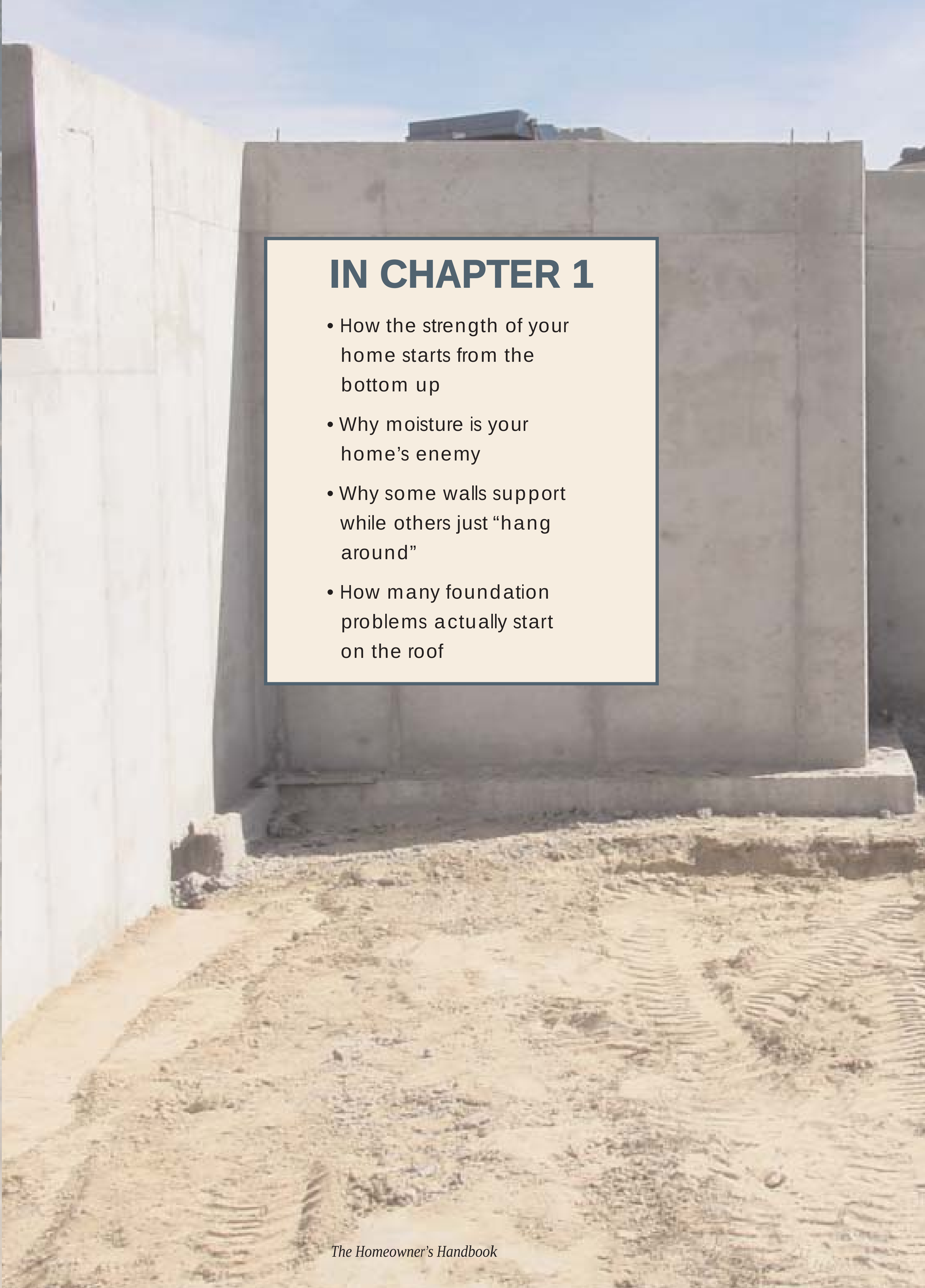


IN CHAPTER 1

- How the strength of your home starts from the bottom up
- Why moisture is your home's enemy
- Why some walls support while others just "hang around"
- How many foundation problems actually start on the roof

Overview

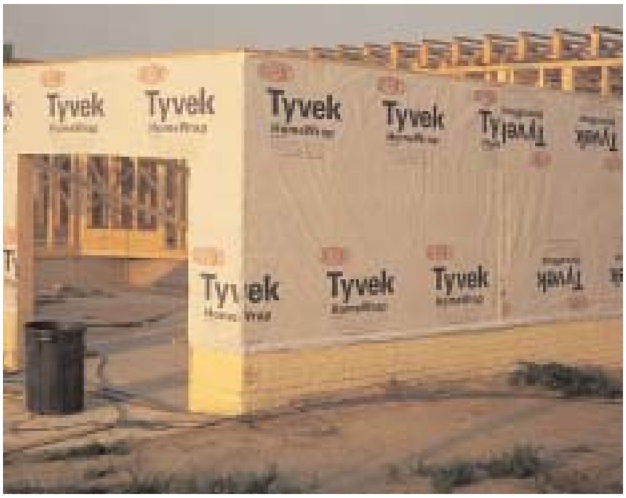
It is easy to fall in love with a home. Spacious rooms, a unique style, a pastoral setting—all can work their magic. A home may be the fulfillment of a dream; but a home is still a structure. This is why we are beginning “The Homeowner’s Handbook” by discussing your home’s main structural elements: the foundation, walls, and the roof.

