

Building Envelope Technology Symposium

THE LAST FEW FEET: PARAPET DESIGN, ISSUES, AND REPAIR

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ABSTRACT

The design considerations and service life issues for parapet walls can be very complex. If not detailed, constructed, or maintained properly, parapet walls can be a source of water infiltration into the building and/or result in structural deficiencies of the façades and structural roof system. This presentation will discuss general design principles and considerations as well as common issues observed in both historic and modern parapet detailing and construction. Case studies of parapet repairs and replacements will be presented. Case studies will discuss the challenges of retrofit designs for the parapet wall structural system and detailing of integral flashing systems.

SPEAKERS

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LOGAN COOK is an Associate II with WJE. Mr. Cook graduated from Purdue University with a B.S. in construction engineering and management and an M.S. in engineering. Since joining WJE in 2012, he has served as a project engineer on assignments related to the analysis, investigation, repair, construction, and restoration of new and existing buildings.

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Since joining WJE in 2000, MATTHEW NOVESKY has been involved in projects related to the inspection, investigation, and repair of distressed conditions in existing buildings. He has conducted investigations related to distressed façade conditions and water leakage, provided recommended repair options, and observed installation of repair solutions for masonry construction and water leakage mitigation. Mr. Novesky has authored papers on exterior façade materials related to typical construction detailing and failure mechanisms for numerous building materials.

THE LAST FEW FEET: PARAPET DESIGN, ISSUES, AND REPAIR

INTRODUCTION

The last few feet at the top of many buildings consist of façade extensions above the roof level, known as parapet walls. Parapet walls can serve many functions, including but not limited to fire protection from adjacent buildings, concealment of mechanical or HVAC equipment on rooftops, and guardrails for outdoor roof terraces. Parapets can significantly vary in design, material, and construction technique. The tops of buildings can be highly decorative, with projecting cornices and balustrades; or they can be minimal, with a low profile or no parapet and only a gravel stop. Regardless of the construction or function, the design, maintenance, and repair of parapets is important and can pose a number of challenges due to as-built construction and exposure to natural elements.

Building systems that interface parapet walls—in particular, masonry parapet walls—include roofing, waterproofing, water management components, building façades, structural components, and even mechanical and electrical systems. Successful integration of these systems requires planning, communication, and foresight during design and construction.

This paper will discuss the design of masonry parapet walls and structural/water-leakage issues and concludes with two case studies of masonry parapet repair projects designed by the authors.

DESIGN

The performance of building systems is dependent on the design and construction of proper detailing. Masonry parapet walls are no exception to this generalization. There are numerous important structural and architectural-design criteria that must be considered, including wind loads, thermal movement, attachment to roof structure, integration of various building materials, exposure to environmental elements on three surfaces, and water management.

Structurally, parapet walls behave as a vertical cantilever or overhanging beam projecting above the roof levels. Therefore

shear, axial, and bending forces must be resolved at the base of the parapet wall. Local building codes define structural requirements for building elements based on their height and exposure. At a minimum, lateral resistance from wind loads must be calculated. The lateral resistance of a parapet wall is a function of the height above the roof level (or highest connection point to the building structure), width, and reinforcing (if present).

Historically, parapets were mass masonry walls constructed as an element continuous with the façade. Expansion of masonry parapet walls, due to the natural absorption of moisture by clay material and thermal properties, often results in displacement and cracking within the wall. Incorporation of expansion joints in building façades, particularly at parapets, helps to accommodate this movement. Expansion joints in contemporary building types, when integrating various construction materials, are critical to allow the building to function properly.

Successful integration of parapet walls with roofing, waterproofing, and water management systems requires knowledge of these systems and their detailing requirements. Detailing the termination of the roofing system at the parapet needs to be coordinated with wall flashings to ensure that water is neither trapped in the parapet wall nor allowed to bypass water management systems. Proper detailing should be developed between the two systems to facilitate discharge of water that infiltrates the system. In order to mitigate moisture that can enter through the parapet wall, roofing and waterproofing terminations should be designed to provide adequate drainage of the flashing systems. Water management systems are ideally coordinated with parapet designs to ensure the proper drainage of water through scuppers or drains. In some instances, parapet waterproofing systems are integrated with flashing systems in the façades; one example of this is at window locations.

When constructing parapets, coordina-

tion between the trades (roofers, masons, sheet metal workers, etc.) is critical to successfully execute proper detailing at the parapet and create a watertight system. Furthermore, it is important that the project architect conduct regular site visits to observe the construction and integration of the building materials, particularly at interfaces, to ensure that the as-built conditions represent the original design intent and function.

The construction of masonry parapet walls has varied widely throughout history and has changed with the integration of multiple façade materials and waterproofing systems. When investigating or repairing masonry parapets, it is important to investigate and document the system, as repairs to appropriately address the issues will vary. The following section will provide an overview of historic and contemporary masonry parapet systems and their performance.

