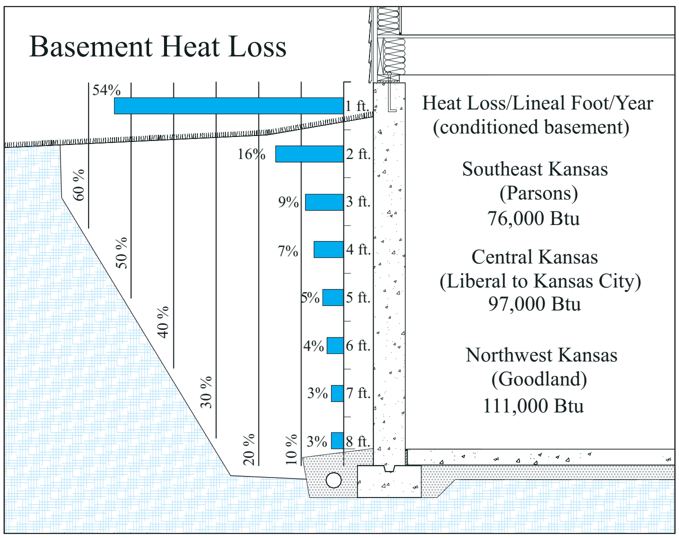
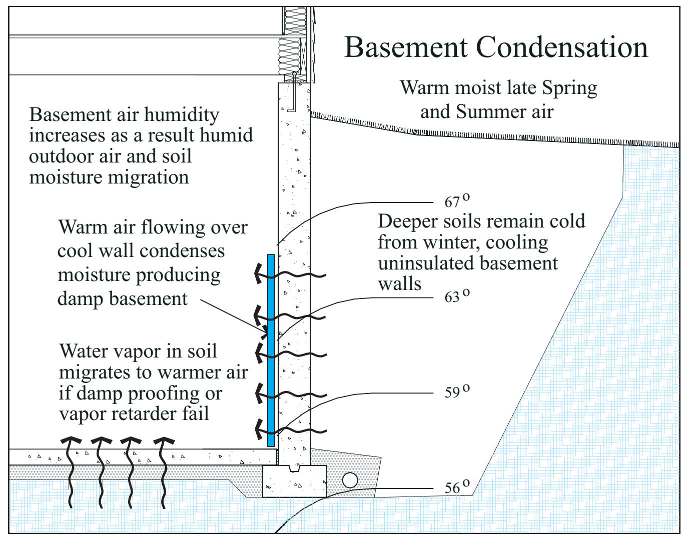
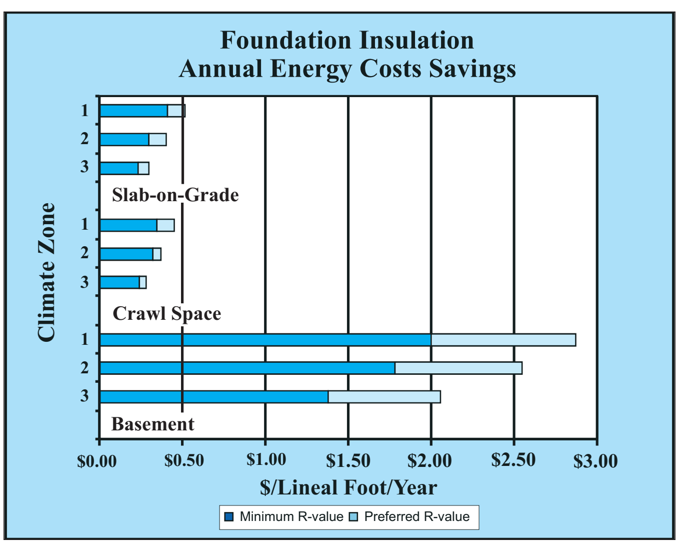
A Builder's Guide to Residential Foundation Insulation



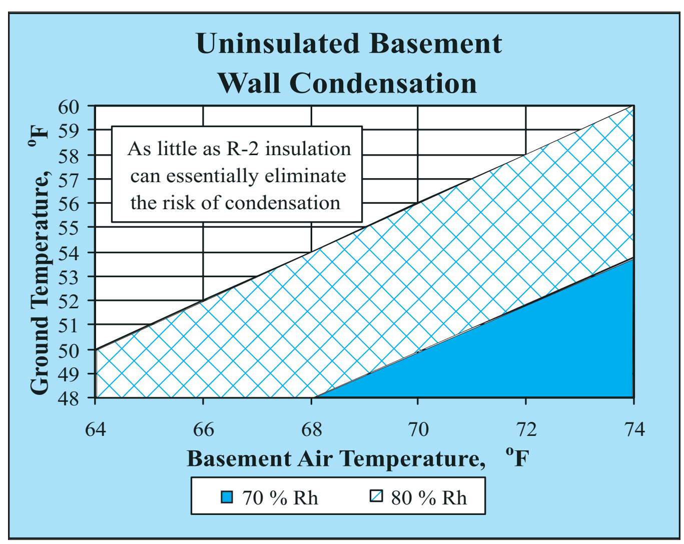
Uninsulated Foundations Loose a Lot of Energy



Uninsulated Foundations Cause Condensation

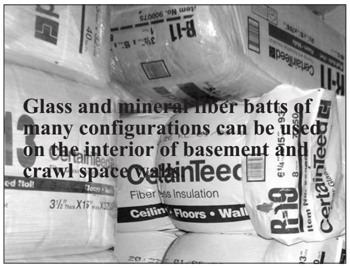


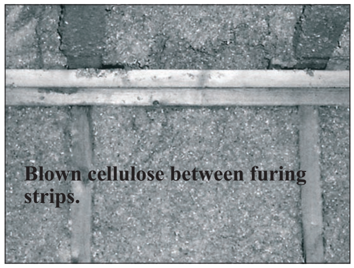
Foundation Insulation Heating Cost Savings



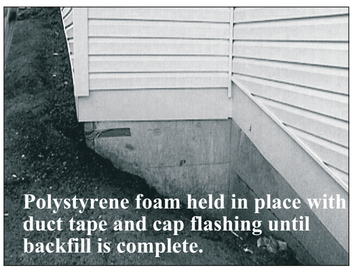
Foundations Insulation Cuts Moisture Problems

A wide variety of foam boards are well suited to foundation insulation.

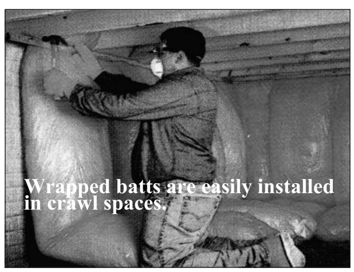

Glass and mineral fiber batts of many configurations can be used on the interior of basement and crawl space walls.


Blown cellulose between furing strips.

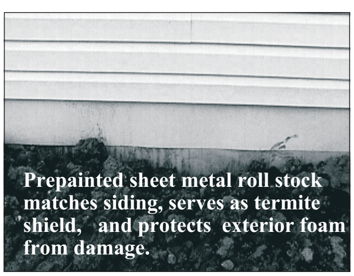
Foundation Insulation


Polystyrene foam held in place with duct tape and cap flashing until backfill is complete.


Fiberglass batts stapled to furring studs.


Wrapped batts are easily installed in crawl spaces.

Installation Methods


Prepainted sheet metal roll stock matches siding, serves as termite shield, and protects exterior foam from damage.


Stucco over rigid foam board.


Cement board nailed to plate protects exterior foam from damage.

Insulation Protection

A Builder's Guide to Residential Foundation Insulation

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Fall 1999

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This material was prepared with the support of the U. S. Department of Energy (DOE) Grant No. DE-FG48-97R802102. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of DOE.

Acknowlegements:

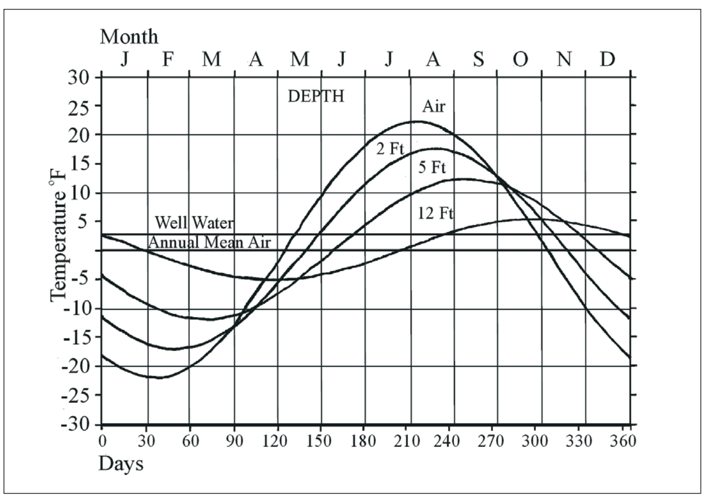
We greatly appreciate the support and encouragement of Jim Ploger, Director of Energy Programs at the Kansas Corporation Commission, and Steve Palomo of the U. S. Department of Energy's Denver Regional Office.

The Purpose of a Building's Foundation

Vitruvius set forth building design guidelines in 1st century B.C. Greece, stating that "Durability will be assured when foundations are carried down to the solid ground and materials wisely and liberally selected...," a concept that remains just as valid as we enter the 21st century.

Foundations connect a building to the ground structurally, transferring the weight of the building to stable soil. A properly designed and constructed foundation insures a building endures seasonal changes in temperature and moisture with little movement. Foundations also connect a building to the ground thermally.

- The common statement that "soil temperatures are constant and therefore below grade insulation is of little value" is not correct.
- Unless geothermal heat is present, the heat that comes from deep in the earth is insignificant compared to the flow of solar energy at the junction of the air and the ground.



Soil Temperature Change with Depth and Season

- While the earth is often thought of as a stable temperature mass, soil temperatures at depths less than eight feet vary considerably during the year. The graph above shows how soil temperature varies with depth and season from both ground water and mean air temperature which ranges from 56° in northwest Kansas to 62° in the southeast.

A team of building scientists at Oak Ridge National Laboratory conducted a comprehensive investigation of the impact of residential foundation insulation practices. In ***The Building Foundation Design Handbook*** that resulted, they concluded, "an uninsulated basement may represent up to 50% of the heat loss in a tightly-sealed house that is well insulated above grade."

Kansas Residential Energy Disclosure and the Model Energy Code

The Energy Policy Act of 1992 strongly encouraged states to upgrade their residential building energy standards to require efficiency levels at least equal to the Model Energy Code. In response, the 1997 Kansas legislature required all new homes have a disclosure form itemizing their energy performance features, or stating the home complies with the Model Energy Code (MEC). Compliance with MEC provides a home buyer with assurance that the home has an integrated set of energy features meeting minimum standards, and it almost always requires foundation insulation. This guide is intended to provide home builders and home buyers with concise information on available foundation insulation materials, installation details and methods, installation costs, and benefits.