Of all the chapters in this book, Chapter 1 can help save you the most money. The reason is simple: structural problems in a home are expensive. In fact, they can cost you tens of thousands of dollars in repairs! For example, did you know that too much moisture in your attic or crawl space could crack, rot, or warp parts of your house? This chapter will give you ideas for avoiding those problems and for maintaining your home’s structure. By using the information in this chapter, you can keep your home sound, your bank account healthy, and your sleep peaceful.

All Homes are Composed of Three Basic Elements:

A Foundation

A System of Supporting (Bearing) and Non-Supporting (Partition) Walls



A Roof Structure

Section 1: The Foundation—Getting to the Bottom of It All

Let's start with your home's foundation—and the soil that surrounds the foundation. Buried in the ground and hidden behind finished walls, a foundation is the least visible part of your home. Chances are, however, that it required the most engineering because it supports your whole house on the load-bearing walls.

Before we continue discussing foundations, it may be helpful to understand the term "load-bearing wall." Imagine stacking two columns of blocks, three high, and connecting them on top with a wooden plank, Diagram A (below). In this simple illustration, you are building two load-bearing walls (the block columns) to support a load (the wooden plank).

In your home, the weight of the roof and the load that it carries (such as wind, rain, or snow) are supported by a system of bearing walls, Photo 1-01 (below). They make up the outside perimeter of your home. Bearing walls also appear inside your home in key areas. When a bearing wall is built on a strong foundation, it can support you, your furniture, appliances, and pets and still be strong enough to hold up the roof.

"A solid future begins with a solid foundation." This saying is also true for your home. In fact, the foundation is the most important part of your home's structure.

Many hours of engineering went into designing and constructing your home's foundation. Three main types of foundations are used in home construction, and your home has one of them. Just what type of foundation you have depends on factors such as (1) the weight of the home, and (2) the type of soil on which the house was built. The second factor, the soil, is especially important to a home's foundation. For example, if a home is built on soil that swells when it rains, the swelling could seriously damage the foundation, and the rest of the house.

This section will help you determine your home's type of foundation and why it was chosen. At the end of this chapter, we will discuss the steps you can take to protect your home's foundation and other structural parts.

Diagram A *– Load-bearing wall*

1-01 Load bearing walls supporting the roof

Perimeter Wall on Spread Footing Foundations

Diagram B (right) shows the basic parts of a spread footing foundation. Spread (or continuous) footings are used in areas where the soils are stable, well drained, and not likely to swell because of moisture from rain or snow. The width of the footing depends on the type of soil and the weight of the home. In other words, weak soils or heavy homes mean a wider footing, Photo 1-02 (below).

During harsh winters and in colder climates, the soil often will freeze from several inches to several feet below the surface. The bottom of the frozen layer is called the "frost line." When the ground freezes, it expands and can lift or move objects. Unfortunately, this means these expanding soils could damage your home's foundation.

To avoid this problem, new building standards state that footings must be set at or below the point where the soil freezes during a normal winter. Diagram C (right) shows a footing placed below the frost line.

If your home was built between the 1920's and 1940's, it probably has a perimeter wall foundation around the entire edge of the home. In older homes, perimeter wall foundations are made with stone or brick masonry. Now, they are usually made with poured-in-place concrete. However, concrete cinderblocks, treated lumber, and even plywood sometimes are used.

Perimeter wall foundations remain popular because they allow for crawl spaces or basements under a home. Perimeter walls are also called stem wall foundations. Diagram D (right) shows a cross section of a cinderblock perimeter wall (right) and the "foundation's footprint" (left).

