Assessment and Repair of Historic Plaster Systems (Part 1)

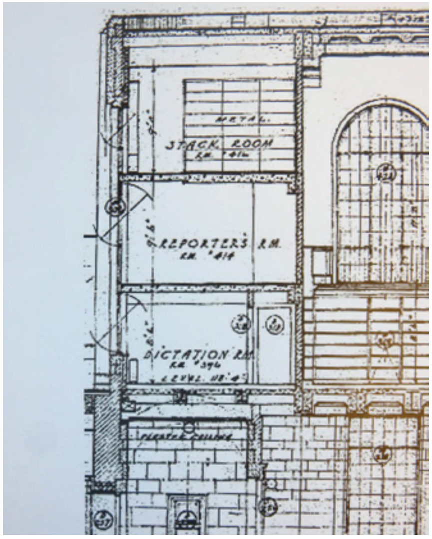
BY TIMOTHY M. CROWE, ALA, SE, PE AND KENNETH ITLE, ALA, AIA

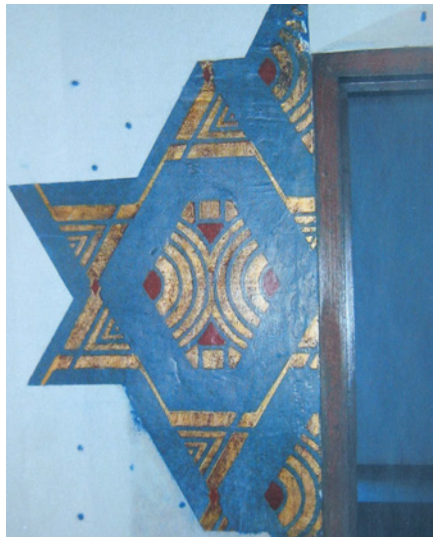
Gypsum plaster is often a character defining material of historic interior spaces. Plaster can be formed and molded into an unlimited variety of shapes, and decorative finishing techniques can make plaster a key aspect of interior design. However, plaster is also vulnerable to loss, and historic finishes can be damaged by water infiltration or inappropriate modifications to building structures or mechanical systems. Plaster can be a durable product that has demonstrated a long serviceable life when properly installed and maintained. With historic structures, a proper assessment of the existing plaster is critical to the successful repair or remediation. Beyond moisture related issues, assessment of the underlying structure assembly is important to diagnose plaster distress effectively. This two-part article will present case studies that examine two different plaster remediation projects that presented technical challenges where performance assessments, mock-ups, laboratory testing, and structural modeling proved valuable to verify adequacy of proposed repairs. The first project includes corrective measures to enable the long term restoration of interior plaster finishes within the law library of the Nebraska State Capitol.

Nebraska State Capitol Library

Plaster finishes within the law library reading room of the Nebraska State Capitol have been problematic since the original building construction. The reading room was built as part of the first phase of the Capitol construction in the 1920s and is shown in Figures N-1 and N-2. The Capitol was constructed in four phases from 1922 to 1932. The reading room measures approximately 40 feet long (east to west) by 32 foot wide (north to south) and has a ceiling height of approximately 29 feet. Book stack storage and ancillary spaces flank the

Nebraska State Library
Figures N-1 top, and N-2 bottom. Historic photo from Capitol archives (left) looking west, and view of plaster distress conditions at library wall.





Figures N-3 left, and N-4 right. Partial section through library (left) from the original drawings. A view of the concealed ornate gilded finish is shown to the right in Figure N-2.

room at the east and west sides. A section through the reading room and adjacent storage and support areas is shown in Figure N-3. The wall construction consists of scored terra cotta tile with direct-applied plaster, supported by steel framing and concrete floors. The plaster walls were initially painted a plain color, as seen in Figure N-1. Decorative finishes were subsequently applied to the walls as the Capitol construction progressed.

Horizontal cracks within the wall required repair campaigns that ultimately led to the decorative finishes being covered with an off-white coating. Finishers were further disrupted by the addition of mechanical systems (supply air registers) at the east and west sides of the reading room around 1965. The plaster repairs had been performed to cover horizontal cracks along floor beams located at the stack storage rooms on both the east and west sides of the room. As part of larger scale building improvements, the Office of the Capitol Commission—a group of architects, archivists, artisans, and additional staff who act as stewards of the landmark building—commenced a study of the finishes of the room. Exposure windows (careful removal of finishes in selected areas to expose painting schemes) revealed the historic green paint and gold stenciling shown in Figure N-4. The ultimate goal was the restoration of this historic finish throughout the room.

However, the horizontal cracking shown in Figure N-2 and N-5 was a recurring phenomenon that needed to be addressed to confirm that the cracking would not recur after finish restoration. To help determine the cause of the cracking, field examination of the finish materials and assemblies was performed. Laboratory microscopy of extracted finishes was also performed to review the coating layers and composition. Given that the cracks were located in line with the stack storage floor, a structural analysis was also performed to assess movement within the floor assembly.