Foundation Building Code Requirements

Several requirements of the widely adopted ***CABO One and Two Family Dwelling Code*** affect foundation insulation:

- drains are required around all concrete and masonry foundations enclosing habitable or usable space below grade,
- concrete foundation walls enclosing basements must be dampproofed with a bituminous material from the footing to grade,
- masonry foundation walls enclosing basements must be parged with portland cement prior to dampproofing,
- foundation walls of habitable rooms below grade must be waterproofed,
- exterior foundation insulation must be protected from weathering, sunlight, and physical abuse,
- all foam plastic exposed to the interior must have a maximum flame spread rating of 75 and a maximum smoke-developed rating of 450 (ASTM E-84) and shall be covered with a ½" gypsum wall board or equivalent thermal barrier.

These requirements and all other health and safety requirements of codes adopted by local jurisdictions prevail over the MEC and any suggestions in this guide.

Benefits of Foundation Insulation

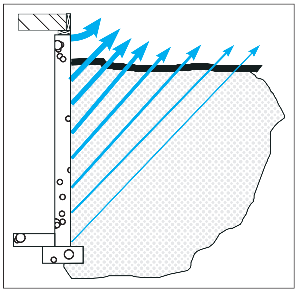
Insulating a home's foundation offers many benefits.

- Foundation heat loss can be reduced significantly and space heating costs can be reduced as much as 50% in an otherwise well insulated home.
- Insulation improves foundation moisture control and indoor air quality. Insulation on either side of the wall results in a warmer interior surface, reducing the potential for condensation and associated mold growth that reduces indoor air quality and can cause material damage.
- The warmer surface also results in a more comfortable space, not only in the basement, but also the floor above.
- Exterior insulation provides protection for dampproofing or waterproofing, extending their life.

These benefits are evaluated in detail in the following sections.

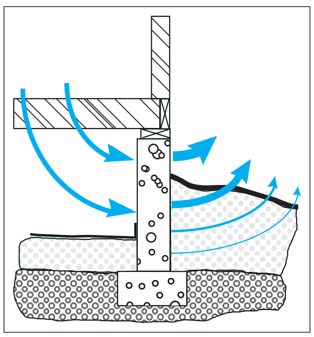
Foundation Heat Loss

Soil can hold a great deal of thermal energy, particularly if damp, but it is not a good insulator. Depending on soil type, 7 - 11 feet of soil would be required to provide the same insulation as two inches of foam or three inches of fiberglass insulation. Uninsulated basement walls loose the most heat where exposed to winter air above grade and at shallow depths where the ground is often frozen.



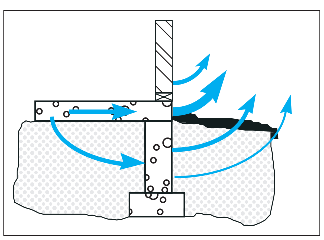
Basement Heat Loss

Floors above crawl spaces can be insulated but are often not to prevent pipes in the crawl space from freezing. Heat passing from the floor into the crawl space is lost through the foundation wall similar to basements.

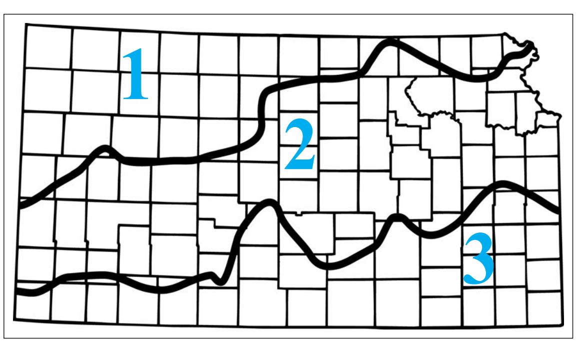


Crawl Space Heat Loss

Slab-on-grade floors wick considerable heat to the exposed slab edge often resulting in a cold floor. Additional heat flows through the soil beneath the slab and out the perimeter foundation. Actual foundation heat loss varies by climate zone, soil type and moisture content, the temperature maintained in the house and a host of other subtle variables. The map below shows three widely recognized Kansas climate zones.



Slab-on-Grade Heat Loss



Kansas Climate Zones

The table below shows typical net annual heat loss, in Btu per lineal foot of foundation, for the three major foundation types in the three climate zones.

	Kansas Climate Zone		
	1	2	3
Full Basment	111,000	97,000	76,000
Crawl Space	47,000	41,000	32,000
Slab-on-Grade	60,000	52,000	40,000

Annual Foundation Heat Loss

(Btu per lineal foot per year)

Potential Cost Savings

While foundation insulation has many benefits, the principal criteria for determining how much should be installed is the economic value of energy savings. Foundation insulation may actually slightly increase cooling energy use since the foundation looses less heat to the ground during the cooling season, but the effect is negligible in the Midwest. Cost of space heating energy (natural gas, electricity, or propane) and the efficiency of the space heating system are also important.

The prescriptive method of complying with the MEC sets out minimum insulation values for each type of foundation (basement, slab, crawl space) for individual climate zones based on average energy prices. The table below shows the MEC required minimum foundation insulation for each of the three foundation types for each of the three climate zones.

While it is seldom possible to comply with the MEC without foundation insulation, there is actually a great deal of flexibility. The performance method of compliance allows improved performance of one building envelope component, such as windows, walls, or attic insulation, to offset lower performance in another area, such as foundation insulation.

	MEC Minimum R-Value		
	Zone 1	Zone 2	Zone 3
Full Basment	10	10	8
Crawl Space	16	16	10
Slab-on-Grade	5 (min. 4 ft)	5 (min. 2 ft)	5 (min. 2 ft)

Foundation Insulation R-values

(MEC prescriptive minimum)

For a more detailed evaluation of such trade-offs investigate the ***MECcheck***™ software developed by Pacific Northwest National Laboratory for the U. S. Department of Energy. This easy to use software is available from the Kansas State University Engineering Extension Service (785-532-4994) or it can be downloaded from <http://www.energycodes.org>.

Energy Cost Savings

The foundation insulation levels shown in the preceeding table will yield estimated annual energy costs savings shown in the following table. The cost levels used in the table are based in the following delivered heat costs:

Low	less than $8.00/million Btu
Medium	$8-12.00/million Btu
High	more than $12.00/million Btu.

These costs are based on typical energy purchase prices and combustion system efficiencies. Use the low energy price if you have natural gas heating and conventional air-conditioning, an air-source heat pump with costs below $.05/kWh, or a water-source heat pump with electric costs below $.08 per kWh. Use the medium energy price if you use propane in combination with a conventional air conditioner, an air source heat pump with electric costs below $.07 per kWh, or a water-source heat pump with electric costs below $.12 per kWh. Use the high energy price if electric costs exceed those noted above or you use electric-resistance heat.

	Kansas Climate Zone		
	1	2	3
	High Energy Costs		
Full Basement	**$256**	**$197**	**$160**
Crawl Space	**$107**	**$92**	**$70**
Slab-on-Grade	**$134**	**$117**	**$92**
	Medium Energy Costs		
Full Basement	**$182**	**$140**	**$107**
Crawl Space	**$75**	**$63**	**$48**
Slab-on-Grade	**$95**	**$83**	**$65**
	Low Energy Costs		
Full Basement	**$126**	**$92**	**$68**
Crawl Space	**$51**	**$43**	**$32**
Slab-on-Grade	**$66**	**$58**	**$46**

Foundation Insulation Annual Energy Cost Savings

(1700 square foot house with 170 lineal ft. perimeter)

Foundation Moisture Control

Most new homes in Kansas have basements. Home buyers expect them to provide useful space, first for storage but eventually as finished space. Nothing detracts more from this expectation than a damp musty smelling basement.

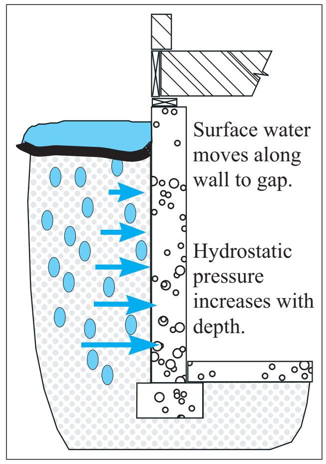
Aside from broken pipes and flooding, basements get damp in four ways:

- free flowing surface or ground water entering through cracks or openings in the basement wall or floor,
- soil moisture wicking through the basement wall by capillary action,
- water vapor migration from cool damp soil to a warmer basement, or
- condensation of water vapor on cold basement walls.

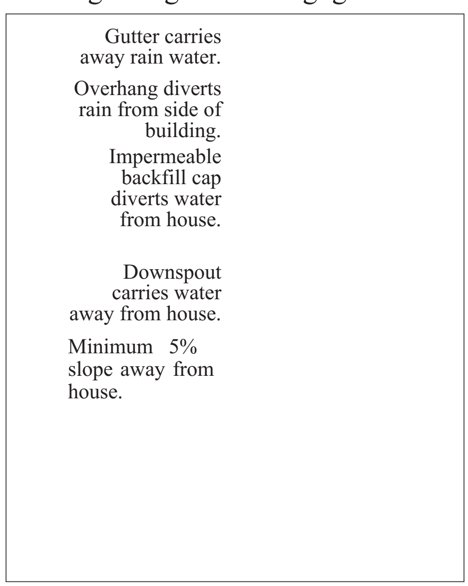
Causes and solutions for each of these potential sources of moisture problems are reviewed in the following sections.

Surface and Ground Water

Surface water problems are caused by inadequate slope away from the foundation or poor control of roof drainage. Water adjacent to the foundation seeps through pervious backfill until it finds a crack, cold joint, or utility penetration through which it enters. Incorporating overhangs in the building design installing gutters and downspouts, capping backfill with impervious clay, and providing proper drainage away from the house can provide effective control of surface water.



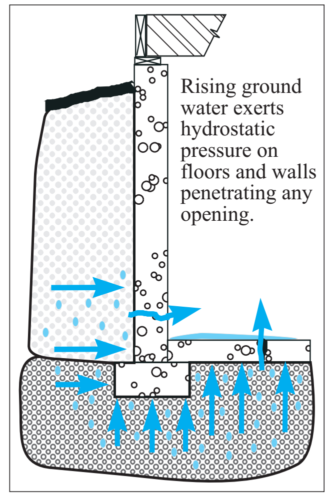
Surface Water Entry



Surface Water Control

When ground water rises above the house floor it exerts hydrostatic pressure on the floor and wall; penetrating any opening. Drain tiles on the outside and in some cases both sides of the footing are required to remove high ground water. If site conditions do not permit sloping the drain to "daylight" an electrically powered sump pump is required. Since storms producing high water are sometimes accompanied by power outages, many elect to install a battery back-up.

