INNOVATIVE PARTNERSHIP LEADS TO FIRST USE OF PBUs AND UHPC BY THE NHDOT

Joshua Lund, P.E., McFarland Johnson, (603) 225-2978, jlund@mjinc.com
L. Robert Landry, Jr., PE, New Hampshire DOT, (603) 271-2731, Robert.Landry@dot.nh.gov

INTRODUCTION

This bridge rehabilitation project located in East Kingston, NH replaced a three-span superstructure over the Pan Am Railway during a 25-day roadway closure. The New Hampshire Department of Transportation (NHDOT) partnered with McFarland Johnson (MJ) to develop and implement the first use of Prefabricated Bridge Units (PBUs) and Ultra High Performance Concrete (UHPC) in the state of New Hampshire. The project was partially funded through the FHWA Accelerated Innovation Deployment (AID) Demonstration program. Based on the success of this initial project, the NHDOT is incorporating PBUs and UHPC as viable options for future ABC projects.

BACKGROUND

The bridge carries NH Route 107A over the Pan Am Railway and a residential drive in East Kingston, NH and was constructed in 1937. The existing structure consisted of three simple spans with painted steel beams and a thin reinforced concrete deck. The existing 1937 bridge replaced an at-grade railroad crossing by building up the approaches and utilizing shallow, closely spaced beams to attain the vertical clearance over the railroad. Each of the three simple bridge spans are approximately 40 feet, totaling 120 feet. There are no sidewalks on the bridge, or on the approaches, and the out-to-out bridge width is 32 feet with a curb-to-curb width of 28 feet. The existing deck thickness was 6½ inches with a 2-inch thick pavement overlay.

The middle bridge span is over the Pan Am Railway. The Pan Am Railway supports both freight cars and the Amtrak Downeaster high speed passenger rail, with up to 10 crossings per day running at speeds up to 70 MPH. The high service volume railroad would require frequent intermittent work stoppages and was a challenge for this site. The southern span provided access for a private residential drive. There were no maintained roads under the northern span, however it provided access to a landlocked Town conservation parcel.

The existing full-height concrete counterfort abutment walls were in good condition having been rehabilitated in the 1980s. The existing piers consisted of painted steel columns with a painted steel pier cap founded on concrete spread footings. The piers were in satisfactory condition with minor deterioration and a failing paint system. The superstructure and substructure were in Satisfactory condition (condition rating 6), but the deck was in Serious condition (condition rating 3), thereby categorizing the bridge as 'structurally deficient'.

OBJECTIVES

The primary goal of this project was to remove the bridge from the State's 'Red List' (list of structurally deficient (poor) State-owned bridges in the NHDOT inventory). The work required replacement of the concrete deck and repainting or replacement of the existing beams to extend their service life. Repainting of the steel pier columns and minor concrete substructure repairs were also required.

PROJECT CHALLENGES

The presence of the active Railroad greatly complicated this rehabilitation project. The frequency of the train traffic, combined with the safety measures required for each train passing, would have significant impacts to the duration and cost associated with conventional construction. In addition to the frequency of the trains, the vertical clearance also posed a construction challenge. No impacts to the vertical clearance would be allowed during train movements, significantly impacting the ability to repaint the steel beams in-

place while providing the required containment. The only viable option for the railroad span would be to remove the existing beams and clean, paint, and re-install them.

PROJECT SOLUTIONS

The NHDOT partnered with MJ to evaluate innovative rehabilitation alternatives that would minimize impacts to the travelling public and railroad. It was identified early that improvements to the bridge approaches to raise the profile and gain clearance for additional structure depth would be impractical. Therefore, a bare concrete deck was proposed to maintain the existing vertical clearance and provide a thicker structural concrete deck. Initial alternatives considered repainting the existing steel and using full depth precast deck panels, however repainting the steel would be costly and time consuming due to the active rail line.

The NHDOT collaborated with MJ to develop an ABC alternative to meet the project objectives while mitigating risk associated with construction within the railroad right-of-way. The NHDOT had limited, but successful, previous experience with the application of ABC and had been looking for opportunities to continue the use of ABC on future projects. There were several factors that made this project an ideal candidate for the use of ABC. The traffic volumes were relatively low at 2,200 ADT. The low traffic volumes combined with the proposed detour (all on State routes) adding only one mile to the through traffic, significantly reduced the potential risk associated with an unforeseen extended closure. Due to the frequency of trains, an ABC option would be cost competitive with conventional construction and improve overall project safety by minimizing the construction duration within the railroad corridor.