Diagram B *– Spread footing foundation*

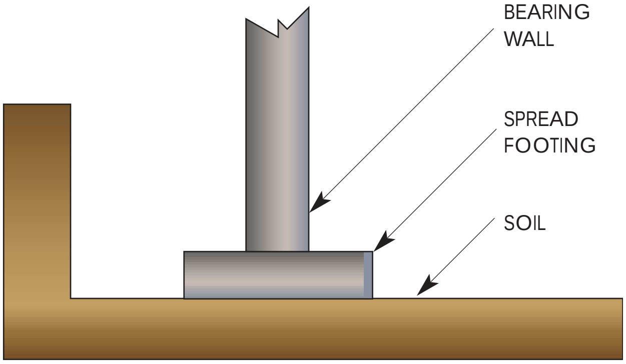


Diagram C *– Spread footing set below the frost line*

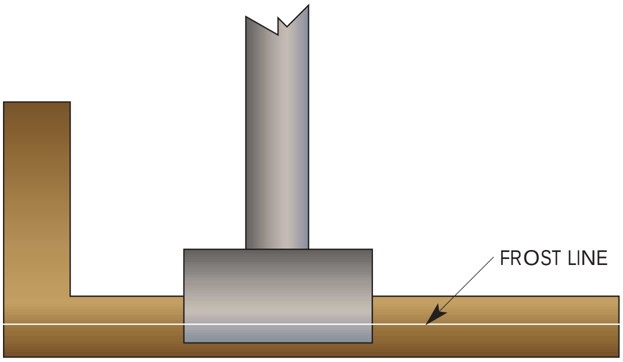
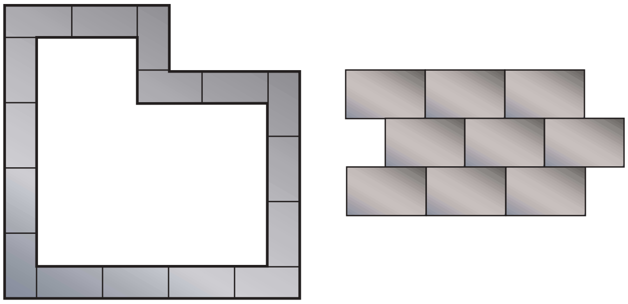


Diagram D *– Perimeter wall foundation*



1-02 Soil, climate, and the weight of the house dictate the type of foundation used. Shown here is a perimeter wall on spread footing.

1-03 A grade beam on caisson foundation

Grade Beam on Caisson (kaysahn)

The spread footing foundation and the perimeter wall foundation work well in stable soils. However, not all soils are stable. For example, soils that have a large amount of clay can swell when it rains or when snow melts. In fact, this soil can expand many times its original size and put a lot of pressure on a foundation. The problem is even greater if there is poor drainage away from the foundation.

Swelling soils could damage a foundation and cause a whole house to shift. In rare cases, swelling soils have made some homes so unstable that they had to be abandoned. However, even the problem of swelling soils can be managed if the right foundation is used.

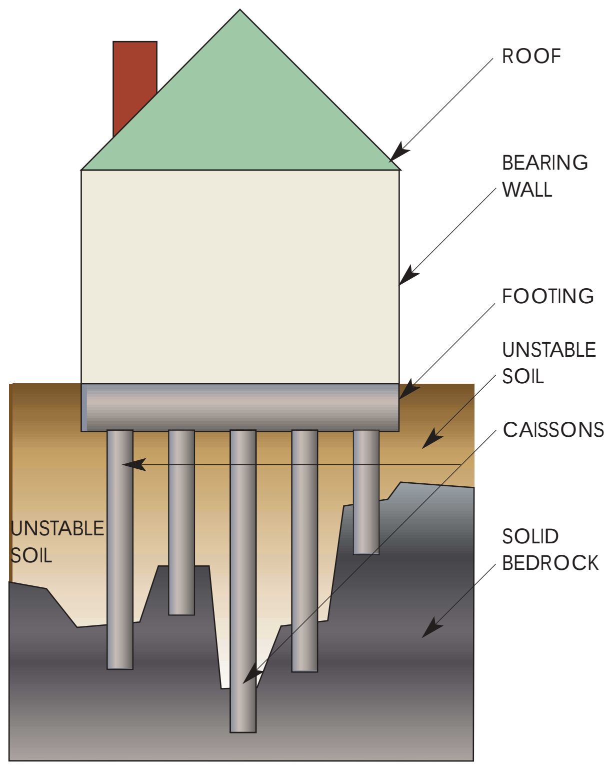
One modern foundation that works well in expanding soils is called grade beam on caisson (or grade beam on drilled pier), Photo 1-03 (above). With this type of foundation, the home is sitting on solid earth and not swelling clay, Diagram E (right). The following paragraphs describe how this is done.

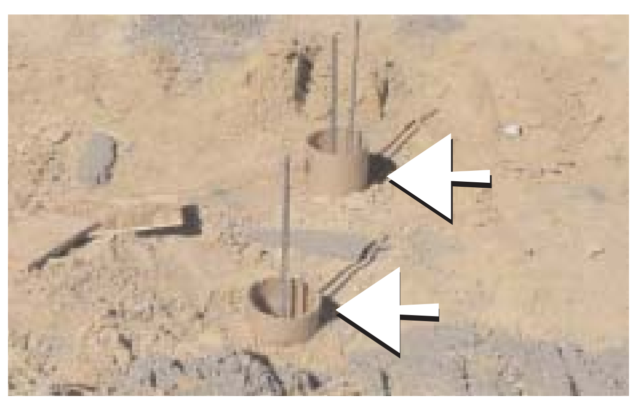
A grade beam on caisson foundation is started by using a truck-mounted drill rig to drill several holes into the bedrock. For most homes, a diameter of 10 inches is used. The depth of the holes can range from 5 to 25 feet or more below the foundation. The holes are drilled at each corner of the foundation "footprint" as well as about every 8 feet between the corners.

After the holes are drilled, a "cage" of reinforcing steel is placed into each hole before it is filled with ready-mixed concrete. The resulting columns are called "caissons." Photo 1-04 (right) shows the caissons shortly after they were poured.

