Inside the Concrete-Free

An innovative plywood slab-on-grade means less time, money, and carbon

BY JOSH SALINGER

As the costs of concrete and excavation have increased steadily in the Pacific Northwest, where my company designs and builds, local builders are more frequently turning to slab-on-grade (SOG) foundations. These assemblies require less concrete and labor than full basements and have a number of advantages over crawlspaces: better thermal performance, much lower risk for water and animal intrusion, and lower maintenance overall. SOG's also make universal design easier to achieve.

In our ongoing quest to improve residential construction methods, we've embraced a number of new approaches to SOG foundations, developing team expertise with each new one we design and build. One of those approaches is the concrete-free slab. While we did not invent the concept, we have tried to

Slab

refine our approach with every new concrete-free slab we install by improving both efficiency and effectiveness. We are so comfortable now with plywood slabs that we've committed to using them in all our future SOG foundations. We recently designed and built two almost identical, 800-sq.-ft. accessory dwelling units (ADUs), each with a 665-sq.-ft. SOG. Both are aiming for zero-energy-ready certification, with owners who are trying to reduce the buildings' environmental footprints. These projects proved to be perfect for a concrete-free slab. □

Josh Salinger is founder and CEO of Birdsmouth Design Build, a residential design-build firm in Portland, Ore. Photos by Asa Christiana.

WHY WE DITCHED THE CONCRETE

REDUCED EMBODIED CARBON

Concrete has a high amount of embodied carbon, and companies like ours that specialize in high-performance, environmentally conscious construction are always looking for innovative ways to use less of it. Roughly 40% of all greenhouse-gas (GHG) emissions in the United States come from our buildings, 11% of which comes from the carbon embodied in the materials used to make those buildings.

Concrete is one of the biggest single contributors to GHG emissions, responsible for 8% of total emissions on the planet. So it makes sense to reduce not only the amount of energy used in operating our buildings but also the amount of concrete we use to build them.

FEWER DELAYS AND MOISTURE REDUCTION

A plywood slab is not only more environmentally sound than the full concrete approach, but it offers a number of practical benefits too. Our carpenters can build the slab themselves, saving on costs and allowing us to better control the timeline, avoiding delays due to subcontractor schedules and more. We can also start exterior and other load-bearing framing as soon as the stem walls cure, without waiting for the slab to be poured and waiting again for it to cure.

Plus, unlike concrete, the plywood slab does not load significant moisture into the building envelope during the curing process.

HASSLE-FREE FLOORING

Another big advantage of a plywood slab is that finished flooring can be installed directly onto it—no different than installing flooring on a plywood-and-joist floor. We used a floating, engineered cork floor in the accessory dwelling units featured in this article, and we're planning a nailed-down, tongue-and-groove (T&G) hardwood floor on a future plywood slab. To install flooring on a concrete slab, on the other hand, a vapor barrier must be applied over the top with additional accommodations—such as wood sleepers and a plywood subfloor—depending on the flooring chosen.

To make the plywood slab as durable as possible, we choose a vapor-permeable flooring for the largest areas of the slab. This allows any incidental moisture—from spills, toilet overflows, or whatever else happens above the floor—to dry to the interior and not build up in the plywood. That said, we feel comfortable using impermeable flooring such as tile in smaller areas (kitchens and baths, for example) as long as it's installed over a decoupling membrane to allow the slab to flex and move below it and as long as there are adjacent permeable areas for the plywood to dry to.

Bottom line: The plywood won't degrade as long as it has more of an opportunity to dry than it has potential for retaining moisture.

CONCRETE-FREE SLABS

START OFF ON THE RIGHT FOOTING

Building codes in our climate zone (4C) require a minimum R-15 thermal break at the edge of a concrete slab, where up to 60% of heat loss occurs. Compared to concrete, however, a plywood slab-on-grade (SOG) has very little thermal loss at the edges because it's only 1½ in. thick, and it's made of wood. One could reasonably argue that the standard level of slab-edge insulation isn't as necessary with a plywood SOG. However, making this argument to your local building inspector might not be worth the headache; the code has no guidance on anything other than concrete slabs.

We use a stem wall made from insulated concrete forms (ICFs). Made of reinforced foamboard that stays in place after the pour, ICFs (ours are made by BuildBlock Building Systems) provide a two-sided thermal break that creates a very high-performing SOG and surpasses code requirements. A typical R-15 slab-edge thermal break translates to roughly 3 in. of GPS or XPS foam.

