STONE PANEL REPAIR AT THE FAIRMOUNT CEMETERY MAUSOLEUM

BY STEPHEN H. GETZ

Fig. 1: Exterior view of Fairmount Mausoleum

Fig. 2: Interior view with marble-clad ceiling, beams, and walls

Constructed in the 1920s, the Fairmount Memorial Mausoleum is located on the 110 acre (0.45 km^2) grounds of the Fairmount Cemetery in Newark, NJ. The 250 ft (76 m) long by 92 ft (28 m) wide "H"-configured building has a granite exterior built over a cast-in-place concrete frame and floor (Fig. 1). The building has four functional levels, including a basement. The interior walls and ceiling are veneered with 1 and 2 in. (25 and 50 mm) thick marble stone panels (Fig. 2). The mausoleum's interior environment was not conditioned for climate, and over nine decades of changing weather have challenged both the stone durability and anchorage connections.

INTERIOR STONE VENEER CONSTRUCTION

The marble ceiling panels are configured such that four panels are butted to form a square. Each of the four panels has two edges common to another panel. They are suspended near center by copper wire ties attached to the stone edges by field-bending the wire to achieve an approximately 1 in. (25 mm) deep embedment in the stone. The wire's opposing end is tied to the reinforcement of the floor above within a pocket created by removing the concrete cover to expose the ceiling reinforcement. Although the integrity and effectiveness of the existing ties were of concern, such a system was not unusual at the time of construction. Typical anchorage of the 8-gauge copper wire ties from a removed panel segment is shown in Fig. 3. Typically, the ties occurred at 12 to 16 in. (305 to 406 mm) from the unsupported free end of the panel, or mid-hallway location. The outer perimeters of the 250 to 300 lb (113 to 136 kg) stone panels are supported by the vertical wall panels lining the hallway. The chase between ceiling panels and concrete differed by floor and the distance between the stone panels and concrete slabs varied from 14 to 41 in. (356 to 1041 mm).

The hallways throughout the building have marble-encased concrete beams (Fig. 4) occurring at approximately 8 to 10 ft (2.4 to 3 m) intervals. Where concrete beams did not exist, a false marble beam was provided for aesthetic continuity. The beams are covered on three sides with 1 in. (25 mm) thick marble veneer. The marble pieces span the hallway and are simply supported at the end. A center wire tie was observed during an inspection of an exposed beam. The beam length varies from 7 ft (2.1 m) to approximately 10 ft (3 m). At most locations, the marble encasement measured a nominal 18 in. (457 mm) wide by 18 in. (457 mm) deep.

CEILING PANEL FAILURE AND SOLUTION

The untimely failure of a ceiling panel alerted the owner to the potential dangers of future collapse, and that repair was essential and urgent. The marble veneer was intact and functionally sound; however, the task to remove and reset hundreds of heavy ceiling panels and three-piece marble-clad beams was not financially feasible. Accordingly, the project team investigated a cost-effective supplemental anchoring solution.

The challenges in developing the anchoring repair were as follows:

- Develop a post-installation anchor to bridge chase distances of 14.5 to 43 in. (368 to 1092 mm);
- The anchor must be capable of supporting a working load of 350 lb (159 kg) tension and not induce tension loads on the existing marble panels;
- The anchor assembly must interact with the stone panels so that a face-mount anchor will support the stone panel without stone fracture;
- Provide anchorage spacing and location dimensions that optimize anchor performance and does not overstress marble;
- Develop an anchoring scenario for stairwell ceiling panels installed at an angle to match the 8:12 pitch created by the stairs;
- Anchor finish must be aesthetically matched to the existing wall artifacts, sconces, gates, and miscellaneous metal hardware;
- Develop a beam encasement anchorage system to capture and support the marble panels; and
- Provide necessary installation means and methods criteria to assure that the marble and anchor combination will perform effectively.

ANCHORAGES DEVELOPED

MARBLE CEILING PANELS

For the basic ceiling panel anchor, a 0.5 in. (13 mm) diameter brass expander element, torque-activated for the concrete connection, was developed. Torque provided an important means of inspection and performance assurance. The anchor embedment depth in the concrete was tested at a minimum of 1.5 in. (38 mm) and averaged over 1200 lb (544 kg) capacity and induced a preload of 1060 lb (481 kg). These results provided safety factors greater than the industry standard of 4:1. The variable air space between the 4 in. (100 mm) thick ceiling slab and the existing panels was accommodated with a standard shaft length for the variable condition, connected by a suitably long stainless steel shaft assembly (Fig. 5). The head of the anchor was a 1.5 in. (38 mm) diameter stainless steel round bearing plate capable of supporting the stone panel.

