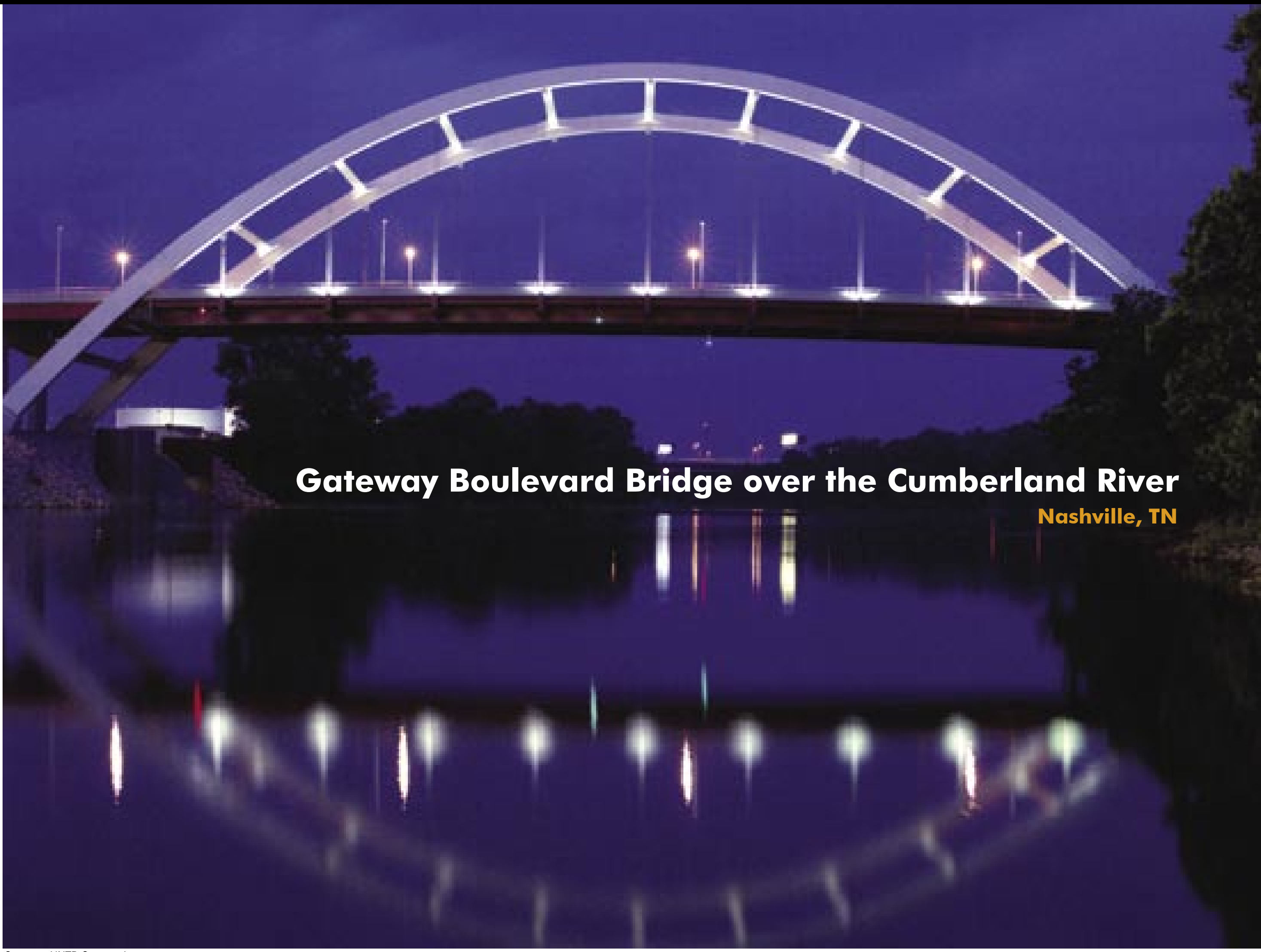
NATIONAL AWARD

MAJOR SPAN



Gateway Boulevard Bridge over the Cumberland River

Nashville, TN

Courtesy HNTB Corporation.

Owner
Tennessee DOT, Nashville, TN

Architect and Engineer of Record
HNTB Corporation, Kansas City, MO

Detailer
Tensor Engineering, Indian Harbour Beach, FL, NSBA/AISC member, NISD member

Erector
American Bridge Co., Coraopolis, PA, NEA member

General Contractor
Ray Bell Construction Co., Inc., Brentwood, TN

The Gateway Boulevard Bridge in Nashville connects the eastern part of the city with its revitalized downtown business and entertainment district. This $31.5 million through-arch bridge totals more than a quarter mile in length—1,660' from end to end—with approximately 699' comprised of steel structure.

