Building codes are the starting point—not the end goal—for low-slope roof system design

GOING

Code compliance is without a doubt an important consideration when designing and installing roof systems. The requirements for most U.S. jurisdictions are based on the International Codes, or I-Codes, and the 2018 version is the most recent edition. Most low-slope roofing requirements are based on provisions in or referenced by Chapter 15 of the International Building Code® and Chapter 4[CE] of the International Energy Conservation Code.®

According to IBC,® the codes' intent is to "establish the minimum requirements" of numerous criteria, which means code requirements are neither best practices nor the best level of performance as some may mistakenly assume. In my experience as a forensic architect, clients generally expect a level of performance beyond the minimum, especially when experienced contractors and roof system designers are involved.

The other important truths about code provisions are: Not all aspects of roof system design and installation that are important to achieve long-term performance are included in the codes, and not all provisions represent the same level of stringency.

In my experience, there are ways to go beyond simply meeting minimum code requirements to achieve superior roof system installations.

Building code provisions

IBC's Chapter 15 is the code's main roof system-related chapter. Section 1507 identifies minimum slope requirements and roof system material standards. The scope statement for the section indicates: "Roof coverings shall be applied in accordance with applicable provisions of this section and the manufacturer's installation instructions."

Generally speaking, most roof system manufacturers provide information about their roof systems that reference the material standards listed in Section 1507.

For example, Section 1507.12 includes minimum slope requirements and material standards for EPDM roofs. It also lists special requirements applicable only to EPDM roofs that are noted in 1507.12.3, which addresses ballasted thermoset low-slope roofs.

Additional subsections within Section 1507 similarly reference other common commercial low-slope roof systems such as built-up, polymer-modified bitumen, thermoplastic single-ply, spray polyurethane foam and liquid-applied. Section 1507 provides a basic framework for identifying the most basic attributes for low-slope roof systems such as slope, material performance and special requirements based on system types and should be referenced when specifying roof systems to ensure compliance with current code requirements.

Roof system design

To go beyond the code, roof system designers should critically examine manufacturer information and installation instructions related to the requirements of specific projects. Although installation instructions are technically a code requirement as noted in Section 1507.1, in my experience, becoming familiar with requirements from individual roof system manufacturers is not something every roof system designer does but is critical to consistently achieving roof system installations that perform well long term.

It also is important to note installation instructions, as well as guidance offered by manufacturers in the form of design guides and technical bulletins, can change. Sometimes, installation instructions conflict with code requirements especially when newer code editions are adopted. One way to become familiar with current requirements and resolve apparent conflicts is establishing and maintaining relationships with technical representatives from roof system manufacturers and coordinating with them frequently, particularly during the roof system design phase.

BEYOND THE CODE

BY JASON WILEN, AIA, CDT, RRO

Another important aspect of roof system material selection not specifically noted in building codes is material compatibility. Sometimes, this simply is a matter of choosing the correct product within a manufacturer's product line (for example, choosing the right membrane in combination with a compatible attachment method or selecting a liquid-applied flashing membrane material appropriate for a situation). More challenging is ensuring compatibility with adjacent substrates or products not provided by the roof system manufacturer (such as when a sealant needs to adhere directly to roof system components or when a flashing material needs to adhere to a particular surface). Ensuring material compatibility and roof system manufacturer "buy-in" with compatibility is essential for long-term roof system performance and provides helpful documentation if there is a performance issue in the future.

Drainage

IBC Section 1502 references sections in Chapter 11 of the International Plumbing Code.® These sections principally indicate how roof drains and scuppers shall be sized based on the roof area to be drained. Also, within Section 1502 are basic requirements for secondary (emergency) drainage, scupper design and gutter combustibility.

Section 1507, as previously noted, contains minimum roof slope requirements and Section 1511 allows for the minimum slope to be reduced to "positive slope" in reroofing scenarios.

To go beyond the code, roof system designers should look at roof drainage design in relation to potential rooftop elements that may inhibit proper (or even adequate) roof system drainage.

