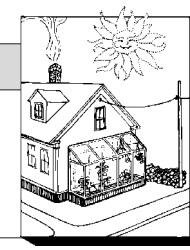

Should You Insulate the Basement?

by J. D. Ned Nisson

Heat loss through the uninsulated basement of an otherwise well-insulated house can account for up to 40% of the total house heat load. That fact should justify spending a reasonable amount of money on basement insulation. But computer simulations, controlled experiments, and field studies consistently suggest otherwise.

Since most basements are not fully heated, the below-grade heat loss is so small that, based on energy savings alone, full wall insulation is rarely cost effective and sub-slab floor insulation is never cost effective.

Figure 1 shows the calculated annual heat loss from a basement located in a cold climate (Madison, Wis.). Notice the huge difference between the fully heated (68°F) basement and unheated (50°F) basement cases. This is what makes basement insulation different from upstairs wall and ceiling insulation. If the temperature in an unheated basement floats around 50°F, the total heat loss below grade is less than one million Btu per year. With natural gas heating, that's worth about $6. The only part of an unheated basement with significant heat loss is the above-grade wall section, which loses more heat than the rest of the wall and floor areas combined.

Realistically, however, many "unheated" basements have enough unintentional heat sources (ducts, pipes, etc.) to keep the average air temperature at 60°F or higher. But even with this average basement air temperature, the total below-grade heat loss is still probably not sufficient to justify full-wall or sub-slab insulation systems.

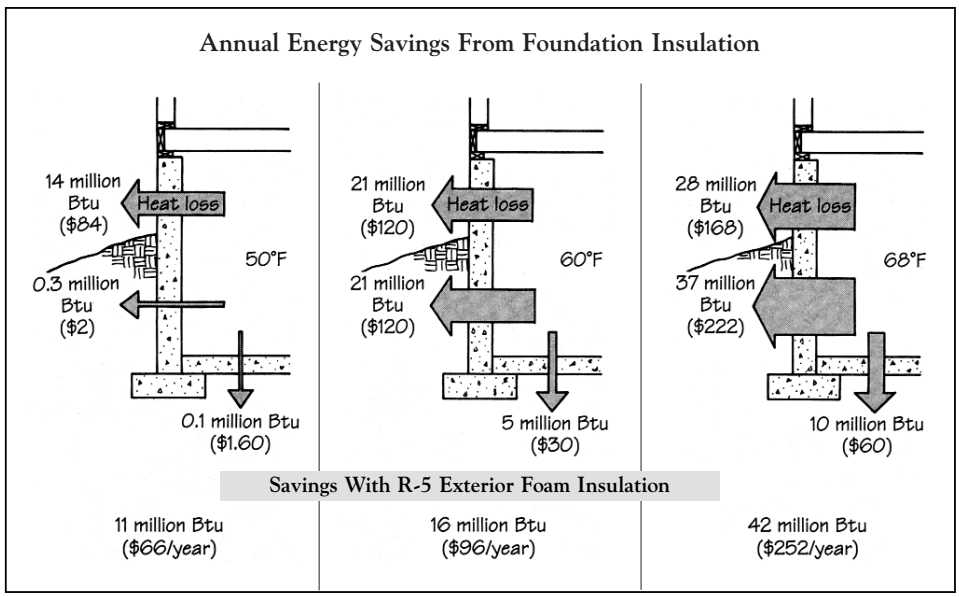

Figure 1. *Using the HOT2000 computer program, researchers calculated the annual heat loss from the foundation of a 50 x 30-foot house in Madison, Wis. In an unheated basement (left), the heat loss is so low that adding insulation does little to reduce energy costs. For a tempered basement (center), the savings improve but they still don't fully justify the cost of the improvement, except possibly on the top portions of the basement walls. In a fully heated basement (right), the heat loss is high enough to justify full-wall insulation. The heating costs are based on natural gas at $6 per million Btu.*

Field Studies Show Long Paybacks

Making the leap from computer simulation to actual field tests, two research studies in Minnesota confirmed that wall insulation in unheated basements does little to reduce energy costs. The first was performed by the Minneapolis Energy Office. Twenty basements were retrofitted with either half-height exterior R-10 foam or full-height interior R-11 fiberglass. The average savings over one full winter was only $85. The calculated average payback period was over 20 years (see Table, right).

