906 Grand Building Masonry Repairs

Kansas City, MO

Submitted by Structural Engineering Associates

Originally named the Rialto, this 13-story structure served as an office building on the major business street of Grand Avenue in downtown Kansas City, MO, during the bustling days of the 1920s and for decades after.

As with many buildings constructed during the early 1900s, the 906 Grand building is a "transitional age building." During this time period, the engineering and construction professions were transitioning from purely masonry buildings, using brick and stone as the primary framing support systems for the buildings, to structural steel- and concrete-framed buildings. The use of structural steel allowed for the construction of significantly taller buildings with thinner exterior walls.

During this time period, however, architects were still using reservoir wall systems, which consisted of multiple wythes of masonry that encased the structural steel framing system. As the moisture entered through the exterior wythes of masonry, it came in contact with the structural steel frame.

Over the decades, this has led to serious corrosion problems in buildings of this age and construction type. These corrosion problems occur in many elements of the structural steel frame, including columns, beams, and miscellaneous steel elements. One element that is particularly susceptible is the steel-framed cornices that project outward from the face of the building and hang over the sidewalks below. The 906 Grand building experienced these same corrosion-related problems.

The exterior skin of the 906 Grand building consisted of terra cotta with brick backup on the east (Grand Avenue) face and the north (9th Street) face. The south and west faces did not face the street and were constructed entirely of brick. The use of terra cotta allowed for the construction of very ornate pieces of masonry, including the distinctive rams' heads. The terra cotta also allowed for the ornate use of colors. On the 906 Grand building, the bottom three stories used a green base color with several other tones of brown and ivory. The remaining floors used a gray base tone with darker tones.

Years of water infiltration through deteriorated mortar joints progressively attacked the structural steel framing. As the steel corroded, it expanded and cracked the brittle terra cotta, allowing more moisture to enter. This created a cyclical process, which led to more destruction and other deterioration mechanisms, such as freezing and thawing. Conditions observed included cracking and displacement in the terra cotta at many locations on the north and east faces of the building. The mortar joints were open and the brick was showing signs of deterioration.

In the 1960s, the front of the building underwent an architectural modification, which used white marble to cover the existing terra cotta of green and

Fractured and dislodged terra cotta

Fractured terra cotta

Corroded steel and cornice framing

ivory tones. The marble was buckling and literally dissolving as a result of attack from moisture and deicing chemicals being applied to the sidewalk.

INVESTIGATION

The owner commissioned an engineering firm with expertise in masonry restoration to perform a condition study on the exterior face of the building and provide recommendations for repair. A restoration contractor was employed by the engineering firm to assist in access and exploratory demolition.

The investigation consisted of the following steps:

- Performing a visual observation of the face of the building from the ground level, adjacent buildings, and rooftops;
- Performing a visual observation of the face of the building within arm's length at a few select locations using swing stage access;
- Performing a visual observation of the cornice;
- Providing four exploratory test locations on the top of the cornice to expose the condition of the concrete gutter and steel frame below;
- Performing continuity tests and half-cell potential tests on the cornice to determine the possibility of using impressed current cathodic protection;
- Documenting and quantifying areas and the severity of deterioration of the brick and terra cotta units, as well as the mortar joint condition; and
- Documenting the condition of steel framing at four test locations.

The investigation revealed that there was a considerable amount of deterioration in the mortar joints and terra cotta on the cornice, with a much less severe level of deterioration of the individual terra cotta and brick units in the main field of the walls.

The condition of the cornice was problematic. At the four exploratory demolition areas, the deterioration of the structural steel framing inside the terra cotta cornice ranged from severely deteriorated with significant cross-sectional loss to no corrosion or loss of cross section. A majority of the terra cotta surrounding the steel framing of the cornice was either cracked or fractured. In many locations, the existing terra cotta appeared to be held in place simply from friction caused by coursing and stacking of the units. The cracking and movement was due to either severely corroded hangers from the structural steel framing or the framing itself lacking the ability to support the terra cotta. Steel pins holding large "scroll" pieces of terra cotta had corroded and expanded, resulting in radial fractures through the terra cotta. Hangers had rusted entirely in half. This created a very unsafe condition for pedestrians below.

