

This is an excerpt from the book

**Habitat For Humanity:
How to Build a House**
by Larry Haun

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FIRM, FLAT, LEVEL, AND SQUARE:

Foundations and Floors

FLOORS MAY SEEM TO BE THE SIMPLEST OF THE CHALLENGES facing a new builder, but the importance of establishing a firm, sound, dependable connection between a house, the foundation, and the earth cannot be overstated. Everything rests, quite literally, on the quality of the foundation and framing work done in the first few days or so after the concrete contractor has left. Our first house, in coastal Oregon, had a concrete foundation made from beach sand. Sixty years of wind and rain had washed much of that sand back toward the beach, leaving us with a shaky, tilted floor that wasn't even bolted to the foundation.

Know the Foundation Fundamentals

Take a deep breath. Having found and purchased a lot, bought or drawn up the plans, obtained the permits, cleared and run power to the site, and completed the necessary grading, drainage, and excavation work, you're finally ready to begin working on the foundation. You've already come a long way.

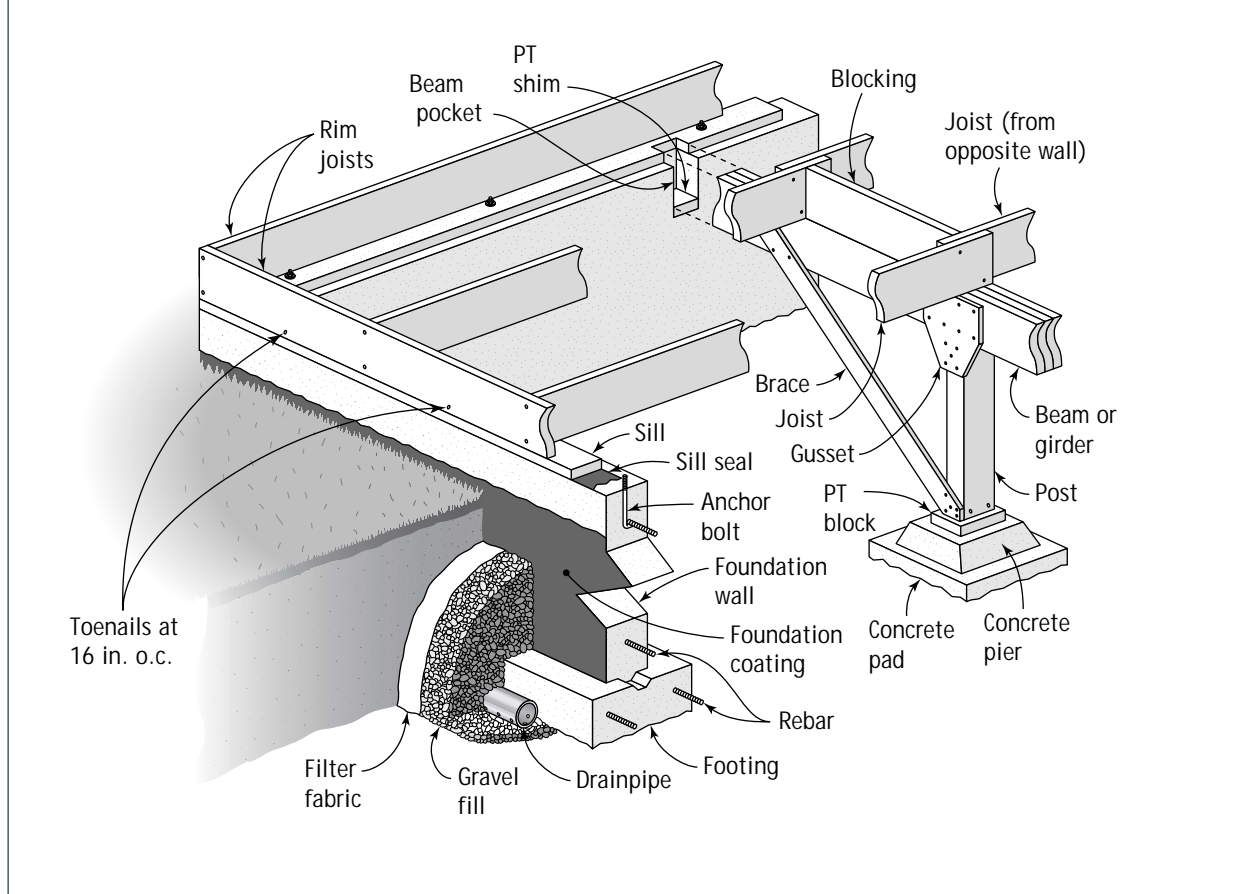
Whenever I think about foundations, I can't help but recall being told as a child, "You're on your feet most of the day, so wear good shoes." A foundation is like a pair

