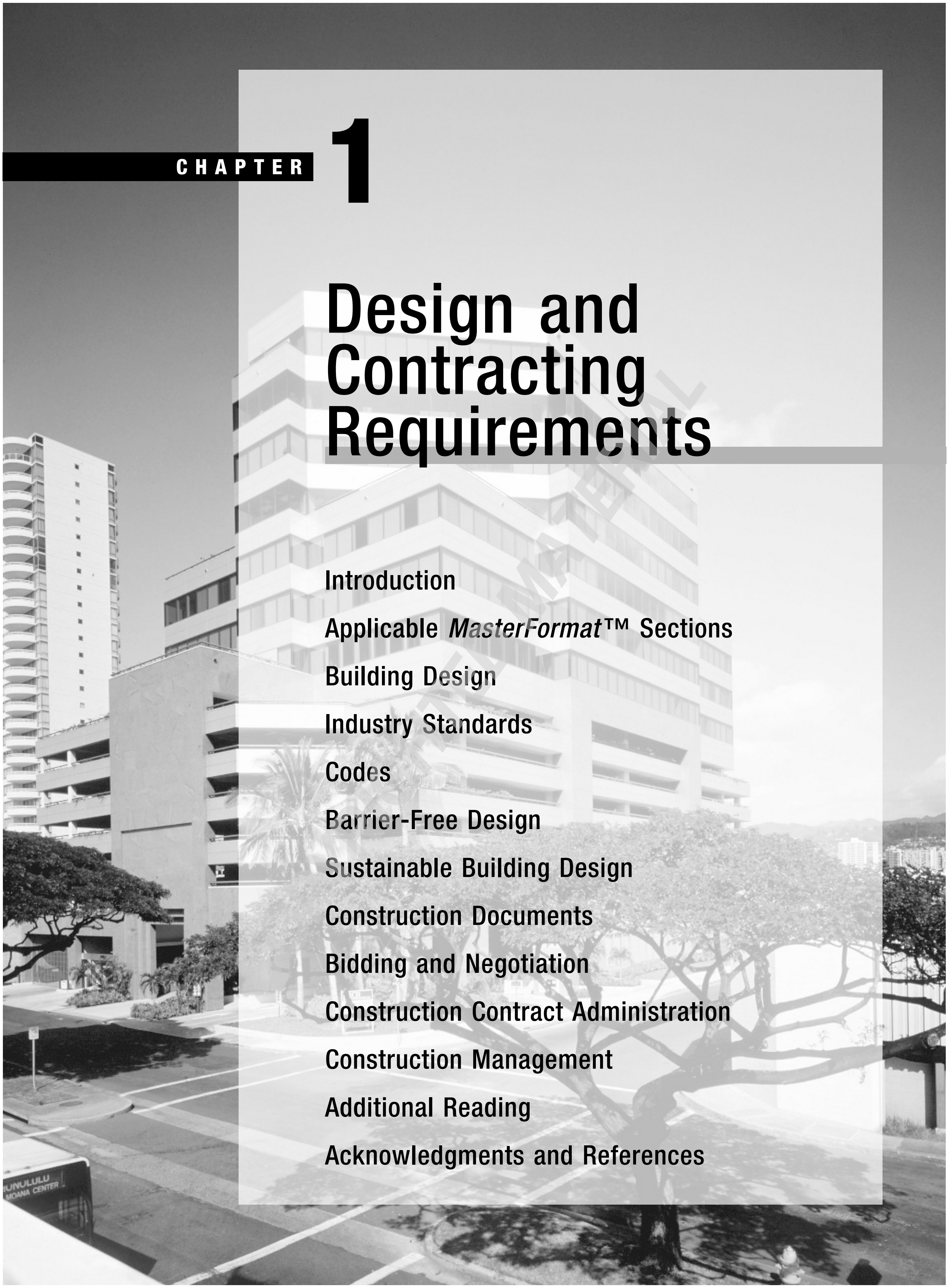


CHAPTER 1

Design and Contracting Requirements

Introduction

Many factors influence an architect's work related to building design and construction contract administration. In addition to architectural design, an architect must be aware of and conversant in site, structural, mechanical, and electrical design. He or she must also be aware of the legal constraints, such as codes, laws, and regulations, and of the many industry standards that influence design and construction. An architect must also be knowledgeable and conversant in the production of construction documents and must understand the means and methods used in constructing buildings. He or she must understand the construction process and be able to render an architect's services during the construction phase of a building project regardless of the construction contract type or employment by the owner of a construction manager. He or she must understand the financial constraints on building construction and be able to design within those constraints. And in all of these, an architect must not be just a jack-of-all-trades; he or she must be a master of them all.

This chapter covers facets of the building design and construction process that a professional must understand to be able to carry out an architect's responsibilities in the design and construction of buildings. The chapter also addresses the function of a construction manager in the construction process and the architect's relationship to a construction manager. Chapters 2 through 23 address construction materials and methods of design and construction of which an architect must be knowledgeable. Chapter 24 addresses the fundamental properties of materials. Chapter 25 describes the metric system of measurement.

The first five parts of this chapter discuss some of the many factors affecting building design.

Sections 1.6, 1.7, and 1.8 discuss the services architects provide related to a building construction project. The American Institute of Architects (AIA) has divided an architect's services into the categories *basic* and *additional*.

Basic services are those included in standard services contracts developed by AIA and included in the architect's basic fee for services.

Additional services are optional and are performed only when agreed to by the architect and the owner, with additional compensation to the architect.

Following the flow of a project from conception to the completion of the warranty period (one year after construction completion), an architect's services can be broken down into *predesign* services, *design* services, *construction* services, *postconstruction* services, and s*upplemental* services.

Predesign services are *additional* services. They include such acts as programming, existing facilities studies, project budgeting, and site analysis.

Basic services include *design* and *construction* services. Design services are further broken down into *schematic* design, *design development* (a further refinement of schematic design documents), and *construction documents* services.

Construction services include services performed during the *bidding and negotiation* phase and those performed during the *construction contract administration* phase.

Postconstruction services are additional services performed after substantial completion of the building. They include such acts as maintenance and operational programming, record drawings, start-up assistance, and warranty review.

Supplemental services are additional services. They include such items as renderings, models, life cycle cost analysis, quantity surveys, graphic design, and many others.

Section 1.9 addresses the function of a construction manager related to a construction project and a construction manager's relationships to the owner, the architect, and the contractor.

Applicable *MasterFormat* Sections

The following *MasterFormat* 2004 Level 2 sections are applicable to this chapter.

00 11 00	Advertisements and Invitations
00 21 00	Instructions
00 22 00	Supplementary Instructions
00 23 00	Procurement Definitions
00 24 00	Procurement Scopes
00 25 00	Procurement Meetings
00 26 00	Procurement Substitution Procedures
00 31 00	Available Project Information
00 41 00	Bid Forms
00 42 00	Proposal Forms
00 43 00	Procurement Form Supplements
00 45 00	Representations and Certifications
00 51 00	Notice of Award
00 52 00	Agreement Forms
00 54 00	Agreement Form Supplements
00 55 00	Notice to Proceed
00 61 00	Bond Forms
00 62 00	Certificates and Other Forms
00 63 00	Clarification and Modification Forms
00 65 00	Closeout Forms
00 71 00	Contracting Definitions
00 72 00	General Conditions
00 73 00	Supplementary Conditions
00 91 00	Precontract Revisions
00 93 00	Record Clarifications and Proposals
00 94 00	Record Modifications
01 11 00	Summary of Work
01 12 00	Multiple Contract Summary
01 14 00	Work Restrictions
01 18 00	Project Utility Sources
01 21 00	Allowances
01 22 00	Unit Prices
01 23 00	Alternates
01 24 00	Value Analysis
01 25 00	Substitution Procedures
01 26 00	Contract Modification Procedures
01 29 00	Payment Procedures
01 31 00	Project Management and Coordination
01 32 00	Construction Progress Documentation
01 33 00	Submittal Procedures
01 35 00	Special Procedures
01 41 00	Regulatory Requirements
01 42 00	References
01 43 00	Quality Assurance
01 45 00	Quality Control

01 51 00 Temporary Utilities
01 52 00 Construction Facilities
01 53 00 Temporary Construction
01 54 00 Construction Aids
01 55 00 Vehicular Access and Parking
01 56 00 Temporary Barriers and Enclosures
01 57 00 Temporary Controls
01 58 00 Project Identification
01 61 00 Common Product Requirements
01 62 00 Product Options
01 64 00 Owner-Supplied Products
01 65 00 Product Delivery Requirements
01 66 00 Product Storage and Handling Requirements
01 71 00 Examination and Preparation
01 73 00 Execution
01 74 00 Cleaning and Waste Management
01 75 00 Starting and Adjusting
01 76 00 Protecting Installed Construction
01 77 00 Closeout Procedures
01 78 00 Closeout Submittals
01 79 00 Demonstration and Training
01 81 00 Facility Performance Requirements
01 82 00 Facility Substructure Performance Requirements
01 83 00 Facility Shell Performance Requirements
01 84 00 Interiors Performance Requirements
01 85 00 Conveying Equipment Performance Requirements
01 86 00 Facility Services Performance Requirements
01 87 00 Equipment and Furnishings Performance Requirements
01 88 00 Other Facility Construction Performance Requirements
01 89 00 Site Construction Performance Requirements
01 91 00 Commissioning
01 92 00 Facility Operation
01 93 00 Facility Maintenance
01 94 00 Facility Decommissioning

1.1 Building Design

An architect's first and primary contractual responsibility related to building construction is design. Building design requires training, experience, an aesthetic sense, and an understanding of certain basic principles. Among these principles are (1) the objectives good design should strive for, (2) an architect's responsibilities related to design, (3) basic building use and shape types, and (4) available construction systems and methods.

1.1.1 DESIGN OBJECTIVES

An architect's primary design objective should be to produce buildings that serve their intended purpose and that permit the activities that take place in them to proceed with appropriate dispatch and ease. They should be efficient in their use and operation. In addition, commercial buildings should be capable of producing a profit.

An architect's buildings should be of good-quality construction, and should be able to be built at as low a cost as is practicable. An architect's designs should produce individual buildings that are aesthetically pleasing and that do not diminish the beauty of or reduce the quality of the natural environment around them. They should also produce the most practicable conservation of energy and the least practicable degradation of the environment.

1.1.1.1 Environmental Considerations

In addition to his or her responsibility to the public as defined by law and ethical considerations, an architect bears a responsibility to protect and maintain the environment. One factor in fulfilling this responsibility is to design buildings for sustainability, as discussed in Section 1.5. But protecting the environment goes far beyond designing green buildings. It also entails consideration of how a building works and how it fits into its environment. This concern must be considered not just for the present, but also throughout the life of the building.

A building should be designed so that it fits within its site and does not overpower the environment. Fitting is accomplished by placing and orientating building elements to take the best advantage of sun angles, site features, and prevailing weather patterns such as wind. Where practicable, earth-sheltered design and passive solar design can be used to reduce heating and cooling loads on a building. Refer to Section 17.6 for a discussion of solar heating and cooling.

Whenever possible, buildings should be sited so as to preserve as much of the existing vegetation and land features as is practicable. Means should also be provided to assure the protection of existing preservable vegetation and land features, such as wetlands and waterways, from damage during construction.

Where possible, construction waste should be reduced to the smallest amount possible, which can be aided by selecting materials that have little waste and by employing off-site prefabrication of building elements. Debris and waste should be recycled where possible, preferably on the construction site.

Most jurisdictions require the prevention of storm sewer water and groundwater pollution by prescribed methods of control. This should be accomplished whether or not it is required by law or code.

Designing buildings for energy conservation is discussed in Chapters 17 and 18; for sound reduction, refer to Chapter 13.

1.1.1.2 Occupant Health Considerations

It is important to consider the health of the occupants when designing a building. It is necessary, for instance, to design heating, cooling, and ventilating systems that will not introduce toxic gases into the building. Ductwork should be easy to clean internally and maintain. Design of ventilating systems is discussed in Chapter 17.

In creating a healthy environment in a building, it is important to select nontoxic building materials. Emanation of toxic compounds and gases from building materials can create a condition known as "sick building syndrome" and can cause serious conditions such as allergies and even cancer. In addition, products that are known to have high rates of outgassing of volatile organic compounds (VOCs) should be avoided. Even the materials necessary to clean some building products can lead to indoor air pollution.

Another factor in maintaining healthy building is the control of moisture intrusion and condensation, which can lead to the growth of mold and mildew. Conditions that create condensation problems are discussed in Chapter 17. Control of moisture and free water penetration are discussed in Chapter 7.

1.1.2 THE BUILDING CONSTRUCTION TEAM

Many organizations and individuals must work together to produce buildings. These include owners, design professionals, constructors, members of supporting professions and industries, and sometimes construction managers.

Owners are the architect's clients. They are not necessarily the users of a building, but they conceive, finance, and usually own the project.

A *design professional* is a person or organization that designs a construction project. The *prime design professional* is the one who is hired by the owner to lead the design team. In building construction projects, the prime professional is usually an architect. An engineer may be the prime design professional on some primarily engineering projects—for example, in the construction of bridges or in the major renovation of an existing heating, ventilating, and air conditioning system. In this section, it is assumed that the project being considered is a building and that the prime design professional is an architect. In other project types, the chores here delineated as the responsibility of the architect may fall to an engineer as the prime design professional for a particular project.

It is ordinarily the architect's responsibility to (1) determine the legal, financial, and other constraints on project design, (2) program and design the project, (3) produce contract documents, (4) provide professional services during the bidding or negotiation phase, and (5) provide construction contract administration services. For a residence or other small building, an architect may carry out these functions alone. Larger and more complicated buildings often present design problems that are beyond the expertise of most architects. For these more complicated building construction projects, an architect functions as a member, usually as the leader, of a team of design professionals that includes structural, mechanical, civil, and electrical engineers, and interior designers, who function as consultants to the architect.

The architect and each of the architect's consultants will design, produce construction documents, and provide construction contract administration for the one portion of a building's components that falls within his or her field of expertise. The architect coordinates the activities of all design team members.

FIGURE 1.1-2 Modern buildings are seldom rectangles. (Honvest Corporation, Honolulu, Hawaii. Architect Leo A. Daly and Associates. Photo courtesy Bethlehem Steel Corporation.).

The construction process often also requires input from a second group of design professionals working as consultants, either to the owner directly or to one of the team members. These other professionals include, but are not limited to, those with special knowledge about schools, hospitals, food service facilities, laboratories, industrial complexes, computer systems, communication systems, furniture, specialized equipment, and many other components. The architect usually coordinates the activities of these other professionals.

Constructors, also called *builders*, are usually a group of organizations that together erect construction projects. They also provide most of the training of construction workers (Fig. 1.1-1). They consist of many types of *contractors*, including, but not limited to, *general contractors*, who oversee the work of, and usually hire, the others; and specialty, or *trade*, contractors, such as those who provide sitework, excavation, concrete, masonry, steel, carpentry, casework, moisture protection, doors, windows, finishes, specialties, equipment, and conveying, plumbing, electrical, and mechanical systems. Supporting these contractors are suppliers, who provide construction equipment, such as cranes,

FIGURE 1.1-1 An instructor in a construction firm works with an electrical technician student. (Courtesy BE&K.)

and product suppliers who furnish the materials, products, systems, and equipment that go into a building.

Supporting professions and industries include, but are not limited to, construction managers (see Section 1.9); legal professionals; accountants; lenders and investors, who provide construction money and long-term loans that permit construction projects to be erected; insurance providers; testing and research agencies, which develop new products and test existing ones; and regulators, including code and law writers and enforcers, who control health and safety issues, aesthetics, environmental issues, zoning, utilities, financial institutions, and design professionals' licensing and practices.

1.1.3 BUILDING USE TYPES

Construction projects can be identified by their use: residential, commercial (stores, office buildings, etc.), institutional (hospitals, schools, jails, etc.), industrial (manufacturing, laboratories, etc.), and nonbuilding types (bridges, towers, etc.). From this point forward, this chapter addresses only those building construction projects for which an architect is the primary professional. In such projects, it is the architect's job to determine the design requirements specific to each use. For example, there is little resemblance between the requirements for a single-family residence and those of a hospital. There may be major differences even within a group. There are great differences, for example, between the requirements for a single-family residence and a high-rise apartment building. A local jail will probably bear little resemblance to a federal prison.

Some buildings are designed for *common use*, meaning that they have more than one use type in the same structure. Street-front stores may have residential or office spaces above them. High-rise buildings may house commercial uses on the lower floors, office uses on intermediate floors, and apartments on the upper floors.

1.1.4 BUILDING SHAPE TYPES

Buildings take many forms and shapes, depending on their use, the materials used to build them, the needs and desires of the owner, the construction budget, the building's potential operating costs, and the designer's preferences. Buildings other than single-family residences and townhouses are so varied in size and shape as to make simplification of their types difficult (Fig. 1.1-2). However, some basic types and construction methods can be identified (Fig. 1.1-3).

The simplest building is a one-story, single-span, slab-on-grade structure with

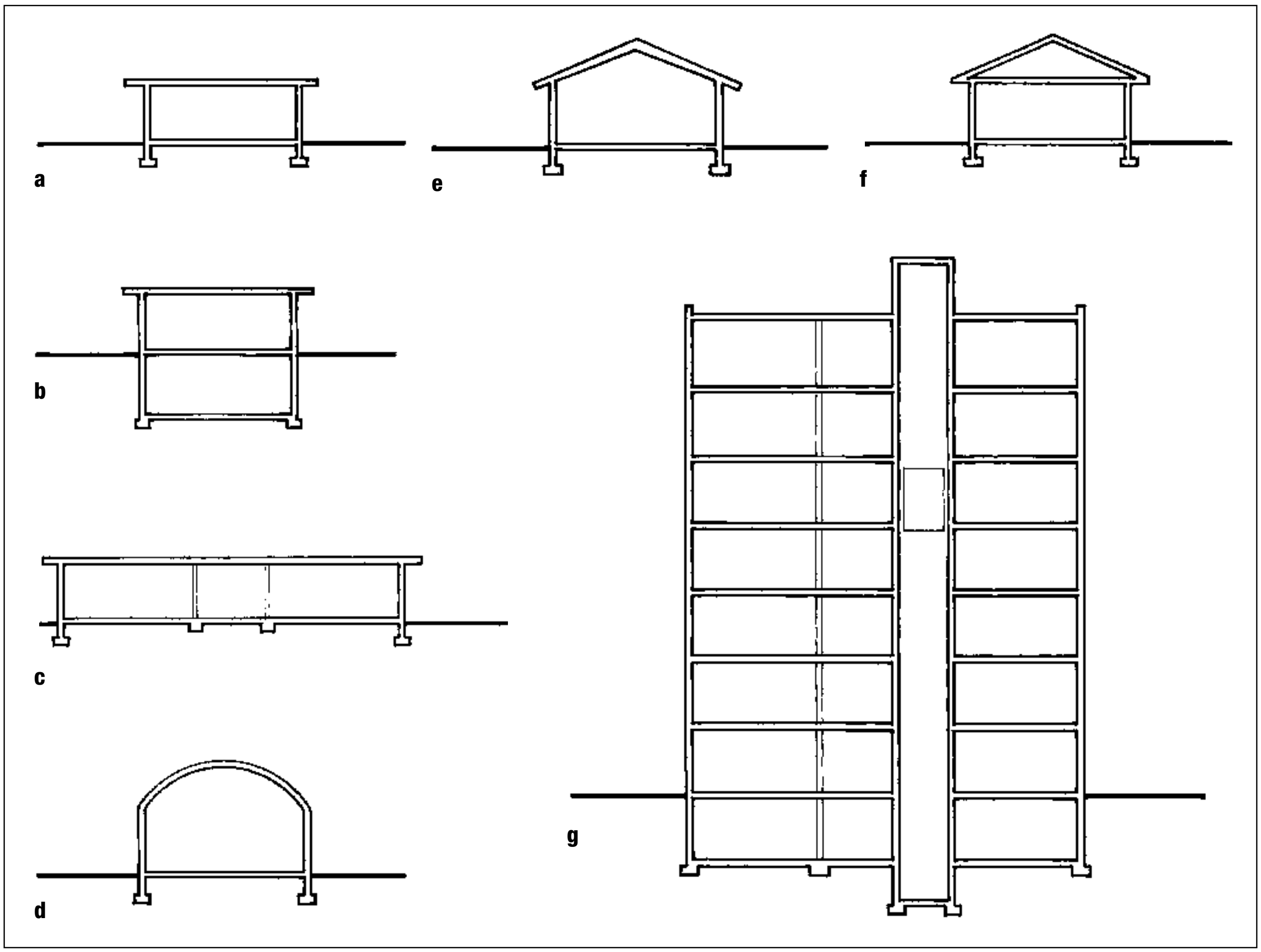


FIGURE 1.1-3 **Basic building types for other than single-family residential buildings: (a) one-story; (b) one-story with basement; (c) one-story with multiple framing bays; (d–f) typical roof shapes; and (g) multistory.** (Drawings by HLS.)

a flat roof (Fig. 1.1-3a). Similar buildings with basements are also commonly built (Fig. 1.1-3b). Single-story structures with more than one structural span (Fig. 1.1-3c), in which one or more intermediate rows of walls or columns supports the roof structure, enclose more space per unit of exterior wall cladding than do smaller buildings.

Single-story buildings may also have full or partial basements. The structural systems in buildings of this type may be concrete, masonry, steel-framed, or woodframed bearing walls with steel, concrete, or wood roof framing systems; steel, concrete, or wood interior and exterior columns with steel, concrete, or wood roof framing; or a combination of these systems. Foundations are usually poured concrete, but treated wood foundations are sometimes used (see Section 6.5). The roof of a single-story building may be either flat or any of a wide variety of shapes (Figs. 1.1-3d–f). Roof decks may be of wood, steel, or concrete. Basements may have either poured concrete or reinforced masonry walls, depending on the level of the earth against the wall and the height and hydrostatic head of adjacent underground water. Floors above basements may be steel-framed with a concrete or wood floor, concrete-framed with a concrete floor, steel-framed with a concrete floor, wood-framed with a wood floor, or a combination of these systems.

The same principles apply to multistory structures (Fig. 1.1-3g). The construction materials and structural systems in multistory structures and the height of such buildings are usually dictated by economic factors, such as land cost, but may be affected by codes and laws that restrict building height, land area coverage, or the materials that may be used. Fire codes, for example, may restrict the types of construction systems and the materials that may be left exposed. Many fire codes do not permit wood construction or the exposure of wood finishes on the exterior of buildings in certain locations.

Multistory buildings require less roof surface than single-story buildings with the same floor area. This results in a savings in the cost of roofing materials. In addition, multistory buildings require less land per unit of usable space. Because of their higher ratio of interior space to building shell area, they are also generally more energy efficient than single-story buildings. Except in rare instances, these advantages increase with the number of stories. The lower costs are somewhat offset by the increased costs for maintenance of the exterior surfaces of multistory buildings, the relatively high costs of materials that can be used there, and the increased cost of construction associated with moving materials to high levels and working with them far above ground level.

Low-rise multistory buildings may be of steel or concrete construction or a combination of these. Some even have masonry bearing walls. Steel columns and concrete floors are common. Foundations are usually poured concrete spread footings, although poor soil conditions sometimes dictate the use of piles or caissons.

High-rise buildings are usually framed in steel, with thin concrete floor slabs, because concrete structures of great height have heavier and larger framing members than steel structures, which reduces the amount of usable space and increases the cost of construction. Some recent very high buildings have been designed as a series of steel shells or tubes that extend for the entire height of the building; others have been designed using the same principles as tall radio and television towers. Foundations are either poured concrete footings or pads, piles, or caissons, depending on the soil conditions and the size and load imposed on the soil by the building.

Sometimes the desire to create a statement for ego-enhancing or advertising purposes affects the size, height, and appearance of a building. For example, a corporation may wish to use its headquarters building as a symbol or may just want to own the tallest, largest, or most spectacular building in town.

Multistory buildings need elevators or escalators to make their use practicable. In addition, in most types of uses, federal accessibility laws and rules make elevators or wheelchair lifts a legal requirement in every building that is not inherently accessible to the handicapped (see Section 1.4), which, of course, includes every multistory building. The additional cost of this vertical transportation must be considered in deciding whether to construct a multistory building.

The basic building types used in single-family and townhouse construction are easier to define. Figure 1.1-4 shows some common types. Most of these types are also used for buildings other than single-family homes or townhouses, however, so they should not be thought of for only these restricted applications. The most prevalent of these is a one-story building (Fig. 1.1-4a), because this type provides the most size and shape variations. These buildings may or may not contain a basement. Their roofs may be sloped, as shown, or flat.

One-and-one-half-story buildings, with or without basements (Fig. 1.1-44b), are sometimes used for housing. They offer more living space than single-story buildings with a minimum of additional cost. The second-floor space varies with the building size and roof slope. Light, ventilation, and a view can be provided by dormers.

One-and-one-half-story buildings are seldom built for other types of uses because their inherently small second-floor rooms, with their sloped ceilings, while adequate for sleeping rooms, often do not make satisfactory work spaces.

Two-story (Fig. 1.1-4c) or taller buildings, with or without basements, provide the maximum usable area at relatively low cost. Two- and three-story single-family houses and townhouses are common. These types of buildings can reduce construction costs, depending on the value of the land. When they must be accessible to the handicapped (see Section 1.4), buildings of more than one story require elevators, as described earlier for multistory buildings. Bilevel buildings (Fig. 1.1-4d) are well suited for single-family houses, townhouses, or small commercial buildings in hillside locations. They provide habitable space at both grade levels when connected with full flights of stairs. In certain types of uses, accessibility restrictions may require that elevators be included. This configuration can also be used for two different occupancies, such as an apartment on one level and a small store on the other. In this case, both levels can be easily made independently accessible to the handicapped. Roofs may be either sloped, as shown, or flat.

Split-level (Fig. 1.1-4e) and bilevel/split-entry (Fig. 1.1-4f) buildings are used mostly for single-family houses and townhouses. They are infrequently used for other purposes because of the difficulty of making them accessible to the handicapped. Split-level houses offer distinct separation of functions, either on three levels or four, including a base-

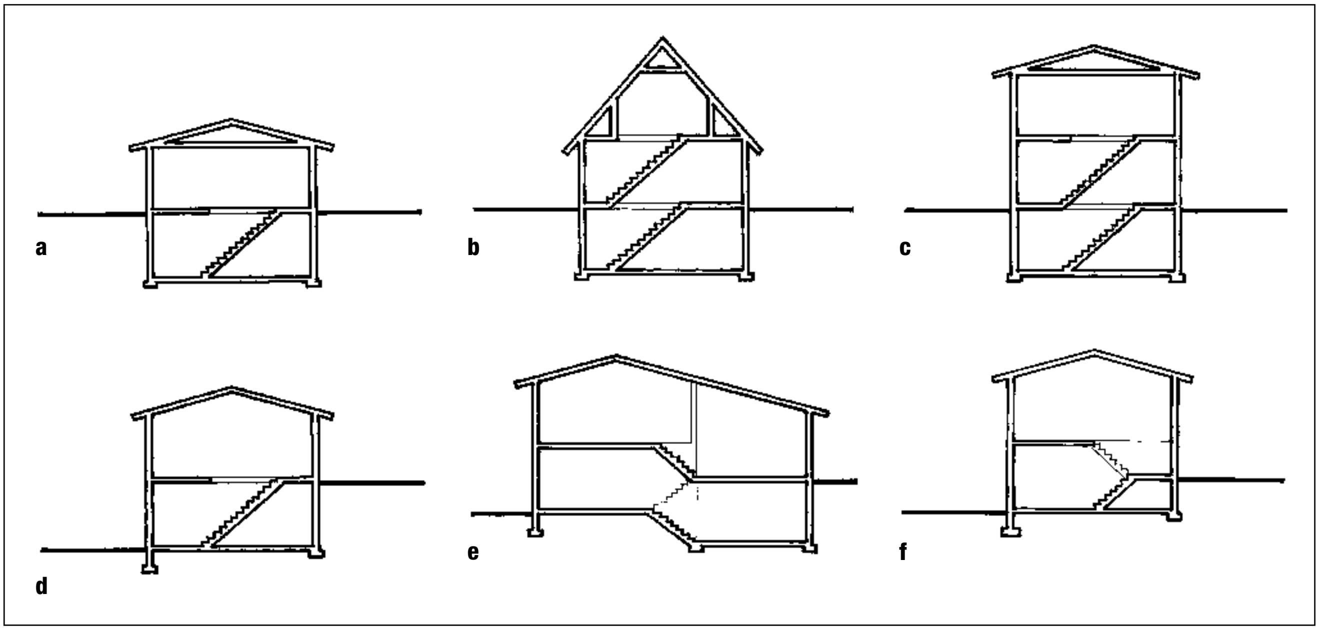


FIGURE 1.1-4 **Basic single-family residential building types: (a) single-story; (b) one-and-one-half-story; (c) two-story or higher; (d) bilevel; (e) split-level; and (f) bilevel/split-entry.** (Drawings by HLS.)

ment. These are best suited for sloping lots. They offer numerous design possibilities but can have awkward proportions if not carefully designed.