A similar study sponsored by the U.S. Department of Energy (DOE) last year found even more discouraging results. For another group of twenty basement retrofits in Minnesota, the average savings from 2-inch exterior foam was only $15 per year and the savings from full-height interior R-13 fiberglass was only $60 per year. The calculated payback period for the exterior foam retrofit was over 120 years!

When considering this data, it is important to remember that all the basements in the study were unheated. Had they been fully heated, the savings would have been several times higher. One study of insulation effectiveness for heated basements was conducted at the University of Minnesota Underground Space Center. Using small 20 x 20-foot test basements, University researchers found that full-height R-10 foam insulation saved about 9 million Btu over a four-month winter period. If the results of this small-scale experiment are extended to a full-size house over an entire year, total savings would be well over $200 and the payback period under 10 years.

Note: *This table shows the average savings, cost, and payback for 20 homes retrofitted with foundation insulation in Minneapolis, Minn.*

Payback for Retrofit Foundation Insulation

	Average Savings ($)	Average Retrofit Cost ($)	Average Payback (Years)
Interior	$109	$1821	20.8
Exterior	$61	$1170	20.7

The Real Purpose Of Basement Insulation

Insulation puts the basement inside the thermal envelope and makes it a more usable space. In both Minnesota retrofit studies, all the homeowners were happy with their basement insulation, despite the disappointing energy savings. The basements were warmer, drier, and generally more livable. (The average temperature in the "unheated" basements was 5°F higher after the retrofit.) The warmer wall surfaces were also less prone to moisture condensation in both summer and winter.

If energy prices continue to rise, basement insulation will eventually become cost effective, even for unheated basements. At this point, however, the main purpose of the insulation is to enclose the basement within the thermal envelope of the house. That way, the basement can be heated efficiently or left unheated without extreme discomfort or moisture problems. David Robinson, principle investigator of the DOE basement study, strongly recommends basement insulation for all new houses simply because the basement will probably be heated some day. "It's a whole lot easier and cheaper to put it in during construction than to retrofit later," says Robinson.

Four Insulation Options

If basement insulation is not cost effective and if the main benefits can't be quantified, then how does a builder decide when and how to add insulation? The following guidelines are based on

a combination of calculated cost-effectiveness and practical considerations.

Typically, a builder has four options: half-height exterior 1-inch foam, full-height exterior 1-inch foam, interior R-11 or R-13 fiberglass, and no insulation at all.

Option 1: Half-height exterior foam. For unheated basements, half-height foam is the only exterior insulation system that can be economically justified from energy savings, regardless of climate. If you know the basement will never be used for conditioned living space, this may be the insulation system of choice. However, I would not use it for heated basements in any climate with more than 3000 heating degree days.

One practical drawback is that, unless the insulation is firmly attached to the foundation or joists, there is a tendency for it to slide down during backfilling or to be gradually pulled down the wall as the soil subsides around the foundation (see Figure 2).

Option 2: Full-height 1-inch exterior foam. I would use full-height exterior foam for basements that might be used as conditioned space in any climate with more than 3000 or 4000 heating degree days. For wet sites, it is the system of choice because it is not subject to water damage.