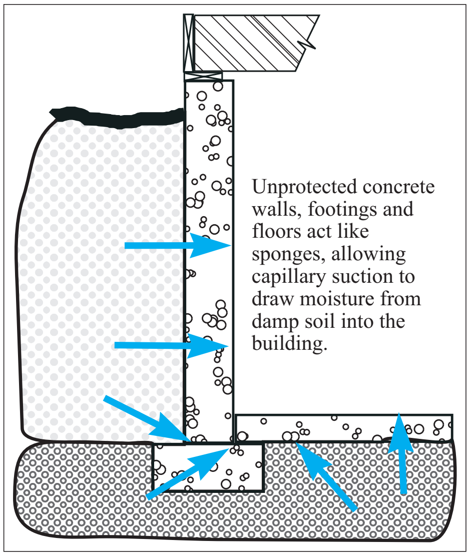
On persistently wet sites, where ground water is know to rise to or above floor level, or where habitable spaces are below grade, the basement wall must be waterproofed. Many effective water proofing products are available, including liquid and sheet membranes, cementious coatings, built-up tar and felt, and bentonite clay. Some liquid membranes and adheshives used with other systems chemically dissolve foam insulation. In selecting a water proofing system make certain all components are compatible with any exterior foam foundation insulation that will be installed.



Ground Water Entry

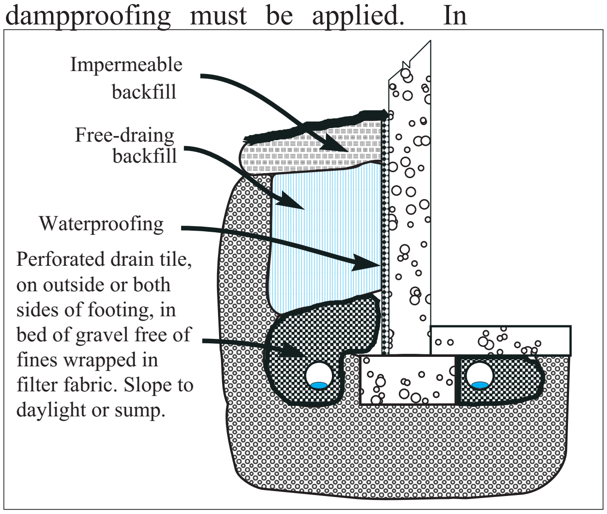
Capillary Moisture Migration

Soil without free flowing water may still contain considerable moisture. The wicking of ground moisture through materials with small pore size, often called capillary movement, can be a significant source of moisture penetration. To break the capillary action between a basement wall and soil the outside surface of the wall must be completely covered with dampproofing. Dampproofing fills the poors in the concrent to prevent wicking. Waterproofing also provides dampproofing, but where a basement wall



Capillary Movement of Ground Moisture

does not require waterproofing, dampproofing must be applied. In



Drain Tiles and Water Proofing

addition to waterproofing, approved dampproofing materials include spray or roller applied bituminous and acrylic modified cement based coatings. Capillary moisture entry through the floor is prevented by using a gravel base. The pore size between stones (3/4 inch stones with fines omitted) is too large to permit capillary suction.

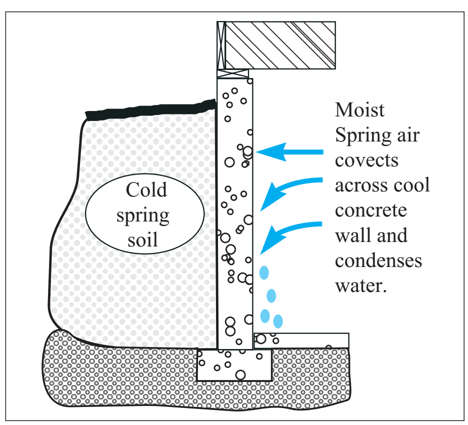
Vapor Diffusion Moisture Movement

Water vapor will move from high vapor pressure to low vapor pressure. Above grade this usually means water vapor moves from the warm (winter) interior to the cold exterior. Below grade water vapor can, depending on the circumstances, move in either direction. Diffusion retarders, materials with a perm rating of 1.0 or less, are installed on the exterior of below grade concrete to reduce the inward movement of water vapor from the soil into the building. Dampproofing and waterproofing are effective diffusion retarders on walls. Polyethylene vapor barriers are placed below floors on top of the gravel bed and can also be used on exterior walls.

Moisture Condensation on the Inside of Foundation Walls

Shallow soil temperatures rise gradually in the Spring, but at a depth of five feet the temperature typically remains around 50-60^o F through mid-June. An uninsulated basement wall will have an inside surface temperature close to ground temperature and will condense moisture from 72^o F air with a relative humidity of 45 - 65%. Insulating the wall shifts the thermal profile, raising the inside surface temperature much closer to the indoor air temperature, greatly reducing the risk of condensation.

Improved Indoor Air Quality



Condensation on Cool Basement Walls

Moisture is not a pollutant, but as relative humidity in a home rises above 60% mold, mildew, and dust mites begin to thrive. Tighter more energy efficient homes often experience higher relative humidity. There are many sources of moisture in a house, but moisture problems in upper floors can be aggravated by excessive moisture in basements and crawl spaces. Mositure can diffuse through the floor system, moist air can flow through cracks and stairs to replace air drawn out of the house by wind or stack pressure, or basement air can be distributed by a forced air heating sytem that intentionally or accidentally draws return air from the basement. Controlling basement and crawl space moisture can reduce the risk of indoor air quality problems.

Improved Comfort

Insulating basement walls raises the surface temperature of the wall and the floor above. Insulating crawl space walls or the floor above increases the floor temperature of the space above. Insulating slab-on-grade foundations increasing the slab floor temperature. In all three cases foundation insulation improves the comfort of the habitable space.

Other Benefits

- Foundation insulation installed during original construction is usually more easily installed properly and less expensive than when retrofitted.
- Foundation inulation can often result in smaller and therefore less expensive heating equipment.
- Foundation insulation makes a basement more attractive for future owner conversion to finished space.
- Reduction in fossil fuel use and associated green house gas emissions has long term benefits for everyone.

Insulation Material Properties

Insulating performance is measured in R-values with units of hr • ft^2 • ^{o}F / Btu. R-values of multiple layers can be added. The inverse of the R-value (1/R) is the U-value, the coefficient of overall thermal transmission, with units of Btu / hr • ft^2 • ^{o}F. U-values can not be added. An uninsulated concrete foundation wall has an overall R-value of about 1.1 and a U-value of 0.9. For each degree of temperature difference between the inside and outside, each square foot of wall will transmit .9 Btu each hour from the warm side to the cold side (U-value x Area x Temperature difference = Heat flow). If insulation with an R-value of two is added to the wall, the total R-Value becomes 3.1, the U-value .32 Btu/hr• ft^2 • ^oF, and the heat flow .32 Btu per hour, a 65% reduction. If the insulation is increased to R-6 the U-value and heat flow becomes .14, an 84% reduction. The first Rs have the most impact. Sound detailing and proper installation are essential for achieving real performance. Gaps and thermal bridges of conductive material can significantly reduce the effective R-value.

Strength, beyond the ability to remain intact, matters little for batt insulation. For board insulation below grade on an exterior wall or beneath a slab, compressive strength must be considered.

Water Absorption is the amount of water absorbed by an insulating material as a percent of total volume when fully immersed for 24 hours. Water absorption reduces effective R-value and materials with higher absorption should not be used in locations where they will likely encounter water.

Permeability is the ability of water vapor to pass through a material in response to differing vapor pressure on opposite sides. When water vapor moves through a material and reaches a temperature below its dew point, condensation will occur. Water in sufficient quantity will cause insulation performance to deteriorate and material damage may occur. Materials with a perm rating of 1.0 or less are considered effective vapor barriers, although some prefer the term vapor retarder because completely effective barriers are almost impossible to achieve. Uninsulated foundation walls often have an interior surface temperature below dew point allowing condensation to occur resulting in a damp and often moldy smelling basement even though no water leakage has occured. Exterior foundation insulation generally raises the wall temperature above dew point preventing condensation. Interior foundation insulation actually causes the foundation wall surface temperature to drop, increasing the risk of condensation. A vapor barrier is required on the inside surface of the insulation.

Early installation of the vapor barrier can create other moisture problems. The new concrete contains a great deal of water. Because the exterior is dampproofed or waterproofed and in contact with soil most of the excess moisture must esacpe to the inside as the concrete cures. Early installation of a vapor barrier can trap water vapor allowing it to condense inside the wall or within the insulation. Delay installing interior foundation insulation until late in the construction process to allow the concrete to cure. When the insulation will be left exposed consider use of a vapor barrier with small perferations, such as Certainteed's basment wall insulation.

Flame spread and **smoke development** ratings of combustible building materials are based on the ASTM E84 test. Values for foam insulation may not exceed 75 and 450 respectively. Unless specifically approved otherwise by the building code official, all foams must be covered with ½ inch of gypsum wall board or other approved thermal barrier, regardless of location.

Surface protection is required for all exterior insulation above grade. All types must be shielded from structural damage and foams must be protected from degradation from the ultraviolet (UV) portion of the solar spectrum.

Environmental Impact Issues

The cost saving benefits of foundation insulation are accompanied by environmental benefits of reduced greenhouse gas emissions. These benefits far outweigh the environmental impact of manufacturing and installing the insulation. In selecting which product(s) to use however, you should consider a variety of environmental impacts resulting from their production. Check product labels and brochures regarding the topics listed below.

Embodied energy is the energy contained in the material and consumed in its manufacture, delivery, and installation. Materials with lower embodied energy are preferred.

Ozone depletion, the destruction of the earth's protective stratospheric ozone layer, is caused by gases that were until recently widey used to blow the bubbles that make foams effective insulators. Manufacturers have shifted to other gases with lower ozone depletion potential, including HCFs and HCFCs.

Global warming potential (GWP) refers to the impact carbon dioxide and other gases have on increasing global temperatures. Carbon dioxide has a global warming potential of 1. CFC 12, a common foam blowing agent ten years ago, has a GWP of 7,100. The gases now used have GWPs ranging from 1 - 1,300. Ironically the lowest is carbon dioxide, but it's use reduces insulation performance by about 1/6.

