ABC DEMONSTRATION PROJECT COMPLETED IN OHIO AND MASSDOT'S ABC BRIDGE REPLACEMENT SCHEDULED FOR CONSTRUCTION USING SPS BRIDGE DECKS

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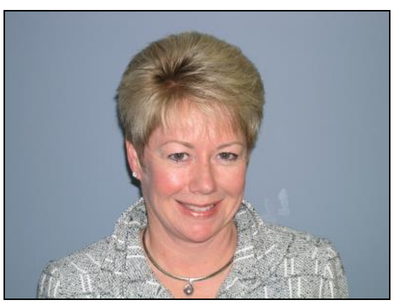

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BIOGRAPHY

Rolando Moreau has been with the Bridge Division of Intelligent Engineering since 2014 and holds the position of Bridge Lead. He has designed SPS bridge deck solutions for the rehabilitation of historic truss structures, ABC bridge projects, pedestrian bridges and in-situ reinforcement of orthotropic steel deck using SPS Overlay. These designs have been completed for bridge structures in United States, Canada, Luxembourg, Germany and Australia.

Ms. Jimison studied Business and Accounting at Portland State University in Portland Oregon, with continued studies in Political Speaking, Communication and Media Studies in San Francisco with Dale Carnegie in 1984-86. She offers over 30 years of experience in the advancement, acceptance, and implementation of new technologies and innovations, working with local, state, and federal government for approvals, as well as, private and military applications.

SUMMARY

In Muskingum County Ohio, an existing steel bridge was replaced by a 52'-6" SPS bridge deck integrated with press-braked tub girder. The bridge was part of a demonstration project funded by the FHWA AID program. Prefabricated half-width SPS bridge modules complete with guardrails were delivered to site on two trucks and erected within 20 minutes The bridge was open to traffic within 26 days ahead of the maximum allowable road closure of 30 days. The bridge was designed for a 100 year service life.

In Lee Massachusetts, an existing short-span steel bridge is scheduled for replacement in summer 2018. Vehicular closure is limited to a maximum of one day to minimize disruption to residents. This will be achieved through a staged construction schedule which always allows for pedestrian access even during vehicular closure. The installation of SPS bridge decks will require small light-weight construction equipment given the restricted site access. The deck will have immediate load-carrying capacity for vehicular traffic when installed. SPS met the needs of the residents and minimized the impact to the environment.

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SPS Bridge Decks

SPS comprises two steel plates bonded to a polyurethane elastomer core to form a strong light-weight composite (Figure 1). SPS bridge deck panels are less than 2" thick and up to 70% lighter than equivalent concrete decks. Compared to conventional precast or cast-in-place concrete decks, SPS bridge decks can be preassembled offsite to create light-weight modular units which can be rapidly assembled onsite, allows for immediate load-carrying capacity and reduces construction cost and time. SPS is an all steel construction with no wet work on site. SPS results in a simpler, safer and more predictable construction. Due to reduction in dead load, SPS bridge decks have been used to increase vehicular, pedestrian and cycling capacity for deficient bridges.

Figure 1: Typical SPS bridge deck sample

Ohio's ABC Demonstration Project

Project Overview

Muskingum County, Ohio, received an FHWA AID demonstration grant in 2016 for the replacement of an existing bridge on Cannelville Road with SPS bridge decks. Although SPS bridge decks can be pre-assembled to wide-flange steel beams, it was elected to use press-brake formed steel tub girders (PBTG) for this site (Figure 2).

The grant was used to demonstrate the ABC attributes of using SPS bridge decks over conventional concrete construction. Road closure was limited to a maximum of 30 days which included demolition of the existing bridge, construction of new abutments on pile foundations, assembly of superstructure, construction of new approach slabs and placement of asphalt wearing surface. A short road closure will minimize traffic impact to local residents who will experience a 7 mile detour during bridge closure (ADT = 760 based on year 2036).

