Unit 7 Construction Specialties

In this Unit:

Hands-On Math Project Preview

Professional Green Painting

After completing this unit, choose paint for your room and calculate how many gallons you will need based on the room's size and the paint's spread rate. You will also estimate how long it will take to complete the job based on the number of coats needed and the forecast temperature and humidity.

Project Checklist

As you read the chapter in this unit, use this checklist to prepare for the unit project:

✓ **Measure** the square footage of the walls and ceiling of the room you will paint.

✓ **Identify** calculations, such as calculating spread rate or paint, used in determining materials required for a specific job.

✓ **Think** about how temperature and humidity can affect the work of different specialists.

Go to **glencoe.com** for this book's OLC. Find the WebQuest activity for Unit 7 called "The Future of Green Building."

Construction Careers

Profile Painters apply paint, stain, varnish, and other finishes to buildings and other structures. Paperhangers cover walls and ceilings with decorative wall coverings made of paper, vinyl, or fabric.

Academic Skills and Abilities

- geometry
- mathematics
- blueprint reading
- interpersonal skills

Career Path

- on-the-job training
- apprenticeship programs
- trade and technical school courses

Go to **glencoe.com** for this book's OLC to find more information about carpentry and construction careers.

Explore the Photo

Finishing Touches Many construction specialties require specialized skills and equipment. *What safety issues do you see in this photo?*

CHAPTER 29

Steel Framing Basics

Chapter Objectives

After completing this chapter, you will be able to:

- **Describe** the three types of steel frame construction.
- **Identify** tools used in steel framing.
- **Tell** the difference between welding and clinching.
- **Describe** how to lay out steel floor joists.
- **Explain** why steel framed structures use in-line framing.
- **Explain** how to set steel ceiling joists.

Discuss the Photo

Working with Steel Steel framing is relatively new in residential construction. *What might some advantages of steel framing be?*

Writing Activity: Experiment Results

Screw together two scrap pieces of steel framing stock with one or two screws of the same size and length. The flat sides of the pieces should be together and the open side should face out. Test the pullout capacity of the screws by trying to pry the two pieces apart. Try this same test again with screws of a different length and diameter. Use good safety practices. Report the results in a one-page summary.

Chapter 29 Reading Guide

Before You Read Preview

Steel frame construction is similar to wood frame construction. Choose a content vocabulary or academic vocabulary word that is new to you. When you find it in the text, write down the definition.

Content Vocabulary

- cold-formed steel
- performance method
- prescriptive method
- feathering
- pullout capacity
- welding
- clinching
- in-line framing
- axial load
- joist tracks
- clip angle
- roof rake

Academic Vocabulary

You will find these words in your reading and on your tests. Use the academic vocabulary glossary to look up their definitions if necessary.

- sequence
- remove

Graphic Organizer

As you read, use a chart like the one shown to organize content vocabulary words and their definitions, adding rows as needed.

Content Vocabulary	Definition
cold-formed steel	sheet steel that is bent and formed without using heat

Go to **glencoe.com** for this book's OLC for a downloadable version of this graphic organizer.

Academic Standards

Mathematics

Geometry: Use visualization, spatial reasoning, and geometric modeling to solve problems (NCTM)

Algebra: Use mathematical models to represent and understand quantitative relationships

English Language Arts

Use written language to communicate effectively (NCTE 4)

Use different writing process elements to communicate effectively (NCTE 5)

Science

Physical Science: Motions and forces (NSES)

Science and Technology: Abilities of technological design (NSES)

Industry Standards

Non-structural Steel Wall Framing

NCTE National Council of Teachers of English
NCTM National Council of Teachers of Mathematics
NSES National Science Education Standards

Section 29.1

Steel as a Building Material

Steel Framing

Where is steel framing common?

The steel that is used for residential steel framing is cold-formed steel. **Cold-formed steel** is sheet steel that is bent and formed without using heat. This type of framing system is sometimes referred to as light-gauge steel framing. Unlike wood building materials, steel is not damaged by insects and it is treated with a hot-dipped galvanized coating to resist rust and corrosion. Steel is 100 percent recyclable. New steel-framing materials contain at least 25 percent recycled content.

Sizes and Shapes

Steel framing is formed into shapes and sizes that are similar to what builders are accustomed to seeing in dimensional lumber (2×4, 2×6, 2×8, 2×10, 2×12, and so forth). Steel framing members are formed by passing the sheet metal through a **sequence** of rollers to form the bends that make the shape, such as the web, flanges, and lips of a stud or C-shape. Because this process is done without heat (also called *cold forming*), the studs and joists are stronger than the sheet steel.

When ordering steel framing materials, it is important to be aware of the variety and applications of the various shapes, encapsulated by the acronym **STUFL**. These letters stand for **S**tud, **T**rack, **U**-channel, **F**urring, and **L**-header.

A stud includes wall studs, joists, and rafters because they are all of the same shape. Track is the top and bottom *plates* of a steel wall or the rim of floors and rafters. U-channel can be used for bridging, blocking, and customized for cabinet backing. Furring channel is used as purlins, bridging, backing, and for subassembly sound separation. L-headers are members that can be doubled and used as headers.

Cold-formed steel is specified by a universal designator system called out by web dimension, shape, flange dimension, and thickness. In addition, yield strength and anti-corrosion coating are required for each order. Web and flange sizes are expressed in 1⁄100ths of an inch and thickness is expressed in 1⁄1000ths of inch, or *mils*. Typical dimensions are shown in **Table 29-1**.

Common mil thickness for load-bearing walls are 43 and 33 mil, roof rafters are typically 33 mil, while floor joists often range between 97 and 54 mil. Steel framing also may be called *light gauge*, a term that has been used in the past to describe the thickness of the material. A comparison of "mil" and "gauge" thickness is shown below:

- 12 gauge (97 mil)
- 14 gauge (68 mil)
- 16 gauge (54 mil)
- 18 gauge (43 mil)
- 22 gauge (27 mil)
- 25 gauge (18 mil)
- 29 gauge (33 mil)

Steel Framing Design

Architects and engineers design steel frame houses using either the performance method or the prescriptive method.

Performance Method The **performance method** is a method of framing that depends upon established engineering principles and design-load specifications. Architects and engineers use these principles and specifications to calculate size and strength for individual steel-framing members.

The performance method is time consuming. Standard sizes of framing members are not always used, adding to costs and inefficiency.

Table 29-1: Typical Wood and Steel Dimensions

Wood	Steel	Web Depth	Flange Size	Thickness (mils)
2×4	350S162-43	3½"	1⅝"	43
2×6	600S162-43	6"	1⅝"	43
2×8	800S162-43	8"	1⅝"	43
2×10	1000S162-43	10"	1⅝"	43

Prescriptive Method The **prescriptive method** is a method of framing that uses standardized tables that give specifications and other information. These tables, such as the one in **Table 29-1**, are created using regional or national design codes, regional design-load data, structural limitation data, and knowledge of engineering practices. Data for specfic elements such as earthquake, snow, and wind load are also determined by using tables for specific geographic regions.

The prescriptive method provides architects and engineers with:

- specifications for standard cold-formed steel members
- an identification system for labeling the members
- minimum corrosion protection requirements
- floor joist, ceiling joist, and roof rafter span tables
- wall stud specifications
- wall bracing requirements
- connection requirements
- construction details.

The prescriptive method has several advantages. It helps reduce the engineering costs for steel frame houses. Builders can pre-select stud, joist, and rafter sizes. Building inspectors can easily check and identify stud, joist, and rafter sizes by their labeling. Manufacturers can determine the framing members that need to be supplied for specific markets and geographic areas.

The National Association of Home Builders (NAHB) Research Center developed the prescriptive method for residential cold-formed steel framing in 1995. Since then it has been significantly expanded and is now recognized in the International Residential Code. The prescriptive method applicability limits are shown in **Table 29-2** on page 834.

Types of Steel Construction

Residential steel-framing construction is categorized into three types: stick-built, panelized, and pre-engineered.

Stick-Built Construction Stick-built steel framing is similar to wood framing. The names for the basic steel-framing members are the same as for wood members: stud, joist, and header.

JOB SAFETY

PERSONAL PROTECTION Protective clothing and safety devices must be worn when working with steel framing members. Work gloves help to prevent cuts and punctures, burns from steel exposed to heat or direct sunlight, and freeze burns from steel exposed to cold weather. Thin protective gloves are recommended. Thick gloves make precise movements and placement of materials more difficult. Ear protection, such as sound-reducing ear plugs, is required when noise levels are higher than normal conversational levels. The high-pitched noise caused by steel cutting saws can cause permanent hearing loss. Safety glasses prevent injuries caused by flying bits of metal from chop saws, circular saws, drills, and grinders.

Go to glencoe.com for this book's OLC for more on job safety.

Table 29-2: Prescriptive Method Applicability Limits	
Attribute	**Limitation**
General	
Building dimension	Maximum width[a] is 36–40 feet Maximum length[b] is 60 feet
Number of stories	2 story with a basement
Design wind speed	150 mph
Wind exposure	Exposures C (open terrain) Exposures A/B (suburban/wooded)
Ground snow load	70 psf[b] maximum ground snow load
Seismic design category	A, B, and C
Floors	
Floor dead load	10 psf[b] maximum
Floor live load First floor Second floor (sleeping rooms)	 40 psf[b] maximum 30 psf[b] maximum
Cantilever	24 inches maximum
Walls	
Wall dead load	10 psf[b] maximum
Load-bearing wall height	10 feet maximum
Roofs	
Roof dead load	12 psf[b] maximum total load (7 psf[b] maximum for roof covering only)
Roof/Snow live load	70 psf[b] maximum ground snow load (16 psf minimum roof live load)
Ceiling dead load	5 psf[b] maximum

[a]Building width is in the direction of horizontal framing members supported by the wall studs.
[b]Building length is in the direction perpendicular to floor joists, ceiling joists, or roof trusses.

Spacing of studs and joists for stick-built framing is set at the standard 16" or 24" OC intervals, as in **Figure 29-1**.

Cutting and assembly are performed on the job site. Instead of being nailed, the steel pieces are screwed, welded, or fastened together with pneumatic pins or rivets.

Panelized Construction Panelized construction is used to pre-build flat components such as walls and floors. These components are built to engineering specifications and tolerances on platform tables and jigs, as in **Figure 29-2**. Multiple components can be made using the same templates.

Components may be built at the job site or at an off-site production facility. The panelized components are set in place as units.

Wall panelization has several benefits. Straight walls can be consistently produced and are fairly easy to set in place. They can be completely constructed on a panel table. Assembly line methods allow faster construction and better quality control.

Pre-Engineered Construction In pre-engineered construction, individual steel studs, joists, headers, and roof members are used to assemble pre-built columns, beams, and rafter assemblies. Each assembly is

Figure 29-1 Stick-Built Steel Framing
Stick-Built Note the standard spacing.

Figure 29-2 Panelization Table
Pre-Built Panels can be built to exact specifications and tolerances.

designed and constructed for a specific purpose. This method closely resembles metal-frame commercial construction using structural columns.

Pre-engineered construction may produce a rigid or semi-rigid frame. Engineered columns may be spaced at 4' or 8' OC or greater in designs that call for large open areas.