Recycled content is a widely recognized environmental feature of building insulation. Most cellulose and mineral wool insulation are manufactured from recycled material. Fiberglass and foam insulation manufacturers are increasing the amount of recycled material they use. A list of insulation manufacturers using recycled materials is available from the U.S. Environmental Protection Agency (EPA) at:

<http://www.epa.gov/epaoswer/non-hw/procure/products/building.htm#productinfo>.

Insulation Materials

A wide variety of materials are suitable for insulating foundation walls. They can be divided into three general categories; board, batt, and blown. Some products can be used on the inside or outside of the wall while others are only suitable for interior use.

Boards

Board insulation materials commonly used for foundation insulation include extruded polystyrene (XPS), expanded polystyrene (EPS), polyisocyanurate, fiberglass, and rockwool.

Polystyrenes
Extruded Polystyrene (XPS)

XPS is manufactured from polystyrene resin and a gas blowing agent in a continuous extrusion process producing a homogeneous cellular structure.

Advantages

< High R-value per inch, high compressive strengh, low moisture absorption, low perm rating.

< Widely available in various sizes and thicknesses and easily installed.

Disadvantages

< Requires UV and structural protection above grade when applied on the exterior and thermal protection when installed on the interior.

< Chemically attacked by some adhesives, dampproofing and waterproofing compounds.

Expanded Polystyrene

EPS differs from XPS in that it is produced from styrene beads placed in a mold and expanded under heat and pressure with a foaming agent.

Advantages

< The least expensive foam board, available in a wide range of densitites, sizes and thicknesses.

< Available with borate additives to reduce termite risk.

Disadvantages

< Somewhat lower R-value than other foams and more easily damaged, particularly if used on the exterior.

< Higher permeability and water absportance than other foams.

< Like all foams, requires exterior protection above grade and thermal protection when used on the interior.

Polyisocyanurate

Polyisocyanurates are manufactured from a plastic resin and a foaming agent and can have fiberglass or foil facing.

Advantages

< Highest R-value of any foam. Available with foil face which can serve as vapor barrier and can provide increased R-value when installed with dead air space.

< One product, Celotex's Thermax, can be installed without a thermal barrier when approved by the local code official.

Disadvantages

< Generally higher in cost than other foams and initially very high R-values declines a bit with age.

< Low compressive strength.

Batts

Batt insulation materials include fiberglass and rockwool. Fiberglass in made from sand and recycled glass cullet. Mineral wool is made from iron ore blast furnace slag and natural rocks. Batts can be unfaced, kraft paper faced, foil faced, or poly wrapped. In addition to the many sizes commonly installed in above grade frame walls, specialty batts are available for interior basement walls and crawl space walls.

Advantages

< Inexpensive and widely available in many sizes, thicknesses, and facings.

Disadvantages

< Batt insulation can be saturated and difficult to dry if moisture penetration occurs.

< Furring required for installation and easily damaged in high traffic areas if not protected by drywall or paneling.

Blown

Nonload bearing 2 x 4 or 2 x 3 stud walls can be erected directly adjacent to or set back from the basement wall creating a cavity for foundation insulation. While batts are typically placed in the stud cavity, blown cellulose, glass fiber, or mineral wool insulation can be used. Cellulose is typically manufactured from waste paper with fiber and insect retardent chemicals. A netting may be installed over furring to hold insulation in place.

Advantages

< Inexpensive, compeletely fills cavity.

Disadvantages

< Like batts, sprayed insulations can be quickly saturated and difficult to dry if significant moisture penetration occurs.

< Again, like batts, furring required for installation and needs protection in high traffic areas.

< Special installation equipment required.

Termites

Subterranean termites live in large colonies 15-20 feet underground. They live entirely on plant matter, ranging widely through a system of tunnels in search of food. They enter buildings through wood in contact with the ground, cracks in foundation walls or slabs, the dry joint between the footing and foundation wall, utility penetrations, and through and behind foundation insulation. Wood structures attacked by termites can sustain extensive and costly damage. While foundation insulation is not a food source and does not increase the likelyhood that a particular building will be attacked, it may make detection and treatment more difficult.

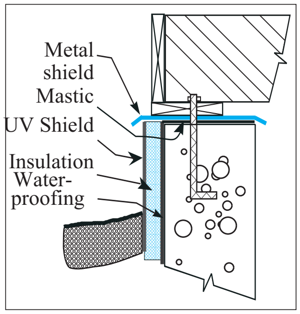
Insecticides like chlordane were once widely used to control termites. They were effective, persisting in the soil for many years, providing long term protection, but when it was discovered they were carcinogenic they were replaced by other insecticides. While effective in controling termites, todays termiticides dissipate with time requiring retreatment. Borates are also used to discourage termites.

Termites are small and persistent, capable of squeezing through tiny cracks. The best strategy is to avoid inititial infestation entirely using one or more of the following defenses:

< Avoid attracting them. During construction keep all wood, including framing scraps, sawdust, paper, and tree roots and trimming out of the ground for as far back from the house as feasible.

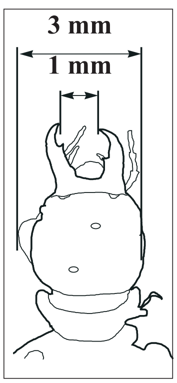
< Keep all wood at least six inches above grade and use only termite resistant or treated wood in contact with the foundation. Do not use wood mulch near the house.

- Install a continuous metal termite shield with soldered or sealed lap joints. Termites can tunnel around it, but they can then be detected and treated.
- Consider pretreating all wood framing within four feet of the ground with borates.
- Consider installing termite bait systems marketed by professional pest treatment companies. They permit detection of termite presence and the use of highly effective targeted insecticides.



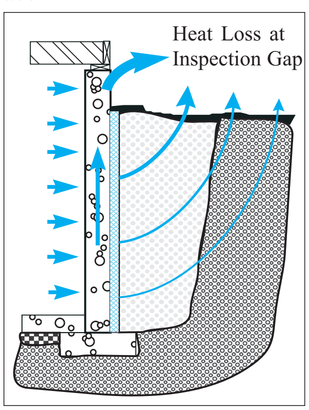
Termite Shield

- Consider installing sand barriers. While still experimental and more expensive than conventional treatment, sand barriers provide a non-chemical method of protection. Sand that just passes through a 16 grit wire screen takes subtle advantage of the termites anatomy. The gaps within the sand are too small for them to crawl through, but their jaws do not open wide enough for them to pick them up and move them. Sand barriers can be placed around a foundation wall at grade and around potential entry points in slabs.
- Consider pretreating the soil with EPA approved termiticides.



Termite Size

- Have the house inspected annually.
- Avoid heat loosing inspection strips.



Inspection Gap

Estimated Foundation Insulation Cost per Lineal Foot

Actual project costs are region and project specific. Variation from the values below should be expected.

Foundation/Material	Height (depth)	Thick-ness	Material R-value	Exterior	Interior
Basements - Foam Boards					
Extruded Polystyrene (XPS)	8 ft.	½ in.	2.5	$7.60	$12.50
(Blue, pink, yellow, green)	8 ft.	1 in.	5	$8.80	$13.60
	8 ft.	1-1/2 in.	7.5	$10.70	$15.60
	8 ft.	2 in.	10	$12.70	$17.60
Expanded Polystyrene (EPS)	8 ft.	1 in.	3.8	$7.80	$12.70
(White beadboard)	8 ft.	1-1/2 in.	5.6	$9.10	$13.90
	8 ft.	2 in.	7.7	$10.30	$15.20
Polyisocyanurate	8 ft.	¾ in.	5.4	$8.50	$13.40
(If foil faced and furring is	8 ft.	1 in.	7.2	$9.00	$13.80
on top to create a dead air space	8 ft.	1- ½ in.	10.8	$9.50	$14.40
increasse the R value by 2.8)	8 ft.	2 in.	14.4	$10.70	$15.60
Exterior cost includes metal flashing protection, reduce $0.40 for cement board, increase $1.70 for stucco. Interior cost includes furring and ½ in. drywall. Reduce cost $7.00 if omitted (requires code approval)					
Glass Fiberboard	8 ft.	1 in.	4.3	$9.00	$13.80
	8 ft.	1-1/2 in.	6.5	$12.20	$17.10
Basements - Batts					
Std densifty, 48 in. or 72 in.	8 ft.	3- 1/8 in.	11	n.a.	$4.20
Std density, 23 in.	8 ft.	3-1/2 in.	11	n.a.	$11.60
High density, 23 in.	8 ft.	3-1/2 in.	15	n.a.	$12.10
Mineral wool (kraft faced)	8 ft.	3-1/2 in.	12	n.a.	$12.00
Cost includes furring and faced batt or vapor barrier. Add $5.30 for drywall.					
Crawl Spaces - Foam Boards					
Extruded Polystyrene (XPS)	4 ft.	1 in.	5	$10.30	$4.90
(Blue, pink, yellow, green)	4 ft.	2 in.	10	$12.10	$6.80
Expanded Polystyrene (EPS)	4 ft.	1 in.	3.8	$9.80	$4.50
(White beadboard)	4 ft.	2 in.	7.7	$10.90	$5.60
Polyisocyanurate	4 ft.	1 in.	7.2	$10.40	$5.00
(See note above on foil facing)	4 ft.	2 in	14.4	$11.10	$5.70
Exterior includes 2 feet of stucco, interior includes 3 feet of furring and drywall thermal protection.					
Crawl Space Batts					
Perimeter installation (wrapped batts)		8-3/4 in.	25	n.a.	$3.50
Floor installation	Sq. ft.	3-1/2 in.	11	n.a.	$0.60
(Includes wire retainers, turn	Sq. ft.	6 in.	19	n.a.	$0.74
facing up)	Sq. ft.	8-1/2 in.	30	n.a.	$1.08
Slab-on-Grade - Foam Boards (protection same as for basements above)					
Extruded Polystyrene (XPS)	2 ft.	1 in.	5	$3.60	$1.20
(Blue, pink, yellow, green)	4 ft.	1 in.	5	$4.60	$2.20
	2 ft.	2 in.	10	$4.50	$2.20
	4 ft.	2 in.	10	$6.40	$4.10
Expanded Polystyrene (EPS)	2 ft.	1 in.	3.8	$3.30	$1.00
(White beadboard)	4 ft.	1 in.	3.8	$4.10	$1.80
	2 ft.	2 in.	7.7	$3.90	$1.60
	4 ft.	2 in.	7.7	$5.20	$2.90
Polyisocyanurate	2 ft.	1 in.	7.2	$3.60	$1.30
	4 ft.	1 in.	7.2	$4.70	$2.30
	2 ft.	2 in.	14.4	$4.00	$1.70
	4 ft.	2 in.	14.4	$5.40	$3.00
Exterior cost includes metal flashing protection, reduce cost $0.40 for cement board, increase cost $1.70 for stucco.					

