

BOB GRAHAM SUNSHINE SKYWAY BRIDGE STAY CABLE PAINTING PROJECT – LESSONS LEARNED

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Abstract: The Sunshine Skyway Cable Stay Bridge is the signature bridge in the State of Florida. During 2004 the decision was made to repaint the stay cables for corrosion protection and aesthetic issues. The authors participated in a coatings condition assessment, plan development for refurbishing the coating system, and project execution. This paper identifies areas that made the Sunshine Skyway Bridge a challenging project such as: coatings condition assessment, paint specifications, access, containment system, execution, and final acceptance.

INTRODUCTION

The Bob Graham Sunshine Skyway Cable Stay Bridge (Skyway Bridge) is the signature bridge in the State of Florida. The 21,880-foot long Skyway Bridge is part of Interstate 275 that links the major metropolitan areas of Tampa / St. Petersburg and Bradenton / Sarasota across the lower Tampa Bay on the West Coast of Florida. The main span is supported by two towers and each tower has an array of 42 stay cables, twenty-one to either side, located in the center of the bridge. The stay cables consist of grouted strand tendons housed in steel pipes and are continuous through saddle system in the tower. The towers are located at Pier 111 and Pier 112.

In 2004 the Florida Department of Transportation (FDOT) decided to repaint the stay cables for restoring corrosion protection and aesthetics. This would be the first complete repainting of the stay cables since the bridge was opened to traffic in 1987. The coating system had protected the stays but had ended the end of its useful life. This project also included recoating of the concrete barrier walls for the full length of the bridge and stay cable lighting upgrade.

The project design included existing coatings assessment and contract plans development. The project was awarded in July 2006 for construction and was completed at the end of November 2008. This date has only been able to be met by a collaborative effort from the owner, designer, contractor, and the construction engineering and inspection team (CEI). From the beginning of the construction project, the contractor has encountered several issues that have caused delays: accessing the stays; containment system; surface preparation; application of coatings, especially the clear coat; and weather conditions. The objective of this paper is to describe these issues, provide a history of actual experiences and lessons learned.

DESIGN AND SUPPLEMENTAL SPECIFICATION DEVELOPMENT

The two primary objectives of the project were to provide extended corrosion protection of the stay cables by use of protective coatings and at the same time to impart an aesthetically pleasing view for the public. Although not the main reason for the project, aesthetics was a factor since the appearance of the stay cables has been an issue based on comments from the public for several years. Figure 1 shows the general appearance that has had the public questioning the splotchy appearance that was a result of a spot repair job from the late 1990's.



Figure 1- Sunshine Skyway pre-project typical spot coat appearance.

The first step was to have a coatings consultant provide a coatings condition assessment of the existing coatings on the stay cables to determine adhesion, heavy metals content, generic coating type, dry film thickness and determine the best approach for recoating of the stays.

The assessment was performed in December of 2005. Figures 2 and 3 show typical examples of the test area findings.



Figure 2- Typical test area for the assessment.



Figure 3- Corrosion typical of the condition on stays in the upper areas at project start-up.

The condition assessment revealed several other findings:

- The previous coating repairs did not include a zinc primer. The repair coatings consisted of only an additional yellow topcoat.
- The adhesion was generally poor.
- The dry film thickness range was 18 mils to 28.2 mils and averaged 19.0 mils.
- Hazardous heavy metals were found
- The generic coating system was identified as epoxy base coat and an aliphatic urethane topcoat.

Although the original design plans and maintenance manual identified the presence of inorganic zinc in the primer, comprehensive field and laboratory sample testing did not identify so.

The topcoat of the repaired and original coatings was deteriorated which included chalking and disbondment. The topcoat was also brittle. Based on these findings the maintenance painting options were limited and it was concluded the most cost effective approach would involve removing and replacing the existing coating system. Another consideration in choosing full removal and replacement was the accessibility of the stays. The designers and owners were aware that access would be an issue and a costly part of the project so designing a system that would give long-term corrosion protection, while maintaining good aesthetics, was needed. These reasons also favored the choice of full removal and replacement.

Once the maintenance option was chosen, the designer and FDOT worked together on the aesthetics aspect. The importance of achieving a good aesthetic appearance could not be overstated. FDOT wanted to restore the vibrant yellow of the original construction and in keeping with the name of the bridge - "Sunshine Skyway Bridge." This was non-negotiable and more important than the consideration that a vibrant yellow would fade much faster than a lighter color. To that end, the original paint supplier and color name was researched. Once this information was found, the supplier was contacted for a sample color swatch. This sample was the comparison basis for the contractor's selection in construction.