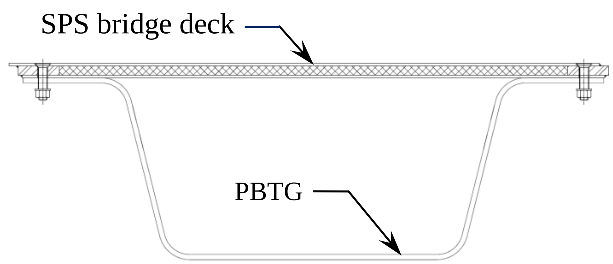


Figure 2: Cross-section of SPS deck on PBTG

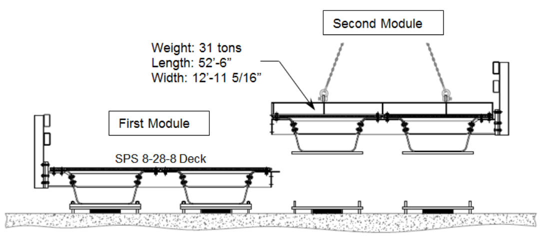
The existing bridge spanned 38'-0" and was located above a low-lying acidic stream which often flooded resulting in the collection of tree limbs and debris underneath the bridge As a result, the beams and deck suffered extensive deterioration and the bridge was scheduled to be replaced. Compared to other design options, the closed smooth shape of the PBTG is ideal for this location as any debris such as root balls or trim limbs will easily flow under the bridge. The superstructure depth is minimized for this low-lying area using a thin light-weight SPS deck acting compositely with a PBTG cross-section.

ABC Design

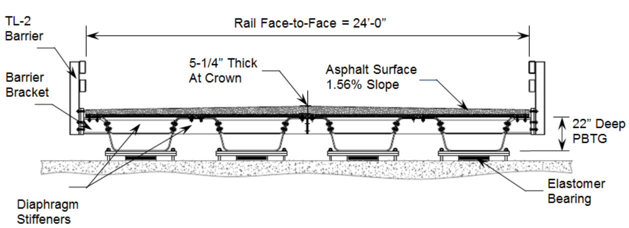
The bridge was designed in accordance with AASHTO LRFD 2012 [1] for HL-93 loading and ODOT Bridge Design Manual 2007 [2]. The design was driven by ABC and site hydraulic limitations.

Since the bridge spans over a low-lying stream, the superstructure depth was minimized using SPS such that the 10-year flood level event occurred below the girders.

The construction sequence envisioned consisted of demolition of the existing bridge and construction of new abutments on pile foundations. Next, the entire superstructure would be delivered on two trucks each consisting of one-half of the bridge with pre-attached traffic barriers, expansion joints, splice plates, sole plates and lifting beams (Figure 3). The two half-width bridge modules are placed on the abutment seats, longitudinally connected in one day and ready to receive the asphalt wearing course.



a) Erection of second SPS bridge module



b) Assembled SPS bridge modules with asphalt

Figure 3: Accelerated erection sequence of two-half width SPS bridge modules

Structure Description and Geometry

The replacement bridge consists of two traffic lanes for a clear rail face-to-face width of 24'-0" (Figure 3b) and an overall length of 52'-6". The bridge width consists of four tub girders each press-braked from 101" wide by 5/8" thick plate to form a girder width of 5'-10 1/2" and depth of 22" (Figure 3b). SPS 8-28-8 bridge decks weighing 39 psf (5/16" thick faceplates and 1-1/8" core) are made composite with the PBTGs by bolting to the top flanges using 7/8" diameter countersunk bolts. For this site, a four girder system allows for the most rapid assembly as half the bridge width could be shipped pre-assembled as an oversize load. However, other SPS bridge deck assemblies are possible depending on site requirements.

