Assessment and Repair of Historic Plaster Systems

(Part 2)

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As discussed in the fall issue of Licensed Architect, gypsum plaster is often a character defining material of historic interior spaces. Formed and molded into an unlimited variety of shapes, and decorative finishing techniques, plaster can be 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. Decorative finishes can be lost or obscured due to gradual accumulation of dirt or poorly conceived attempts to "modernize" or "brighten" a space. 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 is the second part of a two-part article has presented technical challenges where performance assessments, mock-ups, laboratory testing, and structural modeling proved valuable to verify adequacy of proposed repairs. This project includes corrective measures to address detailing and finishes needed to restore an ornamental interior plaster ceiling finishes within Michael J. Howlett Building.


H-1. Overview of the Hall of Flags.

Michael J. Howlett Building

The second project involved the reconstruction of a collapsed decorative plaster ceiling and the supplemental anchoring of similar remaining ceilings. The Michael J. Howlett Building was constructed in Springfield, Illinois, in 1923, with additions in 1928 and 1966. It is a five-story stone-clad building housing State of Illinois offices. On the first floor is the Hall of Flags, a ceremonial space where Civil War Illinois regimental battle flags were displayed (Figure H-1).

On June 26, 2012, one bay of the decorative gilded plaster ceiling in the Hall of Flags collapsed and fell approximately 30 feet to the floor. Fortunately, building staff had noticed cracks in the ceiling the day before, and the room was unoccupied at the time. No structural distress, moisture infiltration, or outside influences were observed or reported that could have led to the ceiling collapse.

H-2. The center panel of the collapsed bay was constructed on metal lath secured by metal tie wire and remained intact.

H-3. View of plaster wads used to support the majority of the ceiling.

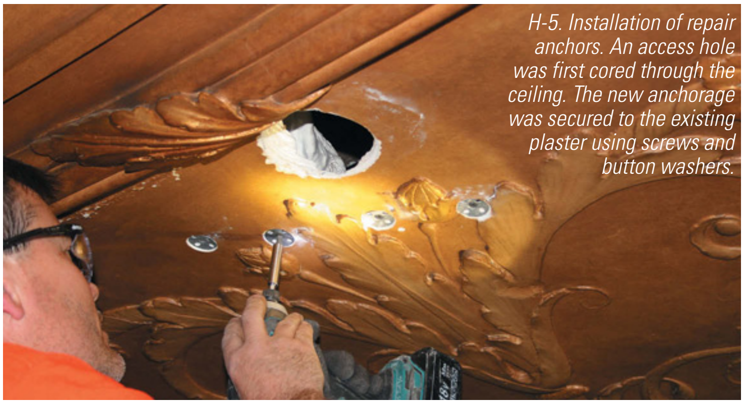
H-4. At the area of the collapse, plant fibers at many wads were found to be poorly integrated with the plaster.

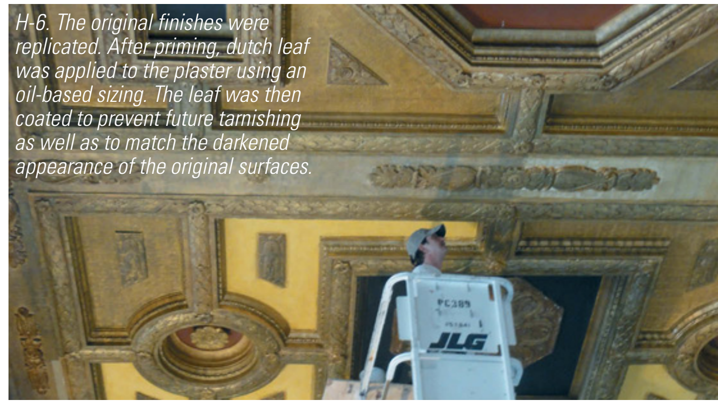
During the investigation, it was determined that the ornate plaster ceiling was actually built using two distinct assemblies. Relatively flat center panels in each bay were constructed of plaster applied to metal lath, and the metal lath was secured by wire ties to light-gauge iron framing above. This system was found to be robust; in fact, the center of the collapsed bay remained intact while the remainder of the ceiling fell around it (Figure H-2).