Several coatings systems were investigated to determine the one that would provide the best results. Some of the coatings looked into included siloxanes and fluoropolymers. Siloxanes were an attractive consideration due to the excellent corrosion properties, good wetting capabilities, high gloss and color retention, and number of required coats. However, FDOT did not have experience with this type of coating on their bridges. This caused some apprehension on choosing this option for such a high profile project and was ultimately not chosen. Likewise, FDOT did not have direct experience with fluoropolymers which are popular as architectural finishes and have found some use in the water tank industry. Both siloxanes and fluoropolymers are also considerably more expensive than the aliphatic polyurethane they would replace.

Because the vibrant yellow would fade more quickly FDOT wanted to further enhance the system against ultraviolet light exposure. Therefore, it was decided to add a clear coat as the

top coat. The clear coat is expected to add 10 years protection from sunlight. Therefore, a four coat paint system consisting of organic zinc rich primer, epoxy intermediate coat, aliphatic polyurethane finish color coat, and a polyurethane clear coat was chosen. The third finish color coat was tinted a special “Skyway Yellow” for the Sunshine State. Figure 4 shows the vibrant yellow color. The three coat system is a well used and documented system on providing corrosion protection for at least 15 years. The additional clear coat, although not well documented in Florida, was chosen to provide enhancement as previously discussed.



Figure 4- Completed section in October 2008 of the yellow color with the clear coat chosen by FDOT.

The project utilized applicable sections of the FDOT Standard Specifications for Road and Bridge Construction (Standard Specification) Section 560 “Shop, Field and Maintenance Painting of Structural Steel” as the basis for preparing the project specification package, including the supplemental specification section specifically applicable to bridge painting. During this time, FDOT was rewriting Section 560 of the Standard Specifications to create a more thorough specification. Up until that point in time, technical special provisions (TSPs) were individually written for coatings projects. FDOT wanted to include information common to the TSPs into a more comprehensive section 560 of the specification and only have information unique to the project in the contract plans, such as coating types. FDOT also created a website to house the results of hazardous material information in lieu of including them in the plan set. This process occurring at the time of this project caused extra levels of coordination between multiple FDOT offices and the design team. There were also extra levels of work that resulted in the development of TSPs and ultimately plan notes at the very final stages of the project. The last minute change to plan notes resulted in the hazardous material content being removed from the contract plans and being added to the newly established website after the project was let for construction.

The designer recommended and FDOT approved the Society of Protective Coatings (SSPC) SP10 “Near White Blast Cleaning” over which the four coat system would be applied. Near white blast cleaning is a surface preparation requirement in Section 560 and the most commonly specified standard for full removal and replacement of existing coating systems on bridges.

ACCESS, CONTAINMENT SYSTEM AND WEATHER ISSUES

One of the most challenging aspects of the project was access the work areas and containment. Due to the presence of heavy metals, environmental considerations and the proximity to traffic, the containment requirement was SSPC Class 2A. Clearly, the means of access would have a significant impact on the execution and inspection of the work and most importantly on the safety of the workers and traveling public. FDOT required any scaffolding/containment system to be approved by them, the Engineer of Record (EOR) of the contract plans, and be signed and sealed by a professional engineer in the State of Florida.

There is not a significant number of stay cable bridges in the United States or around the world to make this type of operation a routine, well tested operation. In addition to stringent safety requirements, FDOT required an access system plan that would result in no undesirable impacts to the structure. The plan had to be certified by a specialty engineer registered in State of Florida and submitted for the FDOT's and Engineer of Record (EOR) review and approval prior to implementation.

The contractor had to customize an access and containment system and considered alternatives ranging from the basic scaffold type to sophisticated automated systems. The height of the stays, the strict maintenance of traffic, the impact to the existing structure, the nature of the applied loads for site, and cost were important factors that affected the contractor's selection process and rendered a number of alternatives prohibitive.

- A self-contained gondola system was considered but proved to be uneconomical.
- An automated self-contained multiple operation system that would ride the cables was impractical because of the presence of the grout ports on the cables.
- The contractor also considered a full height scaffold system which could have been feasible. However, it was not selected because of the removal requirement and consequent project time impact in case of a significant storm event, the structural limitations of the supporting median slab and the traffic safety issues during erection and dismantling.