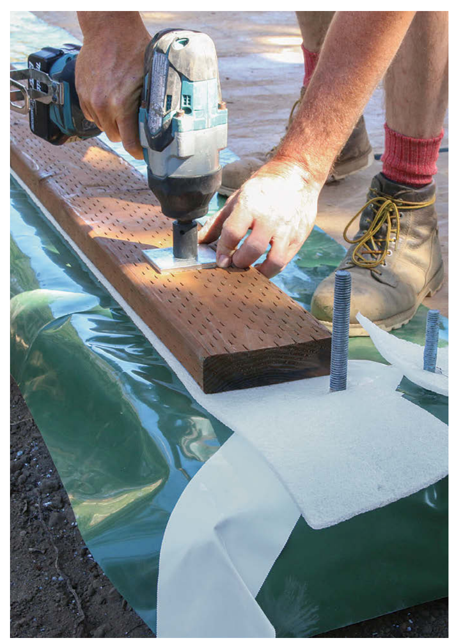
One thing to consider is that the foam, located where the slab and stem wall connect, can make it difficult to fasten hardwood flooring or carpet at the edges. With the ICFs we ordered for this project, each foam layer is only 2½ in. thick, making the problem area a bit thinner to start with. To erase the problem almost entirely, we bevel the interior side of the ICF at 45°, allowing us to run the plywood slab very close to the wall while still meeting code.

We also like ICFs because we don't have to own and store concrete forms and the associated materials, nor rely on outside foundation subs. Instead, we can form and pour foundations on our own schedule, using our own crew, which has become quite adept with these systems. In addition, ICFs are small, lightweight, and portable, making them especially useful for smaller structures with limited access, such as the accessory dwelling units (ADUs) we build in Portland's dense historical neighborhoods.

Not interested in using ICFs? Find two more practical approaches for traditionally formed stem walls at FineHomebuilding.com/magazine.

FRAME THE FOOTINGS AND SET UP THE STEM-WALL FORMS
Footings are framed with 2x12s, and the sides are reinforced to keep them from bulging under load. The ICF forms are fitted with rebar and stay in place after the pour. Most of the lumber is reused for framing.

BEVEL THE INSIDE EDGE OF THE FOAM
A 45° bevel makes it possible for the drywall and baseboard to cover the top of the foam at the edges of the floor.

