

Working With Rebar

The bones beneath concrete's muscle, rebar has to be cut, bent and tied properly to do its job

BY HOWARD STEIN



Why should you have a spare tire in the bed of your truck? It's not required by law, and the truck will run just fine without it. Using essentially the same logic, some people might ask why we use rebar in our residential foundations. Many houses are built without it (East Coast building codes don't require it), and if a house is built with rebar, building inspectors often don't inspect its placement.

The simple answer is that rebar is cheap insurance against the potential problems that can develop after concrete is poured or, worse, after the foundation has been back-filled. A foundation that has gone wrong is extremely expensive to repair. Just to be safe, my crew and I reinforce concrete in footings and walls, in piers and columns, and in structural slabs, and we also use rebar to tie new work to old.

Concrete used in residential construction is usually specified in a range of compressive strength in 500-lb. increments between 2500 psi and 4000 psi. It's obvious that concrete can support phenomenal compression loading. However, when it is under tension or shear forces, concrete has lower values compared with other common construction materials. If the underlying soils are of uneven densities, differential settling beneath the foundation can cause large cracks in the walls. Concrete is also subject to

shrinkage cracks, especially when poured with a high water-to-cement ratio. When properly sized and embedded in concrete, rebar partially compensates for these deficiencies. (Remember that excess water produces lower-psi concrete that is weaker and more prone to shrinkage. Even reinforced with rebar, high-water-ratio concrete shouldn't be used.)

Sizes and grades of rebar

Rebar comes in many sizes and grades (photo to right). In residential work, we mostly use bar sizes #3, #4 or #5. These sizes translate to the diameter of the stock, measured in $\frac{1}{8}$ -in. increments; #3 bars are $\frac{3}{8}$ in. in dia., #4 bars are $\frac{1}{2}$ in. ($\frac{1}{2}$ in.), and #5 bars are $\frac{5}{8}$ in. The grades 40 and 60 refer to the yield (tensile) strength (40,000 psi and 60,000 psi, respectively). Grade 60 is harder to cut and bend. Both grades are priced the same. The designer usually specifies which one to use for a particular purpose. If the grade is not specified, I buy the softer grade 40 for short lengths and bends, and grade 60 for long straight runs with few or no bends.

Make sure the rebar is delivered where you want it

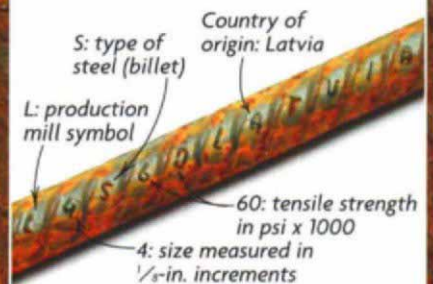
Rebar is available at some lumberyards and from most masonry suppliers. However, nine times out of ten, I order it from a steelyard

KNOW YOUR REBAR



Deciphering the code

A series of letters and numbers stamped along a length of rebar tells a great deal of information.