Inspection openings confirmed that the cracks in the plaster corresponded to the top and bottom surfaces of the encased beam within the wall. The cracks on both sides of the room generally ran parallel to the top and bottom edges of the encased beam but converged to a single crack before reaching the south wall. To the north, the cracks along the top of the beam turned upward, and the cracks along the bottom of the beam continued to the north wall of the reading room (Figure N-6). The upward-turning cracks corresponded with perpendicular masonry walls on the opposite sides of the east and west walls at this location.

The tile walls above and below the beam were built tight to the structural framing, with no accommodations for floor deflections or differential movements beneath the floor or roof framing. The plaster was a two coat system applied directly to the clay tile masonry and the concrete encasement of the beams. The two coats consisted of a 1/2 inch

N-5. Closer view of cracks on east wall of reading room toward the south (left). Note how the cracks parallel to the top and bottom edges of the encased beam converge to a single crack near the corner of the room. View of similar cracking on west wall of room (right).

N-6. Inspection opening at east wall of Reading Room. Note the underlying concrete-encased steel beam and terra cotta tile walls above and below.

to 3/4 thick brown coat (gypsum plaster with lime, sand, and animal hair), covered by an approximately 1/4 to 3/16 inch thick finish coat (gypsum plaster and lime). No lath was included in the system. Total plaster thickness varied between approximately 3/4 and 1 inch.

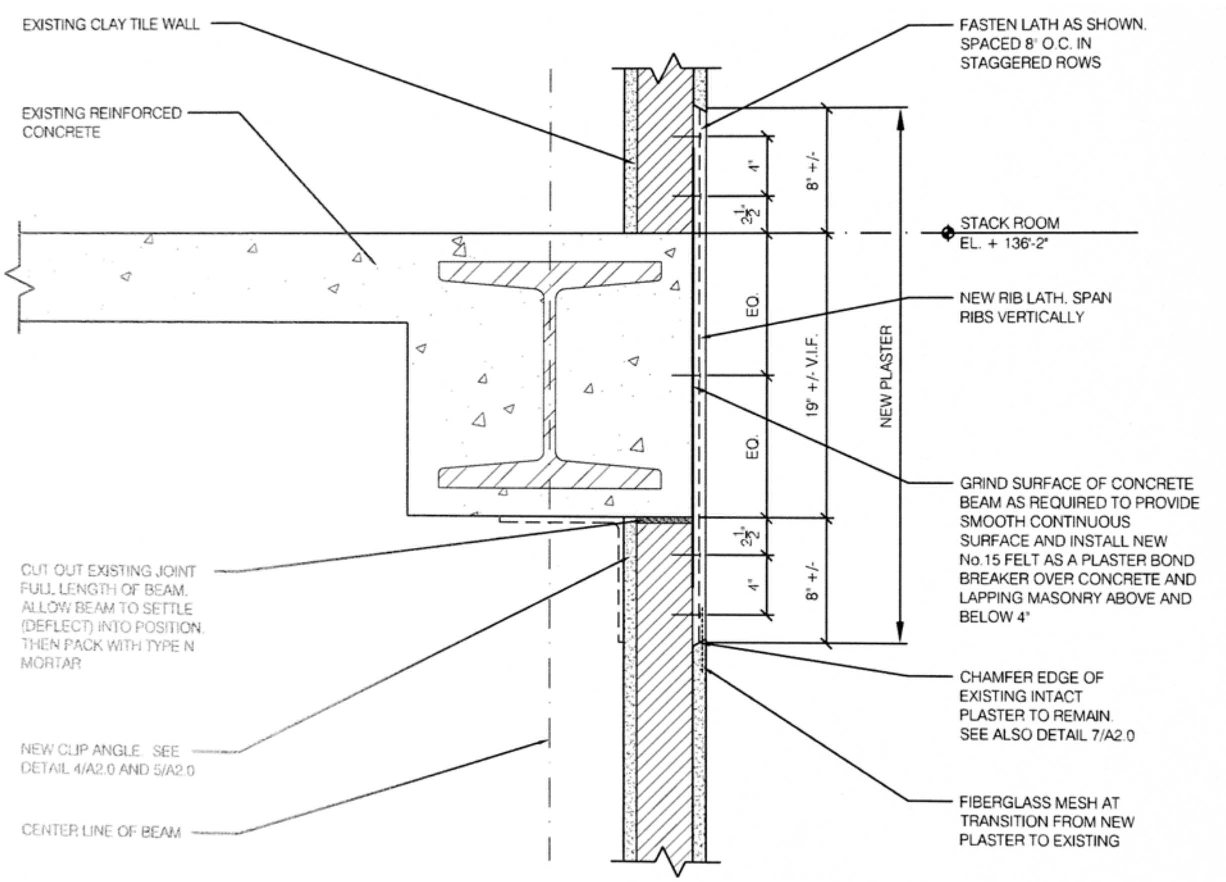
With information obtained on site and from original drawings, structural analysis of floor and roof beams was performed to evaluate strength and deflection characteristics. The analysis revealed that the floor beams have adequate strength to support anticipated loads and that deflections would be well within acceptable limits. Potential torsion/rotation of the floor beams was determined to be about 1 degree at the wall support in question. The roof framing was also within acceptable stress and deflection limits for code prescribed loads. Anticipated deflections of the beam along the wall were as much as 5/8 inch over the 32 foot span, depending upon composite action. This amount of deflection would typically be considered within acceptable design values, and torsional movement would be small. However, the clay tile infill wall and plaster finish restrain vertical movement at the floor and roof; therefore the wall lacks adequate flexibility to accommodate deflections of this magnitude. Consequently, when the structure is loaded, forces are transferred to the clay tile infill walls, contributing the recurring cracking of the plaster. Seasonal temperature variations within the roof would further contribute to cyclical movements within this assembly.