Historic Masonry Parapets (pre-1950)

Historic masonry parapet wall construction varies based on the time period and style that the building was constructed. Generally, historic masonry parapet walls consisted of multiwythe mass masonry walls with mortar-filled collar joints between wythes and limestone or terra cotta coping units. It was generally assumed that the self-weight of these mass masonry parapet walls resisted the demands from wind loads, though the design was not based on current factors of safety. Roofing systems typically terminated on the face of the wall or underneath the coping units.

Mass masonry walls were generally intended to function as a barrier system without flashing and integral waterproofing systems. The outer wythe of the mass masonry wall is depended upon to shed as much water as possible; however, the porosity of the brick and, more importantly, the mortar joints, allows water absorption into the wall. The backup brick masonry also absorbs moisture as it penetrates through the face brick and holds water until it evap-

orates during drying periods. These periods of wetting and drying, in conjunction with temperature changes within the masonry walls, result in expansion and contraction as well as freeze/thaw-related deterioration. This movement was accommodated by incorporating various forms of setbacks in the façade walls. Although designers were aware of these movements within buildings and materials, the technology of sealants and expansion joints was not refined to current standards until the 1960s.

Contemporary Masonry Parapets (post-1950)

Contemporary masonry parapet walls can be constructed from a number of different materials and wall types. Often in contemporary construction, masonry parapet walls are constructed as cavity walls. Cavity walls typically include an outer wythe of masonry, an air cavity, an air/vapor barrier system, insulation, and a backup wall. The backup wall in contemporary construction can consist of brick masonry, concrete block, cold-form steel stud framing, structural steel framing, or structural concrete framing. Demands from wind forces are resisted by the anchorage of the backup wall to the building structure, which is typically the roof framing. The face brick is laterally anchored to the backup wall at regular intervals to provide lateral resistance to wind load on the exterior face of the parapet wall. Sheet flashings and membranes are applied to the exterior face of the backup wall to minimize water infiltration into interior space.

Similarly to mass masonry walls, the face brick in cavity walls serves as a rain screen for the wall's moisture management system. Water that enters the wall system is managed by wall flashings and membranes to direct moisture back to the exterior through weeps.

Movement in contemporary masonry parapet walls due to different thermal expansion and contraction properties of the materials is accommodated with vertical and horizontal expansion joints. Expansion joints are regularly spaced to divide the wall system into individual sections to control expansion or contraction of the given materials. Expansion joints are also often used to separate different wall materials at transition locations. Sizes of the joints vary based on anticipated movement of the parapet. Backer rods and sealant are relied

upon to fill the expansion joints to create a watertight barrier that accommodates the movements of the joints.

THE ISSUES

Deficiencies that can be associated with deterioration or poor performance of a masonry parapet wall during its service life are very similar to those found in façade walls of similar construction. This list includes water infiltration, freeze/thaw deterioration, and displacements or cracking due to building movement or material expansion. The causes for these deficiencies vary, and it can be challenging to identify them and determine appropriate repairs.

Water Infiltration

Water infiltration into the top floor is often immediately attributed to the roofing system or the exterior façade system. However, it may not always be due to the material or installation itself but rather to the detailing of these materials. As discussed in the previous section, proper detailing of the interface between the roofing system and a masonry parapet wall requires an understanding of how each of these components performs individually. If the masonry parapet wall incorporates flashings, the roofing system details should be coordinated to ensure that water draining from the masonry via the flashing is permitted to drain outside of the roofing system. This solution is often detailed with the masonry flashing system installed above the termination of the roofing system.

As previously discussed, many mass masonry walls were historically constructed without the use of flashings, as it was assumed that the multiple wythes of the masonry wall would accommodate moisture by retaining it until it evaporated during drying periods. When terminating roofing at these parapet walls, it is important to understand that moisture will penetrate the outer wythe of the masonry wall. Moisture within a wall system can be trapped by and damage a roofing system if not properly detailed.

When a roofing system is replaced at the end of its service life, the repair and maintenance of masonry parapet walls are often not included in the scope of work. To maintain a watertight exterior building envelope, it is important that parapet walls be repaired and maintained, not only to provide a good substrate for the roofing system,

but also to mitigate water that can bypass the flashing or roofing systems.

Freeze/Thaw

Freeze/thaw deterioration in masonry occurs when excess moisture saturates masonry materials and repeated freezing and thawing cycles result in expansion forces due to natural expansion of water as it freezes. Depending on the properties of the masonry, the saturation level at which freeze/thaw deterioration occurs varies. Freeze/thaw deterioration is exhibited by spalling or exfoliation of the masonry and can cause excess moisture to enter into the parapet wall system. In extreme cases, it can result in the loss of capacity of the parapet wall to resist the impact of wind.

There are a number of deficiencies that can lead to the wetting of brick masonry and freeze/thaw deterioration. Excess moisture can enter the system through open or deteriorated mortar joints, and moisture which enters the parapet wall system may not be able to adequately drain to the exterior due to poor design or inappropriate repairs previously implemented. This excess moisture can accumulate and saturate the brick to such a level that freeze/thaw occurs.

