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ANSI/ASHRAE 62.1-2016: *Ventilation for Acceptable Indoor Air Quality*, 2016. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

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CSI: *MasterFormat*, 2016. Construction Specifications Institute, Alexandria, VA.

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IBC: *International Building Code*, 2015. International Code Council, Washington, DC.

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IECC: *International Energy Conservation Code*, 2015. International Code Council, Washington, DC.

IgCC: *International Green Construction Code*, 2015. International Code Council, Washington, DC.

IMC: *International Mechanical Code*, 2015. International Code Council, Washington, DC.

IPC: *International Plumbing Code*, 2015. International Code Council, Washington, DC.

IRC: *International Residential Code*, 2015. International Code Council, Washington, DC.

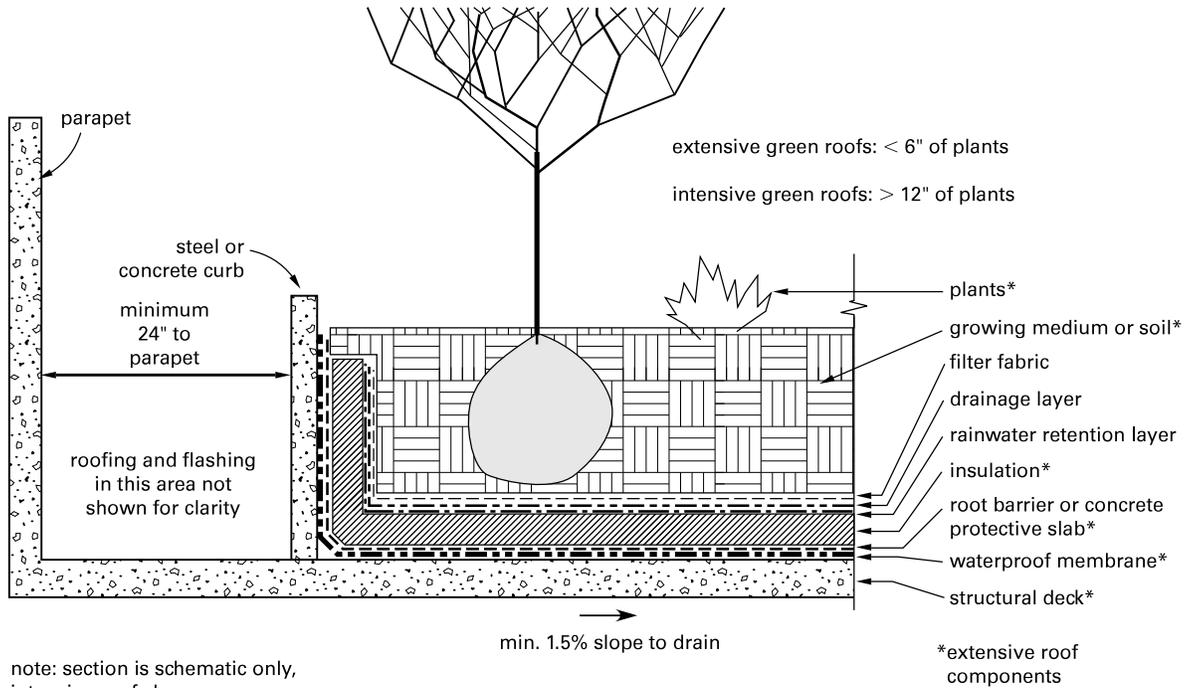
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The Secretary of the Interior's Standards for Rehabilitation, 2010. *Code of Federal Regulations*, Title 36, Part 67.

**Figure 12.20** Green Roof Construction

## Green Roofs

A *green roof*, also called a *vegetated roof*, *garden roof*, or *eco-roof*, is a system consisting of planting containers filled with soil and a layer of vegetation, that is installed on top of a roof that has been designed for this purpose. Some advantages of a green roof include

