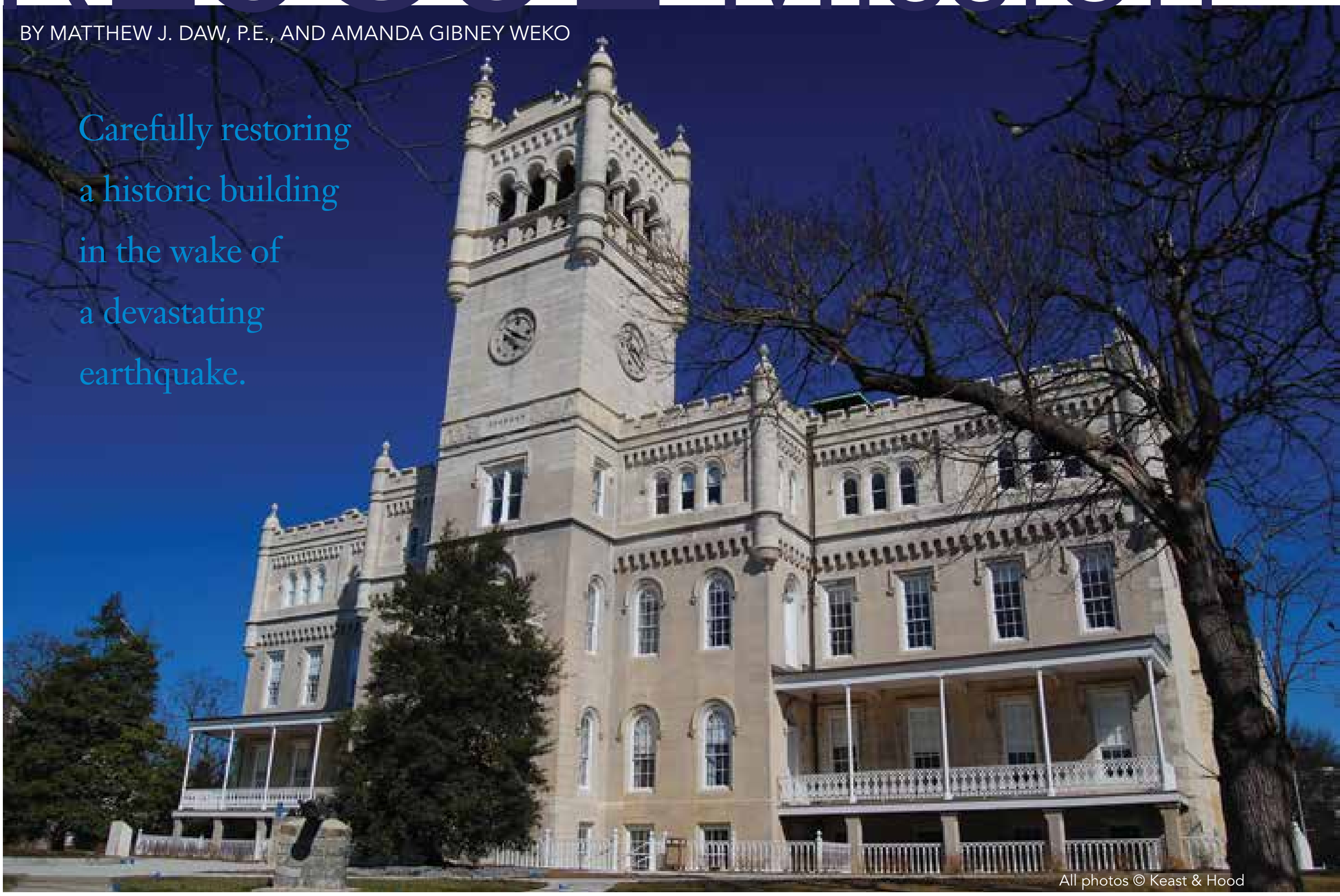
RESCUE Mission

BY MATTHEW J. DAW, P.E., AND AMANDA GIBNEY WEKO

Carefully restoring a historic building in the wake of a devastating earthquake.



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▲ The renovated Sherman Building, a piece of national history and a safe haven for veterans, was heavily damaged in a 2011 earthquake.

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IN AUGUST 2011, a 5.8-magnitude earthquake centered in Mineral, Va., inflicted significant damage to numerous buildings throughout the Mid-Atlantic region.