In a new construction scenario, it is important to coordinate roof system design with other building elements to ensure:

- Proper flashing heights are possible
- Enough room is provided to accommodate tapered insulation high points
- Necessary rooftop penetrations (especially large ones for ventilation ducts and the like) are located away from roof drains and scuppers or in a way that will not interfere with proper drainage

Curbs for rooftop equipment, dunnage frame posts and similar elements also should be carefully placed for similar reasons. When overburden is planned, such as paver systems or vegetative elements, it is important to ensure desired top surface elevations are coordinated with adjacent building elements.

In reroofing scenarios, it is important to determine the thickness of the existing roof system to be replaced. Often, thicker roof system insulation is necessary in replacement roof systems to comply with current minimum roof system thickness requirements.

Sometimes, elements of existing construction create limitations for flashing heights (such as HVAC equipment curb heights, door thresholds or windowsill heights, parapet heights, weep holes, etc.). Increasing insulation thickness without the ability to raise roof system flashing heights may result in reduced roof slope. Drains can be added to help alleviate this issue, but this solution can be expensive and is not always possible because of building configuration or location of existing drainage system elements.

Although Section 1511 allows for this reduced roof slope, the resulting reduction in drainage efficiency may create ponding that is technically code-compliant but unacceptable to a building owner. If such conditions are determined early in the process, roof system designers can evaluate options that may include coordination with code officials to discuss the trade-offs of thicker insulation versus reduced drainage capacity and find a solution acceptable to code officials and building owners.

Fire classification

Roof system fire classification requirements are found in IBC Section 1505, and Table 1505.1 lists required minimum classifications for types of constructions. Possible classifications include Class A—effective against severe fire test exposure; Class B—effective against moderate fire test exposure; and Class C—effective against light fire test exposure. Such classifications for commercial low-slope roof systems are based on roof assembly testing per ASTM E108/UL 790, "Standard Test Methods for Fire Tests of Roof Coverings."

Values in Table 1505.1 determine the minimum fire classification required based on the construction type of the building; a classification of B or C is required. Class A is required elsewhere in the I-Codes for specific (rare) situations such as required separations between vegetative roof systems and certain building elements, between vegetative roof areas that are of the maximum square footage allowed or roof systems installed in areas that have adopted the International Wildland-Urban Interface Code.®

Roof system manufacturers test their various roof assemblies and generally will provide roof assembly test reports when asked or when needed to demonstrate code compliance.

To go beyond the code, roof system designers should coordinate designs with roof system manufacturers' testing reports. Because fire classifications are based on the collective performance of all components included in the tests, swapping of individual components may affect a roof system's overall fire classification.

> "To go beyond the code, roof system designers should coordinate designs with roof system manufacturers' testing reports"

Additionally, it is not uncommon for building owners to desire a Class A roof assembly even when such a requirement is not required by the building code. Also, roof system designers should carefully consider alternative roof systems that may be presented as part of a "value-engineering" exercise or as a voluntary alternative in a bid process. Such alternative roof system designs may not have testing to demonstrate a specific fire classification or may have a classification less than desired.

Wind-uplift pressure resistance

Although a complete review of wind-uplift pressure resistance design for commercial low-slope roof design is beyond the scope of this article, it should be noted the current edition of IBC references ASCE 7-16, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures," in Section 1609.5.2, and Section 1504.3 indicates roof coverings installed on roofs that are mechanically attached or adhered shall resist design wind-load pressures per Section 1609.5.2. In other words, low-slope roof systems shall be designed to resist wind-uplift loads as calculated per ASCE 7-16.

IBC design wind load requirements for roof systems is an example of a code requirement many believe is beyond "minimum" and perhaps overly stringent. Roof system designers should calculate roof system design pressures per ASCE 7-16 as prescribed in IBC Section 1609.5.2. Once design pressures are known, roof system designers should coordinate with roof system manufacturers to ensure designed roof systems have been evaluated to resist determined roof system design pressures. IBC Section 1504.3.1 indicates built-up, polymer-modified bitumen, fully adhered or mechanically attached single-ply roof systems must be tested in accordance with FM 4474, "Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures"; UL 580, "Tests for Uplift Resistance of Roof Assemblies"; or UL 1897, "Uplift Tests for Roof Covering Systems."

