Design Guide for Parapets: Safety, Continuity, and the Building Code

COURSE CREDITS: 1.0 AIA LU/HSW, 1.0 PDH

Parapets vary from plain to ornate, but all must provide stability and moisture protection. Photo courtesy Hoffmann Architects

ABOUT THE AUTHORS

Juan A. Kuriyama, AIA is Vice President and Director, Architecture with Hoffmann Architects, an architecture and engineering firm specializing in building exteriors. With expertise in addressing complex design details, he leads project teams in addressing building enclosure challenges for parapets, roofs, and exterior walls. He may be reached at j.kuriyama@hoffarch.com.

Eric Au, LEED Green Associate is Project Coordinator with Hoffmann Architects. Experienced in the demands of high-rise structures and urban settings, he develops engineering solutions that balance rigorous design with practical considerations. He may be reached at e.au@hoffarch.com.

LEARNING OBJECTIVES

After reading this article you should be able to:

+ DESCRIBE the design of parapet components, including copings, cladding, sealants, mortar joints, in-wall flashings, and vapor barriers, and explain how each functions to protect wall and roof assemblies from water infiltration.
+ DISCUSS the impact of code requirements for energy performance (e.g., the International Energy Conservation Code) on parapet design, including regulations for continuous insulation and air and vapor barriers.
+ EVALUATE structural considerations for new and existing parapets, addressing wind loads, height requirements, and accommodation for movement as part of a comprehensive design that provides the requisite safety and stability.
+ APPLY best practices for assessing existing parapets to determine appropriate repair and/or replacement strategies that meet code requirements, comply with historic/landmark preservation regulations, and respect the aesthetic integrity of the building.

Originally designed to protect against enemy attack, the parapet in modern construction is far removed from its antiquated roots. Though the word *parapet* is derived from the Italian *parapetto*, meaning to guard/defend (*papare*) the chest (*petto*), the parapet serves many other purposes, foremost among these as a critical transition between the building facade and the roof.

Characterized as a low wall, the parapet projects above the roof plane and typically spans around the perimeter of the roof area. Historically, parapets were constructed of masonry, consisting of multi-wythe walls with mortar-filled collar joints, capped with a coping. Usually unreinforced, these masonry walls were built to withstand environmental forces by relying on the weight of the wall. Due to construction failures and the development of new materials and building systems, modern parapets, constructed of diverse materials from reinforced concrete to masonry to steel, have since incorporated provisions for structural reinforcement, along with accommodations for moisture mitigation, such as in-wall flashings and vapor barriers.

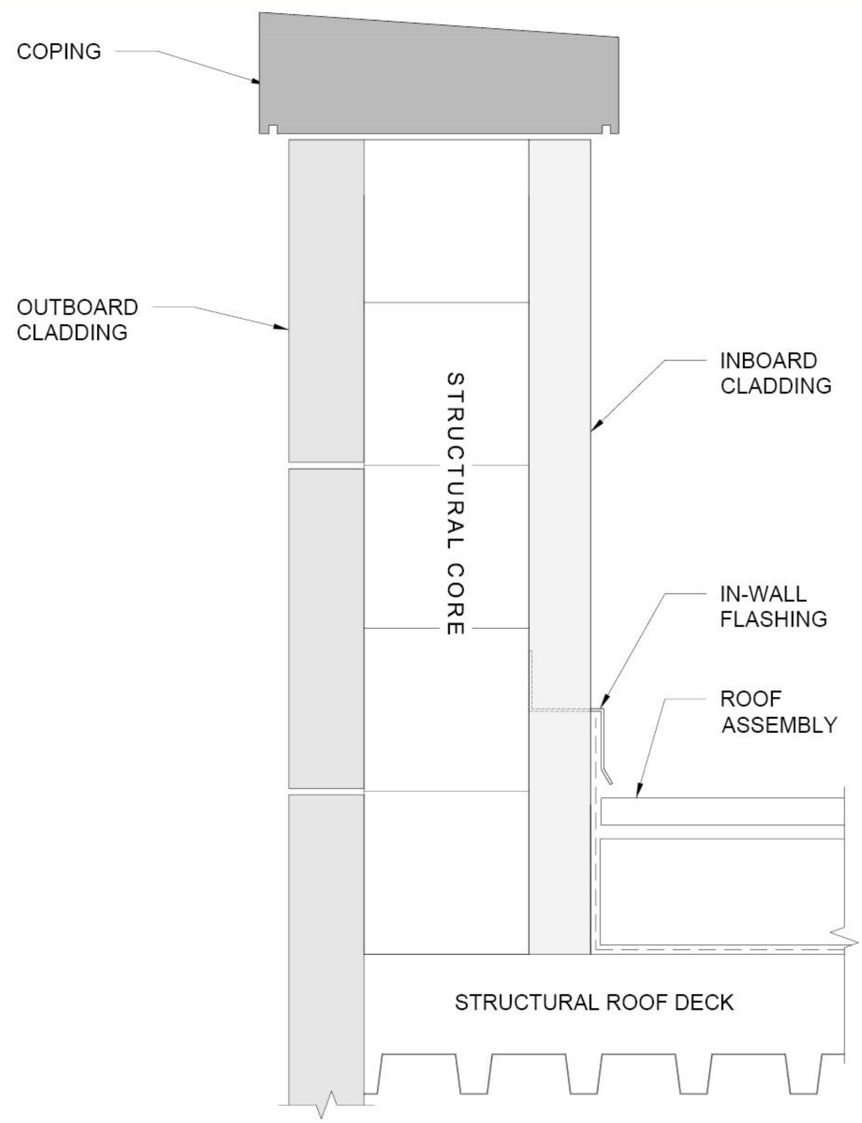
Parapets serve not only as a functional building component, but also as an aesthetic statement. By incorporating elements such as cornices, bands, pediments, balusters, and embattlements, a parapet can provide a continuation of the facade, or a visual termination.

