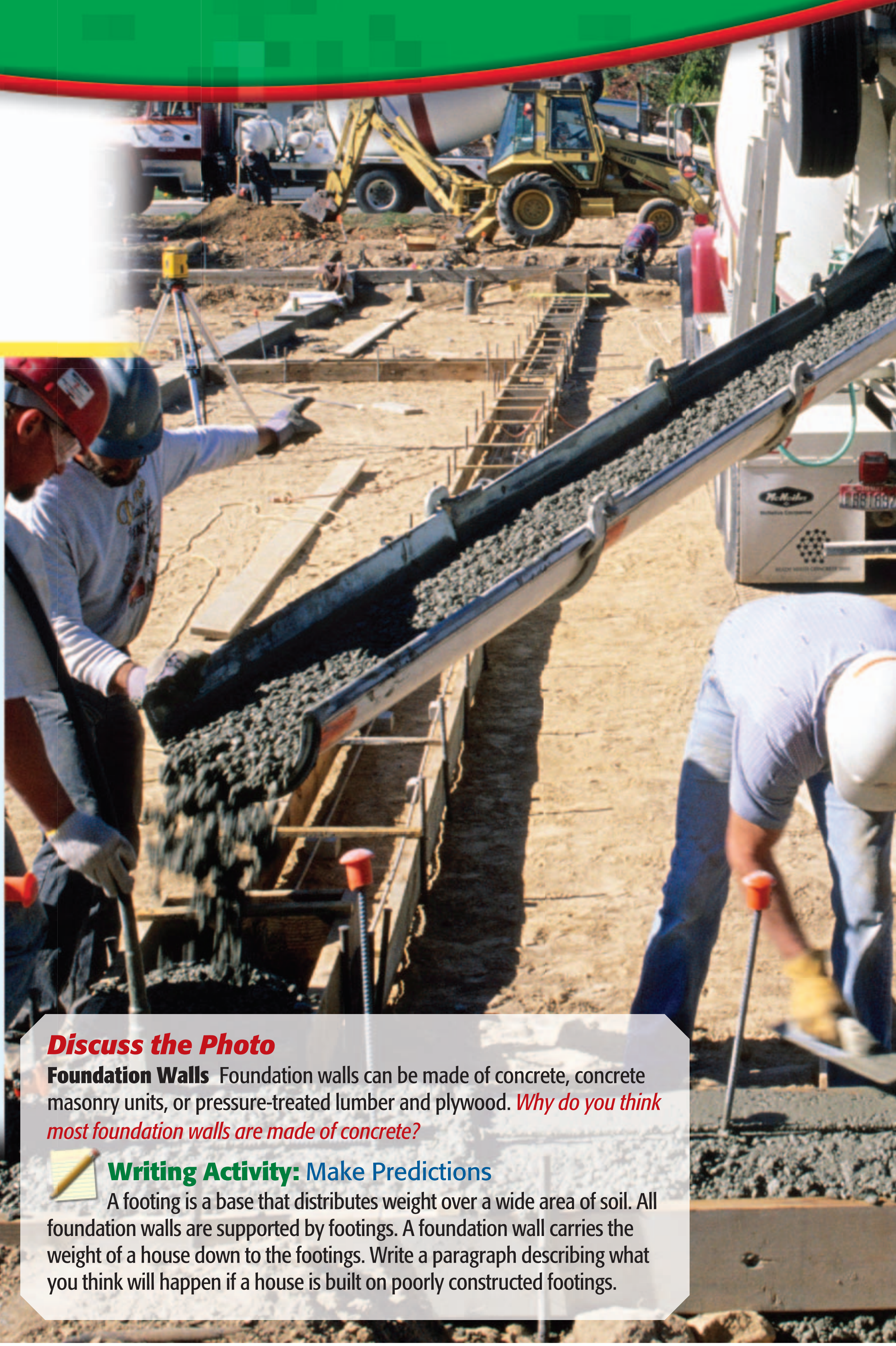
CHAPTER 10 Foundation Walls

Section 10.1
Footings

Section 10.2
Concrete Foundation Walls

Section 10.3
Concrete Block Walls



Chapter Objectives

After completing this chapter, you will be able to:

- **Explain** the purpose of footings.
- **Determine** the exact location of the footing.
- **Explain** how concrete foundation walls are formed.
- **Identify** the two types of foundation walls.
- **Describe** the process of laying a concrete block wall.
- **Identify** the types of concrete block used in concrete block walls.

Discuss the Photo

Foundation Walls Foundation walls can be made of concrete, concrete masonry units, or pressure-treated lumber and plywood. *Why do you think most foundation walls are made of concrete?*

Writing Activity: Make Predictions

A footing is a base that distributes weight over a wide area of soil. All foundation walls are supported by footings. A foundation wall carries the weight of a house down to the footings. Write a paragraph describing what you think will happen if a house is built on poorly constructed footings.

Chapter 10 Reading Guide

Before You Read Preview

A foundation anchors a house to the earth and provides a solid, level base for framing. 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

- footing
- wales
- cold joint
- head joint
- bed joint
- story pole
- control joint
- parging
- radon

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.

- framework
- incorporate

Graphic Organizer

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

Content Vocabulary	Definition
footing	a base that provides a surface that distributes weight over a wide area of soil

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Academic Standards

Mathematics

Problem Solving: Build new mathematical knowledge through problem solving (NCTM)

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

English Language Arts

Use language to accomplish individual purposes (NCTE 12)

Science

Science and Technology: Understandings about science and technology (NSES)

Earth and Space Science: Geochemical cycles (NSES)

Industry Standards

Foundation Systems

Concrete Forms and Flatwork

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

Section 10.1

Footings

Wall Footings

Why do you think the base of a foundation wall is called a footing?

All foundation walls are supported on a widened base called a footing. A **footing** is a base that provides a surface that distributes weight over a wide area of soil. Footings are generally made of concrete. In some cases, the footing is placed first and the foundation wall is built on top of it later, as shown in **Figure 10-1**. In other cases, the footing and the wall are built as a single unit, sometimes called a *monolithic wall.*

The size and shape of a footing are specified on the building plans. The depth and width are based on factors such as the weight the footing must bear, the bearing capacity of the soil, and local building codes. If a building official thinks the bearing capacity of the soil may be less than 1,500 lbs./sq. ft., he or she may require a soil test to determine the soil's actual bearing capacity.

Footings must always rest on undisturbed soil (soil that has not been dug up previously). This lowers the chance of the foundation settling unevenly. It is especially important where the building site has been raised by adding compacted fill. If the site for a footing has been dug too deep, it should never be filled with soil. It should be filled with concrete to make the foundation more stable.

Reading Check

Describe *What factors determine the depth and width of a footing?*

Figure 10-1 Footing Forms

Shaping Concrete Wood or steel forms prevent the concrete from spreading out as it is placed.

Table 10-1: Minimum Width of Concrete or Masonry Footings in Inches				
Load-Bearing Value of Soil (psf)	1,500	2,000	3,000	≥4,000
Conventional light-frame construction				
1-story	12	12	12	12
2-story	15	12	12	12
4-inch brick veneer over light frame or 8-inch concrete masonry				
1-story	12	12	12	12
2-story	21	16	12	12
8-inch solid or fully grouted masonry				
1-story	16	12	12	12
2-story	29	21	14	12

Footing Design

Local building codes specify the strength of the footing concrete and the minimum footing depth. Footings should be placed at least 12" below grade. In cold climates the footings should be far enough below finished grade to protect them from frost.

The width of a footing depends on the bearing capacity of the soil, specified in building code charts such as **Table 10-1**. On standard soils, footing size is generally based on the thickness of the foundation wall. The width of the footing should be twice the thickness of the foundation wall. The footing would project out one-half the thickness of the foundation wall on each side, as in **Figure 10-2**. If the load-bearing capacity of the soil is low, wider and thicker footings may be needed.

Footing Reinforcement The strength of a footing is greatly improved when reinforcing bar, or rebar, is embedded in it. Reinforcement often consists of two lengths of ½" diameter (#4) rebar. The rebar must be at least 3" above the bottom of the footing.

Footing Forms

The exact location of footings is determined by plumb bobs hung from the foundation batter boards. Once the location is known, the shape and size of the footing can be established. The shape of the footing

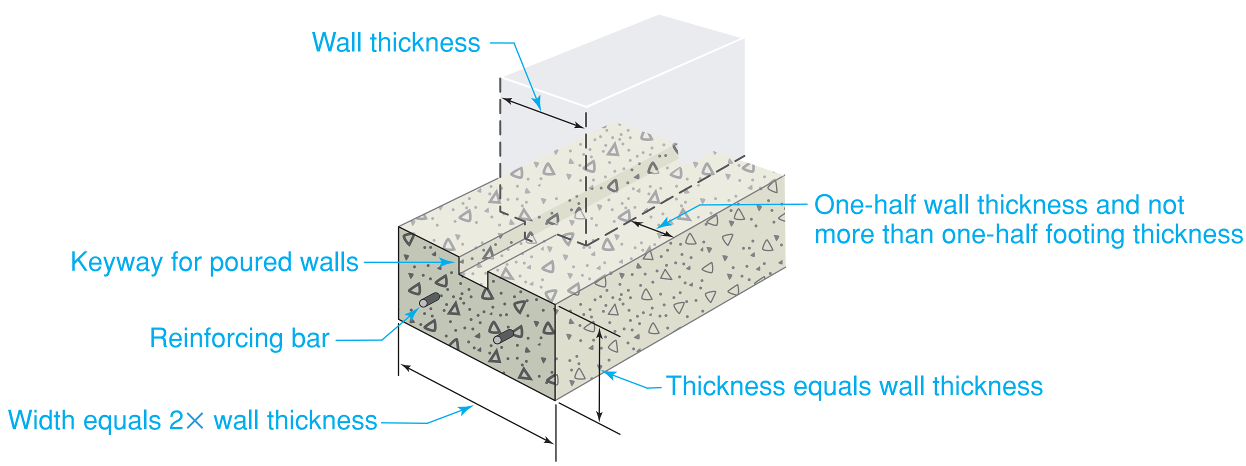

Figure 10-2 Typical Footing Dimensions

Standard Footing The basic proportions noted here are guidelines only. Always refer to the building plans.

REGIONAL CONCERNS

Ground Conditions Local building codes usually specify the depth frost penetrates into the soil. In the northern United States, this may be 48" or more, which means the footings have to be placed deeper. In areas prone to earthquakes, such as California, local codes have additional requirements for footings, such as steel reinforcement.

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is created by pouring it into a form. A form is any **framework** designed to contain wet concrete. Forms can be made of steel, lumber, or a combination of lumber and plywood. A common type of wall footing form is shown in **Figure 10-3**. The sides are formed by 2×4 lumber and braced to prevent them from being spread apart by the wet concrete. These boards are sometimes called *haunch boards. Spreaders*, or *form brackets*, are the boards that hold apart the sides of the forms. Lumber formwork is often assembled with duplex head nails to make disassembly easy later on.

A keyway should be formed in the top of the footing, as shown in Figure 10-2. The keyway locks the foundation walls to the footing. This prevents moisture from seeping between the wall and the footing. A keyway is usually 3½" wide and 1½" deep because a 2×4 is often used to form it. After the concrete has been placed, lengths of 2×4 can be pressed into the footings directly below where the foundation wall will be. They are removed after the footings have cured.

Some builders form the key by sliding a short length of 2×4 along the top of the footing before the concrete starts to stiffen. After the rebar has been positioned and the footings have been poured, the top of the footing should be troweled smooth.

Other Types of Footings

Other load-bearing parts of a structure, such as columns and chimneys, must also be supported by footings. Their exact size and location are specified on the building plans.

