

PROJECT

SPANNING

the Wolf River Wetlands in Tennessee

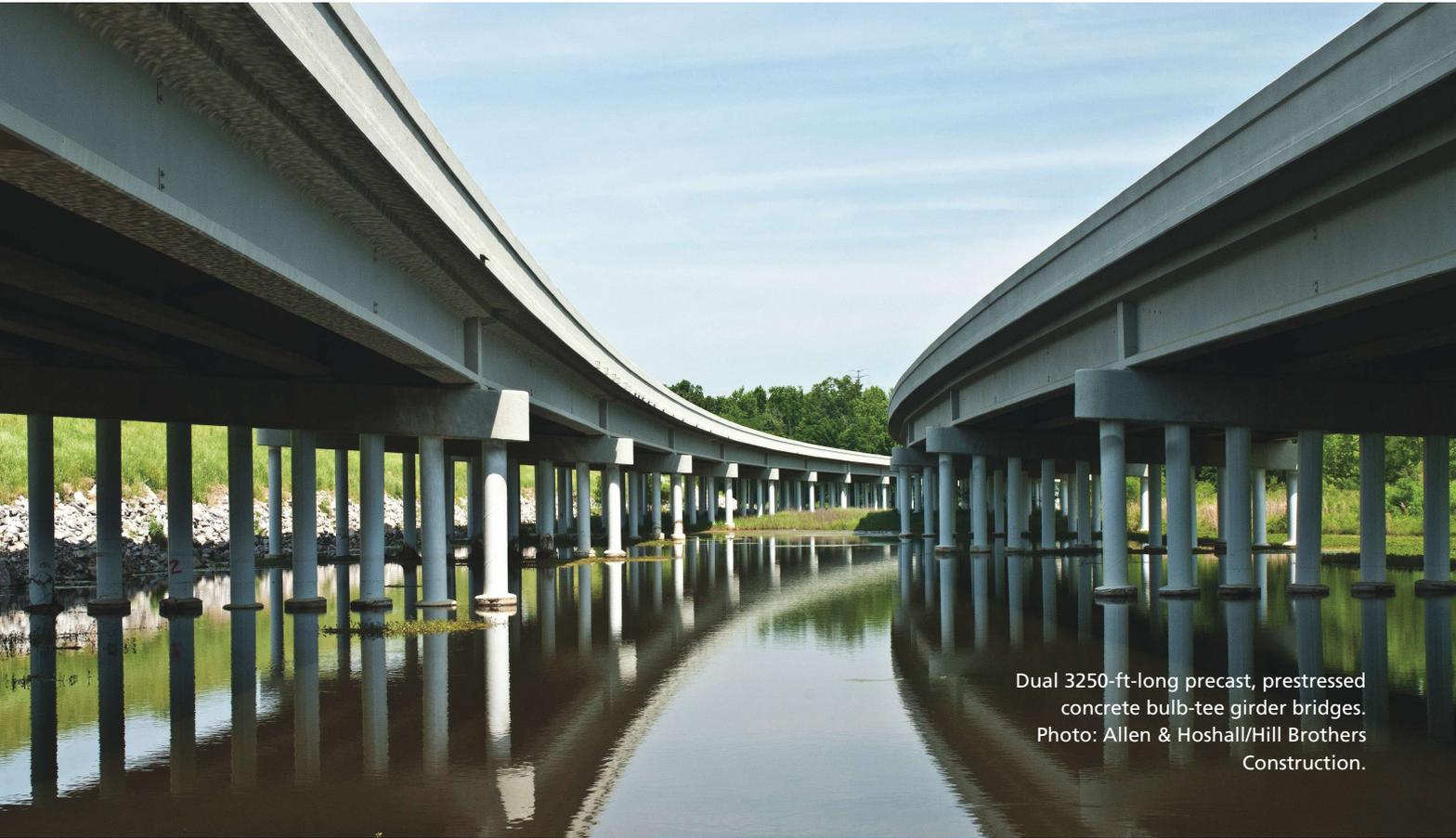
by Tim Huff, Tennessee Department of Transportation

As part of the proposed transportation improvements in southwest Tennessee, the Tennessee Department of Transportation completed plans for a new highway between existing State Routes 193 and 196 in Fayette and Shelby counties. The SR 385 (also known as I-269) project originally consisted of nine bridges. Bridge No. 3, with a length of 720 ft, crossed the Wolf River. Bridge No. 4, with a length

of 177 ft, crossed a Wolf River tributary. The original concept for these two Wolf River bridges used precast, prestressed concrete girders on cast-in-place concrete columns with pile caps. Given the extreme depth of the soil profile in this area of the Mississippi embayment, concrete friction piles would typically be used for such a concept.

