Choose the Best Insulating System

A plethora of insulating materials and techniques can help designers find the perfect way to negate thermal transmission and create an efficiency wall system.

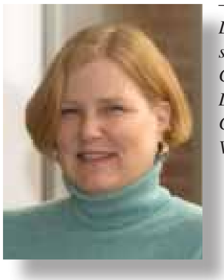
— By Beth Buffington, AIA, LEED AP BD+C

When designing virtually any type of buildings, architects seek to create a barrier that slows the inevitable transfer of heat as much as possible. That requires creating a continuous layer of insulation between the buildings's interior and exterior. Devising the most effective way to provide this continuous layer provides a significant challenge to designers.

With some notable exceptions—picnic pavilions; open parking structures and beachfront bars, to name a few—a building's interior environment requires a different temperature and humidity than the exterior environment just inches away. The barrier created between these two environments typically consists of a series of components:

- A skin or shell, which prevents water from entering the building.
- Insulation, which reduces heat transfer between sides of the barrier.
- A vapor barrier, which impedes the flow of vapor transpiring on the skin of the building.

Traditional architecture relied on mass (usually masonry) or airspace cavities in the building materials to



– Beth Buffington, AIA, LEED AP BD+C, is studio principal for Community at Little Diversified Architectural Consulting in Arlington, Va.

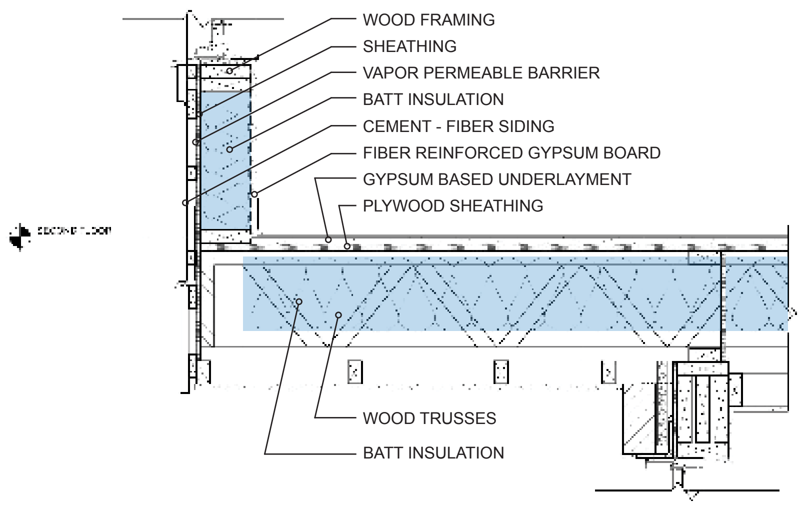


Illustration 1. *A typical frame structure using batt insulation faces the challenge of being penetrated by various materials as well as outlets, conduit and ductwork. Drawing: Little Diversified Architectural Consulting*

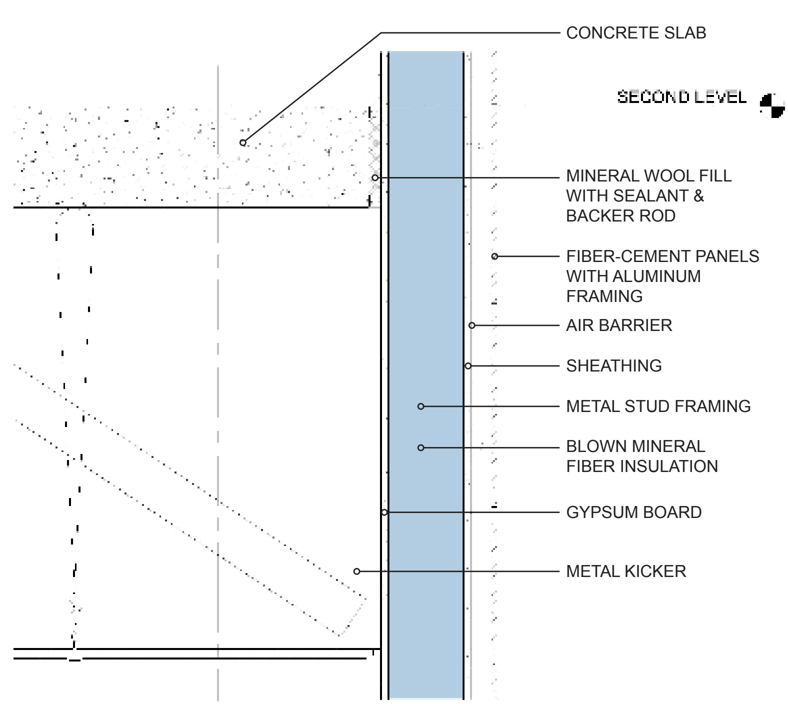


Illustration 2. *For a recent clinic project by Little, light-gage steel framing was filled with loose-fill cellulose insulation. The system avoids the conflict between the slab edge and framing connections, but it still requires penetrations and interruptions. Drawing: Little Diversified Architectural Consulting*

delay heat transfer. However, as more high-performance buildings are created, the insulation layer's thermal resistance and continuity have come under more scrutiny to raise the efficiency.