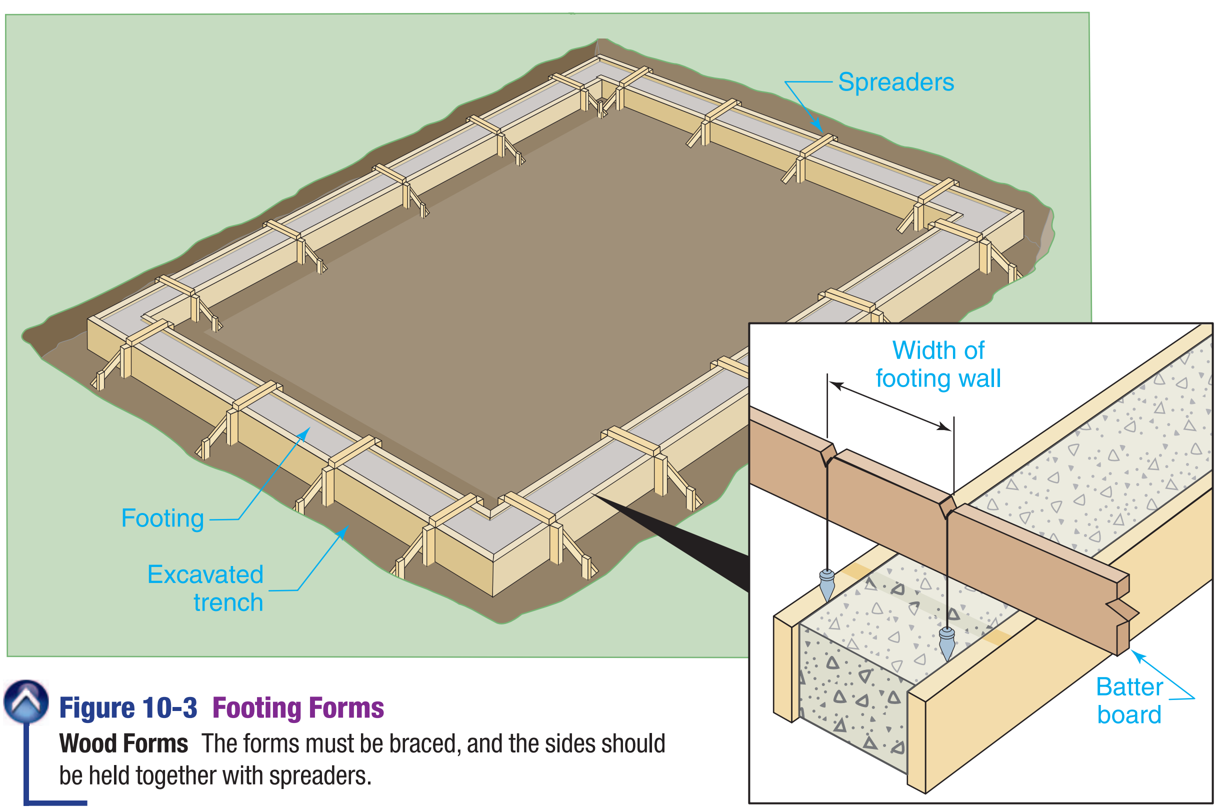


Figure 10-3 Footing Forms
Wood Forms The forms must be braced, and the sides should be held together with spreaders.

Pier Footings A footing for a pier can be round or square. A *pier* is a block or column of concrete separate from the main foundation. It is often used to support girder floor systems or exterior decks. A steel pin or a metal bracket is sometimes anchored in a pedestal above the footing, as shown in **Figure 10-4**. The pin or bracket will secure a wood post. A pedestal should be about 3" above the finished basement floor and at least 12" above finished grade in crawl-space foundations.

When steel posts are used, they are sometimes set directly on the footing and concrete floor is then poured around them. If a concrete column is poured on top of a footing, rebar placed vertically in the footing will keep the column in position.

Stepped Footings *Stepped footings* are often used on a lot that slopes. Instead of being set at the same height around the entire foundation, the footings "step" down the sloped

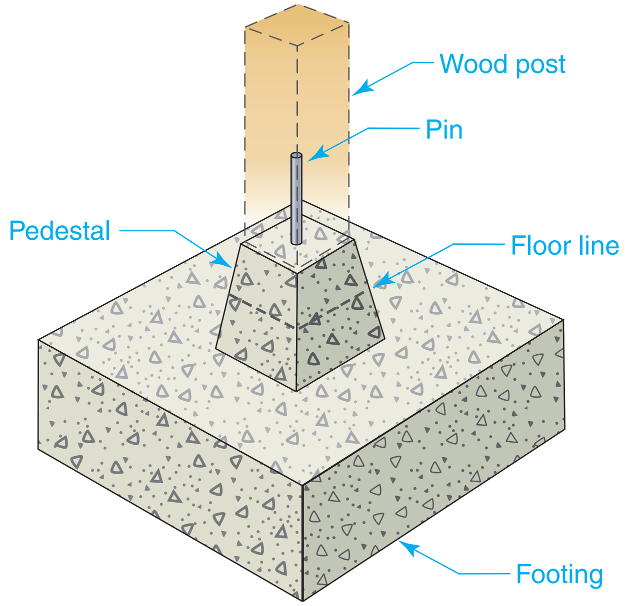


Figure 10-4 Pier Footing

Post Support A steel pin can be used to anchor a post, but many builders use a metal bracket instead.

Estimating and Planning

CERTIFICATION PREP

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Reinforcing Bar for Footings

Working with Rebar

Footings do not always have to be reinforced. Where steel reinforcing bar (rebar) is required, the building plans should identify the size, number, and placement of the rebar.

Step 1 Identify the combined length of all the footings. Suppose a foundation measures 42' by 24'. The total length of the footings is 132' ((42' + 24') × 2).

Step 2 Determine the exact number of lineal feet (l.f.) of rebar. Multiply the number of bars by the length of the footings. If a house has 132 l.f. of footings and two bars are required for each, it will need 264 l.f. of rebar (132 × 2).

Step 3 Add an amount for overlaps. Each length of rebar must overlap the connecting length by an amount determined by local codes. In most residential projects it is enough to add 10% to the total lineal footage. Using the example above:

$$264 \times .10 = 26.4$$

$$264 + 26.4 = 290.4$$

Step 4 Rebar typically comes in lengths of 20 ft. To figure the number of lengths needed, divide the total lineal footage by 20.

$$290.4 \div 20 = 14.52\text{, rounded up to } 15$$

15 lengths of 20' rebar will be needed for the footings.

Estimating on the Job

Determine how many lengths of 20' long rebar will be needed for a house with a foundation that measures 58' by 38'. Local codes call for 3 reinforcing bars in the footing.

site (see **Figure 10-5**). The vertical step should be poured at the same time as the rest of the footing. If the foundation wall is built with concrete block, the height of the step should be in multiples of 8". This is the height of a block with a standard ⅜" mortar joint.

The bottom of the footing is always placed on undisturbed soil below the frost line. Each run of the footing should be level. A *run* is a horizontal section between two vertical sections. With a concrete block foundation, the runs should be calculated so that the horizontal spacing of the block can be maintained across the step.

The vertical step should be at least 6" thick and be the same width as the rest of the footing. On steep slopes, more than one step may be required. It is good practice, when possible, to limit the vertical step to 2' in height. This results in a stronger wall and makes finish grading much easier.

Table 10-2 provides estimated material and labor for footings.

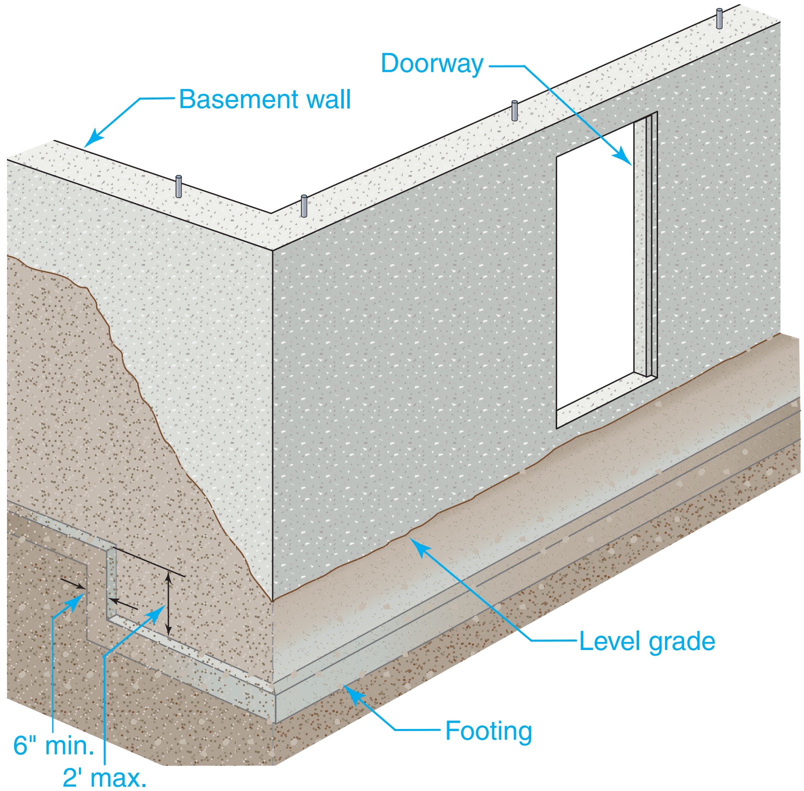


Figure 10-5 A Stepped Footing

Footing Details The details of a stepped footing, such as its height and thickness, will be shown on the plans.

Table 10-2: Estimating Material and Labor for Footings

Footing Size	Material			Labor	
	Cubic Feet of Concrete Per Lineal Foot	Cubic Feet of Concrete Per 100 Lineal Feet	Cubic Yards of Concrete Per 100 Lineal Feet	Excavation Hours per 100 Lineal Feet[a]	Placement Hours per Cubic Yard[b]
6×12	0.50	50.00	1.9	3.8	2.3
8×12	0.67	66.67	2.5	5.0	2.3
8×16	0.89	88.89	3.3	6.4	2.3
8×18	1.00	100.00	3.7	7.2	2.3
10×12	0.83	83.33	3.1	6.1	2.0
10×16	1.11	111.11	4.1	8.1	2.0
10×18	1.25	125.00	4.6	9.1	2.0
12×12	1.00	100.00	3.7	7.2	2.0
12×16	1.33	133.33	4.9	9.8	2.0
12×20	1.67	166.67	6.1	12.1	1.8
12×24	2.00	200	7.4	15.8	1.8

[a]Reduce hours by ¼ for sand or loam. Increase hours by ¼ for heavy clay soil.
[b]Placement labor based on ready-mixed concrete.

Estimating and Planning

CERTIFICATION PREP

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Concrete and Labor for Footings

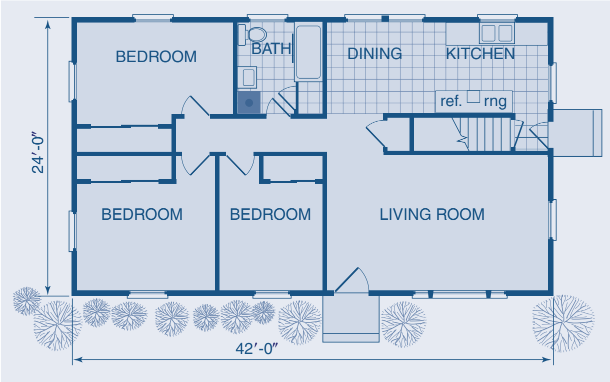
Concrete Details

To determine the amounts of concrete required for footings, calculate the total length of the footings and the volume. Another way to do this is to refer to a volume table such as Table 10-2.

1. Note that the foundation in the house plan below measures 42' × 24'. The perimeter (the total length of the four sides) is 132 lineal feet.
2. Suppose that the footing size is 8" × 16". Table 10-2 shows that for 8" × 16" footings, 3.3 cu. yds. of concrete are needed for 100 lineal feet. The footings in the example are longer than 100', so additional calculations are needed. If 3.3 cu. yds. of concrete will fill 100', how many cubic yards will be needed for 132'? Divide 132 by 100. The answer is 1.32. This indicates that the house footings are 1.32 times longer than 100'. Therefore, multiply 1.32 × 3.3 to find the total amount of concrete needed. The answer is 4.36 cu. yds. (Note: A cubic yard is a measure of volume that represents a cube measuring 3' by 3' by 3', or 27 cubic ft.

Labor for Excavation

The hours of labor required for excavation of the footings can also be determined using Table 10-2.



1. For 8" × 16" footings, Table 10-2 shows that it will take 6.4 hours to excavate 100 lineal feet. Because the perimeter is 132 lineal feet, allowance must be made for the excess over 100. You again divide 132 by 100 and get 1.32.
2. Multiply 1.32 by 6.4 for an answer of 8.448 hours of labor, rounded off to 8.5. In other words, if it takes 6.4 hours to excavate 100 lineal feet, it will take 8.5 hours to excavate 132 lineal feet.

Labor for Placing Concrete

Table 10-2 can also be used to determine the hours of labor needed to place the concrete in the footing forms. Note: This figure is based on the use of a ready-mixed concrete.

1. The house required 3.3 cu. yds. of concrete per lineal foot. The table shows that for 8" × 16" footings, it will take 2.3 hours to place one cubic yard of concrete in the forms.
2. To calculate the total time, multiply 2.3 (placement hours per cubic yard) by 3.3 (yards of concrete to be placed). The answer is 7.59 hours, rounded off to 7.6 hours of labor. This also includes the time for forming the footings. Estimates may have to be corrected to account for differing soil conditions, as noted at the bottom of the table.

Estimating on the Job

Using Table 10-2, estimate the cubic yards of concrete needed and the hours required for excavation and placement of 10" × 12" footings for a foundation that measures 62' × 38'.

Footing Drains

Why should holes in a drainpipe be on the bottom of the pipe and not the top?

If water builds up on one side of a foundation wall, the pressure created may force moisture through the concrete and into any joints. This is called *hydrostatic pressure.* Footing drains, sometimes called *foundation drains* or *perimeter drains,* relieve pressure by allowing water to drain away. As shown in **Figure 10-6**, they are located near the outside face of the footing.

Drains are generally required for full-height foundation walls. They are also required where a house is located near the bottom of a long slope that is subject to heavy runoff. The drains direct subsurface water away from the foundation. This helps to prevent damp basement walls and wet floors. Many builders install drains even when they are not required to do so by code.

REGIONAL CONCERNS

Ordering Gravel What you get when you order "gravel" varies in different parts of the United States. In some areas gravel means crushed stone; in other areas it means crushed stone with added fines. The latter is not suitable to cover drainpipe. Always specify the use for the gravel you order. For example, ask for drainage gravel instead of driveway gravel.