To assess whether the cracks remained active, plaster patches were installed, cured, and monitored. Loads applied to the stack storage were maintained at a constant value, and the patches were periodically inspected (Figure N-7). Cracks recurred within two months. During this period, mobilization for roofing work had occurred above the reading room. No excessive loads were applied, although vibration of the roof framing occurred with this mobilization. It was apparent that cracks resulted from restrained deflections and vibration of the structure under changes in loading, given the lack of differential movement accommodations at the roof and floor. The patches remained in place for several months and cracking was observed to worsen, clearly demonstrating that this movement is active and would recur in a restored wall if appropriate repairs were not implemented. Accordingly, repairs were developed to accommodate differential movement and avoid transfer of vibrations.

N-7. New cracks in patch at east wall observed after two months, with no changes in floor loading.

Two approaches were initially considered. Approach 1 consisted of furring out the wall and providing a new continuous plaster surface, isolated from the structural beams and clay tile infill walls. Approach 2 consisted of installing a flexible joint in the existing wall construction and finish beneath the floor beams. Both approaches included isolating the wall from the roof structure above. These options were quickly rejected as Approach 1 would alter the wall profile, and Approach 2 had aesthetic implications contrary to the restoration goal due to the addition of the new joint.

Restoring the historic plaster required that the wall plane remain continuous. Thus, a third approach was developed to relieve wall stresses and avoid a soft joint beneath the floor. This approach included cutting continuous joints through the wall beneath the floor and roof framing, to isolate the wall from the structure above. Lateral connections were installed at the top of the wall sections. A compressible joint was provided beneath the roof framing similar to Approach 1; however, the joint beneath the floor



N-8. Repair details for plaster installation over floor framing system.

framing was repointed after time had passed, to accommodate restrained deflection and then provide a sound substrate to receive a plaster finish (Figure N-8).

Repair of the horizontal cracks (at the floor beams at the stack room levels) required that existing plaster be removed for a distance of approximately 8 inches above and below the beam. The underlying masonry and concrete were examined and repaired, and new plaster was applied over metal rib lath that spanned vertically across the floor structure. The lath was secured to the masonry above and below, and to the concrete at the floor. Repair of cracks away from the stack room floor level also included removal of damaged plaster to underlying masonry, and installation of an expanded metal lath secured to the masonry. A multi-coat plaster system was then installed and blended into existing intact finishes, and is currently awaiting final repairs to finishes.

This repair will not entirely accommodate future vertical floor deflections; however, the addition of the rib lath provides ductility to better control cracks from changes in floor loading. The isolation of the roof structure reduced the transfer of vibrations and load effects from above. This repair was installed on a trial basis to allow monitoring over an extended period of time, prior to commencing a complete restoration of the interior plaster and conservation of the decorative finishes, to confirm that this approach will provide acceptable results.

In credits: *Work on the Nebraska State Capitol was performed in collaboration with Bob Ripley, FAIA, and Thomas Kaspar, AIA, of the Nebraska State Capitol Office of the Capitol Commission.*

Timothy M. Crowe, *ALA, SE, PE, is an Associate Principal with Wiss, Janney, Elstner Associates, Inc. (WJE) in Northbrook, Illinois, with over twenty-five years of experience in the design, investigation, and repair of archaic and contemporary building and structures. He can be reached at tcrowe@wje.com.*

Kenneth Itle, *AIA, is an Associate Principal with Wiss, Janney, Elstner Associates, Inc. (WJE) in Northbrook, Illinois, specializing in architectural preservation. He can be reached at kitle@wje.com.*