STEP BY STEP

- 1 | Form and Pour the Footings
- 2 | Build the Foundation Walls
- 3 | Backfill around the Foundation
- 4 | Attach the Sills
- 5 | Build Midspan Support for Joists
- 6 | Install the Joists
- 7 | Install Extra Joists and Blocking
- 8 | Install the Floor Sheathing



FOUNDATION AND FLOOR FRAMING OVERVIEW



Helping Hand

All foundations need proper drainage. In addition to installing drainpipe around the footings, make sure that the finished grade slopes away from the house. If gutters and downspouts are installed, use elbows and splash plates to direct runoff away from foundation walls.

of shoes—quality makes all the difference. Walk around all day in poor shoes and your whole body feels lousy. Build a house on a poor foundation and the entire house is unstable.

There are quite a few foundations that can be used for houses. The three major types—slabs, crawl spaces, and full basements—are discussed in the sidebar on pp. 46–47. Because our Charlotte house has a crawl space foundation, we'll cover the step-by-step process for this type shortly. The main parts of this foundation are shown in the illustration above. However, if you're planning to build a house, it's a good idea to consider all your foundation options. Talk to builders and foundation sub-

contractors in your area to find out which foundations and special site conditions to consider. If you're building a crawl space foundation, as we did here, find out about the ventilation requirements. In some areas, vents are required in crawl-space foundations. In other areas, codes have been updated to allow for an unvented crawl space (see the sidebar on the facing page).

Clay can cause problems

Local soil conditions have a lot to do with choosing and constructing a foundation. Extra care must be taken when building on clay-rich soils, which exist in many parts of the country. Clay expands when saturated with moisture.

Techniques | VENTING A CRAWL-SPACE FOUNDATION—OR NOT

UNTIL RECENTLY, most crawl-space foundations were built with vents to promote air circulation and help prevent damaging levels of moisture from building up beneath the house. In northern states, builders often install vents that can be closed in the winter to keep out cold air. The same is done on the Oregon coast to keep out moist air. Many local building codes require crawl-space ventilation, so be sure to check with your building department to find out which requirements are in effect.

Codes requiring vents usually stipulate that a vent be installed 2 ft. from each corner of the foundation and every 6 ft. on at least three sides

a poured concrete wall. Others are sized to fit in concrete block walls. For a simple, inexpensive, and attractive vent, cut sections of 3-in.- or 4-in.-dia. plastic pipe and put them in the foundation wall forms before pouring the concrete. Use adhesive to secure pieces of ¼-in. wire mesh (also called hardware cloth) over indoor pipe sections to keep out animals. Still another way to ventilate a crawl space is by cutting openings in the rim joists, as shown in the illustration below.

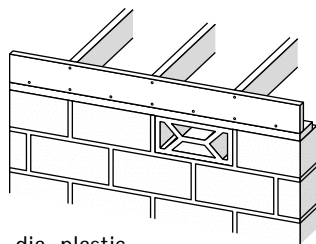
Unvented Crawl Spaces. Based on relatively new research, builders in some regions are beginning to eliminate vents and treat crawl spaces like small

basements. The idea behind this type of construction is that you start with a dry crawl space and keep it that way. Sealing off a wet crawl space can lead to disaster, but it is possible to create a warm, dry crawl space by preventing moisture and air from entering. Follow the good drainage guidelines explained in the sidebar on p. 48.

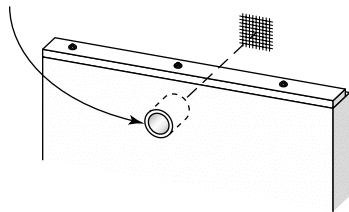
Dirt floors must be sealed with a sheet of 6-mil plastic that laps up onto the foundation and is fastened against it with mastic. Rigid insulation should be used on foundation walls, eliminating the need for

insulation in the joist spaces under the floor. With the help of a heating contractor, you can even supply a crawl space with a small heating duct to help keep it dry. You can create access to the crawl space through a trap door framed in the floor of a closet.