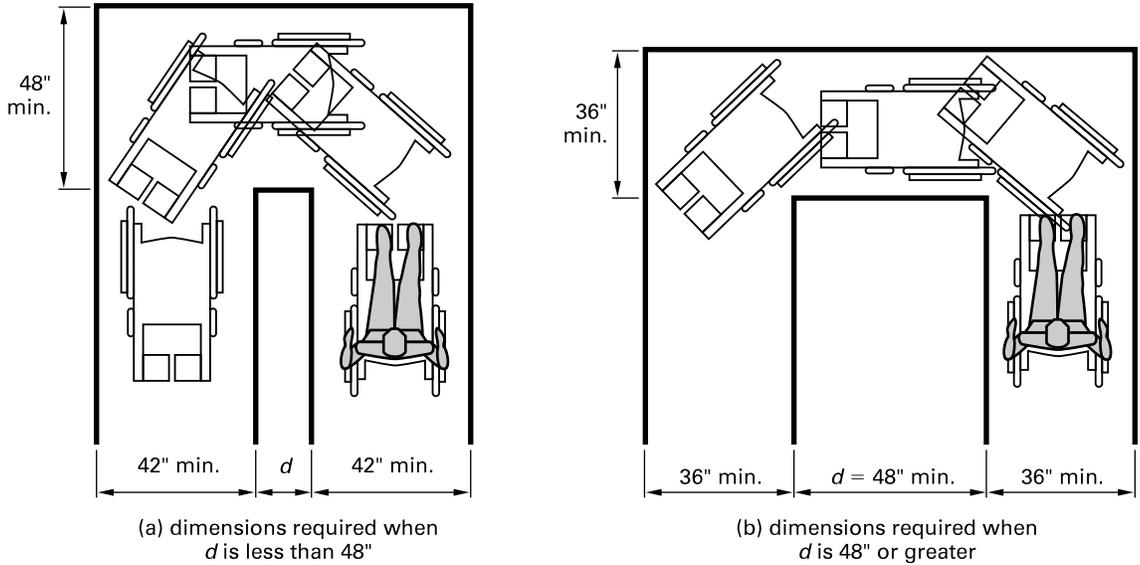
- conserving energy by reducing cooling and heating loads
- reducing storm runoff
- absorbing carbon dioxide
- reducing ambient air temperatures
- filtering the air and binding dust particles
- reducing the heat island effect normally caused by exposed roofing membranes
- protecting roofing membranes from ultraviolet light degradation, temperature extremes, wind, and hail
- adding acoustical insulation
- adding aesthetic appeal to the roof

There are two types of green roofs: extensive and intensive. *Extensive green roofs* use soil less than 6 in deep, which is capable of supporting meadow grasses, sedums, herbs, and perennials.

*Intensive green roofs* use deeper soil (usually 12 in or more) and support complex landscapes, including shrubs and small trees. Intensive green roofs may feature landscape elements such as ponds and fountains, and building inhabitants may be invited to use the roof as they would use a garden at grade.

In either case, a subsurface irrigation system is generally recommended to help the plants become established. The system usually remains in place and is used for supplemental watering as needed.

**Figure 15.3**  
Turn in Corridors  
or Around  
Obstructions



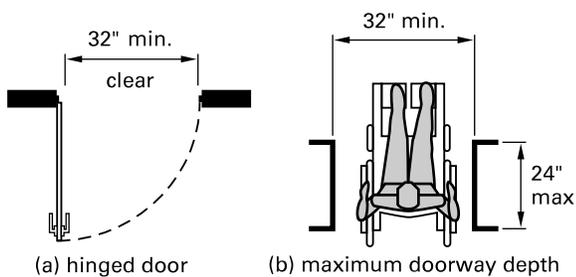
**REACH RANGES**

When a forward reach is unobstructed, the high forward reach is 48 in and the low reach is 15 in minimum above the floor. For example, outlets must be located no less than 15 in above the floor. When the forward reach is over an obstruction, like a countertop, the high forward reach for obstructions over 20 in up to 25 in is a maximum of 44 in. When a clear floor space allows a parallel approach to an element the side reach is a maximum of 48 in. When there an obstruction and a parallel approach is possible the side reach is still 48 in if the obstruction has a maximum depth of 10 in and a maximum height of 34 in. Refer to the *ADA Standards* for reach ranges for children and other exceptions.

**DOORWAYS**  
**Width and Arrangement**

Doors must have a minimum clear opening width of 32 in when the door is opened at 90°. The maximum depth of a doorway 32 in wide is 24 in. If the area is deeper than this, the width must be increased to 36 in. See Fig. 15.4.

**Figure 15.4**  
Doorway  
Clearances



Maneuvering clearances are required at standard swinging doors to allow easy operation of the latch and provide for a clear swing. For single doors the clearances are shown in Fig. 15.5. For two doors in a series the minimum space is shown in Fig. 15.6. Note the 48 in space requirement. If sufficient clearance is not provided, the doors must have power-assisted mechanisms or be automatic opening.