The final plan was developed by a specialty engineer and involved rigging on the two highest stay cables (#20, #21) at each of the arrays. This rigging allowed for the surface preparation and painting of Stay #21 in containment, as shown in Figure 5, and it also allowed for the use of a two point suspension scaffold system. An independent third line was used for fall protection for the construction crew. The suspension scaffolding system consisted of two platforms that moved vertically up and down on retaining cables. This review and processing system involved more coordination from the project team. The specialty engineer had to visit the site and submit a signed and sealed safety inspection letter

prior to use of the scaffolding by the contractor and the inspection team. The rigging on Stay #21 allowed for the inspection of all welds on Stays #21 after blast cleaning. This was a much needed inspection to help assure that no noticeable defects of the welds had occurred when checked by magnetic particle testing.



Figure 5- Rigging on Stay cables 21 & 20

Even this approach had challenges that occurred during the initial set up, use, and dismantling including damage to prepared and painted surfaces, safety issues, and time constraints. It also became apparent from the first use that wind was more of a factor than anticipated. One of the most difficult aspects was handling two platforms that had to be lifted on separate sides of the stay cables and then tied together in the wind once at the appropriate work elevation to create the appropriate containment. See Figure 6. The wind blows hard every day on the Skyway, pushing one stage into the stays and one stage away from the stays. One of the worst times caused the platform to be blown out over the traffic, causing the traffic to be stopped and the safety of the worker to be of concern. Vertical restraining cables were added to the design to improve this situation. Due to the difficulties in handling the platforms, the contractor used aerial lifts to perform work on the lower areas that were accessible from the lifts.

Wind of course was not the only weather concern. Other concerns included pop up thunderstorms with lightning and tropical storm systems with strong winds and rain. The lightning was a particular safety hazard, as workers had to be removed from the location as quickly as possible when the storms occurred without warning. The tropical storms presented a higher wind hazard and FDOT regulations required the contractor to secure everything and remove equipment from the bridge. These situations also created concerns

throughout the project with the ambient conditions both during and after surface preparation and painting had occurred.

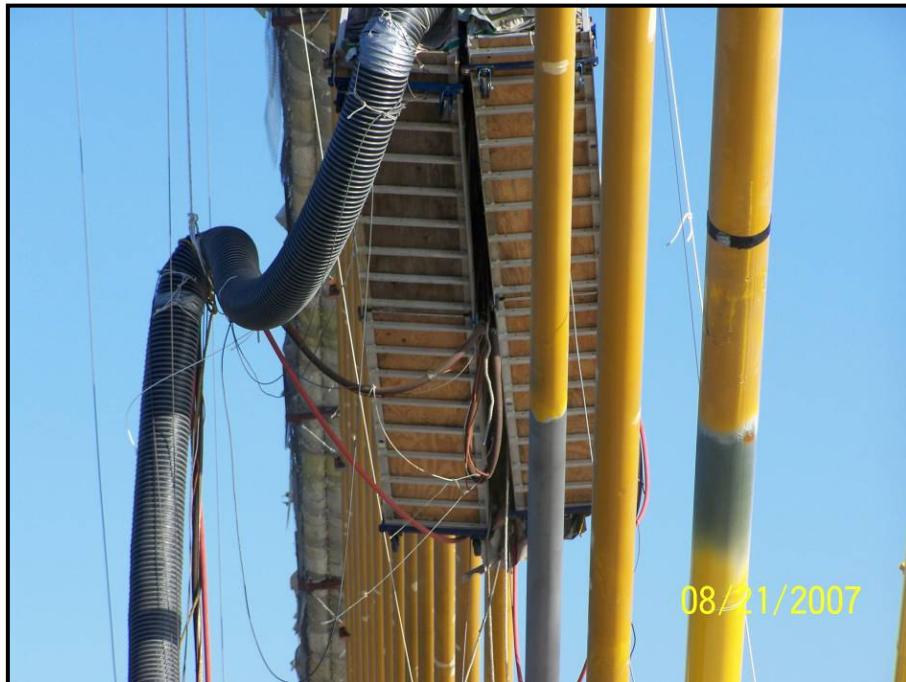


Figure 6- Rigging platforms tied together to form the containment before restraining cables were installed.

MAINTENANCE OF TRAFFIC

The project team was very concerned with the maintenance of traffic for the duration of the project. The contractor was required to provide lane shifts both north and south bound to keep all four lanes open at all times creating a work zone on either side of the median. This was accomplished by using lighted barrels that needed around the clock maintenance. The contractor was required to have at least one employee on the bridge at all times when equipment was present in the traffic zone. Figure 7 shows the traffic control work zone.



Figure 7- Typical work zone on the project both north and south bound directions.

