

# THE BASICS OF

**L**ike any other factors that make up a building exterior envelope, a metal roof has several basic elements that, when designed and installed properly, will provide a building with a roof surface that will yield decades of satisfactory service. These basics hold true for both new and retrofit metal roofs. On the other hand, if the basics are not adhered to, the finished metal roof system will provide only marginal service. An architect, engineer, or consultant, knowing these basics and making sure they are incorporated into metal roofing projects, ensures that the building owner is getting a roof system that will last well beyond its warranty terms.

A metal roof is a functional element of a building that has certain wind-load-resistance responsibilities. It is certainly responsible for protecting the interior contents from the exterior atmospheric elements, but it has to have the capacity to remain in place in order to provide this protection. As has been evidenced by the effects of hurricanes, tornadoes, and the like, metal roofs' capacity to withstand such devastating forces is unsurpassed in the roofing industry. The reality, however, is that a metal roof's capacity to withstand these extreme loads is dependent upon its being properly designed and installed per contract documents. Let's discuss how the basic elements can have a positive effect on a metal roof system.

First, a locally licensed

professional engineer must be retained to produce the structural design work associated with the roof. This work must be compatible with the building's main structural design. That does not mean that if the consultant is not a licensed engineer he or she does not need to understand the design basics. A roof consultant needs to be able to understand the professional design results in order to be effective in his or her capacity on a metal project. The main design elements for a metal roof are:

1. Determination of wind loads by utilizing proper documents.
2. Choice of proper metal product to resist these loads.

In most areas, the effects of wind uplift pressure on different portions of the installed roof surface are the most severe roof loads to consider. The American Society of Civil Engineers (ASCE) has a publication that is accepted in the International Building Code (IBC) as the standard for determining these loads. The IBC is almost uniformly accepted by all states. The publication, *ASCE 7 - Minimum Design Loads for Buildings and Other Structures*, clearly defines how to determine the various zones on the roof that have different design loads, along with the actual loads for those respective areas. Chapter 6, "Wind Loads," goes into great depth to show what wind speeds should be used, depending on the geo-



*Photo 1 – Retrofit metal roof on a condominium located in Ocean City, Maryland.*

# METAL ROOFING

BY  
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graphic location of the building. It also provides information necessary to determine the dimensions and locations of the various wind zone areas within the plane of the roof. In addition, there are several variables that impose increasing and decreasing factors on the design load based upon parameters such as surrounding topography, building occupancy, building height, etc. All of these factors need to be understood and considered when determining the required wind loads for a metal roof.

After the proper loads are determined for all zones, a metal roof system must be analyzed to determine how it can resist these loads. The American Society for Testing and Materials (ASTM) has developed a pressure testing procedure commonly referred to as an “airbag test” (*Photo 2*). This procedure applies uniform pressure from the bottom of the panel surface by introducing air into an airtight chamber and allowing pressure to form on the bottom of the panel. This pressure produces forces on the panel that simulate actual wind pressure forces that would be introduced onto the panel system when wind blows over the roof. The actual procedure is labeled as an ASTM E-1592 test and yields ultimate load forces that the panel and its attachment components can withstand. Needless to say, the spacing of the attachment components greatly determines the capacity of the engineered metal roof system. The spacing of these attachment points and the associated allowable load capacity are shown within the report.

The use of the ASCE 7 design loads and the ASTM E-1592 metal panel system capacity will properly determine conditions under which a panel system can be used to resist the design loads for a particular roof. These methods should always be incorporated into any metal roof design to ensure that the proper metal roof system, as well as the proper attachment method, are used.