Adjacent tub girder modules are longitudinally connected together using splice plates (Figure 4) and completion top faceplate welds. A standard side-mounted ODOT twin-steel tube bridge railing (TST-1-99) to achieve TL-2 performance is bolted to the exterior modules using steel brackets (Figure 3b) at 6'-0" spacing. These brackets are bolted to stiffener diaphragms placed on the inside of the exterior modules to minimize possible damage to the tub girders (Figure 3b). These stiffener diaphragms may not be required depending on the traffic barrier configuration, tub girder thickness and required performance level. Deck-mounted posts and rails to achieve TL-4 performance are possible.

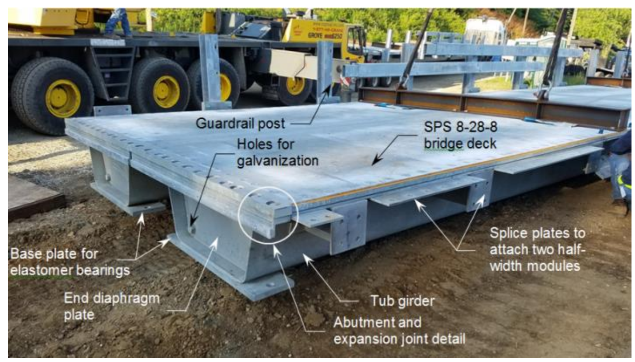


Figure 4: Components of one-half bridge width SPS module

Asphalt with a transverse cross-fall of 1.56% is placed over a standard ODOT Type 3 waterproofing membrane with a thickness of 5-1/4" at the crown (Figure 3b). Camber was not required as the deflection of the bridge under dead and superimposed dead load was computed to be less than 0.5".

To provide a seamless asphalt surface, the expansion joint system consists of two ODOT standards: polymer-modified asphalt expansion joint system over top of compression seal expansion joint (EXJ-2-81) (Figure 5). Similar to other construction in the area, the superstructure is supported on elastomeric bearing pads anchored to the abutment seats supported on pile foundations.

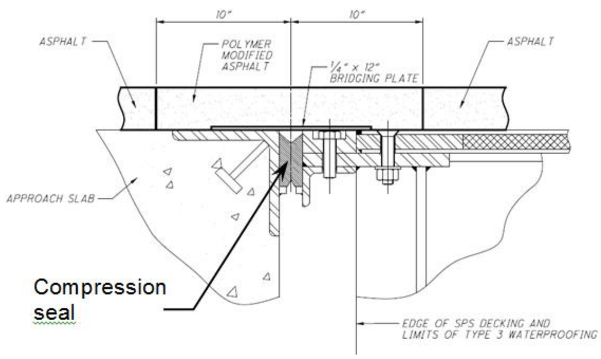


Figure 5: Expansion joint at abutment

All superstructure steel was fabricated from ASTM A709 Grade 50 plate material. All surfaces of the SPS bridge decks were thermal spray zinc metallized to AWS C2.23M/C.23: 2003, NACE No. 12, SSPC-CS 23 averaging 7 to 12 mil coating thickness with a maximum of 20 mils. All other superstructure steel components were hot-dipped galvanized. There are two inspection access hatches and two drain plugs per PBTG module.

Bridge Fabrication and Assembly

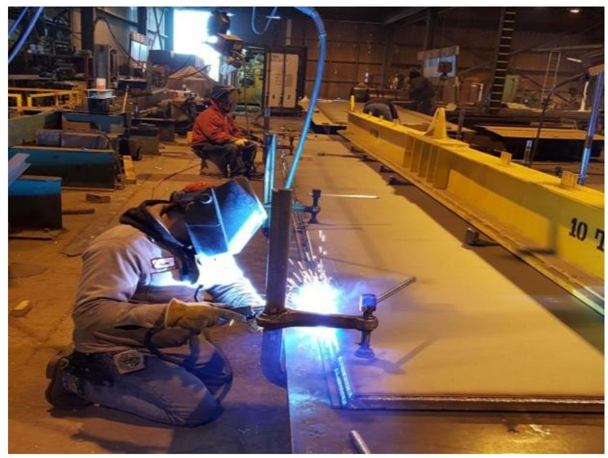
The bid was awarded to U.S. Bridge on 28 July 2016. The fabrication and assembly of the two half-width portions of the bridge, excluding traffic barriers, was awarded to Maico Industries Inc. in Kansas. The bridge was fabricated in the shop during the 2016-2017 winter period in preparation for a spring bridge replacement.

