top and the bottom of the link (Figure 32-35). With a twisting motion, spin the disconnected loop out of the fabric to separate the fencing (Figure 32-36). To lengthen the fabric and/or join pieces of fabric, overlap loops of the fabric and place a **stretcher bar** through this overlap (Figure 32-37). A more attractive

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Figure 32-34 Chain-link fencing fabric layout.

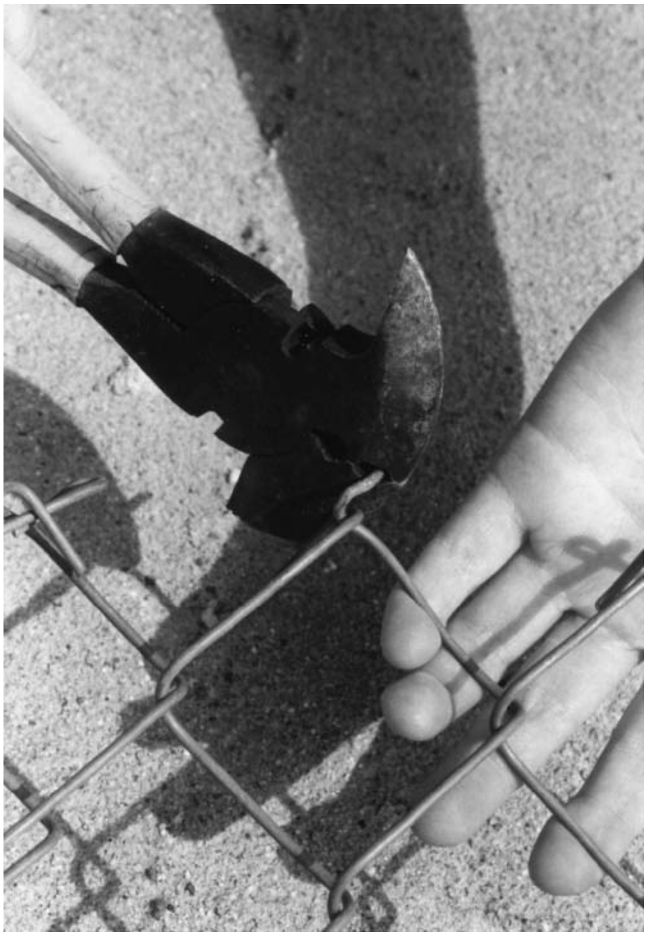

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Figure 32-35 Disconnecting top link.

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Figure 32-36 Chain-link fencing separating links.

splice is achieved by using a single link of fabric to join two pieces. Overlap the pieces and start weaving this link from top to bottom using a rotating motion. When you have joined the pieces, twist a bend in the top and bottom of the link to prevent unraveling.

Prepare for stretching by measuring 24 inches back from the new end of the fabric. Locate a loop at this point and insert a double stretcher bar. Attach a jack around the corner post and to the double stretcher near the center of the fabric. Slowly jack the material toward the second corner post (Figure 32-38). Lift and drop the fabric in a bouncing motion while stretching to free the material from any hang-ups along the ground. When the new end of the fabric reaches the corner post, insert a single stretcher bar through the last loop in the fabric and install clamps around the corner post and stretcher bar. Install one clamp for each foot of fence height (Figure 32-39). Loosen and remove the jack and the double stretcher bars from the fabric. Tall fences may require placing two jacks, one near the top and the other near the bottom of the fabric to stretch it evenly.

Install the tension wire by first attaching the clamps around the base of each corner post. Connect the tension wire to one clamp and stretch tightly between the two corner posts. Attach it to the clamp at the base of the second corner post.

Attach the fabric to the top rails, posts, and tension wires using aluminum fence **ties** (Figure 32-40). Work from the side of the fence framework opposite the fabric. Place the hook end of the tie over a strand of the fabric. Holding the hook in place, use one finger to bend the tie around the post or rail. Push the straight end of the tie back through the fabric and bend it around a strand of fabric. Repeat every 2 feet on posts and every 4 feet along the top rail and the tension wire.

Gates

Gates require that a framework be measured and constructed on the ground and then "hung" from a gate post. Install hinge hardware on one gate post. Check the opening for square and measure from this hardware to the edge of the other gate post. Cut pieces of top rail to match this measurement and the

Figure 32-37 Installing stretcher bar to join sections of fabric.

Figure 32-38 Chain-link fencing stretching and connecting fabric.

Figure 32-39 Chain-link fencing hardware, showing top rail, post cap, stretcher bar, and connector clamps.

Figure 32-40 Chain-link fencing connecting fabric to fence with ties.

gate height. Allow for hardware connections when measuring and cutting the rail. Connect the pieces using gate corner clamps. Install a mid rail in the gate for bracing. Hand stretch and attach fabric with ties over the gate framework. Install the latch and gate hardware on the gate and set it in place.

Preassembled gates are also available from many suppliers. Verify the dimensions of the gate with hardware before setting gate posts. Install hardware and hang the gate in a manner similar to installation of a custom-built gate.

Privacy Slatting

Several manufacturers make plastic **privacy slatting** that can be woven into the fabric of chain-link fence for additional screening. One style uses strips of vinyl or metal that are woven diagonally into loops, using friction to hold them in place. Another style requires that a plastic channel be fed horizontally across the bottom loop of the fence. Vertical slats are then slid down each of the loops and slipped into this channel. A second channel is fed across the top of the vertical slats to lock them in position.

WELDED WIRE FENCING

Installation of welded wire fencing involves two primary phases: post installation and panel installation. Using techniques similar to chain-link fence installation, landscape contractors can accomplish both steps with planning and careful execution. If cutting of posts or panels is required, perform such operations using a cutoff saw with a metal blade. After completing the installation, touch up any damage to the panels, posts, or hardware with a zinc-rich primer and rust-resistant paint that matches the color.

Post installation

Although most are square, posts for welded wire fencing can also be round or custom-manufactured shapes. Sizes can range from 2–4-inch diameter/square and 14–20-gauge. Typical sizes for residential installation are 2-inch diameter/square 16-gauge posts. Most manufacturers recommend burial of the posts in concrete footings for a secure installation. An alternative installation is to use sleeves into which you position the posts after installing the concrete. Mark the location of each post, based on the length of the panels being used plus the hardware dimension. Excavate each hole a minimum of 4 times the diameter of the post and at least 6 inches deeper than the bottom of the post. Terminal, corner, and gate posts may require additional depth for installation. Pour concrete into the excavation, insert the post into the concrete, and position the post plumb and at the correct height. Post height should be adjusted to accommodate stepping up or down slopes. Anchor each post until the concrete has cured (see "Corner/End/Gate Post Installation" under the Chain-Link Fencing section).

Panel Installation

Panel installation hardware typically comes in three styles: wraparound brackets with retaining plates, U clamps with retaining plates, and customized connectors that fasten directly to the post. For wraparound and U-style brackets/clamps, the connector holds a single panel at the end or corner of a run or a panel on either side of the post for in-line runs (Figure 32-41). If panels meet and there is no post, install a retaining plate at the front and back side of the material to join panels. Hold the panel level and fasten it to a post by placing the connector on the backside of the panel material, retaining plate on the front side of the panel material, and threading the bolt through the openings in the connector and the retaining plate. Tighten securely enough, but not completely, to hold the panel in position. Install other connections at the top and bottom of the panel and at posts on both sides. Check for level and adjust if necessary; then tighten all connectors for the panel securely. When installing the panel in an adjacent section, you may need to slightly loosen the connector to install the neighboring panel.

Some manufacturers make posts and panels that require no external hardware. These posts/panels may have hardware already welded to the post or may have notches in the post in which the panels are installed. With specialized installations, verify the spacing of posts before installing concrete; this is a critical step. Only minor variations in spacing are allowed; otherwise, the panels will not fit. To avoid spacing issues, connect the first panel to posts on each end and pour concrete with the panel attached. Once the concrete has cured, attach another panel and post and pour concrete for that post. Continue this process along the entire length of the fence.

Gates

Gates for welded wire fencing are premanufactured and typically have pinned hinges and latch closing hardware. Extra depth is typically required for gate posts to maintain stability. Install the gate posts plumb and with the correct spacing, and then

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Figure 32-41 Wraparound connector holding welded wire panel to post. Special bolts reduce vandalism.

attach the swinging hardware to one side and the closing hardware to the opposite side.

DECORATIVE METAL FENCING

Decorative metal fencing is assembled in a manner similar to wood panel fencing. That is, posts are set in footings, and preengineered panels are connected between the posts.

Footing Installation

Metal fencing requires concrete frost footings for each corner post and may require concrete footings for every post. Verify with the manufacturer or supplier the type, size, and depth of footing required for posts with a particular fence. To install footings, auger a hole to the required depth centered at each post location. Form the top 6 inches of the footing with a box frame or tubular paper form. The spacing and level must be accurate because the fence panels cannot be adjusted to match post locations. Fill each hole with concrete and smooth the surface with a wood float. Insert the anchor bolts supplied with the fence in the top of the footing. Before the concrete hardens, verify the correct dimensions between anchor bolts in each footing. You can make minor adjustments at this point, not after the concrete has hardened. Wait 48 hours before proceeding with fence construction.

Post Installation

Post units should fasten directly to the anchor bolts installed in the footings (Figure 32-42). Place the posts and hand tighten the nuts to allow for flexibility when installing panels. Brace posts to hold them in position until you connect the panels.

Panel Installation

Begin installation of panels at corners or gates. Connect the premanufactured panels to the posts at the top and check the panels for level. Adjust if necessary and tighten the panel connections. Complete the connections at the bottom.

Gates

Gates for decorative metal fencing should come as prefabricated units or kits. Assemble any necessary parts and install the hinge and latch hardware. Hang the gate from the hinges and adjust as necessary.

Finishing

Fencing may come from the factory as primed units that require field painting. This approach minimizes damage to the finish from shipping and

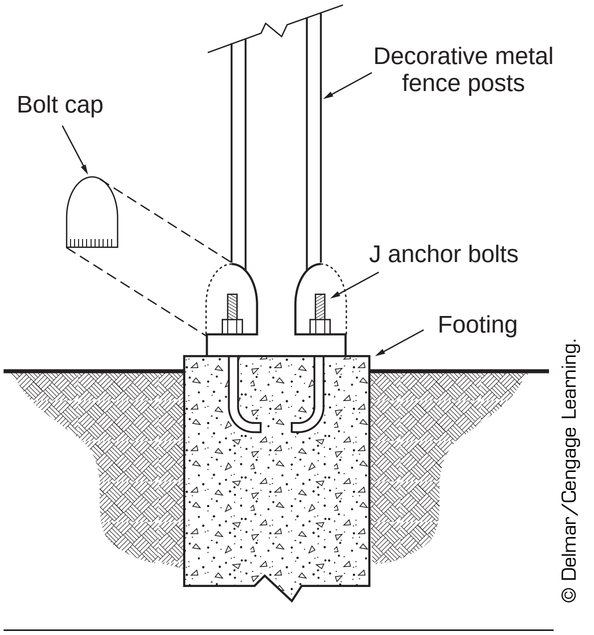


Figure 32-42 Decorative metal fencing footing to post connection.

allows the customer to choose custom finishes and colors. If field finishing is required, install all fencing components and mask any items such as hinges or clasps that will not be painted. Place a drop cloth behind, below, and in front of the fence. Use an airless paint sprayer to apply the finish color. Follow manufacturer's instructions on type of paint and proper preparation of surface. Apply paint on a very still day when there is no expectation of rain for 24 hours. Be cautious of any overspray and its potential to damage buildings, vehicles, and any landscaping in the immediate area.

If the fence is shipped prefinished, touch up any damage that occurred during shipping or installation. Determine the exact paint type and color from the manufacturer before performing any touch-up work. Sand the damaged area and apply paint evenly to match the existing finish.

VINYL FENCING

Most vinyl fencing includes posts with prepunched holes and horizontal rails that are installed between posts. Prefabricated panels, which are hung between posts, are also available. Installation of vinyl fencing is similar to the installation of horizontal wood rail fences with posts properly spaced and the rails installed beginning from the bottom. A special crimping tool may be required to notch the ends of the rails, whereas other fence styles use brackets or connecting pins placed in predrilled holes.

Vinyl fences are typically custom-built with each component attached singly. Although this requires more labor during construction, it also allows you to adjust the fence during the course of the project. Some manufacturers recommend that the fence be installed one panel at a time, with a post set in concrete, the panel installed onto that post, a second post set loosely in the hole, and the panel attached to that post. The second post is then set in concrete, and the process repeats until you have installed the entire fence. Although this method allows adjustment of the fence for length and at gate openings, it is a slower installation method than fastening all of the components and setting posts in a single operation.

Post Installation

Spacing of posts is determined by the length of the rail material and fence design. Regular spacing along the entire length of the fence makes construction of the fence easier. With prefabricated fence systems, the spacing is determined by the length of the rails or panels provided.

Mark each post location carefully so minimal adjustment of segment length will be required. Dig or auger an 8-inch diameter hole the burial depth of the post over every post center location. Using a marker, draw a line near the base of the post that indicates the proper burial depth. Insert posts into the holes and check the post holes for proper depth at this stage, but do not backfill or anchor posts in holes until after you have installed the rail (Figure 32-43). If posts are too tall, you must remove them and deepen the excavation. If the post is set too low, you must add granular material to the hole to raise the elevation. Special posts are manufactured for corners and ends of runs; and to strengthen corner and gate posts, clip together two #4 rebars using spacer clips at the top and bottom; then slid into the post. Stiffening post sleeves that slide into the post are also available from some manufacturers. Verify that the proper post has been selected for line runs and for gates and corners.

On a mild slope, install posts for rail fences plumb and at the same height above ground level as posts on level areas. Place rails at an angle between posts, paralleling the slope. Determine the correct spacing by holding one of the rails between an installed post and the next post to be dug. Abrupt changes in slope are difficult to accommodate using rail sections over 8 feet in length. You may need to cut rail sections and install an extra post to handle a transition from one grade to another.

Figure 32-43 Vinyl fencing post installation.

Figure 32-44 Crimping vinyl fence rail with crimping tool.

Rail Installation

Providing the surfacing for a vinyl rail fence involves the installation of either long rails, spanning several posts, or short rails, spanning only between two posts. Each installation method is covered below.

Long Rail Vinyl Fences. One style of vinyl fence has long rails that span between three posts. Most of these brands of vinyl fencing use rectangular openings in a post through which the rail section can be inserted. Using the **crimping** tool, notch the rail at one end on all sides (Figure 32-44). If the rail uses locking pins, insert a pin at one end of a rail (Figure 32-45). Slide the unnotched or unpinned end of the bottom rail through the bottom hole of the middle post and push it through until the notched end is adjacent to the first post (Figure 32-46). Insert the rail into the bottom opening of the first post. Repeat this process with the middle and top rails.

When the three rails are installed in the first and middle posts, crimp the opposite end of the rail, or install locking pins, and install in the appropriate

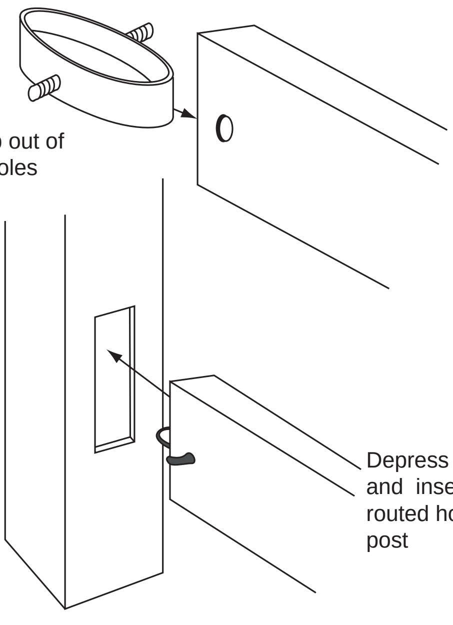


Figure 32-45 Locking pins for vinyl fence components.

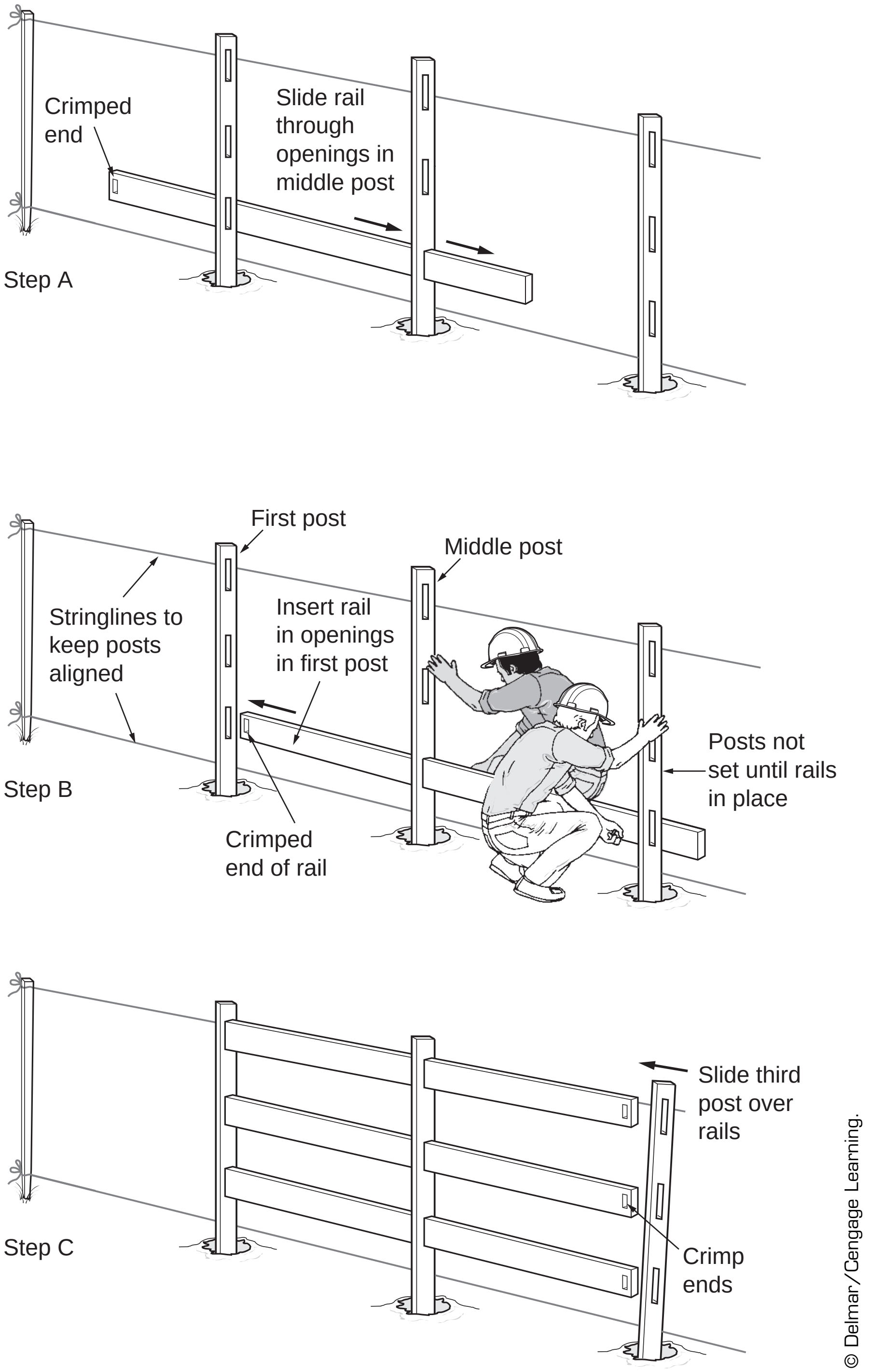


Figure 32-46 Installing vinyl fence rail through post.

openings for the third post. The posts should be loose in the hole when performing these operations; then backfill half of the hole after all rails have been installed to hold the posts in place. Repeat this process for the next rail section, using the third post in the previous segment as the first post for the next unit. The rail section should not extend beyond the center of the post into which it has been inserted. If minor length adjustments are required, trim the rail with a hacksaw.

Rail Vinyl Fences. A second style of vinyl fence has shorter rails that span between two posts. Begin installation for fences that use short railings placed between a pair of posts by crimping all sides of both ends of the rails for one section. If locking pins and predrilled holes are used, crimping is not necessary. Place one end of the bottom rail in the first post. Place the other end in the second post, holding the top of the post angled away from the first post. Insert the second rail in the first post and then in the second, pulling the top of the second post closer to the first. Place the third rail in the first post and in the second post, pulling the second post into a plumb position. Backfill half the hole around the second post and move to the next panel.

Panel Installation

Fences that are designed to use panels, rather than rails, for the surfacing between posts may be provided with a variety of methods for fastening panels. Many manufacturers recommend the use of metal brackets that are screwed to the posts, with the panel slid down into the brackets. Screws are then inserted through the brackets into the panels to hold the surfacing in place. Some fence types will combine rail installation with panels to create decorative effects. In these installations, rails at the bottom are installed first with the panel set into or on the top of this rail. A second rail is then installed on top of the panel.

If there is additional decorative lattice work or trim, a second panel may also be set on top of the second railing with a third rail installed at the top of that panel. Rails and panels may be fastened to posts using brackets, but often the rails are inserted into prerouted holes in the posts and held in place with pins, while the panels are hung from brackets or slid into openings on the rails (Figure 32-47).

Anchoring Posts

When all rail material has been installed, the posts can be set. To save time with height adjustments, stretch a stringline between the corner posts to use as a guide for line posts. The stringline should match the burial mark made on each earlier post. Check the post for plumb by holding a level on adjacent sides of the post. Backfill the holes and tamp with a shovel handle. Recheck for height and plumb when the hole is half full and completely filled. An alternative to soil backfill is to set posts in concrete. Anchor posts beginning at one end and work consecutive posts until you have set the fence posts.

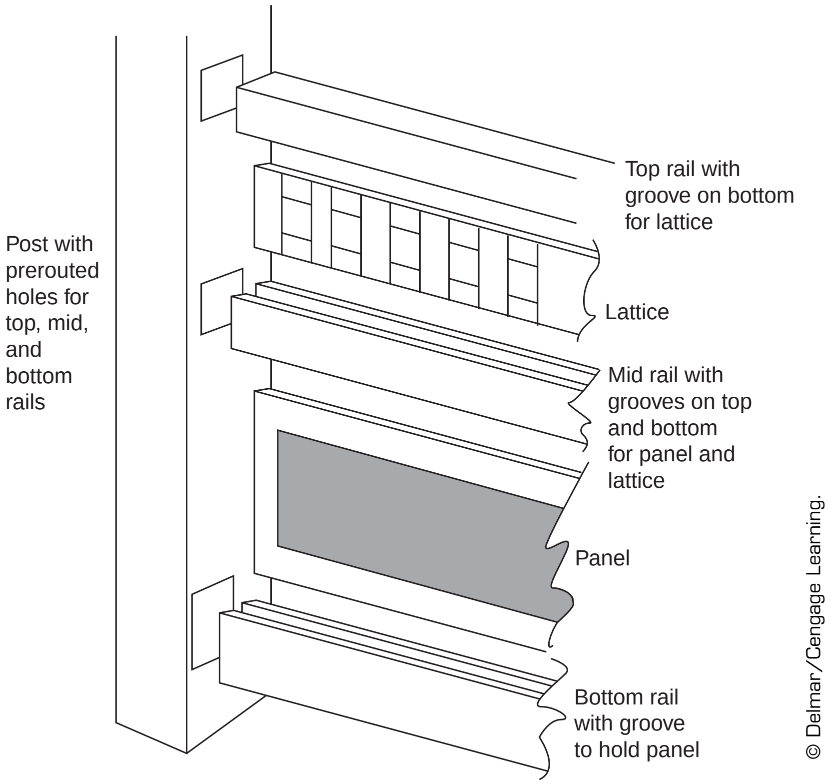
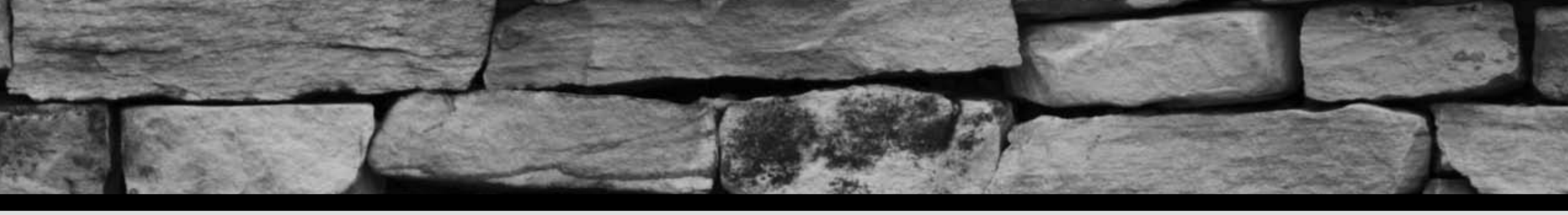


Figure 32-47 Diagram showing vinyl fencing components. Components interlock with each other and slide into prerouted holes in posts.



CHAPTER 33

FREESTANDING WALLS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Plan the successful installation of a freestanding wall.
- Prepare the foundation for a freestanding wall.
- Build a dry-laid stone freestanding wall.
- Construct a freestanding wall of masonry units.
- Pour a cast-in-place freestanding wall.
- Build a rammed earth wall.
- Apply a stucco or veneer surface to a freestanding wall.

When space separation is required but the design dictates a more substantial look, a freestanding wall may be the best choice. The freestanding wall incorporates the benefits of a fence with the permanence of a landscape wall. Although it is expensive and time-consuming to construct, the freestanding wall adds a strong sense of permanence to a site.

Freestanding walls should not be confused with landscape retaining walls (see Section 5). Both retaining walls and freestanding walls require special construction techniques to maintain stability, but their construction is for very different reasons. Retaining walls endure pressure from the forces of soil and water behind the wall, whereas freestanding walls must overcome the force of wind to remain upright. Freestanding walls typically do not retain soil and do not require drainage accommodation. If these conditions exist on all or part of a wall, the design must be adjusted to address these forces.

This chapter provides construction details for installing several styles of freestanding walls. **Fieldstone,** or rubble, walls use stacked stone to recreate the look of antiquity and history in design. Masonry walls consist of manufactured materials mortared together to create visually pleasing barriers. Cast-in-place concrete provides a durable installation and, with additional work, can be an attractive space divider. Most stable freestanding wall materials can be coated with stucco or veneer to add color and texture to a plain installation. Sustainability concerns have led to an increase in rammed earth walls, a durable mixture of soil and cement. In addition, any wall construction can be used for installing piers or columns used to identify entries, to mount signs and lights, and, occasionally, to anchor posts in wood fence construction. Piers can also be constructed simply of rubble-filled cages when a quick temporary marker is required.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6

- Basic Construction Techniques and Equipment Operation, Chapter 7
- Mortared Paving, Chapter 26

MATERIALS FOR FREESTANDING WALLS

Many material choices exist from which walls can be constructed. Included below are some of the common choices.

Dry-Laid Fieldstone (Rubble) Walls

Fieldstone, or rubble, is irregular-shaped round or rectangular stone that is weathered by natural forces. When used in rustic, rural settings, fieldstone walls are one of the most attractive landscape additions available (Figure 33-1). They are primarily used for boundary identification, with separation and enclosure being additional functions. A contractor must be a skilled craftsperson to place stones in a stable, yet appealing, pattern. Maintenance requires occasional reconstruction of wall segments.

Masonry Walls and Piers

Many common building materials (stone, fieldstone, brick, block, and adobe, for instance) can be attractively used in a masonry wall and piers (Figure 33-2). Although they are expensive and require a great deal of expertise to construct, masonry installations perform all functions required of fencing with a high level of aesthetics. Masonry walls and piers require little maintenance.

Cast-in-Place Concrete Walls

Durable walls can be constructed of concrete poured into vertical forms, or **cast-in-place.** Finishes that can be applied to concrete walls include bush hammering, sandblasting, and **stucco** or **veneer.** Concrete walls can also be left unfinished or cast with special integral aggregates or decorative **form liners** (Figure 33-3).

Rammed Earth

The ancient technology of mixing soil, water, and a binding agent and compacting it into place to form a wall has returned to the landscape as an alternative that uses local and other available materials. Creating a rustic surfaced wall that has extreme durability and few environmental impacts, rammed earth walls can be finished with stucco or painted to enhance its appearance. PISE, or pneumatically impacted stabilized earth, a more contemporary twist on the concept of rammed earth, uses a similar mixture that is sprayed onto forms with a low slump, allowing installers to continue their work without constantly moving formwork. PISE construction is not covered in this text because it requires specialized equipment and techniques to install.

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Figure 33-1 Rubble wall.

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Figure 33-2 Stone masonry wall.

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Figure 33-3 Cast-in-place concrete wall cast with a form liner.

Stucco and Veneer-Finished Walls

Specialized finishes of stucco and veneer can be applied over walls constructed of wood frame, precast concrete, and masonry to achieve a variety of visual effects. Stucco, a cement mixture spread in a single heavy layer or several thin layers over a prepared surface, can be colored or finished with a variety of surface textures (Figure 33-4). When selecting stucco products for exterior landscape applications, choose Portland cement stucco rather than EIFS (exterior insulation foam systems) products. EIFS is a waterproof acrylic product more suitable for building structural components, other than landscape posts and walls, that require insulation.

Veneer is a layer of decorative surfacing material applied to a wall using mortar. Typical veneers include brick, stone, and a variety of cultured materials that resemble brick and stone. Veneer layers can be the full thickness of the surfacing material or can be a thin layer of the material laminated to the wall surface.

Rubble Cage Piers

When a boundary marker or entry pier is required but there is no time to build a masonry or other

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Figure 33-4 Stucco-finished wall.

form of pier, rubble stone can be placed loose inside a rounded cage constructed of heavy-gauge wire fencing. Although it requires little craftsmanship, the rubble cage does provide a quick and functional pier of natural materials.

PLANNING THE PROJECT

Beginning a masonry wall with a detailed design will reduce the number of field decisions and problems encountered during construction.

Masonry Patterns

Although fieldstone typically employs a random pattern, several common arrangements are possible for masonry walls. Figure 33-5 illustrates some of the patterns available to the mason.

Masonry Wall Thickness

Most masonry walls using concrete block and wall stone are constructed the thickness of a single material, or **wythe.** A single wythe of these materials often provides adequate strength and wind resistance to keep the wall upright. Brick is typically constructed using a double wythe to provide the necessary stability. These two wythes periodically have a unit running perpendicular between the two as a bridge, or reinforcement, that ties both wythes together. This bridging course, called a **header course,** is common in brick wall construction. A third choice for masonry installations is a veneered wall. A veneer is a single wythe of a concrete block, or other backing material, and a single wythe of brick or stone veneer. Veneer can be placed on one or both sides of the backing block.

Freestanding Wall Shape and Wind Resistance

Because they are impermeable to wind, freestanding walls are subjected to extreme wind load. Strong winds can blow with enough force to topple a tall wall if precautions are not taken to counter these forces. The most common countermeasure is to avoid long, straight sections of wall. With corners or piers added to its structure, a freestanding wall gains significant wind resistance. Adjusting the alignment of a wall by adding a few niches or corners may also prevent the wall from toppling. Although it provides some wind resistance, a serpentine alignment increases the construction difficulty.

DRY-LAID FIELDSTONE (RUBBLE) WALLS

Properly installed dry-laid fieldstone walls represent the best of the landscape contracting palate. Both science and art come together in the preparation and construction of this landscape classic.

Preparing the Base

Lay out the wall using a stringline (or hose/rope for curved walls) along the alignment. Grade preparation for fieldstone walls requires installation of a stable granular base. Excavate a base trench 6 inches deep and 12 inches wider than the wall width along the entire wall alignment. Fill the base trench with granular base material and compact.

As an alternative to a granular base, select large stones and bury them for a base. Place these stones in an excavated trench below grade and lay them with the flattest sides oriented upward.

Placing Stone

Sort stone for use in appropriate courses, reserving the largest flat stones for a wall cap. Stone walls are assembled by hand, laying one course at a time along the length of the wall. Sides should be vertical for walls 4 feet tall and less and have a batter of 1 inch per foot for taller walls. This batter will require widening

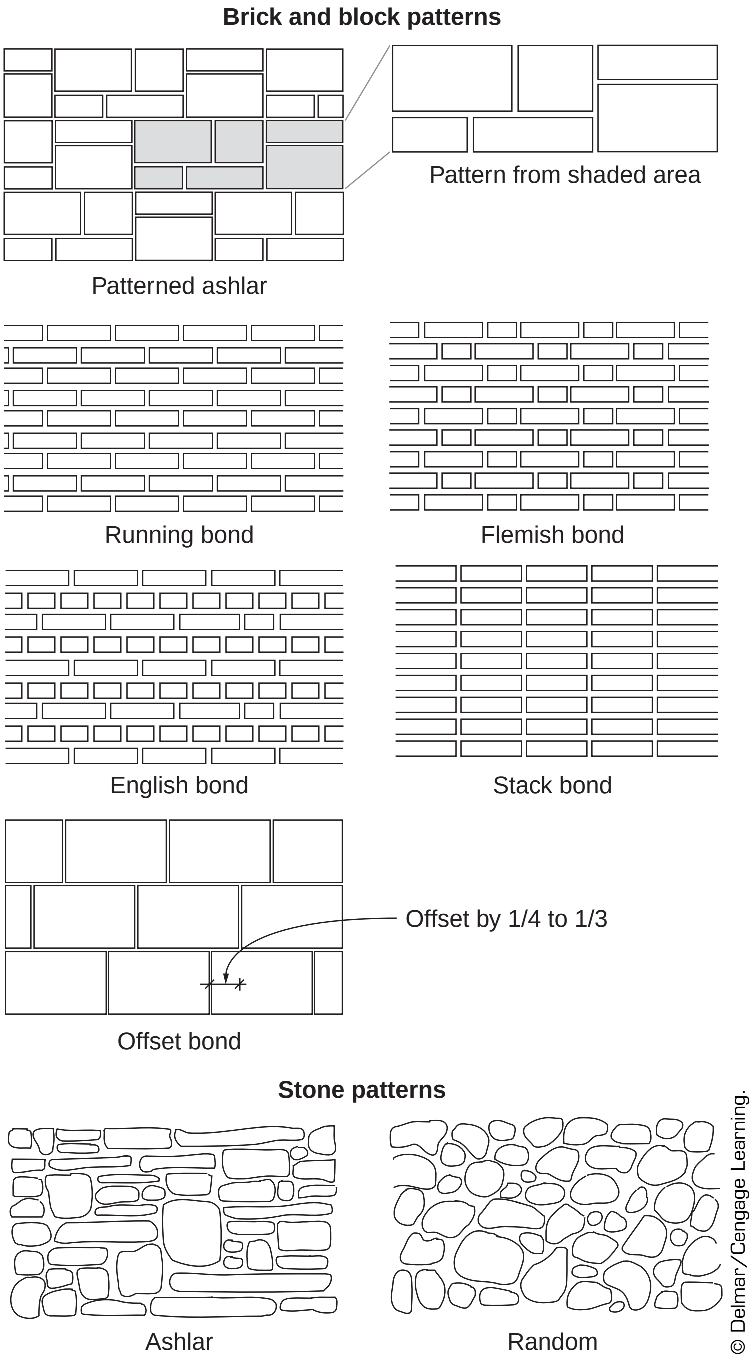

Figure 33-5 Masonry wall patterns.

the base so the wall face can taper back on both sides. The minimum width for a stone wall over 2 feet tall is two wythes. Walls may benefit from slightly battering, or angling, the bottom stones of each wythe slightly inward at the base (Figure 33-6). Rounded stone may require a pyramidal cross-sectional form for the wall. In walls with wide bases, use the most attractive stone for the outer wythes and fill the center with rubble and less workable pieces (Figure 33-7).

Working with stone requires patience and a visualization of how each piece will fit with other pieces (Figure 33-8). Find a nice flat surface to face outward along the wall face. If a stone does not fit with those below, try shaping the surface using a stone hammer. Use small flat pieces to shim under those stones that do not fit perfectly. To enhance the wall's artistic nature, review the techniques for stone placement outlined for dry-laid stone walls in Chapter 19 (see,

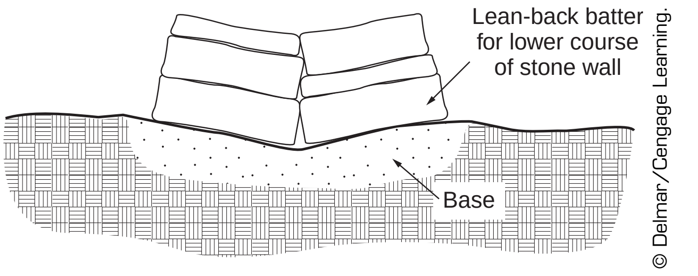

Figure 33-6 Lean-back batter aids the stability of stone walls.

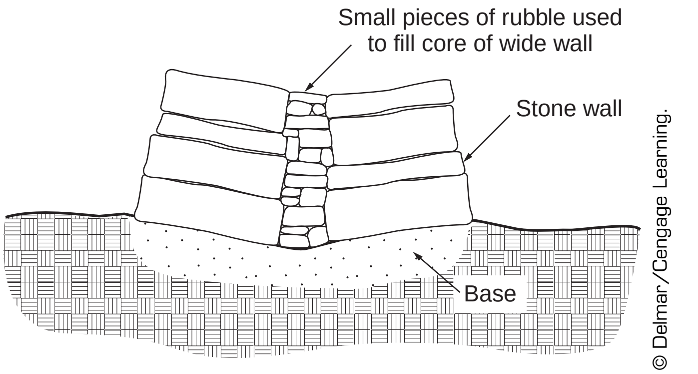

Figure 33-7 Small pieces of rubble can be placed in the center of a wide stone wall.

in particular, Figure 19-7). You can use the same techniques to enhance freestanding walls.

The most attractive placement of the stone is in horizontal courses that are of uniform thickness along most of the wall's length. Courses should be primarily composed of stone that is of a similar thickness; but of interest, you can create short segments by stacking several thin stones. The regularity of the wall can be varied occasionally by placing a taller/larger stone that interrupts the course(s) above. Every 5 feet (more or less) in every other course, place a stone perpendicular to the wall face to tie the courses together (Figure 33-9).

Stepping the courses when the grade rises or falls is preferable to following the grade along the wall alignment. Begin placement at the lowest point of the wall and build courses up to a point where the wall steps. Raise the base and continue with the next course on top of the previous wall courses and the new base. Avoid placing stone in locations that create vertical joints. Stone in an upper course should bridge two or more stones from the course below, and the ends should be at least 4 inches from a vertical joint in the lower course if possible.

Curved walls with tapered edges can be constructed by selecting and placing stone. If the curve is concave, place the narrower end to the outside of

Figure 33-8 Rubble wall stone placement.

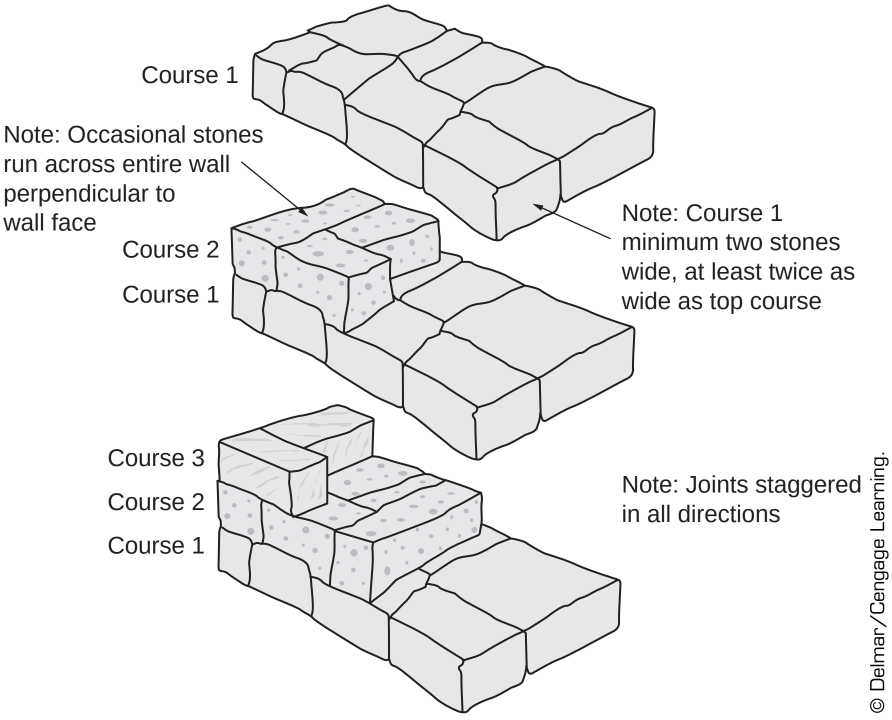

Figure 33-9 Dry-laid stone wall layout of base course and subsequent courses.

the wall; if convex, place the narrower end to the inside of the wall.

When building corners, be certain to interlock the courses as you place them. The last stone for the course entering the corner from one direction should be a longer stone that stretches from the corner deep into the wall well down the other direction. The next course should alternate that arrangement. Complete the wall by installing the reserved capstones. These stones should be large enough to cover all wythes and provide a slight overhang. You may have to perform some shaping to obtain a good fit for the caps.

MASONRY (STONE, BLOCK, AND BRICK) WALLS AND PIERS

Combining the beauty of unit materials with mortar creates a wall that provides durability and presentable aesthetics throughout its life. Stone and brick masonry walls are prized for their attractiveness, whereas block walls provide a less-expensive alternative with several surface treatment options.

Constructing Footings

Successful masonry walls and piers require a stable base to prevent settling and movement. To prepare a stable base, pour a 6-inch deep footing that is 1 foot longer and 1 foot wider than the footprint, or base dimensions, of the proposed wall (Figure 33-10). (Revisit Chapter 23 for information on forming and pouring the concrete slab that serves as the footing.) Reinforce the footing with three #4 rebars running the length of the footing. Finish the surface of the footing with a rough broom finish to provide a surface that will key well with mortar.

Any conduit or plumbing that is required as part of the wall should be installed prior to pouring the footing. Place the conduit so that it projects above the footing in the correct location to the approximate height required for any fixtures. The mason will make final adjustments as the wall is constructed. Cover the ends of the conduit or pipe with duct tape. Pier construction requires preparation and installation similar to that for walls. Before the slab sets, install anchor bolts at the correct locations to tie concrete block and brick walls to the footing.

Performing Layout and Preparing Materials

Prepare the footing to accept the mortar by scrubbing off all debris with water and a broom. When dry, use a chalk line to mark two straight lines

Figure 33-10 Masonry pier footing installation showing bond chasing and anchor bolts placed when foundation was poured.

4 inches in front of the face of the proposed wall. These guidelines will serve as reference marks for alignment of the first course of the wall. When constructing walls using brick or concrete block, carefully measure the wall dimensions and mark beginning and ending positions on the footing. Lay out the brick or block without mortar (a process called **chasing a bond**) to verify dimensions before you start mortaring. Because brick and concrete block cannot be cut like stone to aesthetically fit small voids, your measurements must be precise.

Prepare materials to be used before beginning the wall construction. Clean off any old mortar and discard broken or damaged items. When using brick, be certain that halves are available before you begin laying them. Lay out a variety of stone to speed the construction of a stone wall. Dip the stone in water for a short time before installation; this prevents the stone from drawing moisture too quickly from the mortar. Also, if the stone draws too much water from it, the mortar will dry more quickly, potentially reducing its strength.

Mixing and Placing Mortar

After you have prepared all materials, you can begin mixing the mortar. Typical mortar types for exterior wall applications are S and N. Instructions for selecting mortar are explained in Table 26-1. Refer also to mortar mixing for paving in Chapter 26.

Applying the mortar to the masonry units will take some practice. Use a pointed mason's **trowel** to apply mortar. When placing mortar on the base or the top of a masonry unit, pick up a trowel full of mortar and apply the mortar to the material with a light slapping motion. At first, you may find mortar application difficult; but with practice, you will learn how to place mortar exactly where it should be placed. When applying mortar to the sides of a masonry unit, a slapping motion prevents mortar from sliding off when the unit is held upright. Apply mortar generously to fill the joints since any extra will be squeezed out when you place the unit.

When placing concrete blocks, be aware that they have a top and a bottom. The top of the block has a wider edge than does the bottom; this wider edge holds mortar. Bricks or stones have no top or bottom; however, bricks may have a front and a back.

Placing the Base Course

Using the reference marks as guidelines, place beads of mortar approximately 1 inch thick along the front and back locations of the wall unit. Set the first unit on these beads and check for the proper height and for level in both directions. Use the handle of the trowel to tap the unit into proper alignment and level. If the wall is constructed with a double row of wall units, both units must be level between front and back. When you have properly aligned the unit, use the trowel to vertically slice the excess mortar away from the unit. Slide the excess mortar away from the wall and do not reuse it. Mortar that has come in contact with the ground will pick up soil and other debris that will weaken the mortar if it is remixed.

If installing concrete block or brick, use a stringline to maintain alignment and level for each unit. Place and level the blocks at both ends of the wall and install stringline hooked to each block using a line block, a small wood clip that holds mason's twine in place. This stringline should just touch the top front corner of both end blocks. As the wall grows in height, move the stringline up one course at a time. With brick construction, build a small section of the wall four to five courses high at each end of the wall. You can then stretch the stringline between these end sections while you lay the center part of the wall. You must individually align and level irregular stone units.

Continue laying the wall block by placing two more beads of mortar on the base for the second unit. The second unit should be **buttered** with mortar at the end that abuts the previously placed unit. If mortar fails to stick to the block when buttering, try applying the mortar using a slapping motion with a trowel full of mortar aimed at the block end. Place the unit and use the trowel handle to adjust alignment against the stringline and to achieve proper spacing. Joints between units should be approximately ⅜ inch. With each unit placed, verify for level with the previous unit and check level front to back. Scrape away excess mortar. Continue placing beads of mortar and units along the entire length of the base course (Figure 33-11). If you started laying from both ends, you will need to place a unit between the two end units. Butter this closure unit on both ends and carefully slide it between the units already in place.

Placing Subsequent Courses

Place subsequent courses following the design pattern required. Do not align joints vertically in a masonry wall unless this alignment is specified in the design. Most patterns begin the second course using a manufactured half block or brick. Special end and corner blocks are available for concrete block products. For double-wythe brick walls, you can place a brick perpendicular to the wall direction to create the half required to offset the pattern. For stone walls, you can cut the stone or select a shorter piece to offset the joint pattern.

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Figure 33-11 First course laying and leveling.

Install subsequent courses by first applying a layer of mortar to the top of the previous course and placing a block on it. Check for joint spacing, alignment, and level in both directions. Setting blocks on both corners first will allow you to move the stringline up one course. Continue laying block in subsequent courses in the same manner as the base course (Figure 33-12).

Reinforcing should be installed every third course for brick, block, or veneer stone. The standard horizontal reinforcing is a narrow steel ladder with angled crosspieces that is buried in the mortar placed on top of the units (Figure 33-13). No. 3 rebar is used for vertical reinforcement for tall walls. Every 32 inches, place a vertical bar into a core of the block or opening between wythes. **Grout** around the reinforcement to hold it in place. Unless the courses are laid with straight, horizontal joints, reinforcment is impractical in wall stone applications.

If the wall or pier has a mechanical fixture such as a light base, water spigot, signage anchor, or gate hardware, lay the wall up to the point where the fixture is to be located. Complete any connections to

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Figure 33-12 Masonry courses showing stringline used to keep blocks aligned.

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Figure 33-13 Horizontal steel reinforcement embedded in mortar.

the previously placed conduit that are required, and place the fixture in the next course. Placement may require cutting or piecing a partial unit to make room for the fixture. Fill around the fixture with mortar and continue adding courses. Small additions such as gate hardware or anchors for signs may be embedded in the mortar between courses. Verify the dimensions and locations for all such installations before work progresses and mortar hardens. If the wall or pier has a veneer finish, place small, galvanized strips of corrugated metal, called **veneer ties**, every other course. Bend these ties into the joints of the veneer to anchor the two wall wythes together.

Allowing for Utility Runs

If the wall requires the installation of lighting, irrigation, or other utilities along its length, a utility run may have to be created through the wall's center. This utility run is typically created by using two narrower block wythes, rather than one wide wythe, then placing utilities in the space between the wythes (Figure 33-14). When you encounter a light fixture, cut the front of a block to place the fixture housing and cut the back of the block to allow access for wiring.

Striking Joints

Joint finishing, or **striking,** is generally performed by running a special tool over the mortar in the joint to smooth and compress the mortar (Figure 33-15). Striking provides a more attractive finish for the

Figure 33-14 Utilities run through the center of a masonry wall.

Figure 33-15 Striking joints on a masonry pier.

mortar and makes the mortar joint waterproof. Several patterns are available, with the most common being a concave pattern. Other choices include a squared, or raked, joint, a rustic joint, an angled joint that is inset at the top and flush with the unit at the bottom, and a V joint (Figure 33-16). Each of these patterns requires a special jointing tool.

Scraping the mortar away from the surface of the wall by striking downward with a trowel creates flush joints. Running a rounded jointing tool over the joint with a firm and steady pressure creates concave joints. The tool should rest evenly on the units on both sides as you strike the joint. Squared or raked, angled, and V joints are created with special jointing tools. Joints should be struck to an even depth along all joints. Hold the jointing tool with your finger running along the units to maintain a consistent strike. Allowing mortar to ooze from between the units creates the rustic joint. Selection of joint style will be based in part on the area's weather and the type of finish to be placed on the wall. Squared and raked joints will hold water and ice in cold-weather climates, creating potential problems from expansion. Because they will leave small gaps between the joints and the units, flush joints are appropriate only for walls that will be veneered or stuccoed.

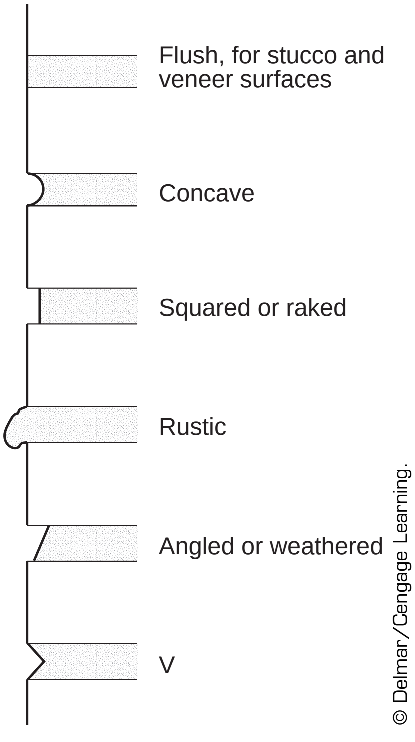

Figure 33-16 Joint patterns.

Begin striking joints at the bottom course with the horizontal joints; then strike the vertical joints. Continue up the wall in this order until you reach the newly laid block. Timing of the striking operation is important. When the mortar begins to lose its sheen, it is time to strike the joints. Striking too soon will push mortar out of the joint; waiting too long will allow the mortar to harden. Laying block at a slow pace may require laying one course and stopping to strike joints. Because you do not remove the excess mortar to achieve the rustic joint, this joint requires no striking.

Grouting Cores

Walls with concrete block, double-wythe brick, or double-wythe veneer block will have an open cavity in their centers. This cavity needs to be filled to maintain structural strength and to reduce moisture infiltration inside the wall. Wait until the mortar has set for 24 hours before filling the cavity with grout. Grout is a light mortar mix with double the sand content of typical mortar. Mix and place the grout in a bucket; then pour it into the cavity until filled.

Capping

When building walls with cavities in the center, the top of the wall must be capped to prevent moisture from entering the wall. Both brick and concrete block have special capstones manufactured for this purpose. Veneer block walls may require cutting and placing a row of block perpendicular to the wall direction as a cap. Some designs select a cap unit that overhangs the wall faces slightly. Finish grouting the wall to the top of the cavity and lay beads of mortar on the top course. Set the cap course in a manner similar to laying any course, checking to maintain alignment and level both directions (Figure 33-17). If any type of structure support or fencing is to be attached to the top of the wall, insert supports or J bolts into the soft mortar between capstones and retouch the mortar. Scrape away excess mortar and strike the joints.