Pre-engineered assemblies are designed using the American Iron and Steel Institute's Specification for the Design of Cold-Formed Steel.

Reading Check

Explain *How are steel pieces fastened together? How is this different from how wood pieces are fastened together?*

Tim Fuller

Section 29.1 Assessment

After You Read: Self-Check

1. What is cold-formed steel?
2. What two steel-framing design methods do architects and engineers use?
3. Panelized construction is used to pre-build which types of components?
4. What safety equipment must be worn when working with steel framing members?

Academic Integration: English Language Arts

5. **Record Information** Make a list of the special safety equipment needed for steel framing. Find out how much it costs and where you can buy it locally (if anywhere). Record your findings in a one-page chart.

Go to glencoe.com for this book's OLC to check your answers.

Section 29.2 Steel Framing Tools

Safety and Tools

What safety issues relate to cutting steel framing?

Before beginning any framing job, the framers should create a list of all the tools that may be needed. With the proper tools in place, framing can proceed quickly and efficiently. The tools used in steel framing may look like their wood-framing counterparts. However, their use and operation may differ greatly. Always follow the instructions and safety precautions supplied with the tools you use. (Note: *A Builder's Field Guide to Cold-Formed Steel Framing*, published by the Steel Framing Alliance, includes a guide to the tools that builders may choose to use. It is a free download at their Web site.)

Power Tools

Most tools used in steel framing are electrically, hydraulically, or pneumatically powered. In some situations, a gasoline engine may power larger tools, such as plasma cutters.

Screw Gun An electric screw gun is specifically designed for attaching screws. It is not an electric drill, although its appearance is similar. Drills are not designed to apply screws to steel framing.

A screw gun has variable speeds. An industrial screw gun can operate at speeds as high as 4,000 rpm. This variable speed prevents damage from friction and overheating.

A screw gun will have a maximum rpm of 1,800 and have a clutch mechanism built into it that allows screws to be feathered. **Feathering** is the process of attaching a screw to the bit without stopping the screw gun, as in **Figure 29-3**. The screw spins only when pressure is applied to the bit and the tip of the screw.

Attachments can feather strips of collated screws automatically to the bit, as in **Figure 29-4**. Stand-up attachments are also available that allow the framer to remain standing while applying roof and floor sheathing, as in **Figure 29-5**.

Figure 29-3 Feathering Screws

Attaching Screws Feathering screws with a power screw gun.

Figure 29-4 Collated Screws

Feathering Strips Using an attachment that feeds collated screws into the screw gun.

The two types of screw guns that are used on a construction site are the framing screw gun and the drywall screw gun. A framing screw gun is designed to connect steel members, such as studs, to bottom and top tracks. A drywall screw gun is designed to attach plywood, OSB sheathing, or wallboard to steel members. It operates at faster speeds

Figure 29-5 Drill Attachment

Remain Standing This drill attachment drives collated screws. It allows the worker to stand while drilling. After this worker positions the tool, she will straighten it to a perpendicular position. Screws should always be driven perpendicular to the floor sheathing.

than a framing screw gun. It also has a depth-sensitive nosepiece, as in **Figure 29-6**. The nosepiece prevents the bit from damaging the surface of the sheathing or wallboard while seating the screw.

Nailer Nailers are commonly used to attach plywood, oriented-strand board (OSB), and other sheathing materials to steel wall and roof members, as in **Figure 29-7**.

Nailers are sometimes called *pneumatic nail guns*. They use compressed air to fire the nails and pins into the sheathing materials.

Portable Shears Portable hydraulic shears are attached to a source of hydraulic power by high-pressure hoses. The hydraulic pressure powers a sharp blade that cuts through the steel. Shears produce a clean, straight cut.

Electric handheld shears are similar in operation to hydraulic shears, as in **Figure 29-8**. An electric motor powers the sharp blades. Electric shears can cut steel as thick as 68 mil (about 1⁄16").

Chop Saw Chop saws resemble compound-miter saws used for cutting wood, as in **Figure 29-9**. The chop saw for cutting steel can be mounted on a table.

Chop saws require an abrasive (non-toothed) blade for cutting steel. The cut

JOB SAFETY

POWER CORDS When using electric power tools, be aware of the dangers of electrical shock. Check all power cords for exposed wiring. Check the cord's insulation for cuts and breaks. Be sure that a power cord is not wrapped around or passing over steel framing members. The sharp edges of the steel can snag and damage the insulation.

Go to **glencoe.com** for this book's OLC for more on job safety.

Figure 29-6 Drywall Screw Gun

Protecting Sheathing A drywall screw gun has a depth-sensitive nosepiece.

Figure 29-7 Nailer

Attaching Sheathing A nailer used to attach sheathing to steel studs.

Tim Fuller

Figure 29-8 Electric Shears
Cutting Steel Electric shears can cut sheet steel.

made is very rough. Sharp burrs remain on the edge. It may be necessary to grind these rough edges to **remove** the burrs.

Chop saw blades cut quickly and produce hot metal chips that can be a safety hazard. They are effective for making square cuts and for cutting bundled studs. However, they are very noisy and ear protection is required.

Plasma Cutter Plasma cutters produce a very hot arc of *plasma* between the tip of the cutter and the steel. Plasma is a heated gas that conducts electrical current. The plasma cuts very quickly and smoothly through steel stock like the flame of a welder's torch.

It may be necessary to grind the edges of a plasma cut. In harsh environments, the edge may require treatment with a metallic coating to resist corrosion.

Circular Saw Circular saws for cutting steel are similar to those used for wood. They must be equipped with a proper blade with carbide-tipped teeth. The carbide tips provide a very hard cutting surface. Abrasive blades are also available. Blades with

Figure 29-9 Chop Saw
Abrasive Blade These tools are used for cutting metal.

Tim Fuller

Figure 29-10 Circular Saw
Cutting Tool A circular saw used for cutting steel.

Figure 29-12 Hand Seamers
Hands On These hand seamers make small bends.

carbide-tipped teeth are expensive. Cost, safety, durability, and cutting ability are important considerations when choosing a blade. A circular saw is shown in **Figure 29-10**.

Press Brake A press brake can create straight-line bends in steel. Builders and framers use a press brake to shape flat sheet steel for use as fascia material, ridge caps, and for other applications, as in **Figure 29-11**. Press brakes can bend flat stock as long as 10 feet.

Figure 29-11 Press Brake
Taking Form A press brake forms sheet steel.

Hand Tools

Manually operated tools used in steel framing include hand seamers, clamps, aviation snips, and hole punches.

Hand Seamer Hand seamers are used to make small bends in metal stock. They have a 3½" flat jaw and are often called *duck-billed pliers*, as in **Figure 29-12**. The tool is useful for bending steel webs or flanges. It is also useful when forming pieces of sheet steel around windowsills and door openings.

Clamps Clamps are used to temporarily hold steel members together while they are fastened. When layers of steel are screwed together, the first layer can “climb” the threads of the screw and pull away from the second layer. This is called *jacking*. Locking C-clamps prevent jacking by holding the layers firmly together, as in **Figure 29-13**. This allows the screw to penetrate both

Figure 29-13 Locking C-Clamps
Prevent Jacking These clamps temporarily hold members together.

Figure 29-14 Aviation Snips

Right or Left A. Red-handled aviation snips are for right-handed people. **B.** Green-handled snips are for left-handed people. **C.** Yellow-handled snips should be used for straight cuts.

layers. Bar clamps are often used to hold headers in place after they are fitted into the top track.

Aviation Snips Aviation snips can cut steel as thick as 43 mil. They are especially useful for coping and making small cuts on such things as flanges. Snips are available in three different models to fit individual users, as in **Figure 29-14**.

Hole Punch Hole punches are used to create holes in the web of steel framing members that are as thick as 33 mil. See **Figure 29-15**.

Figure 29-15 Hole Punch

Packs a Punch A hole punch makes holes in steel members.

Hole punches are designed to fit around the flange of C-shaped members.

Holes made with punches can measure up to 1" in diameter, and larger holes also may be cut. However, the locations of holes must be in accordance with building codes. This prevents the studs from being weakened. Holes are often used to route pipe or wiring. In such cases, they must be lined with a grommet to prevent rough edges from causing damage or to isolate copper pipes from the steel framing.

Fastening Methods

What is pullout capacity?

Steel framing members can be attached with mechanical fasteners such as screws, nails, and pins. They can also be joined by welding or clinching.

More time is needed to join steel members than wood members. Selecting the correct fastening method for the task is important. If the wrong one is used, the connection may fail. The framer must know about the different methods that are available.

Steel Framing Screws

All steel framing screws have a point, a head, a drive type, threads, and plating, as in **Figure 29-16**. They are sized according to length and diameter. They come in many sizes, shapes, and head and thread styles.

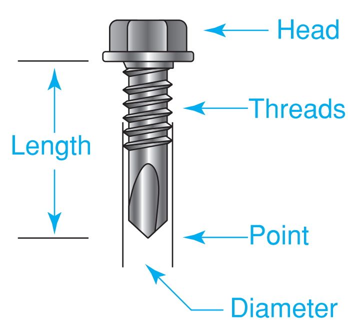

Figure 29-16 Steel Framing Screw

Parts of a Screw Note the point, head, threads, and plating.

Tim Fuller

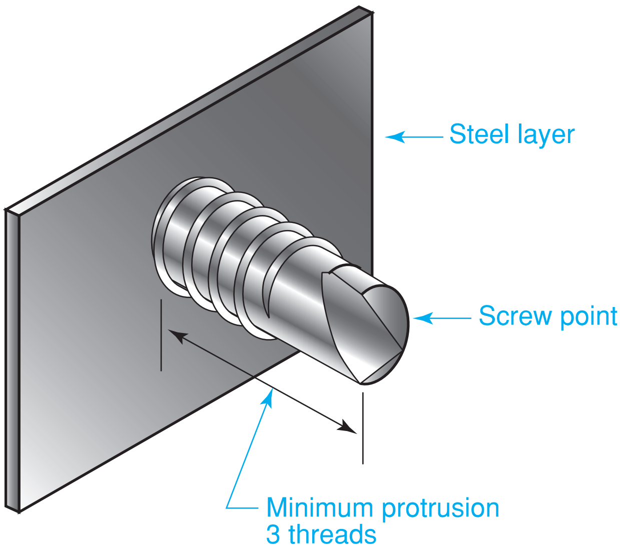

Figure 29-17 Pullout Capacity
Holding Strong Screw penetration indicates pullout capacity.

Screws are rated on their pullout capacity. The **pullout capacity** of a screw is the screw's ability to resist pulling out of the connection. Pullout capacity is based on the number of threads penetrating and holding the connection, as in **Figure 29-17**.

Framing screws are used to fasten steel to steel. Sheathing screws attach exterior sheathing, such as plywood or OSB, to steel members. The tip of the screw penetrates both the sheathing and the steel. The head and the threads hold the sheathing tightly against the steel.

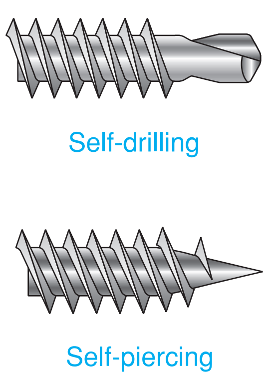

Figure 29-18 Screw Points
Self-Tapping Self-drilling and self-piercing points.

