Building a Block Foundation

How to pour the footing and lay the concrete block, and what to do about waterproofing, drainage and insulation

by Dick Kreh

Foundation walls are often the most neglected part of a structure. But they are actually the most structurally important element of a house. They support the weight of the building by distributing its entire load over a large area. Apart from structural requirements, foundations have to be waterproofed, insulated and properly drained.

Although the depth of a foundation wall may vary according to the specific needs of the site or building, the footings must always be below the frost line. If they're not, the foundation will heave in cold weather as the frozen earth swells, and then settle in warm weather when the ground softens. This shifting can crack foundations, rack framing, and make for wavy floors and sagging roofs.

Concrete blocks are composed of portland cement, a fine aggregate and water. They have been a popular choice for foundations because they're not too expensive, they go up in a straightforward way, and they're available everywhere. Block foundations provide adequate compressive strength and resistance to fire and moisture. They don't require formwork, and they're not expensive to maintain.

All standard blocks are 8 in. high and 16 in. long—including the usual ⅜-in. thick mortar head and bed joints. But they come in different widths. The size given for a block always refers to its width. The size you need depends on the vertical loads and lateral stresses that the wall will have to withstand, but as a rule, most concrete-block foundations are built of 10-in. or 12-in. block.

Footings—After the foundation area has been laid out and excavated, the concrete footings are poured. Footings should be about twice as wide as the block wall they will support. A 12-in. concrete-block foundation wall, for example, should have a 24-in. wide footing. The average depth for the footing, unless there is a special problem, is 8 in.

Concrete footings for homes or small struc-

Chalklines snapped on the cured footing guide the masons in laying up the first course of concrete block for a foundation wall. The blocks are stacked around the site to minimize legwork, yet allow the masons enough room to work comfortably.

tures need a compressive strength of 2,500 pounds per square inch (psi). You can order a footing mix either by specifying a five-bag mix, which means that there are five bags of portland cement to each cubic yard, or by asking for a prescription mix—one that is ordered by giving a psi rating. Some architects and local building codes require you to state the prescription mix when you order. Either way, footing concrete is a little less expensive than regular finishing concrete, which usually contains at least six bags of portland cement to the cubic yard. The six-bag mix is richer and easier to trowel, but isn't needed for most footings. For more on mixing and ordering concrete, see *FHB* #13, pp. 28-35.

There are two types of footings—trench footings and formed footings. If the area where the walls are to be built is relatively free of rock, the simplest solution is to dig a trench, and use it as a form. Keep the top of the concrete footings level by driving short lengths of rebar to the proper elevation. Don't use wooden stakes because later they'll rot and leave voids in your footing. You'll need a transit level or water level to get the rods at the right height. After you install the level rods even with the top of the proposed footing, pour concrete in the trench, and trowel it flush with the tops of the rods. Some building codes require that these stakes be removed before the concrete sets up.

If the ground is rocky, you may have to set up wooden forms and brace them for the pour. I've saved some money in this situation by ordering the floor joists for the first floor and using them to build the forms. This won't damage the joists and will save you a lot of money. When the concrete has set, I remove the boards and clean them off with a wire brush and water. The sooner you remove the forms, the easier it will be to clean them.

After the footings have cured for at least 24 hours, drive nails at the corners of the foundation. To find the corner points, use a transit level or drop a plumb line from the layout lines that are strung to your batter boards at the top of the foundation (for more on laying out a foundation, see *FHB* #11, pp. 26-28). Next, snap a chalkline between the corner nails on the footings to mark the wall lines. Stack the blocks around the inside of the foundation. Leave at least 2 ft. of working space between the footing and your stacks of block. Also, allow room for a traffic lane so the workers can get back and forth with mortar and scaffolding.

Mortar mix for block—For the average block foundation, use masonry cement, which is sold in 70-lb. bags. You have to supply sand and water. Masonry cement is made by many companies. Brand name doesn't matter much, but you will need to choose between mixes of different strength. The average strength, for general masonry work, is universally classified as Type N. Unless you ask for a special type, you'll always get Type N. I get Type N masonry cement unless there is a severe moisture condition or stress, in which case I would use Type M, which is much stronger. The correct proportions of sand and water are important to get full-strength mortar. Like concrete, mortar reaches testing strength in 28 days, under normal weather conditions.