Cleaning the Surface

When all mortar has hardened, clean the surface of the wall. Large pieces of mortar can be removed by rubbing a hammer over the surface. If mortar or grout has run down the wall and stained the surface, you will need to scrub it with a mixture of 9 parts water with 1 part muriatic acid. Use caution for personal health and the health of surrounding plant material when cleaning with these materials.

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Figure 33-17 Capping a masonry pier.

CAUTION

When cleaning pavement using acid and caustic cleaners, follow all safety precautions identified on the label. Wear proper safety clothing. Contact with and exposure to acids and caustic cleaners can cause personal injury and can harm plants.

CAUTION

When mixing acid and water, always add the acid to the water and never add water to acid. Adding water to acid will cause the mixture to spray and splatter, creating the potential for burns. Always wear protective clothing, gloves, and eyewear when mixing chemicals.

CAST-IN-PLACE CONCRETE WALLS

Cast-in-place freestanding walls introduce a number of possibilities to the landscape. Although they are not commonly used in residential settings, the variations of finishes available and their durability make such walls a viable option in many landscapes. They do, however, have limitations. Contractors must dedicate extensive time to construct them and must brace forms to reduce the risk of form failure. Also, pouring a footing separate from the vertical wall requires additional time in construction. Because cast-in-place freestanding walls are difficult to construct, only experienced concrete contractors should undertake their construction. Note that the construction of cast-in-place freestanding concrete walls will be quite different from a structural standpoint than a cast-in-place retaining wall. An experienced contractor should engineer and construct any cast-in-place wall of any height used to retain soil.

Constructing Footings

Footings for cast-in-place concrete walls are constructed as reinforced slabs at least 1 foot wider than the wall's width. A design professional should determine the actual width and thickness of the footing. Under the entire footing location, place a minimum of 4 inches of granular base material. Form the footing using 2 × dimensioned lumber (Figure 33-18). Stake the outside of the pour every 18 inches using 2 × 2 stakes or rerod. Within the footing, place two #4 rerods running the entire length of the footing. Every 2 feet, place a #4 rerod perpendicular to the lengthwise reinforcing. Tie these crosspieces to the lengthwise reinforcing. Use dobies or chairs to support this network of rerod (see Chapter 23).

Brace the pour from the forms on one side to forms on the other side for added stability. Center a metal keyway or a 2 × 4 on the underside of these cross braces before installing them. Coat the keyway or 2 × 4 with kerosene or form break compound. This will form a key or channel, in which the base of the wall will be anchored. At every 2 feet along the length of this keyway, drill holes and insert **J bolts** that protrude 6 inches above the top of the footing and at least 4 inches into the footing. These bolts also assist in anchoring the wall to the footing. As a substitute for J bolts, use #4 rerod bent to an L shape. Any conduit for electrical lighting or signage should

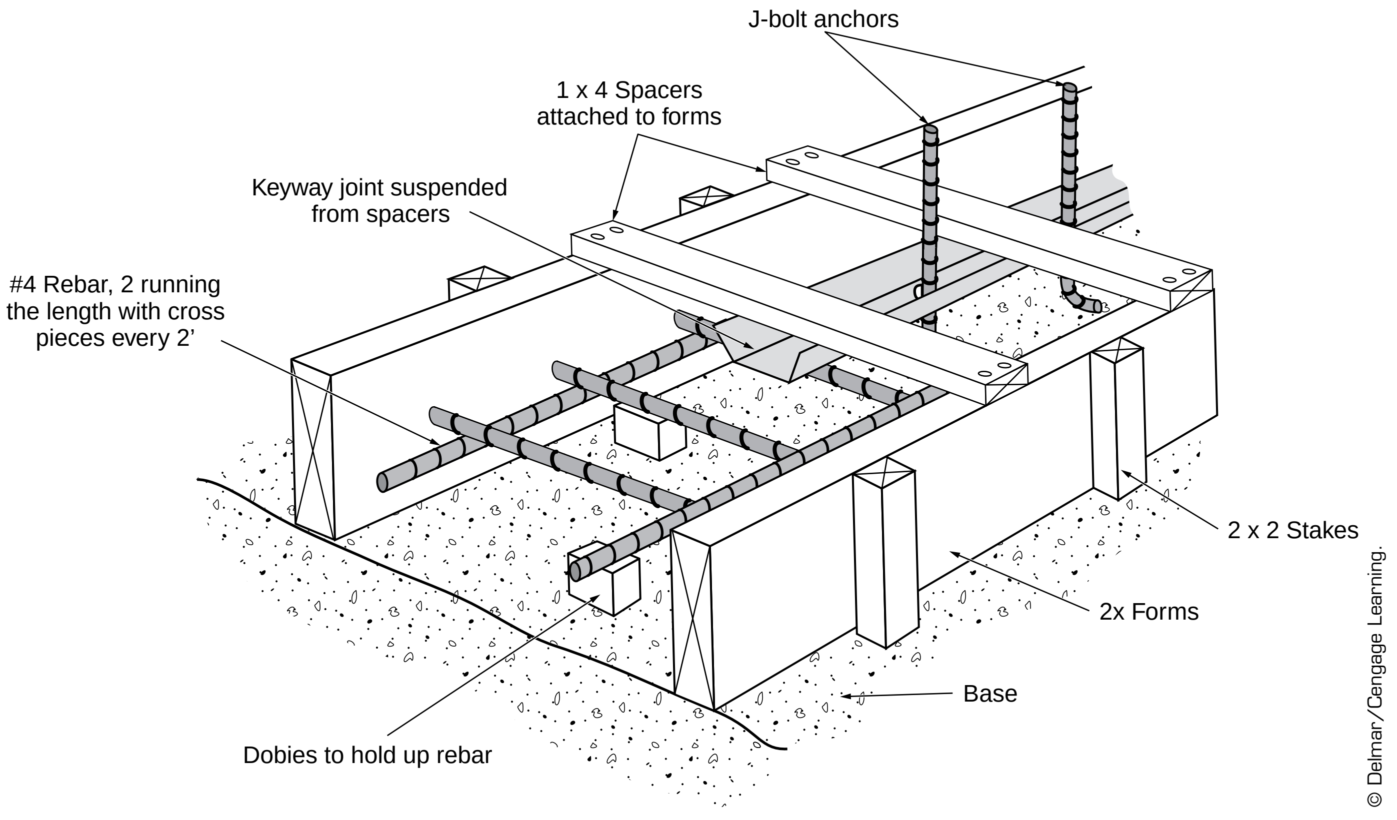

Figure 33-18 Footing for cast-in-place concrete wall.

be placed into the footing before pouring. Stub the conduit through the pour and up through the footing near the center of the proposed wall location. Cover the end of the conduit with duct tape.

Pour the footing, making sure that concrete is tamped under and around the keyway and that the J bolts or rebar protrude directly up from the footing. Cover the pour for curing. After the concrete has cured for a minimum of 2 days, remove the forms and carefully remove the keyway. If you used a 2 × 4 for the keyway, cut and remove it from the pour. Snap a chalk line on the form at the location for the front and back of the wall.

Forming and Pouring Concrete Walls

Assembling and installing the form for one side, installing the interior reinforcing, and then forming and installing the other side are the steps to forming the wall. Common materials for forming include rented metal forms, ¾-inch plywood, or 1 × dimensioned lumber. Install rental forms according to instructions provided by the manufacturer or rental company.

When using plywood or dimensioned lumber, construct the form flat on the ground next to the footing. Build a framework of 2 × 4 lumber with verticals spaced every 1 foot between a base plate and a top plate. Apply plywood to one side of this framework and trim to match the outside edge of the framework. This framework should run the entire length of the wall, but you may build it in sections that a small crew can lift into. If the wall is to have special finishes, such as board forming or form liners, these need to be installed before placing the form in position. Attach these decorative forms to the inside of the form framework.

After the form is complete, tip the framework onto the footing and temporarily brace it into position. Drive 2-foot long 2 × 4 stakes securely into the ground at 2-foot intervals along the entire length of the footing. Correctly position the base of the form on the proper chalk line on the footing. With the form in position, temporarily anchor the base plate of the forms to the footing using concrete nails or a **power driver** sunk into “green” concrete. Have an assistant stabilize the form until it is braced. Brace the top of wall using 2 × 4s fastened to the form framework verticals and angled outward to the stakes along the footing. Add a second brace at the bottom of the form verticals running out to the stake (Figure 33-19). If you built the framework in sections, lift and place each section; then fasten to the previous section using lag screws or carriage bolts.

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Figure 33-19 Form framework for a cast-in-place concrete wall.

When one side of the forming is complete and braced, you can place the interior reinforcement. Cut enough #4 rerods to place one vertically every 2 linear feet along the length of the wall. These rerods should be 4 inches shorter than the wall's height and will serve as vertical reinforcement. At each location where a J bolt protrudes from the footing, tie one of these vertical rerod to the J bolt. Beginning 1 foot above the footing, attach horizontal #4 rerod to each vertical rerod. Continue the horizontal rerod along the entire length of the wall. Install horizontal rerod at 1-foot intervals to the top of the wall. If any conduit is to be placed into the wall for utility connections, place the conduit before you install the other side of the forming. Anchor conduit to the reinforcing and connect it to junction boxes fastened to the inside of the forms (Figure 33-20).

After reinforcing is complete, assemble the forms for the opposite side in the same manner as the first side. To enclose the ends of the pour, first rip cut a length of 2 × lumber to the wall's width. Then trim the board's length to match the height of the wall. Position the piece of 2 × lumber vertically between the wall forms. Fasten the 2 × into the correct position by inserting several deck screws or 16d nails through both side forms and into the 2 ×. When you have correctly positioned and braced all forms, add additional bracing across the tops of the forms. Tall walls may require form ties be installed halfway up the wall along the entire length to securely hold the forms together. Drill through both forms, insert the tie completely through the form, and secure the tie on the outside to hold the forms. Several manufacturers have form ties in lengths and materials that work with different types of forming. When you have completed the forming, spray the inside of the forms with form break compound or light kerosene.

To hold the reinforcing in the center of the wall during the pour, insert 14-gauge wire ties through the forms and tie them to the rerod. Drill ⅛-inch diameter holes through both sides of the forms. The holes should be directly across from each other every 2 feet along the length of the wall and 1 foot down from the top of the wall. Insert the end of a 14-gauge wire through the hole on one side. Reach into the form and pull the length of the wire into the

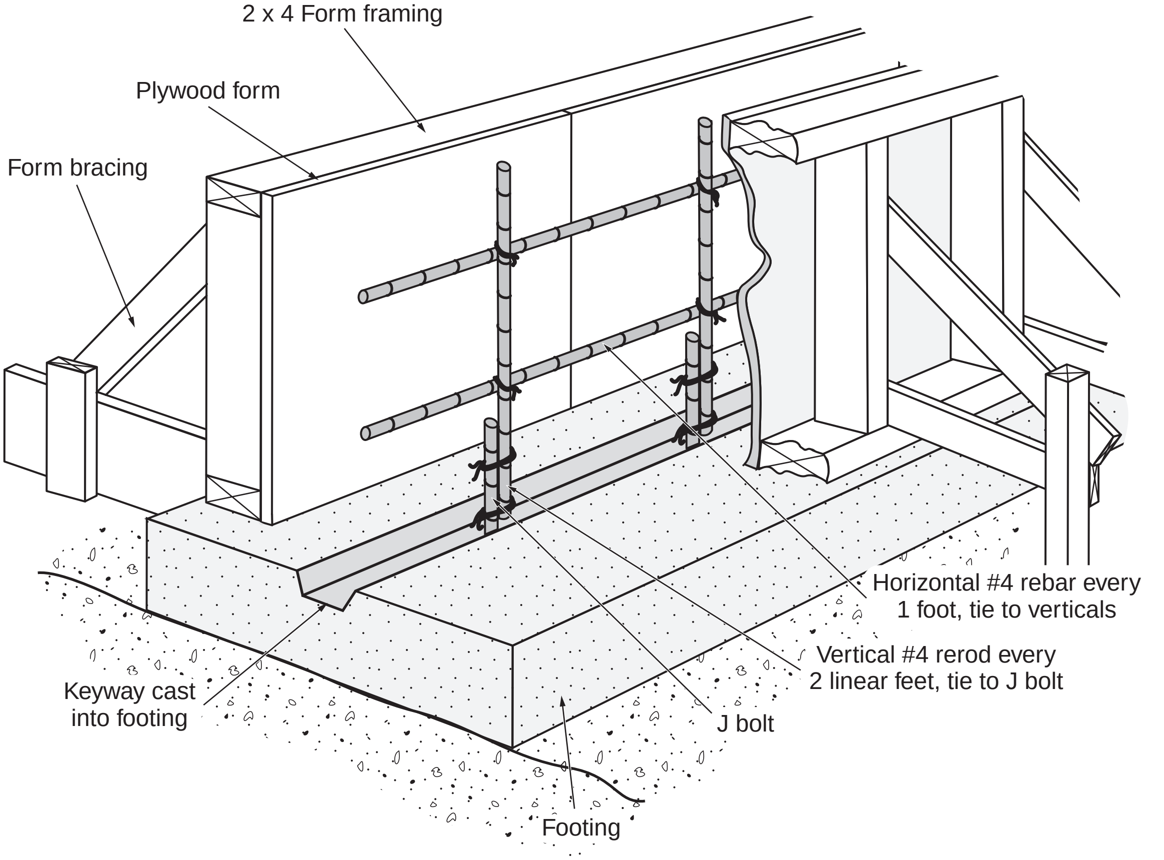

Figure 33-20 Reinforcing cast-in-place concrete wall.

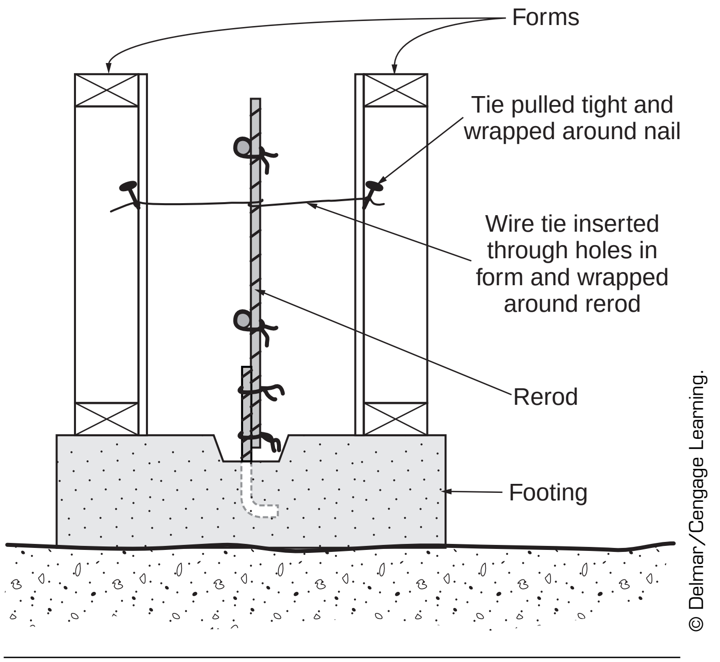

Figure 33-21 Supporting reinforcing in the center of forms using wire ties.

form, leaving the end protruding through the form. Wrap the wire around the rerod reinforcing and push the end out the opposite hole so that at least 8 inches protrude out the other side of the form (Figure 33-21). Pull on the wire from one side of the form until the rerod is positioned in the middle of the forms. When the rerod is positioned correctly, wrap the tie wire around a 16d nail outside forms on both sides. Add any additional bracing necessary to secure the forms. Using heavy stakes, anchor all bracing securely to the ground.

Pouring the Wall

Any special aggregate should be mixed into the concrete before placement. Pour the concrete slowly into the wall cavity, evenly raising the level across the wall. Pour the entire wall in a single continuous pour, unless specific control joints are planned. To aid in the placement of concrete, consider contracting with a **concrete pumping** service that can drop material down into the form cavity, rather than lifting concrete to the top of the forms. As the concrete is poured, constantly check the forms for leaks and bulges and immediately repair any problem areas. Tap the sides of the walls with rubber mallets as the pour progresses to reduce **honeycombing** of the walls. When the concrete reaches to top of the forms, remove the top cross bracing so the top of the wall can be finished. After the concrete has cured for 2 days, carefully remove the bracing and forms. Snap or cut the ties to remove the forms.

Finishing Concrete Wall Surfaces

Many walls are left as plain concrete without any further treatment. However, if a special finish is desired, the surface can be treated by sandblasting, **bush hammering,** or surfacing with stucco, veneer, or paint. Sandblasting creates a slightly rough texture by shooting sand at high pressure against the concrete. Wait 2 weeks before sandblasting. Control the texture of the finish by the speed with which the sandblasting tool is worked across the wall. Specialized aggregate placed in the concrete will typically require sandblasting to expose it on the surface. Bush hammering roughens the surface and is accomplished using a pneumatic or electric-powered drill. Insert a toothed head into the drill chuck, and lightly hammer the entire surface to create a rough, grooved surface (Figure 33-22). Wait a minimum of 4 weeks before applying a bush-hammered surface to a new wall. Stucco or veneer surfaces can also be applied to concrete walls. See the following sections for preparation and installation of these specialized surfaces. Although not common in exterior situations, certain Portland cement paints, acrylic latex paints, and rubber-based paints can be applied. Successful applications of each of these paints rely on a clean surface.


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Figure 33-22 Concrete finished by bush hammering.

RAMMED EARTH WALLS

An alternative in wall construction materials is rammed earth. Used primarily as a wall component in structures, rammed earth is suitable for freestanding walls and, in cases where a design professional engineers them, as retaining walls. Rammed earth has been used a long time, but its contemporary version has brought a renewed interest as an alternative to cast-in-place concrete and other concrete-based wall materials. Rammed earth is a mixture of a prepared soil, a stabilizing agent such as cement or lime, and a small amount of water. This mixture is then placed in forms for short lifts and compacted, or rammed, to about half its volume. The resulting material hardens to a dense, compact wall structure.

For rammed earth walls to be most effective, soil used in the mixture should consist of at least 30% nonexpansive clay, with the balance being sand and small aggregate. The soil must be pulverized, screened, and free of organic material. Hydrated lime and silica volcanic fly ash (pozzolan) are alternatives to Portland cement as stabilizing agents. Rammed earth walls achieve their strength from the bonds between the small amount of remaining water and the soil particles of the wall. Water content is important in that the material needs enough water to wet the components to a friable, crumbly texture, but not so much water that the mixture becomes runny.

To construct a rammed earth wall, prepare a concrete foundation reinforced with steel that is a minimum of 6 inches wider than the proposed wall and a minimum of 8 inches deep (see above in this chapter for footing and forming instructions; footings and forms are similar to cast-in-place concrete walls). Vertical steel reinforcing may be used. These dimensions may vary, depending on an engineer's plans or the size of the proposed wall. Construct sturdy forms for the sides of the wall that equal the height and width of the proposed wall. The ideal forming process would allow lifts of 8–12 inches be poured at a single time and then raised to allow the pouring and ramming of subsequent lifts. Build the forms with horizontal materials such as planking or metal forms and add an additional row for each new lift. If you use pneumatic jacking equipment, raise the entire form and set it for pouring the next lift. You can usually remove or reposition the forms immediately after you complete the ramming procedure.

Although historic applications relied solely on clay soil, you can use a wider range of soils by mixing an appropriate soil with 5% Portland cement

and a slight amount of water to make the moisture content 8%. Blend this thoroughly and pour the mixture into the forms to a depth of 8 inches. Using a hand tamper or powered rammer, compact this mixture until it is 4 inches thick. When selecting a mechanical rammer, locate a low-impact rammer designed specifically for rammed soil applications. Larger commercial rammers may damage the forms and are not as effective as the specialty rammers. Repeat the process until you have reached the desired wall height. The mixture will harden within approximately 1 hour, making any surface finishing difficult after it hardens. You can immediately remove forms to facilitate finishing and patch any rough areas with the original wall material. Depending on wall dimensions, it will take several days of warm dry weather for the wall to harden completely. Leave the top of the wall level and prepare it for installation of a capstone.

Once dry, the wall can be left in its original state or finished with stucco or wood cladding. It is also possible to add colored pigments to the earth when mixing to create a custom color or to place wood timbers inside the forms to integrate wood elements into the finished wall. Rammed earth walls can also be painted or sealed to prevent damage from weather. When selecting wood for exterior applications, verify that the wood is a natural decay-resistant material.

If it soaks into the wall from the top, water can weaken the structure; therefore, the top of exterior applications that are exposed to the elements should be capped with an impermeable material sloped to allow water to run off to one side or another. Place the cap using mortar and extend the edges of the cap 1–2 inches beyond the sides of the wall. If structural components are to be attached to the top of the wall, pour a 6-inch thick concrete bond beam as the final lift and then stain it to match the rammed earth finish.

STUCCO WALLS

Adding color and texture to the idea of landscape walls can be accomplished by using stucco. A versatile material that can be applied over most base wall materials, stucco can be tinted or blended to achieve a variety of surface colors and textures.

Single-Coat Stuccos

A fiberglass-reinforced stucco product may be applied in a single coat of ⅜ inch thickness over cast-in-place concrete and masonry walls. This product is installed without joints or backing mesh. To install this product, construct a framework without joints or mesh, clean the wall surface as described in the following section, and apply the material using a trowel in a swirl texture. Allow the surface to dry for 48 hours before applying any special finishes.

Preparing Framework for Multi-Coat Stuccos

Stucco application can be made to a variety of wall types, including wood frame, masonry, and cast-in-place concrete. With the exception of wood frame, walls can be constructed using the instructions in the preceding sections combined with the additional preparation and finishing described here. Stone walls, both dry-laid and mortared, and any wall material that is not stabilized against shifting and movement are not acceptable frameworks for stucco surfacing.

Applying Stucco to Wood Framework Walls

Stucco application to walls with wood frameworks requires the construction of a concrete footing to minimize wall movement and subsequent cracking. Install the footing using the instructions provided in the concrete paving section, adding anchors to support the wall framework. Construct a heavy framework of 2 × dimensioned, decay-resistant lumber. An alternative to a concrete footing is to install posts in a manner similar to a wood panel fence, with a framework constructed between the posts. This method has the potential for increased cracking as a result of variable settlement of the posts.

Over either type of framework, apply ¾-inch plywood sheathing that has been dried under cover for 60 days to minimize shrinking. Fasten sheathing to the framework using rust-resistant wafer head screws or nails. Using rust-resistant screws, rather than nails to fasten components, particularly the application of sheathing, will provide additional protection against the framework shifting and cracking the stucco finish.

Galvanized flashing, called a **weep screed,** is fastened along the bottom of the entire installation, and metal flashing is installed at any location where the stucco abuts an unfinished surface to direct water away from adjacent wood components. A waterproof membrane of building paper is stapled

to the sheathing to prevent water from reaching the wood structure. Building paper waterproofing should cover the flashing along the bottom and side installations and be placed under the flashing at the top of the installation. Begin installation at the bottom of the wall, and overlap the lower piece 4 inches with the upper piece. Staple building paper waterproofing to the sheathing.

Galvanized wire mesh of 18- or 20-gauge with a 1-inch hex pattern (also called *hex metal*, *hex mesh*, *poultry netting*, or *chicken wire*) or **self-furring lath** of galvanized steel diamond mesh is fastened to the framework over the waterproofing membrane to improve the keying of the stucco (Figure 33-23). Cut the mesh or lath with tin snips at expansion and control joint locations. Cover all surfaces to be finished with this mesh or lath.

Masonry. Clean, rough-textured masonry surfaces can accept stucco without additional preparation. Sandblast or at high-pressure wash surfaces that are not clean. Dirty surfaces can also be prepared for stucco application by rinsing them with trisodium phosphate (**TSP**) mixed according to the manufacturer's directions. Mix the solution, apply it to the wall, and scrub the wall with a wire brush. Let the surface dry before working it. Wear proper protective clothing and follow all safety precautions when cleaning surfaces. Avoid contact between the cleaning solutions and metal.

When constructing new masonry walls intended for stucco surfacing or veneer, install galvanized ties every 12 inches in the masonry joints when the wall is constructed. Flush strike joints in the masonry. You may apply self-furring galvanized steel diamond mesh lath to masonry walls mechanically using galvanized waffle head screws or concete nails.

Cast-in-Place Concrete. In many cases, stucco can be applied directly to concrete walls. If smooth, oily, or coated with any type of lubricant, including form break, the surface must be cleaned before stucco can be applied. Clean the surface using TSP as explained previously in preparing mortared walls. Apply a dash bond, or adhesive, to concrete to improve keying between the wall and the stucco. Dash bonds are liquid mixtures of 1 part cement with 1½ parts sand that are applied with a brush or trowel.

Some concrete bonding adhesives are designed to assist in mortar bonding, and special acrylic modified bonding adhesives can be used when your total surface thickness is less than 1 inch. When using bonding adhesive, apply a layer approximately 1/16 inch thick with a roller in the area you plan to stucco immediately. Apply the base stucco coat when the glue is tacky. If cleaning is ineffective, apply self-furring galvanized steel diamond mesh lath to masonry walls mechanically using galvanized waffle head screws or concrete nails.

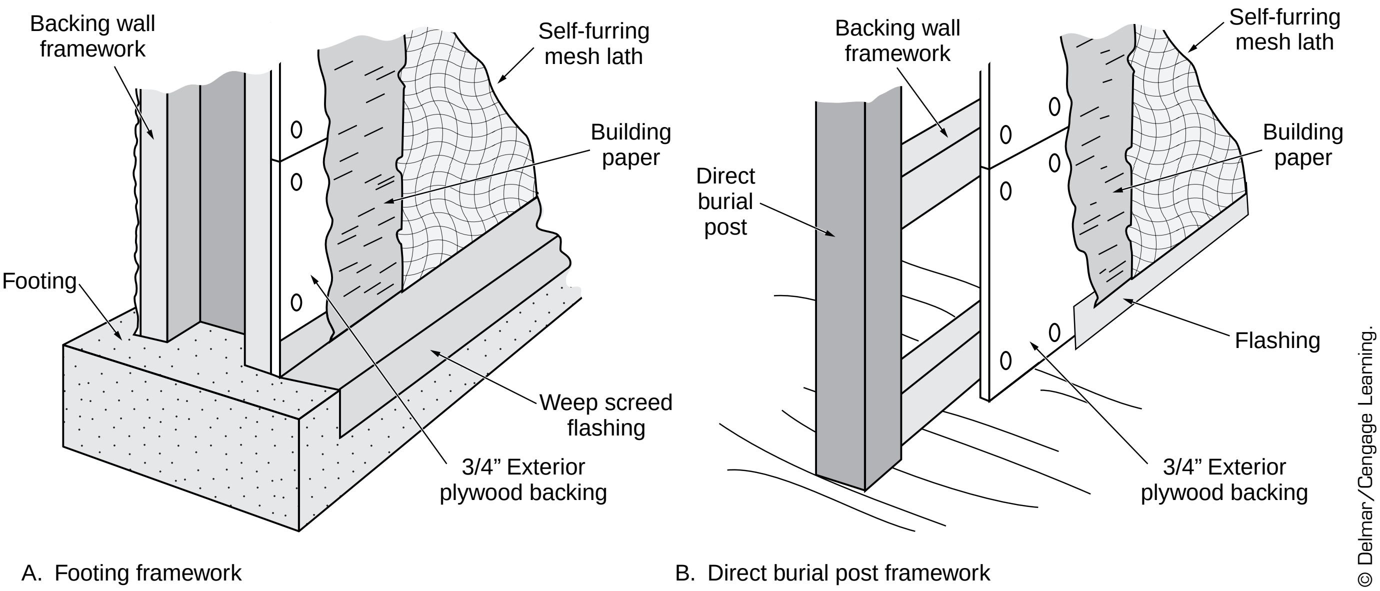

Figure 33-23 Stucco wall construction.

Installing Expansion and Control Joints

If the wall exceeds 15 feet in length, a vertical control joint should be installed to accommodate any expansion or contraction of the surface. Control joints are also recommended for every 144 SF of large wall surfaces, or approximately 12-foot × 12-foot square. Preformed rust-resistant metal joints are available that can be nailed or screwed to the framework. Cut any hex mesh or metal lath with tin snips along the location where a joint is placed. Take care that no stucco material fills the joint when you perform the surfacing.

Applying the Base Coat

The base coat for stucco, also called **scratch coat,** can vary in thickness from ¾ inch if placed over metal lath to ½ inch if placed directly on a wall surface. Thicknesses in this range are applied in either 2 or 3 coats. To mix the stucco base coat, blend 2 parts clean moist sand with 1 part Portland cement. Add water and mix, adding additional water as needed to obtain a thick consistency. When selecting sand, keep in mind that the size of the sand will affect the surface texture.

Before applying the stucco to concrete or masonry wall frameworks, slightly moisten the surface with a light mist to improve the curing. Apply the stucco using a drywall trowel or spray equipment. Begin at the top of the wall and work toward the bottom, applying a ½ to ¾-inch thick coat. The coat should be of uniform thickness and without ridges or low points. Before the stucco dries, use a scratcher or notched trowel to "scratch," or deform, the surface. This process improves the **keying,** or interlocking, with the next coat. Do not gouge ridges thicker than ¼ the thickness of the stucco layer (Figure 33-24).

Let this base coat dry for 48 hours before applying additional coats. If using three coats, apply ¼-inch thick second coat in the same manner without the scratching. Let the second coat dry for 48 hours before finishing. To ensure an even surface for the first or second coat, check the depth and adjust it by running a vertical screed board over the surface. This process, called **rodding,** will knock down areas that are thicker than desired and locate low spots in the surface.

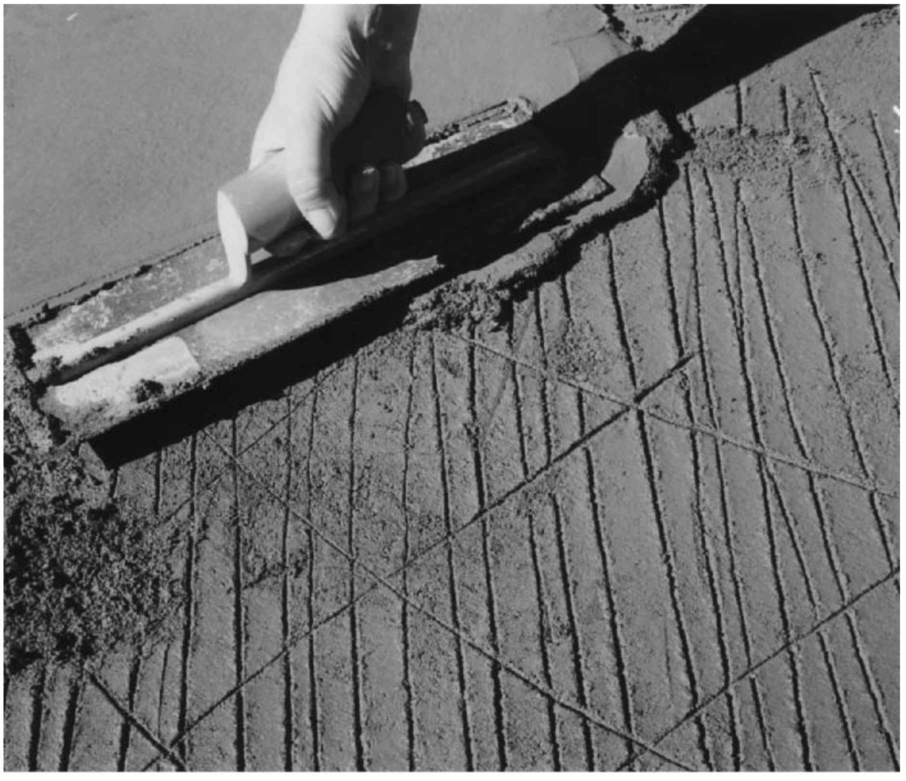

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Figure 33-24 "Scratching" the first coat of stucco to improve keying of the second coat.

Finishing Wall Surfaces

The final layer for a stucco application is called the **finish coat.** This coat may be prepared using the same formula as the base coat if a gray finish is desired or if the surface is to be painted. If light color stucco is to be applied, add 1 part lime to the sand and cement mixture. Many stucco walls are intended to be earthy or bright colors; and to obtain this finish, a pigment is added to the mix. Prepigmented dry stuccos can be purchased, or the pigment can be added with the water used to hydrate the mix. Many of these pigments are mineral-based, including iron oxides that provide a rich range of earthy colors. Special aggregates and sands can also be used in this surface coat to obtain the desired finish.

Mix the finish coat and apply it using the same top-to-bottom technique as the base coat. Apply a finish coat of ¼ to ⅜-inch thickness. If a special texture is desired, apply it before the coat sets. Choices of surface textures include the sand float texture, which is obtained by floating the surface with a concrete float; California texture, which is obtained by applying the finish coat with thick ridges that are knocked down using a steel trowel or concrete float; and the Spanish texture, which is a coarser version of the California. Dabbing with a damp sponge can also finish surfaces. Almost any variation of surface texture can be obtained by practicing with the available tools and methods (Figure 33-25).

If the surface is to be painted or stained, let the finish coat dry for 48 hours prior to applying any coloring. Because stucco allows water vapor to penetrate through the surface, only use paint with 100% latex formulated for stucco or masonry-penetrating stains manufactured with silane or siloxane. Avoid use of silicon or paraffin-based surface coatings, except for the portions of your surface below grade. That area will require sealing to reduce wicking of water and the possibility of efflorescence, the white film that is left on the wall surface when salts are washed out of the stucco.

INSTALLATION OF VENEER FINISHES

Veneer surfaces are used when an attractive finish is desired over a load-bearing backing wall. Stone, brick, and other masonry materials can be applied as a full wythe, or thickness, veneer or a cultured or cut product can be applied as a thin surface veneer. Although the appearance of each application method is similar, the installation differs in preparation and execution. The backing wall may be wood frame, concrete, or masonry prepared to accept veneers.

Full-Thickness Veneers

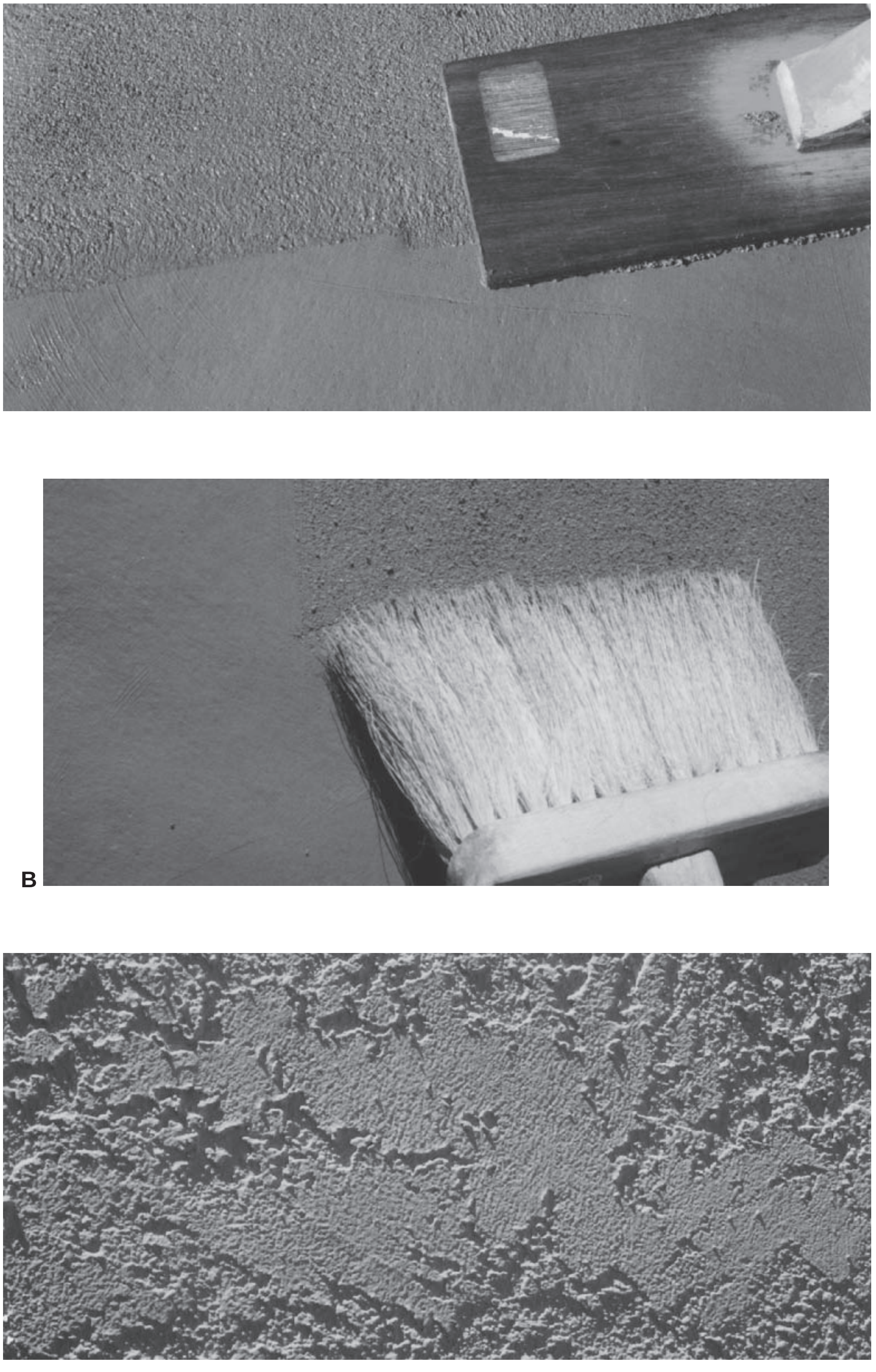
Veneers allow the contractor to create a wall that provides the appearance of brick or stone, without constructing the entire wall from the more expensive materials. In addition, veneers often are applied to a wall that is more structurally suited to situation. This section covers veneers that are the full thickness of the material rather than a thin slice of the material.

Ledger. Preparing a wall for a full thickness veneer requires the installation of a ledger on which the veneer can be set. This ledger must be as thick as the veneer plus 1 inch. Although it is possible to construct a ledger after the backing wall, most are built as part of the original wall construction. A spread footing may be used as a ledger, or a notch formed into concrete walls can also be used for this purpose. With wood walls, widening the concrete footing, rather than the wood frame, is the better practice (Figure 33-26).

Cleaning. For veneers to be applied to masonry or concrete surfaces, the surface must be free of oil, paint, dirt, and other surface irregularities. To clean the surface, you may sandblast, spray with high-pressure water, or scrub with a TSP mixture and wire brush. Follow all safety precautions when cleaning surfaces.

Waterproofing, Flashing, and Weepholes. Veneers set in front of wood-backing walls require a sheet of waterproof sheeting be applied over the wood surface. Building paper or a similar heavy, weather-resistant barrier will work. Lap any joints 4 inches and seal with roofing tar. Metal Z flashing should be applied over the ledger and under the waterproof barrier. When setting the base course of the veneer, insert ¼-inch hollow tubes through the bottom bed of mortar every 16 inches to serve as weepholes for moisture that may pass through the veneer.

Ties. For veneers to be anchored to the backing wall, metal ties are fastened to the backing wall vertically every 16 inches and horizontally every 32 inches. These ties are then placed into the mortar joints of the veneer. Ties are galvanized, corrugated, light-gauge metal strips 1 inch wide and approximately 4 inches long. Fasten to wood



A

B

C

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Figure 33-25 Stucco finishes. A. Float finish created by running a damp wood float over the finish coat. B. A broom finish roughens the finish coat by pulling a hand broom lightly over the surface. C. The California finish is created by applying ridges of stucco to the finish coat, then knocking them down using a trowel. The resulting ridges create an irregular texture.

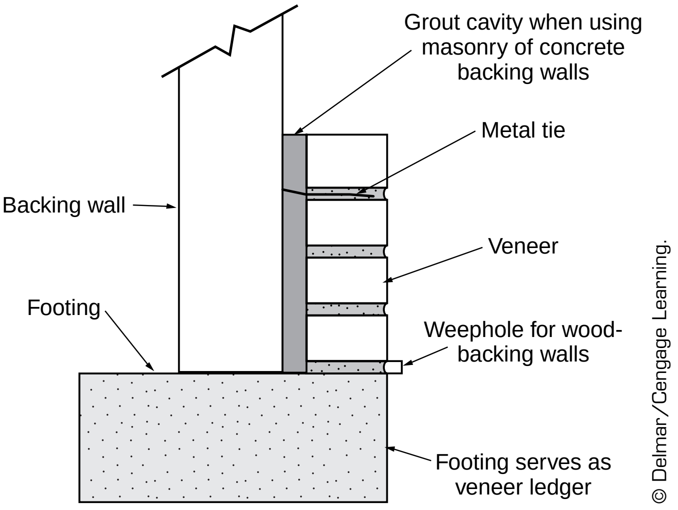

Figure 33-26 Veneer application.

walls using 8d nails or to concrete or masonry walls using concrete nails. You can also place ties in the joints of a masonry backing wall as it is constructed.

Mixing Mortar. Mix mortar using the formula of 1 part Portland cement, 1 part hydrated lime, and 5 parts fine sand. Type N mortar may be substituted for the cement and lime mixture and blended 1 part mortar with 3 parts fine sand. Mix to a thick consistency that is firm and moist. Include any desired color additives as you mix the mortar.

Laying Veneer. Veneers are installed using the techniques explained in the masonry wall construction chapter. Begin by chasing a bond to ensure that the desired units will fit the space to be veneered. Cut any partial units that will be required. Lay a bed of mortar on the ledger and place the first course, remembering the tubing for weeps if applying over wood framing. For bricks and other veneers that are uniform in size and shape, build the corners/ends and lay the courses using the completed corners/ends as a guide. If laying stone or irregular-shaped units, lay each course individually. Maintain the 1-inch space between the veneer and the backing wall; and when encountering the ties, bend them into the joints between courses. Check the installation periodically to verify that the units are installed in the desired pattern and with uniform joints. Strike the joints when the mortar has dried to the touch.

Grouting. When applying veneer over concrete and masonry backing walls, grout the 1-inch cavity between the veneer and the backing wall. With wood-backing walls, the cavity is left ungrouted. Mix and install grout at the beginning of each day for the veneer set the previous day. Use a grout mixture of 1 part Portland cement and 3 parts sand. Blend to a flowable mixture and pour into the cavity.

Capping. If the top course of the veneer does not end under a ledge, eave, or other protected covering, you must place a cap over the veneer and the grout cavity. After grouting to the top is completed, lay a bed of mortar across the top course. Set veneer units that abut the backing wall and cover the wythe of the veneer, plus extend beyond the front of the veneer approximately 1 inch. You can purchase special veneer capping material to complete this course, or you may cut masonry units to create capping material with the correct dimensions. Fill and strike the joints between the capping material.

Cleaning the Surface. If any loose mortar is present, wait 1 week and clean with a wire brush and a TSP mixture. Follow all safety procedures when cleaning surfaces.

Thin Veneers

When cost or dimensions are of critical concern, a thin veneer of material can be applied rather than a full thickness of wall material. The thin veneer is typically a slice of a full piece of material, or a thin piece cultured in a manufacturing plant to appear like the full wall material.

Cleaning. For veneers to be applied to masonry or concrete surfaces, the surface must be free of oil, paint, dirt, and other surface irregularities. To clean the surface you may sandblast, spray with high-pressure water, or scrub with a TSP mixture and wire brush.

Waterproofing, Flashing, and Backing Materials. Veneers set in front of wood-backing walls require a sheet of waterproof sheeting be applied over the wood surface and metal lath to bond with the mortar. Building paper or similar heavy, weather-resistant barrier will work for the water barrier. Lap any joints 4 inches and seal with roofing tar.

If the veneer rests on a ledge at the bottom of the application, apply metal Z flashing over the ledge

and under the waterproof barrier. Apply self-furring, ⅜-inch expanded metal lath using 8d galvanized nails under all areas to be veneered. Mortar can be applied directly to clean concrete and masonry surfaces without the metal lath (Figure 33-27).

Mixing Mortar. Mix mortar using 1 part Portland cement, 1 part hydrated lime, and 5 parts fine sand. Type N mortar may be substituted for the cement and lime mixture and then blended 1 part mortar with 3 parts fine sand. Mix to a thick consistency that is firm and moist. Include any desired color additives as you mix the mortar.

Laying Veneer. Thin veneers are applied from the bottom up one course at a time. If applying the veneer to a concrete or masonry wall, dampen the wall slightly with the fine mist from a hose. Cover approximately 5 SF of the backing wall with mortar using a mason's trowel. Apply a ⅜-inch thick layer of mortar to the back of the veneer unit and press the unit onto the layer of mortar on the backing wall until the mortar squeezes out around the edge of the unit (Figure 33-28). Continue applying veneer units until you cover the surface. Check the installation periodically to verify that the units are installed in the desired pattern and with uniform joints. If additional mortar is required between joints, fill a mortar bag with the prepared mortar and squeeze into the joints. Strike the joints when the mortar has dried to the touch.

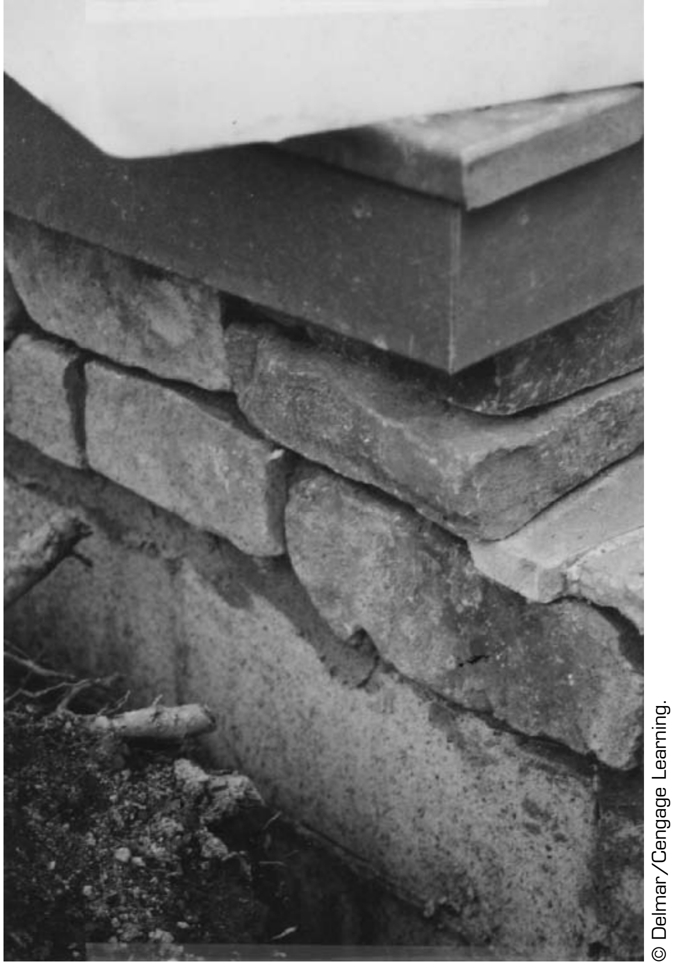

Figure 33-28 Cultured stone veneer mortared to a concrete block wall.

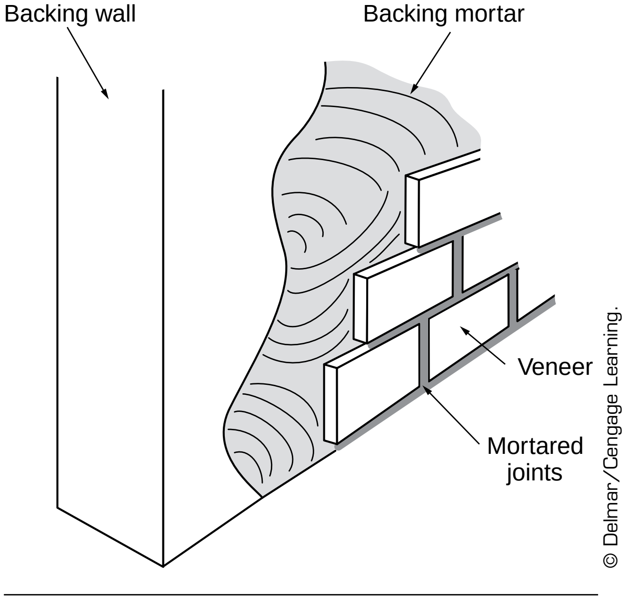

Figure 33-27 Thin veneer application.

Cleaning the Surface. If any loose mortar is present, wait 1 week and clean with a wire brush and a TSP mixture. Follow safety precautions when cleaning surfaces.

CAGED RUBBLE PIERS

To obtain a quick boundary or entry marker, consider the construction of a caged rubble pier. Although simple to build, caged rubble piers have limited durability as a result of the forces of weather and gravity.

Begin installation of caged rubble piers by selecting a heavy-gauge wire fencing the same width as the desired height of your pier. Trim the fence to the correct length, determined by multiplying the diameter of your pier by pi (3.14). Bend the fencing into a circle and create a cage by tying the ends together using 14-gauge or larger wire (Figure 33-29). Secure

these ends at several locations. When connected, position the cage where the pier is to be located. Fill the cage with rubble that has at least one dimension (length, height, or width) larger than the openings in the cage. Rubble can be flat or rounded, or a mix of unused stone. To achieve additional stability, bury the cage 6 inches before adding rubble.

Some piers of this construction can be used as supports for rail fence material. To install fence rails, first place the cages so that the rail will fit between a pair of cages. Remember to include length for the portion of the rail that fits into the pier. Fill both cages to the level where the rail is to be positioned. Insert the rail through an opening in the wire. If necessary, use a fencing tool to cut a larger opening for the rail to fit, and then insert the rail. If using several piers, fill them all and then insert the rails at one level before moving to the next higher rail. Continue placing rubble to the level of the next rail. Repeat the fitting until you have installed all rails.

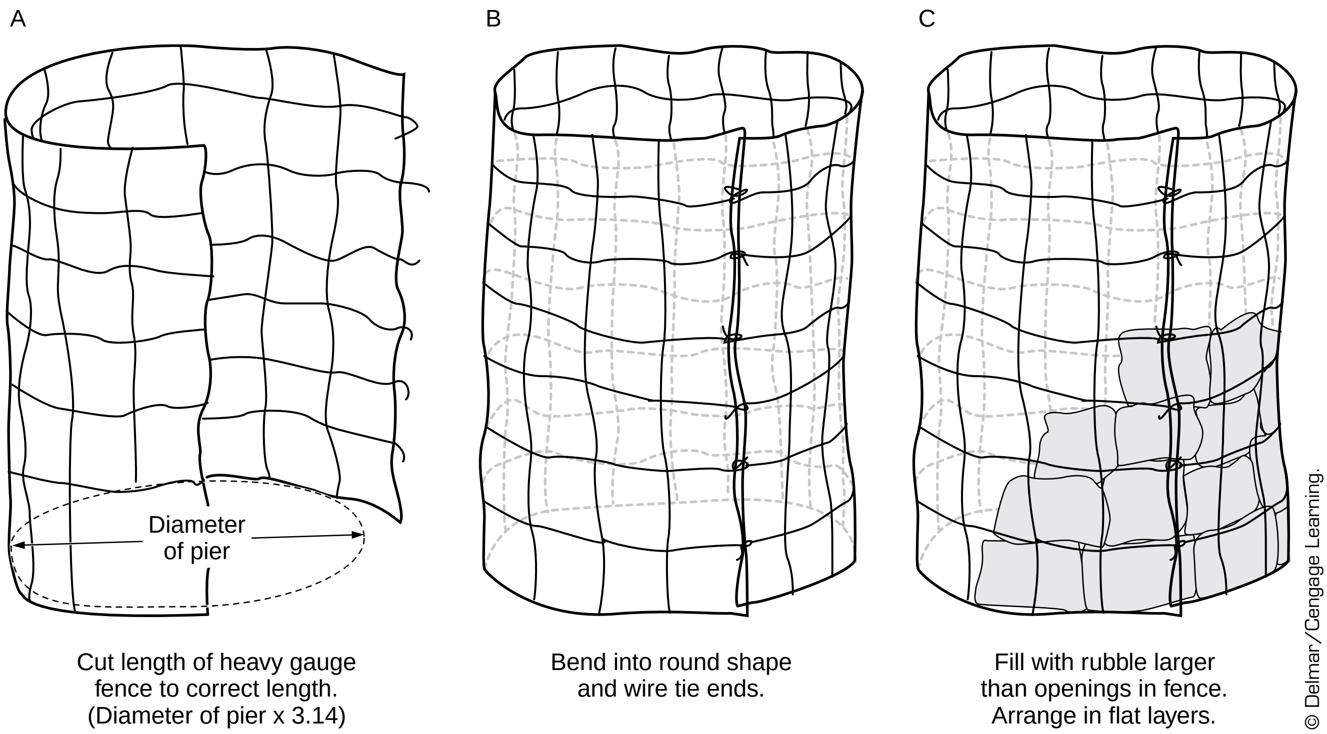

Figure 33-29 Rubble filled wire cage piers.