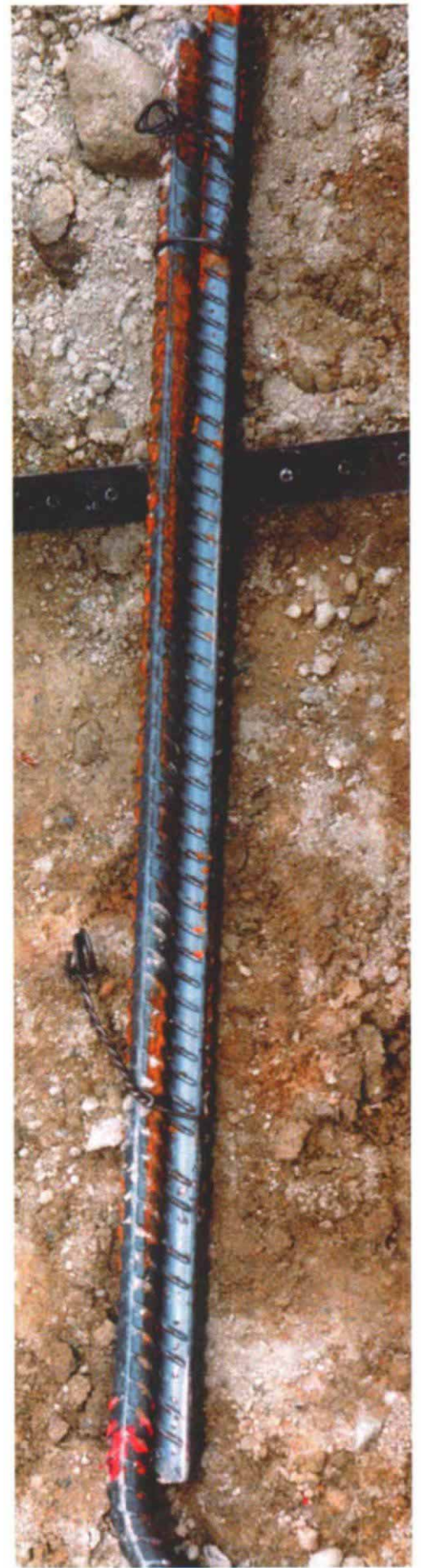


Cutting and bending rebar is a matter of leverage and muscle. Although chopsaws or torches can make quick work of cutting rebar, at a site without electricity, the stock can be cut with the cutter/bender (photo above). The tool's head provides a lever and fulcrum that makes simple bends as well (photo facing page); more complex bends can be made from individual pieces lapped together.