One of these was the Sherman Building. Constructed from 1852-1891, the three-story building and its iconic clock tower form the heart of the Armed Forces Retirement Home. The 272-acre federal campus in northwest Washington, D.C., provides a fully operational retirement community for U.S. military veterans, and since 2007 has been designated a historic district on the National Register of Historic Places and the D.C. Inventory of Historic Sites.

The earthquake impacted many of the 85 buildings on campus, but few as seriously as the Sherman Building, where it collapsed walls, destroyed interior finishes, fractured timber roof trusses and left the masonry exterior with significant cracks, holes and fallen stones. Furthermore, masonry displacement indicated major structural damage.

Over the next two years, a design-build team collaborated to assess, stabilize and restore the building. They worked closely with the U.S. Department of the Treasury Bureau of the Public Debt and the Armed Forces Retirement Home to keep the fast-track project on schedule and under budget, and Veteran residents returned to the building just six months after construction began.

➤ Steel was used to reinforce damaged heel joints in the attic's timber roof trusses.

Based on the team's extensive evaluation, the building required reinforcement and seismic upgrades as well as restoration. Structural steel intervention into the fragile unreinforced masonry structure played a crucial role in the process. Using RAM Elements software to design and detail the new steel structure, structural engineer Keast & Hood sensitively and strategically wove roughly 10 tons of new steel framing elements into the historic building fabric, strengthening the existing structure and bracing the masonry for long-term seismic protection. The steel came in the form of roughly 40 pieces, most of them in the 10-ft to 15-foot range: W14×48, W12×53, W12×30 and W6×16. The 26-ft-tall columns were made of HSS10×10×½.

A steel braced frame was added to the open area of the clock tower, with reinforced masonry shear walls added below the deck. Existing parapets and chimneys were reinforced with concealed structural steel reinforcing and Cintec anchors. Engineers provided positive mechanical anchorage of the exterior masonry walls to the wood-framed floors and bonded the dress stone to the structural masonry backup with concealed helical anchors. Positive anchorage was also provided at the original cast iron portico using concealed stainless steel fasteners.

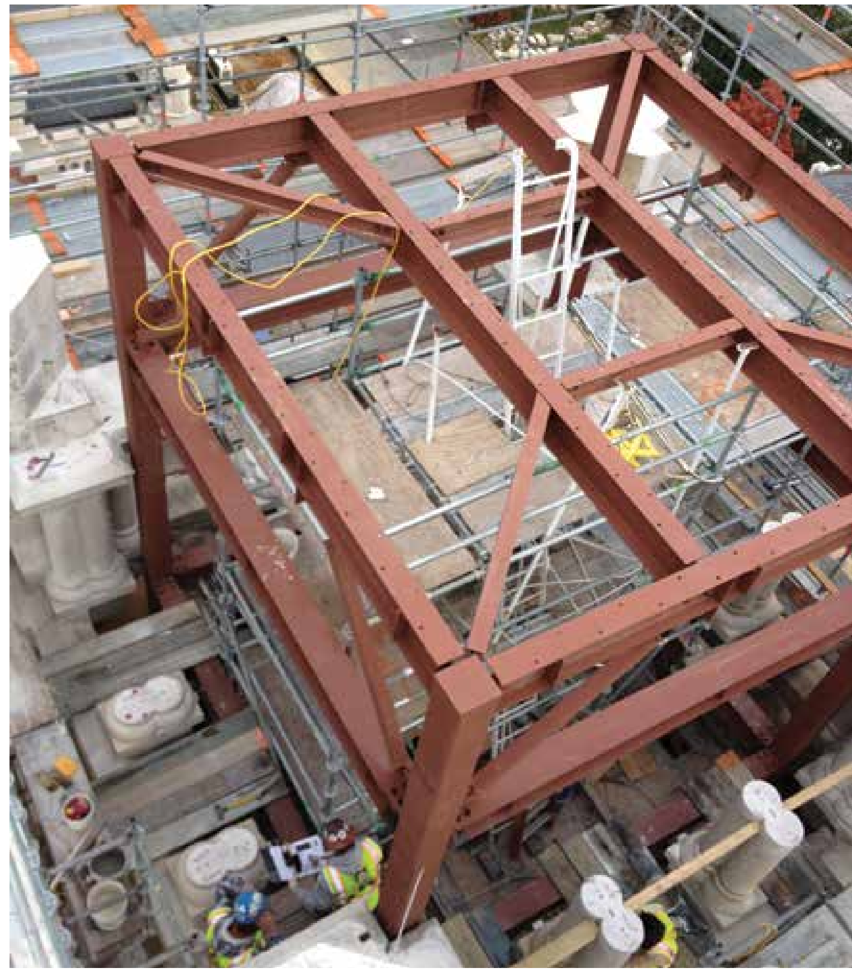
Due to the design-build nature of the project and the irregular building geometry, the structural solution incorporated very little conventional framing. The most common pieces of structural steel were tube shapes and wide-flanges used to frame the clock tower reinforcing and replace the original ramps. Angle pieces were used to create new frames for masonry support. A significant amount of cold-formed plate was used where new steel strap anchors were introduced at the floor levels and wall intersections, and structural steel channel was used to repair roof trusses.