Bilevel/split-entry buildings are also best suited to sloping lots. They are characterized by a split foyer between two full living levels. This configuration can provide either a sunken two-story (or more) house without a basement or a raised one-story (or more) house with a finished basement.

1.1.5 CONSTRUCTION SYSTEMS AND METHODS

The selection of construction methods and systems that produce the basic building types shown in Figures 1.1-3 and 1.1-4 is usually governed by three criteria: functional requirements, cost, and the desired appearance.

These basic criteria may require a consideration of climate, site topography, initial costs, maintenance costs, building codes, zoning ordinances or other laws, availability of materials and labor, builder resourcefulness and size, owner taste, local custom, and other factors.

The selection of methods and systems is further complicated by the thousands of materials, products, and construction system choices available, many of which are interdependent. Sometimes the relationship of these building elements to each other will create situations in which the construction method or system is the major influence on a building's design. For example, the selection of a dome as the means to roof a coliseum may dictate that the shape of the building be circular or near-circular. Conversely, design requirements may dictate the framing system. A dome, for example, may be a poor choice for roofing a theater because of the inherent acoustical difficulties of a dome and because a circular building may not be preferable for the kind of theater that is desired. The cost and availability of very large laminated wood (gluelam) structural elements, as compared with smaller gluelam units, may influence the width or even the shape of a church, or the way in which the gluelam units are fitted together to make a roof structure. The permissible span of the available wood decking may further influence the spacing of these gluelam units or the design of the roof structure and the placement of purlins.

Although there have been experiments with a few revolutionary construction systems since World War II, most new homes and many small commercial and institutional buildings in the United States are still built using conventional light-wood-platform framing (see Chapter 6), often with wood-truss-framed roofs. In many areas, the use of preassembled components, such as those discussed in Chapter 6, is common. In the future, advanced industrialization techniques using new materials and methods may offer new construction forms far different from those typical today.

Other basic systems in use today include wood-post-and-beam framing and wood-pole construction (see Chapter 6); masonry bearing-wall construction (see Chapter 4), sometimes with concrete floors (see Chapter 3), often supported on metal framing or bar joists; concrete-framed construction; and structural steel-framed construction and light-gauge metal framing of walls and roofs (see Chapter 5).

In small construction, conventional wood framing still offers many advantages. As a complete construction system, it still is one of the most economical ways to build. The ease of working and fastening wood together with simple tools provides flexibility, which permits job changes without extensive re-engineering. Wood framing is still the basis for most building codes and labor practices and will probably remain so for some time to come. Conventional framing is adaptable to site fabrication by the smallest builder handling each member piece by piece, as well as to off-site fabrication of individual pieces into larger preassembled components that require additional manpower or machinery for erection.

1.1.6 THE FUTURE

Further industrialization, using more and larger prefinished and prefabricated components, appears essential to help offset the rising costs of land, labor, and materials. Off-site fabrication permits maximum utilization of labor and materials under factory-controlled conditions with little loss in on-site time owing to bad weather. Efficiency may be increased with the use of power tools and machinery; volume purchasing of materials and stockpiling of finished parts is possible; greater convenience for workers and better protection for finished materials is provided; and site erection of components can usually be accomplished more economically and in less time by semiskilled or even unskilled labor.

To save costs, mechanical components for small buildings have been developed that combine a furnace, air conditioner, water heater, and electric power panel in one package. Larger mechanical components include completely furnished kitchens and bathrooms. The concept of prefinishing complete rooms has been extended to prefabricating as much as half of a small building, such as a house, so that upon setting and joining two halves, an entire building is completed. Future developments may include assembling an entire building and completely finishing it prior to site placement.

Some future building construction methods will be highly sophisticated and closely integrated systems. For instance, integrated floor and ceiling systems available for use in commercial construction include structure, lighting, acoustical control, heating, cooling, and air distribution in a single system.

Components should be capable of satisfying varying design requirements; should permit simple modifications in the field in case of errors; and should be sized for ease of shipping, storage, and assembly. As component size increases, design and construction problems increase and design flexibility is lessened. The dimensions of large units are restricted to what can be transported physically and legally over the highways, and larger components usually require more manpower and larger erection equipment at the site.

Accordingly, the design, engineering, or selection of preassembled components requires judgments between size and flexibility. The most useful systems will combine the advantages of fully standardized factory-built modular units, which capitalize on the inherent savings resulting from repetitive production, and those that offer the design advantages of custom fabrication in the field.

Unfortunately, there are also certain disadvantages associated with prefabrication that have so far limited its use. For example, to be profitable, large components require a large market willing to accept a standardized design, which has not been forthcoming. In comparison, because they can be adapted to many building sizes, shapes, and designs, there is a huge market for prefabricated roof trusses, making them relatively inexpensive and readily available.

There are also potential disputes among construction trade unions and between trade unions and manufacturers about the right to do certain work. Union-member plumbers, for example, are not likely to be pleased when the plumbing piping and fixtures in a prefabricated building are installed by nonunion factory workers.

Other problems with prefabrication include consumer and builder resistance to prefabricated structures associated with the preconceived notion that prefabricated buildings will be shabbily constructed and look like house trailers. In fact, while the construction may actually be superior to that of stick-built units, the appearance possibilities are somewhat limited, and design variety is difficult to achieve.

A final deterrent to prefabrication is the lack of consistency among building codes. These differences can require slight, but costly, modifications in prefabricated units to comply with the codes in different jurisdictions.

Construction practices vary widely across the country. Conventional methods and systems are not usually engineered but are based on a combination of long-established custom, rules of thumb, and arbitrary building code requirements. These practices have resulted in buildings that have usually provided satisfactory performance over the years. However, when these practices are unduly conservative, as is often the case, they foster excessive waste and therefore higher cost. New performance standards for methods and systems are constantly being established. These design criteria, based on laboratory and field testing, can materially reduce overdesign, waste, and cost. The members of the building construction industry should continue to encourage the development of criteria based on performance rather than the requirement that a specific product or system be used. They should also take steps to further the design of methods and systems based on these performance criteria. In addition, the industry needs to find the means for quicker acceptance of innovations in the marketplace as they occur.

1.2 Industry Standards

The building construction industry is made up of so many diverse interest groups that it has not been possible to develop a single comprehensive set of criteria or standards acceptable to all concerned. In addition, groups that are more intimately involved in a product or construction system are generally best qualified to establish standards for them. The result is myriad organizations that establish standards.

Before beginning a discussion of construction industry standards, it is necessary to clarify some terms. There is much confusion in the industry about the use of the terms *specifications*, *standards*, and *codes*. Unfortunately, the three are often erroneously used interchangeably, which can lead to some confusion. Specifications are discussed in Section 1.6, codes in Section 1.3. In the sense that they are a detailed, precise description of a product or practice, some construction industry *standards* could be called *specifications*, and some are so called by their producers. Some of the manufacturers' data that designers, builders, and owners rely on are also specifications in the dictionary sense, and those data are sometimes called *specifications* by the manufacturers. But calling either of them *specifications* sometimes leads to confusion. Therefore, this book refers to construction industry standards as *standards* and manufacturers' data as *product descriptions* or *product literature*. Unless specifically modified in the text, the term *specification* is used in its narrow construction industry sense, as defined in Section 1.6.

1.2.1 TYPES, OBJECTIVES, AND USES OF STANDARDS

When selecting materials or determining the suitability of materials and methods, specifiers and builders refer to a variety of *industry standards*. These are also sometimes called *reference standards*.

1.2.1.1 Types of Standards

Some standards result from the efforts of manufacturers, professionals, and tradespeople to simplify and increase the efficiency of their work or to ensure a minimum level of quality. Other standards are the work of governmental agencies and other groups interested in establishing minimum levels of safety and performance. Therefore, standards take a variety of forms, depending on their source and purpose.

MATERIAL STANDARDS

Standards that define the properties of a material are called *material standards*. For example, these include standards for extruded aluminum bars, rods, shapes, and tubes or for a particular type of steel item. They usually specify the constituents of a material, its physical properties, and its performance under stress and varying climatic conditions.

PRODUCT STANDARDS

The requirements of a specific product, such as aluminum windows, are defined by *product standards*. These often define terms, classify constituent materials, and state acceptable thicknesses, lengths, and widths. They may also spell out the acceptable methods of joining separate materials, of fabricating various parts of a product, or of assembling systems.

DESIGN STANDARDS

Design standards define the requirements for sound design using a particular material, product, or system. They are published by such organizations as the American Concrete Institute (ACI), the Architectural Woodwork Institute (AWI), and the U.S. Department of Housing and Urban Development (HUD).

WORKMANSHIP STANDARDS

Workmanship standards are standards for installing materials, products, and systems. ASTM International (formerly the American Society for Testing and Materials) (ASTM) produces many of these.

TEST METHOD STANDARDS

Test method standards spell out acceptable criteria for testing materials and systems. Again, ASTM is a prime producer of standards of this type.

1.2.1.2 Objectives of Standards

Construction standards have two basic objectives: (1) to establish levels of quality that may be recognized by a user, specifier, approver, or buyer of a material, product, or system and (2) to standardize or simplify such variables as dimensions, varieties, and other characteristics of specific products so as to minimize variations in manufacture and use.

1.2.1.3 Uses of Standards

Construction standards are used by manufacturers, specifiers, consumers, communities, and others. Standards may be used and referred to either separately or within collections, such as in the HUD *Minimum Property Standards for Housing*. Standards may also be incorporated into municipal or state building codes by inclusion or reference. Such larger works may have broader objectives than to act only as construction standards. Codes, for example, are concerned basically with minimum acceptable standards of public health, safety, and welfare; the HUD *Minimum Property Standards for Housing* establishes minimum requirements of design and construction for the insurance of mortgage loans. Standards are often incorporated by reference into construction document specifications to help establish requirements for materials, equipment, finishes, and workmanship for a particular construction project.

1.2.2 PRIVATE INDUSTRY STANDARDS

Standards are established by two kinds of private industry organizations: trade associations and standards-setting and testing agencies.

1.2.2.1 Trade Associations

Manufacturers, tradespeople, and suppliers, working through *trade associations*, prepare most private industry standards. Some trade associations are called *societies* or *institutes.* A *trade association* is an organization of individual manufacturers or businesses engaged in the production, supply, or installation of materials or services of a similar nature. A basic function of a trade association is to promote the interests of its membership. Those interests generally are best served by the proper use of the groups' materials, products, and services. The proper use of building materials and methods is guided largely by the development of suitable levels of quality for their manufacture, use, and installation. Some of the most important activities of trade associations are directed toward research into the use and improvement of materials and methods, and toward formulating performance standards. In many instances, trade associations also sponsor programs of certification in which labels, seals, or other identifiable marks are placed on materials or products manufactured to particular standards.

STANDARDS-SETTING TRADE ASSOCIATIONS

Many trade associations engage in developing standards for materials and products their members manufacture and services they perform. APA–The Engineered Wood Association, is an example of a trade association active in developing standards. This association is supported by a large membership of manufacturers producing softwood plywood, oriented strand board, gluelam, I-joists, siding, laminated veneer lumber, and other engineered wood products. The production of various types and grades of these products requires the selection and classification of wood veneers and other components according to strength and appearance. For example, producing plywood from various veneers demands careful manufacturing control of such factors as moisture content and adhesive type. The completed product, properly assembled, bonded, and finished, must conform to a body of material standards, manufacturing procedures, and performance testing standards.

Engineered wood products manufacturers, through their own research and combined efforts within the APA, financially and technically support the research and development of criteria that the association formulates into industry standards. The members of the association then agree to produce products that conform to these standards.

TRADE ASSOCIATIONS STANDARDS AS A BASE FOR OTHER STANDARDS

The standards developed by trade associations often are adopted by or used as a base from which other groups, such as the American National Standards Institute (ANSI), may develop standards. For example, industry standards may be promulgated as *ANSI standards*, which are often incorporated into the HUD *Minimum Property Standards for Housing* or building codes.

CERTIFICATION

Many trade associations and other industry groups provide assurance that established standards have been met by materials and manufactured products. Certification of quality may take the form of *grademarks*, labels, or *seals*. For example, the APA maintains a continuing program of product testing during and after manufacture, with grade markings applied directly to plywood. A grademark is a visible statement that the appropriate APA product standard has been met.

The reliability of certifications issued by manufacturers or their associations varies. Some are excellent. Others are worthless. The most reliable certification is one issued by an *independent testing agency*.

1.2.2.2 Standards-Setting and Testing Agencies

In addition to trade associations, organizations have been established whose primary purpose is the setting of standards or the testing of materials and products to ensure that they comply with established standards. When a material or product is compliance tested by its manufacturer, its trade association, or an independent testing agency, a *testing standard* produced by one of the agencies discussed in this subsection is often used as the standard for the testing procedure.

ASTM INTERNATIONAL

ASTM International (ASTM) is an international, privately financed, nonprofit, technical, scientific, and educational society. The objectives of the society are "the promotion of knowledge of the materials of engineering, and the standardization of specifications and methods of testing." ASTM membership consists of individual engineers, scientists, and educators, as well as organizational members, including companies, government agencies, and universities. Technical committees formulate and recommend ASTM standards covering many types of materials; a number of administrative committees deal with publications, research, testing, consumer standards, and other activities. The society is supported mainly by membership dues, with some income from the sale of publications.

ASTM started in 1898 as the American Section of the International Society for Testing Materials. It was incorporated in 1902 and became the American Society for Testing Materials. In 1961, the name was changed to the American Society for Testing and Materials to emphasize its interest in basic information about materials. The name was recently again changed and is now ASTM International.

Two general categories of information and publications are available from ASTM: (1) *ASTM standards*, which include definitions of terms, materials standards, workmanship standards, and methods of test standards used throughout the industry, and (2) data dealing with research and testing of materials, including monthly and quarterly publications and technical publications that cover symposia and collections of data.

ASTM standards are designated by the initials ASTM, followed by a code number and the year of last revision. For example, ASTM C55-03 refers to ASTM Document C55, "Standard Specification for Concrete Brick," as last revised in 2003.

AMERICAN NATIONAL STANDARDS INSTITUTE

American National Standards Institute (ANSI) is the name adopted by the United States of America Standards Institute (USASI) in October 1969. USASI was created in 1966 by the complete reorganization of the earlier standards organization, the American Standards Association (ASA). ASA was founded during World War I to prevent duplication and waste in war production. In 1918 five leading American engineering societies, including the American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers (ASCE), and ASTM, and three departments of the federal government, Commerce, War, and Navy, formed the American Engineering Standards Committee to coordinate the development of national standards. This committee was reorganized in 1928 into the American Standards Association, which was later incorporated into USASI and subsequently renamed ANSI.

More than 3000 American National Standards have been developed and approved under ANSI procedures. These standards apply in the fields of engineering, industry, safety, and consumer goods.

An American National Standard is designated by the code number and date of the last revision; for example, ICC/ANSI A117.1-2003, "Accessible and Usable Buildings and Facilities." Unlike ASTM, ANSI does not formulate its own standards or provide testing services. Instead, one part of ANSI, composed of national trade, professional, and scientific associations, establishes and maintains procedures for the approval of standards developed by other associations, agencies, or groups as American National Standards. In this way, a standard developed by a trade association, such as the American Architectural Manufacturers Association (AAMA), can become an American National Standard.

A second part of ANSI consists of representatives of industrial firms, labor, and government. The two parts work closely together to recommend areas of standardization deemed essential and to review standards.

ANSI is privately financed by voluntary membership dues and from the sale of the published American National Standards. These national standards are available for voluntary use and often are incorporated in regulations and codes.

UNDERWRITERS LABORATORIES, INC.

Underwriters Laboratories, Inc. (UL) is chartered as a nonprofit organization to establish, maintain, and operate laboratories for the examination and testing of devices, systems, and materials. The stated objectives of UL are (1) to determine the relation of various devices, systems, and materials to life and property and (2) to ascertain, define, and publish standards, classifications, and specifications for materials, devices, products, equipment, constructions, methods, and systems affecting hazards to life and property.

UL, formed in 1894, was originally subsidized by stock insurance companies. Before the turn of the twentieth century, as new electrical devices and products came rapidly into the market, it became necessary to test and inspect them to ensure public safety. The National Board of Fire Underwriters (now the American Insurance Association) organized and sponsored UL to meet this demand.

UL became self-supporting in about 1916. To sustain its testing program, UL contracts with a product submitter for testing, reporting, and listing of devices, systems, or materials on a time and material basis. The cost of the inspection service is provided for either by an annual fee or by service charges for labels, depending on the type of service. Materials and products carrying UL labels and certificates must meet published standards of performance and manufacture and are subjected to UL inspection during manufacture.

Although primarily interested in public safety, UL's policy is to list and label only products that perform their intended function. If a product does not perform with reasonable efficiency, even though it may be perfectly safe, it does not qualify for a UL label. UL standards are designated by the initials UL, followed by a code number. No date of last revision is indicated by the number. For example, UL 70, "Septic Tanks, Bituminous Coated Metal," was issued in 2001.

NAHB RESEARCH CENTER

The NAHB Research Center is a wholly owned subsidiary of the National Association of Home Builders. Its objectives are as follows:

1. To conduct and disseminate the results of research and development with respect to homes, apartments, and light commercial structures for the purpose of lowering the cost and improving the quality of buildings constructed by the U.S. homebuilding industry
2. To conduct, for itself or by contract for others, tests and investigations into and on materials, products, systems, and other matters related to the design, construction, or occupancy of homes and other buildings
3. To encourage lower construction costs and improved quality in the design and construction of residential and related structures
4. To provide a system for labeling materials and products, and to grant a seal or certificate of quality or similar device

The NAHB Research Center was founded in 1964 as an expansion of the NAHB Research Institute, which was founded in 1952. The Research Center's activities have included the design and construction of a number of "research houses" that incorporated new methods and materials. The Research Center also developed the successful TAMAP system, which marked the first time that industrial engineering techniques were used to improve productivity in the design and construction of new homes.

The Center has also carried out product, standards, and systems research, development, and evaluation studies for many homebuilding industry manufacturers and associations. The Center is thereby supported by its clients, including the National Association of Home Builders, a number of building industry manufacturers, trade associations, and other organizations. The Center's laboratories include a broad range of facilities that can conduct ASTM standard tests, vibration studies, acoustical measuring, and temperature-humidity control testing.

NATIONAL FIRE PROTECTION ASSOCIATION

The National Fire Protection Association (NFPA) was organized in 1896 to promote the science and advance the methods of fire protection. NFPA is a nonprofit educational organization that publishes and distributes various publications on fire safety, including model codes, materials standards, and recommended practices. These technical materials, aimed at minimizing losses of life and property by fire, are prepared by NFPA Technical Committees and are adopted at the annual meeting of the Association. All are published as National Fire Codes, a 12-volume compilation of NFPA's official technical material. *The National Electrical Code* is Volume 3.

THE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS

Since 1894, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) and its predecessor societies have pursued their objective of advancing the arts and sciences of heating, ventilating, and air conditioning buildings. ASHRAE conducts an extensive research program, publishes meeting transactions, and establishes standards.

ASHRAE standards are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing heating, ventilating, and air conditioning equipment and systems, and by providing other information that may serve to guide the industry. The creation of ASHRAE standards is determined by need. Conformance is voluntary.

ASHRAE standards are updated on a 5-year cycle; each title is preceded by a hyphenated number. The digits before the hyphen are the standard's numerical designation; the digits after the hyphen are the year of approval, revision, or update. For example, ASHRAE Standard 90.1-2001 (SI edition)—"Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA cosponsored; ANSI approved; Continuous Maintenance Standard), SI Edition"—describes a standard of designation 90.1, approved in 2001.

ASHRAE has developed standards not only in the traditional areas of heating, ventilating, and air conditioning equipment, but also on such diverse subjects as fire safety in buildings, energy conservation, solar energy, pollution control, and ozone depletion.

1.2.3 FEDERAL GOVERNMENT STANDARDS

Many federal agencies either develop standards themselves or commission their development by other federal agencies or private-sector organizations.

1.2.3.1 Department of Commerce

Manufacturers seek to encourage product acceptance and improve their own efficiency by establishing basic levels of quality for materials and products and by coordinating dimensions, terminology, and other variables such as type and style.

Manufacturers cannot legally agree to establish unreasonable standards that might rule out the success of individual competitors, nor can they engage in price-fixing agreements. Therefore, in recognition of the desirability of certain types of industry-supported standardization, the U.S. Department of Commerce provides for the development of Product Standards.

VOLUNTARY PRODUCT STANDARDS

Voluntary Product Standards (PS) are the modern replacement for the older Commercial Standards (CS) and Simplified Practice Recommendations (SPR), previously published by the Department of Commerce.

Voluntary PS are developed by manufacturers, distributors, and users in cooperation with the Standards Services Division of the National Institute of Standards and Technology (NIST). The purpose of a PS may be either (1) to establish standards of practice for sizes, dimensions, varieties, or other characteristics of a specific product or (2) to establish quality criteria, including standard methods of testing, rating, certifying, and labeling of the manufactured products.

The adoption and use of a PS are voluntary. However, when reference to a PS is made in contracts, labels, invoices, or advertising literature, the provisions of the standard are enforceable through usual legal channels as a part of the sales contract.

A PS usually originates with the manufacturing segment of the industry. The sponsors may be manufacturers, distributors, or users of the specific product. One of these three elements of industry (the *proponent*) submits to the Standards Services Division the necessary data to be used as the basis for developing a PS. The Division, by means of assembled conferences, letter referenda, or both, assists the sponsor group in arriving at a tentative standard of practice and thereafter refers it to the other elements of the same industry for approval or for constructive criticism that will be helpful in making necessary adjustments. The regular procedure of the Division ensures continuous servicing of each PS through review and revision whenever, in the opinion of the industry, changing conditions warrant such action.

A Voluntary PS is designated by the letters PS, followed by an identification number and the last two digits of the year of issuance or last revision. For example, PS 1-95 is the PS for "Construction and Industrial Plywood." It was originally issued in 1966 as the first PS. A list of PSs, currently available, a price list, and ordering instructions may be obtained from the Standards Services Division, NIST. Procedures for the development of Voluntary PS are available from the Standards Coordination and Conformity Group of NIST.

1.2.3.2 General Services Administration

The General Services Administration (GSA) of the U.S. government develops *Federal Standardization Documents*, including *Federal Specifications*, *Interim Federal Specifications*, and *Federal Standards*, through the cooperation of federal agencies and industry groups. The purpose of these documents is to standardize the variations and quality of materials and products being purchased by governmental agencies. Approximately 5600 Federal and Interim Federal Specifications have been developed by the GSA. The *Index of Federal Specifications, Standards and Commercial Item Descriptions*, which lists those documents alphabetically by title and numerically, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, and is also available at the GSA Web site.

FEDERAL SPECIFICATIONS

In the pure sense of the dictionary definition, Federal Specifications can be called specifications. According to the definitions we are using in this book, however, and according to the standard practices of the construction industry, even on projects for the government, they are actually used as standards. They are not permitted, for example, as a part of a *project manual* for a building construction project, except by reference. It is not possible to enter Federal Specifications intact into a project manual, and editing them for this purpose is neither permissible nor desirable. However, since the GSA calls them specifications and this terminology is generally accepted in the building industry, we will accede to this convention.

A new Federal Specification is developed when a government procurement need arises, when a present specification becomes obsolete, or when revision is required for other reasons. Although Federal Specifications are gradually being replaced by industry standards, such as those promulgated by ASTM, Federal Specifications are still referenced in government guide specifications and are the only standards available for some products. In addition, Federal Specifications are still referenced by some product manufacturers even when industry standards are available. There may come a day when Federal Specifications are no longer used in the construction industry, but that day has not yet arrived.

The GSA may assign the development of a particular Federal Specification to a federal agency that has specialized technical competence and the necessary facilities. However, nationally recognized industry, technical society, and trade association standards, such as those by ASTM, are used and adopted in Federal Specifications to the maximum extent practicable.

Federal Specifications are designated by a letter and number code. For example, A-A-3130A Paint (For Application to Wet Surfaces) 13-Jun-2003 is the Federal Specification for a particular type of paint. The term Federal Specification is often abbreviated as Fed. Spec. or simply FS.

1.2.3.3 Military Agencies

The federal government is one of the world's largest buyers of equipment, materials, and supplies, with annual purchases in the billions of dollars. Various departments within the Department of Defense have developed specifications covering materials, products, and services used predominantly by military activities.

Military Specifications may be used by any interested civilian organization or specifier. Military Specifications are indexed by the title and code letter prefix MIL.

1.2.3.4 Department of Housing and Urban Development

The National Housing Act, enacted by Congress in 1934 and amended from time to time, created the Federal Housing Administration (FHA) to stimulate home construction by insuring mortgage loans. The functions of this agency were transferred by Congress in 1965 to the newly created Department of Housing and Urban Development (HUD), and FHA became part of this larger cabinet-level department.

The overall purpose of HUD is to assist in the sound development of the nation's communities and metropolitan areas. Encouragement of housing production through mortgage insurance and various subsidies has been one of HUD's chief objectives. Improvement in housing quality and in land planning standards has been another HUD objective mandated by Congress.

FHA/HUD HOUSING PROGRAMS

FHA/HUD makes no loans, nor does it plan or build housing. It functions mainly as an insuring agency for mortgage loans made by private lenders, such as savings associations and commercial banks. For instance, through the Section 203(b) program, FHA/HUD encourages lenders to make loans with low down payments and long maturities on one- to four-family dwellings. The borrower pays an annual insurance premium of a small percentage of the average principal outstanding over the premium year. The Secretary of HUD sets the interest rate ceiling on FHA/HUD loans at a level required to meet market conditions. Another frequently used section, 221(d)(4), provides for mortgage insurance of new or rehabilitated low- or middle-income rental housing.

The traditional role of the FHA was transformed when the agency became the administrator of interest-rate subsidy and rent-supplement programs authorized by Congress since 1965. The Section 235 program combines insurance with interest assistance payments for owner-occupied homes. In addition to insuring the loan, FHA/HUD pays part of the interest the borrower owes the mortgage lender. Section 236 offers insurance and interest assistance for rental projects. Section 237 provides insurance on loans to borrowers with poor credit histories. Section 238 authorizes insurance for mortgage loans in high-risk situations, such as transitional urban areas, not covered by other programs.

HUD MINIMUM PROPERTY STANDARDS

Because not all housing programs authorized by Congress involve mortgage insurance, not all of them are administered by FHA/HUD. For instance, Section 8 of the Housing Act of 1974 authorizes rental subsidies for leased low-income housing. The housing may be existing or new and may be financed either conventionally or with FHA/HUD mortgage insurance. Before 1973, FHA-insured private housing had to conform to the FHA *Minimum Property Standards*, and subsidized public housing was regulated by a different set of standards. With the adoption in that year of the HUD *Minimum Property Standards* (MPS), uniform standards became applicable to all HUD housing programs.

The MPS were intended to provide a sound technical basis for the planning and design of housing under the numerous programs of HUD. The standards described those characteristics in a property that would provide initial and continuing utility, durability, desirability, economy of maintenance, and a safe and healthful environment.

Environmental quality was considered throughout the MPS. As a general policy, property development was required to be consistent with the national program for conservation of energy and other natural resources. Care had to be exercised to avoid air, water, land, and noise pollution and other environmental hazards.