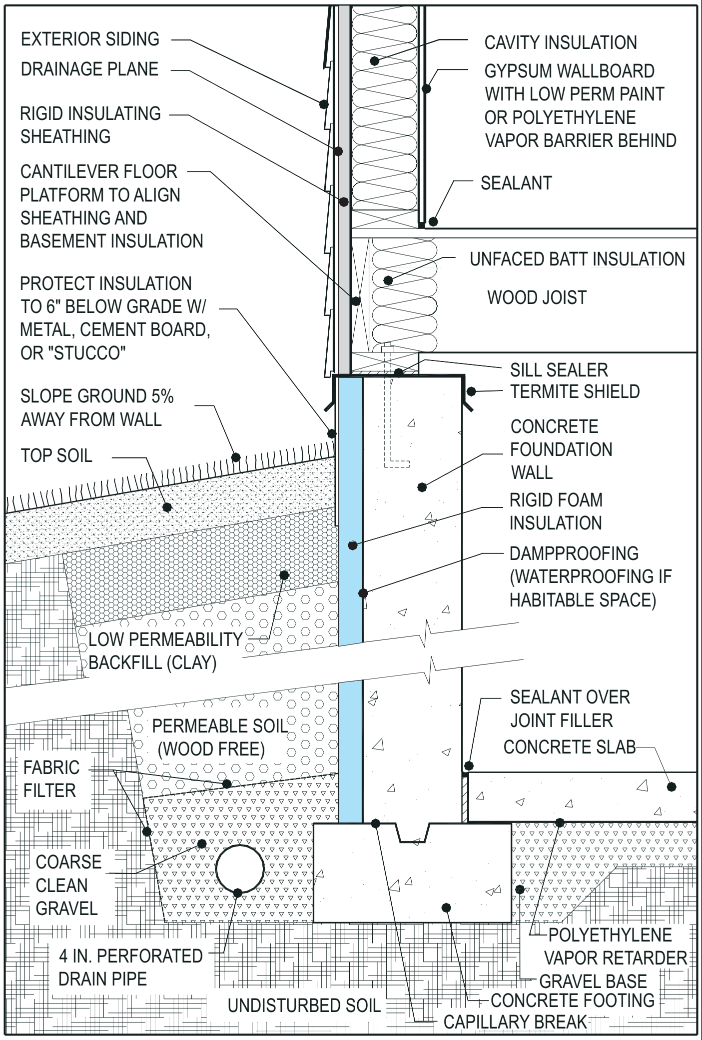
Foundation Insulation Cost

The table above provides estimated foundation insulation installed cost per lineal foot of perimeter. Costs shown include materials, labor, and contractor overhead and profit. Actual costs are project specific and significant variation should be expected.

Foundation Insulation Properties

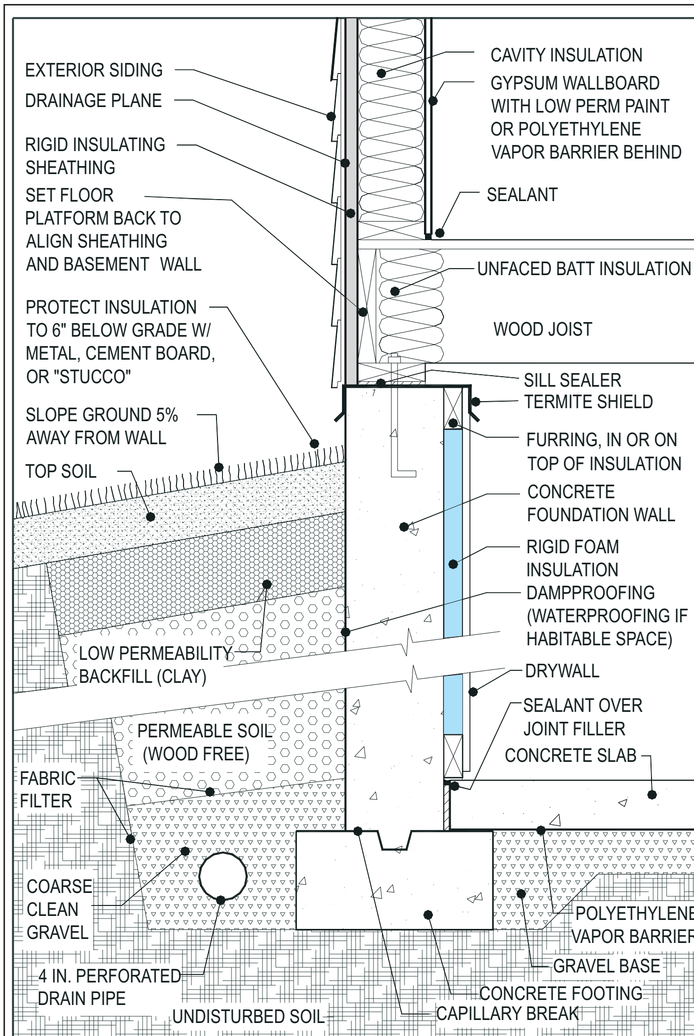
The table below provides basic physical properties of commonly used residential foundation insulation materials. A very wide range of insulation products are available and the table is not comprehensive. Consult each individual manufacture's technical product data sheets, many of which are available on the web, for current information.

Foundation Insulation Material Properties									
	Resistance	**Size**	**Thickness**	**Density**	**Strength**	**Water**		**Fire**	
	(R per in.)	(w x l)	(inches)	(lb/ft^3)	Compress	Absorp-tion	Vapor	Flame Spread	Smoke Development
Material		(Inches)			(lb/in^2)	(%)	(Perm)	E84	E84
Boards									
Plastic Foams									
Polystyrenes									
Type VIII (EPS)	3.8	24, 48, x 96	1 - 40	1.15	13	3.0	3.5	10	125
Type II (EPS)	4.0		1 - 40	1.35	15	3.0	3.5	10	125
Type X (XPS)	4.2	16, 24, 48, x 96	1, 1.5, 2, 2.5, 3, 3.5	1.30	15	0.3	1.1	5	165
Type IV (XPS)	5.0	16, 24, 48, x 96 48 x 108	.75, 1, 1.5, 2, 2.5, 3, 3.5, 4	1.60	25	0.3	1.1	5	165
Type IX (EPS)	4.2	24, 48, x 96	1 - 40	1.80	25	2.0	2.0	10	125
Type VI (XPS)	5.0	24 x 96	1.5, 2, 2.5, 3, 3.5, 4	1.80	40	0.3	1.1	10	125
Type VII (XPS)	5.0	24, 48,x 96		2.20	60	0.3	1.1	10	125
Type V (XPS)	5.0	24, 48,x 96		3.00	100	0.3	1.1	10	125
Polyisocyanurate									
Fiberglass faced	5.8	48 x 96 48 x 108	.75, 1, 1.5, 2, 2.5, 3, 3.5	1.5 - 2.5	20	2.0	4.0	25	45
Foil faced	7.0	16, 24,48 x 96, 108, 120	.75, 1, 1.5, 2, 2.5, 3, 3.5, 4	1.5	20	<1.0	<1.0	20	65 (1 in)
(Add if foil faces dead air space)	2.8								
Glass Fiber	3.9			1.4 - 1.6	0.3 - 2.4	high	high		
Rockwool	4.2	36 x 48 48 x 72	1	11 - 13	25	.25	high		
Batts									
Glass Fiber (std density)	3.2	16, 24 x 48, 93 48 x 50 ft	3.5, 5.5, 6.25 8.5 (+others)		minimal		1 Kraft .5 foil	25	50
Glass Fiber (high density)	3.8	16, 24 x 48, 93	3.5, 5.5,6.25, 8.5		minimal				
Rock Wool					minimal				
Blown									
Glass Fiber (BIB)	4.0	To fit	To fit	1.8-2.3	minimal			5	5
Rock Wool	2.8	To fit	To fit		minimal				
Cellulose	4.0	To fit	To fit	1.6	minimal				



Exterior basement wall insulation is typically one to two inches of foamboard although fiberglass and rockwool boards are used. Insulation exposed above grade requires protection. A metal termite shield reduces the risk termites will use the insulation for undetected entry.

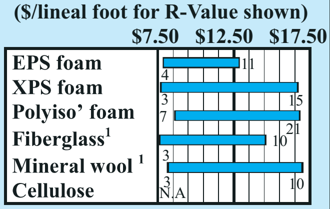
Exterior Foam Basement Wall Insulation



Interior basement walls can be insulated with the same boards used on the exterior. Boards can be glued to the wall, but foamboards required thermal protection. A vapor barrier should be formed on the warm side and a metal termite shield is recommended.

Interior Foam Basement Wall Insulation

Total Installed Cost
($/lineal foot for R-Value shown)

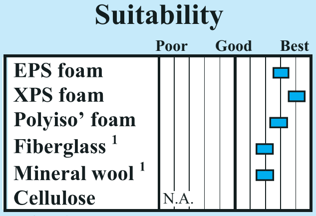


1 = board

Recommended Minimum Basement Wall R-Value

Climate Zone	Energy Cost L	M	H
1	R-10	R-10	R-10
2	R-10	R-10	R-10
3	R-10	R-10	R-10

Suitability

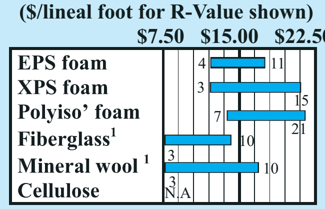


1 = boards

Energy Cost Savings
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	M	H
1	$1.90	$2.70	$3.70
2	$1.65	$2.35	$3.30
3	$1.30	$1.85	$2.55

Total Installed Cost
($/lineal foot for R-Value shown)

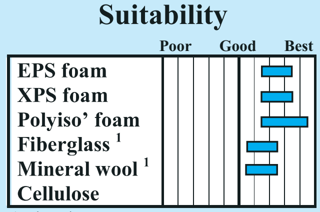


1 = board

Recommended Minimum Basement Wall R-Value

Climate Zone	Energy Cost L	M	H
1	R-10	R-10	R-10
2	R-10	R-10	R-10
3	R-10	R-10	R-10