The next step is to form and pour grade beams along the home's footprint. These beams, which

***Diagram E** – Home built on caissons*





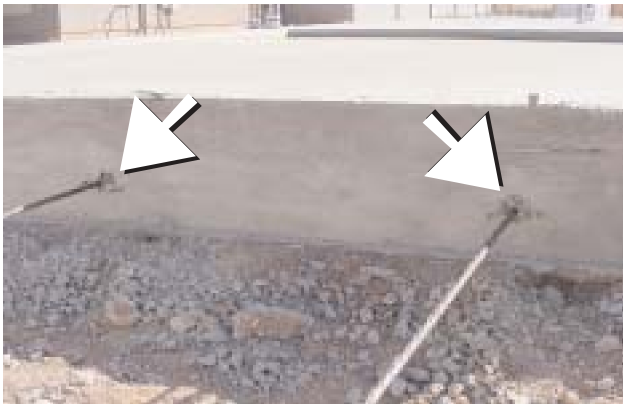
1-04 Caissons shortly after being poured run horizontally from caisson to caisson, are made of ready-mix concrete with reinforcing steel rods. The grade beams look a lot like the perimeter wall foundation discussed earlier, but there is an important difference. The grade beams actually transfer the weight of the home to the caissons. In turn, the caissons transfer the weight to the bedrock.

Because the beams are used in areas with unstable soil, it is important to keep them separated from the soil. To accomplish this, a specific type of material is used. This material often is made of cardboard containing air pockets that give the soil room to expand. In this way, if the soil swells, the compressible material is crushed, but the beams and the home remain intact. One such material is called SureVoid® and is shown in Photo 1-05 (below), between the soil and the bottom of the grade beam .

As noted earlier, a grade beam on caisson foundation can look much like a perimeter wall foundation. If you are unsure about what foundation type you have, consult your qualified home inspector, licensed general contractor or engineer.

Slab-on-Grade Foundations

The term "slab on grade" simply means that a large block of concrete is poured upon the ground and serves as the home's foundation. The positive side of this type of foundation is that it is less expensive than other foundations; the negative side is that you give up the option of a crawl space or basement. With slab on grade, Photo 1-06 (below), the foundation and floor were poured at the same time. This foundation is useful in areas with milder winter climates where frost and soil expansion are unlikely to occur. It also can be a good choice for areas that have high groundwater levels.



1-06 Slab on grade with tensioning cables

1-05 Compressible void material

If the slab is to be used in areas where soil swelling is known to occur, the foundation is reinforced. Reinforcement usually means metal cables or rods are placed in a grid pattern throughout the slab. Photo 1-07 (below) shows the reinforcement materials in place and ready for the concrete pour.

Photo 1-08 (right) shows a home being built on a slab. The reinforcing cables and rods shown in this photo are inside a light blue plastic tube. The tube prevents the cables and rods from bonding to the surrounding concrete when it sets or "cures." After the concrete slab has cured, jacks will be connected to the rods that extend beyond the edge of the slab. These jacks actually pull on the rods and squeeze the concrete slab together. Because the slab is one piece, it can resist cracking when the soil below it shifts or settles. The photo also shows how the plumbing drain, waste lines, and water supply piping extend above the finished slab.

Photo 1-09 (right) shows a similar slab foundation after it was formed and poured.

Just like any foundation, a slab-on-grade foundation must support the weight of the home above. The load-bearing walls are supported utilizing one of two options. The first option is to thicken the areas of the slab to better support the load-bearing walls. As seen in Photo 1-10 (below), the thickened areas are often twice as thick as the rest of the slab.

The second option is to form and pour a separate perimeter wall. After the wall is built, the slab is poured independently inside of the foundation. Photo 1-11 (below) shows a slab-on-grade foundation where the perimeter walls are independent from the floor slab.

Thoughts About Foundations...

Understanding your home's foundation can help you can preserve its strength for years to come. At the end of this chapter, we will detail more steps you can take to protect your home's foundation and other major structures.

1-08 Form work set up for a poured-in-place foundation

1-09 A slab foundation, after it has been formed and poured

1-10 The perimeter may be twice as thick as the rest of the slab

1-07 Form work and tensioning cables ready for concrete pour

1-11 Perimeter wall with the slab independent of the foundation

Section 2: The Floor System—What's Hiding Under The Carpet?

Between the foundation and the carpet, tile, or finished wood that you walk on, there is a floor system. Floor systems come in two general categories: (1) poured-in-place concrete floors (similar to a slab), and (2) floors framed from wood products (such as dimensional lumber or supported by floor trusses). Many homes have both categories, so let's explore further.

Poured-in-Place Concrete Floors

Poured-in-place concrete floors are similar to slab-on-grade foundations. With both methods, the concrete is poured directly on top of compacted gravel or soil. In buildings that have multiple floors, the concrete is poured over some type of reinforcing material. Such materials could include wooden forms or metal "pans," with reinforcing rods and cables.