As building performance standards progress, today’s design professionals face the compound challenge of balancing stringent building codes with the needs of the building owner. As underscored by the codes and standards dictating the design detailing of the critical transition between the facade and roof, this often-overlooked building element can have a big impact on the overall performance and longevity of the structure.

Design to Meet Code Requirements

Fundamentally, the parapet serves many practical purposes beyond its original function of protecting inhabitants from invasion. The modern parapet must provide fire protection, serve as a fall-protective guard, transition and protect the roof/facade interface, conceal rooftop equipment, and contribute to the aesthetic character of the building. As knowledge about building science has evolved, building codes have been developed to disseminate standards for the safe and functional design of parapet walls, and design professionals must consider these regulations when designing or rehabilitating parapets.

Basic Parapet Components



The *International Code Council's International Building Code* (IBC) is the model code for the design of parapet wall heights, structural stability, resistance to the elements, configuration, and anchorage. However, each state and local municipality may adopt different versions of the IBC, as well as code requirements more stringent than or different from those found in the model code.

Weather Barriers and Moisture Management

At some point during their lifetime, parapets will experience some sort of deterioration and will eventually face problems if not properly maintained. If neglected, a parapet will evince common building enclosure issues, such as moisture infiltration, corrosion, cracking and spalling, displacement, open joints, and failed flashings.

The central concern for parapet walls is the mitigation and movement of moisture away from the building facade. Older masonry walls were constructed without provisions for moisture management, often leading to water intrusion and *freeze/thaw deterioration,* whereby water trapped within the wall freezes and expands, causing cracks, spalls, and displacement.

