

Highlights

- Naming a Bridge
- Architectural Considerations
- Construction Engineering

Items

- The Dame Point Bridge
- Double Stay Planes = Parallel Stays
- The Contractor's View of Construction

SPANS



Public Works Department
Bridge Team

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KEEPING UP YOUR END

A new bridge, at a new location (Figure 1), has always presented more than engineering challenges; the least of which is and most often encountered has been, "What to call it". The usual answer comes from local landmarks, natural or man made, and they quite often outlast the official name that comes after the construction period and sometimes well into its operational life. More so, with the case at hand, the "Dames Point" was contested with a contention that the proper name was "Dame Point", nevertheless, common usage has prevailed and "Dames Point" is with us today.

The Jacksonville Transit Authority (JTA) hired the bridge engineering firm of HNTB, in 1979, to design the main span crossing of the St. Johns River for what was to become a two mile long segment in the eastern link of a ring road for the city of Jacksonville, Florida. Typically, for major structures such as this, a number of alternatives are considered in the embryonic stage of the design. HNTB, in consultation with Dr. Ulrich Finsterwalder, who developed the chosen, cable-stayed alternative, carried forth his design. This solution reflected many features employed in his earlier design for the Hoechst Bridge over the Main River, in West Germany, constructed in 1972.

This proven design was advertised in 1979 but the bids had to be rejected for they far exceeded the design estimates and budget. The project was put on hold



FIGURE 1: TWO SETS OF BOW-TIE TOWER STRUTS AND TWO PLANES OF HARPED TENDON STAYS (PARALLEL STAYS)

only to be re-bid in 1984, in a more favorable labor climate, with much lower bids received, resulting in a low bid of \$47 million.

With the contract award to the open-shop, joint-venture contractor, Pensacola – Tyger in 1985, the construction office-trailer was located in the shade under tall pine trees, on the sandy, north bank of the

meandering St. Johns River. The new bridge's 4% profile-grade-line (PGL) was centered on the existing, north-south, New Berlin Street, state Route 9A. This crossing of the entrance to the port of Jacksonville is located 20 miles northeast of the center of the City and 20 miles southeast of the intersection of State Route 9-A and I-95.

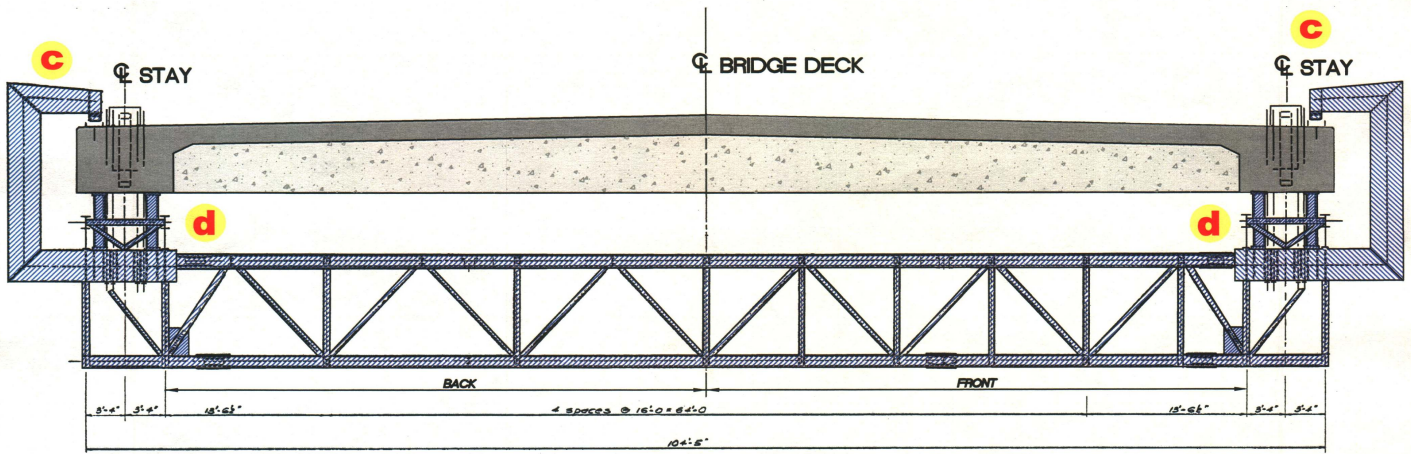


FIGURE 2: TRANSVERSE SECTION OF CIP CABLE STAYED DECK, C-CLAMP BEARING POINTS (c) & (d) AND CONNECTING SPACE TRUSS

Contract plans for major bridge projects clearly indicate what the Client wants and often show "a" method to achieve this end. "The" method for achieving this goal was tailored by design modifications of these documents by the Contractor's CEI Consultant to the specific methods, assets and capabilities of the "at risk" contractor into a viable solution. Usually, there are 6, 8, 10 or more bidders for a project of this type and magnitude but they all will have significantly different bid prices derived from the same contract bid documents. Why is this? Simply put, it is due to the approach to the solution and for major bridges this often boils down to the CE&I Consultant's analysis of the available

assets and conditions, all factored into an engineered, erection scenario.