The MPS consisted of three volumes of mandatory standards: (1) *MPS for One- and Two-Family Dwellings*, HUD 4900.1; (2) *MPS for Multifamily Housing*, HUD 4910.1; and (3) *MPS for Care-Type Housing*, HUD 4920.1. Variations and exceptions for seasonal homes intended for other than year-round occupancy were listed in HUD 4900.1. Exceptions for elderly housing were listed in HUD 4900.1 and 4910.1. A fourth volume, the MPS *Manual of Acceptable Practices*, HUD 4930.1, contained advisory and illustrative material for the three volumes of mandatory standards.

Today these documents have been withdrawn and replaced by a single document, HUD 4910.1, *Minimum Property Standards for Housing*. This document is intended to supplement the requirements of the applicable local and state building codes and the *International Residential Code* (see Section 1.3.3.3).

MATERIALS BULLETINS

The Architectural Standards Division of HUD issues *Use of Materials* bulletins for specific proprietary products or products that HUD engineers have investigated and found their performance to be acceptable. Each bulletin describes a product and its use and is issued to HUD field offices for guidance in determining the acceptance of the product.

The absence of a bulletin for a particular product does not preclude its use. Use of Materials bulletins are not intended to indicate approval, endorsement, or acceptance by HUD. Manufacturers of materials and products for which Use of Materials bulletins have been issued are not authorized to use them in any manner for sales promotion. Copies of Use of Materials bulletins are on file in HUD field offices but are not available for general distribution.

HUD has additional provisions for the review of special materials, products, and construction methods that it may be asked to insure. Design, materials, equipment, and construction methods other than those described in *Minimum Property Standards for Housing* are considered for use, provided that complete substantiating data satisfactory to HUD are submitted. Local HUD field offices are authorized to accept variations from the standards for specific cases, subject to conditions outlined in the standards.

Variations on an area or regional basis, or variations involving a substantial number of properties on a repetitive basis, are authorized only after consideration of recommendations by the HUD field office and approval by the Architectural Standards Division. Under certain conditions, some variations are established and published as Local Acceptable Standards (LAS) for a specific area.

1.2.4 EUROPEAN STANDARDS

In January 1993, 12 European countries joined economically into a *Single European Market* (SEM). In addition, the *European Community* (EC) is moving steadily toward the opening of borders and establishment of the free trade of ideas and goods between the member nations. These major changes in Europe will greatly affect trade and other relationships between the United States and the EC. They will also affect the U.S. building industry in many ways. One effect that will be greatly felt is the change in European standards. As a part of the establishment of SEM, the EC member states have deemed it necessary to unify each of their existing 12 separate groups of national standards into common European standards. The European Committee for Standarization (CEN) and the Committee for European Electrotechnical Standarization (CENELEC) have been charged with publishing standards for the EC member states.

The *International Organization for Standardization* (IOS) is a nongovernmental organization made up of representatives from the standards institutions of 91 countries. The United States is a member, represented by ANSI, but is not very influential there. IOS approves and publishes standards produced by its members. Most of those published by IOS are European standards.

The new EC standards will be based either on reconciling the differences between existing standards in the EC states or simply adoption of the IOS standards. The United States could exert greater influence in this area by increasing its involvement in IOS, but there seems to be little movement in that direction. Although development is in progress, single European standards for construction products do not yet exist. Until they do, EC member states will continue to enforce either their own standards or interim standards.

American firms doing work in Europe and U.S. products sold in Europe today have to comply with the standards of the country in which the work is being done. Eventually they will all have to comply with the unified EC standards. In the interim, there will be a morass of conflicting and possibly overlapping standards in the various countries. Some standards will be the old national ones, some will be the new EC standards, and others will be IOS standards. Probably the best first step of anyone contemplating working in the EC would be to contact the U.S. Department of Commerce Office of European Community Affairs for advice.

What eventual effect the new EC standards will have on U.S. standards is unknown at this point. There will probably be some changes in our standards relatively soon. Down the road, there may be extensive changes as the United States tries to compete economically with a unified Europe.

1.3 Codes

The planning, construction, location, and use of buildings are regulated by a variety of laws enacted by local, state, and federal governments. These statutes and ordinances include zoning, building, plumbing, electrical, and mechanical codes that are intended to protect the health, safety, and general welfare of the public. These codes incorporate many recognized construction industry standards (see Section 1.2), but they do not necessarily contain criteria that ensure efficient, convenient, or adequately equipped buildings.

A *zoning code* (see Section 1.3.2) establishes requirements for land use.

A *building code* (see Section 1.3.3) establishes requirements for the construction and occupancy of buildings. It contains standards of performance and requirements for materials, methods, and systems. It also covers structural strength, fire resistance, adequate light and ventilation, egress, occupant safety, and other considerations determined by the design, construction, alteration, and demolition of buildings.

A collection of building requirements becomes a code when it is adopted by a municipality as a public ordinance or law. Local communities may write their own codes or may legally adopt other codes, such as state building codes or one of the model codes (see Section 1.3.3.3).

1.3.1 HISTORY

Laws controlling building construction are not new. The ancient code of the Babylonian emperor Hammurabi, dating back to about 1800 B.C., is often cited as the first recorded building code. It provided severe penalties for construction practices that violated the health or safety of citizens. For example, if a building collapsed, killing the occupants, its architects and builders were put to death. This ancient code, based on the idea that the strong should not injure the weak, sets the principle for today's construction regulations: The public has a right to be protected from the harmful acts of others.

Modern building regulation evolved over time, starting in the early nineteenth century with the adoption of fire laws in some large cities. These laws prohibited the construction of wooden buildings in congested areas. At about the same time, cities also began to adopt health regulations to improve the living conditions of the poor, which were the forerunners of today's minimum housing codes. Some courts, however, resisted the enactment of such laws as infringements on personal property rights.

As the validity of fire and health laws was slowly established, courts began to accept governmental control of all aspects of building construction involving the health and safety of the public. Today most states and cities, and a great many counties and towns, regulate the planning, construction, and installation of building systems through a variety of laws and ordinances.

The right to regulate building construction constitutionally rests in the states, but before 1960 few state governments exercised that right. The states usually delegated to local governments the power to regulate buildings to protect public health, safety, and welfare. Today many states are taking an active role in building regulation. More than half of the states have now adopted some form of statewide building regulation concerned with the construction of industrialized buildings, mobile homes, and conventional construction.

Federal legislation in the areas of occupational health and safety, environmental protection, pollution controls, and consumer protection, coupled with increased state legislative activity, offer evidence that the building regulatory process will become ever more complex.

1.3.2 ZONING CODES

Zoning codes are developed, interpreted, enacted, and enforced by local jurisdictions (cities, counties, townships, etc.) to achieve the following:

- Promote the general welfare by ensuring adequate light, air, and convenience of access to buildings
- Provide for safety from fire, flood, and other dangers
- Reduce congestion in the public streets
- Create a convenient, attractive, and harmonious community
- Expedite adequate police, fire, and rescue protection
- Expedite emergency evacuation
- Provide adequate public facilities (schools, parks, playgrounds, etc.)
- Reduce encroachment on historic areas
- Protect against overcrowding of land
- Prevent undue density of population
- Encourage economic development

Zoning codes affect building design by controlling where building types may be located, both within their communities and on their particular sites. Zoning codes also restrict the size of buildings that can be built on a specific site and affect the shapes of buildings. Many high-rise buildings owe their shapes to zoning setback rules that require higher floors to be farther from the property line.

A typical zoning code contains specific requirements for the type of use that is permitted in individual zones within the community. The naming of zones differs from community to community. The following are zones included in the *International Zoning Code:*

Agricultural:

A-1, any so designated open space
A-2, any agricultural use
A-3, any public park land or other similar recreational use

Residential:

R-1, single-family
R-2, single-family and two-family
R-3, apartment and multiple-family dwelling

Commercial and Commercial/Residential:

C-1, general business
C-2, light commercial
C-3, amusement uses, wholesale and retail sales facilities
C-4, major commercial and manufacturing facilities
CR-1, uses permitted in C-1, plus some residential
CR-2, uses permitted in C-2, plus some residential

Factory/Industrial:

FI-1, light manufacturing or industrial
FI-2, stadiums, arenas, and light industrial
FI-3, heavy industrial

Special districts may also be established to control requirements for special-use zones, such as historic zones; wetlands; areas where flood damage is likely; architectural districts, where design appearance is controlled; planned development districts, where special rules apply, such as allowance of increased occupant density in exchange for leaving green areas; and water runoff restricted districts established to protect lakes, rivers, and bays. Typical restrictions in a zone include requirements such as those for:

- Permitted uses
- Building height
- Minimum lot size and street frontage length
- Minimum floor area
- Required yards (distance from a building to a property line in front, rear, and sides)
- Building setback (distance from the building to lot lines at each height above the ground, which often increases in cities as the building grows taller)
- Permitted types of accessory buildings and their permitted size and location
- Off-street parking and loading requirements
- Lighting of parking and other site areas
- Visual clearance on corner lots
- Swimming pools
- Site fences and walls

1.3.3 BUILDING CODES

The construction industry is enmeshed in an extraordinary network of building codes that attempt to ensure that buildings and their environs will be safe. They generally accomplish that purpose; however, codes and code administration are criticized widely as restricting building progress by retarding the acceptance of new and improved uses of materials and methods and thereby unnecessarily increasing construction costs. In some instances, the adoption of improved codes has stimulated better building practices. But the existing complex and chaotic building code situation is recognized as one of the problems facing the building industry today because of the use of descriptive-type codes (see Section 1.3.3.1), the lack of code uniformity, the multiplicity of codes, the slow response of codes to change, and inadequate performance standards in the codes (see Section 1.3.3.3).

The major building officials organizations and numerous federal, state, and local groups are constantly working to improve codes and the code regulatory system. The latest efforts center on standardizing the major model codes (see Section 1.3.3.3) into a single code for each discipline. This has currently been accomplished by the introduction in 2003 of the International Building Codes (see Section 1.3.3.3).

Some so-called codes are actually standards because they are voluntary and have no status in law. Only when standards are adopted by legislative bodies and incorporated into law do they become codes. In one sense, the model codes discussed in Section 1.3.3.3 are actually standards that have been adopted in many, but not all, jurisdictions as codes. Other examples of documents called codes that actually are not codes include various ANSI and NFPA codes.

Standards that are called codes by their producers often fall in the design standards category (see Section 1.2.1) but may encompass one or more of the other types.

Because some documents called codes are universally recognized as such, we will accede to that convention in this book. Therefore, publications such as ANSI A17.1, "Safety Code for Elevators and Escalators," NFPA 101, "Life Safety Code," and "National Electrical Code," are here called codes.

1.3.3.1 The Effect of Building Codes on Design

Building codes affect building design in a number of ways. One way is by limiting the construction type and size for each building use. Figure 1.3-1 is a table from the 2006 edition of the International Building Code. Similar tables are included in all the model codes (see Section 1.3.3.3). The table shown lists 26 *groups*. These groups are defined and described in the body of the code and are partially shown in the following list. The list is not all-inclusive.

Groups A-1 through A-5—assembly occupancies, such as theaters, art galleries, restaurants, assembly halls, and so forth
Group B—business occupancies, including buildings for office, professional, or service-type uses
Group E—educational facilities
Groups F-1 and F-2—factories
Groups H-1 through H-5—high-hazard facilities, such as those where the manufacture or storage of materials that constitute a physical or health hazard takes place
Groups I-1 through I-4—institutional facilities, including those for supervised residential environments, hospitals and other medical facilities, and prisons, jails, and other correctional and detention facilities
Group M—mercantile facilities including buildings used for the display or sale of merchandise
Groups R-1 through R-4—residential occupancies, including single-family and multifamily dwellings, apartments, hotels, and assisted living facilities
Group S-1 and S-2—storage facilities
Group U—utility and miscellaneous facilities, such as barns, carports, aircraft hangers, buildings that are accessories to dwellings, greenhouses, and private garages

TABLE 503
ALLOWABLE HEIGHT AND BUILDING AREAS[a]
Height limitations shown as stories and feet above grade plane.
Area limitations as determined by the definition of "Area, building," per story

		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
GROUP	HGT(feet) / HGT(S)	UL	160	65	55	65	55	65	50	40
A-1	S	UL	5	3	2	3	2	3	2	1
	A	UL	UL	15,500	8,500	14,000	8,500	15,000	11,500	5,500
A-2	S	UL	11	3	2	3	2	3	2	1
	A	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
A-3	S	UL	11	3	2	3	2	3	2	1
	A	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
A-4	S	UL	11	3	2	3	2	3	2	1
	A	UL	UL	15,500	9,500	14,000	9,500	15,000	11,500	6,000
A-5	S	UL	UL	UL	UL	UL	UL	UL	UL	UL
	A	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	S	UL	11	5	4	5	4	5	3	2
	A	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
E	S	UL	5	3	2	3	2	3	1	1
	A	UL	UL	26,500	14,500	23,500	14,500	25,500	18,500	9,500
F-1	S	UL	11	4	2	3	2	4	2	1
	A	UL	UL	25,000	15,500	19,000	12,000	33,500	14,000	8,500
F-2	S	UL	11	5	3	4	3	5	3	2
	A	UL	UL	37,500	23,000	28,500	18,000	50,500	21,000	13,000
H-1	S	1	1	1	1	1	1	1	1	NP
	A	21,000	16,500	11,000	7,000	9,500	7,000	10,500	7,500	NP
H-2[d]	S	UL	3	2	1	2	1	2	1	1
	A	21,000	16,500	11,000	7,000	9,500	7,000	10,500	7,500	3,000
H-3[d]	S	UL	6	4	2	4	2	4	2	1
	A	UL	60,000	26,500	14,000	17,500	13,000	25,500	10,000	5,000
H-4	S	UL	7	5	3	5	3	5	3	2
	A	UL	UL	37,500	17,500	28,500	17,500	36,000	18,000	6,500
H-5	S	4	4	3	3	3	3	3	3	2
	A	UL	UL	37,500	23,000	28,500	19,000	36,000	18,000	9,000
I-1	S	UL	9	4	3	4	3	4	3	2
	A	UL	55,000	19,000	10,000	16,500	10,000	18,000	10,500	4,500
I-2	S	UL	4	2	1	1	NP	1	1	NP
	A	UL	UL	15,000	11,000	12,000	NP	12,000	9,500	NP
I-3	S	UL	4	2	1	2	1	2	2	1
	A	UL	UL	15,000	10,000	10,500	7,500	12,000	7,500	5,000
I-4	S	UL	5	3	2	3	2	3	1	1
	A	UL	60,500	26,500	13,000	23,500	13,000	25,500	18,500	9,000
M	S	UL	11	4	4	4	4	4	3	1
	A	UL	UL	21,500	12,500	18,500	12,500	20,500	14,000	9,000
R-1	S	UL	11	4	4	4	4	4	3	2
	A	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
R-2	S	UL	11	4	4	4	4	4	3	2
	A	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
R-3	S	UL	11	4	4	4	4	4	3	3
	A	UL	UL	UL	UL	UL	UL	UL	UL	UL
R-4	S	UL	11	4	4	4	4	4	3	2
	A	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
S-1	S	UL	11	4	3	3	3	4	3	1
	A	UL	48,000	26,000	17,500	26,000	17,500	25,500	14,000	9,000
S-2[b, c]	S	UL	11	5	4	4	4	5	4	2
	A	UL	79,000	39,000	26,000	39,000	26,000	38,500	21,000	13,500
U[c]	S	UL	5	4	2	3	2	4	2	1
	A	UL	35,500	19,000	8,500	14,000	8,500	18,000	9,000	5,500

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2.
UL = Unlimited, NP = Not permitted.
a. See the following sections for general exceptions to Table 503:
1. Section 504.2, Allowable height increase due to automatic sprinkler system installation.
2. Section 506.2, Allowable area increase due to street frontage.
3. Section 506.3, Allowable area increase due to automatic sprinkler system installation.
4. Section 507, Unlimited area buildings.

b. For open parking structures, see Section 406.3.
c. For private garages, see Section 406.1.
d. See Section 415.5 for limitations.

FIGURE 1.3-1 From the 2006 *International Building Code.* Copyright ICC; reprinted with permission.

Figure 1.3-1 shows height and area restrictions for each of these groups, based on each of nine types of construction. The types of construction are also defined in the text of the code and are summarized in the following list.

Types I and II, A and B—construction in which the building groups listed in Figure 1.3-1 are of noncombustible construction

Types III, A and B—construction in which the exterior walls of buildings in the groups listed in the table in Figure 1.3-1 are of noncombustible construction, but interior elements may not be necessarily of noncombustible construction

Type IV—construction in which the exterior walls of buildings in the groups listed in Figure 1.3-1 are of noncombustible construction, and interior elements are of solid wood (heavy timber) construction

Type V, A and B—construction in which the building groups listed in Figure 1.3-1 are of any construction type permitted by the code, including that in which the building is constructed of wood and other combustible materials

As an example of the use of Figure 1.3-1, suppose that an architect has been commissioned to design a building that falls in group E, educational facilities, that is required to have 40,000 sq ft (3716 m^2) of area. The table shows that if the building is Noncombustible Type lA construction, the area and height are not limited by code (UL). Therefore, the building could be entirely on a single floor or built on five floors of 8000 sq ft (743 m^2) each.

Our example building can be also constructed of Type IB or IIA, but not of Type IIB, because we need 40,000 sq ft (3716 m^2) and IIB permits only two floors of a maximum 14,500 sq ft (1347 m^2) each, for a total of only 29,000 sq ft (2694 m^2). Our building could also be built of Type IIIA construction but not IIIB, or of Type lV but not Type V.

Codes further affect building design by controlling materials and methods of construction. This effect is illustrated in Figure 1.3-2, another table from the 2006 International Building Code. In this table, structural elements are listed down the left side and types of construction across the top. These types of construction are the same as those used in Figure 1.3-1. The figures at the intersection of the lines and columns are the hourly fire ratings of the assemblies in the left column for each construction type listed across the top of the table. For example, the floor construction in a Type lA building must have a 2-hour fire rating.

Building codes also restrict fire resistance ratings for exterior walls. Figure 1.3-3 is another table from the 2006 International Building Code. In this table, fire separation distances are listed in the far left column. Types of construction are listed in the second column. The rest of the columns list groups. The types of construction and groups are the same as those in Figure 3.3-1. To determine the required horizontal separation, enter the table knowing the building's type of construction and group and extend the combined line across the table to read the separation distance. Conversely, if the separation distance is known, the table will yield the required type of construction for the group into which the building falls.

Building codes also affect building design in other ways. Building codes are either descriptive or performance oriented. A *descriptive* (sometimes called *specification* or *prescription*) building code establishes construction requirements by reference to a particular material or method. For example, a code may require that exterior walls be built of 2×4 (50×100) wall studs spaced 16 in. (406.4 mm) on center and covered by 1-in. (25.4 mm)-thick board sheathing applied diagonally. A builder seeking to space studs at 24 in. (610 mm) on center, which may be structurally sound and safe, would be in violation of the specifically stated code requirements.

A *performance* code does not limit the selection of methods and systems to a single type, but establishes requirements for the performance of building elements. Such a code states design and engineering criteria without reference to specific materials or methods of construction. For example, an outside wall may be required to support loads (wind, dead, live, etc.) with specific defined values and to meet or exceed stated insulating and permeability requirements. Any system performing as required by the code would be acceptable, regardless of the materials or methods used.

True performance codes are idealistically excellent but impractical in use. To enforce them, local code administrators would have to be extraordinarily competent and equipped to interpret performance criteria and evaluate proposed methods, uses, and systems. Such people and equipment are rare. What's more, these decisions can be more readily challanged. A workable solution lies somewhere between descriptive and performance codes. Both types of codes should adequately provide for the acceptance of alternate methods and systems.

1.3.3.2 Building Code Enforcement

Local administration and enforcement of codes are usually done by a building inspector or engineer who has the authority to approve materials and methods that may not be directly referenced in the code. Qualified people are necessary to administer a building code properly. No matter how good a code may be, it must be enforced by someone who is experienced, informed, and objective. Builders complain about inspectors who do not understand construction and may thus be arbitrary and inconsistent. They are seldom upset by a careful and competent inspector who is consistent even though tough. A competent code enforcer knows when the letter of the code should prevail and when subjective interpretation should be made.

However, local code administrators, faced continually with difficult decisions, may well argue that their job is solely to check compliance. An often-drawn analogy is that a local policeman does not make judgments about whether a law is right or just, but is charged solely with determining compliance. Perhaps it is best that the determination of performance criteria and judgment as to whether methods and systems perform suitably must be made by technically qualified people and not by local code administrators. Members of the model code groups (see Section 1.3.3.3) are qualified to offer this type of service.

Model code groups, which are supported by building officials themselves, have performed a great service to the building industry. But model codes have not fully solved the problems of code uniformity. The reason is, partly, that even though most communities have adopted a model code, some have adopted them with modifications. The National Association of Home Builders (NAHB) has said that many of the changes related to housing made to model codes to adapt them to local conditions come from local

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (hours)

	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
BUILDING ELEMENT	**A**	**B**	**A[e]**	**B**	**A[e]**	**B**	**HT**	**A[e]**	**B**
Structural frame[a]	3[b]	2[b]	1	0	1	0	HT	1	0
Bearing walls Exterior[g] Interior	 3 3[b]	 2 2[b]	 1 1	 0 0	 2 1	 2 0	 2 1/HT	 1 1	 0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[f]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction Including supporting beams and joists	2	2	1	0	1	0	HT	1	0
Roof construction Including supporting beams and joists	$1^1/_2$[c]	1[c, d]	1[c, d]	0[c, d]	1[c, d]	0[c, d]	HT	1[c, d]	0

For SI: 1 foot = 304.8 mm.

a. The structural frame shall be considered to be the columns and the girders, beams, trusses and spandrels having direct connections to the columns and bracing members designed to carry gravity loads. The members of floor or roof panels which have no connection to the columns shall be considered secondary members and not a part of the structural frame.
b. Roof supports: Fire-resistance ratings of structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
c. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
d. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.
e. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.
f. Not less than the fire-resistance rating required by other sections of this code.
g. Not less than the fire-resistance rating based on fire separation distance (see Table 602).

FIGURE 1.3-2 From the 2006 *International Building Code.* Copyright ICC; reprinted with permission.

TABLE 602
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, e]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H	OCCUPANCY GROUP F-1, M, S-1	OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U[b]
$X < 5$[c]	All	3	2	1
$5 \leq X < 10$	IA Others	3 2	2 1	1 1
$10 \leq X < 30$	IA, IB IIB, VB Others	2 1 1	1 0 1	1[d] 0 1[d]
$X \geq 30$	All	0	0	0

For SI: 1 foot = 304.8 mm.

a. Load-bearing exterior walls shall also comply with the fire-resistance rating requirements of Table 601.
b. For special requirements for Group U occupancies see Section 406.1.2.
c. See Section 705.1.1 for party walls.
d. Open parking garages complying with Section 406 shall not be required to have a fire-resistance rating.
e. The fire-resistance rating of an exterior wall is determined based upon the fire separation distance of the exterior wall and the story in which the wall is located.

FIGURE 1.3-3 From the 2006 *International Building Code.* Copyright ICC; reprinted with permission.

codes prepared 20 or more years earlier. Sometimes, progressive time- and money-saving requirements of a model code are revised so that antiquated provisions apply instead, simply to agree with local custom.

1.3.3.3 Model Codes

Problems with code development, use, and enforcement occur for several reasons. Because establishing and enforcing building codes are local functions, a designer or builder who works in more than one community is often faced with a frustrating variety of requirements. A product manufacturer must win acceptance by thousands of local building code administrators, instead of concerning itself only with performance and public acceptance. Much effort has been made to unify the codes used by communities, and considerable improvement has been gained through the local adoption of model codes.

If designers and builders were dealing with a single code, their problems would be greatly simplified. However, in addition to adhering to local building codes that tell them how a structure must be assembled, they have to satisfy a number of other codes covering a variety of subjects such as plumbing, electrical wiring, traffic, utilities, health and sanitation, land planning, building occupancy, access by the handicapped, and zoning.

The lack of code uniformity and the multiplicity of additional regulations often so complicate matters that buildings are designed and built with the use of very conservative and often expensive criteria and methods. Designers and builders alike are often unable to improve their techniques because of the restrictive nature of one or more of the applicable codes.

Codes are often criticized for failing to recognize new materials and methods. Judging new products on the basis of performance criteria must be performed by technically qualified and equipped organizations.

This function is one in which model code groups can exercise great leadership and provide a major stimulus to progress. These groups have responded reasonably to progressive change. However, they are subject to many pressures that deter progress, and they have sometimes been slow in acting on proposed changes. For example, it took almost 4 years for all of the major code groups to accept the NAHB's proposal to eliminate floor bridging in most home building situations, a proposition well documented through extensive research and testing.

As discussed in Section 1.2, no single group of building industry standards exists. In selecting materials or determining the suitability of materials and methods, a specifier and a builder make reference to a variety of trade association certification programs, grademarks and trademarks, UL labels, and many other construction standards. There are independent testing agencies, such as UL, and standards-setting bodies, such as ASTM, and some manufacturers have substantial commitments in research and testing facilities, but no single agency is presently recognized by all groups interested in building construction.

To help fill the need for workable codes, three major organizations of industry and professional groups and states have developed building codes that may be adopted into law for use in local communities. These codes are commonly referred to as *model codes*. The major model code groups are the Building Officials and Code Administrators International (BOCAI), the International Conference of Building Officials (ICBO), and the Southern Building Code Congress International (SBCCI). The major national model codes and their sponsors are listed in Figure 1.3-4.

Model codes have been widely accepted by local communities and now are used by more than 80% of those communities with a population of more than 10,000. The organizations that prepare model codes have also provided for the continuous updating necessary to include recommendations based on industry research and the development of new materials and methods. Other model codes that deal with specialized subjects not fully covered in the major model codes are also available. Most of these codes and their sponsors are listed in Figure 1.3-4. Many local communities have also adopted these codes.

INTERNATIONAL CODE COUNCIL

For years, code developers and building industry practitioners have been talking about developing a single national building code, and these efforts may have actually reached a satisfactory conclusion. BOCA, SBCCI, and ICBO have joined together to create the International Code Council (ICC). ICC produces a series of international codes, which replace those codes produced by these three major model code groups. They also issue codes that replace other model codes, such as the One- and Two-Family Dwelling Code produced by the Council of American Building Officials (CABO). Other codes still are being produced (see Figure 1.3-4). Codes currently produced by ICC include the following *International Codes*™:

International Building Code®
International Residential Code®
International Existing Building Code®
International Fire Code®
International Mechanical Code®
International Plumbing Code®
International Fuel Gas Code®
International Property Maintenance Code®
International Energy Conservation Code®
International Zoning Code®
International Private Sewage Disposal Code®
International Urban-Wildland Interface Code™
ICC Electrical Code®
ICC Performance Based Code™

The first ICC codes appeared in 1995. The first edition of the *International Building Code* was published in 2000. These codes, like all others, must be adopted by local and state jurisdictions before they can have an effect. If history can be relied on, this will take some time. To date, the International Codes have been adopted in more than 75 jurisdictions: the *International Building Code* in 44 states and by the U.S. Department of Defense; the *International Residential Code* in 43 states plus Washington, D.C.; and the *International Fire Code* in 32 states. Although model codes are no longer being updated, they are discussed here because these older codes are still in effect in many jurisdictions. Sooner or later, all jurisdictions will need to adopt the ICC codes as the other model codes become obsolete. When this book refers to code-related data, the reference is to the ICC codes

NATIONAL BUILDING CODE

The first model building code was introduced in 1905 by the National Board of Fire Underwriters, later called the American Insurance Association (AIA). This organization was concerned primarily with public protection against fire hazards, and the original code was designed to guide communities in setting up fire

FIGURE 1.3-4 Model Building Codes and Their Sponsoring Organizations

Building Codes	Sponsoring Organization
International Building Code	International Code Council
International Residential Code	International Code Council
International Existing Building Code	International Code Council
National Building Code	Building Officials and Code Administrators International, Inc.
Standard Building Code	Southern Building Code Congress International
One- and Two-Family Dwelling Code	Council of American Building Officials
Electrical Codes	
National Electrical Code	National Fire Protection Association
Electrical Code for One- and Two-Family Dwellings	National Fire Protection Association
Elevator Codes	
Safety Code for Elevators and Escalators	American Society of Mechanical Engineers
Fire Prevention Codes	
International Fire Code	International Code Council
National Fire Prevention Code	Building Officials and Code Administrators International, Inc.
Uniform Fire Code	International Conference of Building Officials
Housing Codes	
International Property Maintenance Code	International Code Council
Property Maintenance Code	Building Officials and Code Administrators International
Standard Housing Code	Southern Building Code Congress International
Uniform Housing Code	International Conference of Building Officials
Plumbing Codes	
International Plumbing Code	International Code Council
International Private Sewage Disposal Code	International Code Council
National Plumbing Code	Building Officials and Code Administrators International
National Standard Plumbing Code	National Association of Plumbing-Heating-Cooling Contractors
Standard Plumbing Code	Southern Building Code Congress International
Uniform Plumbing Code	International Association of Plumbing and Mechanical Officials
Mechanical Codes	
International Mechanical Code	International Code Council
International Fuel Gas Code	International Code Council
National Mechanical Code	Building Officials and Code Administrators International
Standard Gas Code	Southern Building Code Congress International
Standard Mechanical Code	Southern Building Code Congress International
Miscellaneous Codes	
International Energy Conservation Code	International Code Council
International Zoning Code	International Code Council
International Urban-Wildlife Interface Code	International Code Council
Boiler and Pressure Vessel Code	American Society of Mechanical Engineers
Flammable and Combustible Liquids Code	National Fire Protection Association
Safety Code for Mechanical Refrigeration	American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
Life Safety Code	National Fire Protection Association

safety standards. With subsequent additions, however, its National Building Code laid the groundwork for the development of building codes throughout the country. AIA produced its last edition of the *National Building Code* in 1976. In 1950, BOCAI published the *Basic Building Code*. When AIA ceased publishing the *National Building Code*, BOCAI picked it up and, until recently, has published it since. BOCAI also published the other codes listed for it in Figure 1.3-4. BOCAI is no longer updating these codes.

