16 Stairs

Objectives

After studying this chapter, you will be able to:

- Define common stair terminology.
- Explain the appropriate use of the various stair designs.
- Design a stairway for a residential structure.
- Draw structural details for main stairs.
- Perform stair calculations for a residential stairway.
- Identify model code requirements for handrails and guardrails.

Key Terms

Balusters
Circular Stairs
Double-L Stairs
Enclosed Stairs
Guardrails
Handrails
Headroom
Housed Stringer
L Stairs
Landing
Main Stairs
Narrow U Stairs
Newel
Nosing
Open Stairs
Plain Stringer
Rise
Riser
Run
Service Stairs
Spiral Stairs
Stairway
Straight Run Stairs
Stringer
Total Rise
Total Run
Tread
U Stairs
Well Hole
Wide U Stairs
Winder Stairs

A ***stairway*** or "stairs" is a series of steps that is installed between two or more floors of a building. A stairway may or may not have landings or platforms within the flight of stairs. Stairways provide easy access to various levels of the home. All styles of homes have stairs, except a ranch with no basement. The prime considerations in stair design should be easy ascent/descent and safety.

A house may have a ***main stairs*** from the first floor to the second floor or from a split foyer to the first floor. The main stairs are usually assembled with prefabricated parts of good quality, Figure 16-1. The treads are generally made of hardwoods such as oak, maple, or birch. Some houses may also have ***service stairs*** intended for frequent, heavy use. These are typically constructed on location and made of Douglas fir or pine construction lumber. Service stairs are generally of a lesser quality than main stairs.

For a home where a handicapped person will live or spend time, a stairlift or elevator may be necessary to allow access to other levels of the house. Stairlifts are available for a person to sit on or that will accommodate a person in a wheelchair.

Types of Stairs

Six general types of stairs are commonly used in residential construction. These types are straight run, L, double-L, U, winder, and spiral. Another stair type—circular—is sometimes used in very large, expensive homes.

Straight run stairs, as the name implies, have no turns, Figure 16-2. These are the stairs used most in home construction. They are not as expensive to construct as other types of

Figure 16-1. This beautiful main stairway is visible from the entrance and constructed with quality materials. (Arcways, Incorporated)

stairs. However, straight run stairs require a long, open space that may be difficult to accommodate in the floor plan.

L stairs have one landing and turn at some point along the flight of stairs, Figure 16-3. If the landing is near the top or bottom of the stairs, the term "long L" is used to describe the stairs. L stairs are used when the space required for a straight run stairs is not available.

Double-L stairs have two 90° turns and two landings along the flight, but are not U shaped, Figure 16-4. They may be used when space is not available for either straight or L

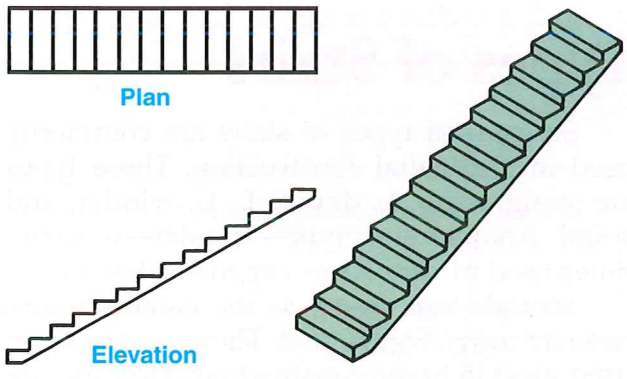
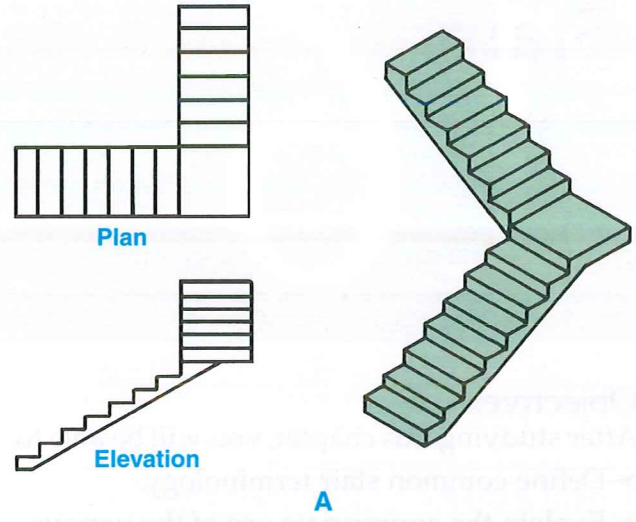


Figure 16-2. Straight run stairs.



A

B

Figure 16-3. A—L stairs. B—These are long L stairs. Notice that the landing and turn are toward the top of the stairs.
(Manufactured Housing Institute)

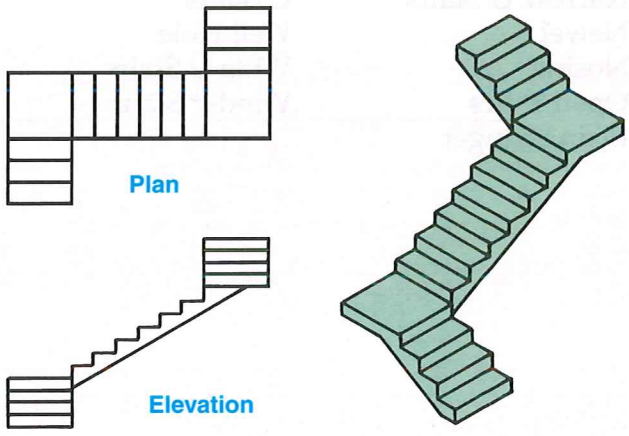
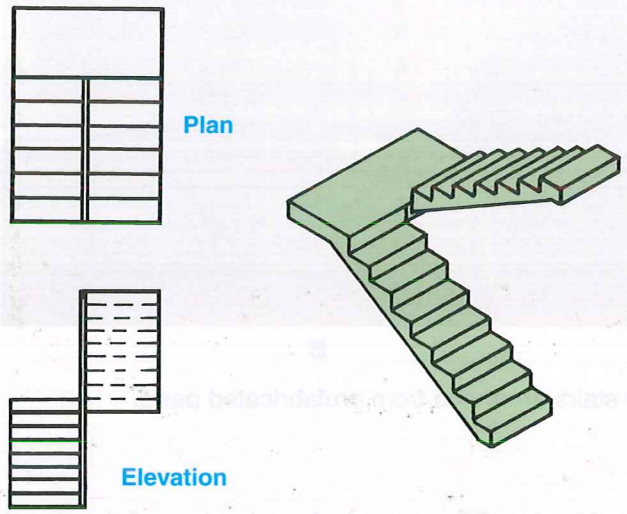


Figure 16-4. Double-L stairs.

stairs. Double-L stairs are not frequently used in residential construction. They are expensive to build and break up the floor plan.