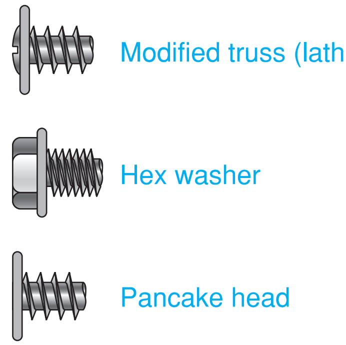

Figure 29-19 Steel Framing Screw Head Types
Thickness Matters Three types of heads.

Point Types Steel framing screws are self tapping. Self-tapping screws create their own holes. A pre-drilled hole is not needed.

Two types of self-tapping points are used: self-drilling and self-piercing, shown in **Figure 29-18**. Self-drilling points have drill tips. The point must be as long as the steel is thick. If the point is too short, the top layer of steel will climb the threads of the screw. Self-piercing points are sharp and can pierce thin steel layers. They are used to attach plywood or wallboard to steel studs that are up to 33 mil thick.

Head Types Common head styles for steel framing screws are shown in **Figure 29-19**. The hex washer head is the most common style for steel-to-steel connections. It provides

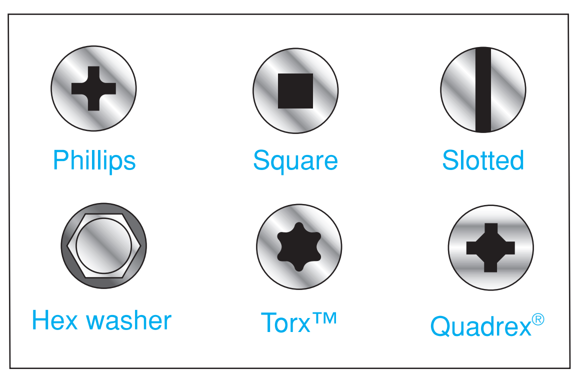

Figure 29-20 Six Screw Head Designs
Common Heads Screw head design determines the type of driving tool used.

Builder's Tip

SCREWS AND BITS Always use the correct bit for the screw head style. A bit that is incorrect in size and shape will damage the head. A damaged head will prevent the screw from being seated properly. A poorly seated screw cannot be properly tightened and may be difficult to remove.

the most positive drive connection. This means that the bit used to drive it fits securely and will not easily slip.

When sheathing and wallboard are applied over a screw head, the modified truss or pancake head styles are preferred. They have a very thin profile. A thin profile allows the sheathing to lie flat.

Drive Types The type of head determines the bit used to drive and turn the screw, as in **Figure 29-20**. The bit needs to fit securely and release quickly. An incorrect bit can become lodged in the screw head.

The most common drive types are Phillips and hex washer. Phillips-head bits are used with modified-truss head screws.

Reading Check

List *In what ways are steel framing members attached and joined?*

Using Drive Pins and Nails

Drive pins and nails are applied with a pneumatic nailer, as shown in **Figure 29-21**. Instead of being screwed into the layers, the pins and nails are fired with air pressure. They are used to attach sheathing materials to steel members.

Plywood and OSB sheathing for walls and roofs can be applied using 1" to 1½" pins. Sheathing is usually attached with screws along its edges and with pins or nails in its field. Sheathing attached to walls must be held firmly against the steel during installation. This is because the fasteners do not draw the sheathing against the steel as a screw does.

Welding and Clinching

Welding and clinching are used to attach steel to steel.

Welding is the process of melting the steel and adding filler metals to fuse the pieces at the point of attachment. Cold-formed steel that is 18 to 33 mil thick should never be welded together due to the likelihood of "burn-through" of the material, and caution should be exercised when welding 43 mil material. Welding is permanent.

Although the galvanized coating on the studs will continue to protect against corrosion for most types of cuts, welding or severe grinding may remove the layer of zinc. In these cases, the affected area should be re-coated with zinc-enriched paint.

Clinching is the process of joining two layers of steel with pressure. A powered clinching tool is used. A clinched joint takes more time and is also permanent.

Figure 29-21 Collated Drive Pins

Drive Pins Collated drive pins used with a pneumatic nailer.

Joe Mallon

Section 29.2 Assessment

After You Read: Self-Check

1. What is feathering?
2. What is special about the nosepiece of a drywall screw gun and why?
3. Why must sheathing be held tightly against the steel member before firing a pin or nail?
4. How is a weld formed?

Academic Integration: English Language Arts

5. **Compare Tools** At your local tool supplier, research the differences among the various electric drills, framing screw guns, and drywall screw guns. Research the difference between a metal chop saw and a compound-miter saw for wood. Summarize the different uses in a two-paragraph report.

Go to **glencoe.com** for this book's OLC to check your answers.

Section 29.3 Steel Framing Methods

Floors

Why is it important to brace floor joists?

As in wood construction, the frame is the supporting structure of a steel-frame house. It supports the weight of the house and defines its shape. The frame includes the side walls, end walls, floor and ceiling joists, and roof frame.

In-line framing is typically used in steel-frame construction. **In-line framing** is framing that aligns all vertical and horizontal load-bearing structural members. A detail of in-line framing is shown in **Figure 29-22**. Because the members are aligned, all axial loads are transferred from the roof through the walls and floor joists to the foundation. The **axial load** is the load carried along the length of a structural member.

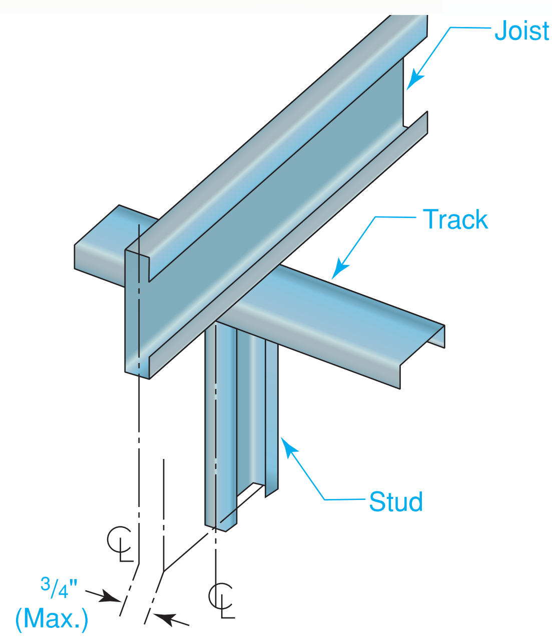

Figure 29-22 In-Line Framing
Frame Up Framing details for a joist track.

Figure 29-23 **Basement Foundation**

Steel Joist A basement foundation with steel floor joists in place.

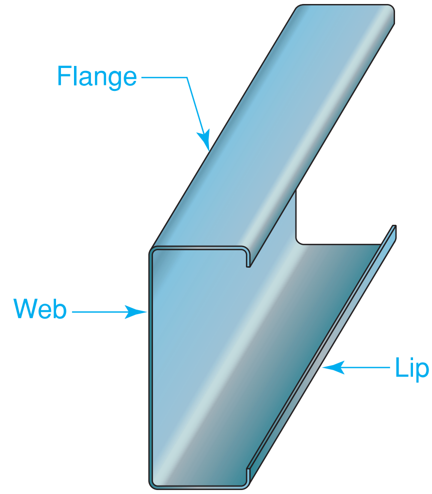

Figure 29-24 **C-Shaped Joist**

Floor Framing Joists are used to frame floors.

The foundation acts as an anchor, as well as a support, for the frame of the house. The foundation may be a concrete slab-on-grade, poured concrete walls, or concrete block walls, as in **Figure 29-23**.

Steel joists, like wood joists, are used to frame floors. A steel joist is shown in **Figure 29-24**. The joists are supported by the foundation and by posts and girders. Joists are attached to the foundation with C-shaped members called **joist tracks**. Each end of the joist is inserted into the track and screwed in place, as in **Figure 29-25**.

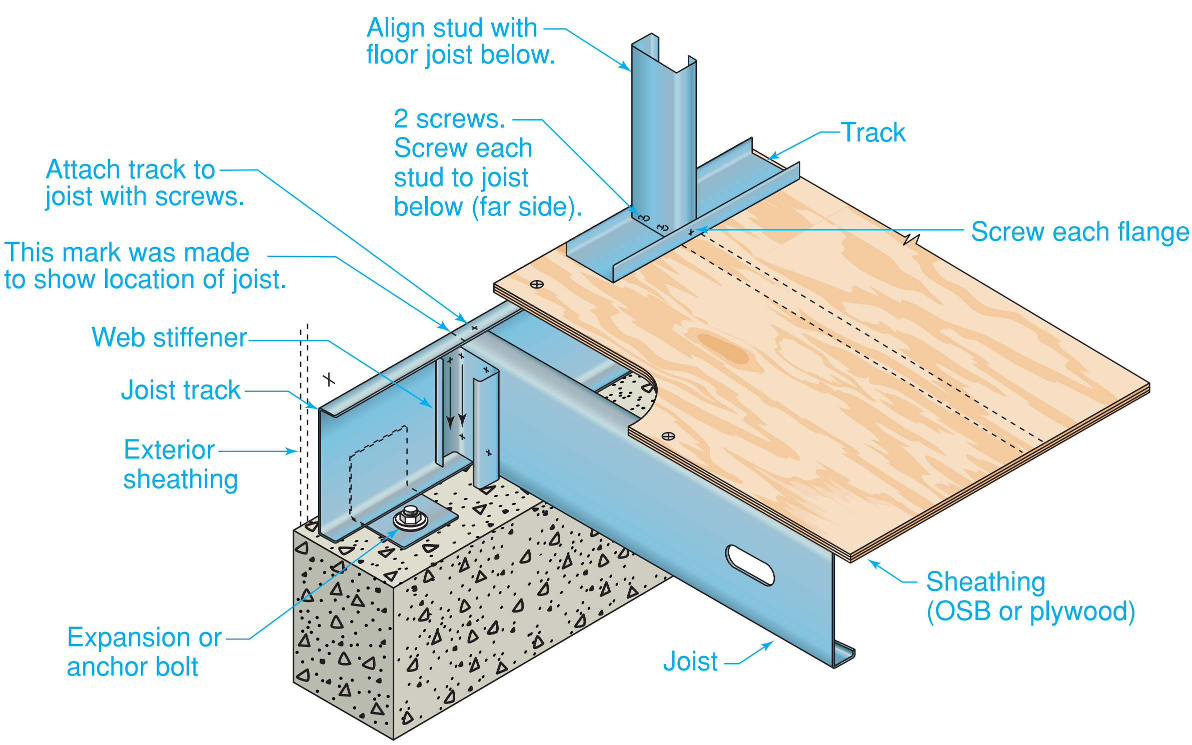

Figure 29-25 **Joists and Studs**

Aligned This drawing shows how the steel joists and studs will be placed in relation to each other.

