Structural Implications of Energy Codes for Steel Framing

By Mark Nowak and Jay Crandell, P.E.

Component or single system design is often the way most cold-formed steel (CFS) and other buildings are approached – the structural engineer uses the AISI specifications and/or other standards and develops the structural system, while the mechanical engineer goes through a similar process for the HVAC system. The same process goes on for the energy related components of the building envelope (insulation, doors, windows), as well as the plumbing, lighting, and other systems. Seldom is there overlap or communication across the various disciplines except at times of conflict. However, the rapid acceleration of stricter energy code requirements in the past year has brought about a new urgency for engineers to become more than just designers of the building's load bearing frame.

For many structural engineers, the *International Energy Conservation Code* (IECC) or the ASHRAE 90.1 standard for commercial building energy efficiency may never cross their mind as something that impacts the structural design of a building. Yet these two documents will have a major impact on building design in nearly all states over the next year. Although all buildings are impacted, CFS designers will especially need to be cognizant of the way they design buildings with regard to energy codes. They might even have an opportunity to expand the services they provide.

Why Are Energy Codes Suddenly Important?

This is a frequently asked question, and rightfully so given the relative unimportance of energy codes to the structural engineer in the past. Perhaps you have seen the acronym "ARRA" on construction highway signs, proclaiming improvements brought to you under the American Recovery and Reinvestment Act. Within its thousands of pages is a section that ties acceptance of ARRA funds to the adoption of the IECC. In exchange for federal funds, States pledged to adopt the 2009 IECC and to upgrade to the 2012 edition when it is available.

The 2012 IECC contains insulation requirements that significantly expand the use and thickness of continuous insulation on the exterior walls of CFS and other buildings (*Figure 1*). Continuous insulation is generally provided in addition to cavity insulation. The amount of continuous insulation, typically a foam plastic board product, depends on the climate zone but generally runs from an inch in the southern zones to several inches in the northern states and Canada (*Figure 2*). More typical in most parts of the United States will be a thickness that provides an R-value of R-7.5. Note that R-value is a measure of thermal resistance of the insulation. An R-7.5 would require 1½ inches of extruded polystyrene foam or about 2 inches of expanded polystyrene.

Figure 1: Foam insulation over a building frame using steel hat channels over the foam to attach the cladding.

The placement of foam insulation on exterior walls raises several new challenges and coordination issues for the design team. The primary issues of interest to the building designer and structural designer are how the foam interacts with the lateral resistance of the building and the attachments of exterior cladding over the foam insulation.

The engineer may be presented with additional scope to design the attachment of siding or other cladding systems. In addition, there may be a need to make sure the application of foam insulation is appropriately coordinated with normal structural design responsibilities related to the lateral force resisting system of the building and axial load requirements of individual wall studs. Typical foam sheathing does not provide an adequate means of buckling or racking support to wall framing. Before these issues are addressed, more discussion on the opportunities that the energy code presents may be helpful.

New Business Opportunity?

With new requirements, there are often new opportunities and that is certainly the case with the recent energy code improvements. The main opportunity is for someone to step up and take on the design of the building envelope and even the HVAC system, perhaps in cooperation with a mechanical engineer. Currently, there is no incentive for someone to fill this role. The result

Mark Nowak is President of the Steel Framing Alliance in Washington, DC. SFA is a trade group representing steel producers, manufacturers, suppliers, and contractors. He can be reached at ***mnowak@steelframing.org****.*

Jay Crandell, P.E. is the proprietor of ARES Consulting of West River, Maryland. He can be reached at ***jcrandell@aresconsulting.biz****.*

is the energy code provisions are often never addressed at the detailed level necessary to make sure they are optimized or, at a minimum, compatible with the structural design and cladding systems. Perhaps the best way to show the benefits to the CFS industry (and the engineer) is through an example showing how an expanded role for the engineer might work.

First, consider that a cold-formed steel product manufacturer retains the engineer to assist on a design at the bid stage. The engineer can go about their business as usual and design an efficient structural system. The cold-formed steel product manufacturer, if not familiar with the energy code provisions, would move forward with the design only to find out later (perhaps from the architect or general contractor) that they have no approved way to attach the 1½ inches of foam required by the energy code to the outside of the CFS walls. Someone has to think of this before hand, yet the incentive to do so may not come naturally to any of the parties involved. This is where the individual engineer or engineering firm has an opportunity to expand his or her scope into the thermal envelope design, thus providing a comprehensive design solution.