*Photo 2 – ASTM E-1592 “airbag test” showing how a metal roof panel deflects while resisting a wind load.*

In addition to the structural evaluation required to determine which materials and associated panel assemblies can be used for the metal roof, there are other, nonstructural, basics to evaluate. Some of the most important are as follows:

### **Drainage**

Every metal roof must have positive drainage to eliminate the possibility of ponding water. This slope (as little as ½ in 12 inches for structural standing-seam panel systems) directs water to the building’s perimeter or internal gutter. The size of the guttering system, location of outlets, size of outlets, distribution of the water when it is introduced to the surrounding areas, etc., need to be taken into consideration when determining the proper performance of a metal roof system. Most panel

manufacturers have design information about their gutter and downspout system’s capacity, and all building codes identify the amount of rain that must be accommodated during a specific time frame. Make sure that these resources are utilized when determining how to accommodate runoff drainage.

### **Flashings and Curbs**

For the metal roof system to be useful for the building owner, it must remain not only structurally sound during design-loading conditions but also remain watertight. After all, that is why we need roofs! For that to be accomplished, the flashings that seal the roof to the eaves, ridges, walls, etc. must be designed to withstand water intrusion. They must also be designed to accommodate thermal movement. Additionally, curbs must be integrated into the roof sys-



*Photo 3 – Low-sloped, unpainted metal roof on a high school in central North Carolina.*

*Photo 4 – The open cavity between this new metal roof and the roof insulation needs to be ventilated.*



tem in such a manner that they, too, will resist water penetration as the panel is transferring collected water to a lower location such as a gutter or exposed eave.

Like the roof flashings, curbs must take panel expansion and contraction into account. As with the drainage design, the metal panel manufacturer will have standard details showing how its total roof system should be flashed and curbed. While this standard information is available, the consultant/designer is responsible for determining the particular requirements of each roof and modifying the standard details to suit.

#### **Insulation and Condensation Control**

With the design and installation of every metal roof, there is a possibility of incorporating thermal insulation under the metal roof panel. The main purpose for this material is to separate the exterior temperatures from the building interior temperatures. Some basic design points are as follows:

- When a vapor barrier is required (and it is in all but a few cases), place it on the “warm” side of the insulation. Make sure the vapor barrier is sealed properly in the field application to prohibit interior air from coming into contact with the exterior metal skin, forming conden-

sation.

- Fill all voids between the top of the insulation and the bottom of the metal panel with insulation. That includes the voids created at the ridge and hips. Left uninsulated, these areas are prone to condensation formation. If the voids cannot be completely filled, the cavity must be vented on the “cold” side of the insulation with outside air (*Photo 4*). Air exchange in any given cavity of

three to five times per hour is required to control condensation in most conditions.

- More insulation is not necessarily better. Usually after an R-value of approximately 20 is attained, the return on investment of more insulation decreases quickly. Do not assume that “If 6 inches of insulation is good, 12 inches is twice as good.” Do the thermal and associated, expected energy-consumption



Photo 5 – Finished painted metal roof in coastal Alabama.

calculations using the most current ASHRAE procedures, and use the most efficient amount of insulation.

- Ensure that the proper insulation and vapor barrier are used for the actual conditions. Consult with the metal panel manufacturer to ensure that either product will not negatively affect the panel or its components.

In addition to reviewing the basics discussed in this article for every metal roof project, it is imperative that documentation of the final design determinations be properly prepared. That requires that a scaled shop drawing, complete with large-scale details for every flashing condition incorporated in the project, be prepared by the contractor and/or manufacturer and reviewed by the consultant/engineer to ensure that the proposed metal roof system meets the expectations of the design documents. During this review process, the consultant/engineer and contractor need to be extremely candid in expressing their expectations, thus eliminating costly disagreements after installation has begun.

Last, but certainly not least to consider, is how the metal roof is installed. Installation errors are by far the leading source of lawsuits for metal roofs. While this phase of the project is often relegated to minimal attention by “junior” staff, it is the most important phase of any metal roof pro-

ject. Making sure that the contractor knows that the installation of the roof will be closely observed to ensure that the finished product meets or exceeds the level of detail



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# BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Test your knowledge of building envelope consulting with the following questions developed by Donald E. Bush, Sr., RRC, FRCI, PE, chairman of RCI's RRC Examination Development Subcommittee.

