FOUNDATIONS

Constructing a High-Performance Slab

For durability and performance, isolate the slab from the earth

BY CHRIS LAUMER-GIDDENS

Photos by Chris Laumer-Giddens; illustration by Tim Healey

Concrete is one of the most durable materials we can build with. That makes it ideal for foundation slabs. But it's also one of the most thermally conductive materials we have. In this story, I'll explain how we detailed the slab foundation for an off-grid project in the North Carolina mountains. Our goal was to build the five slabs for the compound so that they would last virtually forever, and to integrate them into buildings designed to be self-sufficient for energy. Our strategy was to isolate each slab from ground moisture with a vapor barrier and to thermally isolate it from the ground with insulation—essentially, keeping the slab within the conditioned building enclosure.

Treated this way, and with concrete specified and placed according to known quality standards, there's no reason each slab shouldn't last for many generations beyond the lifetimes of the original owners. And especially by insulating the critical slab edge, where the greatest potential for heat loss occurs, we could meet the project's goals for energy self-sufficiency.

PREPARING THE SOIL

A durable slab begins with a solid soil base. In western North Carolina where this project was constructed, there's a lot of good, red clay soil that you don't have to worry about much. But on parts of our site, there was softer material that had washed

The author had to borrow red clay from off site **(1)** to create a strong sub-base for the slab. Trenches for the turndown portion of the slab were dug around the perimeter, then the foundation crew started by running 2-foot-high exterior forms around the perimeter **(2, 3)**. Gravel was placed in the bottom of the trench and leveled **(4)**.

down from the mountain over the years. We had to remove that material and replace it with other soil from the site.

In addition, a part of our chosen home site sloped down at about a 15% grade, and our owners wanted a nice flat, level pad for their home. So we ended up bringing in about 100 truckloads of soil from off site to create the elevation that we needed for the house and outbuildings. We placed this soil in lifts of 2 to 4 inches and compacted it to between 98% and 99.5% compaction with heavy equipment (a sheepsfoot roller compactor).

FORMING UP

Once we had the building pad constructed and compacted, we excavated trenches for the turndown perimeters of the slabs, which were designed as continuous grade beams. Our foundation crew set 2-foot-high plywood forms for the slab edges, screwing the forms together and bracing them against the soil outside the trenches. They placed 4 inches of gravel in the trench, leveling it with a small vibrating plate compactor. (There is no requirement to compact the gravel, but we wanted a nice flat surface for placing the insulation.) Next, the crew placed 4 inches of expanded polystyrene (EPS) foam insulation in the bottom of the trenches. Then they placed mineral-wool insulation on the inside vertical face of the trenches. Once the slab was poured and the forms were stripped, we would insulate the outside face of the footings with 6 inches of the same mineral-wool insulation, for an R-value of R-24 (code requires R-10).

Why did we use mineral wool for the sides of the trench and the under-slab area and use polystyrene for under the footings? The reason has to do with the compressive strength of the two materials. EPS foam, like extruded polystyrene (XPS) foam, comes in various types. In this case, we used R-Tech IV foam from Insulfoam, which has a compressive strength of 25 pounds per square inch (psi).

The crew set R-Tech Type IV polystyrene insulation in the bottom of the footing trenches on top of the gravel **(5, 6)**. They placed Rockwool Toprock DD insulation on the inside face of the trench **(7)**, placed gravel in the sub-slab area, and braced the Toprock DD back using small pieces of polystyrene **(8)**. Finally, they filled in the interior of the slab with Toprock DD **(9)**.

That works out to 3,600 pounds per square foot (psf), which is stronger than the assumed strength of our soil (2,000 psf).

Mineral wool, on the other hand, has a compressive strength in the range of 11 to 15 psi. That's closer to 1,600 psf, too low to support the weight of the building. However, the mineral wool we used (Toprock DD from Rockwool) is sufficient to support the weight of a concrete slab. So we used that material everywhere except in the base of the footings.