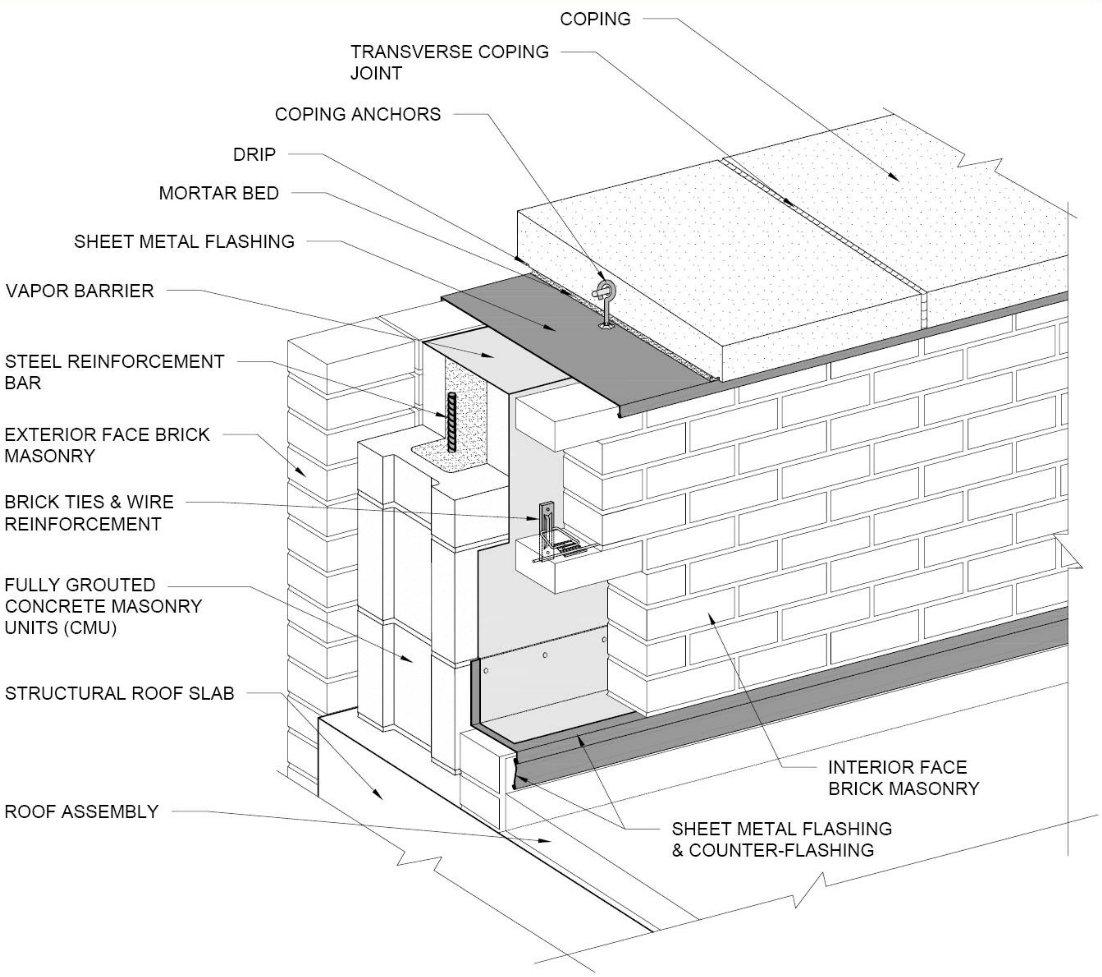
Concerned building owners should rest assured that the development of precise details can promote the longevity of a parapet and prevent common issues like freeze/thaw deterioration from arising. The goal is to diminish the impact of moisture on the wall assembly by redirecting water away from the building.

Copings

The first line of defense for a parapet is the coping. Somewhat larger than the width of the wall, the coping serves as a protective cap situated atop the parapet assembly. Copings are usually constructed of moisture-resistant materials, such as metal, terra cotta, stone, or precast concrete. Because moisture has an inherent cohesive property, or *surface tension,* it is critical to provide adequate slope on the top surface of the coping to direct water onto the roof and not the facade, and to prevent moisture from intruding into the parapet. Copings with *drip edges* break the surface tension of water and diminish the risk of it running down into the wall below.

Insufficient or deteriorated coping anchors represent a potential fall hazard in parapet wall assemblies. For example, traditional clay camelback copings rely on the weight of the coping, the interlocking connection between units, and the mortar bond between the coping and wall to secure the coping in place. Other older parapet walls use steel anchors, which tend to corrode and expand when exposed to moisture. The force of the corroding metal causes displacement and cracking in the surrounding masonry, a process known as *rust-jacking.* Stainless steel anchors offer an ideal solution, as they resist corrosion when exposed to moisture, while securely anchoring the coping against sliding or blowing off. For metal copings, non-corroding fasteners and cleats should be used in securing the sheet metal, including proper cover and under plates at joinery. It is important that all penetrations through the flashings be sealed to prevent moisture infiltration.

Typical Brick Masonry Parapet Assembly



Cladding

Historically, parapets were composed of a single, monolithic element beneath the coping, serving the dual function of structural support and weather-resistive barrier. In modern construction, parapets tend to have a structural core, often of concrete masonry units (CMU), brick, concrete, steel, or metal studs, with outboard and inboard cladding that might consist of brick, stone, stucco, metal panels, or exterior insulation and finish systems (EIFS). These compound assemblies offer more design options and integrate thermal and moisture control layers, but they demand skilled detailing of the various components to provide an uninterrupted, continuous barrier against the elements.

Sealants

Sealant and backer rods are typically installed at the joints between copings, known as *transverse joints.* Failure of sealant at transverse joints between coping stones leads to moisture infiltration, so it is important to identify and replace compromised sealant joints promptly.