Many of the home's utilities must be installed beneath the slab before it is poured. Specifically, plumbing drains, waste lines, water pipes, electrical wiring, heating and air conditioning ducts, and other services must be in place.

However, once laid, concrete floors provide a smooth surface for application of floor finishes.

Framed Floor Systems

Most homes have a framed wood floor system. Traditionally, a floor system was made from 2-inch by 8-inch (or 2-inch by 10-inch) wood boards, also known as "dimensional lumber." Wood I-joists or floor trusses also could be used. This floor system, in turn, supported a subfloor made of plywood or oriented strand board (commonly known as OSB). On top of the subfloor, you would have a finished wood floor, tile, carpet, or so on.

Again, time and materials have changed. Now, the floor system often uses laminates of different woods. This is called "engineered lumber." Engineered lumber weighs less than regular lumber and can be installed more quickly. Factory-fabricated trusses also are available, and are being used more and more. Photo 1-12 (below) shows a framed wood floor system using I-joists. Diagram F (right) shows an I-joist.

Photo 1-13 (below) shows the underside of a floor built on fabricated floor trusses. Notice the spaces between the trusses. These spaces allow room for the placement of ducts, electrical wiring, and pipes.

***Diagram F** — Wood I-beam joist*

1-12 Framed wood floor system, using I-joists

1-13 The underside of a floor built on fabricated floor trusses

"Floating" Floors

Historically, basement floors were made by pouring concrete over the soil left exposed after digging the basement. With this method, the basement floor and the basement walls were all connected. In some cases, swelling soil would push up against the bottom of these floors. This resulted in humps in the floor, cracks in interior walls above, and warped door frames.

Today, "floating" has become the solution to swelling soils under the basement floor. A floated floor simply means that the basement floor and the basement walls are independent of each other. The basement walls actually hang from the floor above. Between the basement walls and the basement floor there is a gap of about 1 to 2 inches, Photo 1-14a (below). This space allows the floor to float if soils swell. The walls and the home above are not damaged by the floating floor.

Photo 1-14b (below) shows how even the basement stairs can be floated. Just like the basement walls, the stairs hang from the floor above. The only contact with the basement floor is at the very bottom of the stairs. The point where the stairs meet the landing is hinged, allowing the staircase to adjust itself if the basement floor rises.

Finishing Basements

Planning to finish the basement in your home? Before starting, you will need to check the key structural components. This means knowing what type of soil is under your basement, what type of foundation you have, and the type of floor system that was used. Fortunately, these things often are easy to determine.

First, find out if the basement floor is a wood system or is concrete poured on grade. Next, you need to determine if soil swelling is a concern. A floating staircase in the basement is a good sign that the builder expected the soil to swell. Another sign would be the presence of compressible material under the bottom of any perimeter foundation wall. Check crawl spaces if your basement foundation wall is not exposed. If you have a poured-in-place concrete floor, further questions should be asked about the soil below.

If there is any chance that the soil could swell, then any new walls should be floated. As discussed earlier, it is important for the walls and the floor to be independent of each other. This way, if the soil under the basement floor rises, the floor can rise without cracking the walls and damaging the home above.

1-14a Floating wall hung from the floor above (note support strap and gap at bottom)

1-14b Hinging at the landing above (arrow) allows the staircase to adjust if the basement floor rises

Section 3: Walls—Supporting the Roof and Keeping the Weather Out

Walls are divided into two types: bearing walls and non-bearing walls. Non-bearing walls are also called partition walls.

Bearing Walls

As discussed in the "Overview," bearing walls carry the load (weight) of the home. Most exterior walls on homes are bearing walls because they support the roof above them, as shown in Photo 1-15 (above). Some interior walls also may be bearing walls if they support floors or part of the roof.

If you have an older home, your bearing walls may have been built with brick, stone masonry, or lumber. Today, if a bearing wall is made of masonry material, it is likely to be cinderblocks. Brick is still popular on exterior walls; however, today the brick is more likely to be used as a veneer rather than as a structural component.

Lumber-framed bearing walls are still popular today and commonly use 2-inch by 4-inch or 2-inch by 6-inch boards. However, other options exist. Some home builders now use finger-jointed studs, Photo 1-16 (right). Finger-joined studs are made through a process where shorter lengths of wood are glued together and cured into longer lengths. Finger-jointed studs have the same, or greater, strength as traditional lumber.

A third option for building bearing walls is called "post and beam." Post and beam framing is popular for its ability to allow large areas of glass walls and can provide an open feeling to a living space by allowing expansive ceilings.

Non-Bearing Walls

A non-bearing wall means just that: a wall that does not bear or carry a structural weight, Photo 1-17 (right). It simply acts as a divider or screen to provide privacy or to keep out the weather. Non-bearing walls can be framed with lumber or built of brick, block, steel studs, or stone masonry. Floating walls also fall into the category of non-bearing walls.

1-15 Bearing walls support the roof

1-16 Finger jointed studs

1-17 Non-load bearing wall (note that it does not support the ceiling)

Section 4: The Roof—Keeping a Lid on It All

Roof structures come in two general categories: (1) joist and rafter systems, and (2) factory-fabricated trusses.

