# Building on Ledge

**Q:** We are considering using foam forms for a stepped foundation on a steep site overlooking the coast. The tricky part is that the site is mostly granite ledge. Can the concrete in the forms be pinned to the ledge? If so, how would one go about scribing the forms to fit the uneven surface?

**A:** *Builder Phil Harrison of Portland, Maine, responds:* It's important to bring in an engineer early on such a project. How you pin a foundation to ledge depends on the strength of the rock to hold the anticipated loads. If you have hard, stable rock, it's possible to hold the foundation with steel dowels. If the rock is loose or shattered, however, it may be necessary to blast down to stable material or drill through the rock for piers. It can get complicated very quickly, particularly on cliff-side sites.

Most of the sites we have built on around Casco Bay have had a solid granite ledge beneath thin patches of "blueberry sod." We have to remove the sod entirely, but the rock itself is stable enough to hold epoxy-set pins, allowing us to pin the poured concrete walls without additional footings or pier bearings. While the uneven surface of the rock provides a good key for the concrete, we typically must use dowels cut from No. 6 (3/4-inch-diameter) rebar. These are usually set 6 to 8 inches into the rock and spaced every 2 feet, depending on the contour of the bearing surface and the wall elevation. The engineer may require a closer spacing near corners or where the foundation radically changes elevation.

We've used foam forms for several poured foundations on ledge. They make sense for a number of reasons. For starters, I feel carpenters are usually better at squaring, plumbing, and leveling than are concrete formers. Also, foam is much easier to cut to fit the complex contour of the rock than are wood forms. And in our area, R-6 insulation on the foundation walls is necessary for the thermal performance of the building, so it makes sense to form and insulate in one step.

### SCRIBE TO FIT

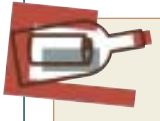
The tricky part, as you seem to understand, is the layout and scribing process. We've done several foundations this way over the years, and we've yet to discover any real shortcut.

We first lay out the corners of the building. Typically, we'll contract with the engineer for this, particularly if the site is very steep. Using a theodolite, a well-trained survey crew can accomplish in an hour what it would take me most of a day with my builder's level, and I wouldn't ever feel very certain of my results. The survey crew gives us clear corners spray-painted on the rock. We can then go to work setting our pins.

To start, we simply stretch a line from the building corners and spray-painted reference marks so we can eyeball the edges of our concrete walls. Then we go to work on the laborious task of drilling for the foundation pins in the center of the wall section. It's not unusual to have 150 pins in a house foundation, so it's nearly a full day for two people just to drill and set the dowels in epoxy.

Once the pins are placed and capped off for safety, we drill additional holes outside the building lines for rebar stakes to support batter boards, and then we string level lines. This is a bit tedious, but once the batter boards are in place and the strings up, we have an essential reference from which to measure to get a rough idea of the difference in elevation for scribing the foam blocks. We rough-cut the blocks with a folding tree saw to match this first rough calculation, then fine-tune the scribe holding a 4-foot level on top of each block. It's slow going, but it ends up fairly accurate. Using this system, we've had good luck avoiding blowouts when pumping the concrete.

Our success at avoiding blowouts can also be attributed to rigorous bracing (we'd rather overbrace



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than risk a blowout), to always using a low (3-inch) slump concrete, and to taking our time to pump slowly, distributing the concrete evenly. We also make good use of a hand-held concrete vibrator to eliminate voids inside the formwork.

### DRAINAGE DETAILS

The most challenging part of building a foundation on ledge is working out an effective drainage plan. Water tends to flow along the ledge, and it can move through fissures in the ledge, so it's not uncommon to have a spring flowing out of a rock outcropping inside the basement. There's no stopping this water flow. The best steps you can take are to contain it and to divert it outside. We typically run perimeter drains inside and outside the foundation walls. Inside the foundation, we dump yards and yards of compacted gravel over the drain lines to level out for a slab. The inside lines are connected to the exterior lines at each low point in a stepped section. Backflow valves at these connection points prevent backed-up lines from overflowing into the foundation.

Because EPS foam will absorb water, I am concerned that the forms might become waterlogged in the vigorous runoff that occurs each spring. We waterproof with a self-adhering rubberized asphalt membrane, applying the membrane wherever the foundation will be backfilled, even on the inside if a significant heap of gravel fill bears against the foundation.