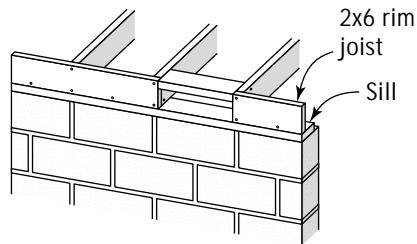
CRAWL-SPACE VENTILATION



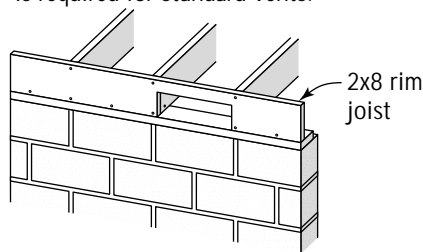
3-in.- or 4-in.-dia. plastic pipe in foundation wall, screen glued to the back



Vent spaces can be built in the foundation wall. If they're not, they can still be cut out of the rim joists.



A 4½-in. by 14½-in. opening is required for standard vents.



Vents can allow moisture to escape and air to circulate in underfloor areas.

of the building. For appearance's sake, most builders try to leave vents off the front of the building.

If you need to install crawl-space vents, there are several ways to do so. Some factory-made vents are designed for installation in openings formed in

Choosing a Foundation

FOUNDATION TYPES VARY by region. When deciding which type of foundation to use, consider the cost, climate, and local preferences. The three major foundation types are discussed below.

Concrete Slab

Slab foundations are popular throughout southern sections of the country and in regions where winter temperatures are mild. A concrete slab is more than a foundation; the slab also serves as the

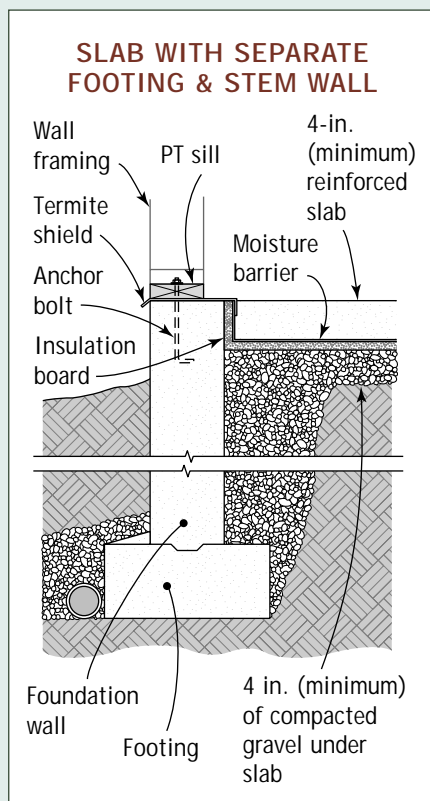
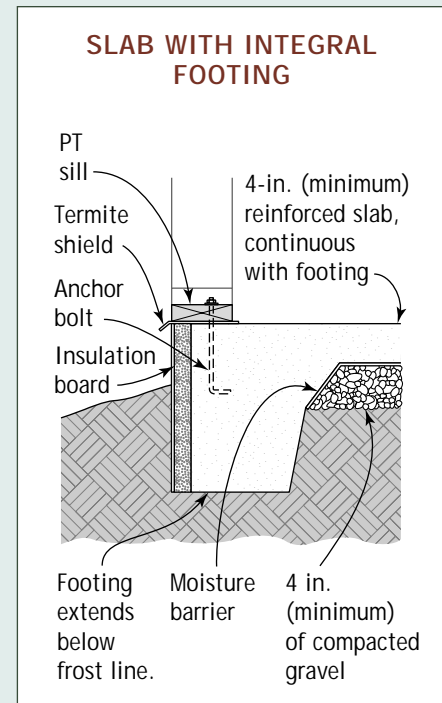
rough or finished floor for the first level of the building. This explains why slab foundations are less expensive than other types. Because concrete has poor insulative qualities, slab foundations are often insulated with rigid foam. Plumbing waste lines are typically cast into the slab, so they must be carefully laid out and installed first. Plumbing supply lines and tubes for radiant floor heating can also be cast into a slab.

