

Permanent Wood Foundations

Good drainage, reliable waterproofing, and the right structural details yield a warm and dry basement living space



by Terry Shields

Pressure-treated wood foundations (also known as permanent wood foundations, or PWFs) have been around at least since the 1940s, and my own experience with them dates back 20 years or so. During my first year on my own as a framing contractor, I was framing homes for a large builder who used wood foundations on many of his projects. Although I was confident of my ability to frame the job from the foundation up, my experience with PWFs was limited. Fortunately, the builder was good enough to assign one of his own experienced carpenters to help me out on my first foundation.

That job went well, and today I still use variations of that same design. I've tweaked some elements, but the overall process has changed very little.

Benefits of Wood

For me as a builder, a key benefit of the wood foundation is that it keeps my guys working in lean times. I employ carpenters, and with a crew trained in foundation

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installation I can keep that part of construction in-house, which helps with scheduling and quality control. It also means one less sub on the job, which saves money. The trades are ready to go as soon as the walls are built, and insulation and drywall are ready with no additional framing required.

The idea of wood foundations might initially make some builders uneasy, but I'm very comfortable with them. Like any foundation, a PWF can be done wrong, but if that happens it's probably the fault of the builder, not the foundation system. I've stayed in touch with many former customers, and I know that the wood foundations I built 15 years ago are as good as ever. For me, that's convincing evidence that the approach works. The builder I learned from years ago is still using them, too.

Choose your foundation. That said, I don't use wood foundations everywhere. I work in more than 40 Michigan counties, and I use conventional concrete foundations

more often than not. Although the cost of a PWF is comparable to that of a poured foundation, it's a better value if the basement will be used as living space, thanks to the ease with which a wood foundation can be insulated and finished. PWFs are especially good on sloping lots where there's a walkout area toward the front of the structure.

Materials

You can't use just any green-tinted lumber for a PWF. Lumber and plywood meant for use in foundations are engineered specifically for that application, and each piece should be clearly marked as such. The grade stamp should also specify a preservative retention of .60, indicating that each cubic foot of material contains .60 pound of preservative. Southern yellow pine is the most commonly used species in PWFs because it accepts preservatives readily. Pressure-treated dimension lumber follows the same grading system as ordinary framing lumber. We ordinarily

use a No. 2 grade for foundation framing.

Conveniently for us, wood foundations are well-known in our work area. The salespeople at the yards we deal with understand our requirements and have never failed to send us the right material.

Health and the environment. Foundation-grade PT lumber is treated with chromated copper arsenate, or CCA. Although CCA-treated lumber was widely used for decades, the EPA sharply restricted its use in 2004 after concerns were raised about its possible toxicity. (CCA is still widely and legally used in marine, agricultural, and industrial construction, however.) One of its few remaining uses in residential construction is for permanent wood foundations.

I take common-sense precautions when working with CCA-treated lumber and have never experienced any ill effects from exposure to it. Since the preservative is said to resist leaching into the soil, I don't think there's anything to worry about once

TABLE A1 – PLYWOOD FASTENER SCHEDULE FOR PWF'S USE STAINLESS-STEEL FASTENERS BELOW GRADE¹

Fastener	Equal backfill (Max. 2-ft. differential)		Unequal backfill (Max. 6-ft. differential)						Intermediates supports	
	Panel edges	Intermediate supports	Long walls ²		Number of stories (above foundation)	Number of interior shear walls in basement ³	Short walls			
			Panel edges	Intermediate supports			15 psf wind zone	25 psf wind zone		
16 Gauge Staple ⁴	4"	6"	4"	6"	One	None	4"	3"	5"	
						One	3"	2"		
						Two	4"	4"		
					Two	None	3"	4"		
						One	2"	4"		
						Two	3"	2"		
16 Gauge Staple ⁴	4"	6"	4"	6"	Two	None or One	6"	4"	5"	
						One	6"	4"		

