

**September 2017 ABC-UTC Webinar Featured Presentation
Ohio's Muskingum County Bridge Replacement with SPS Deck on Press-Brake-Formed Steel Tub Girders**

Questions		Responses
BRIDGE DESIGN (TUB GIRDER & SPS BRIDGE DECKS)		
1	What year storm was this bridge designed for?	10-year flood level event.
2	Where is the 100-year flood elevation in comparison to the bottom of the tub girders?	3-1/2" (89mm) measured from bottom of tub girder.
3	Please explain "Press-Brake-Formed Steel Tub Girders with spray metallized Sandwich Plate System (SPS) deck panels?"	<p>The bridge construction is similar to a deck acting compositely with an open steel trapezoidal steel box. The deck is a prefabricated composite deck (SPS) which is up to 70% lighter than an equivalent concrete deck. Although SPS bridge decks can be pre-assembled to wide-flange steel beams, it was elected to use press-brake tub girders (PBTG) for this site. The PBTG system consists of modular shallow trapezoidal boxes fabricated from cold bending a steel plate of uniform thickness and is suitable for short span steel bridge solutions.</p> <p>Prefabricated SPS deck panels are bolted to the formed girders in the shop to form composite modules. These modules are rapidly erected and connected together on site. The bridge has immediate load-carrying capacity since curing of concrete closure pours is not required. This method of pre-assembly of half-width bridge modules is ideal for ABC practices. The bridge was designed for a 100+ year service by a combination of hot-dipped galvanized PBTGs and thermal spray metallization of all exterior surfaces of the SPS deck panels.</p>
4	Interested in the SPS deck panels, how they are designed and constructed.	<p>SPS bridge panels are designed in accordance with AASHTO LRFD for ULS, SLS and FLS based on HL-93 loading. Please visit the ABC-UTC site under Resources Tab for more information on SPS bridge deck details and panel production.</p> <p>https://abc-utc.fiu.edu/resources/proven-new-technologies/sandwich-plate-system-sps/</p>
5	Maximum length / width for a bridge using your method of design and construction?	There is no limit on the width of the bridge. SPS bridge modules can be added transversely to make up the required roadway width. The length of the bridge is dictated by the maximum length of press-brake available to cold form the steel tub girders. At present, the maximum press-brake available in the US is 60' (18.29m). It may be possible to splice two tub girders together using a bolted splice plate or CJP weld, but these have

		not been done as yet. Alternatively, two press-brake machines can be placed side-by-side to act in tandem to achieve longer girders without using a splice connection.
6	Could you address some of the testing and results that has occurred on this type of construction	Please see the following resource for more information on the development and laboratory testing of the press-braked tub girders: Barth, K.E., Michaelson, G.K., & Barker, M.G. (2015). <i>Development and Experimental Validation of Composite Press-Brake-Formed Modular Steel Tub Girders for Short-Span Bridges</i> . Journal of Bridge Engineering, Vol. 20, Issue 11.
7	What is the live load deflection for this bridge?	Live load deflection of the bridge under HL-93 was computed to be 0.65" (16.5mm) or L/954. This is less than the deflection recommended by AASHTO LRFD of L/800 without pedestrian traffic.
8	Was live load deflection comparison done between the SPS deck and concrete deck?	No live load deflection comparison was performed. It is expected that bridges designed with both deck types will satisfy the requirements of AASHTO LRFD.
9	Can you have large skew with an overall length near 60'? Specifically 59.5'.	Yes, SPS bridge decks and PBTGs can be fabricated with skews with overall length of 59.5' (18.14m).
10	Is there any restraint in the length of a bridge built with SPS?	No limit exists on the length of bridges built with SPS bridge decks. SPS can be connected to any supporting steel structure (rolled beams, built-up girders, PBTG). The panels are fabricated in lengths typically varying between 20' to 45' (6.10m to 13.72m). Adjacent panels can be connected together to make up required bridge length.
11	Slide 36 – are there any engineering/stress issues between the cold-formed plate and the hot dip galvanizing?	No issues were observed in the corners of the tub girders after they were hot-dipped galvanized.
12	Who was the design engineer of the bridge?	The superstructure was designed by Intelligent Engineering (Rolando Moreau: Office No: 1 (613) 569-3111) and the substructure by Muskingum County Engineers' Office (MCEO). The overall bridge plans including the superstructure were stamped by the county engineer.
13	Is the SPS a proprietary technology?	Yes, SPS is patented worldwide. However, it is not sole source as there are several fabricators in the US who can manufacturer SPS bridge decks making it cost competitive.
14	How do you load rate a SPS deck?	Bridges designed with SPS should be load rated in accordance with the applicable state codes. This bridge was load rated in accordance with Ohio Bridge Design Manual (BDM) and AASHTO Manual of Bridge Evaluation. Hand calculations and finite element analysis was carried out to load rate this bridge as allowed by Ohio DOT.
15	What kind of bond does the elastomer have to the steel plate for the SPS system?	The minimum design bond strength between the SPS faceplates and elastomer core is 1.16ksi (8MPa). This is verified during production by performing Posi-test (tensile pull out) on the elastomer casted on a steel

