Feature

Finding Balance: The Next Chapter in Low-Slope Roof Design

By Jason P. Wilen, RRO, AIA, NCARB, CDT

This paper was presented at the 2025 IIBEC Building Enclosure Symposium.

AS A FORENSIC architect practicing in the US and specializing in the assessment of existing and design of new roofing and waterproofing systems, the author has encountered too many underperforming roof assemblies. These roofs have reduced service lives, often falling well short of the typical manufacturer's material warranty period of 20 years. See **Figure 1** for an example of a typical underperforming roof. Why is this so?

Roof system designers often focus on one or two specific attributes while neglecting others. For instance, for projects with environmental goals or the need to accumulate credits, designers may quickly opt for a roof design with highly reflective surfaces or materials that are low in volatile organic compounds or free from redlist chemicals (that is, chemicals that are not allowed for projects required to comply with the Living Building Challenge). However, they may not consider the ramifications of the climate zone where buildings are located or the temperature and dew point limitations of certain products during installation. In some cases, there may be a push to reduce installation costs, leading to the removal or downgrading of critical elements from proposed roof designs, most often cover boards, vapor barriers, or adhesives, in favor of peel-and-stick alternatives. Consequently, tested roof assemblies with predictable performance transform into untested and often non-code-compliant experiments. It is not surprising that such roof system designs tend to perform poorly over the long term and fail to provide good value from a life-cycle perspective, negating any cost savings realized during installation.

A STRATEGY FOR BETTER-PERFORMING ROOFS

It is time to adopt a new strategy that encourages a balanced approach across all categories, leading to resilient roof assemblies that perform well over the long term. Achieving the right balance is crucial in new construction, and it is essential for reroofing projects, where additional flexibility is often needed to accommodate conditions such as low curb and parapet heights, low windowsills and door thresholds (**Fig. 2**), and existing rooftop equipment and structural elements. A crucial first step in creating balanced designs for low-slope roofs is to understand the minimum requirements for developing resilient roofing systems.

BUILDING AND RELATED CODES

Codes dictate the minimum requirements for design and construction. Since the inception of the International Codes, or I-codes, in 2000, the family of model codes that most US jurisdictions and some international locations adopt and amend to establish local and state construction codes, the strategy for establishing minimum requirements for low-slope commercial roof assemblies has remained virtually unchanged. Borrowing from older regional legacy codes, Chapter 15 of the *International Building Code* (IBC) includes the base requirements for designing low-slope roofs. Chapter 15 also includes references to Chapter 16 (structural requirements) of the IBC and to other I-codes (the plumbing and fire codes). Relevant standards by ASTM International (formerly known as the American Society for Testing and Materials), the Single-Ply Roofing Institute (SPRI), and the American Society of Civil Engineers (ASCE) Structural Engineering Institute are also referenced. The I-codes are updated through a hearing and committee process and are published on a 3-year cycle. The current version, as of this writing, is the

Figure 1. *An underperforming roof. Courtesy of Klein & Hoffman.*

Figure 2. *Example of a low door threshold height limiting adjacent roof system insulation thickness. Courtesy of Klein & Hoffman.*

2024 edition, and those are the requirements discussed in this paper.

This web of provisions and referenced standards establishes the minimum requirements for designing and installing low-slope roof assemblies, with a focus on new construction. As indicated by the scope of the IBC, these requirements focus on providing a reasonable level of life safety for building occupants and protecting property from hazards. Additionally, they seek to provide a reasonable level of safety for firefighters and first responders during emergency operations.

Before proceeding, it is essential to understand a few key definitions. A roof assembly, as defined in the IBC, is "a system designed to provide weather protection and resistance to design loads." Roof assemblies are composed of the following two parts: roof decks and roof coverings. The definitions of those terms that appear in Section 202 of the IBC are:

- **Roof Deck:** "The flat or sloped surface constructed on top of the exterior walls of a building or other supports for the purpose of enclosing the story below or sheltering an area to protect it from the elements, not including its supporting members or vertical supports."
- **Roof Covering:** "The covering applied to the roof deck for weather resistance, fire classification, or appearance."