Fig. 3: Corroded tie connection to reinforcement

Fig. 4: Typical 18 x 18 in. (457 x 457 mm) concrete beam encasement in hallway

Because the marble ceiling panels were installed with corners butted at the center of the hallway, the 1.5 in. (38 mm) diameter panel head challenged the installation at this location due to the improbable ability to support each panel equivalently. As a result, a larger support area was required and a bearing plate was incorporated to support the panels in concert with the 1.5 in. (38 mm) round panel head (Fig. 6). Each bearing plate was manufactured of Type 304 stainless steel with a brushed finish.

The bearing plate design was predicated on the panels being supported at the outboard edge. As a result of this support configuration, the bearing plate carries one-half the weight of the panel. The ceiling

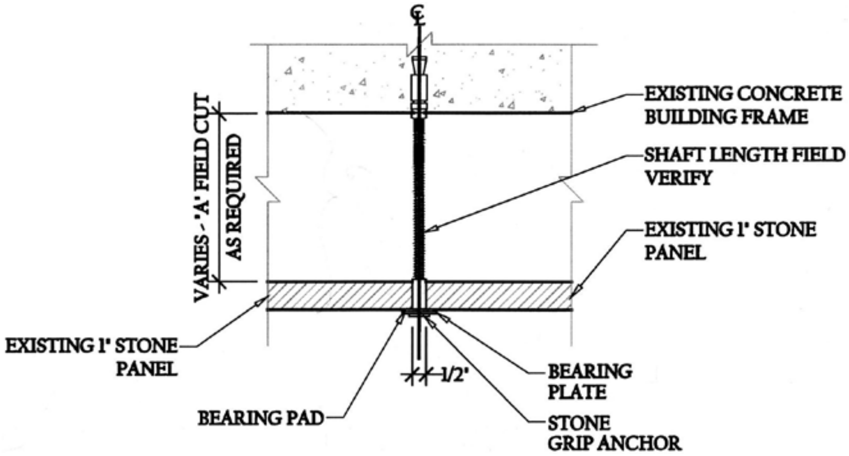

Fig. 5: Detail for ceiling anchors (1 in. = 25 mm)

Fig. 6: Typical ceiling support assembly

panels are installed in pairs, meeting at the centerline of the hallway ceiling. A bearing pad was used to cushion the contact area of the bearing plate against the stone.

Anchor assembly components were manufactured from corrosion-resistant materials. This style of anchorage was used throughout the project. The length of the anchors varied by floor according to the airspace cavity between the stone and the concrete slab. Three different anchor lengths were finalized after a field survey. Except for the extended drilling depth, all anchor assemblies followed the same installation instructions. This was an important feature to avoid customizing individual anchoring assemblies.

STAIRWELL MARBLE CEILING ANCHORS

The anchor assembly used in the stairwells for supporting the ceiling panels incorporated the same hardware as the ceiling panel support anchors. The panels in this area were installed to complement the stair rise and run angle. Because the panels were confined, thrust loads due to the angularity were not an issue. A ceiling shim, manufactured of Type 303 stainless steel, was used to "normalize" the loading application from the plate to the anchor head.

BEAM ENCASEMENT SUPPORT ASSEMBLY

The beam encasement support assembly incorporated the same style of anchorage to the concrete as used for other conditions. Each encasement assembly had three anchors with two assemblies per beam (Fig. 7). The anchor lengths varied with the depth of the beam.

The varying height and width of the box-style beams required an adjustable support hardware configuration. Basically, to transfer gravity loads, intimate contact with the marble was essential for the support characteristics of the load-carrying system to be effective. Each box beam assembly consists of two 0.25 in. (6 mm) thick by 2 in. (50 mm) wide upper-side-mounted brackets (designated as straps in Fig. 7), manufactured of Type 304 stainless steel. The brackets carry the weight of the box beam and could be adjusted both horizontally and vertically. Additionally, the brackets provided support to the ceiling panel adjacent to the beam. Each bracket could carry 240 lb (109 kg).

The top-side brackets are connected to a left- and right-side bearing bracket. This strap system surrounds the beam and overlaps at the center of the beam bottom. Here, too, the strap is capable of both vertical and horizontal adjustment to assure that stone contact is achieved. Once the side brackets were positioned, they were bolted to the top-side brackets via a 3/8 in. (10 mm) stainless steel stud, nut, and washer. The stud was factory-welded to the side-strap bracket. The intent was to support the beam in the event of a primary failure of the original tie/support system. Similar to the ceiling support assembly detail, a bearing pad was installed in the gravity-bearing support areas. The top-side brackets and the left and right bearing brackets were also equipped with bearing pads to insulate the stone from contact unit stresses.