Figure 6a shows the press-braking of a single plate to form one tub girder using two 30' CNC hydraulic press brakes acting in tandem. It is possible to form longer PBTGs by adding an adjacent hydraulic press. Figure 6b shows the seal welding of the perimeter of a typical SPS bridge deck.

The PBTGs were hot-dip galvanized in a single dip to an average measured thickness of 9.3 mils. Figure 7 shows the thermal spray metallization of one SPS bridge deck by AZZ Metalizing at Maico's shop to an average measured thickness of 9.5 mils.

Figure 8 shows the assembly of two individual tub girder modules to form a larger half-width bridge module. The two halves of the bridge were stacked on two trucks (Figure 9) and delivered to the GC.

a) Press-brake of 101"wide x 5/8" thick x 52'-6" long plate to form one tub girder



b) Seal welding of perimeter of typical SPS deck

Figure 6: Fabrication of PBTGs and SPS deck

Figure 7: Thermal spray metallization of typical SPS deck by AZZ Metalizing

Figure 8: Shop completed SPS bridge module

Figure 9: One of two SPS bridge module loads

Bridge Installation

The bridge was closed to traffic on 1 May 2017. The bridge was demolished, site de-watered, piles driven, abutment seats cast and rock channel protection system installed by Day 12 (Figure 10).

Figure 10: Abutments completed by Day 12

This is a standard construction process for a bridge substructure and not unique to SPS bridge decks or PBTGs. The two half-width modules arrived on Day 16 with traffic barriers pre-attached at U.S. Bridge. Each module was placed on the abutments in 10 minutes using a 250 ton crane operating from one side (Figure 11). The two modules were bolted and welded together in one day.

Figure 11: Placement of SPS bridge modules in 20 minutes on Day 16

The remaining superstructure was completed using standard construction practice. Figure 12a shows the laying of an ODOT Type 3 waterproofing membrane on the SPS deck from which the asphalt wearing course was subsequently laid (Figure 12b). The asphalt was saw-cut and removed at the expansion joints (Figure 12c). The polymer modified asphalt was laid in its place to accommodate thermal bridge expansion and to provide a seamless driving surface (Figure 5).

a) Laying of Type 3 waterproofing on Day 22

b) Laying of asphalt wearing surface on Day 23

c) Laying of PMA at exp. joint on Day 26

Figure 12: Completion of superstructure

Project Summary

SPS bridge decks are preassembled to supporting structure to form light-weight modular units which can readily be assembled onsite. In Muskingum County, SPS bridge modules were fabricated offsite and erected in 20 minutes compared to several weeks with conventional construction. The bridge was replaced in a record 26 days (Figure 13) and opened 4 days ahead of schedule minimizing the impact on the traveling public. Residents, Fire and EMS commented on possible life saving due to ABC. The bridge is designed for a 100 year service life. Light-weight SPS bridge decks provide an opportunity to address the aging bridge inventory in the U.S by allowing bridges to be rapidly replaced over conventional construction.

Figure 13: SPS bridge completed in 26 days

MassDOT's ABC Replacement

Project Overview

SPS bridge decks were selected for the bridge replacement of Chapel Street Bridge over Greenwater Brook in the town of Lee, Berkshire County, Massachusetts. The existing bridge is 79-years-old and is located off of US Route 20. The bridge is a single-span steel stringer superstructure supported on unreinforced gravity type abutments. The deck consists of an open grid steel deck welded onto channel purlins which in turn are supported on the steel stringers (Figure 14).