This reconsideration has been aided by the huge range of insulation materials introduced to the market, each with different characteristics and a different specific thermal resistance (usually described as its R-value). Each building design will take advantage of a particular type of exterior wall and a specific type of insulation to create the best building envelope possible.

Local Conditions Matter

Each material will have a different R-value based on its thickness, as the R-value is calculated as ratio of heat transfer per unit area. While more thermal insulation results in better building performance, the cost effectiveness of various insulations must be weighed under the specific climactic conditions.

As a starting point, the U.S. Department of Energy has recommended R-values for each area of the country based on local energy costs for heating and cooling, which help create a basic evaluation. Local building codes (and in many cases the International Energy Conservation Code) provide minimum requirements for the performance of the wall, one component of which will be the insulation.

Another way to determine the insulation-performance requirement for a specific project is to have a mechanical engineer provide a step-by-step evaluation of wall performance. This will determine thermal transmission and the point where moisture will condense (dew point) in the wall system under various interior and exterior conditions of temperature and humidity. This evaluation helps determine the type of insulation to specify and its preferred location in the wall, as well as the location and type of vapor barrier needed to achieve the best overall performance.

Although a large variety of insulation materials are available; from snow and hay bales to fiberglass batts and extruded polystyrene, selection will be based on project type, exterior wall design and project location. For instance, it is common for multi-story commercial and institutional buildings in mixed climatic zones, which require heating in the winter and cooling in the summer, to use rigid, batt, foam or loose-fill insulation as part of the wall system. It typically is located either within the interior wall framing or within the cavity created between the exterior veneer finish and the wall framing.

Illustration 3. *The horizontal band pattern created in a recent clinic project designed by Little required the wall framing to be attached at the slab edge and supported by angle bracing at the floor below. This design impacted the insulation approach, seen in Illustration 2. Photo: Little Diversified Architectural Consulting*

Continuity is Critical

In most conventional wall systems, the structural components of the wall are framed floor to floor, and the insulation is placed in the wall-framing

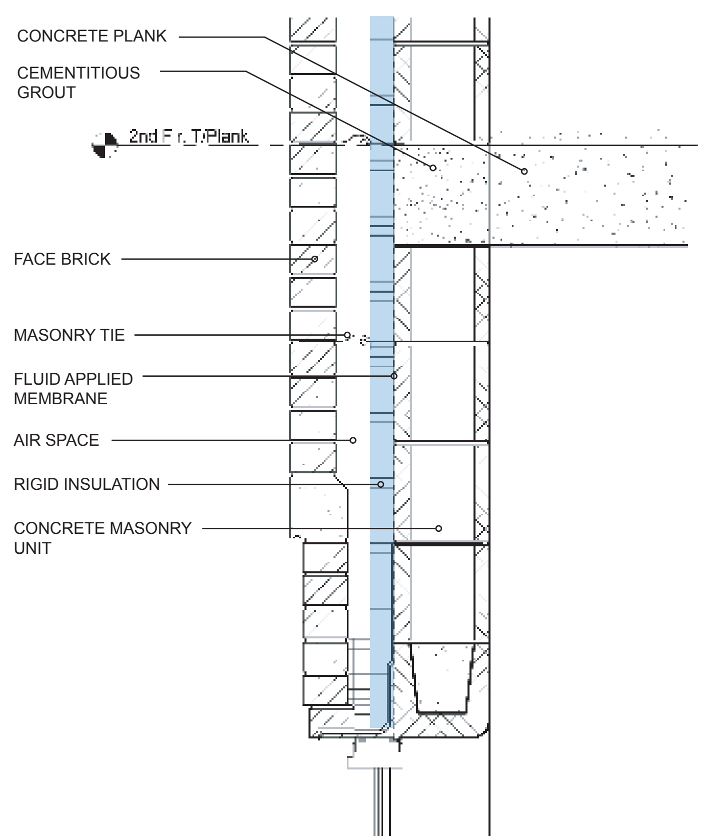


Illustration 4. *This wall system, used for the New Residence Hall at Fairfield University, shows a typical wall section with insulation in the cavity. It eliminates concerns about damaging the insulation layer from the interior. Drawing: Little Diversified Architectural Consulting*