Joist and Rafter System

Diagram G (right) shows the first type of roof structure ever used by humans. This is a primitive form of a joist and rafter system.

With a joist and rafter roof, the joists are laid horizontally to provide protection from weather. The joists span from bearing wall to bearing wall. In primitive times, these roofs were flat. However, as humans evolved and mastered geometry, they learned that the triangle was one of the strongest, most efficient shapes for supporting a load, Diagram H (right). A peaked roof was made by raising the joists. Rafters were then added to provide the slope and it became known as the "joist and rafter system," Photo 1-18 (right). The result was not only a strong roof, but also one that helps shed water, snow, etc.

Joist and rafter roofs are still used in many homes that feature distinctive architecture. This type of roof can be used to create cathedral or vaulted ceilings.

Factory-Fabricated Trusses

Not all homeowners want or can afford elaborate architecture. So, many homes are mass-produced and include factory-made materials. One of those materials is the factory-fabricated truss. These trusses are made by joining individual pieces of lumber by sheet metal truss plates. The plates contain hundreds of projecting "claws" that are pressed into the lumber by hydraulic presses. The truss plates effectively bridge each joint and transfer loads from one member to the next. The result is a strong structural element. Photo 1-19 (right) shows manufactured roof trusses in use. Notice the "truss-packs" sitting on the ground waiting to be installed.

***Diagram G** – Flat roof*

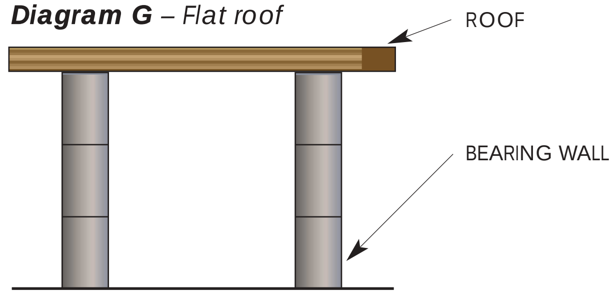
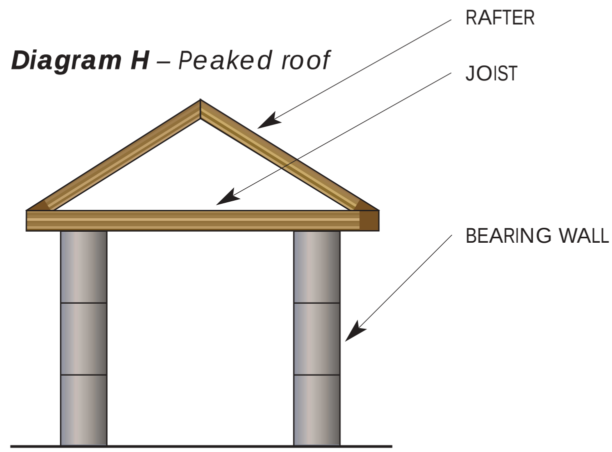


***Diagram H** – Peaked roof*



1-18 Joist and rafter roof structure

1-19 Pre-fabricated roof trusses in use

Section 5: Soil—Its Effect on a Home

As we have stated throughout this chapter, the soil around and below your home can have a major effect on your foundation. Let's look at how the major "soil culprits" (landslide, swelling, shrinking, and settling) can affect your home.

If your home was built on a hillside, more than likely "cut and fill" techniques were used to build a perch for its foundation, Diagram I (right). Cut and fill refers to the process of cutting out the soil from the hill to form part of the platform. Unfortunately, this process could possibly cause a landslide.

Usually, the "cut" portion of the site is very stable, and a home built in this area will not settle. However, the "fill" portion of the site can be quite another story. Because the soil was cut out and moved, it does not compact as it did before excavation. The soil must be manually compacted or else, when it becomes wet, it will settle. In extreme cases, it can slide down the slope.

For these reasons, homes built on cut and fill sites should be monitored, especially during long periods of wet weather. Look for symptoms of settlement over the fill portion of the site. These symptoms might show as vertical cracking in your basement or crawl space walls.

Another issue covered elsewhere in this chapter is swelling soil. Swelling soil can push up concrete, landscaping, and even home foundations. These problems can be avoided with proper design and effective moisture management.

The last, and more common culprit, is soil shrinkage or settlement. This usually occurs where soil has been added or filled, such as around the foundation, Diagram J (right), under driveways and walkways, or in the fill portion of a cut and fill home site. Heavy rainfall, snowmelt, or poor water drainage around the foundation can saturate the soil and cause settlement.