To mix the mortar, use one part masonry cement to three parts sand, with enough water to blend the ingredients into a workable mixture. Mortar for concrete block should be a little stiffer than for brickwork, because of the greater weight of the blocks. You will have to experiment a little to get it right. The mortar must be able to support the weight of the block without sinking.

The mixing water should be reasonably clean and free from mud, silt or organic matter. Drinking water makes good mortar. Order washed building sand from your supplier. It's sold by the ton.

The following will help you estimate the amount of mortar you'll need: One bag of masonry cement when mixed with sand and water will lay about 28 concrete blocks. Eight bags of masonry cement, on the average, will require one ton of building sand. Remember that if you have the sand dumped on the ground, some will be lost since you can't pick it all up with the shovel. For each three tons, allow about a half-ton for waste.

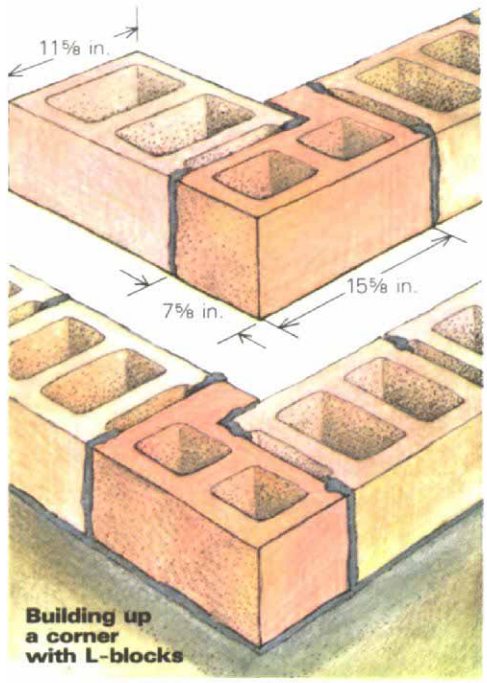
Laying out the first course—Assuming the footing is level, begin by troweling down a bed of mortar and laying one block on the corner. Tap it down until it is the correct height (8 in.), level and plumb.

A block wall built of either 10-in. or 12-in. block requires a special L-shaped corner block, which will bond half over the one beneath. The point is to avoid a continuous vertical mortar joint at the corner. Now lay the adjoining block. It will fit against the L-shaped corner block, forming the correct half-bond, as shown in the drawing and photo at right.

When the second L-shaped corner block is laid over the one beneath in the opposite direction, the bond of the wall is established. On each succeeding course the L corner block will be reversed.

Once the first corner is laid out, measure the first course out to the opposite corner. It's best for the entire course to be laid in whole blocks. You can do this simply by using a steel tape, marking off increments of 48 in., which is three blocks including their mortar head joints. Or you can slide a 4-ft. level along the footing and mark off 48-in. lengths. In some cases, of course, dimensions will require your using a partial block in each course, but it's best to avoid this wherever possible. If a piece of block must be used, lay it in the center of the wall or where a window or partition will be, so it is not as noticeable. After the bond is marked on the footing, a block is laid on the opposite corner and also lined up. Then you attach a mason's line to the outside corner and run it to the opposite corner point. This is called "ranging" the wall.

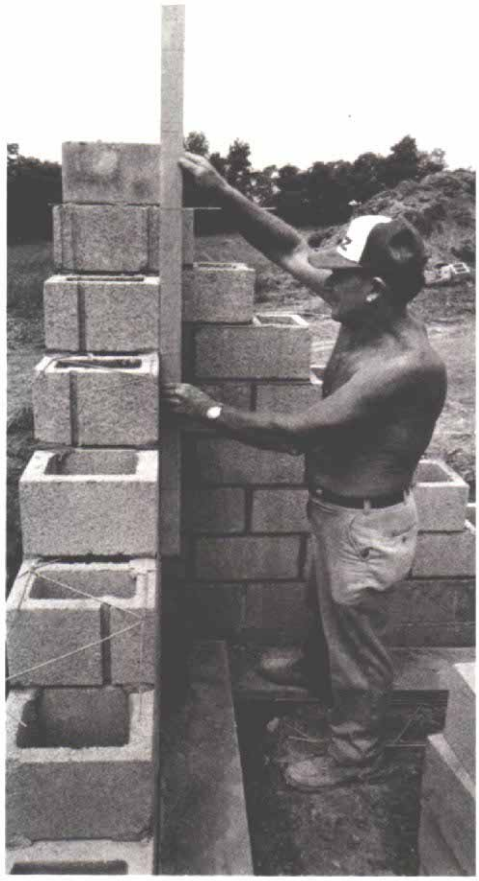
Sometimes there are steps in the footings because of a changing grade line. The lowest areas should always be built up first to a point