It sounds easy enough to just incorporate some foam insulation into the design, right? In theory, yes, but if you want a design that is cost effective, other energy-code-compliant options also should be considered. Structural engineers are familiar with performance based design concepts whereby calculations are done to confirm that structural resistance exceeds the required load demand. Fortunately, for the engineer willing to expand services into the energy system, there is a performance option in the IECC and ASHRAE 90.1 that provides a means to design alternative solutions to prescriptive insulation requirements. In other words, with some relatively inexpensive software and a few hours of training, an engineer could develop a building energy design that traded off the foam insulation, or reduced its thickness as a means of addressing matters related to cladding attachment, wall thickness limitations, or integration with other wall system components such as bracing. This performance path is permissible as long as the total energy use in the building is less than a standard or reference design in the code or standard. However, energy code trade-offs must themselves be evaluated for cost-effectiveness and performance implications. For example, trade-offs of foam insulation should consider whether or not the foam insulation is able to provide additional beneficial functions, such as serving as the weather resistive barrier.

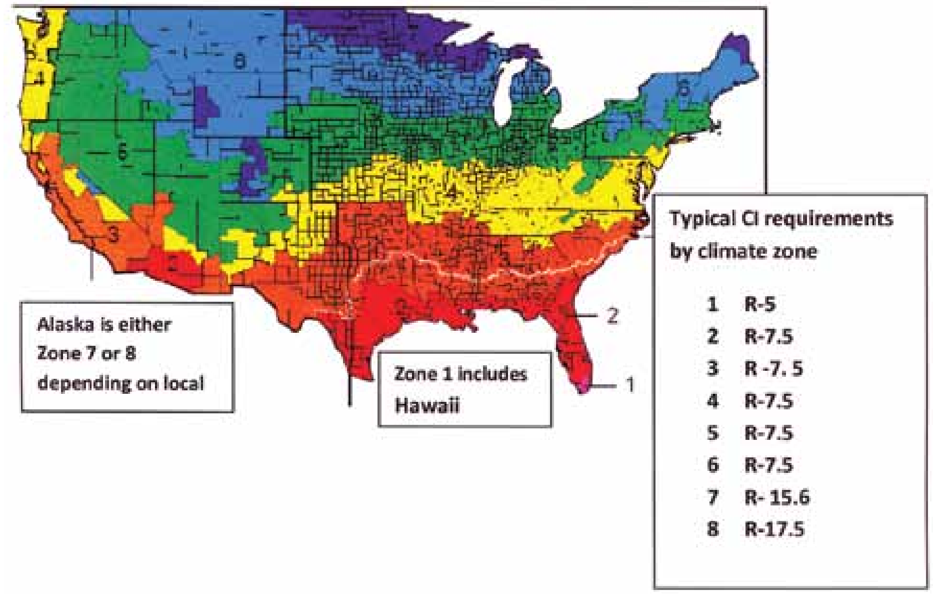

Figure 2: Climate zone map with CI overlay for commercial buildings.

Unfortunately, there is not much incentive for an architect to take on the effort of running simulation software when it is relatively easy to just assume the minimum prescriptive insulation requirements from the energy code. The cold-formed steel product manufacturer, on the other hand, has significant incentive to work the energy analysis into the structural design. The engineer appears to be one of the participants well situated to take on this task for the cold-formed steel product manufacturer.

Suppose the specifications for a project do require foam and won't permit trade-offs, or the simulations can't produce enough energy saving elsewhere to eliminate the foam or if the use of foam insulation is indeed the best solution for code compliance – not an unexpected outcome in a place like Chicago where the insulation is much more critical to energy savings than in a more temperate climate. In these cases, the engineer will need to address at least the two issues raised earlier in this article – the placement of the foam so as to not negatively impact the structural design and the design of a method to fasten siding or other cladding through the foam.

