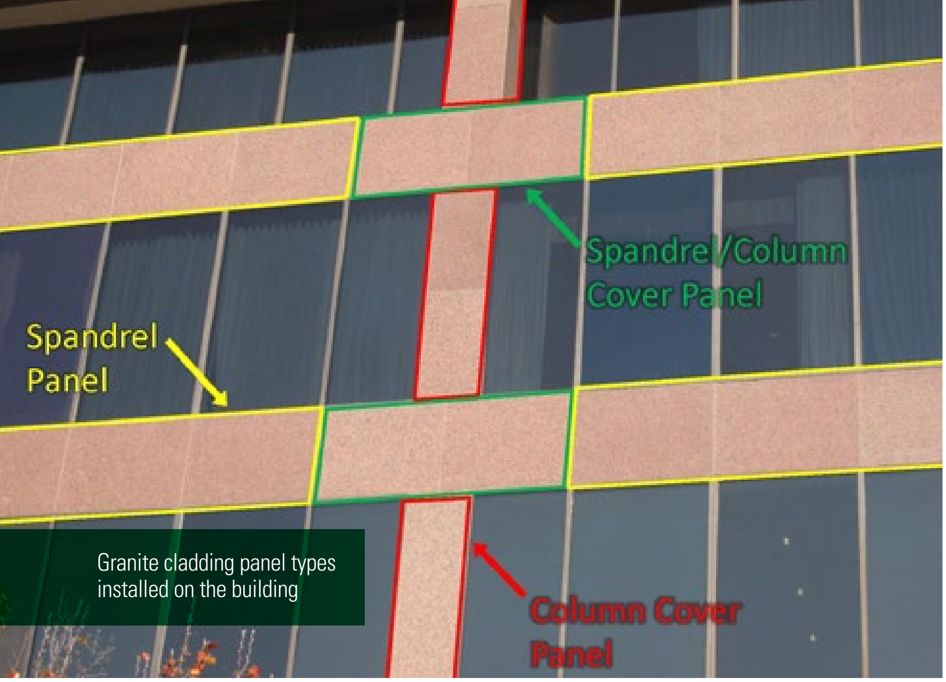
EXTERIOR FACADE REPAIRS AT PNC BANK BUILDING

ADJUSTING FOR UNANTICIPATED CONDITIONS

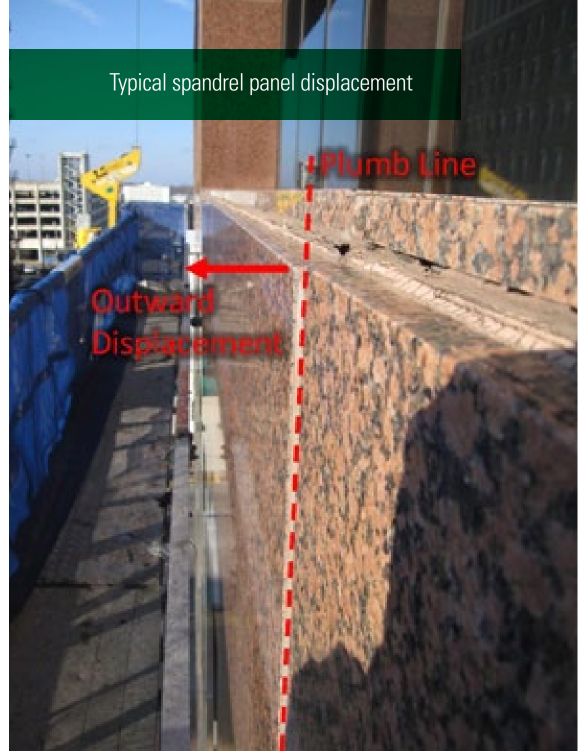
KURT R. HOIGARD, P.E., SECB, F.ASTM AND DAVID C. FORTINO

Originally designed by Skidmore, Owings & Merrill in 1972, the five-story PNC Bank Building is situated at the corner of a busy downtown intersection in the Central Springfield Historic District of Springfield, Illinois. The rectangular-shaped building is located just steps away from the historic Old State Capitol Building and the Abraham Lincoln Presidential Library and Museum.