SURFACE PREPARATION AND COATING

The specifications called for SSPC SP10 “Near White Blast Cleaning” and required a 2 to 3 mil anchor profile. Early on, it was found that the stays had an existing profile of 3 mils, making it very difficult to stay below the upper limit of a 3 mils anchor profile. The contractor worked with manufacturer and changed abrasive size to achieve a 3.2 mils average profile for the project while meeting the cleanliness standard. This was acceptable to the coating manufacturer and approved for the project since the FDOT specifications requires the anchor profile to be per the manufacturer recommendation.

The contractor encountered different issues with the primer application on the arrays of stay cables on Pier 112 because of access and weather delays, respectively. The first issue concerned the re-coat window. The contractor attempted to complete the surface preparation and primer application on all 21 stays of the array before intermediate coat application. With the delays that occurred, it was not possible to apply the intermediate within the primer re-coat window. This led to a need to brush blast or sand areas before the intermediate coat application. The contractor changed his coating process on the stay arrays on Pier 111 and avoided the missed re-coat window issue.

The intermediate and urethane color coat application went smoothly with few problems, although the polyurethane color coat did leave laps marks at tie-in spots from the containment system attachments and the start and stop points during the application process.

The clear coat application, on the other hand, had several difficulties, such as, film thickness, clarity and poor adhesion due to non- visible surface contamination.

The clear coat had a blue color dissipating dye identify the coverage limit during application and inspection. The first concern was if the dye would really totally dissipate. The contractor, manufacturer and the CEI team did test areas before the project began to ensure the dye would truly disappear within the 72 hour period as required by the specification. See Figure 8 & 9 below. The clear coat dissipated in 54 hours on the test patch, which was well within the required period.



Figure 8 – Application of clear coat with dissipating dye.



Figure 9 – 54 hour time lapse for dye dissipation.

The first clear coat application on the lower stays was too thick because the contractor tried to make sure the clear coated surface was totally blue during application. The overly thick clear coat had clarity problems causing the film to appear cloudy after cure. After test applications in the field, the team found that only one pass was required to build the proper thickness and the clear coat film thickness was controlled well after that. Due to the project schedule, the lower stays were left to weather while the upper portions were finished.

After the weathering process, occurred adhesion problems with the clear coat had taken place on the lower stays. Figure 10 shows the poor adhesion to the finish color coat and cloudy appearance. FDOT requested that both the coating manufacturer and the CEI team investigate the cause of poor adhesion. Ultimately, despite all reports from the project that indicated that the ambient conditions were within the specified ranges during mixing and application, it was determined that the clear coat was applied over moisture. Numerous bubbles and voids in the film were consistent with moisture being involved. See Figure 11 for a microscopic view of the failing coating. The manufacturer postulated that the moisture was likely from non-visible, hydroscopic contaminants on the surface. Future applications required that the contractor check the surface for soluble salts ($7\text{ug}/\text{cm}^2$ maximum) and to wipe down the surface with acetone just before application of the clear coat. This procedure solved the adhesion problem.

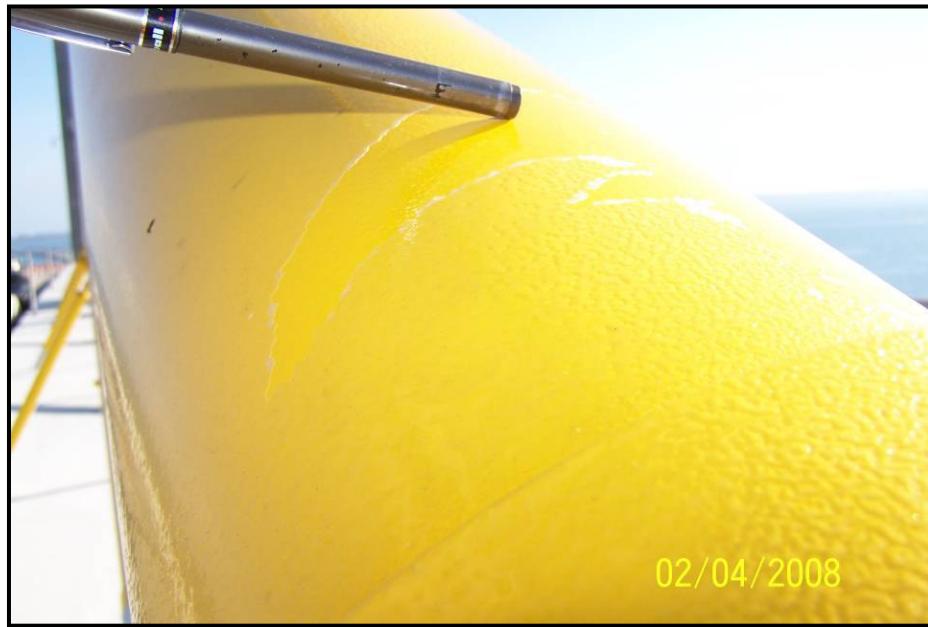


Figure 10- Note the clear pulling away and the thickness and cloudy appearance of the coating.