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Most new houses use a network of plastic pipes as footing drains. These 4" diameter pipes are placed alongside the base of the footing. (See Figure 11-4 on page 297 of Chapter 11, "Concrete Flatwork," for more on foundation drainpipes.) They are usually connected to storm sewers but may run

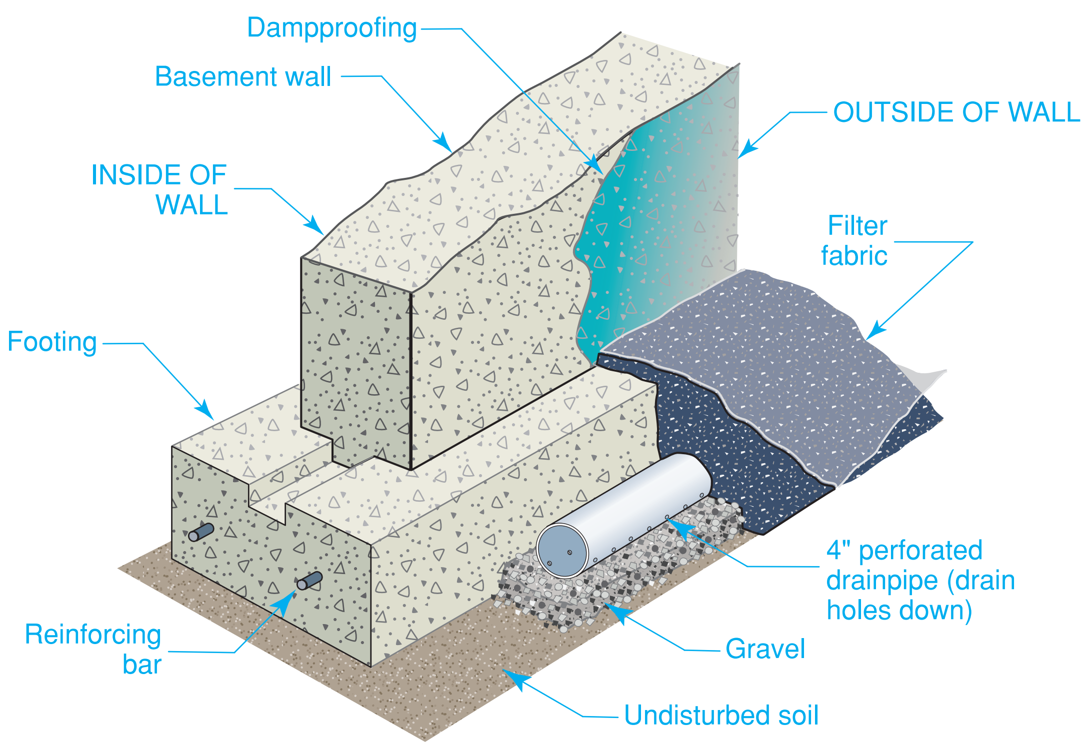

Figure 10-6 Foundation Drains

Pressure Relief Footing drains prevent water from building up against foundation walls.

to daylight. This means that they lead to a low portion of the site and the end of the pipe is exposed at that point. The piping can also drain into subsurface drain fields if permitted by code, but it must not empty into the drain field of a septic system. This is restricted by code because large amounts of water can damage the septic system.

Plastic drainpipe is different from other types of drainpipe. There are many small holes along the bottom edge of the pipes. The pipes should be placed with the holes facing down. In this position, water is carried away from the house as soon as it rises into the pipes. To keep the water moving, the pipes should be sloped toward the drain at least ⅛" per foot. After the pipes are in place, the drainage area should be covered with *filter fabric* (also called *geotextile* or *landscaping fabric*). This fabric is made of polyester or polypropylene. It allows water to pass through but prevents tiny particles of soil (called *fines*) from getting into the drainage system and clogging it. The filter fabric is backfilled with more drainage gravel. The foundation is then backfilled up to rough grade with dirt.

Section 10.1 Assessment

After You Read: Self-Check

1. What is the purpose of a footing?
2. What type of reinforcement is commonly added to strengthen a footing?
3. When are stepped footings required?
4. What is a footing drain, and why is it important?

Academic Integration: Mathematics

5. **Calculating Volume** Concrete footings are poured prior to laying the block for the foundation wall. Footings must be at least twice the width of the block wall above and as deep as the wall is thick. Calculate the cubic yards of concrete needed for the footings under an 8" block foundation that measures 10' × 10'.

Math Concept To calculate accurately, measurements should be converted to like units before adding, subtracting, multiplying, and dividing.

Step 1 Determine the size of the footings for an 8" block foundation.

Step 2 Calculate the perimeter (in inches) of the foundation.

Step 3 Calculate the volume by multiplying the perimeter times the width and depth of the footings.

Step 4 Convert cubic inches to cubic yards. There are 36 × 36 × 36 cubic inches in a cubic yard. Round up to the nearest quarter of a cubic yard of concrete.

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

Section 10.2

Concrete Foundation Walls

Types of Foundation Walls

Why is it important for forms to be properly braced?

There are two types of foundation walls: *full-height foundation walls* and *crawl-space foundation walls.* Full-height foundation walls are tall enough to make room for a basement. Crawl-space foundation walls are shorter, typically less than five feet in height. They do not create enough space for a basement, but allow access to pipes and wiring beneath the first floor.

A foundation carries all the loads of a house and transmits them to the ground. Most foundation walls are made of concrete or concrete masonry units (see Section 10.3). Some walls are made of pressure-treated lumber and plywood, but concrete foundation walls are the most common. They are durable and water-resistant. They can be installed on most building sites and can support any type of house. Some houses can be built using precast concrete panels. Walls used to support and contain concrete slabs are called *stem walls* (see Chapter 11, "Concrete Flatwork").

In residential construction, solid foundation walls usually range from 8" to 10" in thickness. The minimum compressive strength for such walls is 2,500 psi (pounds per square inch). Many foundation contractors pour walls that are 8' high above the footings. This provides a clearance of 7'-9½" from the top of the finished concrete floor to the bottom of the first-floor joists.

Reading Check

Contrast *What is the difference between full-height foundation walls and crawl-space foundation walls?*

Full-Height Walls

Forms must be installed for each concrete foundation wall. Reusable forms are the most cost effective when a contractor does this work regularly. Forms can also be built on site. In any case, the forms must be accurately constructed and properly braced, as shown in **Figure 10-7**. This enables them to withstand the forces of the placing and vibrating operations. When concrete is first placed, it puts considerable pressure on the forms. The higher the form, the greater the pressure. If forms are not constructed properly and braced well, the pressure can cause forms to "blow out." This failure allows concrete to spread over the job site. One or more horizontal members, called **wales**, are usually required to brace forms.

Wall Form Details Wall forms may be made from wood or metal, depending on how durable they must be. Many are made from plywood and lumber. Although any exterior-grade plywood can be used, special form-grade plywood is available. Form-grade plywood made by member mills of APA, the Engineered Wood Association, is referred to as *Plyform*. An overlaid surface material is bonded to both sides

JOB SAFETY

WEAR PROPER CLOTHING When placing or finishing concrete, take care to prevent excessive or prolonged contact of concrete with your skin. It is good practice to wear gloves, safety goggles, long pants, and high rubber boots.

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of the plywood under high heat and pressure to make it stronger. Medium-density overlay (MDO) has a smooth surface and can be reused many times. High-density overlay (HDO) offers the smoothest finish and can be reused the most. Mill-oiled plywood, another type of plywood, has a sanded veneer surface that is coated with a release agent at the mill. This coating prevents the forms from sticking to the concrete walls. The coating must be reapplied periodically.

Forms built on site may be taken apart after the concrete hardens. The lumber can then be reused elsewhere in the project. It is generally more cost effective and efficient to use reusable forms.

Before any concrete is placed, the sides of each form are fastened together with clips or other ties. Thin metal rods called *snap-ties* are commonly used, as shown in **Figure 10-8**. The rods extend through the foundation. Metal brackets attached to the rods prevent the forms from spreading. After the concrete is placed and the forms are stripped (removed), the protruding ends of each rod are snapped off. The end of each rod on the exterior side of the foundation must be sealed with grout to prevent the rods from acting as a conduit for water to enter the interior of the foundation wall. Forms should be left in place for three to seven days before being stripped. This slows the curing process and results in stronger walls.

Insulating Wall Forms Another type of formwork, shown in **Figure 10-9** on page 266, is made of rigid foam insulation, usually expanded or extruded polystyrene. These products are referred to as *insulating concrete forms (ICFs)*. Rather than being

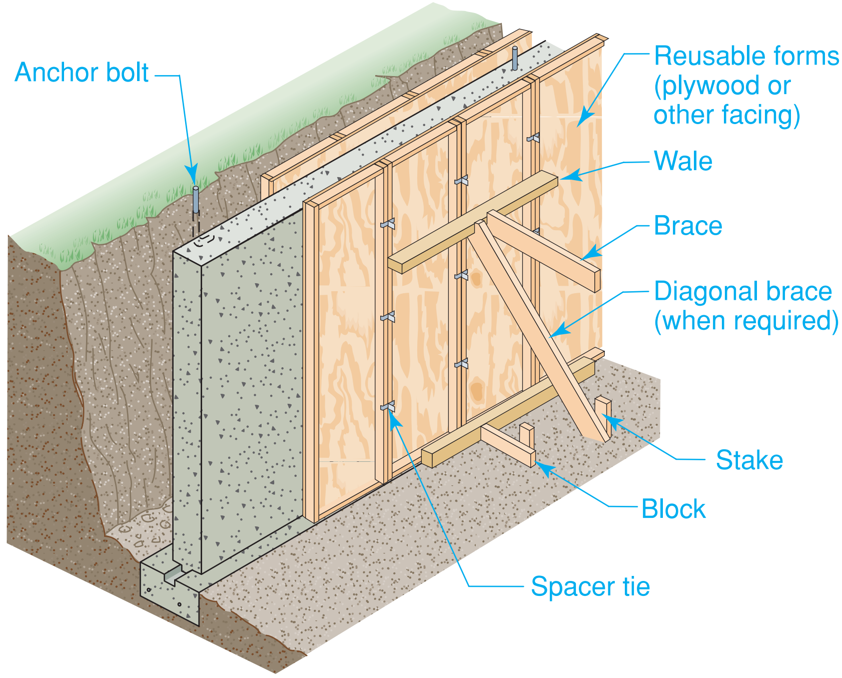

Figure 10-7 Foundation Wall Formwork
Stiff and Solid One method of constructing a form for a concrete foundation wall.

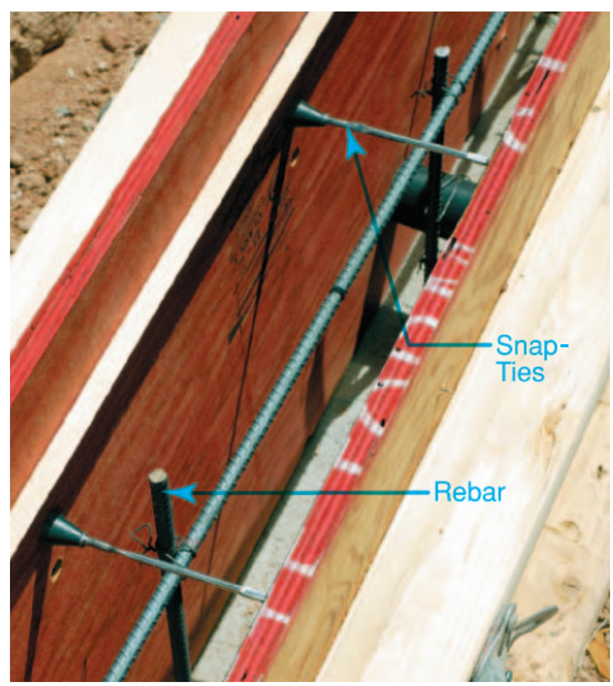

Figure 10-8 Form Ties
Preventing Spread Snap-ties prevent the two sides of a concrete form from spreading apart when concrete is placed.

Figure 10-9 Insulating Concrete Forms

Insulated Walls These ICF forms form above-grade walls. *How will these forms be filled?*

stripped off after the concrete cures, they are left in place permanently. This eliminates the need to strip and store the formwork. It also greatly increases the insulating level of the foundation walls, an advantage when living space is located below grade. Because the forms are very light in weight, they are easy to install. For the same reason, they must be braced with care. Always consult manufacturer's instructions for bracing any concrete placement. Check local building codes for any special requirements for placement of reinforcing bar, and make sure that local codes permit use of the type of ICF you are considering. Care must also be taken to ensure that termites and other insects cannot reach the foam. Insects do not eat rigid foam insulation, but they will tunnel through it to reach wood. In areas where termite infestation is considered "very heavy" by code, ICF construction is not permitted.

The basic components of an ICF can be planks, sheets, or hollow blocks. In many cases, the two sides of the form are held together with plastic or steel connectors that remain within the finished wall. Depending on the product, the concrete placed for the foundation may form a flat surface or a waffle surface, as shown in **Figure 10-10**.

Flat Wall The concrete forms a solid wall identical to a wall poured between traditional concrete forms. See Figure 10-10A.