STANDARD BUILDING CODE

SBCCI drafted the *Southern Standard Building Code* in 1945. Renamed the

Standard Building Code, this model code is designed to recognize the special problems, such as high winds, in the southern region of the country and is used extensively in this area. SBCCI also published the other codes listed for it in Figure 1.3-4. BOCAI is no longer updating these codes.

UNIFORM BUILDING CODE

In 1927, ICBO (initially the Pacific Coast Building Officials Conference) published its *Uniform Building Code*. This code gained wide acceptance, particularly in the West. ICBO also published the other codes listed for it in Figure 1.3-4. It copublished the *Uniform Fire Code* and the *Uniform Fire Code Standards* with the Western Fire Chiefs Association. ICBO also jointly published the *Uniform Mechanical Code* with the International Association of Plumbing and Mechanical Officials. The most recent edition of these codes was published in 1997.

NATIONAL STANDARD PLUMBING CODE

The *National Standard Plumbing Code* is sponsored by the Plumbing-Heating-Cooling Contractors Association (PHCC). The *National Standard Plumbing Code* covers the proper design, installation, and maintenance of plumbing systems according to principles of sanitation and safety, but not necessarily for efficiency, convenience, or adequacy for good service or future expansion of system use. Standards for materials and fixtures are based largely on industry standards such as Commercial Standards, American Standards, and ASTM standards.

UNIFORM PLUMBING AND UNIFORM MECHANICAL CODES

The Western Plumbing Officials Association (now the International Association of Plumbing and Mechanical Officials [IAPMO]) established the first *Uniform Plumbing Code* in 1929 and continues to publish it today. IAPMO also publishes the *Uniform Mechanical Code*. These codes cover the design, installation, and maintenance of plumbing, heating, and air conditioning systems. Materials and equipment standards are based largely on other industry standards. These codes have gained widespread use in the western states, as well as in other communities across the country.

NATIONAL ELECTRICAL CODE

The *National Electrical Code* is produced by the NFPA. Its purpose is to ensure the safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity for light, heat, power, and other purposes. The code contains basic minimum provisions for safety which, with proper maintenance, will result in installations free from hazard, but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use. The *National Electrical Code* makes reference to many industry standards, such as ANSI/ASME A17.1, and to UL labels. It is revised periodically and is adopted by reference into many building codes and federal and state laws and regulations.

LIFE SAFETY CODE

The *Life Safety Code* began in 1912 with a pamphlet entitled *Exit Drills in Factories, Schools, Department Stores and Theaters* and has evolved over the years to cover most building types. It is published by the NFPA to establish minimum requirements for a reasonable degree of safety from fire in structures. It addresses requirements for egress; design and construction that will prevent undue danger from fire, smoke, and gases; fire detection and alarm systems; and automatic sprinklers and other fire extinguishing systems. It includes requirements for building design and construction and for heating, ventilating, air conditioning, and electrical systems

ONE- AND TWO-FAMILY DWELLING CODE

In 1971, the American Insurance Association, BOCA, ICBO, and SBCCI adopted a consensus code entitled the *One- and Two-Family Dwelling Code*. This model code is now published by the ICC as the 2006 *International Residential Code*.

The *International Residential Code* contains requirements for building planning and construction, including requirements for heating, cooling, and plumbing. HUD requires compliance with the *International Residential Code* in addition to its own *Minimum Property Standards for One- and Two-Family Dwellings* and local and state building codes for consideration for HUD/FHA loan guarantees.

Publication of this single national model code for one- and two-family dwellings constituted a significant step toward uniform minimum regulations in the housing industry, but it still has not been recognized and adopted by every state and local government.

1.3.4 NATIONAL ENERGY CODES

In the United States, energy consumed in buildings amounts to about one-third of all energy consumption. Building energy consumption has been increasing rapidly for many years. The U.S. Department of Commerce's earlier estimate, that energy consumption would increase by 25% between 1984 and the year 2000, appears to have been fairly accurate. That increase represents an annual growth rate of 1.14% for housing and 1.66% for commercial use. Slowing the rate of increase through increased efficiency in building systems design can significantly reduce overall energy demand.

The *National Energy Plan* calls for substantial decreases in energy consumption through conservation. A major element of an energy conservation program is enforcement of thermal efficiency standards and insulation requirements in new and renovated buildings by state and local governments.

The National Conference of States on Building Codes and Standards (NCSBCS) in 1973 requested the National Bureau of Standards (NBS) (now the National Institute of Standards and Technology [NIST]) to develop standards that could be used by all states for energy-efficient design in new buildings. NBS completed these standards in 1974, but they were considered too complex for most state and local code enforcement officials to administer. As a result, NCSBCS requested ASHRAE to translate the NBS standards into enforceable language.

In 1975, ASHRAE published its Standard 90-75, "Energy Conservation in New Building Design." This standard was the first nationally recognized standard for energy-efficient design applicable to all building types. It was, however, written for use by design engineers. State and local practitioners still needed a document that could be administered through the traditional code enforcement system. In 1976, NCSBCS translated ASHRAE Standard 90-75 into the Model Code for Energy Conservation in New Building Construction. Under a grant from the Energy Research and Development Administration (now the Department of Energy), NCSBCS worked with building officials from all parts of the country who administer model codes so that the Model Code for Energy Conservation would be applicable to all geographic areas in the country and could be incorporated easily into existing codes. The NCSBCS Model Code for Energy Conservation in New Building Construction was published in January 1977.

The *Energy Policy and Conservation Act* (EPCA) became law in 1975. The law provided for substantial grants to those states that developed and implemented statewide energy conservation plans aimed at reducing statewide energy consumption 5% by 1980. State energy conservation plans had to include at least five elements: (1) mandatory lighting efficiency standards for public buildings, (2) programs to promote the availability and use of car pools and van pools, (3) mandatory standards and policies related to procurement practices of state and local governments, (4) a traffic law that permits a right turn on red after stopping, and (5) mandatory thermal energy standards and insulation requirements for new and renovated buildings.

In 1976, Congress passed the *Energy Conservation and Production Act* (ECPA). Title III of ECPA contained the following provisions: (1) HUD is directed to develop performance-oriented thermal energy efficiency standards, (2) HUD is to monitor the progress of state and local governments in implementing the standards, and (3) if a substantial amount of new housing is not constructed in conformance with the standards, HUD can recommend to the Congress that the standards be made mandatory. If Congress concurs:

1. All construction assisted by federal money will have to be consistent with the standards. This will include federal grants, loans, and loan guarantees and will apply to all savings and loan associations that are federally insured.
2. Local governments will not be required to incorporate the standards into their building codes. HUD and the states will be responsible for ensuring that all proposed construction is in conformance with the standards. However, local governments that elect to adopt the standards will be reimbursed for the cost of the certification.
3. If a local government incorporates the federal standards into its codes, then no further approvals will be required. Money will be available to communities to assist them in incorporating and enforcing the federal standards.

Current requirements for insulation are addressed in Section 7.3. The currently accepted standards for energy conservation and thermal design criteria are discussed in Chapter 17.

1.3.5 CODE ADVANCEMENT

The growing complexity of building design and construction and the subsequent increase of regulatory controls have induced several organizations to improve the effectiveness of the regulatory process with better code documents, administration, and enforcement.

1.3.5.1 National Institute of Building Sciences

The Housing and Community Development Act of 1974 authorized the creation of the National Institute of Building Sciences (NIBS). NIBS was initiated by the federal government with the assistance of the National Academy of Science and the National Academy of Engineering Research Council to help improve the way building construction is regulated. NIBS gives the United States a national center for (1) assembly, storage, and dissemination of technical data and related information on construction, (2) development and promulgation of nationally recognized performance criteria, standards, test methods, and other evaluating techniques, and (3) evaluation and prequalification of existing and new building techniques.

1.3.5.2 Council of American Building Officials

In 1972 the governing bodies of BOCAI, ICBO, and SBCCI established the Council of American Building Officials (CABO). CABO's policies are determined by a board of trustees composed of representatives of the governing bodies of the member organizations.

Examples of CABO's work include (1) advancing the *One- and Two-Family Dwelling Code* as a recognized national standard through the procedures of ANSI, (2) sponsoring the development of model performance standards that will complement the requirements of model codes, (3) sponsoring a national research activity that provides a single approval agency for manufacturers of building components, systems, and materials, (4) developing and adopting a model mechanical, plumbing, and fire prevention code as the standard for all three organizations, and (5) establishing ICC to implement a single group of international codes to replace all the model codes in current use.

1.3.5.3 Associated Major City Building Officials

In 1972 building code officials from the nation's 20 largest cities created an organization called Associated Major City/County Building Officials (AMCBO). Its purpose is to exchange ideas, experience, and information on the growing complexities of code administration and enforcement in densely populated urban areas.

1.3.5.4 National Conference of States on Building Codes and Standards

NCSBCS was formed in 1967. The organization is composed of state delegates designated by their respective governors to represent the 50 states in discussions and programs pertaining to building regulation; state and local building officials; various representatives of the building industry's design, manufacturing, and construction sectors; federal government officials; and consumers. It has affiliations with governmental agencies, such as NIST and the Consumer Product Safety Commission. Its members participate in the activities of many organizations, including CABO, BOCAI, ICBO, SBCCI, NFPA, ASHRAE, HUD, NIBS, the American Institute of Architects (AIA), ANSI, the Council of State Community Affairs Agencies (COSCAA), and ASTM.

NCSBCS was established to (1) provide a forum for states to discuss and develop solutions to code regulatory problems, (2) promote adoption and administration of uniform building codes and standards that regulate construction in and between states, (3) create an effective voice for state input on the committees of nationally recognized standards-writing organizations, (4) support comprehensive training and educational programs for code enforcement personnel, and (5) foster cooperation and encourage innovation between code administration officials and the design, manufacturing, and consumer interests affected by the code regulatory system.

1.4 Barrier-Free Design

As related to building design, a *physically handicapped* person is an individual who has a physical impairment, including impaired sensory, manual, or speaking abilities, that results in a functional limitation in gaining access to and using a building or facility.

Until recently, most of the buildings, facilities, transportation systems, and other structures and spaces in which we work, play, and live (the built environment) were designed for use by average, able-bodied, young adults who walk without aid or assistance (ambulatory). People who were older, younger, smaller, taller, or who had physical handicaps were at a disadvantage in most places. Many buildings were inaccessible to them, and some were even dangerous. Fortunately, this picture is rapidly changing.

Physical conditions that make a building or facility unsafe or confusing or that prevent physically handicapped people from using them are called *architectural barriers*. *Barrier-free*, or *accessible*, design eliminates or avoids creating such barriers. Barrier-free design is frequently thought of as a way to accommodate a few special people called the *handicapped.* The wheelchair symbol, used to designate public parking spaces, toilets, telephones, and water fountains, tends to foster the belief that barrier-free design offers accessibility mainly to those in wheelchairs. Actually, barrier-free design benefits everyone, because it makes facilities safer and more convenient to use.

Barrier-free design benefits not only the physically handicapped, but also (1) children who are physically and mentally immature, (2) pregnant women who have reduced agility, stamina, or balance, (3) people who care for children and must carry them, hold their hands, or maneuver their baby carriages, (4) older people who may suffer progressive degeneration of physical, perceptual, and mental faculties, (5) those disabled by size-related disorders such as giantism, dwarfism, or obesity, (6) able-bodied people who suffer temporary illness or injury, and (7) even able-bodied people who are carrying large packages.

Some people are born with a limited or unusable physical, mental, or sensory function (*disability*), but even a normally able-bodied person can become either temporarily or permanently disabled at any moment as the result of an illness or injury. *Disabilities* include visual impairment, hearing impairment, mental or perceptual impairment, confinement to a wheelchair, and coordination disability.

Nationwide, about 22% of those between the ages of 15 and 64 and about 59% of those 65 and older are disabled to some degree. That adds up to about 20% of the total population over 15 years old, or more than 37 million disabled people. Some sources put the number of disabled people at more than 43 million. It is most likely that the percentage of disabled people will rise in the future, because many people today survive illnesses and injuries that were once fatal. In fact, the average life span has increased dramatically during the twentieth century. In addition, the U.S. population as a whole is getting older. The number of people more than 65 years old is projected to grow from a little more than 10% of the total population in 1986 to more than 20% by 2040.

This section divides barrier-free design into four broad categories: (1) safety, (2) general accessibility criteria applicable to all buildings, (3) recommendations applicable to buildings for people with specific disabilities, and (4) requirements for making buildings adaptable for future use by the handicapped.

1.4.1 THE LAW AND APPLICABLE STANDARDS

In the late 1950s, the *President's Committee on Employment of the Handicapped* joined with consumer groups, such as the *National Easter Seal Society*, and standards makers to develop standards for making buildings accessible to handicapped persons. The result was ANSI A117.1, which was first published in 1961 by the American Standards Association (now ANSI). ANSI A117.1 quickly became, and remains today, a major standard for design for the handicapped. It is a voluntary standard, of course, having force only when adopted by a governing body.

In 1968, Congress passed the *Architectural Barriers Act*, which required that access for the handicapped be achieved in accordance with standards to be established by the GSA, HUD, and the Department of Defense (DOD). The rules they developed established ANSI A117.1 as the generic standard of access for buildings owned or leased by the federal government. Enforcement, however, was spotty at best. As a result, Congress passed the Rehabilitation Act of 1973, which established the *Architectural and Transportation Barriers Compliance Board* (ATBCB) to enforce the Architectural Barriers Act. The ATBCB issued a document called *ATBCB Minimum Guidelines and Requirements*.

The various states followed the federal government in passing laws requiring that buildings be made accessible to the handicapped. Unfortunately, many of them did not require compliance with ANSI A117.1 or with the *ATBCB Minimum Guidelines*, but rather developed their own standards. In an attempt to gain wider acceptance, ANSI expanded and reissued A117.1, but it still failed to gain universal acceptance. To make matters even more complicated, different federal agencies required compliance with different editions of ANSI A117.1.

In 1984, in the midst of all this confusion, GSA, HUD, DOD, and the U.S. Postal Service jointly issued the *Uniform Federal Accessibility Standard* (UFAS). Its purpose was to cause all federal agencies to follow the same technical requirements for complying with the Architectural Barriers Act. It was based on the *ATBCB Minimum Guidelines* but incorporated the basic requirements of ANSI A117.1 with some changes and additions.

As a result, various agencies of the federal government were requiring compliance with four different standards, two versions of ANSI A117.1, UFAS, and the *ATBCB Minimum Guidelines*. In some states, those four were being used in addition to the state's own standards. Some states actually require compliance with more than one standard. Even at the federal level, compliance with more than one was required by some agencies.

Gradually the two major standards have become the latest edition of ANSI A117.1, which at the time of this writing was ICC/ANSI A117.1-2003, "Standard on Accessible and Usable Buildings and Facilities," for private sector work and the UFAS for federal government work, although the others mentioned are still required by some state and local authorities. More than half of the states have adopted some version of ANSI A117.1 or incorporated it into their own standards. The International Codes, all model codes, and the NFPA 101 *Life Safety Code* incorporate or reference some edition of ANSI A117.1.

The *Federal Fair Housing Act of 1988, Title VIII of the 1968 Civil Rights Act*, prohibits housing discrimination based on a physical handicap in housing projects with four or more dwelling units. Basically, it says that everything in such dwelling units must be adaptable for accessibility by the handicapped, and all public areas serving such dwelling units must be accessible. Compliance must be in accord with the *Final Fair Housing Accessibility Guidelines* published in the Federal Register on March 6, 1991.

The *Americans with Disabilities Act* of 1990 prohibits discrimination on the basis of disability in places of employment, public service (transportation facilities), or in public accommodations (restaurants, hotels, theaters, doctors' offices, retail stores, museums, libraries, parks, private schools, day care centers, and others), and in telecommunications services. The standards developed by the ATBCB to implement this law differ slightly from and expand on ICC/ANSI A117.1 and the UFAS but may ultimately incorporate one or the other as the basis of the new standard.

The recommendations in this section come from many sources, but most of them comply with the requirements of ICC/ANSI A117.1, the *Uniform Federal Accessibility Standards*, the HUD *Minimum Property Standards for Housing*, and the HUD document *Adaptable Housing*. Keep in mind that there are some differences between these standards, and that state and local requirements may contain some other differences. In addition, these standards and the *Fair Housing Accessibility Guidelines* issued in conjunction with the *Federal Fair Housing Act of 1988* are subject to modification at any time. Therefore, when dealing with an actual project, whether for a federal or state agency or for a private sector owner, it is necessary to determine the specific requirements of the project and local, state, and federal laws and ordinances that dictate the requirements for accessibility.

Rules for providing accessibility have developed slowly and will no doubt continue to expand and change as more is understood about the needs of handicapped people. Until a single standard emerges, it is a mistake to follow any one standard alone, or any edition of a standard, before verifying the actual requirements. It is necessary also to remember that both the Federal Fair Housing Act of 1988 and the Americans with Disabilities Act of 1990 are civil rights laws rather than code compliance laws. Accordingly, it is best to comply with their spirit and not try to circumvent their intent. In the event of a compliance dispute, a court is likely to favor the intent of the law rather than the wording of the standards with which it requires compliance.

1.4.2 SAFETY

Many accidents in buildings can be traced to obvious causes, such as slippery floors, the lack of grab bars, or inappropriate or faulty stair railings. Accident prevention requires elimination of these obvious causes as well as other measures. Floors that are likely to get wet, such as those of approach walkways, stoops, entryways, corridors, toilet rooms, bathrooms, shower rooms, locker rooms, and kitchens, should have slip-resistant surfaces. Throw rugs and area rugs should not be used in public spaces; where they are appropriate, they should have a nonslip backing.

1.4.2.1 Doors and Sidelights

Safety glazing consisting of tempered glass, laminated glass, or plastic should be used in all glazed or glazing-insert doors and sidelights. Most building codes and regulations require such glazing.

Rounded door and jamb edges or resilient door edges minimize injury to fingers.

1.4.2.2 Stairs

To help reduce the many accidents that occur on stairs, (1) the number of risers in a series should be at least three, because people are careless on fewer, (2) treads and risers should be uniform, (3) treads should be no less than 11 in. (280 mm) wide, measured from riser to riser, and should have a slip-resistant surface, and (4) risers should be not more than 7 in. (180 mm) high and should be closed.

NOSINGS

Nosings should project not more than $1^1/_2$ in. (38 mm), and their undersides should be rounded. The radius at the leading edge of the tread should not be greater than $1^1/_2$ in. (13 mm).

HANDRAILS

Handrails should run continuously along both sides of a stairway, extend parallel to the floor at least 12 in. (305 mm) beyond the top and bottom of the staircase, and be free of protrusions that might snag clothing. Rails should be securely mounted at a height of 30 to 34 in. (815 to 865 mm) from the floor. If children regularly use the stairs, an extra railing should be mounted at a height of 24 in. (610 mm) from the floor. The space between balusters, if present, should be no more than 5 in. (127 mm) since wider spacings may allow a child's head to become trapped.

LANDINGS

Because long flights of stairs can be tiring, a landing should be provided for flights with more than 16 risers.

1.4.2.3 Toilet Rooms, Bathrooms, Shower Rooms, Locker Rooms

Most accidents in toilet rooms, bathrooms, shower rooms, and locker rooms involve falls caused by slipping or burns caused by scalding.

WATER

A person can receive a third-degree burn in just 2 seconds in 150°F (6°C) water, 6 seconds in 140°F (65.6°C) water, and 30 seconds in 130°F (54.4°C) water. Many people have limited sensitivity to heat and may not be able to adequately gauge the temperature of water in a lavatory, sink, tub, or running shower. Others may not be able to react quickly enough to a sudden surge of hot water.

To prevent scalding, the temperature of hot water should be regulated by (1) setting the temperature of the heated water to below 115°F (40.6°C), (2) providing a temperature-regulating device on tub fillers and shower heads, or (3) providing a temperature-regulating device on the hot water supply lines. The use of either individual fixture-mounted temperature controls or a temperature-regulating device on supply lines is preferred because other uses, such as dishwashing and clothes washing, require temperatures from 120°F (48.9°C) to 140°F (60°C). Fittings are available that can be set to maintain a specific water temperature either at the fixture or at the supply pipe.

In addition, exposed hot water supply and drain pipes should be wrapped with insulation to prevent contact burns.

SHOWERS AND TUBS

Nonslip strips should be provided on the bottom surfaces of tubs and showers. Soap dishes, tub fillers, and controls should be recessed so that users cannot fall on them.

GRAB BARS

Firmly mounted grab bars should be placed in and near tubs and showers and adjacent to water closets to help wheelchair users transfer from the chair to the fixture and to help those with other disabilities and the elderly get up and down and maintain their balance.The width of a grab bar gripping surface should be $1^1/_4$ to $1^1/_2$ in. (32 to 38 mm). The shape of the bar should allow a natural grip. There should be no protrusions or rough surfaces to catch clothing or cause injury.

Bars should be spaced with $1^1/_2$ in. (38 mm) clearance from the wall to allow proper grasping but prevent the arm from slipping behind the bar.

1.4.2.4 Kitchens

Kitchen accidents, such as burns and falls, can be reduced by proper planning.

APPLIANCES

More accidents are related to cooktops and ranges than to any other kitchen appliance. To prevent such injury, cooktop and range *controls* should be front- or side-mounted so that a cook does not have to reach over hot burners to adjust them. When dwelling residents include small children, controls should be out of sight on a horizontal surface and should either have a protective lid or require an extra movement, such as pushing, before a control can be turned to activate a burner. Electric cooktops should be equipped with a light to indicate that burners are on.

CABINETS

Reaching for cabinets above refrigerators requires standing on a stool, which presents a falling hazard. Reaching for cabinets over cooktops or stoves may cause burns. Therefore, placing cabinets over refrigerators and stoves is not desirable.

1.4.2.5 Protruding Objects

Objects, such as telephones, located between 27 and 80 in. (685 and 2030 mm) above a finished floor should not project more than 4 in. (100 mm) into a room or circulation path (see Section 1.4.3.1). Objects mounted at or below 27 in. (685 mm) may project any amount because they are detectable by a moving cane. Free-standing objects mounted between 27 and 80 in. (685 mm and 2030 mm) on posts or pylons may overhang a maximum of 12 in. (305 mm). No projection should reduce the clear width of an accessible route or maneuvering space.

When objects project into circulation spaces, a change in texture or a contrast in color of the floor surface can serve as a warning. Such warning devices should, however, be used with discretion, because overuse will diminish their effectiveness.

1.4.2.6 Lighting

Sufficient glare-free lighting should be available everywhere to meet the varying intensity needs of different tasks and to eliminate dark shadows that may conceal hazards. Changes in light intensity should be gradual so as to give the eyes time to adjust.

The paths people follow to get from one place to another in the built environment are called *circulation paths* (see Section 1.4.3.1). Good, glare-free lighting in circulation paths, especially those in potentially hazardous areas such as stairways, is particularly important in the creation of a safe environment.

1.4.3 GENERAL ACCESSIBILITY

An *accessible* site, building, facility, or portion thereof is one that complies with current standards and can be approached, entered, and used by physically handicapped people.

1.4.3.1 Accessible Route

A *circulation path* is an exterior or interior way of passage from one place to another for pedestrians, including, but not limited to, walks, hallways, courtyards, stairways, and stair landings.

An *accessible route* is a continuous, unobstructed circulation path connecting every accessible element and space in a facility that can be negotiated by a person with a severe disability using a wheelchair and that is also safe for and usable by people with other disabilities.

1.4.3.2 Site Planning

Barrier-free design should include the planning of accessible site facilities. Individuals with disabilities should have as much freedom of movement outside as inside.

Barrier-free buildings demand barrier-free routes of access, including (1) convenient parking, (2) accessible walks and curb ramps, (3) suitable paving, and (4) logical organization.

Direct routes should be provided into a building from public transportation, parking lots, and passenger loading zones.

PARKING

Parking spaces and passenger loading zones for people with disabilities should be located as close as possible to an accessible entrance and should be identified by the *international symbol of accessibility* (Fig. 1.4-1). If an accessible entrance cannot be seen from the parking area, signs should direct users to it.

Accessible parking spaces should be at least 96 in. (2440 mm) wide and have an adjacent access aisle at least 60 in. (1525 mm) wide. Two adjacent spaces may share one access aisle. Passenger loading zones should have an access aisle at least 48 in. (1220 mm) wide and 20 ft (6100 mm) long, adjacent and parallel to the vehicle pull-up space.

Curbs between access aisles and walks should have *accessible curb cuts* and *curb ramps*, as described in a following section, "Curb Ramps."

FIGURE 1.4-1 International symbol of accessibility.

WALKS

Walks and other access paths should be at least 36 in. (915 mm) wide for single passage and 60 in. (1525 mm) wide for passing. Paths that are less than 60 in. (1525 mm) wide should have periodically spaced areas where a pedestrian or wheelchair user can move over to allow passing. The clear *passage space* should not be reduced by protruding objects.

Walks should be smooth and nonslip, with gaps of not more than $^1/_4$ in. (6 mm) and level changes of not more than $^1/_2$ in. (13 mm) (see Section 1.4.3.4). Textural changes should warn users of level changes, projecting objects, and other hazards.

CURB RAMPS

Curbs define and separate walks from vehicular traffic areas. A *curb ramp* is a short ramp cutting through a curb or built into it to remove barriers for wheelchair travel. There should be a curb ramp whenever an accessible route crosses a curb and the path changes level more than $^1/_2$ in. (13 mm).

Curb ramps should be at least 36 in. (915 mm) wide and should not project into vehicular traffic (Fig. 1.4-2c), unless there is a *safety zone* on the roadway. Their slope should be 1:12 or less.

If anyone must cross perpendicular to a curb ramp, the side should be flared at a maximum slope of 1:10 (see Fig. 1.4-2a) or protected by planting strips or some other nonwalking surface (see Fig. 1.4-2b).

Curb ramps should be of a different texture than the surrounding passage to warn visually handicapped users of hazards. This *textural warning* area should extend for the entire width and depth of the curb ramp

PLANTING STRIPS

Figure 1.4-3 shows typical *planting strips*. These strips are a good way to keep protruding objects and street furniture from intruding on a clear accessible path. Planting strips can be combined with benches to provide convenient resting places for the elderly or for those with limited stamina (see Fig. 1.4-3b). Hazards should be marked with *detectable warnings*, as recommended in Section 1.4.4.1.