Jon P. Muzzarelli

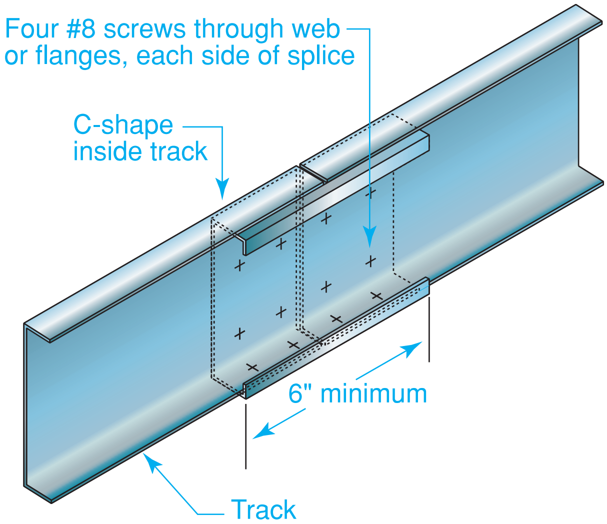

Figure 29-26 Track Splice
Minimum Length A track splice showing the 3" lap of each section.

Joist tracks may also be called *rim tracks* because they are attached to the rim of a foundation (or a header).

Track splices are used whenever a single section is not long enough to extend the entire length of a foundation wall or header. The minimum length of a track splice is 6", as in **Figure 29-26**. This allows for 3" of lap on each section.

Laying Out Floor Joists

Floor joists may be laid out from one end wall to another or from one side wall to another. The floor joists should run in the same direction that the roof trusses or rafters will.

When beginning the joist layout, place joist tracks for both sides on one side of the structure. Temporarily clamp their webs together. This allows you to mark both tracks for layout at the same time.

Start the layout by marking for a joist at one end. Mark the location of the next joist on the joist track so it will be in line with the first roof member. It will be 24" or less from the end joist.

Continue from that mark along the length of the joist tracks, making a new mark every 24". Place an X on the side of each mark where the flange of that joist will be. The flanges must all be oriented in the same direction, or on layout. The open side of the joist should face away from the starting point.

Continuous-span joists span the entire floor opening. The Xs are all on the same side of the joist location marks, as in **Figure 29-27**.

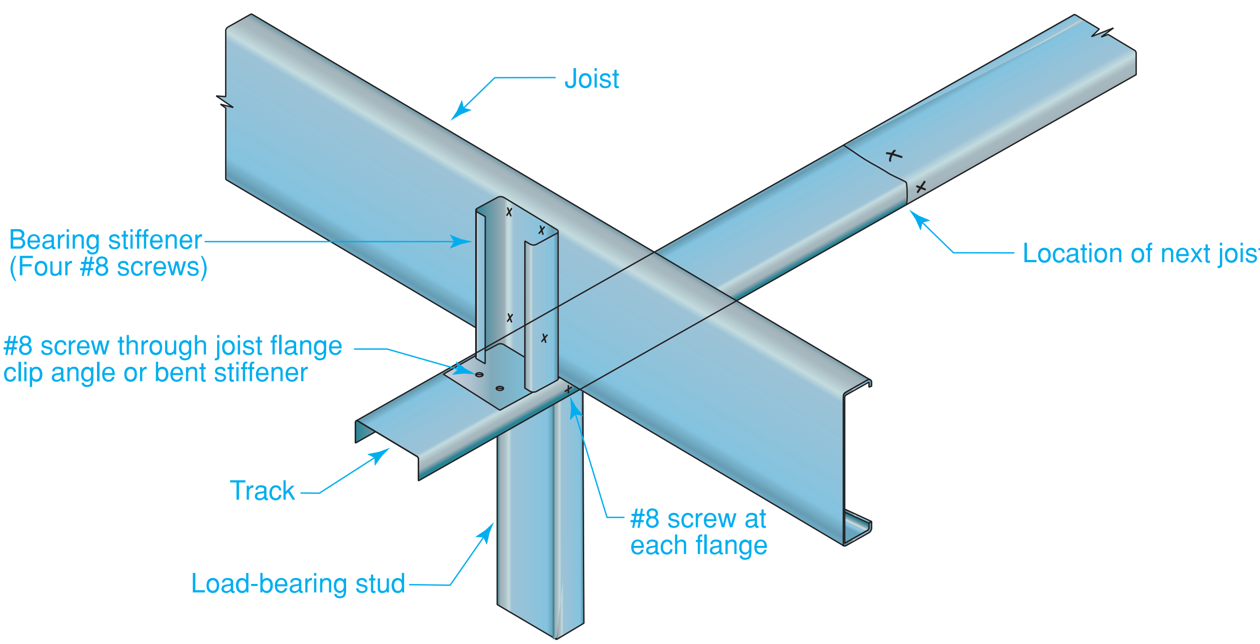

Figure 29-27 Continuous-Span Joist
Floor Support A continuous-span joist spans the entire floor.

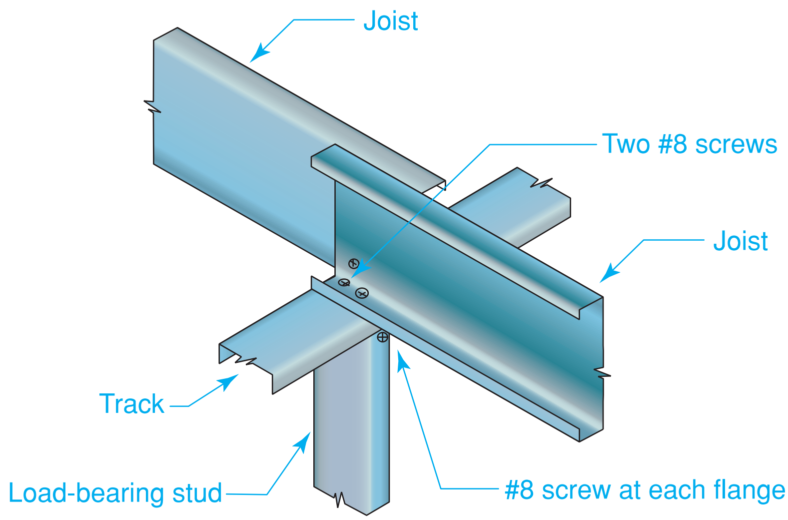

Figure 29-28 Lapped Joist
Intermediate Support Lapped joist across a load-bearing stud.

A non-continuous joist, or *lapped joist*, is in two pieces. The pieces meet and overlap over an intermediate support, as in **Figure 29-28**. The Xs for the opposing track are on the side opposite the joist location marks.

Fastening Joist Tracks

A steel frame must be securely attached and anchored to the foundation. This is done with either embedded or epoxied anchor bolts. The bolts extend through a hole that is punched in the bottom of the joist track. Washers and nuts are tightened onto the bolts to hold the frame in place. Embedded anchor bolts are set in place before a concrete foundation is poured, as in **Figure 29-29**. When the concrete cures and hardens, it holds the bolt securely in place.

Epoxied anchor bolts are installed in cured concrete or in concrete block. A hole is drilled into the foundation and filled with epoxy. Epoxy is a type of adhesive. A threaded bolt is placed into the hole. When the epoxy hardens, it provides a strong bond that holds the bolt in place.

The joist tracks must then be fastened to the foundation. Place one track on each end wall or side wall. Stand the track on one flange with the web toward the outside of the foundation wall, as in **Figure 29-30** on page 848. Keep the web of the joist track aligned with the edge of the foundation wall by tacking the track to the wall. Place a clip angle (see Figure 29-30) over the anchor bolts at each anchor bolt location. A **clip angle** is a small piece of galvanized steel attached to a structural member to accept a structural

Figure 29-29 Anchor Bolt
Anchored Embedded anchor bolt.

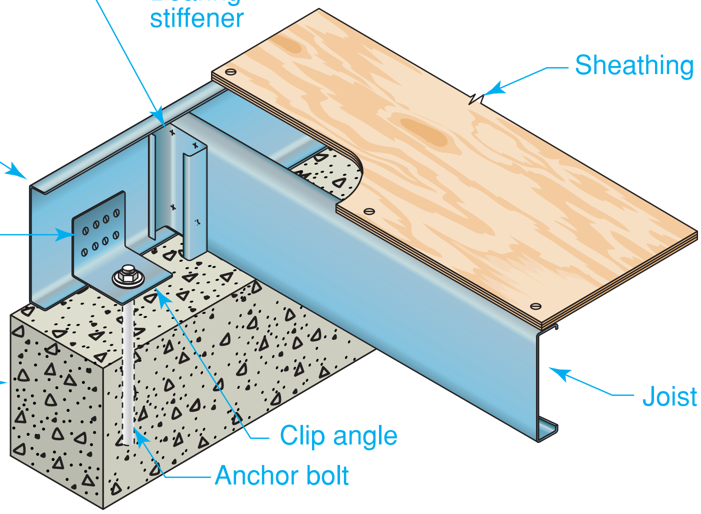

Figure 29-30 Clip Angle and Anchor Bolt

Firm Foundation Track attached to foundation with clip angle and anchor bolt. The web faces the outside of the foundation wall.

load. If the clip angle that is used is made on site (rather than a pre-engineered clip being used), it must be made with material that is the same thickness as the studs or joists it is being used to connect. Clamp the clip angles to the joist track to hold them in place. Attach them to the joist track with eight #8 screws as shown above. Place a washer and nut over the anchor bolt to secure the clip angle to the foundation.

Setting the Joists

The joists are set into the track after the track is secured, as in **Figure 29-31**. Turn the joist at an angle to fit between the flanges of the joist track. Twist the joist into position and set it inside the track. Keep the web sides of the joists oriented in the same direction. Position them on the same side of the mark on the track.

Use a triangular framing square to adjust the end of each joist so it is perpendicular to the track. Allow a ⅛" gap between the track and the end of the joist to prevent squeaks.

Screw the joist into position through its top and bottom flanges and the top and bottom track flanges. Use a minimum of one #8 screw at each point. Use screws with low-profile heads on the top flange to allow for the subflooring.

Figure 29-31 Floor Joists and Joist Tracks

On Track Fastening the floor joists in the joist tracks.

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For lapped joists, lap the second joist toward the wall from which the layout was started. Otherwise, the distance between the starting point and the lapped joists will be greater than 24", which will cause problems when laying the subfloor. Check the layout at the intermediate supports and screw the lapped joist into the support. Set the remaining joists across the entire structure.

Bracing the Joists

Braces prevent joists from rolling or twisting in the tracks, as in **Figure 29-32**. The top flanges are braced with sheathing or subflooring. The bottom flanges are braced with gypsum board or a steel strap and blocking or bridging. Floor spans of 12' or less do not require bracing on bottom flanges.

Web Stiffeners Web stiffeners are added to joists to prevent them from bending under the weight of floor loads. A web stiffener is made from stud or track material. It should be the same thickness and depth as the floor joist.

Stiffeners must be added when the joists and joist tracks are installed. The stiffener is screwed to either side of the web. A stiffener is required under every load-bearing wall. Stiffeners are also required where non-continuous joists lap at an intermediate support.

Subflooring Be sure to check your local building code for the type of material to use for the subflooring and how it should be attached. When the joists are spaced 24" OC, 23⁄32" tongue-and-groove APA-rated sheathing plywood is used. Generally, the sheets of plywood are attached to the floor joists with #8 screws, 6" OC on the edges, and 10" OC on the joists in between. The sheathing should be tight against the joists. Use *bugle-head screws* and a drywall screw gun with an adjustable depth setting.