**Opening Force**

The maximum opening force (torque) required to push or pull open interior hinged doors cannot be more than 5 lbf-ft. This force does not include the force required to retract the latch bolts or disengage other devices that may hold the door closed. Maximum opening forces may be greater if the door is a fire door and regulated by the local code jurisdiction. Automatic doors and power-assisted doors may also be used if they comply with ANSI/BHMA Standard A156.10 (automatic doors) or ANSI/BHMA Standard 156.19 (low-powered, automatic doors).

When closers are used, the sweep period of the door must be adjusted so that from an open position of 70°, the door will take at least 3 sec to move to a point 3 in from the latch as measured to the leading edge of the door.

One special alloy, used primarily for roofing, is *Monel metal* (a trade name), which is a combination of copper and nickel with small amounts of other elements. It is also highly resistant to corrosion and is easily worked.

**Miscellaneous Nonferrous Metals**

Zinc is resistant to corrosion and is sometimes used for sheet roofing and flashing. Zinc fasteners are also made. The metal is more commonly used for coating steel to produce galvanized steel.

Lead is also resistant to corrosion and is occasionally used to cover complex roofing shapes because it is very easy to form around irregularities. However, its density makes it ideal for acoustical insulation, vibration control, and radiation shielding. An alloy of 75% lead and 25% tin can be used to plate steel for roofing. This is known as *terneplate*.

**STRUCTURAL METALS**

**Steel Shapes**

The two metals used in structural applications are steel and aluminum, although steel is by far the most common. The structural use of aluminum is limited to small structures or minor portions of structures. Steel is used for beams, columns, and plates; in light-gage framing such as steel studs; for floor and roof decking; as prefabricated truss joists; and for many types of fasteners.

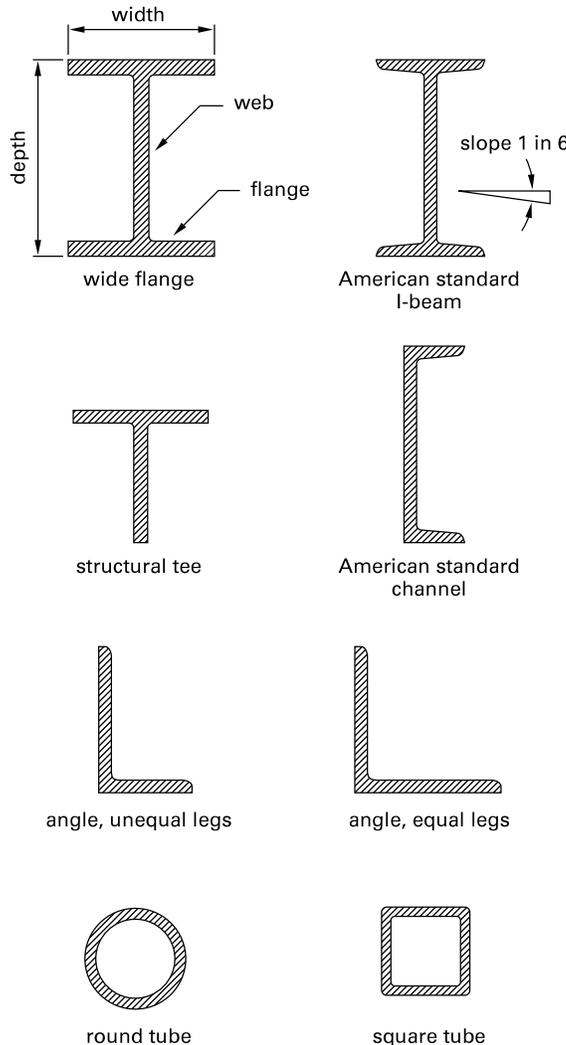
Structural steel comes in a variety of shapes, sizes, and weights, giving the designer a great deal of flexibility in selecting an economical member that is geometrically correct for any given situation. Figure 24.1 shows the most common shapes of structural steel.

*Wide-flange members* are H-shaped sections used for both beams and columns. They are called wide flange because the width of the flange is greater than that of standard I-beams. Many of the wide-flange shapes are particularly suited for columns because the width of the flange is very nearly equal to the depth of the section, so they have about the same rigidity in both axes.