U stairs have two flights of steps parallel to each other with a landing between, Figure 16-5. This type of stairs may be constructed as either wide U stairs or narrow U stairs. The difference between the two is the horizontal space between the flights. ***Narrow U stairs*** have little or no space between the flights, as shown in Figure 16-5. ***Wide U stairs*** have a space between each flight. This space is called a ***well hole.***



A

B

Figure 16-5. A—U stairs. B—These stairs are narrow U stairs. Notice the lack of a well hole. (California Redwood Association)

Winder stairs have pie-shaped steps that are substituted for a landing, Figure 16-6. This type of stairs is used when the space is not sufficient for the L, double-L, or U stairs. The midpoint width of the triangular steps in winder stairs should be equal to the tread width of the regular steps. For instance, if the regular tread width is 10″, then each triangular step should also be 10″ at the midpoint. Winder stairs are not as safe as other types and should be avoided whenever possible.

Spiral stairs are steps that rise in a circle about a center point, Figure 16-7. These stairs are gaining in popularity and can be very decorative. Spiral stairs may be used where little space is available. Most spiral stairs are made from welded steel. However, they can be constructed from modular wood components. Several manufacturers supply components and finished stairs. Spiral stairs are not very safe since they generally have triangular steps similar to winder stairs.

Circular stairs are trapezoidal steps that rise along an irregular curve or arc. These stairs are custom made. Many fine, large homes utilize these stairs, Figure 16-8. Circular stairs require a lot of space and are expensive to build.

Stair Terminology

Several terms are associated with stairs. The following list defines the terms you must understand before beginning the design of stairs. Refer to Figure 16-9, Figure 16-10,

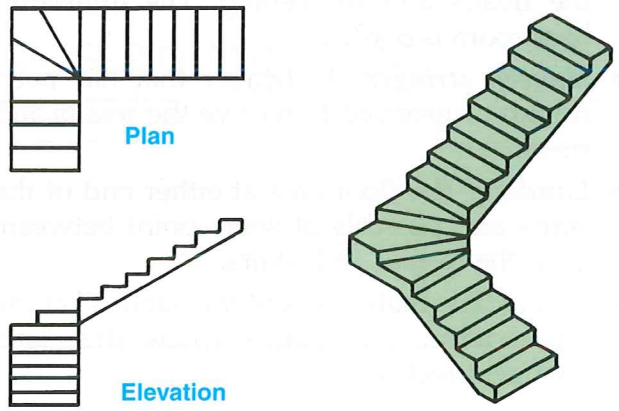
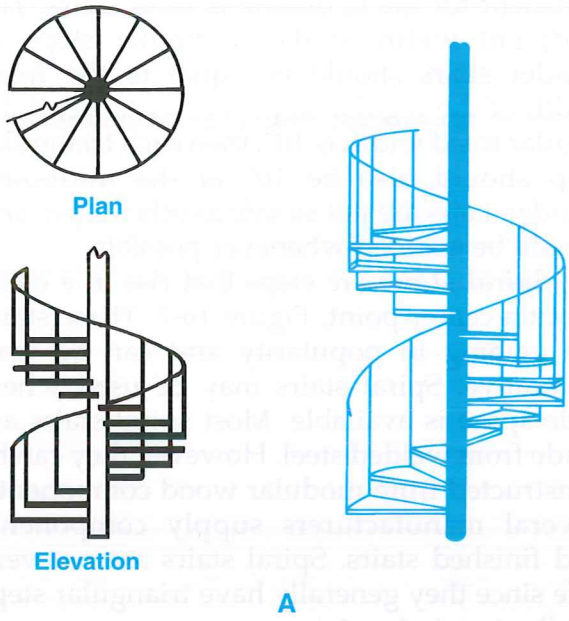


Figure 16-6. Winder stairs.

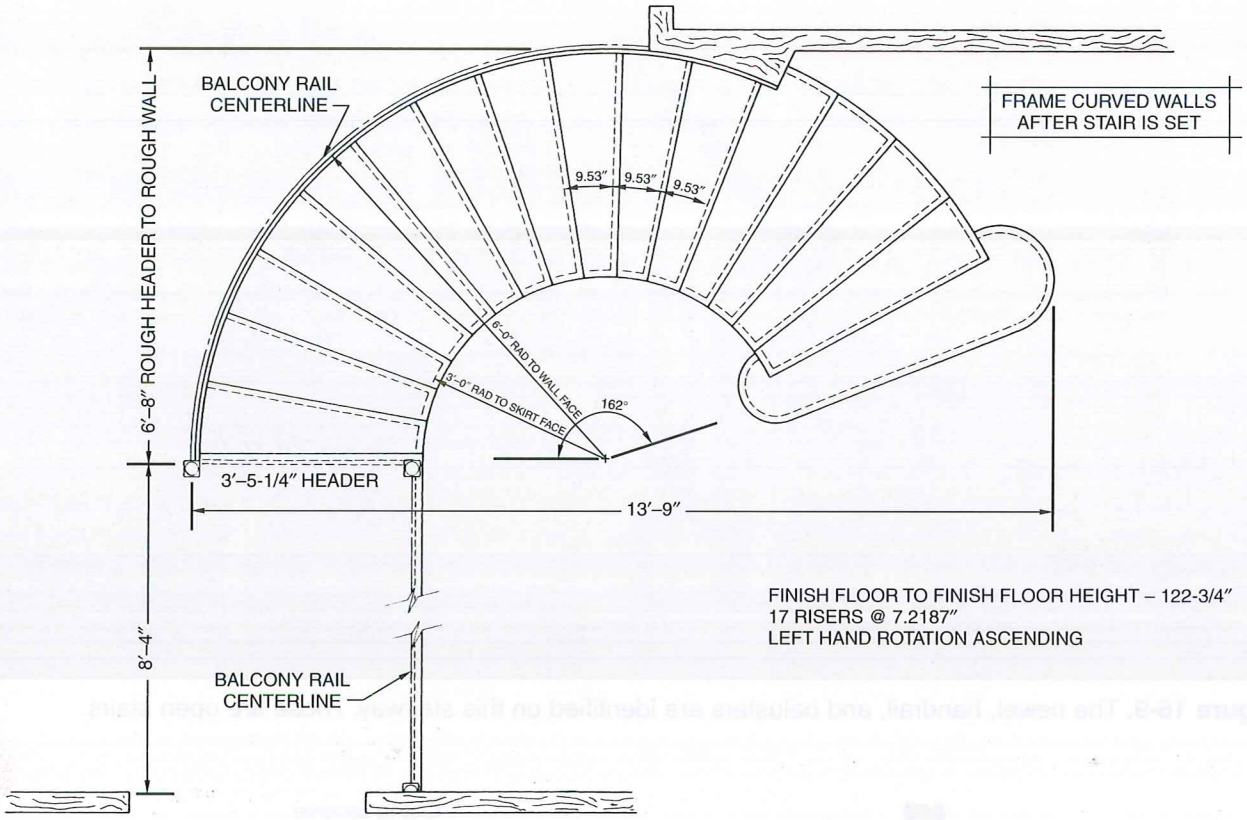



B

Figure 16-7. A—Spiral stairs. B— These decorative spiral stairs are made from prefabricated parts. (Arcways, Incorporated)

Figure 16-11, Figure 16-12, and Figure 16-13 as you study this list.