Reading Check

Analyze *What may occur if floor joists are not braced properly?*

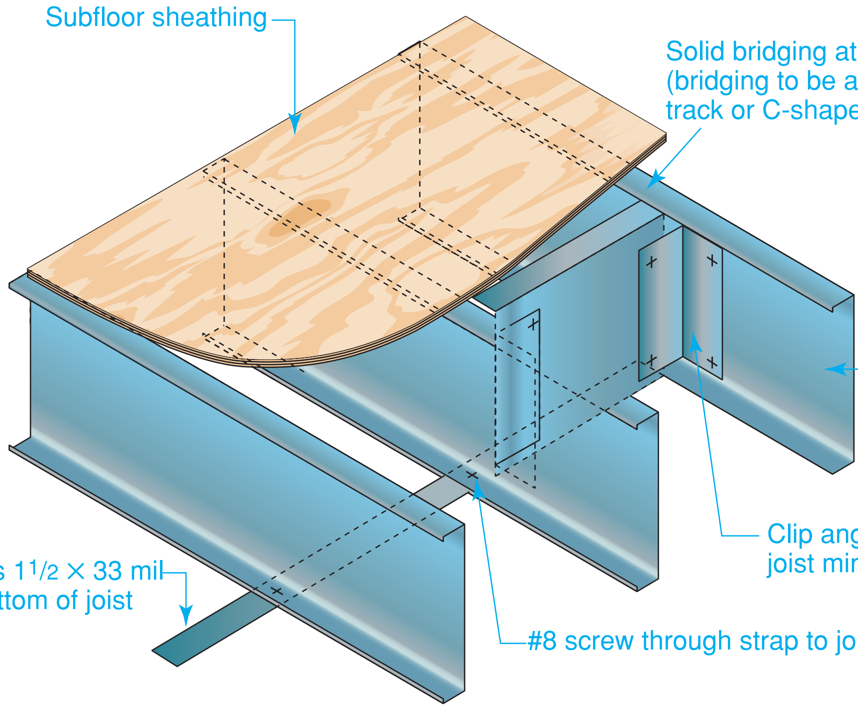

Figure 29-32 Joist Bracing

Roll Prevention Joist bracing using a steel strap.

Builder's Tip

JOIST ORIENTATION Steel joists are much straighter than wood joists. When setting them, there is no need to compensate for a crown or bow.

Walls

What is in-line framing?

Construction and placement of the walls can begin after the floor joists, joist bracing, and subflooring are installed. Walls are either load bearing or nonload bearing (partitions).

Load-Bearing Walls

Load-bearing walls help support the weight of the house above them. Steel framed structures typically use in-line framing, meaning that all load-bearing studs must be aligned with the trusses, joists, or rafters above and below the wall. To properly carry the load, each stud must butt tightly inside its track, as in **Figure 29-33**. If the stud is not tight, the load will placed directly on the screws that attach the stud to the track. This could cause them to fail. Special instructions for panelized walls are included in the Step-by-Step Application on page 855.

Wall Length The maximum length of a wall depends mostly on the workforce available at the job site. The longer the wall, the larger the workforce needed to build and place it. Longer walls tend to twist if they are not placed properly, which may result in damage to the wall.

Walls are easier to frame in short sections and require a smaller workforce to put in place. Tracks for short sections are often spliced together to make longer walls. Care must be taken when splicing wall sections. The tracks must be kept aligned and straight. Two walls meet at an intersection.

Intersections Intersecting walls occur at the corners of the house where wall sections meet. A detail is shown in **Figure 29-34**. Depending on the stud sizes being used—3½" or 5½"—the bottom track will be shorter than full length.

To form an intersecting wall, cut the top and bottom tracks to the correct length. The bottom track should be 7 or 11 inches shorter (two times 3½" or 5½").

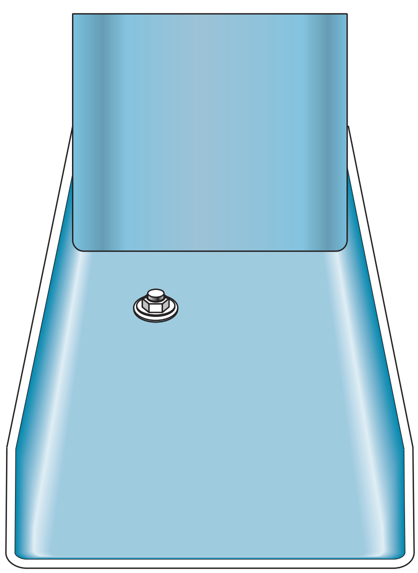

Figure 29-33 Installed Stud
Inside Track A properly installed stud is butted firmly inside the track.

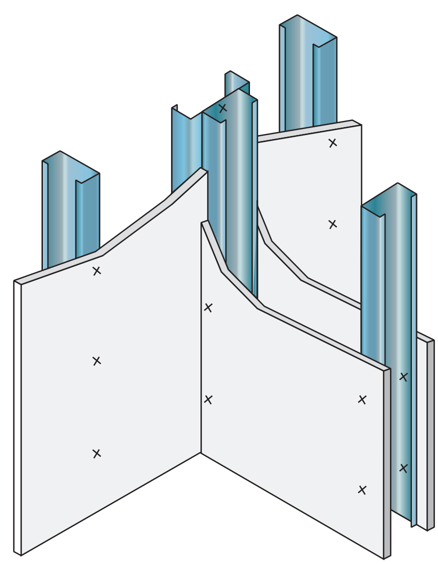

Figure 29-34 Intersecting Wall
Wall Sections Two walls meet at an intersection.

Figure 29-35 Braced Walls
Proper Support Temporary wall bracing.

Setting and Placement Load-bearing walls must be prepared, placed, spliced, and connected. When anchor bolts are used, measure their locations in the foundation. Make holes in the bottom track of the wall panels at these locations. Place temporary bracing material near the foundation so it is ready. Move the wall section into position. Tilt the wall up and position the bottom track over the foundation bolts.

Clamp the temporary bracing material to the wall studs in two or three locations, as in **Figure 29-35**. Install a brace every 8' to 12' along the wall. Secure each brace to a stud with a #10 hex-head screw before removing the clamps. Secure the bottom of the braces to a stake driven into the ground to hold them in place. Adjust the bracing to plumb the walls. Repeat this process until all load-bearing walls are in place.

Builder's Tip

THERMAL PERFORMANCE The thermal efficiency of a steel building is dependent upon several things. All joints must be tight to prevent air infiltration. Steel studs must be spaced properly, not clustered or grouped. Clustering forms cold spots. Insulation should fill the entire wall cavity, including the open sides of the C-shaped steel studs. Additional exterior foam sheathing should be used in colder climates.

JOB SAFETY

RAISING AND PLACING WALLS Raising and placing long wall sections require extra safety precautions. Be sure the on-site workforce is adequate to lift the length of wall being placed. Have temporary bracing and support beams readily available. Do not raise walls when strong winds could cause a lack of control. Securely brace the wall after it is in position.

Go to **glencoe.com** for this book's OLC for more on job safety.

Splicing and Connecting Sections Splicing wall sections must conform to accepted engineering practices. Center a 6" or larger piece of C-shaped material inside the two sections of track to be spliced, as shown in **Figure 29-36**. Screw the splice material through the flanges on both sides of the track with #8 screws. When each section is properly positioned, plumb it. Attach the walls to the frame at the corners with #10 screws. Leave the bracing and bottom track in any door openings until roof framing and permanent bracing are completed.

Attaching Sheathing After the wall is up and braced, Type II plywood or OSB sheathing can be attached. If openings in the wall are not extensive, the sheathing can act as bracing and protect the wall from racking and twisting. *Racking* occurs when the wall shifts and studs are forced out of plumb.

To be effective, the sheathing must cover the full height of the wall from top track to bottom track, as in **Figure 29-37**. It should be installed with the long dimension parallel to the stud framing. It should also be fastened tightly to the steel members with #8 self-piercing screws to draw the sheathing tight against the studs.

Interior Load-Bearing Walls Interior load-bearing walls increase the capacity of the house to resist shear forces, such as those that occur during earthquakes. That is because they stiffen the structure. They may also help increase the load capacity of the floors above the main floor. Mark the top and bottom track for layout. Anchor the bottom track in place. Then secure studs in each end of the bottom track. Next, position the top track at the ends with intermediate studs. Install the remaining wall studs. After the wall is standing and properly positioned, install headers, X-bracing, or sheathing.

Figure 29-37 Bracing an Exterior Wall
Panel Bracing Sheathing can brace an exterior wall and prevent twisting and racking.

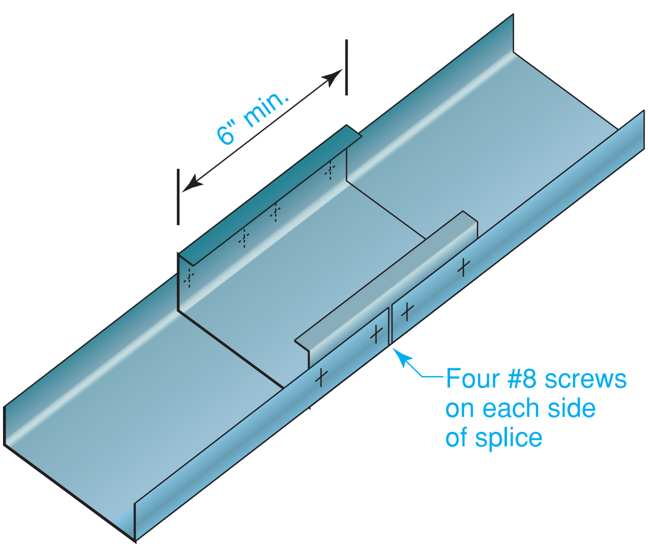

Figure 29-36 Spliced Sections
Tied Together Splicing two wall sections together.

Nonload-Bearing Walls

Interior nonload-bearing walls, or *partitions*, do not support or carry the weight of the structure. They are built to enclose rooms, closets, and other spaces. In-line framing is not required for these walls. The

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structural members of nonload-bearing walls can be of a thinner gauge material than those of load-bearing walls. However, residential structures may need 33-mil (29-gauge) studs to prevent bending or damage during construction.

Nonload-bearing wall framing is similar to load-bearing wall framing. Generally, walls are stick built. However, they may also be panelized and then raised into position.

Cabinets and shelving may be attached directly to partition studs and to blocking materials in the walls with #8 2" self-drilling screws. Wall studs must be 33 mil (29 gauge) or thicker. Wood cabinet blocking is installed as shown in **Figure 29-38**. One end of the wood block is notched so it fits over the lip of the stud. When steel blocking is used, the flanges of the track material are notched.

Stick-Built Framing Stick-built framing of a nonload-bearing wall begins with attaching the bottom wall track to the floor. The top track of the wall is positioned using a stud and a level. (The location of the top track for sloped walls or a cathedral ceiling can be set with a plumb bob.) The top track is screwed to the ceiling joists, the bottom chord of a truss, or a second-story floor joist.

Where interior walls run parallel to the joists or trusses, pieces of track or stud material are placed every 24" as blocking material, as in **Figure 29-39**. Blocking material should be cut 2" longer than the distance between the trusses. One inch is then clipped from the flanges on each side of the blocking material. This allows the webs to overlap. The blocking is screwed on both ends with #8 self-drilling screws. The track is then marked for a stud spacing of 16" to 24".