To prevent the box beam side-wall stone panels from collapsing inward, they were anchored to the left and right strap assemblies as a final connection of the hardware to the stone. Masonry fasteners incorporating Type 360 brass expander elements with 18-8 stainless steel hardware were used. These fasteners were torque-activated to maintain intimate contact of the marble side-wall panels with the support hardware. The anchor length allowed a portion of the expander to project from the rear side of the marble. As the anchor was torque-activated, it created a "rivet" connection effect between the stone and steel strap.

SUMMARY

The marble beam encasement and support assemblies were used at 370 locations throughout the building. The entrance level (first floor) and second floor required the center anchor to span a

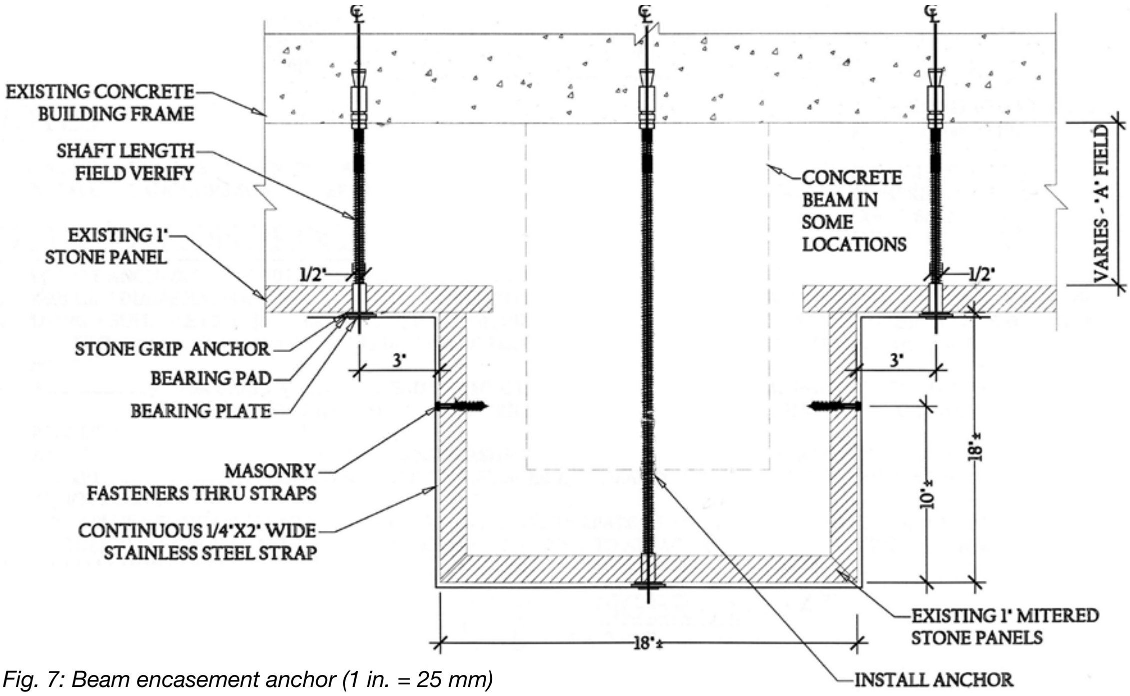

Fig. 7: Beam encasement anchor (1 in. = 25 mm)

maximum of 31.5 in. (800 mm) and the two top supports to span 14 in. (356 mm). The third level was 43.5 in. (1105 mm) at center support and 25 in. (635 mm) at top-side supports.

A critical element to the anchor installation was the method used to drill through the stone. Dry-drill carbide-tip nonimpact stone drilling bits were used for the task, as well as concrete drill bits 52 in. (1321 mm) long having SDS drives to install the concrete anchors.

The quality and resourcefulness of the project team contributed to a successful execution of the restoration project and provided a result that fulfilled functional and aesthetic concerns while completing the project weeks ahead of schedule.

Fig. 8: Box beam encasement assembly for 18 x 18 in. (457 x 457 mm) beam

Fairmount Cemetery Mausoleum

OWNER
Fairmount Cemetery
Newark, NJ

PROJECT ENGINEER
Structural Workshop, LLC
Parsippany, NJ

PROJECT ARCHITECT
Cordasco & Socci Architects
Denville, NJ

REPAIR CONTRACTOR
Allied Contracting II Corp.
Long Island City, NY

MATERIAL SUPPLIER
CTP, Inc.
Michigan City, IN

Stephen H. Getz *is the Owner and President of Construction Tie Products (CTP), Inc., in Michigan City, IN. CTP specializes in the development of masonry and stone cladding restoration systems. For over 30 years, Getz has been a productive figure in the concrete and masonry construction industry. He has been responsible for the development of fasteners and anchors used in concrete and masonry structures. Getz also participates in various trade-related organizations that strive to develop relevant standards and codes aimed at the construction and preservation of concrete and masonry structures.*