Grid Wall The concrete forms a wafflelike grid and varies in thickness at different places. This type uses less concrete than other ICF foundations. See Figure 10-10B.

Placement Concrete should be poured continuously, without interruption. This prevents a cold joint. A **cold joint** occurs where fresh concrete is poured on top of or next to concrete that has already begun to cure. A cold joint is more likely to leak and is weaker than the surrounding wall.

The water content of concrete is very important. Although it is tempting to add extra water to make the concrete flow better into the forms, this weakens the finished walls and encourages cracking. Concrete should always be as stiff as is practical. Concrete should always be placed as close as

Mathematics: Converting Units

Working with Cubic Units Concrete is frequently purchased in cubic yards, a measure of volume. When calculating the volume of a footing, you will probably work with measurements in feet or inches instead of yards. Create a chart or list showing the number of cubic inches in one cubic foot and one cubic yard, and the number of cubic feet in one cubic yard.

Starting Hint Volume is found by multiplying length by width by height. To find the number of cubic inches in a cubic foot, multiply 12 × 12 × 12.

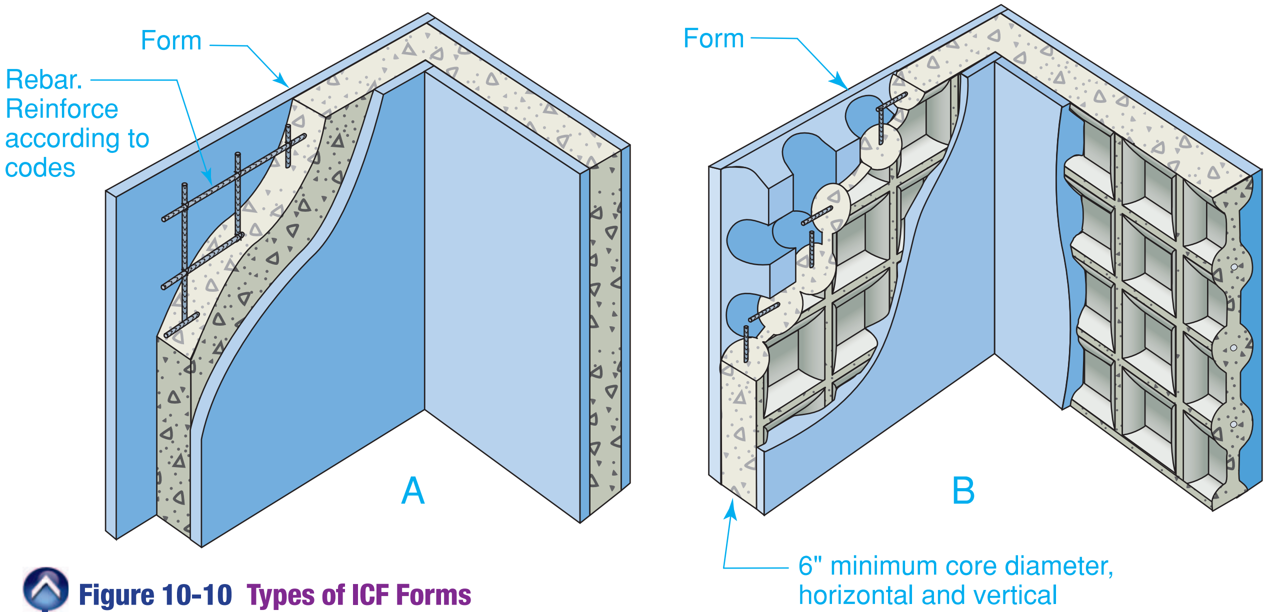

Figure 10-10 Types of ICF Forms

Basic Types A. Standard ICF walls create a channel for concrete that is similar to traditional formwork. **B.** A waffle-like grid wall uses less concrete than other ICF foundations.

possible to where it is needed. This reduces the need to push it around with shovels.

Concrete is normally delivered by ready-mix trucks. As it is placed in the forms, it should be worked to remove air pockets and to help it flow. The most basic technique is to jab it repeatedly with a shovel or pipe as it is being poured. This is generally enough for residential foundations. However, a *concrete vibrator*, sometimes called a *stinger*, is more effective. It is commonly used in commercial construction.

Crawl-Space Walls

Crawl-space foundations are common in mild climates. A crawl-space foundation is shown in **Figure 10-11** on page 268. One of the main advantages of the crawl-space foundation is reduced cost. Little or no excavation or grading is required except for the footings and walls. For crawl-space foundations:

- Soil beneath the house must be covered with a material to block moisture vapor from reaching the floor structure. This material, called a *vapor retarder,* is often 6-mil or 8-mil thick plastic sheeting. The best products are reinforced to minimize tearing.
- The crawl space usually must be ventilated. Check local codes.
- The floor framing above the crawl space should be insulated to reduce heat loss.

Poured-concrete or concrete-block piers are often used to support floor girders in crawl-space houses. They should be no closer than 12" to the ground. To prevent ground moisture from reaching floor framing, bare dirt should be covered with 6-mil plastic sheeting. Otherwise, the floor framing may absorb enough moisture to encourage fungi. When temperatures favorable for fungus growth are reached, much decay may result. To protect

REGIONAL CONCERNS

Flood-Resistant Foundations The building code now requires special construction details for foundations built where flooding is likely. Foundations must be designed to resist "flotation, collapse, or permanent lateral movement" due to stresses caused by flood waters.

Go to **glencoe.com** for this book's OLC for more information about regional concerns.

Figure 10-11 Crawl-Space Foundation

Walls and Piers A crawl-space foundation (shown at left) is sometimes combined with a concrete slab (being prepared at right). Circular piers in the crawl space will support the floor framing system.

the plastic from damage, some builders cover it with a layer of pea (rounded) gravel.

Reinforcement for Walls

In some parts of the country, it is not required to reinforce concrete foundation walls with steel. Some builders add vertical and horizontal rebar anyway to provide extra strength. The rebar should be centered in the wall. Window and door openings in the wall call for special attention. The concrete over these openings should contain rebar according to local codes. In earthquake hazard zones, the code requires that foundation walls be reinforced. Always check local codes for reinforcing requirements.

Where concrete work includes a connecting porch or garage wall not poured with the main basement wall, rebar ties must be provided. The rebar is placed as the main wall is poured. Keyways may also be used to resist sideways movement by forming a lock between the walls. Connecting walls should extend below the normal frost line and be supported by undisturbed soil.

Sill-Plate Anchors

In wood-frame construction, the sill plate must be securely fastened to the foundation. In areas exposed to high winds or earthquakes, well-anchored plates are especially important. For this reason, anchorage requirements are more stringent in such areas. Bolts or other anchoring devices may have to be placed closer together. In some cases they must be connected to reinforcing bar within the wall.

Most builders use ½" diameter L-shaped bolts called *anchor bolts* (shown in **Figure 10-12A**). These are embedded in the concrete immediately after the top of the foundation walls have been smoothed. They should be spaced no more than 6' apart and no more than 12" from the ends of any plate section or

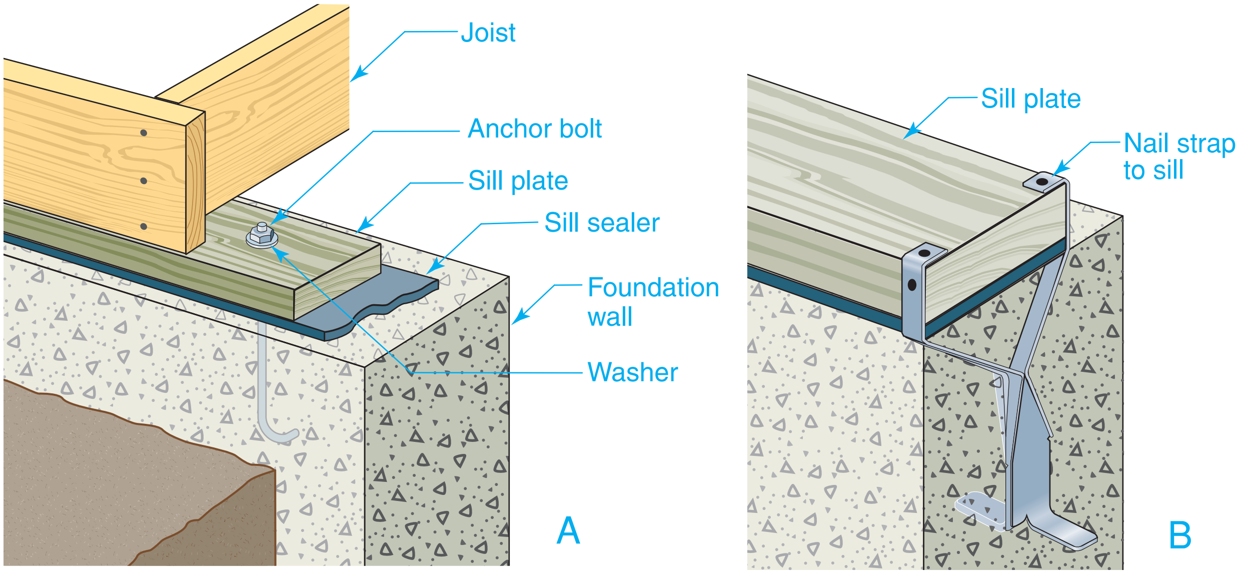

Figure 10-12 Sill-Plate Anchors

Secure Connection A. Anchor bolts embedded in the foundation wall are used to secure the sill plate. **B.** Some builders use metal straps embedded in the concrete.

wall corner. Each bolt must extend at least 7" into the concrete. A large flat washer must be used beneath the nut that holds the sill plate in place.

Another type of anchor is a metal strap that is embedded in the concrete, as shown in **Figure 10-12B**. The legs of the strap wrap around the sill plate.

A sill sealer is often placed under the sill plate on poured walls to smooth any uneven spots that might have occurred during placement. If termite shields are used, they should be installed under the plate and sill sealer. A termite shield is typically a continuous length of galvanized sheet metal with the edges bent slightly downward.

Foundation Wall Details

A foundation wall must often have special details, such as brick-veneer siding or utility sleeves. These details must be accounted for in the design of the foundation.

Masonry Ledges Brick or stone veneer is often used for the outside finish over wood-frame walls. In such cases, the foundation must include a *masonry ledge,* a supporting ledge or an offset about 5" wide, as shown in **Figure 10-13** on page 270. Including a masonry ledge results in a space of about 1" between the masonry and the sheathing that is needed for ease in laying the brick. A *base flashing* is used at the brick layer below the bottom of the sheathing and framing. The flashing should be lapped with sheathing paper. *Weep holes* (to provide drainage) are also located at this course and are formed by omitting the mortar in a vertical joint. (Brick-veneer walls are discussed in Chapter 24, "Brick Masonry & Siding.")

Utility Sleeves It is often necessary for pipes, such as the main drain to the sewer or septic system, to pass through the foundation walls. Other pipes may also need to pass through the foundation, including water supply pipes and electrical conduits. It is easier to provide space for these pipes as the forms are being placed rather than drill large holes in the foundation later. Where a pass-through is required, a tight-fitting foam block is placed within the formwork and secured with nails. A short length of plastic pipe can also be used. These barriers prevent concrete from flowing into these areas, creating a hole in the wall at that point.

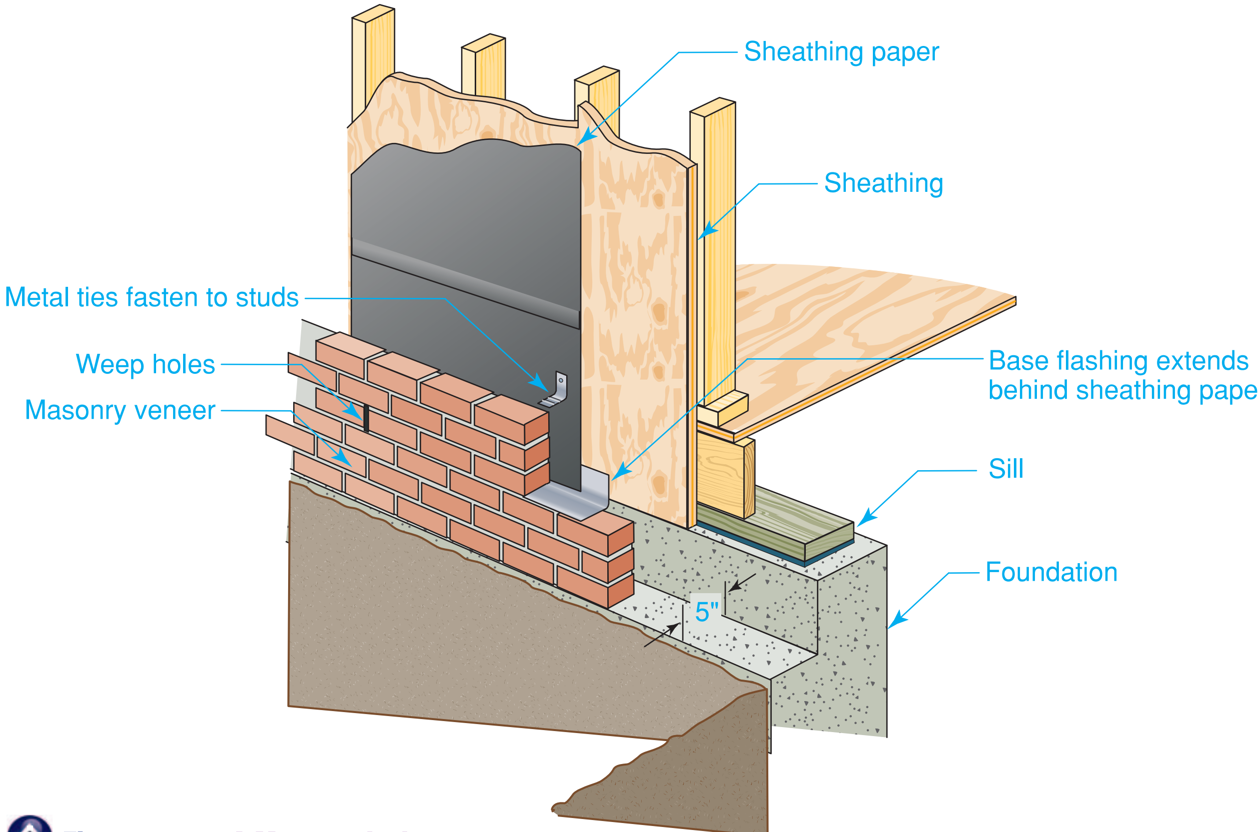

Figure 10-13 A Masonry Ledge
Brick or Stone Support A foundation wall with a masonry ledge. Note that weep holes in the brick veneer are located just above the base flashing.

