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Inorganic Protective Coatings and Fiber Reinforced Polymers Demonstration Project: Route 47 Wildwood Drawbridge Bridge House Rehabilitations

FINAL REPORT
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16. Abstract

The primary scope and objective of this project was to demonstrate the use of fiber reinforced polymers for repair and rehabilitation of transportation structures located near the ocean. The structures selected were two bridge houses (towers) that are used to facilitate ship movement at the Route 47 Wildwood drawbridge. In the North Tower, the degradation of concrete occurred due to salt ingress in concrete walls. The salt water source and deterioration was more acute around window openings. In the South Tower, the water is entering near the roof and around window openings. In this tower an addition was constructed to house the bridge operating personnel, and detailing on the four corners seems to be the source of the water entry.

The primary objective was the repair and rehabilitation of these structures. The work consisted of identifying and stopping the water ingress, and applying an inorganic coating on the inside walls. This coating protects the interior concrete surface and reduces water penetration, resulting in lower humidity inside the buildings. The permeability of the coating material is much less than the permeability of concrete, but it allows the release of vapor pressure build-up. Therefore, the coating does not delaminate from the parent surface. Fiber reinforced polymers (FRP) with highly extendable polymers were used to seal the joints between the concrete, timber beams, and roof connections to the timber beams. Other repairs to improve the aesthetics of the buildings were also made.

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INTRODUCTION

Scope and Objective

The primary scope and objective of this project was to demonstrate the use of inorganic protective coatings and fiber reinforced polymers for repair and rehabilitation of transportation structures located near the ocean. The structures selected were two bridge houses (towers) that were used to facilitate ship movement at the Route 47 Wildwood drawbridge. The two towers located on either side of the bridge were built from the water level all the way up to a level where the operators can see both ship and automobile traffic. The towers rise from the water level to about 9 -18 feet (south tower about 18 feet and north tower about 9 feet) above the bridge roadway level. The bases were built with reinforced concrete and some parts of the top structures were built using timber and other conventional building materials such as sheetrock and floor-tiles. Both towers experienced deterioration mainly due to water ingress; primarily form the roof and window openings. In the North Tower, the degradation of concrete occurred due to salt ingress in concrete walls. The salt water source and deterioration was more acute around window openings. In the South Tower, the water is entering near the roof and around window openings. In this tower an addition was constructed to house the bridge operating personnel, and detailing on the four corners seems to be the source of the water entry. It is possible that the design details may not have been followed accurately.

The primary objective was the repair and rehabilitation of these structures. The work consisted of identifying and stopping the water ingress, and providing an inorganic coating on the inside walls. This coating protects the interior concrete surface and reduces water penetration, resulting in lower humidity inside the buildings. Fiber reinforced polymers (FRP) with highly extendable polymers were used to seal the joints between the concrete, timber beams and roof connections to the timber beams. Other repairs to improve the aesthetics of the buildings were also made.

Background Information on Fiber Composites

In a previous study sponsored by the New Jersey Department of Transportation (NJDOT), a fiber reinforced-inorganic polymer composite was formulated. The composite was evaluated as a protective coating material for transportation infrastructure. The unique features of this composition are as follows:

- The matrix used in the composite is inorganic, and fire and UV resistant.
- The system is water-based and has no toxic substances. No toxins are released during the application or curing.
- The coating can be applied with minimum surface preparation.

- The permeability of the coating material is much less than the permeability of concrete but it allows the release of vapor pressure build-up. Therefore, the coating does not delaminate from the parent surface.
- The matrix is compatible with concrete, bricks, steel and wood.
- The matrix cures to a glassy texture, and hence organic paints do not adhere to geopolymer coated surfaces. This aspect can be effectively used to create a graffiti resistant surface, which was one of the primary motivations for this earlier study.

For more information see the following relevant reports cited in References, Page 7: Balaguru, P., Kurtz, S., and Rudolph, J. (1996); Balaguru, P., Slattum, K. (1995); Foden, A., Balaguru, P., and Lyon, R. (1996A).

