KHH Green Paper:

Envelop The Steel

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Much of any building’s environmental impact comes from the amount of energy that will be needed to heat or cool its interior spaces over the building’s service life. In many cases, this impact can be more significant than the entire environmental impact of the construction of the building. Structural engineers, therefore, should coordinate their work with the rest of the design team so that the exterior building envelope’s thermal insulation and air barrier systems perform well. As a building’s energy performance becomes more critical, details that allow heat energy to pass through the building envelope become more and more important to control.

A characteristic of all types of steel that needs to be properly addressed when it is used in building applications is its very low thermal resistivity. In the United States, a materials’ resistance to heat flow is defined as its R-value, and is measured in degrees Fahrenheit, square feet hours per Btu, (ft^2·°F·h/Btu). With the R-value of steel at approximately 0.003 per inch, as compared to other construction materials such as wood (average R-value of approximately 2.5 per inch) or normal weight concrete (average R-value of approximately 0.1 per inch), steel functions effectively as a thermal conductor. As such, its use in a building’s exterior building envelope needs to be carefully considered, with details that create minimal thermal bridging across the insulation layers.

Cold-Formed Steel Studs

Cold-formed steel studs with insulation infilled between the studs have a significant reduction in the systems’ R-value, as compared to the same thickness of uninterrupted insulation. In addition, the presence of top and bottom stud tracks in a typical exterior wall result in an additional reduction of total insulation value. The total effect of these is called the “framing factor”. For example, a wall with 5½" steel studs spaced at 16 inches on center using R-21 fiberglass batt insulation with top and bottom track has a framing factor of about 0.35, making the total wall system’s effective R-value approximately 7.4. This assumes no workmanship errors and that a continuous and effective air barrier is present.

In addition to reduced thermal building envelope performance, metal studs with infill insulation and the commonly used ½" or e" thick water-resistant gypsum board sheathing across their exterior face (which has an R-value in the range of 0.6), are prone to condensation in cold climates during the heating season. This moisture in the stud wall cavity can lead to corrosion of the steel, reduced effectiveness of some water-sensitive insulation materials such as fiberglass, and, if food sources are present, the development of mold.

Strategies to overcome this reduction in effectiveness of the building envelope include:

- Providing continuous rigid insulation across the exterior of the studs. Manufacturers have developed boards that consist of structural sheathing material factory-bonded to insulation.

- Use of exterior horizontal subpurlins to attach exterior sheathing, with spray-on foam insulation applied to the inside surface of the sheathing and between the studs. This limits the extent of the steel thermal bridging to the intersection points between the studs and the subpurlins.

- Use of proprietary studs, such as slit-web steel studs, which have been shown to decrease the thermal transfer across the studs while having a fairly minimal effect on the studs’ strength reduction.

Facade Support

For buildings faced with brick or other exterior masonry cladding, any steel that supports the cladding and passes through the insulated building envelope represents a significant path for building heat loss to occur during heating seasons, and for cooling loss during cooling seasons.

- Steel Lintels - Whenever possible, lintels over doors and windows that support the exterior wythe of masonry should not be continuously connected with a steel plate or angle across the insulation plane. Lintel support hangers should be spaced as far apart as practical to minimize the amount of continuous steel across the insulation. Loose lintels should not have a continuous plate across the full width of the opening. If closure is necessary across the gap, consider using a thin-gauge cold-formed stud or track, or a fire-treated fiberglass plate.

- Relieving Angles - As with lintels, avoid continuous steel between the relieving angle and the structure. Space support clips as far as the angle will accommodate. Six-inch reinforced clips spaced 32 inches on center represents an 80% reduction of the thermal heat transfer, compared to a continuously supported relieving angle.

Steel Framing Details

- Perimeter Columns and Spandrel Beams - Their sizes and positions must be coordinated so as to allow the building envelope insulation to pass by continuously. Also, if the steel elements are adjacent to the building envelope's air barrier plane, a slight offset may produce corner details that complicate the proper execution of the continuous air barrier.

- Wall and Roof Intersections - Details that allow minimal interruption of the insulation and air barrier continuity across this transition is critical to a building's energy performance. When a continuous steel angle is needed at the edge of the roof deck as a component of the structural diaphragm, any roof edge blocking support angle should be discrete, not continuous, and clipped to the continuous angle or spandrel. The air barrier systems of the wall and roof should be detailed (and accommodated by the structural engineer) to ensure continuity, possibly with the use of an adhesive membrane adhered to, and overlapped across, the steel elements.

- Exposed Steel Columns or Posts - Being thermally connected to the structural steel frame inside the insulated building envelope, any steel support element that passes through unconditioned space should be completely insulated, including, when possible, around the pier foundation support.

- Balconies and Canopies - The amount of steel elements that structurally connect across the insulated building envelope and air barrier should be minimized. Discrete point connections, with minimal thermal insulation interruption and carefully detailed air barrier continuity, are much more efficient than continuous connections.

References
ASHRAE 90.1-2004
http://www.steelframing.org/PDF/FinalDesignGuideSept82008.pdf
Slit-wall Steel Studs: http://www.steelframing.org/PDF/research/RP02-9.pdf