		plate prepared with the same surface preparation and cleanliness as the faceplates used to produce the deck panels.
16	Does plug welding the steel plate (injection and venting port steel blanks) hurt the elastomer?	There are injection and venting holes in the bottom plate of the SPS panel used during panel production. These holes are closed by welding steel blanks into the holes. The size of the welds is kept small and low-heat welding is applied to minimize damage to the adjacent elastomer. Should any localized damage occur to the elastomer, it will be over a very small area and will be of no structural consequence.
17	Would asphalt damage the polyurethane panel due to heat?	No, the application of the asphalt wearing surface will not damage the polyurethane core. It has been found by laboratory testing and numerical simulations that the temperature at the interface of the top steel faceplate and the core during the application of asphalt is below the temperature at which the polyurethane will begin to degrade.
18	What is the possibility of using a weathering steel instead of galvanizing or metalizing of the tub and SPS deck?	The tub girder and SPS deck can be fabricated from weathering steel provided that the location is suitable for the use of weathering steel. SPS bridge decks have been fabricated from weathering steel and have been in service in Texas since 2008.
19	What are the temperature limitations of the SPS panels? For example, fire resistance and cold temperature glass point?	The polyurethane core was developed by BASF to have specified structural material characteristics over an operating temperature range of -76°F (-60°C) to 230°F (110°C). SPS deck plates form a hermetically-sealed system that is non-combustible. If an extreme (unforeseen) fire event occurs where a SPS deck plate is subjected to damage, it can be quickly and easily removed and replaced (all-bolted construction) reinstating the deck to its original condition.
20	Can SPS be overlaid with a CIP concrete deck?	It is not clear what benefit may be derived to overlay SPS with a concrete deck. SPS deck is the main load-bearing deck element and can be overlaid with asphalt, light-weight or gravel wearing surfaces.
21	Can the SPS panels be used with p/s (prestressed) concrete beams?	SPS panels have not yet been used with p/s concrete beams but it may be possible using bolts or studs for the right application. SPS terraces have been installed on concrete rakers for stadia application.
22	Have sidewalks been used on top of the SPS deck panels? If so, are connection details available?	Yes, SPS has been used as sidewalks panels. Please contact Intelligent Engineering for connection details.
23	What about roadway drainage/scuppers in SPS deck?	SPS deck panels can be detailed to accommodate drain holes/trench drains. A cut-out is provided in the panel during production to accommodate drain inserts at any desired location. Steel curbs can be accommodated which facilitate drainage. Please contact Intelligent Engineering for connection details.