- ***Balusters:*** Vertical members that support the handrail on open stairs.
- ***Enclosed stairs:*** Stairs that have a wall on both sides; also known as closed, housed, or box stairs.
- ***Headroom:*** The shortest clear vertical distance measured between the nosing of the treads and the ceiling. The minimum headroom is 6′-6″.
- ***Housed stringer:*** A stringer that has been routed or grooved to receive the treads and risers.
- ***Landing:*** The floor area at either end of the stairs and possibly at some point between, as in the case of an L stairs.
- ***Newel:*** The main posts of the handrail at the top, bottom, and points where the stairs change direction.
- ***Nosing:*** The rounded projection of the tread that extends past the face of the riser.
- ***Open stairs:*** Stairs that have no wall on one or both sides.
- ***Plain stringer:*** A stringer that has been cut or notched to fit the profile of the stairs.
- ***Rise:*** The distance from the top surface of one tread to the same position on the next tread.
- ***Riser:*** The vertical face of a step.
- ***Run:*** The distance from the face of one riser to the face of the next.
- ***Stringer:*** A structural member that supports the treads and risers; also called the carriage.
- ***Total rise:*** The total floor-to-floor height of the stairs.
- ***Total run:*** The total horizontal length of the stairs.
- ***Tread:*** The horizontal member of each step on which a person steps.



A

B

Figure 16-8. A—Plan view of typical circular stairs. (Arcways, Incorporated) B—Ample space is available in this gracious home for a circular stairway. (Pittsburgh Corning Corporation)

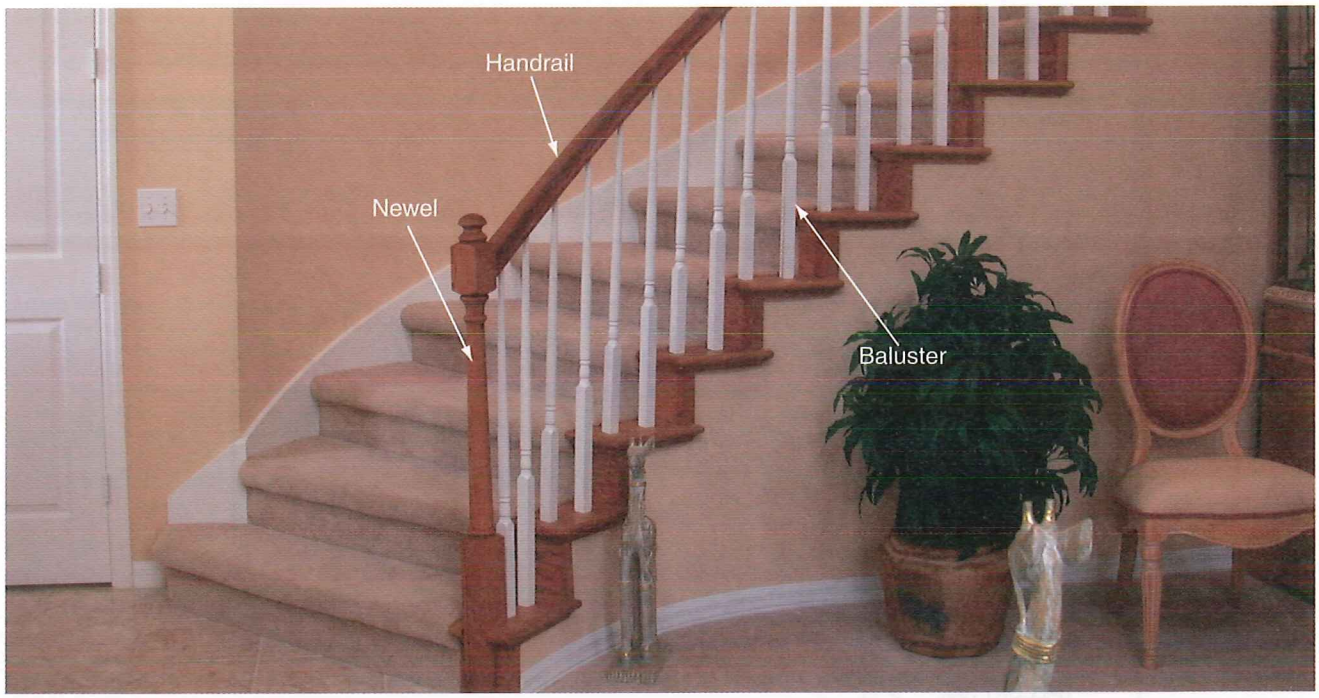


Figure 16-9. The newel, handrail, and balusters are identified on this stairway. These are open stairs.

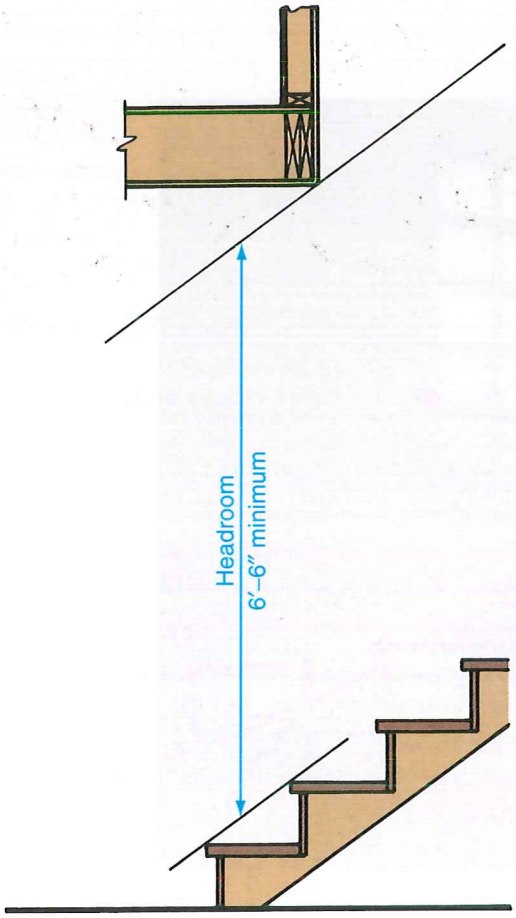


Figure 16-10. Sufficient headroom is an important consideration in the design of stairs.