MINIMUM STRUCTURAL REQUIREMENTS

TABLE 8 – BASEMENT FOUNDATIONS, ONE-STORY CONSTRUCTION

Maximum Backfill Height (ft.)	Stud and Plate Size (nominal in.)	Stud Spacing (inches o.c.)	No. 1 Southern Pine		No. 2 or higher grade Southern Pine ²	
			Maximum Building Width (ft.)	Maximum Roof Live Load-Snow (psf)	Maximum Building Width (ft.)	Maximum Roof Live Load-Snow (psf)
86	2 x 6	12	36	43	36 (No. 1)	43
	2 x 8	16	36	43	36	43
72	2 x 6	16	36	43	36	43
	2 x 8	16	36	43	36	43
48 or less ¹	2 x 6	16	36	43	36	43

¹ Use backfill 24 inches or less per PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

² Foundation: 8" x 16" maximum. Steel reinforcement: 4" x 16" maximum. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

³ Interior walls: 8" x 16" maximum. Exterior walls: 8" x 16" maximum. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

⁴ Based on No. 1 Southern Pine. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

⁵ Based on No. 2 Southern Pine. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

⁶ Based on No. 3 Southern Pine. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

⁷ Based on No. 4 Southern Pine. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

⁸ Based on No. 5 Southern Pine. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

TABLE 9 – BASEMENT FOUNDATIONS, TWO-STORY CONSTRUCTION

Maximum Backfill Height (ft.)	Stud and Plate Size (nominal in.)	Stud Spacing (inches o.c.)	No. 1 Southern Pine		No. 2 or higher grade Southern Pine ²	
			Maximum Building Width (ft.)	Maximum Roof Live Load-Snow (psf)	Maximum Building Width (ft.)	Maximum Roof Live Load-Snow (psf)
86	2 x 6	12	36	43	36 (No. 1)	43
	2 x 8	16	36	43	36	43
	2 x 6	16	36	43	36	43
	2 x 8	16	36	43	36	43
72	2 x 6	12	36	43	36 (No. 1)	43
	2 x 8	16	36	43	36	43
	2 x 6	16	36	43	36	43
	2 x 8	16	36	43	36	43
60	2 x 6	16	36	43	36	43
	2 x 8	16	36	43	36	43
48 or less ¹	2 x 6	16	36	43	36	43

¹ Use backfill height of 48 inches or less per PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

² Foundation: 8" x 16" maximum. Steel reinforcement: 4" x 16" maximum. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements. See the PWF's minimum design and load requirements.

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			Maximum Building Width (ft.)	Maximum Roof Live Load-Snow (psf)	Maximum Building Width (ft.)	Maximum Roof Live Load-Snow (psf)
66	2 x 6	12	36	40	36 (No. 1)	40
72	2 x 6	16	36	40	36	40
80	2 x 6	16	36	40	36	40
48 or less ¹	2 x 6	16	36	40	36	40

TABLE 9 – BASEMENT FOUNDATIONS, TWO-STORY CONSTRUCTION

Maximum Backfill Height (ft.)	Stud and Plate Size (nominal in.)	Stud Spacing (inches o.c.)	No. 1 Southern Pine		No. 2 or higher grade Southern Pine ²	
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66	2 x 6	12	36	40	36 (No. 1)	40
72	2 x 6	16	36	40	36	40
80	2 x 6	16	36	40	36	40
48 or less ¹	2 x 6	16	36	40	36	40

¹ For backfill heights of 48 inches or less, 2nd story can be 12 or 16 inch o.c. may be used for PWF basement walls in one-story construction. See the 2015 Manual for PWF for complete details, available from NAFB.

² Except use No. 1 Southern Pine where indicated.

³ Except use No. 1 Southern Pine where indicated.

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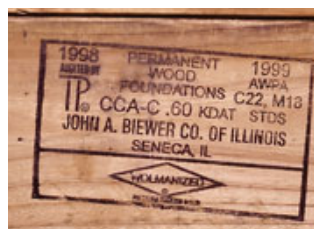
¹⁹ Except use No. 1 Southern Pine where indicated.

²⁰ Except use No. 1 Southern Pine where indicated.