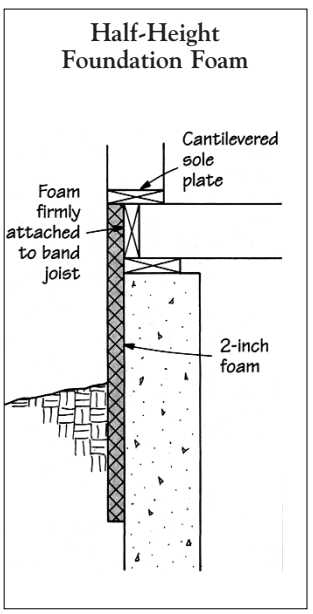

Figure 2. *Half-height exterior foam should ideally be installed over the band joist, as shown above. This not only insulates the joist area, but it provides a good nailbase for the foam to help prevent it from slipping during backfilling.*

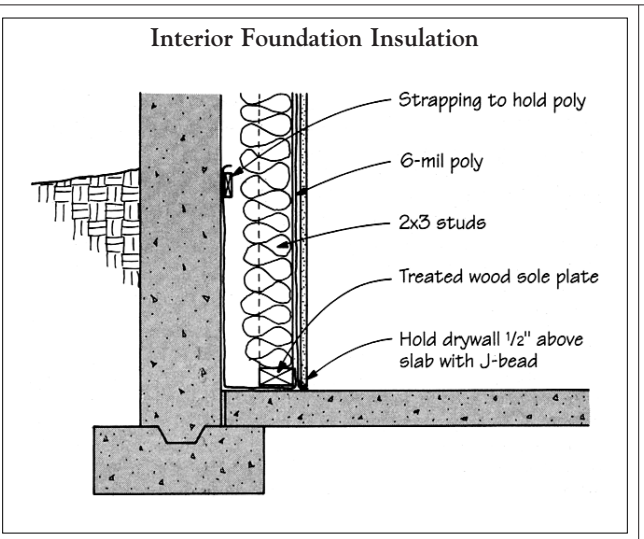

Figure 3. *This interior stud wall with R-11 or R-13 fiberglass insulation has proven itself in both the U.S. and Canada. Notice that the polyethylene moisture barrier ends at grade level to allow an escape route for moisture through the top of the foundation.*

Option 3: Interior R-11 or R-13 fiberglass. Interior framed walls with R-11 or R-13 cavity insulation make the most sense in most climates for several reasons. First, they create finished living space — a visible selling point compared to exterior foam, which is hidden. This is also the least expensive way to install R-11 to R-19 on a basement wall (see Figure 3). This makes it a practical choice for most heated basements except for those in very wet sites, in which case I would opt for exterior foam.

Option 4: No insulation at all. For basements that will clearly be used only for storage, I wouldn't bother with wall insulation in any climate with less than 3000 to 4000 heating degree days.

Basement Ceiling And Floor Insulation

Basement ceiling insulation looks good on paper for unheated basements. But because of all the obstructions and penetrations in most basement ceilings, the insulation system is usually not very effective. As for basement floor insulation, it doesn't make sense from an energy standpoint unless the floor is heated. Though it would raise the floor surface temperature, making it more comfortable to walk on, carpeting would provide the same degree of comfort at less cost. One other advantage of sub-slab insulation is that, in very humid climates, it should reduce the potential for summer moisture condensation on the floor.

Misunderstood Thermal Mass

Exterior foundation insulation places the mass of the foundation wall inside the thermal envelope, where it can theoretically serve as "thermal mass." Although thermal mass can enhance the energy performance of some passive-solar home designs, it is not useful in a basement; it is only beneficial in spaces with large temperature swings. Unless there is a lot of sunshine or a blazing wood stove in the basement, the added mass should have little if any effect.

Researchers at the Minnesota Underground Space Center tested the difference between interior and exterior foam insulation on three specially constructed masonry block test basements. Two inches of extruded polystyrene (R-10) was applied to the interior wall surfaces of one basement and the exterior wall surfaces of another. A third control basement was left uninsulated. All three basements were electrically heated to 68°F during a winter test period. For all practical purposes, the performance of the two insulated basements was identical. Both used about 50% less heating energy than the uninsulated control. ■

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