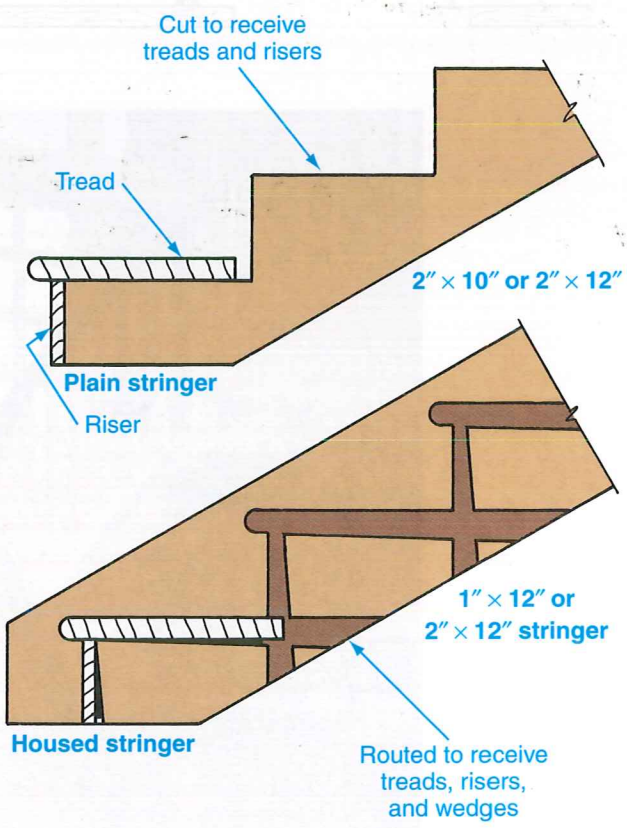


Figure 16-11. Details of plain and housed stringers.

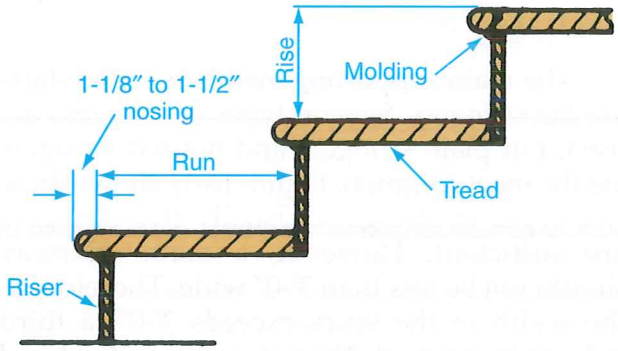


Figure 16-12. Tread and riser terms.

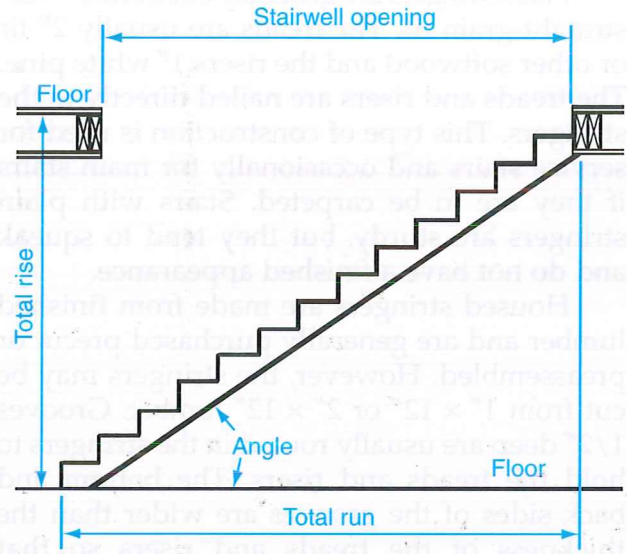


Figure 16-13. Critical stair dimensions.

Designing with CADD

Many AEC CADD programs have features to aid the drafter in creating stairs that are safe and of a structurally sound design. These features may come with the software or may need to be purchased as a special add on. In addition, some large manufacturers provide software to aid in specifying their product. Figure 16-14 shows a residential design incorporating exterior stairs that were designed using CADD.

Stair Design

Properly designed and constructed stairs must support the weight required by the application. They will also be wide enough to provide easy passage of people and furniture. The proper slope for stairs is between 30° and 35°, Figure 16-15.

Figure 16-16 illustrates a stair design that is simple and appropriate for some types of construction. This type of stairs is called open riser stairs. Notice that the stairway is open, has large treads, and does not have risers.

Figure 16-14. The stairs on this home were drawn using CADD software. (Helmuth A. Geiser, member AIBD)

Figure 16-15. These exterior stairs are constructed at the proper angle to afford safe travel to the upper level of the condo.

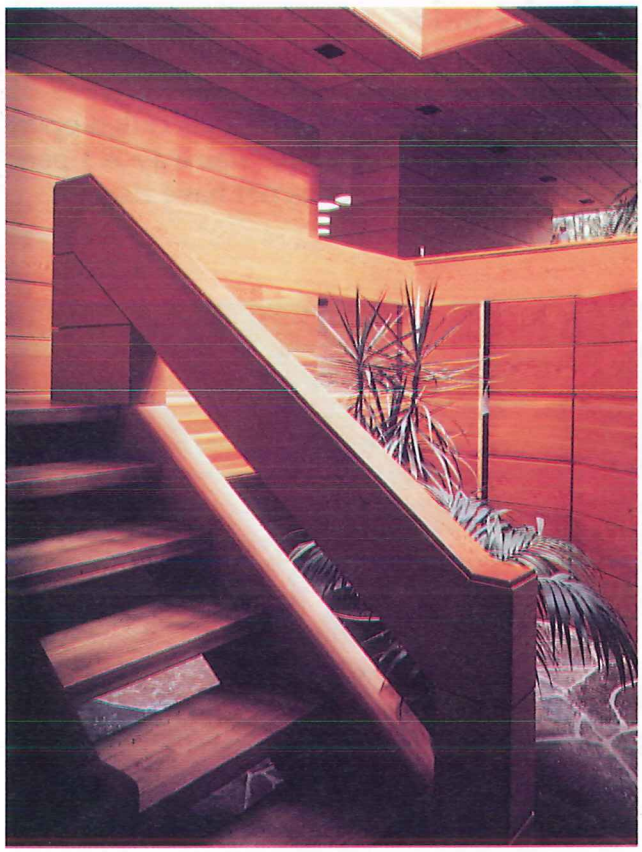


Figure 16-16. This is an open riser stairway. Notice the large treads and lack of risers. (Western Wood Products Association)

Stringers

The main supporting members of the stairs are the stringers. Several types of stringers are used, but plain stringers and housed stringers are the most common. Figure 16-11 shows these two types of stringers. Usually two stringers are sufficient. However, a main stairway should not be less than 3′-0″ wide. Therefore, if the width of the stairs exceeds 3′-0″, a third stringer is required. The extra stringer is placed midway between the outside stringers and under the treads and risers.

Plain stringers are generally cut from 2″ × 12″ straight-grain fir. The treads are usually 2″ fir or other softwood and the risers 1″ white pine. The treads and risers are nailed directly to the stringers. This type of construction is used for service stairs and occasionally for main stairs if they are to be carpeted. Stairs with plain stringers are sturdy, but they tend to squeak and do not have a finished appearance.

Housed stringers are made from finished lumber and are generally purchased precut or preassembled. However, the stringers may be cut from 1″ × 12″ or 2″ × 12″ lumber. Grooves 1/2″ deep are usually routed in the stringers to hold the treads and risers. The bottom and back sides of the grooves are wider than the thickness of the treads and risers so that wedges may be driven in to hold them in place. Figure 16-17 illustrates how the wedges are inserted in the grooves. The treads, risers, and wedges are glued and nailed in place.