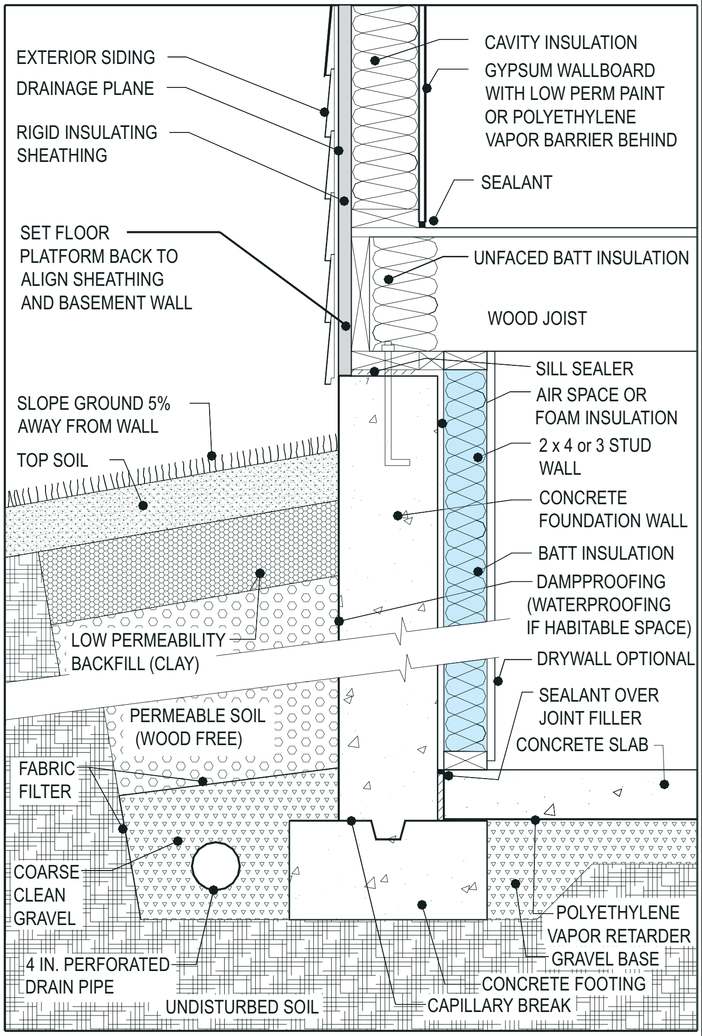
Suitability



1 = boards

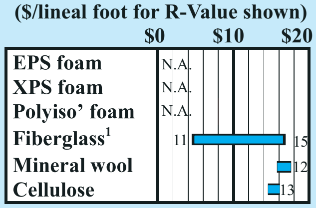
Energy Cost Savings
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	M	H
1	$1.90	$2.70	$3.70
2	$1.65	$2.35	$3.30
3	$1.30	$1.85	$2.55



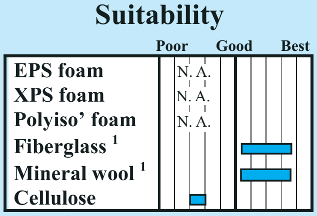
Interior basement walls can also be insulated with batt or blown insulation placed between furring strips or non-bearing stud walls. The bottom plate should be treated and an effective vapor retarder placed on the inside surface. Particular care should be taken to avoid surface or ground water penetration.

Interior Batt or Blown Basement Insulation



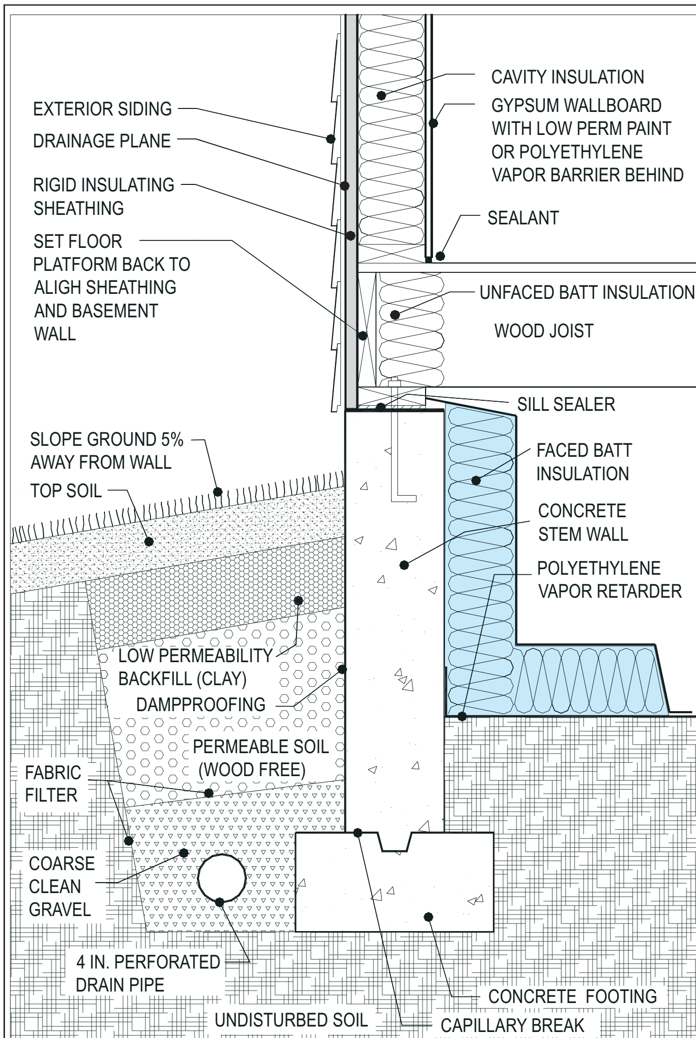
Recommended Minimum Basement Wall R-Value

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1	R-10	R-10	R-10
2	R-10	R-10	R-10
3	R-10	R-10	R-10



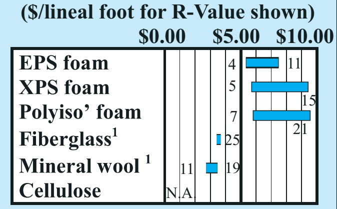
Energy Cost Savings
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1	$1.90	$2.70	$3.70
2	$1.65	$2.35	$3.30
3	$1.30	$1.85	$2.55



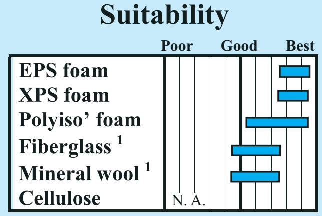
Crawl spaces can be insulated with board insulation on the exterior or interior just like a basement wall. Alternatives are to insulate the floor joist cavities with batts or blown insulation or to insulate the interior of the foundation wall with poly wrapped batts. Make sure to install a well sealed vapor barrier on the floor.

Interior Crawlspace Insulation



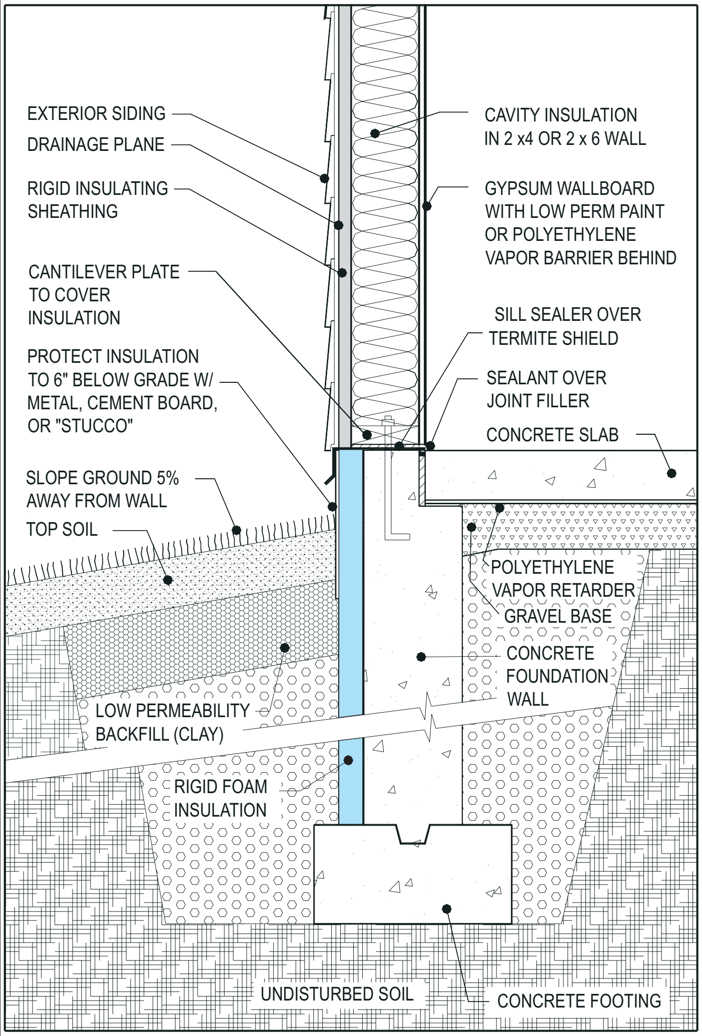
Recommended Minimum Crawl Space Wall R-Value

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1	R-16	R-16	R-16
2	R-16	R-16	R-16
3	R-10	R-16	R-16

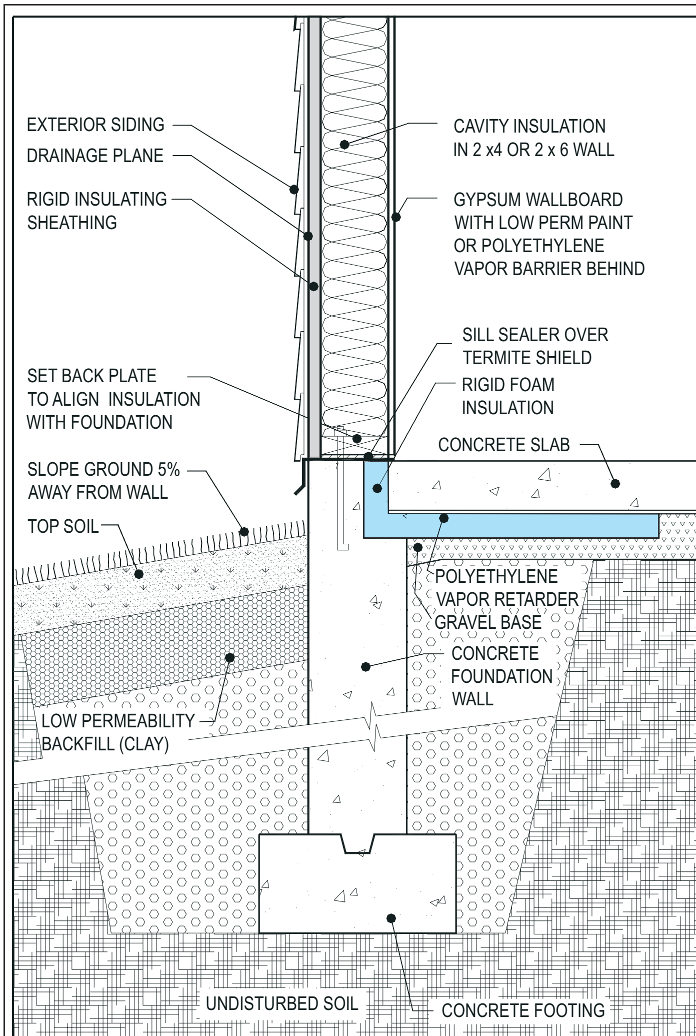


Energy Cost Savings
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1	$0.30	$0.40	$0.60
2	$0.25	$0.35	$0.55
3	$0.20	$0.30	$0.40



Foam boards are the most common form of exterior slab-on-grade insulation. The above grade portion must have UV and structural protection and a metal termite shield is recommended. Foundations in climate zone 1 in the colder northwest should be insulated to a depth of four feet.