SECTION 8

SUMMARY

When a separation or definition of space is necessary, a fence or freestanding wall is often sought as the solution. Section 8 explained the installation of such separators. Included in the section was information pertaining to the selection of materials and site preparation, as well as chapters that described the specific installation techniques for wood premanufactured panel fencing, wood rail and stringer fencing, chain-link fencing, decorative metal fencing, vinyl fencing, dry-laid fieldstone walls, and masonry walls. Preparation for all of these requires a consideration of alignment, slopes, surface appearance, maintenance, and access to the construction site.

Construction of wood fences requires the installation of a fencing framework, usually posts, to which additional support or panels are connected. Wood premanufactured panel fencing involves fastening panels directly to support posts or “hanging” panels between posts. Rail and stringer fencing requires the attachment of horizontal rails directly to posts, or hanging stringers between posts to which vertical facing can be connected. Gates for either fence type can be custom-built or premanufactured and require an opening that is plumb and square.

Chain-link fencing also requires setting posts at each end or corner of a fence section. Line posts are then driven in at regular intervals between these anchor posts. A railing is attached to the top of the posts and fabric is applied to the completed framework. With chain link, the fabric is stretched between end posts and anchored to the framework. Gates are custom-built or prefabricated.

For increased security over chain link, without going to the expense of decorative metal fencing, welded wire fencing can be chosen. Welded wire fencing is fabricated of panels of heavy-gauge steel wires welded in grids, then anchored to posts. Most welded wire fences offer strength but do not create a significant visual impact on the landscape.

Decorative metal fencing necessitates a concrete base for footings. Posts are attached to anchor bolts set in these footings. Premade panels and gates are then installed between the posts.

Vinyl fencing requires direct burial of all posts along an installation. Beginning at one corner, rectangular vinyl rails are crimped and slid through openings in the posts. Both crimped ends are inserted into posts, and the process continues until all rails are installed. Posts are then plumbed, leveled, backfilled, and fitted with a cap.

Dry-laid fieldstone (rubble) walls are constructed by placing stones of irregular shape along the proposed alignment of the wall. Stone may be placed at its natural angle of repose, or it can be laid to maintain sides that are vertical.

Masonry walls and piers require a footing on which to place masonry units. Alignment is checked, mortar is mixed, and units along the base course are placed, carefully leveled, and plumbed. Each of the following courses is carefully placed on top of the previous course, with the height and spacing maintained throughout the construction. Reinforcement is placed in the mortar joints, and joints are struck as the project goes up. When the wall is complete, the center cavity of the wall is filled with grout and the wall is capped.

Cast-in-place concrete walls as described in this section are not designed to be used as retaining walls. Concrete walls require the pouring of a footing separate from the wall. Inserted in the footing are ties that anchor the wall to the footing. The wall is formed and cast separately. Stucco walls are a surfacing that can be applied to wood frame, masonry, or concrete walls. Stucco is typically applied in one or more coats over a prepared

surface. Finishes for stucco can provide rich color and textures to an otherwise bland wall. Veneers also provide a decorative surface of brick, stone, or other wall material over a structural background. Built on a ledge or adhered to the wall surface, veneers enhance the appearance of a plain wall.

The search for a sustainable wall material may take you to rammed earth as a choice. Rammed earth is a heavy structural wall material made when soil, a binding agent, and water are combined and compressed within forms. Either left rustic in appearance or finished with paint or stucco, rammed earth is an age-old choice for freestanding walls.

SECTION 9

SITE AMENITIES

INTRODUCTION

Sound, aesthetic design depends on the creative arrangement of major landscape elements such as walls, structures, paving, plantings, and lawns. However, in many designs, the site amenities provide the "flair" and extra interest. These amenities, which include everything from decorative pools to flagpoles, can enhance and enrich the overall design scheme, often making a qualitative difference in a project (Figure S9-1).

Amenities that landscape contractors typically install are discussed in this section. Each of the three chapters covers a different type of amenity: water features and bridges; premanufactured **site furniture** and play equipment; and edgings, planters, and plant protection. The first chapter on water features explains the installation of static pools created from flexible pool **liners,** cascades, waterfalls, fountains, and bridges. The chapter on site furniture details the anchoring and assembly of benches, trash receptacles, signage, bike racks, play equipment, and other exterior furnishings. Safe surfacing for play equipment is also covered in the play equipment chapter. Patio amenities such as outdoor kitchens, firepits, and patio misters are also covered. Finally, the process of edging installation for several different materials, including natural edges, plastic and metal edgings, brick, stone, precast, and concrete curbing, is explained. Also presented in the final chapter is the installation method for premanufactured landscape elements such as planters, root barriers, **tree guards,** and **tree grates.**

If the scale of the project is very large, landscape contractors may have a small role in completing amenity installation. As project size increases, so does the chance that a specialized subcontractor may have to finish the work. When responsibility does fall to contractors, they must pay careful attention to the plans and specifications of the job. Many times the designer or property owner has selected a particular amenity for its type, style, or detail; and should contractors substitute the wrong model number, they will have to correct that error, a costly correction. Private clients use amenities to enhance a landscape, but the cost of designer benches, pools, and similar details can be very high. To provide this extra level of detail to a residential setting, contractors can rely on the wide range

Figure S9-1 Seating in an urban plaza.

of premanufactured amenities available through distributors.

SUSTAINABILITY SUGGESTIONS

- Make use of recycled and reused materials before purchasing newly manufactured products.
- Reduce energy consumption by selecting local amenities, rather than importing materials from great distances.
- Select amenities made of biocomposite materials, rather than from virgin resources.

CHAPTER 34

WATER FEATURES AND BRIDGES

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Build a cast-in-place concrete pool.
- Install a rigid liner pool.
- Install a flexible liner pool.
- Add a fountain to a garden pool.
- Construct a water cascade.
- Install a decorative fountain.
- Install a bridge over a water feature.

Whether a design relies on the reflections of a static pool or on the dynamic sound and motion of a waterfall, a well-planned addition of water can be more provocative than any other design element on a site. New construction materials have made the introduction of water into the landscape a feasible undertaking. Traditionally, landscapes have relied on construction using concrete-lined pools with underground plumbing. Although this construction technique has not disappeared, the advent of pool liners, small pumps, and plastic tubing has made the addition of water features more affordable and has brought the world of water into the residential domain.

Although today's technology allows for water features to be easily implemented in landscapes, their high-maintenance character has changed very little. In all climates, the pool owner must make a commitment to regulate water quality; and in some climates, the pool may require periodic draining if the feature is to stay attractive and functional.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- DC Site Lighting and Related Electrical Work, Chapter 14
- Water and Irrigation System Installation, Chapter 15
- Concrete Paving, Chapter 23
- Wood Decks and Platforms, Chapter 29
- Wood Stairs, Railings, Seating, and Skirting, Chapter 30
- Freestanding Walls, Chapter 33

TYPES OF WATER FEATURES AND BRIDGES

Pools and water features can take many forms in the landscape. The components of water features can be combined and shaped to follow any design concept desired. Following are the components whose installation is described in this chapter:

Pools and Water Features

Standing and moving water is used in many forms in the landscape to attract attention, to provide sensory experiences, or to support aquatic wildlife.

Whether moving or static, water features can be generally categorized into the following groups:

Static Pools. Static pools are water reservoirs without any moving water. Static pools can be constructed of concrete, which is common for larger or commercial applications, or with vinyl pool liners. Pool size, form, and depth vary based on design.

Cascades. Water that gently flows on the surface from a higher elevation to a lower elevation is termed a **cascade**. A shallow channel, often lined with stone or gravel, contains the water as it flows between elevations. Cascades can be constructed on steep or gradual slopes and with either a concrete or vinyl channel. A water source, either a pump outlet or a pool, and an ending pool and drain are required to make the cascade function properly. Water is often circulated from a lower pool to the top of the cascade to produce the water movement visible in the cascade.

Waterfalls. Water that drops from a higher elevation into a lower reservoir is a waterfall. Depending on the effect the designer attempts to achieve, the drop can be a constructed as a quiet, simple, short drop; a loud, dramatic, tall drop; or a combination of both (Figure 34-1). Waterfalls require a water source at the top and a reservoir at the bottom to collect outflow.

In-Pool Fountains. Fountains are powerful pumps with special orifices that project water upward out of a reservoir. Depending on the size of the pump and type of orifice, water may project several feet into the air or simply bubble to the surface. Different types of fountains can be combined for special effects. Fountains can be designed and incorporated into walls, pools, and rock formations.

Decorative Fountains. With the advancement in manufacturing of materials such as precast concrete decorative and metalworking, decorative fountains can now be used as an accent anywhere in the garden. Built separately from any pool or dynamic water feature, these decorative elements come in a variety of shapes, materials, and finishes that allow water to be used as an accent for almost any landscape theme. Decorative fountains typically require a reservoir basin for water recirculation and one or more higher level pools and/or water outlets to feed the fountain.

Bridges

A wide variety of prefabricated bridges are available. Many large and small bridges are constructed of **Cor-Ten® steel** and require only footing construction

© Courtesy of Margaret Sauter.

Figure 34-1 Waterfall.

and placement. Smaller bridges can be constructed by building a wood platform or by placing a large slab of stone over a water feature. Although these simple structures may not require heavy piers, they still require careful anchoring and placement.

PLANNING THE PROJECT

The need for planning the construction and the placement of site amenities exceed most aspects of landscape construction. In addition to the complex nature of the construction, many amenities require utility connections, paving and foundations, and plantings as part of the installation. Details of amenity planning are described below.

Timing of Water Feature Placement

Water feature construction must occur in several phases. During utility construction (see Section 4), consideration should be given to drainage, water source, and electrical source issues. Multilevel water features may also require landscape walls. Placement of liners, edging, pumps, and other necessary elements typically occurs between finish grading and planting operations.

Design of Water Features

The design of the water feature must address several issues that will affect construction. The purpose of the water feature will determine the shape, depth, and equipment choices. Clients may desire flat sheets of water for reflection, pond gardens with plants, or ponds for fish. Reflection pools may require dark surfacing on the pool to enhance the water's reflectivity, whereas aeration and filtration systems should cause minimal disturbance in the water surface. Pond gardens will require varying depth levels to accommodate the various types of plants necessary to maintain an attractive and balanced garden. If the pond is to house fish, depth and filtration will be critical issues to maintain pond quality. Each of these water features will require special filtration and aeration to reduce problems with algae and unwanted aquatic plant life. With this range of choices, professional design assistance is recommended for any water feature, simple or complex.

Pumping Equipment. Pumps perform essential functions of circulating water for pools, ponds, waterfalls, cascades, and other water features. Typical pumps for water features are electrical submersible pumps using magnetic drives sealed in waterproof plastic housings. Most pumps are rated by the amount of water they pump per hour, or gallons per hour (GPH), with some rated by the number of gallons they pump per minute (GPM). A general rule for selecting equipment is to install a size that will pump half the pond volume every hour (e.g., a 1000-gallon pond should have a minimum of a 500-GPH pump). The pump may need to be larger if water filtering equipment is connected to the pump or if water features require water to be pumped out of or above the surface level of the feature. In many instances, the best approach is to use two pumps. One pump can be dedicated to water circulation and a second dedicated to filtering and/or waterfalls or cascades. Pumps should be UL rated for underwater use and connected to a circuit that is GFCI protected.

Filtration and Aeration. Water within a pond or pool will require various types of filtration to maintain water quality and clarity. Solid wastes in water features are typically removed by mechanical or sand filters. With these filters, the water is pumped through the filter; and the larger particles are trapped in the filtering medium. Skimmers can also be placed in a pond or pool installation to assist in trapping solids. Skimmers are an intake placed at the edge of the pond into which water flows by gravity. Solids are trapped in the skimmer filter, and the water is recirculated to the pool. A type of filter commonly used in ponds that house fish are biofilters. To break down wastes that fish produce, particularly nitrogen wastes, bacteria must be present. Biofilters house a media with extensive surface areas on which these beneficial bacteria grow. In some pond installations, stones or rocks are placed in the bottom of the pond to support plant growth and to create surface for bacteria growth.

The bacteria that filter water require oxygen to survive. To improve its oxygen content, water must be aerated. Aeration can be accomplished through recirculation, often using bubbler fountains. A general rule for good pond aeration is to recirculate the entire volume of the pond every 2 hours. In addition to encouraging bacterial growth, filtration is often used to reduce algae growth in water features. Ultraviolet (UV) clarifiers remove suspended algae from the water and improve water clarity, particularly for reflecting pool installations. As with pumps, all electrical equipment should be rated for submersible use and connected to a GFCI circuit.

Plants for Garden Ponds. Plants are often a key aesthetic part of a water feature as well as a water purifier. Ponds and pools that are properly constructed can support a variety of aquatic plant life that enhance the beauty of the feature, oxygenate the water, and reduce algal growth. Types of pond plants include those that oxygenate the water, marsh plants, lilies, floating plants, and marginal plants. Selection and planting requirements for each are as listed below.

Oxygenating Plants. Plants that grow in water both oxygenate the water and maintain its quality. Examples of oxygenating plants include water buttercup, curly pond weed, water milfoil, red star ludwigia, anarchis, rotala, dwarf sagittaria, and hornwort. Oxygenating plants will be placed at various depths, depending on the species, with a minimum water depth of approximately 1 foot to a maximum of around 3 feet.

Marsh Plants. This class of plants typically are set on ledges at depths varying from 1–1½ feet. Typical plants include equisetum, reeds, rushes, water irises, and water hyacinth.

Lilies. A wide range of lily species are available for aquatic plantings. Most lilies grow in water up to depths of 5 feet. Line the bottom of a one or two gallon nursery container with shade cloth or newspaper. Plant the lily tuber in the pot at a slight angle. Fill the top with small lightweight stone and set the pot in the pond. Do not overplant with lilies, as they can spread and overgrow in pond settings.

Floating Plants. Floating plants that are useful for garden ponds include fairy moss, greater bladderwort, water soldier, orange snowflake, snowflake, American golden club, and big bunch parrot's feather. As the name suggests, floaters are not planted but instead placed on the surface of the pond. The parrot's feather should have a small weight (a sinker or a large hardware nut) attached to the root mass with a rubber band.

Marginal Plants. Marginal plants are placed around the perimeter of the water body in areas that are either covered with shallow water or on land but in soils that are occasionally or constantly saturated. The placement will depend on the species. Typical species include iris, flag, arrowhead, marsh marigold, pitcher plant, and taro. Plants can be installed in the ground or placed in containers that are set on a shallow shelf or ringed with stone.

A general rule of thumb for plant selection is that 25–50% of the water surface should be covered by plants. Plant material can be planted in stone and rock placed at the bottom of the pond, placed in special baskets with an aquatic compost, or left in the original plant container and covered with sand and small-diameter stone or lava rock. Covering the root-ball with stone will reduce the opportunities for fish to disturb the soil and make pond water murky. When planting in containers, most designers recommend using a planting medium with low nitrogen and phosphorus content to reduce algae problems.

Laying Out Water Features

Pool locations should be located by painting the perimeter of the installation prior to excavation (Figure 34-2). Stakes within the reservoir area can mark proposed finish grades and guide filling and excavation procedures. Dynamic water features often involve pools on multiple levels with connecting features such as cascades and waterfalls. Each of these features should have location and grade verified prior to construction (Figure 34-3). Electrical and recirculation piping routes should also be identified before beginning construction. Preliminary layouts may reveal minor adjustments necessary to improve the feature's performance.

Testing Water Feature Operation

Unlike for most landscape features, the visual appearance of a water feature is not the final test of a proper installation. Testing of the various components as they are completed is important to avoid disruption of features for repairs later in the project. Test the utility connections when they are installed. As you install component features, test the liners for leaks, the pumps and tubing for proper operation, and waterfalls and cascades for flow before moving to the next stage.

Testing waterfall and cascade operation is critical. Few adjustments can be made after the landscape treatments are completed. Fill all reservoirs and turn on the pump or water supply. Verify that the basins are maintaining the proper water elevation. If necessary, make adjustments in pump and weir opening size to correct flow problems in these two areas.

Cascades can be tested by filling all reservoirs and operating the pump. Water should flow evenly from top to bottom down the center of the channel. If the liner pieces are not properly placed, the flow of water may miss the decorative liner completely.

Figure 34-2 Layout of a multilevel water feature to be constructed with flexible pool liners. White lines indicate the approximate outside edge of each pool. Overlap area is where the waterfall will be placed.

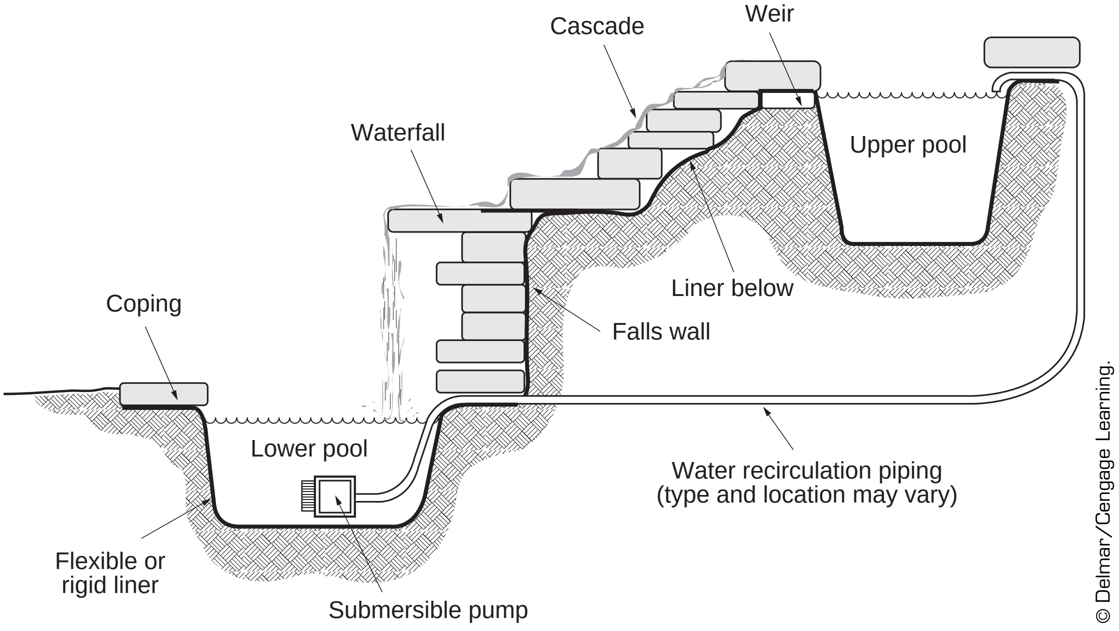

Figure 34-3 Cross section of water feature showing components.

For a flexible liner, adjust the pieces by twisting them so the water flows down the center. For a concrete liner, add small pieces of stone, or perhaps even mortar, to divert the water back to the center. Position the stone placed over the liner so that water flows over, and not under or around, the pieces.

Locating Bridges

Bridge location should be based on the bridge function, aesthetics, and water conditions of the feature. If the bridge is crossing a body of moving water, care should be given to the position of the footing. Consult a design professional if you have doubt about the stability of the footing position or about potential bridge failure.

SITE PREPARATION FOR WATER FEATURES

Depending on the size and type of water feature, preparing the site may require several activities ranging from utility connections to grading and drainage to foundation preparation.

Site Conditions

Grade preparation is essential before pools and channels can be excavated. Because pools require level surfaces, it is easier to grade a level, compacted area prior to digging the reservoir area. Similarly, cascades and waterfalls need varying degrees of grade change, meaning the subgrade for each must be prepared before construction begins. Hours of hand excavation can be saved if the locations of features are marked before filling operations are undertaken. Because settlement will disrupt the level conditions required to make the features work properly, it is also important to maintain proper compaction in areas under and around water features.

Electrical Source

Electrical circuits that supply power to exterior fixtures should be ground fault circuit interrupt (GCFI) circuits. If the feature is to be serviced by running a power cord to an exterior receptacle, the contractor's primary concern will be ensuring a nearby receptacle exists and locating a concealed route from the pump to the receptacle.

A large feature will usually have a dedicated circuit(s). Burial of the electrical source should be accomplished before excavation of the feature. Conduit is required for high-voltage circuits, and the conduit may be placed now and the wire pulled in at a later time. Stake the electrical service point for the feature and excavate an 18-inch deep trench between the two points. In the trench, place a 2-inch or larger Schedule 40 PVC conduit with radius ends that bring the conduit to the surface. Cover the ends with duct tape. A licensed electrician should perform electrical wiring.

Water Source

Water may be provided through a hose connected to an external **hose bibb** or through a separate line dedicated to the water feature. Water provided through a hose requires minimal preconstruction preparation and is usually an acceptable way to supply water for a small residential setting. Larger pools and commercial applications have a much higher demand for water, and frequent filling with a hose will prove to be a nuisance. In these cases, provide a separate underground supply line to save time and maintenance over the long run. As with the electrical source, final, above-grade connections of the water source can be completed after the water feature is installed.

If a separate water supply line is provided for an exterior feature, it should be either excavated below frost depth or sloped toward the source to allow for backdraining when necessary. The source of water will most likely be inside a nearby structure where a supply line is located. Inside the structure, provide a water shutoff and backdrain to allow the system to be shut down and drained to protect pipes from freezing. Consideration should also be given (and may be required in some locations) to installing a backflow preventer in the water line. This will prevent accidental contamination of potable water supplies from exterior sources. The backflow preventer should be installed 2 feet higher than the high point of the water supply line. If the outflow end of the water supply never comes in contact with the water feature (air break), the backflow preventer may not be necessary. Verify water source requirements with a professional engineer or building official before beginning installations.

Drainage of Pools

At some point, the water feature will need to be drained. Emptying the pool can be accomplished using a portable submersible pump. Pumping water out of the pool, rather than building a drain, provides fewer risks of leakage, and drain plugging, and

may be a more cost-effective method if the pool is not drained frequently. Pumping, however, does require the rental of equipment and the constant monitoring of the pump and outlet to prevent back-ups and flooding.

CAUTION

When installing any electrical device in or near a pool, there is a danger of electrical shock or electrocution. Buy only devices approved for submersible use. Assemble, place, and connect such devices according to the manufacturer's instructions. Connect all exterior devices to GFCI circuits.

Installation of Subdrains

When positioned over soils with high water tables or poor internal drainage, subsurface water can lift and damage a rigid or flexible liner. A subdrain is necessary under the pool to remove subsurface water and to reduce the chance of such damage. Excavate the entire pool basin 4 inches deeper than required. Excavate a 6-inch deep × 6-inch wide trench along the center of the entire length of the pool basin's bottom. In this trench, install a 4-inch diameter socked, perforated drain tile. Continue the trench and tile to an outlet point. Cover the tile and entire bottom of the excavation with 4 inches of pea gravel before installing the liner or constructing the pool.

INSTALLATION OF FLEXIBLE AND RIGID LINERS FOR STATIC POOLS

Liners allow a variety of shapes and configurations for pools. Flexible liners are placed in shapes matching a custom design, whereas rigid liners are molded into a variety of interesting shapes. Although not appropriate for all installations, liners allow for a variety of shapes and depths in pool construction.

Layout

Begin flexible pool installation by marking the proposed perimeter of the pool with paint. This marking provides a guideline for excavation of the reservoir. Rigid liners require transferring the exact pool perimeter dimensions to the location where the pool will be placed (Figure 34-4).

Excavation

Excavate the **reservoir basin** to the correct depth over the entire area. Very steep angles work best to create side walls; but in a sandy soil, the angle may have to be shallower to avoid sidewall collapse. The bottom of the flexible pool liner basin can be excavated to different levels if the design requires, but each terrace should be sloped slightly toward the low end of the basin. Bottom areas where fountains or pumps are planned should be excavated level to allow the pump to set flat. Remove all rocks and prune any roots protruding into the pond basin. You can make corrections to the base by adding sand.

Around the entire edge of the reservoir basin, excavate a level ledge for **coping material.** The depth of this ledge should be the same as the thickness of the coping material and the width of the ledge slightly narrower than the width of the coping material you have selected. If edge installation is unstable, excavate the ledge deeper and install precast concrete wall caps level around the entire pool perimeter (Figure 34-5). The depth of this ledge should be deep enough that when edge material is placed, it will match the finish grade of the material that is adjacent to the pool (walk, patio, lawn, etc.). *Verify that all points of this ledge are level.* Any low point in this ledge will create an unplanned drain where water will spill out of the pool. Correct low points by filling with fine granular material. You can vary the depth of the bottom excavation to create shelves on which plants, lighting, and fountains can be placed (Figure 34-6).

Protective Barrier (Liner Pad)

When excavation is complete, install a spunbond geotextile protective barrier (also called a *liner pad* in some publications). This barrier can be a heavy-gauge, nonwoven weed barrier. The barrier will need to be large enough to cover the entire basin. Place the barrier in the basin and form it to the shape of the sides and coping ledge. Trim the barrier at the back of the coping ledge.

Flexible Liner Placement

The pool liner must be sized to provide seamless coverage of the reservoir. To calculate liner length, add the maximum length of the pool, plus twice the depth, plus 3 feet. To calculate liner width, add the maximum width of the pool, plus twice the depth, plus 3 feet. For large pools, you can splice separate liners together using bonding material available from the manufacturer. Unfold the pool liner on a

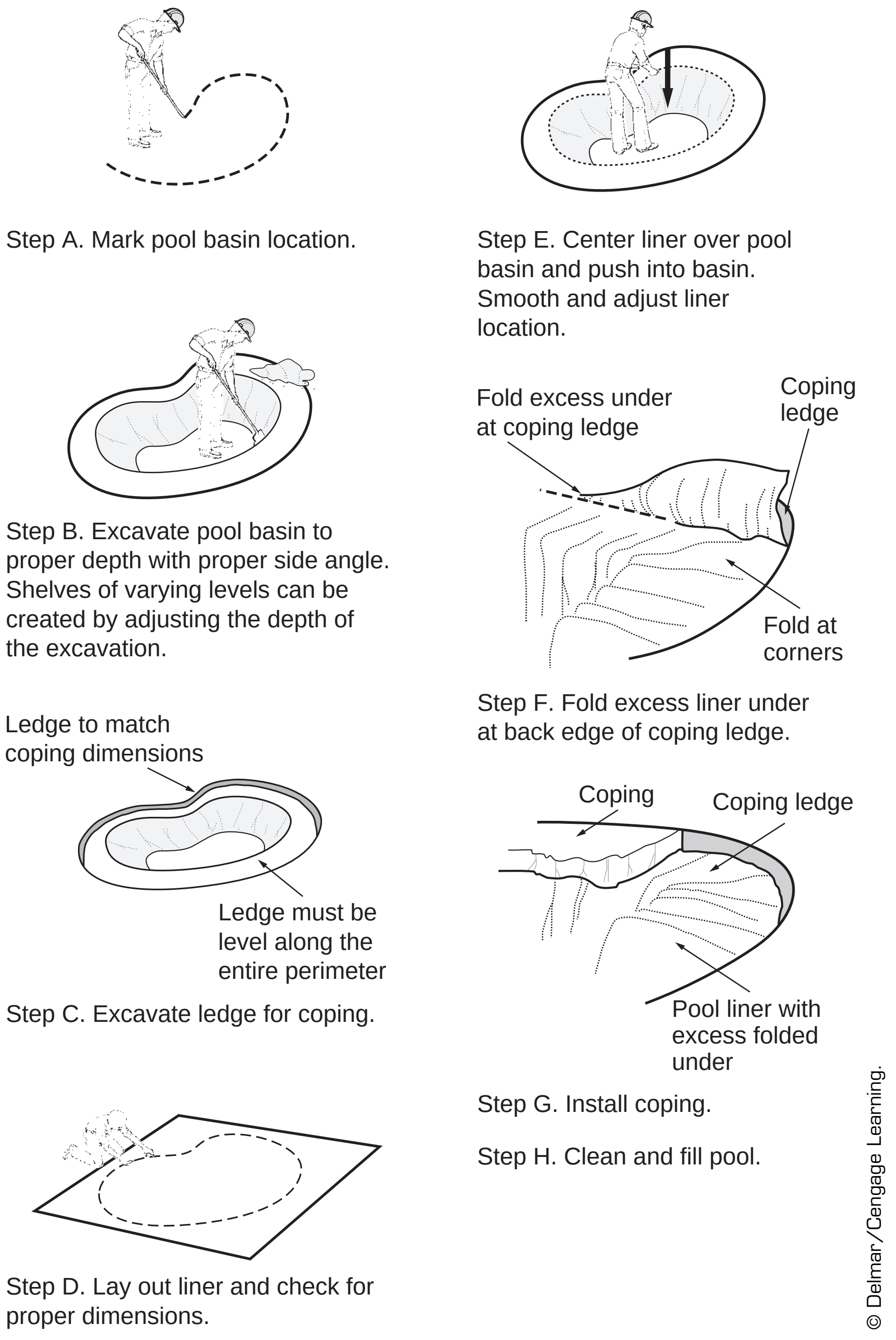

Figure 34-4 Installation steps for a flexible liner pool.

flat area (Figure 34-4). Pull the liner over the reservoir basin; step carefully inside the reservoir and gently work the liner down to the bottom of the basin (Figure 34-7). It is best if workers remove their shoes to reduce the risk of puncturing the liner. Be sure the liner sets as flush as possible on the bottom of the basin. After the workers have molded the liner to the basin shape, add a few inches of water to the pool to assist in forming the liner to the bottom of the excavation. Mold the liner over terraces, tucking and folding where necessary to accommodate grade changes. Use the same process to fold the liner up the vertical sides and over the coping ledge created at the top of the pool. Fold and tuck the liner if required to adapt to corners. Wipe the liner clean before climbing out.

Verify again that the coping edge is level around the entire perimeter. Adjust if necessary. Fold any

Figure 34-5 Flexible liner pool excavation.

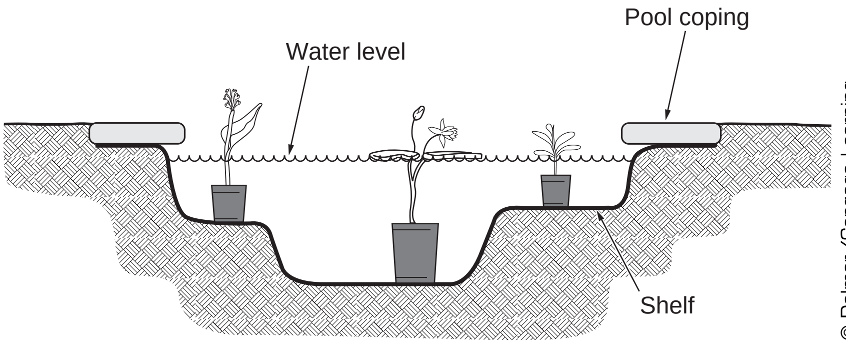

Figure 34-6 Varying pool depth to create shelves.

excess liner back under the pool at the coping ledge. This will provide additional liner in the event adjustments are necessary. Using a sharp utility knife, trim and remove extreme excesses (exceeding 2 feet) that disrupt the even placement of coping. Check to make sure the liner is snug against the sides and bottom of the basin. Use caution not to puncture the liner; even small holes create serious leaks. If you damage a liner, take it to a tire shop for repair.

Rigid Liner Placement

Follow similar steps for installing a rigid pool liner. Mark the location based on the actual shape of the pool. Excavate the pool to the proper depth, leaving

Figure 34-7 Installation of liner in flexible liner pool.

ledges in the subgrade where there are ledges in the pool. Excavate a level ledge for the coping around the top edge of the pool (Figure 34-8). After you have completed the excavation, carefully place the rigid liner into the basin and test it for snug fit. If the liner sides bow, or if the liner does not sit level or completely in the excavation, remove the liner and adjust the excavation. If the liner sets too low in the excavation, adjust the bottom elevation using sand or pea gravel. When you have correctly positioned the liner, use sand to backfill any visible voids between the liner and the excavation.

Edge Treatment

Once you have stabilized the flexible or rigid liner, you can place the coping material. Select and place coping pieces so that they fit together tightly with no liner visible between pieces. Place the coping pieces so that they overhang the edge of the pool approximately 2 inches to hide the top edge of the liner (Figure 34-9). Clean inside of the pool with water and sponge. Fill the pool to within 2 inches of the bottom of the coping.

Lighting

Lighting can be added to a pool by purchasing a submersible waterproof lighting kit. Most pool

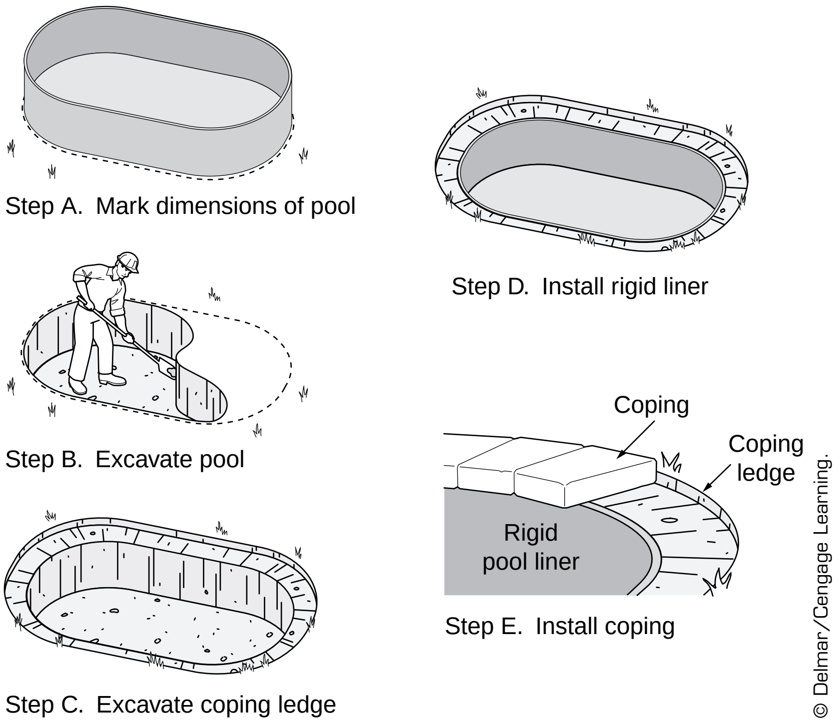

Figure 34-8 Installation steps for a rigid liner pool.

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Figure 34-9 Edging a flexible liner pool.

lighting is used to provide a low level of light that highlights the surface or plant material growing in a pool. Lighting that is installed on a switched circuit can be controlled from a remote location.

Assemble the kit according to the manufacturer's instructions and place it on a level portion of the pool's base. If a higher elevation is required, paint a concrete block black and set the block on a level location on the bottom of the pool. Place the light on top of the block. Run the cord for the light along the bottom and up the side of the pool. Place the cord under the coping at the top edge of the pool and route the cord to a GFCI circuit. Hide the cord in conduit or under plant material.

Filters and Aerators

Biofilters and UV filters are often designed with submersible housings and connected to pumps that force water through the filter. If pressurized in this manner, the filter can be placed at any water level. An ideal location is to place the filter directly in front of the pump assembly. Passive filters that use gravity and natural circulation to filter the pump must be placed at the highest discharge point for water entering the pool or pond. Skimmers are placed with the inflow elevation at the desired water elevation of the pool or pond. For best performance, skimmers should be positioned opposite any water discharge into the feature such as a waterfall, cascade, or recirculation tube. Special aeration equipment must be mounted slightly below the water surface level with the discharge orifice projecting above the surface level. To obtain the proper elevation for setting aerators, you may need to excavate a shelf or stack stone or heavy blocks on the pool's floor. On large water features with multiple aerators, space the equipment equally around the feature.

INSTALLATION OF FOUNTAINS

Fountain installation can be accomplished using a stationary pump or a floating fountain. Most fountain installations are placed within a pool or pond and use

water from the basin of the pool for spray. Fountains that do not have pools typically include some method for water recirculation or water supply. A licensed electrician should complete electrical connections.

Stationary Pump Fountains

Select a location in the pool basin that places the fountain on a level surface at the correct depth. If necessary, place a support block (concrete block painted black) in the pool to raise the fountain pump. Lower the pump into the basin and secure it in place. Bring the electrical connection out through a preplaced conduit in a concrete pool or between coping pieces for a liner pool. Complete the electrical connection by plugging into a GCFI electrical receptacle or connecting to a GCFI switched circuit. Fill the basin with water and test the fountain for proper operation (Figure 34-10).

Floating Fountains

Floating fountains require that the pool be filled before placement. Fountains that float in a pool are anchored to the sides or bottoms using cables/ropes or a weighted anchor. A maintenance rope is also run to the side and placed where it can be used to pull the fountain in for repairs. To anchor the fountain, fasten the anchor to the fountain using stainless steel cable or polypropylene rope. Load the fountain and anchor into a boat (or alternatively, wade into a shallow pond) and position the fountain in the desired location. Lower the anchor into the pond and verify that it is securely resting on the bottom. For ponds that have fluctuating water levels, manufacturers typically recommend mooring the fountain to the side of the pond. Use stainless steel cable or polypropylene rope fastened to a duckbill® anchor placed just below the waterline at the shore. Attach electrical cables to the fountain with waterproof connections and float them out with the maintenance cable. After you have completed the anchoring and electrical connections, test the fountain.

INSTALLATION OF WATERFALLS AND CASCADES

The creation of waterfalls and cascades requires installation of basic elements that, when assembled properly, can create a dramatic landscape feature.

Lower Basin

The first element to consider for waterfall or cascade construction is the basin that will collect water at the bottom of the falls. The basin may be constructed using the flexible or rigid liner pool techniques described earlier in this chapter, but the pool must be constructed with part of the basin positioned directly under the location where the falls will deliver the water. The projected fall of water should land in this lower basin far enough from the edge to allow water displaced by splashing to remain in the pool. If you use a flexible liner for the lower basin, build the vertical sides of the pool basin in this area with concrete blocks under the liner to provide stability (Figure 34-11). This wall can also provide support for the falls and any basin used above to supply the falls. The lower basin contains the pump that recirculates water to the top to supply the falls.

Water Supply/Upper Basin

The second consideration for a waterfall or cascade is the water source at the top of the falls. The falls

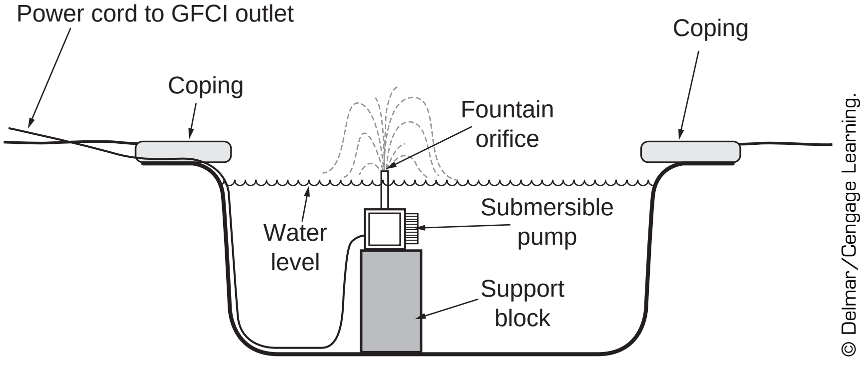

Figure 34-10 Installation of a pool fountain.

Figure 34-11 Construction of a wall between flexible liner pools set at different levels. The upper pool is adjacent to the lower pool with a waterfall planned between the two.

can be supplied by water flowing out of an upper reservoir basin or directly from a water supply line recirculating water from a pump in the lower basin. Because an opening is needed to allow water to exit the pool, rigid vinyl liners cannot be easily used for upper basins unless they are molded to accommodate water falls.

When an upper basin is constructed for a waterfall, the edge should be placed as close as possible to the lower basin. Flexible liner basins will rely on the retaining wall to support the portion of the upper basin that will supply the falls (Figure 34-11).

Weir and Pump

Pools require the construction of a weir at the location where water is to drain from the pool to supply the falls or cascade. A **weir** is an opening in the edge of the basin with dimensions that allow only a calculated amount of water to pass (Figure 34-12). The depth and width of this opening should be taken from plans or calculated by a design professional because the size of the opening will control the amount of water that supplies the falls. In the absence of precise weir calculations, construct an oversized weir because the flow through the weir can be restricted but not easily increased. The weir needs to be placed lower than the perimeter level of

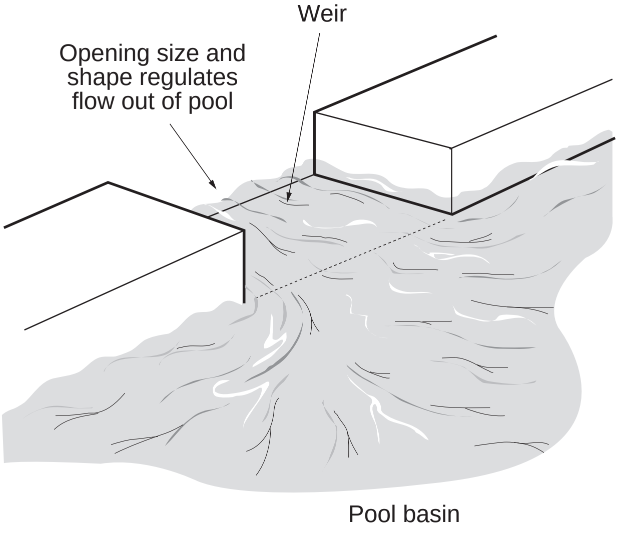

Figure 34-12 Weir diagram.

the pool to allow water to exit the pool. Construct the opening in a flexible liner pool by overexcavating the earthen dam to the dimensions desired.

The amount of water that flows through a waterfall or cascade is not a chance occurrence. Control of the water amount is primarily the weir's function. Another factor that controls the water flow is the capacity of the recirculating pump. Both of these factors work together to provide either a light or a heavy flow of water through the falls channel. If the water flow from the falls does not meet design expectations, consider installing a higher volume capacity pump or using more than one pump. Flows over a waterfall can be concentrated by narrowing the weir. If the lower basin is running dry and the upper basin is running over, the weir is undersized and needs to be enlarged or the volume of water being pumped needs to be reduced.

Recirculation Piping

Installation of waterfalls and cascades requires piping for recirculation of water between basins. Rigid piping is required in higher volume operations, whereas flexible tubing can be used for pumps with a capacity of less than 10 GPM. This piping should be placed between supply and use locations while the basins are being constructed. With flexible liner pools, the piping runs over the edge of the pool hidden between coping pieces. Piping between pools can be hidden by plants. To hide the installation of flexible tubing and reduce kinking of the tube, place a 3-inch diameter, nonperforated drain tile along the route of the recirculation tubing and slightly underground and pull the tubing through it.

Projection Channel

Rigid wall pools may have water spill directly from a weir into the lower basin, but many water features have a projection channel that carries the water from the supply out over the lower basin (Figure 34-13). This projection ensures that the water will fall into the lower basin and will not miss the pool. The projection channel can be custom-cast out of concrete or can be constructed from pieces of flat stone.

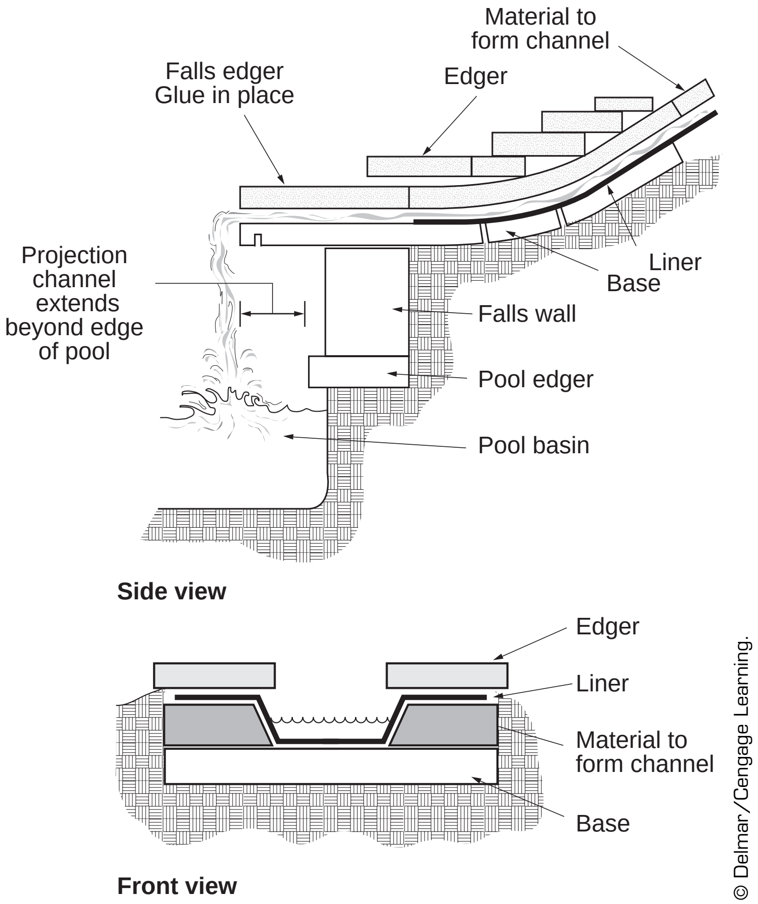

Figure 34-13 Projection channel construction for waterfall.

Large volumes of water require special construction to ensure the water does not flow off the sides of the projection channel. Supporting the channel also requires some form of structure under the channel and anchoring. The greater the amount of projection for the channel, the more difficult it will be to anchor. If possible, the channel should be tilted forward slightly to help the water project farther out into the lower basin and slightly concave on the surface.

If water is clinging to the end of the projection channel, either tilt the channel farther forward or cut a **reglet** (Figure 34-14), or a shallow cut across the underside of the channel. Reglets break the surface tension between water and the projection channel, allowing water to fall, rather than to adhere, to the surface. Cut a reglet with a wet masonry saw; the reglet should be approximately ¼ inch deep and run the full width of the channel.

Multiple Falls

Installations that call for multiple falls can be constructed using multiple basins and projection channels, or they can be constructed as a series of falls where the projection channel is the supply for the next falls (Figure 34-15). Either arrangement requires careful positioning of channels to ensure that the water falls on its target.

Cascade Channel

The channel for the cascade is a wide, shallow, U-shaped channel that runs from the top weir to the lower weir. The cross section of the channel should be approximately twice the cross section of the upper weir to accommodate the water flow and decorative lining material placed in the channel. The channel may follow any alignment desired, as long as the proper cross section and downward slope are maintained.

Excavate the entire route of the channel. Maintaining a consistent slope provides an even flow of water from top to bottom. Varying the slope provides a more interesting water flow but requires that the channel be widened to accommodate heavier flow in areas. Edges of the channel need to be elevated high enough that water stays in the channel (Figure 34-16).

Waterproofing the channel can be accomplished by cutting a linear strip of pool liner material and placing it in the excavated channel. If splices need to be made or corners must be turned, overlap two pieces of liner approximately 1 foot, placing the higher section on

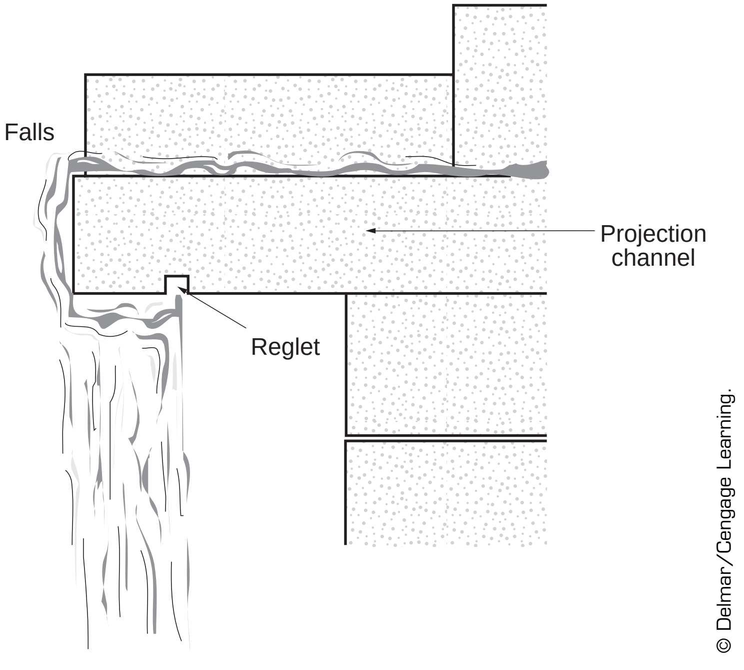

Figure 34-14 Location of reglet, used to break surface tension of water.

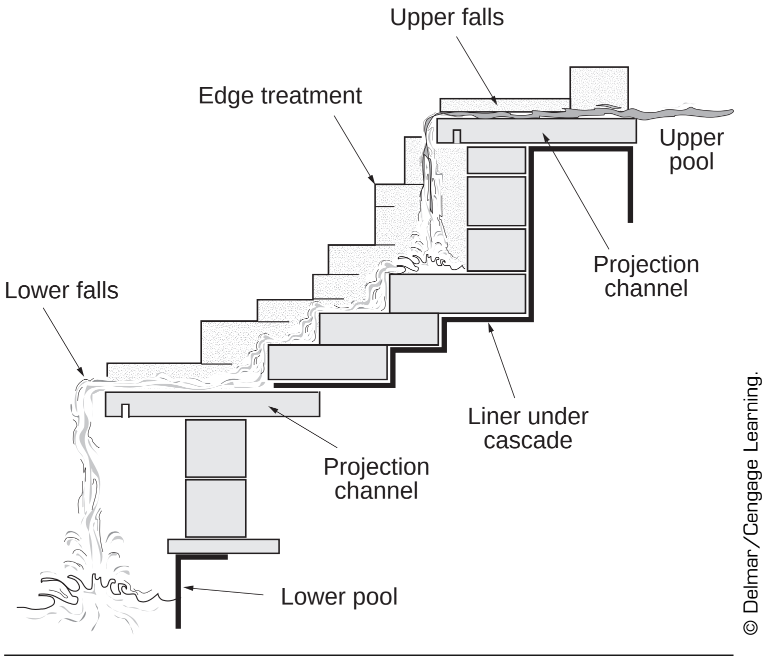

Figure 34-15 Falls channel construction for multiple falls.

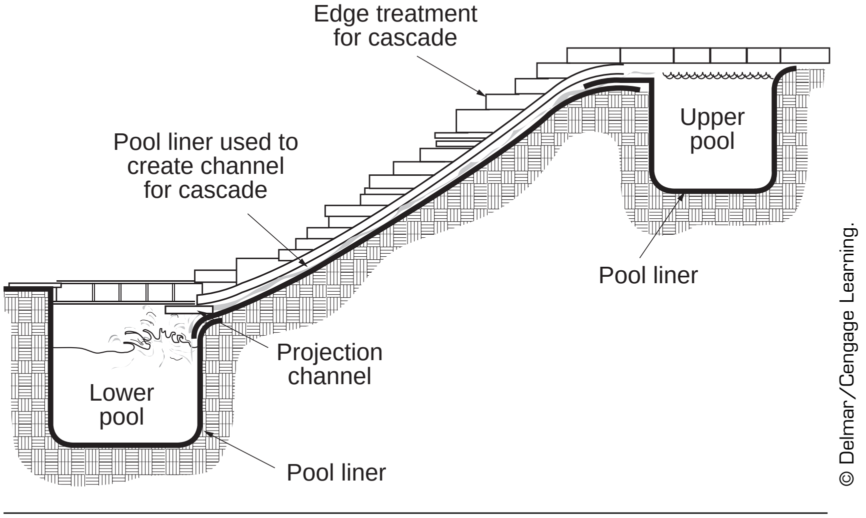

Figure 34-16 Falls channel construction for a cascade.

top of the lower section. When the waterproof lining is completed, decorative material such as rock or stone is placed in the channel to hide the waterproofing. Rock is placed along the entire length of the channel, spread from side to side to obtain complete coverage of the liner. Stone must be placed in the channel beginning at the bottom. Each succeeding piece of stone should overlap the previous piece and should have a slight forward slope.