Types of Slab Foundations

Concrete slabs can be poured inside stem walls that bear on conventional footings. Another construction method is to form and pour the floor and footing together. With this type of slab, the floor is simply thickened at the perimeter of the house (and beneath any load-bearing walls or interior posts) to form the footing. As with other foundations, the footing should extend below the frost line.

Crawl Space

Crawl-space foundations are very compatible with affordable housing. In humid, high-moisture areas (such as the Southeast and Pacific Northwest), this type of foundation raises the living space off the ground, away from wet soil. A house built on floor joists over a crawl space



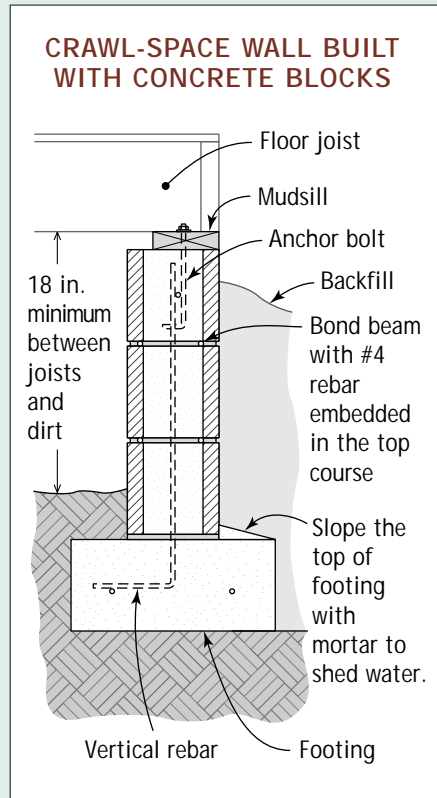
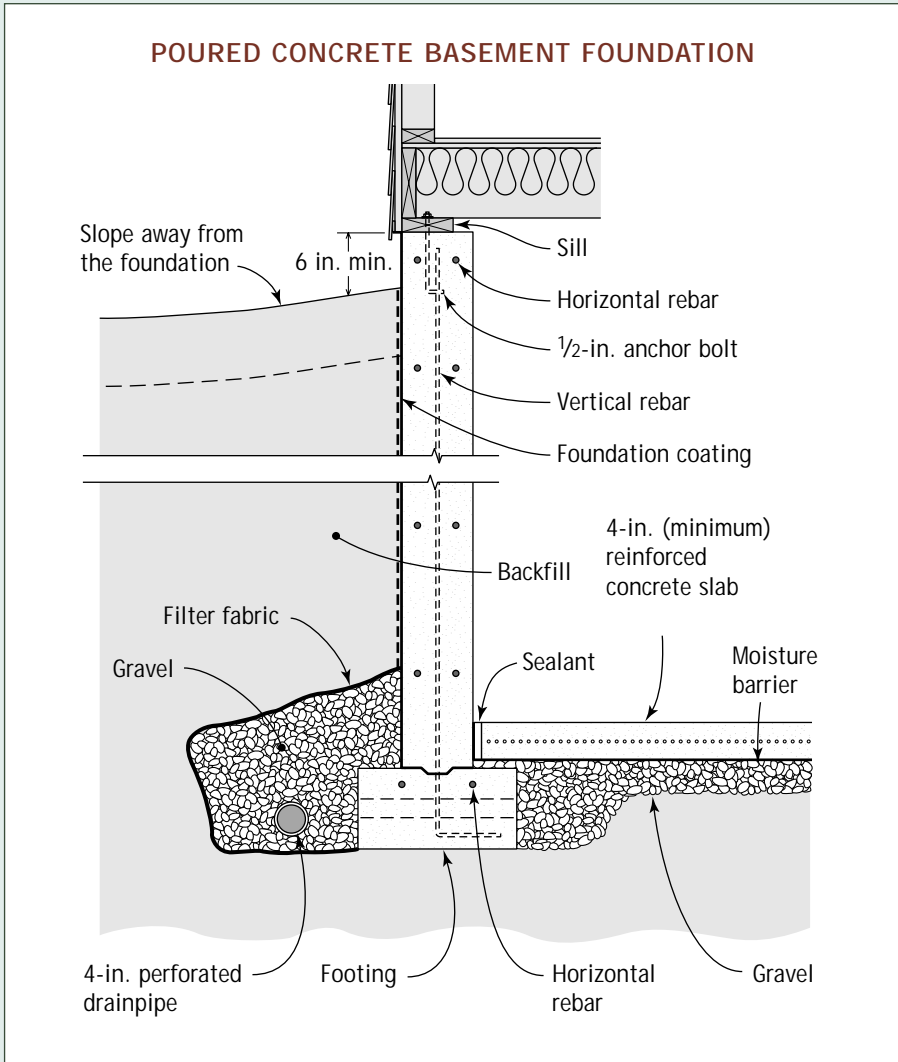
provides a more resilient and more comfortable floor than a slab. It also allows for easy access to plumbing pipes, under-floor insulation, and electrical wiring.

