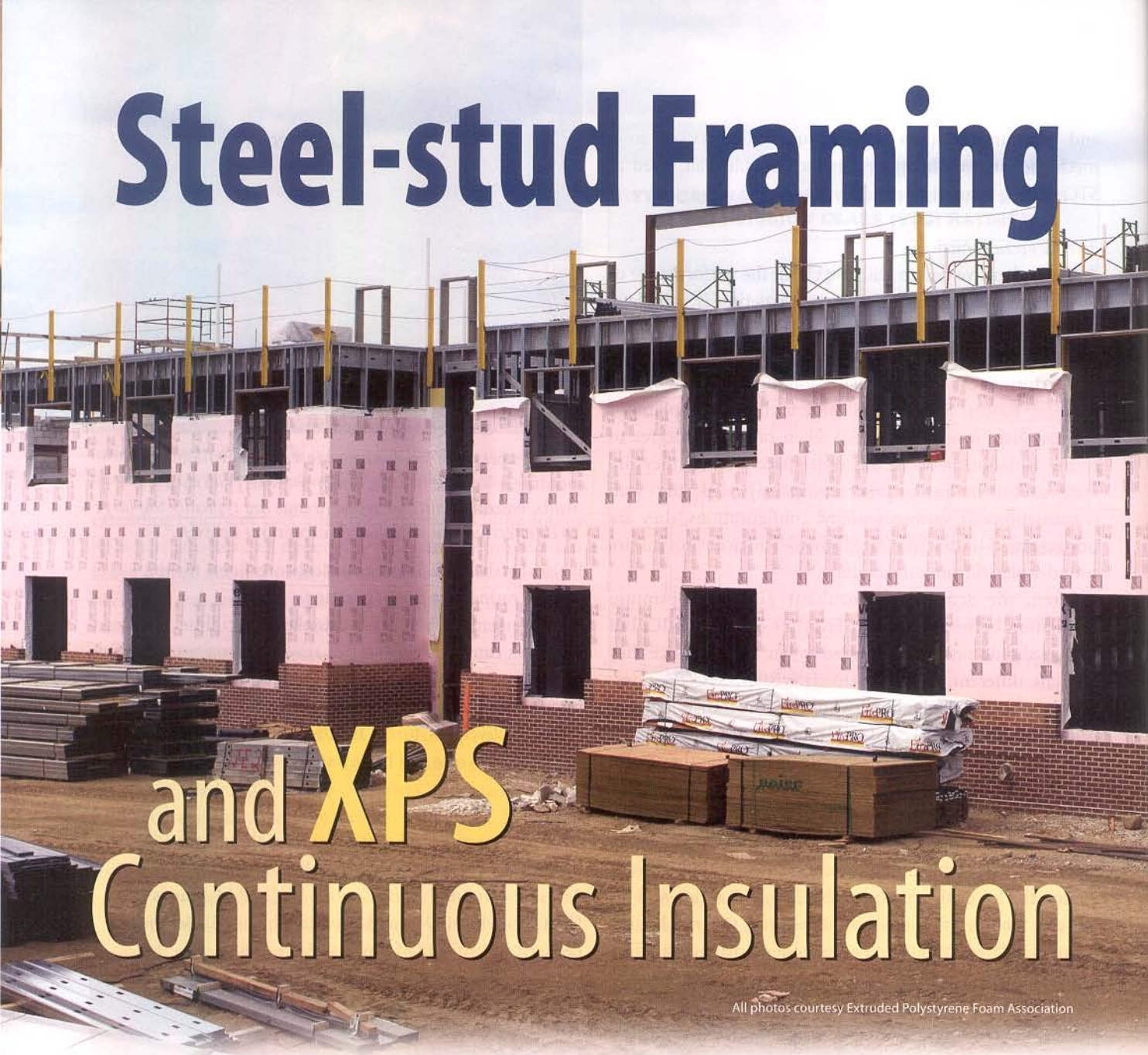
Steel-stud Framing and XPS Continuous Insulation



All photos courtesy Extruded Polystyrene Foam Association

by Susan Herrenbruck and Herbert Slone, RA

When designing a brick-veneer wall system, steel-stud construction provides an alternative to concrete-block backup. Combining the look and durability of brick with the structural reliability and lower cost of steel, this method can be effective—when properly insulated. Many state commercial energy codes greatly emphasize continuous insulation (ci) in steel-stud construction, for which extruded polystyrene (XPS) is well-suited. Steel studs must be covered with a layer of ci in most regions of the United States, to minimize thermal bridging that robs building energy. Design professionals should also consider exceeding energy code requirements to achieve maximum thermal performance and energy-efficiency.

ASHRAE/IESNA 90.1

American Society of Heating, Refrigeration, and Air-conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA) 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings,* applies to most commercial buildings in the United States. For most U.S. regions, the code requires a layer of insulation continuous across all structural members, without thermal bridges other than fasteners and service openings. Depending on the climate zone, insulation requirements vary for steel-framed, above-grade walls for non-residential and residential commercial construction. Figure 1 shows a cross-section of a brick veneer wall system with steel stud.