The term *roof covering* is commonly used in building codes. However, the author finds this term misleading, as it may lead one to believe that it refers only to the top surface of the roof, rather than encompassing all the layers of material and attachments above the roof deck. A more accurate term is *roofing system.* This term is defined in ASTM D1079-24, *Standard Terminology Relating to Roofing and Waterproofing,* as "an assembly of interacting components designed to weatherproof and typically insulate a building's top surface."

Why are these definitions important? Here are the key points to remember:

- Roof assemblies must be tested according to standards referenced in the code to ensure installed roofs meet minimum requirements for fire and wind pressure resistance. This testing applies to complete roof systems and is specific to the type of roof deck used. For instance, roof systems that have been tested on concrete roof decks may exhibit different properties when tested on steel or wood decks due to differing thermal performance characteristics of specific deck types.
- Roof assemblies must be designed to provide adequate drainage according to the methodologies outlined in building codes. This is essential to ensure the load of rainwater, referred to as *design rain load* in Section 1611.1 of the IBC, does not exceed the structural capacity of buildings during heavy storms. Insufficient drainage capacity, especially in cases where emergency overflow drainage systems are either absent or undersized, can lead to significant water ponding on roofs as it awaits drainage.

You might think that the information listed above seems like a significant extension of the actual definitions, but they are indeed closely related. It is essential to understand that code definitions are not enforceable on their own. Most jurisdictions align their regulations for low-slope roofs with Chapters 15 and 16 of the IBC. These chapters outline the specific building code-related requirements applicable to roofs.

As mentioned above, the base requirements relevant for low-slope roof assemblies are established for new construction. For reroofing, the IBC includes a section that indicates reroofing projects must comply with requirements for new construction, with the following exceptions:

- The minimum slope for roofs that are replacing existing roofs can be reduced from the ¼ in. per foot (6.35 mm per 30.48 cm) (2% slope) that is normally required for new construction, as long as positive roof drainage is achieved. *Positive roof drainage* is defined in Section 202 of the IBC as "a design that accounts for deflections from all design loads and has sufficient additional slope to ensure that drainage of the roof occurs within 48 hours of precipitation."
- Where positive roof drainage is achieved, a secondary (overflow) drainage system does not have to be added where none exists under certain conditions.

The limitations of these exceptions are discussed in a later section. In addition to reroofing exceptions typically noted in code, where the IBC is used as a base for code adoption (most US locations), some jurisdictions have a restoration code that addresses construction related to existing buildings. Often, the *International Existing Building Code* (IEBC) is adopted for this purpose, and for reroofing, Sections 706.2 and 706.3.1 of the IEBC contain requirements and exceptions related to low-slope roof assemblies that are similar to the IBC with the following additional requirements:

- When roofing or rooftop equipment is replaced and new roof systems and/or rooftop equipment cause an increase in load of more than 5% to specific load-carrying structural building elements, affected structural elements are required to be evaluated and improved or replaced as necessary to carry the loads required by the current building code, and not for the code in force at the time the building was constructed.
- In some instances, roof diaphragms resisting wind loads in high-wind regions may be required to be enhanced.

ENERGY CONSERVATION CODES

Traditionally, energy conservation codes have been developed separately from building and related codes. Most jurisdictions in the US have adopted the *International Energy Conservation Code* (IECC), which generally applies at the state level. The current version is IECC 2024, and the requirements discussed in this paper are based on it. This means the provisions are designed to be implemented across all state jurisdictions. However, some states permit local jurisdictions to establish more stringent requirements. In some instances, energy conservation standards may be adopted solely at the local level, even in the absence of a state requirement.

Before moving on, it is essential to understand a few more definitions:

- ***R*-Value (Thermal Resistance):** "The inverse of the time rate of heat flow through a body from one of its bounding surfaces to the other surface for a unit temperature difference between the two surfaces, under steady-state conditions, per unit area (h × ft^2 × °F/Btu [m^2 × k)/W])." *Note: The higher the* R-*value, the more resistance there is to heat moving through an assembly.*
- ***U*-Factor (Thermal Transmittance):** The coefficient of heat transmission (air to air) through a building component or assembly, equal to the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films (Btu/h × ft^2 × °F) [W/(m^2 × k].
- **Solar Reflectance Index (SRI):** An indicator on a scale of 1 to 100 of the ability of a surface to return solar energy to the atmosphere.

