

CATHODIC PROTECTION OF HISTORIC TERRA-COTTA CORNICE

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As part of a major historic museum in Washington, DC, this building was constructed in 1904 and currently houses the administrative functions of the museum. Originally built as a printing facility, the building is load-bearing brick with a terra-cotta cornice. The terra-cotta cornice is supported in the typical fashion, with a steel armature embedded in the masonry. The building has two stories with attic space and features large floors and expansive windows. Located along the Mall, the facility is an important destination for many and is a National Historic Landmark. As such, the repair team had to follow the Secretary of Interior Guidelines for Historic Preservation and preserve the integrity of the building without altering its appearance.

In 2005, a firm specializing in conservation services and a structural engineering firm provided a condition report for the structure. The report detailed a scope of work that included repairing an entire exterior envelope, repointing of the brick, patching and repair of the terra-cotta elements, cleaning of the exterior brick façade, removing old scaffolding pins, and cleaning of the decorative metal elements on the windows. Many of these elements are typical of a thorough historic preservation and repair project.

In addition to the aforementioned items, the report revealed that the main joint above the terra-cotta modillions, which was cracked and open in

areas, had been previously repaired with a portland cement mortar. The cement mortar should not have been used in these joints because it is too rigid, which caused it to adhere to the masonry instead of becoming a sacrificial building material. Some of the steel elements that support the terra-cotta elements are located within the open mortar joint, which allowed moisture and oxygen to be in free contact with the steel, creating corrosion. The corrosion product was up to 0.75 in. (190 mm) thick, causing downward stresses and cracking on the terra-cotta modillions.

The owners of the facility recognized the deteriorated state of the building and wanted to explore additional repair options specifically for the terra-cotta cornice to protect the historic integrity of the building as well as to prevent further damage. The project team contacted a specialty firm with experience in preservation of historic masonry buildings with cathodic protection systems to address the corrosion-related issues on the cornice. The repair team was interested in developing a solution that did not involve the complete removal and replacement of the terra-cotta modillions.

CORROSION INSPECTION

The repair team evaluated removing and replacing the terra-cotta, but this solution was deemed to be cost-prohibitive. Stainless-steel straps could have been used to support cracked terra-cotta;



Access to top of building's cornice was provided by scaffolding for the overall façade restoration



Damaged terra-cotta from corrosion of steel supports

however, this approach is unsightly and intrusive to the visual appeal of the structure. Additionally, this repair would not provide any ongoing protection from corrosion.

The project team brought on the corrosion engineering firm to assess the damage and to verify that an impressed current cathodic protection (ICCP) system was a viable solution. The corrosion engineering firm conducted a week-long investigation and trial on the cornice. Several non-destructive and semi-destructive tests were performed to determine the best strategy for preserving the cornice and determine if there were any stray bits of metal within the terra-cotta that could impact the performance of an ICCP system.

The detailed corrosion assessment determined that an ICCP system would be the best method for preserving this landmark building's cornice. After a thorough investigation and polarization trial, it was concluded that the cornice could be treated with an ICCP system through a carefully planned and well executed design. ICCP was the best solution for this project for several reasons, including the non-destructive nature of the technology, cost savings associated with this system versus terra-cotta replacement, and the long-term solution to corrosion-related damage that ICCP provides.

SYSTEM DESIGN

ICCP systems are precisely controlled and programmed to deliver optimal protective current to the steel within the structure. Although ICCP for steel framed buildings has been used on hundreds of buildings in the United Kingdom and has proven performance, it is not commonly used in the U.S. The repair team opted to use it here because it would provide the best solution for the corrosion-related deterioration, and it is the only repair that provides a long-term solution for corrosion. Further, ICCP was selected because it would not compromise the historic integrity of the façade and allowed for the salvage of original materials.

