FOUNDATION REPLACEMENT

BY GREG CASORSO

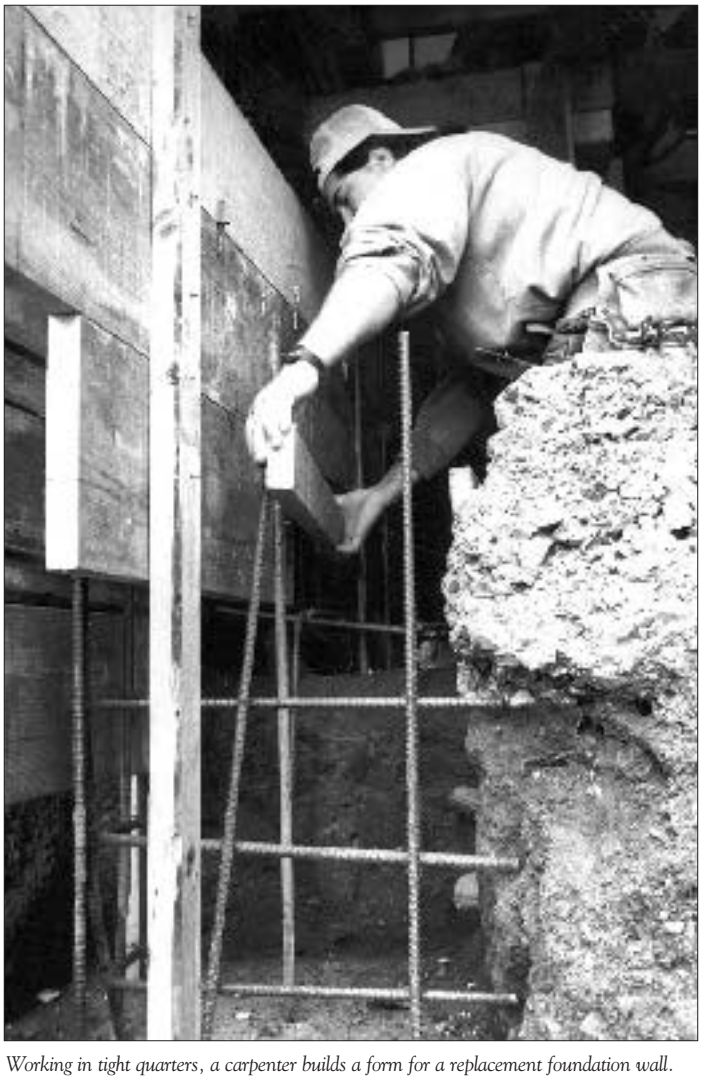
A large part of my business as a foundation contractor in northern California is replacing foundations. Many of these foundations are intact, but are built of unreinforced masonry that is inadequate to support future loads from expected earthquakes or a major renovation. The foundation may already show signs of distress, whether it is from seismic activity or just bad drainage. This distress often shows up when siding is pushed out of plumb and cripple-wall studs no longer bear on the concrete, because the foundation has "rolled" (Figure 1, next page). In other cases, a grade beam may be cracked into separate pieces in several locations. Such problems justify the replacement of the distressed section of foundation. In this article I will describe some of the methods I use to complete such a job.

A Word About Business

Foundation replacements are viewed by all parties involved as a big deal, and require careful negotiation. I often find myself in the position of mediator. Owners often express frustration because the contractors, engineers, and architects present conflicting opinions about the extent of damage and propose wide-ranging solutions from epoxy repair for a few cracks to replacing entire foundations. Coordinating the efforts of these three parties is essential to producing an accurate estimate.

I make it a rule to always get engineering input and guidance before presenting an estimate, even if engineering is not required. By working closely with a structural engineer, and a soils engineer when needed, I spare the client a lot of confusion and am better able to balance the owner's needs against structural priorities. If an engineer and architect have already been engaged, I make a point to get involved as early as possible to influence the final solutions.

