Highlights

- Highest cable-stayed bridge deck when opened to traffic in '91
- 100 ton steel form traveler + 200 tons of water ballast = 300 ton segment pour

SPANS

The Quarterly Newsletter of Inspired Bridge Technologies

Hillsborough County Florida

April, 2007 – Volume 5

Uniting the North and South

The replaced Talmadge steel truss bridge (Figure 1) was functionally obsolete for roadway traffic but structurally sound. However, its' 135 foot vertical, navigational clearance rendered it obsolete for modern cargo ships traveling to port facilities upstream on the Savannah River. Moreover, this dilemma was graphically illustrated when an inbound freighter preparing for a rapid turn around, unsecured their derrick booms and raised them before passing under the bridge superstructure. The loosely positioned boom struck the bridge with a glancing blow and luckily inflected only superficial damage to the superstructure, without bringing down the bridge. Nevertheless, the way was set for replacing the old bridge and the Federal, Truman-Hobbs Act was the vehicle used to accomplish this task. This law was enacted (By Senator Harry S. Truman) to replace a specific bridge that had been struck by a passing ship. This act was repeatedly amended and used to replace other bridges damaged by passing ships

Mr. Wendall Lawing, P.E. was the Georgia Department of Transportation's State Bridge Engineer and he was ablely assisted by his deputy, Charlie Lewis, P.E., in the consultant selection process, the design oversight, the contractor bidding process and the construction oversight

Figure 1:The view, down river, of the new cable-stayed bridge, under construction, framing the replaced steel truss, beyond.

for this $74.4 million bridge project. The state was required, by Federal Law, to solicit two designs in alternate materials, one in steel and one in concrete. They received six bids for the concrete and no bids on the steel alternate.

Contract 1, the 2039.33' long, cast-in-place, three span, cable stayed, high level river crossing (Figure 2:) was awarded to Monterey Groves (Guy F. Atkinson & S.J. Groves, Joint Venture) with their bid of $25.7 million. The Construction Schedule for Contract 1 was to begin September 1, 1987 and take 36 months. Correspondingly, on Contract 2, Hardaway was the low bidder at $46.5 million for 1.2 miles of approach bridges and 2.05 miles of approach roadway. The approach bridges and roadway construction was scheduled for June 2, 1988 through June 1, 1991. Monterey Groves chose as their Construction Engineer the Vancouver, B.C. based bridge engineering firm, Buckland and Taylor. The principal design was executed by the Joint Venture of DRC Consultants Inc. and PBQD- Atlanta.

At the time, cast-in-place cable stayed decks in the USA were a rare commodity and, consequently, many precedents were to find their way into the fabric of the finished Talmadge Memorial Bridge. The typical, designed reinforced concrete segments