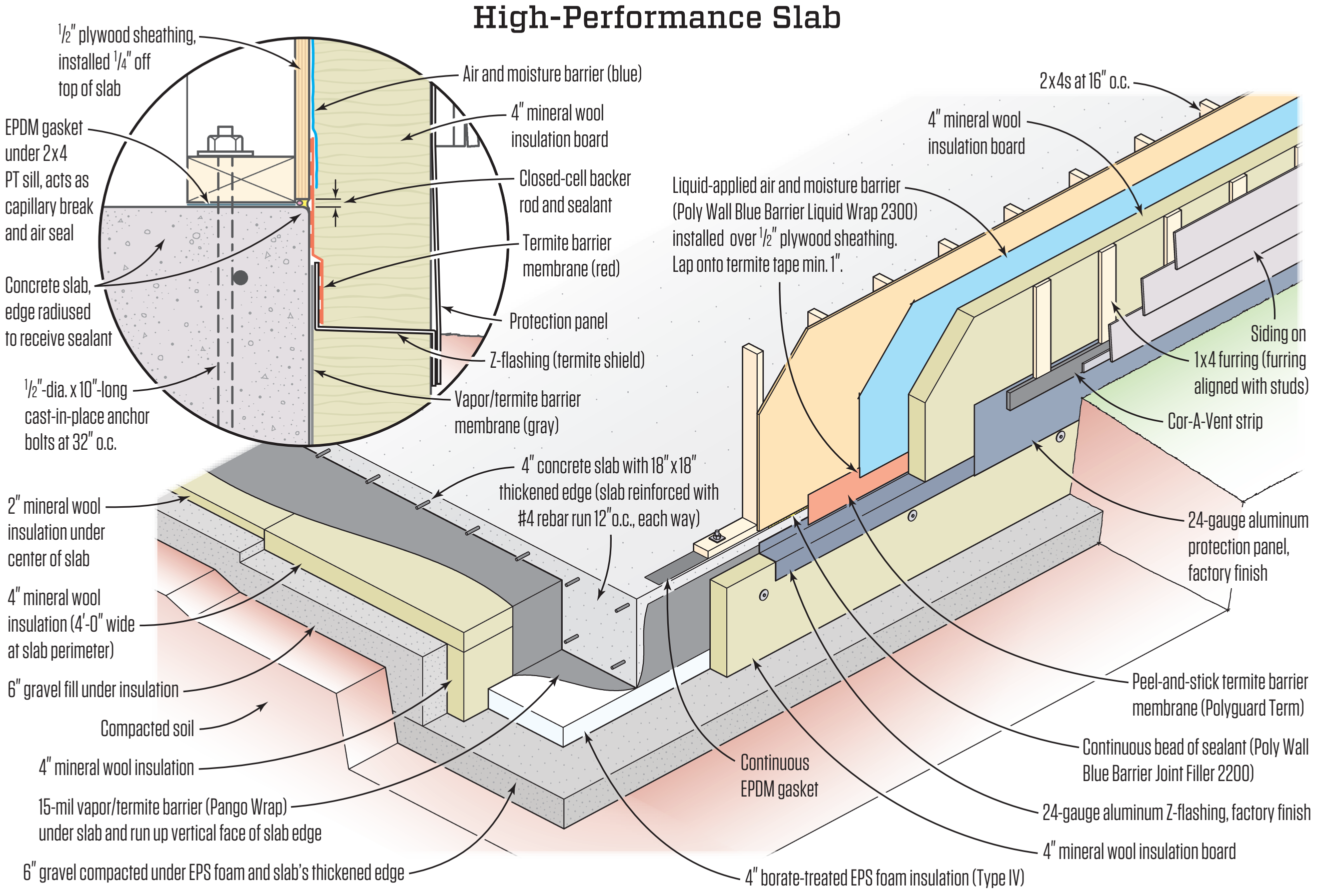
In its product literature, by the way, Rockwool North America recommends its Comfortboard product, not Toprock, for under-slab applications. Toprock DD is used primarily for low-slope ("flat") roof applications and is denser with a higher compressive strength (15 psi at 25% compression for Toprock DD versus 10 psi at 25% compression for Comfortboard 110), primarily so that it can support the foot traffic.

Comfortboard is what the manufacturer recommends for under-slab use because it is adequate for that application. The manufacturer doesn't recommend against using Toprock; it's just that it's not necessary. But it turned out that Toprock cost slightly less than Comfortboard. So it was a win-win for us to use the Toprock DD throughout the foundation.

PREPARING THE SUB-SLAB AREA

The next step was to place gravel for the slab sub-base. This gravel did not need to be compacted. Once it was spread and leveled, I called my plumbing and electricals subcontractor in to run their rough-ins.

Once the rough-ins were done and backfilled, we placed 4 inches of mineral wool around the interior perimeter of the footing forms, then placed 2 inches of mineral wool across the whole remaining area of the slab base, for an R-value of R-8 (code requires no insulation at this location).



Above is a version of the author's slab detail from a wood-framed house in Marietta, Ga. Here, the author has used a bent metal termite-control flashing integrated into a sub-slab Pango Wrap termite-control vapor barrier membrane. The slab and the wood structure are all contained within the conditioned envelope of the building.

INSTALLING THE VAPOR BARRIER

A thorough vapor barrier is one of the keys to a high-performance house. So the next thing we did was install a 15-mil vapor barrier on top of the insulation, covering the entire portion under the slab and around the entire turndown and up the edge to the top of where the slab would be. For most of our projects, we use Stego Wrap, a multilayer polyolefin sheet, for the vapor barrier. In this case, we used an equivalent product, Perminator from WR Meadows, because of availability to the installing contractor.

We overlapped the seams 12 inches and sealed the seams carefully with a tape that has been tested with that vapor barrier to ensure a tight seal. Any penetrations through that vapor barrier, such as plumbing pipe or electrical conduit, we also wrapped in the vapor barrier material and then sealed with the tape.