The C-shaped studs must open toward the starting point of the layout, especially if they are 18-mil studs. The studs are twisted into the wall layout and the flanges on both sides of the tracks are secured with #6 or #8 self-piercing screws.

Rough Openings The rough openings in nonload-bearing walls do not need to be as strong as those in load-bearing walls. When framing rough openings, allow 1½" on each side of a door opening to install wood studs. Line all interior and closet door openings with wood studs to provide extra support at

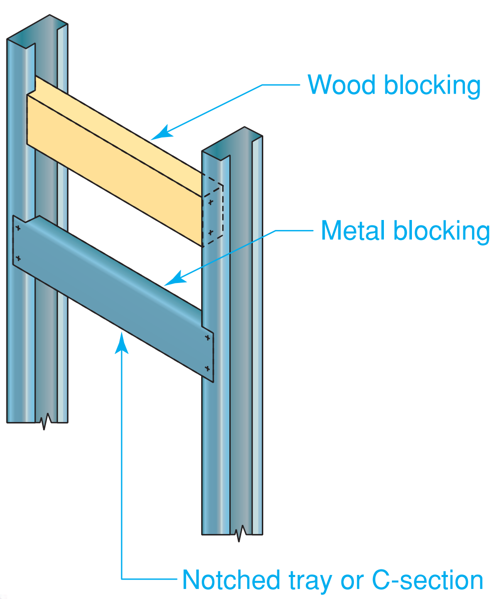

Figure 29-38 Cabinet Blocking
Blocking Wood or metal blocking can be used to support cabinets.

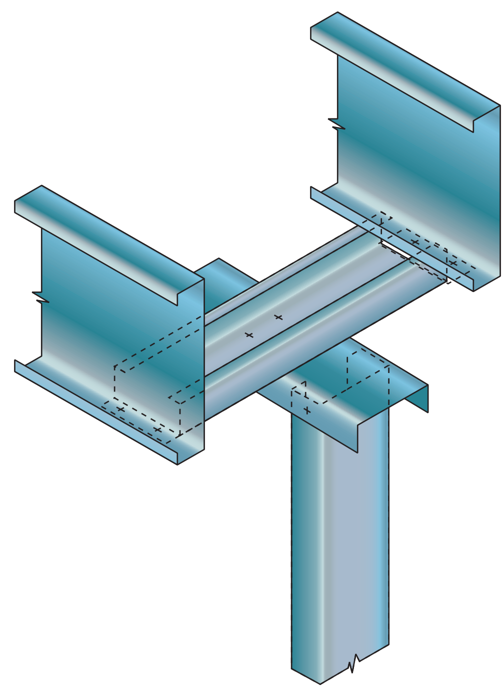

Figure 29-39 Metal Blocking
Track or Stud Blocking material between joists is used when the wall is parallel to the joists or trusses.

the hinge and strike plate. Place steel studs behind the wood studs with the flat side facing the opening.

Use wood or steel for the header of the opening. When using steel, cut the web back so the flanges provide an extra inch on each side. Install the cripple studs above the rough opening as necessary.

Reading Check

Recall *Why is in-line framing not required for interior nonload-bearing walls?*

Panelized Walls

As discussed in Section 29.1, panelized walls are pre-assembled. The location of the studs in the wall is governed by the roof and floor layout. It is important to accurately lay out the wall studs with reference to the roof and joist framing.

The following information applies only to panelized walls. Setting and placement are the same as for stick-built walls.

Wall Layout Panelized walls are built to engineering specifications and tolerances on templates such as platform tables and jigs, as in **Figure 29-40**.

Figure 29-40 Panelized Walls
Pre-Assembled Sections These panelized wall sections were built on a flat surface.

Builder's Tip

PUNCHOUTS Holes and punchouts are placed in steel studs to provide paths for utilities. When placing these paths, make sure both pre-punched and new holes line up. Place punchouts in the studs under windows if utilities will be run through them. Remember that the number of holes and punchouts will reduce the strength of a stud. Never punch a hole in the flange of a stud, joist, or track. Use grommets to cover the edges of holes and punchouts. The grommets prevent damage to wires. They also prevent the electrolytic corrosion of steel caused by contact with copper pipe or pipe hangers.

When laying out a panelized wall on a platform table, place the top and bottom tracks on the straight edge. Start with a stud at one end of the wall. Place a line on the flanges of the top and bottom tracks where the web of the stud will be located. Place an X on one side of this line to indicate the location of the stud flanges, as in **Figure 29-41**. Continue marking the locations of all studs every 16" or 24" on center.

Arrange and temporarily clamp wall members with all of the webs facing in the same

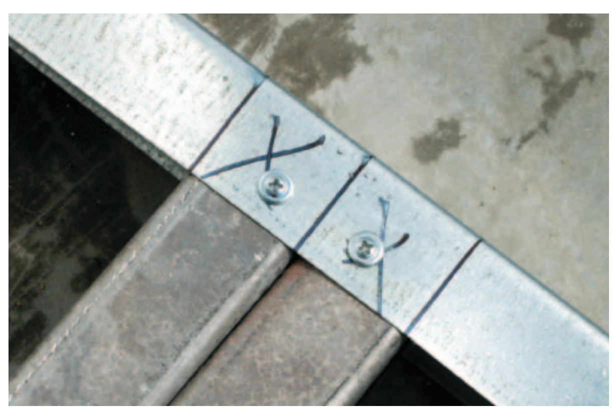

Figure 29-41 Stud Location
Locate Flanges Note the line and the X.

direction. The studs must fit tightly against the straight edge at the end of the wall.

Rough Openings After the wall is laid out, the rough openings for doors and windows are marked, as in **Figure 29-42**. Locate the door and window locations on the architectural drawings. Check the size of the openings. Mark the center of each opening on the top and bottom tracks. Add 12" to the width of the window openings. Using a tape measure, center the dimensions over the marks on the track. Mark the location at each end of the tape to indicate the location of the king studs. Place an X on the side of the mark away from the window. The webs of the king studs will be on the rough-opening side.

Figure 29-42 Rough Openings
Rough Opening for a Window Note position of header in wall.

Step-by-Step Application

Wall Stud Assembly After the layout is complete, assembly of the panelized wall can begin.

Step 1 Separate the top and bottom track members that were placed on the straight edge of the platform table.

Step 2 Install a stud at each end of the wall between the top and bottom tracks.

Step 3 Temporarily clamp the stud flanges to the track flanges at each end with locking C-clamps.

Step 4 Tap the tracks with a hammer to seat the top and bottom of the studs as tightly as possible.

Step 5 To prevent the studs from twisting, attach the flange of each stud to the flange of the track on each side of the wall using a #8 low-profile screw.

Step 6 Install the studs so all open sides face the same direction on parallel load-bearing walls.

Step 7 Align the punchouts in the studs to provide straight paths for plumbing and electrical runs, as in **Figure 29-43**.

Step 8 Install the king studs at the rough openings. Do not install studs at the markings between the king studs. These markings indicate the position of the cripple studs.

Step 9 Continue down the length of the wall until all studs are screwed into place. Do not remove the wall panel from the table until the header framing is complete.

Figure 29-43 Punchouts
Aligned Punchouts are aligned for straight runs of electrical wiring. Notice the grommets that cover rough edges.

Go to **glencoe.com** for this book's OLC for additional step-by-step procedures, applications, and certification practice.

Adding 12" of width simplifies header assembly. It allows for two trimmer (jack) studs, one on each side of the header, and a wood stud on each side of the opening.

Framers may vary the length of the headers. Two trimmer studs may not be required at every opening. However, standardizing header length helps to simplify cut lists.

For wall stud assembly, see the Step-by-Step Application on page 855.

Box Header Assembly A box header is a common header that is built from standard C-shaped steel framing members, as in **Figure 29-44**. A header jig is used to support the steel members and to keep them straight during assembly. A header jig can be built from C-shapes attached to a table and placed at the exact dimensions of the rough opening. The header can be built between these members.

To frame a box header, cut a section of wall track 2" longer than the header. Snip the flanges of the track back 1" at each end. Bend the web toward the flanges with a hand seamer. Make sure the bend is clean and straight.

Clamp the header track to the jig. Screw the web of the header track to the flanges of the C-shapes with two #8 screws spaced 24" OC.

Cut web stiffeners from 3½" stud material. Install the stiffeners in each end of the header with the flat side of the stiffener facing out. Attach four #8 screws through the web of the header pieces into each side of the stiffener flanges. Insulate the header before it is installed in the wall.

L-Headers The L-header consists of one or two angle pieces that fit over the top track and one leg extending down the side of the wall above window or door openings.

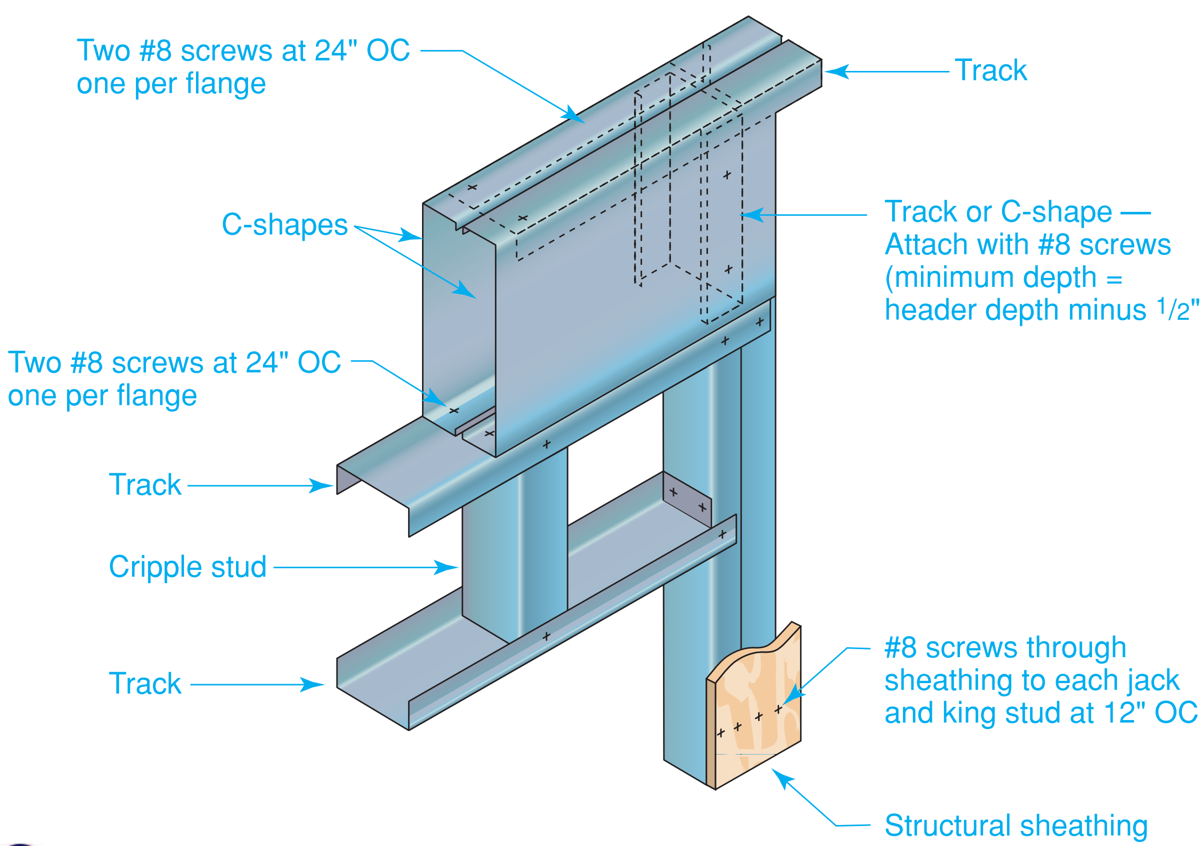

Figure 29-44 Box Header Detail
Box Header A box header is built from C-shapes.