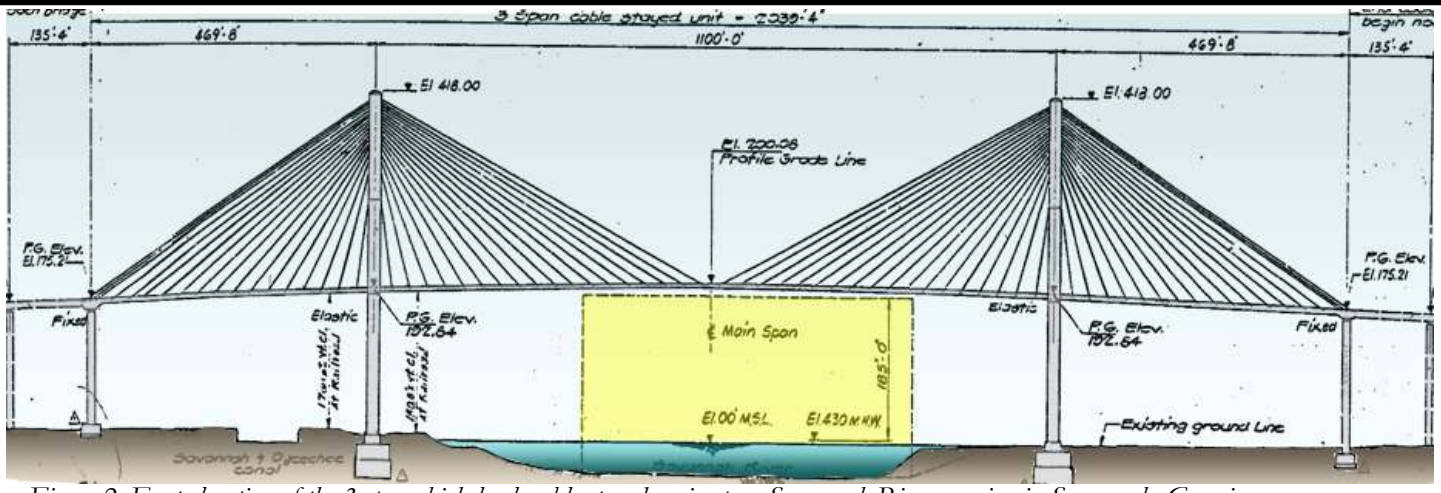

Figure 2: East elevation of the 3-span, high-level, cable-stayed main span Savannah River crossing in Savannah, Georgia.

measured 28 feet 3 inches in length and 80 feet (Figure 3), out to out, in width, and weighed 300 tons. The supporting stays which march out from the concrete pylons, along the edge girders, with a varying angle of attachment at the edge girders starting nearest the pylon at 74 degrees and progressively decreasing in scope, as they approach mid span, to the minimum angle of 24 degrees. The longest, mid-span stays would have the maximum stress of 700 tons.

The form travelers have two rigid steel frames reaching ahead, as runners on a sled, which are in line with the stays. These structural steel runners are curved, with a radius of 23', to allow the stays to be anchored, on the radius, at their specified angle, against the steel runners. An initial, partial, pre-stress is applied, for the weight of the form travelers, and before the concrete is placed.

Moreover, these 100 ton form travelers also carry ballast tanks with plumbing and pumps that can carry 50,000 gallons of water whose additional 200 tons allows the stays to be further tensioned against the travelers, anticipating the 300 tons of wet concrete. It is at this point in the segment construction cycle, without the maximum loads, the leading edge of the forms can be tilted up or down to effect changes to the profile grade line (PGL) to within the ½"of allowable tolerance per segment.

Subsequent to these checks and adjustments, 200 tons of water is loaded into the ballast tanks in preparation for the 300 ton concrete pour. The stress in the stays is increased for a 400 ton segment load. The pouring of the 300 tons of wet concrete into the segment forms begins and, simultaneously, the draining of the ballast begins. Two hundred tons of water ballast is released, in a coordinated sequence, that leaves a constant 400 ton load on the stays. Once the concrete has hardened, stay cable force is transferred from the steel form traveler runners to the concrete deck. Only then are the forms lowered in preparation for their advancement to the next segment location. This operation leaves a net uplift that is sufficient to carry traffic (design live load).

DRC Consultants Inc. was further retained by the GADOT to monitor the construction geometry, which included the PGL for this cable stayed bridge (Figure 2). When opened to traffic in 1991 the Talmadge Memorial Bridge had the highest deck elevation of all cable stayed bridges in the USA at 200.08'. This height provided for the 185' vertical clearance above the mean high water (MHW) of 4.3'. And, the skewed shipping channel and its increase in width from 400' to 600' further affected the PGL

The two, 418' tall, "H" shaped towers (1N &1S) support the 80' wide deck girder (Figure 3) suspended between the two planes of cables, each with a pattern of 18 cables radiating in a fan pattern from the tower heads to the main span and anchor span edge girders for a total 72 stays per tower. The 2039'- 4" long deck hangs free of the towers but rests on and is anchored to piers 2N & 2S with a deck elevation of 175.21'.The 469'-8" side spans were shortened from 550,' with 3 stays, from each cable plane, gathered at the anchor piers by being attached to a 13.75' extension of the edge girder. These extensions are deeper than the typical, 4'-6" edge girders and embrace the end diaphragm.