Treads and Risers

The two other primary parts of a set of stairs are the treads and risers. Standard treads are available in 1-1/4″ oak in 10-1/2″ and 11-1/2″ widths. Both widths are 1-1/16″ thick actual size. The rounded nose is not included in calculations. A tread width of 10-1/2″ is the most popular choice. Risers are 3/4″ thick actual size and vary in width depending on the slope of the stairs. The ideal riser height is between 7″ and 7-5/8″. Clear white pine is the customary riser material.

The slope of stairs may be specified in degrees or as a ratio of the rise to run or riser to tread. Several rules have been devised for

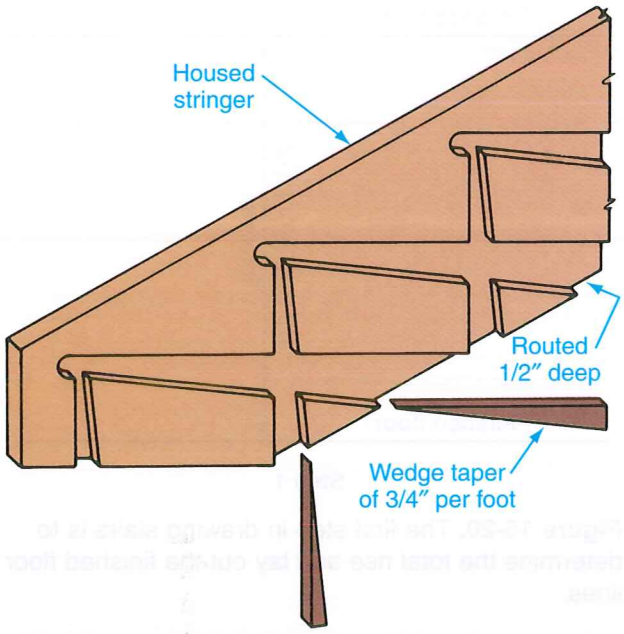


Figure 16-17. Wedges are used in a housed stringer to help hold the treads and risers in place. Treads, risers, and wedges are glued and nailed to the stringer.

calculating the slope of stairs. Four of these rules are:

- **Rule 1.** The slope of the stairs should be between 30° and 35°. Many older stairs are too steep and, therefore, not safe. Figure 16-18 shows an example of such a case.
- **Rule 2.** The sum of two risers and one tread should equal 25″.
- **Rule 3.** The product of the riser height multiplied by the tread width should equal approximately 75″.
- **Rule 4.** The sum of one riser and one tread should equal 17″ to 18″.

If a 10″ tread is used in an example for each of the rules, the following riser heights will be required.

	Tread Width	Riser Height	Approximate Slope
Rule 1	10″	7″	35°
Rule 2	10″	7-1/2″	37°
Rule 3	10″	7-1/2″	37°
Rule 4	10″	7″ to 8″	35° to 38°

In these examples, a riser height of 7″ is the only one that creates stairs that fall within the

Figure 16-18. These stairs in an older home violate Rule 1 of good stair design because they slope at close to 45°, rather than the appropriate 30° to 35°. (Brad L. Kicklighter)

proper slope angle. However, the slope angle can be reduced by increasing the tread width. For example, if the tread width is 10-1/2″ then the riser height would be 7-1/4″. Using Rule 2, this combination would result in an angle slightly less than 35°. A ratio of 7-1/4″ to 10-1/2″ is considered ideal.

The first rule generally will not be applied to service stairs since they are normally steeper than main stairs. However, if the treads are 10″ wide, the riser should be between 5-3/4″ and 7″ to produce a 30° to 35° slope. A riser height of less than 7″ is considered too short; therefore, a 7:10 ratio and 35° slope are acceptable for service stairs.

A stairway must provide a handrail for support while ascending or descending the stairs. Unless the stairs are very wide, one rail is sufficient. The recommended height of the handrail is shown in Figure 16-19. Note that the height is greater at a landing than along the incline. Also, refer to the section *Code Requirements For Handrails and Guardrails* later in this chapter.

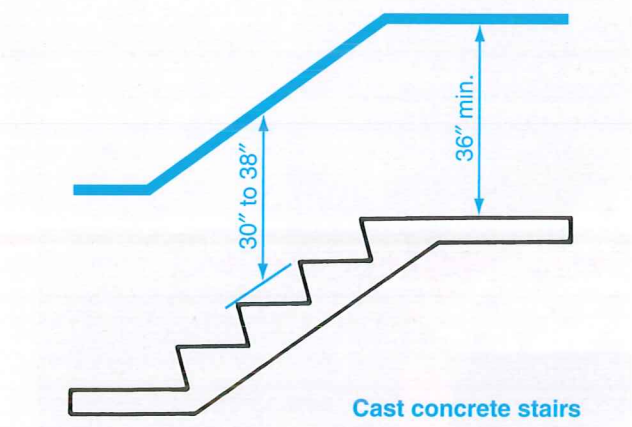


Figure 16-19. Recommended handrail heights for all stairs.

Stair Calculations and Drawing Procedure

The following procedure may be used to determine the number and size of treads and risers for a set of stairs. This procedure can be used with manual drafting or CADD.

1. Determine the total rise of the stairs. The total rise is calculated by adding the distance from finished lower floor to finished ceiling, the thickness of the ceiling material, the width of the floor joists, the thickness of the subfloor, and the thickness of the finished floor, as shown below.

Finished lower floor to finished ceiling	8′-0″
Thickness of ceiling material (drywall)	1/2″
Width of the floor joists (2″ × 10″ lumber)	9-1/4″
Thickness of the subfloor (1/2″ plywood)	1/2″
Thickness of the finished floor and underlayment	1″
Total rise =	8′-11 1/4″

Since the size of each step is in inches, the total rise is converted to inches (total rise = 107-1/4″). Figure 16-20 shows the first step in drawing stairs.

2. Determine how many risers will be required by first dividing the total rise by seven. Seven inches is an ideal riser height and, therefore, a logical place to start. When 107-1/4″ is divided by seven, the result is 15.32 risers. The number of risers must be a whole number, so either 15 or 16 risers will be required. When 107-1/4″ is divided by 15, a riser height of 7.15″ is produced. This figure seems to be acceptable so further calculations will be based on 15 risers each 7.15″ high. Figure 16-21

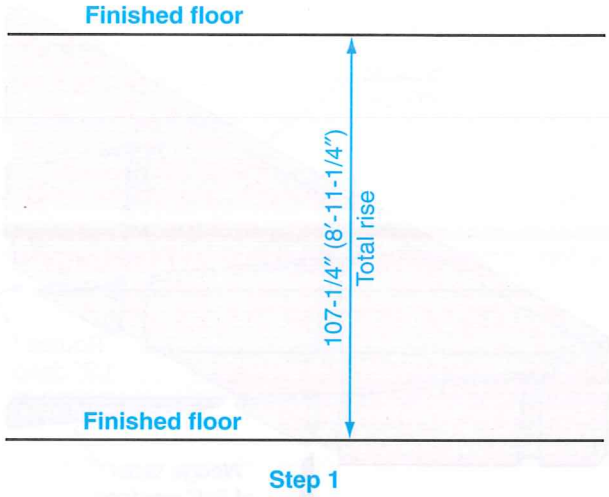


Figure 16-20. The first step in drawing stairs is to determine the total rise and lay out the finished floor lines.

