REHABILITATION AND WIDENING OF THE STATE ROUTE 99 BRIDGE OVER INTERSTATE 24 IN MURFREESBORO, TENNESSEE

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ABSTRACT

The State Route 99 Bridge over Interstate 24 in Murfreesboro, Tennessee was built in 1970 as part of the construction of the interstate. A surge in population growth in Murfreesboro resulted in the need for a new interstate interchange and the widening of the existing bridge.

Two alternates were studied to determine the most cost effective solution for rehabilitating and widening the existing 286 foot, four-span bridge. As a result, a new precast, prestressed concrete superstructure was chosen to replace the existing cast-in-place, haunched reinforced concrete beams. The new 100 foot wide superstructure was made integral with the substructure resulting in the elimination of expansion joints in the deck. The substructure units were widened and integrated into the new structure, reducing the cost of construction. All construction activities were phased during the extensive rehabilitation so that traffic could be maintained with minimal interruption throughout the duration of the project.

The new bridge and interchange was opened to traffic in January 2008--five months ahead of schedule. In view of the low initial cost of precast, prestressed concrete I-beams, the ability to incorporate the existing substructures into the widened bridge, and the low cost of future maintenance, the new structure is attractive, durable, and cost effective and will serve the public for many years to come.

Keywords: Case Study, Construction, Bridge Rehabilitation, Prestressed Concrete, Standard Specification

INTRODUCTION

A surge in population growth in Murfreesboro, Tennessee resulted in the need for a new interchange on Interstate 24 at the State Route 99 crossing. To accommodate the increase in traffic, which would result after completion of the new interchange, the existing State Route 99 Bridge needed to be widened to provide additional traffic lanes. Two alternates, whether to widen the existing superstructure or to replace the entire superstructure, were considered in determining the most cost effective solution that also minimized impacts to the motoring public.

ORIGINAL BRIDGE

The existing bridge was built in 1970 during the construction of Interstate 24. The 286'-0" long structure consisted of four continuous spans with expansion joints at the abutments. The vertical profile of the bridge was within a 1400' crest vertical curve. Additionally, the bridge was skewed 24 degrees normal to its centerline.

The existing superstructure consisted of a 7" cast-in-place concrete deck placed monolithically and supported by six cast-in-place, haunched beams (Fig. 1). The beams varied in depth from 3'-7" at midspan to 6'-1" at the supports. The bridge deck had been overlaid with 4" of asphalt pavement. The total out-to-out width of the bridge deck was 50'-0" which carried two lanes of traffic with shoulders.

The substructure units were stub abutments supported by steel H-piles and three column bents with spread footings bearing on rock.

Figure 1 Existing bridge before rehabilitation.

REHABILITATION AND WIDENING ALTERNATES

With current increases in costs of materials and labor, owners and engineers need to look at alternates that maximize their investment. A study was performed to determine the best use of the Tennessee Department of Transportation's (TDOT's) construction dollars.

The first alternate proposed widening the existing bridge using six new precast concrete T-beams that were to be haunched at the bents similar to the existing bridge profile and placing a concrete overlay on the existing bridge deck. As part of this project, the Interstate 24 corridor below the bridge was being expanded from a four lane divided section with a 60'-0" depressed median to an eight lane section with no median. The proposed grade of the bridge along with the profile of the haunched beams resulted in a vertical clearance that was below the 16'-6" minimum requirement for interstates. To provide the required minimum vertical clearance, the existing interstate grade would need to be lowered and/or the bridge would need to be raised by jacking the existing superstructure. As a result of drainage concerns in this area, the interstate could only be lowered by 6". In addition to the 6" grade drop on the interstate, the existing bridge would have to be raised 1'-3" to satisfy vertical clearance requirements. Raising the bridge by that amount while trying to maintain traffic would add to the complexity of the project.

The second alternate proposed removing the existing 37-year old superstructure and replacing it with new precast, prestressed AASHTO Type III I-beams and new 8 ¼" concrete bridge deck. The AASHTO Type III I-beams had a height advantage over the deeper haunched beams of Alternate One. The depth of the I-beams required the proposed grade on the bridge to only be raised by 8" to satisfy vertical clearance requirements and did not require any lowering of the interstate below.

The bridge inspection report prepared by TDOT indicated that the substructure units were in good condition. Consequently, the existing abutments and bents could be widened and incorporated into the proposed structure for both alternates.

A cost analysis was performed to determine which alternate met the goal of a cost effective, low maintenance, and aesthetically pleasing design. The estimated cost of widening the bridge by adding additional T-beams on both sides as proposed in Alternate One was compared to the estimated cost of removing the existing beams and deck and replacing them with new precast, prestressed I-beams and cast-in-place deck as proposed in Alternate Two. It was estimated that Alternate Two would provide an initial minimum savings of approximately $150,000 over Alternate One. This savings did not include the additional cost of raising the existing bridge and undercutting the interstate below required for Alternate One. Additionally, life cycle costs were not added but would provide further savings in the future.

Alternate Two was recommended to TDOT as the preferred alternate for widening the bridge. TDOT agreed and selected the replacement of the bridge superstructure as the proposed alternate.

