Measuring Up to Steeple Remediation

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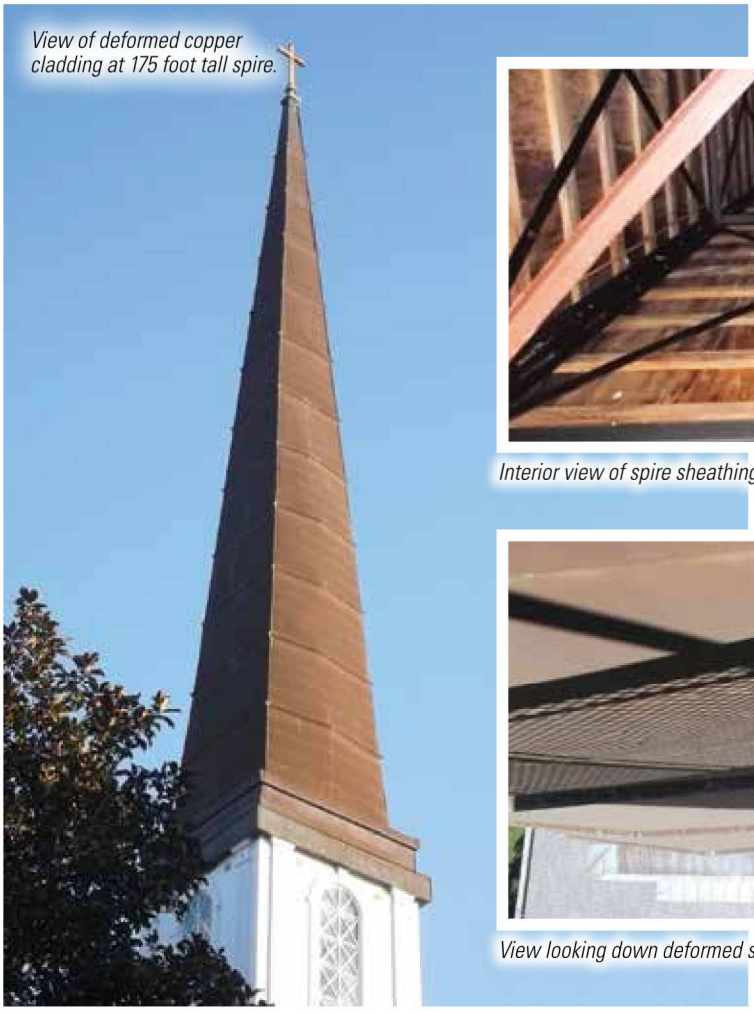
Prior *Second Chances* articles have reviewed both structural and material characteristics in buildings and remediation challenges that can arise. In this article, church spires and steeples are discussed. As with any assembly, considering the materials involved is imperative to develop appropriate remediation strategies to extend the serviceable life of these structures. When working on steeples and bell towers, investigations can expose unsuspected deterioration or impaired conditions that are otherwise concealed from the owners or maintenance staff. Like many roofs and building claddings, these assemblies are frequently only viewed from a distance, and regular maintenance is not always performed due to challenges accessing these elements.

Thus, proper care is frequently postponed until bigger issues emerge. So, when assessments are implemented, the opportunity must be seized to get appropriate information to develop remediation strategies and educate owners regarding regular maintenance needs. Three bell towers are briefly discussed below that represent different challenges and corrective actions that were not initially apparent.

Metal Clad Bell Tower in Summerville, South Carolina

A 175-foot tall bell tower in Summerville experienced recurring distress, raising the church's



View of deformed copper cladding at 175 foot tall spire.

Interior view of spire sheathing construction around the braced steel framing.

View looking down deformed spire cladding from crane basket.