Environmental concerns, which

identified the surrounding area as wetlands, necessitated a change in the plans for Bridge Nos. 3 and 4. It would not be possible to fill in the wetlands between the two bridges and the entire area would need to be bridged. The two structures were combined and lengthened to become dual, 3250-ft-long structures, each comprised of 33 spans in four continuous units with pile bent substructures. Double



Dual 3250-ft-long precast, prestressed concrete bulb-tee girder bridges.
Photo: Allen & Hoshall/Hill Brothers Construction.

profile

STATE ROUTE 385 OVER THE WOLF RIVER / FAYETTE AND SHELBY COUNTIES, TENN.

BRIDGE DESIGN ENGINEER: Tennessee Department of Transportation, Nashville, Tenn.

CONSTRUCTION ENGINEERING INSPECTION: Allen and Hoshall, Memphis, Tenn.

PRIME CONTRACTOR: Hill Brothers Construction Company, Memphis, Tenn.

PRECASTERS: Prestress Services Industries of Tennessee, Memphis, Tenn.—a PCI-certified producer (girders) and Construction Products Inc. of Tennessee, Jackson, Tenn.—a PCI-certified producer (deck panels)

bents were provided at the adjacent ends of each unit. Approximately half of each structure lies in a horizontal curve having a 2865-ft radius with the other half in a tangent section.

Alternatives

Two alternative designs for the superstructure were included in the contract plans. The two options were a 54-in.-deep bulb-tee concrete girder design with a typical girder spacing of 9 ft and a rolled steel girder design.

The steel girder alternative required more transverse deck reinforcement, and less longitudinal deck reinforcement, compared to the bulb-tee girder alternative. The net effect was a deck reinforcement total of 2,450,898 lb for the concrete option and 2,117,119 lb for the steel option.

Given that the bulb-tee girders each weighed 686 lb/ft, while the steel

girders weighed 149 lb/ft, a significant substructure savings was possible for the steel option. Eighteen inch-diameter pipe piles with a wall thickness of $\frac{3}{8}$ in. were required for the steel girder alternate versus $\frac{1}{2}$ in. for the bulb-tee alternate. This savings was not realized at the bents at the main channel of the Wolf River (bents 23 and 24). Due to a longer unsupported length, 24-in.-diameter by $\frac{1}{2}$ -in.-thick piles were required for both design options at these substructures. The total steel piling estimates for the alternates were 3,015,910 lb for the steel option and 4,721,580 lb for the concrete option.

Specified concrete compressive strengths for the bulb-tee girder alternative were 5.0 ksi at transfer and 6.0 ksi at 28 days.

Both prestressed concrete and rolled steel girder alternatives were designed



Double bents were used at the ends of continuous span units. Photo: Tennessee Department of Transportation.

and detailed to behave as simple spans for non-composite dead loads and continuous thereafter.

Site Characterization

The project limits lie in the Mississippi embayment of the New Madrid seismic

Completed dual structures. Photo: Tennessee Department of Transportation.



STATE OF TENNESSEE, OWNER

BRIDGE DESCRIPTION: Dual, 33-span, 3250-ft-long, precast, prestressed concrete bulb-tee girder bridges

STRUCTURAL COMPONENTS: Three hundred and thirty 54-in.-deep, bulb-tee girders (31,941 ft); 3384 $\frac{3}{8}$ -in.-thick, precast, prestressed concrete deck panels with 4.75-in.-thick cast-in-place concrete deck; and cast-in-place concrete pier caps, pipe-pile-bents, and integral abutments

BRIDGE CONSTRUCTION COST: \$14,220,000 (\$50/ft²)

zone (NMSZ). The embayment depth was estimated to be approximately 2000 ft from maps in the literature.¹ As site amplification in AASHTO is based on properties in the upper 100 ft of the profile, it is clear that the effect of embayment depth in the NMSZ is one area in which research is needed. Eighteen, 80-ft-deep borings were made to investigate subsurface conditions.