If you are planning a crawl-space foundation, decide whether you want the crawl space to be ventilated (see the sidebar on p. 45). You'll also need to decide between poured concrete walls and concrete block.

Basement

Building a house on a full basement provides all the advantages of crawl space construction with the added

benefit of extra room below the main living area. Of course, basement foundations are more expensive than other types, and the living space they provide can be damp and lacking in natural light. To overcome these disadvantages, some basements incorporate window wells—windows located just below grade level—surrounded by a metal or concrete retaining wall on the outside of the foundation. When a basement will be used as a living space, the foundation walls must be waterproofed on the outside, insulated on the outside or on the inside, and finished on the inside. Today, many basement foundations are built with poured concrete walls. Other builders construct basement foundations with concrete block.



Concrete Block vs. Poured Concrete Walls

If you have a large crew, like we do on most Habitat projects, it makes sense to build foundation walls with concrete block. All you need are a couple of experienced masons and enough volunteers to keep them supplied with blocks and mortar as they work their way around and up, course by course. A crawl-space foundation can be completed in just a couple of days. When building walls with concrete block, it's

easy to form beam pockets and openings for vents, doors, and windows. And by switching to a smaller block just below the planned grade level, you can create a ledge for brick veneer.

If you want a full basement and you don't have a Habitat-size crew, poured concrete is the way to go. Most basement foundations are built with poured concrete walls that are formed and poured by foundation contractors.

This can exert tremendous pressure on a foundation. I have seen how this expansive action moves footings, cracks slabs, and causes extensive damage to a house. When builders are aware of the potential problems with clay soil, they can take precautions to avoid damaging effects. (See the drainage guidelines discussed in the sidebar below.) I have worked on sites where several feet of clay soil were removed and replaced with nonexpansive soil, which was then compacted before the footings were poured.

Foam forms are worth considering

If you haven't done so already, take a look at the possibilities offered by insulated concrete forms (ICFs). These lightweight foam forms are easy to handle and assemble, and they stay in place to provide wall insulation after the foundation wall is poured (see the sidebar on the facing page). With an ICF system, laying up foundation walls doesn't demand back-breaking labor. Even so, many home-builders still prefer to hire a foundation contractor to take on this phase of the construc-

Techniques | ENSURING PROPER DRAINAGE

WE NEED WATER. We just don't need it in our basements or under our floors, causing dampness, mold, and rot. We may not be able to hold back the Mississippi when it floods, but we *can* control most of the rainwater that falls around our homes. Follow the guidelines below and you'll stand a good chance of keeping water on the outside of your foundation.

1. Don't build on the lowest part of the lot.
2. Seal all holes around the pipes that go through the concrete.
3. Install perforated drainpipes at the bottom of the concrete footings around the outside of the foundation (see the photo at left).
4. Coat the foundation walls with a suitable damp-proofing or waterproofing treatment. Check with builders in your area or the local building department to find out which foundation coatings are rec-

ommended. Tar coatings are inexpensive but not as effective as more recently developed waterproofing treatments.