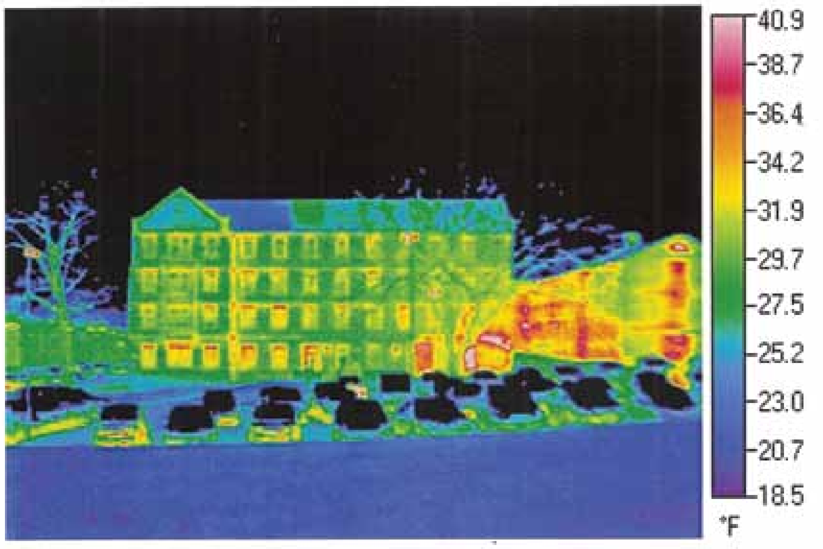


Illustration 5. *This thermal image of Millennium Hall at the Catholic University of America, a veneer masonry building with EPS insulation in the cavity shows where heat can escape through penetrations in the wall cavity. Photo: Little Diversified Architectural Consulting*

Illustration 6. *In contrast to illustration #5, this thermal image of the precast concrete wall system at Opus Residence Hall at Catholic University of America indicates that little heat is escaping anywhere in the building's wall system. Photo: Little Diversified Architectural Consulting*

cavity. However, illustration #1, which shows a fairly simple frame structure with batt insulation in the wall cavity, indicates the problems that can be encountered. At each junction, the framing that joins the structure together makes it difficult to maintain insulation continuity.

In addition, the insulation's location within the wall framing cavity makes it vulnerable to interruptions and penetrations from the building's interior. For instance, any outlets, conduit, ductwork or diffusers installed in the exterior wall will interrupt the insulation. Each penetration will be created by a different trade at a different point in construction, and the penetrations may not be repaired. Resulting discontinuities in the insulation will lead to reduced efficiency of the overall envelop and increase opportunity for heat loss and gain through the wall.

In a more sophisticated version of a batt-insulation system within a structural frame, Illustration #2 shows the wall system used in the Unity Anacostia Health Care Center by Little. The windows' horizontal band pattern required the wall framing to be attached at the slab edge and supported by angle bracing at the floor below (as seen in Illustration #3).

Loose-fill cellulose insulation was placed within the wall cavity. Because of the building design, the exterior wall framing by-passes the slab edge. Attaching the wall framing outside the structural slab edge avoids one problem associated with insulating within the wall framing cavity by eliminating conflicts between the slab edge and framing connections. This creates good insulation continuity and improves overall wall-insulation performance. However, the wall still is subject to the same interruptions and penetrations from interior systems as the wall in Illustration #1.

Inside the Cavity

For a variety of reasons, designers often prefer to locate insulation within the enclosure cavity. The benefits include better insulation continuity, location of the vapor barrier outside of the occupied space and reduced potential for penetrating and damaging wall insulation located in the framing cavity. The cavity is located between the wall framing and the veneer-finish material, be it brick, cementitious panels or stone. This detailing is fairly common in institutional masonry construction, whether the wall framing consists of concrete masonry units (CMU) or light-gage steel studs.

In this system, extruded-polystyrene (EPS) insulation is placed in the exterior wall cavity behind the brick veneer. Since modern veneer masonry provides a rainscreen, there is the potential for water to penetrate this cavity. But as EPS is inert, its insulation value is not impacted by moisture.