Also, before presenting an estimate I make sure to take the time to listen to the owner. Often the owner has already fully investigated the project, and has interviewed several engineers, architects, and a couple of other contractors, and is fully aware of the scope of work and has a reasonable idea of the cost involved.



Working in tight quarters, a carpenter builds a form for a replacement foundation wall.

Evaluating The Damage

When scoping out an old foundation, there are two questions I must answer before I can decide what part of the foundation, if any, needs replacing: (1) What is the cause of the failure? (2) What is the full extent of the damage?

No foundation can simply be repaired without considering the cause of failure. Is there adequate drainage around the house? What are the soil and ground water conditions near the house? Is the existing concrete reinforced? What are the forces that come to bear on the structure? How will these forces change over time? These are all questions that must be considered before work proceeds.

In the course of scoping out the work, I need to separate major from minor repairs (see "Minor Foundation Repairs," page 21). First, I consider where the damage is located. In general, a perimeter wall is structurally more critical than footings or grade beams within the footprint of the building. Corners of buildings are very critical. Sections downhill or near a slope are usually weaker than sections on level ground. Retaining walls often support a structure directly or hold back earth that threatens a structure, and must be included in the work.

Also, it's important to look beyond the immediate problem. When a foundation cracks, the crack itself is often not as important as the effect the cracking has on the rest of the house. Are the walls out of plumb? Are the floors noticeably out of level? Do the doors and windows function properly? Is there massive stucco cracking on the exterior? Is there significant drywall or plaster cracking inside? Is the trim work coming apart? Are tile or hardwood floors opening up? Are cabinets separating from the walls? These are all signs of possible foundation failure.

A lot of the major foundation repair I do is combined with extensive renovations to the house, and the scope of my work is often defined by the renovation design. For instance, a bad section of foundation may not have to be replaced if a new foundation in a different location can easily pick up the building load.

Demolition And Excavation

If I have to remove a foundation, I begin by excavating to fully expose both the interior and exterior foundation walls. I also deliberately exca-

SAFE FOUNDATION REPAIRS REQUIRE SMART SCHEDULING, STURDY SHORING, AND A LOT OF BRUTE FORCE

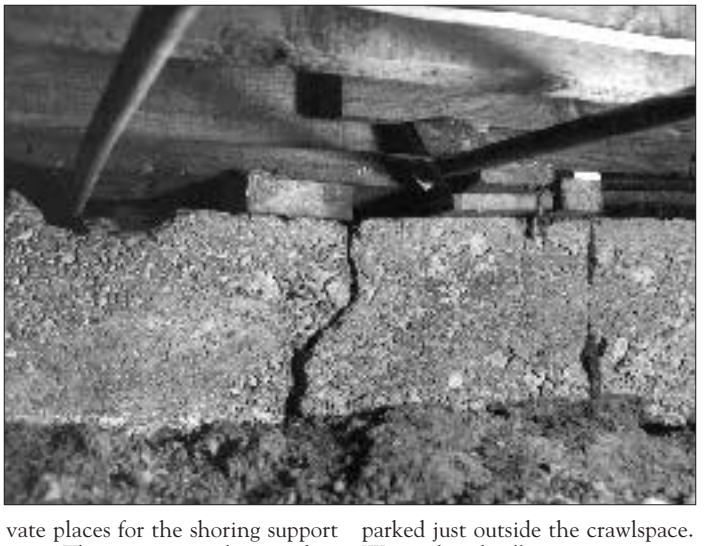


Figure 1. ***Signs of trouble.*** *Unreinforced concrete foundations often fail, either from seismic activity or poor drainage. Hydrostatic pressure has caused this stemwall foundation (left) to tilt outward, pushing out the bottom courses of siding. This grade beam (below) has separated into sections, possibly as the result of earthquake. The damage in both cases is beyond repair; the foundation sections must be replaced.*

vate places for the shoring support posts. These posts must bear on firm soil very near to the level that will be excavated for the new foundation. If you don't do this, the house could settle. Also, I think through the future construction and working access so the shoring and trenching don't create unworkable obstacles.

