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Standing Seam Spotlight

An Educational Bulletin for Metal Roofing Professionals

Top 10 Engineering Considerations with Metal Roofing

by Mike Huber, PE

When it comes to designing or specifying commercial metal roofing, knowledge is power. This article breaks down 10 fundamental areas to consider when designing with metal roofing. Although the particulars vary according to geographical region, system profiles used, and the characteristics of each building, an awareness of the principles underlying each of these areas is a valuable tool for design professionals.

1. Building code requirements

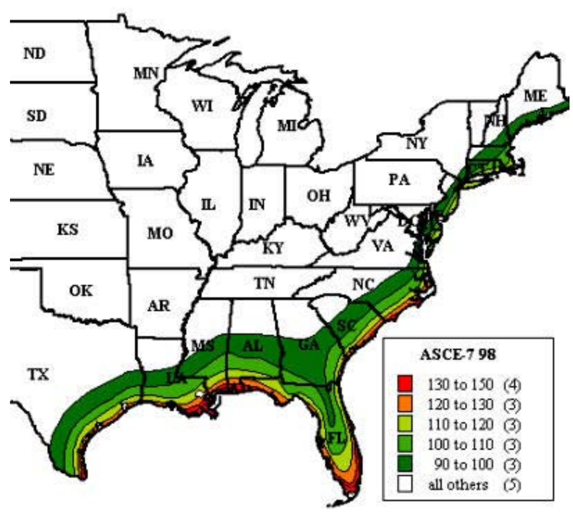
There are currently more than 40,000 building codes across the United States. Although the majority are based on the International Building Code (IBC), some local jurisdictions enforce stricter standards to address regional concerns. Designers will always have to take into consideration any additional mandates prescribed by local jurisdictions.

It is absolutely crucial to review and understand all applicable codes when designing and specifying roofing systems. Several industry resources area available to assist designers in this area, and in some cases, the manufacturers themselves offer engineering support to help ensure the proper system is specified and tested appropriately.

2. Wind uplift

The non-continuous attachment of metal roofs makes them particularly susceptible to wind uplift. The major factors relevant to a roof's ability to withstand these pressures include:

- **Wind speed** - the greater the speed, the greater the wind uplift
- **Building elevation** - the higher the building, the greater the pressure
- **Exposure to wind** - protection from wind by surrounding structures
- **Roof slope** - the lower the slope, the greater the uplift
- **Building geometry/dimensions** - not only the size of the roof, but also the geometric complexities of its design that may break or facilitate wind flow



American Society of Civil Engineers (ASCE) 7 provides a methodology for calculating the relative force exerted on a particular roof when subjected to the anticipated wind uplift pressures.

Due to the complexity of the ASCE 7 methodology, a structural engineer typically evaluates the parameters of a roof design, conducts a **wind uplift analysis**, and provides specifiers with appropriate clip spacing distances for each of the zones.

3. Value engineering

In the realm of roof performance, reducing up-front costs for short-term savings inevitably leads to higher costs and liability down the road. Learning to analyze the bottom-line benefits of rooftop longevity is critical to specifying appropriate metal solutions. The performance-to-cost ratio varies with every roof specified, and can only be identified through a comprehensive review.

For example, since metal roof systems can significantly outlast many traditional alternatives and require less maintenance, property owners can realize a significant return on investment from metal's lifecycle cost benefits.

4. Lifecycle cost analysis

Lifecycle cost analysis (LCA) is a worthwhile exercise when attempting to establish the value of metal systems in comparison with non-metal alternatives. ASTM E 917, Standard Practice for Measuring Lifecycle Costs of Buildings and Building Systems, is a uniform procedure for establishing lifecycle costs for all types of roofing. All anticipated costs over the working life of a roof are added to the initial material and installation costs to arrive at a realistic total cost.

5. R-value

The roof's principal function is to protect the insulation — and everything else under it — from water damage. The critical measurement for determining the effectiveness of a roof's insulation is the R-value, which measures how well a particular material resists heat transfer. Since wet insulation is typically considered to have an R-value of zero, once a roof develops leaks that reach the insulation, the owner's R-value investment is virtually lost.

One misconception is that the heat-conductive nature of metals somehow adversely impacts the insulation's ability to provide R-value protection. This is untrue—metal systems do not require more insulation than any other type of roofing to achieve the same effectiveness from a given type and amount of insulation.

