Highlights

- COMPARATIVE ANALYSIS BETWEEN A STEEL TRUSS AND CONCRETE CABLE-STAYED BRIDGE
- THE VAGARIES OF BIDDING BRIDGE PROJECTS IN THE US CONSTRUCTION MARKETPLACE
- CURRENT ELECTRONIC BRIDGE RENDERINGS FROM DESIGN DRAWINGS

SPANS

Hillsborough County Florida

Public Works Department
Bridge Team

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# A BRIDGE TOO FAR - BARELY

The year was 1983 and the New York City Consulting Engineering Firm, DRC Consultants Inc., was selected by the Kentucky Highway Cabinet to design the Concrete Alternate for the Ohio River crossing between Portsmouth, Ohio and South Shore, Kentucky. This Consultant had been in business for only four years but had considerable concrete bridge experience as the in-house engineering arm for a large, post-tensioning tendon supplier for the North-American construction market.

They were given autonomy by the parent company, Dyckerhoff & Widemann, AG. (Dywidag), in 1979 and transferred this enormous engineering capability into DRC, which stood for Design, Research and Construction. They teamed up with Fred Meyers of HMB, a Frankfort, Kentucky Engineering firm, for the bridge design in order to better address all of the local issues associated with a project of this significance.

When the United States expanded westward in the early 19th Century they often used natural boundaries, such as rivers, to mark their territory and they did not stop at the near shore but, instead, reached for the far bank to include the rivers in this expansion. Rivers have always been, and still are, main transportation arteries as evidenced by the chain of locks along the Ohio River that the US Army Corps of Engineers has built and maintained for nearly 200 years (Figure1).

**FIGURE 1: The bridge to span the Ohio River and connecting Portsmouth, Ohio (beyond) with Greenup County, Kentucky**

Not unlike today's Real Estate grabs for locations near the crossing of two Interstate Highways the confluence of rivers provided similar opportunities and towns such as Portsmouth, Ohio appeared and flourished. The Scioto River empties into the mighty Ohio River from the north, just west of Portsmouth, Ohio.

Less than one mile south of this confluence of rivers we presently have the Carl D. Perkins Bridge that connects two lanes of highway traffic for Ohio State Route 852 and US Truck Route 23 with Kentucky Route S8. This steel, cantilever truss bridge was designed by the long established bridge designers, Hazlet and Erdal. Their steel design was the winning alternate, when bid on January 18, 1985, under the federal mandate that all federally funded bridges must have two, independent designs in alternate materials, steel and concrete.

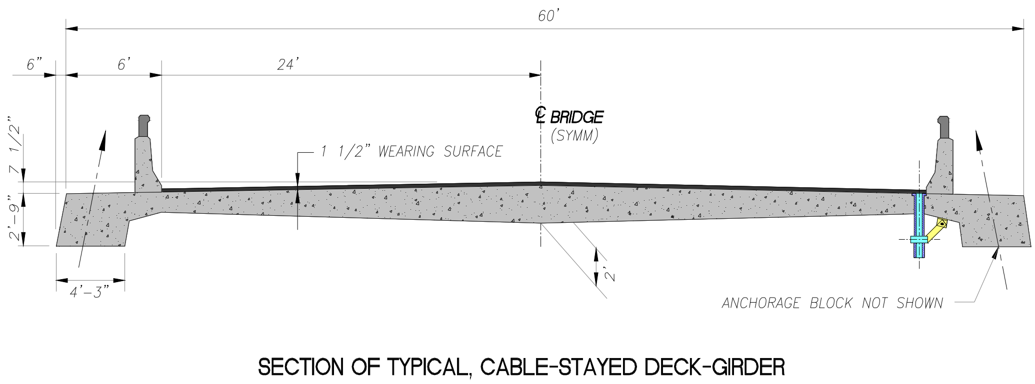



**FIGURE 2: A typical cross-sectional view of the 2000' long, cast-in-place, cable-stayed deck girder**

Thomas R. Layman, P. E. was the then Director, Division of Bridges for the Commonwealth of Kentucky and he administered the designs and the development of the bid packages for the alternates to advertise for construction. The concrete alternate was the first cable stayed bridge design the department had ever entertained and they were determined that they were going to get it right, especially since Kentucky would have the maintenance responsibilities for the winning alternate.

The concrete designer developed a 60'-0" wide deck girder that was a cast-in-place, post-tensioned, prismatic section with only two longitudinal edge girders between which the deck slab hung (Figure 2). These edge girders were supported by a total of 188 stays (425.8 tons of steel) with cast-in-place anchors spaced 20'-0" longitudinally and centered on the typically 4'-3" wide, 2'-9" deep edge girders (Figure 3). The symmetrically positioned, twin, tuning fork shaped pylons were spaced 940' apart and tower 315'-10" above the normal pool elevation of the Ohio River at this location (484.4'). The minimum vertical clearance is 86.8' above normal pool elevation, the 100 year design flood elevation is 50.4' above this level and, amazingly, the record flood in 1937 had the river flowing at 59.4' above normal pool.