*Wide-flange sections* are designated with the letter W followed by the nominal depth in inches (millimeters) and the weight in lbm/ft. For example, a W18 × 85 is a wide flange nominally

alloy	UNS no.	name	nominal composition
110	C11000	copper	99.9% copper
220	C22000	commercial bronze	90% copper 10% zinc
230	C23000	red brass	85% copper 15% zinc
260	C26000	cartridge brass	70% copper 30% zinc
280	C28000	Muntz metal	60% copper 40% zinc
385	C38500	architectural bronze	57% copper 40% zinc 3% lead
655	C65500	silicon bronze	97% copper 3% silicon
745	C74500	nickel silver	65% copper 25% zinc 10% nickel

**Table 24.2**  
Composition and Description of Copper Alloys



**Figure 24.1**  
Structural Steel Shapes

Project Planning

### Other Miscellaneous Metal Fabrications

Other common miscellaneous metal fabrications include gratings, steel ladders for service areas, stair treads, pipe handrails and guardrails, sheet metal enclosures, prefabricated utility stairs, and protective steel bollards, bumpers, and corner guards.

#### Example 24.2

The stringers of prefabricated steel utility stairs are normally constructed of

- (A) angle iron
- (B) channel sections
- (C) steel plate
- (D) tube sections

#### Solution

Although any of the listed forms can be used, the stringers are *normally* constructed of steel channel sections with the flanges turned away from the stair. The steel treads and risers are welded to the webs of the sections.

**The answer is (B).**

### ORNAMENTAL METALS

Ornamental metals include a wide variety of both functional and decorative products, such as handrails, guardrails, and elevator interiors. Metal may also be used for custom doors and door facings, partition and architectural woodwork facing, building directories and kiosks, signs, custom light fixtures, ceilings, or as part of nearly any construction assembly. The decorative options available to the architect are almost limitless. The most commonly used ornamental metals include stainless steel, the copper alloys of bronze and brass, and aluminum. Carbon steel, copper, iron, and porcelain enamel are used less frequently.

Stainless steel and copper alloys are available in several stock forms that fabricators use to construct custom assemblies. Some of the common shapes for brass and bronze are shown in Fig. 24.6. Sheet and bar stock are also available in a number of thicknesses.

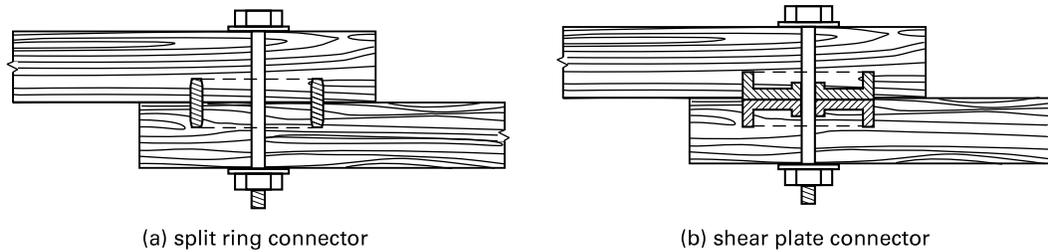
#### Detailing Stainless Steel

Custom details for stainless steel are developed in the same way as for plain carbon steel or any other metal. Combinations of bar, plate, tubing, sheet stock, and other shapes are detailed to nearly any configuration and in any combination. Stainless steel can be joined by welding, mechanical fasteners, and in some cases, with adhesives. For the smoothest joint, welding is preferred. However, the finish specified must make it possible to smooth and work the weld to match the adjacent finish. Some rolled and proprietary finishes cannot be matched after shop welding. When mechanical fasteners such as screws, bolts, and rivets are used, they should also be stainless steel to prevent galvanic action and rust stains caused by carbon steel fasteners. Adhesives are typically used to laminate sheet stock to other materials. In order to simplify fabrication and minimize cost, the smallest sizes and gages that satisfy the application should be used.

#### Detailing with Brass and Bronze

As with stainless steel, basic shapes are used to fabricate custom assemblies by various forming and fastening methods. Brass can also be extruded and cast. Extrusion is common for door and window frames, railings, and trim, whereas casting is used to manufacture hardware and plumbing fixtures.

Brass can be fabricated to any size required, but it is more economical to design and detail ornamental brass using standard shapes (see Fig. 24.6) and sizes whenever possible. Hexagonal and octagonal tubing



**Figure 25.11**  
Timber  
Connectors

### Example 25.1

Which of the following woods must be treated for resistance to decay when used in an exterior application?

- (A) cedar
- (B) spruce
- (C) redwood
- (D) cypress

#### Solution

Spruce trees are not inherently resistant to decay, but the heartwood of cedar, redwood, and cypress all possess a natural resistance that makes them a good choice for use in exterior applications such as siding, shingles or shakes, and decking. The outer rings of these species do not possess the same decay-resistant qualities, so it is important to specify that only heartwood may be used when decay resistance is of concern. These woods are considerably more expensive than other species that are more commonly used for construction such as pine, hemlock, fir, and spruce.