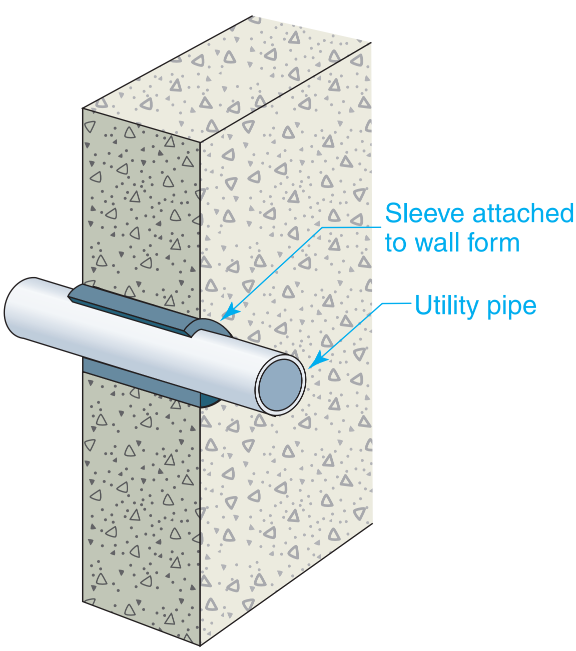

Figure 10-14 A Pipe Sleeve
Hole Through Foundation A sleeve provides openings through the basement wall for utilities.

After the forms have been stripped, the block is removed. Later, pipes can be routed through the hole, as shown in **Figure 10-14**. Any space around them can be sealed with hydraulic cement and waterproofed.

Foundation Vents and Windows In crawl-space foundations, metal or wood-framed vents are sometimes installed within the forms before the concrete is poured. Vents are visible in Figure 10-11 on page 268. In full-height foundation walls, frames for small, grade-level windows may also be placed in the forms. The rust-resistant steel frame of these windows will then be locked securely to the foundation. Where larger openings are required, wood frames may have to be inserted in the forms. In this case, the wood is sometimes left in place after the forms are stripped away. This wood must be pressure treated. Small anchor bolts should be inserted into pre-drilled holes in the wood frame before the concrete is poured.

Beam Pockets A wall notch, or beam pocket, is needed for basement beams or girders, as shown in **Figure 10-15**. The notch allows the top of the girder to be flush with the top of the sill plate. It should be large enough to allow at least ½" of clearance at the sides and ends of the beam. This clearance is for ventilation. If wood beams and girders are so tightly set in wall notches that moisture cannot readily escape, they may decay. A waterproof membrane, such as roll roofing, is applied under the end of the beam to reduce moisture absorption.

Stripping and Maintaining Forms

Forms should not be removed until the concrete has enough strength to support the loads of early construction. Leaving the formwork in place also slows the loss of moisture, which improves the strength of the concrete. At least two days (preferably longer) are required before forms can be stripped in temperatures above freezing. A week may be required when outside temperatures are below freezing.

Metal prybars should not be used when stripping wood forms. They can easily damage the edges and faces of the panels. Use wood wedges to pry panels away from the concrete. As soon as the forms have been removed, they should be cleaned, inspected for damage, and repaired if necessary. Concrete residue and scaling can be removed by scraping the surfaces with a hardwood wedge and brushing them with a stiff bristle brush. Do not use a wire brush because it can damage the wood surface. Before the forms are used again, recoat them with a *form-release agent*. This is a liquid that prevents concrete from sticking to the forms.

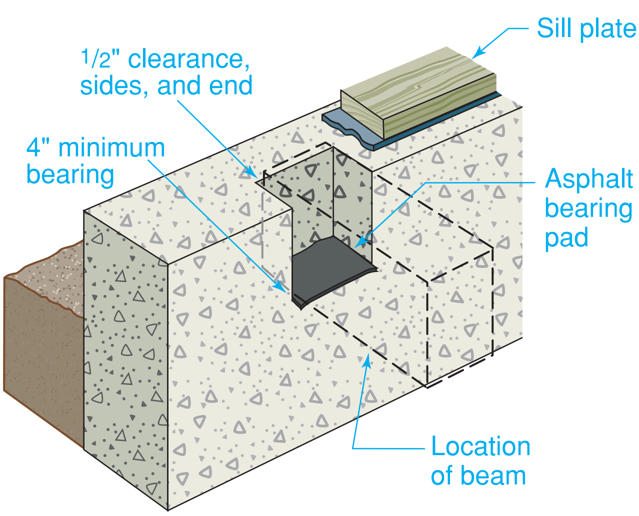

Figure 10-15 A Beam Pocket
Solid Bearing A beam pocket is a notch created to support the end of a beam.

Moisture Protection

Before full-height concrete foundation walls are backfilled, steps must be taken to protect them from ground moisture. Where the walls will be exposed to standard soil conditions and no unusual drainage problems, this may be done by *dampproofing* them. Dampproofing is now required by code for all foundation walls, not just those enclosing habitable space. The walls are coated with a material that protects against ordinary seepage, such as seepage that may occur after a rainstorm. The coating should extend from the top of the footings to the finished grade level. It should not be applied until the surface of the concrete has dried enough. Otherwise, it may not stick. Various materials can be used. The most common is a black bituminous coating that is either sprayed or brushed over the walls.

Where the soil drains poorly, where the water table is high, or where living spaces will be located below grade, greater efforts must be made to protect the foundation. They often involve applying a waterproofing membrane to the foundation walls. The membrane should extend from the top of the footings to the finished grade level. All joints in the waterproofing membrane must be overlapped and sealed with an adhesive suitable for the membrane material. Various materials can serve as a waterproofing membrane:

- 2-ply hot-mopped felts
- 55-lb. rolled roofing
- 6-mil PVC or polyethylene sheeting
- 40-mil polymer-modified asphalt
- 60-mil flexible polymer cement
- 1/8" cement-based fiber-reinforced waterproof coating
- 60-mil solvent-free liquid-applied synthetic rubber

In some cases, a multilayer combination of rigid insulation board, drainage media, and spray- or sheet-membranes may also be approved for use.

Backfilling

Backfilling, shown in **Figure 10-16**, is the process of filling in the excavated area around a foundation with soil. This brings the area around the house up to rough grade.

Figure 10-16 Backfilling

Careful Work To avoid damage, only an experienced operator should use heavy equipment to backfill a foundation.

Estimating and Planning

Concrete Foundation Walls

Formwork

Refer to the floor plan on page 273, which measures 40' × 26'.

1. To determine the total foundation wall area, assume that the wall is 8' high. Multiply 8' × 132' (perimeter of the building). The answer is 1,056 sq. ft.
2. Assume the wall thickness is 8". Refer to the **Table 10-3** on page 273. Read down the column headed "Wall Thickness" to 8". Then read across to the column titled "Forming." Remember, the wall is to be 8' high. The table shows that the wall will require 7.75 hours per 100 sq. ft. of wall area.
3. Next, calculate the total time for installing the forms. Since you know it will take 7.75 hours for each 100 sq. ft., divide the total number of square feet by 100 and multiply by 7.75.

$$1{,}056 \div 100 = 10.56$$

$$10.56 \times 7.75 = 81.84$$

It will take about 82 hours to install the forms.

4. Next, calculate the time needed to remove the forms. According to the table, between 2 and 3 hours are needed to remove forms for 100 sq. ft. of an 8' wall. Using the larger number as an example, the calculation would be:

$$10.56 \times 3 = 31.68$$

It will take about $31\frac{2}{3}$ hours total labor time for removing the forms.

Concrete

You can also calculate the amount of material needed using the table. In our example, the wall is 8" thick and has a total area of 1,056 sq. ft.

1. Find the 8" thickness in the column at left. Reading across, under "Material" you find that 2.47 cu. yds. of concrete are needed for every 100 sq. ft. of wall. Therefore you must again divide the total area by 100 to

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Table 10-3: Estimating Concrete Foundation Walls						
Walls	Material		Forming			Concrete Placement
	Per 100 Feet of Wall		Hours per 100 Square Feet of Wall			Hours per Cubic Yard
Wall Thickness (inches)	Cubic Feet Required	Cubic Yards Required	Place		Remove	
			0' to 4'	4' to 8'		
4	33.3	1.24	4.7	7.13	2.0	Average 3.25 Hours
6	50.0	1.85	4.7	7.75	Varies as to Height	
8	66.7	2.47	5.0	7.75		
10	83.3	3.09	5.0	7.90		
12	100.0	3.70	5.0	7.90	3.0	

find how many hundreds of square feet there are.

$$1{,}056 \div 100 = 10.56$$

2. Then multiply by 2.47.

$$10.56 \times 2.47 = 26.08$$

Round your answer to the next larger ¼ cu. yd. Thus, a total of 26.25 cu. yds. of concrete are needed.

Labor

To estimate placement of concrete in the forms for the wall, again use the table.

1. Under "Concrete Placement," it says that 1 cu. yd. takes an average of 3.25 hours.
2. Multiply the total cubic yards by the time required to pour 1 cu. yd. This will tell you the total time required. In our example, 26.25 cu. yds. of concrete are required. Therefore:

$$26.25 \times 3.25 \text{ (hours)} = 85.31$$

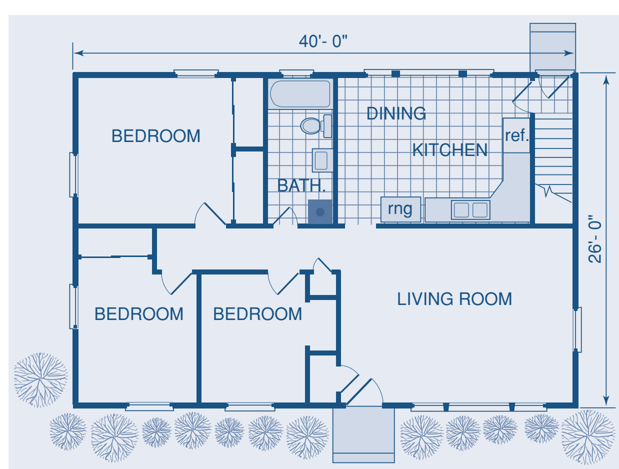
Rounded off, this comes to 85⅓ hours of labor.

CERTIFICATION PREP

This estimating and planning exercise will prepare you for national competitive events with organizations such as SkillsUSA and the Home Builder's Institute.

Estimating on the Job

Using the table, estimate the time to install and remove forms, the cubic yards of concrete needed, and the time required to place the concrete for a foundation that measures 43' × 27'. The wall will be 8' high and 10" thick.



Backfilling should be done as soon as possible for safety. Backfilling also makes it easier to transport materials to and from the house. A foundation must not be backfilled too soon. The weight of the earth can damage walls that are not yet strong enough to withstand the pressure. During backfilling, the vertical portions of drainpipes should be temporarily capped to prevent soil from getting into the drain system.

All foundation drainage, dampproofing, and waterproofing must be complete before backfilling begins. Under ideal conditions, the floor framing (or floor slab) is also in place. This braces the tops of the foundation walls. In cases where the wall must be backfilled before floor framing is in place, the walls can be temporarily braced from inside the excavation. This can be done using framing lumber.

Follow the best local building practices when choosing backfill material. Do not use materials that expand and drain poorly, such as clay. Layer gravel into the excavation as needed to ensure proper drainage. Backfill 6" to 8" at a time, and compact the soil to prevent it from settling too much later. Do not allow wood debris, such as lumber scraps and tree limbs, to be included in backfill. This encourages insects and uneven settlement when limbs and/or wood debris decompose.

JOB SAFETY

FALLS AND CAVE-INS The area around a new foundation wall is an open excavation. Care must be taken when working around this area to prevent falls. To prevent cave-ins, keep trucks and other equipment well away from the perimeter.