The main river span is a 545'-long steel through-arch bridge spanning the Cumberland River. The east end approach consists of 961' of 72" bulb tee girders arranged in nine spans. The continuous approach span is integral at the abutment. All thermal expansion is accomplished at a single expansion joint located at the interface with the transition span prior to the arch unit.

The west end approach consists of a 128'-long curved steel plate girder. Additionally, the main arch deck span is buffered by two transition spans made of 59'-long steel plate girders.

Arch Ribs

The arch ribs are steel box girders, over 6' deep, 3' wide, and 638' long, with lateral support provided by steel box Vierendeel struts. The arch ribs are anchored to concrete abutments, resisting the total arch thrust, with 4"-thick base plates attached by 55 1 "-diameter post-tensioned rods. The post-tensioning process required tensioning each rod with a minimum of 142,000 lb and a minimum final elongation of ½". The base plate design required a 4"-thick steel plate shop welded to the arch rib with pre-drilled holes for the post-tensioning anchors.

Due to the through-arch design, the steel arch ribs not only have a large vertical load, but also tremendous horizontal thrust. The site is characterized as having a high limestone bluff on the west side of the river and relatively deep rock on the east side. The design had to determine the optimum configuration of the abutment stem and footing while providing adequate resistance from the fractured rock. On the east side, the contractor had to excavate well below the water table to achieve proper founding of the arch abutments. The top of the east arch abutment footings were built approximately 65' below existing grade and a minimum of 5' below the top of the rock. The bottom of the 16½' by 46'-long footings are 21½' below the top of the rock.

Courtesy HNTB Corporation.

The east arch abutment footings were constructed below the bottom of the sheet piles without a concrete seal. To provide the necessary foundation, the footings needed to be "socketed" into rock. It took tremendous skill to properly seat and seal the steel cofferdam sheets, thereby allowing the footings to be constructed in relatively dry conditions.

The ribs were erected working from both arch abutments, using steel towers and cable stays to hold the erected pieces in place. The members were erected using cranes on barges in the river. Only while the center three sections of arch rib were lifted into place was barge traffic stopped. These three sections totaled 115', weighed 95 tons, and were lifted into place more than 190' above the center of the river. To accomplish the proposed erection sequence, the contractor used a 4100 ringer crane with 280' of boom mounted across three barges.

The post-tensioned anchors at all arch abutments were grouted after tensioning to provide protection from corrosion and other environmental attacks. During the construction sequence, some of the grouting tubes for the rods were damaged. Due to concern about not being able to adequately blow out the tubes, it was decided to use a vacuum grouting procedure on each tube. This procedure provided a much more thorough cleaning and filling of the grout tubes, thus providing better protection for the post-tensioning rods. This is the one of the first instances where a vacuum grouting procedure has been used.

Arch Deck

The arch deck has 49' of clearance above regulated high water and sits 79' above the normal pool stage for the river. The top of the arch ribs is 98' above the roadway. The arch deck is 453' long and is supported by 72 2"-diameter high-strength steel cables. The arch deck is a steel girder floor system made of nine transverse floor beams with two longitudinal stiffening girders and 11 stringers framed into them. The deck system is anchored at each end by steel box end struts where the transition span girders and floor system tie in. The connection to the west end strut is a pinned connection bolted to the web, while the connection to the east end strut has a pot bearing expansion device, capable of 8" of longitudinal and 1" of transverse movement. The floor system is topped with a concrete deck made composite using field welded shear studs.

The three additional steel spans include two transition spans and a curved span. The transition spans are simple spans, 59' in length, made of steel plate girders. They attach to the end struts with a pinned connection bolted to the web of the end strut. The west approach, or span one, is a 72"-deep steel plate girder with a 8˚-19'-00" degree of curvature and a minimum radius of 643'.

At 102' out-to-out, the extremely wide bridge deck geometry created challenges in placing the concrete deck itself. The contractor determined that it was not feasible to place concrete continuously in the transverse direction, instead recommending a longitudinal construction joint down the center of the arch deck. Because of the construction joint, deflections in the steel arch ribs, floor beams, and other floor system members had to be recalculated. The resulting stretch in the hanger cables subjected to unbalanced construction loading also had to be considered. ★