

## Transportation Category

# Sunshine Skyway Bridge Trestle Span Repairs

Tampa Bay, Florida

Submitted by Sika Corporation



Sunshine Skyway Bridge in Tampa Bay, FL

The Sunshine Skyway Bridge is one of the most recognized structures in the U.S. With its signature bright yellow stay cables, the bridge resembles a sailboat, with its towers holding up the triangular sails across Tampa Bay.

The Skyway Bridge is just as impressive from an engineering viewpoint as it is from an aesthetic one. At the time of construction, it was the world's longest bridge, having a cable-stay main span with an overall length of 5.5 miles (8.9 km). The main span is 1200 ft (366 m) and the vertical clearance is over 190 ft (58 m). Built at a cost of \$244 million, it opened to traffic in 1987.

## Problems that Prompted Repair

The Sunshine Skyway Bridge comprises the main span, the high-level approach, and the low-level trestle spans. A total of 650 precast concrete girders support the northbound trestle spans and another 650 girders support the southbound span. American Association of State Highway and Transportation Officials (AASHTO) Type IV girders were used for a majority of the 100 ft (30 m) long trestle spans.

Shear cracking was observed during routine inspections of the trestle span girders. Inclined shear cracking was much more prevalent in the exterior girders than the interior girders. In addition to the deficient AASHTO girders, cracks were observed in

numerous pier caps. In some cases, these cracks were very large and exhibited visible signs of water penetration and damage.

## Inspection

Close examination and comparison of the as-built plans to the final design plans revealed significant deviations. These deviations had an impact on both the flexural and shear capacity of the girders. One of the conclusions was that the reduction in shear capacity was due to the excessive strand debonding at the ends of the girders. Because the beams were designed to remain uncracked under full design service loads, the observed cracking presented a serviceability problem. The opening and closing of these cracks under applied loads would create a durability issue. Situations where the cracks extended into both faces of the web were considered critical due to the transfer of the shear force from the concrete to the steel. A repair was critical to guard against fatigue of the existing reinforcement.

## Full-Scale Load Testing

Prior to the start of construction, load testing was performed on full-scale AASHTO Type IV precast girders in the Florida Department of Transportation (FDOT) Structures Lab in Tallahassee. This testing was done on four different test setups to simulate

the loads on the bridge and the various strengthening configurations. In one scenario where the load was applied at a 15 ft (4.6 m) offset, the carbon fiber-reinforced polymer (CFRP) strengthened beam achieved an increase in shear capacity of 21%. In the other scenario where the load was applied at a 7.2 in. (2.2 m) offset, the CFRP strengthened beam achieved an increase in shear capacity of 10%. This testing confirmed the engineer's calculations that a CFRP upgrade would be the best solution for repairing the shear deficiency in the AASHTO girders.

## Repair System Selection

To first address the shear cracks present in the AASHTO girders and the pile caps, a specification was written to epoxy-inject all cracks having a width exceeding 0.012 in. (0.3 mm). All spalls were patched using a cementitious repair mortar in compliance with ICRI guidelines. All uneven surfaces were filled in with a leveling mortar and all bug holes and smaller cavities were repaired using an epoxy paste. In addition, a clear protective sealer was applied to protect the concrete from further moisture and chloride intrusion.

It was also determined that the deficient girders would need to be structurally strengthened to carry additional loads. The use of a carbon fiber system was chosen to structurally repair the girders for a variety of reasons. A bidirectional carbon fiber fabric provided reinforcement in the 0/90 degree directions.

## Carbon Fiber Repairs

To restore the shear deficiencies at the end of the AASHTO girders, a bidirectional carbon fiber fabric was used to wrap the members. The carbon fiber was applied in a special sequence and orientation to achieve the strength necessary to reinforce the girders and meet the design live load requirement of HS 20-24 per FDOT specifications. First, a 24 in. (610 mm) wide strip was placed vertically down the girder, around the bottom, and up the other side to create a U-wrap similar to a stirrup. Next, a strip was wrapped around the bottom bulb of the girder to strengthen the flange. Finally, another strip was placed longitudinally along the top flange adjacent to the soffit of the bridge deck. The reason for using a bidirectional fabric was to achieve supplemental loading in multiple directions without having to install additional plies.

