Transportation Category

Galvanic Cathodic Protection of La Unidad Bridge

Col. San Rafael, CP, Mexico

Submitted by Electro Tech CP

Overall view of the bridge structure

Located in a remote area of Mexico, La Unidad Bridge is critical to two villages. The bridge connects the village of Isla Aguada with the city of Ciudad del Carmen and is vital to the well-being and economy of these two towns, as well as the entire Yucatán Peninsula. Nearly 2 mi (3.2 km) long, the 30-year-old bridge is subjected to an aggressive marine environment and is part of a major highway that runs along the coastline from Texas to the tip of the Yucatán Peninsula.

PROBLEMS THAT PROMPTED REPAIR

A visual inspection of the structure revealed that cracks had penetrated the concrete matrix and corrosion of the reinforcement was present and active. Because the bridge is essential for the community—and any detour would be substantial—the Mexican federal and local transportation authorities elected to repair it.

INSPECTION/EVALUATION METHODS

The first repair attempt, completed in the 1990s, included standard point and patch repairs, which did not last as long as the owner would have liked. The second repair, completed in 2002, involved adding fiberglass jackets around the concrete piles with an epoxy filler material. Whereas this repair approach provided a few more years between repairs, it still did not provide the long-term repair strategy that the owner desired because this strategy does not address the ongoing corrosion of the reinforcement. When the jackets were removed, the corrosion activity had increased and it was evident that a corrosion-mitigation solution was needed. After a visit to Florida, the team opted to use a cathodic protection system.

CAUSES OF DETERIORATION

Cracks had penetrated the concrete matrix, which exposed the reinforcement. Located near an aggressive marine environment, the salt in the air caused corrosion of the reinforcement. In addition, a lack of concrete cover over the reinforcing steel in the bent caps permitted the chloride intrusion to the depth of the steel to be accelerated.

REPAIR SYSTEM SELECTION

To find a better solution, officials representing the bridge owner visited bridges in Florida that are subjected to similar conditions. These officials saw a number of structures repaired by the Florida Department of Transportation using various methods, including the Lifejacket System, a fiberglass jacket with an integral cathodic protection system. During this visit, the team met with the system supplier to learn about cathodic protection and determined that this technology would be a good

solution for La Unidad Bridge. Cathodic protection systems operate by causing a direct current to flow from an external source (the anode) to surfaces of the reinforcing steel (the cathode) within the structure. When the current is adequate and properly distributed, corrosion is mitigated and the structure is cathodically protected. After this visit and inspection, the owner decided that the Lifejacket System, in combination with a sacrificial, metalized zinc cathodic protection system, would be the most appropriate and long-lasting solution for La Unidad Bridge. The selected system consists of a combination of lifejackets for the marine piles and a metalized zinc cathodic protection system operating in galvanic mode for the pile caps.

Because this was the owner's first experience with these systems, they decided to conduct a test to see how the cathodic protection system would perform. In October 2004, the owner, system supplier, and system installer teamed up to evaluate the structure to ensure they understood the corrosion mechanism. This included a visual investigation and electrochemical testing. This information was used to design the cathodic protection system and establish the baseline for measuring the cathodic protection system's performance.

The prototypical cathodic protection system was then installed on one of the bents in November 2004 and was monitored for 2.5 years. Fourteen fiberglass jackets with a cathodic protection system were installed in bent number 20 along with a metalized cathodic protection system for the bent cap. The test system was designed and installed in 2 months. The team worked with a contractor who was already mobilized on the bridge to install the systems. The owner was pleased with the results and they opted to install the system on the bridge.

SITE PREPARATION

Access to the piers was provided by hanging scaffolds that were adjusted to the required elevation for work on the bent cap or piles. Because of a wide shoulder on the roadway and flexible maintenance of traffic regulations, lane closures were kept to a minimum and flagmen handled any traffic direction.

DEMOLITION METHOD

Prior to installing the system, the old fiberglass and epoxy jackets were removed. At this point, crews noticed that several piles would need to be recast because of the severity of damage. For the piles that did not need to be recast, all loose or spalled concrete was removed to the depth of the reinforcement. Crews then began to check and establish electrical continuity within the steel. After the continuity work was completed, negative connections were attached to the reinforcing steel using wire with a brazed connection for the piles and a stainless steel threaded rod welded connection for the bent cap.

Removal of deteriorated concrete

Metalizing bent caps

Bent cap with metalized cathodic protection system installed and pilings prepared for Lifejacket System

SURFACE PREPARATION

Surface preparation for both the piles and bent cap was accomplished by abrasive blasting. On the bent caps, care was taken to avoid exposing too much aggregate, which would affect the adhesion of the metalized zinc anode.

Lifejackets filled with concrete

Completed cathodic protection system on bridge piles and bent cap

APPLICATION METHOD SELECTION

Because of the unavailability of a properly sized concrete pumping machine, it was decided that manual placement of the concrete mortar from above would be used. This resulted in extra attention being concentrated on vibrating methods to consolidate the mixture in the jacket.

For the application of the metalized zinc anode on the bent caps, an electric arc metalizing unit was employed.

REPAIR PROCESS EXECUTION

For the bridge in Campeche, the jackets were placed around the piles after electric continuity was confirmed or established among all the reinforcing steel within the pile. The contractor assembled the jackets around the pile and poured a mortar mixture into the annular space. The anode grade zinc mesh, preinstalled at the factory, is on the inside face of the pile. The anode is connected to the steel reinforcing at a small junction box above the jacket. The jacket comes with a preinstalled copper wire and a similar wire is connected to the steel in the field. The connection is competed at the junction box. Reference electrodes were placed at strategic locations on several piles to provide information about the system's performance. In addition, the amount of electrical current that is leaving the jacket is monitored using shunts installed at the junction box. This allows the team to determine the efficiency of the system and estimate the serviceable life of the system.

Immediately after surface preparation, the metalized zinc anode was applied on the surface of the bent caps. To ensure uniformity, thickness measurements were taken for every 25 ft^2 (2.3 m^2) of surface area. Adhesion tests confirmed the ability of the metalized zinc to properly function as an anode.

Based on the readings, the system is working well and will be in place for a minimum of 25 years, providing the long-term solution that the owner desired. More than 1400 piles are scheduled to be repaired and protected using this technology. To date, 240 jackets have been installed during the first two phases of this project.

SPECIAL FEATURES

Cathodic protection is a technology introduced to the bridge owner only recently and La Unidad Bridge is the first structure in their transportation system using cathodic protection to extend the useful life of a very important structure. In spite of the remote location and the limited resources available in the area for a project as complex as this, the local work force, contractor, and local authorities demonstrated resourceful skills, clear understanding of the concepts, and a commitment to use advanced technologies to preserve an important component of the infrastructure in southern Mexico.

La Unidad Bridge

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