Displacements or Cracking

Masonry materials, particularly brick, expand and contract based on their inherent temperature and moisture content. As the temperature or moisture content increases, clay masonry expands. As the temperature or moisture content decreases, clay masonry shrinks. The rate of expansion and contraction is dependent upon the masonry materials, but buildings with long uninterrupted lengths of masonry walls can produce significant expansion and contraction forces. When this movement is not properly accommodated by expansion joints or other methods, stresses in the masonry can accumulate and cause cracking and displacement. Permanent displacement or "walking" of masonry can occur through the natural expansion of masonry material. The day that a clay masonry unit is fired and removed from the kiln, it is the smallest size it will ever be. Subsequent to manufacturing and often corresponding with installation, clay masonry units expand due to their absorption of moisture from the environment.

Another cause of displacement and cracking of masonry is the result of differ-

ential building movements. While this phenomenon can occur in all building types, it is more predominant in buildings that mix structural and façade elements, such as a concrete-framed building clad with a masonry veneer. In contrast to masonry materials, concrete tends to shrink and creep. Shrinkage in concrete begins to occur as the hydration process takes place, which often corresponds to placement. Creep occurs over longer periods of time with sustained loading, such as the dead load of the structure. The differential movement of masonry façade materials and the concrete structural frame can cause the accumulation of stresses in masonry façade systems that have been integrated with the structural system, which results in cracking and displacement. Often, the magnitude of the displacements are greater at the top of the façade due to the greater length of differential movement due to uninterrupted length, exposure to moisture on both sides, and exposure to changing temperature on both sides.

Another cause of masonry displacement and cracking is due to the corrosion of embedded steel elements. In most brick masonry construction, steel elements are incorporated into the system such as shelf angles, lintels, lateral ties, or even building structural members. Corrosion of steel is an electrochemical process that requires the presence of moisture and oxygen. If moisture is permitted to come into contact with unprotected, mild steel elements, and oxygen is present, corrosion will occur. In contemporary construction, corrosion-resistant materials that are used include stainless steel, galvanized steel or steel protected by corrosion-inhibiting coatings, and flashing systems.

Corrosion scale can occupy a volume four to ten times the original volume. If corrosion scale is permitted to accumulate and is confined by adjacent materials, it can cause cracking and displacement of adjacent materials. Corrosion of embedded steel elements at the base of the parapet wall can introduce cracking and bond separation between the parapet wall and the main body of the building. In some extreme instances, the accumulation of scale can result in upward displacement of the entire parapet. Lateral displacement or leaning of the wall may then occur due to the dimensional changes caused by the accumulation of corrosion scale or decreased structural capacity caused by cracking.

Falling Fragments or Collapse

If building movement or high loading occurs while the masonry parapet exists in a deteriorated state due to the distress mechanisms described above or lack of maintenance, falling fragments or collapse can occur. Falling fragments or collapse of masonry parapet walls pose a life safety risk to pedestrians and property below.

CASE STUDY 1

Our first case study is a five-story condominium building on the northwest side of Chicago. Built in 2004, the exterior façade consists of jumbo-sized face brick, cast stone, and limestone accent units. Each unit has a balcony on the exterior building façade that is accessed through sliding glass doors. The top of the building is adorned with decorative parapet walls at the building corners and centers of the façades. These decorative parapets incorporate various brick patterns (running bond, soldier, and stack bond courses) and project outward from the main façades with stepped courses and corbeled brackets. The remaining portions of the parapet walls are straight and flush with the main building façades. The top of the parapet walls were originally capped with limestone units and overlaid with aluminum sheet metal. The roofing membrane was turned up onto the backside of the parapet wall and terminated underneath the original limestone coping units.

Wiss, Janney, Elstner (WJE) investigated an ongoing water leakage issue at the top-floor level along the exterior walls. Interior water leakage was observed at the

drywall soffits above the balcony doors and at various random locations within the field of the exterior wall to the fifth-floor ceiling. Our investigation started with limited water testing followed by inspection openings in the masonry façade to document concealed as-built details and material conditions.

During our investigation phase, we reviewed the original architectural and structural drawings that were provided by the ABAA (hereinafter referred to as “the association”). Details were limited for the parapet wall construction, and differences were noticed between the architectural and structural sets.

In the structural drawings, the concrete masonry unit (CMU) backup wall was identified to be reinforced with vertical reinforcing in fully grouted cells at 16-inch centers. The structural drawings also called for the CMU course above the head of the fifth floor window to be a reinforced, fully grouted bond beam. This bond beam was shown to provide support and anchorage for the steel bar truss roof joists. These details were not called out or referenced on the architectural drawings. Our limited inspection openings at the parapet provided evidence that indicated that some of the design details had not been constructed. For example, open head joints in the backup CMU course above the fifth floor windows were open, indicating that it was not a solid bond beam.