## Quality Control

Testing was conducted on the CFRP system prior to job start-up and also throughout the project for quality control. No work was allowed to begin until pulloff testing verified a minimum tensile bond strength of 200 psi (1379 kPa) in accordance with the specifications. After the initial pulloff test was successfully accomplished, an additional 20 tests were performed at randomly selected areas by the engineer prior to the application of the protective



*Typical shear cracks*



*AASHTO Type IV girders*



*Load testing of AASHTO girders in lab*

coating. Once the in-place testing verified the required strengths, a water-based acrylic protective coating was applied over all the repairs to help achieve the desired service life of the bridge.

In addition to the tensile pulloff testing, quality control testing was also conducted on the epoxy/carbon fiber system throughout the project. Witness panels were made by the contractor on site, allowed to cure, and sent to an independent laboratory to verify the tensile strength, modulus of elasticity, and strain on the laminates.

## Special Challenges

Most of the repairs for this project took place over the water, so this presented some unique challenges to the contractor. The first obstacle was how to gain access to the underside of the bridge to perform these repairs. The contractor elected to work off a barge, but even this was difficult because the vertical clearance from the barge to the underside of the girders on the trestle span was still around 15 ft (4.6 m). Thus, man lifts were needed on the barge to get close to the girders. Because Tampa Bay is an extension of the Gulf of Mexico, the waves and tides were a major concern, as were the threat of hurricanes during the summer and fall seasons.

To provide a large enough work platform for the contractors to work from, to support the heavy manlifts, and also to remain stable in rough water, a large barge was used. A licensed tug boat captain was hired to operate the barge and his challenge was to position the barge so both spans could be accessed without repositioning it during the day. Due to security concerns, the area beneath the Sunshine Skyway Bridge is secured and patrolled by the U.S.



*CFRP layout on AASHTO girders*



*CFRP with protective coating*

Coast Guard. All workers on the barge were required to have special in-house training for safety and working in a marine environment.

## Environmental Considerations

Working in a marine environment, the contractor had other special provisions that they needed to account for. Absolutely no degradation of the water quality was permitted, especially when working with epoxy resins, silane sealers, solvents, and other corrosive materials. All waste was properly disposed of in conjunction with local, state, and federal requirements. Staging was not permitted in any environmentally sensitive habitat or wetlands. Also, the area around the bridge is designated as a Manatee Watch Area and whenever the barge or boats were moved, a lookout was required to watch for the protected mammals.

Despite difficult working conditions, the project was a success. The repairs were able to be made underneath the bridge without having to even take out one lane of traffic during the entire process. In fact, most of the traveling public was not even aware, even to this day, that the AASHTO girders supporting the trestle spans were in such bad shape that the service life expectancy of the bridge was in jeopardy.

The contractor had two major concerns in regard to finishing on time (and under budget). They were always aware of the potential for hurricanes to strike this part of Florida coming off the Gulf of Mexico. Also, they would be penalized with liquidated damages should they finish behind schedule. By planning out the construction sequence and using a well-trained work force that had previous experience in working with CFRP materials in the past, the job was completed 1 month ahead of schedule. This made not only the contractor happy, but the FDOT as well.

## Sunshine Skyway Bridge Trestle Span

### Owner

Florida Department of Transportation  
*Tampa, Florida*

Project Engineer/Designer  
SDR Engineering Consultants, Inc.  
*Tallahassee, Florida*

Repair Contractor  
Intron Technologies, Inc.  
*Jacksonville, Florida*

Material Suppliers/Manufacturers  
Sika Corporation  
*Lyndhurst, New Jersey*

University of Florida  
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