The Pennsylvania Housing Research Center

Insulating Basements: Part 2
Materials

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INTRODUCTION

As part of the overall building envelope, insulated basement wall systems include more than just structural components and materials. Those materials that are selected in order to control the flow of heat, air, and moisture make up the overall below-grade enclosure system. The main concern when selecting materials for basement walls involves material properties that address heat, air, and moisture flow such as thermal resistance and permeability.

Insulating Basements consists of three PHRC Builder Briefs addressing fundamental building physics, basement wall materials, and basement wall systems. This second brief covers important material properties of basement wall components. All materials are referred to in this brief according to their generic name without reference to specific brands. Some properties may vary between manufacturers.

MATERIAL PROPERTIES

The main material properties that drive basement wall design and component selection involve the transfer of heat and moisture through the material. While some of these properties are governed by building codes, others are specified by the builder.

Thermal

The essential material property that relates to heat transfer and thermal insulation is thermal resistance. Thermal resistance is more commonly referred to as R-Value in the construction industry. The concept of the R-Value of a material is rather straight-forward: the higher the R-Value, the better the insulating value of the material. Although a material's thermal resistance is typically referenced as "R-number", it is important to understand the units associated with this property in the Inch-Pound system. The units of a material's R-Value are as follows:

$$R-Value = \frac{(hour \times feet^2 \times {}^\circ\mathrm{F})}{Btu}$$

In other words, for every Btu of energy that passes through one square foot of area in an hour's time, the R-Value represents the temperature difference between each surface, or the number of degrees Fahrenheit difference between surfaces. For example, R-19 insulation (commonly found in walls) will allow one Btu of energy to pass through one square foot of surface area in an hour's time when there is a temperature difference of 19°F between surfaces.

Water Vapor Flow

When considering water vapor flow in relation to building enclosures, permeability is the most common material property used to quantify a material's vulnerability to moisture infiltration. A material that has a high permeability allows more moisture in vapor form to be transported through the thickness of the material than one with a low permeability. The common unit used to quantify permeability in materials is perm. It is important to understand the units associated with this property in the Inch-Pound system. The units of perm are as follows:

$$perm = \frac{grain}{(hour \times inch\,Hg \times feet^2)}$$

In other words, for one perm, one grain of water vapor will pass through one square foot of area per hour given one inch Hg pressure difference between surfaces. Note: 7000 grains = 1 pound.

Based on the permeability of a material, it can be classified in general terms and also in relation to its effectiveness as a vapor retarder. Table 1 shows some standard descriptions of building materials based on their permeability.

Table 1: Vapor Permeability

Classification	Permeability (perm)
Vapor-Impermeable	0.1 or less
Vapor-Semi-Impermeable	0.1 – 1.0
Vapor-Semi-Permeable	1.0 – 10.0
Vapor- Permeable	Greater than 10.0

All of the categories shown in Table 1 except for vapor-permeable materials are considered in general to act as a vapor retarder, as they provide some level of resistance to the transfer of water vapor through the material. Table 2 shows more specific classifications of vapor retarders.

Table 2: Vapor Retarder Classifications

Vapor Retarder	Permeability (perm)
Class I	0.1 or less
Class II	0.1 – 1.0
Class III	1.0 – 10.0

A Class I vapor retarder is considered to be a vapor barrier. Some common examples of Class I vapor retarders would be glass and foil-faced sheathings.

It is important to note that classification of a material as a specific category of vapor retarder does not necessarily correlate to its effectiveness as an air barrier. When analyzing the resistance to air infiltration, materials must be analyzed for this property independently of their water vapor transmission characteristics.

Compressive Strength

One of the most important material properties when considering basement wall systems beyond those associated with thermal resistance and permeability involves the compressive strength of thermal insulation. This is an especially important property for insulation systems with the insulating layer located on the exterior of the wall system. In this case, the insulation must be able to resist the lateral pressure caused by the adjacent compacted soil layer as well as any hydrostatic forces that may be exerted on the wall system.

Compressive strength also helps to determine the installation method used when using an interior insulation. Insulation with a high compressive strength can be installed without the use of a stud wall, allowing for a more continuous thermal insulating layer thereby reducing the effect that thermal bridging has on the performance of the wall system.

THERMAL INSULATION

One of the main purposes of basement walls is to manage the flow of heat across the basement wall. Thermal insulation is included in the enclosure system for this purpose. In general, thermal insulation can exist as blankets, blown-in or loose fill, spray foam, or rigid insulation. There are various commons types of foam insulation, including extruded polystyrene (XPS) and expanded polystyrene (EPS or bead board). It is possible for basement wall systems to include multiple insulation types.

Table 3 on the following page shows properties relating to the transfer of heat and moisture through common insulating materials as well as other material properties.

Table 3: Material Properties

Material	Thermal Resistance	Water	Fire		
	R per inch	Vapor Perm	Flame Spread (E84)	Smoke Development (E84)	Must be covered
INSULATION - Boards					
Plastic Foams - Polystyrenes					
Type VIII (EPS)	3.8	3.5	10	125	Yes
Type II (EPS)	4.0	3.5	10	125	Yes
Type X (XPS)	4.2	1.1	5	165	Yes
Type IV (XPS)	5.0	1.1	5	165	Yes
Type IX (EPS)	4.2	2.0	10	125	Yes
Type VI (XPS)	5.0	1.1	10	125	Yes
Type VII (XPS)	5.0	1.1	10	125	Yes
Type V (XPS)	5.0	1.1	10	125	Yes
Plastic Foams - Polyisocyanurates					
Fiberglass Faced	5.8	4	25	45	Yes
Foil Faced	7.0	< 1.0	20	65 (1 inch)	Yes*
Add - foil faces dead air space	2.8				
Other					
Glass Fiber	3.9	high			No
Rock Wool	4.2	high			No
INSULATION - Batts					
Glass Fiber (std density)	3.2	1 Kraft, 0.5 foil	25	50	Y-Kraft, N-foil, vinyl
Glass Fiber (high density)	3.8				Y-Kraft, N-foil
INSULATION - Blown					
Glass Fiber (BIB)	4.0		5	5	
Rock Wool	2.8				
Cellulose	4.0				