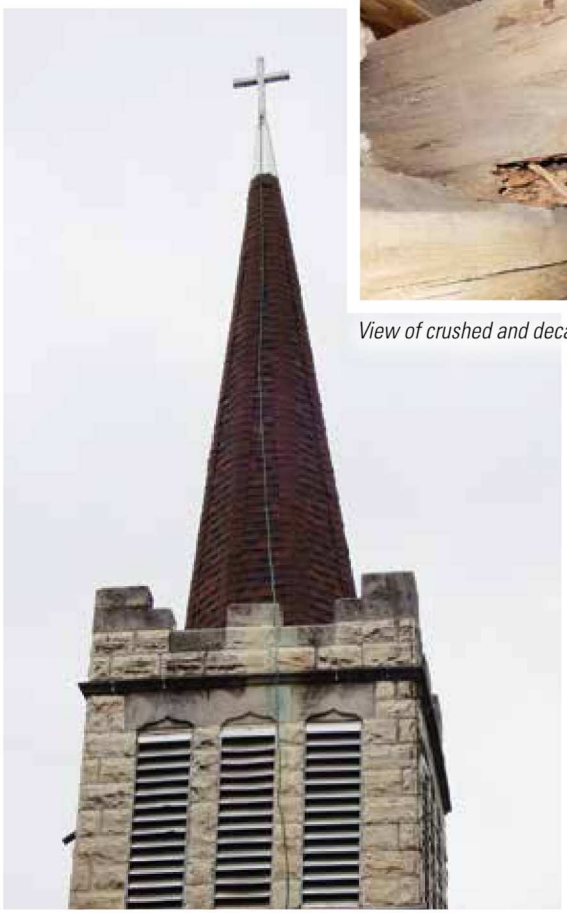
concerns regarding copper cladding on the pyramidal spire above the tower belfry. The distress was initially attributed to hurricane activity along the coast, but closer examination revealed other factors as well. This structure, built in 1976, required spire cladding repairs address wind damage caused by Hurricane Hugo in 1989. In 2003, similar but less extensive distress was reported and patches at copper tears and failed attachments were installed. In 2018, spire cladding concerns were again raised and the damage was suggested to have been the result of Hurricane Matthew (October of 2016 event). However, Matthew only resulted in winds of approximately 50 to 60 mph and gusts of 70 mph in the vicinity of the tower. This results in approximately 50 percent of the wind loading required by the 1976 codes. Thus, other contributing factors were suspected.

Structural assessments revealed that the spire's braced steel armature could resist code wind loads. However, plywood sheathing supported by 2x4 wood members secured to the corners of the steel frame comprised the copper-cladding substrate, and was too flexible. When negative wind pressures pulled on the cladding, this sheathing assembly was vulnerable to significant deflections with even moderate wind loads. Deflections resulted in crimping of the metal and the copper sheets experienced tears and deformations. Further inspection revealed that the copper had been installed over the plywood without underlayment. The lack of an underlayment subjected the plywood to moisture from recurring condensation on the inside face of the copper when dew-point temperatures are experienced — a frequent occurrence in the southeast United States region. Wet plywood reduced pull-out capacities of the cladding fasteners and promotes rot, further weakening cladding support. Thus, repairs that include a stiffer sheathing support and a properly detailed underlayment were recommended with cladding remediation.

1895 Spire in Lemont, Illinois

The Lemont church tower and belfry is a stone masonry structure with a wood framed spire built around 1895, and is 90 feet tall. The spire is clad with asphalt shingles and adorned with a metal cross. Concerns regarding apparent decay at the belfry roof framing prompted our inspection. Our investigation revealed that advanced decay of the timber framing led to member crushing and

View of crushed and decayed timber.



Partial view of leaning spire at 1895 church in Lemont.

Removal of spire for future restoration.

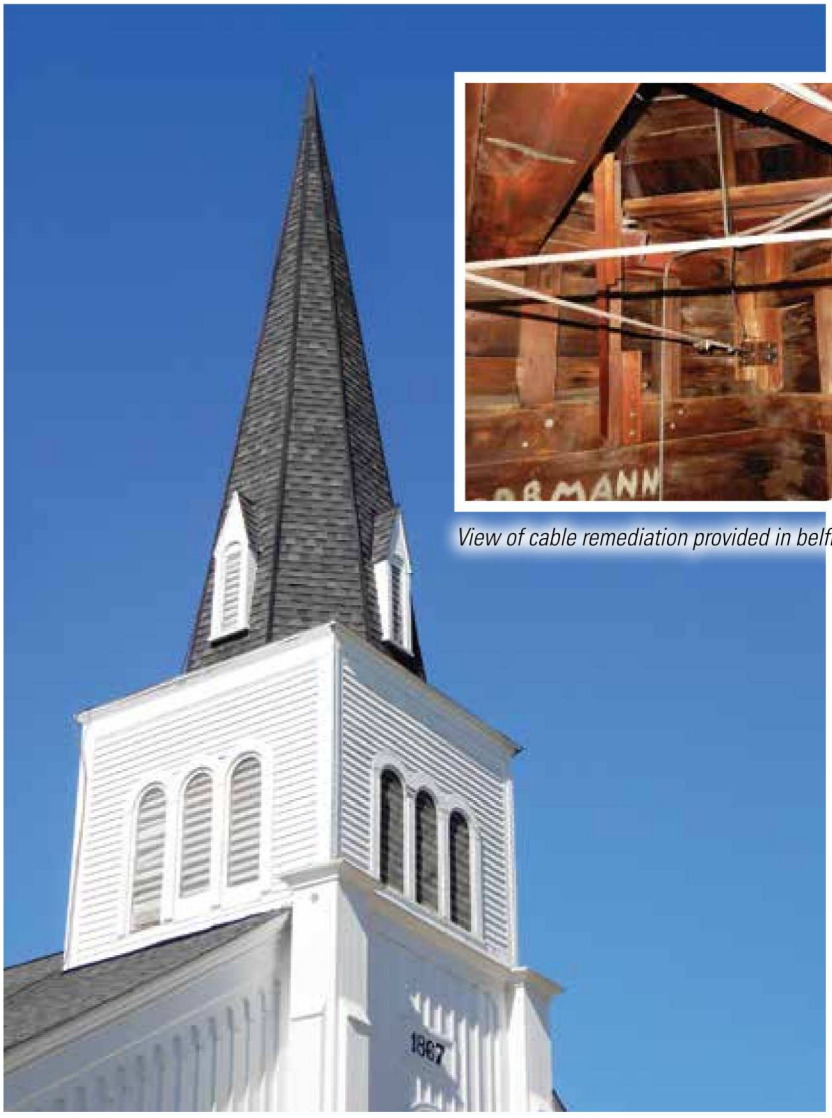
corresponding leaning of the spire. Though the stick-framed spire generally remained intact, the extent of framing decay demonstrated that moisture infiltration had been ongoing at its base. Support deterioration and spire displacement posed significant safety concerns regarding whether the spire may collapse under even moderate wind loads.

