Avoiding Moisture in Habitable Basement Design

Figure 1: A habitable basement. (Source: Adobe Stock)

Basements serve as the structural foundations of buildings. They are expected to keep the external environment out of the structure, including heat, cold, rainwater, snow melt and ice and they are expected to withstand structural challenges from soil movement, earthquakes, wind events, freezing, and thawing.

Furthermore, basement assemblies are expected to prevent condensation of indoor air moisture on the inside of basement walls and floors as well as equipment and furnishings. In other words, basements are expected to keep the outside, outside; and keep the inside, inside, while supporting the building above.

This paper examines basement assemblies useful in the construction of habitable basements with special emphasis on insulation choices for basement wall assemblies. It endeavors to ask the right question: What insulation materials help to maintain a habitable basement?

Functionality of Basements

One of the first questions to be asked when designing a basement foundation is What is the desired functionality of the basement?

At one end of the spectrum, a basement may provide comfortable, fully habitable spaces comparable to the above-grade portions of the building. In the middle of the spectrum, the basement may be less habitable than the main living areas. In other words, it will be cold in the winter and damp much of the year. At the far end of the spectrum, the basement may serve only as a structural foundation and nothing more. (See Figures 1 and 2.)

Swinton and Kesik list service criteria and limitations/allowances for different classes of basements [1]. According to their classification system, Class A basements provide a below-grade living space comparable to the living space of the floors above. To ensure long-term performance the design and construction of Class A basements must be virtually defect free and provide critical, redundant moisture control measures. They emphasize that the construction of a comfortable and habitable basement (i.e., a Class A basement) requires much more attention to the components and the system design compared to the design of basements that are not intended to be used as living spaces.

Figure 2: This basement has a water management problem. A habitable basement must have effective environmental separation, meaning bulk water must not penetrate the interior of the basement. (Adobe Stock)

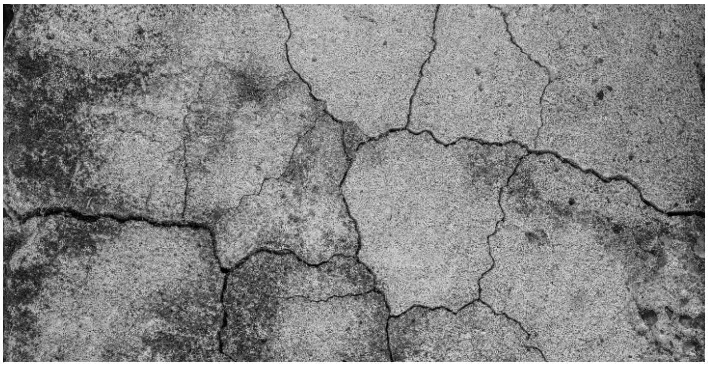

Figure 3: Concrete will absorb moisture and if unchecked will crack over time, resulting in musty smelling basements. (Adobe Stock)

There may also be health and safety requirements as well as HVAC requirements, which go beyond the scope of the 2005 Report by Swinton and Kesik.

A heathy home begins with a firm foundation that assures structural support for dead and live loads, lateral stability and minimal building movement. In colder climates, the foundation usually extends below the frost line so the home will not significantly move when the ground freezes in the winter. In other words, basements have a role in preventing frost heave that translates to excessive building movement and foundation cracking. Such relatively deep foundations typically result in basements instead of crawl spaces.

Foundation Drainage System

In an IRC Technology Update [2], Swinton et al. describe their approach to managing water exposure to basements in terms of "two lines of defense":

> *The most effective strategy for managing water is to provide two lines of defense. When exterior basement insulation is used, the first line of defense is the exterior surface of the insulation, which supplies a continuous means of managing water from the ground surface down to the gravel and drainpipe at the footing. The second line of defense is the outer face of the foundation (cast-in-place concrete, concrete block, or wood sheathing in a permanent wood foundation), which can handle the incidental quantities of water that may get by the first line of defense.*

Since 1999, much research has been dedicated toward accumulating valid experimental data on how insulations perform when placed on the outside of a basement wall in contact with the earth, and when insulation is placed beneath floor slabs. The continuous monitoring of the thermal performance of thirteen different basement insulation systems by the Institute for Research in Construction throughout two heating seasons provided some answers [2].

The military "two lines of defense" analogy in the IRC Technology Update is apt. The outer lines of defense are expected to protect against liquid water penetration. This outer layer is sometimes referred to as "effective environmental separation." If the first line of defense allows liquid water to reach the second line of defense, then the second line of defense must provide some protection against liquid water penetration. The basement certainly could not be considered a Class A basement.

Drainage does more than help prevent leaks through the basement wall. Drainage helps to address potentially significant reductions in R-values of insulation (up to 50%) due to water absorption and retention. (Figure 3)

However, drainage of water does not address the negative effects of water absorption on R-value entirely. If liquid water and water vapor are not properly managed, then the insulation R-value is reduced.

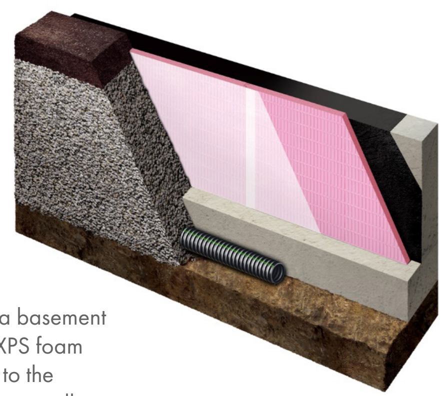

Figure 4: Schematic of a basement wall assembly, showing XPS foam insulation board exterior to the waterproofing and concrete wall. (Courtesy of Owens-Corning)

Summarizing, the defense against liquid water for the structural foundation is an applied layer of damp-proofing or waterproofing. The defense against liquid water for exterior insulation is to assume a reduced R-value and increase the thickness of the exterior insulation accordingly, and to provide proper drainage of liquid water. Highly water absorbent insulation materials are impractical for this application because of the dramatic drop in R-value (due to the presence of water) and reduced longevity after repeated freeze-thaw cycles over the life of the building. Lower absorption insulations such as polystyrene foam are favored exterior insulation materials, and polystyrene foam (XPS or EPS) should have their thickness increased based on reliable data from long-term, in-service studies. Facers could be used to mitigate water absorption in the insulation, but the facers may eventually be compromised over the life of the building, and the insulation thickness adjustments nonetheless should be applied.

References

[1] "Performance Guidelines for Basement Envelope Systems and Materials: Final Research Report" By Michael C. Swinton, IRC/NRC and Dr. Ted Kesik, University of Toronto (Institute for Research in Construction / National Research Council Canada) October 2005

[2] Swinton, M.C.; Bomberg, M.T.; Kumaran, M.K.; Normandin, N.; Maref, W. "Performance of thermal insulation on the exterior of basement walls,"
NRC Construction Technology Update, Number 36, Institute for Research in Construction (1999-12-01).
https://nrc-publications.canada.ca/eng/view/ft/?id=2a7aded0-f4cd-4718-9de8-51b9ba9b17ec