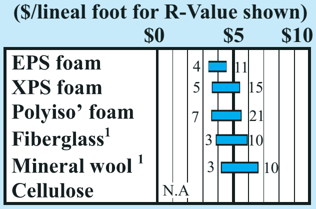


Interior slab-on-grade insulation can be horizontal. Interior placement avoids the need for protection, but may require cutting small pieces and more difficult details.

Exterior Slab-on-Grade Insulation

Total Installed Cost

($/lineal foot for R-Value shown)

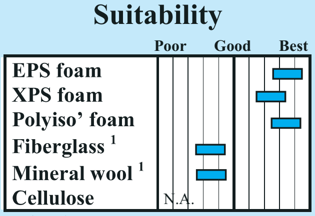


1 = board 2 ft. depth

Recommended Minimum Slab Perimeter R-Value

Climate Zone	Energy Cost L	M	H
1 (4 ft.)	R-5	R-10	R-10
2 (2 ft.)	R-5	R-8	R-10
3 (2 ft.)	R-5	R-5	R-8

Suitability



1 = boards

Energy Cost Savings

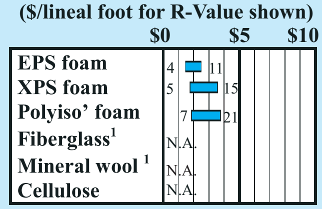
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	M	H
1 (4 ft.)	$0.30	$0.50	$0.75
2 (2 ft.)	$0.25	$0.45	$0.65
3 (2 ft.)	$0.15	$0.30	$0.40

Interior Slab-on-Grade Insulation

Total Installed Cost

($/lineal foot for R-Value shown)

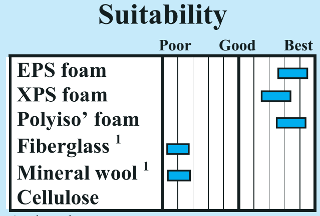


1 = board 2 ft. depth

Recommended Minimum Slab Perimeter R-Value

Climate Zone	Energy Cost L	M	H
1 (4 ft.)	R-5	R-10	R-10
2 (2 ft.)	R-10	R-10	R-10
3 (2 ft.)	R-5	R-10	R-10

Suitability

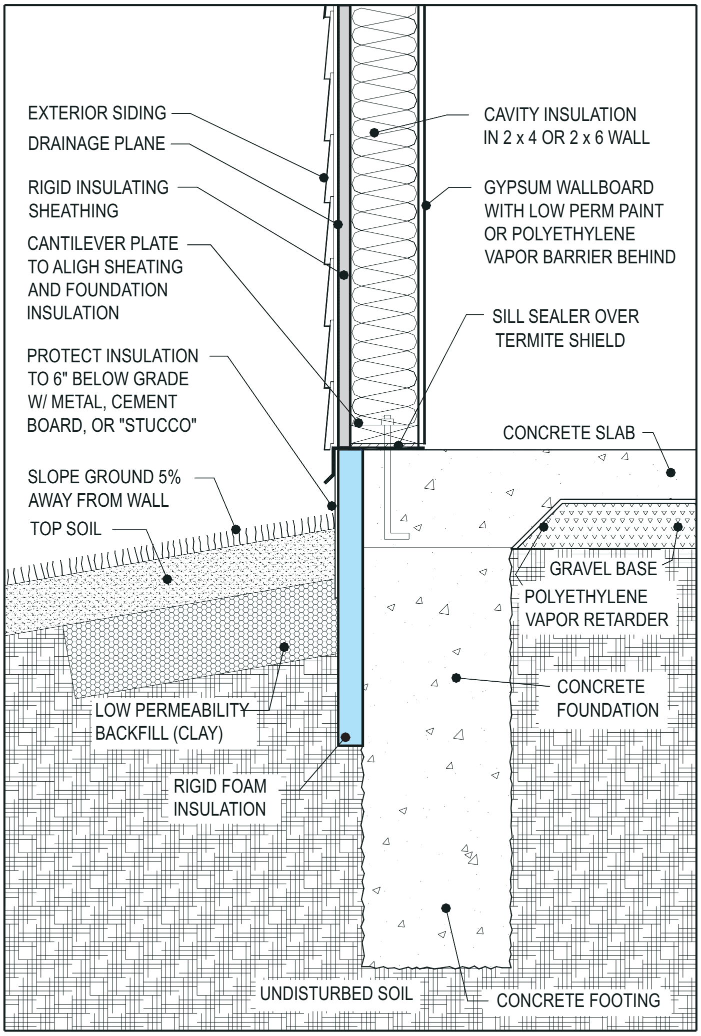


1 = boards

Energy Cost Savings

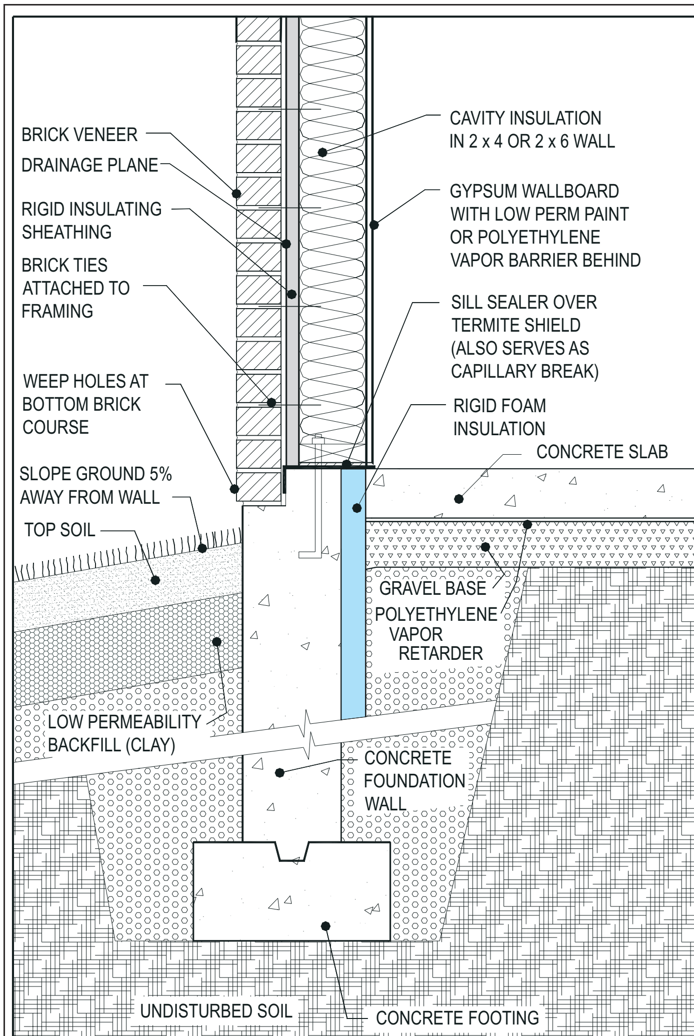
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	M	H
1 (4 ft.)	$0.30	$0.50	$0.75
2 (2 ft.)	$0.25	$0.45	$0.65
3 (2 ft.)	$0.15	$0.30	$0.40



Trench footings or monolith pours can be easily insulated by attaching foam board to the perimeter form board. The portion above grade requires UV and structural protection and a metal termite shield is recommended.

Exterior Insulation on Trench Footings



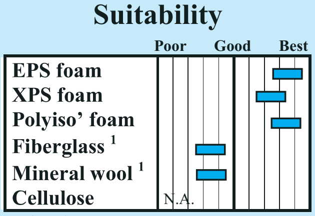
Interior slab-on-grade foundation insulation can be installed vertically but to maintain continuity it must be carefully detailed to permit acceptable floor finish. A metal termite shield is recommended.

Interior Slab-on Grade w/ Brick Veneer Wall

Recommended Minimum Basement Wall R-Value

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1	R-5	R-10	R-10
2	R-5	R-8	R-10
3	R-5	R-5	R-8

Suitability

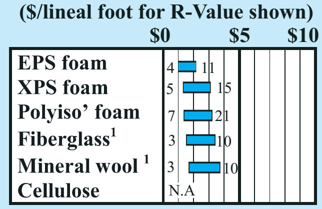


1 = boards

Energy Cost Savings
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1 (4 ft.)	$0.30	$0.50	$0.75
2 (2 ft.)	$0.25	$0.45	$0.65
3 (2 ft.)	$0.15	$0.30	$0.40

Total Installed Cost
($/lineal foot for R-Value shown)

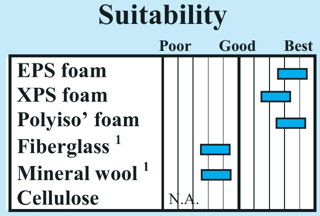


1 = board 2 ft. depth

Recommended Minimum Basement Wall R-Value

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1	R-5	R-10	R-10
2	R-5	R-8	R-10
3	R-5	R-10	R-8

Suitability



1 = boards

Energy Cost Savings
($/lineal foot/year)
(R-Values Recommended Above)

Climate Zone	Energy Cost L	Energy Cost M	Energy Cost H
1 (4 ft.)	$0.30	$0.50	$0.75
2 (2 ft.)	$0.25	$0.45	$0.65
3 (2 ft.)	$0.15	$0.30	$0.40

Frequently Asked Questions

If a basement is unfinished does it still need foundation insulation?

Yes, unless the floor above is insulated. Even if used only for storage and heating and cooling equipment the basement is thermally connected to the rest of the house.

Is floor insulation above a basement or a crawl space an alternative to foundation insulation?