The previous study established the viability of the product for protective coating applications. The primary objective of the current study was to demonstrate the use of this product for structures located near the ocean and aged-deteriorated concrete surfaces.

Recently, high strength fiber composites, known as Fiber Reinforced Polymers (FRP), have been evaluated for rehabilitation of the transportation infrastructure, and have been found to show excellent potential. For example, fiberglass boats have been known to provide excellent service for 50 years with little or no maintenance. Some of these boats are constantly exposed to sea water, and bridge decks and other structural elements are exposed to the same type of aggressive environment. If a protective layer of composite can be placed around superstructures, such as exposed piers and pier caps, their service life can be extended.

In this project the concept of fiber reinforced polymer was used to create water tight junctions between the concrete, timber and aluminum alloy used for the roof. Highly extendable polymers with an extension capacity of 50% were used as a polymer for sealing various junctions.

PRIMARY TASKS AND EXECUTION OF THE PROJECT

The following were the primary tasks.

1. Patch walls with fiber reinforced repair mortar.
2. Apply a durable and breathable inorganic coating to all walls in both towers.
3. Apply materials to the inside and outside of the towers to fix cracks and prevent future deterioration.
4. Use fiber reinforced polymers to seal the various junctions between the steel beams and bottom concrete surface, steel beams and timber beams,

timber beams and joists, and timber beams and roof sheets made of aluminum alloy.

5. Remove the drop ceiling and seal the entire perimeter with a flexible sealer between the timber, the roof, and the steel beams.
6. Seal the space between the roof and the new cement composite sections with a flexible sealer.
7. Monitor performance of the rehabilitations.
8. Prepare quarterly progress reports and a final report detailing the rehabilitations of each tower and evaluating the performance of the repairs over the monitoring period.

The work was completed by faculty and students of Rutgers University and NJDOT personnel and contractors. NJDOT personnel and contractors helped to remove the old sheet rock panels, apply the coatings, place new sheet rock panels and tiles, and apply final finishes.

On the following pages, Figures 1-6 show some of the work that was done. Figures 1 and 2 show the outside of the North Tower. Figures 3 and 4 illustrate work that was carried out inside the North Tower. Figures 5 and 6 illustrate work done inside the South Tower.

Inspection after 6 months showed that the repairs are performing well.

