

## Highlights

- 266 SPANS TEMPORARILY LOCKED AS SIMPLE SPANS UNTIL CONTINUITY TENDONS ARE ADDED
- 250 MILE BARGE TRIP PROVES ECONOMICAL WITH LARGER SEGMENTS

# SPANS



Public Works Department  
Bridge Team

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## US ROUTE 1 RESTRINGS FLORIDA KEYS

A two hundred mile long Florida reef reaches south west from the US mainland and is populated with a series of sand swept, palm tree covered islands, most of which have land elevations no more than six feet above normal sea level. The proximity to Cuba, of this land bridge, prompted Henry Flagler to extend his Railroad 128 miles from the mainland, across this chain of islands, to Key West by bridging, intermittently, more than 30 miles of open seas and, in 1912, the Florida East Coast Railroad began service to Key West

After a turbulent and short 23 year existence the 1935 hurricane broke the Bridge and the Railroad so the State of Florida purchased the Route. The Florida Highway Commission converted the single rail line to a 21 foot wide, two lane roadway that became known as the "Overseas Highway". When opened to vehicular traffic in 1938 it extended US Route 1 to Key West. For more than three decades highway traffic flowed, but in the early 1970's, maintenance costs had reached an unconscionable \$3 million per year.

Consequently, the Federal Government allocated \$180 million toward a bridge replacement program which was augmented by an additional 30% State contribution for the 37 bridges in the program. Four of these bridges were designed with a precast,



**FIGURE 1: View looking South with new bridge beyond on Oceanside**

segmental, concrete, box girder alternate. The Niles Channel, the Long Key and the Channel Five Bridges were all built by Michaels Construction Company using precast segments cast at their Niles Channel casting yard. The 2,127 segment, Seven Mile Bridge was built by Misener Marine with all segments for this fourth segmental bridge being cast in the Misener,

Tampa casting yard and barged the 250 miles south to the bridge site for erection.

The precast, segmental, concrete design for the New Seven Mile Bridge (Figure 1) was by Figg & Muller Inc. and the contract to build it was awarded to Misener for \$45 million in March, 1979. The Florida Department of Transportation (FDOT) hired Post, Buckley, Schuh and Jernigan (PBS&J) to be their representative during the project's construction. PBS&J chose DRC Consultants, Inc. as their segmental concrete construction consultant. DRC's services included providing two site engineers, Eric Aigner and Vince Black, and one casting yard engineer in Tampa, Ian Hubbard.

Ian oversaw the casting of all of the superstructure girder segments and the box, pier segments for the one mile section of vertical curve over Moser Channel (Figure 3) providing the required 65' of vertical clearance for this fixed span over the Intercoastal Waterway. The original swing span, at this location, was permanently removed. Eric and Vince had the assigned responsibility of overseeing the erection of the box piers at the vertical curve and the entire superstructure including all post-tensioning, tendon protection, geometry control and quality control.

