



Buildings for the 21st Century

Buildings that are more energy efficient, comfortable, and affordable...that's the goal of DOE's Office of Building Technology, State and Community Programs (BTS). To accelerate the development and wide application of energy efficiency measures, BTS:

- Conducts R&D on technologies and concepts for energy efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy/money saving opportunities to both builders and buyers of homes and commercial buildings
- Works with state and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use
- Provides support and grants to states and communities for deployment of energy-efficient technologies and practices



BASEMENT INSULATION

Create a comfortable basement environment that is free of moisture problems and easy to condition

INTRODUCTION

The primary foundations in the United States are slab-on-grade, crawlspace, and basement. Basements can be a good choice for sites that slope steeply and in climates having cold winters with deep frost penetration. Although deeper excavation is required for structural reasons, the additional cost can result in a comfortable and habitable space.

Basements are notorious for problems with water intrusion, cold temperatures, humidity, mold, and uncomfortable, if not unhealthy, living conditions. A properly sealed, insulated, and moisture-protected basement will increase comfort, save on energy costs, improve durability, and reduce entry of moisture, soil gases, and other potential irritants or pollutants into the home.

However, basement walls are one of the most controversial areas of a home to insulate and seal. Many builders, even in far northern states, feel that insulating basement walls is

too expensive and does not provide a reasonable payback. Also, builders of daylight or walkout basements often only insulate the framed section of the basement. Yet energy codes typically require a thermal boundary between the house and unconditioned basement or between a conditioned basement and the outside air and earth.

KEYS TO AN EFFECTIVE BASEMENT

Moisture control – using a water-managed foundation system to drain rainwater and groundwater away from foundations.

Airtight construction – sealing all air leaks between the conditioned space and the outside prior to insulation installation.

Complete insulation coverage – properly installing the correct insulation levels, making sure the insulation coverage is continuous and complete, and aligning the insulation barrier with the air barrier.

ANNUAL SAVINGS WITH BASEMENT WALL INSULATION

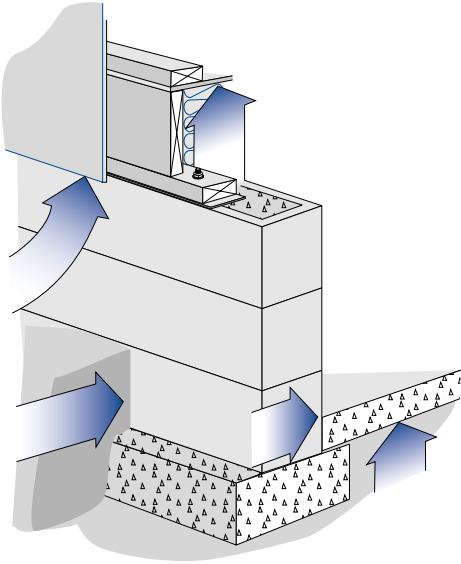
The energy savings of basement wall insulation vary depending on the local climate, type of heating system, cost of energy, and lifestyle of the occupant. Typical annual savings are provided in the table for a standard, 1,500 square-foot home with a conditioned basement that is heated by natural gas (\$0.72/therm).

U.S. Cities	R-10*	R-20**
Buffalo, NY	\$350	\$390
Denver, CO	\$310	\$360
Minneapolis, MN	\$400	\$450
Seattle, WA	\$280	\$320
St. Louis, MO	\$250	\$290
Washington, DC	\$250	\$280

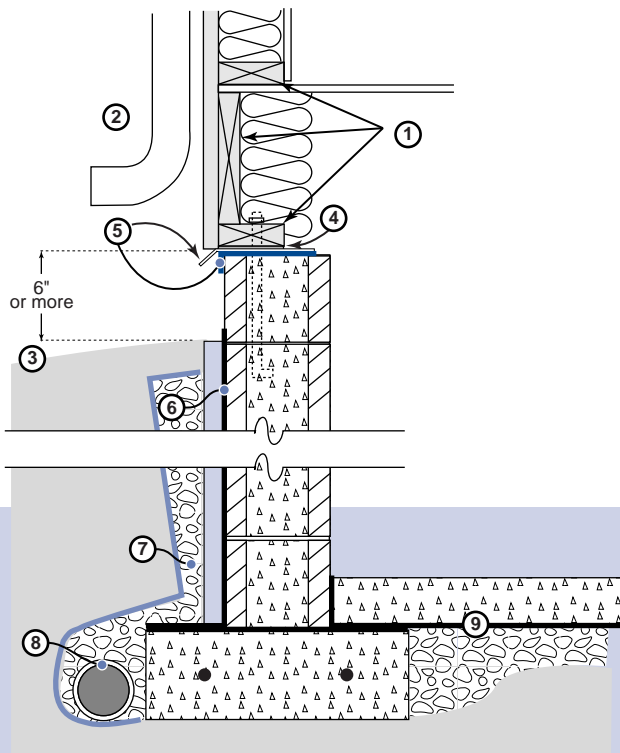
* Such as 2 to 3 inches of exterior foam insulation.
 ** Such as with most insulated concrete forms.