The two towers were founded on bedrock with cofferdams and a concrete seal pour onto which a tower footing was built up to elevation 472.4'.

The south abutment and six south piers were all on pile caps supported by piles to bedrock. Likewise, the north approach had five piers and one abutment on pile caps and piles to bedrock. The close proximity of infinite bearing capacity equalized the weight difference between the superstructure alternates with neither having a distinct foundation advantage.

The remainder of the 2000', cable-stayed girder was balanced in equal parts about the main span by 440' and 90' spans. The Kentucky approach had 5 conventional spans and the Ohio approach had 4 for a total length of 943' of conventional construction adding to the total bridge length of 2943'. The concrete alternate had aroused a lot of curiosity and a scale model of the bridge was developed, reviewed and publicly displayed.

The two designs were a study in contrasting structural systems (Figure 4) with the steel cantilever truss acting primarily with beam action and the concrete having basically tension and compression elements.

Constructability was key to both concepts with the steel side spans being floated into position in large sections and built over the main piers to cantilever to inflection points in the main span. Having both side spans in place and made continuous over the main pier supports with cantilevers into the center span to the inflection points, the large main span truss section could be positioned on barges in the river and hoisted from the inflection points into their final, geometric position and made continuous with the side spans.

Accordingly, the cable stayed pylons are built to their full height and anchorages installed only in the "tuning fork" handle with their proper orientation in order to receive the cable stays that would be radiating down to their anticipated locations along each edge girder in the main-span and the four side spans. The decks begin at what is called a pier table, a stayed, temporarily fixed 56'-0" long deck element centered on and temporarily locked between each leg of the fork.

Twenty foot long, incremental segments are cast on form-travelers in a balanced pattern about each side of the pier-table.

**FIGURE 3: One of the twin, 315.83' towers supporting half of the 940' main-span and two side spans of 440' and 90'.**

**FIGURE 4: The competing designs were a study in contrasting structural schemes: top scheme features flexure; bottom, tension-compression**

Once the concrete cures, the stays are stressed and the forms are advanced to their next location progressing the deck to a closure pour in the middle of the main span. The two 90' anchor spans see the edge girder deepened to 5'-0" and extended back into the cable-stayed side spans 56'- 0" to a 4'-0' closure pour. The two outer most stays each extend to an anchor point 20'-0" into the two 90'-0" anchor spans.

The steel truss (continuous beam) has hundreds of tension and compression elements that are also subjected to local bending and are working together as a single unit to resist vertical, horizontal, longitudinal and torsional loadings. Correspondingly, for the same loading conditions, the cable stayed bridge responds with tension in the steel stays, compression and bending in the concrete pylons and compression with local bending in the concrete deck.

A pre-bid conference was convened and was well attended by the KDOH, the Ohio DOT, material suppliers, contractors and the design engineers in order to give vent to any concerns that may be lingering about the issued bid documents. This gathering produced no significant concerns and so the bidding process continued. The night before the bids many of the participants had dinner in the local Holiday Inn and the rumor was about that the concrete was low. The following morning the cold reality was that the steel alternate won with a low bid of $18,920,853.30. The low bid for the Concrete alternate was $19,340,880.06 or 2.2 % too expensive.

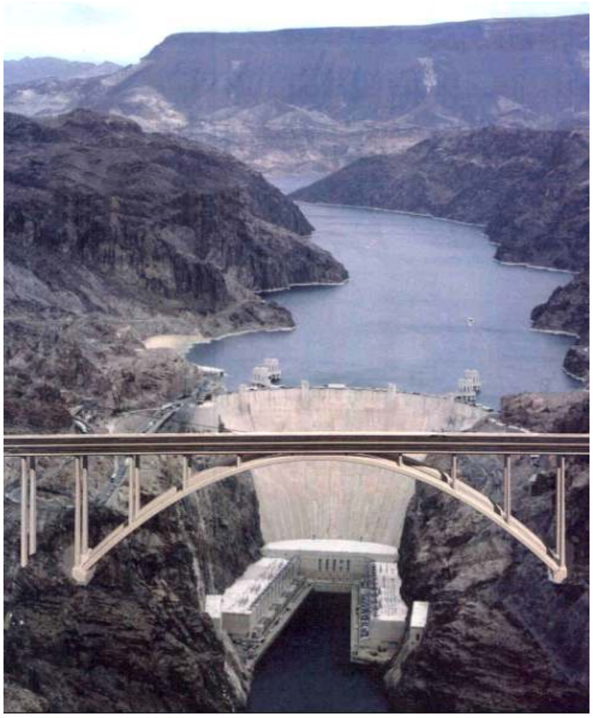
Some time after the KDOH award it was learned that one of the competing steel suppliers had a bid pending on another major bridge crossing with more than three times the Portsmouth Bridge's 5330 tons and they were the apparent low bidder. However, at the eleventh hour, the other state had ruled that they had to be 5% lower than any domicile, qualified bidders and they awarded the contract to their native son. Needless-to-say, the steel supplier scrambled back to the bidders in Kentucky on the morning of the Portsmouth bid with his very best price and the rest of the story is history (Figure 5).