An alternative to flexible liners for a cascade channel is pouring a concrete channel. Dimensional requirements for the cross section remain the same as those for the liner channel. Before the concrete has hardened, the decorative pieces should be placed. For rock, pour them into the channel and seat them into the concrete using a trowel. Wash lightly after the concrete has hardened slightly. To place stone, begin at the bottom of the cascade and

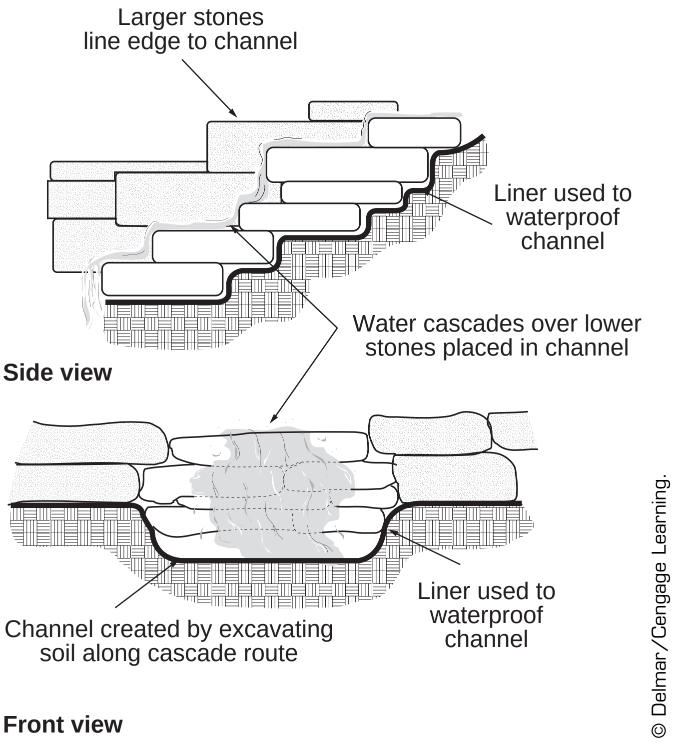

Figure 34-17 Cascade edge treatment.

push the decorative liner pieces into the concrete, forming the base of the channel. Continue placing the stone tilted slightly forward and toward the center of the channel until you reach the top weir.

Edge Treatment

Complete the installation by treating the edges of pools and adding edging material or plants. In falls and cascade channels, stacking stone pieces two to three high in some locations can create the illusion of water flow that has cut through several layers of stone (Figure 34-17). Careful placement of plant material can hide wiring, tubing, and other rough edges of the falls installation.

INSTALLATION OF DECORATIVE FOUNTAINS

When designing a decorative fountain, an almost infinite number of possible forms and styles are available. Precast concrete, metal, and stone have been used to create standing and wall fountains, and creative garden designers are turning urns and old pottery into focal water features. Fortunately, the installation requirements are very similar for almost all styles available. Most fountains are constructed using a reservoir basin at the lowest point to collect the water and house a recirculation pump. Above that level is typically a water outlet where the water for the fountain is discharged. Between those points is a tube that carries water from the pump to the outlet and, depending on the design, one or more intermediate basins or surfaces over which the water cascades into the reservoir (Figure 34-18). To make the fountain function, water must be added by a water supply, possibly even a hose or bucket, and electricity is necessary to operate the submersible pump.

Before extensive preparation is undertaken, review the type of fountain to be installed. Certain fountains require preparation similar to installation of water features, whereas other fountains are kits that require only a stable foundation (or placement method), an electrical outlet, and a hose/bucket to supply water. Review fountain directions, if provided, to verify what steps need to be undertaken to create a successful installation.

Figure 34-18 A decorative fountain with multiple cascade basins.

Foundation/Mounting

A key to any water feature is to keep it upright, and this requires stable installation on a footing or wall. If the fountain is wall mounted, first verify with an engineer that the mounting wall is strong enough to hold the fountain's weight and that plumbing and electricity necessary can be brought to the site without significant remodeling. Wall-mounted fountains typically come with a bracket that is secured to the wall studs with lag screws or into masonry or concrete with expanding screws. The fountain is then "hung," or mounted, to the bracket for support. It is not uncommon to have multiple mounting brackets for a single fountain. When installing the bracket, verify that it is level in order for the fountain to function properly. Depending on how the water is recirculated and how the power is supplied, you may need to drill holes in the wall before mounting the fountain.

For standing fountains, a stable footing should be constructed to support the fountain. Lightweight fountains may be able to stand on concrete blocks or bricks on stable soil, but fountains over 50 pounds should have a concrete footing poured to support the fountain and keep it level. Using the instructions for pouring concrete in Chapters 23 and 14 ("Light Fixture Footing Installation"), form and pour a footing that matches or slightly exceeds the dimensions of the fountain base. Place conduit for water supply, drain, and electrical connections through the center of the footing. Verify that the footing is level and if any anchor bolts are required before completing the forming and pouring the concrete.

CAUTION

A properly licensed contractor should complete all utility connections.

Utility Connections

Utility connections will vary, depending on whether the fountain is preplumbed, wall mounted, or standing. Preplumbed fountains need only the electricity connected (often by plugging the fountain cord into a GFCI outlet) and water placed in the fountain. If the fountain is not preplumbed, utility connections will differ. If wall mounted and separate plumbing is required, the holes for utility connections should have been created prior to mounting. Behind the wall, connect the electricity to a GFCI outlet or circuit, connect the fountain to a water supply (if a separate supply is required), and route the recirculation tubing from the pump in the reservoir basin to the supply at the top of the fountain. In rare cases, the fountain may also require a separate drain be connected to a sanitary sewer system. Standing fountains require that the reservoir basin or any support pedestal be set and plumbing connections run inside the fountain. Access is typically gained to utility connections before upper basins are set or through a handhold in the fountain's base (Figure 34-19).

When making utility connections, verify that all electrical outlets are connected to a GFCI circuit. A separate switched circuit for fountains and any associated lighting makes operation and maintenance easier. Water supplies that are connected to potable water should have a separate backflow prevention and shutoff valve installed. All pumps used should be rated for submersible use. For maintenance and to accommodate issues with freezing temperatures, a method to drain water from the fountain should also be installed. In small fountains, this can be accomplished using a drain plug at the low point of the fountain or a hand pump and hose; but in large fountain installations, a drain should be plumbed to a nearby sanitary sewer or other appropriate disposal point. You may be able to route fountain drains to gray water systems or to cisterns for irrigation.

Basin Placement

Once utilities are connected, finish placing any upper basins or water outlets for the fountain. Wall-mounted fountains typically come as a single piece, but certain models may require a backing plate and upper water outlet be installed over a basin. Fasten these components as directed by the manufacturer. Standing fountain components are typically stacked, with each subsequent basin or element fitted into the one directly below. Before placing the water outlet, finalize any connections of recirculation tubes to the fixtures supplying the outlet.

Testing

When you have made all connections, fill and test the fountain to verify proper operation. Any necessary adjustments in level will be apparent through uneven flow through the components of the fountain. Use plastic or metal shims placed under the reservoir basin to make any adjustments in standing fountain. Wall-mounted fountains may require repositioning of the bracket(s) to obtain even flow.

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Figure 34-19 Utility stubouts for a decorative fountain. Electrical and plumbing run through the hole in the center of the base. Other stubouts are for lights and irrigation for the planter.

Once you have verified proper operation, install aesthetic treatments to hide utility sources, footings, and other functional parts of the fountain.

INSTALLATION OF BRIDGES

Bridge installation involves two phases: **pier** construction and placement of the structure. If the bridge is more than 10 feet long or is over moving water, a specialist in concrete work should be hired to perform installation work. If concrete abutments or full supports under the ends of the bridge are specified, a contractor specializing in concrete pours should be subcontracted to perform that portion of the work. Landscape contractors can typically complete custom or prefabricated bridges under 10 feet in length that use wood post or cast-in-place concrete piers. To place prefabricated bridges, rent or contract truck-mounted cranes or similar types of special lifting equipment.

Pier Construction

Prefabricated bridges rest on two or more piers that carry the load for the bridge. Carefully review the working drawings from the manufacturer to determine the dimensions of the footing, reinforcement required, and bolt pattern necessary to make connections to the bridge. Most bridge piers, regardless of size, extend below frost depth to prevent movement.

Small custom-built wood foot bridges can be placed on posts excavated to frost depth. Locate the center of each post and excavate a hole by hand or by using a post auger. Place a small amount of granular material in the hole and place the post in the hole. Plumb and trim to the elevation required for deck framing (Figure 34-20).

Piers for small bridges may also be cast-in-place concrete poured in paper tube forms. When using paper tube forms, you must brace footings against movement. A vertical column can tilt when filled with concrete, altering the dimensions for the bridge. Auger holes to the dimensions required for the pier and slide a piece of tubular paper forming down the hole. Insert two #4 rerods into the form. Stabilize the rerod by driving it into the soil at the bottom of the hole. Measure and, using a reciprocating saw, cut off the top of the tubular paper form at the required elevation. Adjust for plumb and

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Figure 34-20 Use of posts installed as bridge piers.

proper location. Pour concrete and set anchor bolts, verifying that the spacing of bolts is correct before the pour hardens. Additional permanent bracing may be required after the piers are set. This bracing should be designed by a licensed design professional.

Bridge Placement

Using a contracted truck-mounted crane is the easiest way to set a prefabricated bridge. Crane operators can place the structure quickly and with minimal damage. The delivery and placement should be carefully timed to make the operation cost-efficient. Allow the crane operator access as close to the structure as possible. Wrap lift belts under the bridge and lift and place it over anchor bolts. When the structure has been placed on the anchor bolts, install washers and nuts and tighten them securely.

Custom Bridge Construction

Construction of custom-framed bridges is essentially deck construction with railings added for safety. Refer to the instructions given in Chapters 29 and 30. Framing can be either attached to wood posts or set and anchored to piers, as described in this section (Figure 34-21).

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Figure 34-21 Deck framing for wood bridge.

CHAPTER 35

SITE FURNITURE, SIGNAGE, PREFABRICATED PLAYGROUND EQUIPMENT, OUTDOOR KITCHENS, AND PATIO AMENITIES

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Assemble site amenities.
- Anchor site amenities.

Adding furniture and site amenities to a landscape design often provides a finished touch difficult to obtain through use of other landscape elements. The aesthetic effects of pavement, walls, lawn, and plant material are enhanced by the thoughtful placement of seating and lighting. The use of the site is improved when trash and bikes are contained and proper signage is provided. Play equipment adds energy to parks, schools, and playgrounds. Although typically reserved for the commercial landscape, use of such design tools has expanded into the home landscape with the advent of residential grades of amenities.

Much of the furniture for a site is purchased from custom manufacturers, and landscape contractors can install it. Although there are similarities among installation methods, be certain to review the instructions provided by the manufacturer carefully to ensure that neither you nor the property owner void warranties or guarantees. See resources in Appendix F.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Concrete Paving, Chapter 23
- Carpentry, Section 7
- Fences and Freestanding Walls, Section 8

TYPES OF SITE AMENITIES

Property owners and landscape contractors have a variety of amenities from which to choose to enhance the site. Not only do these amenities enhance the site's appearance, but they also increase the site's functionality and usefulness.

- Benches. Site seating is available in a variety of shapes, materials, and finishes. Styles most often found include contour and historic benches. Seating is manufactured in wood, metal, stone, fiberglass, recycled plastics, and precast concrete. Most seating anchors directly to concrete slabs, with some seating requiring footings or posts that are direct buried in the ground.
- Park Tables and Grills. Heavy-duty picnic tables and charcoal grills are designed for use in park and recreation areas. Most tables are manufactured of metal and/or wood and grills are welded steel. Direct burial and concrete slab mounting are the most common installation options for these amenities.
- Firepits. For decoration and for warming during the cold seasons, cauldrons where a fire burns real or artificial logs create a cozy setting in residential and commercial settings. Firepits can be as simple as a level surface where wood is burned or as complex as gas-fired, auto-starting porcelain logs set into a fireproof hearth.
- Patio misters and foggers. When heat overwhelms outdoor spaces, water that is converted to mist or fog can be used to cool an area. Domestic water piped under pressure through misting heads creates tiny water droplets that evaporate, countering the heat buildup on patios, on decks, and in other hot spaces.
- Outdoor Kitchens. The concept of outdoor grilling has advanced to the point where entire meal preparation and service are now possible in an outdoor kitchen. Equipped with grills, refrigerators, sinks, and storage, an outdoor kitchen gives cooks an escape from the summer heat and allows them to enjoy modern conveniences in the exterior environment.
- Trash Receptacles. Trash receptacles are decorative enclosures into which garbage containers are placed. Materials used to construct the receptacles include wood, metal, precast concrete, or fiberglass. Most are manufactured to be anchored to a concrete slab, but some are mounted on a post that is buried in the ground or anchored to a footing. Shapes of receptacles can vary, but most are typically round or square.
- Signage. Identification of businesses and traffic routes or just a display of general information can be conveyed in the landscape with signage. Many types of signage are available, with ground-mounted, also called *monument,* and post-mounted signage being the most common. Many signs also require placement of electrical lines to illuminate the sign for night viewing.
- Bike Racks. Many designs are available for securing bikes. Most are manufactured from metal and anchored to a concrete slab or are directly buried (Figure 35-1).
- Bollards. **Bollards** are short posts used to identify the perimeter of a plaza or circulation route (Figure 35-2). Often used to separate pedestrian and vehicular traffic, bollards can be manufactured of wood, metal, stone, or other materials and may have lighting incorporated. Installation can be direct burial or concrete slab mounted. Some bollards are designed to be removed for access and emergencies, hence requiring a footing installation.

Figure 35-1 Bike rack anchored in a concrete slab.

Figure 35-2 Bollards used to separate vehicular and pedestrian traffic.

- Flagpoles. Flagpoles are available in various heights, operation mechanisms, and materials. Although flagpoles are usually metal, some are made of precast concrete and wood. Flagpoles require direct burial or anchoring to a footing buried to frost depth or deeper.
- Light Standards. The posts on which pedestrian lights are mounted are called **standards.** Styles include contemporary, historic, western, or architectural. Materials typically include metal, wood, or precast concrete. Most light standards require a footing that is buried to frost depth or deeper.
- Prefabricated Play Equipment. Similar to other amenities, play equipment has a wide variety of choices available. Most pieces are manufactured with a framework of wood or metal posts that are directly buried or mounted on a footing. Engineered equipment for play activities is then attached to the framework. Platforms, slides, climbers, and many other pieces of play equipment are available to the client. Custom-built wood structures follow plans prepared by the design professional and typically use direct burial for post installation. To maintain a safe environment, the surfacing placed below the play structures must meet playground safety standards. To address this issue are several loose or rubberized surfaces that can be installed under play equipment.

PLANNING THE PROJECT

Planning for amenity installation can be characterized as organizing chaos. Differing pieces of equipment from a variety of manufacturers, each with unique requirements for preparation

and installation, create a situation that requires extensive planning on the contractor's part.

Timing Placement of Site Furniture and Play Equipment

Footings and slabs on which the furniture is anchored can be efficiently constructed when concrete for paved areas and structures is poured. Because it is often shipped assembled and finished, site furniture should be protected until installation and until completion of major exterior construction projects. Furnishings that require assembly and/or finishing can be more conveniently prepared off-site and then installed near the end of the project.

Manufacturer's Specifications and Shop Drawings

Materials purchased from manufacturers typically include installation and finishing specifications and **shop drawings** for proper installation. Contractors should obtain these specifications and drawings before any planning and installation begins and should compare them to those the design professional has provided. If there are discrepancies in materials, finishes, construction, installation, or other aspects, bring these immediately to the designer's attention.

Layout of Site Furniture, Signage, and Play Equipment

Site furniture is typically located by staking the footings used to anchor the amenity. Locate either the edges or the center lines of mounting slabs. Measurements should carefully conform to drawings. Once you set a footing for an amenity, you cannot adjust it to match the dimensions of the fixture.

Because most pieces of play equipment have multiple posts, layout is a challenge. As for site furniture, obtain the working drawings from the manufacturer before proceeding. Layout using a grid with two baselines is a common method for identifying post locations. Verify that the two baselines are square to each other and check measurements for square often. Because any variation will twist the play equipment structure, proper level must also be maintained between footing locations. Use grade stakes for each post to show the elevation and location of each footing. Verify the level between points if an amenity has several supports that must be buried. A level stringline, set at the proper burial depth, can be moved between each support location to verify that all supports are buried to the proper depth. Control burial depth for individual supports by placing a mark indicating ground level on the side of each support.

ANCHORING SITE FURNITURE, SIGNAGE, AND PLAY EQUIPMENT

Site preparation for furniture, signage, and play equipment is primarily limited to the construction of footings. Three common methods of anchoring most site furniture and signage include (1) direct burial of amenity supports, such as legs or posts, that are connected to the furniture; (2) installation of a slab onto which the furniture is anchored; and (3) construction of a frost-depth footing onto which the furniture is anchored. Signage may also be anchored by attaching to an existing structure such as a building, fence, or pole. The following sections describe the construction common for each of these techniques.

Direct Burial

For a fixture that requires direct burial, begin by locating the burial points where each support must be sunk. Burial can be accomplished by either driving the support into the ground using a sledgehammer or post driver or excavating a hole and placing the support. The excavation technique is more beneficial when you must place multiple posts and need a small amount of flexibility while making the connections. When selecting the first method, wrap the top of the support with heavy rags or place a block of wood on top of the support to avoid contact damage when driving. Using a firm stroke, drive the support into the ground. Stop periodically to check for plumb, for correct spacing between supports, and for proper orientation. Continue driving until the support is at its proper depth.

If you select the excavation approach, bore a vertical hole that is only slightly larger in diameter than the support. When you have reached the proper depth, set the support and backfill. To maintain proper elevation of the support, place a mark on the post at the correct elevation. Fill the hole a few inches at a time and compact, rechecking to verify plumb, proper depth, and orientation. Slightly raise supports that are set too deep by gripping the post, lifting straight up, and then adding a small amount of granular material. Supports with flanges or anchors may require a twisting or rocking motion as

you raise them. After adjusting the support, verify plumb and recompact the soil. If specified by the manufacturer, certain direct burial supports may require the hole be filled with concrete.

Slab Anchoring

If the furniture or monument signage is to be anchored on a slab, you must form and pour the slab (see Chapter 23 for instructions on pouring concrete) and set anchors at proper dimensions before the concrete hardens. If electrical connections are required, see the section on construction of footings with electrical service later in this chapter. Verify the surface material and/or finish of the slab before pouring. The finish surface under a bench may not be the same as the adjacent paved surface; and if a special finish or allowance for pavers is required, this foundation slab must conform. To properly locate anchors, use stringlines or directly measure the placement locations. Place anchors shortly after the slab has been finished by pushing the bolt/anchor stem into the wet concrete and lifting up or wiggling slightly to settle the concrete around the stem. If the anchor sinks into the concrete, wait 15 minutes and attempt to reset it. Do not wait too long to set the anchors, or they may not insert into the slab. Wait at least 48 hours before connecting the amenity (Figure 35-3). You can install bolts after the concrete slab is finished. See "Attachment to an Existing Slab or Footing" in Chapter 29.

Frost Footing

Some amenities require the stability afforded by a footing that extends below the frost line. The actual depth to avoid frost heaving varies based on geographic location. When a footing is required, excavate a vertical hole that is the diameter required by the manufacturer or by the drawings. Verify that the depth meets the specifications. Amenities that have several supports may require multiple excavations. These holes typically do not need to be

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Figure 35-3 Anchoring of an amenity support post to paving using an anchor bolt placed through the paving.

joined by a continuous footing if each extends below frost depth. However, if one hole is not the proper depth, it will move up and down at a different rate than the others, causing damage to the amenity.

If steel reinforcement is required, cut rerod 8 inches longer than hole depth and secure by driving them into the soil in the bottom of the footing hole. Many footings can be poured without being formed by placing the concrete and finishing the top of the footing with a trowel. However, you may need to form the entire footing, or at least the top 6 inches of the footing, using a tubular paper form. These conditions include situations where the footing extends above the finish grade, where unstable soil conditions may collapse the hole, or where the hole was excavated in an irregular shape. To prevent them from frost heaving, footing holes should have vertical sides. Holes that have a wider diameter at the top are subject to frost pushing up on the footing, countering the advantage of having a footing below frost depth.

Finish the top of a footing with a wood float, doming the surface slightly so that water can drain away from the post. After the footing is poured, place anchors on the top of the footing by pushing the anchor stem into the concrete and lifting or wiggling slightly to settle concrete around the stem. Before the concrete hardens, verify the spacing between anchors for fixtures that have multiple supports (Figure 35-4).

Figure 35-4 Anchoring of an amenity support on a footing poured separately from the concrete walkway.

Footings with Electrical Service

In some cases, before the concrete is poured, the footings or slab may require additional work. For example, if the amenity will have light fixtures or lighted signage, you will need to install electrical conduit through the form before the pour can take place. For slab pours, excavate the trench for conduit and place the conduit in the proper finish location. Cover both ends of the open conduit with duct tape. Backfill the trench with granular fill material and proceed with the pour.

To install a round lighting footing, use an auger to excavate a round hole of the diameter specified and to the required footing depth. Select a tubular paper form of the specified diameter for the footing and trim it to a length the same as the footing depth. Through the side of the form, cut a 2-inch round opening for electrical conduit. The location should match the depth and position where the conduit enters the footing. Cut and connect a conduit bend and a straight section. Place duct tape over the openings at both ends of the conduit. Place the conduit in the form, with the bend exiting the opening and the straight section extending above the top of the form. Use duct tape wrapped around the conduit at the top of the form and at the side opening to position the conduit inside the form. Excavate an extra channel along the side of the footing to accommodate the conduit extending out of the footing. Lower the form into the footing excavation and orient the stub of the conduit bend in the proper direction. Keeping the form in a plumb position, backfill with soil around the form. If reinforcing is required, construct the framework and place it inside the form. Pour premixed concrete into each form. Before the concrete hardens, center the conduit and insert any anchor bolts required for anchoring the fixture. When the concrete has set, peel away the top of the paper form.

Anchoring Signage to Another Structure

If no separate support is planned for signage, you may use existing structures to anchor signs. Connect signage to wood structures with lag screws placed into support posts or studs, or anchor signage to masonry units with expanding masonry bolts. If signage is attached to metal objects such as a fence, a backing strap is required. Position the sign at the proper location and insert a galvanized bolt through a hole in the sign (or through the sign's mounting bracket), through the fence, and through a hole in the mounting strap. Secure and tighten the nut using a lock washer. Various forms of mounting straps (Figure 35-5) will accommodate fencing, light standards, and other types of metal landscape amenities.

INSTALLING SITE FURNITURE AND PLAY EQUIPMENT

Installation of most amenities requires placing and finishing the furniture piece. In some installations, welding or special finishing may be required; and for other installations, an electrician or other construction specialist may need to complete the work.

Placement and Adjustment

Depending on the manufacturer's instructions, preassembly of all or part of an amenity may be required before installation. Amenities assembled piece by piece can be put together beginning at the anchors/supports and working up. Assemble any portions that are required and position them over the anchors. Carefully set the fixture on the anchors/supports and install connection hardware. Secure the fixture and then begin the process of leveling and plumbing.

There are two key criteria for placement of an amenity: (1) it must be placed at the proper location and elevation (Figure 35-6) and (2) it must be placed level and plumb. To maintain these criteria, connect the fixture securely but not fully tightened (termed *finger tight*). Check for level on a horizontal surface and plumb on two adjacent vertical surfaces. Adjust level as necessary and complete the

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Figure 35-5 Attaching signage to decorative metal fencing.

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Figure 35-6 Layout of a custom-built play structure.

tightening of all fasteners. If you need to make adjustments for level, remove the amenity and place galvanized washers over the anchor bolt to adjust the amenity to the proper level.

Surfacing

Safe surfacing below play equipment is required to maintain a fall zone. Consult the guidelines in *Playground Audit Guide*, published by the Consumer Product Safety Commission, for recommended materials and depths. If granular surfaces such as mulch, granulated rubber, sand, or gravel are being used, excavate to the proper depth and layer the material into the area with minimal compaction (Figure 35-7).

Resilient Surfacing. Of the many surfaces used to mitigate falls from play equipment, resilient surfaces

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Figure 35-7 Prefabricated play structure with resilient surface below.

not only offer protection, but also provide color and access. Resilient surfaces are typically rubber products blended with polymers to create a soft, yet durable surfacing. Grouped into two general categories based on how they are installed, resilient surfaces provide an alternative to granular materials and mulch for playgrounds that are used often. Basing their decision on the type of playground equipment and the heights from which children may fall, the designer and the manufacturer specify the thickness of the surface material. The design criteria will also specify whether to install the surface using individual tiles or by pouring a mixture over a base. For each method, the preparation of the site and base is similar.

Subsurface Preparation. For a resilient play surface to be effective, a solid base must be prepared to support the surfacing. Most manufacturers recommend concrete for the base, but application over asphalt can be specified in some projects. In rare cases, compacted granular bases are also possible. For concrete, pour a slab that has a slight slope to allow good surface drainage. The concrete should have a heavy broom finish and be cured for 14–28 days prior to installation. Asphalt should also have a slight slope for good drainage and have a wearing course with small surface aggregate and a tight surface. A granular base should be a minimum of 4 inches of compacted stone, typically a fine granular base, with a minimum surface variation of ¼ inch. A slight slope for drainage is also necessary. For granular bases, a filter fabric is required over the base. All base material should be clean and free of debris and serious surface variations. Any play equipment, site furniture, or other vertical elements within the play surface area should already be installed.

Installation of Tiled Products. Once the base has been prepared, installation of the resilient tiles can proceed. The installation will be generally the same for all products, with variations depending on whether the tiles are installed using adhesive or held in place using interlocking edges or pins. For either fastening method, lay the tiles out for 24 hours prior to installation so they can consistently adjust to the temperature. Tiles shrink and swell during temperature extremes, and all products should be at the same ambient temperature before installation. It is also helpful to plan and mark the installation prior to placing the tile. Because few sites have square corners and sides, identify a starting point where there is a right angle or use a center starting position with a horizontal and vertical layout line at right angles to keep the installation square. When marking the layout, be certain to leave space for containment around the perimeter if necessary (Figure 35-8).

Adhesive Installation. Before beginning installation, verify that the surface is clean and dry. Adhesive installation will not work over granular bases. When you have completed the layout, select a starting point along one of the straight edges. Typical adhesive for elastic tiles is polyurethane, but follow the manufacturer's recommendations

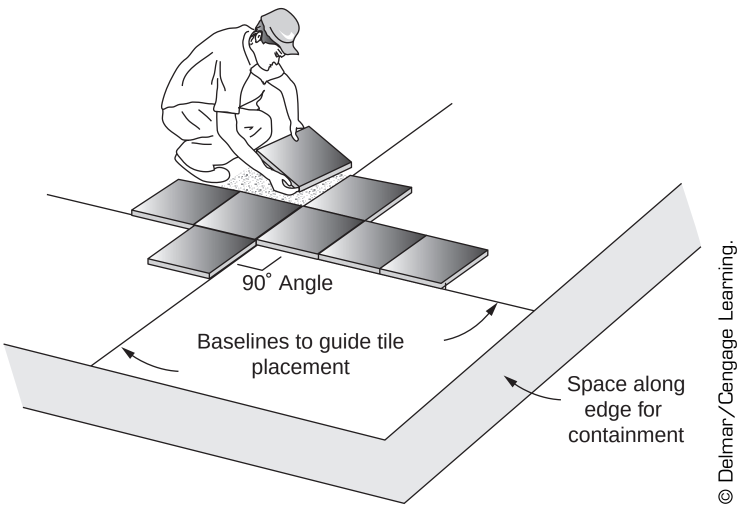

Figure 35-8 Guidelines used to lay out resilient paving tiles.

for all adhesives. Apply glue for a small number of tiles using a ¼-inch square or V-notched trowel. Set the tiles along the guideline, using a mallet to carefully adjust the alignment. Most manufacturers recommend application of adhesive to the side of each tile where it abuts an adjacent tile. Use a caulking gun with a tube of adhesive for side application. When you encounter a vertical object, make a cardboard template of the cutout and trace the pattern onto a tile. Use a band saw or jigsaw with a coarse blade to make any cuts. Continue placing tile until you reach the boundary. Place any containment tiles or containment materials at the completion of the interior of the project.

Interlocking Installation. Before beginning installation, verify that the surface is clean and dry. Begin installation along one of the straight edges laid out in the previous step. Place the initial tile and interlock the second tile using the mechanism provided by the manufacturer. Some products will require the placement of several tiles before you insert a pin to hold the tiles in place. When you encounter a vertical object, make a cardboard template of the cutout and trace the pattern onto a tile. Use a band saw or jigsaw with a coarse blade to make any cuts. Continue placing tile until you reach the boundary. Place any containment tiles or containment materials at the completion of the interior of the project.

Installation of Poured Products. Resilient surfaces that are poured require similar base preparation as noted above. In many poured products, the edge treatment may differ from tiled installations. Typical poured edges include containment blocks or keyways to anchor the surface at the edges. In addition, resilient surfaces typically are poured in two stages, one pour for a base coat and a second pour for a wearing top coat. To pour a resilient surface, begin by masking any areas that are not to be primed or surfaced, including structures within the play area and elements outside the work area. Apply the manufacturer's recommended primer, typically with a large nap paint roller. Prime any vertical surface that will abut the resilient surface.

If mixing is required, mix enough material that you can use in a reasonable time period. Pour the mixture onto the primed base and spread it using a trowel or, if supplied or recommended by the manufacturer, a spreading squeegee. Spread the mixture evenly and smoothly to the depth required. Treat equipment with soapy water or mineral spirits to prevent the mixture from adhering to the trowels. Allow this base coat to dry completely before following with a surface coat. A second coat of primer may be required before you can apply the wearing coat. Mix, if necessary, and spread the wearing coat over the base coat to the depth required. In many applications, the wearing coat is applied ½ inch thick, but verify the depth with drawings and/or manufacturers specifications. Allow this coat to dry before walking on the surface.

Finishing

Site furniture can be shipped prefinished or unfinished, requiring various degrees of **field finishing.** Selection of finished or unfinished materials is based on cost, risk of damage during shipment or installation, and the contractor's ability to field finish the product. Prefinished materials should be covered or wrapped with a protective material until the construction project is complete. Finishing activities can range from priming and painting of a fixture to touching up minor surface damage caused by transportation and installation. Among the most common finish activities that landscape contractors complete are painting of light poles, staining or painting of benches, installing hardware, and installing liner cans for trash receptacles.

Contractors can perform finishing work after the fixture is placed. However, field finishing can be difficult because dust, inclement weather, or other construction activities can interrupt, delay, or even damage finishing work. The recommended process is to perform any painting or staining activities in an enclosed environment, carefully transport the items to the site for installation, and perform only touch-up finishing in the field if necessary. Finishing should be one of the last activities performed prior to the owner's final acceptance of the project.

INSTALLING OUTDOOR KITCHENS

Outdoor living continues to expand beyond relaxation and recreation. Since the advent of the outdoor grill, the concept of cooking outdoors to avoid summer heat has expanded with the outdoor kitchen. Once reserved to regions with mild climates and to the more affluent property owners, the outdoor kitchen continues to grow in popularity throughout the nation and across income groups.

Construction of an outdoor kitchen can take many forms, from a makeshift setup of an ice cooler supplementing the grill, to a full-service kitchen with complete utility functions. To complete the high-end outdoor kitchen, skills from several chapters throughout this text, as well as specialty construction skills from several trades, will be required. Carpentry, foundation, utility, and finish work will all be necessary to complete the ultimate in outdoor living, the outdoor kitchen.

CAUTION

Verify with local building officials all codes and ordinances required to construct an outdoor kitchen. Obtain any permits before beginning work. Licensed plumbers and electricians should perform all utility installations and connections.

Planning

As with most other aspects of the landscape, the key to success in creating a functional outdoor kitchen is design and planning. Even more so than with a deck or patio, attention must be given to the components and the flow of activities to make an outdoor kitchen work. A design professional should design such a space to assure that all requirements of this specialized area are met. Among the many considerations are what appliances to put in the kitchen, how large the kitchen should be, what materials are needed, and, of course, what the climatic conditions are in the region.

A full range of appliances are available for use in many outdoor situations. Gas grills are the foundation of most designs, and many grills can be rolled into a compartment or set into a counter. To enhance grilling activities and to expand food production, side burners and food warmers are available as drop-in units that can be set into the counter. Stainless steel sinks and compact refrigerators are available for cleaning and storage, and a wide variety of prep stations, storage units, shelving, and trash compartments can be purchased as drop-in units set into prefabricated or custom-framed counters (Figure 35-9).

General sizes and specific dimensions will both be critical in outdoor kitchen design. Each appliance chosen will add to the counter space required. An outdoor space that is large enough to

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Figure 35-9 An outdoor kitchen with a stovetop, side burner, refrigerator, sink, and storage below. Firepit and lighted seat wall are in the foreground.

accommodate the required counter length, as well as provide dining and seating area and allow free traffic movement, will be necessary. On a detailed level, dimensions such as counter heights and clearance around cooking appliances will not change from interior spaces. Minimum counter heights of 32–36 inches and depths of 24 inches will be required not only to meet code, but also to make the space comfortable to use. Clearances around gas appliances and the provision of back splashes and vent hoods may also be necessary requirements.

Utility connections will also create planning challenges. Most outdoor kitchens use connections to interior household utilities, but the installation may not be as simple as running line indoors. A complete outdoor kitchen will require water (possibly hot and cold), gas, electricity (on a GFCI circuit), sanitary sewer, and possibly even communications (phone, internet, cable) connections. Routing and implementing utility connections should be verified early in the planning process, and a licensed professional should install all exterior stubouts.

Because they are exposed to the elements, the materials for outdoor construction must not only be attractive, but also be weatherproof and fireproof. Prefabricated components are available for outdoor kitchens, requiring the contractor to only assemble and level adjustable legs to complete setup. With the installation of a countertop and help from a specialized contractor to install and connect the appliances, an almost instant kitchen can be obtained. Custom construction can be framed with wood or metal, surfaced with stone, metal, or veneers, and finished with a variety of countertop materials. Because the construction is exterior, galvanized or rust-resistant metals or decay-resistant wood are recommended, and countertops of stone, stainless steel, or tile provide greater durability and more fire resistance than many typical interior materials. These materials also provide surfacing that can withstand the elements and cleanings to which outdoor kitchens are subject.

Among the other planning considerations for the outdoor kitchen are the access to the structure, protection of the work areas from the climate, and how the space will function during colder times of the year. Location near an access point to interior family space and/or kitchen increases the functionality of the outdoor kitchen. Adding an arbor or overhead screen also makes the space more usable with protection from the sun and rain, and adding a patio heater can extend the use of the space into the early spring and late fall months in most climates. Planning the installation so critical appliances like the refrigerator can be removed for the winter and water lines drained to avoid freezing allow even those who live in the coldest of climates to enjoy the outdoor kitchen space.

Installation of Custom-Framed Outdoor Kitchens

The installation of outdoor kitchens will focus on the custom construction, as the makers of prefabricated kitchens provide ample instructions to assemble the elements of their product. Although not significantly different in end results, the custom installation requires adherence to several steps of the carpentry construction process to create a functional space.

Utility Connections. All necessary utilities for the outdoor kitchen should be stubbed in prior to completing the foundation. As noted at the beginning of this section, licensed professionals should complete all connections. Plot the service location where utilities will enter the cabinetry of the kitchen, and trench and place the lines into this location. A location where access can be gained during cabinet construction will minimize problems when appliance connections are made. Where applicable, shutoff valves should be provided at this location and expansion joint material should be wrapped around the utility line where it passes through the foundation.

Foundations. Because of the utility connections and rigidity of the structure, the outdoor kitchen must be anchored to a stable foundation. This foundation can be a reinforced poured concrete pad or reinforced footing, but the strength of the foundation should match the freeze/thaw conditions of the region where the kitchen is being constructed. In warmer climates, a thickened slab may be adequate; but in climates with deeper frost depths, a frost footing should be considered. Anchors can be placed while the foundation is being prepared or can be drilled after the foundation is complete. The framing for an outdoor kitchen can be placed over veneered or special finished surfaces, as long as the anchors penetrate through this surface to the foundation below. More information on this topic can be found earlier in this chapter and in Chapters 23 and 29 ("Attachment to an Existing Slab or Footing").

Cabinet Construction. The cabinets that house the appliances will require the framing of a backing wall (if necessary), a base, and then the divider walls and compartments for the appliances. The backing wall will form the primary support for the cabinets. If the kitchen will be against the wall of an existing structure, remove the siding or veneer down to the sheathing in the area where the backing wall is to be placed (Figure 35-10). (Note that building codes will require that a fireproof backing wall be constructed against any structure if there is a cooking appliance in that section of the kitchen.)

If properly constructed, the framing of the existing structure may be usable as the backing wall. If an existing structure is not available or if the framing is inadequate, construct a new backing wall with a base plate, top plate, and studs similar to the construction of a residential wall. Sheath one side of this wall with ¾-inch exterior grade plywood for stability, and attach composite decking material

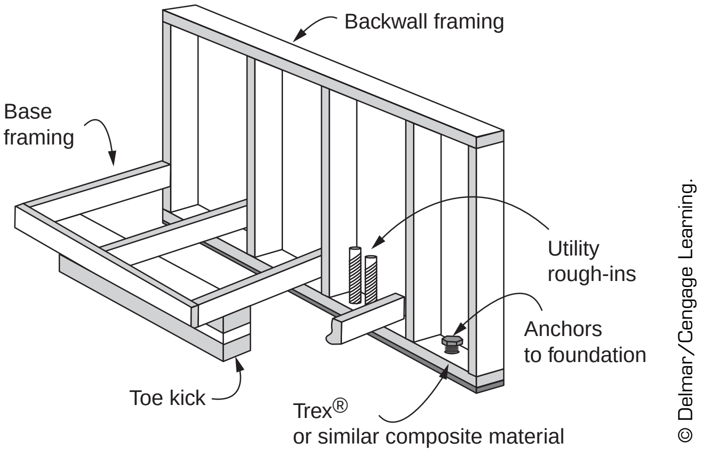

Figure 35-10 Framing the backwall and base for an outdoor kitchen.

(Trex® or similar) to the bottom of the base plate (Figure 35-11). Sheath with fireproof materials if required. Set the base plate on the foundation in the proper alignment, and then shim the plate with cedar or plastic shims to level. When level, attach the base plate securely to the foundation using preset anchors, carriage bolts in drilled anchors, or long concrete screws. Brace the wall to hold it level and plumb while you frame the remainder of the cabinet.

Build a base for the cabinets out of decay-resistant or galvanized materials. Under the front of the base, build a 6-inch tall support wall that is set back from the cabinet front approximately 4 inches to create a toe kick area at the front bottom of the cabinet. This short support wall should have composite material attached to the bottom plate similar to the backing wall. Slide the base to the backing wall and attach it temporarily. Level the front of the base, shimming as necessary, and anchor it to the concrete. Loosen the temporary attachments and level the base to the back wall; then fasten it securely to the back wall. Sheath the top of this base with 1-inch exterior grade plywood.

After you have framed and leveled the back and base, frame divider walls between the appliance compartments, for the front of the cabinet and for any appliance compartments. Measure to allow space for drop-in appliances, sheathing, and any finishes that may be necessary for a compartment.

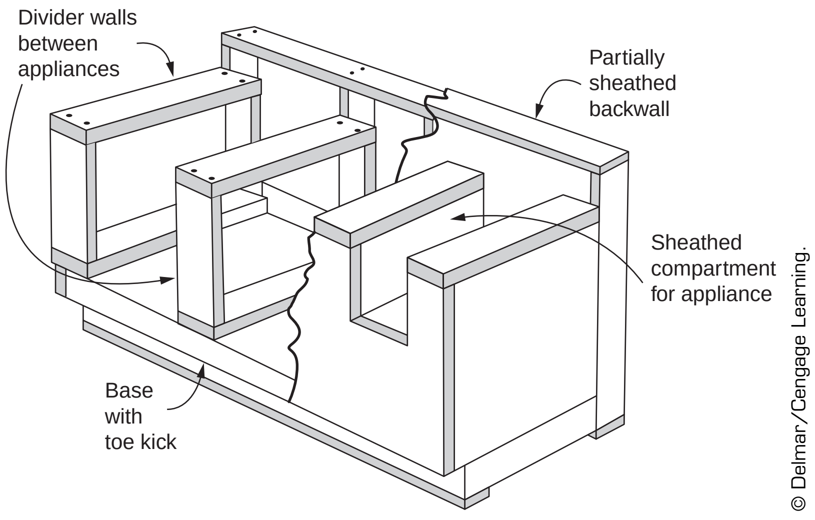

Figure 35-11 Framing divider walls and compartments for appliances in an outdoor kitchen.

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Figure 35-12 Outdoor kitchen after framing. Storage and some of the appliances have been installed and the unit is covered to protect it from damage. The hood is also installed.

Extra dimension may be needed because of spacing required around a grill or for room to insert and remove appliances for winter storage (Figure 35-12).

Routing Utilities. A licensed professional should then route all of the utilities to appropriate service locations. This would include any connections for gas appliances, water lines and drains for sinks, boxes for outlets and igniter switches, and other utilities designed as part of the installation. The rough-outs for utilities should be completed before sheathing and surfacing proceed.

Sheathing. Fully sheath the sides of the cabinetry, including lining compartments for drop-in appliances, with ¾-inch exterior grade plywood. Do not sheath the top surface where countertop is to be placed. In areas where cooking appliances are to be placed, substitute fireproof sheathing materials for plywood. Cut or leave openings for utility connections and cabinet doors.

Countertop. Over the top of the cabinets, install a 1-inch plywood backer for countertops. Securely screw and glue the backer onto the framework of the cabinets. Cut openings for all appliances using templates provided by appliance manufacturers. Install countertop surface material over the backer and cut openings that match those in the backer material. If necessary, apply trim to countertop edge at this time.

Finishing. Apply any surface finishing to the exterior sides of the cabinets. Metal may be installed directly over sheathing; but if installing veneer, screw a cement backer board to the sheathing before mortaring veneer onto surfaces. Chapter 33 ("Installation of Veneer Finishes") has more information on installation of veneer surfaces.

Appliances. At this point, a licensed professional can install the appliances into the compartments and make the necessary utility connections.

Door Installation. Most doors for exterior kitchens are premanufactured stainless steel units with

built-in hinges. To install the frames, place the frame in the door opening and, using 2-inch wood screws, attach the frame to the cabinet framework through the predrilled holes. If predrilled holes are not provided, place the frame and mark locations along the sides, top, and bottom for screws, remove the frame, and drill the holes using a metal drill bit. After you have installed the frame, fasten the door to the hinges and remove any protective surfacing.

INSTALLING FIREPITS

Firepits formalize the romantic idea of the campfire into the landscape. Used in residential and commercial settings, firepits take the fire concept to a new level by introducing safety, convenience, and aesthetics. Firepits can be extensive custom additions or simple installations—e.g., a large metal cauldron with legs in which logs are loaded and a fire started. Many available premanufactured kits provide the necessary equipment required to enjoy the "modern campfire." Custom firepits are typically a decorative surround wall that creates an area inside which a fire can be safely managed (Figure 35-13). Custom-built firepits add features such as draining away water after a storm, fueling the fire using gas, and creating a surround that is durable and attractive.

CAUTION

Verify that local codes and ordinance allow open fires within your jurisdiction. Many locales have banned burning of wood as a result of air pollution issues, and many fire departments require screening over open fires to reduce the possibility of embers starting fires off-site. A licensed plumber should make all gas connections. A licensed electrician should make all electrical connections.

Planning

If the choices of what type of firepit to build or where to place it fall under the contractor's responsibilities, the safe construction begins with planning considerations. Based on what is legally allowed, a choice must be made regarding a firepit that burns wood and is ignited using a supplemental flame or

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Figure 35-13 Firepit surround with coping and fireproof brick installed. Utility stub outs can be seen at the bottom.

a firepit that is equipped with gas burners and uses lava rock or porcelain logs as the heating medium. Placement will require identification of a level location that is free of any overhead and underground utilities, away from combustible materials such as structures and plant material, and provides a wide apron around the pit that accommodates seating and provides safe access.

Surround Construction

At the firepit's site, remove turf under the pit and in the apron area; then using marking paint, mark the location of the surround wall. Excavate the surround area to the depth of the pit, plus base a minimum of 6 inches of material. If drainage below the pit is poor, a supplemental drainage system may be required to remove excess water. If the firepit will use gas for a fuel, the gas line should be stubbed under the base material near the inside edge of the surround wall location. A shutoff valve will be required near where the gas supply is located or where the line passes under the surround wall. Codes may require shutoffs in both locations. Any electronic ignition components should also be stubbed in using galvanized conduit. Installing a heavy-duty handhold over the service lines is a good place to locate valves and igniter switches (Figure 35-14). Place base material under the surround wall location and build the wall. Walls can be made of any fireproof material including stone, precast segmental wall stone, brick, or concrete. If an exterior or veneer is required, concrete or mortared materials provide the most stable backing.

After you have completed the wall, line the interior of the firepit using fire brick or a metal campfire ring (Figure 35-13). This lining will reduce long-term damage to the surround wall. Install any exterior veneer and surround wall cap required by the design. Place a layer of free-draining 1-inch drain rock in the base of the firepit to create a base for burners and/or fuel placed in the pit. Place a ring of expansion joint material around the outside of the firepit and install the apron material around the exterior. If the firepit uses wood lit by a supplemental flame, a purchased or custom-made metal screen may be installed over the firepit to contain embers.

Burner Installation

Please note that a licensed plumber should complete the following connections and testing. When

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Figure 35-14 Handhold in paving for utility valves and connections.

building a firepit that uses gas-fired burners, the burner installation can be completed after the drain rock has been installed. Make the connections between the gas line stubbed into the pit and the igniter and burners. The igniters are a small valve that regulates the flow of gas and mix of air similar to those used in gas grills. The openings on the igniters and burners should be facing downward and supported approximately 3–4 inches above the drain rock with metal supports. Position the burners and, using a propane grill lighter, turn on the gas and test the flame. Make any adjustments in the flame using the venturi valve on the igniter. After you have satisfactorily adjusted the flame, cover the igniters with wire mesh dome guards and place the lava rock or porcelain logs in the pit (Figure 35-15).

INSTALLING PATIO MISTERS AND FOGGERS

In climates that suffer excessive heat with little humidity, misting and fogging systems can be used to alleviate extreme conditions. Such systems work best where seasons are very hot (over 85°) and reasonably dry (relative humidity under 40%), but applications for plant growth and livestock cooling can be effective in a wide range of climates. Even in humid climates, when temperatures are extreme, many people benefit from the cooling created by misting systems.

Using water from domestic supply lines under standard pressure, or boosted with a pump for better performance, custom or system misting installations can reduce ambient temperature in certain situations by several degrees. Misting (and, depending on the water droplet size, fogging) systems work by forcing water through small nozzles at high pressure. These tiny droplets, typically measured in microns, use the heat in the air to evaporate. Through this process of water evaporation, the temperature in the general area misted is lowered. Misters can be used in exterior applications for patios, with mist heads mounted under eaves or in arbors, and interior applications for greenhouses. Careful judgment should be used when installing misting systems in areas where excess water may build up on pavement, causing slippery surfaces. If you doubt your abilities to install such a system, consult a licensed plumber for assistance with choosing and setting up a misting system.

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Figure 35-15 Completed firepit. Lava rock and burners were installed in the bottom, with porcelain logs in the upper area of the surround.

Installation materials and techniques will depend on whether a kit is purchased or a custom-designed system is planned. Factors that will also influence the installation are availability of water and power and the pressure of the water at the supply point to the misting system. Most components for a system can be purchased through on-line vendors or through irrigation or greenhouse product suppliers.

Water Supply, Valves, Pumps, and Filters

Water for a misting system is supplied by a potable water supply servicing a property or structure. A licensed plumber should make all connections to the supply to assure that proper backflow prevention and valves are present. A shutoff and backdrain valve is also recommended to aid in servicing the system and draining it during cold temperatures. It is also advisable to install a timing valve at the supply point (or at a pump, if installed). This will cycle the system on/off when continuous operation is not desired. A manual switch for the circuit on which a pump is installed will also allow the system to be shut off when not in use.

Many misting systems perform adequately using the pressure available at the supply line, but supplemental pumps can boost the pressure and performance. Choosing to use a pump will require the measurement of the water pressure at the pump installation point. Pressures of under 45 PSI may have difficulty providing adequate water through the misting heads, making the mist more of a rain shower. Using a pump may require upgrading the piping and fittings used to distribute the water within the system. Failure to match the pump pressure and the piping strength can lead to a faulty system.

Lower pressure systems often use flexible poly tubing and compression fittings; but installing a pump may require use of rigid copper, galvanized, PVC, or other durable piping with threaded or sweated fittings (see Chapter 7 for pipe connections). In addition, pumps will require either 110- or 220-volt power supplied through a GFCI circuit. If installing a pump, verify the requirements for power and plumbing with the pump manufacturer. Position the pump in a location that can be screened but will still provide access for service. Pumps often vibrate and create high-frequency noise, so placing the pump on a concrete slab that is separated from outdoor use areas will minimize the disturbance. With the pump installation, filters before the pump and after the pump will help protect the system components. They should be securely installed in the plumbing line with fittings appropriate for the piping type. It will also be necessary to install an auto-drain valve near the pump, so positioning the pump where water can flow into planted areas or into surface drains will reduce the potential for ponding. The auto-drain should be installed in the water line at the lowest possible point between the misting heads and the supply/pump.

System Piping and Misting Heads

Regardless of whether a pump is used, water must be distributed from the supply to the misting heads. Heads are typically mounted overhead and placed 2–3 feet apart, with the wider spacing used for lower installations. Most heads can be mounted under eaves or alongside the joists of an overhead arbor. Discreetly route the pipe from the water supply/pump on the side of a structure or behind a post to the location where the first head will be located. Secure the pipe to the structure/post using tubing clips or strapping. Insert the connection for the first misting head at this location using either compression fittings (flexible copper or poly piping) or T fittings (stainless steel, rigid copper, galvanized, or PVC piping). Aim the fitting downward. If hanging the piping from the eaves, use insulated wrap-around clips or hangers screwed into the framing of the eave.

Whether hung or fastened to the sides of structural members, piping should be fastened loosely until the system is pressurized, then secured tightly after pressurization to avoid vibration (Figure 35-16). Do not insert any of the misting heads until the entire distribution system has been installed and flushed. Insert a length of pipe running to the second head and insert the second fitting. Repeat this process until you have installed all misting heads (Figure 35-17). Cap the end of the line and turn on the pump or supply water to flush the system. Allow the water to flow for 2 minutes; and when flushing is complete, turn the water off and install the misting heads into each fitting. Test the system to ensure proper operation. If water drops, rather than mist, are spraying from misting heads, either finer heads or a supplemental pump will be required.