  Note: The higher the number, the cooler the surface will be when exposed to solar energy versus a surface with a lower SRI value, especially on a day without cloud cover.
- **Prescriptive Path:** Demonstrating compliance with the IECC's commercial energy efficiency provisions by meeting or exceeding specific, detailed minimum low-slope-roof-related requirements in the code.

  Note: This approach is most common and is the basis for the requirements discussed in this paper.
- **Performance Path:** Also called *simulated building performance,* this is a process where proposed building designs are compared to standard reference designs to estimate relative energy use against baseline designs. Approved designs must achieve a specific improvement over baseline designs.

  Note: This approach is most commonly used for new construction. Projects limited to a reroofing scope would not use this method to demonstrate code compliance.

The IECC has three principal requirements related to low-slope roof assemblies. The requirements apply to roof areas above conditioned space, defined as "an area, room, or space that is enclosed within the building thermal envelope and is directly or indirectly heated or cooled." There is also an exception for roofs above spaces that use very little energy, as defined in the IECC.

For roof assemblies that meet the above requirements, Chapter 4 of the IECC includes the three principal requirements for commercial buildings:

- **Minimum Thermal Resistance:** Low-slope roof assemblies must be insulated based on the location of the buildings. The IECC includes a US climate zone map with the southernmost locations in Climate Zone 1 and the most northerly areas in Climate Zone 8. Per the IECC, when roofs are insulated entirely above the roof deck, the minimum *R*-value for insulation must be between *R*-20 and *R*-35, with the higher minimum required *R*-value in more northerly zones. When roofs are insulated in any configuration other than entirely above the roof deck, the required minimum *R*-value range is *R*-38 to *R*-60.
- **Roof Solar Reflectance and Thermal Emittance:** For buildings in Climate Zones 0 to 3 and for roofs above cooled condition spaces only, the sunward-facing surface of the roof system is required to have a minimum 3-year-aged solar reflectance of 0.55 and a minimum 3-year-aged thermal emittance of 0.75. Alternatively, the roof surface must have a minimum 3-year-aged SRI of 64.
- **Air Barriers:** A continuous air barrier shall be provided throughout the building thermal envelope, defined as "the basement walls, exterior walls, floors, ceilings, roofs and any other building element assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space." For roof assemblies that are a part of the building thermal envelope, air barrier materials are required to be continuous, and construction details must be developed to allow for air barrier components of the roof and adjacent construction to be uninterrupted and/or

connected in a way that does not interrupt the barrier to air flow.

In reroofing situations, Chapter 5 of the IECC contains an exception that exempts having to comply with the air barrier requirement where the scope of work does not also include alterations or repairs to the remainder of the building's thermal envelope for projects where the overall energy use of buildings does not increase as a result of changes that occur as part of projects.

DESIGNING ROOFS TO COMPLY WITH BUILDING AND ENERGY CODES

As someone who participates in the code development process, the author understands the challenge of avoiding unintended consequences. Committees of subject matter experts consider potential code changes, and it is not reasonable to expect each committee to immediately understand all possible ramifications of a change, especially in seemingly unrelated areas of the code.

The requirements related to low-slope roof assemblies are mature, meaning the structure of the related code sections and many of the provisions have been similar for decades. Significant changes often take multiple code cycles to be considered and ultimately approved.

An interesting aspect of the history of low-slope code requirements in the I-codes is that energy conservation provisions have been developed separately from the building and related code provisions without "pointers" between the two. A pointer is a reference in one part of the code that also directs a designer to related requirements in other parts of the I-codes.

For example, the following is a provision in Chapter 15 of the IBC. The pointers are shown in bold:

> *"1502.2: Secondary (emergency overflow) drains or scuppers. Where roof drains are required, secondary (emergency overflow) roof drains or scuppers shall be provided where the roof perimeter construction extends above the roof in such a manner that water will be entrapped if the primary drains allow buildup for any reason. The installation and sizing of secondary emergency overflow drains, leaders, and conductors* ***shall comply with Section 1611 of this code and Chapter 11 of the International Plumbing Code.****"*

See **Figure 3** for an example where this has not been done.