24	Slide 19 – is this table available to the industry (selection table for steel tub girder and SPS deck)	<p>Yes. A pdf of the presentation can be found on the ABC-UTC website under monthly webinar archives.</p> <p>https://abc-utc.fiu.edu/mc-events/ohios-muskingum-county-bridge-replacement-with-sps-deck-on-press-brake-formed-steel-tub-girders/?mc_id=311</p>
25	What is the rationale for the pendulum test?	<p>Pendulum tests were carried out by Texas Transportation Institute in 2005 to determine the crash load rating of SPS decks. SPS bridge decks were found to achieve a TL-4 performance level as specified in AASHTO LRFD. Inelastic deformations are limited to the crash barriers while the SPS deck will remain elastic under a TL-4 loading event. In the event of a collision, the barrier post can be dismantled and a new post installed.</p> <p>The equipment simulates vehicle impacts on crash barriers mounted to the deck. The pendulum uses known weight to induce kinetic energy into a test article for evaluation of strength, energy absorption and failure characteristics.</p>
26	The SPS deck is bolted to the girders for the composite connection. What theory was used to establish bolt size and spacing? Would these be slip critical connections?	<p>The bolt size and spacing was determined using shear flow calculations from first principle mechanics. The section properties of the composite section can be computed by hand by using the steel components of the SPS panel and the tub girder. The elastomer core is ignored in this calculation. The maximum shear can be computed for each girder in accordance with AASHTO LRFD. The shear flow equation is then applied to size the bolt size and spacing. The bolts were designed to be slip critical under Service II loading case as per AASHTO LRFD.</p>
27	Max. weight/dimensions of panels/assembly.	<p>SPS panels are typically fabricated in widths from 5' (1.52m) to 10' (3.05m) and lengths between 20' (6.10m) and 45' (13.72m). The weight of the panels range from 36psf (176kg/m²) to 50psf (244kg/m²). Please see question 5 for discussion on bridge length.</p>
28	Did they not have to field bolt the two preassembled panels together in the field?	<p>Yes, the two SPS bridge modules were field bolted and seam welded together in 1 day. The bridge then has immediate load-carrying capacity as curing of concrete closure pours is not required.</p>
29	More design examples	<p>Please visit the ABC-UTC site under Resources Tab for more information on bridge projects using SPS bridge decks.</p> <p>https://abc-utc.fiu.edu/resources/proven-new-technologies/sandwich-plate-system-sps/</p>

BRIDGE FABRICATION		
30	Is heat used when forming the steel tubs?	No. The tub girders are formed by cold bending a single sheet of steel plate into the desired shape using a hydraulic press brake.
31	How easy is it to add camber into the tub girders?	Due to the lightweight of the SPS deck and the stiffness of the tub girder, camber in the tub girders is not required.
32	What is the maximum plate size possible for the brake-bent tub girders?	The maximum plate width and thickness that could be press-braked will vary between fabricators depending on their machine capabilities. Please see question 5 for discussion on tub girder length.
33	Are fabricators receptive to new beam shapes or does it require significant retooling or excessive costs?	One cost benefit of the press-brake tub girder is the forming of the girder from a single sheet of steel plate without any welding. Tooling requirements will vary between fabricators. For this project, the inside bending radius was taken as 5 times the plate thickness which is a standard bending radius. Therefore, no new tooling was required to form the tub girders.
34	Slide 27 – was there any attempt to maximum cut plate widths from the 16' stock plate?	The water table used to cut the tub girder plate is 16' (4.88m) wide and does not refer to the tub girder plate width. The plate width ordered was 104" (2.64m) and it was trimmed to 101" (2.57m) to form the tub girder.
35	Why not galvanized top and bottom plate of SPS before fabricating the SPS?	This has not been done as yet but is worthwhile investigating. Plate flatness and weldability will be the main considerations. The completed panel cannot be hot-dipped galvanized since the heat from the kettle will damage the polyurethane core.
36	Can you please expand/reiterate on the reasons the fabrication was performed in a plant so far from the bridge site. Was it the press break equipment required that was unavailable at any plants located closer to the jobsite?	For this project, it was more economical to fabricate the SPS deck panels and the tub girders at the same plant. However, SPS bridge decks can be produced at multiple locations.
IN-SERVICE PERFORMANCE		
37	How thick is the galvanized coating for 100 year service life?	The average measured thickness of the galvanized coating for the press-brake tub girder was 9.3mils (236 microns).
38	What does the metalized system consists of?	Metallization was done by melting zinc wire in an electric arc and projecting the liquid zinc droplets onto the SPS panel. The average measured thickness of the metalized coating for the SPS panels was 9.5mils (241 microns).
39	How is the internal inspection of the tub girders accomplished?	There are two access hatches in each tub girder. The inside of the girders can be inspected by someone with a flashlight or using a mobile camera.
40	How do you get past the diaphragms in the tub when you use the access?	Please see response to question 39.