Conversely, installation of sealant for masonry applications is not always the appropriate solution and should be used conservatively. If a parapet is designed for mortar, it is usually a good idea to stick with mortar, as properly designed brick masonry walls are intended to get wet and dry out. Sealant at joints intended for mortar will trap water within and promote freeze/thaw damage.

Mortar Joints

Masonry construction is especially susceptible to moisture. In the case of brick masonry parapets, architects and engineers will often look for signs of mortar joint deterioration as indicators that there may be underlying issues within the parapet. Often, mortar that has softened, broken apart, or cracked is caused by thermal movement of masonry elements and/or freeze/thaw cycles. Openings in the joints admit further moisture and generate an ongoing problem that could proliferate.

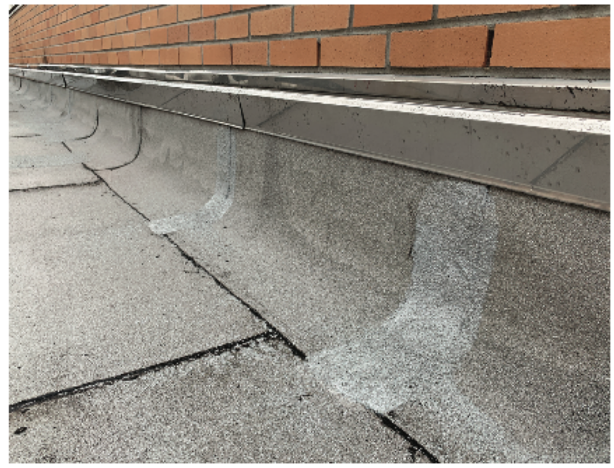
Selecting an appropriate repair mortar that will match the existing mortar in color, profile, hardness, and texture is key to long-term performance. Equally important, accurate mortar matching maintains consistent appearance and performance, especially for historic structures. The Brick Industry Association (BIA) Technical Note 46, "Maintenance of Brick Masonry," provides guidelines for formulating, testing, installing, and tooling repointing mortar.

Though repointing mortar joints may seem like a quick fix, issues such as unmitigated exposure to weather or moisture should be resolved first, to address the root cause of persistent deterioration. Otherwise, problems are likely to recur and lead to wasted money, effort, and time attempting to chase after a systemic problem with short-term repairs.

In-Wall Flashings

Under-coping flashings are a secondary layer to further mitigate the infiltration of water into the parapet wall. Sandwiched between the coping stone and wall assembly, the flashing should be comprised of corrosion-resistant metal. Any penetrations, such as anchors in the flashings, should be sealed.

While under-coping flashings provide an effective means of preventing moisture from entering the wall, there is a direct impact to the appearance of the parapet. In most cases, a continuous, shiny drip edge is visible underneath the coping and may not be desirable from an aesthetic standpoint. Moreover, for historic and landmark structures subject to review by a preservation commission or other authority, such an alteration may be prohibited. The design professional should exercise good judgement in balancing the performance of the parapet with the visual impact of under-coping flashings.



Flashings are critical to moisture management. Under-coping flashings (left) direct water away from the parapet and exterior wall, while base and counter-flashings (right) protect the roof. Photos: Hoffmann Architects

At the transition between the parapet and roof, in-wall flashings provide a seamless transition between the vapor barrier within the parapet wall and the roof assembly. The National Roofing Contractors Association (NRCA) *Roofing Manual* recommends positioning in-wall flashings at least eight inches above the finished roof assembly to allow adequate height for installation of roof flashings, insulation, and membranes, and to provide protection from snow accumulation. Given changes in energy code requirements in recent years, it may be prudent to allow additional space below in-wall flashings to accommodate increases in insulation thickness.

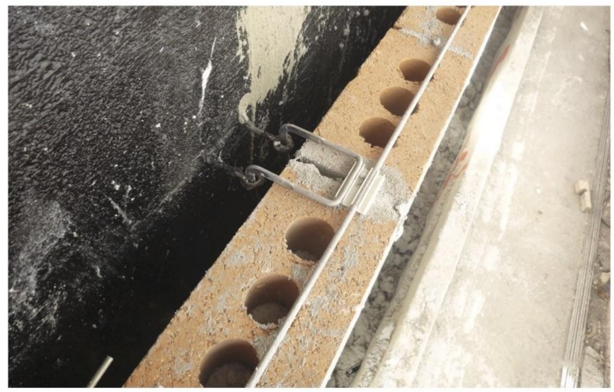
Vapor Barriers

According to IBC 1403.2, “Weather Protection,” the building enclosure must provide “a weather-resistant exterior wall envelope.” Based on the code in effect at the time of original construction, the extent of rehabilitation work, and the interpretation of the local authority having jurisdiction (AHJ), parapet walls may need to meet this requirement.