Figure 3. *Example of a roof drain without a corresponding secondary (emergency overflow) drain or scupper. Courtesy of Klein & Hoffman.*

The text discusses specific conditions outlined in the roofing chapter of the IBC. When these conditions arise, the section directs roof system designers to a related section in the structural chapter of the IBC and to a chapter in the plumbing code that contains requirements for addressing the issues identified in the roofing chapter. Without these references, the designer may not be aware of relevant information in other areas of code. In the author's experience, this has been an issue with roof system design, as the promulgators of building codes have traditionally relied on pointers to make users aware of relevant code provisions outside of Chapter 15. Such pointers have not been added in the IBC for relevant IECC provisions. Similarly, users of the IECC are often unaware of roof assembly requirements beyond the IECC.

Beyond the lack of pointers, in the author's experience, there has been a noticeable lack of coordination between the teams responsible for building code development and those focused on energy code provisions. This disconnect may stem from a traditional lack of understanding of each other's issues that they are trying to overcome. As a result, when optimizing a roof assembly design for energy efficiency, it sometimes comes at the expense of compliance with building codes, and vice versa.

The lack of coordination also results in negative consequences that extend beyond just ensuring code compliance. In the following sections, three examples will illustrate common challenges that often arise.

THE REROOFING THICKNESS PROBLEM

In reroofing situations, a common challenge is that replacement roof systems are often thicker than the roof systems being replaced. This is primarily due to the increased required minimum *R*-values for roof systems installed entirely above the roof deck, which have evolved through several cycles of energy code development. As a result, the minimum required *R*-value has become higher, necessitating thicker systems to comply.

Currently, the minimum required *R*-value for most of the US (Climate Zones 2 to 6) is *R*-25 to *R*-30. This equates to about a 4½ to 5½ in. (11.43 to 13.97 cm) thickness of polyisocyanurate insulation, plus other components and required roof system flashing heights. Roof systems installed 20 to 30 years ago often have thinner insulation, in some cases as thin as 1 in. (2.54 cm) or less. Additionally, many low-slope roof systems rely on tapered insulation to achieve the required ¼ in. per ft (5.35 mm/m) slope for new construction. In other words, a typical tapered insulation system gains 1 in. (2.54 cm) of thickness every 4 ft (1.219 m) of distance from a drainage point. It is not uncommon for such tapered systems to require up to 12 in. (30.48 cm) of thickness just for the insulation at points furthest from primary drain points, or a bit less if drains are spaced closer together. It is sometimes possible to insulate below roof decks, although the IECC requires additional thickness in this configuration, typically 6 to 8 in. (16.24 to 20.32 cm) of insulation thickness. However, it is not always an option to insulate below roof decks, especially if the original construction did not have under-deck insulation. When undertaking a reroofing project, adding additional thickness to insulation can pose several challenges. One of the main concerns is that increased insulation thickness occupies more vertical space than the existing roof system. This commonly leads to complications.

For instance, the heights of parapet walls are often designed based on original roof thicknesses. Additionally, access doors to roofs are typically positioned with their thresholds above original roof heights, where thicker roofs may exceed threshold heights. The same is true for certain window types with set windowsills. Other critical considerations include maintaining existing through-wall flashing outlets that drain moisture from walls, which must remain above neighboring roof surfaces to prevent water from draining into and wetting roofs, thereby creating interior leaks. Moreover, rooftop equipment, including curbs and supports, as well as louvers and gutter blocking, must be accounted for in relation to replacement roof systems. In many cases, it may not be feasible to adjust the heights of adjacent constructions to meet required roof system terminations and flashing heights required by roof system manufacturers as a condition for warranty coverage. The cost of modifying existing structures to accommodate these changes can, in some instances, exceed the expense of the reroofing itself.