SUPERSTRUCTURE REPLACEMENT

The new superstructure is comprised of eleven precast, prestressed AASHTO Type III I-beams spaced at 9'-3" on center. The span lengths are 49'-0", 94'-0", 94'-0", and 49'-0" for a total bridge length of 286'-0". The low span-to-depth ratio resulted in a sleek superstructure that is aesthetically pleasing. The 100'-0" wide concrete deck is 8 ¼" thick and provides for 5'-0" sidewalks, 2'-0" gutters, four 12'-0" traffic lanes, a 12'-0" median, and 12'-0" shoulders (Fig. 2). The use of precast I-beams facilitated rapid construction with reduced disruption of traffic.

The original expansion joints at the ends of the bridge were eliminated making the abutments integral. Expansion joints not only have a high initial installation cost, but also carry a maintenance cost throughout their service life. The new superstructure was made continuous for live load and composite dead loads. The superstructure has fixed supports at all of the bents. Without expansion joints, the new superstructure will have a longer service life and provide motorists with a smoother ride.

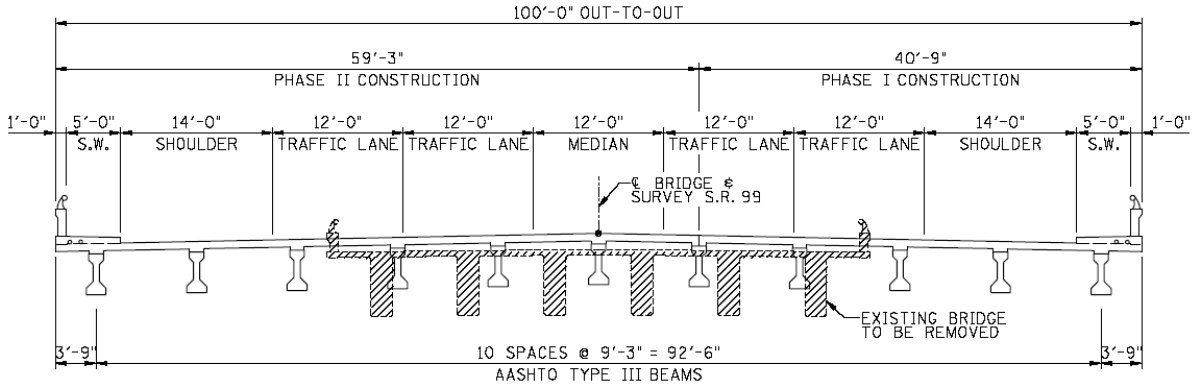

Figure 2 Proposed Typical Section.

SUBSTRUCTURE MODIFICATIONS

The substructure units were in good condition and did not require any repairs. Consequently, they were widened and integrated into the new structure. This further reduced the cost of construction.

To accommodate the new vertical grade that was raised to increase the vertical clearance under the bridge, the existing bent caps were removed and the existing columns extended (Fig. 3). New columns supported by spread footings were constructed for the widened portion of the bridge. A new tapered bent cap was used to tie the existing columns to the new columns to create a single bent.

The existing abutment endwalls were removed to the top of the abutment beam, and the wingwalls were completely removed to the back of the abutment beam. The existing pile supported abutment beams were overlaid with new riser blocks to raise the beam seat elevations for the new superstructure. The existing abutment beams were extended and new wingwalls constructed to accommodate the new widened superstructure. The abutments were made integral by connecting the new endwalls to the superstructure.

Figure 3 Removal of a portion of existing superstructure and bent cap.

PHASED CONSTRUCTION

State Route 99 is a major arterial carrying traffic in and out of the city of Murfreesboro. It was essential that the roadway remain open during construction. Also, it was mandatory that two lanes in each direction on Interstate 24 remain open with minimum interruption throughout the project. As with many projects today involving widening and rehabilitation, the engineer must deal with the challenges of completing construction while under traffic. Traffic control involving shifting existing traffic and phased construction was a key component in the rapid construction of this bridge.

The bridge was designed to be constructed in two phases. For phase one, traffic was shifted to one side of the existing bridge allowing for a portion to be removed. Removing part of the existing bridge allowed 40’-9” of the new superstructure to be constructed. Phase two construction required that traffic be shifted to the newly constructed portion of the bridge built during phase one (Fig. 4). This permitted the remaining 59’-3” of the new superstructure to be constructed to complete the bridge.

Lane shifts were used so that the existing concrete deck could be removed without closing the interstate below. A minimum number of short term closures utilizing rolling road blocks were used on Interstate 24 for the removal of the existing beams and setting the new precast

I-beams. These closures were limited to 30 minutes and done between the hours of 8:00 pm and 5:00 am and on Sunday mornings to minimize the impact to motorists.

Figure 4 Phased construction of superstructure.

CONCLUSIONS

The widening of an existing bridge presents design issues that require special attention. The details of the widening must be carefully developed in order to minimize any construction problems as well as future maintenance problems. The goals of this project were achieved by utilizing precast, prestressed concrete I-beams, incorporating the existing substructures into the widened bridge, eliminating the expansion joints, and minimizing the cost of future maintenance. The new structure is attractive, durable, and cost effective and will serve the public for many years to come (Fig. 5).

The new bridge and interchange was opened to traffic in January 2008, five months ahead of schedule. The widened bridge, with the addition of the interchange, is helping relieve some of the heavy traffic on the adjacent interstate exits (Fig. 6).

Figure 5 Bridge after widening and rehabilitation.

Figure 6 Aerial view of completed bridge.

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