PENSACOLA BAY BRIDGE PROJECT

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PROJECT OVERVIEW

The Pensacola Bay Bridge replacement project, owned and managed by the Florida Department of Transportation (FDOT), will replace the Senator Philip D. Beall Sr. Memorial Bridge, which represents a crucial link and fundamental hurricane evacuation route on U.S. 98 in Escambia and Santa Rosa counties. The existing bridge, built in 1960, is near its design nominal life and is undersized for handling the current traffic on the route. Based on an analysis of life cycle costs, FDOT opted for a replacement of the bridge instead of rehabilitation.

The new bridge is parallel to the old bridge and has three structures: one for eastbound traffic, one for westbound traffic, and the third is a multi-use structure for pedestrians and cyclists in the middle. This tied-arch bridge has a 375 ft (114 m) span and a 78 ft (24 m) rise. The steel arch opens into two legs at each end that pass on the deck sides and intersect the two main steel box tie-girders supporting the deck. The concrete deck is supported by steel transverse and diagonal beams. Two planes of 14 slightly inclined and regularly spaced hangers connect the deck to the arch. The new Pensacola Bay Bridge is one of the first applications in the United States using hot-dip galvanized, waxed, and high-density polyethylene (HDPE)-coated strands for stay cables.

STAY CABLE SYSTEM

The hangers consisted of four parallel strands, made of four hot-dip galvanized, waxed, and individually HDPE-coated, low-relaxation, seven wire strands (Grade 270 [1860 MPa], with a nominal diameter of the bare strand equal to 0.62 in. [15.7 mm]). This type of strand, commonly used in the European stay cable market, provides the best performance in terms of strength and durability, which is strongly improved by the multi-level protection solution. To provide an additional protection layer against environmental actions, the bundle of strands was enclosed in an outer smooth HDPE duct.

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Each stay cable was prefabricated with a socket anchorage (Fig. 1) connected at the arch with a pin and an adjustable anchorage made of a threaded anchor head and a ring-nut placed on a bearing plate and welded in the tie-girder. The adjustable anchorage was designed to provide adequate destressing and restressing capacity for future replacement or load adjustments. In the bottom anchorage, a form tube protruding from the tie-girder was provided to connect the hanger and guide it along the whole deviation length. At the end of this pipe, a deviator disk equipped with an internal elastomeric damper (IED) system was installed to center the cable and damp out vibrations due to wind and traffic.

Protection caps, to be injected with wax, were provided both at the bottom and at the top anchorage to permanently shelter the strand tails and wedge gripping zones.

OVERVIEW ON GALVANIZED STRAND

Grade 270 galvanized steel stay cable strand was produced and provides added corrosion protection to the steel strand before, during, and after cable stay installation if either of the outer two protective layers become damaged or allow moisture into the strand. The strand meets all requirements of ASTM A416[1] and PTI DC45.1-12,[2] including strength and fatigue performance. The added zinc layer can also help reduce the influence of strand fretting or abrasion. This cable stay strand design has been produced in Europe[3] for many years for cable-stayed bridge projects around the globe. Now with the ability to produce the strand in the United States, while meeting Buy America requirements, it is available for U.S. DOT projects.

The strand manufacturing process is similar to that of typical Grade 270 uncoated steel stay cable strand. The coating process is accomplished by galvanizing each wire