Figure 14: Existing Chapel Street bridge (following images courtesy of MassDOT)

The bridge carries two 10’-0” traffic lanes with no shoulders or sidewalks. The barrier consists of two steel tube railing and post welded to the deck with a brushing channel plate.

The bridge is deemed structurally deficient and functionally obsolete and was posted in 2013. There is widespread corrosion on all steel beams with major cross-section lost of the webs at the beam ends. The bridge will be replaced on existing alignment with a structure of the same width using light-weight SPS decks on galvanized steel beams.

Why SPS Bridge Decks?

The existing bridge provides the only foot and vehicular access to the three residents on the other side of US Route 20. The dead end on the other side of the bridge presented unique site challenges:

1. Residents must have vehicular access to their homes during construction.
2. The staging area is confined and crane access is difficult for erection of heavy prefabricated superstructure modules.
3. The abutments are unreinforced concrete and it is economically and environmentally desirable to reuse the abutments with minimal rehabilitation.

Several design options were evaluated ranging from complete bridge closure during construction to installation of a temporary pedestrian bridge. However, residents need continuous vehicular access to their homes and impact to wetlands need to be minimized. Prefabricated bridge units using reinforced concrete deck were examined but found to be unsuitable since larger equipment with heavier pick weights will be needed.

Instead, SPS bridge decks met all site challenges. The prefabricated SPS deck allows for a staged construction program where residents will have continuous vehicular access to their homes. Complete bridge closure will be avoided with SPS. Small light-weight equipment such as a telehandler can readily maneuver on site to install the stringers and SPS panels while minimizing slope impacts. A lightweight deck will allow the existing abutments to be repaired thereby minimizes impact on the wetlands.

SPS Bridge Deck Design

The entire bridge design was driven by a staged construction sequence which allowed for a maximum of 8 hour vehicular closure during final assembly of the bridge and for the application of the polymer overlay driving surface. Pedestrian traffic will always be maintained even during vehicular closure. This approach best met the needs for the residents. The existing reinforced concrete substructure will be rehabilitated with excavation and reconstruction of the bridge seats and backwalls.

The bridge was designed in accordance with AASHTO LRFD for HL-93 loading. The replacement bridge consists of SPS 8-25-8 weighing 39 psf (5/16” thick faceplates and 1” core) made composite with galvanized steel stringers spanning 32’-0” center-to-center of bearings. Thrie beam rail with handrail will be mounted onto prefabricated steel curbs bolted to the SPS panel. The bridge deck is superelevated at a 2% slope and will receive a 3/8” thick epoxy overlay (Figure 15).

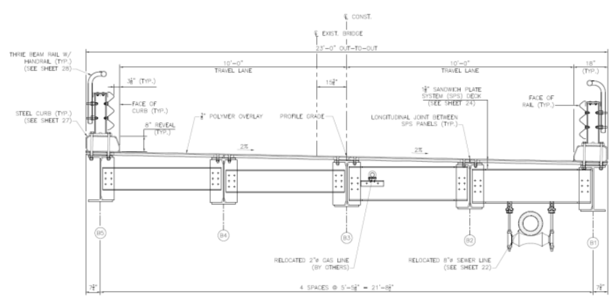


Figure 15: SPS Bridge cross-section

Proposed Construction Sequence

The superstructure will be replaced in two phases to accommodate vehicular access for the three residential properties beyond the bridge. One travel lane of alternating traffic will remain open at all times except during periods where the final SPS deck plate is placed and the wearing surface is applied. Pedestrian traffic will always be maintained.