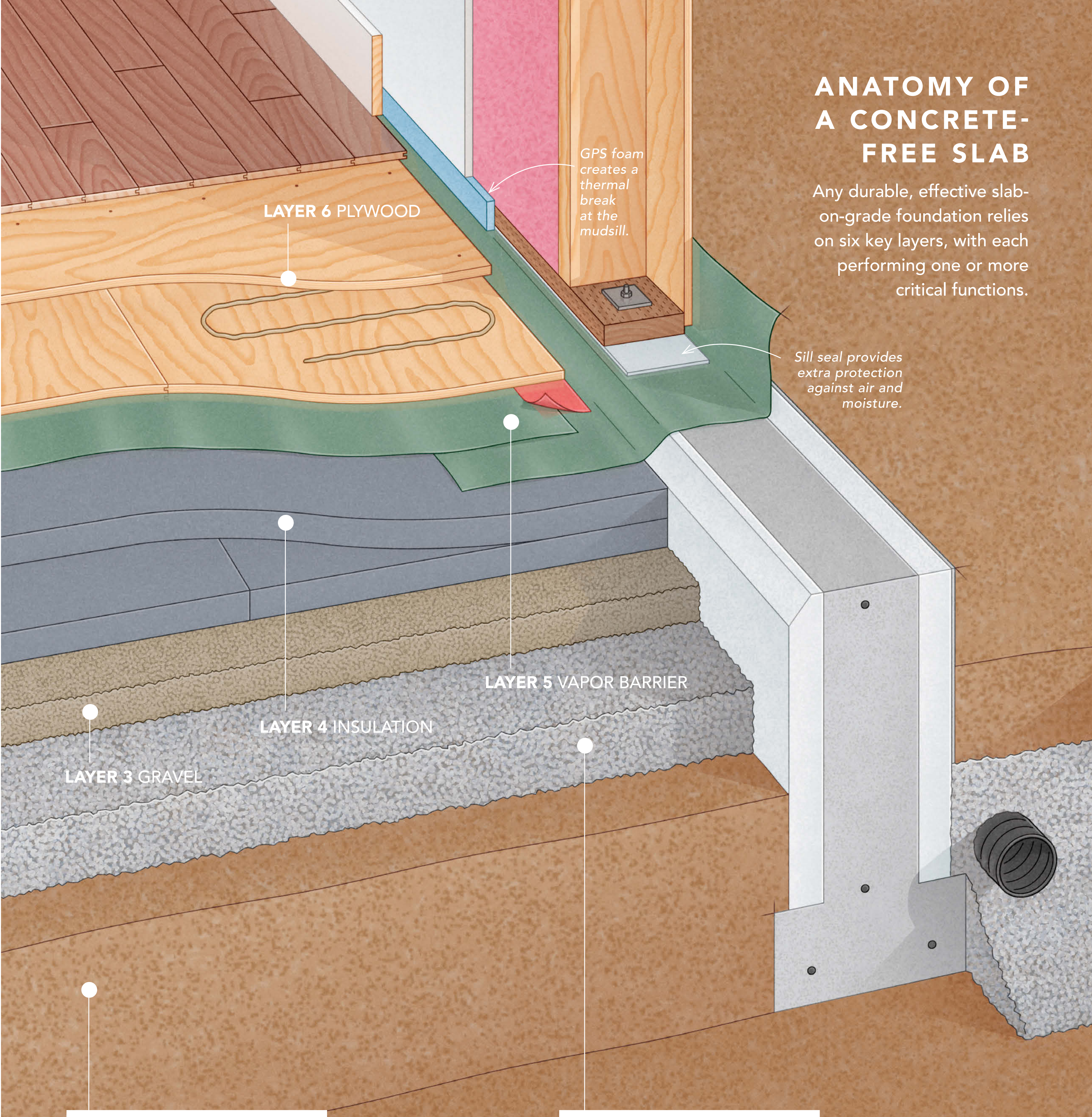


VAPOR BARRIER UNDER THE SILL
The crew runs a strip of the vapor barrier under the sill plate before framing, later taping it to the interior vapor barrier.

Drawing: Peter Wojcieszek

ANATOMY OF A CONCRETE-FREE SLAB

Any durable, effective slab-on-grade foundation relies on six key layers, with each performing one or more critical functions.



LAYER 1 STABLE SOIL IS AN IMPORTANT FIRST STEP

The first layer is the native, undisturbed soil or engineered fill that the slab, its footings, and ultimately the building bear on. Since we designed the building featured here to have no interior point loads, all the bearing is on the perimeter stem wall and footings, and the slab has no structural function. When we have a building with point loads or load-bearing walls on the interior, we add interior footings, just as we would with a concrete slab.

LAYER 2 CRUSHED STONE ACTS AS A CAPILLARY BREAK

The second layer consists of a minimum of 4 in. of compacted, ¾-in. crushed stone with no fines. Its primary function is to act as a capillary break, preventing moisture from being wicked up through the slab and into the building. This second layer also functions as a "pressure field extender" for the soil-gas ventilation system, with perforated pipes either passively or actively keeping radon from entering the home, depending on local requirements.

LAYER 3 GRAVEL KEEPS THINGS LEVEL

On a concrete-free SOG, we add a 2-in. to 3-in. layer of 1⁄4-in.-minus gravel above the capillary-break stone. This layer is much easier to screed level and flat so that we can then set our foam-insulation layers in full contact without any voids or settling, which could create bouncy or uneven floors. We set a laser line on the wall for reference and use a grading rake to get the gravel close to level; we check it with a tape measure. After that we use a 2x4 as a screed, working it back and forth to set the grade perfectly flat, 6 1⁄4 in. below the stem wall.

Since the grade of each ADU was high enough relative to the plumbing hookups at the main house, we were able to run the water supply and sewer connections below the footing. After framing we invited our plumber in to trench the gravel and install the radon, supply, and drain lines from their connection points under the footing to their interior stub-outs. As he dug, we were sure to keep the 3⁄4-in. stone in separate piles from the 1⁄4-in. gravel. We also made sure the plumber set the horizontal runs lower than the grade of the gravel so we wouldn't have to carve out the foam around the pipes.

GRADE THE GRAVEL
The top layer of 1⁄4-in.-minus gravel is easier to rake and screed level than the 3⁄4-in. crushed stone below. Note the connecting strip of vapor barrier, which is tacked up onto the wall for now.

LAY DOWN TWO LAYERS OF GPS
We measure down from a laser line as we grade the gravel and lay down two overlapping layers of 2-in. GPS foam insulation, each laid perpendicular to the other and with alternating seams.