Around vertical pipes and conduit, we wrapped a band of sill sealer material and taped it at the planned height of the top of the concrete. Later, when the concrete was poured and set, we would dig out the sill sealer and pour in a seal of liquid-applied flashing (either Prosoco or Polywall will work for this). This provided an additional air seal around the pipes and a barrier to insect intrusion. On later jobs, however, we learned that wrapping the pipes with sill sealer wasn't necessary; during the finishing process, you can run a trowel around the pipes and make a suitable groove for the liquid flashing.

PLACING CONCRETE

Quality control for concrete can be tricky, and it's a whole topic of its own. In our case, we hired a local consultant, named Roy Keck, to specify our concrete mix based on the weather conditions, the location, and the end use. We planned to use the concrete slab as the finish floor, so it would be polished and sealed

The crew placed a 15-mil polyolefin vapor barrier (Perminator from WR Meadows) across the slab and down into and up out of the footing trench **(11)**. They wrapped the conduit and pipe that penetrated the poly with more poly, tape, and sill sealer **(12–15)**. Later, they would remove the sill sealer and seal the gap using liquid-applied flashing.

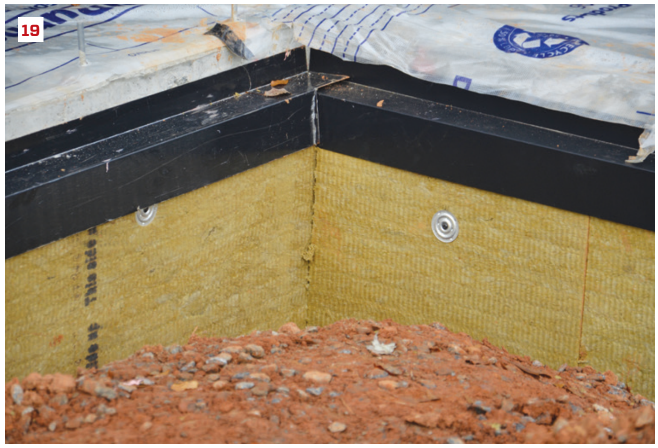
after it was cured and after the rest of the house was framed. We had warm weather and we were almost an hour's drive from the concrete plant, so those factors needed to be considered as well. Roy phoned our order in to the plant, and we poured starting in the early morning.

This large project consisted of three small residential buildings, which we placed in two separate pours. We decided to pour the slabs on different days to simplify things. Each pour began in the early morning and was done before noon, so we had plenty of time.

I had a few main concerns. One was that the compressive strength of the concrete was adequate—I made sure that the mix was designed for at least 3,000 psi. Another was the slump—throughout the pour, I checked the concrete from each truck using a standard cone slump test to make sure that the slump was as specified. (For more information about measuring concrete slump, see "Concrete Basics," Jun/00.) The specification was for a 4-inch slump, plus or minus one inch. We kept the slump between 4 and 5 inches.

Once the concrete was placed and struck off, the placing crew left and the finishing crew arrived. But finishing couldn't start until the slab was ready—that is, until the standing bleed water was gone. Some finishers make the error of troweling that bleed water back into the concrete, but that is a big mistake—it leads to surface defects, such as flaking and scaling, in the concrete.

You can pull some water off the slab with a bull float, but basically, you need to wait. In this situation, the sub-slab vapor barrier prevented water from bleeding out of the bottom of the slab, so the only way for the water to exit was through the top surface. That significantly extended the drying time. When the bleed water had finally evaporated, the finishers power-troweled the slab and moved on.



The author specified a 3,000-psi mix placed at a slump of 4 to 5 inches **(16)**. Bleed water had to evaporate completely before the slab could be power-troweled **(17)**. After finishing, the crew applied protective plastic over the slab to maintain good curing conditions **(18)**. On a later project, the author specified a termite shield over the mineral-wool insulation **(19)**.

CURING CONCRETE

In the presence of moisture, concrete continues to harden for months or even years. As soon as the finishing crew was done, we covered the slab with a recyclable plastic protection membrane called KleenRunner to hold in the moisture and keep the concrete from drying out. While the concrete was dry to the touch when we placed the plastic, moisture began to bead up on the underside of the plastic as soon as we applied it.

Although there is a perforated version of KleenRunner, which is designed for protecting wood floors during construction, we use the nonperforated version of the material for this application. The idea is to leave the plastic in place as we frame the house, and cut it out around the wall plates later on. That way, the concrete will have months of ideal curing conditions, it will be protected against muddy footprints and staining, and the plastic will be left as a capillary break under the wall plates for the long run.

TERMITE CONTROL

Where subterranean termites are a problem, codes require pretreatment of the ground below a slab foundation. The off-grid project shown here was framed and sided with steel and sheathed with gypsum, so we could justify omitting the soil treatment because there was no wood in the structure. But in a wood-framed project we did later, in Marietta, Ga., we took termite control a step further. Instead of the basic vapor barrier membrane, we used a newer product (Pango Wrap from Stego Industries) that is a termite barrier as well as a vapor barrier. We installed a termite shield of bent metal on top of the slab edge insulation, taping the metal to the wall membrane to integrate it into the building. This also protected the insulation from foot traffic during construction.

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