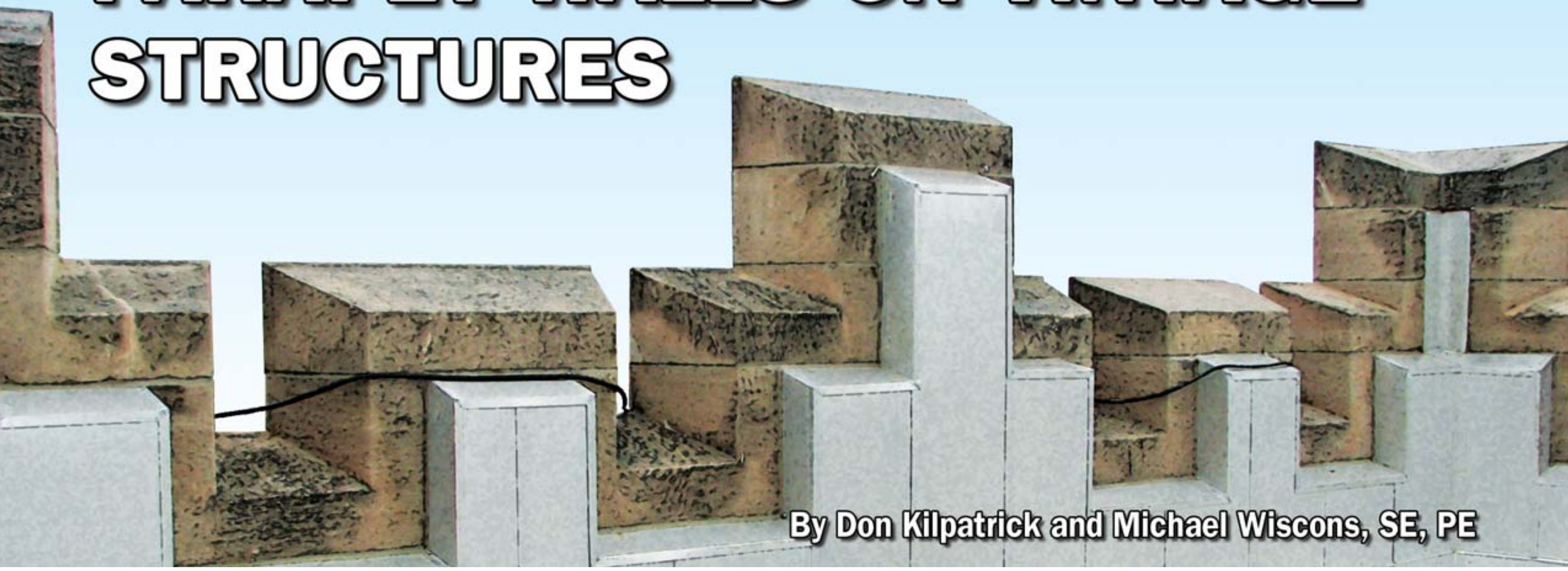
REPAIR OF ABOVE-ROOFLINE PARAPET WALLS ON VINTAGE STRUCTURES

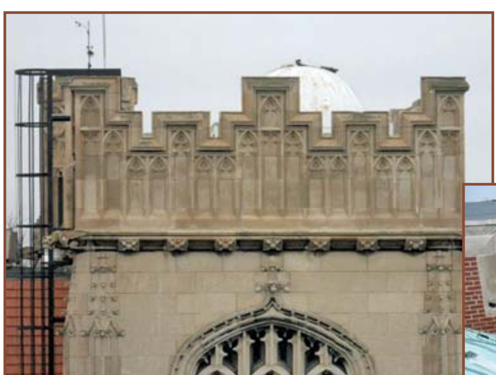


By Don Kilpatrick and Michael Wiscons, SE, PE

Our nation's inventory of vintage structures has evolved to include a broad range of signature features. Many vintage structures have crenellated above-roofline parapet walls with heights ranging from 12 in. up to 10 ft. above the roofline, with the latter commonly referred to as battlements. Historically, the regular intervals of projected high (merlons) and low (crenels) points provided cover and openings from which combatants could exchange fire with the enemy. Architects of the 19th and 20th centuries included these features, focusing on the form as an architectural embellishment rather than the original function, which went the way of moats, drawbridges, and dungeons. This type of construction features a geometric, symmetrical-toothed appearance at the top of the parapet wall, commonly as in-fill between projected buttresses and neighboring outcroppings of even higher towers and turrets.

It is not unusual for a design professional to perform a due-diligence evaluation on a vintage structure for an owner considering roof replacement. Often, the mind's eye turns from the involved roof area, only to find that the adjacent near- and above-roofline parapet walls are exhibiting varied levels of distress. This place marker in a building's history brings renewed meaning to the "out of sight, out of mind" adage often thought reserved for the roofing side of the building envelope industry. In some instances, the conditions (out-of-plane, deteriorated brick masonry back-up, evidence of movement) have evolved to a point resulting in challenges for the project participants. The seemingly routine task of roof design expands to include the potential for masonry restoration, minimally to an extent that will offer the new roof cover the promise of a service life consistent with the effort. At the extremes of the conditional variables are the low-profile installations, perhaps 12-18 in. above a partially hidden integral gutter, to parapet wall installations that reach heights of 6-10 ft. above the adjacent roofline. Lower parapets are commonplace at the gutter line on steep-sloped roofs. The higher parapet walls offer continuity to the gothic theme while offering a means to conceal the presence of a low-sloped interior roof area.