The end result is often to use as thick an insulation layer as possible, but this often falls short of the required insulation thicknesses for new construction. This may also necessitate reducing the roof slope to preserve enough vertical space for flashings. While building codes allow for reduced slopes in reroofing as long as positive roof drainage is maintained, achieving proper drainage can be challenging. Factors such as roof geometry, material deflection, rooftop equipment layout, and existing scupper heights can complicate this. Reduced slopes often lead to ponding water, which is undesirable for several reasons: it can be visually unappealing, cause staining after evaporation (this also reduces surface reflectivity), serve as a breeding ground for insects, and shorten the roof's service life. In extreme cases, significant ponding can lead to "ponding instability," compromising roof deck integrity and risking structural collapse. Thus, it is crucial for designers to carefully balance insulation thickness and roof slope to avoid these issues.

As the thickness problem is especially common, language was added to the current version of the IECC to address this issue. When the minimum insulation entirely above the roof deck, as required by the IECC, cannot be met due to limiting conditions, the following remedies were added to IECC Section C503.2.1:

- Construction documents that include a report by a registered design professional or an approved source documenting details of the limiting conditions affecting compliance with the insulation requirements can be submitted to the code official having jurisdiction for approval.
- Construction documents that include a roof design by a registered design professional or an approved source that minimizes deviation from the insulation requirements.

While the above remedies do offer a path where roof system designers can demonstrate code compliance when dealing with limiting conditions for adding additional insulation thickness, in the author's view, they fall short in three critical ways:

- Pointers are not included to identify requirements in the IBC where slope is critical for achieving the required drainage. As insulation thickness and slope are often interconnected, this oversight is significant.
- Both remedies require registered design professionals (except for those jurisdictions that have approved alternative entities to serve this function, a relative few in the author's experience) to provide a deliverable, such as a report or construction documents, to code officials, who must then approve the proposed approach. Since most jurisdictions do not require a registered design professional to obtain a building permit for a roof replacement, this adds significant costs to a project, and the outcome does not guarantee a favorable result for the owner. The code language also lacks guidance for code officials on how to determine the validity of a particular approach. As a registered design professional specializing in roof system design for over 30 years, the author would like to point out that most of his peers do not specialize in roof system design and, as a result, may lack the experience to confidently address issues in this area. Additionally, many building code officials lack sufficient knowledge in roof system design to feel confident in determining whether a particular approach is adequate.
- In the author's experience, many building departments, particularly in smaller jurisdictions, often lack the budget to have staff available to review and approve technical documents for roof replacement projects in a timely manner, or sometimes not at all. This issue is especially prevalent before a permit is applied for. The inability to know the approved insulation thickness for specific projects creates challenges, as this information is crucial for designing roof systems, typically well in advance of applying for a permit.

THE COOL-ROOF CONDENSATION PROBLEM

In Climate Zones 0 to 3 (southern US), the IECC requires a minimum roof solar reflectance and thermal emittance for roof surfaces above cooled conditioned spaces, as noted in a previous section. Roofs designed with such reflective surfaces are sometimes called cool roofs. As we will see, there are certain situations where cool roofs are too cool and can cause condensation issues within roof assemblies or in spaces below such roofs.

The climate zone map included in the IECC was developed by US Department of Energy researchers at the Pacific Northwest National Laboratory and is based on heating and cooling degree-day data collected from weather stations. The border between Climate Zones 3 and 4 indicates where cool roofs are mandated in the IECC. This line extends from east to west, passing through southern Virginia, eastern North Carolina, several southern counties in Tennessee, most of Arkansas, Oklahoma, Texas, southern New Mexico, southern and eastern Arizona, a small southwestern corner of Utah, the southern tip of Nevada, and central and southern California. Mandates have also been enacted in more northerly jurisdictions, notably Denver and Chicago, which are both in Climate Zone 5. Alternatively, Tennessee, with some Climate Zone 3 counties, has moved away from cool-roof mandates to preserve flexibility in low-slope roof design.

The research most frequently cited when discussing cool-roof mandates was conducted over 20 years ago and involved roof assemblies that were insulated to levels significantly less than what is required today, typically *R*-8 and below, about three times less than IECC requirements for roofs in Climate Zones 3 and 4. At that time, the rationale for mandating cool roofing was that a white or high-albedo roof surface material would reflect a portion of the incoming solar radiation away from a building's roof before it could be transmitted to and absorbed by the building and place stress on internal cooling systems, resulting in energy and cooling cost savings. However, the potential for condensation issues with roofs was generally overlooked. In addition to energy cost savings, although not part of the IECC's scope, some proponents argue that cool roofs can help mitigate urban heat islands (UHIs), which are areas in cities that experience higher temperatures than their surrounding rural environments.