LIGHTING

Proper illumination is just as important outdoors as it is indoors. Weatherproof fixtures should provide a minimum of 5 footcandles (53.82 lx) of light on the travel surfaces at entrances, ramps, and steps. Weatherproof surface or post lights or floodlights should provide 1 footcandle (10.76 lx) and at least $^1/_2$ footcandle (5.38 lx) of light along paths of travel and in parking areas.

ORGANIZATION AND ARCHITECTURAL HARMONY

Frequently used public spaces inside and outside a building should be easy to find and use. Elements that make buildings

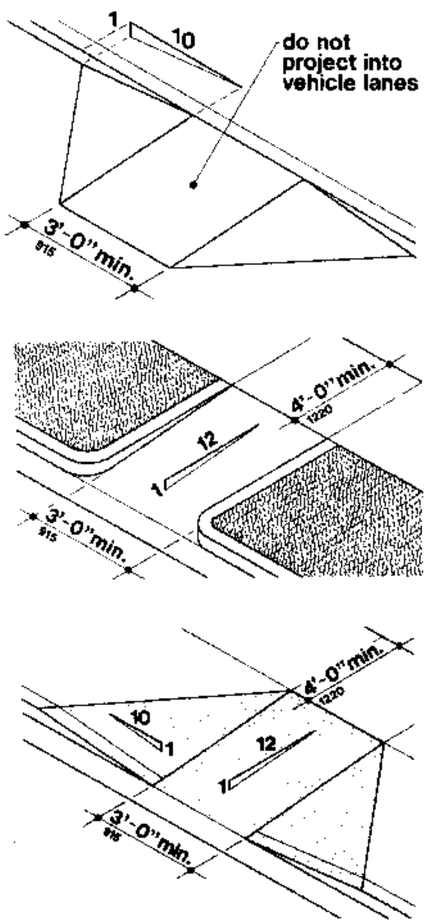


FIGURE 1.4-2 Curb ramps may either (a) start at the curb or walkway and project into the roadway or (b and c) be curb cuts.

a b

FIGURE 1.4-3 (a) Planting strips help organize and separate street furniture from the pedestrian path. (b) Rest areas may be integrated with planting strips to provide convenient stopping places outside the circulation path.

FIGURE 1.4-4 An attractively landscaped, fully accessible space provides a pleasant meeting area for everyone.

accessible, such as ramps, curb ramps, and signs, should blend harmoniously with other building elements. Careful design and site development in new construction can often reduce the need to add special elements that single out the handicapped. For example, a single-level building with appropriately sized doors and grade-level entrances would require no ramps, elevators, platform lifts, or special entrances.

Landscaping also contributes to the site (Fig. 1.4-4). Care should be taken to choose plants that do not obstruct the view or leave excessive debris in walkways. Use of poisonous and thorny plants should be avoided.

1.4.3.3 Entries and Passageways

Entries should be at grade level or made accessible by means of elevators or lifts (see Section 14.1). Doorways should have a minimum clear opening of 32 in. (815 mm) with the door open 90 degrees, measured from the face of the door to the opposite stop.

Hallways and corridors should be at least 36 in. (915 mm) wide. Where a door opens into a corridor, the corridor should be 54 in. (1370 mm) wide. Corridors where wheelchair users must pass each other or where wheelchairs must turn around should be 60 in. (1525 mm) wide.

1.4.3.4 Ramps

Passageways and walks are said to *blend to a common level* when their various portions meet in such a way that there is no abrupt rise or drop in the surface. Level changes up to $^{1}/_{2}$ in. (6 mm) high need no edge treatment; those between $^{1}/_{4}$ in. (6 mm) and $^{1}/_{2}$ in. (13 mm) should be beveled with a slope no greater than 1:2. Level changes greater than $^{1}/_{2}$ in. (13 mm) require a ramp in order to be accessible by wheelchair users (Fig. 1.4-5) and to provide easier passage for those who must use crutches, canes, or walkers. Ramps are the primary means by which wheelchair users enter buildings that do not have level entryways.

A *ramp* is a walking surface in an accessible space that has a running slope greater than 1:20. A *running slope* is the slope of a pedestrian way that is parallel to the direction of travel. Conversely, a *cross slope* is the slope of a pedestrian way that is perpendicular to the direction of travel.

Ramp slopes should be as gradual as possible. The maximum slope should be 1:12, but more permissive ramp dimensions are sometimes allowed for existing construction where space limitations prevent the use of this preferred slope. The maximum rise for a ramp is 30 in. (760 mm); minimum clear width is 36 in. (915 mm).

Level *landings* at least as wide as the ramp itself and at least 60 in. (1525 mm) long should be provided at the top and bottom of each ramp. Landings are also necessary at intermediate levels where the rise of a ramp exceeds 30 in. (760 mm). If a ramp changes direction, the landing should be a minimum of 60 by 60 in. (1525 by 1525 mm). The width of the platform at a *switch-back ramp* should be at least as wide as the width of the two ramp portions plus the width of the space between them (Fig. 1.4-6).

The surfaces of ramps and landings should be *slip resistant* and should not collect water. Their edges should have

FIGURE 1.4-5 Ramps can be made to blend with other building elements.

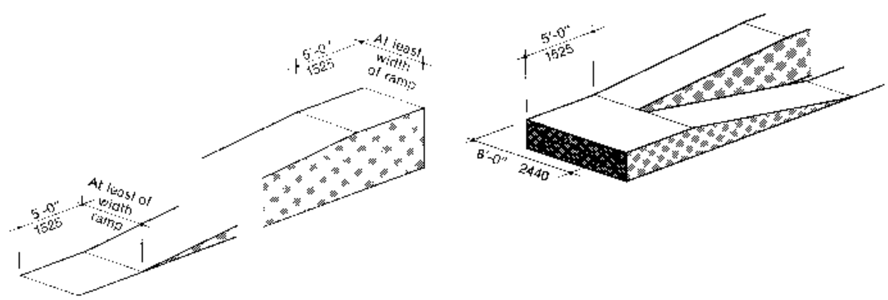


FIGURE 1.4-6 Layouts and sizes of flat platforms at ramps. For clarity, railings are not shown.

curbs, walls, railings, or other protection to prevent people from falling.

Handrails should be provided on both sides of ramps that rise more than 6 in. (150 mm) or are longer than 72 in. (1830 mm). Handrails should (1) extend at least 12 in. (305 mm) beyond the top and bottom of a ramp, (2) be parallel with the ramp, (3) have a clear space of $1\frac{1}{2}$ in. (38 mm) between the handrail and any adjacent wall, and (4) be 30 to 34 in. (760 to 865 mm) above the ramp surfaces. Inside handrails on switch-back or *dogleg ramps* should be continuous.

Because many handicapped people find it easier to negotiate stairs than ramps, both should be provided in buildings with an above-ground-level entry.

1.4.3.5 Stairs

Stairs should comply with the requirements stated in Section 1.4.2. In addition, there should be *detectable warnings* (see "Texture" in Section 1.4.4.1) at least 36 in. (915 mm) wide at the top of every stair run. Stairs should have closed risers of uniform height, treads should be slip resistant, and nosings should not be square or abrupt.

Steps and landings should have sharp color contrasts to help people with limited sensitivity to light and dark and limited depth perception. It is also helpful if the edge of a stair contrasts with the rest of the tread.

1.4.3.6 Signage

Signage is defined as verbal, symbolic, and pictorial information presented in a graphic, two-dimensional format.

Informational and warning signs should be easy to find and to read; that is, (1) they should be positioned as close as possible and perpendicular to the path of travel, (2) the information on them should contrast with the background, and (3) they should be made of glare-free materials.

Signage should also have a consistent format or use *international symbols*.

LOCATION AND VIEWING DISTANCE

Most people can see within an angle of 30 degrees to either side of the centerline of their faces without moving their heads. People with disabilities often have limited head movement or reduced peripheral vision. Therefore, signs should be positioned as close as possible and perpendicular to the path of travel. Signs close enough to touch should be positioned for easy hand detection by a standing person, 54 to 60 in. (1372 to 1524 mm) from the floor.

The distance from which a sign will be read determines the size of the letters, numbers, and symbols used on it.

DESIGN AND PROPORTION OF LETTERS, NUMBERS, AND SYMBOLS

Letters and numbers should be of sans serif (block) type and should be sized and proportioned as recommended in Figure 1.4-7.

Characters on signs that must be read from a distance should be large enough to be read easily from the maximum viewing distance expected. Characters on signs close enough to touch should be raised at least $^1/_{32}$ in. (0.8 mm) from their background. They should also be at least $^5/_8$ in. (16 mm) tall, but no taller than 2 in. (50 mm), and have a stroke width of at least $^1/_4$ in. (6 mm) in order to be easily detectable by one finger (Fig. 1.4-8).

The raised characters on each sign close enough to touch must be accompanied by grade 2 Braille. *Braille* is a special raised touch alphabet for the blind that uses a cell of six dots. Unfortunately, only about 10% of those with visual impairments can read braille, but raised Arabic symbols can be read by anyone, regardless of visual handicap. To aid those who can read it, braille characters in the standard dot size and spacing may be added to the left of standard characters.

Borders, which may confuse a reader with a visual impairment, are not recommended on signs.

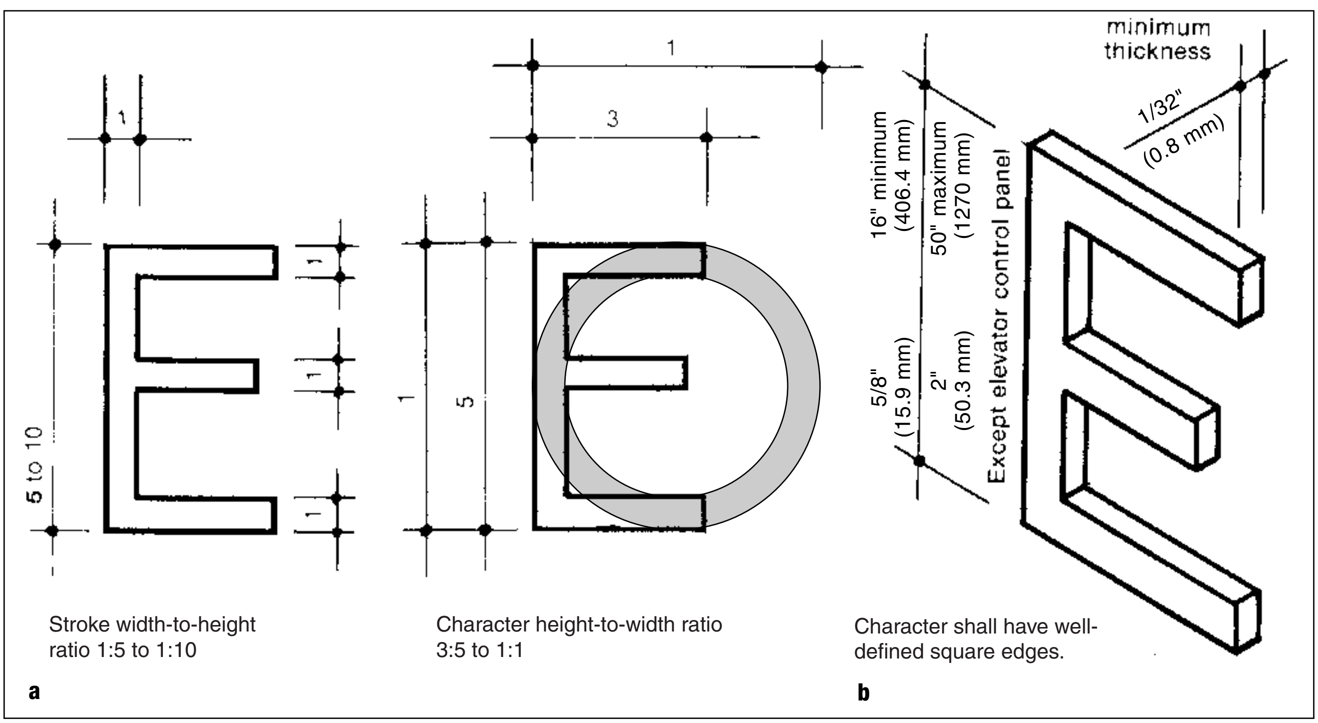


FIGURE 1.4-7 (a) Proportions of letters expressed as a ratio; (b) dimensions of letters for signs close enough to be touched.

FIGURE 1.4-8 A sign with raised lettering can be read by both those with normal sight and those with visual impairments.

COLOR CONTRAST

The background and characters on a sign should contrast. Dark characters may be used on a light background, but light characters on a dark background are more easily readable. Surfaces should be glare free.

1.4.3.7 Surfaces

Floor surfaces should be nonslip. When practicable, they should be carpeted to add the advantage of noise reduction, which helps those who must use hearing aids.

Carpet should (1) be securely attached, (2) have either a firm backing or no backing, and (3) have a pile height not in excess of $^1/_2$ in. (13 mm) so that it remains usable by those in wheelchairs. Shag carpets should be avoided. Carpets should be of *antistatic* materials or treated to be static free, because static electricity interferes with hearing aid operation. Humidifiers may be used to help control static electricity. Exposed carpet edges should have carpet trim along the entire carpet length.

1.4.3.8 Electrical

Electrical outlets should be centered at least 15 in. (380 mm), and preferably 24 in. (610 mm), above the floor.

The best height for wall switches is centered 48 in. (1220 mm) above the floor, but they should never be placed higher than 54 in. (1370 mm) above the floor. Where persons in wheelchairs will approach from a forward position, as is the case when switches are located over counters with knee spaces, switches should be centered between 36 and 40 in. (915 and 1016 mm) above the floor. In no case should switches and outlets over counters be placed more than 48 in. (1220 mm) above the floor.

Lighting should be as described in Sections 1.4.2 and 1.4.3.2.

1.4.4 SPECIFIC HANDICAPS

The kinds of specific handicaps discussed in this section include (1) *visual impairments*, (2) *hearing impairments*, (3) *mental and perceptual impairments*, (4) *disabilities* that require the use of a wheelchair, and (5) *coordination disabilities*.

Designs that *remove barriers* for people with one kind of disability sometimes *create barriers* for those with a different type of disability. For example, curb ramps (see Fig. 1.4-2) installed to permit easy street crossings for wheelchair users can cause a person with a visual impairment to wander unknowingly into automobile traffic. Both environmental needs can be met by providing a textured pavement that will act as a warning to those with visual impairments but will not impede wheelchair travel.

The recommendations in Sections 1.4.2 and 1.4.3 apply to spaces for those with specific handicaps, but the more demanding provisions discussed in this section are also necessary to accommodate specific disabilities.

1.4.4.1 Visual Impairment

Only about 10% of those with visual disabilities are totally blind. Legal blindness is usually defined as vision at or below 20/200. Some of those with visual disabilities have impaired peripheral vision; others cannot distinguish light and dark; some cannot perceive the full spectrum of colors.

Many people who have a visual impairment rely on memory instead of their eyes. They use a long cane, a guide dog, or other devices such as an *infrared detector* as aids for traveling to specific destinations. These destinations have often been explored with the help of someone with sight. Dwelling units may need little adaptation, because those with visual impairments become familiar with their surroundings.

Persons with visual impairments learn to rely to a certain extent on *tactile response* (touch). A *tactile object* is one that can be perceived using the sense of touch.

SIGNAGE

The proper type of signage is a very important means of communication for visually handicapped people. This signage should follow the rules set down in Section 1.4.3.6.

TEXTURE

A *cue* is a device that alerts a handicapped person to an upcoming condition. Cues may be *audible*, *visual*, or *textural*. A cue that consists of a standardized surface texture applied to or built into a walking surface or other element, to warn visually impaired people of a hazard in the path of travel, is called a *detectable warning*.

Detectable warnings help those with visual impairments to avoid hazards such as automobile traffic, level changes, and physical obstacles. Detectable warnings on walking surfaces include (1) exposed aggregate concrete, (2) rubber or plastic cushioned surfaces, (3) raised strips, and (4) grooves. Textures used for warning should contrast with surrounding surfaces but should be uniform in design within any building or site. Grooves should be used indoors only. Handles on doors leading to hazardous areas (such as spaces housing mechanical equipment) should be knurled or roughened as a warning.

OBSTACLES

Benches and other obstacles in the direct path of travel should be surrounded by detectable warnings to aid those with visual impairments, unless the obstacles are encircled by other indicators such as curbs (Fig. 1.4-9).

FIGURE 1.4-9 The textured surface around the planter and the bench serves as a warning to those with visual impairments.

PROJECTIONS

Many people with severe visual impairment use white canes to aid their mobility. However, the cane technique is useful only if hazards are detectable. Refer to Section 1.4.2 for requirements related to projecting objects.

SOUND

An *audible cue* is a sound or verbal alert. These are other means of helping those with visual impairments. Audible alarms should be incorporated into emergency warning systems. Alarm signals should be at least 15 decibels (dB) louder than the room's normal sound level but should not exceed 120 dB.

1.4.4.2 Hearing Impairment

There are more than 13,000,000 people in the United States with partial or total hearing loss. Just as sound compensates those with visual impairments for the loss of sight, visual cues help those with hearing impairments to make up for their loss.

WARNING AND INDICATION LIGHTS

Emergency signals, such as fire and burglar alarms, should have *visual* as well as *audible warning systems*. These should be located so that the signal or its reflection is clearly visible and should flash with a frequency of not more than 5 cycles per second (Hz).

Elevator *directional lights* should be at least $2^1/_2$ in. (63 mm) in the smallest dimension and should be mounted at least 72 in. (1830 mm) above the floor. Refer to Section 14.1 for additional requirements.

SOUND

Control of background noises and amplification of sound can help those with partial hearing loss to communicate.

For hearing aids to function properly, reduction of background noise, including reverberation, and control of sound frequencies are important. Use of ultrahigh-frequency sound security systems and low-cycle electric transformers should be avoided. Further information may be found in Section 13.1 and in Chapter 18.

Wheelchair-accessible telephones and 25% of all other telephones must be fitted with adjustable volume controls and other devices. Such telephones in public areas must be identified as such (Fig. 1.4-10a).

Text telephones (TTYs) are required in some locations. Where TTYs are required by the applicable standard (ICC/ANSI 117.1 or USAF) in public areas, they must be identified by a sign bearing the international TTY symbol (Fig. 1.4-10b).

a b

FIGURE 1.4-10 (a) Sign identifying a volume-adjustable telephone for those with hearing impairments; (b) international TTY symbol. (From CD-ROM version 3.0 of Architectural Graphic Standards. Courtesy John Wiley & Sons, Inc.)

1.4.4.3 Mental and Perceptual Impairment

Clear signage and good organization are especially important for those who are *mentally immature* or who have *perceptual* or *cognitive disabilities*.

If people must frequently ask for the location of a commonly used facility such as a washroom, that environment may have a barrier. Many individuals with disabilities are self-conscious and will not ask for help; if they feel uncomfortable in a facility, they often will not use it. Public facilities should be easy to locate and to utilize.

SIGNAGE

It is especially important to those with mental impairments that signs be easy to locate and to read. The basic requirements for signs are discussed in Section 1.4.3.6. Many individuals with mental impairments who are unable to read learn to recognize information by word length. For example, *women* is a longer word than *men*. Use of the words *ladies* and *gentlemen* may confuse those familiar with the three- and five-letter words.

ORGANIZATION

The location of specific rooms within an area should be clearly identified. If corridors in different areas are similar in appearance, an effort should be made to create *landmarks* using color or other decoration. Stairways and other circulation areas should be clearly identified or sited in highly conspicuous locations.

1.4.4.4 Wheelchair Users

The abilities of wheelchair users differ widely. Disability may affect only the legs or may involve the entire body. Pressure sores, muscle atrophy, and blood pooling are frequent problems. Paralysis reduces the muscle tone of the affected area. Barrier-free environments encourage mobility, and the exercise gained helps prevent additional medical problems.

WHEELCHAIR ACCESS

Most adult-sized wheelchairs are of a standard size; some special wheelchairs may be larger. Wheelchairs need an accessible route from parking spaces or bus stops to the interior of a building and within the building to the final destination of the wheelchair user.

Site Access Refer to Sections 1.4.3.2 and 1.4.3.4 for requirements.

Elevators and Lifts Unless every space is accessible by level movement, or ramps or other vertical means of access are provided, elevators or platform lifts should be provided for wheelchair users. In some applications, *chair-type stair lifts* can be provided to assist persons who cannot readily climb stairs, when the stairs cannot be eliminated and elevators or platform lifts cannot be provided.

Entries and Passageways Refer to Sections 1.4.2 and 1.4.3.3 for requirements for doors, hardware, and thresholds. Figure 1.4-11 shows the recommended minimum approach spaces necessary for convenient maneuvering of wheelchairs at doorways.

Wheelchair users frequently use the wheelchair itself to push a door open, scuffing or scratching the door. Therefore, the bottom 10 in. (255 mm) of hinged accessible doors should have a smooth, hard-surface *kickplate* (Fig. 1.4-12).

ROOM SIZE AND ARRANGEMENT

Accessible spaces for wheelchair users should be on one level and have adequate circulation and maneuvering space. Windows and doors should be located so that furniture arrangements do not obstruct wheelchair circulation.

The minimum clear floor area that will accommodate a wheelchair is 30 by 48 in. (760 by 1220 mm). The minimum diame-

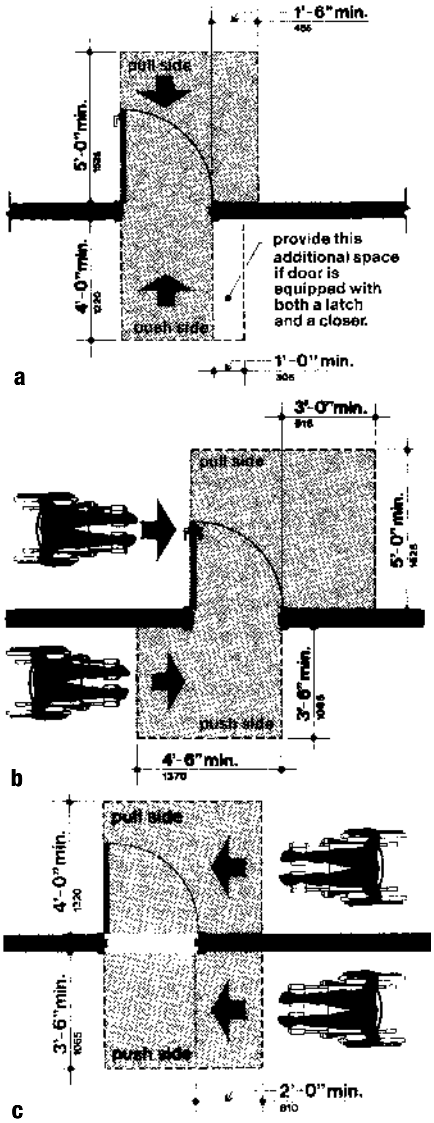


FIGURE 1.4-11 Minimum clear floor space at doors: (a) front approach, (b) hinge side approach, and (c) latch side approach.

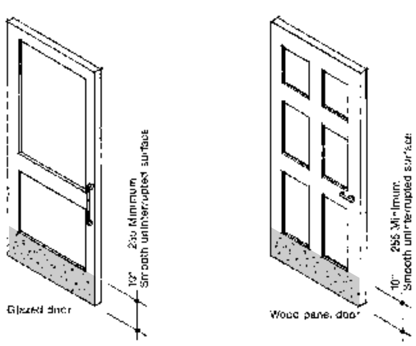


FIGURE 1.4-12 An abrasion-resistant kickplate of stainless steel or hard plastic should protect the lower 10 in. (254 mm) of doors intended for wheelchair users.

ter needed for a wheelchair user to execute a 180 degree turn is 60 in. (1525 mm).

Figure 1.4-13 shows examples of accessible bedroom plans. In an accessible dwelling, at least two bedrooms should be on the main level.

TOILET ROOMS, SHOWER ROOMS, AND BATHROOMS

Wheelchair users should be able to enter and use toilet, shower, and bathroom facilities without squeezing past obstructing fixtures or doorways.

Clear Floor Space Accessible toilet rooms, shower rooms, and bathrooms should have the recommended clearances around plumbing fixtures and controls. Ideally, an accessible facility should have a clear floor area 60 in. (1525 mm) in diameter so that a wheelchair user can make a 180 degree turn. The clear floor spaces of the fixtures, controls, and turning space may overlap.

Doors Doors should have a minimum clear opening of 32 in. (815 mm). Doors should not swing into the clear floor area of a fixture or obstruct entrance to the room. If a door must swing out, it should not obstruct passage through a corridor or any other circulation space.

Water Closets Water closets in an accessible public toilet room should be 17 to 19 in. (430 to 484 mm) high measured to the top of the toilet seat. In a dwelling, the seat height should be at least 15 in. (380 mm). The bowl should be centered 16 to18 in. (405 to 455 mm) from each side wall.

Lavatories Lavatories should be mounted so as to provide at least 29 in. (735 mm) of knee space to the underside of the apron. Exposed water pipes that intrude into the knee space should be padded and insulated.

Mirrors Mirrors should be mounted with the bottom edge not higher than 40 in. (1015 mm) from the floor. Medicine cabinets should be mounted with a usable shelf not higher than 44 in. (1120 mm) above the floor.

Bathtubs and Showers Depending on the location of the bathroom door, a bathtub should have a clear floor space 30 to 48 in. (760 to 1220 mm) wide and 60 to 72 in. (1525 to 1905 mm) long. Showers should have a clear floor space at least 36 in. (915 mm) wide and 48 in. (1220 mm) long for *transfer stalls* and 60 in. (1525 mm) long for *roll-in stalls.*

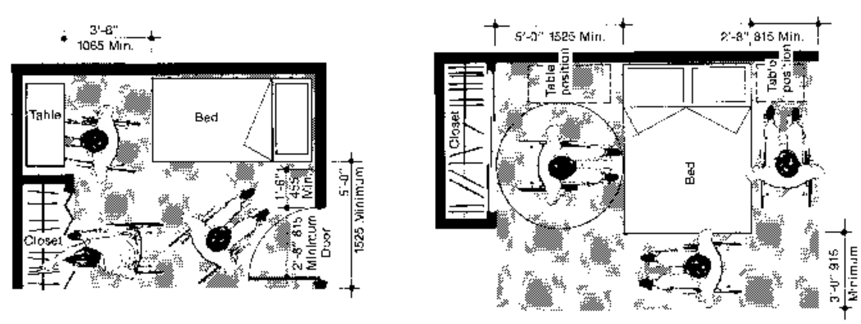
Seats should be provided in both transfer shower stalls and tubs. In shower stalls the seat should extend the full depth of the stall on the wall opposite the controls.

A shower spray unit that can be used either as a fixed shower head or a hand-held shower should be provided. The hose should be at least 60 in. (1525 mm) long.

Curbs in shower stalls 36 in. (915 mm) square should be no higher than 4 in. (100 mm). Stalls, such as those 30 by 60 in. (760 by 1525 mm), that allow a wheelchair to be rolled in should not have curbs, but may have a maximum $^1/_2$ in. (13 mm) threshold.

Enclosures on bathtubs and showers should not obstruct the use of controls or the transfer from wheelchairs to seats.

Faucets The controls on bathtubs, showers, and lavatories should be within comfortable reach of a wheelchair user. Controls such as handle and drain mechanisms should be operable with one hand and not require tight grasping or twisting.



Single bed

Double bed

FIGURE 1.4-13 Minimum dimensions for accessible bedrooms.

STORAGE

A clear floor space at least 30 by 48 in. (760 by 1220 mm) should be provided near storage areas. Closet rods should be mounted not higher than 54 in. (1370 mm) above the floor.

KITCHENS

Suitable kitchen appliances, proper countertop heights, and adequate circulation space are the primary requisites of a wheelchair user's kitchen.