When I scope out the job, I make note of the condition of the concrete. A lot of the foundations we work on can be removed with a claw hammer. Many old brick and mortar foundations in our area have decomposed to a powdery state, and some older concrete foundations have been poured with such a "weak mix" that removal is not that difficult. Other foundations might need a jackhammer to demolish.

Retrofit concrete work requires a crew that has both finesse and brute force. Excavation requires more of the latter. We usually shovel dirt into 5-gallon plastic buckets, and dump these into wheelbarrows parked just outside the crawlspace. We tip the wheelbarrows into a container via a wooden chute or ramp.

Take time to make your excavation wider and deeper than you think you need. Working underneath a house with restricted access and moving dirt around in buckets is no one's idea of a good time. But the better you prepare the access, the faster the work will proceed later. One note of caution while excavating: Often old utilities can be buried in the foundation, so dig and jackhammer with care (see "A Cautionary Clause," page 22).

Excavation is further complicated by jobs in congested urban areas. Remember that the container, your truck, employees' vehicles, and supply vehicles can all take up scarce neighborhood parking space. Try to minimize this impact.

One of the costliest aspects of the job can be the dirt removal. Demolition, excavation, loading, and dirt removal and disposal

MINOR FOUNDATION REPAIRS

About half of the jobs I do are minor retrofits and repairs. Many of these don't involve any structural concerns, but they are unsightly to an owner. These include:

Sill replacement. Many problems that are diagnosed by a homeowner as a foundation failure have nothing to do with the concrete, but are framing failures. Sills below grade are usually rotten and must be replaced. Much of the work can be done in sections with only minimal shoring. Besides the carpentry, the main cost of such a project is in excavating and regrading.

Small localized cracking. I don't get too excited over one crack up to about 1/8 inch in width. But if foundation cracks are pervasive, or the cracks are larger than 1/4 inch wide, then there might be serious structural problems that require a full or partial replacement.

Epoxy injection is often a sufficient fix for small cracks (see "Epoxy Concrete Repair," 12/92). Keep in mind that, while epoxy forms a strong bond when applied properly, it is primarily an aesthetic fix or is intended to seal the crack against water. It can also serve as a useful gauge when the extent of damage is not immediately obvious. If a crack returns after it has been sealed with epoxy, I have strong reason to suspect a serious structural problem.

If additional reinforcement is needed, I often sister a concrete bond beam inside the foundation. To bond the old work to the new, we epoxy rebar dowels into the existing foundation before the pour.

Short replacement. A more expensive foundation crack repair than epoxy injection or pouring a bond beam is a short replacement. This involves jackhammering out a section of the foundation on either side of the crack and pouring a new foundation. All of this work is done much like a major replacement, but requires less shoring, depending on the amount of foundation to be replaced. To tie the new work to the old, we epoxy rebar dowels into the old concrete before pouring the new concrete.

Post and girder problems. Often, posts that support a girder are out of plumb or missing, or the post may have separated from the pier or beam. While this looks alarming to many homeowners, this is a minor and inexpensive problem to repair. Usually a few men can remove, excavate, and recast new pier footings, and replace the posts in just a few days for an average size home.

In extremely poor soil conditions, more work might be required to stabilize the post and girder system. Highly expansive soil heaves up and down with the seasons and can cause all kinds of problems on a house's interior. An exterior perimeter drainage system can be installed to help keep water away from the piers. If this doesn't keep the water away, deep drilled piers have to be installed, which is expensive.

Seismic reinforcement. Older concrete foundations aren't anywhere near the quality of new, well-built foundations. However, the structural deficiency is often not in the concrete itself, but in the connection of the framing to the concrete. Generally speaking, foundations do not crumble or disintegrate in earthquakes. Instead, the structure jumps or slides off the foundation.