Water testing of the exterior face of the parapet walls was performed using a calibrated spray rack. Testing produced interior leaks at window heads directly below the shelf angle. Face brick was removed above

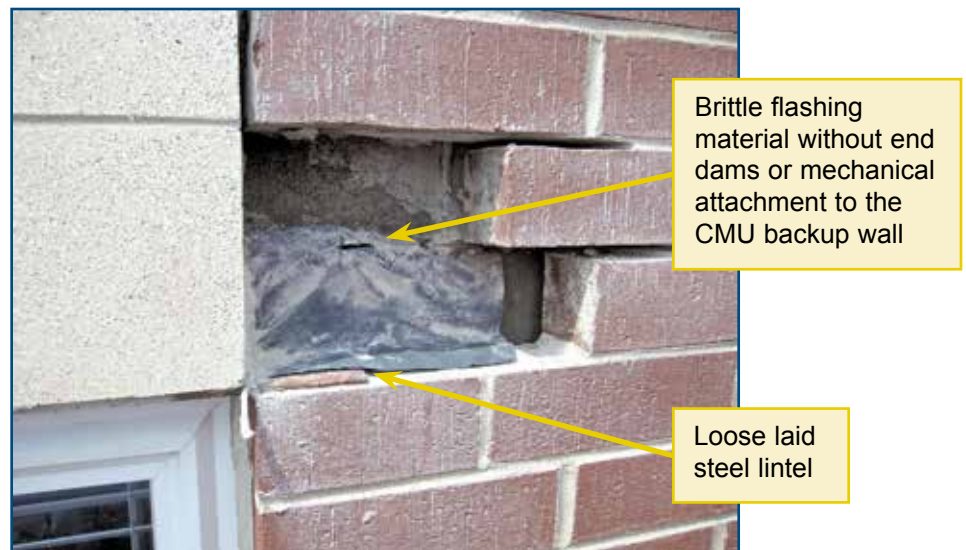


Figure 1 – Typical view of inspection opening with inadequate flashing details.

the shelf angle at the fifth-floor windows to observe the condition of the underlying flashing and construction of the façade walls. The inspection openings revealed that the original flashing had numerous issues, including but not limited to embrittlement of the flashing membrane that allowed cuts and splits in the membrane, lack of sealant at membrane splices, lack of mechanical attachment of the membrane to the backup wall along the top leading edge, and missing end dams at the ends of lintels (*Figure 1*). In addition to flashing issues, the as-built construction of the wall system was also problematic. The backup wall was CMU with open head joints. No flashing system or weather barrier had been applied to the backup wall, and the cavity space between the backup wall and the backside on the face brick was insufficient for a true cavity wall system. The cavity space was actually a collar joint that measured approximately ½ to ¾ in. wide and was partially filled with mortar.

Based on our testing and observations from the inspection opening, we determined that the interior leakage was a result of improper flashing details and installation, and as-built construction. Water that entered the parapet wall past the face brick could migrate past the flashing system and enter into the building. We recommended that the face brick from the window head of the fifth floor, up to and including the parapet coping, be removed to allow for the installation of new flashing at the window head, repair of the backup wall construction, installation of a new weather barrier on the backup wall, and reconstruction of the brick veneer with new copings.

Because our initial investigation was limited in regards to the amount of masonry removed, we were not able to verify the construction of the parapet wall in terms of its reinforcing and structural capacity. Therefore, we discussed with the association our concerns that the existing parapet walls were not constructed as originally designed and recommended that the structural system of the backup wall be reviewed as part of the repair project to the flashing system.

Once the association retained a masonry contractor, the removal of the brick veneer began. When a substantial amount of the veneer was removed, we began our evaluation of the backup wall and structural system. The sheet metal and limestone copings were removed from a portion of the wall.

Looking down at the top of the CMU backup wall, it was observed that the cores were filled with mortar and debris. The contractor drilled down into the cores at numerous locations and determined that the fill was only approximately one course deep. Since vertical reinforcing and vertical grouted cells could not be identified from the top view, we used a metal detector in an effort to locate vertical reinforcing bars. When vertical reinforcement was not detected, the masonry contractor drilled holes in the CMU wall to verify whether or not cells were grouted solid as per the spacing call-out on the structural drawings. Vertical reinforcing or grouted cells were not encountered at any of our inspection locations.

In some areas, the contractor removed the face cell of the CMU at the course directly above the window head to verify whether or not a bond beam existed at this location. We observed that horizontal reinforcement was installed at this course level, but the CMUs were not grouted. The reinforcement was loosely laid in the CMU and was not engaged. During our structural investigation, we also reviewed the anchorage of the roof joists. The top flanges of the joists were observed to have been installed into and bearing on the interior face shell of the CMU wall. The ends of the joists were not mechanically fastened to the building.

Since the backup wall did not appear to have any reliable structural reinforcement, we performed a limited structural analysis of the existing parapet walls. Calculations revealed that the as-built taller parapet walls at the building corners and center of the façades were not adequately con-

structed to resist wind loads specified in the Chicago Building Codes for the time the building was constructed. Based on these observations, we presented additional repair options to the association to address structural deficiencies. Structural repair options included the following:

- Install vertical reinforcement at 16-in. centers and grout the cells solid to resist the required wind loads or reduce the height of the taller parapet walls to an adequate height.
- Install 6-in.-long horizontal steel bars at the roof joint embedment location. These bars would be welded to the flange of the joists, and the cells grouted solid to provide positive anchorage of the joists to the building structure.