Borings away from the main channel of the Wolf River indicated average blow counts computed in accordance with *AASHTO Guide Specifications for LRFD Seismic Bridge Design* of about 19, while those nearest the main channel were in the 12 to 15 blows/ft range. These blow counts correspond to Site Class D conditions away from the main channel and Site Class E conditions at the main channel of the Wolf River. Using the site latitude and longitude, software was used to establish an inferred shear wave velocity for comparison to the blow count correlations already reported. The software calculated an inferred shear wave velocity of 785 ft/sec. The range for which Site Class D conditions are applicable is 589 to 1178 ft/sec. Thus, blow count data combined with an inferred shear wave velocity of 780 ft/sec. indicate Site Class D conditions.

The project lies in Seismic Design Category "2" in accordance with the *AASHTO LRFD Bridge Design Specifications* at the time of design work. Thus, no pushover analysis was required for the structural design.

Unique Design Features

For the prestressed concrete bulb-tee alternative, end blocks were incorporated into the discontinuous ends of the girders to enhance shear capacity and to resist bursting forces at these critical points. Vertical post-tensioning was included to provide added shear and bursting capacity,

Abutments were designed and detailed to behave integrally. No expansion bearings were used at the double bents. Rather, movements from thermal expansion and contraction were accommodated via flexure of the pipe piles at each double bent.

Precast Concrete Superstructure Component Summary

Structure	Girder Type	Girder Qty, ft	Deck Panel Size	No. of Panels
SR-385 / Wolf River Lateral	Type II	2298	8 ft 7 in. by 8 ft	256
SR-385 / Fletcher Road	BT-72	2278	5 ft 8 in. by 8 ft	248
SR-385 / Wolf River	BT-54	31,941	5 ft 10 in. by 8 ft	3384
SR-385 / Wolf River O.F.	Type II	1710	8 ft 7 in. by 8 ft	194
SR-385 / Wolf River Tributary	BT-63	1170	5 ft 10 in. by 8 ft	256
Raleigh-Lagrange / SR-385	BT-63	1075	8 ft 1 in. by 8 ft	102
SR-385 / Johnson's Creek	BT-63	1166	5 ft 10 in. by 8 ft	128
SR-385 / Monterey Road	Type IV	1768	7 ft 8 in. by 8 ft	200

Note: BT = bulb-tee

To simultaneously permit longitudinal thermal displacements and prevent transverse (out-of-phase) deformation at the expansion double bents, a series of four pipe restrainers per bent was installed. To accommodate the transfer of seismic loads from the superstructure to the cap to the piles, a reinforced concrete 'plug' was designed at the interface between piles and bent caps. The design force for restrainers in such an application may be conservatively taken as twice the transverse seismic shear on one of the bents, equivalent to assuming that the bents would move in opposite directions simultaneously during strong ground shaking.

Construction

Five contractors submitted bids for the SR 385/I-269 project. All bidders selected the 54-in.-deep bulb-tee girder

alternative over the rolled steel girder option. While this article focuses on the Wolf River Bridge, cost data are reported for the entire project.

The awarded bid for the project totaled \$53,473,493, which consisted of \$32,079,825 in roadway costs and \$21,393,668 in bridge costs. The state estimate was \$55,433,176. The dual, 44-ft-wide Wolf River bridges totaled \$14,220,000 (\$50/ft²).

For the eight bridges on the project, prestressed component bid prices were

- \$85/ft for Type II AASHTO I-beams,
- \$150/ft for Type IV AASHTO I-beams,
- \$129/ft for 54-in.-deep bulb-tee girders,
- \$175/ft for 63-in.-deep bulb-tee girders,



- \$155/ft for 72-in.-deep bulb-tee girders, and
- \$36/ft for 14-in.-square precast concrete piles.

Precast, prestressed concrete deck panels that are 3.5 in. thick were selected by the contractor for each of the eight bridges on the project instead of an 8.25 in. full-depth, cast-in-place concrete deck. Epoxy-coated reinforcement was used in the precast, prestressed concrete deck panels and in the deck. Girder type, number of deck panels, and deck panel nominal sizes are given in the table. In addition to the precast concrete superstructure elements, 20,805 ft of 14-in.-square precast concrete piling was installed on the project.

Reference

1. Fernández, J. A. 2007. *Numerical Simulation of Earthquake Ground Motions in the Upper Mississippi Embayment*, Atlanta, Ga., Doctoral Dissertation, Georgia Institute of Technology. 

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The deck consisted of precast, prestressed concrete panels with a composite cast-in-place concrete topping. Photo: Allen & Hoshall/Hill Brothers Construction.



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