Reconstruction Time

Much of the structural recovery scope focused on reconstructing the iconic 130-ft clock tower, which suffered the most damage. Additional structural work included assessment and reconstruction of retaining walls, ornamental parapets, chimneys and timber roof trusses.

The team performed a digital point cloud laser-scan survey in the field to understand the building's geometry and displacements. The survey documented existing conditions within the tower's unique configuration and the building's unusual geometry to ensure accuracy in repairs.

In response to the extent and severity of the observed distresses, partial deconstruction of the tower was required. Over 20 courses (rows of bricks) of the masonry tower were dismantled and rebuilt around a new structural steel eccentric braced frame (EBF) assembly in conjunction with selective internal reinforcements. Existing conditions such



▲ New internal steel framing in the partially deconstructed tower.

➤ The partially deconstructed clock tower and the new steel frame.

Internal reinforcements within the reconstructed clock tower.

as rounded stone edges, tapering brick backup and the varying cuts and sizes of the original stone impacted the design.

Although engineers investigated alternative reinforcement options for the tower (options included shotcrete, cast-in-place concrete and reinforced masonry), steel was chosen because it offered flexibility for design and construction. This decision also made sense from safety, schedule and aesthetic perspectives. Steel could be fabricated off-site and installed quickly, benefitting the project's fast-track schedule.

Steel erection only took a few days, and installation required scaffolding the entire tower and deconstructing the tower to a working level just below the existing clock tower deck. New steel was installed using a self-erecting tower crane. A new CMU shear wall was built to support the base of the internal steel frame. A scaffold system was then erected in the third floor office to the underside of the clock level. Due to the tight confines of the existing spiral stair, which was blocked by the scaffolding, a small opening was cut in the clock level floor to haul block pallets and other construction materials up into the tower.

Tucked Away

New and innovative building designs often express structural steel as part of the architectural vocabulary. In the case of the historic Sherman Building, the structural steel insertion was carefully sized and painted to be hidden from the exterior view within the open clock tower, while maintaining accessibility within the tower interior. The effort represents the delicate balance of structural reinforcement and historic preservation required by the project. In addition, using steel at the upper open levels of the tower allowed for the strengthening and anchorage of unreinforced single-wythe stone masonry without adding significant weight to the tower or its foundations. It also provided necessary support to new CMU wall panels installed to offer additional strengthening of the fragile exterior stone shell.

Within the attic, existing wooden roof truss distress was visually apparent, with damage related to both the earthquake and years of moisture decay and termite infestation. Heel joints at the exterior walls, already weakened by earlier deterioration, failed during the earthquake and caused wall separation. Structural steel again made a suitable intervention. The existing timber trusses required an in-depth review using non-destructive resistance drill testing. Since no two trusses were exactly alike, structural steel made a suitable intervention.

Taking cues from the firm's past historic intervention approaches, notably Philadelphia's Academy of Music, Keast & Hood engineers designed steel reinforcements that were carefully threaded into the attic to reestablish the truss heel-joint connections with the wooden trusses. The design necessitated a detailed survey by the fabricator and meticulous installation. Carpenters from Oak Grove Restoration Company worked in tandem with fabricator Crystal Steel to install each new piece of steel by hand.

Large protruding corner turrets were repaired with a grouted sock anchor approach. Stainless steel threaded rods within fabric socks were inserted into dry core-drilled holes in the masonry and filled with cementitious grout for proper bond and compatibility with the historic fabric. This solution stabilized the fragile masonry while providing permanent reinforcement for the turrets and tower. The main chimneys also collapsed during the earthquake and required new structural elements to replace the fragile and flexible masonry structure. New stainless steel armatures were installed to resist future seismic activity and wind loads, with original stone masonry rebuilt around the new frames.

