William H. Natcher Bridge

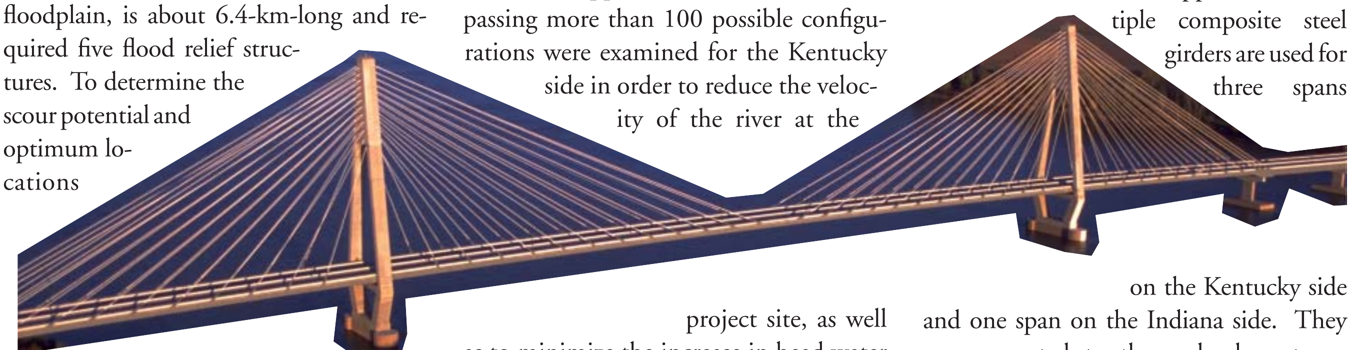
Owensboro, Kentucky

By Vijay Chandra, P.E. and Ruchu Hsu, P.E.

The new "jewel" of the Ohio River is the William H. Natcher Bridge (*See below*), named for the longest serving United States Congressman. The new bridge opens areas along the transportation corridor to development on both sides of the Ohio River in Kentucky and Indiana. The bridge was designed for ease of inspection and maintenance.

The Bridge

The 1,373-m-long Natcher Bridge carries Route 231 between Owensboro, Kentucky and Rockport, Indiana. Indiana is planning to extend Route 231 north to I-64, creating a major industrial corridor. The total crossing, including the Kentucky floodplain, is about 6.4-km-long and required five flood relief structures. To determine the scour potential and optimum locations for the flood relief structures in the floodplain, a two-dimensional finite element hydraulic surface modeling program was used. The results, assisted in determining scour as well as potential ship impact forces on the structures.



The main crossing over the river is seven-span continuous, composed of a three-span steel composite plate girder structure with spans of 84-108-84 m on the Kentucky side followed by a three-span cable-stayed bridge of 152-365-152 m and an 84-m composite steel plate girder structure on the Indiana side. Precast prestressed concrete approach spans over land flank the main crossing, with four 34 m continuous spans on the Kentucky side and five 42 m continuous spans on the Indiana side. The total length of the main crossing is 1,017 m between expansion joints. The bridge provides a 24-m minimum vertical clearance over a 305-m-wide navigation channel, with two lanes of traffic in each direction with shoulders and a median.

Hydraulic Studies

The crossing's many engineering "firsts" include a two-dimensional finite element model hydraulic analysis to reduce the impact of the bridge on the environment. The bridge crosses a floodplain which is inundated at least once a year. To protect the floodplain from erosion and to minimize the effects of the new structure on the agricultural lands and wetlands at the site, the design team performed a state-of-the-art hydraulic analysis for the 90 square km of the floodplain around the site.

The hydraulic study included modeling analysis for the floodplain, with and without the completed bridge, for flood cycles of both 100 and 500 years. In addition, 17 approach alternatives encompassing more than 100 possible configurations were examined for the Kentucky side in order to reduce the velocity of the river at the project site, as well as to minimize the increase in head water (upstream water) elevation.