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

Section 10.2 Assessment

After You Read: Self-Check

1. What is a wale?
2. Why might ICFs be used to form foundation walls for a house that was designed to include a basement recreation room?
3. Why must concrete always be poured in as stiff a mix as is practical?
4. Name three important aspects of crawl-space foundation construction.

Academic Integration: English Language Arts

5. **Foundation Walls** There are two types of foundation walls: full-height foundation walls and crawl-space foundation walls. Walls tall enough to create a basement are full-height foundation walls. In mild climates, it is more common to find shorter walls called crawl-space foundation walls. Choose one of these types of foundation walls and write a paragraph outlining its advantages over the other type of foundation wall.

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

Section 10.3

Concrete Block Walls

Block Basics

What is a CMU?

Concrete block is popular for building foundation walls (see **Figure 10-17**). This is because the walls do not require formwork and the blocks are fairly inexpensive. Unlike work on a solid concrete foundation, which must be done all at once, work on a block foundation can start and stop as needed.

Full-height foundation walls are often constructed of eleven *courses* (rows) of block above the footings, with a 4" solid cap block. The cap block seals the cores of the foundation walls. The cores, or *cells*, are the hollow part of the block. This results in about 7'-4" of headroom between the joists and the basement floor. A wall with 12 courses of block would add another 8" of headroom.

Figure 10-17 Concrete Block Walls
Building a Wall Concrete blocks should be stacked near where they will be used. *Why might this be?*

Strengthening Walls Sometimes a block wall must be strengthened with rebar. If this is required by the building's designer, #4 to #7 rebar is inserted into the vertical channels created in the wall by successive block cores. Each core containing rebar is then filled with concrete. This creates a reinforced column within the wall. These columns should be spaced as required by local codes, depending on the height of the wall and the local soil type. Generally, columns in a 12" thick wall will be spaced no more than 72" OC (on center).

Adding pilasters to the wall is another way to strengthen it. *Pilasters* are projections resembling columns that may be used to strengthen a wall under a beam or girder. Pilasters are placed on the interior side of the wall and are constructed as high as the bottom of the beam or girder they support. Basement door and window frames should be keyed to the foundation for rigidity and to prevent air leakage.

Types of Block

Any hollow masonry unit is called a concrete block, or *concrete masonry unit (CMU)*. The most common type is made with Portland cement, a fine aggregate, and water. Concrete blocks come in many shapes and sizes for a large variety of applications. Some of the most common sizes are shown in **Figure 10-18** on page 276. The most widely used sizes are 8", 10", and 12" wide (nominal dimension). The nominal dimensions allow for the thickness and width of a standard ⅜" mortar joint. Thus, the actual dimensions of a standard block are usually 7⅝" high by 15⅝" long. This results in assemblies that measure 8" high and 16" long from centerline to centerline of the mortar joints. A vertical mortar joint is called a **head joint**. A horizontal joint is called a **bed joint**.

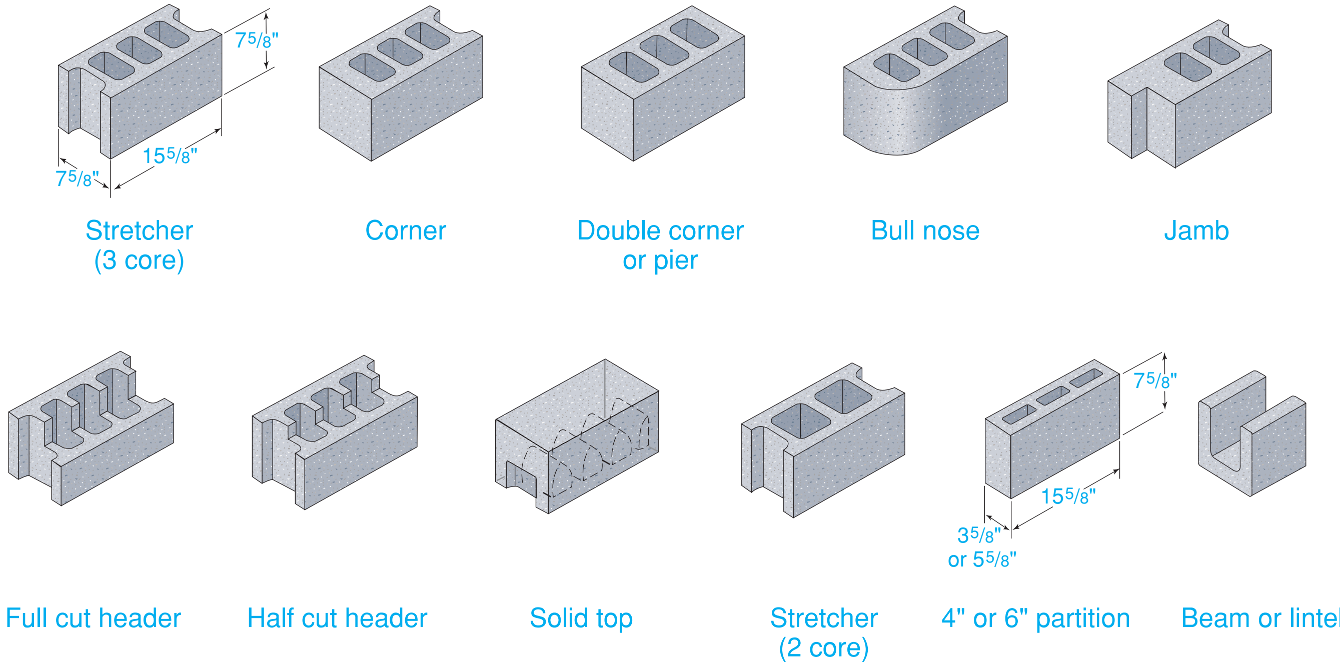


Figure 10-18 Concrete Masonry Units

Common Shapes Typical shapes and sizes of concrete masonry units. Half-length sizes are usually available for most of the units shown above.

Specialty blocks are made for specific purposes. Split-face blocks have one rough face that looks something like stone, as shown in **Figure 10-19**. Insulated blocks come in various forms, including some that contain inserts of polystyrene. Heat transfer from one surface to another is reduced when blocks contain rigid insulation. Another type of block has one or more glazed surfaces. It can be used as a structural as well as a finish material.

Bond Patterns

Block courses are laid in a *common bond*. A common bond is the overlapping arrangement (see **Figure 10-20A**). Joints should be tooled smooth to seal them against water seepage. Mortar should be spread fully on all contact surfaces of the block. Such spreading is called a *full bedding*.

When exposed block foundation is used as a finished wall for basement rooms, the *stack bond* pattern can give a pleasing effect. In a stack bond, blocks are placed directly above one another, resulting in continuous vertical joints, as shown in **Figure 10-20B**. It is

Figure 10-19 Split-Face Block

Rough Surface Split-face block is sometimes used for decorative effect in exposed locations.

necessary to add some type of joint reinforcement at every second course. This usually consists of steel rods arranged in a grid pattern.

Protecting Block Walls Freshly laid block walls should be protected in temperatures below 32°F (0°C). Freezing of the mortar before it has set will often result in low adhesion, low strength, and joint failure. Care must be taken to keep blocks dry on the job. They should be stored on planks or other supports so the edges do not touch the ground. They should be covered for protection against moisture. Concrete block must not get wet just before or during installation.

Block walls should not be backfilled until they have gained sufficient strength. Follow the precautions noted in Section 10.2 regarding backfilling.

JOB SAFETY

SILICA DUST Cutting concrete block with a circular saw produces silica dust. Inhaling this dust is very hazardous.

- When cutting concrete or masonry, use saws that spray water on the blade.
- Use a dust collection system whenever possible.
- Always wear safety goggles and a respirator designed to protect against fine, airborne particles.

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

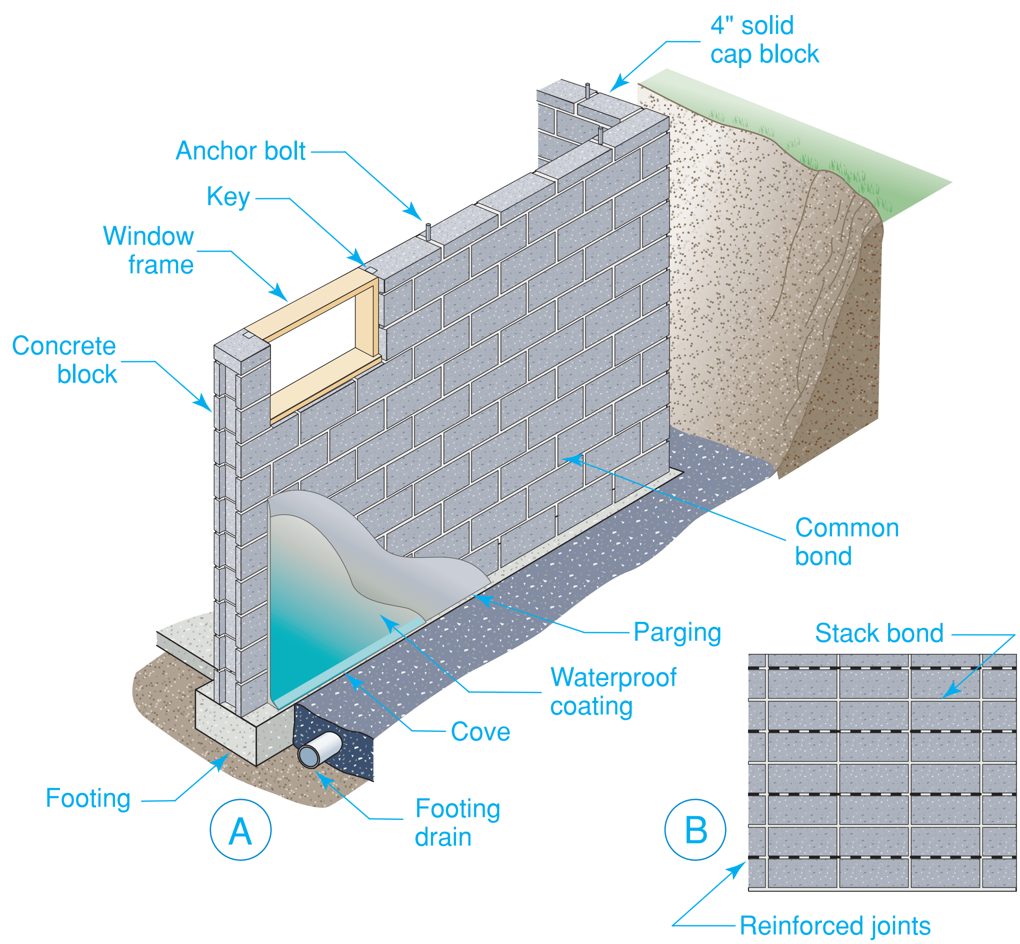


Figure 10-20 Bond Patterns

Foundation Walls A. Block walls are usually laid in a common bond, as shown here. **B.** In some cases, walls are laid in a stack bond, with horizontal reinforcing as needed.

Cutting Block Blocks are usually available in half-length as well as full-length units. It is sometimes necessary to cut a block to fit it into place. This can be done in two ways. The traditional method is to use a brick hammer and chisel to cut block, as shown in **Figure 10-21A**. The block is scored on both sides with the chisel to make a clean break. A faster method to cut block is to use a masonry saw, as shown in **Figure 10-21B**. The saw leaves a smooth, uniform edge but takes time to set up. It is also possible to cut block with a standard circular saw fitted with a dry-cutting masonry blade, but this method creates clouds of dust and should be avoided whenever possible.

Mortar

Good mortar is essential for a strong, solid wall. The strength of the mortar bond depends on:

- The type and quantity of mortar.
- The workability, or *plasticity*, of the mortar.
- The surface texture of the mortar bedding areas.
- The rate at which the masonry units absorb moisture from the mortar.
- The water retention of the mortar.
- The skill of the person laying the block.

Mortar Mixtures Mortar is a mixture of Portland cement, hydrated lime, sand, and water. The individual ingredients are often mixed together on site using a mechanical drum mixer. Mortar mixes for various purposes are shown in **Table 10-4**. Varying the ingredients yields mortar with different characteristics. A relatively high proportion of Portland cement improves strength. Lime reduces compressive strength but increases flexibility and makes the mortar "stickier." Sand reduces shrinkage as the mortar cures.

Mortar can also be made from prepackaged mortar mix or masonry cement. These products must be mixed with water on site. Mortar mix contains all the dry ingredients, including sand. Masonry cement contains all the dry ingredients *except* sand. Various masonry cement mixes are shown in Table 10-4. The following types of mortar are the most common:

- Type N mortar has average strength for most general masonry work above grade. It has only moderate compressive strength.

A

B

Figure 10-21 Methods for Cutting Block

Hand or Power Saw A. To cut by hand, score the blocks along both sides with a chisel. **B.** A masonry saw is fast and precise.

Table 10-4: Proportions of Mortar Ingredients by Volume					
Mortar type	Parts by Volume				
	Portland or blended cement	Masonry cement type			Fine aggregate
		M	S	N	
M	1	–	–	1	4½ to 6
	–	1	–	–	2¼ to 3
S	½	–	–	1	3⅜ to 4½
	–	–	1	–	2¼ to 3
N	–	–	–	1	2¼ to 3
O	–	–	–	1	2¼ to 3

- Type M mortar has high compressive strength and is particularly durable. This makes it good for heavily loaded or below-grade foundation walls.
- Type S mortar has a high tensile strength as well as high compressive strength. This makes it suitable for regions exposed to earthquakes or high winds.
- Type O is a low-compressive-strength mortar used primarily for interior walls.

