Building Code Vigilance for Commercial Building Envelope Construction and Renovation

By Tom Diamond, PE and John Pierson, PE

Industry guidelines in regards to building structure and energy conservation for commercial buildings have become voluminous over the years, as formal and quasi governmental agencies become more prescriptive in their attempts to safeguard construction workers and building occupants. Staying on top of the newest standards can be a daunting task. No single article could thoroughly encompass every building code and energy code requirement and the growing number of regional variants. Our intent here is to focus on a few critical areas of building envelope performance, specifically:

- In regards to building code…
    - Wind Uplift
    - Gravel Aggregate
    - Drainage
    - Roof System Slope Limitations
    - Reroofing
    - Retrofit Framing Considerations
- In regards to energy code…
    - Insulation
    - Air Barriers
    - Vapor Retarders

Wind Uplift for Roof Systems

Whether you are dealing with new construction, retrofitting an existing roof system or complete tear-offs, wind uplift calculations need to be performed. Codes are revised approximately every three years, and you need to be confident your roof systems are compliant with the most recent code requirements. International Building Code (IBC) requires that *"Wind loads on **every** building or structure shall be determined in accordance with Chapter 6 of ASCE 7."*

Code further provides wind-resistance performance requirements for different types of roof systems such as asphalt shingles, clay and concrete tile, ballasted and non-ballasted low slope roofs, built-up, modified bitumen, single ply, through-fastened metal panels, and standing seam metal panels. For instance, built-up, modified bitumen, single-ply and through-fastened metal roof systems must be tested in accordance with FM 4474, UL 580 or UL 1897. Standing seam roof systems must be tested for wind uplift resistance in accordance with either ASTM

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E1592 or UL 580.

2012 International Building Code has adopted the 2010 revision of the ASCE 7. ASCE 7-10 includes a different method of calculating wind uplift pressures when compared to the previous ASCE 7-05 version; most notably, in the area of design wind speed.

A handful of states have already adopted the ASCE 7-10 as their current standard. Moving forward, as states begin to adopt the new 2012 IBC, the revised method of calculating wind uplift pressures will be universally required.

How New Wind Uplift Requirements Will Affect Design

Unlike previous versions of ASCE 7, the new ASCE 7-10 uses three different maps to identify wind speed requirements; one each for the first two classes of building and a third for Class III and IV buildings:

- Class I, considered low-risk in the event of failure, includes buildings such as storage sheds or agricultural structures.
- Class II encompasses the vast majority of buildings, from offices to homes.
- Class III, considered high-risk in the event of failure, includes schools and other structures where a large number of people congregate.
- Class IV, also considered high-risk, includes essential facilities such as healthcare and buildings essential to national security.

For example, an Importance Class III building in the Midwest United States is assigned a design wind speed of 90 mph in ASCE 7-05. In ASCE 7-10, the design wind speed assigned to this region will be 120 mph. However, the new 2012 IBC permits an allowable stress design factor to be applied to the wind speed that actually reduces them to similar or even lower levels than the ASCE 7-05 version.

Another significant change reclassifies hurricane coastlines as an Exposure Category D, as opposed to the Category C used in previous versions of ASCE 7.

Wind Uplift for Edge Metal

Another critical concern for the wind uplift resistance of roof systems is the metal edge system. The perimeters and corners of a roof experience the highest wind pressures. As a result, metal edge system failure is responsible for the majority of all roof failures. The International Building Code addresses this concern by requiring all low-slope roof metal-edge systems to be tested for wind uplift resistance in accordance with the ANSI/SPRI ES-1 standard. This standard tests fascia and coping systems for wind uplift resistance. The test is applicable to roof slopes less than 3:12, with no gutter conditions.