Recent studies on roof albedo conclude that decisions by cities and building code governing bodies to mandate reflective roofing in certain climate zones have preempted economic and science-based individualized design decisions, predicated upon critical factors such as local geography, building use, or the roofing materials' carbon footprint.[1] Focusing on the reflectivity of roofing materials as a means of addressing the impacts of UHIs is misplaced and unproven. The article, "An Updated Holistic Look at Old Assumptions: Insights from Three New Studies on Roof Albedo," further notes that all too often, mandates like those some US cities have been enacting regarding the use of cool roofs on all new construction and roof replacements limit the flexibility to consider other options by focusing too intently on one environmental attribute, in this case roof reflectivity, instead of taking a more comprehensive approach and considering the overall sustainability and resilience of the roof assembly.[1] Such restrictions limit the ability of roofing design professionals to use their education and training to design, specify, or recommend a particular roof membrane, and thereby prohibit them from implementing the best and most sustainable solution for the situation at hand. In the author's opinion, the ideal scenario would involve the code providing sufficient guidance and flexibility, allowing both code officials and designers to demonstrate and confirm compliance with the overall intent of the code. This collaboration would enable them to find solutions that balance the overall performance of buildings, especially in cases where adhering to individual code provisions could lead to negative performance consequences in other areas.

Mandates are especially problematic in reroofing situations, as discussed in the "The Reroofing Thickness Problem" section above, where the ability to add insulation to the roof system is limited. Often, in these situations, a warmer roof surface can help limit or prevent condensation where a cool surface cannot. Having the flexibility to utilize a warm roof surface in cooler months is especially important in Climate Zone 3 and the north. When roofs are sufficiently insulated, as has been required in the I-codes since 2015, when minimum required *R*-values for above-deck roof insulation reached currently required levels after rising in every code edition since 2006, recent research has demonstrated that the temperature of the roof surface has a minimal effect on cooling within many buildings in climate Zone 3 and most buildings in climate Zone 4 and north,[1] thereby negating the need to mandate a specific roof surface color or reflectivity. When roofs are less insulated, as is sometimes the case in reroofing situations, a darker color is often preferred, as this helps mitigate condensation potential within roof assemblies, as darker-colored roof surfaces promote downward drying, which is not a characteristic of cool roofs and such moisture accumulation can be cumulative.[2] See **Figure 4** for an example of condensation damage below a white roof membrane.

Mandates for cool roofing have also been proposed as a solution to combat UHIs. However, a review of results in cities with long-term cool-roof mandates in Climate Zones 4 and 5 has indicated that these cool-roof mandates have not been effective in reducing UHIs.[1] Additionally, a study from Harvard University in 2024 presents data that suggest the energy from reflective surfaces does not disappear but is instead redistributed, leading to increased heating in less affluent areas.[3] Also, a study from Stanford University in 2017 found that prominent UHI studies that advocate for the use of reflective roofing do not account for feedback of changes in local temperatures, moisture, and their gradients to large-scale weather systems.[4] It also found that such studies cannot distinguish temperature changes in urban areas due to the UHI from temperature changes due to greenhouse gases, carbon dioxide domes over cities, cooling or warming aerosol particles, transmission or use of electricity, stationary or mobile combustion, or human respiration, which also occur in urban areas. Lastly, a study by the Institute for Atmospheric and Climate Science in 2015 shows that increasing land surface albedo, and not high roof reflectivity, preferentially cools hot extremes and that such cooling intensity is projected to increase in the 21st century.[5] In other words, unlike high roof reflectivity, the study found that increasing vegetative land (like urban tree canopy) does mitigate regional heating.

THE ROOF SYSTEM MATERIAL PROBLEM

When designing a roof assembly, several requirements must be addressed to ensure compliance with minimum building codes. In addition to these code concerns, roof system manufacturers have their own warranty requirements. Building owners may also need to meet criteria set by their insurance providers or adhere to environmentally focused guidelines to achieve institutional or voluntary goals. Furthermore, roofs frequently serve as platforms for various elements, including amenity decks, rooftop equipment, roof anchors, and solar systems (that is, photovoltaics or

Figure 4. *Example of condensation damage beneath a cool-roof membrane in Climate Zone 5. Courtesy of Klein & Hoffman.*

rooftop-mounted solar panels). This means that roof system designers must accommodate many factors in their designs.