5. Compact loose fill as you backfill around the foundation, but be careful, because excessive compaction can damage masonry walls. Make sure that the finished grade (ground level) slopes away from the foundation. But remember that loose fill can settle. A finished grade that slopes away from the house may later slope toward the house should settling occur.
6. Use gutters and downspouts to manage high roof water runoff. Make sure you keep gutters unclogged and install downspouts to direct water away from the house.
7. Get advice from your building department. The time to protect your house from water infiltration is while you are building. Fixing a leaky basement or a damp crawl space after the house has been built can be very expensive.



Materials | BUILDING WALLS WITH INSULATED CONCRETE FORMS

INSULATED CONCRETE FORMS (known as ICFs) offer builders an easy way to build insulated concrete walls for crawl space and basement foundations. Made from polystyrene or another rigid foam, these forms are designed to stay in place; they aren't stripped off like standard forms.

It doesn't take a lot of building skill to stack these blocks properly. On a recent job in Oregon, we snapped chalklines on the concrete footing to mark where the first course of form blocks would fit. We then started from the corners and laid two courses of blocks to form the crawl space walls. With four of us working, it took less than two hours to lay the blocks.

Polystyrene blocks interlock, so very little extra bracing is needed to hold them in place as concrete is poured into them. A horizontal 2x4 screwed to the outside or inside of the wall helps hold the forms straight. Drive a stake in the ground every 4 ft. or so, and run a brace between the stake and the horizontal 2x4. This will keep the walls straight



throughout the pour. To strengthen the wall and prevent the forms from floating up and away, tie together a network of horizontal and vertical rebar, as shown in the photo above.

There are some concerns with ICF walls. The foam can offer a hidden pathway for subterranean termites. To avoid this, install a metal termite shield under the sill plate. Also, the foam surface is rather soft and can be easily dented and gouged. To prevent this, cover the outside walls with 2-ft. by 8-ft. fiber-cement panels.

tion project, and there's nothing wrong with that choice. The important thing is to begin building on a base that's level, square, and guaranteed to remain solid and stable for many years to come.

STEP 1 | Form and Pour the Footings

Thick, solid, and strong, footings evenly spread the weight of the house (and everything inside it) over a wide area, ensuring that the finished house does not settle. With some slab foundations, it's possible to pour the footings and the slab at the same time. In other cases, the footings and the slab must be formed and poured separately. In many areas, a footing inspection by the building depart-

ment is required; this must be done before the foundation walls are built.

Footings must be set on solid, undisturbed earth, not on fill dirt. Local soil conditions determine the depth and design of footings. In areas of the country where the ground freezes solid in the winter, footings must extend below the frost line, which can be 4 ft. or deeper in northern regions. This prevents the freeze-thaw cycle from moving the foundation, cracking it, and causing damage throughout the entire house. The building department in your area will know the footing depth that is required. They'll also know about local soil conditions that may require a larger size footing or the use of rebar (steel reinforcing rod) in the footing.

Helping Hand

If the corner of your house is settling, chances are it is on the lot's lowest spot. Every time it rains, water collects there, saturating the ground and causing the foundation to settle. To fix the problem, try pouring a concrete sidewalk, which covers the low spot and causes water to drain away from the house rather than toward it.

Forms for footings

Footings are typically poured in temporary forms constructed from plywood or 2x lumber. Wood stakes and braces hold the forms in position. The top edges of the footing forms must be level, and the footings must be set to the dimensions specified on the plans. A ready-mix truck is called in to fill the footings with concrete. If the site conditions make it difficult or impossible for the truck to get close to the forms, a mobile concrete pumper can be brought in to pump the concrete from the truck to the forms. Check with your building department about code requirements for footings. It also may be necessary to embed vertical rebar in the footings so that the upper part of the reinforcing rods can extend into the foundation wall.

Pads are poured

It's common practice to pour any pads required in the plans at the same time the footings are poured. In a crawl space foundation that includes a post-and-girder framework, poured concrete pads provide a base for concrete piers and wood posts (see the illustration on p. 44). A common size for these pads is 16 in. square by 8 in. deep. If you're building a basement foundation, pads are also required to support each post or Lally™ column. These pads are poured below the level of the basement floor and will be covered when

the slab floor is poured. If a wall will provide midspan support for joists, a continuous footing is poured instead of separate pads.