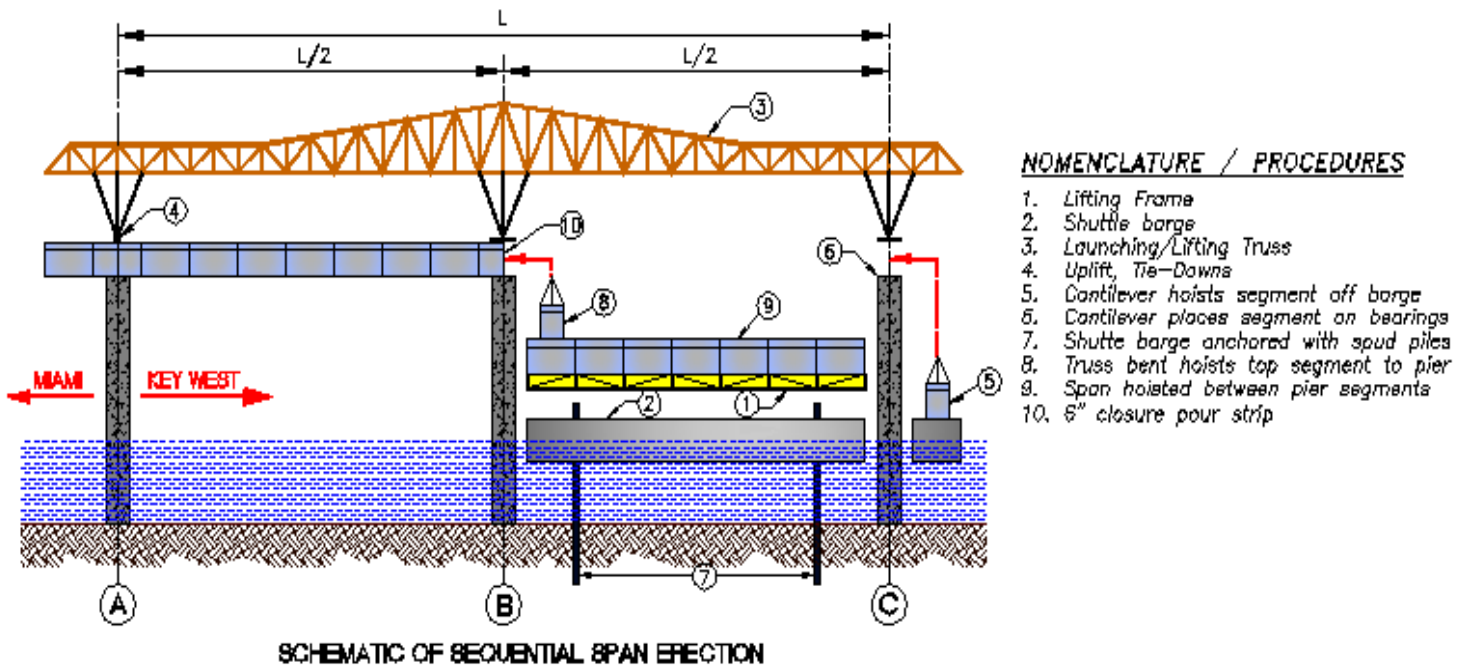


FIGURE 2: Cantilevered erection of Miami Segment at "C", with bent erection of Key West Pier Segment at "B" followed by bent erection of span "B"- "C".

Misener Marine elected to organize their project with the subcontracting of the erection and pre-stressing for the superstructure to the VSL Corporation and the leasing of their harbor-side yard in Tampa to the Santa Fe Pomeroy Corporation for their subcontract to precast all of the superstructure segments and the vertical curve, box pier segments. The entire substructure was the direct responsibility of the General Contractor (GC) along with the logistics of moving the double stacked segments on barges that were tugged the 250 miles to the construction site. The GC then transferred, placed and positioned these segments onto an erection frame mounted on a shuttle barge that was to be positioned between two piers, spud locked to the bottom and moored to the piers before superstructure erection by the subcontractor, VSL. (Figure 2).

The five and a half miles of flat roadway is supported by piers composed of three foot diameter, twin, concrete columns (Figure 4) down to the waterline where they bear on four foot diameter, drilled shafts that carry their loads to the water bottom then through 15 feet of overlying silt to limestone. These shafts were anchored a minimum of 10 feet into the limestone with the longest overall shaft length being 40 feet.

The one mile of vertical curve, over Moser Channel and the Intercoastal Waterway (Figure 5), is typically supported on match cast, segmental concrete, box sections that bear on four foot thick, reinforced concrete caps supported by four, three foot diameter, drilled shafts socketed into the limestone rock bed. The two highest piers, bracketing the channel, each towering 65 feet above the water surface, are founded on spread footings recessed into the coralline limestone rock bottom and are bolted in-place to the rock with grouted, all-threaded, Dywidag, pre-stressing bars (Figure 3).

The 2,127 superstructure segments that carry two 12' wide lanes of roadway traffic and two 6' wide shoulders across the top of the substructure could have been more than 4,000 segments with the more traditional, segmental girder construction. Typically, pre-cast, segmental, concrete, box girders have to be delivered to the site by truck which limits their lengths to the 8-10 feet that will fit into the 12' highway lane widths. With the limited availability of space, skilled labor and materials down on the Keys, it was decided to manufacture



FIGURE 3: 65' vertical clearance of new bridge at Moser Channel with old bridge, foreground, having swing span permanently removed



**FIGURE 4:** 5.5 miles of level spans on 3' diameter concrete shafts.

the segments at the Misener, waterfront facilities in Tampa and ship them by water to the job-site and eliminate these short comings.

With no such limitation in segment lengths to deal with when they were delivered on barges, the segment length was nearly doubled to 18 feet which simplified the entire pre-casting operation. Moreover, the design called for external tendons (outside the concrete girder cross section) but within the tunnel of the box section, threaded through deviation blocks which allowed for a major reduction in the concrete cross-section and permitted the use of fewer, but larger tendons. This design feature made for a lighter per foot segment weight. The maximum segment weight for these 18' long, concrete elements was a very manageable 60 tons.

These segments were transported loose, stacked two high, two spans per barge and were unloaded by crane onto a lifting frame mounted on a shuttle barge. The segments were aligned on the frame and pulled together with four, temporary, 0.6" diameter, pre-stressing strand tendons. The total project superstructure is comprised of 38, 7 continuous span, pre-stressed concrete box girders. A typical span erection sequence is depicted in the schematic of Figure 2.

The overhead, steel erection truss extends across two spans with the leading span dedicated to the lifting and the following half of the erection truss performing the launching operation. This mobile truss is organized with two spans that have three equally spaced bearing points straddling the bridge roadway. The truss is launched forward on the approach roadway with the lead span cantilevering to Pier "C", with full bearing at Pier "B" and having the uplift at Pier "A" countered by anchoring the truss to the girder, at this point, with two, 1-3/8" diameter, Dywidag, pre-stressing bars.

The lead, single, pier segment is hoisted off of a barge by the cantilevered front (lifting) span and placed on neoprene bearing pads on the Miami half of Pier "C". The free cantilevered, front bearing point of the Truss is positioned over the top, center of this lead pier segment. Once the lead segment is in place the tie downs at position "A" can be released, allowing the lifting half of the overhead truss to now distribute the full lifting capacity of this span to bearing points "B" and "C". The shuttle barge below is locked to the bottom with spud piles, between "B" and "C", with the seven span segments on the lifting frame and the Key West half of the Pier Segment "B" conveniently resting on top of the other span elements, all waiting to be lifted into their final position.