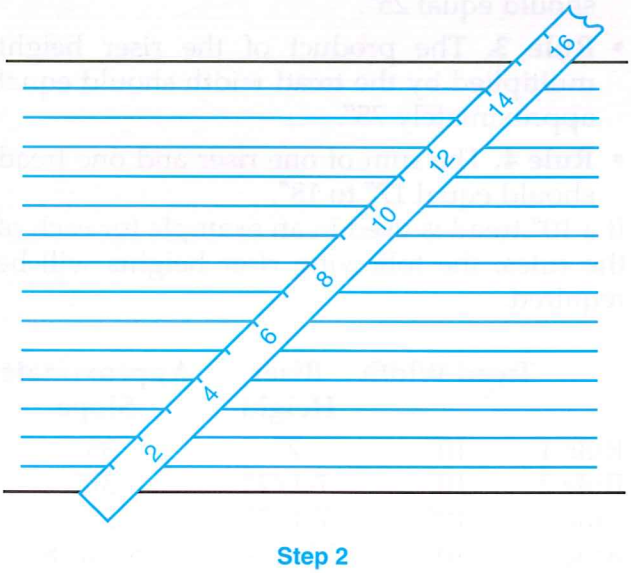


Figure 16-21. Divide the total rise into the specified number of risers. The number of risers in this example is 15.

shows how the total rise is divided into 15 equal parts. In CADD, the "divide" function can be used or you can place points every 7.15" vertically. *Each riser must be exactly the same height.*

3. Determine the tread size and total run that will yield a stair slope between 30° and 35°. A 10-1/2" tread width is common and will be used for a trial calculation. *There is always one less tread than the number of risers.* This is because the second floor serves as the top tread. The sum of two risers (7.15" + 7.15") and one tread (10-1/2") equals 24.80". This is very close to the sum of 25 required by Rule 2 and indicates that the combination will be acceptable.
   For comparison, Rule 3 and Rule 4 will be applied. Rule 3 says that the product of the riser height and tread width should be approximately 75". Therefore, if 7.15" is multiplied by 10.5" the product is 75.1". This is acceptable. Rule 4 indicates that the sum of one riser and one tread should equal 17" to 18". If 7.15" is added to 10-1/2" the result is 17.65". This is within the required range. After all examinations, the tread width will be 10-1/2".
   The total run, which is 147", is determined by multiplying the tread width (10-1/2") by the number of treads (14). Figure 16-22 shows how the total run and tread widths are drawn. In CADD, use the divide command to determine the locations of the 14 risers.
4. Darken the tread and riser lines, draw the bottom edge of the stringer, and locate stairwell rough opening size. This dimension is a function of the headroom dimension. Minimum headroom is 6'-6". Step 4 is shown in Figure 16-23.
5. Remove all construction lines. Add dimensions and notes, Figure 16-24.

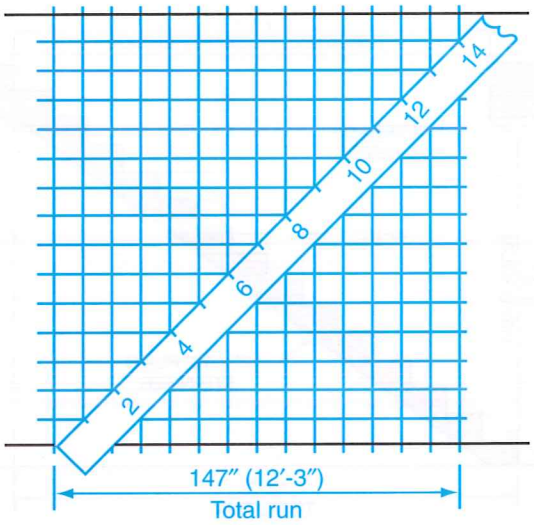


Figure 16-22. Lay out the total run and divide it into the required number of treads. The number of treads in this example is 14.

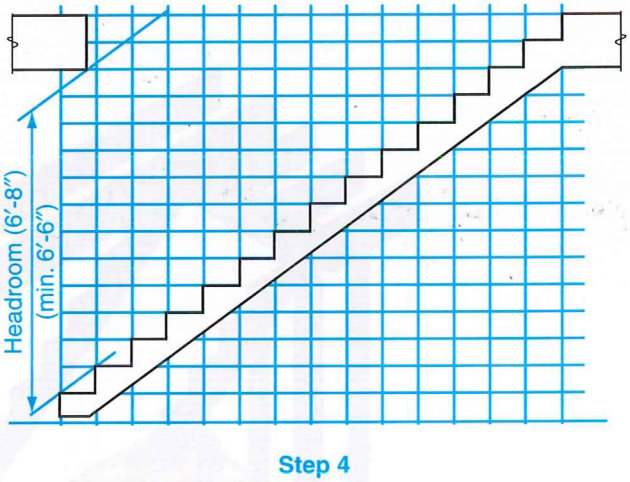


Figure 16-23. Darken the tread and riser object lines. If using CADD, trim the construction lines to create the final object lines. Also, draw the stairwell rough opening.

Structural Details

Procedures for building stairs vary widely from one part of the country to another. Local codes often specify restrictions. Also, carpenters have their own preferences that add to the variations. Regardless of the procedure followed, the construction techniques must produce stairs that are sound. Figure 16-25 shows the rough framing for open, straight run stairs with plain stringers. Ordinarily, this rough framing is not shown on a set of construction drawings. However, a plan view and elevation with various section details are shown. Figure 16-26 illustrates a typical stair detail drawing found in a set of residential plans.

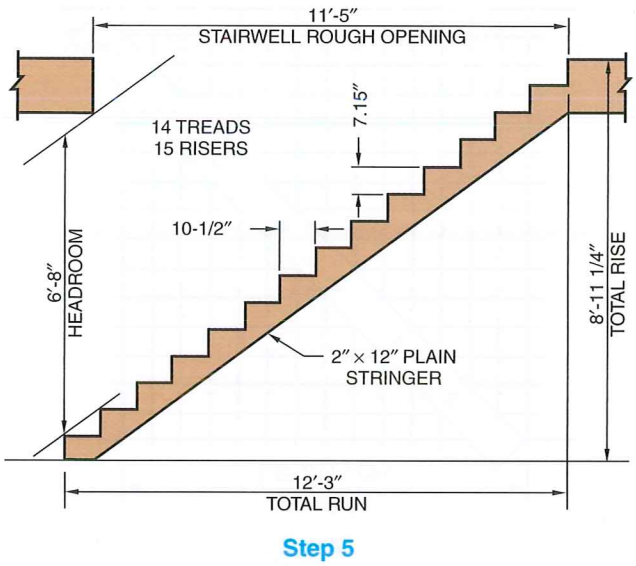


Figure 16-24. Erase all construction lines. In CADD, you can erase the lines or turn off their layer. Also, add dimensions and notes.