STEP 2 | Build the Foundation Walls

The Charlotte house has concrete block walls. With a crew of helpers to move blocks and mix mortar, an experienced block mason can erect a simple crawl space foundation wall in just a couple of days. However, in many parts of the country, poured concrete walls have surpassed concrete block walls in popularity. Subcontractors—specialists who have the equipment and experience to do the job quickly and, hopefully, with a high degree of accuracy—often form and pour concrete walls. If a foundation contractor arrives in the morning with a truckload of wall forms and rebar, he or she will probably have everything erected before the end of the day. Don't forget to have the forms inspected before the ready-mix truck arrives to fill them with concrete.

Forms are usually stripped a day or two after the pour. It takes about a week for concrete to get its first hard set, but you can begin to lay out and install the sills as soon as the forms come off. Even though you may not be forming and pouring the walls yourself, it's useful to know about some aspects of the process. This applies whether you're building

SNAPSHOTS

Without a floor on top, there's just a big empty space inside the foundation walls. Getting all the joists in place seems like a huge job . . .

The masonry walls look square and level, but we have to check them anyway . . .

We use pressure-treated 2x6s for the sill plates . . .



the foundation walls with concrete block or with insulated concrete forms.

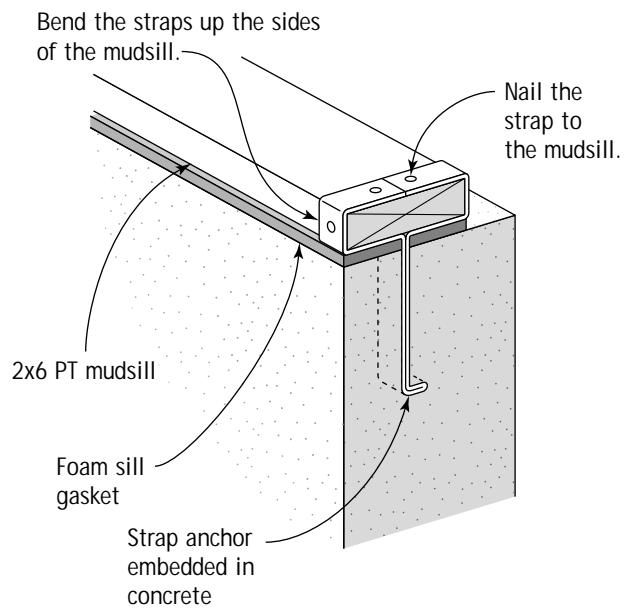
Anchor bolts and tie-downs

Regardless of the type of foundation, anchor bolts are required around the perimeter to hold the sill plates and the walls securely in place. In earthquake and hurricane zones, the building code may call for additional hold-downs, such as metal straps that are embedded in the concrete and extended to the sills, rim joists, and wall framing (see the illustration at right). Most codes require that a long piece of rebar be planted in the concrete near the planned location of the main electrical panel so that it can be used as a ground for the electrical system.

Beam pockets

Beams or girders that tie into the foundation usually do so by means of pockets built into the foundation walls (see the illustration on p. 44). If a post-and-girder system is planned for a basement or a crawl space foundation, the beam pockets are located in the end walls, in line with the concrete piers where the posts will be installed. It's critical for the pockets to be correctly sized and located as the foundation walls are built. To hold a 4x6 girder, the pocket should be 4½ in. wide and 5½ in. deep. This provides clearance between the girder and the concrete so that moisture in the con-

FASTENING MUDSILLS WITH METAL STRAPS



Metal straps can be embedded in the concrete foundation. After the bottom plate is down, the straps are nailed to it. Metal hardware creates a positive connection between the foundation and the house frame. This is especially important in earthquake and high-wind areas.

crete doesn't seep into the wood, potentially damaging it. The 5½-in. depth also allows a pressure-treated 2x4 shim to be installed beneath the girder, bringing its top edge flush with the sill.

Pockets are cast into poured concrete walls by fastening pocket-sized wood or rigid foam blocking inside the forms. In a concrete block or ICF wall, pockets are created as the walls are laid up.

Once they're installed, we begin with all the joists . . . There's a rhythm to rolling the joists up onto their layout lines and then anchoring them in place by driving nails through the rim joists . . .

Before long, it's time to start installing the floor sheathing. We're already looking forward to wall framing.