PBUs were identified as the preferred ABC solution for this specific site. PBUs are a prefabricated system consisting of a pair of steel beams and a precast concrete deck section. PBUs are installed side by side to form the bridge deck and are connected with a separate concrete closure pour. The PBU beams are typically spaced at four to five feet to maintain an overall section width of less than 10 feet, this allows for standard transport on roadways without requiring wide load accommodations. The PBU option benefitted the NHDOT because the fabrication closely resembled conventional construction and utilized standard materials and specifications, reducing the NHDOT's risk associated with their first use of this new bridge element.

The PBUs were designed and detailed to closely match the existing superstructure configuration, consisting of eight beams at a four-foot spacing, minimizing impacts to the substructure. The PBU design allowed the vertical clearance over the railroad to be maintained and limited the approach roadway work by matching the existing profile. The rapid nature of PBU installation would minimize the number of intermittent construction shutdowns due to the active rail line, particularly if erected at night when trains are less frequent.

The closure pour material provided another opportunity for innovation on this project. A non-shrink grout would typically be used, however, given the necessity for a bare deck, this was not desirable for long-term durability. UHPC was the recommended solution to address the long-term durability concern. UHPC is an innovative cementitious material that achieves minimum 28-day compressive strengths of 21.7 ksi. A high percentage of discontinuous metal fibers are the key to the high compressive and tensile strengths associated with UHPC. UHPC also has a discontinuous pore structure that significantly enhances durability as compared to conventional concrete and grout and is ideal for long-term performance on a bare deck application.

The high strength of UHPC allows for shorter reinforcement development lengths and a significantly narrower closure pour as compared to conventional construction. UHPC's superior bond strength alleviates concerns of future joint leakage and deterioration typically associated with closure pours on bare concrete decks. The proposed rehabilitation included UHPC link slabs over the piers to eliminate the need for deck joints. The material properties of UHPC are well suited for use with link slabs due to its increased rupture strength which helps to mitigate potential cracking.

CONSTRUCTION

The Contract included Incentive/Disincentive provisions associated with a 28-day closure to encourage timely completion of construction. The provisions of the Contact also allowed for, and the Contractor did, self-fabrication of the PBUs. Allowing the contractor to self-fabricate the PBUs reduced cost and risk on the project, as the contractor had complete control over their schedule and fabrication tolerances. The Contract also included provisions for the supplier of the UHPC to be on site to supervise the preparation, batching, testing, and installation of the UHPC. This provision is common and helped mitigate the NHDOT's risk associated with their first use of this new innovative material.

The project was successfully completed in 25 days (three days ahead of schedule). The use of PBUs and UHPC greatly reduced the construction duration and impacts to the roadway users. By having the elements prefabricated the PBUs enabled rapid erection of the replacement superstructure, taking only one night to complete. The construction method traditionally employed by NHDOT to deliver a comparable project would have required up to a six-month duration which may have included phased construction. For this project, conventional construction would have been heavily impacted by the shutdowns required for the frequent passage of trains however, by making use of PBUs and UHPC, this project realized a savings of five months.

CONCLUSIONS

Implementing new and innovative design and construction concepts can be a daunting step for any Owner however, when done correctly, can be very rewarding and beneficial. An accelerated roadway closure is a high-risk endeavor by itself due to potential impacts to the travelling public. The mitigation of the additional risk resulting from implementation of new innovations is crucial, both from a Contractors perspective and from an Owners perspective. Selecting the appropriate project for the first use of an innovative technique is critical to the success of the project and the innovation.

This project was an overall success and well received by the Public. The experience gained on this project will lead to the continued use of ABC and implementation of innovation on future NHDOT projects. PBUs will become a useful tool in the NHDOT's toolbox for future bridge projects. UHPC will also be added to the toolbox and utilized provided the application warrants the considerable cost. This bridge will be monitored for durability of the UHPC joints, though they are expected to function as intended.

LESSONS LEARNED

Exposed Aggregate Finish

To maximize the bond strength of the closure pour between the PBU concrete and the UHPC, an 'exposed aggregate finish' is specified for all concrete surfaces exposed to UHPC. The Contractor self-performed the PBUs and did not attain desired finish on the surfaces exposed to UHPC.

Ensure the concept and process of achieving an 'exposed aggregate finish' is understood by the project team, especially Contractors with limited experience with UHPC. Although the plans and specifications noted an exposed aggregate finish with a minimum ¼ inch amplitude throughout, the Contractor was not aware of its importance nor the process to achieve it. A construction submittal outlining the procedure for attaining the exposed aggregate finish may alleviate this issue in the future.

Saturated Surface Dry

Better define the saturated surface dry condition. The surfaces exposed to the UHPC were specified to be saturated surface dry, however this condition was not well defined. A more prescriptive process to achieve the saturated surface dry condition would be better for the Contractor and the inspector.