The Dames Point, CE&I consultant, DRC Consultants Inc, of New York City, saw that the bridge was unusual for an American cable stayed bridge in that the stays were not delivered as coiled strand or wire cables but, instead, came as all threaded, 60' straight length, high strength steel pre-stressing bars.

Dr. Finsterwalder's design developed 471' tall, "H" shaped towers straddling a 105' -9" wide roadway deck carrying six lanes of traffic across a main span of 1,300' and two side spans, each at 650' in length. The deck was constructed by casting, in place, segments with 8'-0" wide, cable-stayed, edge girders that have a minimum edge depth of 6'-0" and one, full-depth, transverse girder centered 4'-6" back from

the segment's leading edge, all cast monolithically with the deck slab (Figure 2). These edge girders bracket the 17'-6" long segments and are supported with one stay on each side of the roadway which are capable of supporting a maximum of 100 tons each. The double plane of stays, there-by effected, are designed as parallel elements so that when viewed from any angle they will not present a confusing clash of lines but, instead, have a consistent, harped pattern when juxtaposed, one plane against the other.

Another aesthetic consideration was for the shape of the main tower legs. The towers embody some very architecturally pleasing shapes with rectangular columns having their main axis rotated from an east-west orientation at the water and twisting through a 90 degree arc as they rise to a north-south orientation at the deck, all of which produces some very interesting, triangular facets to the towers' legs. An additional, aesthetic feature to these towers is found where they are strutted with what were called "bow-ties" at two locations high above the deck and a half bow-tie, flat up against the bottom of the main deck.

Two sets of steel form-travelers (Figure 3) were designed by Boris Gimien, P.E., of DRC Consultants, in a fashion to reduce weight by using the cable-stays in two stages; one for the transitional erection process (a) and the other (b) for the permanent, primary function of holding up the deck for the passage of roadway traffic. The Form-Traveler (F-T) is composed of 3 space trusses: one under each of the longitudinal edge girders(Figure 3) and one transverse truss (Figure 2) locking all three elements into a large, "H" configured space truss, oriented horizontally and positioned under the deck. These space trusses carry the advancing segmental formwork and are initially positioned against the north and south sides of each tower and up against the previously cast on strutted forms, roadway deck spanning between each leg of the main towers.

The segmental forms are installed and

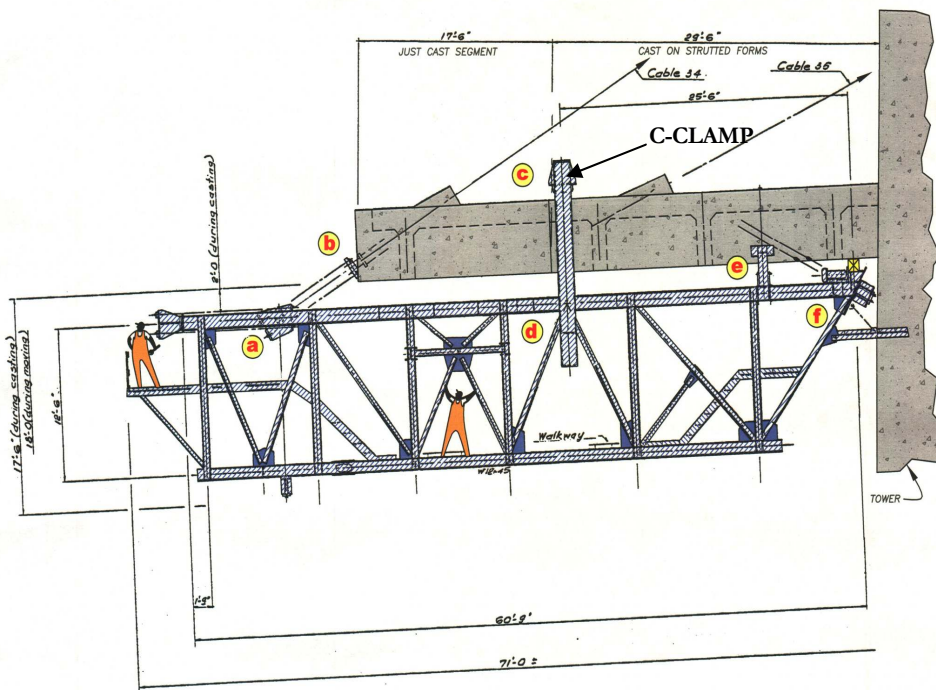


FIGURE 3: ELEVATION, SIDE SPAN, STARTER SEGMENT

positioned, in a balanced fashion, on each traveler located on either side of the towers. The traveler is tugged forward and rides on the lower jaw (d) of the C-clamp. With the advancing center of gravity moving to the front side we see the front end rotate down about the C-clamp, which is acting as a fulcrum. With the trailing end, consequently, rotating upward to brace against the bottom of the edge girder (e) we see the F-T projecting, as a free cantilever, 35.25 feet beyond the fixed, C-clamp.