TABLE A2 – GENERAL NAILING SCHEDULE			
Joint Description	Minimum Nail Size ¹	Number or Spacing	
Bottom plate to footing plate – Face nail	10d	12" o.c.	
Bottom plate to stud – End nail – 2" plate	16d	2	
– 1" plate	8d	2	
Top plate to stud – End nail minimum (See Table A3)	16d	2	
Upper top plate to top plate – Face nail minimum (See Table A3) (No overlap of plywood)	10d	8" o.c.	
Header joint to upper top plate – Toe nail minimum (See Table A4)	8d	16" o.c.	
Joint to upper top plate – Toe nail minimum (See Table A4)	8d	2	
End joint to top plate (plate parallel to wall) – Toe nail minimum (See Table A4)	10d	4" o.c.	
Plywood flooring to blocking at end walls (See Table A3)	–	–	
Window header support studs to window sill – End nail minimum	16d	2	
Window sill to studs under – End nail minimum (See Table A3)	16d	2	
Window header to stud – End nail	16d	4	
	16d ²	2	
	8d ²	2	
st-Height of stud	16d ²	1 per stud	
	16d ²	2 per stud	
	8d ²	2 per stud space	
nail	10d	24" o.c.	
	16d	18" o.c.	

Figure 1. The Southern Pine Council's "PWF Design and Construction Guide" contains an abundance of prescriptive data, including span tables, fastening schedules, and detail

drawings. All framing lumber and plywood used in ground-contact areas must carry a grade stamp identifying it as suitable for foundation use (left).



the treated lumber is completely enclosed in a wall.

Most of my customers seem to agree, because I've never had anyone express any concern about this issue — including the owner of the home shown on these pages, who is an environmentally conscious organic farmer. From an environmental standpoint, in fact, a wood foundation is arguably a much “greener” choice than concrete, which takes enormous amounts of energy to manufacture.

The right fasteners. For long life, all fastenings used in a PWF must be stainless steel — hot-dipped fasteners won't cut it here. Stainless fasteners are available to fit both coil and stick nailers and cost about 50 percent to 60 percent more than conventional fasteners.

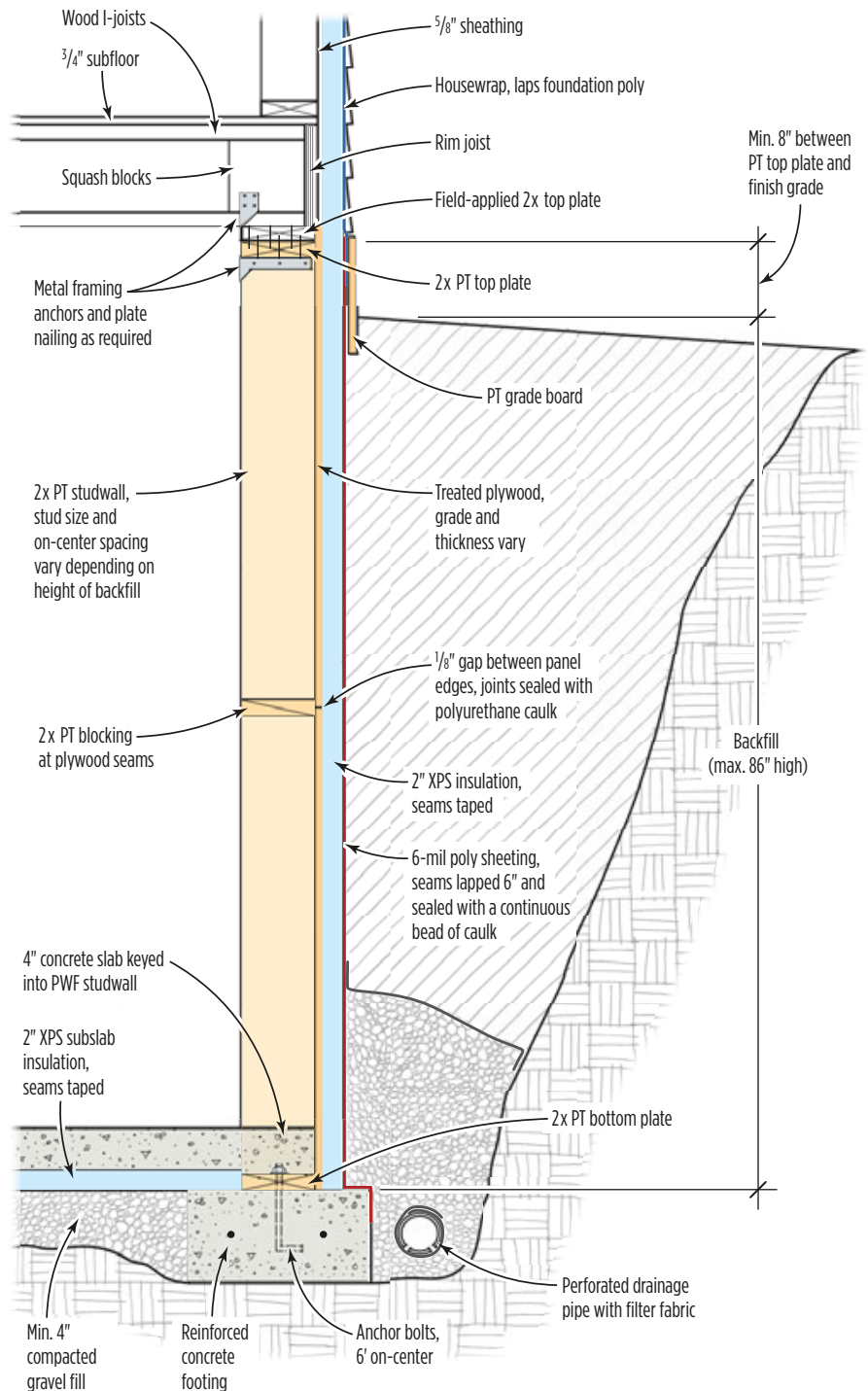
The code does permit us to use regular galvanized framing connectors, though, and we've never had any problems with them. There are probably two reasons they're allowed: First, the connectors are on the dry side of the wall, so there's no moisture present to cause rust or corrosion. Second, CCA-treated lumber seems to have a fairly low potential for corroding metal — most problems with damaged hangers and fasteners are associated with the newer lumber treatments that have come along since CCA was phased out for general use.