The challenge is achieving the goals in owners' programs without compromising code compliance. It is important to remember that roof systems are composed of layers of materials and various attachment methods. Most jurisdictions require that installed roof assemblies meet or exceed building code requirements, including minimum fire classification, drainage and overflow capacity, and wind uplift pressure resistance. Additionally, they must comply with energy conservation code requirements, which include a minimum *R*-value, air barriers that meet specified air permeance standards, and, typically, reflective surfaces for buildings located in Climate Zones 0 to 3.

To comply with standard code provisions, roof system manufacturers test their product assemblies and can provide test reports as a method to demonstrate code compliance. Chapter 15 of the IBC outlines the required assembly testing standards and requires that roofs be applied in accordance with the applicable provisions of the code and the manufacturer's installation instructions. In practical terms, this means the code requires that the roof system manufacturers test every possible combination of products, a challenging proposition. The reality is that not every roof system manufacturer tests every possible material combination. Why is this an issue? Diligent roof system designers confirm their designs during the design process with roof system manufacturers to ensure that testing has been conducted using the specific materials and attachment methods proposed for the particular roof deck types being used. This confirms that the resulting roof assemblies meet or exceed the required wind uplift pressure calculated for projects. The same principle applies for fire classification. The following common situations often complicate things:

- Many projects, particularly those related to public work, require an "open specification" for roof system designs. This means that the acceptable design must allow for multiple manufacturers to participate. For roof system designers, this entails a verification process with various manufacturers to confirm that testing has been conducted to support the proposed designs. However, the fees typically paid to roof system designers often make this verification process challenging.
- Many projects undergo a process to reduce costs, often referred to as value engineering. During this process, proposed roof system components may be modified or removed. Additionally, during the summer months or periods of supply chain stress, certain components may become scarce or unavailable, leading to the consideration of alternatives. As a result, the system that is ultimately installed may differ from the original design that underwent thorough review. In my experience, the as-built construction sometimes does not receive adequate evaluation for code compliance, particularly regarding wind uplift pressure resistance and fire classification.
- In an effort to comply with sustainability goals, sometimes products are considered for environmental reasons without fully considering the impact on building-code-related requirements and the associated referenced testing requirements.
- According to a 2025 report by investment bank Brown Gibbons Lang & Company, reroofing projects account for 80% of roofing work in the US. Most reroofing projects are designed and permitted by contractors since most jurisdictions do not require design professionals to sign and stamp permit applications for these projects. In my experience, the level of expertise among roofing contractors varies greatly, particularly regarding their understanding of code-related issues. Additionally, building departments sometimes do not review reroofing permit applications with the same rigor as they do for new construction projects.

MOVING TO A BALANCED APPROACH

The three examples presented in the previous sections highlight the complexities involved in designing roof assemblies to meet minimum code requirements. The challenges observed in these examples could be addressed more easily if building codes and energy conservation codes were fully integrated. There are at least three improvements that need to be made urgently, as implementing these changes would likely enhance the resiliency of roof assemblies without increasing construction costs, since most jurisdictions already include these requirements in their codes:

- Pointers should be added in Chapter 15 of the IBC that alert roof system designers to roofing-related provisions in Chapters 4 and 5 of the IECC and vice versa.
- The remedies outlined in Chapter 5 of the IECC, which address situations where code-mandated levels of above-deck roof insulation are required for reroofing projects, should be expanded to reference Chapter 15 of the IBC. This would identify the minimum drainage requirements necessary for effective roof design. Tapered insulation is frequently used to create slope as part of a storm drainage strategy, and the most effective roof assemblies achieve an optimal balance between slope and thermal resistance without compromising either element.
- Another important improvement to the remedies outlined in Chapter 5 of the IECC would be to give roof system designers the flexibility to specify lower-SRI roof surfaces when necessary to address potential condensation issues. This is especially relevant for reroofing projects where it is not feasible to provide code-mandated roof insulation. Additionally, consideration should be given to buildings with high internal relative humidity, since condensation is more likely to occur during the winter months in areas that use cool roofing.