Since a contractor was already on site and moving forward to perform the original repair scope of work, the association moved quickly in making repair decisions. They decided to reduce the overall height of the parapet walls to a consistent height around the building and install the supplemental anchorage at the ends of the roof joists.

With the additional structural repair work defined, the entire scope of repair work consisted of the following:

- Reduced the parapet wall height to approximately 16 in. above the roof level. CMU and brick veneer were removed and the top course of the remaining CMU wall was grouted solid to allow for anchorage of wood blocking and installation of a new

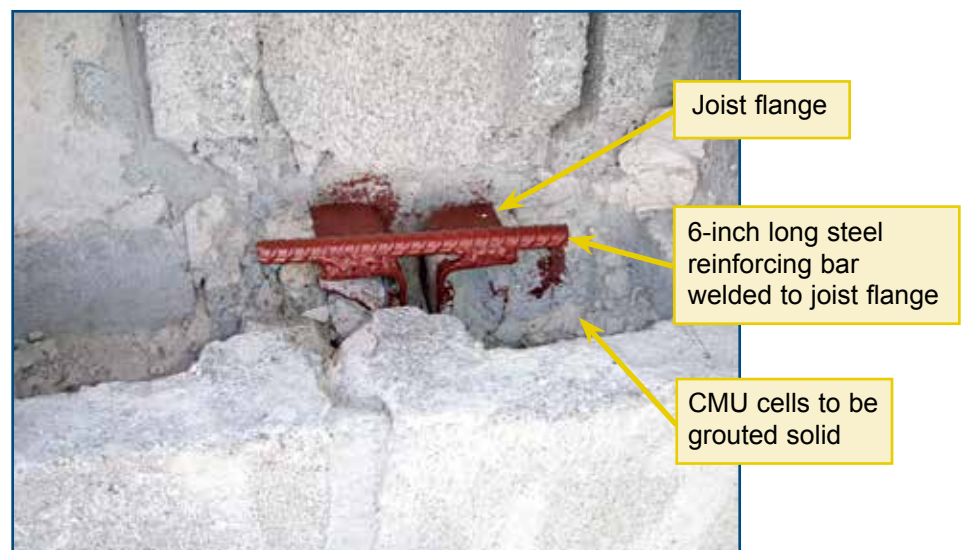


Figure 2 – Typical repair of steel joists in CMU wall.

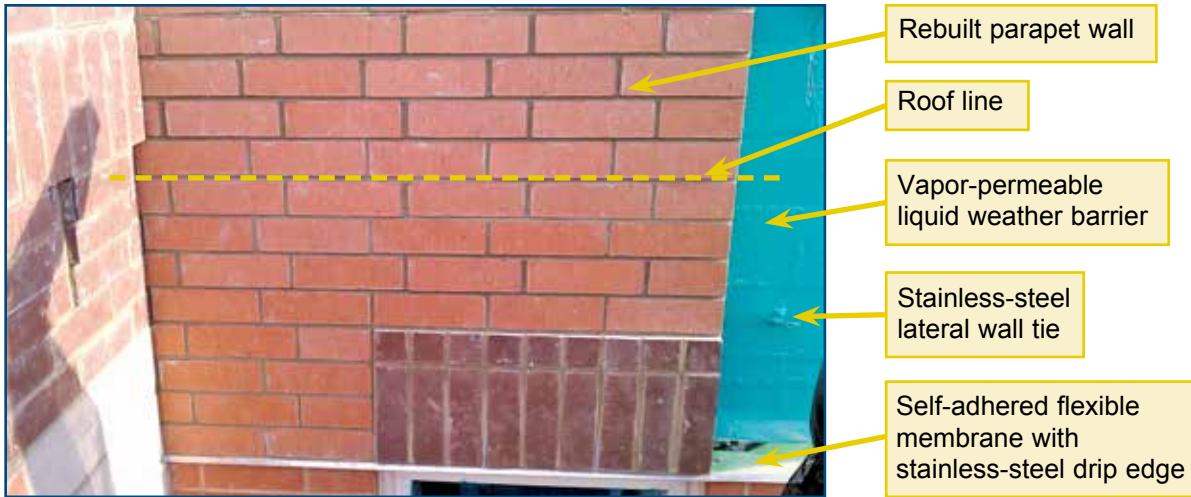


Figure 3 – Typical repair at parapet wall.

metal coping.

- The exterior face shell of CMU was removed at the embedded joist locations, and new 6-in.-long horizontal steel reinforcing bars were welded to the top of the joist flanges. The cells with the horizontal bars were grouted, and the face shells reinstalled. See *Figure 2*.
- The remaining CMU backup was pointed to fill the open joints solid.
- Steel shelf angles were cleaned and painted. None of the angles had experienced significant section loss; therefore, replacement was not required.
- A vapor-permeable liquid weather barrier was applied on the exterior face of the CMU wall.
- Self-adhered flexible membrane was installed on top of the shelf angles and turned up onto the face of the backup wall.
- Stainless steel lateral wall ties were installed at 16-in. centers vertically and horizontally and staggered for

the height of the parapet wall.

- New face brick was installed, with plastic cell vents at every other head joint and placed directly on top of the lintel at the top of the fifth-floor windows.