Diagram I *– Cut and fill site*

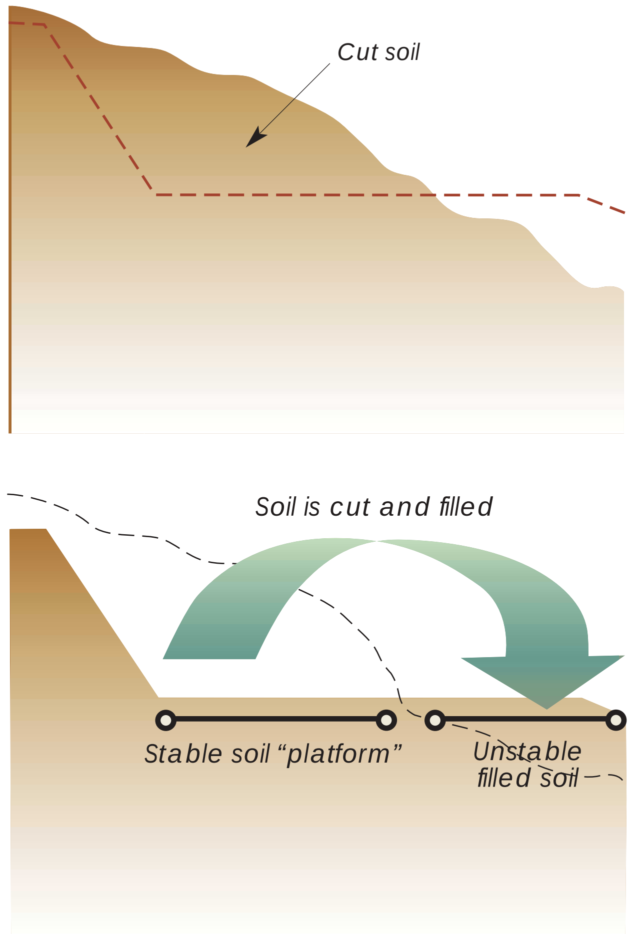
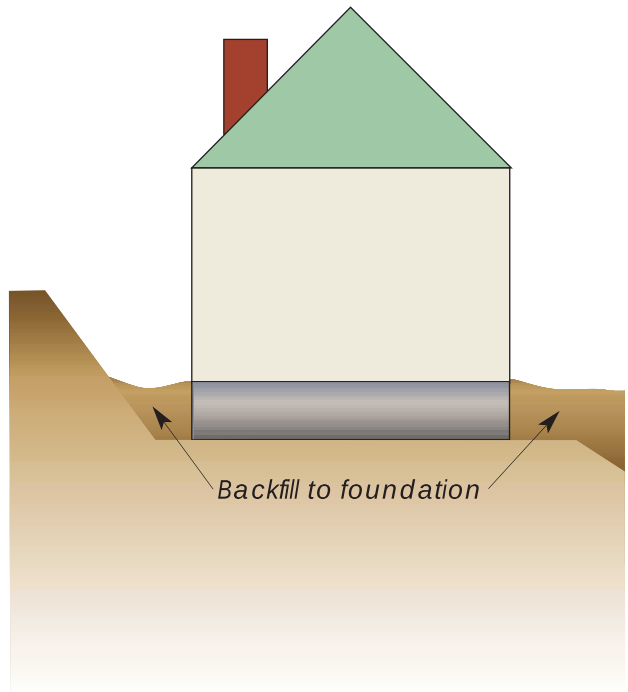


Diagram J *– Shrinkage or settlement*



Section 6: Exterior Moisture—Its Effect on a Home

One important step you can take to prevent foundation damage is to monitor for signs of water in and around your home's structure. Too much moisture can seriously damage your home in several ways, including the following:

- Wood could soften, warp, rot, and even fail.
- The foundation could shift, heave, or settle. This can result in cracked walls, sloping floors, or doors that stick or fail to close.
- Pipes, ductwork, and other equipment could corrode.
- The effectiveness of insulation is reduced.
- Sidewalks and driveways could heave or settle. People could be injured by tripping.
- Personal items kept in a basement or crawl space could be damaged or ruined.
- Harmful molds and mildew could grow. These can cause respiratory illness in some people.

To protect your home, you need to be aware of where and how moisture becomes a problem.

The fact is, 90 percent of moisture problems start on the roof. If the water that hits the roof isn't directed away from the foundation, you could end up with water in the basement or crawl space. That is why a properly designed roof drainage system needs to be a priority in every home.

The drainage system involves gutters, scuppers, and downspouts. Together, they collect water from the roof and move it properly to the ground and away from the foundation. "Properly" is the key word. The water must be properly directed so that it does not pond near the foundation. Water from the roof, water hitting the sides of the home, and even water falling next to the home needs to be channeled away from the foundation. All downspouts should be extended or piped to a discharge well away from the vicinity of the home.

Sloping the ground surrounding the foundation is another good way to properly dispose of water. In general, 1 inch of fall for every foot of distance away from the foundation is sufficient. We recommend that at least the first 6 feet be sloped.

1-20 Swale

1-21 Swale

If your lot does not lend itself to extended slopes away from the home, a system of "swales" can be used to channel the water. Photos 1-20 (left) and 1-21 (left, below) show swales designed to keep water away from the foundations on these homes.

Other drainage systems can be buried when the home is built. These include foundation, French, and curtain drains. Photo 1-22 (right) shows a foundation drain before the backfill is placed. Gravel and rocks channel water extremely well, which is why they are being used here.