MOISTURE FLOW IN BASEMENTS

Water forces attack a basement foundation at several points. It is key to deter water at these entry points to preserve the integrity of the dwelling and enhance the living environment.



WATER-MANAGED BASEMENT WALL AND FOUNDATION



WATER-MANAGED FOUNDATION SYSTEM

Most basement water leakage is due to either bulk moisture leaks or capillary action. Bulk moisture is the flow of water through holes, cracks, and other discontinuities into the home's basement walls. Capillary action occurs when water wicks into the cracks and pores of porous building materials, such as masonry block, concrete, or wood. These tiny cracks and pores can absorb water in any direction—even upward.

The best approaches for preventing these problems will depend on the local climate and style of construction, but the following general rules apply to most basement designs.

1. Keep all untreated wood materials away from earth contact.
2. Provide drainage, such as gutters, to conduct rainwater away from the house.
3. Slope the earth away from all sides of the house for at least 5 feet at a minimum 5% grade (3 inches in 5 feet). Establish drainage swales to direct rainwater around the house.
4. Add a sill gasket to provide air sealing.
5. Install a protective membrane, such as caulked metal flashing or EPDM-type membrane, to serve as a capillary break that reduces wicking of water up from the masonry foundation wall. This membrane can also serve as a termite shield on top of the insulation board.
6. Dampproof all below-grade portions of the foundation wall and footing to prevent the wall from absorbing ground moisture by capillary action.
7. Place a continuous drainage plane over the dampproofing or exterior insulation to channel water to the foundation drain and relieve hydrostatic pressure. Drainage plane materials include special drainage mats, high-density fiberglass insulation products, and washed gravel. All drainage planes should be protected with a filter fabric to prevent dirt from clogging the intentional gaps in the drainage material.
8. Install a foundation drain directly below the drainage plane and beside the footing, not on top of the footing. This prevents water from flowing against the seam between the footing and the foundation wall. Surround a perforated 4-inch plastic drainpipe with gravel and wrap both with filter fabric.
9. Underneath the basement's slab floor, install a capillary break and vapor retarder, consisting of a layer of 6- to 10-mil polyethylene over at least 4 inches of gravel.

BASEMENT INSULATION

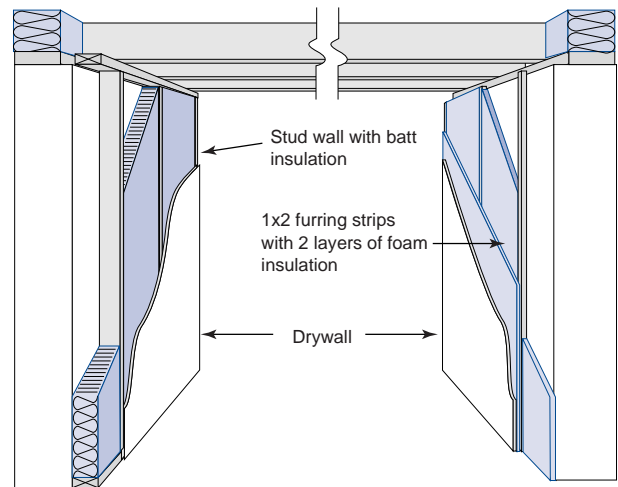
BASEMENT INSULATION PLACEMENT

In most cases, a basement should be considered a conditioned space with insulation installed in the exterior basement walls. Even in a house with an unconditioned basement, the basement is more connected to the other living spaces of the home than to the outside. This makes basement wall insulation preferable to insulating the basement ceiling.

Advantages of basement wall insulation include:

- Basement spaces, whether conditioned or not, are warmer and more comfortable.
- Compared to insulating the basement ceiling, insulating basement walls:
 - requires less insulation (1,350 square feet of wall insulation for a 36- by 48-foot basement with 8-foot walls, compared with 1,725 square feet of basement ceiling insulation),
 - more easily achieves continuous thermal and air leakage boundaries because basement ceilings are typically penetrated with electrical wiring, plumbing, and ductwork,
 - requires little, if any increase in the size of heating and cooling equipment—the heat loss and air leakage through the basement ceiling is similar to that through the exterior walls of the basement.
- Piping and ductwork are located within the conditioned volume of the house so they do not require insulation for energy efficiency or protection against freezing.

INTERIOR BASEMENT WALL INSULATION STRATEGIES



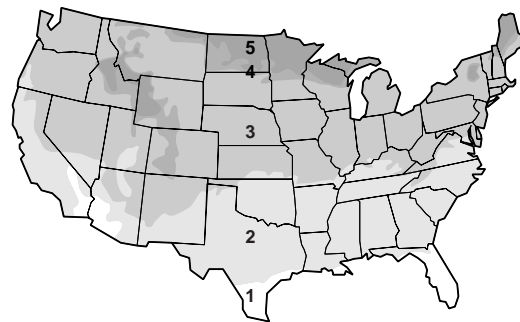
Disadvantages of basement wall insulation include:

- Costs may exceed those for insulating the basement ceiling, depending on the materials and approach selected.
- If the surrounding soil contains radon gas, the home will require a mitigation system underneath the basement floor.
- In termite-prone areas, exterior foam insulation in ground contact allows a path for termites to access the walls of the home undetected. Check with local code officials to determine acceptance of exterior foam application. Some installations will require non-invasive termite detection systems, such as termite baits. One of the nation's leading foam insulation manufacturers has released a rigid foam with borate insect repellent.