The recommended approach is for contractors to use pre-manufactured ANSI/SPRI ES-1 tested and compliant edge and coping systems or for the contractor to obtain certification through the NRCA to fabricate their ANSI/SPRI ES-1 compliant edge metal shapes. Any material submitted as an ANSI/SPRI ES-1 compliant edge and coping solution should be accompanied by a report from a certified test agency.

Aggregate on Roof Tops

There are restrictions in the International Building Code prohibiting the use of gravel on roof tops if wind speeds are too high in the area or if the building is too tall. Guidelines have been imposed that prohibit the use of gravel and stone on any building where the mean roof height exceeds that permitted by Table 1504.8 of the 2009 and the new 2012 International Building Code. The use of gravel is also prohibited in hurricane-prone regions.

TABLE 1504.8
MAXIMUM ALLOWABLE MEAN ROOF HEIGHT PERMITTED FOR BUILDINGS WITH AGGREGATE ON THE ROOF IN AREAS OUTSIDE A HURRICANE-PRONE REGION

BASIC WIND SPEED FROM FIGURE 1609 (mph)[b]	MAXIMUM MEAN ROOF HEIGHT (ft)[a, c]		
	Exposure category		
	B	C	D
85	170	60	30
90	110	35	15
95	75	20	NP
100	55	15	NP
105	40	NP	NP
110	30	NP	NP
115	20	NP	NP
120	15	NP	NP
Greater than 120	NP	NP	NP

For SI: 1 foot = 304.8 mm; 1 mile per hour = 0.447 m/s.

a. Mean roof height as defined in ASCE 7.
b. For intermediate values of basic wind speed, the height associated with the next higher value of wind speed shall be used, or direct interpolation is permitted.
c. NP = gravel and stone not permitted for any roof height.

A hurricane-prone region is defined as the U.S. Atlantic Ocean and Gulf of Mexico coasts where basic wind speeds exceed 90 mph, or in Hawaii, Puerto Rico, Guam, Virgin Islands and American Samoa, according to the 2009 IBC.

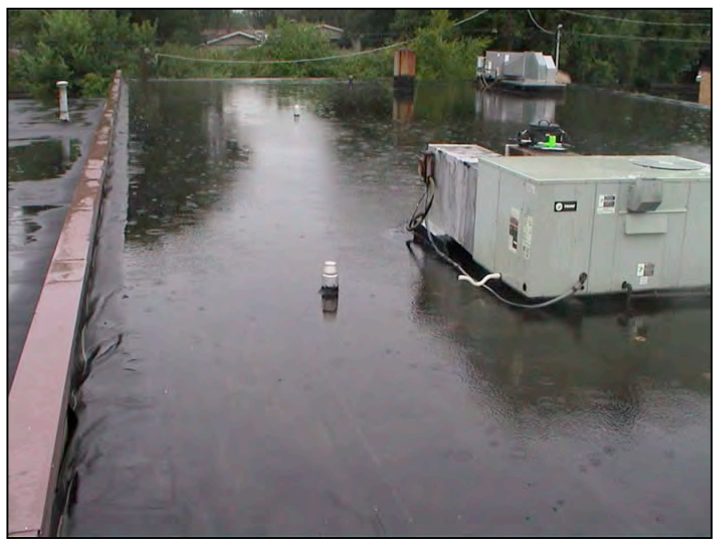
Wind speeds have increased in the new 2012 IBC; specifically, wind speeds that were 90 mph in 2009, are now referenced as 115 mph in 2012. However, you will notice that the 2012 IBC shows the hurricane-prone defining wind speed as 115 mph instead of 90 mph. Because the 2012 IBC permits an allowable stress design factor to be applied to the wind speeds, the design requirement is brought down to a level similar to previous versions of IBC. The net effect is that gravel restrictions remain the same.

The main reason these restrictions have been imposed is to reduce the risk of damage to other buildings due to the breakage of glass, windows, or other glazing. Field assessments have shown that gravel or stone blown-off roofs due to high wind speeds have broken windows in surrounding buildings. Once these windows have been broken, the wind pressures can cause high internal building pressures that can result in structural damage to interior walls and to the walls and roof surfaces that are subjected to negative external wind uplift pressures.