Design

The bible for wood foundation design is the “PWF Design and Construction Guide,” available as a free download from the Southern Pine Council (SPC) at southernpine.com (see Figure 1, previous page). In our area, code officials stick pretty much to the guide, because the state building code doesn't cover the subject in any detail. Its tables and construction details let you choose the right fastening schedule, lumber dimensions, and stud spacing for most common situations.

The design guide typically calls for deeper and more closely spaced framing

Typical PWF Framing Details



Plans for pressure-treated basement foundations with backfill depths of up to 86 inches can be drawn up by following prescriptive design tables. Deeper fill or other site-specific conditions that fall outside the scope of the tables will require a plan stamped by an engineer.

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members than you'd find in an above-grade wall. For example, a 9-foot basement I built recently — 2 feet of which was above grade — was framed with 2x8s spaced 16 inches on-center and sheathed with $\frac{3}{4}$ -inch foundation-grade plywood. Foundations that will be backfilled to a depth of 86 inches or less can be designed with the prescriptive specs in the guide, but deeper walls will require an engineer's stamp.

Load paths. A key difference between a wood and a concrete foundation has to

do with how each accepts point loads: In a concrete foundation, a point load that falls within a wall — from a structural ridge, for example — can be transmitted to the mud-sill wherever the load-bearing vertical member happens to end up. But because a treated wood foundation is essentially just another studwall, the load path in a PWF has to remain continuous all the way to the footing at its base. These loads should be accounted for and called out on the plan to make sure they are properly

transferred to the footing. Depending on the load, it may be necessary to beef up the section of footing beneath the point load.

Shear walls. Most buildings that have a front-to-back grade differential of more than 4 feet will need at least one internal shear wall to resist the lateral thrust from the uneven soil pressure. In structures from 24 to 48 feet wide, the shear wall must be located in the middle third of the basement. Buildings more than 48 feet wide will require two shear walls, which must be no farther than 24 feet from one another or from an end wall.

An internal shear wall can often be omitted where the grade differential occurs between the shorter sidewalls, since the long exterior walls that connect them often provide adequate shear resistance in themselves. The SPC design guide provides detailed shear-wall nailing requirements for a range of situations.

Whenever shear walls will be required, it's important to work out their locations during the design stage, because they have a big effect on the quality of the living space. The goal is to come up with a floor plan that allows the shear walls to serve as useful partitions rather than obstructions.