A *continuous vapor barrier* behind the exterior cladding of the parapet should provide a clear drainage plane that redirects water away from the building and allows moisture in the form of vapor to escape from the interior. Typically, the vapor barrier encapsulates the top of the parapet wall directly underneath the coping, transitioning along the vertical face of the wall, and down onto the horizontal face of the roof level. Self-adhered and liquid-applied air and vapor barrier systems prevent moisture from traveling beneath the membrane, providing an additional waterproofing redundancy while also allowing the wall assembly to dry if water does get in.

Depending on the climate zone, the *International Energy Conservation Code* (IECC) requires that the building thermal envelope be provided with a vapor barrier and *continuous air barrier.*

Steel bars reinforce the concrete masonry unit core of the new parapet.



Brick ties anchor the cladding to the CMU structural core.

A liquid-applied air barrier provides a continuous layer of moisture protection.

With the copings and flashing in place, the parapet is nearly complete.

PHOTOS COURTESY OF HOFFMANN ARCHITECTS

Energy Efficiency

In addition to requirements for air or vapor barriers, the IECC requires *continuous insulation* across wall and roof systems, including parapets. Based on the climate zone, building use, and construction materials, the energy code dictates minimum *R-values,* or insulating effectiveness, as determined by the type, thickness, and density of the insulation. As with air and vapor barriers, continuity for insulation in complex parapet assemblies should be documented in the design details. With various control layers for air, moisture, and thermal management, coordination among trades and appropriate construction sequencing are key considerations to avoid compromising the integrity of one system through the installation of another.

Structural Considerations

Subjected to wind and weather on both the outboard and inboard side, parapets are especially vulnerable to rain, wind, snow, and thermal forces. These stresses, or loads, are the basis for determining the structural capacity of a parapet. Notably, wind loads acting on the perpendicular face generate an *overturning moment,* or the force attempting to topple the parapet. Therefore, it is especially important to provide reinforcement that restrains parapet walls against anticipated *lateral loads,* which act perpendicular to the vertical face of the wall.

Often, parapets require incorporation of steel reinforcement bars to deliver the necessary structural stability. Alternatively, structural piers or pilasters built out from the walls can provide additional lateral support. For much taller and thinner walls, installation of steel bracing secured to the structural roof deck may be necessary. The bracing system should be designed by a qualified engineer or architect to resist the required design loads, based on the geometry and construction of the parapet.

Wind Loads

Building components are subjected to wind forces that vary based on building profile, orientation, and the profile of each building element, factors which considerably alter the pressure differences at various points along the building exterior. Studies have shown that parapets offer some relief for roof assemblies in resisting wind uplift, as parapets reduce wind pressures at the roof perimeter. Nevertheless, parapets themselves experience stress due to wind loads, which must be considered in the design.

The IBC provides structural requirements for design wind pressures, citing the American Society of Civil Engineers (ASCE) Standard 7, "Minimum Design Loads for Buildings and Other Structures," as a basis of reference for understanding wind loads and their impact on buildings.

Height Requirements

The height of a parapet is governed by local building code. Many such codes are based on IBC 705.11.1, "Parapet Construction," which stipulates that "the height of the parapet shall be not less than 30 inches above the point where the roof surface and the wall intersect." However, while a 30-inch parapet might satisfy the IBC model code, design professionals should check state and municipal code requirements, as some jurisdictions have stricter rules for parapets acting as fall-guards.

For example, the *New York City Building Code* requires buildings taller than 15 feet to have parapets with a minimum height of 42 inches. (Buildings constructed prior to 1938 are exempt from the requirement, provided that no significant repairs are performed on the parapet.) New York City's Facade Inspection and Safety Program (FISP) requires design professionals to assess whether parapets meet the height requirements of the building code in effect at the time of construction. Should a parapet fail to meet this standard, corrective action, such as installation of a code-compliant guardrail or reconstruction of the parapet, may be required. Depending on the historical significance and construction of the building, these code-compliant changes may also impact the aesthetic of the parapet.

