XPSA
EXTRUDED POLYSTYRENE FOAM ASSOCIATION

Technical INSIGHTS

Below Grade, Number 8

# Habitable Basement Thermal Control Challenges

Thermal challenges for basements include the following functions: keeping temperature extremes outside the basement wall, especially cold temperatures, and preventing condensation of the basement air onto the interior of walls in the basement. Insulation strategically placed on the exterior side of the foundation plays an especially important role in each of these objectives (Fig. 1).

**Figure 1:** Exterior insulation and damp-proofing or waterproofing along with effective drainage helps prevent water intrusion into the basement. (Courtesy of Kingspan.)

## Keeping temperature extremes outside

Structural materials typically perform rather poorly in keeping heat and cold outside. On the contrary, insulation plays a significant role in decreasing heat transfer through basement walls and floors. Heat from the interior of the basement can quickly transfer through basement walls and floors in contact with the surrounding soil if the basement is not sufficiently insulated on the walls below grade.

Insulation of basement walls above grade and insulation beneath the floor slab of the basement are also important in managing basement temperatures, especially when the intention is to create a habitable space. Basement insulation moderates the surface temperatures of basement walls and floors. As for sustainability objectives, insulation reduces the environmental footprint and energy costs by decreasing the heat transfer that occurs in the heating and cooling of basements.

The placement of the insulation on either the interior or exterior of the wall (or both) makes a difference in human comfort. When the interior surface of the basement wall is warm, it feels much more comfortable to the occupant. Placing the insulation on the exterior side of the basement wall keeps the basement wall surface temperature closer to the overall interior temperature of the room.

XPS and EPS do not have the same thermal resistance and are impacted differently by the presence of moisture. R-value is the resistance to heat flow. Higher numbers indicate lower heat flow and better insulation. R-values for XPS and EPS insulation are listed in Table 1. The “dry” EPS and XPS insulation values are what is shown on the insulation label and literature. The “wet” insulation values for EPS and XPS are building code approved reduced R-values that assume long term water absorption over the life of the building. The “wet” insulation values for XPS include both the effects of moisture and aging.

## Preventing condensation

Once the basement wall is protected from liquid water penetration, it is also necessary to protect the basement wall from the condensation of water vapor in the basement air space. Of course, if the basement wall has already been compromised by a failure to provide protection from bulk water, then such additional measures will not be very effective. In this sense, the basement wall assembly is a system of components, and each component must be free from defects. No one element is independent of the other.

Basements may be prone to high humidity. Interior moisture often is removed using dehumidifiers but that is not a complete solution. If thermal conduction between the masonry or concrete walls and floors to the surrounding soil is excessive,

then the masonry or concrete may become cold enough for moisture condensation even at moderate humidity levels.

When moisture condenses on or is absorbed into concrete walls and concrete floor slabs, basements can become cold, dank and musty (Fig. 2). The most reliable long-term solution to prevent condensation is to maintain concrete wall and floor temperatures well above the dew point of the ambient air in the basement space. In this manner, condensation on the concrete wall and floor slab can be avoided.

Depending on the types of insulation and the quantity and locations of the insulation on the basement walls and floor, insulation can have a positive effect on managing the condensation of interior moisture.

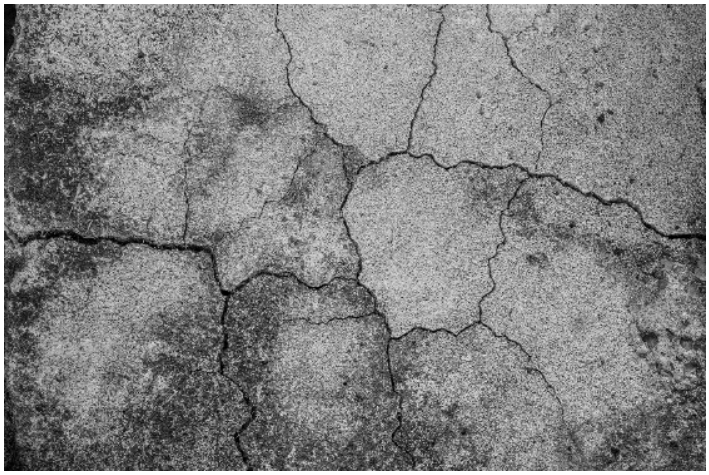

**Figure 2:** Concrete will absorb moisture and if unchecked will crack over time, resulting in musty smelling basements. (Adobe Stock)

| Material | R-value per inch ($ft^2$ °F h/BTU) | Source |
|---|---|---|
| **"Dry" XPS**<br>Above grade applications | Nominal – R-5.0 per inch | ASTM C578 Standard specification for rigid, cellular polystyrene thermal insulation |
| **"Wet" XPS**<br>Exterior below-grade application, subject to below-grade moisture | R-4.5 per inch in vertical applications, R-4.0 per inch in horizontal applications .See Brooks et al. [1] | IRC, Table R403.3(1); and ASCE 32-01, Table A1 |
| **"Dry" EPS**<br>Above grade applications | Nominal – R-4.0 to R-4.3 per inch | ASTM C578 Standard specification for rigid, cellular polystyrene thermal insulation |
| **"Wet" EPS**<br>Exterior below-grade application, subject to below-grade moisture | R-3.2 to R-3.4 per inch in vertical applications, R-2.6 to R-2.8 per inch in horizontal applications. See Brooks et al. [1] | IRC, Table R403.3(1); and ASCE 32-01, Table A1 |

**Table 1:** R-values of interest for habitable basements

## References

**[1]** Rob Brooks et al., "Effects of Moisture Absorption Mechanisms on In-Service Design R-values of Polystyrene Insulation," XPS Insulation Performance, Below Grade Series ID: IP-BG-02
https://xpsa.com/wp-content/uploads/2021/05/XPSA-IP-BG-02_May.14.2021_Preprint.pdf

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