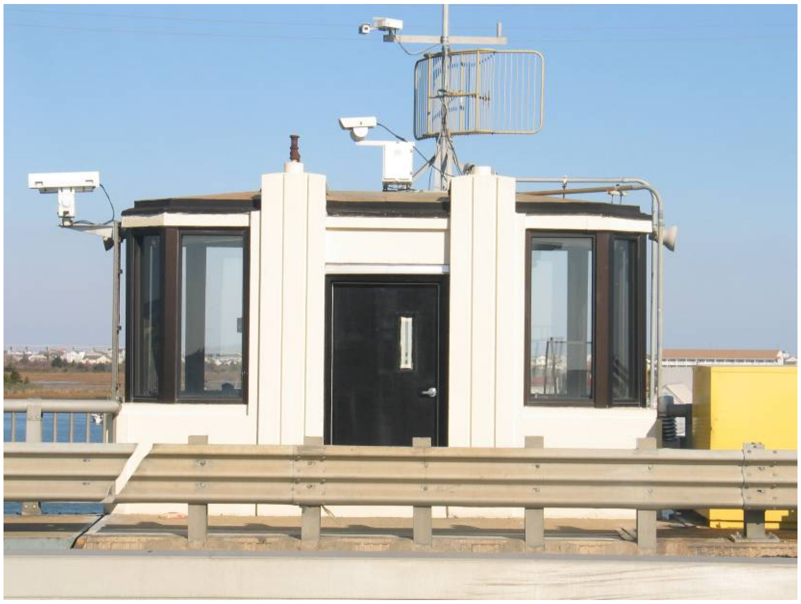

Figure 1 - View of North Tower

Figure 2 - View of North Tower – Close-Up

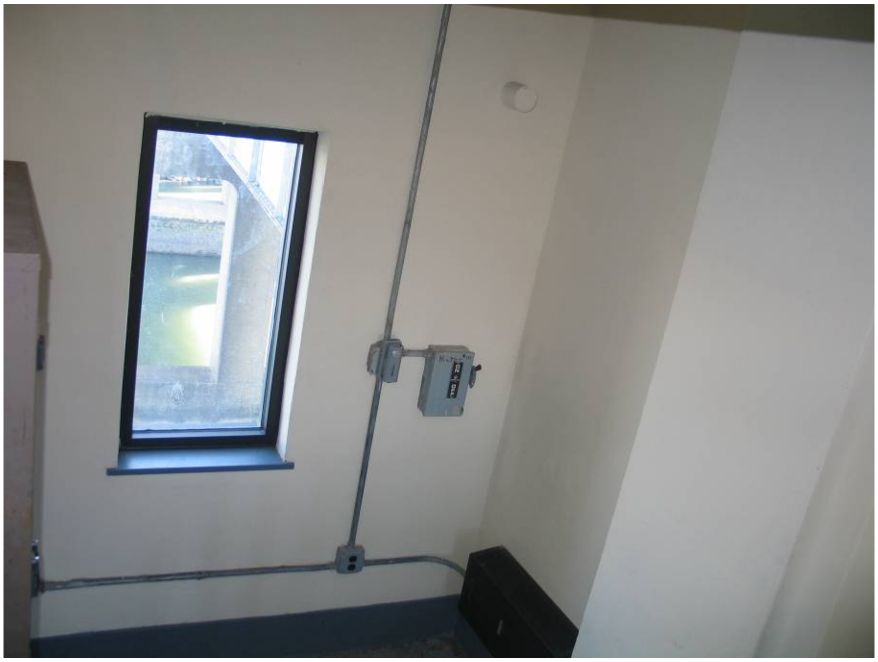

Figure 3 - Finished Inside Surface Including Treatment Around Window (North Tower)

Figure 4 - Details Near Fixtures (North Tower)

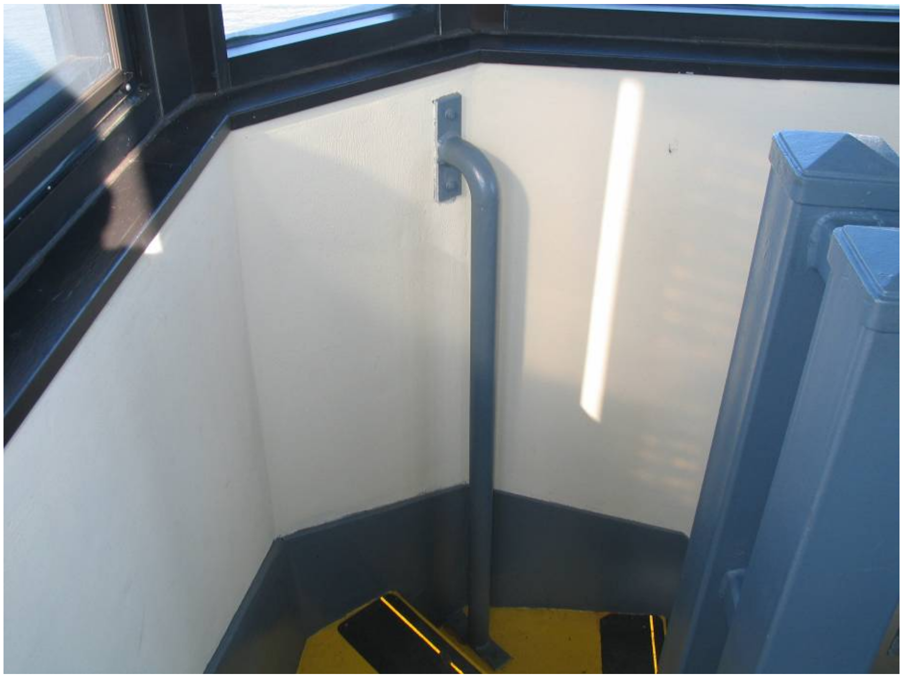

Figure 5 - Details Near Steps (South Tower)