Species that are not inherently decay resistant must be chemically treated to protect them from rotting when exposed to moisture. Waterborne salts are pressure-impregnated into the wood to prevent decay, often for as long as 30 years. After a waiting period, salt-treated wood can be painted or stained.

**The answer is (B).**

## WOOD FRAMING DETAILING

There is a growing emphasis on energy efficiency and sustainability in regard to the use of wood resources. Wood framing and ways to minimize the use of wood are discussed in this section. Sustainability issues with wood are also discussed in Chap. 13.

### Energy-Efficient Detailing

As with other types of construction, careful attention should be paid to insulation and to controlling air infiltration when detailing the various parts of wood frame residential and light commercial construction. Both the *International Energy Conservation Code* and the *International Residential Code* give performance and prescriptive requirements for both.

When detailing wood frame construction, the weather barrier concepts discussed in Chap. 27 apply. There are several ways this can be accomplished. Figure 25.12 illustrates one possible way these principles can be applied in residential construction.

Figure 25.12 shows an ideal configuration in which structural sheathing (e.g., plywood or oriented strand board) is applied to the wood studs and provides a firm base for the house wrap or other *air barrier* or *water resistant barrier* (WRB). Rigid insulation is applied over this to protect the WRB against wind loading, to provide insulation as required by the climate and applicable building codes, and to prevent thermal bridges. This is in addition to insulation installed in the stud cavity.

Special varieties of gypsum wallboard include

- Type X, for fire-rated partitions
- foil-backed, for vapor barriers
- backing board, for use as a base for tile
- water-resistant, for moist conditions
- abuse-resistant, for high-traffic areas
- mold-resistant, which uses inorganic facings instead of paper
- predecorated with vinyl wall covering

Gypsum board faced with fiberglass mat is often used as exterior sheathing over studs and as a backing for water-resistant barriers.

Gypsum board can be applied to wood or metal framing with nails or screws, or to concrete or masonry walls with mastic. The joints are finished by embedding paper or fiberglass tape in a special joint compound and allowing it to dry. Additional layers of joint compound are added and sanded smooth after each application to give the wall surface a smooth finish. After this, the surface can be left smooth for the application of other wall coverings or covered with one of several types of textured finishes.

Because gypsum wallboard is produced in such large quantities, its manufacture, use, and disposal have a noticeable effect on the environment. Since the 1950s, gypsum wallboard manufacturers have been using recycled paper to create the surfaces of wallboard. In addition, some manufacturers use recycled newspaper mixed with gypsum as the core material; this yields a product that is more rigid than standard wallboard yet still maintains all the other advantages.

**Because gypsum wallboard is produced in such large quantities, its manufacture, use, and disposal have a noticeable effect on the environment.**

About half the gypsum used in wallboard in the United States is synthetic. Synthetic gypsum is chemically identical to natural, mined gypsum, but it is a by-product of various manufacturing, industrial, and chemical processes. The main source of synthetic gypsum in North America is *flue-gas desulfurization*, a process by which sul-

fur dioxide is removed from the exhaust gases of power plants and other industrial processes to prevent its release into the atmosphere. In this way, efficient use is made of refuse material that would otherwise have to be discarded.

A larger environmental concern involves the disposal of used gypsum wallboard, which cannot be reused for its original purpose after being ripped out of an old building or a renovation project. Some gypsum wallboard plants around the country will recycle old drywall, as long as it is free of screws, nails, asbestos, and lead paint. However, the cost of collecting, separating, and transporting the old wallboard is a disincentive for recycling.

Old wallboard can also be pulverized into pieces no larger than  $\frac{1}{2}$  in and worked into the ground as a soil additive. Farmers in California and parts of Colorado use recycled gypsum as a soil conditioner for grapes, peas, and peanuts. If local and state regulations allow it, it is possible to work the gypsum directly into the soil around a job site, as long as the land has adequate drainage and aeration.

### Framing

Gypsum wallboard framing for vertical construction can be either wood or metal. In residential construction, wood is generally used, in part because wood stud walls can double as load-bearing walls. Although metal framing could be used, residential contractors usually prefer wood.

In commercial construction, metal studs are commonly used because they are noncombustible, lightweight, non-shrinking, and easy to work with. Wood studs are occasionally used in smaller commercial projects when allowed by the building code.