Building up a corner with L-blocks

Laying the first course begins at the corners. Once the four corners are laid and aligned, the entire bottom course is laid directly atop the footing. Most foundation walls are built from block 10 in. or 12 in. wide, and special L-shaped corner blocks, like the one shown here, have to be ordered. Only 8-in. wide blocks can be laid up without L-shaped corner blocks.

Illustrations: Christopher Clapp



where a level, continuous course of block runs through from one corner to the other. Steps in footings should be in increments of 8 in. so that courses of block work out evenly.

After one course of block is laid completely around the foundation to establish the bond and wall lines, it's time to build up the four corners. But before you begin laying block, you should make a story pole, sometimes called a course rod. Do this by selecting a fairly straight wooden pole and marking it off every 8 in. from the bottom to the height of the top of the foundation wall.

Any special elevations or features, such as window heads, door heads, sills and beam pockets, should be marked on the pole to coincide with the 8-in. increments wherever possible. After checking all your pencil marks, make them permanent by kerfing the pole lightly with a saw. Then cut the pole off even with the top of the foundation wall and number the courses of block from the bottom to the top so you don't find yourself using it upside down.

Now you can start laying up the corners so that you end up with only one block at the level of the top course. Successive courses are racked back half a block shorter than the previous ones (photo top left), so trowel on only enough mortar to bed the blocks in a given course. If the local code or your specifications call for using wire reinforcement in the joints, leave at least 6 in. of wire extending over the block. At the corners, cut one strand of the wire, and bend the other at 90°, rather than butting two sections together and having a break in the reinforcement.

Check the height of the blockwork periodically with the story pole. The courses of block should line up even with the kerfs. Once the corners are laid up, you can begin to fill in the wall between. Keep the courses level by laying them to a line stretched between the corners. Keep the corners plumb by checking every course with a spirit level.

Using manufactured corner poles—So far, I've described laying a foundation using the traditional method of leveling and plumbing. But in recent years, manufactured metal corner-pole guides have become popular with builders. They guide the laying up of each course and require less skill than the old way. They work like this. The corner poles are set on the wall once the first course of block is laid out. They are plumbed, then braced in position. Each pole has course heights engraved on it. Line blocks are attached to the poles on opposite corners at the desired course height, and the wall is laid to the line. There is no doubt that the use of manufactured corner-pole guides has increased the mason's productivity without adversely affecting the quality of the work.

After the first course is laid, the corners are built up to the topmost course. Above left, a mason checks course heights against a story pole, which is graduated in 8-in. Increments.

Reinforced concrete lintels, left, are used to tie the main foundation to walls that are laid at a higher level, such as porch foundations or garage walls.

If you have to tie a porch or garage wall into a main foundation at a higher elevation, lay a concrete-block lintel in mortar from the corner of the wall being built to the footing at the higher elevation (photo bottom left). Then lay blocks on the lintel to form the wall. This saves time and materials in an area that doesn't require a full-basement foundation.

Stepping the wall at grade line—As you build up to the natural grade line of the earth, you can set the front of the wall back about 4 in. to form a shelf for a brick veneer, if the plans call for it. This is done by switching to narrower block—from 12-in. block to 8-in. block, or from 10-in. block to 6-in. block. The inside of the wall stays in the same plane.

Making the last course solid—On some jobs, specifications require that the last course of block be solid to help distribute the weight of the structure above and to close off the holes. You need only grout the voids in the top course of block. Broken bits of block wedged into the voids in the course below will keep the concrete from falling through. The sill plates will rest on this top course, and the floor joists on top of the plate.

The sill plate has to be bolted down to the top of the foundation wall. So you have to grout anchor bolts into the top of the wall every 4 ft. or 5 ft. These bolts should have an L-bend on the bottom and be mortared in fully so they don't pull out when the nut is tightened against the sill plate. They should extend about 2 in. out of the top of the wall. In some parts of the country, building codes require that the walls include a steel-reinforced, poured-in-place concrete bond beam in every fourth course.

