SUPERSTRUCTURE REPLACEMENT OF ROUTE 676 BRIDGES OVER NORTH BRANCH OF NEWTON CREEK UTILIZING ACCELERATED BRIDGE CONSTRUCTION

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INTRODUCTION

In the spring of 2019 Dewberry Engineers Inc. (Dewberry) completed a $6,780,000 federally funded project for the New Jersey Department of Transportation (NJDOT) utilizing accelerated bridge construction techniques for a bridge superstructure replacement.

The bridges carry an estimated 81,000 vehicles per day over the North Branch of Newton Creek. Due to the high traffic volume NJDOT required that all lanes of traffic remain open during rush hour and specified that a minimum number of lanes be maintained throughout non-peak hours.

EXISTING CONDITIONS

The circa 1954 bridges were 80' long single span. The SB structure was listed in the bridge inspection report as "Structurally Deficient" due to the poor condition of the deck, and the deck of the NB structure was rated in fair condition.

The existing superstructure was comprised of rolled steel beams with welded cover plates on the bottom flanges and a 7.5" thick composite reinforced concrete deck slab. Both bridge superstructures were supported by common reinforced concrete full height abutments founded on timber piles. There were U-shaped wingwalls on the outside of the roadway, with elephant ear sections that followed the existing ground elevation. The abutments were constructed with no skew on the southbound structure and with a skew of approximately 4º on the northbound structure. The existing structures each had a curb-to-curb width of 64'-0" and an overall width of 70'-0". The bridge cross section consisted of four 12 foot lanes, a 3 foot left shoulder and an 11 foot right shoulder. The northbound roadway followed a curve horizontal alignment with a radius of 3,982 feet. However, the beams were tangent with varying overhang widths. The southbound roadway was tangent. The North Branch of Newton Creek is a tidal waterway, and the existing structure had a freeboard of 6.5' based on the mean high water level.

PROPOSED CONDITIONS

Dewberry was selected as the design consultant for the Final Design phase of this project. The project met the requirements for NJDOT's Limited Scope Concept Development (LSCD) Process, and therefore was able to graduate directly from the Concept Development Process into Final Design.

Concept development Preliminary Preferred Alternative (PPA)

The original project scope developed during the concept development phase was to replace the deteriorated deck with prefabricated deck slabs during weekend closures starting at 9:00 pm on Friday and ending by 6:00 am on Monday, giving the contractor a total of 57 hours per closure.

Through extensive research and coordination with contractors and fabricators the required duration for each construction activity was calculated. Each activity was modeled into the overall construction schedule, which resulted in an overall duration that would greatly exceed the allowable closure. Therefore, it was determined that a deck replacement utilizing precast deck panels was not feasible during the allowable closure window, and additional alternatives were investigated.

Dewberry Modifications to the Preliminary Preferred Alternative (PPA)

Dewberry performed an alternative analysis to investigate additional feasible alternatives. These alternatives included conventional construction with long term closures, and a full superstructure replacement utilizing Prefabricated Superstructure Elements (PSU's) and other accelerated bridge construction (ABC) details to replace the existing bearings and approach slabs.

Based on the results of the analysis it was determined that the design would utilize a combination of ABC and conventional construction details to replace the superstructure, bearings, and approach slabs during the weekend closures, and the bridge parapets and wing walls under long term closures of the shoulders.

Design Considerations

The proposed bridge geometry was set to match the existing geometry to avoid fit-up issues with the existing abutments supporting the replacement superstructure, and avoid the need for widening the substructure. The existing low chord elevation was held, which allowed for the hydraulic opening to remain unchanged.

As part of the design process, Dewberry consulted PSU fabricators to ensure that the proposed units were constructible, transportable, and erectable. In addition, special consideration was given to the construction loading conditions. The deck was designed to carry traffic loading before and after the joint was constructed to accommodate the traffic staging. Added complexity due of the varying girder spacing required a more refined analysis to check the capacity of the beam, and determine the deflection and camber values accurately. The existing abutments and timber piles were analyzed to ensure they would be able to resist the increased loading, and Dewberry found that they would have sufficient capacity.

Accelerated Bridge Construction (ABC) Details

In order to ensure the required work could be completed within the allowable weekend closure window multiple ABC details were incorporated into the design. These included the use of PSU's, precast approach slabs, and precast bolsters to support the elastomeric bearings. The precast approach slabs selected were a proprietary system called Superslab ® designed and fabricated by Fort Miller. Since they were the only fabricator of this type of system a sole source waiver was required by FHWA. Dewberry specified a modified backwall detail to limit the amount of demolition and re-construction required, and avoid the need for temporary sheeting along the stage lines. The top portion of the backwall was saw cut and removed. A non-shrink grout pad was poured directly onto the saw cut, and a neoprene pad was placed. The approach slab sat directly on this pad, and was doweled into the existing backwall.