1. What are the basic exterior wall types?
2. Why are cavity walls considered by many to be the preferred method of construction in most climatic and rainfall zones in the United States?
3. There are generally four types of precast panels used as part of building envelopes. What are the four types?
4. What are the most common uses of precast concrete for building envelopes?
5. What is a curtain wall?
6. What is an effective strategy to reduce the exposure of windows to weather?

Answers on page 22

# BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Answers to questions from page 21:


1. **A. Cavity wall.  
B. Barrier wall.  
C. Mass wall.**
2. **The resistance to pressure equalization and redundancy offered by this type of wall assembly to resist uncontrolled, bulk rainwater penetration.**
3. **Cladding or curtain walls, load-bearing wall units, shear walls, formwork for cast-in-place concrete.**
4. **Precast cladding or curtain walls.**
5. **Any exterior wall that is attached to the building structure and that does not carry the floor or roof loads of the building.**
6. **Recess windows from the exterior face of the wall or projecting horizontal features (e.g., roof overhangs). This also helps shield windows from the weather.**

#### REFERENCES:

*Whole Building Design Guide (WBDG)*

indicated in the approved shop drawings sets the stage for a very successful metal roof project. As a consultant, establish this understanding early in the schedule and maintain its diligence throughout the entire project. It will yield positive dividends for all parties involved.

The bare basics of metal roofing have been introduced in this article. Each of the listed basics deserves further explanation and research by the consultant serious

about providing related services to a building owner. As with all areas of building envelope study, the basics of metal roofing need to be explored exhaustively in order to provide excellent advice on a project. Take the basics described in this article as a foundation from which to build a greater understanding of the proper design and installation for a system that will perform properly. 

Chuck Howard



Chuck Howard is a 1973 graduate of Ohio State University College of Engineering, with a BS degree in civil engineering. He received his accreditation as a professional engineer in 1978 in Ohio and is currently licensed as a professional engineer in eight states. He has pursued a career in commercial construction since college graduation, with an emphasis on metal roofing from the start. In the early 1980s, Howard started a company that specialized in both new and retrofit metal roof construction. He pursued that career into the early 2000s, having one of the largest commercial metal roof contracting companies in the U.S. During that time, he was responsible for approximately 25 million sq ft of roofs, including design. In 2002, Howard left the contracting arena and entered the consulting field, where he is operating now as Metal Roof Consultants. He provides commercial roof consulting for contractors, architects, and building owners. He is accepted as a professional expert in metal roofing in legal proceedings. Howard is a member of NSPE, ASCE, NRCA, and RCI.

## TENNESSEE RULES "QUALIFIED REGISTRANT" IS REQUIRED FOR REROOFING

Policy changes were recently passed by the Tennessee Department of Commerce and Insurance and the Tennessee Board of Architectural and Engineering Examiners and published in *Tennessee Design Lines'* Fall/Winter 2008 issue.

Section 6 of the Seal Exemptions Clarification policy regarding reroofing, the magazine announces, was amended at the December 11, 2008, board meeting by deleting the word "replacement," so that the revised paragraph reads as follows:

6. **Reroofing.** Normal maintenance or repair of an existing roof where the weight, drainage, fire protection, and other code-related requirements of the original design are not changed or compromised. This brings the policy into conformity with question #27 in the *Reference Manual for Building Officials and Design Professionals*, which reads:

***Is it necessary for a registered architect or engineer to prepare documents for a roof replacement on an existing building?***

Yes. A qualified registrant is required for roof replacements or reroofs of all buildings in excess of 5,000 square feet or more than two stories. When a roof is replaced, structural loads during and after installation can change, energy requirements may be affected, drainage conditions can change, etc. Notwithstanding the above, a registrant is also required for public works projects under \$25,000 if the structural, mechanical, or electrical system of the project is altered.