However, the majority of the ceiling was found to consist of fiber-reinforced pre-molded gypsum plaster elements (without lath), suspended from the iron framing above using plaster wads (Figure H-3). Plaster wads are hand-formed, tube-shaped elements reinforced with fibers. During construction, the wet plaster wads were applied to suspend the molded plaster elements. When the plaster wads dried, they provided a rigid support for the ceiling. Over time the plaster wads cracked, resulting in the collapse of the plaster ceiling.

Laboratory analysis determined that the fibers were jute, a plant fiber commonly used for plastering applications. However, as the fibers dry out over time, they gradually become brittle and lose strength. The investigation also revealed that the fibers within each wad were not well integrated with the plaster (Figure H-4); this deficiency in the original installation may have contributed to the gradual loss of strength and the failure of the plaster wads. The failure of one wad increased the loads applied to other adjacent wads, leading to progressive failure of the ceiling support.

Based on our investigation, installation of supplemental safety anchorage was recommended at all remaining portions of the Hall of Flags ceiling. The primary design for the supplemental anchorage is intended to support the entire gravity load of the plaster ceiling safely. At the subject ceiling areas, the remaining existing plaster wads are intact and support the ceiling. However, the long-term reliability of the existing wads is in doubt, and inspection and long-term monitoring of this support system is impractical if not impossible. Based on the experience of the June 2012 collapse, very few outward signs of deterioration were observed until an extensive portion of the ceiling failed. Therefore, a system was needed to safely support the ceiling even in the


H-5. Installation of repair anchors. An access hole was first cored through the ceiling. The new anchorage was secured to the existing plaster using screws and button washers.



H-6. The original finishes were replicated. After priming, dutch leaf was applied to the plaster using an oil-based sizing. The leaf was then coated to prevent future tarnishing as well as to match the darkened appearance of the original surfaces.

event that all plaster wads in a given area fail.

The supplemental anchorage was designed to have minimal visual impact on the highly decorative ceiling and allow for reasonable repair of installation access locations. The supplemental anchors were installed on the concealed side (upward face) of the plaster ceiling. Because a significant number of anchors were required, and close-up access to the ceiling is difficult, the anchor system was designed so that installation was as straightforward as possible, easily repeatable, and could be performed with a small crew (Figure H-5).

Prior to the finalization of the anchor design, samples of the plaster assembly were tested to verify the system weight and document the plaster thickness in several representative locations. Plaster specimens were also tested to establish the pull-out and flexural strength of the ceiling system, since a key limiting factor of the new anchor design was the strength of the original plaster ceiling itself. Several prototypes of the anchor system were tested in the laboratory to determine pull-out strength, and a statistical reliability analysis was performed to determine an allowable value for pull-out strength to be assumed for the new anchors. The new anchor consisted of a plastic bar screw-fastened to the original plaster and secured by metal tie wire to the light gauge metal framing above. Once a final design was established, the contractor was required to test anchor mock-ups as part of a quality assurance program.

In addition to the installation of supplemental anchorage, the decorative plaster ceiling in the area of collapse was reconstructed as part of the project. The new plaster assembly was constructed entirely on metal lath, with larger individual castings secured using steel tie-wire, and smaller decorations adhered using wet plaster. Also, at each anchor location the plaster surface was patched.

Finally, the original decorative finish scheme was replicated at the reconstructed bay and each patch location. Analysis of the original finish determined that the golden-color leaf was “dutch leaf,” consisting primarily of copper with a small amount of true gold. The leaf was protected by a clear varnish to prevent tarnishing over time. Since the 1920s, the original varnish had darkened, and a film of tar-like residues had accumulated on the surface (likely from tobacco smoke in the interior in previous decades). Although several cleaning techniques were studied, most processes were either too aggressive, resulting in removal of the fragile original leaf, or too painstaking and slow to be practical for application to the expansive ceiling surface. Therefore, in the patched and reconstructed ceiling areas, a series of water-based glazes were applied to darken the newly installed dutch leaf (Figure H-6).

The craftsmanship and detail of historic plaster finishes and systems can be a valuable asset in our historic building heritage. The gilded finishes and ornamentation found in these assemblies is a critical component of the building fabric of our historic structures. In order to ensure the longevity of these systems, it is imperative that the materials themselves are properly understood when remediation efforts are undertaken. These systems have demonstrated centuries-long serviceable lives when these spaces are properly maintained.

In credits: *Work on the Howlett Building project was completed in collaboration with Ferry and Associates Architects, Springfield, Illinois, for the Illinois Capital Development Board and the Physical Services Department of the Illinois Secretary of State’s Office.*

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