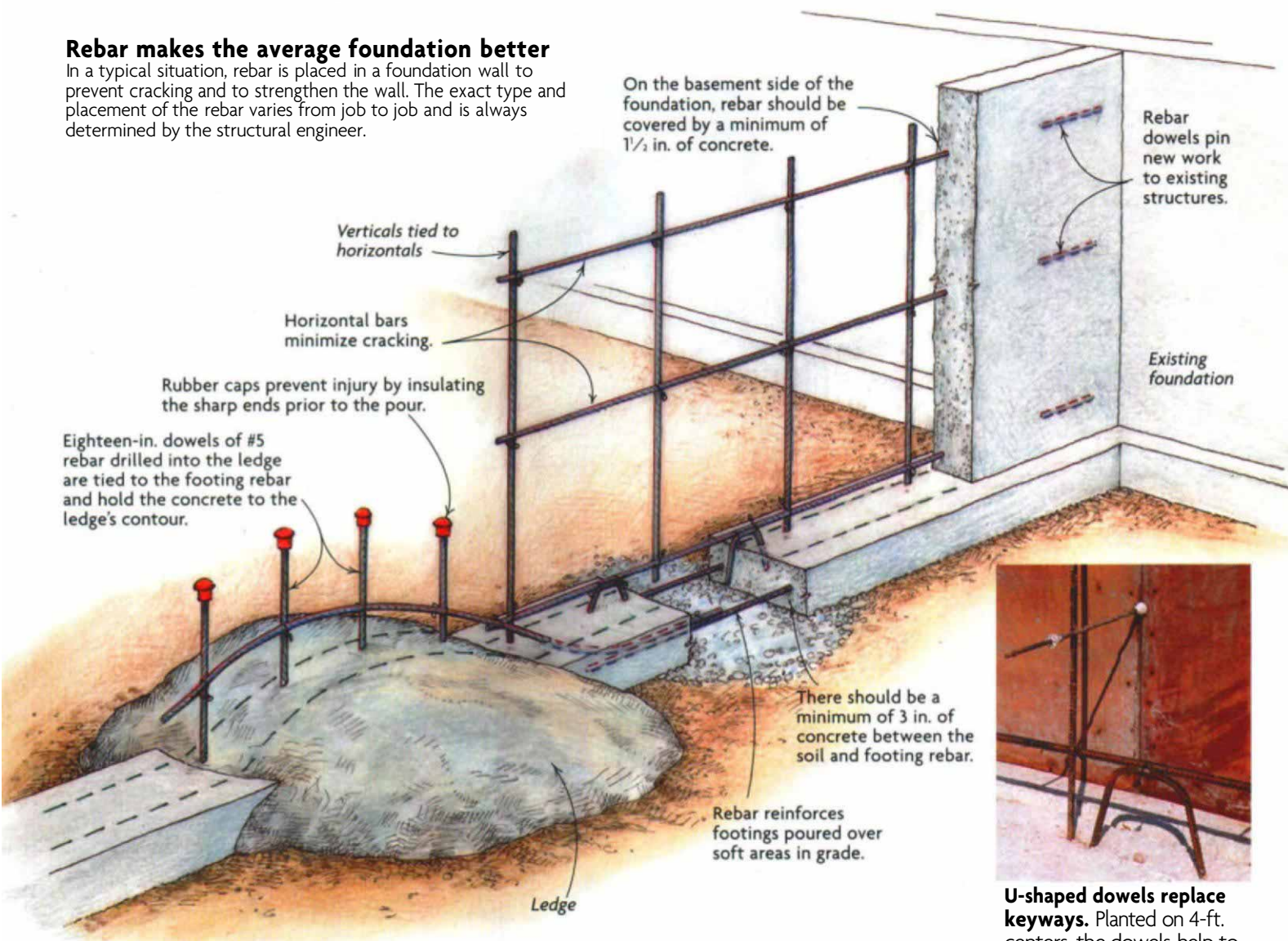
TWISTED WIRE HOLDS THE REBAR IN PLACE

Prelooped wire ties are twisted around the junction of two pieces of rebar to hold them in place until the concrete is poured. The wooden-handled hook (photo above), known as a twister, speeds up the process. On longer runs or in place of multiple bends, rebar can be lapped. The overlap should be a minimum of 36 bar diameters and tied together with wire in two places (photo right).



Rebar makes the average foundation better

In a typical situation, rebar is placed in a foundation wall to prevent cracking and to strengthen the wall. The exact type and placement of the rebar varies from job to job and is always determined by the structural engineer.



U-shaped dowels replace keyways. Planted on 4-ft. centers, the dowels help to anchor the footings to the walls and to the rebar.

that stocks both grades, that always has #5 bars and that delivers to the site. If the site has good access and if we have an excavating machine available during the delivery, the machine can lift the rebar from the truck with a chain sling. If we don't have equipment on site, I let my suppliers know so that they can deliver my order on the outside edge of the truck bed, where it can be levered off and onto the ground.

If the delivery is early or late or if the machine is unavailable, we drop the bundles off the side of the truck onto blocks of wood; it's easier to maneuver the chain and slip hooks under the load when we are ready to move it to the foundation area. We also store the rebar off the ground at its staging area so that it doesn't get muddy or sit in puddles. Dirty rebar must be cleaned before use.

The Concrete Reinforcing Steel Institute (847-517-1200) has something to say about

clean rebar in its manual *Placing Reinforcing Bars*: "The surface condition of reinforcing bars may affect the strength of the bars in bond. The main factors affecting bond are the presence of scale, rust, oil and mud." Scale is caused by the manufacturing process; loose scale usually falls off when the bar is handled or bent. Tight scale and light rust are acceptable and actually enhance the bond with concrete because they add more surface area. Too much form oil on rebar can adversely affect the bond, according to the CRSI manual.

The grunt work of cutting and bending rebar

If there's power on site, steel can be cut using a circular saw outfitted with a metal abrasive wheel or a 14-in. chapsaw with the same blade. The latter cuts the bar more easily, but we need to bring the steel to the saw. Using

either saw, we can cut three to six pieces of rebar to common lengths simultaneously. Incidentally, wearing goggles and earplugs is a must when cutting steel with a saw.

Without electricity, rebar can be cut to length with an oxyacetylene torch or a cutter/bender (photo left, p. 81). Lacking a torch, we use the slower cutter/bender, mounted on a 2x8 for stability, and cut one piece at a time. Available from masonry-supply houses and some tool catalogs, cutter/benders have cast-steel heads, feature replaceable cutters and cost \$250 to \$300. Many cutters have a 52-in. long handle that gives you plenty of leverage. Even so, the process is slow, and if we're cutting #5, grade-60 bar, we really have to throw our weight into it.

We've found that the best way to mark steel for cutting is with a quick shot of spray paint (photo p. 84) from a can designed to work upside down. With anything else, the



Spray paint marks the spot. A spray can that's made to shoot upside down marks the position of bends or cuts on a piece of rebar. The mark is waterproof, easy to read and nearly indelible.

marks can be pretty hard to see. Exact length is seldom critical with rebar. Because it's designed to overlap, if you're off by an inch, it usually doesn't matter.