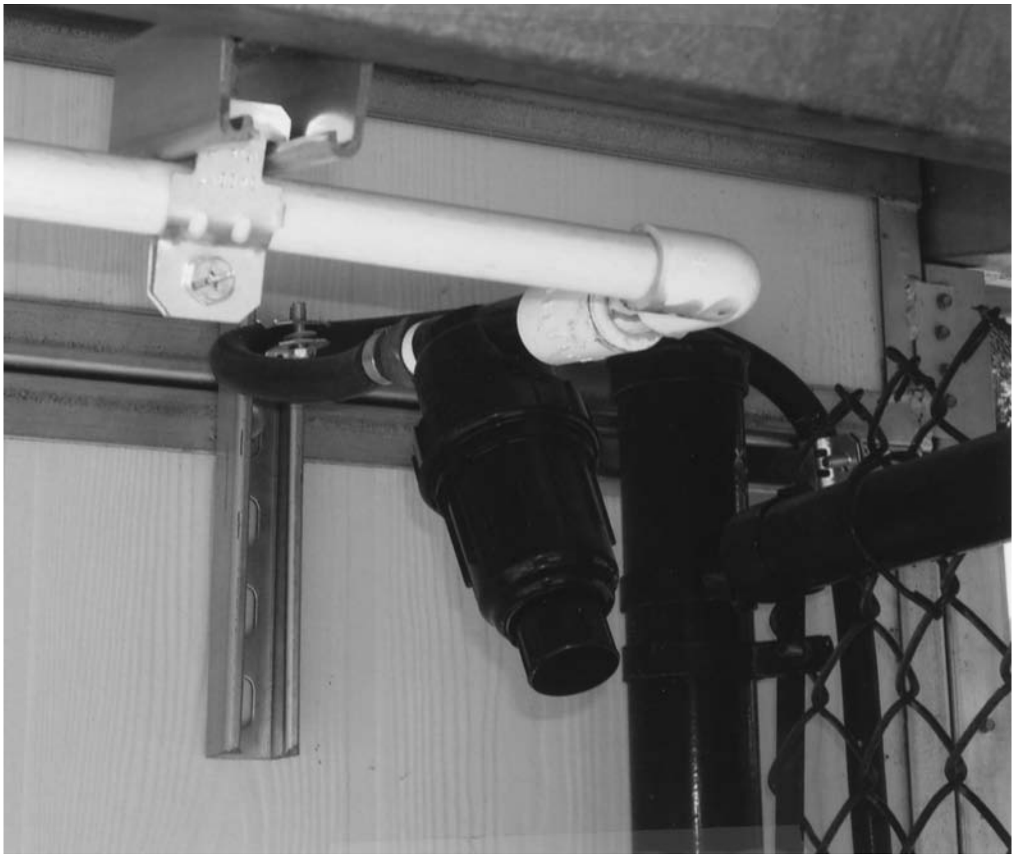

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Figure 35-16 Supply pipe for patio misting system with filter installed. Brackets mount distribution pipe to eave.

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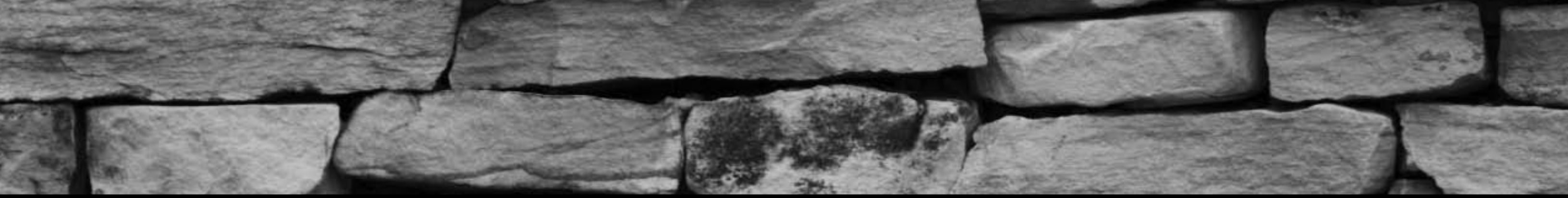
Figure 35-17 Misting head installed in distribution pipe.



CHAPTER 36

EDGING, PLANTERS, AND PLANT PROTECTION EQUIPMENT

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Select a material for edging.
- Excavate a natural edge.
- Install plastic edging.
- Install metal edging.
- Install brick and stone edging.
- Install curbing.
- Install wood edging.
- Set planters.
- Install root barriers.

Defining, containing, and protecting plants require a variety of specialized construction materials and techniques. Edging is one of the more versatile materials available to the landscape designer. Edging can be used to define areas, hold pavement in place, and separate turf from planting beds. Edging materials require excavation of a trench, either by hand or by machine, and placement of material within the trench. Techniques are available for installing concrete edging using a special curbing machine.

Planters are valuable for providing proper planting environments in paved areas. Manufactured from wood, precast concrete, fiberglass, or composite materials, most planters require only placing and filling. Other installations may require that the planter be anchored to a paved surface. Tree grates allow air and moisture to reach tree roots in paved areas, whereas tree guards protect the trunk of the plant from damage. Tree grates and guards require preliminary work during the site paving stage and are placed and connected after planting is completed.

RELATED INFORMATION IN OTHER CHAPTERS

Information provided in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Construction Math, Chapter 4
- Safety in the Workplace, Chapter 6
- Basic Construction Techniques and Equipment Operation, Chapter 7
- Concrete Paving, Chapter 23

PLANNING THE PROJECT

Planning the amenities associated with plant material typically occurs after the majority of the site construction has been completed, but ordering materials and preparation for items such as edger and tree grates will require action during earlier stages of construction.

Timing of Edging and Plant Protection Placement

Plant bed edging should be placed after the planting bed has been prepared but before the installation of

weed barrier, plantings, and mulch. Installation of the edging prior to installing any weed barrier or mulch provides a depth guide for both. If the installation will not disrupt or damage the plant material, edging can be placed after planting.

Planters and plant protection devices should be installed as the project nears completion. Planters should be placed after all major site construction is completed but before planting operations begin. Although preliminary work for tree grates and guards is performed during the paving stages, finishing and placement should not occur until after all plant materials have been placed.

Layout of Edging

Painting is the easiest method to identify edging location (Figure 36-1), but a stringline may be used for straight applications. Experienced contractors may be able to locate edging as they excavate the trench, but errors require that disturbed areas be reseeded or resodded. Measurements for edging quantities can be performed by pacing or by using a measuring wheel (Figure 36-2).

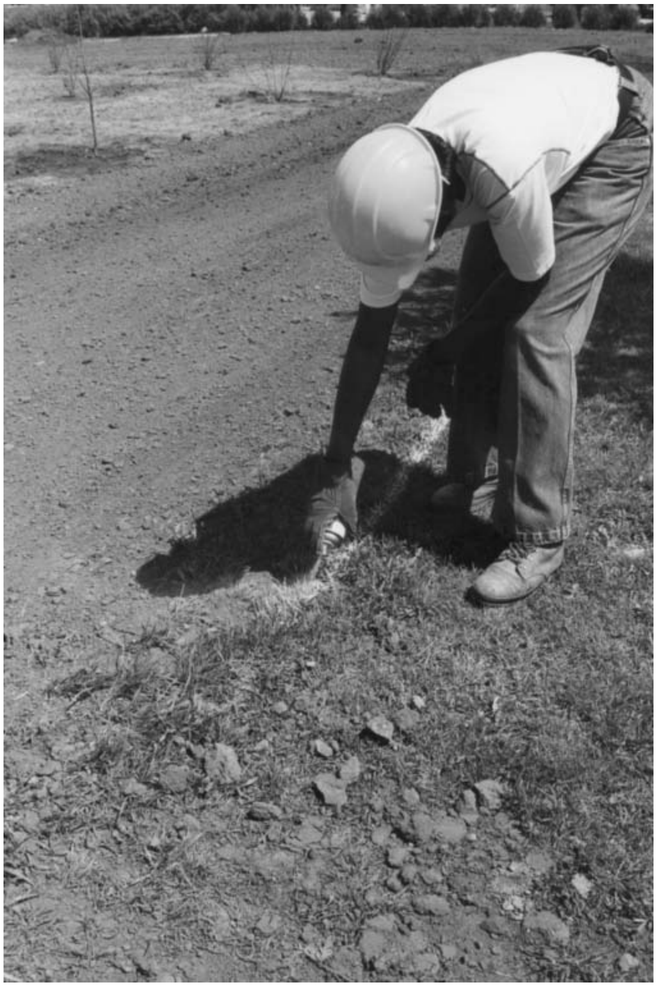


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Figure 36-1 Layout of edging using marking paint.

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Figure 36-2 Measuring for edging with measuring wheel.

INSTALLING LANDSCAPE EDGING

Although trench preparation requires consistency, it can be a laborious task. Preparation for landscape edging can be done by hand for small areas; but it is best done mechanically for large installations. To edge for landscape installations, follow the steps listed in the following sections:

Excavation of Edging Trench

Along the entire alignment, excavate a shallow, shaped trench that is approximately 1 inch deeper than the vertical dimension of the edging (Figure 36-3). The outside edge of the trench (side nearest the lawn or paving) should be excavated with a straight, vertical edge (Figure 36-4). This allows

Figure 36-3 Proper trench for edging showing vertical excavation on lawn side.

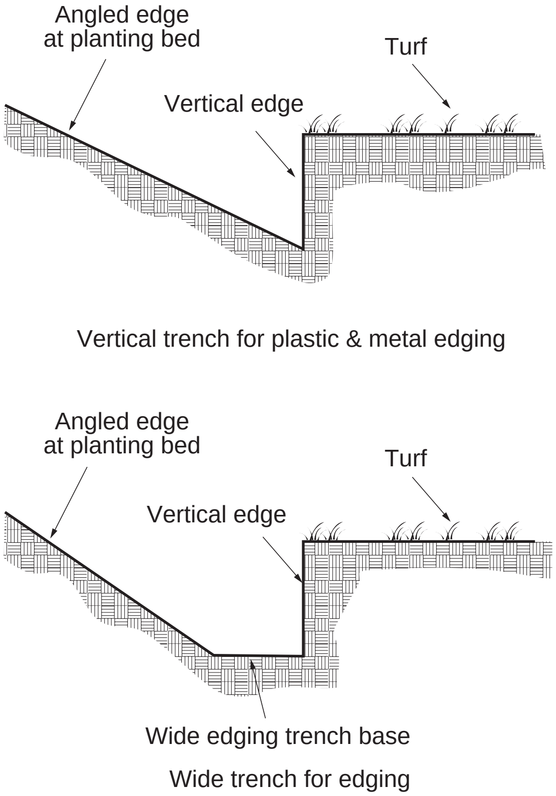

Figure 36-4 Cross section of edging trenches.

edgings to be positioned tightly against the adjacent material. The inside edge of the trench (side toward the planting bed) should be excavated at a 45° angle. For curbing and stone, brick, and precast edgings, the trench should be excavated with a flat bottom that is 2 inches wider than the width of the material. Depending on the type and what is placed on either side, the placement depth may vary. If the edging abuts a seeded area, the top should be flush with the finish grade. If the edging abuts a sodded area, the top should be placed 1 inch above the soil grade before sod is placed. Unless the manufacturer specifies otherwise, edging that abuts paved areas should be placed flush with the top of the paved surface.

For large installations, rental of an edging machine is recommended. This piece of equipment cuts trenches with vertical and angled sides to the proper depth for plastic or metal edging (Figure 36-5). Additional blades are available that adapt the trench to wide materials or steeply angled

Figure 36-5 Excavation for edging using an edging machine.

trenches. The edging machine can be used to cut smooth radius corners and will save many hours of hand-digging. To operate the edging machine, mark the alignment of the edging and orient the machine with the rubber guard aimed toward the planting bed. Start the machine and gradually lower the cutting blade onto the alignment mark. Pull the edging machine slowly along the marking.

Edging Placement

Placement of specific edgings varies, depending on the material and type of installation. Installation techniques for many of the common edging materials are described in the following sections:

Natural Edges. A simple edge that conforms to any shape and requires little special preparation is the natural edge. Created by cutting a vertical trench with a shovel, natural edges join the planting bed with the lawn with no manufactured separator installed. Natural edges require periodic maintenance to keep the edge clean. Respading during the year is necessary as turf encroaches the planting bed.

Natural edges are created by using only the trench as a separation. Excavate the trench as instructed previously to a depth of 6 inches. Place the excavated material into the planting bed area. Continue this excavation along the entire length of the edging location. After the planting bed is tilled, fill the bed and trench with mulch.

Plastic Edging. One of the most commonly used edgings is the black plastic material manufactured in rolls and long strips. Flat and flexible, this edging can be bent to very tight radii, is installed with metal stakes, and has only the rounded bead on top visible after installation. The maintenance for plastic edging is high, as the edging is often worked up by frost and equipment and “shaved” by mowers.

Begin installation by placing a length of the edging flat against the vertical side of the trench. If the edging has a fold of plastic, or a V channel, place the fold to the planting bed side of the trench. Verify that the top of the edging, usually the rounded bead, is at the top of the trench and is set at the proper elevation. Place an edging stake in the V channel at the bottom of the edging. Holding the stake at a slight angle toward the turf area, drive the stake through the edging into the subgrade (Figure 36-6). Place edging stakes every 2 feet along the length of the edging. Turn corners by bending the plastic edging around the corner. If the edging buckles when turning corners, cut 2-inch slits up from the bottom to **kerf** the edging.

Figure 36-6 Staking plastic edging by driving metal stakes through lip at bottom. Edging must be held flat against the edge of the trench with its top flush with finish grade.

Join pieces of edging by cutting 6 inches of the rounded bead off the top of one end of an edging piece. Verify that both pieces are facing the same direction. Push a joining tube halfway into the rounded bead of that piece of edging (Figure 36-7). Overlap the flat sections of edging and slide them together. Slide the remaining half of the joining tube into the rounded bead on the other piece of edging. Driving a nursery nail through the overlapped pieces will reduce the chances of unintentional separation. If smaller pieces of edging are required, measure and cut edging with a hacksaw or tin snips (Figure 36-8). Backfill and compact along the edge, leaving the grade on the planting bed side low enough to accommodate mulch.

Steel and Aluminum Edging. Typically reserved for commercial or large installations, steel or aluminum is a more permanent and higher priced

Figure 36-7 Joining pieces of plastic edging using tubing joiners supplied with edging kits. Notching the edging will improve connection.

Figure 36-8 Cutting plastic edging using a hacksaw. Tin snips may also be used.

choice for edging. Although not as flexible as plastic, metal edgings can still be used to wrap around corners or curves and is less likely to be worked up by frost or equipment.

Place a piece of metal edging in the trench flat against the vertical side and with the top at the desired finish elevation. Insert a stake through the slots in the edging and drive the stake straight down into the subgrade. Place stakes in every slot, typically every 2–3 feet. Turn corners by bending pieces at the proper location (Figure 36-9). Most aluminum and lightweight steel edgings bend easily, but you may have to bend heavy steel edgings in a vise or cut them with a hacksaw halfway up from the bottom of the edging before they will bend. Measuring and bending before placement may make the process easier for heavy-duty edgings, but you must accurately measure the bends to achieve a proper fit.

Metal edgings typically have notches cut from each end of the pieces that interlock for joining. Some edgings are joined by hooking these notches together; others interlock using an edging stake (Figure 36-10). Make the connection with the pieces setting in the trench and continue staking. If smaller pieces of edging are required, measure and cut

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Figure 36-9 Turning corners with metal edging.

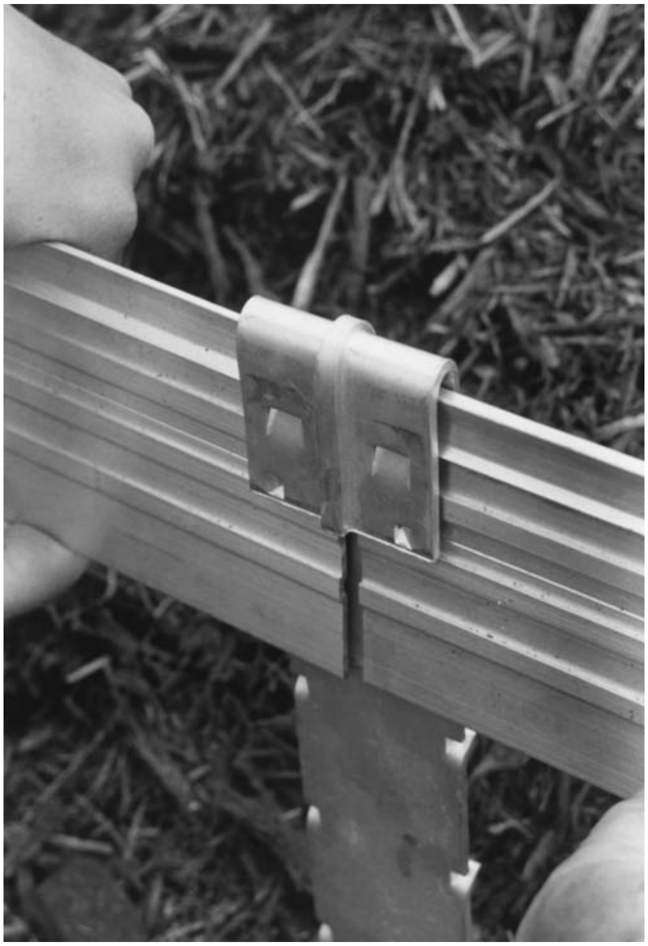

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Figure 36-10 Joining pieces of metal edging using stakes provided by manufacturer.

using a hacksaw (Figure 36-11). Backfill and compact along the edge, leaving the grade on the planting bed side low enough to accommodate mulch.

Vertical Brick Edging. Vertical bricks can be used for an edging for paved surfaces or planting areas. When stood on end, or edge, the bricks can introduce earthy textures and colors into the design, in addition to matching a paving material. Installation of brick edgings is more expensive and labor-intensive than installation of most edgings, but brick edgings are relatively maintenance-free when completed.

To install vertical brick edging, excavate the trench along the entire perimeter of the edged area the same depth as the long dimension of the bricks. The trench must form a vertical edge on the lawn side of the trench. Place a small amount of sand in the trench and place brick vertically against the sod edge. By adding or removing sand, adjust the height of the edging so that it is set at the desired elevation. Backfill and compact along the edge, leaving the planting bed side low enough to accommodate mulch. The installation will be more stable if you backfill with a small amount of mortar in place of soil. When the mortar hardens, cover it with soil. Turn corners by slightly flaring the brick, leaving small gaps between bricks at one end.

Flat Brick Edging. An alternative to the vertical brick edge is to place paving bricks flat, either edge to edge or end to end. This installation requires slightly less labor and material than installation of vertical brick edging.

Installation of a flat brick edging requires the excavation of a shallow trench the same depth as the brick thickness and 2 inches wider than the brick length. Flat brick edgings function nicely if the trench is angled up slightly on the planting bed side, leaving the bricks with a slight upward slant after installation. Place strips of landscape fabric in the trench before placing brick to reduce weed growth. Place the fabric flush with the outside edge of the trench and let it extend into the planting bed a few inches to overlap weed barrier placed in the bed. Place the bricks side by side, flat in the trench. Turn corners by fanning the brick around the corner, which will leave a small gap at the top or bottom between bricks. For a tighter fit around corners, diagonally trim every other brick with a wet masonry saw. If the trench is the proper depth, backfilling is usually not required.

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Figure 36-11 Cutting metal edging using a hacksaw.

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Figure 36-12 Placement of precast concrete edging. This edging piece may be placed in straight or curved alignments.

Precast Block Edging. Manufactured concrete block can be used as an edging in almost any setting. Cast in a variety of colors and forms, these solid blocks are small enough to turn tight radii and are easy to work with. When properly installed, the precast units are low in maintenance.

Excavate a square or rectangular cross-section trench with a depth the same as the block height and 2 inches wider than the block width. Place strips of landscape fabric in the trench before placing blocks to reduce weed growth. Place the fabric flush with the lawn edge of the trench and let it extend into the planting bed a few inches to overlap the bed weed barrier. Place the blocks end to end in the trench with one side flush with the lawn edge. Turn corners by fanning the block and leaving a small gap at the front or back of the block. Special block is available with shaped ends that interlock or alternate to form smooth straight and curved sections (Figure 36-12). Backfill the edging, leaving the bed side lower to accommodate mulch.

Concrete Curb Edging. Concrete curbing makes a durable and distinct edge for a planted area. Whether installed by hand or with a curbing machine, concrete provides a low-maintenance edge that blends with many design concepts. A variety of shapes and widths are also available with this choice. Price for curbing may be expensive as a result of equipment rental or hand labor required for forming.

To install curbing, begin by excavating a square, cross-section trench along the perimeter where the curb is to be placed. The depth should match the thickness of the edging selected. Place a small amount of granular backfill in the bottom of the trench to level the base. Construct forms (see concrete installation in Chapter 23) with the top set at the desired finish elevation. Pour concrete into the forms and tap the sides to settle the mixture. Complete filling and use a float or trowel to smooth and finish the top. After the concrete has hardened, remove forms and backfill, leaving the planting bed side lower to accommodate mulch.

If it is available, a curbing machine will speed the placement of curb edging. The curbing machine requires either that a trench be excavated to the depth of the edging or that the finish grade be built up after the edging is completed. No forms are required. A curbing machine places mixed concrete in a uniform shape along the path

where the machine is operated. Finishing of the edging's top with a trowel is usually required.

Stone Block or Flagstone Edging. Wall stone or flagstone can also be used for edging planting beds. Using stone requires more extensive site preparation than done for plastic or metal edgings. Stone is more costly than most edgings but is relatively maintenance-free and attractive.

Stone block and flagstone are installed by excavating the trench the same depth as the thickness of the material and 2 inches wider. For irregular-shaped flagstone, excavate the trench the same width as the widest dimension of the stone. Place strips of landscape fabric in the trench before placing stone to reduce weed growth. Place the fabric flush with the lawn edge of the trench and let it extend into the planting bed a few inches to overlap weed barrier in the bed. Place the blocks end to end in the trench with one side flush with the lawn edge (Figures 36-13 and 36-14). With flagstone, select the straightest edge and place that edge along the lawn edge. Flagstone leaves an irregular inner edge with interesting shapes and lines. Turn corners using smaller pieces of stone. Backfill the edging, leaving the bed side lower to accommodate mulch.

Composite Materials and Bender Board Edging. Bender boards and composite materials can be effective when used as edging for planting beds. Both materials are useful when edging curved applications or when a wood feel is desired. Although there are limitations on how tight a curve can be bent using these materials, they will traverse slopes and rounded edges that cannot be addressed when using wood. Both come in long strips and require decay-resistant wood stakes and rust-resistant fasteners to install.

To install composite materials or bender board, excavate a 6-inch wide trench slightly deeper than the edger width along the perimeter of the planting bed. Install treated 12-inch long 1 × 2 stakes every 18 inches along the desired alignment of the edging (Figure 36-15). The top of the stakes should be driven at least 1 inch below the top of the edging. Beginning at one end, hold the edging material to the stakes and drive galvanized 10d nails through the stake into the edging. If necessary, adjust the elevation of the

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Figure 36-13 Edging with wall stone placed on weed barrier.

Figure 36-14 Edging with flagstone placed on weed barrier. Straight edge of flagstone is placed along turf edge, with irregular edge facing planting bed. Place edging flush with turf and sloping up into planting bed.

stake before fastening. Substitute 2-inch rust-resistant screws for nails to minimize disturbance of the stake and to make a stronger connection.

Bender board is turned around corners by allowing the overlapping boards to slide past each other. This will leave one end with staggered boards. If the overlap from the next section does not fit with the staggered boards, trim the staggered end before continuing the next section. Composite materials can be left in the sun to improve their bending ability for corners. Using a hacksaw, trim the edging to the proper length before installing the final section. When sections require jointing, drive stakes at the end of each abutting section. If the sections are manufactured with interlocking joints, connect the pieces and place an additional stake at the joint. Backfill the outside and planting bed side of the edging.

Wood Edging. Relatively inexpensive and low in maintenance once installed, wood presents a natural material choice for edging beds. Wood edgers can be difficult in installations that have undulating slopes and curved edges. Use only treated or decay-resistant lumbers that will contact the soil.

To install wood edging, select a decay-resistant, dimensioned lumber, typically a 2 × 6, and cut to length for each section to be edged. Cut enough 1-foot long 1 × 2 treated stakes to place one at both ends of each edging piece and one every 2 feet along the perimeter. Excavate a vertical trench 8 inches deep along the edging alignment. Place the wood edging in the trench tightly against the vertical side and at the desired elevation. Attach a stake at each end of the edging to stabilize the piece. Holding the stakes tightly against the edging, drive the stakes into the subgrade (Figure 36-16). Hide the tops of all stakes by driving them 1 inch below the top of the edging. Drive form nails through the stake into the edging. Adjust to the desired elevation by prying the edging up with a

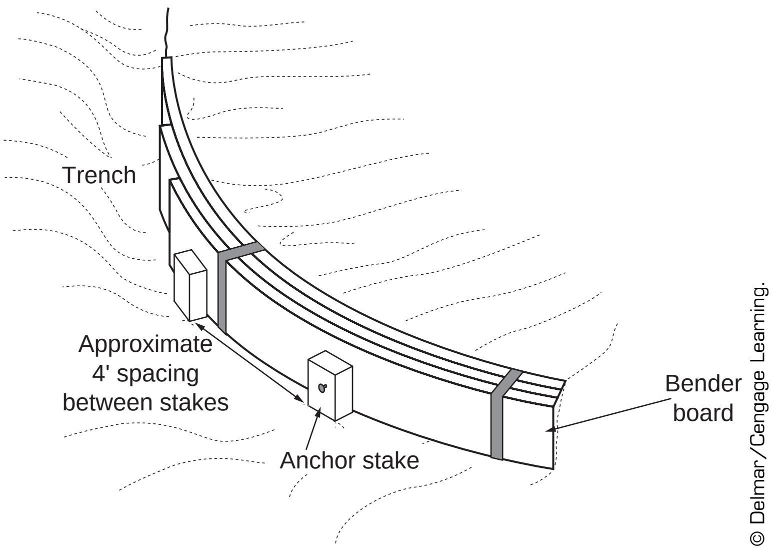

Figure 36-15 Anchoring of bender board.

Figure 36-16 Staking for wood edging. Place end stakes and adjust for level. Joints should overlap a single stake.

shovel or driving the stakes down. After edging elevation is set, place additional stakes every 2 feet and nail them to the edging. Backfill on both sides of the edge, leaving the planting side low enough to accommodate mulch.

Turn corners by butting one section of edging into another and end nailing to hold the two pieces together. Joining two sections is strengthened by nailing a treated 1 × 4 stake across the joint on the back side of the two pieces being joined.

An alternative to staked wood edgers is treated 4 × 4s or 6 × 6s as edging material. These edgers require a trench excavated to the same depth and width as the material. Place the material in the trench and backfill. Turn corners by cutting short pieces of material and placing them fanned along the curve alignment. No staking is required.

Installation of Weed Barrier

Installing a weed barrier is one effective method for reducing undesired vegetation in planting beds. Weed barriers are thermally spunbond or woven fabrics engineered to allow water and oxygen penetration from above but to reduce plant penetration from below. Although most weed barriers provide some degree of protection, those that are thermally spunbond, forming a dense cloth-like mat, perform best in preventing unwanted vegetative growth. Those barriers that are open weave or needle punched allow some stem and root penetration through the openings in the fabric. Because it does not allow air and water to pass through, plastic sheeting is not acceptable as a weed barrier. Dark colors that are opaque also provide better protection than clear or translucent fabrics or plastic sheets. Coupling the weed barrier with a layer of mulch increases the effectiveness in reducing vegetative growth.

To install weed barrier, first prepare the surface by removing any existing weeds through mechanical or chemical means. Remove any vegetative debris and level the planting area, removing any sharp items that may puncture or tear the fabric. If the weed barrier is not held at the perimeter of the planting bed by edging, excavate a 6-inch deep × 6-inch wide trench around the perimeter of the area to be planted. Lay the fabric over the planting area with the edges tucked into the contour of the trench. Completely cover the planting bed with weed barrier. Where pieces of barrier meet, overlap the edges of the barriers a minimum of 1 foot (Figure 36-17). To create a more stable installation, insert a sod staple every 2 feet along the seams, every 2 feet around the perimeter at the bottom of the trench, and every 3 feet across the open areas of the planting bed. Cover the entire weed barrier with 2–3 inches of mulch, and fill the trench around the perimeter with mulch. To plant in the covered bed, identify the planting locations and cut an opening twice the diameter of the container. Remove the weed barrier scraps or fold them under at the planting hole. Install the plant in the opening created.

A successful weed barrier application will require periodic maintenance, including refreshing the mulch cover, repairing any gaps in the barrier cover, and removing any weeds that have begun to grow in the organic material that accumulates on top of the barrier. Although no installation should be considered permanent, a correctly installed and maintained barrier should last for several years.

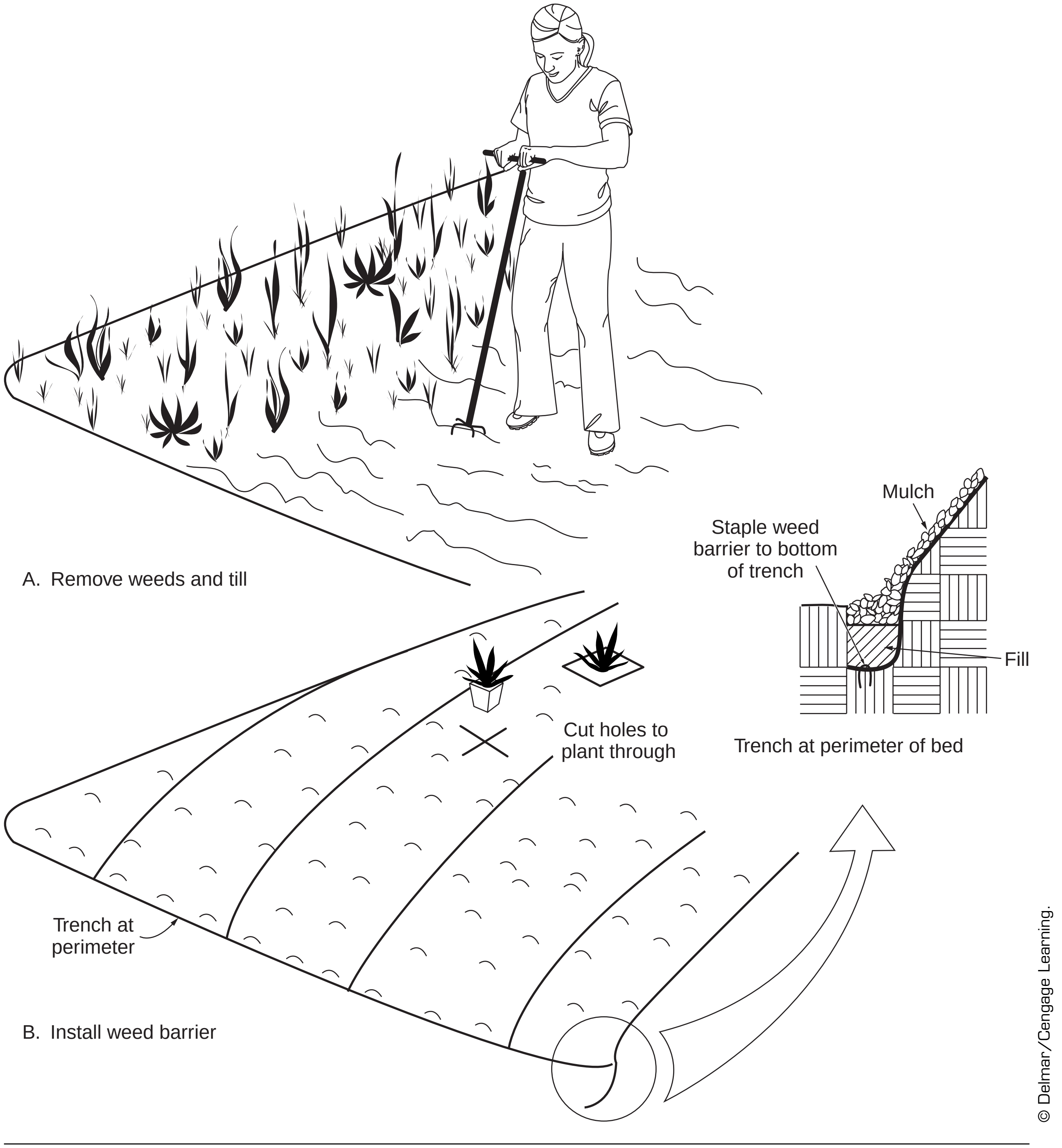

Figure 36-17 A. Preparation of a bed for weed barrier. B. Installation of weed barrier.

INSTALLING PLANTERS

To install plants in interior or in certain exterior applications, planters may be required. Planters come in square, rectangular, or round shapes, with custom shapes available, and are made of wood, metal, terra cotta, fiberglass, and precast concrete. Although typically designed to set on a paved surface without any further anchoring, some planters require anchoring to slabs and others are permanently built into projects.

Prefabricated Planters

Planter installation requires unpacking, possibly assembling, and placing at the appropriate locations throughout the site (Figure 36-18). If the planter is anchored at a specific location, anchor bolts should be placed during the paving portion of the project. When anchor bolts are preplaced, cover with Styrofoam painted a fluorescent color to reduce potential damage from traffic. Because outdoor surfaces are usually sloped for drainage, level placement

Figure 36-18 Planters in an urban plaza. Many planters are placed on pavement without anchors.

of planters may require cedar shims. Use a carpenter's level placed on a horizontal surface of the planter to determine the amount of shimming required. Break off a shim the correct thickness, lift the empty planter, and slide the shim underneath. Multiple shims may be required to level in all directions. If planters must be lifted and adjusted several times, use double-stick tape to hold the shims at the correct location on the bottom of planters. Tuck shims under the edge so they are not visible from the side.

Built-In Planters

Landscape projects occasionally make use of built-in planters, which are typically enclosed retaining walls that have been backfilled with planting soil to support plant growth. Walls for planter construction should be constructed using the same techniques described in Section 5. When constructing walls for built-in planters, accommodations for drainage may be required. To drain excess water from the planter, extend a socked, perforated drain tile around the entire interior perimeter of the wall. Connect to an underground tile or storm sewer or drain through an opening in the wall.

INSTALLING TREE GRATES, TREE GUARDS, AND ROOT BARRIERS

Cast metal grids that are placed at openings in walkways where plant material is to be installed, tree grates allow the water and air necessary to sustain plant growth to pass through what would otherwise be a paved surface. Tree grates have enough solid surface that they can support foot traffic. Working in conjunction with tree grates are tree guards, which are metal enclosures that form a protective surrounding for tree trunks. Guards protect trees from damage from contact with vehicles, bikes, and other types of traffic. Tree guards are usually installed with tree grates.

Tree grate and tree guard installation requires preliminary work during the paving stage of the construction process. Tree grates are placed on a frame that is set into the concrete paving around the plant opening. The concrete used to place this frame can be part of the walkway, or it can be a curb poured separately from the walk (Figure 36-19). Although the grate frame and a separate curb can be installed after the walk installation is complete, this will require additional forming and delivery of paving materials. The opening for the grate frame needs to be formed to the correct size and the frame placed at the proper depth for the tree grate to set flush with adjacent paving. Verify with the manufacturer the dimensions of the tree grate prior to forming the walk or curb that will support the frame.

Before placing any plant material in the tree grate opening, excavate all undesirable fill material from the hole and replace it with suitable planting soil. After plant material has been installed, the tree grate may be placed on the curbing. Grates come in two or more sections to fit around the tree. If the design requires, bolt the two sections together with rust-resistant hardware. Manufacturers typically design grates so that when the opening is too small for plant material, interior rings can be cut from the grate. Use a cutoff saw with a carbide blade to remove enough inner rings to accommodate plant size. Tree guards come in two pieces and are bolted together and then to the tree grate for stability (Figure 36-20). Use touch-up paint if required to repair any finish damage.

To reduce potential problems from plant roots invading foundations and lifting pavement, root barriers have been created. Root barriers are plastic

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Figure 36-19 Curbing with tree grate in place. This curb was formed and poured separately from the walk and included a lip on which the grate was placed.

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Figure 36-20 Tree grate sections bolted together. Sections of guards are placed around the tree and bolted together, then bolted to the tree grate.

or metal panels/sheets that are installed between the root zone and the areas to be protected. The barrier forces the roots to grow downward and under the protected features. To reduce the possibility of roots growing horizontally and girdling the plant, vertical ribs are formed into the barrier. Barriers can be linear installations, used along roadways and walks to keep roots in boulevard strips, or can be circular containments placed around newly planted trees to force all roots down to a lower level (Figure 36-21).

Identify and mark the location of the root barrier. When possible, it is best to install root barrier material at the time of planting. If addressing an existing situation, then make every attempt to install the barrier beyond or at the outer reaches of the root zone. Damage to the plant by severing major roots can be as devastating as the damage to the pavement you are attempting to protect.

For linear installations, along the route of the root barrier, excavate a trench that is 8 inches wide and 10 inches deeper than the depth of the root barrier. Backfill this trench with 1 foot of amended backfill and compact. Place the root barrier vertical against the outside edge of this trench. If the barrier has ribs, verify that the ribs are facing the plant. The top edge of the root barrier should extend between ½ and 1 inch above the finish grade. If placed under tree grates, place the top of the barrier so it is touching the bottom of the grate. If multiple sections of barrier are required, join them using the channeled end or assembly strips provided by the manufacturer (Figure 36-22). If the trench runs up or down a hill, step the barrier panels and trim the excess from the top. Backfill the front side of trench with native or amended backfill and compact.

Circular installations are placed in the planting hole just before the plant is installed. The same procedures are followed, with a planting hole being substituted for a trench. Install the barrier with the ribs facing inward, and the top edge ½–1 inch above finish grade. Once the barrier is in place, set the plant and backfill the planting hole.

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Figure 36-21 Circular root barrier around plant awaiting backfill.

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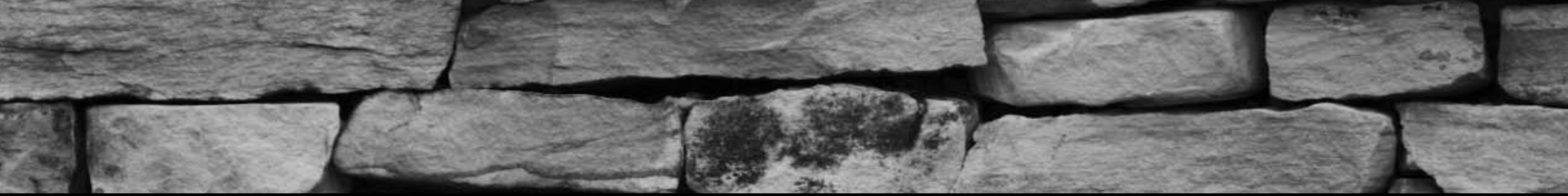
Figure 36-22 Root barrier material. Pieces are joined by sliding locking edge into channel on adjacent piece.



SECTION 9

SUMMARY

Although other elements of sitework create the major functional framework for a design, site amenities create the finishing details of the hardscape. In Section 9, the installation of several common amenities was discussed. Although the variety of site amenity treatments is extensive, the most common installations include use of water as a design feature, bridges, site furniture, play equipment, outdoor kitchens, edgings, and plant protection devices such as tree grates and tree guards.

Because water features are so creatively and diversely used in the landscape, attempting to classify uses of water can be difficult. For the purposes of this text, water-related features were grouped into flexible and rigid liner pools, waterfalls, cascades, fountains, and bridges. Preparation for these features requires planning the layout to accommodate the topography, electrical sources, water sources, drain installation, and recirculation piping. Bridge location also requires planning for its placement, the size and type of the bridge, and the support of bridge.

Installation of flexible and rigid liner pools is accomplished by marking the location for the pool and excavating a basin into which the liner is placed. Flexible liners can have variable levels and shapes, whereas rigid liners require excavation to the predetermined size and shape. Liners are placed and leveled, then edge treatments are applied to hide the top edge of the pool. Pools are filled and ready to operate. Submersible pumps are used if water is to be recirculated to other basins. Lighting filters and fountains can be added to enhance the installation.

Waterfalls require the construction of one or more basins into which water can fall. A lower basin to receive water is required and, in many waterfalls, an upper basin to supply water is also installed. Pool construction techniques can be used to create the waterfall basins. The water source and recirculation mechanism must be designed and tested to ensure that the desired amount of water will circulate into the lower basin. At the top of the falls, an engineered opening, called a weir, controls the amount of water that passes over the falls. If multiple basins or multiple falls are part of the design, the channels between these elements must also be constructed to conduct the proper amount of water. Cascades are constructed in a manner similar to construction of waterfalls. A lower basin captures water that spills down a gently sloped channel. When waterfalls and cascades are constructed using liners, the surfaces and edges are typically covered with landscape material to hide the liner and to create a natural appearance.

Fountains and lighting can be placed in pools as stationary elements or floated onto a pool. Each installation requires proper sizing of the pool, a pump motor, and a supply of electricity to the fountain pump. Bridge installation by the landscape contractor is typically restricted to crossings of minor water features. Both custom-built and premanufactured bridges are available to span pools, ponds, and small streams. Bridge installation begins with the accurate placement of piers for each end of the bridge. Premanufactured bridges are lifted into place with a crane. Custom bridges require framing a platform and railings, as identified in the wood construction section of this text.

Installation of site furniture and premanufactured play equipment begins with the accurate layout of the amenity. Amenities purchased may require assembly according to factory instructions and exact tolerances for placement of anchors and posts. Amenities typically have posts that are either directly buried in the ground, connected to a concrete slab using anchor bolts placed when the slab was poured, or anchored on top of a frost footing. Each anchoring method requires that the posts resist frost action. Certain amenities may require

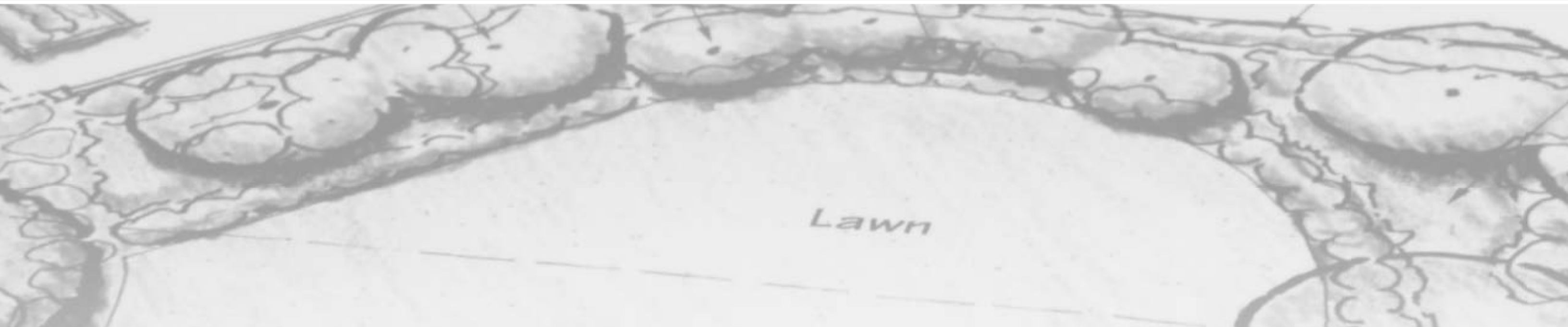
that conduit for supplying electrical wiring or reinforcing be placed when frost footings are poured. Play equipment also requires the placement of a resilient surfacing below and around the equipment. Some manufacturers require field finishing or touch-up of metal amenities.

The home is enhanced through the addition of amenities such as outdoor kitchens, firepits, and patio misting systems. The great outdoor spaces created through all of the paving and construction receive the final touches when the family can prepare meals, dine, relax, and enjoy the exterior spaces in the same comforts as they do the interior spaces of a home. Outdoor kitchens require extensive planning and complex construction when building a custom cabinet that houses grills, sinks, and refrigerators. Firepits require the construction of a surround to contain the fire and accommodation of a natural or gas-fueled flame. Misters require plumbing the overhead outdoors in order to cool spaces too hot to enjoy in warm seasons.

Amenities related to plant installation include edgings, planters, tree grates, and tree guards. Natural edging is accomplished by excavating a clean border between planting beds and turf. Permanent edging installation requires excavation of a trench and placement of the edging material flat against the turf side of the trench. Plastic edging is joined using short tubes and anchored using metal stakes driven through the edging. Metal edgings are overlapped and joined with a metal stake driven through a slot in both adjoining pieces. Metal stakes are driven along the length of the edging to secure it. Wood edging, bender board, and composite material are anchored at each end, and at regular intervals, using wood stakes. Other edgings, including bricks, stone, and precast concrete, are installed by laying them edge to edge in the trench and backfilling. Edging can also be accomplished using a curbing machine that lays a shaped bead of concrete in an excavated trench. When planting beds are edged, weed barriers can be installed to reduce unwanted plant growth.

Planters are typically placed in the proper location, filled with soil, and planted. In certain locations, planters may require leveling to match pavement grades. Tree grates require a cast-in-place concrete curb to support the framework for the grate. The framework is set in the curb and the grate is set in place after plant material is installed. Many frames come in two or more pieces that are bolted together. Tree guards come in two pieces and are placed around the tree, bolted together, and bolted to the tree grate.

SECTION 10
PLANTING



INTRODUCTION

Few landscape projects can be considered complete without the addition of plant material. With endless attention paid to developing a site's hardscape, it is the plant material that truly adds life to a project. To accomplish this phase of the project, contractors must shift their thinking from working with inanimate objects to working with living organisms. Regardless of the planting method they use, contractors must understand the environment in which plants are to be placed. Knowing the soil conditions, how to properly place plants, maintaining appropriate irrigation, and initiating post-planting care programs are the basis of creating long-term, healthy plant installations.

The chapters of this section address planting in two steps: installing plant material and establishing turf and meadow-like areas. Installing plant material will describe the installation of bare-root, container, balled and burlapped, boxed, and machine-moved plant material. This range of methods covers the majority of transplanting methods currently available within the industry. This chapter will also address site preparation, soil amendment, post-planting care, and installation of plants in difficult situations. Also included in this chapter is information regarding more recent additions to the sustainability movement, green roofs and living walls.

Turf and meadow establishment includes the starting of lawns, prairies, pastures, and roadsides using seeding, sodding, or plugging/sprigging techniques. Also included in this section are the preparation of the site and specialty seeding techniques such as hydroseeding. Although not a living plant material, artificial turf is also included in this chapter.

SUSTAINABILITY SUGGESTIONS

- Mulch plantings and planted areas to reduce evapotranspiration and weed growth.
- Encourage the use of Integrated Pest Management (IPM) to maintain plantings.
- Add mychorrizae as a soil amendment to improve water and nutrient uptake by plant material.
- Consider naturally occurring and organic soil amendments when modifying the soil.

- Compost any plant trimmings made during this phase of construction.
- If allowed to select plant material, select plants that are native to the region and plant material that reduces water demand.
- Plant for diversity; include plants that will attract beneficial organisms to the garden to help control pests.
- Space plant material appropriately.
- Select plant material that is disease-resistant.
- Make soil amendments only as needed to help the plant material get established.

PRODUCTIVITY SUGGESTION

- Formulate soil amendments in large batches prior to planting.

CHAPTER 37

PLANT MATERIAL INSTALLATION

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Evaluate plants for installation.
- Prepare planting beds.
- Install plants that are bare-root, containerized, balled and burlapped, boxed, and machine moved.
- Care for plants after installation.
- Describe the process for installing green roofs and living walls.

Planting a site is usually reserved for near the end of the landscaping process. Once all the hardscape has been installed, the irrigation is operational, the amenities are complete, and the structures are probably occupied, plant installers are asked to ply their trade. But despite this step being near the end of the process, the impact of plant installation, along with turf/meadow establishment, often provides the most dramatic change. The walkways, walls, structures, lights, and other site elements take on meaning once spaces are created, framed, and backdropped with plantings. As dramatic as the initial change might appear, over time the impact of a successful planting will even further enhance the site.

Installing plant material has been made somewhat routine by the advent of modern plant growing methods and the availability of equipment to dig, move, and install plants. The creation of a site with canopy and bloom is a blend of the work of artists and craftspeople with the laborer and engineer. In the past, plant material was hand-dug, lifted and transported via pulleys, cables, and hand trucks, and the installation was work exclusively for healthy individuals with strong backs. Seldom is a contemporary site planting project relegated strictly to hand labor, with crews using augers and backhoes to dig holes and skid-steers and cranes to place plants. Although the hand labor is not entirely removed from the operation, the addition of automation to plant installation has made the process more efficient and has provided more opportunity to add extensive plantings to even the most modest of sites.

Although the equipment may be the star of the planting process, balancing mechanization is the increased need for landscape contractors to make judgments regarding the quality of plants, planting methods, types of backfill, and post-planting care. Mental activities have supplanted the physical in the drive to make our residences and commercial sites green. Although hard work has not been eliminated from the process, a contractor's diminished labor load has been countered by increased responsibilities in management.

RELATED INFORMATION IN OTHER CHAPTERS

Information in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Site Drainage, Chapter 12
- Water and Irrigation System Installation, Chapter 15

SELECTING PLANT MATERIAL

Quality plantings require quality plants. When working with living organisms such as plant material, landscape contractors need to place the right plant in the right place; otherwise, there will be no successful plantings. Although much of a job's success relies on a designer's ability to choose plants that will culturally and aesthetically perform, determining the right plant will also depend on evaluating the health of the plant material to be installed. Whether inspecting plants in a nursery or as they are set off the delivery truck, completing a stock inspection before purchasing, accepting, or installing plants will boost the chances of success. The ANSI standards for nursery stock (ANSI Z60. 1-2004) serve as the current standard for evaluating the size, species, and vigor of plant material.

When evaluating stock, above ground components to review include the correct species and cultivar, proper growth for that container size (typically determined by caliper or number of stems/canes), proper number of branches that are evenly spaced around the trunk, absence of pests and diseases, strong branch unions, proper color and healthy, well-shaped leaves, overall good appearance, and similar characteristics. Remove the plant from its container and inspect the root zone (Figure 37-1). In the root zone, look for girdling roots, dry or dead spots, pests, and moist fibrous roots. Specifications may also call for plant material that is of specific branching height (for placement along walks and streets) or for plant material that is matched (similar height, form, and branching characteristics).

Although they must follow the specifications provided on the planting plan, contractors can realize benefits if the option to select plants arises. If allowed to select plant material, it is often more economical, and healthier for the plant, to choose a smaller size, rather than a very large plant, of the same species (e.g., selecting 1- or 5-gallon containers rather than 15-gallon containers). Not only are smaller plants typically priced lower, but they also often acclimate to new conditions better. Within a few years, that smaller plant will be as large and as healthy as its larger specimen.

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Figure 37-1 Inspecting the root zone of a container plant.

PREPLANTING CARE

In the world of construction, having materials show up the instant they are required is not the standard. Having materials arrive late can be devastating, but having materials arrive before they are needed creates new problems, especially when those materials are plants. Unlike hardscape that can be set in a secure storage area and largely ignored until used, plant material must be maintained on a daily basis until it is planted.

Initially, contractors should determine whether they will accept plant material prior to installation date. Many plants cannot be stored, and how long those that are held can be stored will depend on the type of plant. Timelines for larger jobs may necessitate that plants be held for several days while the installation work progresses. Trees, shrubs, perennials, and most annuals and ground covers that arrive early can be stored with proper care for up to 2 weeks and show few detrimental effects. This would include plants that are in flats, containerized, balled and burlapped, and boxed. Larger containerized trees and shrubs can be stored much longer. In contrast, bare-root plants require continual moisture and benefit from refrigeration. These plants should be returned, rather than stored. Trees that are machine moved cannot be stored, and that operation should be done only on an as-needed basis. Seed and dry materials can also be stored in a dry, cool place for an indefinite period; but any sod that arrives before needed should be rejected. Sod will start to deteriorate after only 1 day on a pallet. In whatever location you store them, all plants should be kept in a secure area to reduce the chances of theft (Figure 37-2).

To protect plants that arrive early, keep their roots cool and moist and protect them from physical damage and injury from excess light, heat, and wind. Just as plants are protected during their transport to a site, the storage area must also create a safe growing environment. If possible, storage in an area that is similar to the conditions where the plants will ultimately be placed will help with "hardening off" (the process of plants adapting to new environmental conditions). Place the plants in the storage area and water them thoroughly. Heel in plants by

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Figure 37-2 Plants staged in a storage area.

packing the containers/root-balls together and covering them completely with a thick layer of mulch. Set up a temporary irrigation system that will water at least once a day, and add supplemental water if material begins to dry out. Until you plant them, check the plants on a daily basis to ensure proper moisture, that plants are not setting in water, and that no pest or other physical condition is inflicting damage on them. Once accepted on a job site, plants become the landscape contractor's financial responsibility.