The diagram of the wall system for the New Residence Hall at Fairfield University shown in Illustration #4 presents a typical wall section with the insulation in the cavity. It provides an improvement over the inclusion of insulation in the interior wall-frame cavity, since it eliminates concerns about damaging the insulation layer from the interior. But this system creates challenges of its own.

First, there continue to be detail conditions that make it difficult to maintain insulation continuity. There also are dimensional tolerances that make it difficult for the contractor to install insulation according to the manufacturer's recommendations and maintain a continuous vapor barrier. In addition, in masonry veneer buildings more than three stories tall, steel relief angles are required at the floor slab to support the weight of the brick.

Thermal Images Reveal Gaps

The impact these elements can have is shown by taking thermal images of the project. Thermal images are created at night on a cold evening when the building is being heated. Blue indicates the surface temperature of the building is cool. Yellow and red show areas where heat is escaping the building.

Illustration #5 shows a thermal image of Millennium Hall at the Catholic University of America, a veneer masonry building with EPS insulation in the cavity. The thermal image indicates the relieving angles that support the brick at each floor break the insulation continuity and act as a conduit for heat to leave the building.

Illustration #6, a thermal image of Opus Residence Hall at Catholic University of America in Washington, D.C., shows a thermal image that is virtually all blue. No heat is escaping this building except at an open window. The exterior wall system consists of an insulated precast concrete panel system. Innovations with this system, such as wythe connectors that do not allow thermal bridging, provides an excellent example of the ways in which the industry is improving wall construction to meet the challenge of creating more energy efficient buildings.

Completed in 2008, the exterior wall consists of insulated precast concrete panels composed of 4 inches of structural precast, 2 inches of polyisocyanurate insulation and 3 inches of veneer precast (as shown in Illustration #7). Bonded together in the precast plant, these panels create edge-to-edge insulation continuity and provide an R-value of 26. The insulation is wrapped in a vapor barrier to prevent moisture transmission.

The panels are large, more than 30 feet long and 10 feet high. Bays that stand out from the primary building mass are U-shaped panels, so the continuity of the insulation envelope is virtually flawless. Hand-tooled concrete provided the interior finish of the space, and because of the excellent insulation in the wall, the interior surface temperature remains the same as the air temperature. No penetrations from the interior impact the panels in any way.

The building was designed to be compatible with adjacent traditional masonry buildings on a university campus. Thin brick in a color and finish that matched adjacent buildings was incorporated into the precast panels. The result, shown in Illustration #8, was a beautiful, well insulated and high performing building design. (For more on this project, see the Summer 2011 issue of *Ascent*.)

Every building has many criteria that impact design solutions and material selections. Putting a little extra time into considering the many insulation choices, selecting the appropriate product and carefully detailing the installation will reward the designer with long-lasting benefits in both improved building performance and user comfort. ■

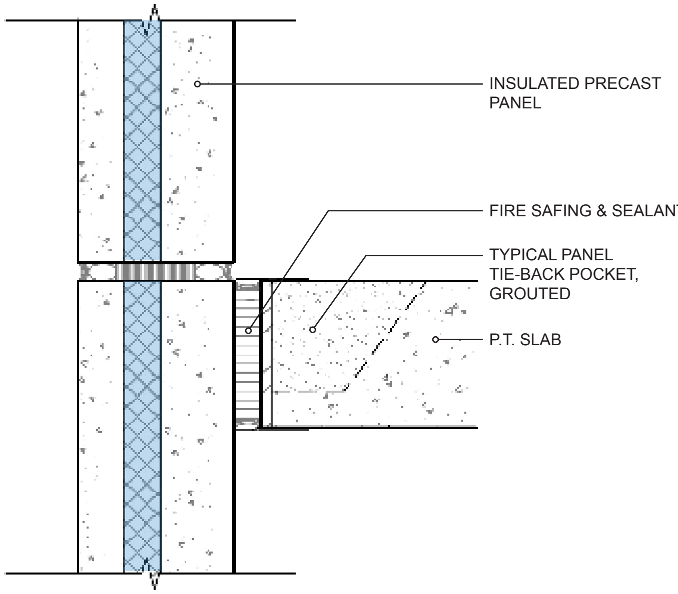


Illustration 7. *The exterior wall system at Opus Residence Hall at Catholic University of America consists of insulated precast concrete panels sandwiching a layer of polyisocyanurate insulation. Drawing: Little Diversified Architectural Consulting*

Illustration 8. *The Opus Residence Hall at Catholic University of America used precast concrete insulated sandwich wall panels with embedded thin brick to create a look that blended with nearby campus buildings and also provided a highly efficient insulating wall system. Photo: Little Diversified Architectural Consulting*