The permanent stay anchor is located in the forms (b) to be permanently cast in place; however, another anchor is fixed, on the F-T truss (a), outboard of the segment being cast, but on a sliding axle that accommodates all angles between the deck and stays. These two anchors [permanent (b) and temporary (a)] are aligned and coupled with all-threaded, high strength bars and, as a consequence, they provide intermediate support for the free cantilevered end, greatly reducing stresses with a consequent weight reduction in the trusses.

The temporary F-T anchor (a) will carry some of the cantilevered F-T weight and some of the newly cast, concrete segment weight with the remaining load balanced across the bottom jaw (d) of the C-clamp and restrained by the embedded, construction anchors at the trailing edge of the F-T (f). The two induced force components, at the F-T anchor (a) are initially balanced by the cantilevered truss in the vertical direction and with the F-T anchor, horizontal component countered by the trailing anchor (f). When the poured concrete segment is properly cured the permanent anchor is stressed (b) which relieves the F-T anchor (a) of its full load and once again the F-T becomes a pure cantilever.

To advance the F-T into position for the casting of the next segment: disconnect the stay cable extensions (a & b) at the front and loosen the horizontal and vertical restraints at the rear(f); lower the C-clamps so the upper jaw (c) bears on their rollers and rides forward in tracks just relocated to the top of the newly cast edge girders; the compression struts (e) at the trailing end of the F-T have rollers which are brought to bear against the bottom of the edge girder when the leading edge



FIGURE 4: BOTTOM BOW-TIES OMITTED DURING CONSTRUCTION PERMITTING CRAWLER CRANES MOVEMENT ON DECK.

tugger advances the F-T and its' rear rotates up, about the C-clamp fulcrum, against the soffit of the edge-girder.

This sequence is executed, in conjunction with the installation of the bar stays, between their two fixed anchors, which are cast into the edge girder and tower concrete, 84 times for each tower. The stays are laid out and assembled into one complete element, varying in lengths from 65' to 720' on the deck. These elements are like giant pretzel sticks and are gingerly raised into position as fore-stays and back-stays in the east and west stay planes by crawler cranes that move about on the completed deck (Figure 4). To facilitate this mobility the lower "bow-tie", between each tower leg, was omitted until all stays were installed (Figure 4).

Another unique feature of this design is the expansion joint at the center of the main span and the side spans being fixed at each abutment pier (Figure 5). The mathematical analog for the expansion joint design condition is a simply supported bar resting on two rollers acting as supports. The re-design for the main girder and stays, as constructed, was done by DRC's Jee Bong Louie, P.E.. The owner, the Jacksonville Transit Authority (JTA), was represented by Steve Arrington and Larry Wehner.

The Dames Point Bridge was opened to traffic in 1989 but somewhere over these intervening 17 years it has picked up it's official name of the "Napoleon Bonaparte Broward Bridge".

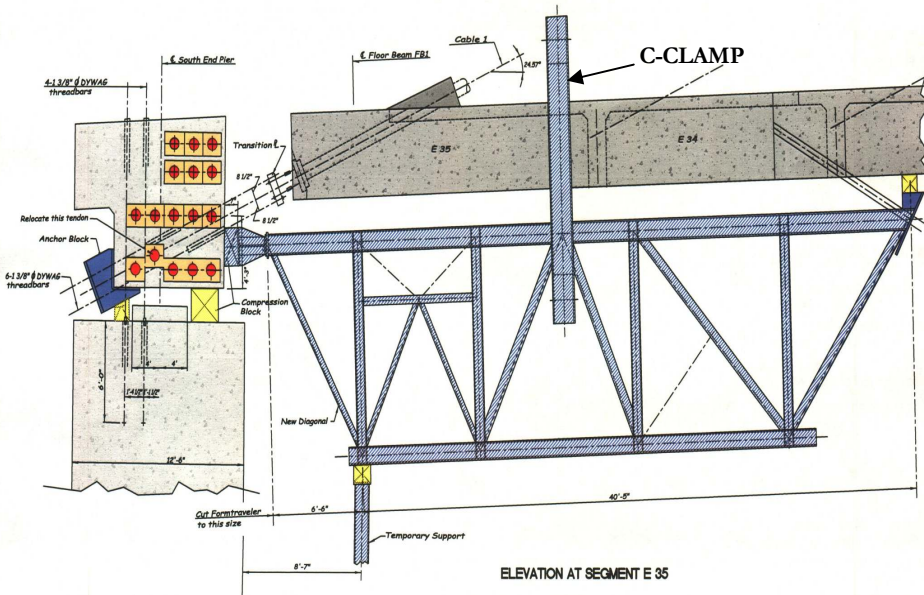


FIGURE 5: SIDE-SPANS FIXED TO ABUTMENT PIERS WITH MODIFIED F-T TRUSS AND TEMPORARY SUPPORT.