Keep in mind that we are discussing restrictions set forth by the International Building Code. Your local or state codes may reference these same restrictions, or they may provide allowances in certain circumstances (Florida, for example). So before you dismiss a surfacing option that includes aggregate due to height or location restrictions, be sure to check with your local code official to see if gravel is permitted on a particular roof.

Clarifications of the code are currently underway to permit heavy paver ballast and small aggregate when fully adhered in a flood coat, so be sure to keep abreast of code revisions.

Drainage



Chapter 15 of the International Building Code and Chapter 11 of the International Plumbing Code provide a methodology for determining code-compliant drain and scupper sizes. The required drain or scupper size is dependent upon the area of roof that the drain/scupper must service, as well as the geographic location of the project. Generally, if the roof perimeter extends above the roof surface, code requires every primary drainage component to have a secondary drainage component capable of servicing the same minimum drainage capacity as the primary system.

In most cases, secondary drainage units must have a separate outlet in addition to the primary unit. This outlet should be above grade and in a location that can be seen by building occupants. It should also be noted that if scuppers are used for the secondary drain system, they should be sized and located to prevent ponding water from overloading the structure if the primary system were to back up.

Drainage Calculations performed according to Chapter 11 of the International Plumbing Code will provide the following:

- Required Primary Drain or Scupper Size to service a specific area of roof
- Required Overflow Scupper or Secondary Drain Size

It should be noted that the quantity and location of the drainage units is not provided in the drainage calculation. Code only provides a method for determining the required size of a

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drainage unit based upon the serviced roof area and the rainfall intensity associated with a particular geographic location. It is left up to the designer to apply these results to a given roof layout.

To ensure that drainage units function properly, a maintenance routine should be established to ensure that drains and scuppers are free of dirt and debris. Drains and scuppers should be checked for blockages. Also keep in mind that drainage units can only drain the water that they receive. If a roof is not sloped properly or a drain or scupper is set too high, ponding water is liable to occur. Be sure to review cricket locations and slopes when considering the drainage of the roof.

Chapter 15 of the IBC also provides minimum slope requirements for different types of roof systems to assure positive drainage. The minimum slope requirements follow:

Roof System Type	**Minimum Slope Requirement**
Asphalt Shingles	2:12
Clay and Concrete Tile	2 ½:12
Metal Panel with Lapped, Non-Soldered Seams, No Sealant	3:12
Metal Panel with Lapped, Non-Soldered Seams, with Applied Sealant	½:12
Standing Seam Metal Panel System	¼:12
Metal Roof Shingles	3:12
Mineral Surface Roll Roofing	1:12
Slate Shingle	4:12
Wood Shingles	3:12
Wood Shakes	4:12
Built-Up Roofs	¼:12
Coal-Tar Built-Up Roofs	1/8:12
Modified Bitumen Roofs	¼:12
Thermoset & Thermoplastic Single Ply Roofs	¼:12
Sprayed Polyurethane Foam Roofing	¼:12
Liquid-Applied Roofing	¼:12

Keep in mind this exception to the above minimum slope requirements: Section 1510.1 of IBS states that: "*Reroofing shall not be required to meet the minimum design slope requirement of ¼ unit vertical in 12 units horizontal (2-percent slope) for roofs that provide positive drainage.*"

The key to this exception is *positive drainage*. Unless the roof is installed perfectly, positive drainage on roof slopes of less than ¼:12 is very difficult to achieve. Ponding water decreases the service life of any roof system. If the nature of your project does not allow for adding slope, you may need to consider coal tar membranes. Coal tar remains the only material permitted by IBC for installations below ¼:12, due to its superior durability. Today's coal tar modified membranes are among the highest performing materials available today.