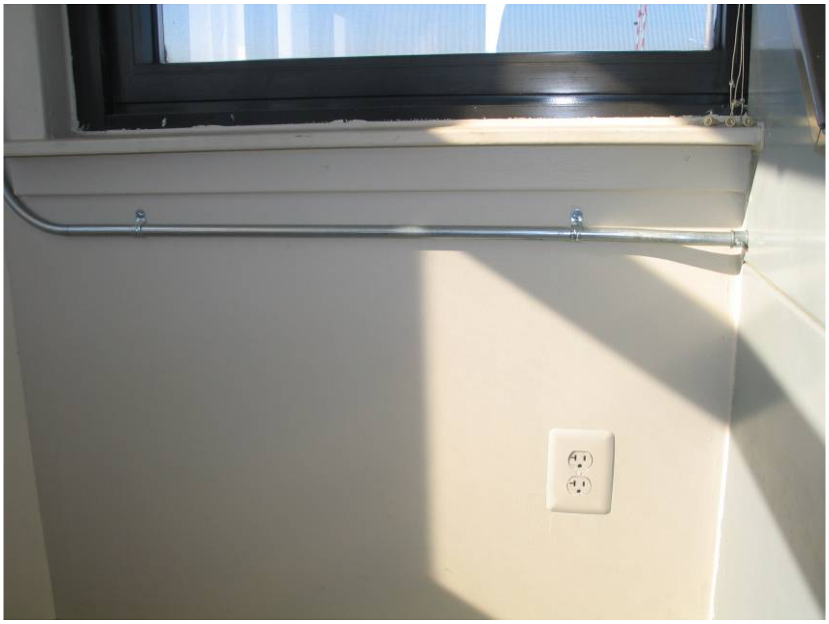

Figure 6 - Details Near a Large Window (South Tower)

CONCLUSIONS

The following conclusions were drawn from the use of inorganic protective coatings and fiber reinforced polymers for repair and rehabilitation of structures located near the ocean.

- Both inorganic and organic polymer based composites were used successfully for both protection and sealing of junctions made with different construction materials such as concrete, steel, aluminum alloy, sheet rock, and ceramic tiles.
- The inorganic polymer coating was used successfully for coating deteriorated concrete surfaces.
- The coating was applied using rollers and brushes by both students and laborers not skilled as painters.
- The organic polymer system adhered to all the parent surfaces; namely, concrete, timber, aluminum alloy, tiles, and sheetrock. (The long-term performance of these applications will continue to be monitored by Rutgers and NJDOT beyond the end of this research study).

REFERENCES

Balaguru, P., Kurtz, S., and Rudolph, J. (1996). "Geopolymer for Repair and Rehabilitation of Reinforced Concrete Beams," *Civil Engineering Report 96-14*, Rutgers University, 19pp.

Balaguru, P., Slattum, K. (1995.) "Test Methods for Durability of Polymeric Fibers in Concrete and UV Light Exposure," *American Concrete Institute - Special Publication Number 155*, Detroit, MI, pp. 115-136.

Foden, A., Balaguru, P., and Lyon, R. (1996A.) "Mechanical Properties and Fire Response of Geopolymer Structural Composite," *41st International SAMPE Symposium,* May 30 – June 3*.*

Foden, A., Balaguru, P., and Lyon, R. (1996B.) "Mechanical Properties of Carbon Composites Made Using an Inorganic Polymer," *ANTEC*, pp. 3013-3018.