PREPARING SOIL FOR PLANTING

For a plant to survive, it must adapt to its new permanent environment in the soil. To facilitate the plant's survival, many believe that the soil around the plant should be modified to encourage vigorous growth. Others believe that because the plant must eventually adapt to soil that is native to its new location, that process should begin the instant the plant is installed. This argument over soil preparation for planting has been ongoing for decades, and it will most likely continue well beyond the life of any plant the contractor will install. This text sides with neither position but, instead, provides the information necessary to modify planting beds and planting soil if so required or desired. This information is offered even if the contractor chooses to use native soil as backfill material when planting.

Plant Bed Preparation

Many plants require no special site preparation for installation in the landscape. In particular, trees, shrubs, and plants that are planted individually and not in large masses require only excavation of the planting hole. However, annual and ground cover beds, masses of perennials, decorative grasses, and sometimes shrubs do better when contractors prepare the entire root zone area to assist plant growth. Areas that require preparation are typically easy to identify on planting plans by lines around the perimeter of the beds. To prepare the bed, identify the edge using marking paint. Remove any sod or other plant growth covering the area. If any soil amendments are planned, distribute them evenly over the planting bed. By hand, using a garden fork or using a rototiller, till the bed to a depth of 6–8 inches. After it is tilled, the bed will be ready to plant.

If time is not a priority and the bedding area is relatively flat, a more sustainable alternative to removing plants and rototilling a bed for preparation is sheet mulching. Identify the area to be developed and cut plants to ground level, leaving the plant debris on the site. Water the area thoroughly and cover with a light layer of compost. Place several thicknesses (4–6 sheets) of newsprint or a single layer of cardboard over the entire area. Cover the newsprint/cardboard with a 4-inch layer of biodegradable mulch such as wood chips or compost. Let this stand until the newsprint has decomposed, after which the area can often be planted without significant tillage. There are several formulas for sheet mulching, and the process can take up to 2 months to complete. However, the resulting beds typically make ideal planting areas.

Plant Soil Amendments

A wide range of choices exist for backfill soil used in planting. In reference to the argument made in the first paragraph of this section, many people are adamant about backfilling around newly installed plants with the same soil that was removed from the planting hole. Other people will recommend that the original soil be recycled elsewhere on the site and that the plant be backfilled with a plant-friendly medium, typically composed of compost and topsoil.

This amended backfill may also include slow-release starter fertilizer, mychorrizae, bt, or other biological organisms, and additional substances intended to enhance plant growth (Figure 37-3). These amendments range from alfalfa meal to zeolites, with supplemental nutrients, vitamins, moisture-holding compounds, seaweed, earthworm castings, mushroom compost, and others tested as soil additives at one time or another. A third option is to create a blend of native soil with amended backfill for use with newly installed plants. Although there is no perfect answer, a few characteristics of backfill have been recognized as helping plants establish themselves in a new environment. These characteristics include:

- Backfill that is placed around the plant should be friable and compacted without leaving air holes around the plant.
- Mychorrizae, while often existing in the native soil, has been shown to improve the performance of new plantings in many situations when added as an amendment.
- Any fertilizer added should be in small quantities and should be slow-release.

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Figure 37-3 Amended soil staged to backfill a plant.

- Naturally occurring compounds such as meals (bone, blood, feather, etc.) can provide essential nutrients without creating fertilizer "burn."

INSTALLING PLANTS

Once the site, plant material, and amendments are prepared, installation of the plants can begin.

CAUTION

Locate all utilities in the planting area prior to excavating for plant material installation.

Layout of Planting Areas

Plant installation begins with locating the plants on the site. Several layout methods are available, with the simplest being setting the plants in the locations where they are to be installed (Figure 37-4). This allows the designer to identify any problems and adjust plant locations prior to planting. In more specific situations such as planting beds and ground cover areas, plantings may be laid out using string-lines or lines painted on the ground.

Spacing of plant material is often specified on a planting plan or in a plant schedule. Typical dimensions and terms used include the abbreviation *O.C.*, which stands for "on center" and identifies the distance between the centers of plants; grid spacing, which will identify the spacing between rows and columns of plants; and triangular spacing. Triangular spacing is particular to plant material and is commonly used to position plants to avoid the open space left between plants when installed in a grid pattern. Triangular spacing places the rows slightly closer than the diameter of the plant and offsets the plants in every other row to a position halfway between the plants in neighboring rows.

Excavation of Planting Holes

Excavating a good planting hole is as essential to plant survival as selecting a quality plant. A plant often fails to survive because it was installed too high or low, the planting hole was undersized, or the hole was not properly prepared. To excavate a hole for installing plant material, begin by setting the plant(s) in the desired location. If the plant is small, use spray paint to mark a circle around the container. If the plant is larger (1 gallon and up), mark an *X* over the spot with the legs of the *X* extending at least 2 feet beyond the plant (Figure 37-5). This extra

Figure 37-4 Placing plants for inspection.

Figure 37-5 Layout of plant material for planting. Where the legs of the *X* cross is the center of the plant. Extending the legs of the *X* beyond the hole allows the center to be located after excavation.

marking will allow you to locate the center of the hole after excavation. If planting in an area where minimal disturbance of the surrounding landscape is desired, cut a 4-foot by 4-foot piece of landscape fabric on which to place excavated soil and to mix backfill (Figure 37-6).

Using a shovel, auger, or backhoe, dig the hole to the proper diameter (Figures 37-7 and 37-8). For difficult soils, use a breaker bar or jackhammer with a spade bit to break through the surface. In larger projects, a skid-steer mounted auger is often used to excavate planting holes. Larger plant material (4-inch caliper or larger, 36-inch box or larger) will benefit from using a backhoe to excavate the planting hole (Figure 37-9). To determine the proper diameter of the planting hole, bare-root and container stock holes should be excavated to twice the diameter of the container, whereas boxed and balled and burlapped holes should be 2 feet wider than the root-ball. Boxed material will require a properly oriented square hole, whereas other holes can be round.

Excavate the hole to the proper depth. Determine the proper depth by measuring either the level of the soil in the container or the distance from the bottom of the root-ball to the soil line on the plant trunk. Once you have excavated the hole, examine the sides of the hole for glazing of any clay soils. If the sides have been smoothed and compacted by excavation, use a mattock to scarify the surface. Use a breaker bar or shovel to loosen the soil in the bottom 6 inches of the planting hole. Replace approximately 1–2 inches of soil into the planting hole to raise the planting depth to approximately 1 inch above the surrounding grade. This raised height will create the proper planting depth when the plant has settled after the first few waterings. If you make a mistake on planting depth, it is better to plant too high rather than too low. The edges of the root-ball

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Figure 37-6 Using a drop cloth to store excavation and backfill material.

Figure 37-7 Excavating a planting hole.

Figure 37-8 Excavating planting holes in clay soil using an auger installed on an electric drill.

can be shaved or fill can be placed around the plant if it is too high; but if the plant is installed too low, it is difficult to correct.

If the planting is in heavy clay soil, an urban location, or other situation where drainage is poor, consider excavating one or more sumps in the bottom of the planting hole. Create a sump by excavating a hole 8 inches in diameter and 3 feet deep using a posthole excavator or auger. Fill that hole with large, rounded drainage rock and cover the hole with landscape fabric. The sump(s) will hold excess water away from the root zone in poor draining areas. If the planting location is in heavy clay soil, another technique that can be used is to fill the planting hole with water and wait until the hole drains before planting. If the hole has not drained in 1 day, other options such as sumps or subdrainage should be considered to protect the plant from excess water.

Other situations can arise in a plant installation operation that require special techniques. One such situation is planting on a hillside. Although shrubs and smaller plants are planted with the slope of the hillside, trees will appear out of plumb if similarly planted. To plant trees on a hillside and maintain the trunk in a vertical position, bench the area where the planting hole is placed prior to digging the hole. Benching requires a minor cut and fill operation above and below the center of the planting hole. Excavate on the back half of the planting area and transfer that soil to fill on the front half (Figure 37-10). Bench an area wide enough to accommodate the planting hole plus an additional 1 foot apron. Then excavate the planting hole in the newly created level area. When the tree is placed, verify that it is on the original soil, not the fill added from above the hole. If the soil is unstable, then you may need to move the hole farther

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Figure 37-9 Augering planting holes using a skid-steer attachment.

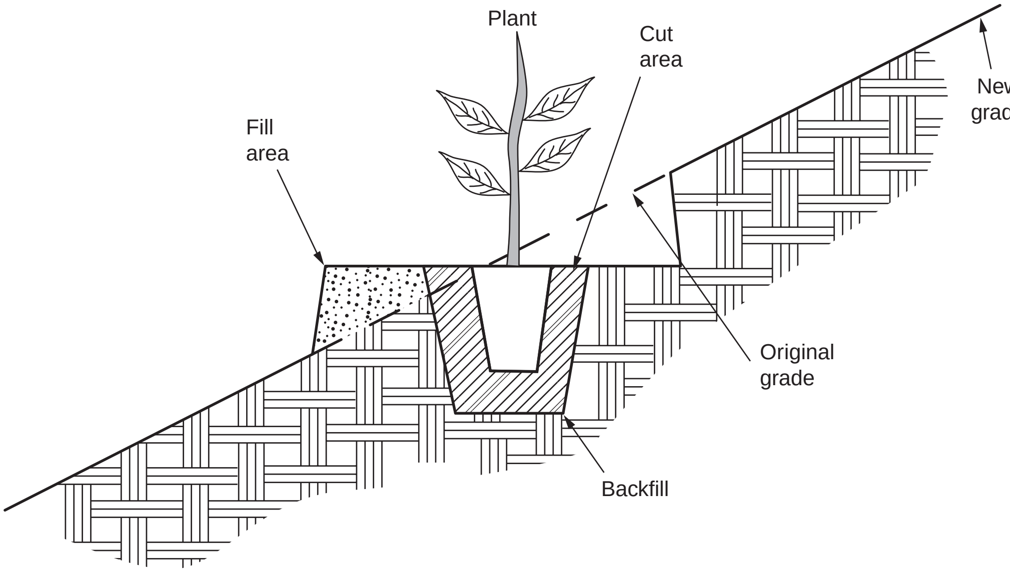

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Figure 37-10 Planting on a hillside.

into the hill or possibly build a tree well to create a level planting area.

Installation of plants that are too large for one or two people to move will also require special techniques and equipment. For large plants, one technique is to place a heavy wood plank at the edge of the hole and slide the plant down the plank into the planting hole. A second method is to excavate a small ramp on one side of the planting hole so that the plant can be pulled or rolled

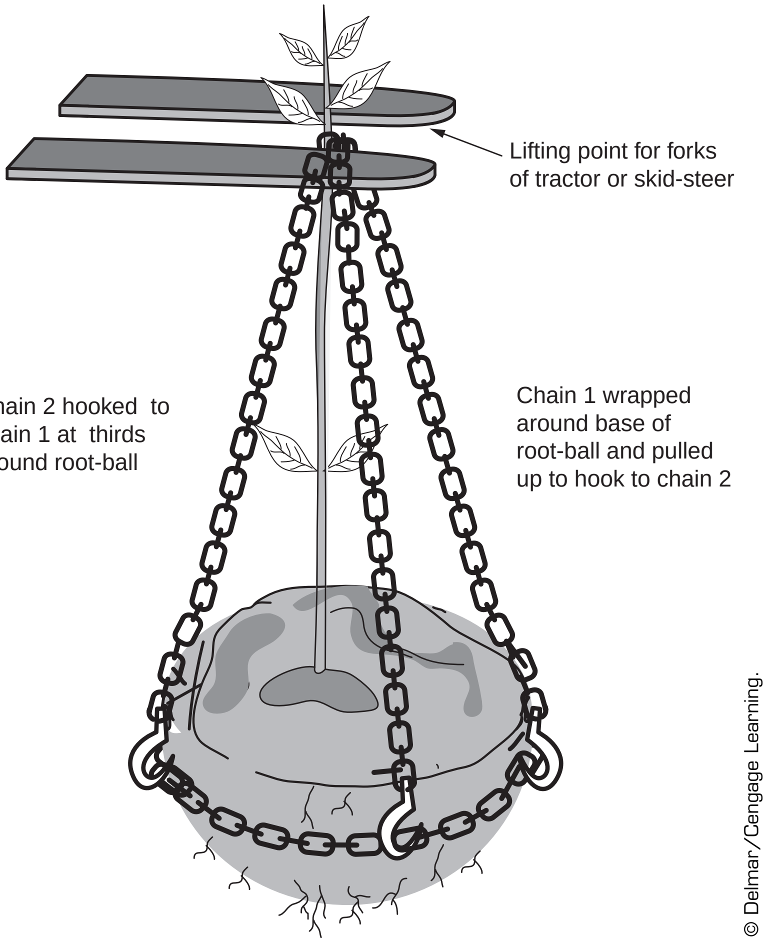

Figure 37-11 Chain sling for lifting heavy objects.

into the planting hole. Another technique is lifting the plant and the root-ball supported by a chain sling (Figure 37-11) or tow straps with a skid-steer, backhoe, or crane. Tow straps can be worked under the root-ball/container by lifting one side and sliding a strap under, lowering the plant, and repeating on the opposite side. The forks of a skid-steer can then be positioned under the chains, and the plant can be lifted and placed in the hole.

CAUTION

When lifting any plant material, verify that all lifting devices are secure. Never pass under a suspended plant.

Installation of Bare-Root Plants

Bare-root is a common method for supplying contractors with roses, berry plants, small fruit trees, and certain perennials. In simple terms, bare-root is a plant that has had the growing medium removed from the roots. Only certain plants have roots vigorous enough to overcome the removal of soil, but packaging in such a manner greatly reduces the shipping costs for those plants. Bare-root plants can be installed anytime during the year, but installing while the plant is dormant or just emerging from dormancy is the optimum planting time. Before planting bare-root plants, remove the plant from its packaging and remove any sawdust, moss, or other packaging from the roots. Place the roots in a bucket filled with water and a quart of soil, and leave them in this “gravy” mixture for at least 2 hours and up to 24 hours before planting. This technique will rehydrate the roots and help stimulate new growth from the root hairs.

To install bare-root stock, use the following steps (Figure 37-12):

- Excavate the planting hole A.
- In the center of the hole, create a cone-shaped mound of soil. The height of the

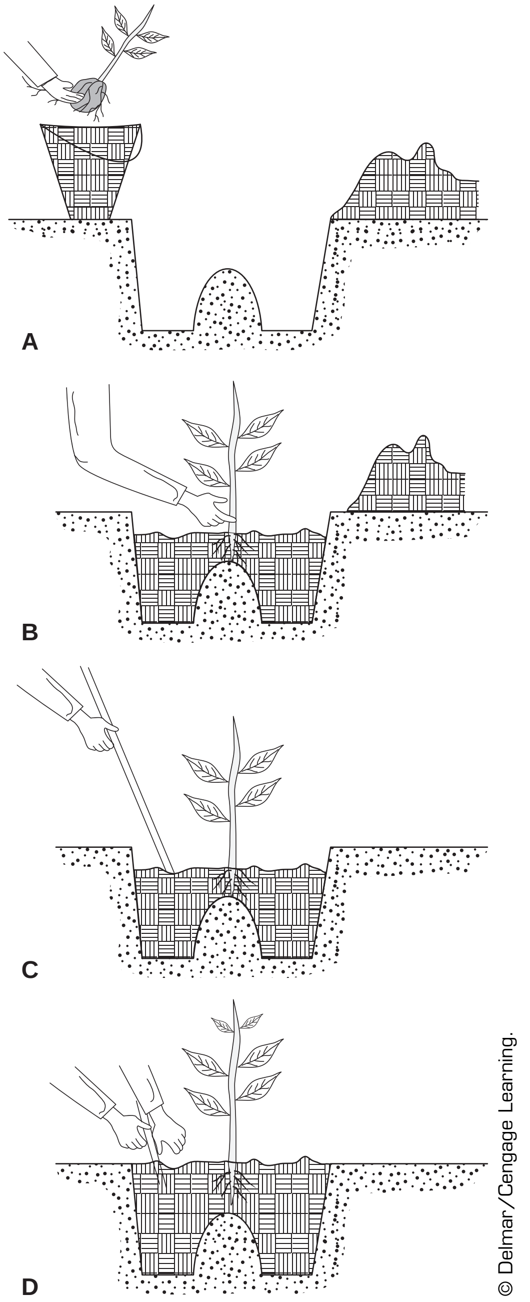

Figure 37-12 Installation of bare-root plant material.

cone should be approximately half the depth of the planting hole.
- Remove the plant from the soaking bucket.
- Prune any damaged roots and stems.
- Orient the plant with the best side facing forward B.
- Spread the roots evenly over the soil cone (Figure 37-13).
- Hold the plant at the graft or soil mark while backfilling.
- Gently backfill ½–⅔ of the hole.
- Adjust the planting depth if necessary to assure the plant will be 1 inch above the surrounding grade after planting. Adjust the plant depth by gently pulling up on the plant's trunk.
- Compact the backfill by foot or by using the handle end of a shovel C.
- Complete the backfilling and compact.
- Remaining soil can be used to build a temporary berm around the perimeter of the planting hole, creating a basin for watering.
- Deep water and mulch the plant (see "Postplanting Care") D.

Installation of Container Plants

Container-grown plant material now dominates the landscape industry. Reasons for growing plants in containers include consistency of growing medium, ease in transplanting, and less weight for shipping. Container stock now accounts for the vast majority of plants installed in landscapes. A wide variety of containers can be found in service, ranging from 2-inch square "cells" in a growing flat to nursery containers of up to 45 gallons.

To install container-grown stock, use the following steps (Figure 37-14):

- Excavate the planting hole A.
- Place the plant near the planting hole.
- Carefully remove the plant from the container (Figure 37-15). For small containers up to 4 inches, place a hand under the container and squeeze the plant out. For larger containers, set the container on its side and grasp the plant by the base of the trunk or stem. Pull to remove the plant. If the plant will not come out of the container, slap the container with the heel of your hand on several sides and pull again. If the plant will still not come out, cut away the container using tin snips.
- Examine the roots and remove or straighten any girdling roots. Scarify the root-ball if compacted root growth exists.
- Set the plant in the hole (Figure 37-16).
- Orient the plant with the best side forward.

Figure 37-13 Bare-root plant with roots spread over soil cone in planting hole.

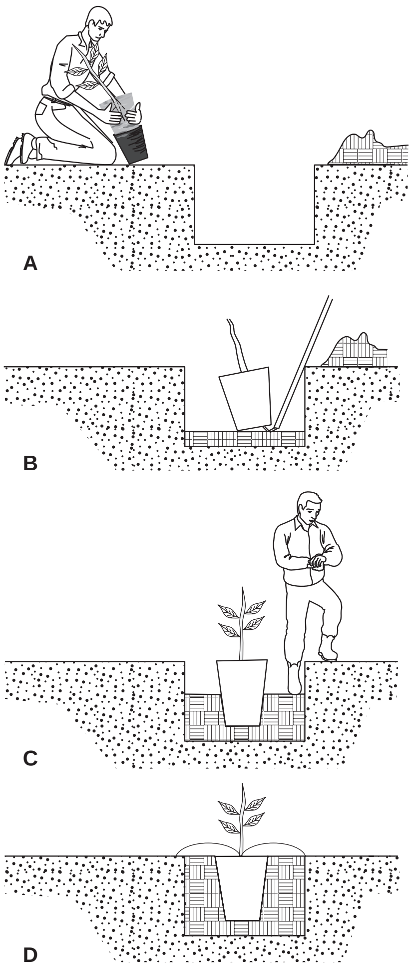

Figure 37-14 Installation of container plants.

- Adjust the plant to proper depth by either removing soil under the root-ball with your hand or tipping the plant and adding soil. If the plant is large, you may need to make several smaller adjustments to raise or lower the plant and maintain proper orientation and plumb B.
- Backfill half of the hole and compact with foot or with the handle end of a shovel.
- Verify that the plant is at the correct planting depth, slightly above the surrounding grade. Adjust the height of the plant if necessary.
- Complete the backfilling and compact C.
- Deep water and mulch the plant (see "Postplanting Care") D.

Installation of Balled and Burlapped Plants

Field-grown plant material is typically harvested using a method called **balling and burlapping,** or B & B. B & B uses one or more large sheets of burlap to protect and contain the root-ball of the excavated plant, often with twine or a metal basket supplementing the burlap containment. Although B & B is reasonably stable, exercise care when handling B & B stock to avoid breaking the root-ball and roots contained within.

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Figure 37-15 Removing a plant from a container.

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Figure 37-16 Container plant placed in a planting hole.

To install balled and burlapped stock, use the following steps (Figure 37-17):

- Excavate the planting hole A.
- Position the plant near the hole and determine the best orientation and depth for the plant. Adjustments are easier to make at this stage, rather than waiting until the plant has been lowered into the hole.
- Place the plant in the planting hole.
- Adjust the depth by leaning the plant to one side and removing or adding soil; repeat for

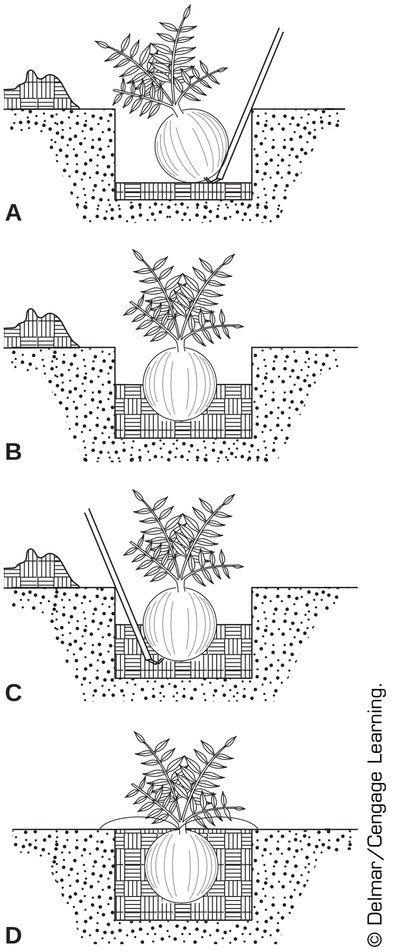

Figure 37-17 Installation of balled and burlapped plants.

the opposite side. Plants should be installed with the soil line 1 inch above the surrounding grade.
- Once you have properly positioned the plant, cut and remove the twine surrounding the root-ball. If the plant is placed in a wire basket, attempt to remove as much of the upper portion of the basket as possible using bolt cutters. Some experts sanction leaving the wire basket in the planting hole intact B.
- Remove the burlap from the top half of the root-ball using a sharp utility knife. Tuck the remaining burlap as far under the root-ball as possible. If the burlap cannot be cut, roll it down the sides of the root-ball and tuck it under the root-ball.
- Trim any girdling or damaged roots that are exposed. Scarify the root-ball if compacted root growth exists.
- Backfill the hole halfway and compact with your foot or with the handle end of a shovel.
- Complete backfilling and compact C.
- Deep water and mulch the plant (see “Postplanting Care”) D.

Installation of Boxed Plants

Trees and larger plants are often grown to certain sizes in containers; and when the root-balls and plants become too massive, they are transferred to large wood boxes. These boxes are specially constructed with a removable bottom, sides that angle outward, and metal straps that hold them intact. Using this method, trees can be grown to large sizes in boxes that are up to 5 feet across or larger.

To install boxed stock, use the following steps (Figure 37-18):

- Excavate the planting hole A.
- Position the plant near the hole and determine the best orientation and planting

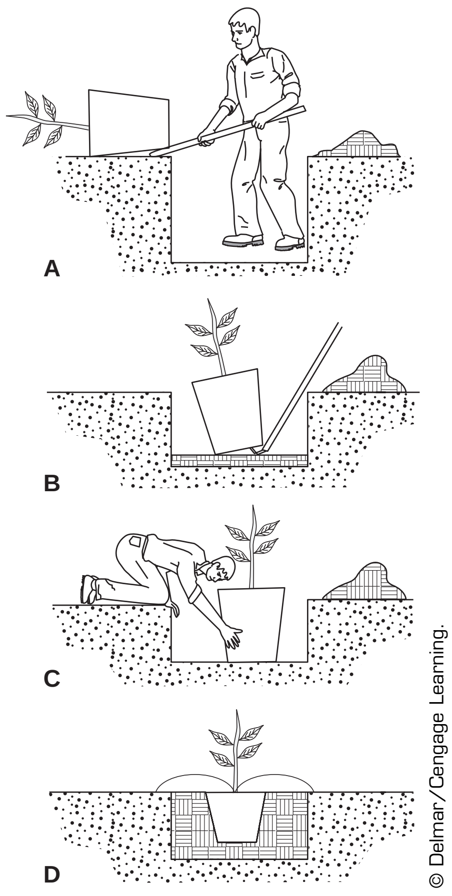

Figure 37-18 Installation of boxed plants.

depth for the plant. Adjustments in depth and hole size are easier to make at this stage, rather than after the plant is in the hole.

- Tilt the plant on one side of the container using caution not to damage any branches or canopy.
- Remove the bottom of the box with pry bars and hammers (Figure 37-19).
- Lower the plant into the hole (Figure 37-20).
- Adjust the depth if necessary to place the soil line approximately 1 inch above the surrounding grade. This can be done by leaning the box one direction and adding or removing soil. Then lean the box the opposite direction and add/remove soil. Repeat until you attain the correct planting depth B.
- Orient the plant to the desired position.
- Using tin snips, cut the wire bands holding the sides of the box. Several cuts may be required to free the sides from each other (Figure 37-21).
- Remove the sides and lift them out of the planting hole. If necessary, twist the side to loosen it from the root-ball (Figure 37-22) C.
- Trim any girdling and damaged roots that can be reached. Scarify areas of the root-ball where compacted root growth is present.
- Backfill the hole halfway and compact using the handle end of a shovel.
- Complete the backfilling and compact.
- Deep water and mulch the plant (see "Postplanting Care") D.

Installation of Machine-Moved Plants

Situations will arise when large plants are in the incorrect location. As a result of construction, expansion, or other activities, you may need to move plants that are too large to hand-dig. In these instances, you will need the services of a **tree spade,** a hydraulic-operated excavation tool that is mounted on a truck or towed by a tractor. Tree spades typically have four large triangular blades that are pressed into the ground surrounding a plant, coming to a point directly below the tree. Once you have completely inserted them into the ground, the blades sever all roots and cut the soil, allowing the tree to be lifted out of the ground by the hydraulic arms of the tree spade. The plant is then transported to its new location where the process is reversed and

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Figure 37-19 Removing the bottom of a planting box.

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Figure 37-20 Lowering a boxed plant into the planting hole.

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Figure 37-21 Cutting the bands of a planting box using tin snips.

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Figure 37-22 Removing the sides of a planting box.

the tree is planted in a predug hole. Although expensive to own and operate, tree spades can prove invaluable when moving important plants or substantial quantities of large plant material.

CAUTION

Locate all utilities, overhead and underground, before operating a tree spade. Verify that the tree spade equipment can negotiate the route between excavation and planting sites.

To machine move a plant, use the following steps:

- Begin by using the tree spade to excavate a hole where the plant is to be moved.
- Deposit the soil plug from this hole next to where the tree is removed, or dispose of the soil elsewhere on site.
- Position the tree spade around the plant to be moved and remove the plant from the ground. The process for operating the equipment will vary, depending on the manufacturer, but typically involves closing the blades around the plant, lowering each blade in small increments until completely lowered, then lifting the plant from the ground.
- Transport the plant to the planting site.
- Position the tree over the hole and lower it into the ground.
- Remove the tree spade.
- Backfill any voids left between the root-ball and the planting hole. If the tree was not set squarely into the hole, there may be significant voids.
- Deep water and mulch the plant (see "Postplanting Care").

POSTPLANTING CARE

The third step in plant success, along with selection of quality plants and proper installation, is the care of plants after they have been planted. Even the hardscape portions of a landscape require care after completion, and this care is multiplied with living elements such as plants. Care of a plant for the first 4–5 years after planting, including irrigating, mulching,

and pruning, is the pathway to long life for most plants. Not all of the postplanting care tasks listed below are required for a successful planting. Therefore, evaluate each situation to determine what type of maintenance schedule is necessary for each plant.

Deep Watering

Deep watering provides the first substantial irrigation for the newly installed plant and works to remove air pockets and voids that may remain in the backfill area. Failure to remove these voids may lead to crown rot in newly installed plants, particularly for balled and burlapped plants.

To deep water plants, connect a hose to a water source that supplies pressure similar to household plumbing (no pressure sprayers). Remove any nozzles on the hose and crimp the last 6 inches. Turn the water on full pressure, uncrimp the hose, and push it below the surface in the backfill area of the plant (Figure 37-23). Let the pressure of the water "auger" a small hole for the hose. Hold the hose in that position until the water begins to bubble back to the surface, typically in just a few seconds. Recrimp the hose and move to the opposite side of the plant and repeat the process. Small plants (1 gallon) require only two insertions, whereas larger plants may require four or five insertions. After all water has drained back into the holes, use excess soil to backfill the holes made by the hose.

Mulching

Of all the postplanting activities, mulching is probably the most valuable in protecting the plant's health. Mulching holds moisture near the root zone, reduces competition from weeds, and keeps mechanical equipment such as mowers and string trimmers away from the new plant. If not specified, select natural mulch that is heavy enough to stay in place and slowly degrade to compost. Choices that work well in planting situations include bark, shredded bark, wood chips, and coarse compost. If the plant is planted singly in an open area, place mulch around the new plant in a circle that is 18–24 inches diameter and 2–3 inches thick. Pull the mulch away from direct contact with the trunk of any trees to prevent decay. If plantings are placed in a bed, mulch the entire bed to a depth of 2–3 inches, also keeping mulch away from the trunk of trees and larger shrubs.

Figure 37-23 Deep watering a newly installed plant.

Staking

Staking of plant material is a valuable tool to support trees that lack the ability to stay upright, or to prevent plants from rocking in windy conditions and tearing new roots that are growing out of the root-ball. Other than for these two reasons, staking new plantings is generally unnecessary. Plants that lack the structure to stay upright were most likely improperly staked while grown in the nursery. Such plants will benefit from a single small stake placed approximately 1 foot from the plant. The height of the stake should not exceed ⅔s of the plant's height, allowing the top ⅓ to move in the wind and stimulate growth along the plant's trunk. Drive the stake into solid ground and fasten loosely to the plant using a staking strap.

Trees that are being protected from windy locations, particularly evergreen plants, should have a minimum of two stakes placed on opposite sides of the plant (paralleling the prevailing wind if possible). An arrangement of three stakes spaced evenly around the plant is preferable. The stakes should be placed outside the backfill area and driven securely into solid ground. The stakes should not exceed ⅔s the plant's height and should be fastened securely using staking straps (Figure 37-24). Conifers may benefit from guying, rather than staking. **Guying** uses three to four anchors placed in the ground, with wires angled up and over branches approximately halfway up the plant (Figure 37-25). Straps used for staking or guying should be covered with cloth, rubber, or other material that will prevent

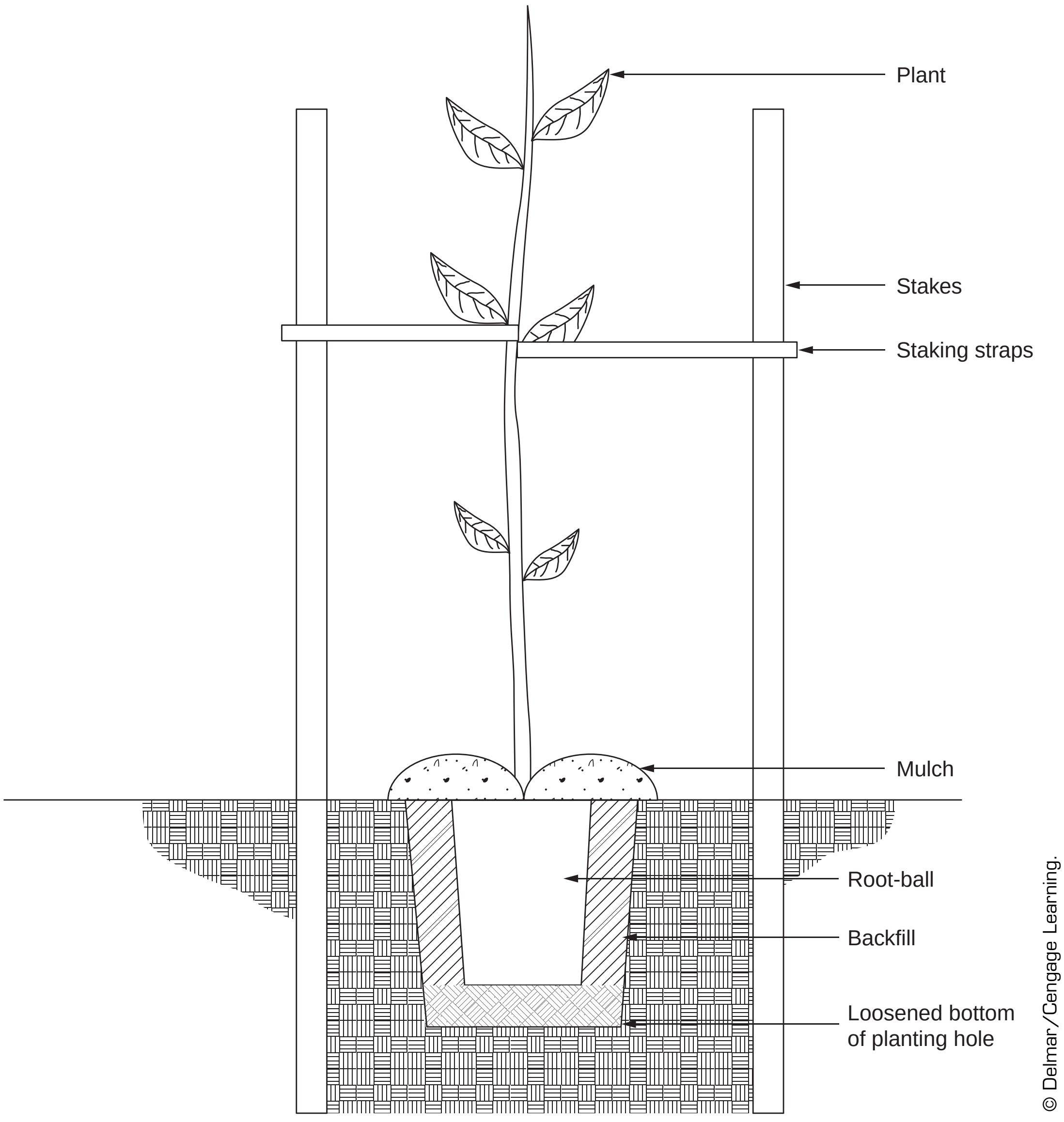

Figure 37-24 Staking and mulching for newly installed plant.

Figure 37-25 Guying a newly planted tree.

anchoring wires from damaging tree bark. Staking or guying should remain on plants for no more than two growing seasons. In most cases, staking and guying can be removed after 1 year if the plant has become established.

Wrapping

Protecting small trees with smooth bark requires wrapping. Although not every plant will require this step, plants with smooth bark are subject to sunscald, or splitting bark from the winter sun warming the sap on one side of the tree. Plants can also have issues with excess sun in the summer if all the feather growth has been pruned off the trunk. Tree wrap is typically a roll of double-layered kraft paper with tar between the layers. Other choices include synthetic materials or vinyl. Begin wrapping at the base of the tree, overlapping the wrap by 50% for each turn around the trunk. Continue wrapping up to the first scaffold or major branch. Cut the wrap and staple it to the trunk using construction staples. To protect trees from sunscald, install the wrap at the first sign of freezing temperatures and remove the wrap again in the spring. Continue wrapping any necessary trees each year until their bark begins to develop ridges and texture.

GREEN ROOFS AND LIVING WALLS

One of the landscape-related innovations of the green movement has been the integration, or reintegration, of plant material with the structure. Although this movement began many years ago, the concept of placing plant material on the roofs and walls of structures to save energy and improve the environment has gained new momentum in the past few decades. With more innovations undoubtedly to come, the focus for the current era is on creating living environments on rooftops, also called green roofs.

The idea is simple: Replace or cover composite roof materials and mechanical equipment with meadows and living habitats that take in rather than shed water, that absorb rather than reflect heat, and that support life rather than defying it (Figure 37-26). In implementation, however, the idea is not quite so simple, even though the concept that plants can replace tar on roofs has become plausible. More recently the same philosophy has been applied to the vertical surfaces of structures, both inside and out. Creating a wall out of living plants performs many of the same functions that plants on a roof accomplish, typically on a smaller and more attainable scale (Figure 37-27). Although the technology is specialized and ever-evolving, this text must mention the new frontiers facing landscape contractors on the roofs and walls of the structures they now work around.

Green Roofs

Green roof technology requires high levels of engineering, as well as integration of several trades, to be successfully accomplished. Not only must the success of the plant material be considered, but also the structural stability of the building and the protection of the occupants from a porous roof.

Green roofs can be categorized as either extensive or intensive installations. Extensive green roofs are characterized as having 1–6 inches of soil and would typically support succulents and low-growing plant material. Intensive green roofs have 6–24 inches of soil and are capable of hosting a

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Figure 37-26 An extensive green roof with grasses and perennial plantings.

wider range of plant life. As expected, both extensive and intensive green roofs require enhancement of the building's structure to support the weight of growing medium and plant material, as well as improved waterproofing installations. Above the structural and waterproofing elements, both types of green roofs typically have membranes that prevent the chance of root penetration into the structure, an additional drainage layer for the planted portion of the roof, and growing media with plants. Drainage for the planting media may be granular material such as pumice or could be constructed of manufactured drainage systems similar to Enka Drain®.

Irrigation for the green roof is typically composed of drip systems, emitter tubes, or subsurface irrigation that can deliver water directly to the plant roots. Occasionally, an overhead system with low-rise sprinkler heads is used, but in general the overhead systems are not as effective in providing water to the root zone. The distribution system will often be above grade, perhaps even surface mounted. Even the "soil" in which green roof plants are growing is not a traditional soil but a blend of lightweight components similar in nature to the mix used in container plantings. Two general methods for installing plants include (1) planting directly into a layer of media and (2) growing plants in modular trays with several cells and then transferring the cells to the roof for permanent installation. For green roofs, the plants are mostly succulents, including sedums, mosses, grasses, and short flowering plants. For intensive roofs, trees and shrubs, as well as perennials, vines, forbs, and the full range of smaller plants, are available. Plants that have reduced water demands are priorities for each type of roof.

Because of the many specialized activities, the role of the landscape contractor in green roof installation will be far from traditional. It is possible that the landscape contractor may find a role in growing the plants, placing modular trays, mixing and placing the media, installing the irrigation system, or installing the plants. Much of the work will be done by hand and without the benefits of large equipment; and with the extreme growing conditions, the warranty requirements will be continually evolving.

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Figure 37-27 A living wall installation in a patio area.

Living Walls

Living wall technology and its adoption into the everyday landscape may not be as extensive as green roofs, but the two technologies share many of the same environmental benefits. Living walls help clarify the air; they can reduce noise and pollution, in addition to absorbing heat and protecting structures from environmental stresses. Living walls also have two general categories: (1) green walls, composed of plants that are directed up walls on support networks, and (2) living walls, which are vertical installations of plant material in growing medium. Although green walls would be considered primarily an exterior technique, they can be either an interior or exterior application.

Green walls consist primarily of planting space or containers in which to grow plants, often positioned on the ground or in lower levels of structures, and a framework on which plants can grow. This framework can be as simple as a latticework fastened to a house wall or as extensive as a wire or fencing network anchored to the walls of a large office building. The plant materials, often vining plants, are grown in the lower levels and encouraged to extend up the growing framework. The presence of a plant buffer serves to absorb light and heat, hence cooling the structure. Although not without challenges, including maintenance and habitat for undesired wildlife, green walls can produce measurable environmental benefits.

Living walls are a fabricated environment in which panels with upward angled cells are filled with growing medium and planted with species such as sedums, vegetables, grasses, succulents, and similar plants. Each of these panels has a channel running across the top to accommodate drip or emitter hose irrigation. These panels are then hung on a framework that provides the vertical support. At the bottom of the wall is a channel to collect excess runoff from the panels.

Manufacturers of living wall panels such as ELT® provide kits with the framework, panels, and irrigation equipment necessary to plant and assemble a wall. Although attractive and environmentally sound, living walls are somewhat limited in height by the framework in which they are hung. To scale larger structures, extensive support systems for the panels must be constructed. Living walls are well suited to patios, lanais, interior courtyards, and exterior applications in milder climates.

CHAPTER 38

ESTABLISHMENT OF TURF AND MEADOWS

OBJECTIVES

By reading and practicing the techniques described in this chapter, the reader should be able to successfully complete the following activities:

- Prepare an area for turf and natural area planting.
- Install turf and natural areas using seeding, sodding, sprigging/plugging, and hydroseeding methods.
- Install artificial turf.

Much of a site's planted area is occupied not by trees, shrubs, and perennials, but instead is covered with turf or large-scale plantings such as pastures, prairies, and roadsides. Used as athletic fields, picnic areas, natural areas, or negative spaces to balance the larger plant material, these large-scale areas create the bulk of the visual landscape. To describe every different type of open space planted with grass and forb species, and the slight nuances used to establish each, could take an entire text. To simplify the description of establishment methods, two general types of areas, turf and meadows, are considered in this chapter. Although this may be a significant overgeneralization, most establishment techniques can be applied to one or both of these general categories. These two areas and their descriptions are as follows:

- Turf Areas. Turf is used in the landscape primarily for aesthetic or athletic purposes. Although a variety of plants may be utilized, the vast majority of manicured spaces are composed of turf grass species. Plants in turf areas are typically short sod-forming grasses that are mowed and granted a high level of maintenance such as irrigation, fertilization, and related cultural practices. Typical plant species would include Kentucky bluegrass, fescues, ryes, Bermuda, zoysia, buffalo, and bent grasses.
- Meadow Areas. This large group could include spaces labeled as pastures, prairies, and roadsides, as well as other similar types of spaces. Meadows typically include a mixture of grasses, either pasture or native, and forbs to create attractive and diverse habitats while providing erosion control and site protection (Figure 38-1). Meadows could also include turf grasses that are left unmowed, such as red or sheep's fescue, or in masses of decorative grasses. Few of these spaces are mowed or require mowing as a result of the use of the space. Typical plant species would include native forbs, clovers, vetches, trefoils, and a wide range of pasture and native grasses.

Although there are many visual benefits to each of these areas, meadow spaces are often home to a vast diversity of species that help pollinate flowers, control pests, and provide an important link in nature's food chain. Turf areas, although not considered sustainable because of their high demands for water and maintenance, do create the ideal exterior surface on which to play.

Each of these spaces requires techniques for establishment that are much different than the planting of the more ornamental landscape. No one would consider raising all of the plants for a lawn in

Figure 38-1 A meadow of unmowed grasses serves as an attractive and reduced-maintenance entry to a facility.

containers and then proceeding to plant them individually. The same is true for the establishment of pastures, prairies, and roadsides. Instead, these spaces require planting methods that can deliver large quantities of plants in an economical and efficient manner. Those demands have led to the development of several planting methods common to the large-scale open spaces. Seeding, sodding, using sprigs and plugs, and hydroseeding are the methods by which most turf and natural areas are established.

An addition to the range of turf areas is the idea of artificial turf. Although not a living product, artificial turf products have provided an option for those who need turf but are concerned about the issues of maintenance, watering, fertilizing, and pest management.

RELATED INFORMATION IN OTHER CHAPTERS

Information in this chapter is supplemented by instructions provided elsewhere in this text. Before undertaking activities described in this chapter, read the related information in the following chapters:

- Site Grading, Chapter 11
- Site Drainage, Chapter 12
- Erosion Control, Chapter 13
- Water and Irrigation System Installation, Chapter 15

SELECTING PLANT MATERIAL

Any successful planting project begins with selection of quality plant material, and the same is true for the installation of turf and reduced-maintenance grass areas. Whether picking seed, selecting sod, revegetating a roadside, or determining what native grasses and forbs are best for your prairie, you will note the qualitative differences in the products available.

Selecting Species and Cultivars

Numerous factors must be considered when selecting a seed species and cultivar. The first is to determine the type of planting to be undertaken. If planting a prairie or roadside, your choices of species may be restricted to those specified or appropriate to a specific region, with a limited number of cultivars available. For meadows and turf areas, the number of species and cultivars can be extensive. Key factors to consider when selecting seed should include the following:

- Climate and Conditions. Most species and cultivars, particularly the turf grasses, have particular ranges of heat and cold tolerances. Although reduced-maintenance grasses and species often grow in wide ranges, turf grasses are classified to their success in cool season and warm season areas, as well as in arid versus humid areas. Most species will have limitations on whether they will be successful in sun or shade, and many are intolerant of salt levels found in regional soils. It will also be necessary to consider the availability of irrigation and the type of soil.
- Intended Use. Although the classification of the planting suggests types of plant material that will work best, understanding whether the desire is to support heavy traffic and rigorous play such as a golf course versus occasional strolls and low-impact traffic of a park will lead to smarter species choices. Both aesthetic and functional concerns play a role in selecting a mix of species and cultivars that provide a tight, manicured look or a natural, rough-hewn presentation.
- Regional Seeds. Although turf, pastures, and roadside plant material have only moderate sensitivity to where they are grown and planted, prairies and native plantings are best purchased from a grower within the same region as where they are to be planted. Seed and herbaceous materials imported from foreign regions sometimes struggle to survive outside their adapted conditions.
- Maintenance Level. The amount of care intended for the planting will play a significant role in selecting species. Roadsides, prairies, and meadows are typically planted and left unattended, often for the lifetime of the project. Selection of plants with high-maintenance requirements and inability to adapt to conditions will lead to quick failure. Turf areas, however, are the most highly maintained areas of the landscape. Support from constant irrigation, fertilization, aeration, and other cultural activities allows selection of a higher maintenance plant.
- Blending and Mixing of Species/Cultivars. It would be uncommon for any of the categories of turf or reduced-maintenance grass areas to be composed of a single species and/or cultivar. For turf areas, blending species/cultivars that bring sun and shade tolerance, fine and coarse textures, and quick versus slow establishment is common practice. For roadside plantings, it is normal to blend a substantial number of forbs (often half) with grasses to create the desired textures and survival rates. Pastures and prairies can often be composed of 75% grass species with forbs rounding out the balance of the mixture. Within each of these categories, the blend of grass and forb types will include several species suited to the aesthetic and functional concerns of the project.

Selecting Seed

Seed is one of the most rigorously evaluated plant products available to the landscape contractor. In addition to selecting the species and cultivars, the contractor must be able to evaluate the product label. In the case of turf grasses, label information will provide a veritable history of the product. In other grass types, including pasture and native grasses, the information may not be as extensive but can still provide valuable help in verifying suitability for a project. Information typically available when evaluating the label of seed products include those items listed below:

- Germination Rate. Explains what percent of the seed actually germinated during tests.
- Pure Live Seed. The actual percentage of desired grass seed that is expected to germinate.
- Lot number.
- Name and address of labeler.
- Kind and variety of turf grass seed, listed in order of predominance. This will identify the percentages, by weight, of each species and cultivar included in the blend.
- Percentage of other crop seed.
- Percent by weight of weed seed.
- Percent of undesirable grass seed.
- Percent by weight of inert matter.
- Date on which germination test was conducted.

PREPARING THE SITE

Site preparation will be one of the critical steps in establishing any seeded or sodded area. Begin by clearing the site of any debris and perennial weeds; then complete the rough grading to mirror the desired finish grade. Respread any topsoil saved during earlier grading steps to establish the finish grade. In situations where planting is to be on existing grade, gilling should be performed. **Gilling** is a process of loosening the top few inches of soil using a toothed cultivator pulled behind a tractor. Desirable soils for any planted area would be loamy or sandy loam soils placed in a lift of 4–6 inches but with turf areas, this soil type is a requirement. Any amendments that are planned should be added during this phase. Blending a starter fertilizer with the ratio of 1-1-1 (e.g., an 8-8-8 or 16-16-16 grade fertilizer) into the topsoil will provide an additional boost to turf plants immediately after planting.

Grade the surface to a smooth finish that is free of bumps or clods, following the proposed contours as closely as possible. For seeded areas, the grade should be finished to the exact finish grade; for sodded areas, the grade should be 1 inch below the finish grade to allow for the soil carried with the sod. Before sodding, lightly roll the surface to further level the grade. If any edgers are to be installed, they should be placed after grade preparation and before planting operations begin (Figure 38-2).

INSTALLING PLANT MATERIAL

Several methods are available for installation of turf and related seeded materials. Sowing seed is the standard for most large sites, with sodding common for smaller areas or for installations that require instant turf. With certain grasses, plugs or sprigs are available for establishing turf areas. More recently, hydroseeding has become popular for establishing turf and low-maintenance grass areas. Seeding, sodding, and plugs/sprigs are common for turf grasses, whereas seeding is traditional for natural areas such as pastures, meadows, and prairies. Hydroseeding is often used in areas where seeding equipment will have difficulty accessing the site.

Seeding

Seeding is a common method for establishing a wide range of spaces and is the preferred method for pastures and prairies. Large spaces planned for

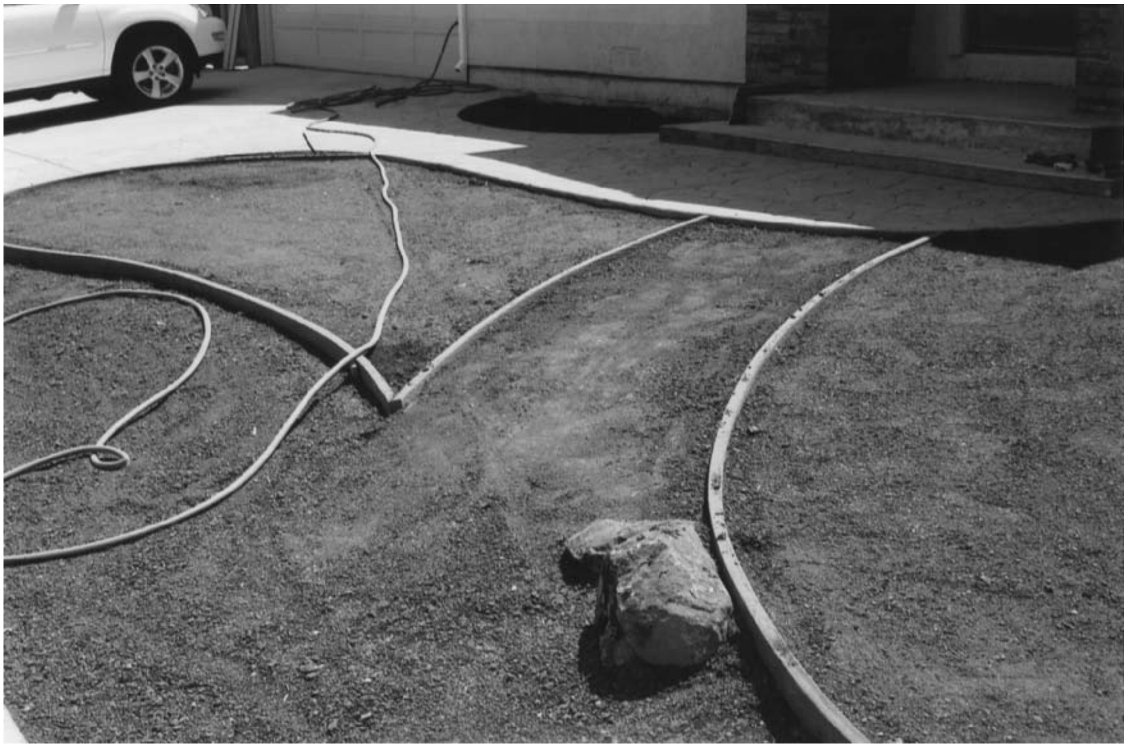

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Figure 38-2 A site prepared for sod. The grading has been completed and the edger installed. Note that the soil grade has been left below the top of the edger to accommodate the thickness of the sod.

turf are also candidates for seeding operations. Based on the climate, seeding operations may be limited to seasons where the chances for seed success are the highest. In warm climates, seed can be applied to a site at any time of the year; but in colder climates, the best success will be obtained when seeding during the fall. Regardless of the method of installation, irrigation, either permanent or temporary, should be ready to supply water to the site if natural rainfall cannot perform that function.

Seed application can be accomplished by hand sowing, using a drop spreader or using a broadcast spreader. The last two pieces of equipment may be smaller hand-operated units or can be larger tractor-towed implements. It is important to test the seeding equipment to assure proper application rate for the type of seed being sown. Small seed can readily pass through an improperly set opening, and large seed may not make it out of the hopper. For seeding projects that have seeds of significantly differing sizes, you may need to make multiple applications with the equipment appropriately set for each pass.