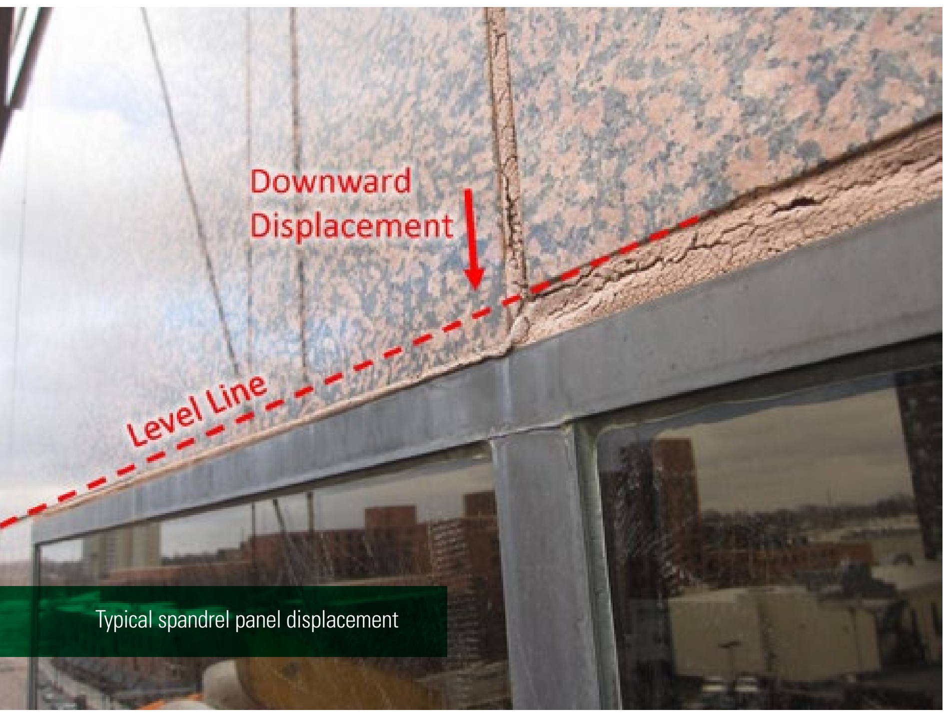
The building has a structural steel frame and concrete floor slabs. The exterior walls primarily consist of granite cladding panels and aluminum-framed strip windows. The granite cladding panels are present at floor lines adjacent to mechanical plenum space and at structural steel framing locations. The granite panel types consist of spandrel panels located at building floor lines, spandrel/column cover panels which span over structural



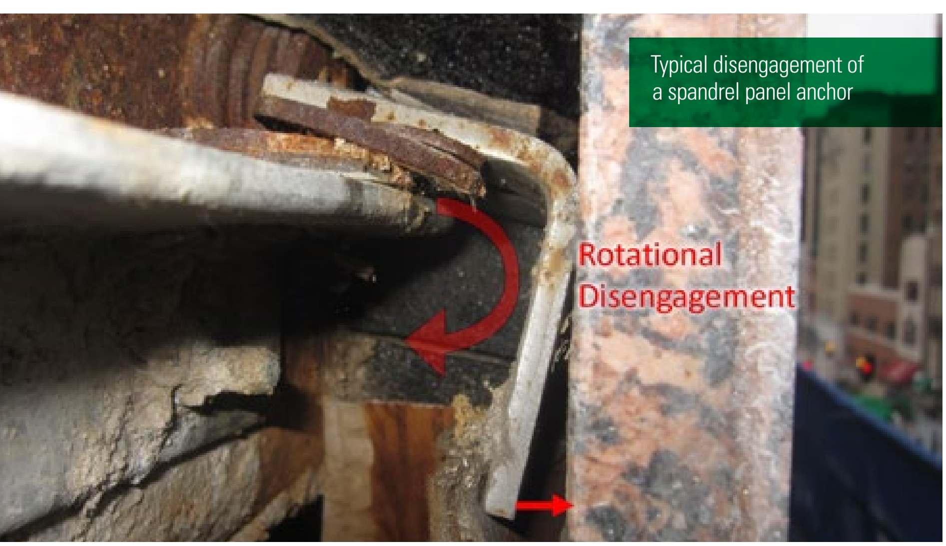
Granite cladding panel types installed on the building