Climate zones and requirements

For all climate zones in the United States, ASHRAE 90.1 requires the minimum insulation level to be R-13, by prescription, in the stud cavity of steel-framed commercial buildings. However, not all climate zones are required to have continuous insulation—the Deep South and Gulf Coast, for example. Table 1 (page 75) and Figure 2 (page 76) summarize U.S. climate zones and the ASHRAE 90.1-prescribed R-values for steel-stud cavity insulation (typically batts), and continuous insulation (typically rigid-foam plastic), over steel-stud framing.

Benefits of continuous insulation

Thermal Control

Extruded polystyrene (XPS) insulation meets ASHRAE 90.1's criteria for ci by minimizing transverse heat flow along the length of a wall. Transverse heat flow results when highly conductive building layers, such as non-insulating sheathing, are present over the wall's entire surface area. Unlike non-insulating gypsum sheathing, XPS diminishes lateral heat flow through the sheathing itself, limiting the amount of energy radiated from the wall surface. The insulation also reduces thermal bridging by thermally

Figure 1

Brick-veneer Wall System, with Steel-stud Construction

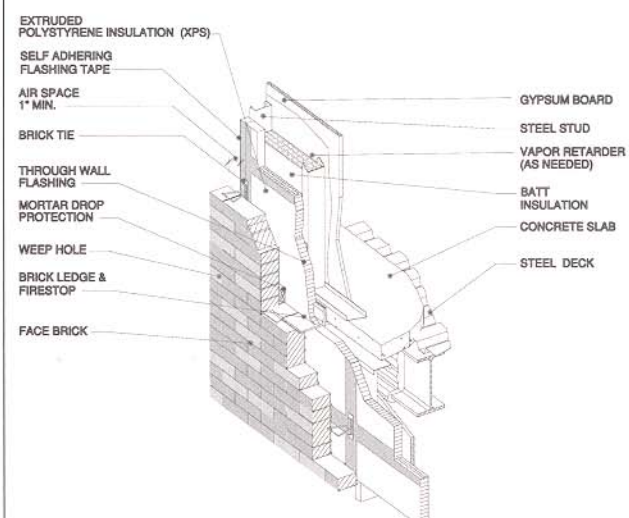


Image courtesy Extruded Polystyrene Foam Association

Using steel stud, a brick-veneer wall system can provide good durability at fairly low cost. While a minimum R-value of 13 is required for such structures, not all climate zones demand continuous insulation.

As well as controlling heat, continuous insulation can also act as an air barrier, a weather-resistive sheathing, and a vapor retarder, depending on the climate and method of detailing.

isolating the stud. Continuous insulation limits the flow of heat energy through steel studs from inside to outside as well as the flow of heat energy moving in the opposite direction. Energy movement through the steel studs can affect interior conditioning loads and both interior and exterior condensation potential, depending on the season.

Moisture control

Properly detailed, continuous insulation can also act as an air barrier layer, a weather-resistive sheathing, and, in certain climates, an external vapor retarder. In all these applications, the stable R-value and moisture-resistant properties of XPS are helpful. Year-round performance must be evaluated, as moisture can enter wall assemblies during certain seasons and dry from them during others. Moisture intrusion can come from inside or outside (*e.g.* in rain penetration, moisture vapor through air intrusion, or vapor permeation). Water migrating from the outside into and/or across the air space behind brick veneer should drain harmlessly across the hydrophobic XPS surface to weep holes at the base of the wall. Properly sealed against air intrusion, XPS continuous insulation can also serve as an air-retarding layer that resists the intrusion of moisture-laden air into the wall assembly. The stable R-value and relatively low perm ratings of XPS ci sheathing moderates cavity temperatures and helps control the location of dew point in the wall assembly.

Cavity temperature

Concerns about dew point and condensation are greatest in winter conditions, when vapor pressure differential between inside and outside can be greatest. Assuming a cold outside temperature and a warm inside temperature, a ci insulation layer placed between the stud cavity and the cold exterior air will increase the temperature of the stud cavity relative to the outside, since it is more thermally isolated from the exterior. Warm air holds more moisture than cold air—by increasing the cavity temperature, it is able to hold more moisture before reaching dew point. Therefore, by altering the cavity temperature, moisture (or relative humidity) tolerance is altered in the cavity, and the dew point location is forced outward to colder regions of the wall section.

Benefits of exceeding ASHRAE 90.1

Cost savings

While compliance with ASHRAE 90.1's minimum insulation level is mandatory, specifiers can often justify exceeding it based on economic and sustainability objectives. Often, the first cost of exceeding the minimum is repaid in less than five to seven years, with projected payback time calculated using standard thermal performance and financial equations.[1] Variables include severity of climate, heating/cooling set points throughout the year, heating/cooling system efficiencies, installed cost of added insulation, cost of energy, and energy-cost escalation rates. Total life-cycle energy-cost savings for buildings exceeding the energy code minimum can amount to hundreds of thousands of dollars.