Temporary stabilization was not practical as shoring systems would have hampered church functions, obstructed future repair implementation, and was costly. Thus, the objective was to develop a strategy to immediately remove and salvage the spire for future restoration.

Temporary roof details were also prepared to enclose and protect the belfry until restoration work could be performed. Removal work included the extraction of rotted timbers and bell-ringing mechanisms. Detaching the spire revealed that the sole anchorage of the 35-foot tall wood cone was a single 1/2-inch diameter bolt through the spire mast and a strap to the decayed framing. Consequently, all parties involved were very relieved when this element was safely secured to the ground. Modifications of this spire attachment along with enhanced water management at the spire base will be necessary as part of the restoration effort.

1867 Bell Tower Restoration in Crystal Lake, Illinois

The Crystal Lake tower and belfry is a timber assembly centrally located at the front of the Gothic Revival church. The tower structure has mortise and tenon joinery that encloses the belfry and has a stick-framed octagonal spire above clad with asphalt shingles. Water infiltration



Partial view of 1867 bell tower from the exterior.

View of cable remediation provided in belfry.

occurring near the tower base and belfry, and apparent water staining and framing distress within the belfry prompted further review and assessment. We examined the bell tower and provided remediation recommendations. Our inspection revealed areas of decay within this framing, though conditions were generally dry when measured with a moisture meter. Past structural repairs and apparent reinforcing efforts were noted. Steel straps and cables were installed that secured opposing corner posts as an apparent measure to enhance lateral stability of the framing as a number of timber knee-braces were no longer intact. Supplemental framing, steel straps, and angles had also been secured to the spire framing that were somewhat irregular, but generally appeared intact. Other more recent plank-sheathing was observed that was reportedly part of cladding repairs from 1957. An interior sheet metal roof at the belfry floor was is in poor condition and vulnerable to moisture that could bypass wood louvers at the belfry walls. Irregularity in the cladding near the base of the belfry and open seams within metal flashings were also observed from the exterior.

The tower was dry, well ventilated, and generally intact. However; damaged framing members and missing bracing components had impaired the structure's ability to resist lateral loads. Though the steel cable installations may have been performed to help correct framing deficiencies, structural analyses revealed the cables lack the necessary stiffness to effectively resolve load paths. Consequently, the structure was vulnerable to lateral movement when subjected to moderate wind events. These movements damaged to the exterior wood cladding, created flashing system breaches and introduced paths for moisture infiltration.

Recommended repairs included properly reinforcing the structure to provide a reliable load paths against wind loads, replace the metal roofing within the belfry, and repair belfry louvers and affected cladding. Further examination of the spire roofing was also recommended so that asphalt shingle issues and flashing be corrected as appropriate.

Summary

Spire and bell tower structures, like other building systems, necessitate a methodical approach that considers both material and environmental conditions for their assessment and repair. These structures experience extremes in wind forces, temperature, and moisture resulting from seasonal changes. Temperature ranges and humidity (particularly with metal and/or non-porous cladding) results in additional moisture sources that need to be accounted for. Also, as demonstrated in the copper clad spire above, the rigidity of the cladding substrates need to be compatible with the cladding attachment systems.

Regular inspections are an important part of tower maintenance. Though older structures may produce challenges in completing these tasks, it remains vital that proper assessments be performed with attention to water management systems included. During inspections, structural considerations and awareness of material behaviors is vital when identifying sources of distress and developing remediation strategies. When assessments are scheduled, critical information must be captured to get a complete picture of the issues at hand. These structures must be evaluated by a knowledgeable professional familiar with these constructions who can develop meaningful repair strategies to extend the serviceability of these elements.

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