Anchor bolts might need to be retrofitted, or wood framing with rot or beetle infestation might need to be replaced to strengthen this connection. This work is frequently minor unless the rot is extensive.

Capping or saddling. A concrete "cap" or "saddle" is often poured over the existing foundation. This work is usually done in escrow to clear a termite report and allow loan approval. It is important to understand that the structural part of the foundation isn't much improved. The strength of the new work relies on the integrity of the existing footing, which is usually marginal at best, or else it wouldn't have needed to be repaired. However, capping can solve an earth-to-wood contact problem by raising the concrete elevation.

Foundation releveling. In most cases, out-of-level floors are symptoms of structural failure. If the floors are simply releveled without addressing the cause, the problem will occur again within a year or two. — G.C.

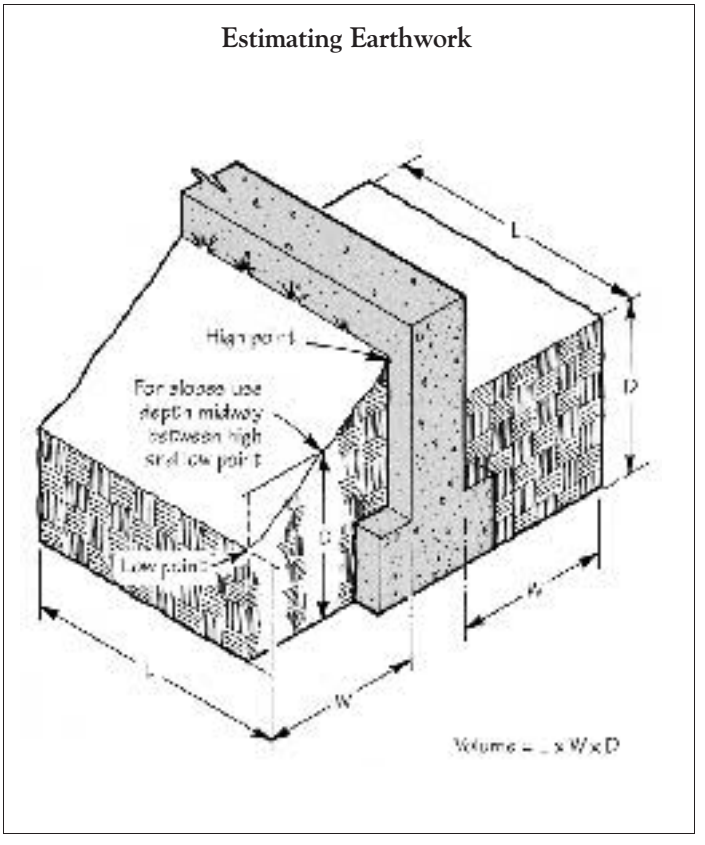


Figure 2. ***When calculating the volume of sloped earth,*** *measure the depth of the cut midway between the high point and the low point of the slope.*

A CAUTIONARY CLAUSE

Not long ago, we were replacing a concrete garage that was set into the hillside below a house. As one of my crew members was jackhammering the wall, he hit a steel pipe, which turned out to be the gas line into the house! Fortunately, no sparks were created as the line was ruptured, and we managed to get the line turned off without first causing an explosion. This experience was a good reminder of what can happen when mucking around with old concrete and mechanical systems. Potential hazards exist with all plumbing, electrical, and fuel lines running into the house.

When presenting a client with a contract, I spell out how an inadvertent rupture of a mechanical system should be handled, using the clause below. So far this has cleared up client concerns, and provided a way to deal with these contingencies.

— G.C.

