PENNSYLVANIA TURNPIKE COMMISSION - EB117 ABC BRIDGE REPLACEMENT

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The Pennsylvania Turnpike Commission employed accelerated bridge construction (ABC) techniques to replace a deteriorated 3 span non-composite steel girder bridge over the Norfolk Southern Railroad. The replacement structure is a single span composite steel girder supported by full height concrete abutments on a micropile foundation. The project was awarded to the contractor on August 30, 2018 with a final completion date of November 1, 2019.

The bridge is located along a busy corridor of the Pennsylvania Turnpike in the Harrisburg, PA area with daily traffic volumes exceeding 30,000 vehicles per day. As a toll roadway, it is important to the PA Turnpike to limit delays and inconvenience to their customers through a prolonged single lane condition which will result in travel delays and inconvenience to motorists. Since traffic volumes are slightly less on the weekends, the Turnpike Commission proceeded with implementing two weekend closures of the Turnpike to permit the ABC replacement of the eastbound and westbound Turnpike bridges. The closure period of the Turnpike was heavily influenced by the presence of an active Norfolk Southern Railway which does not have the option of fully ceasing or detouring train traffic for the weekend closures. Significant coordination during design and construction was required to insure a successful outcome.

DESIGN AND RAILROAD / CONSTRUCTABILITY CONSIDERATIONS

The Turnpike identified this project as an ABC project during the early design phases to limit impacts to travelers. Early studies settled on a single span structure to minimize the size of the bridge that would be constructed using ABC techniques. The single span bridge also eliminated deck joints and minimized the deck area for future maintenance.

The substructure alternatives investigated centered around the ability to build it under existing spans 1 and 3 while maintaining normal Turnpike traffic. In addition to new substructure units, the conversion of the existing piers into abutments via the use of geofoam/lightweight backfill and lateral tiebacks was also considered. The reuse of the existing piers was ultimately dismissed due to several factors including the need to widen the existing structure and concerns by the railroad of not improving the horizontal clearance. The railroad desired to have the substructure units outside of their right of way which required the removal of the existing piers. Ultimately, the design team chose full height reinforced concrete abutments constructed between spans 1 and 3 supported on micropile foundations. Micropiles were used to construct the new abutments while keeping the existing superstructure in service given the limited vertical clearance. Due to the presence of stub abutments and sloping backfill from the bottom of the pier to top of the stub abutment, the use of soil nailing for excavation support was proposed to create adequate space to install the micropiles and ultimately construct the abutments.

The railroad requirements included minimum vertical and horizontal clearances which were easily addressed. In addition, work within the railroad right of way has more stringent requirements for crane use which includes the need for a 1.5 safety factor on all crane capacity charts. As part of the TS&L preparation, the design team thoroughly investigated crane placement, size and availability when finalizing the superstructure type. The site constraints (utilities, steep slopes, railroad and a limited access) combined with the 1.5 crane safety factor, resulted in relatively large cranes that required careful consideration with respect to site access and the ability to locate them favorably so as not to interfere with the numerous work crews/equipment that would be onsite throughout the weekend closure. An evaluation

of available cranes throughout PA and nearby states resulted in a limited number of large capacity cranes (i.e. 500 ton) that were adequate to meet the required factor of safety. The weight restriction resulted in a change during design to lightweight concrete in the deck and barriers. It also required adjustment to the two beam module sizes to balance the crane loads and allow the same size crane for several lifting locations.

The more intrusive requirement that had a larger impact on the design was the 24 daily trains and limited ability by the railroad to reduce or completely stop train movements. During the early stages of design, several coordination meetings were held with the Railroad to determine potential time periods during the weekend in which the railroad could cease or limit rail operations. Ultimately the railroad indicated that a single 5-hour rail traffic stoppage on a Sunday along with the normal maintenance outages (2-hours for every 8-hour period) for the weekend could be utilized for construction. Using this information, a construction schedule was developed which resulted in the need for a 59-hour detour of the Turnpike to complete the construction of one bridge (i.e., east bound or westbound). This schedule was scrutinized by the designer, Turnpike Construction personnel and the Railroad to come to a consensus that each bridge (i.e., eastbound and westbound) could be built over two separate weekends. Normally this type of bridge is built over a single weekend for both the eastbound and westbound structures, however the limited outage windows available created a prolonged schedule between train movements.

The PennDOT and PA Turnpike standard for approach slabs utilizes a sleeper slab, and a beam notch at the superstructure to reduce the chance of approach slab settlement. In evaluating the construction schedule, one of the elements the design team and PTC decided to eliminate was the use of a sleeper slab under the approach slab. Other state DOT standards were evaluated and several were found that do not use the sleeper slab and place it on compacted fill. Flowable fill was specified as the backfill behind the abutments since the placement and adequate compaction of stone behind the abutments was difficult with the presence of the existing superstructure. The use of flowable fill eliminated concerns of settlement and insured an expedited backfilling operation. In addition, it allowed the backfill to be placed very close to the abutment seat prior to the existing bridge demolition. After demolition, the contractor was required to place approximately 2 feet of compacted fill to the required subgrade. The approach slabs were placed directly on the compacted subbase and still supported by the beam notch at the superstructure.