Mixing and Placing Mortar To ensure that ingredients are well blended, mortar should be mixed in power mixers. For very small jobs, it may be mixed in a wheelbarrow or a mortar tray.

Mortar will stiffen after being mixed because of evaporation and hydration. Evaporation occurs when moisture is lost from the mixture. In that case, water can be added and mixed in to restore the mortar's workability. Mortar stiffened by hydration should be thrown away. It is not easy to tell whether evaporation or hydration is the cause. A judgment can usually be made on the basis of how much time has passed since initial mixing. Mortar should be used within two-and-a-half hours when the air temperature is 80°F (27°C) or higher, and within three-and-a-half hours when air temperature is below 80°F (27°C). If more time has passed, assume that any stiffness is caused by hydration.

Mortar must be sticky so that it will cling to the concrete block. Mortar is taken from the mortar board with the trowel and then "set" on the trowel with a quick vertical snap of the wrist. The excess will fall from the trowel with the snap of the wrist.

Laying Block Foundation Walls

What is a mason's line used for?

Laying block foundation walls is a job for skilled masons. The following section is intended primarily as an overview of the process.

Concrete block is heavy. It should always be stacked close to the work area as to minimize the need to carry it, as shown in Figure 10-17 on page 275. Boards, building paper, or tarpaulins should be used to cover the tops of unfinished block walls at the end of the day's work. This prevents water from entering the cores.

Building the Corners

The corners of the wall are built first, usually four or five courses high. After locating the outside corners of the wall, use a chalked line to mark the footing and help align the first block accurately. A full mortar bed should then be spread with a trowel. The corner block should be laid first and carefully positioned.

JOB SAFETY

PRECAUTIONS WITH MORTAR Prolonged contact with wet mortar is harmful to your skin. Wear protective clothing, including gloves, to minimize contact with the material. If skin does come into contact with mortar, wash off the mortar as soon as possible. Change clothing that has become saturated with mortar.

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

The first course of the corner should be laid with great care to make sure it is properly aligned, leveled, and plumbed. This will ensure a straight, true wall. After three or four blocks have been laid, use the mason's level as a straightedge to ensure correct alignment. Make blocks plumb by tapping them with the trowel handle.

After the first course is laid, apply mortar to the top of the face shells. A *face shell* is the side wall of a concrete block (**Figure 10-22**). In some cases, a full mortar bed may be specified (**Figure 10-23**). Mortar for the vertical joints can be applied to the ends of the next block or to the ends of the block previously laid. There is the danger of building up the joint size when applying mortar to the ends of both blocks and it is also a wasted motion (multiplied over 300 or 400 blocks set per man per day). Buttering one end of the block is usually sufficient.

As each course is laid at the corner (**Figure 10-24**), check it with a level for alignment, for levelness (**Figure 10-25**), and for plumb (**Figure 10-26**). Check each block carefully with a level or straightedge to make certain that the

Figure 10-23 Full Mortar Bed
No Bare Spots This is what a full mortar bed should look like.

Figure 10-22 Bedding the Face Shell
Mortar Bed Mortar bedding the face shell in preparation for laying up additional courses.

Figure 10-24 Laying the Block
Block Pressure The weight of the block will usually be sufficient pressure to embed it in the mortar.

faces of the blocks are all in the same plane. Check the horizontal spacing by placing the level diagonally across the corners of the blocks (**Figure 10-27**). A **story pole**, or *course pole*, is a board with markings 8" apart. It can be used to gauge the top of the masonry for each course (**Figure 10-28**).

Figure 10-25 Check for Level

Level Check the alignment of the blocks frequently.

Figure 10-26 Check for Plumb

Plumb After the corners have been built up, be sure to check the corner for plumb before continuing.

Figure 10-27 Check Alignment

Alignment If the blocks have been positioned correctly, the alignment can be checked by holding a level or straightedge diagonally across the corners of the block.

Figure 10-28 A Story Pole

Height A wood story pole marked with the course levels should be used to maintain the proper height of the courses.

David R. Frazier Photolibrary, Inc.; Tim Fuller

Figure 10-29 Laying to a Line

Mason's Line After the corners have been built up, stretch a mason's line from corner to corner for each course. Between the corners, set the blocks so their top edges align with the mason's line.

Filling In Between Corners

When filling in the wall between the corners, a mason's line is stretched from corner to corner for each course, as shown in **Figure 10-29**. The top, outside edge of each block is laid to this line.

Handling or gripping the block correctly is important and is learned with practice. Roll the block slightly to a vertical position and shove it against the adjacent block. Final positioning of the block must be done while the mortar is soft and plastic. Any attempt to move or shift the block after the mortar has stiffened will break the mortar bond and allow water to seep into the completed installation. "Dead" mortar that has been picked up from the scaffold or from the floor should not be used.

To assure a good bond, mortar should not be spread too far ahead of actual laying of the block or it will stiffen. As each block is laid, excess mortar at the joints is cut off with the trowel. Applying mortar to the vertical joints of the block already in the wall and to the block being set results in well-filled joints.

The block that fills the final gap in a course between corners, shown in **Figure 10-30**, is called the *closure block*. To install this block, spread mortar on all edges of the opening and all four vertical edges of the block itself. The closure block should be carefully lowered into place.

Figure 10-30 Fitting the Closure Block

Last Block The closure block is carefully placed in position to complete a course.

Intersections

Load bearing walls built of intersecting concrete blocks should not be tied together in a masonry bond, except at the corners. Instead, one wall should end at the face of the other wall, with a control joint at that point. A **control joint** is a joint that controls movement caused by stress in the wall. The joints are built into the wall in a way that permits slight movement without cracking the masonry. They are continuous from the top of the wall to the bottom. They are the same thickness as the other mortar joints.

Control joints should be placed at the junctions of bearing as well as nonbearing walls, at places where walls join columns and pilasters, and in walls weakened by openings.

For sideways support, bearing walls are tied together with a metal reinforcing bar called *tie bar*, shown in **Figure 10-31**. The bends at the ends of tie bars are embedded in cores filled with mortar or concrete. Pieces of metal lath placed under the cores support the concrete or mortar filling.

For tying nonbearing block walls to other walls, strips of metal lath or ¼" mesh galvanized hardware cloth are placed across the joint, as shown in **Figure 10-32**. The metal strips are placed in alternate courses. When one wall is constructed first, the metal strips are built into the first wall and later tied into the mortar joint of the second wall. Another type of reinforcement is called *ladder-reinforcement*. Lengths of ladder-shaped metal wire can be set lengthwise into horizontal mortar joints. In some cases, this is required in every third course of a block wall. Ladder-reinforcing significantly strengthens the wall.

Figure 10-31 Tie Bar
Reinforcing a Corner A reinforcing bar can be placed in the mortar joint to tie intersecting walls together.

Figure 10-32 Metal Lath
Reinforcing a Joint Metal lath placed across the joint is used to tie a non-bearing intersecting wall to the main wall.

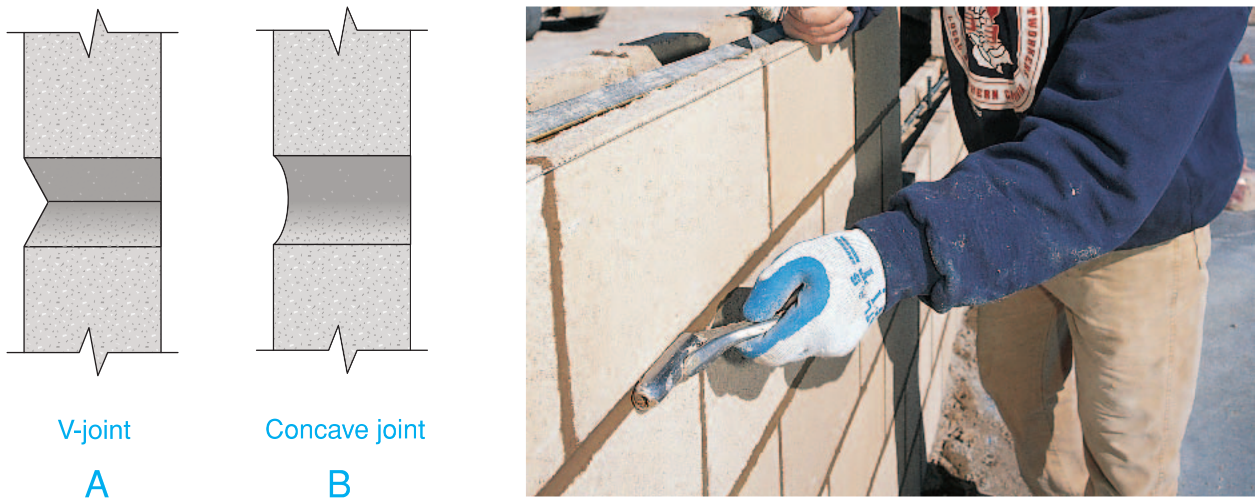


Figure 10-33 Tooling the Joints

Bed Joints Joints are usually tooled with a jointer shaped to create either **A.** a V-shaped joint or **B.** a concave joint

Tooling the Joints

Weathertight joints and a neat appearance depend on proper tooling. This is done after the mortar has become "thumbprint hard" (the thumb makes no indentation when pressed into the mortar). Tooling is a process of using shaped metal bars to compact the mortar and force it tightly against the masonry on each side of the joint. Proper tooling produces joints of uniform appearance, with sharp, clean lines. Unless otherwise specified on the plans, all joints should be tooled in either a concave or V-shape.

Tooling of the head joints should be done first, using a small S-shaped jointer. Tooling of the bed joints should follow, as shown in **Figure 10-33**. The horizontal joint should

Estimating and Planning

Block Walls

CERTIFICATION PREP

This estimating and planning exercise will prepare you for national competitive events with organizations, such as SkillsUSA and the Home Builder's Institute.

Estimating Materials

When estimating materials for block walls, you must consider several factors. These include the number of blocks, the amount of mortar, and the cost of labor.

Block

The number of blocks needed for a foundation can be determined by the area of each wall to be built.

1. Nine 8" × 8" × 16" blocks will make eight square feet of wall area. Therefore, take the total number of square feet in the wall and divide it by eight. Multiply the result by nine. You will then have a good estimate of the number of blocks needed for the wall.

For example, consider a house with a 25' × 40' foundation that is 7' high. The simplest way to find the total square footage is to multiply the perimeter times the height. The perimeter (the total length of the four sides) is 130'. Multiply this by 7' to find the total area of the four basement walls, which is 910 sq. ft. Now apply the formula:

$$910 \div 8 = 113.75$$

$$113.75 \times 9 = 1{,}023.75$$

Rounded off, your answer would be 1,024.

2. Next, because the courses overlap or interlock at the corners, subtract one-half block for each corner of each course. The wall in the example would be 11 blocks high; therefore, subtract 5½ blocks for each corner, or 22 blocks altogether.

$$1{,}024 - 22 = 1{,}002$$

A total of 1,002 blocks would be needed. This number would be reduced even more to allow for windows or other openings.

3. The number of concrete blocks necessary for a wall can also be determined by referring to the table. In the left column, find the size of the block used. If you select an 8" × 8" × 16" block, the table indicates 110 concrete blocks for each 100 sq. ft. of wall. The walls in our example have an area of 910 sq. ft. Divide this by 100 to find the number of square feet expressed in hundreds: 910 ÷ 100 = 9.1.

   The table shows that 110 blocks are needed for each 100 sq. ft., so multiply 9.1 by 110 to find the total number of blocks needed: 9.1 × 110 = 1,001 total blocks.

   Some adjustment may still be necessary if there are openings in the wall. The table allows for the overlapping of blocks at the corners, so it is not necessary to subtract for this as in the previous example. Note also that the answer is not precisely the same as when calculated by the first method. However, the estimates are very close, and both methods are reliable.

Mortar

The number of cubic feet of mortar needed for a block wall can also be determined from the table.

1. For the walls in our example, the table shows that 3.25 cu. ft. of mortar would be needed for every 100 sq. ft. of wall area.

2. There are 9.1 hundreds of square feet in the walls. By multiplying 9.1 by 3.25 you find the total amount of mortar needed.

   9.1 × 3.25 = 29.575 cu. ft. of mortar, rounded off to 29.6

Labor

To determine labor costs, again consult the table.

1. You will see that 8" × 8" × 16" blocks are laid at a rate of 18 per hour.

2. Using the figure 1,001 for the total number of blocks, divide by 18 to learn the number of hours needed:

$$1{,}001 \div 18 = 55.6$$

3. Multiply the hours needed by the hourly rate of pay to find the labor cost.

Estimating on the Job

Using the table, determine the number of blocks, amount of mortar, and labor hours needed to make a 22' × 38' foundation that is 7' high. Concrete blocks that measure 8" × 8" × 16" need to be used.