Clear Floor Space The minimum clear floor space between opposing base cabinets, countertops, appliances, and walls should be 40 in. (1015 mm), unless the kitchen is U-shaped. U-shaped kitchens should have 60 in. (1525 mm) of clear floor space between opposing cabinets (Fig. 1.4-14). Clear floor space of 30 by 48 in. (760 by 1220 mm) should be provided at appliances such as a cooktop, oven, refrigerator, and dishwasher.

Controls Knobs, faucets, and appliance controls must be within comfortable reach and operable with one hand.

Counters One 30 in. (760 mm) section of counter, intended for food preparation, should be adjustable to a range of heights, including at least three positions: 28, 32, and 36 in. (710, 815, and 915 mm).

There should be no cabinets under the adjustable counter, and it should have a clear knee space 30 in. (760 mm) wide by 19 in. (485 mm) deep over a finished floor space. Counter thickness and supports should be 2 in. (50 mm) maximum over the necessary clear space. The underside of the counter should not have any sharp protrusions or rough surfaces.

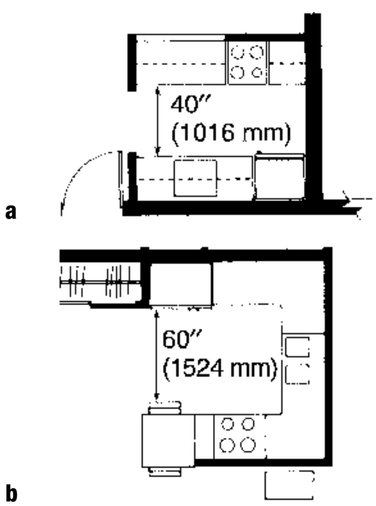


FIGURE 1.4-14 Minimum clearances between opposing cabinets in (a) parallel and (b) U-shaped kitchens.

Appliances Refer to Section 11.1.2 for accessibility requirements for kitchen appliances.

Cabinets Both base and wall cabinets should be reachable from a wheelchair. At least one continuous shelf in the cabinets above a work counter should not be higher than 48 in. (1220 mm). Upper cabinet doors should have pulls located as close to the bottom as possible; base cabinets should have pulls located as close to the top as possible. Because of the necessity for knee space, cabinets should not be built under counters. Instead, pantries should be used for storage. They should have storage below the 54 in. (1370 mm) height and a clear space of 30 by 48 in. (760 by 1220 mm).

Pull-out shelves in base cabinets, and lazy Susan rotating corner units are highly recommended.

Sinks Sink heights should be adjustable to 28, 32, and 36 in. (710, 815, and 915 mm). The minimum width of a counter surrounding a sink should be 30 in. (760 mm). Plumbing should be roughed in for sinks mounted at the 28 in. (710 mm) height. Counter thickness and supports should be 2 in. (50 mm) maximum over the necessary clear space. A sink bowl should be not more than $6^1/_2$ in. (165 mm) deep; in a double-bowl sink only one of the bowls needs to be so shallow.

Faucets should be at the side of the sink and operated by a single lever control.

ELECTRICAL

The location of electrical outlets and switches should be as described in Section 1.4.3.8. Lighting requirements are discussed in Section 1.4.2.

1.4.4.5 Coordination Disabilities

Coordination disabilities include balance, leg, upper limb, and flexibility impairments. Many people have problems with balance, stamina, and coordination, which do not confine them to a wheelchair but do limit their use of an environment. They may have difficulty walking and may need aids such as walkers or crutches, which require approximately the same amount of space as wheelchairs. Others may have difficulty bending, sitting, kneeling, or rising; still others may find it difficult to push open doors or turn knobs and faucets.

The needs of those with coordination disabilities and the needs of the elderly frequently overlap. However, younger people with disabilities do not want to be associated or housed solely with the elderly.

ENTRY AND CIRCULATION

People who use walking aids need the same amount of *circulation space* as those who use wheelchairs. Many people with coordination disabilities prefer stairs to ramps because ramps are more tiring to use. However, ramps may be beneficial to crutch and walker users who cannot negotiate stairs as easily. Ramps should be constructed according to the criteria established in Section 1.4.3.4. Wherever possible, both stairs and ramps should be provided.

SURFACES

Unevenness, raised joints, and debris can be hazardous to those with walking disabilities. Surfaces should be kept free of debris; joints and level changes should be less than $^1/_4$ in. (6 mm).

1.4.4.6 The Elderly

Accessibility recommendations for the elderly overlap those for wheelchair users and persons with coordination disabilities. Sensory losses accelerate at various ages. For example, hearing starts to diminish at 40; vision, at 50; taste, between 55 and 60; smell, after 70. The actual ages and degree of loss vary considerably.

The elderly have a higher rate of visual impairment than those in other age groups. Age impedes the eyes' ability to change focus, adjust to sudden changes in light intensity, and function at low levels of light intensity. For example, an 80-year-old may need three times as much light for comfortable reading as a 16-year-old. As it ages, the lens of the eye becomes increasingly rigid, yellow, and opaque. This process affects the ability to discern color, especially blues and greens, and to distinguish between colors such as pink and lavender. With aging, depth perception decreases and glare becomes a greater problem.

Aging also increases hearing loss, reducing the ability to hear sounds in general and high-frequency sounds in particular.

The cushioning of the foot degenerates with advancing age. This loss can cause pain and contributes to the shuffling gait characteristic of many elderly people (Fig. 1.4-15).

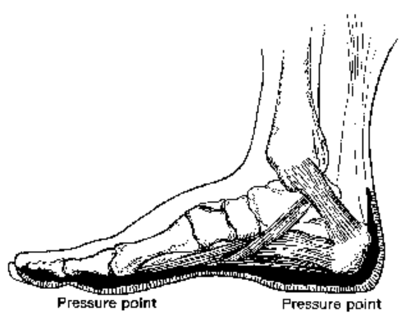
The mobility of the elderly varies from complete ambulatory freedom to wheelchair confinement. Entries and other access facilities should be barrier-free for elderly persons, including wheelchair users. Only the criteria that add to or differ from those established for wheelchair users will be mentioned in this section.

SIGNAGE

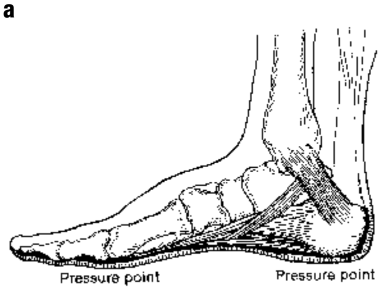
Many elderly people suffer visual impairment, and others may be easily confused; signage and lighting should conform to the recommendations outlined in Sections 1.4.3.6 and 1.4.4.1.

ROOM SIZE AND ARRANGEMENT

Recommended room sizes for the elderly are greater than the minimums specified for wheelchair users. This is partially because the elderly sometimes have coordination problems that make it more difficult for them to maneuver a wheelchair within the minimum spaces recommended for other wheelchair users.



a



b

FIGURE 1.4-15 **The foot of a younger person (a) contains more cushioning material at pressure points than that of an older person (b).**

The criteria for corridor widths and floor surfaces should follow those indicated in Sections 1.4.3.3 and 1.4.3.7, respectively.

COLOR AND TONE

As mentioned earlier, changes in the eye lens caused by aging often affect color perception. It may be difficult for some elderly people to distinguish between the light tints of pastel colors such as blue, lavender, and pink, and sometimes even between dark colors such as navy, brown, and charcoal. Therefore, the selection of colors for elderly persons should emphasize objects against their background. Examples include light entry–dark door jamb and light floor–dark furniture.

ELECTRICAL

Electrical outlet and switch locations and lighting requirements should be as described in Section 1.4.3.8.

BATHROOMS

Because the elderly may have to use a wheelchair at times, bathroom requirements should be the same as for wheelchair users.

KITCHENS

The requirements for kitchens used by the elderly vary. Some of the elderly are reasonably able-bodied; others use wheelchairs. Kitchens for the elderly generally should follow the recommendations for adaptable kitchens (see Section 1.4.5), thus permitting ready alterations to suit the specific needs of the occupants.

Kitchen storage should be accessible without endangering the safety of the elderly. Because not all of the elderly are wheelchair users, the use of wall cabinets is acceptable. However, these are not recommended above a refrigerator or cooktop. Pantries are an excellent means of providing safe and accessible storage. Base cabinets should have *pull-out* shelves and corner lazy Susans to make items in them more accessible.

1.4.5 ADAPTABILITY

Most people with disabilities resent being segregated into housing built specifically for the handicapped. They prefer *mainstreaming*, a process which (1) equips people who have disabilities with the personal devices and adaptive skills needed to function effectively in the built environment and (2) removes physical barriers that prevent handicapped people from functioning like able-bodied individuals.

Current laws and regulations require that most types of buildings be made fully accessible to handicapped people. Other laws and regulations have been proposed that would mandate making new housing also fully accessible. When they take effect, the following discussion may become moot. Until then, however, one way to prevent the segregation of people who become disabled into housing prepared specifically for handicapped people is to build adaptable buildings. An *adaptable* building is one that can be modified to satisfy the needs of an occupant's physical limitations with ease and without excessive costs. The kinds of elements that may be modified or added in an adaptable house, for example, include, but are not limited, to kitchen counters, sinks, and grab bars.

Adaptability for wheelchair users requires the most modification and should therefore receive the greatest attention in the design process.

The recommendations in Sections 1.4.2 and 1.4.3 apply fully to adaptable buildings. In general, adaptability requires that the following design requirements be followed.

1.4.5.1 Entries

When practicable, entrances should be at grade level so that ramps or stairs will not be needed. When this is not practicable, an adaptable dwelling can be on a level accessible by a ramp or an elevator or platform lift.

DOORS

Passage doors should have a minimum clear opening of 32 in. (815 mm) with the door open 90 degrees, measured from the face of the door to the opposite stop.

Hardware Door knobs, handles, pulls, latches, and locks should have a shape that is easy to hold with one hand and does not require tight grasping, pinching, or twisting. Extensions are available that adapt a regular door knob for people with manual disabilities such as those caused by arthritis.

Thresholds Thresholds on exterior sliding glass doors should not be higher than

$^{3}/_{4}$ in. (18 mm). A recessed track is preferred where suitable, such as for interior sliding doors. Thresholds on hinged passage doors should not exceed $^{1}/_{2}$ in. (13 mm) in height and should be beveled. Exterior doors should have weather stripping applied to the bottom edge of the door, because weather stripping applied to thresholds can present a tripping hazard (Fig. 1.4-16).

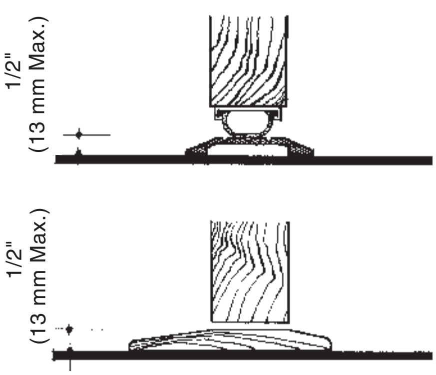


FIGURE 1.4-16 Thresholds.

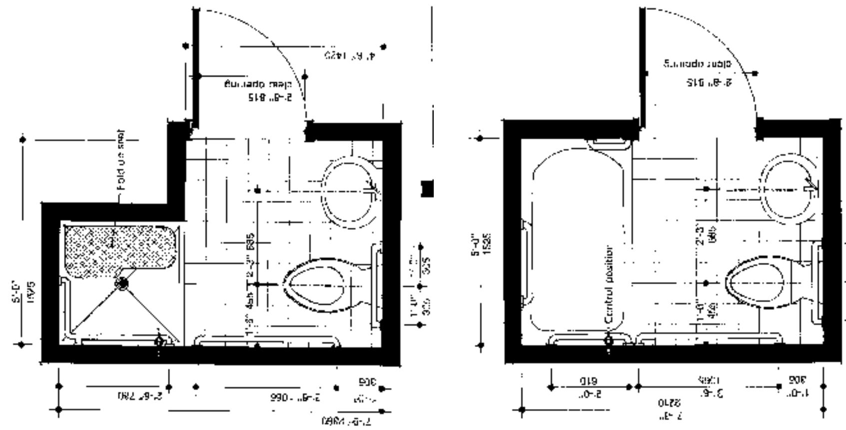


FIGURE 1.4-17 Recommended minimum dimensions for accessible bathrooms.

1.4.5.2 Room Size and Arrangement

A single-level dwelling is the preferred type for adaptability. Rooms should be large enough to permit convenient furniture arrangement and wheelchair maneuvering. Most living rooms, dining rooms, and bedrooms already meet the requirements for adaptability. Bathrooms and kitchens require the most modification.

CORRIDORS

Hallways and corridors should be a minimum of 36 in. (915 mm) wide. If a door opens into a corridor, the passage width should be 54 in. (1370 mm); corridors where people must pass each other should be 60 in. (1525 mm) wide.

BATHROOMS

An adaptable bathroom has the appearance of a conventional bathroom but with the layout and clearances suitable for later adaptation to the needs of those with disabilities.

Clear Floor Space A typical bathroom should have a minimum width of 60 in. (1525 mm). Clear floor spaces around fixtures should be as shown in Figure 1.4-17.

Doors Bathroom doors should have a minimum clear opening of 32 in. (815 mm); doors should not swing into the clear floor space around fixtures or obstruct entrance into the bathroom.

Bathroom doors can be rehung to open out in order to gain the necessary clear door space, but should not obstruct corridors or other circulation space outside the bathroom.

Lavatories Lavatories should be mounted so as to provide at least 29 in. (735 mm) of clearance from the floor to the underside of the apron. The clear floor space should be at least 30 in. (760 mm) wide by 48 in. (1220 mm) deep; the lavatory basin should take no more than 19 in. (485 mm) of that depth, and pipes should not protrude into the knee space.

Water Closets Water closet seats should be at least 15 in. (380 mm) above the floor. Clear floor space and structural wall reinforcement for grab bars should be provided.

Mirrors The bottom edge of mirrors should be mounted not higher than 40 in. (1015 mm) above the floor. Medicine cabinets should be mounted with at least one usable shelf not higher than 44 in. (1120 mm) above the floor.

Bathtubs and Showers Depending on the location of the bathroom door, bathtubs and showers should have adequate clear floor space to accommodate wheelchairs.

Structural wall support and floor space should be provided so that grab bars and a seat can be readily installed for a resident with a handicap. A flexible-hose shower unit that can be used as either a fixed or hand-held head should be provided. Shower stalls 36 by 36 in. (915 by 915 mm) should have curbs not higher than 4 in. (100 mm). Stalls 30 by 60 in. (760 by 1525 mm) should not have curbs so that a wheelchair may be rolled in; a $^{1}/_{2}$ in. (13 mm) threshold is permissible, and the stall floor should be pitched slightly toward the drain to help avoid drainage problems.

Grab Bars Structural reinforcement or other provisions should be provided near bathroom fixtures in the locations where grab bars would be installed.

KITCHENS

Adjustable-height counters, sinks, and cooktops, and adequate circulation space are the key elements of an adaptable kitchen that allow a wheelchair user to maneuver freely within the space.

Clear Floor Space Clear floor space requirements are the same as those for wheelchair users (see Section 1.4.4.4).

Counters One section of counter 30 in. (760 mm) wide should be capable of being repositioned to heights of 28, 32, and 36 in. (710, 815, and 915 mm) to provide a comfortable area for food preparation. Cabinets may be mounted under the adjustable counter, but should be readily removable in order to provide the necessary knee space for a wheelchair user.

Appliances Appliances in adaptable kitchens should fulfill the accessibility requirements indicated in Section 11.1.

Cabinets Wall cabinets should have pulls located as close to the bottom as possible; base cabinets should have pulls located as close to the top as possible.

Cabinet pulls should be smooth and rounded, without any sharp edges or pointed projections. Because storage under adjustable spaces may have to be removed, pantry storage is very desirable. Other helpful devices are lazy Susans for corner cabinets, pull-out shelves in base cabinets, and cutting boards with mixing bowl cutouts.

Sinks The requirements for sinks are the same as those outlined in Section 1.4.4.4, except that cabinets may be mounted under the sink; however, they should be removable in order to provide the necessary knee space for a wheelchair user.

FLOORS

Flooring should be *nonslip* even when wet.

ELECTRICAL

Lighting should be as described in Section 1.4.2. Electrical outlet and switch locations should be as indicated in Section 1.4.3.8.

COST

When practicable, new dwellings should be made adaptable, because the cost of making an adaptable dwelling suit the needs of a wheelchair user is small in comparison with the cost of retrofitting an existing conventional house. In addition, making a house adaptable does not in any way harm its use by the able-bodied.

1.5 Sustainable Building Design

Until relatively recently, architects and constructors have had a tendency to take little notice of the extensive use of materials, some of them nonrenewable, in their building projects. It seemed that the supply of wood, for example was inexhaustible. Electricity and fuel oil were relatively inexpensive. Architects tried to preserve the natural environment adjacent to their buildings as much as was practicable, but often took little notice of the environmental impact of the building materials they were specifying. The exhausting of irreplaceable materials in the making of building products was more or less ignored, as were the production of waste as a result of the manufacturing of these products and the introduction of toxic by-products to the air, water, soils, and people. Only recently have we become more aware of the need to conserve both materials and energy in constructing our environment.

Recent studies have shown that for every 10.76 sq ft (1 m^2) of building 131,000 Btu (138.2 million J) of energy are expended, 815 lb (369.7 kg) of green house gasses are produced, and 132 lb (59.9 kg) of solid waste go into a landfill. These amounts do not include the effects of building operations after construction.

As our awareness has grown, we have struggled with the means to effect the kinds of changes necessary to preserve the environment without making buildings too expensive to build. Slowly, the terms *green buildings* and *sustainability* have come into vogue, but there have been no consensus definitions of them. Before architects could effectively design green buildings, there had to be a common standard of measurement for them. It was first necessary to define the problem in a way that was understandable to building professionals and the public alike.

The purpose of producing green or sustainable buildings is to meet the needs of the present society while preserving the ability of future generations to meet their own needs. To design sustainable buildings, it is necessary to think in terms of integrated whole-building design. Other than small residential and commercial projects, most buildings today are designed in several separate segments. Architects are the designers of the overall building; structural engineers make buildings stand up; and the mechanical, plumbing, and electrical services necessary are the responsibility of the architect's mechanical, plumbing, and electrical engineering consultants. Other consultants design other portions of a building. The architect coordinates all of their work. It is difficult to produce sustainable buildings using these methods. Buildings use too much power, their useful life span is reduced, and they are not easily brought up to date when new methods and systems arrive. As depletable materials become less plentiful, not only will the cost of producing building materials increase, the environment will become more toxic and less livable. To remedy this situation, architects must incorporate resource conservation into their design philosophies, and architects, engineers, and constructors must provide environmental leadership in the building industry. They and governmental agencies together must raise consumer awareness of the benefits achieved by the production of green buildings, and they must stimulate competition among building product producers to provide products that are less stressful of the environment. Doing so will increase the availability of relatively inexpensive green building materials.

1.5.1 LEED®

The best current attempt to alleviate the lack of standards for green buildings is the LEED program developed by the U.S. Green Building Council (USGBC). With contributions from representatives of most segments of the building industry, the USGBC developed the LEED program, and continues to contribute to its evolution. *LEED* is an acronym for "Leadership in Energy and Environmental Design."

The LEED Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. The LEED Project Checklist shown in Figure 1.5-1 demonstrates the extent of the measures necessary to provide sustainable design and the rating necessary to become a LEED-certified building.

The USGBC also certifies buildings for compliance with LEED guidelines. More information about the USGBC and LEED, and a copy of the LEED certification program, including the checklist reprinted in this section, are available at the USGBC Web site (http://www.usgbc.org).

1.5.2 LIFE CYCLE

To determine the sustainability or lack of sustainability of a building, it is necessary to assess the effect of the building on the environment during its entire life cycle. Factors that must be addressed include the following:

- The life cycle of each of the materials proposed for use in the building
- The most significant environmental risks associated with the building
- The opportunities available to provide for sustainability in the building and

Sustainable Sites — 14 Possible Points

Y			Prereq 1	**Erosion & Sedimentation Control**	Required
Y	?	N	Credit 1	**Site Selection**	1
Y	?	N	Credit 2	**Urban Redevelopment**	1
Y	?	N	Credit 3	**Brownfield Redevelopment**	1
Y	?	N	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
Y	?	N	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
Y	?	N	Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
Y	?	N	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
Y	?	N	Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
Y	?	N	Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
Y	?	N	Credit 6.1	**Stormwater Management**, Rate and Quantity	1
Y	?	N	Credit 6.2	**Stormwater Management**, Treatment	1
Y	?	N	Credit 7.1	**Heat Island Effect**, Non-Roof	1
Y	?	N	Credit 7.2	**Heat Island Effect**, Roof	1
Y	?	N	Credit 8	**Light Pollution Reduction**	1

Water Efficiency — 5 Possible Points

Y	?	N	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
Y	?	N	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
Y	?	N	Credit 2	**Innovative Wastewater Technologies**	1
Y	?	N	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
Y	?	N	Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Energy & Atmosphere — 17 Possible Points

Y			Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
Y	?	N	Credit 1	**Optimize Energy Performance**	1–10
Y	?	N	Credit 2.1	**Renewable Energy**, 5%	1
Y	?	N	Credit 2.2	**Renewable Energy**, 10%	1
Y	?	N	Credit 2.3	**Renewable Energy**, 20%	1
Y	?	N	Credit 3	**Additional Commissioning**	1
Y	?	N	Credit 4	**Ozone Depletion**	1
Y	?	N	Credit 5	**Measurement & Verification**	1
Y	?	N	Credit 6	**Green Power**	1

FIGURE 1.5-1 LEED Project Checklist, Version 2.1. (Courtesy U.S. Green Building Council.)

Materials & Resources 13 Possible Points

Y			Prereq 1	**Storage & Collection of Recyclables**	Required
Y	?	N	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell	1
Y	?	N	Credit 1.2	**Building Reuse**, Maintain 100% of Shell	1
Y	?	N	Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell	1
Y	?	N	Credit 2.1	**Construction Waste Management**, Divert 50%	1
Y	?	N	Credit 2.2	**Construction Waste Management**, Divert 75%	1
Y	?	N	Credit 3.1	**Resource Reuse**, Specify 5%	1
Y	?	N	Credit 3.2	**Resource Reuse**, Specify 10%	1
Y	?	N	Credit 4.1	**Recycled Content**, Specify 5% (p.c. + 1/2 p.i.)	1
Y	?	N	Credit 4.2	**Recycled Content**, Specify 10% (p.c. + 1/2 p.i.)	1
Y	?	N	Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	1
Y	?	N	Credit 5.2	**Local/Regional Materials**, of 20% in MRc5.1, 50% Harvested Locally	1
Y	?	N	Credit 6	**Rapidly Renewable Materials**	1
Y	?	N	Credit 7	**Certified Wood**	1

Indoor Environmental Quality 15 Possible Points

Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
Y	?	N	Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**	1
Y	?	N	Credit 2	**Ventilation Effectiveness**	1
Y	?	N	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
Y	?	N	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
Y	?	N	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
Y	?	N	Credit 4.2	**Low-Emitting Materials**, Paints	1
Y	?	N	Credit 4.3	**Low-Emitting Materials**, Carpet	1
Y	?	N	Credit 4.4	**Low-Emitting Materials**, Composite Wood	1
Y	?	N	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
Y	?	N	Credit 6.1	**Controllability of Systems**, Perimeter	1
Y	?	N	Credit 6.2	**Controllability of Systems**, Non-Perimeter	1
Y	?	N	Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	1
Y	?	N	Credit 7.2	**Thermal Comfort**, Permanent Monitoring System	1
Y	?	N	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
Y	?	N	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Innovation & Design Process 5 Possible Points

Y	?	N	Credit 1.1	**Innovation in Design**	1
Y	?	N	Credit 1.2	**Innovation in Design**	1
Y	?	N	Credit 1.3	**Innovation in Design**	1
Y	?	N	Credit 1.4	**Innovation in Design**	1
Y	?	N	Credit 2	**LEED™ Accredited Professional**	1

Project Totals 69 Possible Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

FIGURE 1.5-1 *(Continued)*

- how those are affected by construction cost and the operating cost of the completed building
- The client's attitude and resources

1.5.2.1 Building Materials Life Cycles

A material's life cycle begins with extraction of the raw materials used to manufacture it and ends when it is removed from the building and disposed of. This life cycle includes obtaining the raw materials, manufacturing the product, and its packaging, distribution, use, and ultimate reuse, recycling, or disposal. The environmental impact of a building material is affected by whether or not the material is renewable, the amount of toxic and waste materials that occur as a result of the conversion of the raw material into a building product, and the amount of energy the product consumes during its entire life cycle.

RAW MATERIALS

To assess the life cycle of a building product, we must take into account the energy cost of obtaining the raw materials that make up that product and whether the raw materials are available locally, where the available manufacturing facilities are to convert the raw materials into a finished building product, and the toxicity of the raw materials. We must also take into account the energy that must be used to extract and refine the raw materials and the pollutants and other environmentally harmful by-products of that extraction.

MANUFACTURE, PACKAGING, AND DISTRIBUTION

Another analysis that must be made when considering the sustainability of a building product is the expenditure of energy and the amount and type of harmful by-products associated with the manufacture, packaging, and distribution of the product. It is also necessary to ascertain whether the product is reusable, and if not, whether it or its raw material is extractable and recyclable and, if so, how many time it is recyclable before it becomes useless. Other factors to consider include whether the packaging is recyclable and whether it is manufactured with nonrenewable materials.

THE CONSTRUCTION PROCESS

Sustainable building products must be examined to determine the difficulties associated with installing them in a building, including the energy used to install them and the waste and harmful by-products that may be produced during that installation. It is also necessary to take into account whether the waste produced by this installation is recyclable.

BUILDING USE

The energy expended in using and maintaining a building product is another factor affecting its life cycle. Other considerations include the toxicity of materials required to clean the product, the amount of air pollution the product generates within the building, and how much water and other consumables are necessary for the use of the product.

REUSE, RECYCLING, OR DISPOSAL

The final aspect of a building product's life cycle has to do with what happens to the product when it is removed from the building or the building is demolished. Considerations include whether the product can be reused, or its raw materials or the product itself can be recycled, or whether the product is not usable. If the product is recyclable, what is the energy expenditure to recycle it? If the product is not recyclable, how much damage will discarding it do to the environment?

1.5.3 DESIGNING FOR SUSTAINABILITY

Factors necessary to consider when designing sustainable building include, but are not limited to, the following:

- Select building materials and products with the most favorable life cycles.
- Take measures to reduce the impact on the environment of the materials and products selected.
- Design to reduce materials use by such measures as using the smallest building footprint that is practicable, configuring the building to reduce waste, and simplifying the building's geometry.
- Design for durability by using materials that have long life spans and configuring the design to prevent deterioration of materials and ensure easy replacement of components.
- Design for adaptability so that the building can be modified to take into account new systems and products or changing uses.

1.5.4 ADDITIONAL INFORMATION

Additional information related to sustainable building design occurs in most chapters of this book where relevant. In addition, environmental concerns and design consideration for building occupant safety are addressed in various chapters. Energy conservation is also addressed in several chapters, including, but not limited to, Chapters 11, 17, and 18.

1.6 Construction Documents

Architects and their consultants provide predesign and design services. In the predesign phase of their work, they may be engaged by the owner to provide such services as programming, existing facilities surveys, feasibility studies, and site analysis. In the design phase of their services, they provide schematic design, design development, and construction document services. Building predesign and design methods and the presentation of designs are beyond the scope of this book.

Construction documents include both drawn and written documents. Their presentations vary somewhat with different project delivery systems.

1.6.1 PROJECT DELIVERY SYSTEMS

There are three basic project delivery systems in general use today. The team responsible for project delivery remains the same, regardless of the delivery system used. They are the owner, the architect, and the constructor. The three delivery systems are *design-bid-build*, *construction management*, and *design-build*. There are several subcategories in the three basic systems. Documents will be organized differently for each of the three delivery systems and may also vary somewhat to accommodate variations within the systems.

1.6.1.1 Design-Bid-Build Delivery Systems

In the past, most construction projects were built using the design-bid-build system. In spite of the infusion of other delivery systems, the design-bid-build system is still used extensively today. There are several variations within the design-bid-build delivery system. In the first and most common of these, a project is built under a single prime contractor agreement. In such agreements, a single general contractor is the contractor of record who signs a construction agreement with the owner. There is only a single construction agreement. In this system, the architect prepares the construction documents and the constructor offers a bid to build the project for a fixed bid price.