R-VALUES RECOMMENDED FOR BASEMENT INSULATION

The International Energy Conservation Code's basement wall insulation requirements, based on Heating Degree Days (HDD), are as follows:

HDD Zone	R-value Interior	R-value Exterior
1 (0-1,500)	none	none
2 (1,501-4,500)	R-5 to R-9	R-5 to R-10
3 (4,501-8,500)	R-9 to R-10	R-10
4 (8,501-9,000)	R-10 to R-19	R-10 to R-15
5 (> 9,000)	R-19	R-15



HDD=HEATING DEGREE DAYS

Consult your local weather bureau for your city's actual Heating Degree Days, a measurement commonly used to determine fuel consumption and/or the cost of heating during a heating season.

BASEMENT INSULATION

For more information, contact:

Energy Efficiency and Renewable Energy Clearinghouse (EREC)
1-800-DOE-3732
www.eren.doe.gov

Or visit the BTS Web site at www.eren.doe.gov/buildings

Or refer to the Builder's Guide Energy Efficient Building Association, Inc.
952-881-1098
www.eeba.org

Written and prepared for the U.S. Department of Energy by:

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U.S. Department of Energy's Oak Ridge National Laboratory
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865-574-2694
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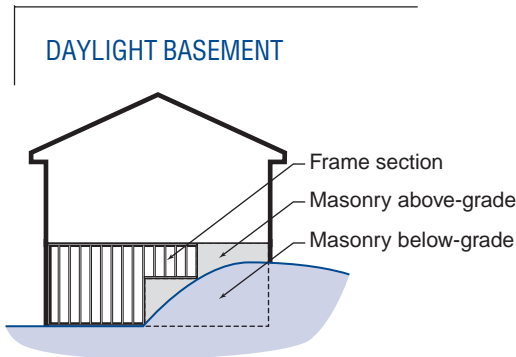
International Energy Conservation Code can be obtained from the International Code Council by calling 703-931-4533
www.intlcode.org

MECcheck, a companion compliance software package, can be ordered from DOE by calling 1-800-270-CODE or downloaded directly from the Web at www.eren.doe.gov/buildings/codes_standards/buildings/.

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BASEMENT INSULATION TECHNIQUES

Basement insulation levels should be selected in accordance with the International Energy Conservation Code or DOE Insulation Fact Sheet (DOE/CE-0180), which can be obtained from DOE or the web at www.ornl.gov/roofs+walls. Be sure to insulate both the masonry and stud walls of daylight basements.



There are three primary ways to insulate the masonry portion of a basement wall:

- 1. Exterior insulation**—1 to 3 inches are recommended for most climate zones. Extruded polystyrene (R-5 per inch) is durable and moisture resistant. Expanded polystyrene (R-4 per inch) is less expensive, but it has a lower insulating value. High-density, drainable, fiberglass insulation or fibrous drainboard does not insulate as well as foam but provides a drainage plane. Leave a 6-inch gap between the insulation and wood foundation elements to provide a termite inspection area. Insulate rim joists.
- 2. Interior insulation**—usually installed behind interior framing or with furring strips placed against the foundation wall (see figure on page 3). Joints and penetrations through the drywall must be well sealed to prevent movement of moisture laden air into the insulation and possible condensation. Insulate rim joists.
- 3. Insulated Concrete Forms**—comparatively new products that are relatively easy to install. Once the hollow foam blocks are stacked, the cores are filled with concrete.

Most products provide continuous insulation on the interior and exterior. They also provide surfaces for attaching drywall, brick ties, and other finish materials. Many new insulated concrete forms are treated with termite-resistant chemicals. Insulate rim joists.

RADON CONTROL IN BASEMENTS

Radon is a radioactive gas that occurs in some soils. It can enter a home through the foundation and floor system. If it occurs in concentrations greater than 4 pico-curies per liter, it may pose a health risk to the home occupants.

To guard against radon problems:

- Install a 4-inch or greater gravel base with a continuous layer of 6-mil polyethylene on top of the gravel.
- Embed a “T” fitting attached to a 3-inch or larger diameter gas-tight pipe through the polyethylene barrier into the sub-slab aggregate before the slab is poured.
- Pour the slab and seal all slab joints and penetrations.
- Extend the gas-tight pipe vertically through an interior wall and terminate it at least 12 inches above the roof.
- Have an electrician stub-in a junction box in the attic.
- After construction is complete, test the basement for radon with an EPA-listed radon test kit, or hire a qualified technician. If the test shows concentrations above 4 pico-curies per liter, install a small blower to the pipe in the attic to depressurize the sub-slab space. If use of the blower does not reduce radon levels below 4 pico-curies per liter, consult with local radon experts.

For more detailed instructions, visit the EPA radon web site <http://www.epa.gov/iaq/radon/>.



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