To properly design the ICCP system, metal detection was performed to determine where metal was located in the structure. Continuity tests were conducted to ensure that the steel armature was electrically continuous. To determine the extent of electrical continuity, the team utilized construction details and tested different elements to make sure they were continuous within themselves and with each other. For the impressed current trial, a real-life mock-up was initiated to test different anode types and methods of installation and the performance of the system. The team ran the polarization trial for 24 hours. Results revealed the best anode for the repair project, the required current density, and the practicalities of installation. Additionally, the investigation determined areas that would need to



Removal of portland cement mortar joint above the terra-cotta modillions



Placement of reference electrode into mortar joint above terra-cotta modillion



Discrete anode connected to power supply and ready for placement into mortar joint



Continuity testing of impressed current cathodic protection system to be recorded on quality assurance tracking sheet in lower right of photo



Placement of lime-based mortar after anode and reference electrode installation

be electrically bonded. This approach ensured that the proper information was gathered to optimize the performance of the system.

Additionally, visually matching the existing exterior was crucial to the success of this project, so the conservators had several mock-ups created to ensure that the repair compound for the terra-cotta repairs was the proper match. The team had to ensure that there were no metal oxides in the mortar because of the use of ICCP. Therefore, a lime-based repair mortar was selected for the cornice repair that was different from the mortar that was used on the rest of the building, which had metallic ions in it.

SYSTEM INSTALLATION

Contractor selection and training was a crucial part of the project's success because there have been limited installations of ICCP systems on historic buildings in the U.S. The project team selected a contractor with experience in the installation of these

systems, and historic preservation. The installation crew was also trained on project-specific procedures and quality assurance for this structure.

Access to the cornice was in place via scaffolding that was set up for the overall façade restoration project, so the contractor was able to mobilize immediately and begin preparation of the cornice. Prior to any work being carried out, bee hives had to be removed from the cornice and from within the modillions of the cornice. The contractor first removed the portland cement from the mortar joints and then carefully removed the corrosion scale from the steel outriggers.

Once the contractor began to remove the mortar joint above the modillions, it was discovered that a small portion of the outriggers for the terra-cotta cornice were in far worse condition than previously anticipated. This required additional supports to be added to the cornice and careful planning between the corrosion engineers, quality assurance team, structural engineers, installation team, and masons. All supports had to be carefully bonded to the cathodic protection system so that the new steel was electrically continuous with the old steel.

Based on the system design, anodes were inserted into areas to deliver corrosion protection to the steel outrigger system. The joints were repointed as the installation was occurring, which masked all signs of the system and eliminated prolonged exposure to oxygen and moisture. The installation only required one major joint to be chased out, just above the modillions on each elevation.

The anodes and reference electrodes were installed within this joint, with the external wiring being brought into the structure at the brickwork just below the terra-cotta cornice. The anodes were connected to a DC power supply to deliver low-voltage electric currents, and the potential changes were measured by the strategically placed reference electrodes. The internal components, the power supplies, and main control unit, were installed in the mechanical space within the attic, with all wiring and internal connections terminating at distributed power supplies. The power supplies were then connected to a main control unit, which can be remotely accessed via the Internet for remote monitoring.

PROJECT SUCCESS

The design and installation of the ICCP system was an additional item to the overall façade restoration project's scope of work that faced an aggressive completion schedule. Open communication and teamwork between the conservators, engineers, and the repair contractor were crucial to the success of this project. The system has been successfully running since January 2007 and is controlled by specialized power supplies and a main



Power supply located in the interior of the building's attic space



Monitoring equipment installed inside the building allows for remote monitoring and system adjustment



A view of the restored terra-cotta cornice

control unit specifically designed for steel frame corrosion in heritage buildings.

This project was a large collaborative effort between several entities, including the corrosion engineers, conservators, structural engineers, and a proactive building owner. The forward-thinking owner empowered the team to utilize advanced technology on a high-profile building to achieve the long-term solution that was desired. The use of ICCP provided a better end result, while saving money and materials. This provided the team with more funds to perform other repairs that were needed on the building. As a National Historic Landmark, the team followed the Secretary of the Interior's Standards for Rehabilitation and Guidelines for

Rehabilitating Historic Buildings. ICCP will provide a long-term solution for nearly 25 years, and the system resulted in a huge cost savings because the terra-cotta did not have to be replaced.

Historic Terra-Cotta Cornice

PROJECT ENGINEER

Electro Tech CP

Tequesta, FL

REPAIR CONTRACTOR

Structural Preservation Systems

Elkridge, MD