Piers and Footings

PWFs have traditionally been built on a tamped and leveled bed of pea stone. I started out building that way, but for years now I've relied on conventional steel-reinforced concrete strip footings, like those used with poured concrete or block foundations.

I made this move partly because many of the homes I build have conventionally framed roofs, making it necessary to transmit point loads from carrying beams to the footing. An engineered concrete footing gives me a secure bearing point. Also, pea stone is fickle stuff to handle, and spreading and tamping it is painstaking work. Finally, continuous strip footings make it a lot easier to snap accurate layout lines and provide a convenient place to stack and lay out the plates (**Figure 2**).



Figure 2. Although wood foundations have traditionally been supported by footings of carefully compacted gravel or crushed stone, a poured concrete strip footing (left) can also be used. The poured footing simplifies the process of snapping layout lines and provides a convenient surface for marking plates and assembling wall framing (below).



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As with a conventional footing, we run perforated drainage pipe around the outside perimeter, covered with crushed stone and filter fabric. We run the pipe to daylight or to a sump.

Framing Foundation Walls

I start my wall framing by using a layout laser to find a square starting point on the footings, then pull dimensions and snap the layout lines. I also use the laser to double-check the height of the footings to make sure they are level. From there, I stack and detail plates according to the plan.

Studs, plates, and blocking. Depending on the backfill height and foundation details, studs and plates may be nailed together or fastened with joist hangers or sheet-metal connectors for increased strength. We frame a standard three-stud corner at wall intersections. According to the design guide, nails are acceptable here, but I prefer to use GRK stainless 3-inch Pheinox screws (800/263-5160, grkfasteners.com), spaced 12 inches on-center.

Because the plywood sheathing runs horizontally, we install horizontal blocking to provide secure nailing at all panel edges, with additional blocking where needed for the shear walls. Doing the blocking while the walls are on the ground eliminates any ladder work. We apply the sheathing — usually $\frac{3}{4}$ -inch PT plywood — once the wall framing has been erected, plumbed, and braced (**Figure 3**).

Caulking the joints. In a wood foundation, all sheathing joints must be sealed with a latex or polyurethane caulk. We use a low-VOC polyurethane caulk and apply a double bead to framing members where adjacent panels meet. When the panels are nailed in place, the excess caulk squeezes out and fills the $\frac{1}{8}$ -inch gap between panel edges. Although it's not required, I run an additional bead of caulk at all framing members in the field of the panels — essentially gluing the panels to the framing — because I believe that this helps reduce thermal bridging



Figure 3. The top member of the doubled top plate can be assembled from conventional untreated framing lumber, lapped at the corner as in standard framing (top). Intermediate blocking provides solid nailing at panel edges, all of which are carefully sealed with approved caulk (above).

and makes for better contact between the framing and sheathing.

Floor System

A sheathed floor adds a lot to the strength and stiffness of a concrete foundation, and this is even more true for a wood foundation. If you're using solid lumber joists, the floor system can be designed

from the tables in the design guide. But if you're using engineered lumber, it's best to get design guidance from the I-joist supplier. Most manufacturers have used their products in PWF applications and can provide the necessary expertise.

Joist-to-plate connections. Where foundation walls will be backfilled to a depth of 4 feet or less, I-joists or solid lumber joists

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Figure 4. Once the basement slab has been poured and finished (above), shear walls and partitions can be erected. Two partially sheathed shear walls are visible here (right), each of which extends from the long wall at right to an inside corner at left. A doubled I-joist at the top plates (indicated in photo by dotted red lines) will provide a solid connection between the shear walls and the floor diaphragm overhead.



may be fastened to the plates with toenails alone. Deeper backfill often calls for metal framing anchors in addition to toenails. We use Simpson H3 hurricane ties here, which are most often used to connect rafters to plates in high-wind areas. Where the joists run parallel to the foundation wall, blocking is nailed between the band joist and the next joist inboard of it. Depending on the situation, the blocking will be spaced either 48 or 24 inches on-center, and in some cases will need to continue into one or more additional joist bays.