As previously discussed, evolving energy codes demand increased roof insulation thickness, which directly impacts the height differential between the roof assembly and the top of a parapet wall. When planning to rebuild a parapet or install a new guardrail, building owners should anticipate any changes in the roof assembly thickness, which impacts not only the height of the parapet itself, but also the height of related flashings. Likewise, plans to augment roof insulation should incorporate necessary extension of parapet and/or guardrail height, as well.

Accommodation for Movement

While it is normal to think that buildings are relatively static, building materials experience movement in the form of growth, shrinkage, and deformation in response to environmental changes. As the temperature rises, materials tend to expand, then contract when the temperature falls. Inherent material properties may also cause dimensional changes over time, with dissimilar materials, such as concrete and steel, expanding or contracting at different rates.

Expansion joints are designed to accommodate movement within a wall and allow for differential movement between dissimilar materials or across large expanses of wall. These periodic breaks within the wall are fitted with a compressible filler and sealed at the joints. Since walls tend to expand exponentially outward from the center, with the greatest degree of movement towards their ends, it is especially important to provide expansion joints at or near building corners, as well as at offsets, setbacks, and wall intersections. Though this a general recommendation for brick masonry, the designer should take into consideration the specific building materials, the degree of expected movement, compressibility of the specified joint filler, and the size of the joint relative to the structure at hand.

To accommodate for vertical expansion, continuous horizontal joints in the exterior cladding are usually located below the parapet and roof level. The horizontal joints generally consist of steel relieving angle supports with compressible filler pads anchored to the structural backup.

Eventually, a parapet wall will display signs of distress if provisions for expansion and movement are not provided. This stress propagates along the structure and may be observable as continuous step cracks or bowing and displacement. To prevent hazardous conditions, parapets must be evaluated routinely for initial warning signs of restrained movement.

Assessing an Existing Parapet

There are several tools that can assist the engineer or architect in determining the construction of an existing parapet. To understand the original design intent and confirm the details of the assembly, access to original and record drawings is highly beneficial. Particularly for older structures, these drawings are not always available, or, even when they are, they do not accurately reflect what was constructed in the field. However, an experienced design professional can make a probable diagnosis based on common construction practices. Exploratory probes into the parapet wall may provide valuable information about the overall construction, exposing deficiencies that would otherwise be concealed.

Repair or Replacement

While it is impossible to guarantee that a parapet will not experience some sort of decline over time, there are steps that can be taken to prevent, treat, and repair common issues. Depending on the extent and nature of deterioration, maintenance repairs may be sufficient in limiting the scope of the problem. Corroded anchors, for instance, can be readily addressed through replacement with corrosion-resistant materials. If, however, maintenance is deferred, the outward pressure from corrosion may lead to cracking and displacement of copings and masonry, necessitating more extensive rehabilitation.

Similarly, timely identification of moisture infiltration and installation of proper flashings prevents water from entering the parapet. If left to persist, water intrusion can compromise the structural integrity of the parapet and will likely warrant a rebuild with structural provisions in place.

For parapets classified as historic or architecturally significant, limiting the scope of intervention is often preferred. In severe cases where a parapet requires rebuilding, reconstruction necessitates coordination with historic preservation offices in determining the appropriate strategy for restoration and code compliance.

Where parapet deterioration is acute, temporary stabilization may be necessary to protect the public from loose or unsecured materials. Nylon netting and metal straps are commonly used to stabilize a parapet wall until a more permanent solution can be implemented. Additional public protectives, such as sidewalk sheds, may be mandated for certain repairs, especially in urban locations, where a deteriorated parapet poses a threat to public safety.

To avoid the expense and disruption of reconstruction, routine parapet maintenance and monitoring are vital in addressing emerging problems and preventing deterioration. “Band-aid” repairs may temporarily defer issues in the short-term, but, ultimately, only a well-designed and properly maintained parapet will avoid chronic problems and stand the test of time.

Diverse Materials, Diverse Solutions

Developing the best plan to prevent and treat the underlying issues with parapets follows a proven strategy: investigation of existing conditions, consideration of construction quality, assessment of historical significance and design intent, and evaluation of other factors specific to the structure and situation. A rehabilitative approach that works for a masonry parapet on an 18th century church is not necessarily applicable to a stainless-steel-clad parapet on a recently constructed condominium.

Whether the scope of work involves repairing an existing parapet or designing and building a new one, design professionals have the responsibility of developing a comprehensive approach that balances the needs of building owners, the stipulations of code requirements, the material and structural properties of the wall construction, and the aesthetic qualities of the building.