BIDDING, CONSTRUCTION AND LESSON'S LEARNED

The construction cost estimate for the project was $11,732,451. The three bids received were $12,276,634.35, $12,284,768.73 and $15,333,000.00. The project was awarded to the low bidder and the Notice to Proceed was issued on August 30, 2018.

Construction commenced in Mid-October 2018 with clearing and grubbing. The contractor installed the soil nailing under the existing spans 1 and 3 by February 2019. Micropile installation started immediately after the soil nailing with all micropiles installed by mid-March 2019.

The contractor opted to construct the superstructure deck modules adjacent to the construction site in a nearby pasture. The temporary abutments were constructed using wood cribbing, steel I-beams and a level gravel base. The temporary support mimicked the final condition and permitted the contractor to construct the deck modules in their final condition and eliminate potential reinforcement bar conflicts in the UHPC joints. This method of construction worked well and there were no fit-up issues during the actual construction on the ABC weekends.

The contractor constructed the approach slabs on temporary concrete slabs that were constructed to create a smooth level surface for the approach slab base. The approach slabs were formed longitudinally in two rows for each bridge (EB & WB). This method worked fairly well, but it was discovered during the ABC weekend that the skew of one of the approach slab modules was slightly off which created an issue when aligning it properly in the paving notch. The mismatch in the approach slab skew was filled with UHPC. In addition, it was found that the construction tolerances resulted in up to a half inch elevation difference in the final condition between the top of approach slab and bridge deck elevation that required

adjustments during the first ABC weekend. This issue was addressed during the first weekend through a combination of concrete grinding and making up the elevation difference with the PPC overlay. Since this was anticipated for the second weekend, the contractor ground the approach slab notch to obtain the required fit.

The closure of the Turnpike was scheduled for the weekends of September 20th and 27th 2019 from 7PM Friday until 6AM Monday. The first weekend replaced the eastbound bridge with the westbound being completed on the second weekend. A go-no/go decision was made at noon on the Thursday prior to the scheduled closure and took into consideration weather, traffic, railroad or other potential issues that may impact the weekend closure. Fortunately, the weather and most other concerns were not an issue and the planned closures commenced as planned.

Throughout design, the team spent a significant amount of time reviewing the construction schedule for the weekend closures. Under normal circumstances (i.e., bridge crossing and roadway or stream), we have the option of detouring the roadway/stream users. In the case of the railroad, this was over a major north/south line that could not be detoured or cease operations over the weekend. The schedule was highly dependent on the railroad traffic which limited work over the tracks when there was an active train movement. During the weekend construction periods, there was about one train an hour from 7PM Friday through Saturday afternoon. This coincided with both the demolition and deck module placement during which there is the need to foul the track frequently. At the completion of construction, a comparison of the expected schedule during design and actual construction schedule was developed. While the overall weekend duration was consistent, the amount of time required for demolition and deck module placement went quicker than expected. The time required for the approach slab placement exceeded the expected timeframe from the design schedule and construction schedule. The differences can be attributed to crane placement proposed by the contractor which put them near the railroad track whereas during design it was assumed the railroad would not permit cranes parallel to the track.

At the completion of the project, a review of the project through construction revealed the following lessons learned:

- Extensive constructability reviews are essential during design to ensure the project can be constructed and limit potential claims during construction.
- The contractor needs adequate manpower, equipment and ability to improvise in the event of an issue during the ABC shutdown. Prequalified contractors are a necessity to ensure success.
- UHPC was effective for the closure pours and gained the required strength (12,000 psi) in about a 9-10-hour time frame, which was less than the expected 12 hours. The contractor suggested allowing alternative materials including PPC and high early strength concrete. Future projects should consider alternative methods if they have a proven serviceability, reduced cost and performance record.
- The setting of the approach slabs proved challenging for the contractor due to minor construction tolerance issues (precast to precast fit up) and the precise subbase preparation required. In the case of projects which utilize flowable fill, the potential for settlement at the begin/end of structure is minimized. The use of a non-standard approach slab (i.e., less than 25 feet, say 10 feet) would reduce the required subbase preparation and still provide a transition onto the structure to reduce the potential bump at the bridge. Alternate considerations can also include a recessed approach slab with a thicker overlay (bituminous, PPC or other) and the use of sleeper slabs.
- When constructing the new substructure under the existing superstructure, providing an optional construction joint near the top of the abutment proved useful for the contractor to provide workspace.
- The use of flowable backfill expedites backfilling operations and eliminated compaction concerns given the limited workspace under the existing bridge.

Overall, the project was a success with no major issues. The success can be attributed to several items including: concise and fully developed design plans that considered constructability; a facility owner willingness to consider alternate construction means and methods which permit expedited construction; and a competent contractor with the expertise, manpower and equipment to complete an ABC project.