Code Requirements for Handrails and Guardrails

Stairs have recently received special attention by model codes. Most state and local codes are based on national or regional model codes. Therefore, local codes generally adopt changes in the model codes. The organizations that write model codes are the Building Officials and Code Administrators International (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International (SBCCI). The Council of American Building Officials (CABO) is an umbrella organization to which these groups belong and acts as a model for the other codes.

All codes require railings on stairs and ramps. Railings come in two varieties: handrails

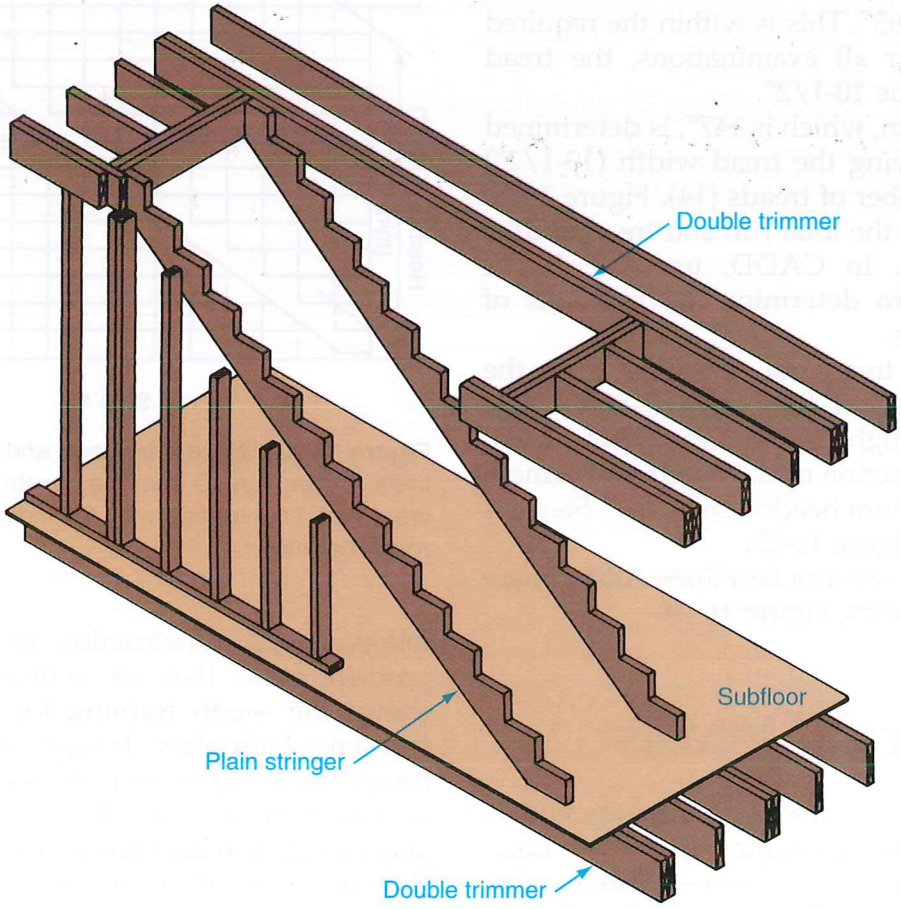


Figure 16-25. This pictorial drawing shows the rough framing for open, straight run stairs with plain stringers.

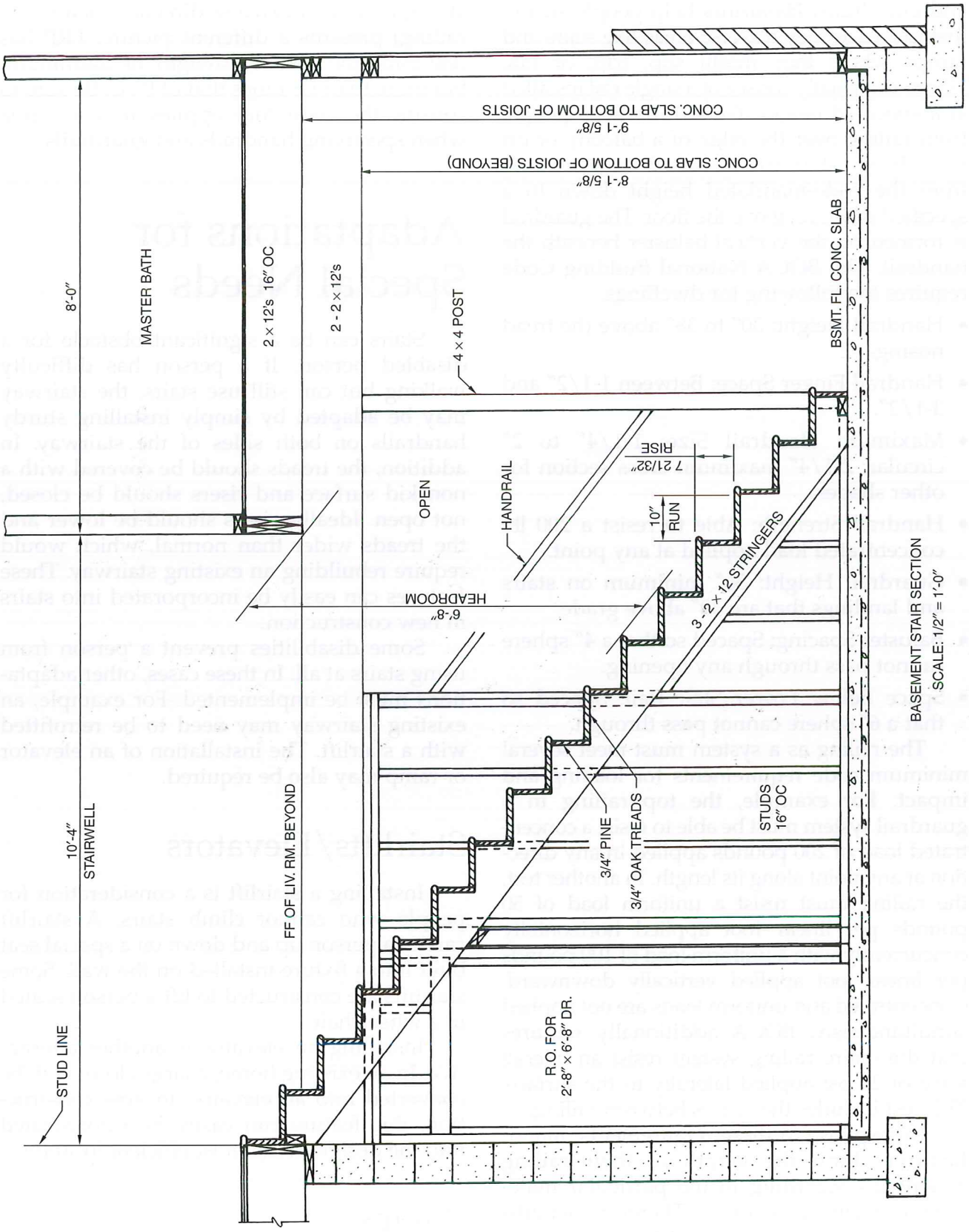


Figure 16-26. This is a typical stair detail that might be found on a set of residential drawings.

and guardrails. ***Handrails*** help people steady themselves as they traverse areas like stairs and ramps where they might slip, trip, or fall. Handrails usually consist of a single rail installed at a specified height. ***Guardrails*** keep people from falling over the edge of a balcony or off the side of a staircase. Guardrails must extend from the code-mandated height down to a specified distance above the floor. The guardrail is formed by the vertical baluster beneath the handrail. The BOCA National Building Code requires the following for dwellings.