See *Figure 3* for typical view of parapet repair.

To prevent the new parapet wall from looking like a typical flat surface, we utilized some aspects of the original parapet wall, such as using two different brick colors (one color at the flat walls and one color at the building corners and center of the façades) and various brick patterns at the building corners and center of the façades. These areas of decorative brick patterns also incorporated changes in the plane of the wall to provide an aesthetic appearance that mimicked the original design. See *Figures 4* and *5*.



Figure 5 – Building façade after completed repairs.

Figure 4 – Building façade before repairs.

CASE STUDY 2

Background

Our next case study is a nine-story residential building, rectangular in plan, with dimensions of approximately 100 ft. by 75 ft. Construction of the building was completed in 2001. Within one year of completion, a routine façade inspection required by the City of Chicago Building Code identified crack-

ing and displacement of brick at the parapets and façade corners. In 2002, masonry repairs were performed at the parapet. In 2003, cracks and distress in the masonry parapets were again reported and subsequently repaired. In 2004 and 2006, the center section of all four-parapet walls, equal to 50 percent of the total length, was rebuilt in another effort to address issues of cracking and displacement. Later in 2006, the parapet wall was deemed to be imminently hazardous during a routine façade examination of the building as required by the code. The building installed a protective sidewalk canopy in 2006 to mitigate the life safety hazard. In 2007, the building owners contacted WJE to investigate the cause of continued cracking and displacement of the masonry façade and parapet and to provide repair recommendations.



Figure 6 – View of the south façade of the building in 2007.

The Design

The residential building is clad with brick masonry veneer with punched window openings on all four façades. Steel lintels support brick masonry and CMU at openings in the exterior walls. No shelf angles were provided in the field of the brick masonry walls. The structural system for the building consists of precast hollow-core concrete floor planks supported by load-bearing CMU walls. The openings in the façade occur as single windows or as ganged windows separated by masonry piers. Vertical bands of brick soldier courses project slightly from the plane of the brick field and extend from the first floor to the parapet. The construction of the façade is similar on all four sides of the building. See Figure 6 for a view of the south façade in 2007.

As originally designed, the parapets are two wythes thick and three brick soldier courses tall that are corbelled outward (Figure 7), and the lowest parapet brick course is arched above the ganged window bays. The inner wythe of the parapet consists of six courses of running-bond brick supported on hollow-core concrete roof planks.

The use of hooked anchor bolts for the coping and the use of shading symbols in the collar joint cavity behind the brick veneer on

the original design drawings demonstrate that the collar joint between the brick veneer and CMU backup at the parapet is intended to be fully grouted. The original drawings specified horizontal adjustable-truss reinforcing in the cavity wall installed at 16 inches on center. The specified compressive strength of the masonry (f'_m) was 2,500 psi using a type “N” mortar.

The original design drawings specify four vertical expansion joints to be provided on each façade. Horizontal expansion joints are not specified on the drawings.

The EPDM roofing membrane was shown in the original drawings to extend up the backside of the parapet wall and over the blocking for the aluminum coping.

The as-built condition of the parapet varied from the original design and was altered a number of times in attempts to repair the distress exhibited by cracking and inward displacement of the masonry. The as-built condition of the parapet in 2007 consisted of a collar joint filled with mortar and brick above the roof slab, typically without lateral ties. See Figure 8 for typical as-built condition during parapet disassembly in 2008.

The Issues

Within a year of completed construction, an investigation by other consultants revealed cracking and displacement of the masonry parapet wall. A 2006 investigation by another consultant revealed maximum inward leans of the parapet walls to be 4 to 6 inches from the vertical plane of the wall, which resulted in the 2006 “imminently hazardous” classification.

Our investigation in 2007, six years after completion and after multiple repair campaigns, revealed the current state of the parapet wall consisted of an inward lean of approximately 1 to 3 inches in three vertical feet at the top-three soldier courses of brick masonry above the arches (Figure 9). Cracking of mortar joints and brick masonry also existed on the parapet (Figure 10).

After inspection openings were made to determine the construction of the parapet, a structural evaluation was performed to evaluate the as-built construction. The structural evaluation concluded that the brick

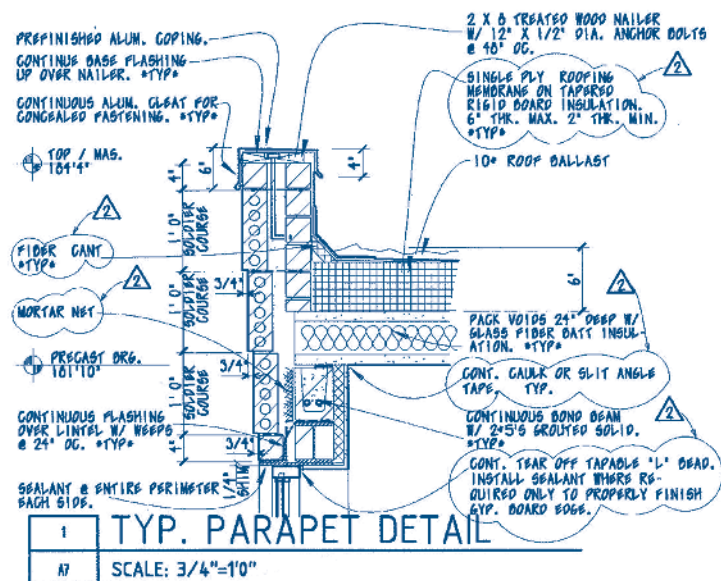


Figure 7 – Typical parapet detail from the original design drawings.