Waterproofing the foundation—The traditional method of waterproofing a concrete block foundation is to parge (stucco) on two coats of mortar and then to apply a tar compound on top of that. This double protection works well, unless there is a severe drainage problem, and the soil is liable to hold a lot of water for a long time.

There are various mortar mixes you can use to parge the foundation. I recommend using a mix of one part portland cement to one-half part hydrated lime to three parts washed sand. This is a little richer than standard masonry cement and is known as type S mortar. The mix should be plastic or workable enough to trowel on the wall freely. Many mortars on the market that have waterproofers in them are all right to use. However, no two builders I know seem to agree on a mix, and most have worked out their own formulas.

Prepare the foundation wall for parging by scraping off mortar drips left on the block. Next, dampen the wall with a fine spray of water from a garden hose or a tank-type garden sprayer. Don't soak the wall, just moisten it. This prevents the parging mortar from drying

Photos: Dick Kreh

Troweling technique

Laying up concrete blocks with speed and precision takes a lot of practice. But it's chiefly a matter of learning several tricks, developing trowel skins and performing repetitive motions for several days. A journeyman mason can lay an average of 200 10-in. or 12-in. blocks in eight hours. A non-professional, working carefully and after practicing the techniques shown here, ought to be able to lay half that many. If you've never laid block before, what follows will show you the basic steps involved in laying up a block wall.

1. First, mix the mortar to the correct stiffness to support the weight of the block. Then apply mortar for the bed joints by picking up a trowelful from the mortarboard and setting it on the trowel with a downward jar of the wrist. Then swipe the mortar onto the outside edges of the top of the block with a quick downward motion, as shown.

2. Apply the mortar bead joint pretty much the same way. Set the block on its end, pick up some mortar on the trowel, set it on the trowel with a downward jerk and then swipe it on the top edges of the block (both sides).

3. After buttering both edges of the block with mortar, press the inside edge of the mortar in the head joints down at an angle. This, prevents the mortar from failing off when the block is picked up and laid in the wall.

4. Lay the block on the mortar bed close to the line, tapping down with the Made of the trowel until the block is level with the top edge of the line. Tap the block in the center so you won't chip and smear the face with mortar. Use a hammer if the block does not settle easily into place.

5. The mortar in the head joint should squeeze out to form a full joint at the edge if you've buttered it right. The face of the block should be laid about 1/16 in. back from the line to keep the wall from bowing out. You can judge this by eyeballing a little light between the line and the block.

6. Remove the excess mortar that's oozing out Of the joint with the trowel held slightly at an angle so you don't smear the face of the block with mud. Return the excess mortar to the mortarboard.

Check the height of the blockwork by holding the story pole on the base and reading the figure to the top of the block. Courses should be increments of 8 in.

Finishing the joints—Different types of joint finishes can be achieved with different tools. The most popular by far is the concave or half-round joint, which you make by running the jointing tool through the head joints first, and then through the bed joints to form a straight, continuous horizontal joint. If you buy this jointing tool, be sure that yon get a convex jointer. These are available in sled-runner type or in a smaller pocket size. I like the sled runner because it wakes a straighter joint.