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Reroofing

When considering reroofing projects, budget restrictions frequently make retrofitting over existing roof systems the most viable option. Here is a summary of IBC's guidelines on this subject. Section 1510.3 of the IBC states:

"New roof coverings shall not be installed without first removing all existing layers of roof coverings down to the roof deck where any of the following conditions occur:
1. *Where the existing roof assembly is water-soaked or deteriorated to the point that the existing roof or roof covering is not adequate as a base for additional roofing.*
2. *Where the existing roof is wood shake, slate, clay, cement, or asbestos-cement tile;*
3. *Where the existing roof has two or more applications of any type of roof covering."*

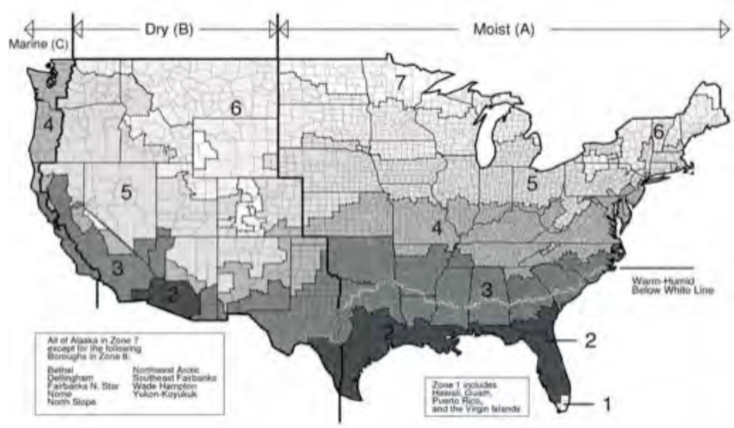
It should be noted that there also is an exception to number 3: a standing seam roof system designed to transmit the new roof load to the structure of the building system is allowed, even if there are two roofs already in place.

A retrofit standing seam roof system typically uses light-gauge framing components. The systems can either be installed at the existing roof's slope or at a greater pitch, to provide drainage to the exterior of the structure.

There are some very serious considerations that should be taken when looking at a potential retrofit option:
- The new roof system should not overload the roof structure. A structural evaluation should always be performed to assure the roof structure has a capacity to withstand the weight of the new framing/standing seam system.
- Existing mechanical units or vents on the existing roof may need to be raised or relocated.
- Creating a sloped roof will drain water onto the grade of the building. Care must therefore be taken to ensure any existing internal drainage system is designed to handle this additional drainage. If it cannot, care must be taken to ensure that the drainage from the roof properly ties into the storm water system.
- Fire codes should be reviewed by a local official to ensure that the new enclosed space beneath the replacement roof is code compliant.
- Depending on your geographic area, snow retention systems may be a consideration.

Insulation and R-Value Requirements

The 2012 International Energy Conservation Code provides R-value requirements for the building envelope. These requirements must comply with ANSI/ASHRAE/IESNA 90.1 or with Chapter 4 of the IECC. These standards and codes assign climate zones to different parts



of the country, based on temperate and humidity profiles. The zones are then used to determine the required R-value of the roof, walls, slab and doors that make up the building envelope. When comparing the older and newer versions of the code, take note of the new requirement for continuous insulation within roof and wall assemblies.