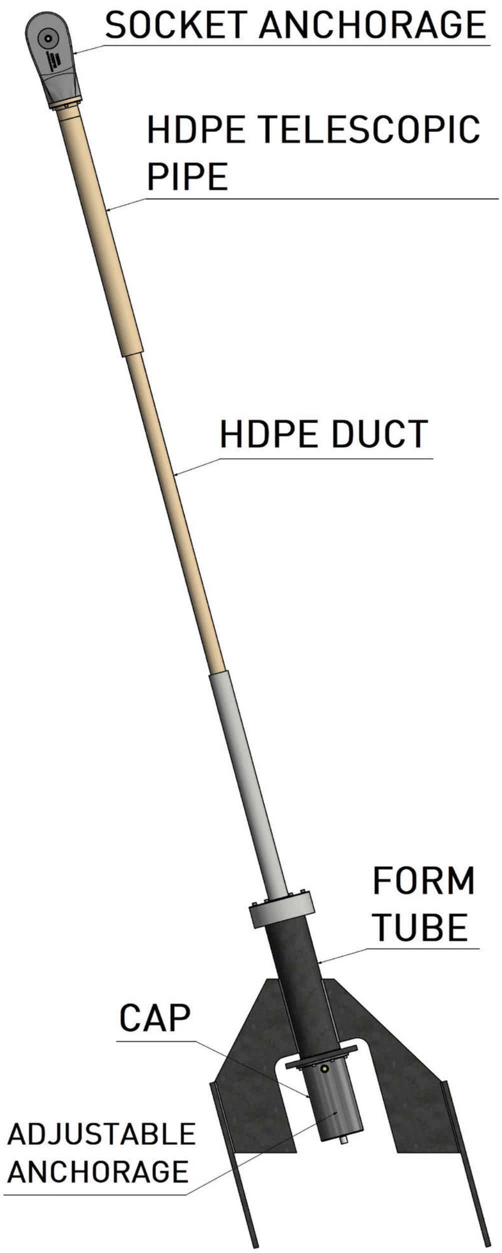

Fig. 1—Lateral view of stay cable system.

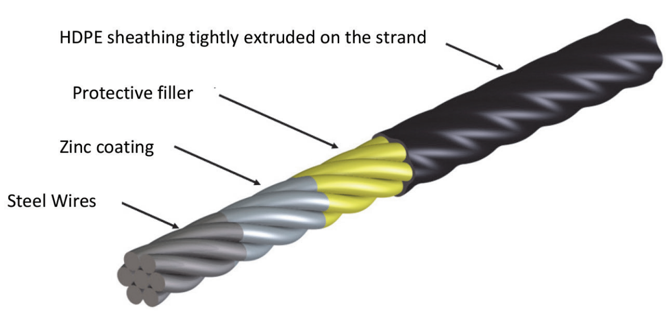

Fig. 2—Galvanized, waxed, HDPE-coated strand for stay cables.

individually before stranding with a minimum 0.62 oz/ft^2 (190 g/m^2) hot dip galvanized zinc coating. This precisely controlled and automated continuous hot dip process ensures a zinc coating that is smooth and complete along the entire surface of the wire. The subsequent stranding and thermal relaxation steps do not harm the galvanic corrosion protection properties. The coating smoothness ensures the wax and sheathing operation can be completed efficiently. The strand is shown in Fig. 2.

The corrosion performance of uncoated steel versus zinc-coated steel is shown in Fig. 3. Following the ASTM B117 salt spray protocol, zinc coatings achieve a normalized performance of approximately 427 Salt Spray Hours for every 1 oz/ft^2 of coating while uncoated steel achieves 1 to 5 Salt Spray Hours.

The results in the graph (Fig. 3) are experimental. Tests have been carried out with different amounts of zinc coating (0.31, 0.41, and 0.82 oz/ft^2), so the Salt Spray Hours is not equal to the results using 1 oz/ft^2. Results are proportional to the theoretical rate of 427 Salt Spray Hours for every 1 oz/ft^2. The additional corrosion protection that zinc galvanizing brings to the cable stay system is approximately 106 times higher than that of uncoated steel. This contributes to the additional life span for the cable stays of the bridge.

FULL-SCALE TESTING

As required by PTI DC45.1,[2] the fatigue and static strength of the stay cable system is proven by project specific testing or by acceptance of prior tests.

In the case of the Pensacola Bay Bridge, project-specific testing (consisting of two full-scale tests) was carried out in the International Laboratory of Structural Engineering (LPM) of Politecnico di Milano, Milan, Italy, and witnessed by an FDOT representative:

- Fatigue and static strength test; and
- Fatigue and leak test.

Both tests were successful, proving the outstanding performance of the stay cable system in terms of fatigue endurance, static efficiency, and leak-tightness.

Fatigue and static strength test

As specified in Section 4.2 of PTI DC45.1,[2] a stay cable specimen (equal to the one referenced in the project, with a minimum length of 11.5 ft [3.5 m]) was installed in the testing rig with the anchorages supported in such a way to create a S-shaped cable profile with a 10 mrad angular deviation at the anchorages (Fig. 4).

The fatigue and static strength tests were carried out in two successive steps. In the first, the sample was subjected to 2 million axial load cycles with an upper stress of 45% MUTS and a stress range of 23 ksi (159 MPa). In the second, the sample was statically loaded up to the maximum attainable load, which shall not be smaller than 95% GUTS and 92% AUTS. During the fatigue phase, no failure of wires or anchorages occurred. In the subsequent phase, the stay cable was loaded up to 97% MUTS and 95% AUTS, with an ultimate strain at maximum load of 2.3%, values that fully met the acceptance criteria.