After the mortar has dried enough so it won't smear (about a half-hour), brush the joints lightly to remove any remaining particles of mortar. —*D.K.*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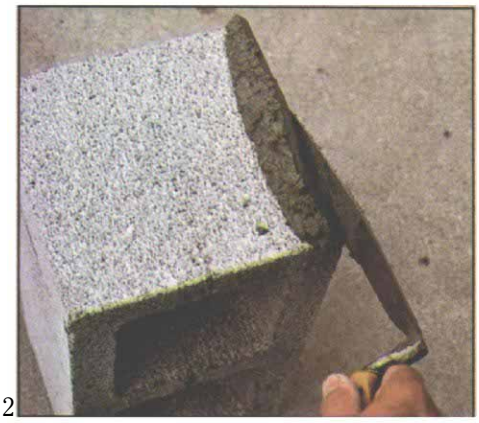
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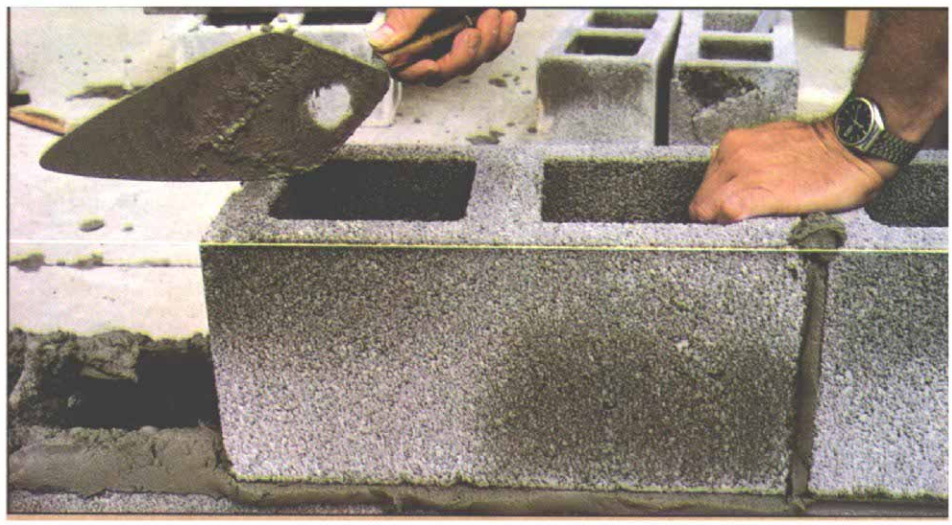
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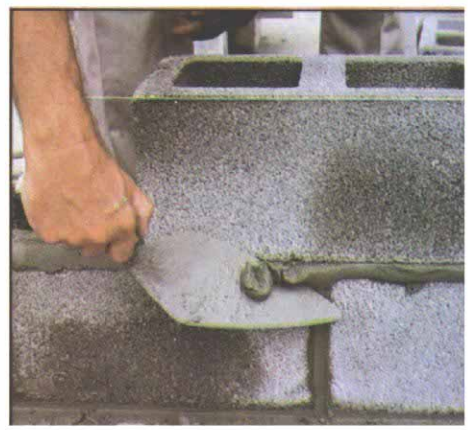
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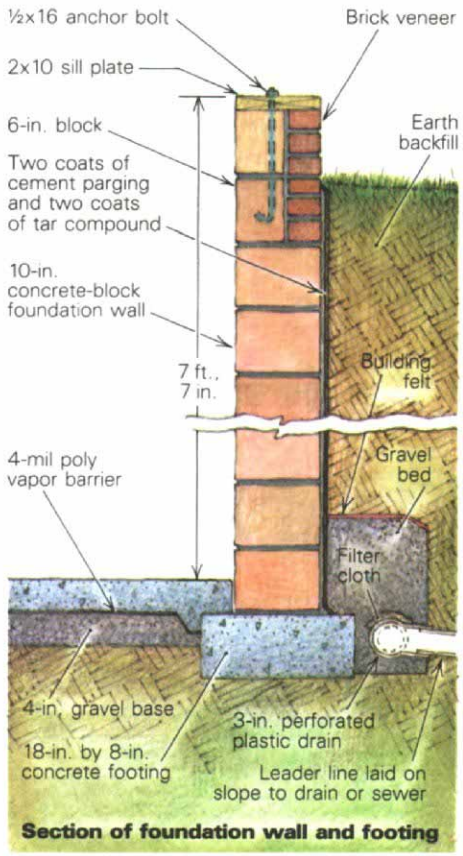

The completed foundation has been sealed with two ¼-in. thick parging coats and topped with an application of tar compound, which finishes the waterproofing. Backfilling should happen only after the first floor is framed and the walls framed up, so the added weight of the structure will stiffen the walls and make them less liable to bulge from the pressure of the earth.

out too quickly and allows it to cure slowly and create a better bond with the wall.

Start parging on the first coat from the bottom of the wall to the top, about ¼ in. thick. A plastering or cement-finishing trowel is excellent for this. After troweling on the parging, scratch the surface with an old broom or a tool made for this purpose. Let the mortar dry for about 24 hours or until the next day, and repeat the process for the second coat. Dampen the wall between coats for a good bond. Trowel the final coat smooth, and let it dry for another 24 hours.