> Oftentimes in older structures, the plumbing, electrical, or mechanical systems are fragile. Even though my crew is experienced and careful, we often cause an existing fragile condition to rupture or become worse. For example, a pipe may break, an electrical circuit may short out, or a duct may have to be taken apart that is too corroded to put back together. These frustrations are simply part of the job when working on older buildings. I agree to repair any utilities which may inadvertently be damaged during the course of my work. However, if the damage cannot be repaired but must be replaced (for example, if a pipe breaks that is so old and deteriorated that fittings cannot be installed but all or a section of the pipe has to be replaced) then an extra-cost item of work is justified even if the problem was caused by my work activities. This assumes the absence of negligence or fraud on my part.

account for at least 35% of the job cost. This can cost as much as $50,000 for a large foundation replacement, so you don't want to get caught underestimating the volume of dirt, rubble, and concrete you have to haul. The volume is always much larger than you think. Dirt becomes entrained with air as you dig, causing the volume of the now loose dirt to swell, usually at least by half.

Even large, commercial grading contractors have a very difficult time estimating volumes of dirt. In 12 years of experience and many conversations with my colleagues, I have learned to estimate the volume in this way: Calculate the volume of *embankment dirt* — the compacted dirt you need to remove — as carefully as possible. Work from measurements of the area you will excavate and a good understanding of the depth you need. Compensate for slope by taking the midpoint between your low point and your high point for the depth in your volume calculation (Figure 2). When you're sure you know this volume, and have checked your calculations carefully, double the amount to find your *loose yardage*. This is not excessive. Do not shortchange yourself in this area. It can be an expensive mistake.

Shoring

Having a house up on temporary post-and-beam shoring is a nerve-wracking part of the job, so you want to make the shoring as strong as possible. Then pour the new concrete as quickly as possible.

The key at this stage of the job is aggressive organization. I get formwork, rebar, new mudsills, anchor bolts, hold-down bolts, and any other materials on site, ready for installation. I get inspections scheduled ahead of time, so I won't have a several-day delay waiting for an inspection. I also schedule the concrete truck and pumper a few days ahead. This limits the time that the house is supported by shoring.

The shoring process is frightening to the inexperienced, but it is actually more straightforward than most people realize. However, my work does not involve lifting a house clear of the foundation and supporting it with large steel I-beams and timber cribbing. For this work you want a "house mover," as listed in the Yellow Pages. In my work I only have to support the house at the level it sits, remove the deteriorated foundation from underneath it, and build a new structure to the height of the old. Most of the time the replacement work is done in sections to allow for access, so the house is seldom supported by shoring alone.

I typically use 4x6 Douglas-fir timbers for the support beam and 4x4s for posts. For large, heavy buildings — two stories or more

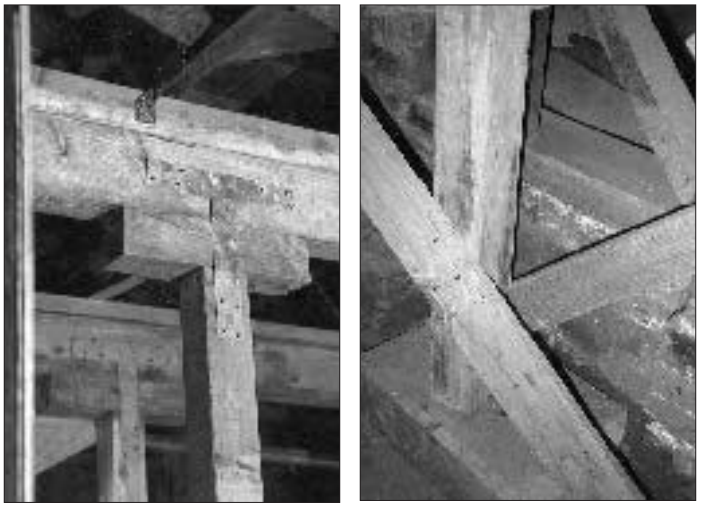


Figure 3. *Shoring details.* *The author uses 4x6 girders and 4x4 posts to support the building before demolishing the old foundation. He snugs the posts into place with wedges cut from 4x4s, nails them in place with duplex nails, then reinforces the whole connection with a metal T (left). At the base, the posts rest on 8x8 blocks that have been sandwiched between 3/4-inch plywood (right). This prevents the wood from splitting as it takes on and loses ground moisture.*