Yes, but keep in mind that pipes, ducts and HVAC equipment located in the basement would then need to be insulated to meet the MEC and to protect pipes from freezing. Sometimes these can be grouped in a small area with insulated walls while the floor above the rest of the basement is insulated.

Doesn't placing insulation on the exterior improve energy performance?

If the basement incorporates passive solar design with a significant amount of south facing windows, exterior insulation will be beneficial, provided the walls are exposed to solar gain. In a typical basement the energy savings are negligible.

Should the interior of foundation walls have vapor barriers?

If interior insulation is used, YES. The concrete must be allowed to dry, but moist basement air typical of Midwest summers should not be allowed to reach the cool wall where in can condense. Batt insulation specifically designed for the interior of foundation walls has a perforated poly facing that prevents air from circulating through the batt, but allows water vapor from the wall to escape.

Will foundation insulation increase the risk of termite entry?

Foundation insulation does not increase the risk of termine entry. If termites are present in the soil and wood is used in the building, the risk of infestation exists. Exterior insulation may reduce the probability of early discovery and inhibit treatment when discovered.

Is an inspection band where foundation insulation is omitted to permit inspection for termites a good idea?

In some southern states with a high incidence of termite infestation, including, Florida, South and North Carolina, Georgia, Alabama, Mississippi, Louisiana, eastern Texas, southern and central California, Georgia, Tennessee, and Hawaii, rigid foam insulation is not allowed in contact with the soil. In other areas a six inch gap between the top of foundation insulation and any wood framing member is required to permit visual inspection for termites. Studies done by ORNL conclude that "if you include a vision strip, you might as well not bother putting any insulation around the foundation."

Will exterior foundation insulation materials be chemically attacked by dampproofing?

In can happen. Avoid ……and always follow the insulation and dampproofing manufacturer's instructions.

What about water proofing?

Codes often require waterproofing instead of damproofing if the wall is adjacent to habitable space. Manufactures of some foam products offer specific recommendations for waterproofing of their foam systems.

How long will exterior foundation insulation last?

Properly installed foundation insulation, interior or exterior, should last as long as insulation installed any where else in the building.

Should foam insulation above grade be protected?

Foam above grade must be protected from both sun and physical damage. Ultraviolet light degrades or destroys most foams. In addition, damage from lawnmowers, balls, and other incidental contact can degrade the appearance and performance of the foam. Common materials used to protect the foam above grade include two- or three-layer stucco finishes, brush-on elastomeric or cementitious finishes, vertical vinyl siding, cement board, aluminum coil stock, and fiberglass panels.

Will insulating the foundation increase the risk of radon problems?

Radon entry into a home is through cracks and other opening below grade. The use of foundation insulation should minimize thermal stresses on the foundation and help minimize cracking, thus reducing of radon entry.

Should crawl space be ventilated?

The CABO One and Two Family Code requires one square foot of crawl space ventilation for each 150 square feet of "floor" area. Operable vents 1/10 as large can be used if a vapor barrier is installed. Warm damp summer air can condense on the cool earth, even when covered with a poly vapor diffusion retarder, increasing the risk of crawl space moisture problems. Installing a vapor barrier and closing the operable vents is preferred. If local code interpretation requires crawl space ventilation, insulating the floor and incorporating a vapor barrier is preferred.

Do foam insulation boards installed on the interior require fire protection?

All foams require thermal protection equal to ½ inch of gypsum wall board when installed on the interior of a building, including a crawl space. The only exception is Celotex Thermax polyisocyanurate which may be installed without a thermal barrier where approved by the local building code official.

Are insulating concrete form (ICF) systems less expensive than an insulated poured in place concrete wall?

ICFs can be competitive but costs are project specific. Foam used in these systesm should address the same concerns outlined above for foam board.

Information Sources

References and On-line Resources

Builders Foundation Design Handbook by J. Carmody, 1991.

Christian, Jeffrey E., ***Energy Efficient Residential Building Foundations***, ASHRAE Journal, November 1991.

Insulation Materials: Environmental Comparisons, Environmental Building News, Vol. 4, No 1, January/February 1995.

The Model Energy Code and One and Two Family Dwelling Code
International Code Council (formerly CABO)
5203 Leesburg Pike, Falls Church, VA 22041
Tel: 703-931-4533 Fax: 703-379-1546
Email: staff@intlcode.org
Web site: http://www.intlcode.org

Kansas Corporation Commission Energy Programs
1500 SW Arrowhead Road Topeka, Kanss 66604
Tel: 785-271-3349
Web site: http://www.kcc.state.ks.us/energy

Kansas State University Engineering Extension
Ward Hall
Kansas State University
Manhattan, Kansas
Tel: 785-532-4994
Web site: http://www.OZNET.ksu.edu/dp-nrgy

DOE Energy Standards and Guidelines
Pacific Northwest National Laboratory
Richland, Washington
Tel: 509-417-7554 Fax: 509-375-3614
Web site: www://energycodes.org/

EPA Energy Star Homes
U.S. Environmental Protection Agency
Climate Protection Division
401 M Street SW MC:6202J
Washington, DC 20460
Tel: 888-782-7937
Web site: http:/www.energystar.gov

Energy Efficient Building Association
490 Concordia Avenue, St. Paul, MN 55103-2441
Tel: 651-268-7585 Fax: 651-268-7597
E-mail: info@eeba.org
Web site: http://www.eeba.org

Environmental Building News
122 Birge Street Brattleboro, Vermont 05310
Tel: 802-257-7300 Fax: 802-257-7304
Web site: http://www.ebuild.com

Material Sources (manufacturers)

(Consult industry associations for more detailed lists)

Insulation

Boards

Expanded Polytyrene

AFM Corporation
24000 W. Hwy 7 Excelsior, MN 55331
Phone: 612-474-0809 Fax: 612-474-2074
E-mail: m-tobin@r-control.com
Website: www.afmcorp-epsfoam.com

Contour Products
4001 Kaw Drive Kansas City, KS 66102
Phone: 800-638-3626 Fax: 913-321-8063
E-mail: contour@unicom.net
Web site: http://www.contourfoam.com

Polyfoam Packers
2320 Foster Avenue Wheeling, IL 60090
Phone: 847-669-1176 Fax: 847-398-0653
Web site: http://www.polyfoam.com

Extruded Polystyrene

Dow Chemical Co.
200 Larkin Center, 1605 Joseph Drive
Midland,MI 48674
Tel: 800-441-4369 Fax: 517- 832-1465
Web site: http://www.dow.com/styrofoam

Tenneco Building Products
2907 Log Cabin Drive Smyrna, Georgia 30080
Tel: 800-241-4402
Web site: http://www.tennecobuildingprod.com

Polyiscyanurate

Celotex Corporation
4010 Boy Scout Blvd. Tampa, FL 33607
Tel: 813-873-1700 Fax: 813-873-4058
Web site: http://www.celotex.com

Johns Manville Corporation
717 17th St Denver,CO 80202
Tel: 800- 654-3103 Fax: 303-978-2318
Web site: http://www.jm.com

Rock Wool

Roxul, Inc.
551 Harrop Drive Milton, ON L9T 3H3 Canada
Tel: 905-878-8474 Fax: 905-878-8077

Batts

Fiberglass

CertainTeed Corporation
P.O. Box 860 Valley Forge, PA 19482
Tel: 610-341-7000 Fax: (610) 341-7571
Web site: http://www.certainteed.com

Johns Manville Corporation
717 17th St Denver,CO 80202
Tel: 800- 654-3103 Fax: 303-978-2318
Web site: http:// www.jm.com

Owens Corning
Fiberglas Tower Toledo, OH 43659
Tel: 419-248-8000 Fax: 614/321-5606 (fax)
Web site: http://www.owenscorning.com

Knauf Fiber Glass GmbH
One Knauf Drive
Shelbyville,IN 46176
Tel: (800) 825-4434 Fax: (317) 398-3675
E-mail: rmg2@knauffiberglass.com
Web site: http://www.knauffiberglass.com

Blown

Cellulose

Central Fiber Corporation
Wellsville, Kansas 66092
Tel: 800-654-6117

Blown-in-batt (BIB)

Rockwool

American Rockwool, Inc.
P.O. Box 880
Spring Hope, NC 27882
Tel: 254-478-5111 Fax: 252-478-4172
Web site: http://www.amerrock.com

Insulating Concrete Foam Systems

AFM Corporation
24000 West Hwy 7 Exelsior, MN 55331
Tel: 800-255-0176 fax: 612-474-2074
E-mail: m-tobin@r-control.com
Website: www.afmcorp-epsfoam.com

Greenblock WorldWide Corporation
P.O.Box 749 Woodland Park, CO 80866
Tel: (719) 687-0645 Fax: (719) 687-7820
E-mail: greenblock@building.com
Web site: http://www.greenblock.com

ICE Block
PO Box 3089 Odessa, TX 79761
Tel: 800-ICE-BLOC Fax: 915-561-5622
E-mail: iceblock@concentric.net
Web site: http://www.concentric.net

Lite-Form, Inc.
PO Box 774 Sioux City, IA 51102
tel: 800-551-3313, tel: 712-252-3704
E-mail: info@liteform.com
Web site: http://www.liteform.com

Reward Wall Systems
4115 S. 87th St. Omaha, NE 68127
Tel: 800-468-6344 fax: 402-592-7969
E-mail: info@rewardwallsystem.com
Web site: http://www.rewardwallsystem.com

Termite Treatment

Sentricon Colony Eliminator System Dow AgroSciences
9330 Zionsville Road Indianapolis, IN 46268-1054
fax: 800-905-7326
Web site: http://www.sentricon.com

Systematic Termite Control FMC
Chicago, IL Tel: 800-321-1FMC
Web site: http://www.fmc-apgspec.com

Industry Associations

North American Insulation Manufacturers Association
44 Canal Center Plaza Alexandria, VA 22314
Tel: 703-684-0084, Fax: 703-684-0427
E-mail: insulation@naima.org
Web site: http://www.naima.org

Cellulose Insulation Manufacturers Association
136 Keowee Street Dayton, OH 45402
Tel: 513-222-2462 Fax: 937-222-5794
E-mail: cima@dayton.net
Web Site: http://www.cima.org

Polyisocyanurate Insulation Manufacturers Association
1331 F Street, NW, Suite 975 Washington, DC 20004
Tel : 202-628-6558 Fax: 202-628-3856
E-mail: pima@pima.org
Web site: http://www.pima.org

Insulating Concrete Form Association
1807 Glenview Road, Suite 203
Glenview, Ilinois, USA 60025
Phone: 847-657-9730 Fax: 847-657-9728
E-mail: icfa@forms.org
Web site: http://www.forms.org