Pinning to Ledge

by Dean Rosnau

A rotary hammer, threaded rod, and plenty of epoxy are essential when anchoring a foundation to solid rock

When a couple from Fallbrook, Calif., approached me last year and asked if I would design and build their Eastern Sierra vacation home, I remember thinking I was in for a hard start. Their 10,000-square-foot lot consisted largely of a terraced granite cliff, with grades as steep as 50 degrees. Getting a house to stay put on that rock hillside was going to be a challenge.

On flatter lots, rock outcroppings are often blasted away to accommodate the floor elevations. Since this lot dropped away from the road access, the floor levels finished above the outcroppings, and we were able to form to undisturbed ledge. The method used to fasten a foundation to ledge depends on the type of rock and its shear strength, and it's important to bring in an engineer early in such a project. We were fortunate that the ledge material we were working with was hard, stable granite, which allowed us to pin directly to the rock without having to blast away any loose or shattered material.

Rough Start

From the beginning, forming to the ledge presented challenges; even the first step of staking the corners required a rotary hammer. To erect batter boards, we drilled 3-inch-deep holes in the ledge, inserted 4-foot-long steel form stakes,

and attached horizontal 1x4 wooden form stakes with drywall screws, screwing through the predrilled holes in the steel stakes (see Figure 1). We found that a 3/4-inch-diameter bit produced the proper-size hole to support the form stakes.

We used the same method to position and hold the first few courses of 2x12 form boards. We ran strings, then used a plumb bob and spray paint to lay out and mark the stake holes for the outside form. After drilling and placing the outer stakes 4 feet on-center, we measured in 11 inches and drilled holes for the inside form stakes. This dimension took into account the 8-inch-thick stem walls, plus two 1 1/2-inch-thick form boards.

Scribing to Ledge

To begin assembling the outside wall form, we first scribed the bottom 2x12 form board to the rock outcroppings (Figure 2). Using a combination of measurement, eyeballing, and a flat carpenter's pencil, we were able to scribe to within 3/4 inch of the outcroppings. This takes a little patience, but prevents any concrete from seeping out the bottom of the form. Once our lowest boards were in place, we were able to quickly stack additional form boards until the wall reached the proper height.

Threaded Dowels

With the outside form completed, the next step was to drill holes for the dowels that would anchor the foundation to the ledge (Figure 3, page 24). Our engineer specified 3/4x12-inch-diameter dowels set 7 inches deep in 7/8-inch-diameter holes. Although we could have used 3/4-inch rebar for the dowels, we chose 3/4-inch galvanized threaded rod instead, because the epoxy used to anchor the dowels would bond better to the sharp thread profile (we were careful to use rod that was free from any oil coatings). At a spacing of 2 feet on-center, we needed 132 dowels.

Figure 1. When working on ledge, even the batter board stakes must be supported in drilled holes.

Figure 2. Carefully scribing form boards to within 3/4 inch of the irregular rock ensured a neat concrete pour.

Considering all the dowel and form stake holes to be drilled, we needed the right tool. As a rock climber, I know first-hand how long it takes to drill dependable rock anchors, so I decided to use a 1 1/2-inch Bosch SDS rotary hammer (S-B Power Tools, 4300 W. Peterson Ave., Chicago, IL 60646; 773/286-7330). It took approximately 90 seconds to drill each 7-inch-deep hole. The drill bit lasted for about 22 holes, but it could be retooled instead of discarded.

I found that keeping the same man on the drill saved time (and drill bits), since a new operator would have had to go through the learning curve of applying the right amount of pressure and finding the easiest drilling points on the



Figure 3. **The author's crew used a Bosch rotary hammer to drill over 300 holes in the rock outcroppings (top left). After blowing the dust out of a hole (top right), they injected epoxy (bottom left). To ensure good coverage, they also coated the rod and worked it up and down in the hole (bottom right).**

rock. Eye and ear protection are a must, as are dust masks, good gloves, and knee pads. The operator should keep a firm grip on the drill — otherwise, wrist injuries can result when the drill binds in the hole. A depth gauge on the drill is also extremely useful. (For more on rotary hammers, see the Fall '96 issue of *JLC*'s *Tools of the Trade* magazine.) Another tool that came in handy on this job was a pipe wrench for stripping form stakes that bind in the holes.