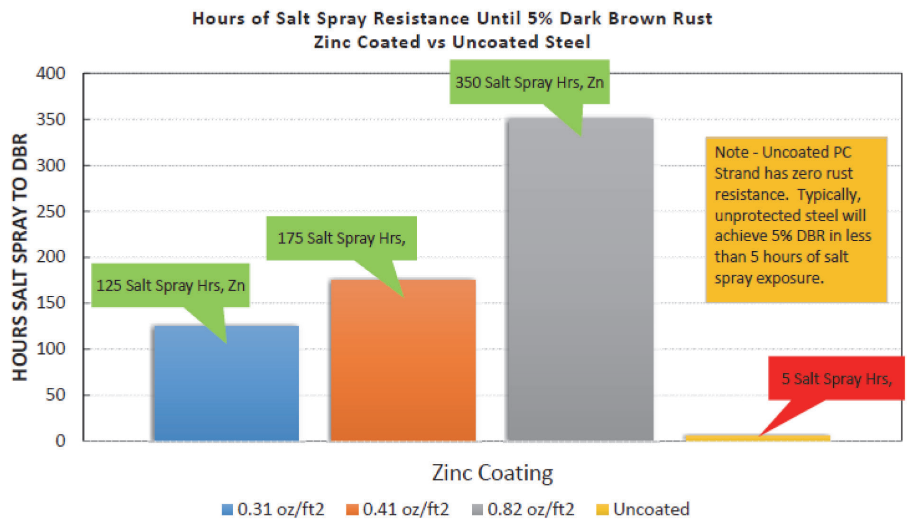

Fig. 3—Performance of galvanized strand in salt spray test. Note: 1 oz/ft^2 = 318 mL/m^2.

Fatigue and leak test

As specified in Section 4.1.6.1 of PTI DC45.1,[2] the fatigue and leak tests were performed in two phases. In the first phase, the sample was subjected to the same fatigue test described previously. Again, no failure occurred at the end of the test. In the second phase, the sample was removed from the testing machine, cut in the free length, and after sealing of the cut surface, immersed in a vertical dedicated steel tube with transition zone, a minimum of 3.3 ft (1 m) of free length, and all caps and seals, coatings and coverings. The effectiveness of protection barriers was tested using a 9.8 ft (3 m) head of water and dye solution for a continuous period of 96 hours. At the end of the test, the sample was subjected to destructive examination. No trace of dyed water was observed on strands, which demonstrated the leak-tightness of the stay cable system intended to be used on the project.

Fig. 4—Fatigue and static test layout.

ERECTION METHOD

The span where the arch bridge was erected is located in the middle of the Pensacola Bay, without any service area where stay cables could be prepared. For this reason, all the hangers were prefabricated in a dedicated yard on the coastland. Strands were laid on specifically designed benches, cut to length, uncoated, and installed through the relevant holes of the socket anchorage. Stay cables were moved by barge to the erection zone. Here, each bundle of four strands was passed throughout the butt-welded HDPE duct and connected at the adjustable anchorage.

The bridge structure was assembled directly on the barge with the help of provisional supports. Hangers were lifted, connected to the arch, and stressed sequentially from the ends of the arch towards the midspan, as shown in Fig. 5 and 6. A low initial tension was provided for removing the cable slack, ensuring that cables could contribute correctly in supporting the deck once the temporary supports were removed. The first stressing phase used a monostrand jack, tensioning each strand individually. A side view of the bridge after stressing is shown in Fig. 7.

Fig. 5—Lifting of prefabricated hanger.

Fig. 6—View of hangers before stressing.

Finally, the arch bridge was lifted into position. The finishing phase, which is still in progress at the time of publication, will require the hanger to be restressed for correcting the deck chamber. For this phase, a multi-strand jack system will be used to pull the whole strand bundle at the same time.

Fig. 7—View of bridge after completion of hangers prestressing.

CONCLUDING REMARKS

The stay cable system used in the Pensacola Bay Bridge project is a milestone in adopting hot-dip galvanized, waxed, and HDPE-coated strands in U.S. bridges with stays.

The higher corrosion protection performance together with ease of installation provides an enhanced durability to critical stay cables.

References

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Team

Contractor: Skanska, USA
Engineer: WSP and Parsons Brinckerhoff
PT Supplier: TENSA America
Strand Supplier: Bekaert Corporation, Van Buren, AR

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