The results of the hydraulic study assisted in determining the scour potential at each of the pier and abutment locations, and provided enough velocity vector data to assist in the ship impact evaluation.

Main Towers and Approach Piers

The main towers of the bridge are A-shaped above the roadway with inward sloping legs below the roadway. The tower tops are 79 m above the roadway level and feature a 31-m-tall chamber where the stay cables are anchored in a protected environment. Access ladders with platforms are located inside the towers to access the anchorages, the aviation warning lights, lightning rods and air circulation vents on top of the towers. For future maintenance, access openings and eye hooks are provided at strategic locations. The approach piers in the river are hammerhead type, while the land piers are pile bents. All of the piers are supported on drilled shafts ranging from 1.5 to 2.4 m in diameter.

Superstructure

The cable-stayed superstructure consists of two slightly sloping longitudinal plate girders with transverse steel floor beams 4.6 m on center and a longitudinal stringer along the center of the bridge. The concrete deck slab consists of precast concrete units that sit on the edge girder, stringer and floor beams with cast-in-place concrete infills. The edge girders are made continuous with the steel approach girders through coupling action accommodated by three floor beams. At the anchor piers, low profile wind locks resist transverse forces due to wind, ship impact and seismic activity. Uplift at the anchor piers is prevented by concrete counterweights and a redundant tie-down system. Simple elastomeric bearings support vertical loads and restrain the longitudinal and transverse movements at the fixed tower. In the approaches, multiple composite steel girders are used for three spans on the Kentucky side and one span on the Indiana side. They are connected to the embankment approaches with four-span continuous composite prestressed concrete girders on the Kentucky side and five-span continuous composite prestressed concrete girders on the Indiana side.

Stay Cables

The 96 stay cables include 18 to 58 high strength seven-wire strands, doubly protected with polyethylene sheathing and grease. They are tensioned using a mono strand system developed by VSL Corporation. The external stay pipes over the strands are co-extruded high-density polyethylene (HDPE) with spiral bead on top to eliminate rain-wind vibration. The stay pipes are white in color on the exterior to reflect ultraviolet rays and enhance aesthetic lighting. In daylight, the white stay cables blend with the environment to provide a dramatic view from a distance, highlighting the superstructure and towers. The stay pipes were filled with grout after construction of the bridge.

spotlight

Cable-to-Tower Anchorage

Designed for ease of construction and maintenance the stay-cables are anchored into steel elements inside the trapezoidal chambers at the top of each tower.

This economical and easy to construct anchoring system includes ladders and platforms within the chambers that provided construction crews direct access to tie the cables to the four corners of each steel anchorage frame.

Cable-to-Girder Anchorage

The design of the cable-to-girder connection at the deck facilitated construction. A bolted connection, rather than welded, eliminated fracture concerns and made field assembly easier.

The design team conceived and designed this detail to provide maximum flexibility during construction. The contractor's cable-to-girder options included: Attachment to the superstructure frame prior to delivery to the site; connection to the superstructure at the site just before erection; or connection after erection of the superstructure. The design team evaluated and executed the design of each of the bridge's critical elements to provide the contractor with a range of options. The cable-to girder detail also provides easy access for inspection and maintenance of the cable anchors without special equipment.

Conclusion

The bridge achieved many outstanding breakthroughs, including:

- Using state-of-the-art hydraulic studies for scour evaluation, approach relief structure location and configuration, and assistance in ship impact evaluation.
- Eliminating expensive and difficult to maintain deck expansion joints by achieving structural continuity over the anchor piers.
- Developing unique superstructure fixity connections at the towers.
- Implementing a new concept in stay cable anchoring technology.
- Achieving graceful, yet highly functional, bridge architecture.▪

Vijay Chandra is a Senior Vice President as well as a Principal Professional with Parsons Brinckerhoff in New York, Ruchu Hsu, P.E. is a Senior Supervising Engineer and a Senior Professional Associate.