Each angle is fastened to the top track above an opening with minimum #8 screws spaced at 12" OC. The "L" angle is placed on both sides of the wall opening to form a double angle L-shaped header (double L-header).

The L-header saves labor because unlike box headers, no special fabrication is required and the number of screws is reduced. The L-shape itself spans the opening for the header.

Bracing Before a panelized wall is removed from the platform table, it must be checked for squareness. Then it must be braced. Measure the panel diagonally from corner to corner. If these measurements are the same, the wall is square.

Lay extra bracing, studs, or truss material across the opening. X-bracing is the most effective at this stage. X-bracing consists of diagonal steel straps, as in **Figure 29-45**. The bracing is attached to the walls with gusset plates and screws so it is permanent.

Figure 29-45 Bracing
Diagonal Support X-bracing using steel straps.

Installation of the bracing straps must be inspected to ensure that the correct number of fasteners is used.

Reading Check

Explain *How is the location of the studs in the wall determined?*

Roofs

What precautions should be taken with framing installed in high wind areas?

Steel roof framing has several advantages over traditional wood-frame construction. With minimal support bracing it can provide more attic space. Fewer members are required. Complex roof designs cost less than when framed with wood.

Installing Ceiling Joists

The procedure for setting ceiling joists is similar to that for floor joists, as in **Figure 29-46** on page 858. Mark the layout for the top track. Start your layout at the same end for both sides. Next, measure and mark the layout over the headers. Also, mark any locations where there are no wall studs and the layout is not obvious.

Install the ceiling joists in the tracks one at a time. Move from where you began the layout to the end of the structure. Anchor the joists at the top of the track using two #10 screws. Install 2×4×33 mil C-shape

JOB SAFETY

CEILING JOISTS Once secured to the tracks with screws, the ceiling joists may be used temporarily as a work platform when installing the rafters. Before placing any weight on the joists, make sure that they are properly braced. Make sure all load-bearing walls below the ceiling joists are secured in place.

Go to glencoe.com for this book's OLC for more on job safety.

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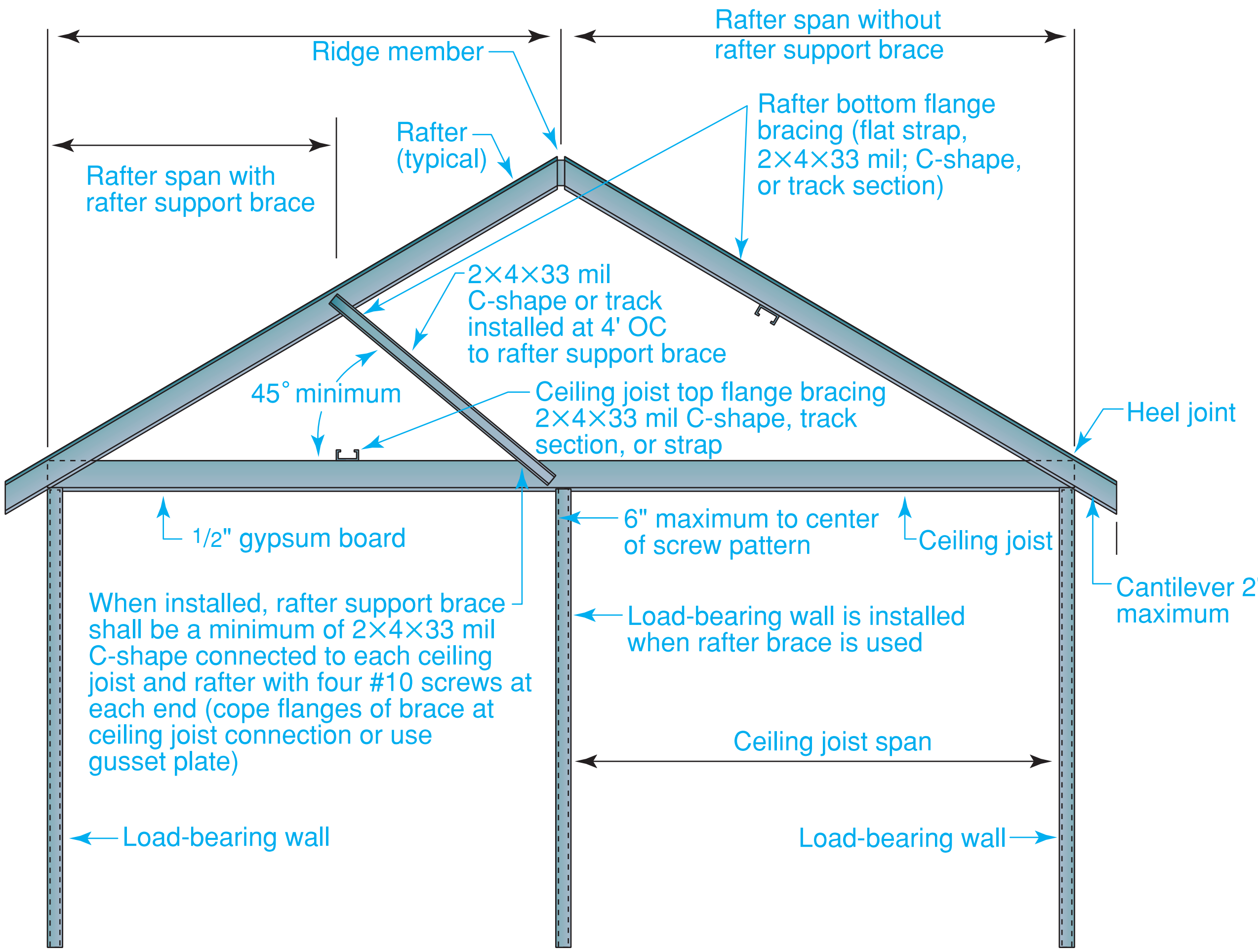

Figure 29-46 Steel Roof Construction

Roof Framing Steel roof construction with joists and rafters.

top-flange bracing on the joists. Blocking must be installed every 12' OC. The blocking keeps the joists from rolling in the tracks.

Preparing the Rafters

All rafters must be installed with the flat sides facing the same direction. The flat side of the rafter at the top track must be in contact with the flat side of the ceiling joist, as in **Figure 29-47**.

Cut the rafters to length. Cut the top end of the rafter to match the slope of the roof. The ridge plumb cut allows the rafter to lie flush against the ridge member. Next, use 2" × 2" clip angles to attach the rafters to the ridge member, as in **Figure 29-48**.

Rafter tails may be cut in advance or after roof framing is complete. However, the fascia material will remain straighter if the tail cuts are made after the roof is framed.

Setting Ridge Height

The ridge height can be determined by the same methods as for wood construction. See Chapter 17, “Basic Roof Framing,” for complete instructions.

Common Rafter Method The common rafter method uses the length of the common rafters to set the ridge height. The length of the rafters must be accurate. The plumb cut at the top of the rafter must match the slope of the roof.

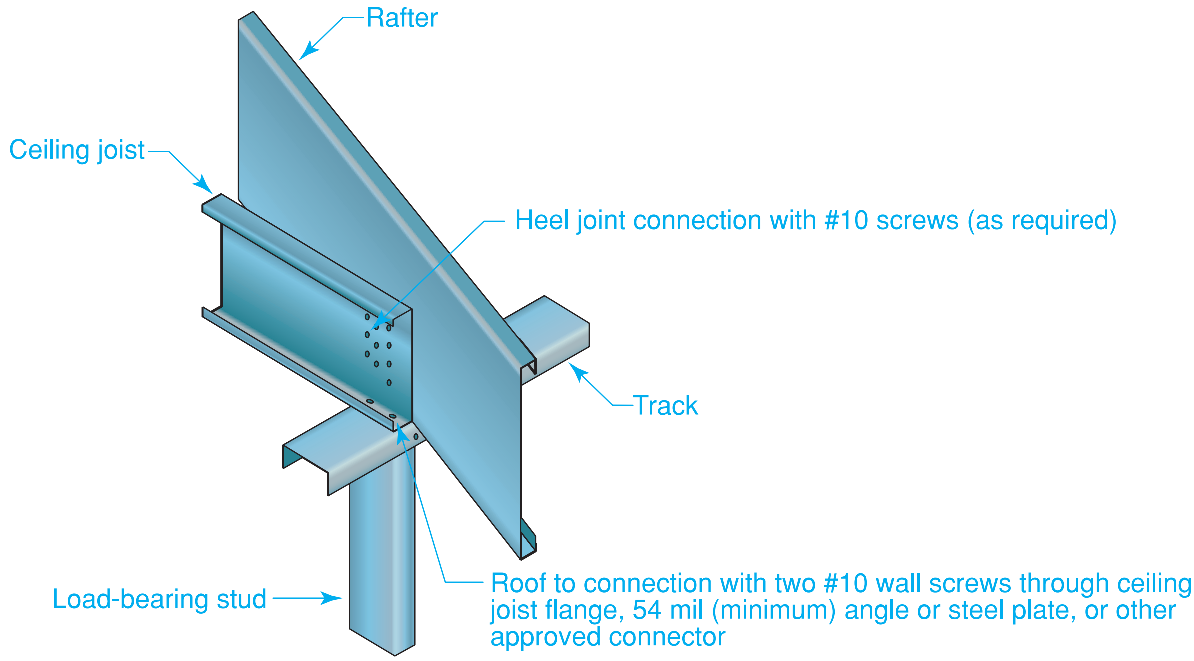

Figure 29-47 Rafter Connection
Flat to Flat The flat side of the rafter must contact the flat side of the joist.

Calculation Method With the calculation method the pitch of the roof and the rafter length are used to determine the ridge height. The steel rafters rest on the top outside edge of the top track. See Figure 29-47.

A steel rafter must not be notched as is done with a wood rafter. Notching will reduce its strength. The lack of a notch must be considered when calculating ridge height.

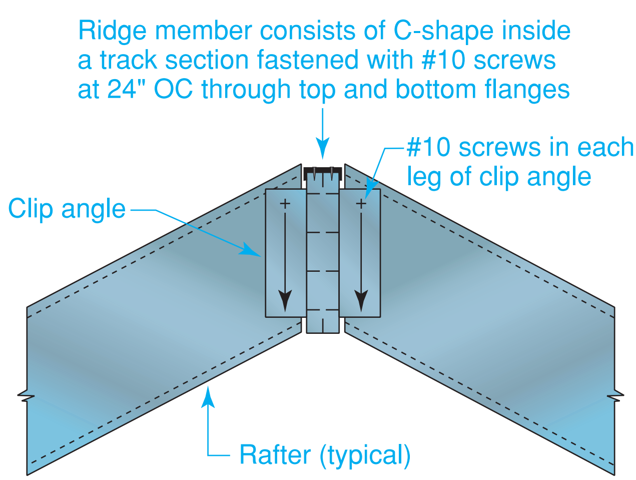

Figure 29-48 Attach with Clip Angles
At the Ridge Attaching the rafters to the ridge member with clip angles.