Vintage structures—seemingly simple compared to current construction practices (e.g., air and vapor barriers, rain screens, cavity walls, through-wall flashings)—rely on the condition and performance of varied interfaced components working together as an assembly for optimum performance. In the absence of current-era sophisticated building envelope features, this type of construction is inherently more susceptible to the elements than any other building envelope component, being subjected to weather



Photos 1A and 1B – Examples of a "crenellated" parapet wall or battlement as identified by the alternating high (merlon) and low (crenel) points of the feature.

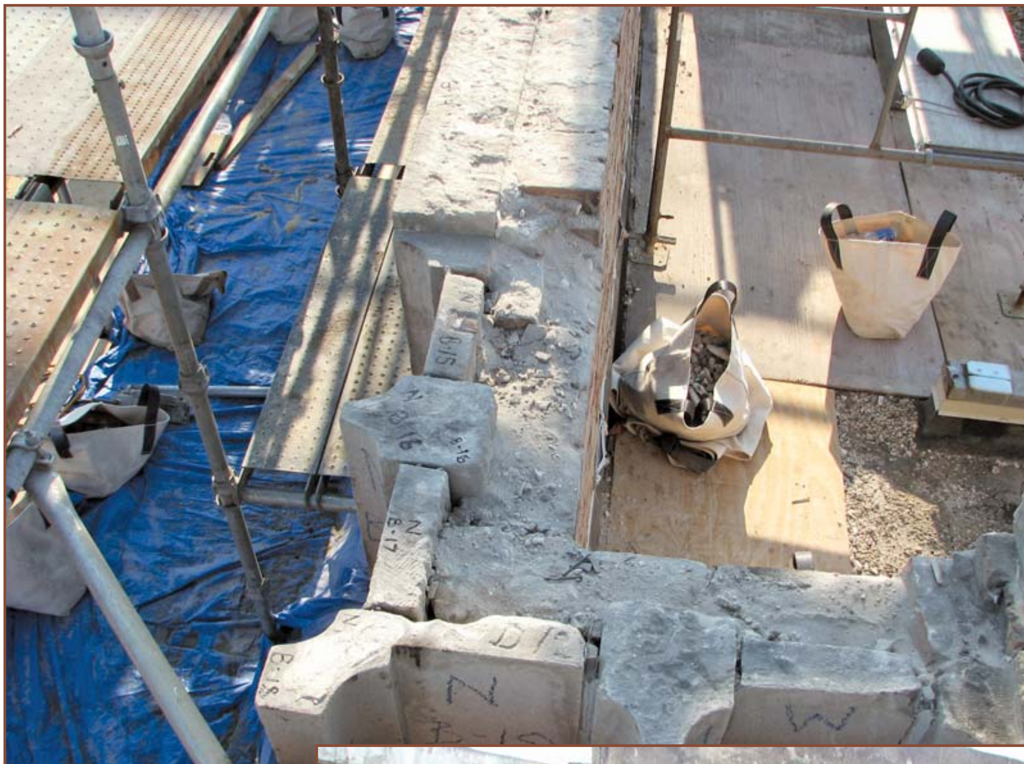


Photo 2 – Cut/carved stones labeled for correct spotting during reconstruction.

Photo 3 – During demolition, the transition from single-wythe backup (A) to multiple-wythe (B) is observed.

extremes on both faces. Depending on the height and overall condition of the feature, the key parameters of performance move from a water management problem centered on roofing and accessory flashings to a structural issue. Components of these stone-clad outcropping walls usually consist of a full-depth capstone dressing the upper limits and providing transition from the exterior-cut/carved stone wall to the brick masonry. The underlying multiple-wythe brick backup wall on the interior and the cut-stone ashlars on the exterior support the capstone assembly. Acknowledging the skyward-facing joinery of the stone copings, craftsmen of the era occasionally set sheet copper flashing between the stone copings and underlying coursing of stone and brick. If present, this flashing may represent the only effort made by the original construction team to manage water.

Upon discovery, the design professional would reasonably be expected to provide the owner with some form of supplemental report of findings. Generally speaking, it is prudent to—at the very least—have a licensed structural engineer perform a review of the conditions where any ornate above-roofline stone/masonry work is considered. The structural engineer has the responsibility to ensure that the components of the building envelope are safe and conform to the applicable building codes. This can be a challenging task and requires particular attention.

Typically, when a deficient masonry component is identified, its repair is somewhat intuitive. Degraded mortar in masonry

Photo 4 – Rebar set for forming and pouring of a new concrete beam above existing roofline.