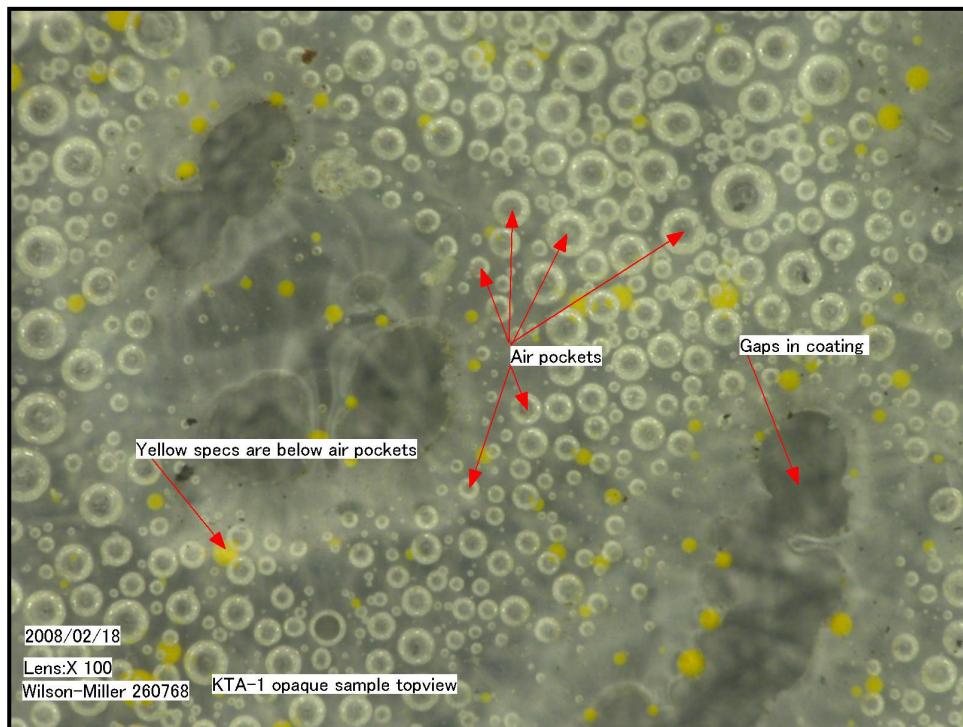


Figure 11- Microscopic view of failing clear coat.

Other difficult challenges faced were all the touch-up areas that were created from the scaffolding. Stays #21 and #20 on both arrays had a total of 27 areas that were addressed from the attachment of the stays. These areas were sandblasted and the coatings were feathered into the new system. The other touch-up areas were created from the scraping of the wire ropes of the platform system against the newly coated surface. Anytime the platform system was used to touch-up these areas, the probability that more damage to the new coating would occur was high. Therefore, these areas were addressed by walking the stays and the use of a lift.

One final coordination effort that was not anticipated at the being of the contract was the biennial inspection of the bridge. The inspection started in summer of 2008, just a few months prior to final acceptance. The FDOT and contractor decided to have a construction crewmember with the inspector during the inspection of the stays to address any further coatings problems. This was decided so the areas could be taken care of immediately instead of waiting on the final report in January/February 2009 and requiring the contractor to remobilize for these minor spots.

CONCLUSION

The issues encountered during the project were often difficult, usually frustrating, but always interesting. The efforts of all team members contributed to overcoming these interesting challenges and allowing the project to move forward.

The lessons learned during this project are as follows:

- Communications is vital to a successful project from design through construction.
- Future stay coating projects may benefit from requiring a sufficiently detailed access plan for evaluation prior to the award of the contract. A clear and thoroughly reviewed work plan submittal can avoid potential problems and delays at the construction level.
- A test patch should have been performed to flush out the potential problems that occurred with the clear coat.
- Only through the collaborative effort of the project team was the project able to result in a final product with the highest level of quality.

The painting of the stays was completed November of 2008. Figures 12 thru 14 show different views of the finished project. The project team is confident the new cable stay coating system will supply corrosion protection and an aesthetically pleasing image for years to come.



Figure 12- Final completion of stays at pier 111 south.



Figure 13 – Final view south bound of completed project with traffic open.



Figure 14 – Nighttime view of newly painted stays.

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