New ideas were introduced with the concrete alternate that saw their way into the fabric of the global infrastructure and the consultant was paid for his design but, you still wonder, what it would have looked like if it had been built ? Well, Kirk Olsson was given the plans and pictures of the site and asked if he could pump life into these musty old images. Two days later Figures 1, 3, 4 & 5 were presented and now, 20 years after the opening of the steel alternate to traffic, (January 28, 1988) a virtual image of the Bridge Too Far – Exists .

**FIGURE 5: The sun sets on the unsuccessful, proposed concrete alternate.**

# *Guest Commentary*

***By: Ron Watson***



**Hoover Dam Bridge rendering**

## Isolation Bearings to Be Used On the New Hoover Dam Bridge

The Hoover Dam Bypass was conceived to address a number of traffic congestion and safety issues related to the function of highway U.S. 93 and its crossing of Hoover Dam. The roadway is the primary route for commerce and travel between Phoenix and Las Vegas, with more than 17,000 vehicles using this section of highway each day. The accident rate in the bypass area is three times higher than the rest of U.S. 93.

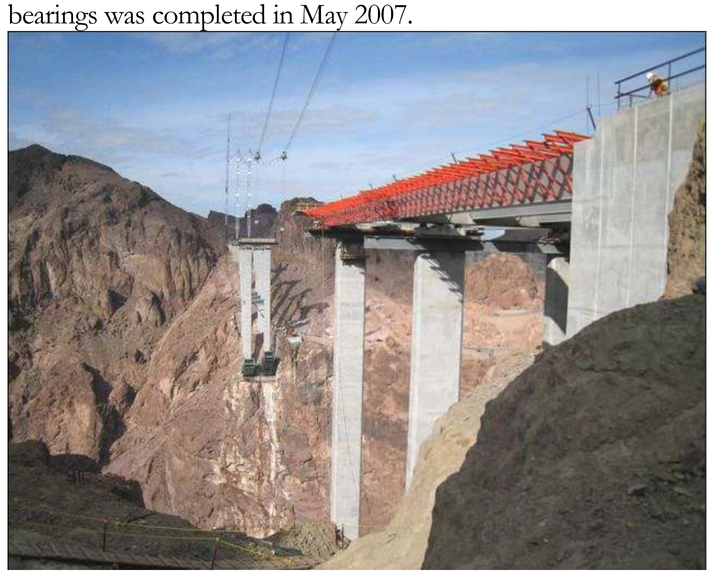
The new Hoover Dam Bypass will include approximately 3.5 miles of new four-lane highway and a 1,900 foot-long bridge over the Colorado River about 1,500 feet south of the dam, and ties into existing U.S. 93 on the east and west. The bridge portion of the Hoover Dam Bypass project has been officially designated by the United States Congress as the "Mike O'Callaghan-Pat Tillman Memorial Bridge." The bridge's name honors two prominent local citizens who dedicated themselves to public service and the greater good.

The $114 million river bridge portion of the $234 million bypass was designed by the team of TY Lin International and HDR. The main span of the bridge is a concrete arch 1060 feet long which is being constructed by a joint venture team of Obayashi Corporation and PSM Construction USA Inc.

During the design of the bridge, the engineers at TY Lin International chose to use sliding isolation bearings at the abutment locations. Normally isolation bearings are used in seismic applications to provide protection from the possibility of strong ground motions. Isolators physically uncouple a bridge from the harmful effects of earthquake ground motions resulting in a substantial reduction in the forces generated by an earthquake.

However in this case isolation bearings are being used at the abutments in order to provide force control. Eight high load multi-rotational disc bearings were modified to provide isolation and are designed for a maximum vertical load of 543 kips with a horizontal capacity of 121 kips and a design rotation of 0.022 radians. In addition the bearings were provided with permanent elastic restraint mechanisms. The control springs were designed with a restoring stiffness of 5 kips per inch over a movement range of +/- 5 inches. The bearings were also provided with temporary restraints to maintain the bearing in a set position during erection procedures.

Full size production bearings have been tested for vertical proof load, compression strain, horizontal proof load, rotation and coefficient of friction. Installation of the sliding isolation bearings was completed in May 2007.



**A January, '08 view of two, 400' tall piers bearing on the arches' thrust-blocks**

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