A program of continuity testing and half-cell potential testing was performed to assess the feasibility of the use of an impressed current cathodic protection system and to attempt to better identify locations of active corrosion on the steel framing. Testing was inconclusive and did not indicate adequate electrical continuity of the steel frame to consider an impressed current cathodic protection system.

REPAIRS

Three options for repair were presented to the owner. One option consisted of removing the cornice and replacing it with a fiber-reinforced polymer (FRP) replica. A second option consisted of removal of the entire cornice. The third option consisted of removing the cornice and replacing it with architectural concrete units.

Cost estimates were developed for each option. The owner wanted a solution that not only satisfied the budgetary demands, but also kept the original historic appearance of the building façade. The replacement using architectural FRP replica panels resulted in a significant cost savings in material and labor without sacrificing the appearance of the building. This option was selected.

The repair contractor developed and constructed a unique scaffold system that cantilevered out of the windows of the 11th floor and provided a two-story working platform for access to the cornice. The scaffolding was a custom design that used the interior structural framing as counterweights to the substantial working platforms on the exterior face of the building.

The FRP manufacturer made latex forms on the existing terra cotta pieces of the cornice 12 stories above street level. FRP panels were manufactured with special attention paid to dimensions, texture, and color. Construction consisted of approximately eight pieces of FRP per column bay in lieu of approximately 110 pieces of individual terra cotta units.

Deteriorated structural steel was identified by the engineer as demolition proceeded. Repairs were analyzed and consisted of full replacement or

Completed FRP cornice

Front entry after completion

strengthening. In some cases, new members were added to provide a new load path past severely deteriorated members that could not be replaced.

New drain lines and waterproofing were installed in the gutters of the cornice to prevent further water intrusion into the cornice. Because the FRP system was modular and could be molded to any shape, this created a unique opportunity to create a new gutter system and drain lines that would better prevent rainwater from entering the cavity. The remaining structural steel was sandblasted to bare metal. To fight against corrosion, a new high-performance coating was applied to the structural steel members.

Individual deteriorated units of terra cotta in the main field of the building were identified, removed, and replaced with architectural cast stone. Forms were fabricated to match the original broom finish and a coating was applied to match the existing terra cotta appearance.

All mortar joints were repointed, the entire building was cleaned with chemical cleaners, and penetrating water repellant was applied to the brick surfaces.

In total, 300 ft (91 m) of terra cotta cornice was removed and replaced with FRP panels. Two hundred thirty-three individual units of terra cotta were removed and replaced with new coated cast stone units. Around the windows, 12,000 linear ft (3658 linear m) of sealant was removed and replaced. The unique cantilevered scaffolding system was dismantled and re-erected eight times as work progressed.

Completed project after repairs

SIGNIFICANCE OF MASONRY REPAIRS

The entire project consisted of masonry repair. Along with the structural repairs to the damaged terra cotta units and the cornice framing, a program of maintenance was implemented that consisted of installation of new sealant around window units, pointing of mortar joints, cleaning, and application of penetrating water repellant.

The project represents a team approach where the owner, engineer, and contractor all worked in a collaborative effort to achieve the owner's goals as economically as possible. The engineering team and contractor worked closely together during the investigative and construction phases, resulting in an exceptional job.

906 Grand Building

OWNER
UMB Bank
Kansas City, MO

PROJECT ENGINEER/DESIGNER
Structural Engineering Associates
Kansas City, MO

REPAIR CONTRACTOR
Western Waterproofing
Kansas City, MO

MATERIAL SUPPLIERS/MANUFACTURERS
LK Custom Fiberglass
Maryland Heights, MO

Architectural Stone Products
Independence, MO