The existing rocker bearings were replaced with elastomeric bearings. Due to the reduced bearing depth of the proposed elastomeric bearings there was a height differential between the existing bridge seat and the masonry plate of the bearing. In order to reduce construction time, precast bolsters were fabricated to sit on the existing abutment seats to make up the height differential. The bolsters were set on grout pads to level the existing bridge seat. Holes were core drilled into the existing bridge seat, and fabricated into the precast bolsters to allow for anchor bolts to be grouted into the seat and bolster. These details minimized the need for timely bridge seat reconstruction.

Dewberry evaluated multiple connection details for the joint connecting the PSUs. For this project, NJDOT required that ultra-high performance concrete (UHPC) be used as the joint filler. Dewberry consulted with UHPC manufactures to determine the connection detail, as well as the specific requirements for the UHPC mix design to specify a mix capable of the required cure durations.

Conventional Construction Details

Dewberry determined that conventional construction practices could be utilized for specific components of the project, that would aide to minimize project costs and still meet the overall project schedule and client expectations. Therefore conventional construction activities were performed both before and after the weekend closures. These activities included repairing the existing abutment stems, installation of the ITS conduits, construction of the bridge parapets, demolition of the existing wing walls, reconstruction of the wingwalls and parapets on the wing walls, and the construction of the pylon on the wing walls for the guiderail attachments. This work was done in long term shoulder closures, or completed without the need for lane closures. Additionally longitudinal diamond grinding was performed during nighttime closures once all of the replacements were completed.

CONSTRUCTABILITY ANALYSIS

As part of the design process Dewberry performed a detailed and thorough construability analysis of the proposed construction. This included the review of the construction schedule performed as part of the alternatives analysis to ensure it was feasible to complete the proposed work within the allowable closure window. Additionally, close coordination with fabricators, designers of proprietary elements, equipment manufactures, and contractors was required to ensure the availability, feasibility, constructability of the ABC elements. In addition, Dewberry performed a detailed analysis of the required demolition and installation/erection to ensure that the work could be completed within the allowable work zones and anticipated timeframes.

CONSTRUCTION

In October 2017, South State Inc. (SSI) of Bridgeton, NJ was awarded the construction contract for the project, with an overall bid for the work of approximately $6,780,000. Due to lane closure restrictions, and the fabrication lead times, the weekend closures were tentatively scheduled for Fall of 2018. Dewberry and SSI worked through the working drawing review process to ensure that all of the prefabricated components were properly fabricated to ensure no issues during the weekend closures as required by the contract documents.

SSI also identified and performed all the construction activities that could be performed prior to the weekend closures including any locations where the proposed anchor bolts did not conflict with the existing bearings, and pre-drilled the anchor bolts to reduce the duration during the weekend closures.

As construction progressed and approached the point in the schedule to start the weekend closures, information regarding the closures was disseminated to the public through a number of sources to provide ample notice to the traveling public of the upcoming closure. SSI scheduled the work to be completed over 4 weekend closures. Each weekend approximately half of each structure was replaced, in order to maintain one to two lanes throughout the weekend closures.

Starting Friday September 14th 2018, SSI initiated the first weekend closure with the re-placement of the stage 1 portion of the NB structure, and was able to successfully open the bridge to traffic by Monday morning when required by contract. This was repeated for the next three consecutive weekends to complete the remaining work. With each weekend closure SSI became more efficient, and was able to successfully open the bridge to traffic by Monday morning.

After the four weekend closures were completed, the work shifted to the conventional construction. The contractor was able to perform and complete this work in the Fall of 2018 bringing the project to substantial completion by December.

PROJECT CONCLUSIONS

Many factors contributed to the success of this project:

- Thorough constructability analysis completed in the early stages planning is critical to minimize risk.
- Modifications to the PPA allowed the contractor to complete construction within allowable closure windows.
- The selective use of ABC techniques balanced the overall project cost and schedule to meet the client's expectations and project objectives while minimizing disruptions to traveling public and surrounding communities.
- Sufficient advance notice through the use of different media was provided to inform the traveling public of the upcoming weekend closures. This allowed the public to use alternative routes and avoid the area during closures and reduced the volume of traffic traveling through the site.

These factors resulted in a new superstructure that will extend the service life of this structure for NJDOT.