Continuous Insulation Placement and Cladding Attachment

Continuous insulation by definition may be placed on the interior or exterior of a wall assembly. Which placement option to use usually depends on a number of factors. Some of the key design considerations and options include the following:

1) **Continuous Insulation on Interior or Exterior Face of Wall?** Generally, it is more common to place continuous insulation on the exterior side of an exterior building wall. This eliminates interference with gypsum or other finishes, issues with electrical boxes, and does not reduce useable floor space as would occur with the insulation on the inside.
2) **Continuous Insulation as Oversheathing or Sheathing?** If structural sheathing is used as wall bracing, an exterior application of continuous insulation must be done as oversheathing. Oversheathing is simply the placement of continuous insulation over top of structural sheathing or gypsum sheathing. In an oversheathing application, the structural or gypsum sheathing layer is considered to provide the primary resistance to component and cladding wind pressures and it must be directly attached to steel framing in accordance with code. Then, the foam sheathing layer is simply installed "over" the underlying structural or gypsum sheathing in accordance with manufacturer installation instructions. If the bracing method used does not require sheathing (e.g., use of steel strap X-braces), then foam sheathing can be installed alone as the wall sheathing. However, the foam sheathing type and thickness must be selected to ensure code-compliant wind pressure resistance is provided

(refer to FSC Tech Matters on code-compliant wind pressure resistance of foam sheathing at **www.foamsheathing.org**).

3) **Continuous Insulation as a Weather-resistant Barrier (WRB)?** When approved as a WRB, various foam sheathing products can serve as continuous insulation (to meet energy code) as well as the WRB behind a cladding material of choice (to meet building code). In this dual-purpose case, the foam sheathing is installed with flashing tape and other details in accordance with a code evaluation report and manufacturer installation instructions. A separate WRB material, such as building wrap, becomes unnecessary. Alternatively, a separate WRB may be applied behind the foam sheathing (when used as over-sheathing) or over the foam sheathing. The WRB must be properly flashed and drained in accordance with the building code and the WRB manufacturer installation instructions.
4) **Continuous Insulation Material Selection.** As mentioned, there are a variety of foam sheathing materials that can be selected to meet a variety of continuous insulation design options as discussed above. The most common products are manufactured in accordance with ASTM C578 or ASTM C1289 and include expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate (Polyiso) foam. Each product type has different thermal properties (which affect thickness required), costs, and capabilities. Spray foam may also be used as continuous insulation when properly detailed on a wall assembly.
5) **Claddings and their Attachment over Foam Sheathing.** Various types of claddings can and have been used successfully over foam sheathing for some time. However, many cladding products do not include explicit information on installations over foam sheathing or limit application to certain thickness of foam sheathing. Cladding attachments must provide the required wind pressure resistance (attachment to framing behind foam sheathing) and must also cantilever through the foam sheathing to support the weight of the cladding and also furring, if used. Various proprietary and standard fasteners can be used for this purpose based on recent testing sponsored by the Foam Sheathing Coalition (FSC), the New York State Energy Research and Development Authority (NYSERDA), and the Steel Framing Alliance (**www.steelframing.org**). The complete report on this research is available from the Steel Framing Alliance at **www.steelframing.org**. FSC Tech Matters (**www.foamsheathing.org**) provides code-compliant fastening recommendations for cladding weights ranging from < 3 psf to 25 psf and foam thicknesses ranging from ½-inch to 4 inches. Requirements are also provided for attachment of wood or steel furring such that cladding attachments do not need to penetrate the continuous insulation layer. Similar fastener requirements have also been adopted into the 2010 *New York State Energy Code*.

Finally, foam sheathing must be applied to a wall assembly in a way that maintains the hourly rating of a wall assembly, especially when exterior fire rating is required. Also, when building area and height disqualifies consideration as Type V construction, a foam sheathed wall assembly must be tested for flame spread in accordance with NFPA 285. These concerns mainly impact commercial construction; comprehensive fire-related material and testing requirements for foam plastics are found in Chapter 26 of the *International Building Code*.

Conclusions

Independent of your past role in the design and construction process, successful engineers will need to "get up to speed" with newer energy codes and standards. Emphasizing only the structural issues without examining interactions with other systems is a practice that needs to be seriously re-examined by all involved in the design and construction of energy efficient steel framed buildings. As we have shown here, the impacts can be minimized with some upfront preparation and understanding of the issues.▪

References

IECC-*International Energy Conservation Code*, International Code Council

ASHRAE 90.1 *Energy Standard for Buildings Except Low-Rise Residential Buildings*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Thermal Design and Code Compliance Guide for Cold-formed Steel Walls. Steel Framing Alliance