The Bridge carries Georgia Alternate Route 17 across the Savannah River with two lanes of traffic in each direction. The PGL arcs across the main span with a smooth vertical curve between the 175.21' road elevation at each anchor pier and the mid span zenith of

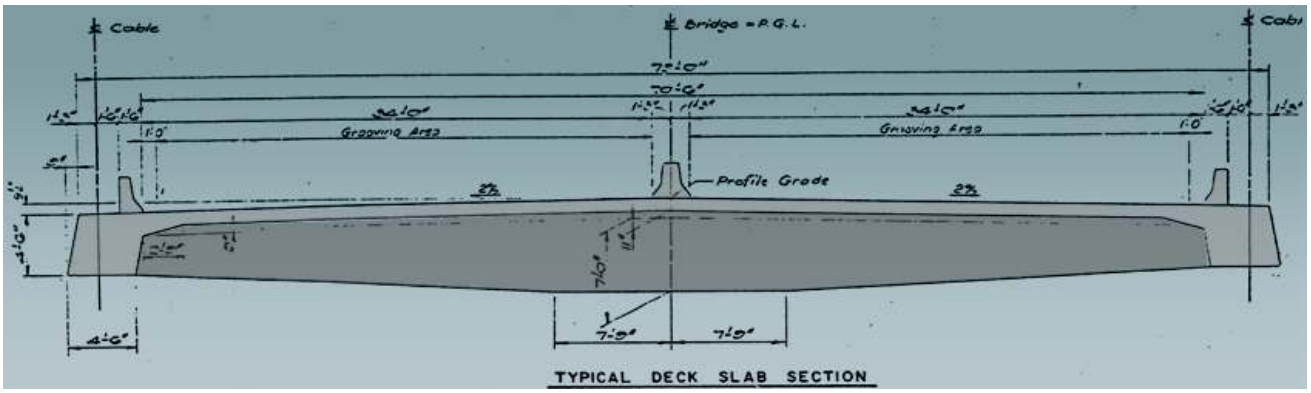

Figure 3:A section through a 28.25', 300 ton, cast-in-place, cable-stayed ,typical segment.

200.08'. Imagine, extending both arms to full length with both index fingers pointing toward each other then, with your eyes closed, you try to touch your finger tips. Accordingly, the deck girder, in 300 ton increments, each 28.25' in length reach for closure at three points; 550' to mid-span and 469.67' to each anchor pier. The task for the DRC field engineer was to follow the construction of each segment to assure that it hugged, within a ½" tolerance, the PGL.

Mr. Ian Hubbard, P.E., was DRC's fulltime field representative checking the alignment of the north half (1N) of the bridge. Ian is a Welshman who gained considerable, cable-stayed experience with the Construction Engineering contract on Florida's Sunshine Skyway Bridge. Ian's career path took him in another direction after the completion of the north half of the cable stayed main span (72 stays). The remaining south half was completed by DRC's Lionel Bellevue, P.E.(72 stays).

Lionel was a Haitian who was educated in Germany and had considerable construction engineering experience, including his work on the now famous Linn Cove Viaduct in North Carolina's Smoky Mountains.

Eighteen, stayed, main span segments and fifteen stayed side span segments were hung from tower 1N and guided into their anticipated geometric locations. The 1N pier table (deck between tower legs) was installed on strutted false-work and three stays are anchored at pier 2 N in the thickened, counterweight, deck slab that was built on ground supported form work as a pier cap beam. Ian's first segment was poured May 17, 1989 and his last was recorded on February 24, 1990. The schedule called for an average of 12.4 days per segment and the actual (omitting bad weather and other misc. snags) was 10.3 days.