Framing with Trusses

Steel roof trusses can be manufactured off site or custom built on site.

Manufactured Trusses Manufactured steel trusses are made in different shapes and styles. One style is shown in **Figure 29-49** on page 860. Several factors are important when choosing trusses. They should be as cost effective as wood trusses. They must be durable enough to withstand normal shipping and handling. They must be able to support the weight of workers framing and finishing the roof. They must be light enough for work crews to lift, move, and place.

Site-Built Trusses Site-built trusses must be built according to approved engineering designs. They are framed with C-members having either mitered cuts or gusset plates at the connection points, as in **Figure 29-50** on page 860. When trusses are mitered, they may be assembled with the members in one plane. The thickness of the truss is the same as the thickness of a C-member. *Gusset plates* are made from pieces of track and have only one flange.

Figure 29-49 Roof Trusses
No Gussets Roof trusses are built in many styles and shapes.

The top and intermediate chord members are positioned flat side up. Bottom chord members are positioned flat side down.

General Framing Details

The following details apply to framing with either rafters or trusses.

Roof Hold-Downs The roof framing is fastened to the top plate with screws. The number and type of screws that make this connection are determined by wind-load data. Two #10 screws are sufficient for 70 mph Exposure C wind loads or 90 mph Exposure A or B wind loads.

Uplift connectors or hold-down clips are required in higher wind conditions, as in **Figure 29-51**. Prescriptive-method tables and charts should be used to determine uplift load and connector requirements.

Figure 29-50 Heel Gusset
Site Built Using a heel gusset to join the chords.

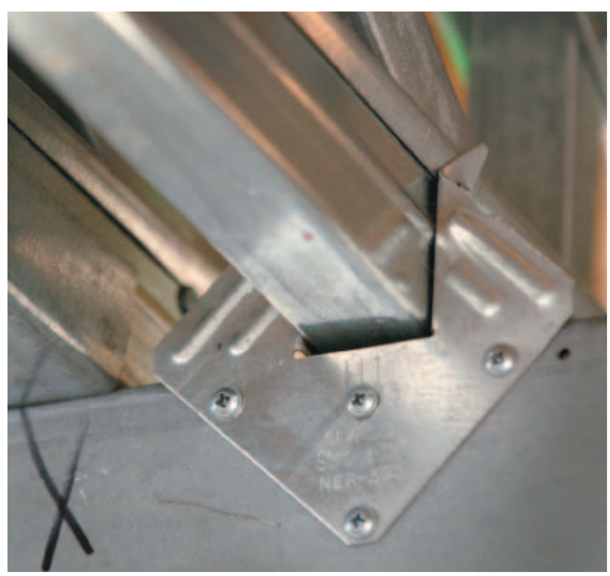

Figure 29-51 Roof Hold-Downs
Connectors Clips and connectors must be solidly screwed to framing.

Tim Fuller

Figure 29-52 Fascia

Plumb Fascia framing that is parallel to the side of the house.

Roof Fascia The roof fascia provides a finished look to the end of the rafter tails. The fascia can be installed so that it is parallel to the side of the house (perpendicular to the ground), as shown in **Figure 29-52**.

Roof fascia can also be installed so that it is perpendicular to the rafters, as in **Figure 29-53**.

Mathematics: Computation

Using a Construction Calculator

Determining the length and number of studs needed for a roof as well as finding the length or a hip or valley rafter is much easier when you use a construction calculator. Determine the length of a hip or valley rafter for a 9⁄12 roof that has a run of 16'-6".

Starting Hint Input the pitch, then the run.

Figure 29-53 Alternate Fascia

Angled Fascia framing that is perpendicular to the rafters.

Tim Fuller

Roof Rake The **roof rake** is that portion of the roof frame that extends beyond the walls on the gabled ends, as shown in **Figure 29-54**. The rake may overhang as much as 12". Rakes are formed using standard C-shaped members.

The rake supports the roof sheathing. Uplift loads determine the size of the rake. Deep rakes require that an engineer approve the design using uplift load data.

Using lookouts is another way of framing a rake. The lookouts are installed 2' OC from the gable end to the barge rafter, as shown in **Figure 29-55**.

Figure 29-54 Roof Rake

Extended Rake A roof rake extends beyond the house walls.

Figure 29-55 Lookouts

Extra Support Lookouts can be used to form a rake.

Tim Fuller; Jon P. Muzzarelli

Builder's Tip

SOFFIT DEPTH The International Residential Code restricts the distance that light-gauge steel rafter tails can cantilever (extend unsupported) past the walls. The maximum length of a rafter tail is 24". This distance is measured horizontally from the face of wall to the lowest point of the rafter tail.

Enclosed Soffits A soffit is the underside of the roof overhang. Soffits cover the truss or rafter tails. Enclosed soffits are usually covered with aluminum, vinyl, or wood. The enclosure may be formed to match the pitch of the roof as shown in **Figure 29-56**. The bottoms of other enclosed soffits may be horizontal and parallel to the ground. This surface often has ventilation openings, which allow air into the building.

Figure 29-56 Enclosed Soffit
Horizontal Method An enclosed soffit with ventilation openings. *What is the purpose of the ventilation openings?*

Section 29.3 Assessment

After You Read: Self-Check

1. What is the difference between continuous-span and non-continuous joists?
2. At what intervals should temporary bracing be installed?
3. What are the advantages of steel roof framing over traditional wood-frame construction?
4. Name the two methods used to determine roof ridge height.

Academic Integration: Mathematics

5. **Fastening Sheeting** Sheathing plywood comes in 8' by 4' sheets and is used as subflooring. It is fastened parallel to the joists along its length. The joists are 24" OC. How many screws will you use if you fasten the plywood with screws that are 6" OC along the joists at the sides and 8" OC along the joists in the middle?

Math Concept Drawing a sketch of a problem situation is an effective problem solving strategy for two- and three-dimensional geometric problems.

Step 1: Draw a sketch of the project.

Step 2: Figure the number of screws needed for one side. Use the sketch to check your work. Multiply by 2, the number of sides.

Step 3: Use the same technique to figure the number of screws needed for the middle joists. Use the sketch to check your work.

Step 4: Add to find the total number of screws needed.

Go to glencoe.com for this book's OLC to check your answers.

CHAPTER 29 Review and Assessment

Chapter Summary

Section 29.1

Steel frame houses are designed using the performance or the prescriptive method. Residential steel framing is either stick-built, panelized, or pre-engineered.

Section 29.2

Most tools used in steel framing are electrically, hydraulically, or pneumatically powered. In some situations, a gasoline engine may power larger tools. A few hand tools, such as clamps, are also used. Mechanical fasteners, such as screws, nails, and pins, attach steel framing members. Framing screws attach steel to steel. Sheathing screws attach exterior sheathing to steel. Processes such as welding and clinching are also used.

Section 29.3

Floor joists are laid out starting from the same end of the building as the roof members. The layout may be from one end wall to another or from one side wall to another. Joist flanges must all be oriented in the same direction. Load-bearing walls support the weight of the house above them. Each stud must butt tightly inside its track to properly carry the axial load. Interior nonload-bearing walls are not intended to carry axial loads and are typically used to enclose rooms. All rafters must be cut with the flat sides facing in the same direction. The flat side of the rafter at the top track must contact the flat side of the ceiling joist. Either the common rafter method or the calculation method can determine the height of the roof ridge.

Review Content Vocabulary and Academic Vocabulary

1. Use each of these content vocabulary and academic vocabulary words in a sentence or diagram.

Content Vocabulary

- cold-formed steel (p. 832)
- performance method (p. 832)
- prescriptive method (p. 833)
- feathering (p. 836)
- pullout capacity (p. 842)
- welding (p. 843)
- clinching (p. 843)
- in-line framing (p. 844)
- axial load (p. 844)
- joist tracks (p. 845)
- clip angle (p. 847)
- roof rake (p. 862)

Academic Vocabulary

- sequence (p. 832)
- remove (p. 839)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *plates* (p. 832), *mils* (p. 832), *plasma* (p. 839), *framing screws* (p. 842), *rim tracks* (p. 846), *lapped joist* (p. 847), *bugle-head screws* (p. 849), *racking* (p. 852), *partitions* (p. 852), *gusset plates* (p. 859).

Review Key Concepts

3. State the three types of steel frame construction.

4. List the tools used in steel framing.

5. Differentiate between welding and clinching.

6. Demonstrate how to lay out steel floor joists.

7. Explain the importance of in-line framing.

8. Tell how to set steel ceiling joists.

Critical Thinking

9. **Analyze** What size wall would you expect a small workforce to be most efficient at constructing? Explain your answer.

Academic and Workplace Applications

STEM Mathematics

10. **Estimating Labor Costs** Installing a floor system typically takes 72 man hours per 1,000 sq. ft. of floor area. A supervisor, a carpenter, a helper, and a laborer work together to install the floor system in a storage building that is 54 ft $\times$ 32 ft. Estimate the total number of man hours needed to complete the job.

Math Concept A proportion is an equation involving two equivalent ratios.

Step 1: Calculate the square footage of the floor area in storage building.

Step 2: Let x represent the unknown quantity, the total man hours needed for the job. Set up a proportion with two equivalent ratios. One compares hours and the other compares square footage.

Step 3: Solve for the unknown quantity.

Step 4: Divide the total hours among the four workers. Round up to the next hour.

STEM Science

11. **Shear Force** Both steel and wood interior load-bearing walls increase the capacity of a house to resist shear forces. They may also help increase the load capacity of the floors above the ground floor. Shear force often affects houses during earthquakes. Use the Internet to learn more about shear forces. Write one or two sentences describing how shear force or stress differs from perpendicular stress.

21st Century Skills

12. **Media Literacy** Read through your local newspaper ads and trade industry magazines that advertise and sell framing tools. Select two ads. Try to determine what audience the ads are directed toward. State how the ad draws the reader's attention. What techniques are used to create desire or arouse interest? Write a short paragraph summarizing your discoveries.

Standardized TEST Practice

CERTIFICATION PREP

Multiple Choice

Directions Choose the word or phrase that best answers the following questions.

13. Which of the following is not a type of steel frame construction?
    - **a.** stick-build
    - **b.** prescriptive
    - **c.** panelized
    - **d.** pre-engineered

14. Aviation snips can cut steel up to which thickness?
    - **a.** 55 mil
    - **b.** 43 mil
    - **c.** 66 mil
    - **d.** 69 mil

15. Interior load-bearing walls increase the capacity of the house to do what?
    - **a.** resist extreme weather
    - **b.** resist shear forces
    - **c.** maintain shape
    - **d.** minimize fire damage

TEST-TAKING TIP

If you have time, review your notes shortly before you take the test.

*These questions will help you practice for national certification assessment.