In a variation of this system, the constructor agrees to build the project for a negotiated sum. In this system, the contractor may be asked to present a bid in competition with other constructors or may be preselected to enter into a negotiated agreement. In this system, the constructor is often selected during the design process and is involved in the building design to the extent of helping to control the building's cost.

In another variation, the constructor agrees to build the project under a fixed price plus a fee agreement. The price and fee may be bid for or negotiated. This method is usually used on projects where the scope of the work involved cannot be determined in advance.

Design-bid-build projects may also be built using more than one prime contractor. In this system, separate constructors are involved for the different disciplines involved, and there is a separate owner/contractror agreement with each prime contractor. That is, there is one agreement for a general works contractor, a separate agreement for a site works contractor, another for a mechanical contractor, still another for an electrical contractor, and so on. Such a project will require as many sets of construction documents as there are prime contractors, and each set may be presented in a slightly different order.

1.6.1.2 Construction Management Delivery Systems

In a *construction management* (CM) contract, the owner employs a firm, or an individual, as a construction manager to oversee the project. Many CM projects are also *fast-track* projects, in which the general contractor is brought on board during the design phase and construction documents are issued as needed for the contractor to price and bid subcontract work. The front-end documents (see Section 1.6.2.3), such as bidding requirements, contract forms, and contract conditions, will be agreed to by the owner and the contractor before the other contract documents have been completely developed. Building costs are usually established as a guaranteed maximum price (GMP) with one or more contingency amounts to take care of unforseen conditions.

This method of delivery is discussed in some detail in Section 1.9.

1.6.1.3 Design-Build Delivery Systems

In a *design-build* system, a team of design professionals (architects and engineers) and one or more constructors are employed by an owner to deliver a complete functioning building ready for occupancy and use. In such projects, drawings are usually similar to those for a single-contract design-bid-build project, though they may be somewhat less detailed. The written construction documents will contain some different provisions, especially in the front-end portions where legal and contractual obligations are delineated

1.6.1.4 Fast-Track Delivery

Any of the three basic delivery systems may be used in fast-tract projects. In a *fast-tract* delivery system, the architect completes early portions of the construction documents, and those portions are then let to a constructor. The constructor builds those portions of the project while the architect continues to design the rest of the project. This system might to used to prepare the site for construction before the building design has been completed.

Foundation and structural framing drawings and specifications may be issued as a package before the rest of the drawings and specifications have been completed. This fast tracking often permits an accelerated construction schedule, lowering the cost of construction and financing. In some cases, fast tracking may even permit occupancy of portions of a project before the rest of the project has been completed. Unfortunately, these cost reductions are somewhat negated by errors that are inevitable in the fast-track method.

Ultimately, when all the drawings have been completed, they will be organized in the same format as they would be for a single prime contractor project. Specifications sections addressing procuring and contract provisions and general project requirements will differ from those of other projects, but the rest of the specifications will be the same as for other project delivery systems.

1.6.2 DRAWINGS

AIA has defined *drawings* as construction documents that "show in graphic and quantitative form the extent, design location, relationships, and dimensions of the work to be done. They generally contain site and building plans, elevations, sections, details, schedules, and diagrams."

1.6.2.1 Organization

The organization of drawings differs from one architectural firm to another, but there are some generalities. Sitework drawings are sometimes issued as a separate set of drawings but often are placed at the beginning of the architectural drawings. The architectural drawings are usually placed first in a set, followed by structural, mechanical, plumbing, and electrical drawings, in that order. Drawings for other elements may be placed in various locations within a set of drawings. For example, furniture and equipment drawings may be placed immediately after the architectural drawings or may be issued as separate drawings attached at the end of the full set.

There is no universally accepted order within the disciplines. There have been numerous attempts to standardize the organization, but none has yet achieved a consensus. One possible order for architectural drawings places general notes first, followed by overall building plans, building cross sections and exterior elevations, floor plan blowups, interior elevations, reflected ceiling plans, vertical circulation (elevators, stairs, escalators, etc.), exterior wall sections and details, and, finally, interior sections and details. Drawings for the other disciplines follow similar arrangements, with notes first, plans next, then elevations, details, schedules, and diagrams.

1.6.2.2 Drawing Production Methods

Until relatively recently, drawings were produced manually on a drawing board using a T-square, parallel bar, or drafting instrument. Standard details and notes were sometimes repeated from project to project, and some firms issued them in a separate bound volume. Drawing sheets had standardized boarders and title blocks.

OVERLAY DRAFTING

An advancement to the manual drafting system included the use of overlay drafting techniques, in which a base drawing was made manually and reproduced on Mylar™ or other plastic film. The film was drilled to fit over a pinned registration bar. Additional sheets were pinned over the first to produce equipment, furniture, mechanical, and electrical drawings. The floor plan was drawn only once. This method effected savings in time and, subsequently, in document production cost and tended to produce more accurate drawings.

CAD

Overlay drafting techniques eventually led to a similar system of production using computers. Today, *computer-aided design and drafting* (CADD or simply CAD) has all but supplanted the earlier methods of drawing production. CAD systems are more expensive to implement than the earlier systems. They require the purchase of expensive hardware and software and extensive employee training. Even so, they are rapidly replacing earlier methods. They are increasingly required by owners, notably federal and state government agencies. Many architectural firms are now requiring new employees to be able to use CAD programs.

All CAD systems are based to some extent on the use of layers. A single CAD file can be used to show a floor plan, a reflected ceiling plan, an electrical power plan, a lighting plan, and more.

In the beginning, there were no recognized standards for organizing or naming CAD drawing files. Every architectural firm had to develop its own standards, which made it difficult for owners, constructors, and building officials to locate requirements in the CAD files, especially when they were dealing with more than one architect's documents. The first industry standard, *CAD Layer Guidelines*, was published in 1990 and updated in 1997 by the AIA. This document provides a standard means for coordinating the work of architects and their engineering and other consultants. It provides a standard for naming and organizing CAD layers and discipline code designations that allocate layers to specific disciplines. For example, architectural drawings are designated with an A, civil drawings with a C, electrical drawings with an E, equipment drawings with a Q, and so forth.

Combining the discipline code with the standard for naming layers gives a method for locating data within a set of CAD files for a building project that is the same from project to project and from design professional to design professional. For example, a CAD layer showing toilet partitions is named A-FLOR-TPTN. A layer showing exit lighting is called E-LITE-EXIT.

The current standard for CAD is the U.S. National CAD Standard (NCS). NCS coordinates the CAD publications of the AIA, the Construction Specifications Institute (CSI), and other CAD-related documents. It was developed using the expertise and input of many construction industry organizations. NCS has been adopted for use by several government agencies, including the GSA and the departments of the Navy and Air Force. It is also used by several large organizations, several states, and many architectural firms.

The aforementioned *CAD Layer Guidelines* are a major component of the NCS, as is the CSI's *Uniform Drawing System*. The *Uniform Drawing System* is intended to format and unify the organization of construction drawings, whether produced in the conventional drafting method or by CAD.

Early CAD packages were used primarily to develop construction contract documents in much the same way that was used to produce manually generated drawings. Many are still used in that manner today, but newer programs are capable of interactive functions that permit a change in one view to automatically change all other views. Change a plan, for example, and sections and elevations change automatically to reflect the plan change. Add a door in a perspective drawing, and the door is automatically added in plans and elevations. Change a wall section, and the elevations change automatically. Even more advanced programs allow a viewer to change the viewpoint of a computer-generated perspective drawing at will, allowing a user to, in effect, walk through a design, looking in every possible direction and from every possible altitude during the walk. Virtual reality systems have been demonstrated that permit a user to see a design in three dimensions and to move or resize elements by merely raising a hand. A window, for example, can be moved in a wall by a wave of the operator's hand. At some time in the future, such systems will revolutionize the design of buildings and render all present methods obsolete.

1.6.2.3 Drawing Reproduction

Traditionally drawings were drawn large and reproduced for use by designers and constructors in the full size in which they were drawn. Half-size prints were occasionally used, but they had to be made during the reproduction process, and maintaining a usable scale was difficult, although not impossible. Drawings are still reproduced in large size for use in architects' and constructors' offices and for bidding purposes. In recent years, however, half-size drawings have been used more frequently, for all purposes, but especially on the job. Half-size drawings are less unwieldy to use, especially in the field (Figure 1.6-1) and less costly to reproduce.

Today, most drawings for buildings are produced on a computer screen and stored in electronic form. They can easily be reproduced in any size desired. Even though drawings should not be scaled for construction purposes, it is still convenient to have drawings in a measurable scale. Careful selection of the scale to use for individual portions of the reproduction can make smaller drawings easier to read. In the past, scale notations on drawings were given at the full size scale. Now, scale notations on half-size drawings are usually given in the scale in which they will exist in the reproduction.

1.6.3 THE PROJECT MANUAL

A *project manual* is a single volume that contains all written requirements for a building construction project.

FIGURE 1.6-1 Using a half-size print on the job. (Courtesy BE&K, Inc.)

1.6.3.1 Concept and Contents

A project manual provides a standardized format and location for all written project requirements. It includes bidding requirements, contract forms, conditions of the contract, information about alternates and allowances, and specifications. The number of possible requirements in project manuals is large, but not all are needed for every project. For example, one project may be of concrete construction and have no requirement for wood trusses. Another may be framed with wood and contain no structural steel.

1.6.3.2 The CSI

In 1948 a group of construction specifiers, frustrated with the chaotic specifications practices of that time, organized the CSI with the broad goal of improving construction specifications practices. CSI's current membership includes primarily specifiers, product manufacturers' representatives, and government agency representatives interested in specifications. Construction Specifications Canada (CSC) is a similar organization operating in Canada.

MASTERFORMAT

Project manuals are complex and need a numbering system to make it possible to find individual requirements. Without a standard to follow, design firms tend to invent their own numbering systems and methods of organizing these materials. This makes it difficult for a contractor to find a particular requirement, thus increasing the possibility of errors in estimating that affect project cost, and errors in the field that affect the completed building. For instance, in a certain project, the requirements for structural steel may be in the third section of the manual, and in another project manual similar requirements may be in the twelfth section. To unify the location of the parts of a project manual, in 1963 CSI and CSC jointly produced a publication entitled *MasterFormat*.

MasterFormat has become the industry standard for naming and numbering the data in project manuals. It has been adopted by AIA in its publications and by most federal government agencies for their construction projects. It is also the format generally used in manufacturers' product literature. It is the basis of organization for Sweet's Catalog Files, McGraw-Hill's yearly collection of manufacturers' catalogs, which are a major source of product literature in most architects' offices, and in all CSI-sponsored publications, including another major source of manufacturers' data, *The Architect's First Source for Products*. It is also the basis for data filing in many design offices. More important to our purposes here, *MasterFormat* is used on the vast majority of private-sector and government building construction projects in the United States.

Because of its almost universal use in the U.S. construction industry, students and professionals need to become familiar with *MasterFormat*. The 1995 edition of *MasterFormat* divided the work associated with construction projects into 16 *divisions*. The chapters in the seventh edition of this book were named and numbered in the same way as *MasterFormat* divisions. In addition, the material there was roughly equivalent to the recommended material in the corresponding divisions of *MasterFormat*. *MasterFormat* 2004 divides its content into two *groups*: the "Procurement and Contracting Requirements Group," which contains the 00 documents in the 1995 edition, and the "Specifications Group," which contains the requirements in Divisions 1 through 16 of the 1995 edition and some added requirements. The "Specifications Group" is further divided in five subgroups: the "General Requirements Subgroup," which contains the requirements in Division 1 of the 1995 edition; the "Facility Construction Subgroup," which contains the requirements in Divisions 2 through 14 of the 1995 edition; the "Facility Services Subgroup," which contains the requirements in Divisions 15 and 16 of the 1995 edition; the "Site and Infrastructure Subgroup," which contains most of the requirements in Division 2 of the 1995 edition and some requirements not formerly included in *MasterFormat*; and the "Process Equipment Subgroup," which contains some requirements formerly in Divisions 15 and 16, but mostly new requirements that were not included in the 1995 edition.

In addition, the 2004 edition has drastically changed the naming and numbering and the subjects included in some divisions. Instead of the 16 divisions in the 1995 edition, the 2004 version contains 49 divisions. Some of the 49 divisions contain no requirements, but are instead reserved for additional requirements in the future. This edition of this book follows the intent of the 2004 edition of MasterFormat, with some necessary modifications. Except for Chapter 1, the chapters in the eighth edition of this book have the same names as the divisions, and the data they contain are roughly those included in the corresponding division of *MasterFormat* 2004. The numbers of Chapters 2 through 14 are the same as the corresponding division in *MasterFormat* 2004. The order and the names of the rest of the chapters are the same as those in MasterFormat 2004's divisions, but the chapter numbers differ from those of *MasterFormat* 2004's divisions because it makes no sense to have chapters in a textbook reserved for future use.

In addition, some divisions of *MasterFormat* 2004 are beyond the scope of this book and are thus not included here. These include divisions covering integrated automation, transportation, waterway and marine construction, and the entire "Process Equipment Group" of the edition of *MasterFormat* 2004.

Furthermore, because the order of sections in *MasterFormat* tends to change slightly from edition to edition, some of the subjects in the eighth edition of this book, as was true in the seventh edition, differ in location from the order used in *MasterFormat* 2004. Moreover, the limited size of the book precludes discussing every section listed in *MasterFormat* 2004.

It is reasonable to assume that over time the construction industry will adopt the 2004 edition of *MasterFormat* to the same extent that it has adopted earlier versions.

UNIFORMAT™

MasterFormat is an organization system based on materials and their uses. CSI's Uniformat is an organization system based on systems and assemblies. *Uniformat* is intended not to replace *MasterFormat* but rather to supplement it.

Uniformat is intended for use in arranging project descriptions to show how a design meets the owner's requirements; developing preliminary cost estimates and construction cost models; filing information and drawing details; and even arranging project manuals for certain design-build delivery projects in lieu of using *MasterFormat*, especially when performance specifications are used.

Uniformat contains multiple levels of involvement. Level 1 divides a building into nine categories. The first, Project Description, is self-explanatory. The succeeding eight categories cover construction systems and assemblies. The first seven are given alphabetic designations from A to G. The designations are substructure (A), Shell (B), Interiors (C), Services (D), Equipment and Finishings (E), Special Construction and Demolition (F), and Building Sitework (G). The eighth category, Z, is called General. It includes contract requirements, general requirements, and cost estimates.

There are also levels 2, 3, 4, 5, and 6. Levels 2 and 3 add numeric designations to subcategories of the level 1 categories. An example would be A10, where A is level 1 and 10 is the level 2 designation, "Foundations." In Levels 4, 5, and 6, numbers designate subdivisions of the subdivisions in a manner similar to those in *MasterFormat*. In fact, sometimes level 4 numbers correspond exactly with *MasterFormat* numbers.

Uniformat and *MasterFormat* are most often used independently for different purposes, but sometimes it is advantageous to use them together. An example is in the production of cost data. They may also be both used in certain design-build projects. When using them together, it is best to use *MasterFormat* numbers for *Uniformat* levels 4, 5, and 6 designations.

1.6.3.3 Bidding and Contracting Requirements

Bidding requirements include invitations to bid, instructions to bidders, a listing of information available to bidders, and bid and bid bond forms. They are issued before bids on a project are offered and are not considered part of the contract for construction.

Contracting requirements documents are also issued to potential bidders before they offer bids, but completed forms and other contracting requirements documents are considered part of the construction contract. Contracting requirements documents include the owner/contractor agreement, bonds (performance and payment), certificates (insurance, conformance, etc.), the conditions of the contract (general and supplementary), and addenda and modifications issued prior to acceptance of bids.

The general conditions of the contract and standard contract documents have evolved over the years from the early beginnings of AIA documents to today's complex and extensive interrelated documents. For example, a current standard form of the owner/contractor agreement produced by AIA is fully compatible with AIA A201, "General Conditions of the Contract for Construction."

Engineering organizations have also formed the Engineers Joint Contract Documents Committee (EJCDC), which has developed standard contract documents for use on engineering projects.

1.6.3.4 Specifications

Specifications constitute that portion of the written requirements for a building construction project that are contained in the divisions of a project manual. AIA has defined specifications as "written requirements for materials, equipment, construction systems, standards, and workmanship for the work as well as standards for the construction services required to produce the work."

Originally, specifications were just notes on the drawings. As the construction world became more complex, lawsuits proliferated, and many new materials and systems were introduced, the notes became too voluminous to put on the drawings. Architects and engineers began to type them and issue them as separate documents. Legal and procedural requirements now occupy as many pages as an entire specification set did in the 1950s.

For most construction projects today, specifications are included in a project manual and are organized according to *MasterFormat* 2004. Within each of the *MasterFormat* divisions, specifications are organized into level 2 sections, level 3 sections, and sometimes level 4 sections. Each level represents a more detailed subdivision of the work. In lieu of the five-digit numbering system used in the 1995 *MasterFormat* edition, sections in the 2004 edition are numbered with a six-digit system. Therefore, each level is represented by two digits instead of the older system's one digit. This increases the possible number of entries at each level 10-fold. As was true in previous editions, the first two digits are the division number and the remaining digits are the section number. For example, in Division 10, "Specialties," and a level 2 section 10 20 00, "Interior Specialties," and a level 3 section 10 21 00, "Compartments and Cubicles." Below that is a level 3 section 10 21 13, "Toilet Compartments," and a level 4 section 10.21.13.13, "Metal Toilet Compartments." Note that the level 4 number is the level 3 designation with a dot preceding the level 4 designation. A user may add level 4 designations as necessary.

Specifications should include clear and accurate descriptions of technical requirements related to materials, products, and services. They should also state a project's requirements for quality and the prescribed use of materials and methods to produce a desired product, system, application, or finish. And they should do all this in a form that is understandable and in a format in which the requirements can be easily found and clearly understood.

Recognizing that a clear and concise format, that was the same from job to job, was essential to producing clear specifications, shortly after the introduction of *MasterFormat*, CSI introduced a three-part section format and soon after that a recommended page format. In the section format, the data in each specifications section are divided into three *parts* as follows:

Part 1: General
Part 2: Products
Part 3: Execution

The content of each part is divided into articles, and the articles are divided into paragraphs.

The content and order of the data in each part have changed somewhat over the years, but the general intent is the same. Part 1, "General," includes requirements that affect the entire section and that are general in nature, such as requirements for allowances; unit prices; alternates and alternatives; submittals; quality assurance; delivery, storage, and handling; project and site conditions related to that section; sequencing; scheduling; warranties; and maintenance. Part 1 also includes definitions related to that section and cross references to other sections.

Part 2, "Products," includes the names of acceptable manufacturers; descriptions of required materials, manufactured units, equipment, and accessories; and requirements for mixes, shop fabrication and assembly, tolerances, and source quality control, including tests and performance verifications.

Part 3, "Execution," includes requirements for examination of conditions prior to installation; preparation for installation; and erection, installation, or application, as applicable. Part 3 also includes requirements for field quality control and testing; adjustments, cleaning, and protection of the installed work; and requirements for demonstration of proper operation of items installed under the section and requirements for scheduling and coordination of the work of this section with other work.

Each part is organized into articles and paragraphs using the following format:

Part 1 General
1.01 Article
  a. Paragraph
  b. Paragraph
    1. Subparagraph
1.02 Article
  a. Paragraph
  b. Paragraph
    1. Subparagraph

The CSI page format addresses the margins and page arrangement, including recommended indents for each level of articles and paragraphs. Most guide specifications (see Section 1.6.2.5) are already set up in the CSI page format or in an organization resembling it.

1.6.3.5 Guide Specifications

Nonproprietary guide specifications sets are commercially available today from organizations representing national associations. For example, Arcom Master Systems, sponsored by AIA, produces *MASTERSPEC®*; Construction Sciences Research Corporation, sponsored by CSI, produces *SPECTEXT®*. Commercial guides are also available from several private organizations, such as Kalin Associates and Building Systems Design, Inc. (BSD), which produces an automated guide set named *SpecLink®*. Most of these sets are available in either paper or electronic form, using various methods of delivery. An advantage of using such sets is that they are updated periodically and cover a wide range of materials and systems. In addition, they are produced by organizations with no vested interest in a particular product, which may make them more reliable in some ways. Some of these sets come with detailed instructions and recommendations for selecting one product type over another. Most of them are thoroughly researched and reasonably up-to-date.

Proprietary guide specifications are available from building product manufacturers by mail and at their Web sites. Some organizations offer direct links to an extensive list of manufacturers' Web sites where guide specifications can be accessed. In addition, guide specifications sections produced by manufacturers are available from a variety of organizations in sets. These sets are often less complete than those produced by the associations. Examples of organizations offering access to manufacturers' sites are ARCAT, Architects' First Source, and Sweet's Group.

Guide specifications are also produced by federal agencies, such as the GSA and the various military services. These are intended for use only on government projects but contain data that can be valuable to a specifier even on private-sector projects.

1.7 Bidding and Negotiation

Construction contracts are let based on the delivery system (see Section 1.6.1) to be used and the cost of construction.

1.7.1 BASIS OF CONSTRUCTION COST

The cost of construction may be determined on the basis of a fixed-price stipulated sum, a cost-plus-fee arrangement, unit prices, a guaranteed maximum price (GMP), or a combination of these.

In a fixed-price stipulated sum agreement, a constructor agrees to provide a building project for a fixed amount of money based on contract documents furnished by the architect. In a cost-plus-fee arrangement, the constructor agrees to construct the project and the owner agrees to pay the constructor's costs plus a fixed fee.

In a unit-price agreement, the cost is based on a price per unit of a material, such as cubic yards of topsoil or rock excavation. The unit costs include the actual cost of the material and an amount to cover the constructor's overhead and profit. Unit-price arrangements are frequently used with other types of pricing, such as fixed-price stipulated sum agreements. They are less frequently used as the basic agreement for an entire project.

A GMP agreement is exactly what it sounds like. Such agreements are usually used with design-build or CM projects where the design document are not complete when the project starts. GMPs are usually established at the time of completion of the design development phase of the architect's services. Thereafter, all concerned parties must ensure that the cost of the project does not exceed the GMP.

1.7.2 METHOD OF SELECTING A CONTRACTOR

Construction contracts are let based on dollar amounts and contract terms determined by either bidding or negotiation. *Bidding* is a process whereby a prime design professional engaged by an owner, and the design professional's consultants, prepare bidding documents and issue them to a group of constructors, who then submit the dollar amounts they will charge to build the building under the terms of the bidding documents. The prime design consultant may be an architect or engineer, depending on the project type. For example, for a bridge, a structural engineer may be the prime design professional. This section assumes that the project under consideration is a building and that the prime design professional is an architect.

Negotiation is a process whereby an architect engaged by an owner, and the architect's consultants, prepare negotiation documents; the owner, often with the advice of the architect, selects a potential constructor; and the architect issues the documents to the constructor, who then submits an offer to construct the project for a set number of dollars and within defined contract conditions. Then, either this offer is accepted or the offer and the terms are negotiated between the owner, with advice from the architect, and the constructor until an amicable arrangement is agreed upon.

1.7.2.1 Bidding

SELECTING BIDDERS

There are several methods for selecting bidders for a building construction project. In most government projects, all licensed contractors must, by law, be permitted to offer a bid. The only way to limit bidders is by imposing requirements for performance and payment bonds. Contractors who are unable to perform the work because of financial or other difficulties will not be able to obtain the required bonds and can be disqualified on this basis.

Some private work contracts are handled in the same way as government projects, whereby bidding is open to all legitimate constructors, but in most cases constructors requested to bid are restricted in some way. In some instances, the owner will simply develop a list of constructors it wants to bid and exclude all others. Sometimes this list is a result of consultation between the owner and the architect, but not always.

For some projects, potential bidders are examined and *prequalified* to ascertain whether they are legitimate, reputable, licensed contractors who are large enough and financially stable enough to perform the work and are not disqualified by legal restrictions. This investigation is usually conducted by the architect, who forwards the results to the owner. The final decision on which constructors are permitted to bid lies solely with the owner. Prequalification is usually performed with the use of standard forms such as AIA's Document A305, "Contractor's Qualification Statement."

Some sophisticated owners develop and maintain lists of prequalified bidders and select from that list for each project. Government agencies are also permitted to prequalify contractors and develop a list of qualified bidders, but the failure to qualify must be based on defined restrictions, such as insufficient financial assets or company size.

BIDDING PROCESS

For government projects and for private-sector projects in which the owner has elected to use completely *open* bidding, the owner or the architect places an advertisement for bids in one or more newspapers and in other publications deemed appropriate. This advertisement lists the pertinent project information, such as its name and address, a general description of the project, the type of contract, the date, time, and place of receiving bids, bid security requirements, and other relevant information.

When the bidders have been preselected, either the owner or the architect issues an invitation to bid to all bidders on the prequalified list. The invitation to bid contains the same information as in an advertisement for bids.

BIDDING DOCUMENTS

When a legitimate bidder responds to an advertisement for bids or an invitation to bid and requests bidding documents, the architect issues one or more sets of bidding documents to each requester. In addition to the advertisement or invitation to bid, the bidding documents issued initially include the following:

- Instructions to bidders, which explain bidding procedures and list the requirements of the bid, such as the requirements for bonds
- Bid forms, which are developed by the owner or the architect to keep the content of all bids in the same format, so as to make interpretation easier and to ensure that bids for required alternates, allowances, and unit prices are included
- Information related to bonds, including bid bonds required to ensure that a bidder will sign an agreement based on his or her bid or forfeit the bond amount, and performance and payment bonds that ensure completion of the signed contract and payment of the constructor's related debts
- Form of the owner/contractor agreement
- The conditions of the contract (general and supplementary)
- Drawings
- The project manual

Bidding documents also include addenda and other modifications to the previously issued documents that are issued prior to contract signing.

1.7.2.2 Negotiation

Bid projects are often negotiated with the lowest bidder, or several of the lowest bidders, to arrive at a final cost and determine changes to the original proposal. Conversely, in a *negotiated* project, a single constructor is selected and the contract sums and terms are negotiated between the constructor and the owner, usually with advice from the architect.

SELECTING POTENTIAL CONSTRUCTORS

An owner may select a potential constructor by firsthand knowledge of the firm or by reputation, or may select several potential constructors and reduce the list to one by a prequalification process similar to that described for bid projects.

A negotiated contract may be a straight single-prime-contractor contract or may have multiple prime contractors. It may result in a fixed-price stipulated sum, cost-plus-fee, or unit price agreement. It may result in a construction management system with a GMP. It may also be used for design-build agreements.

NEGOTIATION PROCESS

The constructor in a negotiated contract is sometimes engaged before the architect's and associated consulting engineer's design work has been completed. The advantage of this arrangement is that the constructor can be called on to issue advice related to systems and products as the design work progresses. This advice can be related to costs, availability, and interface problems that may be encountered in the field. The disadvantage is that materials and systems selections and design judgments are sometimes based on factors other than costs and ease of construction. Care must be taken to ensure that the architect maintains control of the use, safety, and aesthetic aspects of the project.

NEGOTIATION DOCUMENTS

Negotiation documents are mostly the same as bidding documents. However, there is no advertisement, invitation to bid, or instructions to bidders. Additional requirements must sometimes be established, however, for subcontract bids. The conditions of the contract will also vary somewhat based on the delivery system to be used.

1.7.3 ARCHITECT'S RESPONSIBILITIES

In addition to the responsibilities already delineated, the architect should conduct public bid openings, unless the owner elects to do so. The architect should assist the owner in evaluating bids and negotiated contract terms. The architect should also advise the owner in regard to acceptance of bids and selection of a contractor, but the responsibility for these duties and for executing the owner/contractor agreement rests solely on the owner.

1.8 Construction Contract Administration

Some owners undervalue the potential contribution of their architects and consulting engineers during building construction and do not continue their services past the bidding and negotiation phase. Fortunately, most owners understand the advantages of these continued services and employ their design professionals until the construction has been completed. In some types of delivery systems, the design professionals' involvement during construction is essential. Obviously, in a design-build project, the design professionals are part of the design-build team and must continue with the project until completion.