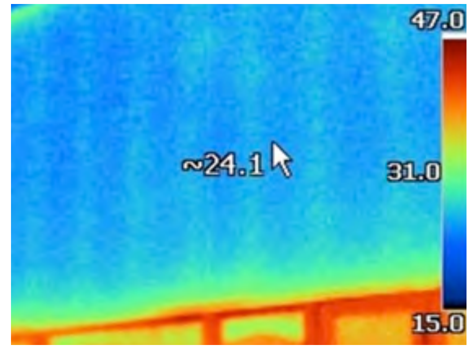


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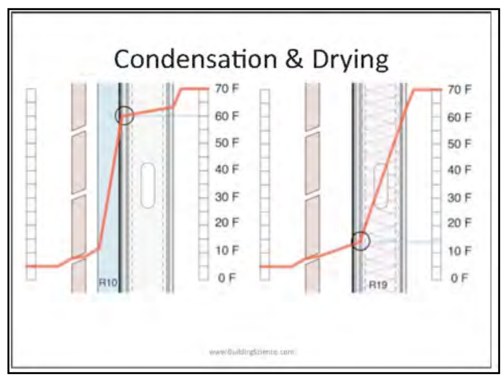
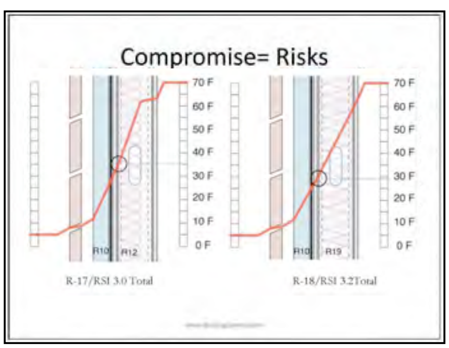
TABLE 5.5-5 Building Envelope Requirements for Climate Zone 5 (A, B, C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building[a]	U-0.055	R-13.0 + R-13.0	U-0.055	R-13.0 + R-13.0	U-0.083	R-13.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[b]	R-5.7 c.i.[b]
Metal Building	U-0.069	R-13.0 + R-5.6 c.i.	U-0.069	R-13.0 + R-5.6 c.i.	U-0.113	R-13.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0

Delivering on the promise of high performance buildings while using traditional batt insulation can be a challenge, as shown in this diagram:

On the first chart, you can see how the continuous insulation keeps the Air & Water Barrier (AWB) at a temperature near room temperature. The AWB, or wallboard supporting it, is the first surface on which condensation will occur. As you can see, the warmer the surface, the lower the risk of condensation.





On the second chart, you can see that the air and the water vapor it is carrying can pass right through the batt insulation to reach a condensing surface that is very cold. The colder the temperature, the greater the likelihood of significant condensation occurring inside the stud wall cavity – despite the fact that the wall on the right of the diagram is as well insulated as the one on the left.

There is a tendency for designers to underestimate the futility of further stuffing a stud wall with batts in an effort to resolve the challenges previously described. As you can see here, although the added batts have increased the R-Value by approximately 50%, they have correspondingly reduced the temperature of the first condensing surface quite dramatically, from 60°F to 35°F. Thus, the effort to improve insulation has resulted in significantly increasing the potential for condensation inside the stud wall. Charts courtesy of Building Science Corporation.

Recently, greater attention is being focused on the fire resistance of the different building envelope components and assemblies, especially when plastics or foam plastic insulation is being used within a roof or wall assembly. Always consult with a local code official to ensure that all building envelope designs are compliant with the code requirements for fire testing and ratings.

Air Barriers and Vapor Barriers/Retarders

The climate zone map used in defining insulation requirements is also used by IECC in defining air barrier standards. The purpose of air barriers is to prevent the transmission of moisture and convective heat through an enclosure. According to the Air Barrier Association of America (ABAA), in a well-insulated building, over one third of heat loss is due to air movement.

Aside from exterior cladding, which protects walls from outside elements, the air control layer of a wall is the most significant factor in achieving high performance building enclosures. If there is air freely moving from your conditioned spaces to your unconditioned spaces or wall cavity, that air leakage can potentially move over ten times as much water vapor through porous building materials than vapor diffusion. Where air moves freely, so does heat and vapor.

Section C402.4.1 of The International Energy Conservation Code states that a continuous air barrier shall be provided throughout the building thermal envelope except in buildings located in Climate Zones 1, 2, and 3.