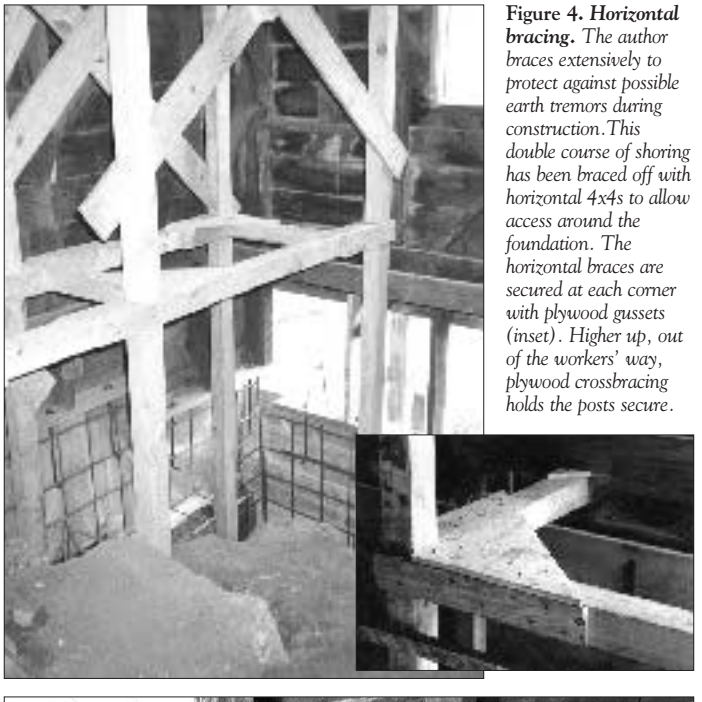


Figure 4. *Horizontal bracing.* *The author braces extensively to protect against possible earth tremors during construction. This double course of shoring has been braced off with horizontal 4x4s to allow access around the foundation. The horizontal braces are secured at each corner with plywood gussets (inset). Higher up, out of the workers' way, plywood crossbracing holds the posts secure.*

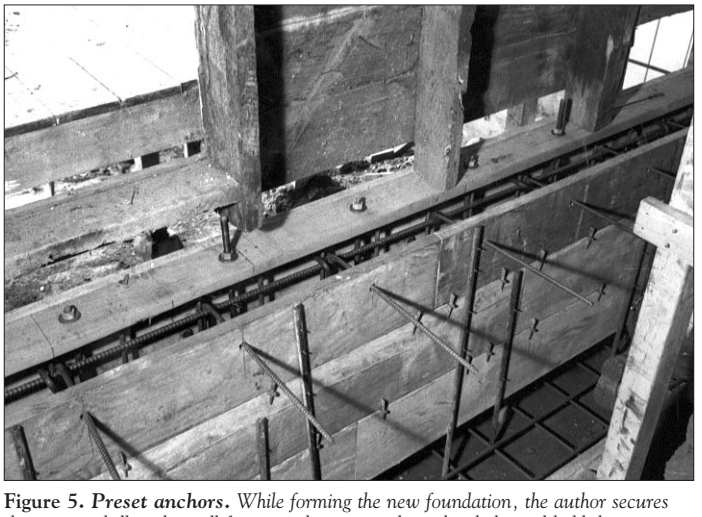


Figure 5. *Preset anchors.* *While forming the new foundation, the author secures the new mudsill to the wall framing, then suspends anchor bolts and hold-downs as needed. The space between the mudsill and the form allows room for the concrete pump hose during the pour.*

with a tile roof — I will use 6x6 posts and beams.

Setting the beams. I set posts every 4 or 5 feet on-center. I use screw jacks and 4x4s to initially set the beam in place. Then I clip the beam to the floor joists using Simpson H3 hurricane ties with 8d duplex nails.