Divide the seed to be installed into two equal portions. Fill your seeding equipment with one portion and begin at one edge of the project. Apply seed in even passes over the entire site, with only slight overlap between passes. When you have covered the site, repeat the process in runs that are perpendicular to the original direction (Figure 38-3). Lightly rake the site and then roll with a water-filled drum roller to improve seed contact with the soil. Water the seed using a light irrigation, stopping when water begins to run off the lower side of the site. To reduce loss of seed as a result of erosion and to preserve moisture, spread light mulch over the newly seeded surface. Germination will vary, depending on the species, but should be fully underway within 10–14 days with most grass types.

The newly seeded, and then germinated, turf must be maintained until the area is established. Maintenance will include minimizing compaction on the surface and irrigating every 1–2 days. Irrigation amounts will depend on site conditions, but enough water should be applied to keep the surface slightly moist and to avoid newly germinated

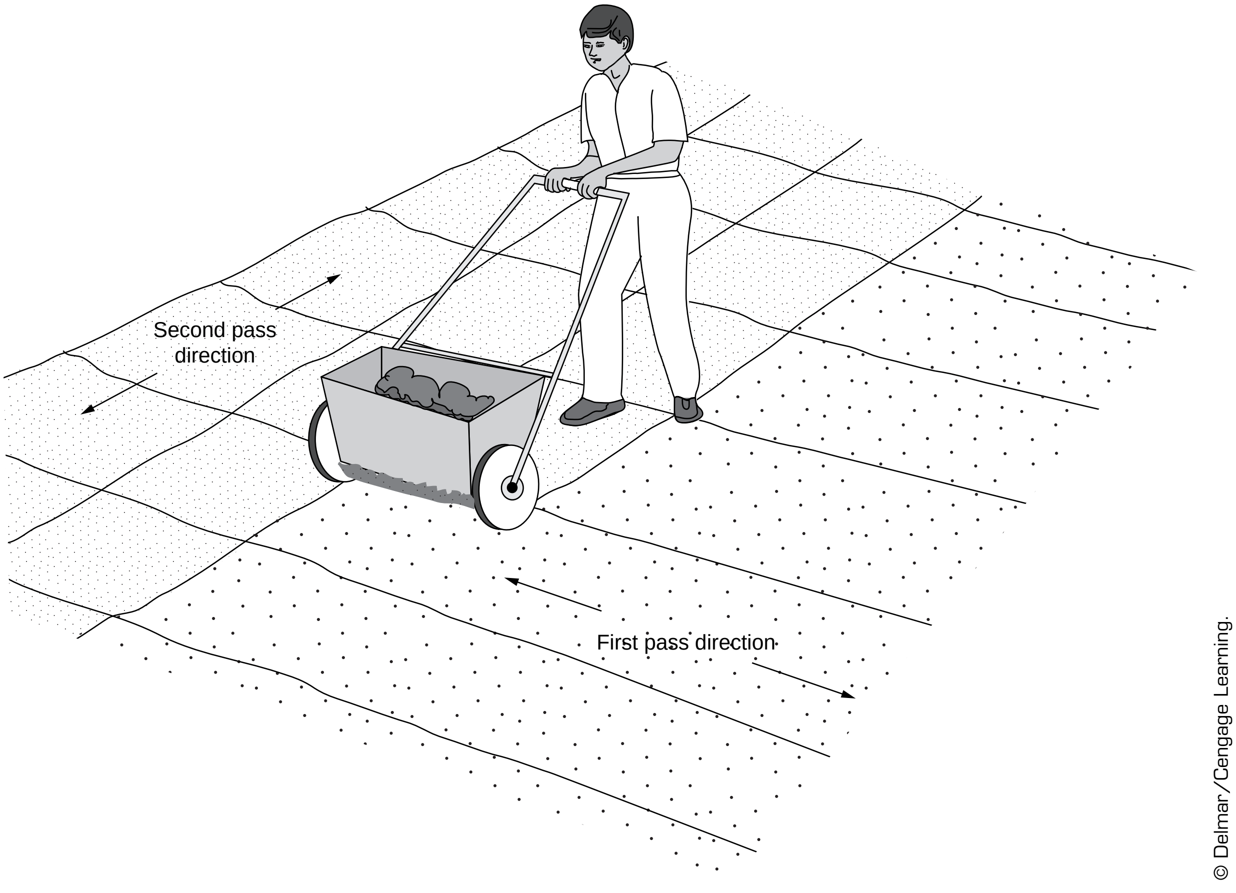

Figure 38-3 Seeding in two passes running perpendicular to each other.

seed from completely drying out. In the case of turf grass, once the grass has reached the height of 4–5 inches, the initial mowing can be performed. At this time, set the watering to a normal irrigation schedule and perform regular maintenance.

Installing Sod

Although a contractor may find occasional vendors selling "native grass" or "wildflower" sod, turf is the primary category to use sod as an establishment method. Unlike seeding, sodding can be performed at almost any time during the year, as long as the site and material are workable. The preferred time for sodding would be during fair weather when the site is dry and no freezing temperatures are expected for a month. Thoroughly water the subgrade 2–3 days before the installation, but avoid overwatering and creating a soft, spongy surface.

To sod a prepared site, select a beginning point that will allow sod to be installed in a straight row. This may be next to a walkway, edger, or a chalk line snapped through an irregular-shaped area. Beginning at the edge of a space will reduce the chances of significant trimming of sod along the entire perimeter. It is also beneficial, though not required, to begin sod placement at the bottom of a hill. Although sod on a hillside is typically staked, the stability of the installation will be increased if the sod follows the contour of the hill, as opposed to running top to bottom.

Sod typically comes in rolls about 4 feet long or in pieces that are folded in half. Unroll or unfold the first piece and place it on the base (Figure 38-4). Check the piece for edges that have torn or curled under. Unroll curled edges before placing them. Reject damaged pieces and save them for trimming areas where smaller pieces will be adequate. If necessary, adjust the position of the piece by grasping the long edges and sliding or turning it until it is straight and snug against any edge or pavement. Continue placing pieces end-to-end to install the initial row. Each subsequent piece should be butted tightly up to the previous piece.

If additional labor is available, part of a crew can be placing sod while other members can be carrying sod and staging it near where future pieces will be installed. Begin the second row of sod by cutting a half piece to stagger the joints with the previous row. To the greatest extent possible, avoid joints that align between rows. An alternative to placing sod by hand is to purchase large rolls of sod that are installed using a tractor. The rolls attach to the hydraulic lift of the tractor and are positioned at the starting point; and as the tractor moves slowly

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Figure 38-4 Placing sod. Note the joints at the ends of the pieces are staggered.

forward, the sod is unrolled and slid into position. This method requires special equipment and sod providers, but it can save time if sodding a large area such as an athletic field.

Trimming can be done by placing the sod piece in position and allowing it to overlap the edge where it is to be cut. Cut the sod using a shovel, utility knife, serrated bread knife, or other sharp kitchen knife (Figure 38-5). Roll the sod with a drum roller half filled with water to improve the contact between the sod and the soil (Figure 38-6). As long as the sod is stable, rolling can be performed on the installed sod behind the installation operation. Sod placed on hillsides will require staking to keep it in position during storms and irrigation. Stakes are metal U stakes or wood pegs that are driven through the sod into the subgrade below. Place two to three stakes along the upper side of the sod pieces. For large installations, you may need to water sections of the sod immediately after installation to prevent drying. After you have completed the installation, or at the end of a day, thoroughly water the entire installation. If the site to be sodded is soft, sodding can still be implemented by setting sheets of plywood over the base to access the installation location. Do not roll sod placed on a soft base until the subgrade is firm.

Until the sod is rooted, avoid traffic over the sod and water it daily to prevent the pieces from drying out. Once the sod is established, which can take from 5 days to 2 weeks, depending on conditions, you can begin mowing and regular maintenance operations. To check for rooting, grasp the blades of grass from a piece of the sod and gently lift. If it has rooted, the sod will resist lifting.

Installing Plugs or Sprigs

Plugs and sprigs are an establishment method used most commonly in turf grass applications, particularly with warm season species. **Sprigs** are short sections of turf grass stems with at least one or two nodes capable of rooting. **Plugs** are small circles or squares of sod, with roots, stems, leaves, and a small "plug" of soil. Both methods are effective at establishing a lawn for grass species that are vigorous rooters from plant crowns and rhizomes.

To establish a turf area using sprigs, begin by lightly watering the prepared subgrade. Broadcast or place the sprigs evenly and lightly over the site, distributing a sprig every 4–6 inches. Rake the surface lightly and then roll with a drum roller half filled with water. Verify that all sprigs are making good contact with the soil. To establish a lawn using

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Figure 38-5 Trimming sod.

Figure 38-6 Rolling newly placed sod with a drum roller.

plugs, excavate a checkerboard pattern of small holes every 6–12 inches across the prepared subgrade. The holes should be the same diameter as the plugs. Place a plug in each hole and then roll with a drum roller half filled with water. Verify that all plugs are flush with the surrounding soil.

Until the turf area is completely established, minimize traffic across the turf and water it regularly. Establishment should occur in 2–3 weeks as the plants spread to fill the voids between starts.

Hydroseeding (with Hydromulch)

Hydroseeding will require specialized equipment and materials to establish roadsides, prairies, meadows, and turf in hard-to-work areas. This method is particularly effective for steep slopes and areas where equipment cannot operate and can also be an effective way to seed and mulch large areas. Additional information regarding hydromulching, which often works in concert with hydroseeding to create a vegetative cover, can be found in Chapter 13 ("Protecting the Site from Surface Erosion").

To hydroseed, prepare the subgrade in a similar manner to all previous establishment methods, if possible. If you cannot access a site and if the expectation for quality growth is not high, you can perform hydroseeding over rough-graded sites and even unprepared subgrades.

A wide range of equipment options are available for implementing a hydroseeding project. Small units are mounted in the beds of trucks, whereas larger units are built on tractor-drawn trailers. All contain a hopper in which the components of hydroseeding are mixed, a powerful pump for spraying the mixture, and a discharge gun or hose used to distribute the mix. The components, with percentages determined by manufacturer's specifications, include water, seed of almost any type, water-soluble fertilizer, a tackifier, and, in most cases, a dyed mulch. The mulch can be wood fibers, paper, or a bonded matrix product with dye added to assist the applicator in determining where the product has been sprayed. The tackifier is typically a polyacrylamide that thickens and lubricates the mixture, holding the hydroseeded components in place for several days until the crop has germinated and is self-anchoring.

In the hopper of the hydroseeder, add the water, seed, fertilizer, and mulch (if desired). Add the tackifier last. If the equipment has mixing capabilities, let the mixture blend for a short while. Start the pump

and, using the nozzle or hose, spray the mixture on the site beginning at the highest point and working evenly to the bottom of the site. Spray slowly enough to obtain an even cover over the subgrade. If using a discharge gun applicator, you may need to move the unit to gain access to the entire site. If applying by hose, plan your route so the application can be continuous and even. Overspray on paved areas can create slippery surfaces; so, when seeding operations are finished, remove overspray by washing with pressurized water or by spreading rock salt over the area to absorb the moisture. Seed installed in this method typically establishes in 5–7 days, but pregerminating by soaking the seed in water for 1–2 days prior to application can speed the process. Avoid traffic and maintain irrigation for the site until the crop has been established. Once the crop is established, start routine maintenance.

INSTALLING ARTIFICIAL TURF

Artificial turf has evolved from the green carpet mat at the front door to thick carpets that more realistically resemble natural grass. Advanced as a more aesthetically pleasing choice that is safer for athletic events, artificial turf has also received some attention as a somewhat sustainable alternative to natural grass. Although that claim can be challenged as a result of the production of artificial turf consuming petroleum products and many other nonsustainable issues, the reduced need for water and pesticides to maintain an "artificial lawn" has helped this alternative grow in popularity. Installation methods for artificial turf will vary, depending on manufacturers, but most require similar steps in base preparation and turf placement.

Preparing the Base

Unlike for living turf areas, the concept of base preparation for artificial turf is significantly different. Although living turf requires a subgrade that allows percolation and root development, the subgrade for artificial turf is designed for quick runoff. To prepare the base for artificial turf, mark out the boundaries of the turf area and any required drainage below the subgrade. Excavate the area to the correct depth, which will be determined by adding the aggregate layer plus the thickness of the turf, any desired cushioning layer plus an allowance on 1–1½ inch for infill materials. The infill materials are typically sand and granulated rubber and will necessarily add this thickness to the installation in order to support the "blades" of grass. Install any subsurface drainage planned for the installation, backfill, and compact the trenches. Because the surface functions as a semipermanent installation and is not easily removed, place any utility lines or conduit for future improvements through the area before installing the turf.

As a result of the improved drainage of artificial turf, subdrains (inlets connected to a tile or storm sewer system) or french drains on the lower edges may be necessary to accommodate the increased runoff. Trench and install the drainage system; then backfill and compact the soil over the drainage trenches. Work the subgrade over the site until it is smooth and gradually sloped (approximately 1–2%) for drainage. Compact the subgrade using a vibratory plate compactor (Figure 38-7). Install any edging that is required for a project boundary, and then cover the entire area with a nonwoven construction grade fabric cut to fit within the perimeter of the turf area.

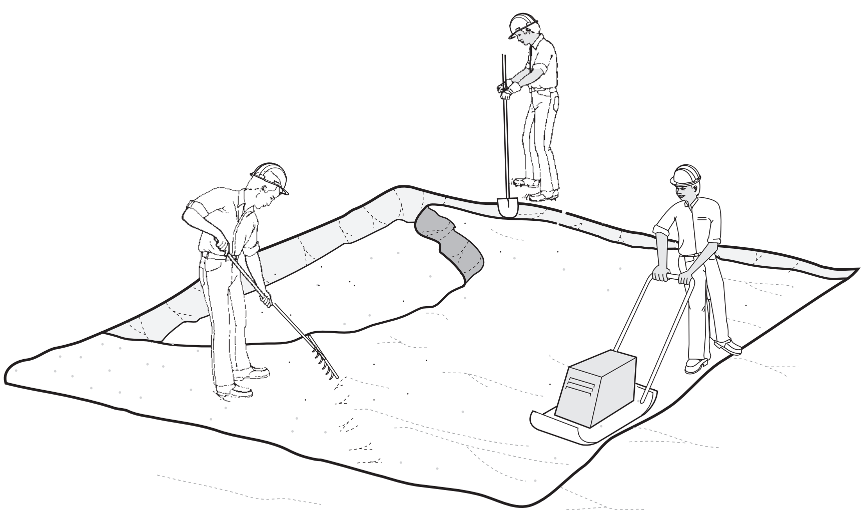

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Figure 38-7 Spreading, leveling, and compacting base for artificial turf.

Install a layer of aggregate base over the subgrade. The depth of the layer and the size of the aggregate will depend on local site conditions and turf manufacturer's requirements. Verify with the turf manufacturer the recommended size for aggregate. Typical sizes range from ¾- to inch with fines. Level the aggregate, mist lightly with water, and compact with a vibratory plate compactor. If the installation has gradual slopes or berms (e.g., putting greens), the compaction should be done with a drum roller half filled with water. Verify that the aggregate base is smooth and properly draining, and repair any high or low spots before adding any turf products. If a cushioning layer is required, lay out the material over the entire site and trim to fit the boundaries. Join any pieces by cutting the edges to match, folding the edges back 1 foot on either side of the seam, and rolling Mylar tape out on top of the base directly under the seam. Fold the cushioning layer back together on top of the tape and apply pressure along all edges to assure a tight seal.

Installing Artificial Turf

To install the turf, roll out the turf over the entire site. If using more than one piece, verify that the turf grain (direction) is the same for all pieces. Overlap the boundaries of the project and each seam by approximately 3 inches, unless a straight seaming edge is provided. Smooth the turf over the site so that there are no ridges, bumps, or creases. The turf should be in direct contact with the cushioning layer or base.

To avoid unraveling and poor edge contact, use a utility knife with a sharp blade to trim and cut turf. Trim and join the seams before trimming the edges. To seam the turf, cut the overlapping seam edges to match. Without changing the position of the turf, gently fold the edges back approximately 1 foot. Lay a strip of wide Mylar tape, sticky side up, on the cushion or base layer. Gently fold the turf back to the base, making sure that the edges continue to match (Figure 38-8). Apply heavy pressure to the edges of the turf to complete the seal with the Mylar tape. Other methods for seaming artificial turf include sewing the seam with heavy nylon cord or stapling the matched edges.

When you have joined all seams, position the turf over the site and verify direct contact with the cushioning layer in all areas and a slight overlap with the edges. Begin trimming the edges of the turf area. Using a sharp utility knife, cut the edge flush with any pavement or edger adjacent to the turf area. If no edge is present, cut flush with the base edge. After the turf is trimmed, gaps between edges and the turf should be no more than ¼ inch. Edges are anchored using 60d (6-inch) galvanized landscape nails driven through the turf and into the base every 6 inches around the perimeter of the turf area. When it is secure, lightly "fluff" the turf using a hand broom to raise the blades before infilling. Infill is typically done using a mixture of natural silica sand and crumbled rubber pellets, filled to approximately 60% of the height of the grass blade. Apply the sand and pellets in separate operations by filling a drop spreader and evenly distributing the infill material over the surface. After each material is applied, work it into the turf using a power broom (Figure 38-9). Hand broom the surface using a coarse bristled shop broom to raise the blades and further distribute the sand and rubber pellets. Complete the operation by trimming any loose threads, refastening any edges or seams that were loosened by installation operations, and verifying that the infill material is evenly distributed (Figure 38-10).

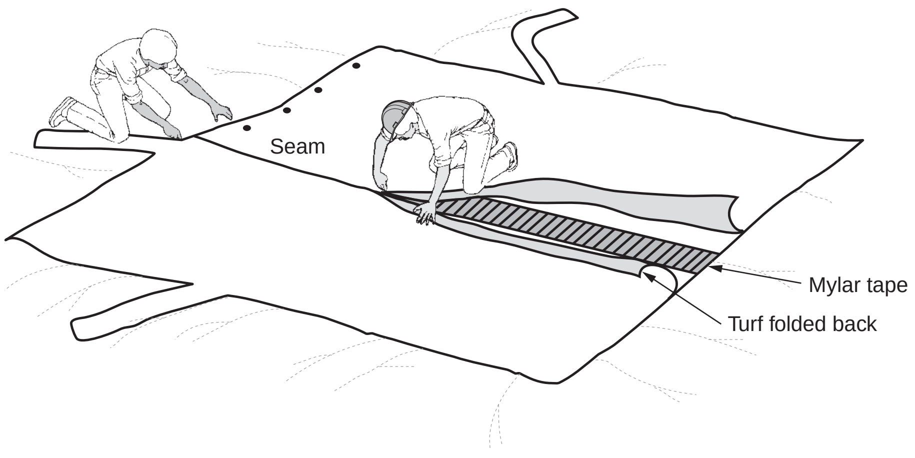

Figure 38-8 Seaming and trimming artificial turf.

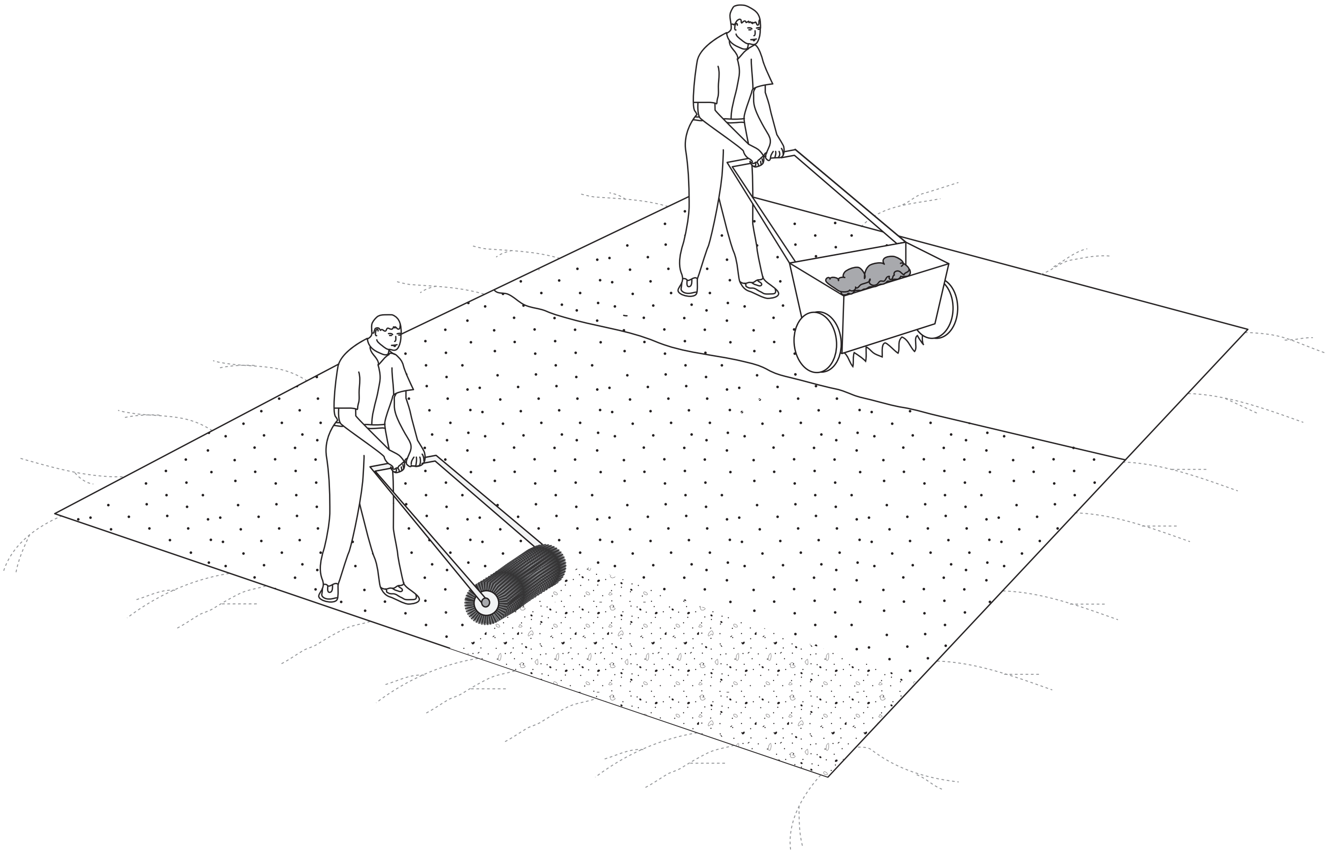

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Figure 38-9 Placing and power brooming infill material for artificial turf.

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Figure 38-10 Close-up of artificial turf with rubber and sand infill mix.

SECTION 10

SUMMARY

No landscaping project can be considered complete until the green element has been added. Installation of plant material is the most environmentally friendly portion of a trade dedicated to improving living environments. Trees, shrubs, flowers, perennials, and ground covers provide the finishing touches that bring a project to life.

In this section, the installation of plant material was covered, as well as the establishment of turf and meadow-like spaces. In both chapters, the importance of selecting quality plant material and good site preparation were emphasized. Planting techniques reviewed included bare-root, containerized, balled and burlapped, and boxed plants. The moving of trees by machine, more specifically a tree spade, was also introduced. Once plants are installed, the post-planting care methods of deep watering, mulching, staking, and wrapping were presented. For the establishment of turf and meadow areas, the selection of plant material and preparation of the site were discussed. Turf areas are generally described as spaces with primarily turf grass species that are mowed and maintained for aesthetic and athletic purposes. The term "meadow" was used to generally describe areas such as pastures, prairies, and roadsides where a mixture of grasses and forbs are present and mowing is seldom encouraged. Establishment of turf areas via seed, sod, sprigs/plugs, and hydroseeding was covered, with seeding and hydroseeding applicable to both turf and meadows.

Sustainability concepts were introduced in the form of green roofs and living walls. Green roofs are rooftops that are planted with specialty plant material in an attempt to absorb water, reduce heat islands, and improve the environment. Living walls are vertical installations of plants that improve air quality and also add ambiance to the environment. Although not necessarily considered sustainable, artificial turf as an alternative to natural turf was presented.

APPENDIX A

EXAMPLE MATERIAL AND WORKMANSHIP SPECIFICATION FOR SEEDING PROJECT

Section 02900 Seeding

Part 1—General Information

1.1 Description of work.
- A. Work included: Provide all labor, materials, equipment, and incidentals necessary to complete topsoil preparation, fertilization, seeding, and mulching where shown on the drawings, as specified herein, and as needed for a complete and proper installation.
- B. Related documents:
  1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

1.2 Quality assurance.
- A. Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.
- B. Seed, fertilizer, and soil conditioners shall be commercial grade.

1.3 Product handling.
- A. Comply with pertinent provisions of Section 1640, Product Storage and Handling.

Part 2—Products

2.1 Grass seed.
- A. Provide mixture consisting of the following proportions by weight:
  1. Kentucky Bluegrass—50% by weight.
  2. Redtop—10% by weight.
  3. Creeping Red Fescue—30% by weight.
  4. Annual Ryegrass—10% by weight.
- B. Lime: Finely ground agricultural limestone containing not less than 85% calcium and magnesium carbonates.
- C. Fertilizer: Free-flowing granular type of uniform composition containing by weight the following:
  1. 5% Nitrogen, with 50% of this total organic.
  2. 10% Available Phosphoric Acid.
  3. 5% Potash.
- D. Mulch: Oat straw.
- E. Water: Available at site.

Part 3—Execution

3.1 Preparation of topsoil.
- A. Deposit additional topsoil as may be required to correct all settlement and erosion.
- B. Apply fertilizer at an approximate rate of 10 pounds per 1,000 square feet over area.
- C. Thoroughly and evenly incorporate fertilizer with the soil to a depth of 3 inches by discing or other approved method. In areas inaccessible to power equipment, use hand tools.
- D. Prepare seed bed in accordance with acceptable horticultural practices. Leave area smooth with a loose, friable seed bed.
- E. Remove roots, sticks, clods, rocks, stones, etc. of golf ball size or larger.

3.2 Seeding.
   A. Apply seed uniformly and evenly over entire area.
   B. Seed may be drilled or broadcast. If broadcast, lightly cover seed.
   C. Apply grass seed at a rate of 3 pounds per 1,000 square feet.
   D. Roll lightly to firm seed bed and cover with mulch.

3.3 Maintenance.
   A. Soak seed bed at initial watering. Maintain damp seed bed through germination period, watering as necessary.
   B. Contractor shall be responsible for the repair and reseeding of all eroded areas and areas that fail to show a uniform stand of grass and ground cover.
   C. Reseed those areas that do not produce proper stand within first year after seeding.

End of Section 02900

EXAMPLE PERFORMANCE SPECIFICATION FOR SEEDING PROJECT

Section 02900 Seeding

Description of work.

Contractor shall provide all labor, materials, equipment, and incidentals necessary to provide a complete and proper seeding installation. Installation shall include topsoil preparation and modification, fertilization, seeding, and mulching where shown on the drawings and in all other areas on the site disturbed by construction activities.

Work in related documents.

Other contract documents that relate to this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, Sections in Division 1 of these Specifications, and Planting and Seeding Plans.

Quality assurance.

Contractor shall provide a vigorous, viable, weed-free turf cover composed of no less than 100 grass plants per square foot at the time of acceptance of the project by owner. Cover crop species will not be considered as part of this assurance.

Products.

Turf shall be composed approximately equal parts of three species of Kentucky Bluegrass and one species of fine textured fescue. Cover crop species may be added as required. All turf species used shall be locally adapted cultivars.

Installation requirements.

Installation shall be coordinated with other site and building construction activities. Installation will be in accordance with recognized horticultural standards. Any soil modifications and finish grade corrections required will be the responsibility of the contractor. Any work disturbed by construction, erosion, or other means prior to final acceptance of project by owner will be repaired at contractor's expense.

Warranty.

Contractor shall warranty the turf completely for 30 days following acceptance by owner. Contractor shall warranty trueness of species for a period of 1 year following acceptance by owner.

End of Section 02900

EXAMPLE LANDSCAPE SPECIFICATIONS

Specification content and layout will vary from one design professional to another. Following are sample specifications written for a variety of landscape related activities that can be used to compare and review the styles used by landscape architects, architects, and engineers.

SECTION 02277

LIMESTONE WALL

McCORKLE RESIDENCE PROJECT
BUENA VISTA UNIVERSITY
STORM LAKE, IOWA

PART 1 GENERAL

1.01 WORK INCLUDED

A. Limestone dry laid edges/walls.

1.02 ENVIRONMENTAL REQUIREMENTS

A. Maintain materials and ambient air to 40 degrees F (5 degrees C) minimum prior to, during, and 48 hours after completion of work.
B. At the end of working day, or during rainy weather, cover exposed stone work with non-staining waterproof coverings, securely anchored.

PART 2 PRODUCTS

2.01 ACCEPTABLE STONE SUPPLIER

A. Quarried and supplied by Weber Stone Co., Inc. Anamosa, IA

2.02 STONE

A. Stone: native Iowa limestone
B. Size: as indicated on the drawings

2.03 STONE FABRICATION

A. Form external corners to irregular joint profile. Clean jagged corners from stone in preparation for setting.
B. Slope exposed top surfaces of stone for natural wash.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify that support work and site conditions are ready to receive work of this Section.
B. Verify that items built-in under other Sections are properly located and sized.
C. Beginning of installation means acceptance of existing conditions and support work.

3.02 PREPARATION

A. Establish lines, levels, and coursing. Protect from disturbance.
B. Clean stone prior to erection. Do not use wire brushes or implements which can mark or damage exposed surfaces.

3.03 INSTALLATION

Source: Delmar/Cengage Learning

Figure A-1 Sample technical specification for stone wall. (Courtesy of Dunbar Jones Partnership, Des Moines, IA)

A. All stone work shall be installed with the following guidelines:
   1. Erect stone in accordance with stone supplier's instructions.
   2. When required, split stone at site to produce clean faces and to fit opening dimensions.
   3. Arrange stone pattern to provide variable joint sizes throughout. Joints between stones on the same course shall be no greater than 3/4" in all walls. Space between courses shall be a maximum of 1/2". Stone courses shall be as dimensioned ±1/2".

B. Dry Laid Walls
   1. Clinkers, or shims, shall be of the same stone as the wall. Use as few shims as necessary to make the wall structural.
   2. Place backfill rock and fabric as the wall is laid up.

3.04 CLEANING

A. Clean soiled surfaces with cleaning solution.

B. Use non-metallic tools in cleaning operations.

END OF SECTION

Figure A-1 *(continued)*

SECTION 02518

INTERLOCKING CONCRETE PAVERS

McCORKLE RESIDENCE PROJECT
BUENA VISTA UNIVERSITY
STORM LAKE, IOWA

PART 1 GENERAL

1.01 WORK INCLUDED

A. Concrete paver units.
B. Sand bed and sand joint filler.

1.02 RELATED WORK

A. Section 03001 – Concrete.

1.03 REFERENCE STANDARDS

A. ASTM C936: Specification for Solid Interlocking Concrete Paving Units.
B. ASTM C140: Method of Sampling and Testing Concrete Masonry Units.
C. ASTM C136: Method for Sieve Analysis for Fine and Coarse Aggregates.
D. ASTM C33: Specification for Concrete Aggregates.

1.04 SUBMITTALS.

A. If manufacturer is different from one indicated below, submit samples of concrete paving units to indicate color and shape selections. Color will be selected by Landscape Architect from manufacturer's available colors.
B. Submit sieve analysis for grading of bedding and joint sand.
C. Submit test results from an independent testing laboratory demonstrating compliance of paving units to requirements of Section 2.02 A below.
D. Submit manufacture's installation instructions if different from Article 3.02.

1.05 MOCK UPS

A. Install a 7 ft. x 7 ft. paver area as described in Article 3.02. This area will be used to determine surcharge of the sand layer, joint sizes, laying pattern(s), color(s), and texture of the job. This area shall be the standard from which the work will be judged.

B. For smaller projects, a mock-up may not be necessary. In order to determine the amount of settlement of the pavers after compaction, a paver shall be placed on approximately 1 inch of bedding sand, and tapped solidly several times with a rubber mallet. The difference in height of the paver from the base from before compaction to after compaction shall be used to determine the height of the stringlines for proper grade.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver concrete pavers to the site in steel band, plastic banded, or plastic wrapped cubes capable of transfer by forklift or clamp lift. Unload pavers at job site in such manner that no damage occurs to the product.

02518-1

Source: Delmar/Cengage Learning

Figure A-2 Sample technical specification for concrete pavers. (Courtesy of Dunbar Jones Partnership, Des Moines, IA)

B. Cover sand with waterproof covering to prevent exposure to rainfall or removal by wind. Secure the covering place.
C. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturer: UNILOCK-Chicago
301 East Sullivan Rd.,
Aurora, IL 60504
Phone: (630) 892-9191
Fax: (630) 892-9215
e-mail: chicago@unilock.com

B. Pavers
1. Paver style: Hollandstone
2. Color: Buff and Charcoal
2. Paving Pattern: Herringbone

C. Other Manufacturers are acceptable if they are members of the CONCRETE PAVER INSTITUTE. If another manufacturer is selected, 25 pavers of each color of each size shall be submitted for approval by the Landscape Architect.

2.02 MATERIAL

A. Pavers: 4"x8"x2 3/8" inch nominal size; selected from manufacturer's standard range. Pavers shall meet the minimum material and physical property set forth in ASTM C936, Standard Specification for Interlocking Concrete Paving Units. Efflorescence shall not be a cause of rejection.
B. Sand for Leveling Base: Clean, non-plastic, and free from deleterious or foreign matter. The sand shall be natural or manufactured from crushed rock. Limestone screenings or stone dust that do not conform to ASTM C33, as specified in the following table, shall not be used.

Bedding Sand Grading Requirements

Sieve Size	Mass Percent Passing
9.5 mm	100%
4.75 mm	95–100%
2.36 mm	85–100%
1.18 mm	50–85%
600 µm	25–60%
300 µm	10–30%
150 µm	2–10%

C. Sand for Joint Fill: Base: Clean, non-plastic, and free from deleterious or foreign matter, conform to ASTM C144, as specified in the following table.

Joint Sand Grading Requirements

Sieve Size	Natural Sand Percent Passing	Manufactured Sand Percent Passing
4.75 mm	100%	100%
2.36 mm	95–100%	95–100%
1.18 mm	70–100%	70–100%
600 µm	40–75%	40–75%
300 µm	10–35%	20–40%
150 µm	2–15%	10–25%
75 µm	0%	0–10%

02518-2

Source: Delmar/Cengage Learning

Figure A-2 *(continued)*

D. Edge restrains shall be along all unrestrained paver edges and supported on a minimum of 6" of aggregate base.

Acceptable manufacturer: Pave Tech, Inc.
P.O. Box 31126
Bloomington, MN 55431
Phone (612) 881-5773
Fax (612) 881-2169

PART 3 EXECUTION

3.01 INSPECTION

A. Verify that base is dry, uniform, even and ready to support sand, pavers and imposed loads.
B. Verify gradients and elevations of base are correct.
C. Beginning of installation means acceptance of substrate.

3.02 INSTALLATION

A. The paving brick installer/contractor must have related experience in installation of concrete paving bricks.
B. Ensure that pavers are free of foreign material before installation.
C. Spread sand evenly over concrete base surface to maximum thickness of 1-1/2 inches.
D. Screed sand to level and even surface, properly accounting for compaction of sand.
E. Place paver units in patterns as shown on drawing, from reference edge.
F. Place half units or special shaped units at edges and interruptions. Maintain evenly spaced joints not to exceed 1/8".
G. Tamp and level paver units with mechanical vibrator until units are firmly bedded, level, and to correct elevation and gradient.
H. Sprinkle sand over surface and sweep into joints. Re-cover joints with additional sand until firm joints are achieved. Remove excess sand.
I. Pavers after tamping must be 1/8" to 1/4" above adjacent edge restraints.

3.03 SAMPLING AND TESTING.

A. Two pavers from each pallet shall be sampled and tested in accordance with ASPM C140.
B. Rejection: In case the shipment fails to conform to the specified requirements, the manufacturer may sort it, and new test units shall be selected at random by the purchaser from the retained lot and tested at the expense of the manufacturer. In case the second set of test units fail to conform to the specified requirements, the entire lot shall be rejected.
C. The expense of inspection testing shall be borne by the purchaser, unless otherwise agreed.

END OF SECTION

02518-3

Source: Delmar/Cengage Learning

Figure A-2 *(continued)*

SECTION 02495
LANDSCAPE ACCESSORIES

RIVER TERRACE
IOWA MEMORIAL UNION
UNIVERSITY OF IOWA

IOWA CITY, IOWA

PART 1 GENERAL

1.01 CONDITIONS OF THE CONTRACT

A. The other Contract Documents compliment the requirements of this Section. The General Requirements apply to the work of this Section.

1.02 SCOPE

A. Furnish and install work, including but not limited to:
   1. Metal Edging
   2. Shredded Hardwood Mulch

1.03 SUBMITTALS

A. Submit manufacturer's product data for each type of factory fabricated accessory required, including finish indicated.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle landscape accessories to prevent damage and deterioration.

PART 2 PRODUCTS

2.01 MATERIALS

A. Metal Edging:
   1. Metal edging shall be 3/16" x 4' stainless steel edging. Submit manufacturer or fabricator for approval.

B. Shredded Hardwood Mulch:
   1. Provide shredded hardwood mulch in all planters, plant saucers, and planting beds to a 4" minimum depth or as shown on details.

C.. Trash Receptacles:
   1. Manufacturer: Forms+Surfaces
      Box 5215
      Santa Barbara, CA 93150
      (805)969-7721 FAX(805)565-1578
   2. Versit Series stainless steel
      Model #AE 7581

PART 3 EXECUTION

3.01 PREPARATION

02495-1

Source: Delmar/Cengage Learning

Figure A-3 Sample technical specification for landscape accessories. (Site amenities, courtesy of Dunbar Jones Partnership, Des Moines, IA)

A. Remove loose material and debris from base surface before placing landscape accessories.
B. Locate and layout all landscape accessory items. Obtain Landscape Architect/University Representative's acceptance of layout prior to installation.

3.02 INSTALLATION
A. Metal Edging:
1. Install metal edging as shown on the drawings.
2. Install per manufacturer's recommendations.
B. Shredded Hardwood Mulch:
1. Install shredded hardwood mulch in all planters, plant saucers, and planting beds, as shown on the drawings, to a 4" minimum depth or as shown on details.
C. Trash Receptacles:
1. Bolt to concrete.

3.03 CLEANING

A. Perform cleaning during installation of the work and upon completion of the work. Remove from site all excess materials, debris, and equipment. Repair damage resulting from landscape accessories work.

END OF SECTION

Source: Delmar/Cengage Learning

Figure A-3 *(continued)*

SECTION 02514

PORTLAND CEMENT CONCRETE PAVING

IOWA CITY WATER DIVISION
WATER TREATMENT PLANT – PHASE 3

IOWA CITY, IOWA

PART 1 GENERAL

1.01 WORK INCLUDED
- A. Concrete sidewalks, curbs and gutters.
- B. Surface finish.
- C. Curing.

1.02 RELATED WORK
- A. Section 01050 - Field Engineering.
- B. Section 02200 - Earthwork.
- C. Section 02618 - Pavement Marking.

1.04 REFERENCES
- A. ASTM C33 - Concrete Aggregates.
- B. ASTM C94 - Ready Mixed Concrete.
- C. ASTM C150 - Portland Cement.
- D. ASTM C260 - Air-Entraining Admixtures for Concrete.

1.05 QUALITY ASSURANCE
- A. Perform work in accordance with ACI 301.
- B. Obtain materials from same source throughout.

1.06 REGULATORY REQUIREMENTS
- A. Conform to applicable codes for paving work on public property.

1.07 TESTS
- A. Testing and analysis will be performed under provisions of Section 01400.
- B. Tests of cement and aggregates will be performed to ensure conformance with requirements stated herein.
- C. Three concrete test cylinders will be taken for every 50 or less cu yds of each class of concrete placed each day.
- F. One additional test cylinder will be taken during cold weather and be cured on site under same conditions as concrete it represents.
- G. One slump test will be taken for each set of test cylinders taken.

1.08 SUBMITTALS
- A. Include data on joint filler, admixtures. and curing compounds.
- B. Submit manufacturer's instructions under provisions of Section 01300.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS
- A. Minimum of 4000 psi compressive strength at twenty-eight days..
- B. As specified in Section 03001.
- C. Water: Clean and not detrimental to concrete.

02514-1

Source: Delmar/Cengage Learning

Figure A-4 Sample technical specification for concrete paving. (Courtesy of Dunbar Jones Partnership, Des Moines, IA)

2.02 FORM MATERIALS

Conform to ACI 301.

2.03 REINFORCEMENT

A. As specified in Section 03001.

2.06 CONCRETE MIX

A. Mix concrete in accordance with ASTM C94.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify compacted subgrade is ready to support paving and imposed loads.
B. Verify gradients and elevations of base are correct.
C. Beginning of installation means acceptance of existing conditions.

3.02 PREPARATION

A. Moisten base to minimize absorption of water from fresh concrete.
B. Notify Landscape Architect minimum 24 hours prior to commencement of concreting operations.

3.03 FORMING

A. Place and secure forms to correct location, dimension, and profile.
B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.
C. Place joint fillers vertical in position, in straight lines. Secure to formwork during concrete placement.

3.04 REINFORCEMENT

A. Place reinforcement at mid-height of slabs-on-grade.
B. Interrupt reinforcement at expansion joints.
C. Provide doweled joints at interruptions of concrete with one end of dowel set in capped sleeve to allow longitudinal movement.

3.05 FORMED JOINTS

A. Place control joints at a maximum of 12 foot intervals to correct elevation and profile. See plans for locations. Align curb, gutter, and sidewalk joints.
B. Place joint filler between paving components and building or other appurtenances.

3.06 PLACING CONCRETE

A. Place concrete in accordance with ACI 301.
B. Hot Weather Placement: ACI 301.
C. Cold Weather Placement: ACI 301.
D. Ensure reinforcement, inserts, embedded parts and formed joints are not disturbed during concrete placement.
E. Place concrete continuously between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

3.07 FINISHING

A. Finish as indicated on the plans.
B. Place curing compound on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.

3.08 FIELD QUALITY CONTROL

02514-2

Source: Delmar/Cengage Learning

Figure A-4 *(continued)*

A. Field inspection and testing will be performed under provisions of Section 01400.

B. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.09 PROTECTION

A. Immediately after placement, protect concrete under provisions of Section 01500 from premature drying, excessive hot or cold temperatures, and mechanical injury.

END OF SECTION

02514-3

Figure A-4 *(continued)*

APPENDIX B

CONSTRUCTION SPECIFICATION INSTITUTE MASTERFORMAT™ NUMBERING SYSTEM FOR SPECIFICATIONS

Following is one of the typical formats used when numbering specifications for construction documents. This system is a standard for classifying work in the construction industry. Occasionally design professionals will modify the number of zeros used, but the lead number seldom changes. Most work related to landscape contracting is located in Division 32, but contractors are urged to review the entire set of construction documents for items related to their work. As of this writing, this format is being reviewed for possible changes and revisions.

Division 1—General Requirements
Division 2—Site Construction
Division 3—Concrete
Division 4—Masonry
Division 5—Metals
Division 6—Wood
Division 7—Thermal and Moisture Protection
Division 8—Doors and Windows
Division 9—Finishes
Division 10—Specialties
Division 11—Equipment
Division 12—Furnishing
Division 13—Special Construction
Division 14—Conveying Systems
Division 21—Fire suppression
Division 22—Plumbing
Division 23—HVAC
Division 26—Electrical
Division 27—Communications
Division 28—Security
Division 31—Earthwork
Division 32—Exterior improvements
Division 33—Site Utilities
Division 34—Transportation
Division 35—Waterway and marine

APPENDIX C

MEASUREMENT CONVERSIONS

As contractor purchase, calculate, and build with the variety of materials used in landscape construction, they will encounter many situations that require conversion from one standard to another. Commonly used conversions are listed here.

Linear:

12 inches	= 1 foot
36 inches	= 1 yard
3 feet	= 1 yard
5,280 feet	= 1 mile
1,760 yards	= 1 mile

Weights:

16 ounces	= 1 pound
2,000 pounds	= 1 ton

Liquid Measure:

16 fluid ounces	= 1 pint
128 fluid ounces	= 1 gallon
2 pints	= 1 quart
8 pints	= 1 gallon
4 quarts	= 1 gallon

Area:

144 square inches	= 1 square foot
9 square feet	= 1 square yard
43,560 square feet	= 1 acre
100 square feet	= 1 square (sod and shingles)
640 acres	= 1 square mile

Volume:

1,728 cubic inches	= 1 cubic foot
27 cubic feet	= 1 cubic yard

Inch/Decimal Equivalents:

1 inch	= .08 feet
2 inches	= .17 feet
3 inches	= .25 feet
4 inches	= .33 feet
5 inches	= .41 feet
6 inches	= .50 feet
7 inches	= .58 feet
8 inches	= .66 feet
9 inches	= .75 feet
10 inches	= .83 feet
11 inches	= .92 feet

Comparative Volume/Weight:

1 cubic foot water	= 64 pounds
1 cubic foot water	= 7.48 gallons
1 gallon water	= .134 cubic feet
1 cubic foot soil	= approx. 90 pounds
1 cubic foot dry sand	= approx. 100 pounds
1 cubic foot aggregate	= approx. 140 pounds
1 cubic yard soil	= approx. 2,400 pounds
1 cubic yard dry sand	= approx. 2,700 pounds
1 cubic yard aggregate	= approx. 3,780 pounds

Metric Conversions:

1 inch	= 25.4 millimeters (mm)
1 inch	= 0.025 meters (m)
1 foot	= 0.30 meter
1 yard	= 0.914 meter
1 millimeter (mm)	= 0.0393 inch
1 meter (m)	= 3.28 feet
1 meter (m)	= 39.37 inches
1 meter (m)	= 1.093 yards
1 square inch	= 654.16 millimeters squared (mm^2)
1 square foot	= 0.092 meter squared (m^2)
1 square meter (m)	= 10.76 square feet
1 hectare	= 2.471 acres
1 cubic inch	= 16,387 cubic millimeters (cm^3)
1 cubic foot	= 0.0283 cubic meter (m^3)
1 cubic millimeter (mm^3)	= 0.00006102 cubic inch
1 cubic meter (m^3)	= 35.314 cubic feet
1 cubic meter (m^3)	= 1.3079 cubic yards
1 fluid ounce	= 28.41 milliliter (mL)
1 gallon	= 4.54 liters (L)
1 milliliter (mL)	= 0.03519 fluid ounce
1 liter (L)	= 0.2199 gallon
1 gram (g)	= 0.0352 ounce
1 kilogram (kg)	= 2.204 pounds
1 tonne (t) (1000 kg)	= 2204.6 pounds
1 kilogram per cubic meter (1kg/m3)	= 0.0622 pounds per cubic foot
1 pound per cubic foot	= 16.108 kilograms per square meter (kg/m^3)

APPENDIX D

SUPPLEMENTAL MATH FORMULAS

Included in this appendix are construction-related math calculations that serve specific but uncommon purposes. Formulas are provided for calculating the heights of objects, quantities of rip rap, the length of french drains, edge restraint, contraction joint spacing in concrete, and wood material calculations.

Determining the Heights of Objects

When it is necessary to determine the height of objects such as trees and buildings, two quick processes can be used. A third process involving trigonometric functions is also available, but this process requires special measurement equipment.

Estimating Object Heights. One method to determine heights that has a relatively high margin of error (approximately 10%) is to estimate heights. To estimate heights, select a ruler or similar object that is approximately 1-foot long. Hold the object at arm's length and align the bottom of the ruler with a point at the bottom of the object for which you need to know the height. This point is labeled the beginning point. Walk toward or away from the object until the top of the ruler aligns with the top of the object directly above the beginning point. Still holding the ruler at arm's length, turn the ruler 90 degrees so that it is horizontal with the ground. Align the end of the horizontal ruler with the beginning point. Scan to the other end of the ruler and identify a second point on the ground that corresponds with that end of the ruler. On the ground, measure the distance between the beginning point and the second point. This distance is the approximate height of the object.

Using a Formula to Calculate Object Heights. You can use a simple ratio to calculate object heights if you have enough light to cast shadows. This calculation will have some degree of error (probably less than 10%). To perform this method, measure the length of the shadow for the object you need to determine the height. Then measure your height and your shadow length. It is easier to perform the math if all of your measurements are in feet and tenths. Insert the measurements into the following formula:

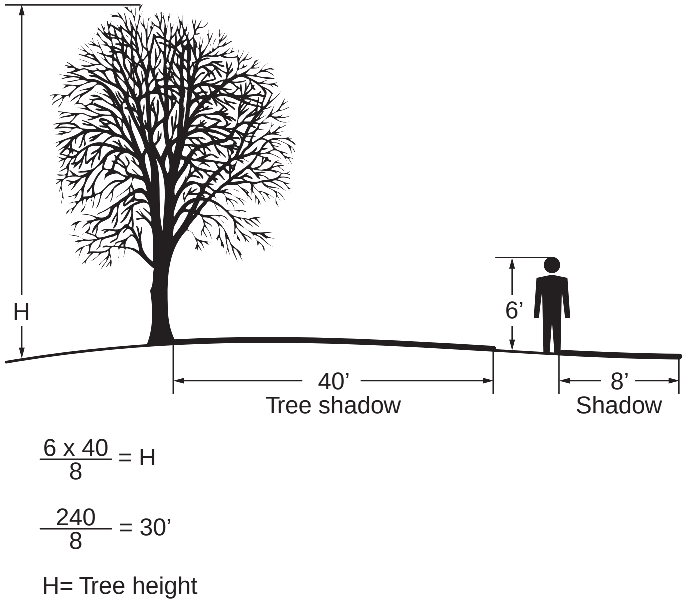


Figure D-1 Calculating the height of an object using a ratio.

(Your height × Shadow length of object) divided by Your shadow length = Height of object

An example of this calculation is shown in Figure D-1.

Using Trigonometry to Calculate Object Heights. If you need a more precise determination of height, then use the formulas from trigonometry. To perform this calculation you will need measurements of your distance from the object and the measurement of the angle between the ground and the top of the object, or the angle of elevation. When performing this work, you must be on a level horizontal plane from the bottom of the object you are measuring. Angles of elevation can be measured using a surveyor's transit. When you have these two measurements, insert them into the following formula:

Distance from object × tangent of angle of elevation (from Table D-1) = Height of object

An example of this calculation is shown in Figure D-2.

Table D-1 Natural tangents

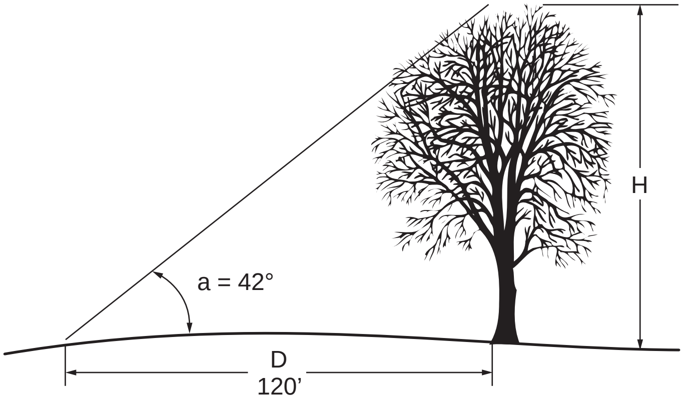
Angle (in degrees)	Tangent	Angle (in degrees)	Tangent	Angle (in degrees)	Tangent
0	.000	30	.577	60	1.732
1	.017	31	.600	61	1.804
2	.034	32	.624	62	1.880
3	.052	33	.649	63	1.962
4	.069	34	.674	64	2.050
5	.087	35	.700	65	2.144
6	.105	36	.726	66	2.246
7	.122	37	.753	67	2.355
8	.140	38	.781	68	2.475
9	.158	39	.809	69	2.605
10	.176	40	.839	70	2.747
11	.194	41	.869	71	2.904
12	.212	42	.900	72	3.077
13	.230	43	.935	73	3.270
14	.249	44	.965	74	3.487
15	.267	45	1.000	75	3.732
16	.286	46	1.035	76	4.010
17	.305	47	1.072	77	4.331
18	.324	48	1.110	78	4.704
19	.344	49	1.150	79	5.144
20	.363	50	1.191	80	5.671
21	.383	51	1.234	81	6.313
22	.404	52	1.279	82	7.115
23	.424	53	1.327	83	8.144
24	.445	54	1.376	84	9.514
25	.466	55	1.428	85	11.430
26	.487	56	1.482	86	14.300
27	.509	57	1.539	87	19.081
28	.531	58	1.600	88	28.636
29	.554	59	1.664	89	57.290

Calculating Length of French Drains

French drains are sized according to the length of trench required to store water currently pounding on the surface. If your work is located in areas where drainage problems are serious or surface storm water storage is required, consult a design professional who is familiar with calculating water storage based on storm intensity, rainfall amounts, runoff coefficients, and allowable outflow to address the problem. If the drainage problem does not create a hazard to life or property, then you can approximate french drain size. Before performing this calculation, observe the drainage area during a rain to estimate the area and depth of the pond. Use the following steps to determine the length of the french drain (Figure D-3):

- Estimate the CF of water that requires storage (volume calculation for ponded area).
- Divide the CF of storage by 1.2 (one and two-tenths).