These drains channel the water to a sump cavity. The cavity is usually located in a corner of the basement or crawl space. If water collects in the sump, a sump pump can be installed to pump the water out and away from the building. The white pipe in Photo 1-23 (below) is the exterior portion of a sump pump discharge. Notice how the water is discharged well away from the foundation and not into the sewer.

Your roof, as well as your crawl space, can be a haven for moisture. It is important to ventilate both places. Gable, roof, soffit, and ridge vents all help to hold down moisture levels in the attic. Plastic sheeting, foundation vents, and forced circulation can be used to reduce moisture levels in your crawl space.

1-22 Foundation drain

1-23 Exterior portion of sump pump discharge

Section 7: Remember the Following Tips When Evaluating Cracks and Their Structural Symptoms

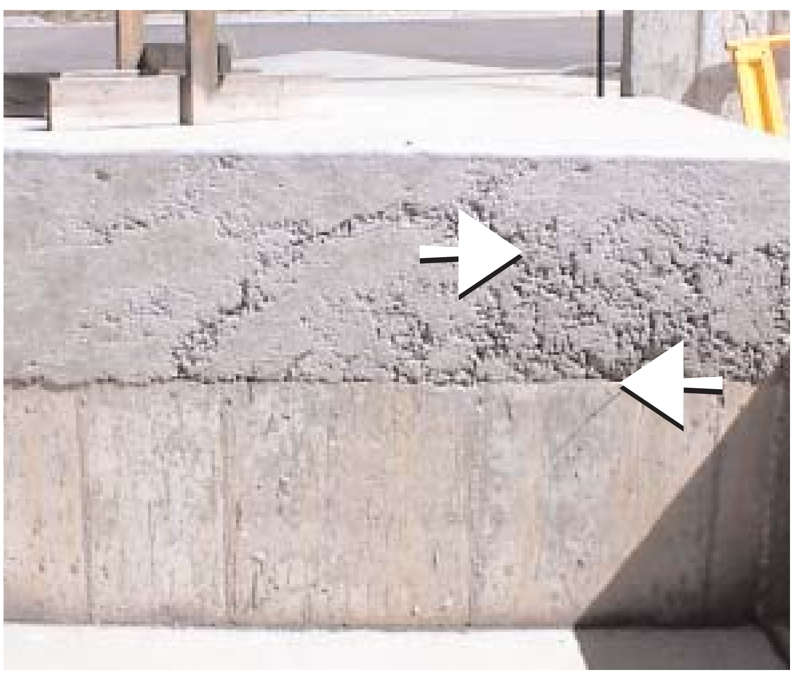
- If you have cracks in your basement or crawl space walls, take note of their direction. If the cracks are small and almost vertical, then they are probably not a cause for concern. However, if they run more horizontally, we recommend consulting a structural engineer.

- Cracks in wood often are not significant if they run parallel to the grain of the wood. These cracks (called "checks") often are the result of the wood drying and shrinking. However, the closer the crack comes to going across the grain, the more serious it could be.

- Hairline cracks in wallboard, plaster or concrete basement walls are usually not a problem unless they are wide and look tapered ("V" cracks). These cracks often radiate out from the corners of window and door openings.

- Voids in concrete foundation walls usually are not serious unless they go deeper than an inch or so. Most of them are a result of inadequate compaction (vibration) of the concrete during placement. If a "rock pocket" allows water to come in from the outside, then we recommend having it filled with injected epoxy or another suitable sealant. Photo 1-24 (below) shows a rock pocket in a harmless location.

- Another feature shown in photo 1-24 (below) is a "cold joint." Cold joints often occur when there has been a substantial delay between the placement of layers of concrete. Usually, a cold joint is not a problem unless it leaks water or shows displacement.



1-24 Cold joint (middle) with rock pockets (above)

Home Protection—Looking Out for Culprits

We end Chapter 1 with a list of symptoms to look for and tips to follow to protect your home's structure. If you spot any of these symptoms, we recommend consulting a qualified home inspector or other expert and following their advice.

Start by Looking at Your Home and Ask the Following Questions

If you answer "yes" to any of the following questions, then there could be evidence of a structural problem (past, present, or in the making).

- Are there any sags in the roofline or in individual rafters?
- Has any part of your roof system cracked or been cut? Cutting out parts of a ceiling to install a whole house fan, or a pull down access stair, is a common and costly error.
- Do your walls have any cracks more than 1/16th inch across? If so, are they are "V" shaped and tapered from closed to wide along their length?
- Do your floors slope noticeably?
- Do your doors close poorly or do they hit their frames?
- Are there moisture stains on ceilings, walls, or floors ANYWHERE IN THE HOUSE?
- Do you feel high levels of humidity under the house or in the attic?

Chapter 1 Conclusion

We hope the information in Chapter 1 has been valuable to you. Understanding your home's structure, and the threats to it, is the best way to prevent costly repairs. Remember that moisture is not a friend to your home's structure. Make sure you keep water away from the foundation and moisture out of your attic and crawl space. By taking these simple, but vital steps, you will be protecting your home—and your investment.

In Chapter 2, we will take a closer look at your home's roof and "weather shell."