Such clarifications and additional commentary within the code would be immensely helpful for roof system designers. Building code officials, in my experience, also appreciate such guidance, especially in areas outside their area of expertise and experience. This is certainly relevant, as most code officials do not have a roofing background.

FINAL THOUGHTS

Integrating building and energy conservation codes is just the first step towards achieving resilient roof assemblies. As new information becomes available, it is crucial for everyone involved in the built environment to remain open to considering the latest practices, products, and technologies. We should incorporate science-based minimum requirements into codes and standards, properly referenced to relevant sections elsewhere in the I-codes. One area in this discussion that exemplifies this evolution is cool roofing. Research referenced in this paper indicates that mandatory reflective roofing has not delivered the anticipated benefits over the past 25 years. Recent data also suggest that the advantages of cool roofing are best realized when applied selectively, particularly for certain building types, especially in Climate Zones 0 to 2. Considering this, the mandated use of roofs with reflective surfaces in Climate Zones 3 to 8 seems outdated and inappropriate.

Lastly, these suggested improvements to model codes have another profound benefit. As model codes are the starting point for most jurisdictions, improved language, pointers, and flexibility will be distributed to all jurisdictions as part of the adoption process. Jurisdictions will not have to find balance in their codes; the balance will come to them, and better, more resilient roof assemblies will be the result.

REFERENCES

1. Thorp, E., and J. Wilen. 2025. "An Updated Holistic Look at Old Assumptions: Insights from Three New Studies on Roof Albedo." *IIBEC Interface* 43 (1): 22-27.
2. Western States Roofing Contractors Association (WSRCA). 2019. *Condensation Potential & Damage Related to White & Light-Colored Roof Systems.* Technical Bulletin 2019 — LSII — 1. Morgan Hill, CA: WSRCA.
3. Cheng, Y., and K. McColl. 2024. "Unexpected Warming from Land Radiative Management." *Geophysical Research Letters* 51 (22): 1-10.
4. Jacobson, M., and J. Hoeve. 2011. "Effects of Urban Surfaces and White Roofs on Global and Regional Climate." *Journal of Climate* 25: 1028-1044.
5. Wilhelm, M., E. Davin, and S. Seneviratne. 2015. "Climate Engineering of Vegetated Land for Hot Extremes Mitigation: An Earth System Model Sensitivity Study." *Journal of Geophysical Research: Atmospheres* 120 (7): 2612-2623.

ABOUT THE AUTHOR

JASON P. WILEN, RRO, AIA, NCARB, CDT

Jason P. Wilen *is a board-certified architect and building enclosure specialist with over 30 years of experience. Wilen joined the Chicago office of Klein & Hoffman (K&H) in 2018 and is now a principal. Before K&H, he served 7 years as a director with the National Roofing Contractors Association technical services section and 18 years with architectural, forensic, and roof consulting firms. He holds a Bachelor of Architecture degree from the Illinois Institute of Technology, Chicago, and is a licensed architect in Illinois, Indiana, Michigan, Minnesota, Maryland, New Jersey, North Carolina, Pennsylvania, Tennessee, Texas, and Wisconsin. Wilen provides leadership for K&H's roof system and waterproofing rehabilitation projects, participates in enclosure commissioning efforts, provides litigation support, and consults for building and energy code development. Additionally, he is a voting member of ASTM Committees D08 — Roofing & Waterproofing, C16 — Thermal Insulation, and E60 — Sustainability, and he serves on UL's Technical Committee 580: Safety Testing for Uplift Resistance of Roof Assemblies. Wilen has authored over 25 feature articles for local and national trade journals and magazines. In 2022, he was awarded IIBEC's Richard M. Horowitz Award, honoring the best technical article published in its technical journal,* IIBEC Interface.

Please address reader comments to chamaker@iibec.org, including "Letter to Editor" in the subject line, or IIBEC, *IIBEC Interface* Journal, 434 Fayetteville St., Suite 2400, Raleigh, NC 27601

IIBEC