LAYER 4 RIGID FOAM ELIMINATES COLD FEET

We run rigid insulation horizontally under the entire slab, just as we did before we switched from concrete to plywood. It's not very costly to do in comparison to the usual approaches, and the benefits to the homeowner are significant. The first is comfort. People don't want to feel cold underfoot, and they tend to complain if they do—something every builder wants to avoid. A full layer of insulation under the slab mitigates this problem significantly. Just as importantly, there is a big benefit in energy efficiency. For the floating plywood slab, this continuous insulation layer is essential, providing a flat, stable surface for the floating raft of T&G plywood. We use two layers of 2-in.-thick graphite polystyrene (GPS) foamboard, oriented perpendicular to one another with the seams offset to ensure minimal air gaps.

PROTECT THE VAPOR BARRIER
We create stops out of 2x4 scraps to prevent the plywood from moving and potentially damaging or pinching the vapor barrier, or shifting the insulation layers below, as we smack the consecutive sheets of T&G plywood together.

LAYER 5 10-MIL POLY BLOCKS MOISTURE MIGRATION

The fifth layer—above the insulation and directly below the slab itself, is a polyethylene sheet that acts as a Class 1 vapor barrier. The vapor barrier isolates the slab from the ground and the water and vapor it contains. Regardless of climate, the relative humidity of the ground always approaches 100%. If this layer were omitted, the concrete or plywood would draw moisture into the building, inviting rot, mold, and humidity issues.

The 10-mil polyethylene sheet we use—W.R. Meadows SealTight Perminator—is a big reason we feel the concrete-free slab is a durable, long-term approach. It's critical to use compatible tapes for sealing the seams and to ensure complete adhesion. Any penetrations, such as plumbing or radon vents, must be taped completely from pipe to poly without gaps, folds, or other sloppy work.

In our approach to the foundation-and-wall connection, this layer also doubles as the air barrier. Although there are other perfectly great ways to detail an air barrier from the sheathing to the stem wall, we run ours below the mudsill. This is not only effective, but it's also efficient for our crew. The connection is as simple as draping a 20-in.-wide strip of poly over the stem walls prior to installing the mudsill. We add a strip of sill seal on top to help take out some of the inconsistencies in the stem wall and to act as a secondary capillary break.

The wide strip of vapor barrier is tacked up temporarily on the inside walls to keep it out of the way. Once the insulation layer is installed, we simply roll out the vapor barrier in the field and then tape down the flap at the perimeter to complete a continuous vapor and air seal. On the exterior, the overlap is brought up over the sheathing and tacked in place. In order to create a continuous air barrier and avoid potential water damage, it's important to lap over and seal the vapor barrier with a self-adhered or liquid-applied membrane rather than a mechanically applied WRB. Our self-adhered water-resistive-barrier membrane gets lapped over it and sealed to create a continuous air barrier.

TAPE SEAMS AND PENETRATIONS
We fill gaps around plumbing penetrations with canned spray foam, and we tape those areas carefully. We also tape to the connecting strip of poly that was installed earlier under the sill plate.

GLUE AND SCREW
Maintain a ½-in. space around the perimeter with blocks before fastening the plywood with glue and screws. With the second plywood layer in place, the slab is ready for interior wall framing and flooring installation.

LAYER 6 A PLYWOOD SLAB IS THE LAST STEP BEFORE INTERIOR WALLS GO UP

The sixth and final layer, resting on the vapor barrier, is the material that creates the slab. This is the strong surface layer that takes the place of traditional rebar and concrete. The plywood is standard ¾-in. T&G CDX subfloor material. Pressure-treated plywood is not only unnecessary but would add chemicals and VOCs to the interior environment. We install two layers, with the second set perpendicular to the first and the joints offset.

We had the opportunity to test the performance of both T&G and regular plywood in two identical buildings. We found that the T&G floor was more robust but took more effort to install. Moving forward, we will be using T&G, but you can use the approach that works best for your situation.

For the first layer, we leave a ½-in. gap between the outside edges and the stem wall to allow the T&G plywood to expand and contract. To maintain that gap as the edges are connected, we install temporary braces between the first row and the framing. The top layer can overhang the bottom layer slightly, because the edges of the ICFs were cut back earlier. The two layers are allowed to float on the layers below and are joined together with construction adhesive and 1¼-in. screws, sized so they don't penetrate the vapor barrier below.