Ballasted roof systems must be designed in accordance with Section 1504.8 and ANSI/SPRI RP-4, "Wind Design Standard For Ballasted Single-ply Roofing Systems," which contains information for designers to determine wind-uplift pressures that are based on ASCE 7-16. As with other types of low-slope roofs, roof system design loads should be calculated by roof system designers and the specified roof system should be coordinated with roof system manufacturers.

Edges of low-slope roofs where a roof system membrane terminates at a metal edge securement (except gutters) must be designed per IBC Section 1504.5, which references ANSI/SPRI ES-1, "Wind Design Standard for Edge Systems Used With Low Slope Roofing Systems." ANSI/SPRI ES-1 includes test methods where roof system edge metal is evaluated for wind pressure resistance upwards and outwards and includes a methodology where design pressures are determined based on ASCE 7 values. Architectural metal companies offer ES-1 tested profiles, and NRCA has a certification program to provide credible, independent means for contractors who shop-fabricate edge metal flashings to demonstrate compliance with ANSI/SPRI ES-1.

Although going beyond the code for wind-uplift pressure resistance may not be necessary because of the stringency of current code requirements, roof system designers can help ensure installed roof systems are

FOR ARTICLES RELATED TO THIS TOPIC, SEE:

"How do I load thee," October 2017 issue

"Collaborating with consultants," July 2013 issue

"Still water runs deep," July 2012 issue

code-compliant by providing clear documentation of design wind pressures within construction documents as required in IBC Section 1603.3. Also, roof system designers can require contractors to provide submittals that include manufacturer-provided test reports or certifications indicating provided assemblies have been tested to meet or exceed construction document requirements.

Energy code provisions

Thermal resistance requirements for commercial low-slope roof systems are found in IECC® Section C402. Although the code provides for a number of methods to demonstrate compliance, most low-slope roofs use rigid insulation installed above structural roof decks with a minimum R-value as noted in Table C402.1.3 based on the climate zone where buildings are located (thicker insulation in northern climates, thinner insulation in southern climates). Additional requirements are noted in IECC Section C402.2.1 where tapered insulation provisions are included.

To go beyond the code, considerations related to minimum required insulation thickness should be balanced with ensuring proper roof system drainage as discussed earlier. Further, roof system designers should review substrates where roof systems will be attached to identify potential conflicts. For example, concrete roof decks (especially lightweight structural concrete) can contain enough moisture within the concrete to create issues within the roof system insulation (poor attachment, deterioration of moisture-intolerant components, condensation, etc.).

Another potential conflict could be structural elements existing within or penetrating the roof system that create localized areas of reduced insulation thickness or thermal bridging. It is important to realize that simply including a minimum roof system insulation thickness requirement may not be adequate to achieve good thermal resistance performance; other building factors may require adjustment of insulation attachment methods, insulation materials or reconsideration of other building elements to create a more appropriate substrate for the roof system.

For new construction scenarios, the IECC includes requirements for the inclusion of a continuous air retarder (sometimes called an air barrier) throughout building enclosures in Section C402.5. Most reroofing projects are exempt from IECC air leakage requirements per an exception noted in Section C503.1. A complete review of air leakage requirements is beyond the scope of this article; an exploration of these concepts is included in *NRCA Guidelines for Condensation and Air Leakage Control*.

The important concept to understand is a roof membrane that is part of a low-slope roof can act as part of a code-mandated air retarder. This is because roof membrane materials almost always have an air permeance that is many times better than the requirement noted in Section C402.5.1.2.1 assuming they are installed per Section C402.5.1.1 (sealed at edges, penetrations and continuously with adjacent air retarder materials, etc.).

To go beyond the code, roof system designers should include specific air retarder construction details as part of construction documents because complex constructions sometimes are needed to properly transition from one air retarder system to another (such details are not specifically mandated in IECC though they are in ASHRAE 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings"; an alternative compliance path for energy code compliance is included as an option in IECC's Section C401.2).

Sometimes, it might be advantageous to include an air barrier layer within roof systems (in addition to the principal roof membrane) as transitioning roof membranes to wall air barrier systems can be difficult or complex because of particular building configurations.

Making good better

I have provided suggestions about how roof system designers can enhance designs to provide roof systems that perform well long term. The challenge is to evaluate all aspects of design and work through the inevitable trade-offs that occur (for example, providing enough insulation while providing proper roof slope while also having termination heights that fit with other building elements).

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