- Handrail Height: 30″ to 38″ above the tread nosing.
- Handrail Finger Space: Between 1-1/2″ and 3-1/2″.
- Maximum Handrail Size: 1-1/4″ to 2″ circular; 2-1/4″ maximum cross section for other shapes.
- Handrail Strength: Able to resist a 200 lb. concentrated load applied at any point.
- Guardrail Height: 36″ minimum on stairs and landings that are 30″ above grade.
- Baluster Spacing: Spaced so that a 4″ sphere cannot pass through any opening.
- Space Below Lower Stair Rail: Spaced so that a 6″ sphere cannot pass through.

The railing as a system must meet several minimum code requirements for loading and impact. For example, the top railing in a guardrail system must be able to resist a concentrated load of 200 pounds applied in any direction at any point along its length. In another test, the railing must resist a uniform load of 50 pounds per linear foot applied horizontally concurrently with a uniform load of 100 pounds per linear foot applied vertically downward. Concentrated and uniform loads are not applied simultaneously. BOCA additionally requires that the entire railing system resist an overall force of 25 psi applied laterally to the surface. This test includes the spaces between railings.

In response to these requirements, manufacturers limit the length of their railing assemblies according to the particular material's capacity for loading. Therefore, lengths generally range from 3′ to 12′. As a general rule, PVC has less than 18% of the longitudinal tensile strength of a similar aluminum or fiber reinforced plastic (FRP) section. Tensile strength in the transverse direction (across the railing) presents a different picture. FRP has one-third the tensile strength of aluminum, but more than 1.6 times that of PVC. Be sure to consult the code that applies in your area when specifying handrails and guardrails.

Adaptations for Special Needs

Stairs can be a significant obstacle for a disabled person. If a person has difficulty walking but can still use stairs, the stairway may be adapted by simply installing sturdy handrails on both sides of the stairway. In addition, the treads should be covered with a nonskid surface and risers should be closed, not open. Ideally, risers should be lower and the treads wider than normal, which would require rebuilding an existing stairway. These features can easily be incorporated into stairs in new construction.

Some disabilities prevent a person from using stairs at all. In these cases, other adaptations must be implemented. For example, an existing stairway may need to be retrofitted with a stairlift. The installation of an elevator or ramp may also be required.

Stairlifts/Elevators

Installing a stairlift is a consideration for people who cannot climb stairs. A stairlift carries a person up and down on a special seat built into a fixture installed on the wall. Some stairlifts are constructed to lift a person seated in a wheelchair.

Installing an elevator is another alternative. In an existing home, a large closet may be converted into an elevator. In new construction, this feature can easily be incorporated into the design in the most efficient location.

Ramps

Ramps may be installed at entries to enable disabled persons to enter a structure. Ramps are required for those persons in

wheelchairs. Ramps should have nonslip surfaces and, if possible, protection from rain, snow, and ice.

The recommended slope for a ramp is 1′ rise for every 12′ of distance, or a ratio of 1:12. In other words, to access a height of 3′, the minimum ramp length is 36′. If a more gradual slope is required, a longer ramp should be planned.

The maximum length of a ramp section is 30′. Ramps longer than 30′ should be built in two or more sections. Each section must be separated by a landing at least 5′ square. Landings are necessary rest stops for individuals who have difficulty moving uphill. An entry platform should extend 18″ beyond the handle side of the door to allow a wheelchair user to open the door easily.

The recommended width of a ramp is 48″. However, the minimum width is 32″; 36″ for wheelchair use.

Handrails should be placed on both sides of the ramp for safety. A handrail height of 3′ is commonly used. Wheelchair users, however, can pull themselves up the ramp more easily when handrails are 30″ high. If curbs are used, they should be placed on both sides of the ramp at least 2″ high.

Internet Resources

www.acornstairlifts.com
Acorn Stairlifts

www.arcways.com
Arcways, Inc., a manufacturer of custom stairways

www.ibhs.org
Institute for Business and Home Safety

www.iii.org
Insurance Information Institute

www.lpcorp.com
Louisiana-Pacific Corporation, a manufacturer of building materials

www.natlhardwood.org
National Hardwood Lumber Association

www.archdigest.com
Architectural Digest

www.sweets.com
Sweets Catalog File

Review Questions – Chapter 16

Write your answers on a separate sheet of paper. Do not write in this book.

1. Stairs connecting the first and second floor or from a split foyer to the first floor are known as _____ stairs.
2. Identify the six general types of stairs.
3. Which type of stairs always has two landings along the flight of steps?
4. The type of stairs that has two parallel flights of steps is the _____ stairs.
5. Pie-shaped steps are generally associated with _____ stairs.
6. Vertical members that support the handrail on open stairs are known as _____.
7. Stairs with walls on both sides are known as _____ stairs.
8. Minimum headroom for stairs is _____.
9. The two main types of stringers used in home stair construction are _____ and _____ stringers.
10. The rounded part of the tread that extends past the face of the riser is the _____.
11. A stair without a wall on one or both sides is a(n) _____ stair.
12. A stringer that has been cut or notched to match the profile of the stairs is a(n) _____ stringer.
13. Define rise.
14. Define run.

15. The total floor-to-floor vertical height of the stairs is known as the _____.
16. The total horizontal length of the stairs is the _____.
17. The proper slope angle for a set of main stairs should be between _____ and _____ degrees.
18. The minimum recommended width for main stairs is _____.
19. Treads on service stairs are frequently made from softwood, but main stair treads are usually _____.
20. The ideal tread-to-riser ratio is _____ to _____.

Suggested Activities

1. Locate as many different stair designs as you can. Measure the tread width and riser height. Identify the materials used for construction. Using CADD, draw a profile of the tread and riser. Measure the slope using the appropriate CADD function. Rate the stairs as to ease of travel and safety.
2. Locate a house in your community that is under construction. Obtain permission before entering the construction site and then examine the stair framing. Measure the floor-to-floor distance and width of the stairs. If possible, interview the head carpenter and ask how a set of stairs is laid out. Report your findings to the class.
3. Using CADD, design an enclosed, straight run stairs with housed stringers. The distance from the finished floor to the finished floor is 9'-1 1/4". The distance between the finished walls is 3'-4". Provide the necessary drawings, dimensions, and notes.
4. Visit a local lumber company that sells precut stairs. Collect information and literature about these stairs. Bring this literature to class to help build a catalog file on stairs.
5. Select a basic type of stairs. Using CADD, create the necessary construction drawings. Then, build a scale model as accurately as possible. Display this model along with the construction drawings.