Guest Commentary

Florida's Path to Post-Tensioned Voided Slab Bridges

By: Rajan Sen

Florida's rapid growth has led to large scale urbanization. The design of bridge structures in urban areas is complicated by space limitations imposed by the high cost of land. As a result, structures are usually continuous and heavily skewed or curved in plan. In addition, the vertical alignment is also curved to allow for super elevation and intermediate support is often provided by discrete columns. Thus, structures must not only meet the complex geometric requirements of the site but must also possess the necessary strength and stiffness to withstand the applied loading.

The uniqueness of geometry at urban interchanges makes pre-cast construction uneconomical. Beam and slab systems can be used but their forms and relatively large structural depths detract from the efficiency and appearance of the interchange. On the other hand, cast-in-place, cellular structures such as box girders and voided slab bridges provide economical yet aesthetic solutions. Their high torsional stiffness insures stability and excellent load distribution characteristics while their closed soffit and joint-less form are aesthetically pleasing.

Moreover, since the riding surface is also part of the structural system with post-tensioned, concrete construction the additional depth for a wearing surface is eliminated. Consequently, the depth is kept to a minimum thereby reducing the approach lengths by the ratio of 1 foot of depth reduction yielding 20 feet of reduction in each approach length and thereby increasing the efficiency of the interchange and cutting costs.

Cellular structures can be used for spans exceeding 100 feet: with voided sections being economical for spans in the 100-140 foot range and box sections used for longer spans. Florida's interest in this type of construction stemmed primarily from first hand knowledge of Ontario Canada's experience of then two decades of good performance for their voided slab bridges.

In 1986, the Florida Department of Transportation, in cooperation with the US Department of Transportation, initiated a three year study with the University of South Florida on post-tensioned, voided slab bridges. As part of the study two scale models of continuous, post-tensioned, voided slab, bridges (one straight and the other curved) were designed, fabricated and tested to failure with a view towards technology transfer.

The opportunity for the implementation of this transferred technology occurred in Miami, Florida in 1991. The FDOT's consultant, Post, Buckley, Schuh and Jernigan (PBS&J) was to design a ramp connecting Miami's S.W. 8th Street to the Florida Turnpike. The ramp is on a 375 foot radius, crossing over the Tamiami Canal at a 42 degree skew, then merging with S.W. 8th at a 14 degree skew.

The spans were dictated by the canal's horizontal width of 28 feet 6 inches coupled with its' skewed orientation with the Canal, spans of 55 to 65 feet were required. Longer spans require deeper beams and resorting to the traditional FDOT construction of pier bents under pre-cast beams which support a cast-in-place deck slab resulted in a structural depth that was 4 feet 6 inch.

PBS&J recognized how this large depth would adversely impact the project. Their Glenn Myers and Antoine Gergess saw that it would require the costly raising of the road profile to match the higher bridge deck level and, in turn, would block existing driveways and require the replacement of an existing toll plaza. The problem was clear: reduce the structural depth of the ramp and ; consequently, eliminate the need for any adjustment to the existing profile grade line.

PBS&J proposed using a four-span, continuous, post-tensioned, voided concrete slab with a total structural depth of 2 feet 4 inches. This solution reduced the structural depth by half, while maintaining the 60 foot maximum span, and the bridge now fits snugly into the existing dimensional matrix without any of the costly adjustments required by the traditional beam and slab solution.

The design of the bridge incorporated many of the findings from the USF research. The structural plans were prepared in accordance with structural drawings and details developed by Ontario's Ministry of Transportation. Construction of the bridge began in late 1991. Although Hurricane Andrew caused several months' delay, the bridge opened to traffic in the spring of 1993- less than three years after the USF research was completed. The prompt implementation witnessed with this exercise in technology transfer will motivate researchers to find practical solutions to infrastructure problems.

Coming Issues:

- The Acosta Bridge Replacement in Downtown Jacksonville
- Savannah, Georgia's Talmadge Bridge
- The most unique Denny Creek Viaduct for Wash D.O.T.
- Why Not Pipe Truss Bridges ?

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