Estimating Table for Masonry Blocks

Lightweight Block	Material for 100 Sq. Ft. of Wall		Labor
Size	Number of Units	Mortar (cu. ft.)	Blocks per Hour
8×4×12	146	4.0	24
8×4×16	110	3.25	22
12×4×12	100	3.25	30
8×6×16	110	3.25	21
Concrete Block	**Material for 100 Sq. Ft. of Wall**		**Labor**
Size	Number of Units	Mortar (cu. ft.)	Blocks per Hour
8×8×16	110	3.25	18
8×10×16	110	3.25	16
8×12×16	110	3.25	13

Note: Mortar quantities based on ⅜" mortar joints, plus 25% waste. For ½" joints add 25%.

Figure 10-34 Filling Cores

Top Course With metal lath in place, the cores of the top-course blocks can be filled and troweled smooth.

appear continuous. A jointer for tooling horizontal joints is upturned on one end to prevent gouging the mortar. For concave joints, a tool made from a ⅝" round bar is fine. For V-shaped joints, a tool made from a ½" square bar is generally used. After the joints have been tooled, a trowel or stiff brush is used to trim mortar burrs flush with the wall face.

Completing the Walls

Foundation walls of hollow concrete block must be capped with a course of solid masonry to distribute the loads from the floor beams and to act as a termite barrier. *Solid-top blocks,* in which the top 4" is of solid concrete, can be used to accomplish this (see Figure 10-18 on page 276). The course can also be covered with a solid 4" thick block called a *cap block.* A third method is to use stretcher (standard) blocks and then fill all cores with concrete or mortar. In this case, a strip of metal lath wide enough to cover the core spaces is placed in the joints under the top course. The cores are then filled and troweled smooth, as shown in **Figure 10-34**.

Subterranean termites can crawl through hidden cracks in a wall to the wood in the building above. Installing metal termite shields on top of the block walls prevents this.

Installing Anchor Bolts

The house framing rests on preservative-treated wood sill-plates that are fastened to the top of the foundation walls. This is done by means of anchor bolts ½" in diameter and 18" long, spaced not more than 8' apart. These anchor bolts are placed at least 16" deep in the cores of the top two courses of block, and the cores are filled with concrete or mortar. The threaded end of the bolt should extend above the top of the wall, as shown in **Figure 10-35**. Pieces of metal lath are placed in the second horizontal joint from the top of the wall and under the cores to be filled. The lath supports the concrete or mortar filling.

Cleaning Block Walls

Any mortar droppings that stick to the block wall should be allowed to dry slightly before removal with a trowel. The mortar may smear if removed while too soft. When dry and hard, most of the remaining mortar can be removed by rubbing it with a small piece of concrete block and then brushing.

Figure 10-35 Anchor Bolt

Position Carefully Fill cores with concrete or mortar and insert the bolt so that the threads extend above the top of the wall. The bolt should be plumb.

Additional Techniques

What is radon?

After the walls are complete, additional steps should be taken to ensure that they are able to resist moisture. In some cases, block walls can be assembled using surface-bonding techniques.

Moisture Protection

Like solid concrete walls, block walls must either be dampproofed or waterproofed. Block walls are sometimes parged as part of this process. **Parging** is the process of spreading mortar or cement plaster over the block, as shown in **Figure 10-36**. A cove should be formed where the wall joins with the footing, as shown in Figure 10-20 on page 277. The parging should be at least ⅜" thick. When the parging is dry, a coating

Figure 10-36 Parging

Moisture Protection Parging a block wall blocks water infiltration. It can be applied to above-grade as well as below-grade walls.

of asphalt is applied to the exterior of the wall. This, along with a properly designed footing drain, will normally ensure a dry basement.

Sometimes added protection is needed, as when soil is often wet. In such cases, the entire wall should be waterproofed like a solid concrete foundation (see Section 10.2).

Lintels and Bond Beams

In some situations, concrete is added to a block wall to span an opening or to provide additional strength. Where openings occur in the foundation, a *lintel* must be installed over the opening to provide support for the masonry above it. A lintel is a horizontal member that supports the weight of the wall above. A lintel in a masonry wall is like a header in a wood-frame wall. It directs loads around the opening. One way to create a lintel is to use L-shaped steel angles. One leg of the L fits under the masonry to support it over the opening.

Another type of lintel is made of reinforced pre-cast concrete. It is a manufactured product that is delivered to the job site in finished form. It is placed over an opening just as a wood header would be placed.

A third way to create a lintel is to use lintel blocks (see Figure 10-18 on page 276). Lintel blocks are temporarily supported over the opening by a wood framework. The open portions of the blocks are then filled with concrete and reinforced with rebar. When the concrete has cured, the wood framework can be removed.

Building codes where earthquakes are a hazard may require that masonry walls be strengthened with a *bond beam*. A bond beam is a course of reinforced concrete or reinforced lintel block. It is sometimes called a *collar beam*. It is often positioned as the top course of a wall. In some cases it is placed in more than one location. For example, a bond beam might be placed at every fourth course in the wall to stiffen the wall. Bond beams can be created by a continuous course of reinforced lintel

Figure 10-37 Surface Bonding
Quicker and Easier Using surface-bonding mortar to build a block wall eliminates the need to mortar each course as the wall is built.

blocks. Another method is to secure metal or plywood forms to the top of the wall. Once the bond beam cures, the forms can be removed and construction can continue.

Surface Bonding

Mortared block walls are the most common type of concrete block wall. Another technique called *surface bonding,* or *dry-stacking,* is also used. It starts out similar to parging. The first course of block is bedded in mortar as usual. Additional courses are stacked dry, with no mortar. Fiberglass-reinforced mortar, or *surface-bonding mortar,* is then troweled over both sides of the walls in a layer at least ⅛" thick, as shown in **Figure 10-37**. The ½" long fibers improve the tensile strength of the mortar much like steel mesh reinforces concrete. Because individual joints are not mortared, walls are built more quickly and are easier for unskilled workers to install. The coating of surface-bonding mortar provides water resistance.

Radon

Radon is a colorless and odorless radioactive gas that travels through soil. According to the U.S. Environmental Protection Agency, radon can be extremely toxic to humans if it builds up inside a house. Long-term exposure to radon has been linked to an increased risk of lung cancer. All types of house foundations, including concrete slabs, should be designed to reduce penetration by radon.

Because house foundations are in direct contact with the soil, they are a common entry point for radon. Radon enters through floor and wall cracks, expansion joints, gaps around pipes, and even through the pores in concrete. Because radon is soluble in water, it can also enter a basement through water seepage and through water vapor.

In addition, radon is nine times heavier than air, so it tends to accumulate in basements. Air circulation and other forces help to distribute radon throughout a house.

Radon-Resistant Construction Radon can be found in every area of the country, but it does not affect every region or every house equally. Therefore, steps should be taken during the foundation construction of every house to minimize radon problems. The following protective features are common:

Gas-permeable layer This is a 4" thick layer of drainage gravel directly beneath the floor slab. It allows radon to move freely beneath the house. A 4" thick layer of sand, topped with geotextile fabric, is an alternative.

Soil-gas retarder Polyethylene sheeting 6-mil thick is placed on top of the gas-permeable layer. This prevents radon from moving through the slab.

Sealants All openings and joints in the foundation floor are sealed to reduce radon entry. Sealant techniques include the use of high-performance caulks as well as plastic covers over sump pits.

Vent pipe A 3" or 4" diameter PVC pipe is connected to the gas-permeable layer. It leads to the roof. The pipe acts as an exhaust to safely vent radon outside the house.

Cap course Concrete block foundation walls must **incorporate** either a continuous course of solid masonry, a continuous course of concrete, or one course of masonry-grouted solid. This prevents radon from moving through the hollow cores of the block.

Building codes in some parts of the country require the use of radon-resistant foundation techniques. Always check local codes for specific construction requirements. For more on radon-resistant construction, see Chapter 11, "Concrete Flatwork," page 299.

Section 10.3 Assessment

After You Read: Self-Check

1. List three advantages of concrete block foundation walls as compared to solid concrete walls.
2. Name the type of packaged mortar that is most suitable for regions where earthquakes occur.
3. What is a story pole and how is it used when laying concrete block?
4. What is parging and what is its purpose?

Academic Integration: Mathematics

5. **Estimating Block** Estimate the number of 8" blocks you would need for a foundation wall that measures 20' in length and 8' in height. Use these facts to guide your estimation:
   - One block, including a ⅜" mortar joint, measures 8" in height. Therefore, 3 blocks will stack 2' high.
   - One block, including a ⅜" mortar joint, measures 16" in length. Therefore, 3 blocks will lay out 4' in length.

   Math Concept Many estimating problems can be solved using basic addition, subtraction, multiplication, and division operations. It helps to visualize a problem if you are using mental math.

   Step 1 Since 3 blocks lay out 4' in length, you must multiply the length of the wall (20') by ¾ to determine the number of blocks needed for every course. Another way to multiply by ¾ is to multiply by 3, then divide by 4.

   Step 2 Since 3 blocks stack 2' high, multiply the height of the wall (8') by 3⁄2 to determine the number of courses.

   Step 3 Multiply the number of blocks in one course by the number of courses to determine the number of 8" blocks that will be needed for the wall. Round up to the nearest whole number.

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

CHAPTER 10 Review and Assessment

Chapter Summary

Section 10.1 Footings provide a base that supports a foundation wall, a pier, or a post. Footings can be reinforced with rebar. Footing drains help prevent damp basements.

Section 10.2 Foundation walls may be full-height for basements or shorter for crawl spaces. Poured foundations require forms. Rebar can be added for extra strength. Dampproofing and waterproofing must be done where moisture is a potential problem.

Section 10.3 Concrete block walls do not require formwork. The blocks are fairly inexpensive. Mortar holds the blocks together. Block walls require protection from moisture.

Review Content Vocabulary and Academic Vocabulary

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

Content Vocabulary

- footing (p. 256)
- wales (p. 264)
- cold joint (p. 266)
- head joint (p. 275)
- bed joint (p. 275)
- story pole (p. 281)
- control joint (p. 283)
- parging (p. 287)
- radon (p. 288)

Academic Vocabulary

- framework (p. 258)
- incorporate (p. 289)

Speak Like a Pro

Technical Terms

2. Work with a classmate to define the following terms used in the chapter: *monolithic wall* (p. 256), *haunch boards* (p. 258), *form brackets* (p. 258), *stepped footings* (p. 259), *hydrostatic pressure* (p. 262), *perimeter drains* (p. 262), *filter fabric* (p. 263), *fines* (p. 263), *full-height foundation* (p. 264), *crawl-space foundation* (p. 264), *stem walls* (p. 264), *snap-ties* (p. 265), *insulating concrete forms* (ICFs) (p. 265), *stinger* (p. 267), *vapor retarder* (p. 267), *anchor bolt* (p. 268), *masonry ledge* (p. 269), *weep hole* (p. 269), *dampproofing* (p. 271), *course* (p. 275), *cell* (p. 275), *pilaster* (p. 275), *common bond* (p. 276), *full bedding* (p. 276), *stack bond* (p. 276), *face shell* (p. 280), *course pole* (p. 281), *tie bar* (p. 283), *cap block* (p. 286), *surface bonding* (p. 288).

Review Key Concepts

3. Summarize the function of the footing.

4. Describe the exact location of the footing.

5. Explain the process for forming concrete foundation walls.

6. Describe two types of foundation walls.

7. List the steps in laying a concrete block wall.

8. Describe the types of concrete block used in concrete block walls.

Critical Thinking

9. Explain Which type of foundation would you recommend to an individual planning to build a house in the southern United States who wished to conserve costs as much as possible? Explain the reasons for your recommendation.

Academic and Workplace Applications

STEM Mathematics

10. Estimating Labor Costs On average, it takes between 4.7 and 5.2 man-hours per 100 blocks to lay, clean, and joint 8×8×16 concrete block. How much time would it take 4 workers to build a foundation estimated to require 1,200 such blocks?

Math Concept A man-hour is the amount of work one individual can do per hour.

Step 1: Determine how many man-hours it will take to complete 1,200 blocks given that it will take one man between 4.7 and 5.2 hours to complete 100 blocks.

Step 2: Divide the number of man-hours by the number of workers on the job.

STEM Science

11. Soil Drainage Where the soil drains poorly, where the water table is high, or where living spaces will be located below grade, greater efforts must be made to protect the foundation of a house. Find out more about soil drainage. Write a paragraph explaining why soil in some environments drains poorly.

21st Century Skills

12. Career Skills Rumblestone Concrete will be undertaking a large concrete project this winter. They will begin work in December, when temperatures are likely to be near or below 32° F. Their new foreman, Jim, has only conducted work in warm climates. You must help Jim ensure that the project is a successful one by outlining some strategies to protect the freshly placed concrete from freezing temperatures. Write a one-page letter to Jim in which you give him advice on how to best protect the concrete.

Standardized TEST Practice

CERTIFICATION PREP

Short Answer

Directions Write one or two sentences to answer the following questions.

13. How far below grade should footings be placed?

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14. What risks are present when freshly laid concrete block walls are exposed to temperatures at or below 32°F?

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15. How do you prevent radon from moving through the hollow cores of block in a concrete block foundation wall?

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TEST-TAKING TIP

If each item on a test is worth the same number of points, do not spend too much time on questions that are confusing. If you do not know the answer to a question, make a note and move on. Come back to that question later, after you have answered all the other questions.

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