Photo 5 – Forms stripped, exposing interior face of new concrete beam fitted with embedded weldments.

joints requires routing and tuck-pointing. Cracked bricks or limestone ashlars end up being replaced or repaired. However, parapet walls in need of repair cannot always be merely replaced in kind. Parapet walls, like all other exterior cladding, must be capable of resisting stresses induced by horizontal wind and seismic loads. Since parapets are laterally unsupported at the top, they behave as cantilevers. Some current building codes require that parapet walls be built to withstand wind loads of a larger magnitude because they are subject to simultaneous windward and leeward wind forces, both acting in the same direction. For example, the current Chicago Building Code stipulates that a wind load of 40 psf should be applied to parapet walls. This is more stringent than the typical wind load applied to building structures.

Vintage structures were built in an era prior to the sophisticated masonry codes that we have now. Up until the middle of the 20th century, masonry structures were designed empirically. Architects used rules-of-thumb based on height-to-thickness ratios of the wall in order to design the masonry. The walls were generally robust and did not contain any reinforcing steel. However, the empirical design did not account for special conditions or unique calculable loads

Photo 6 – Stone requiring field cut to accommodate new tolerances established by the concrete beam.

Photo 7 – Reinstallation of cut/carved limestone cladding with stainless steel anchors.

established by current provisions of code.

Current masonry codes require parapet walls to have vertical reinforcement unless the stresses are small enough to satisfy unreinforced masonry criteria. Hence, there is a need for a structural analysis of parapet walls requiring reconstruction. The engineer or architect proficient in structural evaluation needs to determine if the existing above-roofline feature has sufficient capacity to safely resist the applicable lateral wind and seismic loads imparted onto it. Shorter parapet walls with a height of only a couple of feet generally have adequate strength. However, taller parapet heights cannot be merely replaced in kind.

Most building codes require reconstruction of components to satisfy the current

Photo 8 – Fully integrated zinc- and tin-coated copper receiver flashings below stone copings.

Photo 9 – The introduction of new, galvanized structural framing elements above the original roofline.

requirements. That means that parapet walls deficient by current standards must be rebuilt to meet the more stringent criteria. This generally means that tall parapet walls requiring reconstruction need reinforcing with vertical rebar dowelled into the wall below the roofline in order to attain sufficient strength. Therefore, the parapet wall must be engineered such that vertical rebar of adequate size and spacing can be installed so that the stresses in the wall are within the allowable limits. Whether the newly rebuilt above-roofline feature requires vertical reinforcing or not, it must be properly fastened to the roof framing such that the lateral loads can be transferred into the roof deck (diaphragm). In extreme cases, the capacity of the existing roof diaphragm is insufficient to transfer the code-stipulated lateral loads and requires reinforcement or possible reconstruction.

Depending on the height of the

Photo 10 – Fully completed parapet and new roof assembly.

parapet wall, the additional cost to rebuild the wall to meet current codes can be substantial. This need for a structural review along with the understanding that mere in-kind replacement of deteriorated masonry parapet walls is not always acceptable should be taken into account during the building's condition assessment.

Based on the order of magnitude for the work under consideration, it is also reasonable to require that any scaffold/work platforms be designed by a licensed engineer to ensure that they have sufficient capacity to support workers, equipment, and materials. Most qualified scaffold services are familiar with this and have a means to provide drawings for the project record.

The anatomy of the walls in sections below the capstone usually is composed of random ashlars (referring to the coursing and cut/carved stone cladding) in the field of the wall, ranging in thickness from 4-8 in. nominally, of varying lengths, widths, and, in some instances, ornamentation. The 4-in. stones are typically mechanically anchored to the brick backup materials with mild steel straps resembling heavy staples. Their engagement with the brick masonry backup materials (as many as one or more brick courses toward the interior of the multiple wythe wall) and adjacent stone is a clear indicator that the walls (backup and stone cladding) were built concurrently. The 8-in.-deep stones are set into pockets of the brick masonry backup as a means to further tie the interior and exterior wythes together.

On projects in which the scope includes the complete reconstruction of the brick masonry backup wall—utilizing a steel-reinforced, fully grouted CMU wall section—the 8-in. bond stones may need to be field cut to 4-in. thickness so as not to interfere with the continuity of a bond beam and/or reinforcing steel set in the fully grouted cells of the new backup. Any new steel (generally limited to anchors for resetting of the stone, in the form of pins and clips) should be of stainless steel.

In summary, reroofing, partnered with extensive exterior wall rehabilitations—more notably on vintage structures—requires building envelope consultants who can convey to their clients the need for a significant amount of forward planning and to work with them to understand the hand-in-glove relationship of seemingly disparate elements of our built environment.

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Don Kilpatrick has been with Inspec, Inc. for 25 years, fulfilling varied roles ranging from laboratory supervisor to project manager. For the past eight years, he has been involved in master planning of multiple projects at the University of Chicago. Don is an active member of RCI, serving on the Peer Review Editorial Board for *Interface* (to which he is a regular contributor) and is a past recipient of the Horowitz Award.

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