The next segment movement is the lifting of this pier segment off the top of the span elements and into position atop pier "B". Following this movement, the

seven span elements are then raised into their final roadway alignment, between the now positioned, book-ended, pier segments. With this full span alignment of segments, both pier segments are temporarily post-tensioned to the partially pre-stressed, seven span elements to form a "simple" beam and column arrangement between piers "B" and "C". At "B", 6" spacer blocks create a pour strip against which two of the final six, 27 strand tendons (3 on each side of the tunnel) pull the span segments together with the partial loading of 15% of their ultimate strength.

These designed tendons have been threaded through their ducts, their deviation blocks, up high over the pier and through the diaphragm walls into the previous span's abutment wall where they are anchored and grouted to provide continuity between the spans. Once the closure strip is made and reaches the minimum specified strength of 2,500 psi, usually in 12-14 hours, 4 tendons are stressed to their full load of 446 tons each. With this stage completed, the lifting frame is lowered and the final two tendons are also stressed to 446 tons. Only when the succeeding span is pulled up tight against its spacer blocks and all of its six tendons are fully stressed will this interior span be rendered continuous and join the body of 38, 7 continuous spans that now make-up Florida's Seven Mile Bridge.



**FIGURE 5:** One mile vertical curve on box piers over Intercoastal Waterway.

## Guest Commentary

By: Gary Sanders

### "Feeling Groovy" with The Queensboro Bridge

The great Bridge Engineer, John Roebling, had thoughts about an East River bridge connecting New York and Long Island as early as 1852. His optimum choice for locating the span was where the mid stream Blackwells Island (now Roosevelt Island) minimized the water spans. However, his more notable Brooklyn Bridge became the first East River crossing in 1883 and the Queensboro Bridge had to wait until its design was commissioned in 1901 and after eight years, \$20 million and 50 construction fatalities before this imposing mass of 50 thousand tons of structural steel became a reality, as it was opened to traffic on March 30, 1909.

The project was administered by Gustav Lindenthal, who filled the new position of New York City Bridge Engineer. The Engineer for the Williamsburg Bridge, Leffert Lefferts Buck, was responsible for the design. The double decked, cantilevered truss spans had two cantilevers over the west channel for a total span of 1,182' (no drop-in span), two cantilever spans over Blackwells Island (no drop-in span) for a span of 630' and a 984' east channel crossing to Queens, composed of two cantilevers (also without a drop-in span). The total length of trusswork, when including the Manhattan and Queens side cantilevers, is 3,724'. The original contract included the approaches which brought the length of the bridge to a total of 7,449'.

An original depiction of the bridge cross-section shows the upper deck, between trusses, to have two railway tracks and two pedestrian passageways; the lower level, between trusses, reveals a very crowded 6 vehicular lanes with cantilevers, outboard of the trusses, on both sides of the bridge, each with one trolley track. The present day configuration has evolved with attendant structural modifications: the railroad was removed between the late 30's and early 40's; trolleys were removed in the 50's along with the mid-bridge, Roosevelt Island station.



**QUEENSBORO BRIDGE**

Along with the transition away from rail, somewhere before the end of World War II, the 59<sup>th</sup> Street Bridge became better known as the Queensboro Bridge. However, the musicians Simon & Garfunkel memorialized the name with their "59<sup>th</sup> Street Bridge Song", (Feeling Groovy).

Trying to keep up with this hard working, aging lady the City of New York, Department of Transportation, Bureau of Bridges engaged the engineering consultants, Steinman, Boynton, Gronquist & Birdsall for a retrofit, rehabilitation and repair program which led to a contract with a Joint Venture headed by Kiewit Constructors Inc, a subsidiary of Kiewit Corporation. This \$200 million contract extended across the six years of '95 thru '00 for 42 months and was scheduled around three maintenance-of-traffic phases for all 10 lanes of roadway traffic currently on the bridge.

Pre-Stage involved closing the upper four roadway lanes to allow for painting and overlay work on the upper structure during an 11-month period; Stage 1 was for a 15 month period of lower, outer, roadway reconstruction on the north side and Stage 2 was a 14-month reconstruction of the lower, outer roadway on the south side.

The work consisted of the removal and replacement for the lower, outer roadways, major painting, architectural repairs to the City Shops and Markets Areas housed under the Manhattan approaches, the complete



**59th STREET APPROACH**

replacement of necklace and navigation lighting, south upper roadway overlay replacement and site work (including utility relocation) on both approaches. Unique challenges encountered included a hi-level safety shielding operation over sensitive areas, material handling in an extremely tight workspace and maintenance / protection of traffic on a high-volume, New York City, East river crossing.

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#### ***A Special Thanks to our Guest Commentator:***

***Gary Sanders was P.M. (45-99%) for Kiewit on this major, rehabilitation project. Now retired from Kiewit, Gary is with Micon Development, LLC.***

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