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Repair of Morganza Spillway Bridge Bent Pile Cap Using Carbon Fiber Reinforcement (CFR)

INTRODUCTION

The pile cap of an end bent of the Morganza Spillway Bridge suffered extensive damage at the girder bearing locations, particularly on the side where the pounding of the girders by the adjacent concrete deck located on the approach side of the bent. The primary repair of the damaged pile cap and the replacement of the bearing plates were completed by the contractor working on the project. Structural grade high-adhesive material epoxy concrete was utilized to patch the damaged areas of the pile cap. In similar repairs conducted in the past, the patched area under the bearing plates delaminated. In order to prevent this delamination of the repair material, the repaired areas, i.e., the bearing plate locations, were strengthened by confining them with high modulus carbon composite wrapping. An inorganic polymer coating that provides UV protection and prevention of deterioration was applied to the entire pile cap surface. This coating also has self-cleaning properties that will prevent and eliminate the growth of any mold or mildew and deposits of organic materials. The project was conducted to demonstrate the application of high strength composites for rehabilitation of transportation infrastructure. Two years of monitoring of the repaired areas has shown no evidence of distress of any kind in either the repair zone or the coating. The inorganic repair system is expected to perform satisfactorily for 10 to 30 years.

OBJECTIVE

The primary objective of this micro-repair project was to prevent the delamination of the repair done under the bearing plate using polymer-modified mortar. A confinement scheme was designed using high modulus carbon tows and inorganic polymer to create a concrete-compatible composite. The retrofit operation was carried out to demonstrate the use of high strength composites for intricate repair of transportation infrastructures under the sponsorship of the Louisiana Transportation Research Center (LTRC).

SCOPE

The project and the results presented in this report demonstrate the use of advanced high strength composites for intricate repairs and surface protection of transportation structures. The results can be used for similar repairs such as restoration of bridge sub- and super-structures with local damage. Typical examples are local damage to beams due to impact or spalling of substructures due to salt ingress and other environmental factors. Large-scale rehabilitations such as column wrapping are beyond the scope of this project.

METHODOLOGY

The methodology consisted of (1) design of confinement pattern, (2) laboratory evaluation of the composite, and (3) field application and monitoring of the rehabilitation for two years, which is discussed in considerable detail in the report where the results of the laboratory tests conducted to evaluate the material properties are presented. Since this is a demonstration project, focus is placed on the repair and behavior of the rehabilitated system over a two-year period.

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Read online summary or final report:
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CONCLUSIONS

The inorganic resin was chosen because of its unique properties: complete compatibility with concrete and chemical bonding, long-term durability, high-abrasion resistance, and self-cleaning properties. Carbon tows with a high modulus of 60 million psi were chosen to satisfy the special requirement of high stiffness to prevent possible cracking. The performance of the repair was monitored for 2 years and the inspections focused on distresses of carbon fibers, adhesion of the carbon fibers to the concrete, cracking or peeling of the coating, color fading of the coating, effects of debris falling from the construction joint, and the effectiveness of the self-cleaning properties. The inspections revealed that the repair is performing very well.

The systems cured within 24 hours and rain that occurred on the second day of the project had no ill effects on the system. The inorganic composite materials used are expected to perform satisfactorily for 10 to 30 years.

The preparation of the resin and placement of the carbon reinforcement can be carried out with relative ease by trained personnel, such as DOTD maintenance crews with relatively minor training.

RECOMMENDATIONS

This project demonstrated the viability of the inorganic resin-high strength fiber composite for two areas of field application. The first application is the use of the composite for protecting concrete and steel. For concrete applications, the coating can be used to: (1) seal micro and hairline cracks as well as spalls, (2) prevent cracks and spalls from occurring, (3) provide mold and mildew resistance keeping a pleasant aesthetic surface, (4) protect structures from graffiti, (5) prevent growth of vegetation, and (6) prevent damage due to exterior abrasion. Similarly, steel surfaces in the infrastructure can be coated with this composite. This coating will provide an extremely durable corrosion-resistant surface. As an added benefit, this corrosion resistance also provides an aesthetically pleasing appearance. For both concrete and steel, these inorganic formulations provide a chemically compatible and durable solution as compared to organic resins.

The fiber-reinforced system essentially functions as micro-reinforced concrete, creating the possibility for intricate repairs. This would be quite useful for repairs on distressed areas of pile caps and piers under the support, which can be done efficiently with minimum preparation of the parent surface.

The following steps are recommended for field implementation:

1. Hold a one-day workshop for the DOTD personnel on the use of the composite. Both engineers and trained personnel should be invited to this workshop.
2. Identify possible applications for using the coating and investigators can assist DOTD to complete the initial applications.
3. Prepare an application guideline for additional rehabilitation applications.

Pier-cap pre-repair: delamination under the bearing plate

View of the bent after the repair