veneer and typical exterior bearing walls were structurally adequate to resist design loading. However, evaluation of expansion and shrinkage of the façade resulted in the total differential movement between the CMU backup wall and the brick veneer of approximately 1.2 in. The estimated vertical expansion (moisture and thermal) of the brick masonry for the full height of the building was approximately 0.9 in., and the estimated total shrinkage of the CMU was approximately 0.3 in. This differential movement is consistent with the observed angle of displacement at the parapet wall.

The total differential movement was more pronounced at the parapet due to lack of relief angles and horizontal expansion joints in the field of the wall, which accommodate differential vertical movements by creating brick “panels” that move with the structure. In the field of the wall, the brick veneer and CMU backup were “isolated” with a cavity wall and adjustable lateral ties, permitting independent movement. In contrast, the parapet was constructed in a manner that integrated these two systems, essentially bridging the isolation. Due to the sum of differential movements increasing at higher levels, this integration resulted in the inward lean of the parapet and cracking of the brick masonry. The inward lean was more pronounced at the center along the length of the parapet wall due to the

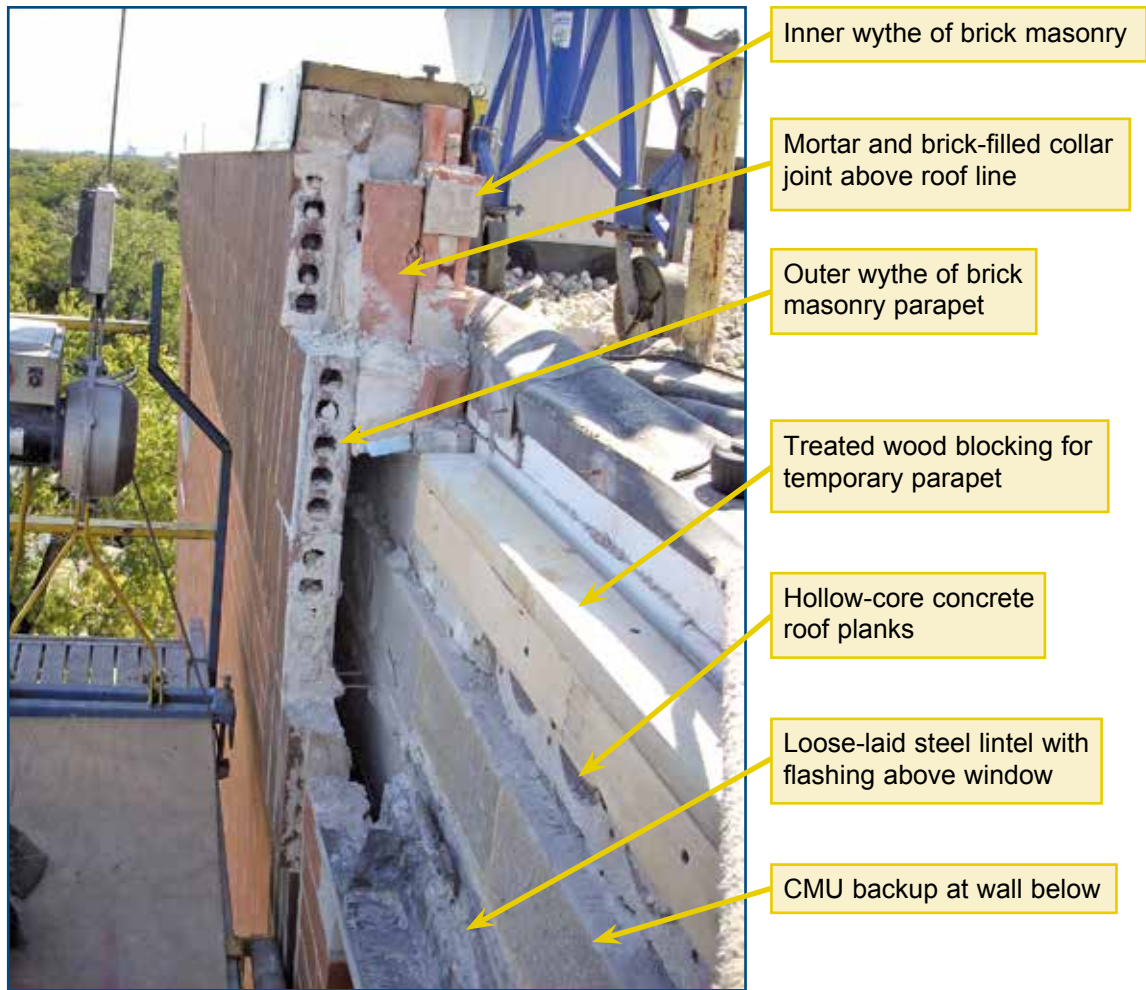


Figure 8 – As-built condition of the parapet from 2007. Photo taken during parapet disassembly in 2008.