Typical spandrel panel displacement



Typical spandrel panel displacement



Typical disengagement of a spandrel panel anchor

columns at floor lines, and column cover panels located between strip windows and aligned with the buildings structural columns.

The exterior walls on the project are face-sealed barrier walls, meaning that preventing water leakage is dependent on precluding water entry at exposed building envelope components such as windows, granite cladding panels, and sealant joints. Due to significant deterioration of existing sealant joints, the building owner retained Otto Baum Construction, Inc. (Otto Baum) in 2011 to perform a comprehensive sealant replacement project at the building.

Shortly after commencing sealant removal activities, workers documented loose, displaced, and/or disengaged granite cladding panels at several locations. The contractor promptly alerted the owner of the hazardous conditions. The owner subsequently directed Otto Baum to stop work associated with the sealant replacement project, and retained Raths, Raths & Johnson, Inc. (RRJ) to investigate the condition of the granite cladding panels and their anchorages.

Granite Cladding Panel Investigation

After reviewing original design documents and cladding shop drawings, RRJ performed a visual condition survey of the facade from grade and a concealed condition survey of the different facade panel types from suspended scaffolding. During the concealed condition survey, direct examination of panel anchorage was performed using borescope photography, informal pull tests, and through the removal of granite panels.

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Typical liner block separation from a column cover panel

Typical column cover panel displacement

RRJ's investigation revealed the following anchorage conditions and issues:

1. Granite spandrel panel gravity resistance was provided by two stainless steel angles with welded threaded rods adhesively bonded into holes cored into the back of the panel near the top corners. Wind resistance was provided by disc anchors installed into edge kerfs near the bottom of the panel.

   The visual condition survey revealed panel displacement evidenced by panels being out of level and/or out of plumb, projecting out from the facade.

   The concealed condition survey revealed the partial disengagement of gravity resistance panel anchors due to adhesive failures of the epoxy. This resulted in rotation and/or pull-out of the panel anchors, causing the panel to fall out of level and/or plumb.

2. Granite column cover panel gravity resistance was provided by concealed liner blocks with pins adhesively bonded to the back of the panel near the bottom, using what was later discovered through testing to be a modified polyester adhesive. Wind resistance was provided by T-shaped rod anchors installed into the top edge of the panel.
   The visual condition survey revealed column cover displacement evidenced by panels being out of plumb, projecting out from the facade.

   A combination of inadequately engaged pins and adhesive failure allowed the liner blocks to separate from the panels at several locations, resulting in a lack of support causing the panels to fall out of plumb and bear onto the panel below. These adhesives failures can be attributed to the unreliable long-term durability of polyester-based adhesives in exterior environments.