Not to be confused with air barriers, vapor retarders also play a very vital role in the building envelope. As opposed to air barriers, which prevent the flow of air through the building envelope, a vapor barrier stops the transmission of water in vapor form through diffusion. Some envelope designs can accommodate trace amounts of moisture through the envelope, especially when the design allows this moisture to dry out. In such cases, a vapor open design (i.e., any design greater than 10 perms) may be applicable. However, there are certain cases in extreme conditions — such as swimming pools in very cold climates or museums and data centers that cannot tolerate even trace amounts of moisture — where a very low perm (Class I or II) vapor retarder is required.

The IBC assigns classes to vapor retarders as follows:

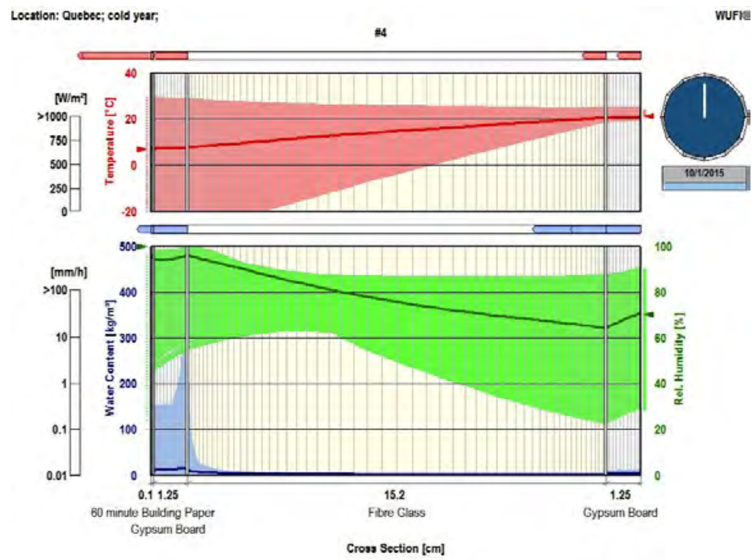
- Class I: 0.1 perms or less
- Class II: 0.1 perms < 1.0 perms
- Class III: 1.0 perm < 10 perms

Chapter 14 of the IBC addresses vapor retarder requirements for walls. However, vapor retarder requirements for roof assemblies are currently not addressed by IBC.

The wall-related code requirement states that Class I or II vapor retarders need to be used on the interior side of wall assemblies in climate Zones 5, 6, 7, 8 and Marine 4. This generally covers colder, Northern climates. There are a few exceptions based on wall construction that permit the use of a Class III vapor retarders in these zones as well. Manufacturers of vapor retarders should provide the perm rating of their vapor retarder materials through certified testing.

Determining proper placement of air barriers/vapor retarders is a challenge during new construction, and even more of a challenge when you are renovating existing structures. A thorough understanding of dew point and how it relates to temperature is required for the proper design and placement of air control barriers. A design professional can help you determine a particular project's requirements in relation to:

- Continuous insulation
- Air/water barrier
- Vapor retarder
- Ventilation



Advanced hygrothermal analysis can help you identify the ways in which water and heat move through a building. Proprietary software packages used by licensed professional engineers construct virtual models of recommended building envelope assemblies, based on a thorough understanding of climate zones and other factors affecting air and vapor flow.

Conclusion

As regulations and their complexity continue to proliferate, engineering support services from building envelope professionals are becoming an increasingly critical aspect of every design equation. Roof factors, including penetrations, through-wall flashings, materials used, roof-to-wall intersections, and drainage systems must be considered. Similarly, wall penetrations, insulation, drainage, and details at grade are factors affecting the design of code-compliant systems. Finally, site conditions such as weather and gutter/drain tie-ins to storm drains will play a role in identifying appropriate solutions.

Your local Garland building envelope professional is supported in the field by the technical services of an engineering department that provides comprehensive building envelope support services. To access engineering support for your new construction and renovation projects, contact your local Garland representative.

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