Figure 10 – Typical cracking of mortar joints at parapet wall in 2007.

Figure 9 – Typical inward lean of masonry parapet wall in 2007.



Figure 11 – Temporary treated wood-framed parapet wall installed in 2008.

inherent stiffness at the corners of the parapet, which helped to restrain movement. Cracking and displacement of the brick masonry also existed at other locations in the field of the wall, primarily adjacent to window locations where the “isolation” of the two systems was bridged by steel lintels and window frames.

Repair


Following the investigation, we recommended that the parapet be disassembled and redesigned. In 2008, the parapet was disassembled and replaced with a temporary parapet constructed of treated wood studs, plywood, and roofing membrane. The EPDM roofing warranty holder was contacted to coordinate the removal of the parapet so that the existing roof warranties were not voided. (See *Figure 11*.)

Construction of a new parapet is currently in progress. The new parapet design consists of light-gauge, steel-stud framing with a brick veneer in running bond, and an aluminum coping at a height of approximately 2 ft. above the roofline. The light-gauge, steel-stud framing is anchored to the hollow-core concrete roof planks with powder-actuated fasteners. The brick veneer is laterally tied back to the framing with stainless-steel lateral anchors spaced at 16 in. on center. Vertical expansion joints are designed to be installed in the same location as the existing vertical expansion joints.

The water management system of the parapet wall consists of self-adhered wall flashing in the cavity wall with end dams and weeps. The design of the new roofing flashing system was coordinated with the EPDM roofing warranty holder to ensure that the tie-in of the new roofing system does not void the remaining warranty of the

roof. The tie-in of the new roofing flashing consists of a fully adhered EPDM flashing membrane extending over the wood blocking and down the back face of the parapet, and adhering to the existing EPDM membrane with seam tape. A reinforced membrane attachment with seam plates and fasteners will be integrated at the interface of the parapet wall and roofing to ensure the membrane does not fail at the corners. See *Figure 12* for a typical parapet repair detail.

CONCLUSION

Masonry parapets serve a variety of functions for a building and exist in many different forms. From the decorative to the purely functional, proper detailing of parapets requires understanding of the number of systems and materials that interface at the parapet wall. Construction of parapets requires the coordination of many trades and ideally includes construction observation by the architect to verify that the as-built conditions adhere to the design intent. The issues associated with masonry parapets are similar to those found in the field of a masonry façade. However, determining the causes and the appropriate repairs for the issues observed at the parapet wall requires an understanding of the systems and materials utilized, proving that sometimes, the last few feet are the most challenging. 

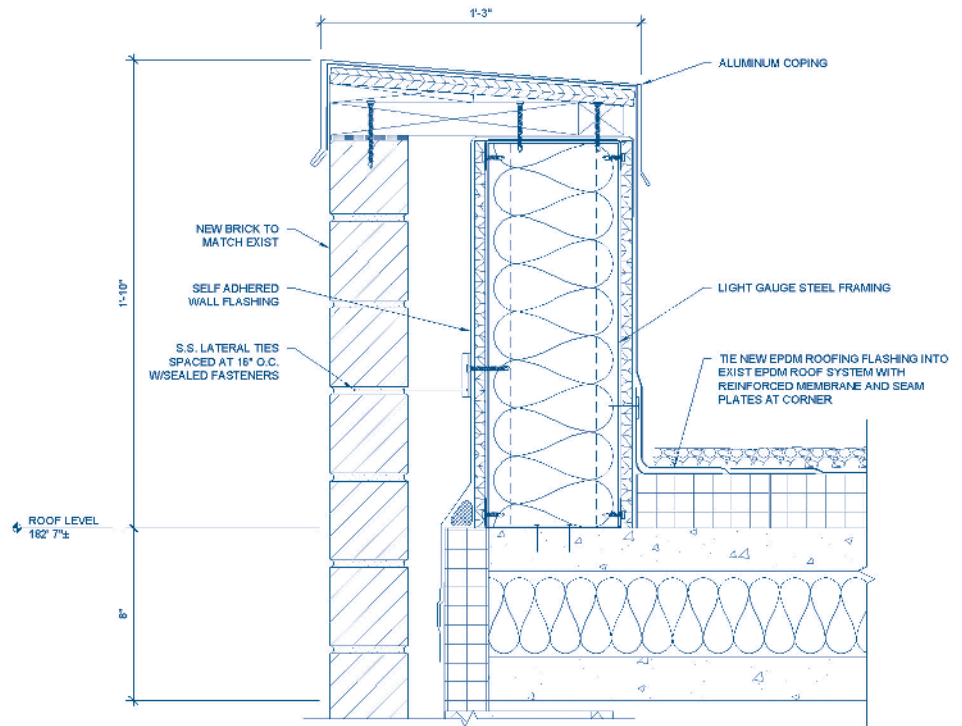


Figure 12 – Typical repair detail for a new parapet wall.