Repair Design Considerations

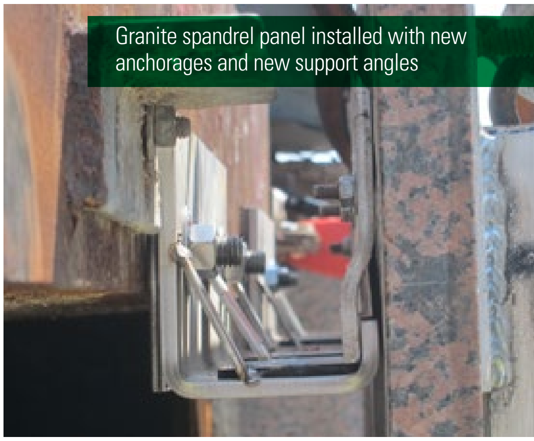
Due to the pervasive panel anchorage issues, lack of redundancy for cladding panel anchors, and the deterioration of the structural adhesives, the owner quickly recognized that the modest sealant replacement project would need to expand in scope to address public safety issues associated with the displaced and loose cladding panels. The owner immediately had overhead protection installed over sidewalks and building entrances until the granite panels could be properly secured to the building.

After installing sidewalk protection, the owner next authorized RRJ to develop options for repair of the building facade. Of the options presented, the owner elected to proceed with a global repair approach necessitating the removal of nearly all of the granite cladding panels on the building and replacement of granite panel anchorages.

Granite specimen flexural strength testing performed in RRJ's Laboratory in accordance with ASTM C880/880M

Individual anchorage strength testing performed in RRJ's Laboratory in accordance with ASTM C1354/C1354M

New anchorages and insulation impaling pins installed into the back of a typical granite spandrel panel



Granite spandrel panel installed with new anchorages and new support angles

Granite spandrel panel installed with new anchorages and mineral wool insulation

Building and Energy Code Considerations

Building code and energy conservation requirements have changed significantly since the original construction of the building in 1972. Due to the extent of the proposed repairs, the components altered by the repairs would require compliance with the currently adopted building and energy code requirements. During the design phase, RRJ met with local building code officials to discuss various repair options and the impact of regulatory requirements with respect to existing conditions and proposed repairs.

Typically, in order to meet building code provisions for fire and smoke resistance, a UL rated assembly must be provided. Due to the existing conditions and wall configurations, an applicable UL rated exterior wall assembly was not possible. The local building official indicated that alternate configurations would be permitted, provided that improvements for fire and smoke protection were made. RRJ's design included application of elastomeric firestop sealant at each floor level as a means of fire and smoke control.

Similarly, the insulation required to meet current prescriptive energy code requirements for exterior walls could not be installed due to insufficient space behind the granite cladding panels. The local building code official indicated the quantity of exterior wall insulation would need to be increased to the greatest extent possible. The final repair design included mineral wool insulation behind the granite cladding panels that increased the exterior wall R-value to the greatest extent possible given the various existing constraints.

Stone and Anchor Laboratory Testing

Physical properties of granite and other natural dimension stone can vary significantly. In RRJ's experience, acceptable in-service performance of natural dimension stone depends on the collection of accurate material data. As such, RRJ performed flexural testing of the granite panel samples in accordance with ASTM C880/880M – *Standard Test Method for Flexural Strength of Dimension Stone*. Results of these tests provided an average flexural strength for the granite in both dry and wet conditions. The test results were reduced by a safety factor in accordance with industry standards and compared against stresses established by finite element analyses of panels at various locations on the building.

New roof coping and flashings installed on the building

Granite panel support rig used to assist in removing, transporting, and re-installing panels

RRJ also evaluated the strength of proposed replacement anchors in accordance with ASTM C1354/C1354M – *Standard Test Method for Strength of Individual Stone Anchorages in Dimension Stone*. After the tested strength values were reduced by appropriate safety factors, the documented anchor strengths were compared to calculated anchor loads caused by code-prescribed gravity, wind, and seismic loads on the granite panels.

The testing and analysis program implemented provided verification for the reuse of the existing granite panels, utilizing new anchor types and spacing. RRJ's final design incorporated a fully mechanical anchorage system to replace the existing bonded stud and adhesively bonded liner block systems.