Typically, the beam sits perpendicular to the joists and about 24 inches inside the foundation. We try to avoid extending the end of the beam through the foundation. However, if we are replacing the foundation on the side of the house that runs parallel to the joists, we often don't have a choice. In this case, we have to form a pocket in the new foundation around the temporary beam. We wrap our rebar around the bottom of the pocket to create continuous reinforcement in the top section of the new foundation. After the concrete has set and the beam is removed, we simply patch in the pocket (no rebar needed) with a small, site-mixed batch of concrete.

Setting the posts. Once the beam is positioned on our initial 4x4s and clipped into place, we set all the support posts on heavy timber blocks laid flat. I typically use blocks about 8x8x18, which tend to split or curl as they dry. To prevent this, I sandwich the block between two pieces of 3/4-inch plywood. We set each block on firm ground that won't be undermined when the foundation is removed.

The tricky part is setting the posts. You want to lift the house ever so slightly so that the post is bearing, but you don't want to lift it so much that you cause cracking to the interior wall surfaces. I use a 20-ton screw jack to lift the house 3/8 inch. Then I set the shoring post, release the jack, and repeat this process with each post. After all the posts are set, I cut the nails between the existing joists and the mudsill. If there is a slight separation, this indicates that your shoring is actually working and gives you the confidence to begin removing the existing foundation.

There are a few tricks to actually setting the shoring posts in place. I cut my posts about 3 inches short. Then between the top of the post and the bottom of the beam I use 4x4 wedges (Figure 3). These wedges are nothing more than 16-inch-long 4x4s cut diagonally. We beat them in place with a sledge. Pounded together against each other, these wedges develop a surprising uplift force that, combined with the jack, is sufficient to get the lift we need. Also, all the posts can be precut because the wedges can give you the needed adjustment in height, and you don't have to beat any one post in place, which might force a previous post out of position.

Once all the posts are in place, we go back and snug all the wedges firm and toenail them into the beam to prevent them from backing out of position. Finally, we connect the post to the beam using an appropriately sized Simpson T-strap or a pair of plywood cleats. All nailing is done with duplex nails to ease removal at the end of the job. Make sure all connection points are firmly seated and nailed in place — you don't want to build a house of cards.

Bracing. All posts must be laterally braced. My primary concern when bracing is lateral resistance to earthquakes, not the vertical load of the existing house. I've become so worried about earthquakes during the course of work that I run a double course of shoring whenever possible. This enables me to brace my posts in both directions with 4x4s and plywood gussets (Figure 4). I aim for the structure to be better supported during the course of construction than before I began work, which is really a very inexpensive way to sleep well at night.

When I have room for only a single line of shoring, I cross-brace with strips of plywood. I used to use 1x6s, but I feel that splitting along the grain at each end might allow the connection to slip.

Unfortunately, lateral bracing makes moving around the work area very difficult, so we try to get as much of the digging done as possible before we brace. Again, use duplex nails so that you can easily remove bracing if you need access.

Forming, Pouring, and Backfill

After the shoring is completed and the old foundation is removed, forming the new foundation is easy by comparison. We start by nailing a new pressure-treated mudsill under the joist and then set all formwork and rebar. We position anchor bolts and hold-down bolts directly in the mudsill and provide any utility openings we need (Figure 5). With the mudsill in place, you have to make sure the formwork is wide enough to allow for concrete placement. With a 2x6 mudsill, I usually cast a 10-inch-wide stemwall to allow a 4 1/2-inch opening for the concrete hose. Just before the concrete arrives, I vacuum the bottom of the trenches to remove any dirt clods that have fallen in.

As we pour the concrete, we work it in by hand to get it underneath the mudsill with full bearing. This is an easy place for air pockets and large voids to occur.

After the concrete is poured, we wait about a week before removing the shoring. Then we are ready for backfill. This is the time to ensure that proper perimeter drainage is in place, including suitable porous backfill. We also make sure the grade slopes away from the house at a 2% pitch. ■

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