Figure 16 shows the proposed staged construction consisting of one vehicular lane with alternating traffic open on the SPS portion of the bridge. Figure 17 shows the assembly of the SPS deck and the stringers on the other side of the bridge. The bridge is then closed for one working day to allow the last SPS panel to be installed thereby completing the superstructure installation (Figure 18). Lastly, the bridge will be closed for one additional working day to allow for application and curing of the epoxy overlay. The bridge will then be often to vehicular traffic in both directions. The bridge has been tendered, awarded and is expected to be replaced in July 2018.

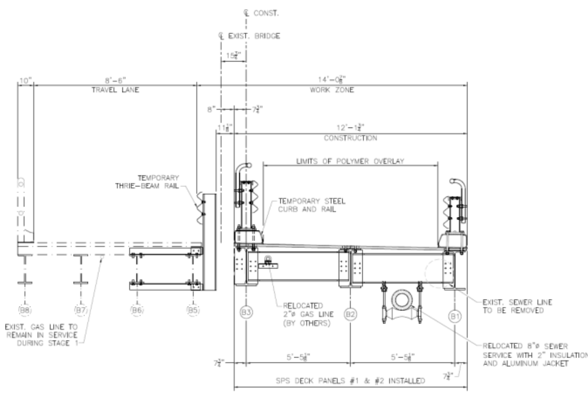


Figure 16: Stage 1 completed with alternating traffic on SPS deck (right side)

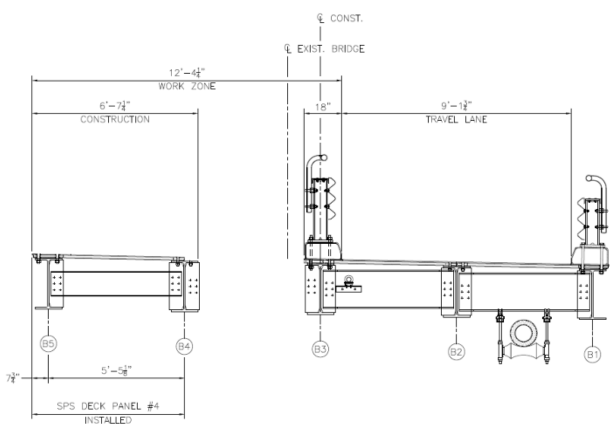


Figure 17: Stage 2 with assembly of second bridge half with SPS deck (left side)

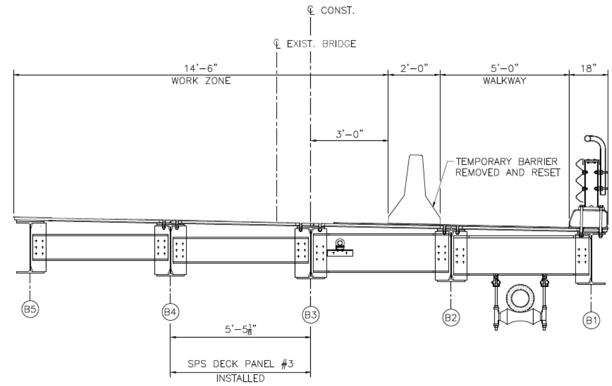


Figure 18: Installation of SPS infill panel with maximum vehicular closure of 1 working day

Conclusions

The design of these two bridges was driven by accelerated bridge schedule to minimize impact to the traveling public, residents and the environment. Larger prefabricated units can be delivered to site or smaller equipment can be used with SPS decks compared to concrete decks. SPS bridge decks are all steel construction with no wet work on site. Immediate load carrying occurs with SPS deck compared to concrete allowing bridges to be open sooner. SPS bridge decks can be used to rehabilitate the aging inventory of bridges by increasing vehicular, pedestrian and cycling capacity of bridges. SPS bridge decks are designed for a 75^+ year service life compared to concrete decks which will likely be replaced during the service life of a bridge.

References

1. AASHTO LRFD Bridge Design Specifications, 6th Edition, 2012.

2. Ohio Department of Transportation (ODOT) Bridge Design Manual (BDM), 2007.