In addition to structural reinforcement, masonry restoration, railing and roof repairs and other preservation efforts were made to bring the Sherman Building back from devastation. More that 3,000 stones in retaining walls, chimneys and parapets were salvaged, catalogued and rebuilt using nearly 100% of the original hand-carved marble. The $14 million project not only restored the building but also reinstated the home and sense of national pride for 500-plus military veterans who reside in the Armed Forces Retirement Home and the Sherman Building. ■

Owner
Armed Forces Retirement Home, Washington, D.C.

Contractor
The Christman Company, Reston, Va.

Architect
Quinn Evans Architects, Washington

Structural Engineer
Keast & Hood, Washington

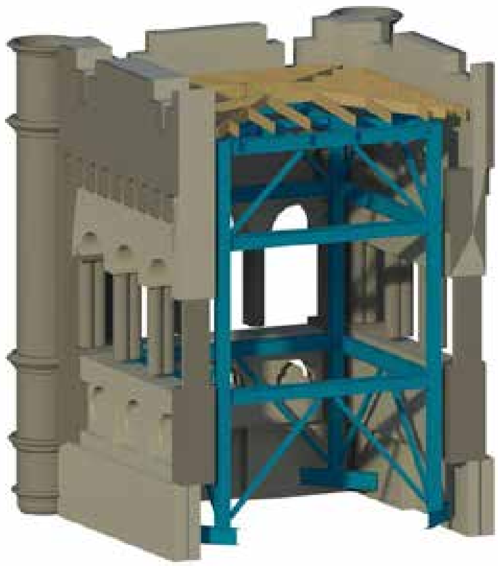
Steel Team

Fabricator and Detailer
Crystal Steel Fabricators, Inc., Delmar, Del
(AISC Member/AISC Certified Fabricator)

Erector
Williams Steel Erection Company, Inc., Manassas, Va.
(AISC Member/AISC Advanced Certified Steel Erector)

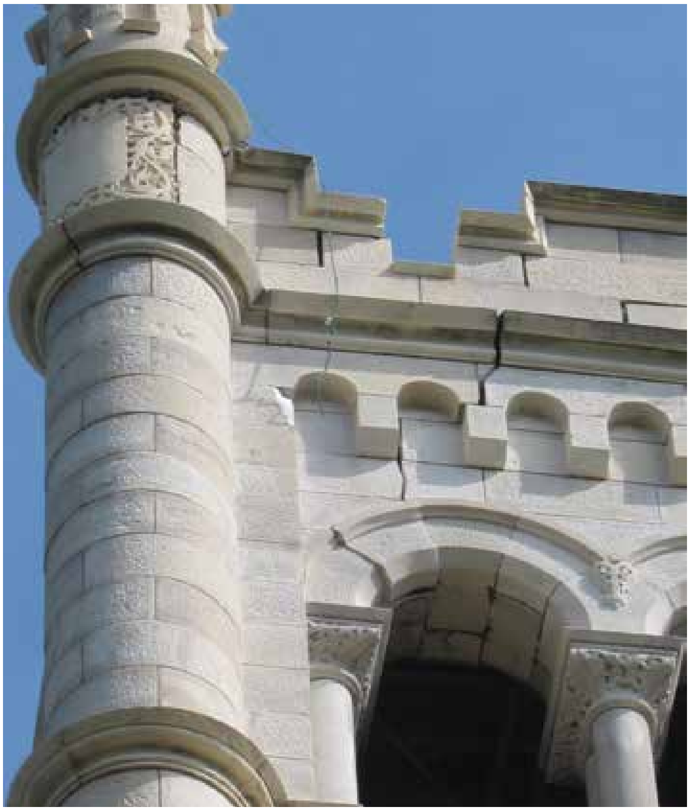
➤ Following the earthquake, significant structural distress was observed at the Sherman Building, with the most damage evident at the clock tower. In the southwest corner view of the tower, masonry displacement, gaps and missing stones are visible.

▼ Damage to the timber roof trusses was a result of both the earthquake and years of deterioration from moisture infiltration and insect infestation.



▲ A 3D model of the tower steel, which was modeled using point cloud data as a reference. The point cloud was taken after the earthquake and documents the stones in their displaced locations as well as stones that were removed for safety. The steel in the tower was placed to avoid conflict with the reconstructed stone elements.

◄ The steel frame was carefully constructed and painted to be hidden from view within the open clock tower.



▲ The new structural steel frame and wood decking in the clock tower as viewed from below.

▼ Contractors assemble the new steel frame within the masonry clock tower.