The easiest way to bend rebar is with the cutter/bender (photo p. 80). After measuring and marking bends with paint, we lay the stock under the head and lever it into shape, using the tool head as a fulcrum. The stock has to be in a straight line when bent. Although some of the newer models have stops at 90° and 180°, we just eyeball the bend and

adjust as needed. We're careful not to over-bend an angle, though, because you can't use the bender to bend it back and because it's hard to do using your hands and feet. To save time, we'll often bend corners while we're waiting for the forms to be completed. If we need more than one bend in a piece of rebar, we've found it's easier to lap with another bent bar; it's awkward to make multiple bends on site, especially with long lengths. In a pinch (such as when we don't have the cutter/bender), we have bent bars around the

pintle on my truck's hitch plate, but I wouldn't want to do more than a few bends this way.

Wiring the rebar together until the pour

To lap or cross rebar, we use prelooped wire ties (photos p. 82). Commonly available in lengths of 6 in. and 8 in., the latter are handy for tying together pairs of #4 or #5 bars. A bag of 5,000 8-in. ties costs about \$45 and will last for several residential-size foundations. Wire is also available on spools, but we find that less convenient.

The simplest tie requires merely bending the tie diagonally over the bars and, using a tool called a twister (top photo, p. 82), hooking the loops and spinning the wire. Over-twisting the wire will simply break it. (The wire adds no strength or integrity once the concrete has been placed.) The twisted wire is then wrapped around the bar (bottom photo, p. 82) so that it doesn't extend toward the exterior surface of the concrete. The wire might rust if it remains exposed to the elements or could lead water into the embedded rebar if exposed below grade. Incidentally, spools of wire are also handy for hanging the rebar at a consistent height in the footings (photo left, facing page). Because the footing is covered later by the waterproofed foundation wall, the wire is never exposed to the elements.

Rebar maintains control of concrete shrinkage

In addition to solving problems related to shear or tension, rebar is also specified for shrinkage control of concrete (drawing p. 83). Because the water in poured concrete is lost by evaporation as it cures, concrete shrinks in volume. Rebar doesn't prevent shrinkage but binds both sides of the eventual cracks into a single wall plane.

According to Val Prest, a structural engineer from Harvard, Massachusetts, "This shrinkage will result in 1/16-in. to 1/8-in. cracks at about every 20 ft. at the top of an unreinforced wall. Add more water to the concrete, and you get more shrinkage—cracks that are perhaps every 10 ft. to 15 ft.—and the concrete is weaker. Horizontal bars will minimize the cracking by causing multiple fine line cracks instead."

Prest also says, "Temperature and shrinkage-designed steel for the average 10-in. thick residential foundation is commonly spaced on 12-in. centers, or every 10 in. horizontally for #4 bars and every 15 in. for #5 bars." For horizontal placement in wall forms, we almost always tie rebar to the tie



KEEPING REBAR AT A CONSISTENT HEIGHT

Rebar placed in footings should always be above grade. To prevent the bars from sinking in the wet concrete, foundation crews often suspend rebar from strapping (photo left) that spans the tops of the forms.

Any exposed wire is trimmed after the concrete sets up and is covered by the foundation wall.

Manufactured supports known as chairs (photos right) offer another option for locating rebar.

Available in different sizes, chairs are usually made of plastic or heavy-gauge wire; plastic feet help to insulate the wire from corrosion that results from ground contact.



rods (or form ties) that hold the outer and inner concrete formwork together. After the concrete subcontractor sets up the outer wall and pushes the tie rods through, we place the steel on these tie rods and wire the rebar to them (drawing p. 83). The verticals are tied to the horizontal bar and to U-shaped dowels in the footing (photo p. 83).

Although steel is specified for its temperature and shrinkage control, Prest says, "99% of the time, steel is designed for shrinkage, not temperature." Some exceptions would

be bridges, concrete roadbeds and large retaining walls built on highways exposed to direct sun.

That said, there are some general rules about placing rebar that can be applied to most situations:

- In footings and walls below grade, rebar should be covered with at least 3 in. of concrete to protect it from groundwater and soil.
- Inside a wall, rebar is positioned on the tension or inner (basement) side with approximately 1½ in. of concrete cover.

· The horizontal shrinkage-control steel is placed first in the wall, followed by shorter vertical bars placed to the inner unrestrained side of the wall.

One note: If there is a dense mat of steel in a slab or wall, it may be necessary to vibrate the concrete with a pencil vibrator to consolidate the concrete without leaving voids. □

Howard Stein is a builder living in Townsend, Massachusetts. Photos by Charles Bickford, except where noted.