Gluing the Dowels

After drilling the holes, we used compressed air to blow out the dust before setting the dowels in epoxy. We used an epoxy cartridge system from Covert Operations (1940 Freeman Ave., Longbeach, CA 90804; 310/986-4212) to meet the strength requirements called out by our engineer. We found both the gun and cartridges easy to work with. The epoxy did not generate heat as it set up, and did not emit the foul odor I've encountered with other brands. (This last point may not seem like a big deal, but the smell from some epoxies I've used stuck to me like glue. When I started noticing that people were looking funny at me when I was in a crowd, I decided to switch brands.)

We injected an inch or so of epoxy into the hole, coated the portion of the dowel that would be embedded, and inserted the dowel in the hole, working it up and down to get a good coating on both the dowel and the walls of the hole. Then we removed the dowel, injected another inch of epoxy in the hole, and reinserted the dowel. Properly embedded dowels would show signs of epoxy squeeze-out. We averaged one tube of epoxy for every 20 dowels.

After the dowels were in place, we tied a continuous run of #4 rebar to the dowels. We used a hand-held rebar bender to shape the bar to the contour of the rock before tying it off 4 inches above the ledge.

With the footing bars in place, we began building the inner wall forms in the same manner as the outer wall forms, installing form ties as the inner form went up. Form tie spacing varied between 18 inches and 4 feet, depending on the height of the wall.

Bracing the Forms

Bracing our formwork to the surrounding rock called for a little ingenuity. Drilling holes for angled bracing stakes proved too troublesome, so we created a bracing system using MST framing straps, 2x4s, and expansion bolts (Figure 4). The 2-inch-wide framing straps are manufactured by Simpson Strong-Tie (4637 Chabot Dr., Suite 200, Pleasanton, CA 94588; 800/999-5099) from 10-gauge galvanized steel; they're typically used to resist lateral movement.

We nailed one end of the framing strap to the form, and placed the other end on the surface of the rock, pounding it with a hammer to shape it to the configuration of the rock. We drilled a 1/2-inch-diameter hole 2 1/2 inches deep in line with the framing strap hole and inserted a Rawlplug tap-in expansion bolt (Rawlplug Co., 200 Petersville Rd., New Rochelle, NY 10801; 914/235-6300). To add rigidity and compressive strength, we nailed a 2x4 strongback to the strap through the prepunched nail holes.

After stripping the forms, we were able to straighten the straps and reuse them for the framing.

Preparing the Piers

This project also had 13 pier footings that needed to be doweled to the ledge. Our engineer specified that a flat surface be jackhammered into the sloping rock where the piers were located, and that two dowel pins be provided per pier (Figure 5). We scribed the forms to the rock and held them in place in the same manner as the wall forms.

Utilities and Drains

Care should be given to protect pipes and wires from abrasion when bringing utilities into a foundation that is built on top of rock ledge. We wrapped all water lines, sewer lines, and conduit with Flex Wrap (WrapCo, P.O. Box 8043, Citrus Heights, CA 95621; 916/723-2121), a closed-cell foam that protects against puncturing or cracking (Figure 6).

We used 4-inch perforated drain pipe in a bed of 3/4-inch stone for seep water, and placed a 6-inch rigid drain line on the high side of the house to pick up runoff water from the hillside above and direct it completely around the house. Swales at critical points directed runoff to intakes in the 6-inch drain line, and all drain outlets exited onto rock slabs to prevent erosion problems.

Added Costs

We drilled more than 300 holes to prepare for a foundation that required nearly a 100 yards of concrete. Forming to a rock ledge can increase costs by 30% or more when compared with a typical "dug" foundation. In our case, the excavation costs were lower but labor was 30% higher and materials about 20% higher.

I found building on rock ledges as satisfying and rewarding as the time I spend climbing on them. It's not that we conquered the mountain; rather that with a little vision, ingenuity, and patience, we achieved a goal worthy of standing back and saying, "Been there, done that." ■

Dean Rosnau owns and operates Peak Construction in June Lake, Calif., a design-build company specializing in custom homes.

Figure 4. Simpson MST framing straps and 2x4 strongbacks, anchored with expansion bolts, braced the forms to the irregular rock outcroppings.

Figure 5. For pier footings, a flat surface was jackhammered into the ledge and two epoxied dowels inserted.

Figure 6. To protect against puncture and cracking, all utility lines were wrapped with a closed-cell foam wrapping (at left in photo).