Stairways. Where the basement stairs run against the foundation wall, there's no floor sheathing or blocking to resist the soil pressure at the opening. To provide the necessary stiffness here, we attach additional members to the double top plate with carriage bolts, creating what's in effect a header turned on its side.

Slab and Interior Framing

Wood foundations with suspended floors over a crawlspace are popular in some parts of the country, but all the foundations I build have slab floors. The slab doesn't care what kind of walls it's enclosed by, so the procedure here is for

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the most part pretty standard.

Subslab insulation. We pour the basement slab over a prepared base of crushed stone, or — where site conditions permit — directly onto well-drained undisturbed soil. Either way, the subslab is insulated with 2 inches of rigid polystyrene foam. We tape the joints between sheets of foam with Duramate tape to control moisture. We don't use an additional polyvapor retarder.

A buried plate. The plywood foundation sheathing serves as a perimeter form for the slab, allowing the slab to fill the bottoms of the stud cavities and completely encapsulate the bottom plate (Figure 4, previous page). Shear walls are nailed to blocking between the outer wall studs and to the overhead floor joists, and are fastened to the slab itself with anchor bolts.

To provide racking resistance, shear walls are sheathed on both sides with OSB. But because shear walls double as partitions and often contain plumbing, I usually apply the OSB on one side and have my plumber do the other side when he finishes up inside the wall.

Insulation, Waterproofing, and Backfill

The caulked plywood sheathing is itself quite waterproof — which is why the same general approach is popular among boat builders — and the perimeter drains channel away any water that might otherwise find its way under the wall. But there are two other layers of protection as well: exterior foam and poly.

Exterior foam. To provide a warm, comfortable basement and help keep the inner surface of the plywood safely above the dew-point, we fasten a layer of extruded polystyrene foam to the outside of the sheathing with plastic-cap nails. Depending on which part of the state we're working in, this usually calls for 1 or 2 inches of foam. To make sure that any condensation that might form inside the wall cavities under extreme conditions can dry to the inside, we don't use a vapor retarder under the interior drywall.



Figure 5. Targeted applications of spray foam air-seal and insulate the rim joists (left) and the bottom plates (below), where scraps of OSB were laid down to protect the slab floor from overspray. Damp-spray cellulose insulates the stud cavities (bottom).



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The exterior foam is carried onto the above-grade portion of the walls, extending all the way to the eaves.

We seal the joints between adjacent sheets of foam with Duramate tape, then cover the foam with a layer of 6-mil poly. To keep the poly from flapping around before we backfill, we stick it to the foam with dabs of polyurethane caulk as we spread it out. Joints between sheets of poly are overlapped by 6 inches and sealed with a continuous bead of caulk, and the bottom of the poly is lapped onto the filter fabric that covers the stone and footing drain to direct water away from the wall.

Grade board. To keep dirt from getting behind the upper edge of the poly as we backfill, we cover it with a 1x12 pressure-treated grade board nailed through the foam to the framing. The grade board also shows us how high to go with the backfill and eventually becomes an exterior trim element, providing separation between the eventual finished grade and the siding.

It's always a good idea to make sure the floor system is in place before backfilling a concrete foundation, but with a PWF this is absolutely critical. We usually backfill the excavation with a skid-steer loader, because we do a lot of work on tight lots where there's little room to maneuver. Using a skid-steer keeps us from getting too aggressive with the backfill. A larger machine could be used,



Figure 6. Before the excavation is backfilled, the below-grade portion of the exterior is wrapped with 6-mil poly (top left), the top of which will be secured to the wall with a pressure-treated grade board. On the sided building, the grade board is carried along the sidewall (top right) and across the walkout front (above).

but it would be important to fill the excavation in several lifts to avoid putting too much pressure on the foundation all at once.

Finishing Up

I used to insulate the foundation walls with fiberglass batts, but now I usually use damp-spray cellulose because it combines excellent insulation with an attractive price point. We use some spray foam at the rim joists and around the bases of the stud cavities (**Figure 5, previous page**).

Once the cellulose has dried for a few days, we hang the drywall.

Exterior finish. When we hang siding on a project with a walkout basement, we like to slope the grade board across the width of the gable-end walls, carrying the line of the foundation wall in back to a corresponding grade board in front of the house (**Figure 6**).

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