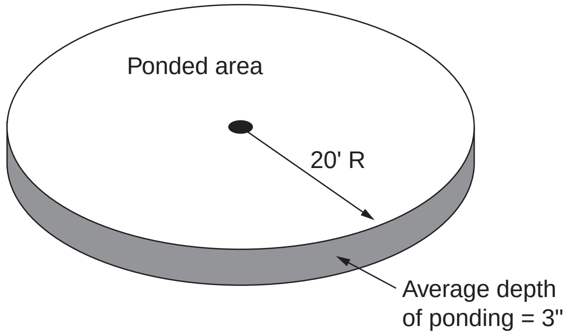
The answer is the length of trench required to store water. The division factor used in the second step provides an answer that is based on the trench that is 12 inches wide, 42 inches deep, and has 6 inches of soil cover. Trenches that have different dimensions will require a different division factor. As trench



D x tan a = H

120' x .90 = 108'
D = Distance from tree
a = Angle to top of tree
H = Tree height

Figure D-2 Calculating the height of an object using a trigonometric formula.



Area calculation: $3.14\ (20^2) = 1{,}256$ SF

Volume calculation: $\frac{1{,}256 \times 3}{12} = 314$ CF

French drain length required: $\frac{314}{1.2} = 262$ LF of french drain required (drain dimensions of 12" wide x 42" deep, with 6" soil cover)

Figure D-3 Calculating length for french drains.

dimensions diminish, the factor value decreases; as trench dimensions increase, the factor value increases.

Edge Restraint Calculations

The amount of edge restraint required for a project is determined by calculating the perimeter of the area being edged. Most edging is purchased by linear foot, and the perimeter measurement will be adequate. Stone edging materials are ordered by the tonnage, similar to wall material. To determine the tonnage required, calculate the square feet of edging and divide by the number of square feet per ton for stone.

Calculating Contraction Joint Spacing in Concrete

When tooling or sawing contraction joints in concrete, the spacing is important to control cracking in the surface. To determine an approximate horizontal distance between contraction joints, use the following formula:

- Multiply the thickness of the concrete times 12.
- The answer is a typical spacing (in inches) between joints.

This formula produces an approximate spacing. Other considerations for locating joints include width, shape, and configuration of paved areas.

WOOD MATERIAL CALCULATIONS

Ordering wood materials requires an item count for each size of structural member used. The most efficient method for performing this count is to prepare a plan for the project and make a list of all types of lumber pieces, hardware, and connectors required. Count the number required, paying special attention to those members that will require specific lengths.

The concept of board foot is sometimes used when referring to lumber. One board foot is the equivalent of a 1 foot × 1 foot × 1 inch piece of wood and is a calculation lumber suppliers use when purchasing and pricing wood. Materials in landscape applications seldom use this method for ordering, but the term may appear on billing statements. To calculate board feet, multiply the width of the board, in inches, by the thickness of the board, in inches, by the length of board, in feet, then divide the answer by 12. Dimensions less than 1 inch are considered as 1 inch.

APPENDIX E

SAMPLE BID FORMS

Following are sample forms that businesses use to bid landscape construction and maintenance work. Forms will vary significantly based on the type of bid to submit.

The Village Gardener
2975 Fair Oaks Avenue
Redwood City, CA 94063
(650) 306-9449
(650) 306 9473 (FAX)

Estimate

DATE	ESTIMATE NO.
4/21/2003	288

NAME / ADDRESS

P.O. NO.	PROJECT

QTY	DESCRIPTION	COST	TOTAL
	Renovate existing irrigation system		
	Front yard:		
	Valve box at right side of house - Raise Hosebib 12"		
4	Weathermatic 1" valve - replace 4 valves (serve front lawn/yard)	185.00	740.00
65	Ln. ft. 1" PVC pipe	3.50	227.50
2	Rainbird nozzle - replace 2 nozzles and check additional 16 for lawn)	3.00	6.00
6	Rainbird 12" pop-up sprinkler - replace in front right side planter	40.00	240.00
6	Rainbird 12" pop-up sprinkler - add to planter beds on right and left side (of door) against house	40.00	240.00
5	Rainbird 12" pop-up sprinkler - at left side lawn change 4 plus add 1	40.00	200.00
	Subtotal		1,653.50
	Valve box at left side of driveway		
1	Weathermatic 1" valve - replace and remove 1 - only 1 valve needed with pop up sprinklers, remove bubblers	185.00	185.00
3	Rainbird 12" pop-up sprinkler - change	40.00	120.00
16	Man hour(s) of labor	40.00	640.00
	Subtotal		945.00
	Backyard (4 valves):		
	Valve box in lawn area-		
6	Rainbird 12" pop-up sprinkler - lawn	40.00	240.00
1	Weathermatic 1" valve - new for drip	185.00	185.00
9	Hunter 6" PGP adjustable pop-up sprinkler - replace PGP's - main lawn area (serviced by 2 valves)	65.00	585.00
16	Man hour(s) of labor	40.00	640.00
Estimate is valid for 90 days		**Total**	

Page 1

Source: Delmar/Cengage Learning

Figure E-1 Sample bid form for irrigation work. (Courtesy of Frank Niccoli, The Village Gardener, Redwood City, CA)

The Village Gardener
2975 Fair Oaks Avenue
Redwood City, CA 94063
(650) 306-9449
(650) 306 9473 (FAX)

Estimate

DATE	ESTIMATE NO.
4/21/2003	288

NAME / ADDRESS

P.O. NO.	PROJECT

QTY	DESCRIPTION	COST	TOTAL
	Subtotal		1,650.00
	Sideyard (3 valves):		
7	Rainbird 12" pop-up sprinkler - additional for areas not met with water (on rose garden) + remove drip system from sprinkler valve	40.00	280.00
1	Weathermatic 1" valve - add for Arbutus area and planter at gate/fence area	185.00	185.00
1	Rainbird nozzle - change to center strip	3.00	3.00
6	Man hour(s) of labor	40.00	240.00
	Subtotal		708.00

Estimate is valid for 90 days	**Total** $4,956.50

Page 2

Source: Delmar/Cengage Learning

Figure E-1 *(continued)*

Proposal

Page # ______ of ______ pages

M. WILSON LANDSCAPE CONTRACTING

Proposal Submitted To: WALTER ANDERSON		Job Name FENCING	Job # —
Address 2855 H. AVE		Job Location SITE	
WILLIAMSBURG, IA 52361		Date 4/22/02	Date of Plans SAME
Phone #	Fax #		Architect M. WILSON

We hereby submit specifications and estimates for:

60 LF REDWOOD ALTERNATING BOARD WOOD FENCE – 6' HIGH
7 – 8' PANELS AND 1 – 4' PANEL

MATERIALS: (ALL CONSTRUCTION HEART REDWOOD)

– 8 BAGS SACRETE @ $3/EACH	$ 24 –
– 9 4×4 – 10' @ $36/EA.	324 –
– 8 2×8 – 8' @ $18/EA	144 –
– 16 2×4 – 8' @ $8/EA	128 –
– 105 1×8 – 6' @ $11/EA	1155 –
– 64 1×1 – 8' @ $5/EA	320 –
– 5 LBS 8d GALV. NAILS @ $3/EA	15 –
EQUIPMENT RENTAL – POWER AUGER, 1 DAY	$ 150 –
LABOR – 48 HOURS (2 PERSON CREW) @ $40/HR	$ 1920 –

We propose hereby to furnish material and labor — complete in accordance with the above specifications for the sum of:

$ 4180.00 (FOUR THOUSAND ONE HUNDRED EIGHTY AND NO/100) Dollars

with payments to be made as follows: HALF UPON ACCEPTANCE, HALF UPON COMPLETION

Any alteration or deviation from above specifications involving extra costs will be executed only upon written order, and will become an extra charge over and above the estimate. All agreements contingent upon strikes, accidents, or delays beyond our control.

Respectfully submitted Michael Wilson

Note — this proposal may be withdrawn by us if not accepted within 7 days.

Acceptance of Proposal

The above prices, specifications and conditions are satisfactory and are hereby accepted. You are authorized to do the work as specified. Payments will be made as outlined above.

Signature ______

Date of Acceptance ______ Signature ______

Source: Delmar/Cengage Learning

Figure E-2 Sample bid for fence installation.

APPENDIX F

RESOURCES

To further supplement the information provided in this text, several organizations related to the construction and design of landscapes are listed in this appendix. This list is for reference only and is not an endorsement of the associations' products or views. This list is current as of August 2009, but changes often occur in the contact information. Addresses and phone numbers are shown as presented in literature and on Web sites. Some organizations require membership or payment of a fee before you can obtain information from them.

Professional Associations

Professional Landcare Network (PLANET) (formerly Associated Landscape Contractors of America)
950 Herndon Parkway, Suite 450
Herndon, VA 20170
800-395-2522

American Nursery and Landscape Association
1000 Vermont Avenue NW, Suite 300
Washington, DC 20005
202-789-2900

Association of Professional Landscape Designers
4305 North Sixth Street, Suite A
Harrisburg, PA 17110
717-238-9780

American Society of Landscape Architects
636 Eye Street, NW
Washington, DC 20001-3736
202-898-2444

The American Institute of Architects
1735 New York Ave., NW
Washington, DC 20006
800-AIA-3837

Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077
847-966-6200

Interlocking Concrete Paving Association
13921 Park Center Road, Suite 270
Herndon VA, 20171
703-657-6900

Professional Grounds Maintenance Society
720 Light Street
Baltimore, MD 21230
410-223-2861

International Erosion Control Association
3401 Quebec Street, Suite 3500
Denver, CO 80207
970-879-3010

National Concrete Masonry Association
13750 Sunrise Valley Drive
Herndon, VA 20171-3499
800-455-4322

The Construction Specifications Institute
110 South Union Street, Suite 100
Alexandria, VA 22314
800-689-2900

International Wood Products Association
4214 King Street, West
Alexandria, VA 22302
703-820-6696

The Southern Pine Inspection Bureau
P.O. Box 10915
Pensacola, FL 32524-0915
850-434-2611

Western Wood Products Association
522 SW Fifth Ave., Suite 500
Portland, OR 97204-2122
503-224-3930

West Coast Lumber Inspection Bureau
P.O. Box 23145
Portland, OR 97281
503-639-0651

GLOSSARY

A

Acid etch. A concrete finish created by rinsing the surface with an acid and water mixture.

ADA (Americans with Disabilities Act). A federal law mandating that the needs of persons with differing abilities be considered in the design of spaces.

Addenda. Official notifications of changes in the project, typically revisions to the construction plans or specifications, that occur prior to bid opening.

Air vent. An irrigation valve that supplies air when draining a system.

Alternating current (AC). Alternating current. High-voltage electrical current.

Amps. The "flow rate" of electricity in a circuit.

Anchor. A structural piece used to hold items to a footing or support.

Angle of repose. Angle formed when materials are piled and allowed to slump naturally.

Arc. Part of a circle; a curve.

As-built drawings. Construction drawings marked to show the actual location of improvements. They typically highlight alterations in the original construction plans.

Ashlar. Random stone pattern composed of cut squares and rectangles of varying dimensions.

Asphalt. A mixture of petrochemicals, sand, and aggregate used to pave surfaces.

Assignable overhead. Nonlabor and nonmaterial costs that are directly attributed to a project.

Auger. A digging tool with a spiral or clam-shaped blade that is turned into the ground to remove soil.

B

Backdrain. A valve and housing that allows water to be drained out of an irrigation system.

Backsite. Measurement taken from survey instrument back to a benchmark.

Balled and burlapped. A plant that has been grown in the ground, dug out, and had the root-ball wrapped in burlap in preparation for transplanting.

Baluster. Narrow vertical post used for railing surfacing.

Bare-root. A plant that has had the soil removed from the roots in order to prepare it for transplanting.

Base. Layer of material below the paving. Provides support for paving.

Baseline. Layout technique that locates objects using measurements made at right angles at calculated points along a straight line.

Base material. Crushed stone used as support material for most paving material. Also referred to as *aggregate, gravel, roadstone,* and other regional names.

Base screed. Tool used to level base material. Typically a straight 2 × 4, with handles on top, slightly shorter than the width of the forms.

Batter. Backward lean of a retaining wall for stability.

Batterboards. L-shaped wooden framework used to mark corners, edges, and elevations of projects.

Beam. A large dimensioned wood structural member often placed on edge to support joists.

Benchmark. Fixed reference elevation.

Bender board. Thin strips of wood bound together that can be used as edge restraint. Thin strips allow the material to be bent into radii.

Bentonite. Finely ground clay material that expands upon contact with water.

Berm. Mounded and shaped soil.

BFM. Bonded fiber mulch. Hydromulch with materials chemically bonded.

Bidding. A pricing process in which contractors compete against each other by calculating their price and submitting their sealed bids to the owner.

Bioswale. A gradually sloped drainage channel with shallow sides that is lined with plant material and, in certain situations, rip-rap. Also called *swales.*

Blocking. Solid wood blocks placed between joists or rafters to maintain spacing.

Blue topping. Placing of project hub stakes, which are blue, to manipulate soil to the desired finish grade.

Bollard. Short post used to separate traffic or protect important site elements.

Bonding. A document that ensures the financial surety of a company or a person.

Bracing. Supports placed in the structural framework.

Breaker bar. A long, heavy, pointed metal bar used to break up hard compacted soil.

Brick (paving brick, pavers). Rectangular fired clay brick with typical dimensions of 4 inches × 8 inches × 2.5 inches thick. Available in a range of colors, paving bricks have no mortar holes and an average strength of approximately 5,000 PSI.

Bridging. Diagonal wood braces placed between joists or rafters to maintain spacing.

Building paper (roofing felt). Tar-impregnated paper used to waterproof roofs.

Bull float. Wide, flat metal (usually aluminum) tool with a long handle used to smooth the concrete surface after it has been screeded.

Bush hammered. A concrete finish created by scouring the surface with a gridded head mounted on a power hammer.

Buttering. Placing mortar on the end of a masonry unit.

Butt joint. Joint formed by placing the square ends of lumber end to end.

Butt stair. Stairs that have tread material that butts up against cheek walls.

Buttress. A support placed in front of or outside an object.

C

CADD (computer aided drafting and design). Drawings prepared with the aid of a computer drafting program.

Canopy. Top vegetative portion of a plant, including trunk, branches, and foliage.

Cantilever. Overhang of a deck beyond outside supports.

Carriage. Structural support member for stairs.

Cartesian coordinates. A measurement and layout system that locates an object using measurements off two baselines set up at right angles to each other.

Cascade. Water feature in which water spills gently from one level to the next.

Cast-in-place concrete. Concrete that is custom formed and poured on the site.

Catch basin. Concrete structure with a sump into which water runoff flows.

Chainsaw. A saw with a sharp chain blade and powered by a gas or electric motor.

Chalk line. Tool composed of a housing holding chalk and string. String is pulled out and snapped, leaving a chalk line used to mark locations.

Change orders. Revisions to the project that occur after the contracts have been signed.

Chasing a bond. Layout of masonry units before installing them to check for fit.

Cheek wall. Side wall that runs perpendicular to the face of a retaining wall. Stairs butt or are interlocked into the cheek wall.

Chord. A line segment that joins two points on a curve.

Circular saw. Hand-operated power saw using a round blade.

Cladding. Covering the sides of a post or column with a decorative surfacing material.

Clamshell digger. A posthole excavator composed of two rounded blades connected to handles.

Cleat. Small wood blocks used to support surfacing materials.

Clinometer (also called inclinometer or tilt sensor). A tool used to measure the degree of slope by aiming the tool up or down a slope and reading an angle measurement in a window.

Coaxial. Cable used for TV with conducting wire in center and conducting mesh wrapped around outside of center conductor.

Cobbled concrete. A concrete slab with large rounded stone set into its surface.

Codes (building, plumbing, electrical). A set of guidelines and rules for proper installation of building improvements.

Colored, impressioned concrete. Concrete surface that has been colored and stamped to look like brick, stone, or other decorative surfaces.

Column. Decorative post.

Composting. Technique for piling and turning of vegetative waste that allows decomposition of waste into usable organic matter.

Concave corners. Wall corners where the radius is measured on the inside. Inside corners.

Concrete. Mixture of cement, sand, water, and aggregate (stone) that hardens to create a solid paving surface. Typical landscape concrete is ordered as 4,000 PSI.

Concrete broom. Stiff-bristled shop broom used to put a texture on concrete.

Concrete pumping. Delivering concrete to a remote location using a special truck that pumps concrete through a series of tubes.

Conduit. Plastic or metal piping in which wiring is placed.

Construction drawings. *See* contract documents.

Construction joint. Joint placed at the end of a concrete pour where work is stopped with plans to continue later. This joint can be a straight edge, an edge with rebar sticking out, or an edge with a keyway.

Container plant. A tree, shrub, perennial or other plant that has been grown in the nursery in a container.

Contour lines. A line on a drawing that connects points of the same elevation.

Contract. A legally binding agreement between two parties that outlines the exchange of services or products for a fee.

Contract documents. Plans, specifications, and related documents used to guide the construction of a project.

Contraction or control joint. Joint in concrete used to control the cracking that happens when concrete dries. These shallow joints are tooled into the concrete while it is still wet or are sawed in after the concrete dries.

Controllers. Automatic switches that turn a DC circuit on and off based on time or light.

Convex corners. Wall corners where the radius is measured on the outside. Outside corners.

Coping material. Flat pieces of edging placed around pools to cover the top edge of the pool.

Cor-ten® steel. Type of steel that has an oxidized (rusted) finish appearance.

Cost plus fixed fee bid. A bid format that lists the time and materials required for the project and includes the profit as a fixed line item.

Countersink. Driving a fastener slightly below the surface of the material being fastened.

Cover crop. Fast-germinating plant material seeded on a site to reduce erosion.

Crimping. Deforming the surface of a material.

Critical path method (CPM). Scheduling technique that identifies project tasks according to their completion time and their order of completion, identifying those tasks that are critical to the timely completion of a project.

Cross section. A side view that cuts vertically through an object.

Curb. A short linear concrete barrier used for directing drainage and delineating planting beds.

Curb inlet. Concrete drainage structure built into a curb into which water runoff flows.

Curing. The process of concrete drying.

Cut and fill. The process of removing and adding soil to a site to achieve desired grades.

Cutoff saw. A gas-powered saw with a circular blade.

D

Darby float. Long, wood hand float with handle on top, used to level concrete after placement.

Dash bond. A thin coating composed of cement, sand, and water that is put on a wall to improve stucco adhesion.

Deadman. Anchor that is connected to the wall face and buried into a hill behind the wall for stabilization.

Deep watering. A post-planting care technique where a large volume of water is injected into the backfill zone of a newly installed plant in order to remove air pockets.

Demolition (site). Removal of existing site improvements that are not part of the finished product.

Design professional. A registered design professional such as a landscape architect, architect, engineer, or land surveyor.

Detail. A drawing that shows the specific materials and dimensions of a landscape element.

Detail key. A symbol found on any plan, indicating the sheet number on which the detail is located and the detail number.

Detention. Holding back of storm water.

Direct current (DC). Direct current. Low-voltage electrical current.

Direct procurement. The acquisition of contracts for services directly from a client.

Drip edge. Metal flashing engineered to keep water from flowing under shingles.

Drip line. Line on the ground directly below the farthest extent of a plant's canopy.

Drip systems. Low-pressure irrigation systems that precisely distribute water directly to the root zone of plants.

Dry-laid stone. Stone pieces that are laid without mortar joints.

Dumpy level. A tripod-mounted telescope that can be leveled and used to measure elevations.

E

ECB (erosion control blanket). Fibers or other mulch-like materials sandwiched between layers of thin nylon netting. Also called *erosion mats.*

Edger. Short tool with a handle on top, flat surface on the bottom, and a ¼-inch lip projecting down along the edge of the tool. Used along concrete forms to create rounded edges.

Edging (edge restraint). Material used along an edge to hold paving materials in place. Used with unit pavers and granular material, edgers can be concrete, stone, brick, wood, metal, or plastic. Edgers are typically anchored into the subgrade with pins or stakes. Also refers to materials placed to separate turf from planting beds.

Elevation. 1. A drawing that shows two dimensions, vertical and horizontal, and shows the surface of an object. 2. The vertical measurement of an object.

Ell (elbow). A pipe fitting that is right angled, or L shaped, and has openings for pipe at each end.

Emitters. Small irrigation heads that distribute water at rates of 1/2 to 5 gallons per hour. Also called drip heads due to the water being emitted in a slow drip.

End posts. Larger diameter posts used at corners and gates in chain-link fencing installations.

Erosion. Removal of soil particles through the action of water and wind.

Erosion mat. *See* ECB (erosion control blanket).
Expanding bolt. Bolt that anchors itself by expanding when the stem is turned.
Expansion joint. Joint placed where concrete intersects with a stable, permanent object. This joint protects the stable object from being moved by the force of expanding concrete.
Expansion joint material. Plastic or fibrous strips that are placed between buildings and walks to protect both when concrete expands in hot weather.
Exposed aggregate. Concrete surface where decorative rock have been imbedded into the surface and rinsed to expose their surface.
Exterior grade plywood. Plywood manufactured with special glues and woods to resist delaminating in exterior applications.

F

Fascia. Material covering structural components.
Felled. Cutting down a tree.
Fibermesh. Concrete with minute fiberglass strands that act as reinforcement.
Fiber optic. Communications utility line composed of a fine glass strand encased in plastic housing.
Field finishing. Painting or touching up amenity finishes after installation.
Fieldstone. Irregular-sized rounded or angular shaped stone weathered by natural forces. Used in freestanding walls.
Finish coat. The final layer for a stucco application.
Finish floor elevation. The elevation of the finish level of a structure's floor.
Firepit. An outdoor cauldron where a real or gas-fired flame can be maintained.
Fixtures. Components such as lights that are attached to an electrical system.
Flagstone. Natural stone that is either cut into standard dimensions or broken into irregular pieces with a thickness of 1½–2½ inches.
Flashing. Metal sheeting installed between structural members to prevent moisture penetration.
Float. A broad, flat tool with a handle on top used to smooth concrete. Manufactured from wood, steel, or magnesium.
Floating and troweling. The laborious step of working the poured concrete surface with flat-bedded tools that push aggregate farther down into the pour and cause water and fine particles to move up to the surface.
Flowable fill. A thin concrete mixed with fly ash.
Footing. A structural support, often of concrete.
Foresite. Measurement taken of a paint to be surveyed from a survey instrument.
Form break compound. Liquid applied to forms to allow them to release easier after concrete hardens.
Form liners. Rubber or metal molds placed inside forms to leave a decorative surface.
Form nails. Special nails used in form construction that have two heads to make removal from the form easier.
Forms. Pieces and strips of wood or metal placed to shape concrete slabs. Forms are secured to the ground and tops are set at the desired height of the concrete.
Free-draining angular fill. Crushed stone without rounded edges or fine granular material used as fill behind a wall.
Free out (swale high point). Low point that allows water to pass out of a drainage area.
French drain. A short, shallow trench drain filled with loose stone. Used for water storage in low areas.
Frost depth (frost line). Average maximum depth at which frost penetrates the soil.
Frost footing. A footing that extends below frost depth.

G

Gabions. Wire baskets that are filled with stone and stacked to create a wall.
Gable. A roof form that has two angled surfaces.
Galvanized. Metal coated with zinc to reduce rusting.
Gannt chart. A scheduling technique that uses a matrix listing all tasks that must be completed on a vertical axis and the duration of the tasks on the horizontal axis. Horizontal bars indicate the starting date and the completion date of each task.
General contractor. Contractor responsible for coordinating work performed by subcontractors from several different trades.
Geogrid. Open-weave fabric used to stabilize retaining walls.
Geotextile. Interwoven structural fabric used to assist in stabilizing subgrades.
Geotextile sock. A textile covering wrapped around a tile to keep fine particles of soil from moving into the tile.
GFCI (ground-fault circuit interrupt). Circuit engineered to automatically shut off if a voltage change or short is detected.
Gilling. A piece of equipment towed behind a tractor and used to cultivate and smooth soil before seeding or sodding.
GPS (Global Positioning System). A method to locate positions on the ground using signals from satellites to triangulate the sender's position.
Grab beam. A beam that is two pieces of structural lumber, one placed on each side of a post.
Grade beam. A concrete footing on buried concrete piers used to bridge poor soils.
Grading. 1. Changing the slope or contour of the land. 2. Designating the quality of lumber pieces.
Granular base. Crushed stone material used to stabilize the bottom course of a wall.
Granular paving. Paving materials that are broken into pieces typically ½ inch or less.

Grape stake. Long, rounded, irregular-shaped stick used for fence surfacing.

Grommets. Round metal rings which protect the openings in fabric through which cords or rope are placed.

Grout. Weak mortar mix used to fill the center cavity of a masonry wall.

Gunnite®. Stiff concrete that is sprayed on a metal framework or surface and finished in place.

Gusset. The piece of dimensioned lumber that is bolted alongside the pieces being spliced to add additional stability.

Guying. A form of tree staking that uses three to four anchors placed on the ground with wires angled up and over branches halfway up the plant.

H

Halogen. An incandescent lamp with tungsten filament sealed into a bulb filled with an inert gas and a small amount of iodine or bromine halogen.

Hammer drill. A drill using a bit that rotates and vibrates to improve boring through hard surfaces such as masonry or concrete.

Hardwood. Deciduous, or broad-leafed, trees such as oak, maple, and walnut.

Haunching. The hand placed trench backfill that holds the pipe and fitting against movement.

Head. An irrigation component that distributes water to plants. Can use spray, flood, or drip methods to distribute water.

Header. 1. Brick course turned perpendicular to other courses. 2. A wood joint in a concrete slab.

Height of instrument. The benchmark elevation plus the backsite. Foresites are subtracted from this number to obtain the elevations of locations on a site.

Honeycombing. Voids or holes that occur when concrete is not properly vibrated or tamped.

Hose bibb. Threaded adapter placed on a hydrant that allows a hose to be attached.

Hydrant. Exterior water outlet, usually with a threaded connector for a hose.

Hydraulic splitter. Table-mounted masonry cleaving tool that exerts hydraulic pressure on a bar to split materials.

Hydromulching. Application of mulch by mixing it with water and a tackifier and spraying it onto a surface.

Hydroseeding. Seed application accomplished by mixing seed with water and spraying on a surface.

Hydrostatic pressure. Pressure caused by the buildup of water behind a retaining wall.

I

Inlet. Concrete or plastic structure into which water runoff flows.

Interceptor channel. A shallow swale lined with concrete or a heavy-grade vinyl liner that is placed along the site's perimeter on the high side.

Interlocking concrete paving block. Unit paving material composed of molded, cured concrete. Pavers come in a variety of shapes and colors, are 3.5 inches thick, and have a typical average strength of 8,000 PSI.

Interlocking stair. Stairs that have treads that interlock with cheek walls.

Irrigation. A system of piping, valves, and sprinkles designed to water plant material.

Itemized bid. A bid format that provides not only a total project price, but also a detailed listing of project materials or work tasks.

J

J bolt. A long metal bolt with a 90° turn at the end forming a J. Used to anchor items to a concrete footing.

Jointer. Similar to an edger, except the lip is located in the center and the tool is used to create contraction joints in a slab.

Joist. A large dimensioned wood structural member placed on edge that supports deck surfacing.

Joist hanger. Metal bracket used to connect joists to other structural elements.

Jumping jack. A handheld gas-powered compaction tool that compacts by bouncing up and ramming down.

Jurisdiction. Defined boundaries within which a person or an organization has control over activities.

K

Kerfing. Shallow cuts along the back of a board that allow the board to be bent.

Keying. Making grooves or indentations in one material so it will interlock with another material.

Keyway. An angled groove placed in concrete by a special form. Used to create a lip where two concrete slabs can be held together.

Kickplate. Vertical support running between posts at the bottom of a fence.

Kneeboard. A 24-inch × 24-inch sheet of ½-inch plywood board used to kneel on when finishing concrete.

L

Landscape architect. A registered (in states with title laws) design professional specializing in landscape projects.

Landscape designer. An individual who possesses special skills in arranging design elements.

Landscape fabric. A geotextile used specifically for preventing weed growth.

Landscape timber. Dimensioned lumber wall unit treated for contact with ground.

Laser plane level. A surveyor's instrument that indicates level using a rotating light beam picked up by a receiver.

Lateral line. A secondary irrigation line that carries water from valves to irrigation heads.

Lath. Thin, narrow piece of unfinished wood used for spacing and surface applications.

Lattice. Framework of lath or small-dimensioned lumber arranged in a decorative pattern.

Ledger. 1. Piece of dimensioned lumber attached to a structure that supports decks and roofs. 2. A ledge on which veneer is placed.

Level spreader. A level spreader diverts storm water from a channel and directs it into a holding pond, or forebay

Lifts. Layers of soil or granular base.

Light emitting diode (LED). A lamp that uses diodes to produce a light.

Light standard. Post to which a light fixture is connected.

Line posts. Small-diameter posts placed between larger posts in chain-link fencing installations.

Liner. Waterproof plastic or vinyl sheet used to line water features.

Lipped wall units. Precast wall units that use a lip cast at the back, bottom edge of the block to align and stabilize between courses. Lips also create a setback batter.

Low-voltage lighting. Lighting that uses electrical power reduced from a high level (110–120 volts) to a lower level (10–12 volts).

Lump sum bid. A bid format in which all project costs are provided to the client in a single number.

M

Mag (magnesium) float. Wide, flat tool with handle mounted on top used to smooth concrete surface. Made out of lightweight magnesium.

Main line. A primary irrigation line that carries water to valves.

Maintenance edge. Narrow strip of weed-proof material placed under the length of a fence to reduce trimming.

Masonry drill bit. Drill bit engineered to drill through concrete and masonry materials.

Material Safety and Data Sheets (MSDS). Printed instructions from manufacturers regarding the safe handling of materials they produce.

Mid rail. Bracing rail placed midway between the top and bottom of a panel of chain-link fence.

Mitered joint. Joint formed by placing angled edges of miter-cut lumber together.

Mortar. Mixture of cement, lime, sand, and water used to space masonry units.

Mortar bag. A vinyl or cloth bag used to squeeze mortar into small spaces.

Mulch. Organic or inorganic ground covering placed around plants to reduce weeds and retain moisture.

Multiplier. An addition to hourly costs to cover unassignable overhead.

Muriatic acid. Acid use for cleaning masonry and concrete.

N

Niche. Realignment of a wall to create a small space and/or additional stability.

Nipple. A short pipe connecting two irrigation components.

Nominal dimension. Dimensions of lumber used for ordering. Represents the actual dimensions before drying and planing.

Nonperforated tile. Plastic tile with no surface openings.

O

Ohm. The resistance between two points of a conductor.

Offset. A practice of placing stakes or lines for an improvement at a consistent, predetermined distance and direction from where the improvement is to be actually installed.

Ordinances (zoning, parking, sign, street tree). Laws that govern the type, size, and location of improvements on private property.

Orifice. Opening in a drainage grate surface.

OSB. Oriented strand board. Sheet lumber composed of chips or strands of lumber joined with special glues.

Overhead. Nonlabor or material costs of operating a business not specifically associated with a particular project.

P, Q

Pacing. A measuring technique that uses walking to obtain approximate dimensions.

Patio misters. Spray nozzles that distribute a fine mist under pressure to cool outdoor spaces.

Paving. 1. Applying a hard surface to an area. 2. The material used to apply a hard surface to an area.

PDF (Portable Document Format). A method of saving and transmitting drawings that allow them to be opened and read using a free program from Adobe® software.

Perforated tile. Plastic tile with small openings to allow water to enter.

Permeable pavement. Asphalt, concrete, or segmental pavers that are constructed with more open space between aggregate to allow water to percolate rather than run off the surface.

Personal protective equipment (PPE). Equipment such as latex gloves and CPR mouthpieces that protect workers from blood borne pathogens.

Phillips drive. Screw with an X pattern driving head.

Photocell. A device that allows a circuit to be turned off or on based on the amount of light present.

Pickets. Vertical boards used for fence surfacing.

Pier. Support for bridge platform.

Pier block. Precast concrete block used to support posts.

Pinned wall units. Precast wall units that use a metal or fiberglass pin to align and stabilize units between courses.

Planimeter. An engineering tool used to measure the area of random shapes.

Plan view. A two-dimensional drawing showing length and width, but not height.

Planting plans. Plans that indicate the location and type of plant material to be installed.

Plant schedule. A listing of plant material used in a design. Often located on the planting plan.

Platform framing. A method for structurally supporting a deck that does not use beams. Joist are "hung" between a framework of structural members.

Plug. A small circle or square of sod with roots, stems, leaves, and a small plug of soil.

Plumb. Placement of an object in true vertical position.

Plumb bob. A weighted tool suspended from a string. Used to determine plumb.

Poly pipe. Polyethlyene pipe.

Portland cement. Powdered blend of lime, coke, and other ingredients that forms the bonding agent in concrete, mortar, and stucco.

Post. A large dimensioned structural support that is set vertically.

Post and beam framing. A method for structurally supporting a deck that connects beams to posts. Joist are then placed on top of beams.

Post driver. A heavy, hollow metal tube with handles that is used to drive fenceposts into the ground.

Power driver. A hammer-like tool that uses a loaded charge to drive nails into concrete and other hard surfaces.

Precast concrete. Concrete that has been formed and hardened before being delivered to a site.

Pressure-treated wood. Wood that has had a preservative forced into the surface under high pressures.

Privacy slatting. Plastic or metal materials inserted into chain-link fence to increase opaqueness of fence.

Program evaluation and review technique (PERT). Scheduling technique that uses charts showing the project tasks and their duration, identifying completion dates that are optimistic, pessimistic, and most likely.

PSI. Pounds per square inch. Strength measurement used for paving materials.

Pumping. Action of soil working up into aggregate through traffic compaction.

Punch. A small-diameter awl used for punching holes in tubes.

Purlin. Wood support that runs perpendicular to rafters and supports roofing materials.

PVC. Polyvinylchloride pipe.

R

Rafter. A large dimensioned wood structural member placed on edge that supports roof surfacing.

Rakes. The end overhang of a roof.

Rammed earth. A method of constructing walls by blending screened soil and a binder, then ramming it into forms.

Rammer (jumping jack). A handheld gas-powered compaction tool that compacts by bouncing up and ramming down.

Rebar. Durable steel or metal rods used in staking or for reinforcement.

Reciprocating saw. An electric-powered saw with a thin vertical blade that vibrates back and forth.

Recycled concrete. Concrete slabs and other surfaces that have been broken into pieces for reuse.

Reglet. Small groove under a waterfall that breaks surface tension of water.

Repetitive motion. An activity in which the same motion is repeated many times in the same manner.

Rerod (rebar). Heavy metal bar used to strengthen edges of concrete slabs. Sold in long lengths that are cut with saw or bolt cutters to length needed. Deformed rebars have a rough surface.

Reservoir basin. Water pool located at the bottom of a waterfall or cascade.

Resilient surfacing. Soft surfacing placed below play structures.

Retaining wall. A wall used to retain soil.

Return walls. Walls that run back from the wall face. Typically used to end a wall into a hillside.

Ridge plate. Dimensioned lumber structural member to which rafters are attached at the top.

Rim joist. A structural wood member that runs around the outside of a deck frame in the platform framing method.

Rip-rap. Large-diameter stone placed on embankments and in channels to reduce erosion.

Riser. 1. Vertical portion of a step. 2. The piping that connects an irrigation head to the lateral line.

Rock salt finish. A concrete finish created by sprinkling rock salt on the surface and then rinsing a few days later.

Rodding. Running a vertical screed board over a surface to which a first or second coat of stucco has been applied.

Roof pitch. The slope of a roof.

Root barrier. A plastic shield placed in the ground to direct root growth.

Root zone. The area under and around a plant where roots are located. A tree root zone can be over 1½ times the size of the canopy.

Rubble. A stone that has natural, untrimmed edges.

Rubble walls. Walls constructed of natural stone without mortar.

S

Sabre saw. A hand-powered saw with a thin vertical blade used for cutting curved and detailed shapes.

Safe surfacing. The surfacing under play equipment.

Scale. Instrument used to measure drawings. Also refers to the percent of reduction used to fit a full-sized site onto a sheet of paper.

Schedule 40. Thick-walled PVC pipe.

Scratch coat. The base coat for stucco.

Screed. Tool used to level concrete after it is placed. Typically a straight 2 × 4 longer than the width of the forms. Also term used for leveling of concrete after a pour.

Screening. Metal or fiberglass cloth used to keep out insects.

Sealer. Clear chemical coating that preserves wood or paving.

Section. A drawing that shows two dimensions, vertical and horizontal, and that cuts through an object.

Segmental precast concrete wall unit. Wall building material that is manufactured by casting concrete in a form.

Self-furring metal lath. A metal mesh with small openings and indentations on one side that hold the lath away from the surface. Commonly used in stucco applications.

Setback. The required distance between improvements and property lines, usually specified in zoning ordinances.

Setting bed. Approximately 1-inch thick layer of sand on which unit pavers are set.

Shank. The shaft of a nail or screw.

Sheathing. Sheeted wood material placed under wall and roof surfacing.

Shop drawings. Construction plans provided by the manufacturers of equipment and amenities, showing their interpretation of the designer's requirements.

Silt fence. Geotextile fabric suspended between posts used for erosion control.

Site furniture. Benches, trash receptacles, bike racks, tables, and other site amenities designed for exterior applications.

Skid-steer. A small multiwheeled tractor that turns by braking the wheels on one side.

Skimmers. Openings around the top edge of a pool designed to capture debris floating on the water surface.

Skirting. Screening placed under a deck to hide the structural framework.

Slab. A flat concrete surface.

Sleeper. Wood support for decking that is laid directly on the ground.

Slope. A percentage that represents the vertical difference between two points divided by the horizontal difference.

Slotted drive. Screw with a straight, grooved driving head.

Slump. A measure of the amount of water in concrete.

Sod. Grass that has been cut into strips, with a layer of soil below, for transplanting.

Soffit. Panel placed under the eave to cover structural work.

Softwood. Coniferous, or cone-bearing, trees such as pine, spruce, and fir.

Soil stabilizer. A material used to bind soil and granular materials.

Spacer. Block of wood used to maintain equal spacing between boards applied to a fence.

Spackle. Thin plaster applied over concrete pool surfaces.

Specifications. Written document that includes general information about a construction project and specific information about materials and installation techniques to be used.

Speed square. Small adjustable tool that can mark square and angled markings.

Spindle. Round or square railing post for porch.

Split rail. A horizontal board fence style where the horizontal pieces are split logs, or rails.

Spot elevations. Elevation of a single point on a site.

Sprig. A short section of turf grass stems with at least one or two nodes capable of rooting.

Square. Placement of two objects with a corner that forms a right angle. Also tool used to establish square.

Square-headed drive. Screw with a square pattern driving head.

Stadia. A process that uses the eyepiece crosshairs of a transit to measure both level and distance in one step.

Stain. Chemical coating that colors wood.

Static pool. Water feature that does not have flowing water.

Static roller. A drum-shaped roller compaction tool that is self-propelled or pulled by a tractor.

Step-back batter (stairstep batter). Batter technique in which the front of each higher course of a wall is set back slightly from the course below.

Stone set (brick set). Chisel-like tool used to cleave brick and stone.

Stretcher. Tool used to stretch chain-link fencing fabric.

Striking. Using a special tool to smooth the joints in a masonry installation.

Stringer. Horizontal structural support for fence and rail surfacing.

Stringline. Tool used to identify location and/or elevation of the edge of a project.

Stucco. A cement and sand mixture applied in heavy coats to walls and vertical surfaces.

Subgrade. Soil material below paving and base.

Sump. Recessed area at the bottom of an inlet that captures debris from runoff.

Surcharge. Water that is forced back out of an inlet.
Swale. Low ditch designed to occasionally carry water runoff.
Swale high point. *See* free out.
Swing joint (swing ell). A riser that has four ells and a straight nipple that joins the laterial and the head.

T

T. A pipe fitting that is shaped like the letter *T* and has openings for pipe at the ends of each tee.
Tack. To temporarily nail objects together.
Tackifier. Sticky substance used to bind hydromulch or hydroseed materials to soil.
Take-off. The process of measuring a drawing to obtain material quantities.
Tangent. A straight line.
Tensile fabric structures (also called shade structures). Fabric stretched between supports to create a covering that can protect whatever it covers from the elements.
Tension wire. Wire used to anchor the bottom of chain-link fabric.
Terrace (Terracing). A series of retaining walls, each set back from the one below it.
Tie. A metal strand or wire that holds opposing forms together.
Ties. Aluminum wires wrapped around chain-link fabric to hold fabric next to posts.
Tile. Round tubing used to conduct drainage of water. Commonly manufactured of plastic, clay, or concrete.
Toe of slope. Low point of a slope.
Toenailing. Securing pieces of lumber by nailing at an angle.
Toggle bolt. A spring-loaded bolt that expands when inserted into a pilot hole and grips when the bolt is tightened.
Top of slope. Upper point of a slope.
Top rail. Top piping of a chain-link fence used to support top of fabric.
Tort. Illegal action that leads to damage of the property of another person.
Transformer. Electrical component engineered to reduce voltage in current.
Transit. Tripod-mounted level that can be used to measure elevations, distances, and horizontal angles on a project.
Tread. Horizontal portion of a step.
Treated woods. Woods that have been treated with preservatives to reduce the potential of decay.
Tree grate. Metal grid that allows water and air access to root systems of trees set in paved areas.
Tree guard. Metal cage placed around trunks of trees in urban areas to protect bark from damage.
Tree well. A retaining wall that keeps soil away from the root zone and trunk of a plant.
Tree spade. A large piece of equipment with hydraulically operated blades that cut through the soil and roots to remove a plant from where it is planted in order to transplant.
Trench drain. A formed/molded linear channel with a grate that sets in a frame on top of the channel.
Trisodium phosphate (TSP). A compound for cleaning masonry and concrete.
Trowel. Wedge-shaped metal hand tool. Used to mix and place mortar and concrete.
Troweling. Smoothing the surface of a material, usually concrete, using a trowel.
Truss. A premanufactured roof support composed of rafters and braces.
Turf. Grass areas.

U

Unassignable overhead. Costs of operating a business that cannot be directly attributed to a specific project.
Unit pavers. Bricks, paving block, or other manmade paving materials that are placed one at a time.
Utility. A wire or pipe that supplies basic services to a site (e.g., sewer, water, phone).
Utility plans. Plans that show the location, type, size, and depth of proposed utilities.

V

Valve. A mechanical device used to regulate the flow of water.
Veneer. A decorative vertical surfacing applied to an exterior wall. Typically brick or stone.
Verticals. Ties or timbers placed with the long dimension set vertically. Usually buried in front of a wall to prevent the wall from falling forward.
Vibrating roller. A drum-shaped roller compaction tool that is self-propelled or pulled by a tractor and vibrates as it rolls.
Vibratory plate compactor. Metal plate with a motor mounted on top and handle for steering. Vibrates and compacts base material as the machine moves.
Virtual design construction (VDC). Scheduling technique that uses computerized models to integrate the aspects of a building project, including the project itself, the organization working on the project, and the process used to implement the project.
Voltage. The electrical potential of a circuit, or the circuit's ability to do work.
Voltage drop. The loss of voltage.

W, X, Y, Z

Waterproof wire nut. A wire connector designed to protect the connection from water by surrounding it in a waterproof substance.

Watt. A measure of the amount of electricity being used.

Wattle. A tubular-shaped nylon netting filled with straw fibers or small sapling branches and used on slopes to control erosion.

Weepholes. Openings in the face of a retaining wall that allow water to drain from behind the wall.

Weep screed. Galvanized flashing.

Weir. An opening that regulates the amount of water flowing past a point.

Welded wire fencing. Panels of welding heavy gauge steel wire in a grid pattern.

Welded (woven) wire mesh (WWM). Metal wires welded together in a grid pattern used to reinforce concrete. Typically 10-gauge wire with 6-inch squares.

Wet masonry saw. Table-mounted circular saw that uses water to aid in cutting masonry materials.

Wet screed. A technique used when a screed is too short or a surface needs to be warped. Performed by resting one end of the screed on a form and holding the other end at a height that is approximately where the other form would be.

Wood float. Wide, flat wood tool with a handle mounted on top used to smooth concrete surfaces.

Wythe. Width of one masonry unit.

Xenon. A lamp that uses ionized xenon gas to produce light.

BIBLIOGRAPHY

Alth, Max. *Do It Yourself Plumbing.* New York: Sterling Publishing Co., Inc., 1987.

Aquascape Designs, Inc. *Professional Pond Kits.* Batavia, IL: Aquascape Designs, Inc., 2000.

California Redwood Association. *Redwood Deck Construction.* Novato, CA: California Redwood Association, 2001.

Collier, Clifford W. Jr. *Tree Wells.* Morgantown, WV: Cooperative Extension Work in Agriculture and Home Economics, West Virginia University and the U.S. Department of Agriculture, 1973.

Construction Specification Institute. *CSINet website.* Alexandria, VA: Construction Specification Institute, 2003. http://www.csinet.org/.

DeCosse, Cy, ed. *Black and Decker Home Improvement Library, Landscape Design and Construction Projects.* Minnetonka, MN: Cy DeCosse Incorporated, 1992.

Everett, T. H. *Lawns and Landscaping.* New York: Grosser Good Life Books, 1976.

Feucht, James R., and Butler, Jack D. *Landscape Management.* New York: Van Nostrand Reinhold.

FX Luminaire. *Specification Guide.* San Diego, CA: 2009.

Gale Pacific Limited. *Coolaroo Installation Guide,* Victoria, Australia: 2009.

Glen-Gery Brickwork. *Exterior Paving with Brickwork.* Wyomissing, PA: Glen-Gery Corporation, 1992.

Greenfix America. *Technical Data, ECB Installation Guide* (www.greenfix.com). Calipatria, CA: Greenfix America, 2003.

Hinze, Jimmie. *Construction Planning and Scheduling.* Upper Saddle River, NJ: Prentice Hall, 1998.

Home How To Institute. *A Portfolio of Deck Ideas.* Minnetonka, MN: Cy DeCosse Incorporated, 1993.

Hughes, Dwight Jr. *Systems for Success.* Cedar Rapids, IA: Dwight Hughes Systems, Inc., 1996.

Ingels, Jack E. *Landscaping Principles and Practices,* 5th ed. Clifton Park, NY: Thomson Delmar Learning, 1997.

Interlocking Concrete Pavement Institute. *Tech Spec, # 2, #3, and #5,* Sterling, VA: Interlocking Concrete Pavement Institute, 1994, 1995, 1996.

International Society of Arboriculture. (Web site search terms: ISA). Champaign, IL: -ISA 2003.

Iowa One Call. *Professional Excavators Manual.* Des Moines, IA: Iowa One Call, 1995.

King's Materials. *Installation Instructions Data Sheet.* Cedar Rapids, IA: King's Materials, 1997.

Lewis, Gaspar. *Carpentry,* 2nd ed. Clifton Park, NY: Thomson Delmar Learning, 1994.

Maylon, Gary. *Walls and Ceilings. National Gypsum Product Information.* Troy, MI: Business News Publishing Co, 2003.

National Association of Home Builders Research Foundation. *Residential Concrete,* 2nd ed. Washington, DC: Home Builder Press, 1994.

Naval Education and Training Command, and Buza, John. *Builder 3 and 2, Volume 1 and Volume 2, NAVEDTRA 12520 and 12521.* Philadelphia, PA: U.S. Navy, 1994.

Physiotherapy Associates. *Protect Your Back—Prevent Injury.* Cedar Rapids, IA: Work Injury Rehabilitation Center, 1995.

Pittenger, Dennis R. ed. *California Master Gardener Handbook.* Oakland, CA: Division of Agriculture and Natural Resources, University of California, 2002.

Portland Cement Association. *Design and Control of Concrete Mixtures,* 12th ed. Skokie, IL: Portland Cement Association, 1979.

Portland Cement Association. *The Homeowner's Guide to Building with Concrete, Brick & Stone.* Emmaus, PA: Rodale Press, 1988.

Portland Cement Association. *Portland Cement Plaster (Stucco)* (Web site search terms: stucco, Portland cement). Skokie, IL: Portland Cement Association, 2003. http://www.portcement.com/.

Presto Products Company. *Cellular Confinement System Installation Technical Guide.* Appleton, WI: Presto Products Company, 2003.

Rayner, Horace, and Schmidt, Milton. *Fundamentals of Surveying.* New York: Van Nostrand Reinhold Company, 1969.

Reid, Jeffrey. *How to Build Ponds and Waterfalls: The Complete Guide.* New York: Tetra Press, 1998.

Roocroft, Tony. *Complete Pond Solver Book,* 2003. http://www.pondprofessorfountains.com/admin/about_us.htm

Sherwood, Gerald, and Stroh, Robert. *Wood Frame House Construction.* New York: Sterling Publishing Co., Inc., 1992.

Spence, William Perkins. *Construction Methods, Materials, and Techniques.* Clifton Park, NY: Thomson Delmar Learning, 1998.

Stone Deck Incorporated. *Natural Stone Decking Installation Guide.* Concord, CA: 2007

Stone Products Corporation. *Culture Brick Installation Instructions* (Web site search terms: cultured stone products), Napa, CA: Author, 1996.

Stryker, Jess. *Jess Stryker's Landscape Sprinkler and Drip Irrigation Installation Tutorial.* Jess Stryker, 2001. http://www.irrigationtutorials.com/.

Sunset Books and Magazines. *Decks.* Menlo Park, CA: Lane Publishing Co., 1975.

Sunset Books and Magazines. *Fences and Gates.* Menlo Park, CA: Lane Publishing Co., 1975.

Sunset Books and Magazines. *Patio Roofs and Gazebos.* Menlo Park, CA: Lane Publishing Co., 1992.

Sunset Books and Magazines. *Walls, Walks, and Patio Floors.* Menlo Park, CA: Lane Publishing Co., 1975.

Tallahassee, Florida, City of. *A Mini-Directory of Tree Protection Techniques.* Tallahassee, FL: 2001.

Townsend, Karen, Ham, Donald, Miller, Ansel, and Chesnut, Timothy. *Soil Aeration Systems—Do They Really Improve Tree Root Zone Conditions Under Fill and Paving?* Clemson, SC: Department of Forestry, Clemson University, 1997.

U.S. Concrete, Central Concrete Supply Co. Inc. *Pervious Concrete Sample Specification.* Houston, TX, 2003.

U.S. Consumer Product Safety Commission. *Handbook for Public Playground Safety.* Washington, DC: Author, 1995.

U.S. Department of Agriculture, Forest Service. *Techline Durability: What's in That Pressure-Treated Wood?* Madison, WI: USDA Forest Service, 2000.

Vivian, John. *Building Stone Walls,* 2nd ed., North Adams, MA: Storey Books, 1978.

Wilson, Bruce. *Efficacy of Erosion-Control Blankets and Soil Stabilizer.* Minneapolis, MN: Regents of the University of Minnesota, 2002.

Wing, Charlie. *Visual Handbook of Building and Remodeling.* Emmaus, PA: Rodale Press, 1990.

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