To complete the waterproofing job, spread on two coats of tar compound (photo, top). You can do this with a brush or roller if the weather is warm. Many builders in my area use a product called Hydrocide 700B (Sonneborn Building Products, 57-46 Flushing Ave., Maspeth, N.Y. 11378). It comes in 5-gal. containers and is available from most building-supply dealers. I like it because it stays a little tacky and seals the wall very well. It's gooey, though, so wear old clothes and gloves when you're applying it. Kerosene will get it off your hands and tools when the job is done.

Drain tile—Most codes require some type of drain tile or pipe around the foundation to divert water build-up and to help keep the basement dry. The design of the drain-tile system is important. Generally, drain tile or pipe is installed around the exterior wall of the foundation, below the wall but above the bottom of the footing, as described below.

Begin by spreading a bed of crushed stone or gravel around the foundation next to the wall. Lay the drain tile or perforated plastic pipe on top of this bed. The bottom of the drain pipe should never be lower than the bottom of the footing, or it won't work properly. Lay filter cloth over the drain pipe to keep mud and dirt from blocking the holes. Then place another 4-in. to 6-in. layer of crushed stone or gravel over the pipe, as shown in the drawing above.

The water collected by the drain tile has to flow away from the foundation. One way to make this happen is to drain the water to a natural drain or sewer away from the foundation area by installing a leader line on a slope lower than the drain pipe. The other method is to drain the water under the wall of the foundation and into a sump pit inside the basement. The water that collects is then pumped out through the plumbing to a sewer or septic tank.

A third method, which has worked well for contractors in my area, is to put the drain tile inside the foundation on a bed of crushed stone, just beneath the finished concrete floor, which will be poured after the drain tile is in place. One-inch plastic pipe is installed about 6 ft. o.c. through the wall at the bottom of the head joints in the first course of block. When the foundation wall is done, crushed stone is spread around the exterior edges as before, but no drain pipes are needed.

The idea is that any water that builds up outside the foundation wall will drain through and into the drain tiles. In addition, the water inside the foundation area will also flow into the drain tile and into the sump pit in the basement floor, where it can be pumped out into the septic or sewer system.

Insulating the foundation—In recent years, the use of rigid insulation applied to the exterior of the foundation wall has helped to reduce dampness and heat loss. This is especially important in the construction of earth-sheltered homes. There are a number of products that will do a good job. Generally, rigid insulation is applied to the waterproofed wall with a mastic adhesive that's spread on the back of the foam board. Use a mastic or caulking that does not have an asphalt base. Most panel adhesives will work. The building-supply dealer who sells the insulation will know the proper adhesive to use for a specific type of insulation board. Also, there are granular and other types of insulation that can be poured into the block cells.

After all of the foundation work has been completed, the backfilling of earth should be done with great care so that the walls don't get pushed out of plumb. It is always better to wait until the first floor is framed up before backfilling. This weight resting on the foundation helps prevent cracking of the walls, and the framing material will brace the block wall and make it more rigid. If the walls are cracked or pushed in from backfilling, the only cure is very expensive—excavate again and replace the walls. □

Dick Kreh is an author, mason and industrial-arts teacher in Frederick, Md.

SEE ERRATA AT END OF ARTICLE

ERRATA

Groundwater runoff

Re Dick Kreh's advice on footer drain tile *(FHB* #15, p. 44): Water collected along the footer should never be piped into a septic system. In most areas it is against sanitation codes to pump groundwater into public sewage systems. A septic system is not designed to handle this.

Groundwater collected along the footer or under the floor is basically clean. The best method, if pumping is necessary, is to pump it to road level and let it drain off naturally. A seepage pit can be used, but to build one large enough and far enough away to work can be expensive. When groundwater is causing problems along the footer, the soil is usually so saturated a seepage pit won't work. In some areas, groundwater can be pumped into a separate storm-sewer system. The easiest solution is to pump groundwater above street level to be drained off naturally.

–Joseph Trembula, Armuchee, Ga.

Dick Kreh replies: Trembula's objection is well taken. A contractor in my area drains his foundations from outside to the inside through 1-in. plastic pipes into a sump pit. The proper method of handling this water is to pump it from the sump pit into a pipe up to grade level and let it naturally drain away. As a rule, the amount of water to be drained off is minimal and presents no problem. It would be against sanitation codes in many local areas to pump water, even if clean, through sewer systems. This was a misunderstanding on my part when I interviewed the contractor.