Repair Scope and Contractor Selection

With guidance from the local code officials and analysis and testing of the granite cladding panels and anchorages completed, RRJ prepared bidding documents for the project. The final repair scope encompassed all spandrel panels and column cover panels above the ground floor. The scope included removal of these panels, installation of exterior wall insulation, provisions for fire and smoke control between floors, re-installation of the panels using engineered anchors, and application of new sealants in panel-to-panel and panel-to-window joints.

The repair scope included replacement of exterior window glazing sealants, installation of new flashings at several locations to reduce reliance on sealant joints as the means for primary weather-protection, and limited roof and coping replacement. The bidding documents included provisions for a mockup installation to allow RRJ and the chosen contactor an opportunity to work through fitment and other field issues prior to commencing with the remainder of the project.

After an in-depth bid and interview period, Otto Baum (the contractor originally selected to perform the sealant replacement project) was chosen to perform the exterior facade repair project.

Site Logistics and Construction Challenges

To assist in removing, transporting, and re-installing the granite cladding panels, some of which weighed more than 350 pounds, the contractor fabricated a custom rig that included supplemental suction cups to assist in lifting the panels. This custom rig was especially useful when maneuvering around windows and other areas of the building with constricted clearances.

During the mockup, and throughout construction, it became clear that a certain degree of adjustability would be required for panel anchorages to account for varying field conditions and locations of supporting structural members. Since the contractor self-performed fabrication of many of the stainless steel panel anchors, measurements were taken immediately after panel removal, and custom fabrication of anchors were completed within a few days.

During construction, the project team worked closely to ensure that the originally specified sealant replacement work was completed in accordance with the contract documents. Sealants applied along panel-to-panel joints, panel-to-window joints, and window-to-window joints had different requirements. Dow Corning worked closely with RRJ during the design phase to ensure that proper sealants and surface preparation techniques were specified. Several mockups were performed to ensure that sealant joints were constructed as specified. Field adhesion testing was performed approximately bi-weekly prior to demobilization from each suspended scaffolding drop throughout the project duration.

Although building occupants at times experienced typical nuisances due to construction activities (noise, odors, etc.), the commercial building remained fully occupied during the project. The contractor provided temporary weather protection, and no leaks were reported during the two-year construction period.


Field adhesion test being performed on building sealants


Temporary weather protection installed on the building and a spandrel panel being lowered down to the second floor

Project Summary

The original, modest, sealant replacement project was anticipated to be completed within a few months. However, due to public safety issues associated with loose and displaced granite cladding panels, the project became a significant restoration undertaking that required planning, design, and two years of construction.

The project was ultimately successful as a result of teamwork and collaboration between a scrupulous and professional contractor, an understanding and sophisticated owner, a flexible and responsive building code official, knowledgeable manufacturers and material suppliers, and a design team with the experience and expertise to handle investigation, testing, code evaluation, repair design, bidding assistance, and construction contract administration.

RRJ's in-house stone testing program allowed reuse of the existing granite panels and incorporated a fully mechanical anchorage system, preserving the aesthetics of the PNC Bank Building in the Central Springfield Historic District for many years to come. •

About the Author

Kurt Hoigard is the President of Raths, Raths & Johnson, Inc. and a forensic engineer with 31 years specializing in the investigation, testing, and repair of distressed and deteriorated structures and the performance of building materials and systems. He provides Principal leadership and management of significant forensic investigations, repair design programs, and litigation support and expert witness testimony for a wide range of building construction, materials failures, and nonperformance issues. A leading industry expert, he is a frequent speaker across the design, construction and legal industry on topics related to structural failures, window and curtain wall testing, masonry leakage, and building enclosure behavior and performance. He can be contacted at krhoigard@rrj.com.

David Fortino is an Architectural Intern III at Raths, Raths, & Johnson, Inc. and has over four years of architectural experience in forensic investigations, contract administration, and on-site quality assurance programs for major repair projects. With his design and construction background, he has broad knowledge and skills in contract document production and project management, and building systems and materials. He can be contacted at dcfortino@rrj.com.