Energy savings and LEED®

Exceeding the ASHRAE 90.1 minimum can also help buildings achieve Leadership in Energy and Environmental Design® (LEED®) certification. Up to 10 of the 26 points required for certification can be earned for reducing a design-energy budget by 60 percent below that defined by ASHRAE 90.1. In Energy & Atmosphere [EA] Credit 1, *Optimize*

Table 1 **ASHRAE 90.1-2004* Insulation Requirements for Steel-framed, Above-grade Wall Assemblies**

Climate Zones	Minimum R-value		Maximum U-value	
	Non-residential	Residential	Non-residential	Residential
1 (A,B)	R-13 + 0 ci	R-13 + 0 ci	0.124	0.124
2 (A,B)	R-13 + 0 ci	R-13 + 0 ci	0.124	0.124
3 (A,B,C)	R-13 + 0 ci	R-13 + 3.8 ci	0.124	0.084
4 (A,B,C)	R-13 + 0 ci	R-13 + 7.5 ci	0.124	0.064
5 (A,B,C)	R-13 + 3.8 ci	R-13 + 7.5 ci	0.084	0.064
6 (A,B)	R-13 + 3.8 ci	R-13 + 7.5 ci	0.084	0.064
7	R-13 + 7.5 ci	R-13 + 7.5 ci	0.064	0.064
8	R-13 + 7.5 ci	R-13 + 10 ci	0.064	0.055

* *Energy Standard for Buildings Except Low-rise Residential Buildings.*

Energy Performance, one point is awarded for reducing a building's energy cost budget by 15 percent, with additional points awarded for each five-percent increment beyond that.

All-continuous, empty cavity insulation

Traditionally, fiberglass is placed in the stud cavity to provide thermal benefit, while dew point location is controlled through the use of continuous insulation and (when necessary) internal vapor retarders. However, one can also specify steel stud walls with no fiberglass batt insulation in the steel-stud cavity. In this case, the entire R-value required by ASHRAE 90.1 is achieved using much greater thicknesses of continuous insulation sheathing on the outside of the steel-stud framing. This design omits

Figure 2

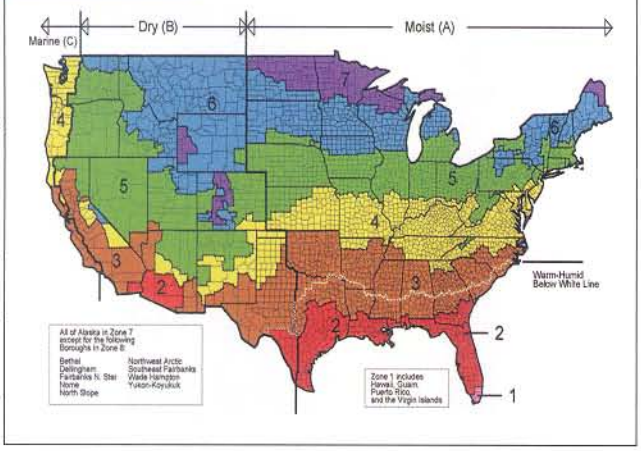


Image courtesy U.S. Department of Energy

The United States is divided into eight climate zones, overlaid with three possible moisture regimes, in ASHRAE/IESNA 90.1-2004, Energy Standard for Buildings Except Low-rise Residential Buildings. *Zone boundaries follow county lines for ease of enforcement.*

fiberglass from the stud cavity, causing the entire stud to be at room temperature, and therefore reducing the chance of condensation around it.

Should thick, continuous insulation be used to achieve ASHRAE 90.1 compliance, then details of the wall assembly must be changed to accommodate the increased thickness. Continuous steel-shelf angles supporting the brick veneer at each floor line must be widened to create a wider cavity for XPS insulating sheathing. Through-wall flashing, parapet caps, window flashing, window pan assemblies, brick-tie base units, and fasteners all must be lengthened to accommodate a thicker layer of ci. Should XPS alone be used to achieve thermal insulation compliance, required thickness ranges from 38 to 76 mm (1.5 to 3 in.). (See Table 1 for a listing of maximum U-values to be used in lieu of the prescribed combination of stud cavity batt and ci.)

Extruded polystyrene insulation is a logical choice when specifying continuous insulation as required across much of the United States by ASHRAE 90.1. The closed-cell structure not only insulates the wall and protects against thermal bridging, it can also help in a building design strategy seeking LEED certification. Further, XPS helps manage moisture intrusion into the wall assembly. As with many things in life, there is value in doing more than the minimum.

Notes

[1] Member companies of the Extruded Polystyrene Foam Association (XPSA) can assist specifiers with economic payback analyses that compare code-required insulation levels to higher levels for the same building. Information is available at www.xpsa.com.

Additional Information

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Abstract

ASHRAE/IESNA 90.1, *Energy Standard for Buildings Except Low-rise Residential Buildings,* provides minimum requirements for continuous insulation across structural members. However, for many parts of the United States, exceeding those minimums can pay substantial dividends.