6. Energy payback

Emissivity (radiated heat) is related primarily to the roofing material, and in the case of metal roofing, the coatings used increase savings through reflectivity.

Metal roofs come in a wide variety of colors, which offer aesthetic versatility as well as varying degrees of albedo and emissivity. Bright white coatings provide the greatest levels of reflectivity, delivering ratings as high as virtually any other type of roofing. Since building owners currently spend more than $40 billion annually on air conditioning, and white roofs reduce energy requirements by as much as 40 percent, the use of white coatings on a metal roof can have a tremendous impact on cooling demands, reducing peak cooling demands by 10 to 15 percent.

7. Fire resistance

Unlike roofing materials derived from asphalt or rubber, metal roof substrates are naturally resistant to fire. Additionally, hot metals will not emit noxious gases to create the additional health and safety hazards associated with some other materials.

When evaluating metal roofing systems, it is necessary to review fire ratings in the roof deck, insulation, and covering. Despite the material's natural resistance, a metal roof installed atop wooden deck presents a fire safety hazard, as the high temperatures could inflame the underlying combustible deck. Non-flammable insulation board and non-meltable barrier boards are two of the methods commonly used to achieve fire-resistance in metal roof assemblies over combustible decking.
The IBC mandates that metal roof systems meet the testing standards of one of two similar protocols:

- ASTM E 108, Standard Test Methods for Fire Tests of Roof Coverings
- UL 790, Test Methods for Fire Tests of Roof Coverings

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8. Condensation

Typically, condensation occurs when humid air comes in contact with a cold surface. In the context of the building envelope, there are several circumstances likely to "precipitate" potentially damaging condensation, such as:
Areas in which large groups of people congregate (e.g. gymnasiums, churches)
Manufacturing environments that exude humid air (e.g. food processing)
Areas that include showers, pools, steam rooms, whirlpools, or other moisture-emitting equipment
Despite its natural susceptibility to corrosion, metal is suitable for all the aforementioned conditions, provided proper insulation and ventilation or vapor retarders are installed. Although metals have a greater propensity towards condensation, a properly installed metal roof system should be condensation-free.

9. Indoor air quality

Moisture penetration through roofing and walls is a major source of mold-breeding moisture that can infiltrate ceiling tiles, carpets, furniture, and HVAC systems. Increased public awareness of the dangers of airborne mold makes leak prevention a critical priority, particularly when specifying roofing for public facilities. Properly installed high-performance metal roof and wall systems equipped with appropriate ventilation and/or vapor retarders can eliminate the water penetration and health hazards associated with airborne mold.

Since all indoor air quality (IAQ) issues concerning the exterior building envelope are ultimately derived from water penetration or condensation, high-performance roofs, such as metal systems can help to alleviate owner concerns about IAQ.

10. Snow/ice retention

In many regions, it is imperative the roof be designed to accommodate the added load of built up snow and ice, and to safely allow them to leave the surface. Interestingly, snow and ice tend to sit on a sloped roof just as they would on a less steep surface; that is, until melting commences, when they become a grave danger to people or property below.

As with wind uplift, snow- and ice-induced pressures tend to vary across the roof. For example, more weight can occur in enclosed spaces or areas where a roof surface abuts a wall. It is critical that the metal panels be designed to accommodate these varying loads. To calculate snow/ice load on a particular roof slope, one should apply the ASCE 7 guidelines, which take into account the building geometry, as well as its varying levels of exposure.

A structural engineer or snow-retention system manufacturer can help design a system appropriate to the particulars of a specific building. The most commonly used methods of retaining snow/ice for metal and non-metal roofs are snow guards—which can be either fastened or adhered—and snow fences, which are fastened or clamped into place.

In Conclusion

Today's trend for sustainable designs that reduce environmental impact is helping drive the metal roofing market to new heights. Understanding the engineering concerns fundamental to the proper design of metal roofing will enable architects, engineers, and specifiers to take advantage of these systems while serving the long-term interests of their clients.

Mike Huber, PE, has been a professional engineer for the last 12 years. He is also presenter of an American Institute of Architects (AIA) accredited course on the engineering and design of metal roof systems.

To request an onsite AIA accredited presentation about metal roofing, e-mail your request to learn@imetco.com.

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