All the construction equipment and experience was repositioned to the south bank of the river. Correspondingly, Lionel's first segment was recorded as being cast on December 16, 1989 and his last was scheduled for September 2, 1990. The scheduled, average days per segment was 9.6 and the realized production was 9.2 days per segment.

The south half was similarly designed, but once the stayed segments were hung from towers 1N and 1S and anchored to piers 2N and 2S we had two, 546 foot long fingers leveled and pointing north and south towards an eight foot gap in the deck girder, anticipating closure. With both cantilevers aligned they were locked together with wide flange, steel beams, top and bottom, then reinforced and closed with the final deck pour on September 23, 1990.

Hurrah to Ian! Hurrah to Lionel! Their efforts in uniting the North and South are much appreciated.

Figure 4:A warm southern night meets the flow of the Savannah River at the bridge.

Guest Commentary

Incheon Bridge – Gateway to the New Business Hub of North East Asia

By : Hyo Seung Nam

The construction started, with the casting of the first foundation pile, on July 8, 2005 for the 7.4 mile long, 1.3 billion dollar Incheon highway bridge that will provide a fixed connection between the Korean Peninsula and the Incheon International Airport (IIA), located on Youngjong Island in the Yellow Sea. The bridge will also act as a symbolic gateway for commerce and other social Interaction to this part of the world. Within a radius of less than a 2 hour flight, centered on the IIA, a circle would encompass Beijing, Shanghai and Tokyo along with a population of more than 700 million people.

The project delivery system is a Build, Operate and Transfer (BOT) contractual arrangement. A group offered to pay for the bridge if they were allowed to design, build and operate the facility for a period of time (30 years) in order to recover their investment with a profit. Subsequently, the fully operational Toll Bridge will be transferred to the Governmental Authorities for the remaining design life (70 years plus) of the bridge.

A Joint Venture (JV) between The Incheon Bridge Company, Ltd. and The Samsung Engineering and Construction Company was formed with the former responsible for the 30 year operation and maintenance period and the latter carrying through with the design and construction. As of June, 2007 the project is 50 % complete with an overall completion date scheduled for October, 2009.

The bridge is composed of three types of structures. First, there is a 5.04 mile, low-level viaduct made with a series of five, 164' long, pre-cast, pre-tensioned concrete box girders. These 164' long girder units are placed span by span with an overhead, moveable gantry, and are subsequently post-tensioned to form the five, continuous span configurations. The high level, main span approaches are 475.6' span, twin, variable depth, continuous, pre-cast, post-tensioned, segmental concrete box girders built with the balanced cantilever method of construction.

These approach structures culminate with them embracing the main channel, cable stayed span of 2624' which is countered by two side spans of 1115.5' each. The total cable stayed deck is 30,000 tons of orthotropic steel plate supported by two planes of cables which radiate from the tower-head and connect equal segments of the deck across the tower anchorages. The cables at the towers are anchored in precisely stacked steel anchorage boxes imbedded in the concrete pylons.

The main span erection process follows a sequence of building temporary pier bents in the side spans then erecting, in four separate sections, the 1115.5 feet of deck, in a post and lintel fashion, with floating derrick cranes. With the side span decks locked together as continuous members, stays are installed from the tower-head and are lead back down to the anchor span edges and attached with equal 49.2' spacing.

The main span deck segments are hoisted into position by barge mounted derricks and attached to the superstructure at one end and with stays at their free ends. These main span stays are countered by the back stays which are anchored to the side span decks and have the tendency to lift the side span off their temporary bearings. With all main span segments in place the temporary side span bents are removed and the main span is closed.

When South Korea's longest bridge is opened to traffic in the fall of 2009 it will connect the new Songdo International Free Trade Zone, now under construction in Incheon, to the International Airport and the rest of the World.

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A Special Thanks To: Mr. Hyo Seung Nam, Samsung's Engineering, Project Manager for the Incheon Cable-Stayed Bridge.

PASS-IT-ON, Please!