Fast-track delivery systems also require the services of design professionals through the construction process. For the most part, in such projects the design and construction documents are not finished until a short time before the construction has been completed. Construction management projects are also frequently fast-track and need the services of design professionals throughout.

When engaged by owners to provide services during the construction phase of a building project, architects and engineers can provide the following services:

1. Hold preconstruction conferences to clarify procedures and establish the responsibilities of the various team members. Who the team members are will vary with the delivery system. At the least, there will be an owner, an architect, consulting engineers, and the general contractor.
2. Review and process the contractor submittals, such as shop drawings, samples, product data, mockups, test results, bonds, and record drawings.
3. Conduct periodic field observations to ensure that the work is proceeding in accordance with the contract documents, to issue field reports detailing these observations and noting the progress of the work, and to reject work found to be not in compliance with the contract documents.
4. Respond in writing to the contractor's questions concerning the intent of the contract documents.
5. Issue documents to make changes in the work. Minor changes can be made by a simple written order by the architect. Changes affecting project delivery time or costs are made by *change orders*. Change orders are sometimes initiated by the architect, who asks the contractor in writing to submit a *proposal request* for the desired changes. The contractor then responds with a proposal, indicating changes in contract time or cost associated with the requested change. In other cases, proposal requests are initiated by the contractor. In either case, the architect reviews the contractor's proposal and advises the owner whether to accept or reject it. Once the terms of the proposal request are acceptable to both the owner and the contractor, the architect issues a change order, which must then be signed by both the owner and the contractor. Signed change orders become a part of the contract for construction.
6. Attend regularly scheduled project progress meetings with representatives of the owner and the contractor.
7. Review and process the contractor's applications for payment. At the beginning of a project, the contractor submits to the architect a *schedule of values*, which is broken down into the various portions of the work. Periodically, usually once each month, the contractor submits to the architect an *application for payment*, indicating the progress of the work to date and the amount of the contract sum due that month. The application is broken down in exactly the same way as the schedule of values so that the two can be compared. The architect and his or her consultants visit the project site and compare the contractor's application with the work accomplished. The consultants report their findings to the architect, who then certifies payment by filling in, on the contractor's application for payment, the dollar amount due that month based on the architect's and consultants' observations. The amount certified may be the amount shown in the application or may be less, depending on the architect's judgment of the work actually completed. When a discrepancy is found, there is usually an attempt to have the contractor revise the proposal, but the certified amount is based ultimately on the architect's judgment, taking into account the consultants' opinions. The architect must submit written justification for payments certified in amounts less than those requested. The owner bears the final responsibility for payment and can pay more or less than is certified. Underpayment, however, can trigger a legal challenge by the contractor and should not be done without documented justification and consultation with an attorney.
8. Handle closeout procedures. When the contractor considers that the work is complete, it initiates *contract closeout*. To do this, the contractor submits a request for a review by the design professional pursuant to *substantial completion*. Substantial completion means that the owner can occupy the premises and use it for its intended purpose. If minor items remain to be completed, the contractor's request must include a list of these items, along with reasons for the incompleteness and the dollar value of each incomplete item. The contractor must also submit all closeout documents required by the contract documents, including, but not limited to, warranties, maintenance agreements, operating instructions, certificates of inspection and occupancy issued by the local jurisdiction, bonds, insurance certificates, and record documents, including drawings and a project manual marked to show all changes made during construction. The contractor must also submit maintenance and replacement stock and keys, and must instruct the owner's personnel in the operation of equipment as required by the contract documents.
9. Upon receipt of a request for a substantial completion inspection, the architect and the architect's consultants will inspect the project. If they consider the work not substantially complete, the architect will so notify the contractor with a list of observed incomplete work. The contractor must then correct the deficiencies and submit a new request for inspection. The architect and the architect's consultants will again visit the site and conduct a second inspection. When the

architect and the architect's consultants deem the work to be substantially complete, and after all required closeout materials have been received, the architect will issue a certificate of substantial completion. If items still remain incomplete at that time, the certificate will be accompanied by a list (punch list) of these remaining items and a date, usually 30 days, within which the remaining work must be completed.
10. Issue a *certificate of final completion*. When the items on the punch list have been completed and the architect is convinced that all contract work and the contractor's other obligations under the contract have been completed, the architect will issue a certificate of final completion. The contractor may then submit a request for final payment.
11. Review and certify the contractor's final request for payment. This will complete the architect's basic services under most construction contracts.

1.9 Construction Management

A construction manager usually acts as an adviser to the owner to determine probable construction costs during the design phase of a building construction project. The construction manager may or may not assist the owner during the bidding or negotiation phase (see Section 1.7). A construction manager may be involved in a project during the construction phase. In this case, the construction manager may be a separate entity or the prime contractor. In either case, the construction manager acts as an agent of the owner, coordinates the work of the prime contractor or multiple prime contractors, and oversees quality control for the project. Whether the construction manager is a separate entity or the prime general contractor, when representing the owner during construction, the construction manager usually bears the responsibility of ensuring that the construction project is completed on time and within its budget.

The architect sometimes functions as a construction manager. An AIA survey done in 2000 showed that 36% of the responding architectural firms offered CM services. More often, however, construction management services are performed by a professional other than the designing architect or by the prime contractor.

CM is a relatively recent innovation in the building construction industry that has gained a strong following. The owners of many major construction projects employ the services of a construction manager in some form. Colleges and universities are now offering degrees in CM. Some architects have expanded their services to include CM.

CM services may be performed by the designing architect, by the prime building contractor, or by a third party representing neither. A construction manager may perform services in one of three ways:

1. As an adviser. In this capacity, a construction manager will act as a consultant on cost management while the design is proceeding, but will have no involvement in the construction process.
2. As an agent of the owner. In this capacity, the construction manager will consult with the owner about cost matters during the design phase, and will be involved in selecting contractors and subcontractors and coordinating the work of the constructors during construction of the building. In this capacity, the construction manager is a consultant only and bears no financial responsibility for the project.
3. As a constructor. In this capacity, the construction manager may be involved in the design phase and also act as the prime contractor during the construction phase. This arrangement is usually done under a GMP agreement (see Section 1.7). A major problem with this arrangement is that the cost estimator (the construction manager), the quality control overseer (also the construction manager), and the constructor (prime building contractor) are one and the same. This can lead to inherent conflicts of interest. It does not, however, mean that such an arrangement should not be considered, so long as the owner is aware of the potential conflict.

Other conditions under which CM services may be provided are also possible.

Many CM projects are also done using fast-tract procedures (see Section 1.6). When this is done, a GMP agreement is usually employed. This combination allows the owner to establish a maximum cost while taking advantage of speedy delivery of the building and quality control during construction. Often the agreement between the construction manager/constructor and the owner stipulates a guaranteed completion date.

1.9.1 ADVANTAGES AND DISADVANTAGES OF THE CM APPROACH

1.9.1.1 Advantages

A CM delivery system offers an owner a single point responsibility and thus accountability for a construction project. It also can lead to increased construction and design quality and a significant cost savings to the owner. Properly done, CM should also assure a better chance of having the building completed within is construction schedule.

1.9.1.2 Disadvantages

There are inherent disadvantages of using a CM delivery system for building construction projects. These are related to the type of CM system used and the relationship of the construction manager to the owner and the project. When the CM services are performed by the constructor or a third party, there is the possibility that providing this additional layer of services will increase the cost to the owner, but there is no guarantee that this additional cost will result in a better project. As stated earlier, there is an inherent conflict of interest that may be difficult to overcome when the same firm estimates the cost of the project, influences which products will be used in the project, and then has to purchase those products. Sometimes the relationships between construction managers and the subcontractors they employ can also result in a conflict of interest.

The owner is somewhat better protected when the construction manager is also the designing architect. Unfortunately, there are drawbacks to this system as well. The owner may be concerned that the architect acting as the construction manager will protect the architect in his capacity as designer when a conflict arises during construction and an interpretation must be made. To alleviate this and other potential problems, an owner may feel the need to engage a full-time observer to oversee the construction manager. This is an increased cost to the owner.

1.9.2 CONSTRUCTION MANAGER QUALIFICATIONS

A construction manager must have the ability to perform as an administrator, must have an extensive background in the construction industry, and must have accumulated the knowledge of both design and construction necessary to act in this capacity. In addition, a construction manager must have the skills necessary to deal with people both on the professional level and in the building trades. The industry skills necessary are an understanding and ability in specifications writing, estimating, and record keeping. A construction manager will encounter many crises during the performance of the work and must be able to handle them without floundering. Competent administrative support is essential to anyone engaging in construction management.

A construction manager must have an extensive knowledge of the relationships between prime contractors, subcontractors, and product suppliers. An understanding of contracts and contractual arrangements is essential.

1.9.3 SCHEDULING

Construction managers are responsible for scheduling and controlling many construction-related activities. Several types of methods are used for scheduling these activities. The bar chart method and the critical path method are the ones most widely used.

1.9.3.1 Bar Chart Method

The *bar chart method* of scheduling is the oldest scheduling control device. In spite of the advent of computerized planning methods, bar charts are still the most widely used scheduling control method today. On projects with no construction manager, the prime contractor is usually required to submit a schedule of activities and to update this schedule periodically, usually monthly, to show the progress of the work. This submittal is required as a supplement to the contractor's application for payment. When there is a construction manager, he or she is often responsible for similar schedules.

Bar charts can take several forms, but the most common is a chart similar to that shown in Figure 1.9-1. The table is basically self-explanatory. The lighter gray bar represents the scheduled (SCH) beginning and end of the task. The darker gray bar represents the actual (ACT) beginning and end of the task. Sometimes the day of the month is indicated above each box. The number in the Weight column is the percentage that task represents of the entire project.

1.9.3.2 Critical Path Method

The *critical path method* (CPM) of scheduling is a computer-based, highly mathematical method that is frequently used on large or complex projects and is often required as a project's scheduling method, especially for government projects. A detailed discussion of CPM programing is beyond the scope of this book, but some basics are included here.

FIGURE 1.9-1 A Construction Schedule Bar Chart*

Description of Task	Weight %		2006												2007							
			J	F	M	A	M	J	J	A	S	O	N	D	J	B	M	A	M	J	J	A
1. Strip site	8	SCH																				
		ACT																				
2. Footing excavation	6	SCH																				
		ACT																				
3. Place footings	7	SCH																				
		ACT																				
4. Foundation walls	12	SCH																				
		ACT																				
5. Column bases	2	SCH																				
		ACT																				
6. Steel columns on site	1	SCH																				
		ACT																				
		SCH																				
		ACT																				
		SCH																				
		ACT																				
		SCH																				
		ACT																				
		SCH																				
		ACT																				
		SCH																				
		ACT																				

*This type of chart is also known as a *Gantt chart,* because it is based on a chart originated by Henry L. Gantt.

CPM begins with the production of a detailed list showing each task that must be performed during a particular construction project. An identifying code, often an alphanumeric one, is assigned to each task. For example, a task might be C1, "Clear North Site."

Next, the relationships between the various tasks are identified. There are four possible relationships: (1) Task 2 bears no relationship to Task 1; (2) Task 2 cannot be started until Task 1 is partially completed; (3) Task 2 cannot be started until Task 1 has been completed; (4) Task 2 cannot be completed until Task 1 has been completed. Network diagrams and precedence diagrams are developed that show these relationships in graphic form. Network diagrams are spider-web-like diagrams. Precedence diagrams are charts. These diagrams show which task must be done before the next task can commence. For example, it is not possible to begin rough grading before clearing has been at least partially done. Obviously, some tasks will not have to wait on other tasks to proceed. For example, Task O1, "Order Topsoil," will not have to wait for Task C1, "Clear North Site," to be completed, or even started for that matter.

Once the relationship between tasks has been identified and charted, it is then necessary to determine a duration time (how long it will take) for each task. This duration time is added to the network diagram.

Once the duration time has been established, a schedule is developed to show the first date that a task can be started (*early start date*) and the first date that it can be completed (*early completion date*). The early completion date occurs on the date revealed by adding the task duration to the early start date. When a task cannot be started before another task has been completed, the early start date for the second task is the same as the early completion date for the first task.

When the schedule showing early start and early finish dates has been completed, a completion date will emerge. Once the completion date has been established, it is possible to work backward through the chart and determine the latest date that each task can be completed, as well as the latest date the each task can be completed without affecting the completion date of the project. For each task, the difference in days between the early start date and the late start date or between the late finish date and the early finish date is called *float time*. This float time is the maximum number of days a task can be late without affecting the project completion date.

From the completed schedule, it is possible to determine the *critical path* for the project. A task that has the same late start and early start date or the same early finish and late finish date is on the critical path. It is essential that tasks that fall on the critical path be completed by their late finish date to avoid jeopardizing the project completion date.

CPM scheduling is time-consuming and costly. It will probably not be justified for small or simple projects unless the owner demands its use. CPM schedules are difficult, almost impossible, to prepare without the use of a computer. Fortunately, several organizations offer software for CPM schedules. These include, but are not limited to, AEC Software in Sterling, Virginia; Primavera Systems, Inc., in Bala Cynwyd, Pennsylvania, and Microsoft Corporation in Redwood, Washington.

1.9.4 PROJECT CASH FLOW

A construction manager involved in the construction phase of a project is usually responsible for keeping track of the progress of the project, and for advising the owner concerning periodic payments to the prime contractor and subcontractors. The prime contractor's monthly progress reports and applications for payment are reviewed by the construction manager before they are forwarded to the architect for review and comment. The construction manager is responsible for determining whether the completion percentages shown by the contract are accurate, and for returning the application for payment to the contractor for revision if such is necessary. An architect involved in the construction phase of a project is also responsible for reviewing these figures, but when a construction manager is involved, the architect reviews the figures after the construction manager has reviewed them and they are accepted or returned to the contractor for revision.

When a construction manager is involved in a construction project, the payment procedure can take more time than for a project where no construction manager is involved and may delay payments to the contractor. Usually the time period from the contractor's submittal of a payment application to the required payment is increased in the construction agreement to a longer time than would otherwise be required to accommodate anticipated delays.

The general contractor's costs of operations are usually not the responsibility of the construction manager unless the construction manager is also the general contractor. In any event, control of construction cost is beyond the scope of this book.

1.9.5 OTHER CONSIDERATIONS

A construction manager is responsible for numerous other activities. When the construction manager is also the constructor, many of the construction manager's responsibilities are the same as those of a general contractor and are beyond the scope of this book.

In addition to the functions already mentioned, a construction manager is responsible for the same activities and to the same extent that the architect is responsible in a project where there is no construction manager. These responsibilities include observation and reporting of safety issues, inferior construction practices, and inferior completed work; violations of the construction agreement; failure to comply with the requirements of the contract document; review of contractor submittals; and most of the other architect's responsibilities delineated in Section 1.8, with the exception of duties that are clearly within the purview of the architect, such as issuing clarifications of the construction documents.

1.9.6 APPLICABLE AIA DOCUMENTS

AIA provides a number of documents to aid architects and owners in obtaining and developing agreements for construction management services. These are listed in Section 1.11.

1.10 Additional Reading

More information about the subjects discussed in this chapter can be found in the references listed in Section 1.11, and in the following publications.

Allen, Edward. 2004. *Fundamentals of Building Construction: Materials and Methods*, 4th ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Allen, Edward and Joseph Iano. 2001. *The Architect's Studio Companion: Rules of Thumb for Preliminary Design*, 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Antill, James M. and Ronald W. Woodhead. 1990. *Critical Path Methods in Construction Practice*, 4th ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Bannister, Jay M. 1991. *Building Construction Inspection: A Guide for Architects*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Belcher, Osmund F. 2001. "Cost Control and Schedule Control Management." *The Construction Specifier* (June): 47 (www.csinet.org).
Construction Specifications Institute 2004. *The Project Resource Manual—CSI Manual of Practice.* Alexandria, VA: CSI (www.csinet.org).
———. *Masterformat 2004*. Alexandria, VA: CSI (www.csinet.org).
Construction Specifications Institute (CSI), American Institute of Architects (AIA), and National Institute of Building Sciences (NIBS). 2004. *National CAD Standard Version 3.0 Update from Version 2.0*. CSI (www.csinet.org), AIA (www.aia.org), and NIBS (www.nibs.org).
Dell'Isola, Michael D. 2001. "Contract Management: Know Your Options." *The Construction Specifier* (September): 38 (www.csinet.org).
Foss, Rebecca. 2001. "Sustainable Building." *The Construction Specifier* (July): 32 (www.csinet.org).
Haney, Craig K. 2002. "Construction Documents for Historic Projects." *The Construction Specifier* (October): 52 (www.csinet.org).
Hartmen, Douglas C. 2001. "Construction Administration—New Tools and Methods for Efficiency." *The Construction Specifier* (November): 56 (www.csinet.org).
Hentschel, Rick. 2001. "Closing the Deal—The Role of the Project Manager in the Justification Process." *The Construction Specifier* (November): 46 (www.csinet.org).
Halpin, Daniel W. and Ronald W. Woodhead. 1998. *Construction Management*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Ingardia, Michael P. and G. William Quatman. 2001. "Computer-Aided Design and Electronic Documents." *The Construction Specifier* (March): 45 (www.csinet.org).
International Code Council. 2003. *International Codes*. Falls Church, VA: ICC (www.iccsafe.org).
Kepler, Stephen and Judith Pinkelny Tibbs. 2000. "LEED: Good for Business, Good for the Environment." *The Construction Specifier* (July): 27 (www.csinet.org).
Langdon, Geoffrey Moore. 2001. "Architectural CADD." *The Construction Specifier* (May): 31 (www.csinet.org).
Liebing, Ralph W. 1999. *Architectural Working Drawings*, 4th ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Mays, Patrick C. and B. J. Novitski. 1997. *Construction Administration: An Architect's Guide to Surviving Information Overload*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Nunnally, S. W. 2001. *Construction Methods and Management*. Upper Saddle River, NJ: Prentice Hall (www.vig.prenhall.com).
Ramsey, Charles George, Harold Reeve Sleeper, and John Ray Hoke, Jr. 2000. *Architectural Graphic Standards*, 10th ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Reifsnider, Randal J. 2002. "National CAD Standard." *The Construction Specifier* (April): 39 (www.csinet.org).
Roberts, Greg. 2001. "The Green Team." *The Construction Specifier* (July): 47 (www.csinet.org).
Snyder, James. 1998. *Architectural Construction Drawings with AutoCAD® R14*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Stovall, Gerald L. 1995. "Project Contract Administration." *The Construction Specifier* (May): 149 (www.csinet.org).
Stratton, Peter A. 2001. "Universal Design." *The Construction Specifier* (February): 27 (www.csinet.org).
Templeton, Peter, Tom Dietsche, and Kris Price. 2001. "Green Buildings in Black and White." *The Construction Specifier* (July): 29 (www.csinet.org).
Wakita, Osamu and Richard M. Linde. 2002. *The Professional Practice of Architectural Working Drawings*, 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
Watson, Wayne. 2001. "Understanding and Classifying Performance Specifications." *The Construction Specifier* (August): 38 (www.csinet.org).
Wilson, Alex. 2001. "Identifying Green Building Products." *The Construction Specifier* (July): 24 (www.csinet.org).
Yee, Rendow.2002. *Architectural Drawing: A Visual Compendium of Types and Methods*, 2nd ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

1.11 Acknowledgments and References

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of the following organizations and individuals in preparing this chapter. We are also indebted to them for permission to use their illustrations when requested and for the use of their publications as references.

American Institute of Architects (AIA) (www.aia.org)
American National Standards Institute (ANSI) (www.ansi.org)
American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) (www.ashrae.org)
ASTM International (ASTM) (www.astm.org)
BE&K, Inc. (www.bek.com)
Bethlehem Steel Corporation (www.bethsteel.com)
Capital Development Board of the State of Illinois (www.cdb.state.il.us)
Construction Specifications Institute (CSI) (www.csinet.org)
Geoffrey Lee Farnsworth, AIA
International Code Council (ICC) (www.iccsafe.org)
National Association of Home Builders (NAHB) Research Foundation (www.nahbrc.org)
National Association of Women in Construction (NAWCI) (www.nawic.org)
National Easter Seal Society (www.cdc.gov/nasd/orgs)
National Institute of Building Sciences (NIBS) (www.nibs.org)

National Institute of Standards and Technology (NIST) of the U.S. Department of Commerce (www.nist.gov)
Betsy A. Pavichevich
Plumbing-Heating-Cooling Contractors Association (PHCCA) (www.phccweb.org)
Associate Professor Edward Steinfeld
T & S Brass and Bronze Works, Inc. (www.tsbrass.com)
Underwriters Laboratories, Inc. (UL) (www.ul.com)
U.S. Architectural and Transportation Barriers Compliance Board (ATBCB) (www.access-board.gov)
U.S. Department of Housing and Urban Development (HUD) (www.hud.gov)
U.S. General Services Administration (GSA), Specifications Unit (www.usgs.gov)
U.S. Green Building Council (www.usgbc.org)

REFERENCES

We would also like to thank the authors and publishers of the publications in the following list for their contribution to our research for this chapter.

American Institute of Architects. 2001. *The Architect's Handbook of Professional Practice*, 13th ed. and supplements. Hoboken, NJ. John Wiley & Sons, Inc. (www.wiley.com).
———. "Construction Management Checklist." This document is included in Chapter 18 of *The Architect's Handbook of Professional Practice*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).
American Institute of Architects (AIA). Washington, DC (www.aia.org). Documents:
- A101, "Owner-Contractor Agreement Stipulated."
- A101/CMa, "Owner-Contractor Agreement Stipulated Sum—Construction Manager-Adviser Edition."
- A111, "Owner-Contractor Agreement Form—Cost of the Work Plus a Fee with or without a Guaranteed Maximum Price."
- A121/CMa (AGC 565), "Standard Form of Agreement Between Owner and Construction Manager Where the Construction Manager Is Also the Constructor."
- A131/CMa (AGC 566), "Standard Form of Agreement Between Owner and Construction Manager Where the Construction Manager Is Also the Constructor; and Where the Basis of Payment Is the Cost of the Work Plus a Fee and There Is No Guarantee of Cost."
- A191, "Standard Form of Agreement Between Owner and Design/Builder."
- A201 "General Conditions of the Contract for Construction."
- A201/CMa, "General Conditions of the Contract for Construction—Construction Manager—Adviser Edition."
- A305, "Contractor's Qualification Statement."
- A310, "Bid Bond."
- A312, "Performance and Payment Bond."
- A491, "Standard Form of Agreement Between Design/Builder and Contractor.
- A501, "Recommended Guide for Competitive Bidding Procedures and Contract Awards for Building Construction."
- A511/CMa, "Guide for Supplementary Conditions—Construction Manager-Adviser Edition."
- A701, "Instructions to Bidders."
- B141/CMa, "Standard Form of Agreement Between Owner and Architect, Construction Manager—Adviser Edition."
- B144/ARCG-CM, "Standard Form of Amendment for the Agreement Between the Owner and Architect—Construction Management Services."
- B352, "Duties, Responsibilities, and Limitations of Authority of the Architect's Project Representative."
- B801/CMa, "Standard Form of Agreement Between Owner and Construction Manager-Adviser."
- B901, "Standard Form of Agreement Between Design/Builder and Architect."
- G701, "Change Order."
- G701/CMa, "Change Order—Construction Manager—Adviser Edition."
- G702/G703, "Application and Certificate for Payment and Continuation Sheet."
- G702/CMa, "Application and Certificate for Payment—Construction Manager-Adviser Edition."
- G703/CMa, "Continuation Sheet."
- G704, "Certificate of Substantial Completion."
- G704/CMa, "Certificate of Substantial Completion—Construction Manager-Adviser Edition."
- G706, "Contractor's Affidavit of Payment of Debts and Claims."
- G707, "Consent of Surety to Final Payment."
- G707A, "Consent of Surety to Reduction in or Partial Release of Retainage."
- G709, "Proposal Request."
- G714, "Construction Change Directive."
- G714/CMa, "Construction Change Directive—Construction Manager—Adviser Edition."
- G722/CMa, G723/CMa, "Project Application and Project Certificate for Payment and Project Application Summary."

American National Standards Institute.
- A117.1. 2003. *Accessible and Usable Buildings And Facilities*. New York: ANSI (www.ansi.org).
- A156.10. 2003. *Power Operated Pedestrian Doors*.
- A156.19. 2002. *Power Assist and Low Energy Power Operated Doors*.

American Society of Mechanical Engineers (ASME). 2004. *Safety Code for Elevators and Escalators*. Fairfield, NJ: ASME (www.asme.org).
Architectural Graphic Standards. See Ramsey et al. (2000).
Arcom Master Systems. *Masterspec*. Salt Lake City, UT (www.arcomnet.com). Basic Sections:
- 01210, "Allowances," 11/02 ed.
- 01290, "Payment Procedures," 11/02 ed.
- 01310, "Project Management and Coordination," 8/04 ed.
- 01330, "Submittal Procedures," 11/02 ed.
- 01352, "LEED Requirements," 2/03 ed.
- 01600, "Product Requirements," 11/02 ed.
- 01770 "Closeout Procedures," 11/02 ed.
- 01781. "Project Record Documents," 11/02 ed.
- 01782. "Operation and Maintenance Data," 11/02 ed.
- 01810. "General Commissioning Requirements," 3/03 ed.
- "HVAC Commissioning Requirements," 3/03 ed.

Construction Specifications Institute. 2004. *The Project Resource Manual—CSI Manual of Practice.* Alexandria, VA: CSI (www.csinet.org).

———. *Masterformat 2004*. Alexandria, VA: CSI (www.csinet.org).

Construction Specifications Institute (CSI), American Institute of Architects AIA), and National Institute of Building Sciences (NIBS). 2004. *National CAD Standard Version 3.0 Update from Version 2.0*. CSI (www.csinet.org), AIA (www.aia.org), and NIBS (www.nibs.org).

Halpin, Daniel W. and Ronald W. Woodhead. 1998. *Construction Management*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

International Code Council. (ICC) 2006. International Codes (see section 1.3.3.3 for a list of ICC codes).

Liebing, Ralph W. 1999. *Architectural Working Drawings*, 4th ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

Mays, Patrick C. and B. J. Novitski. 1997. *Construction Administration: An Architect's Guide to Surviving Information Overload*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

National Fire Protection Association (NFPA). 2002. NFPA 70A, "Electrical Code for One- and Two-family Dwellings." Quincy. MA: NFPA (www.nfpa.org).

———. 2003. *NFPA 101®. Life Safety® Code.* Quincy, MA: NFPA (www.nfpa.org).

———. 2005. NFPA 70. "National Electrical Code." Quincy, MA: NFPA (www.nfpa.org).

Nunnally, S. W. 2004. *Construction Methods and Management*, 6th ed. Upper Saddle River, NJ: Pearson Education, Prentice Hall (www.vig.prenhall.com).

Ramsey, Charles George, Harold Reeve Sleeper, and John Ray Hoke, Jr. 2000. *Architectural Graphic Standards*, 10th ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

Rosen, Harold J. 1999. *Construction Specifications Writing: Principles and Procedures*, 4th ed. New York: John Wiley & Sons, Inc. (www.wiley.com).

Snyder, James. 1998. *Architectural Construction Drawings with AutoCAD® R14*. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

U.S. Department of Housing and Urban Development (HUD). 1988. *Uniform Federal Accessibility Standards (UFAS)*. Washington, DC: HUD (www.hud.gov).

———. 1994. *Minimum Property Standards for One- and Two-Family Dwellings*, HUD-4910.1. Washington, DC: HUD (www.hud.gov).

U.S. General Services Administration (GSA). *Index of Federal Specifications, Standards, and Commercial Item Descriptions*. Washington, DC: GSA (www.apps.fss.gsa.gov).

U.S. Green Building Council. 2003. "LEED NC Version 2.1 Rating System." Washington, DC: Green Building Council (www.usgbc.org.).

Wakita, Osamu and Richard M. Linde. 2002. *The Professional Practice of Architectural Working Drawings*, 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).

Yee, Rendow. 2002. *Architectural Drawing: A Visual Compendium of Types and Methods*, 2nd ed. Hoboken, NJ: John Wiley & Sons, Inc. (www.wiley.com).