## Erosion of Light-Commercial Property

**Q:** I am a manager in St. Augustine, Fla., of a property constructed in 1983. We have a lower parking structure that has suffered erosion because of poor drainage from an upper parking structure (the outlet is simply a square hole). This erosion has washed away the soil below the stucco, leaving about 3 inches of concrete exposed above grade. Which would be the better solution: Haul in dirt to fill the gap and bring the grade up to the stucco line, or bring in 1 to 2 inches of river-rock stone to enable runoff into the drainage ditch that runs horizontally 10 to 12 feet away? Is it true that the concrete being exposed, without stucco on it, makes this lower parking structure more susceptible to cracking?

**A:** *Charlie Gardner, a Philadelphia-based engineer specializing in storm water management, drainage, and hydraulic problems, responds:* When concentrated rainwater falls through air from a roof, it picks up a lot of energy. This energy is showing up at the wrong place on your site, causing long-term erosion, increased foundation exposure, and appearance problems. As a practical matter, think of your problem as requiring a two-part solution: roofing work and work at grade level.

***Roofing work first.*** You mention a square hole through which drainage is discharged from an upper parking structure. It sounds as if you need a downspout sized to handle the runoff. The rate of discharge will be proportional to the area drained. Delegate the calculations and code compliance to your roofer, who should be able to size the rainwater conductor (RWC) according to the applicable local codes or BOCA for the amount of contributing roof area.

A cast-iron or hot-dip galvanized steel collector box with galvanized steel pipe would be used on an elevated highway structure, but this is probably overkill for your application. Regardless, have your roofer show you a picture of the collector box he plans to use and describe how he would hang it. It should be noncorrodible aluminum or plastic. If a plastic RWC is to be used, specify at least Schedule 40 PVC to prevent incidental mechanical damage from minor impacts.

To install it, construct from the roof down. The collector box should be somewhat larger than the aperture in the roof slab to catch all of its discharge. I would try to mount it with an air gap and a 1/4-inch

mesh hardware screen cover to keep out bird nests. The box should be connected with the RWC to the exterior side of a wall and down, terminating in an outward-bending elbow above grade level. You will want
the parts to be well fastened, and probably you should consider tamperproof connections.

Every change of direction takes energy away from moving water. Flow friction next to surfaces also takes energy away from moving water. With the RWC, you obtain two benefits: You have made the energy problem shrink, and you now have the wild water under control.

***The work at grade level.*** Your letter asks about the desirability of bringing in dirt to raise the grade at the building. This is your decision. Keep in mind that grades adjacent to a building should always slope away from the walls. Life would be simple if all buildings were on hilltops. Regardless, you are fortunate in having a ditch 10 to 12 feet away into which you can discharge rainwater. The bottom (we call the lowest point in the ditch cross-section the *invert*) should be well below the soil line on the wall. If this is not the case, you should either lower the ditch invert or raise the fill against the wall, or do both.

If the work is to be done by one contractor, he will
take responsibility for the fitting and matching of parts. If done by different workmen, mark your proposed soil line at the wall and point it out to the roofer so he can allow for the splash block.

It still remains to dissipate the kinetic energy left in the water that will come shooting out. This will only happen during the kind of rain that keeps people indoors, but it *will* happen. Here you have several choices and even some room for creativity. A large splash block should tilt away from the building. Then armor the flow path to the ditch.
I have seen the river rock you mentioned used very attractively. There are several other materials that could be used, including landscaping possibilities. The objective should be to clear the foundation zone and reduce velocity to prevent erosion as the water flows toward the ditch.

***Stucco repair.*** As to the lack of stucco causing cracks in structural concrete, I am somewhat skeptical. Concrete does crack for a large number of reasons, but to my knowledge, lack of stucco is not one of them. Even though well-applied stucco is a quality product, the icing is not what holds the cake together. If the issue is cosmetic, consider reapplying stucco, or even a thorough cleaning followed by a good coat of masonry paint.

Although you did not mention seepage through the wall, the interior lower-level garage will be drier after the new RWC is installed. After all, the best way to waterproof a wall is to not charge the soil behind it with water in the first place.