41	Why were I-beams not considered for inspection ease?	<p>I-beams can be used with SPS bridge decks. However, the bridge is located above a low-lying acidic stream which often floods resulting in the collection of tree limbs and debris underneath the bridge. Using an I-beam structure would have resulted in the collection of debris on the bottom flanges leading to corrosion (same case as the original bridge).</p> <p>The closed smooth shape of the press-brake tub girder is ideal for this location as any debris such as root balls or tree limbs will easily flow under the bridge. The overall depth of the superstructure was also minimized using this efficient cross-section and a thin SPS deck such that the 10-year flood event occurred below the tub girders.</p>
42	Were the piles protected in any way from the highly acidic groundwater?	No special protection was applied to the steel piles.
43	Have SPS decks been in service for more than 10 years in states that use deicing salts?	Not as yet but SPS decks have been in service for nearly 10 years over coastal waters (The Grand Pier – Weston Super Mare, UK). The top of the SPS bridge deck is protected by the wearing surface and the waterproofing membrane while the underside and sides are protected by a steel coating system (paint, metallization).
44	How about the maintenance?	The bridge is maintained like any other steel structure in accordance with maintenance program outlined by the relevant authorities.
45	Was the asphalt overlay picked because of local availability vs. using some other type of material?	Yes, asphalt is locally available and is standard practice for the county.
46	Preventative maintenance needs, life of asphalt overlay?	The service life of asphalt varies but in Muskingum County it is typically replaced every 10 to 15 years.
47	How are the bridges painted? Seems like powder coating would be the way to go. Would you agree?	The SPS deck received thermal spray zinc metallization while all other superstructure components were hot dip galvanized.
COSTS		
48	Financing techniques were used to pay for the bridge	The bridge was paid with a combination of federal AID and county funding.
49	What are the advantages of SPS over conventional prestress concrete girder?	In this application, concrete girders would not have been a suitable solution due to the highly acidic low-lying stream which would have prematurely corroded the superstructure. See response to question 3 for explanation of use of SPS deck with press-brake tub girder.
50	Is the product proprietary and what is the cost comparison vs. cortex bridge system.	<p>The press-brake tub girder is not proprietary.</p> <p>SPS is proprietary. However, it is not sole source as there are several fabricators in the US who can manufacturer SPS bridge decks making it cost competitive.</p>

		The presenters are not familiar with the cortex bridge system but Intelligent Engineering is willing to compare various bridge systems for your project needs.
51	Neglecting cost savings associated with time saved by the public, was this the most cost effective solution?	<p>One of the main objectives of accelerated bridge construction (ABC) methods is to reduce construction time which yields time savings to the travelling public. Therefore, this cost savings should not be ignored when considering project costs.</p> <p>Additionally, the bridge is designed for a service life of 100+ years without any need to replace the SPS deck. For this site, the concrete deck will need to be replaced at least twice during the bridge service life. Therefore, on the basis of life cycle cost, SPS bridge modules were the most effective solution.</p>
52	What was the breakout cost for substructure and superstructure?	The total project cost was \$706k. The SPS deck cost was \$85/ft ² for a total deck cost of \$107k. A break-out of the other costs is not known.
53	Is Ohio DOT considering use of this bridge on other rural bridge replacements?	Yes, Muskingum County is considering using SPS bridge decks on other bridge replacements.
54	Cost of this bridge versus the cost of a bridge that would have normally been used.	The total bridge cost including replacement of substructure was \$706k. An equal bid using a concrete deck for this site is not available and therefore it is difficult to compare costs. The time savings to the travelling public and life cycle cost must be considered if a cost comparison is being done for conventional concrete deck bridge.
55	I'm very interested in the costs to produce the bent plate tub girder and SPS deck. Please share those details.	The cost to produce the press-brake tub girder will vary between fabricators. The SPS deck cost for this project was \$85/ft ² .
ENVIRONMENTAL/NEPA		
56	What are the most relevant environment and social impact of the project?	<p>Environmental Impact</p> <ul style="list-style-type: none"> • Prefabricated superstructure – reduced noise and dust, less wetland impact because no storage or staging area was required. • Life cycle of 100+ years – avoids future deck replacement associated with traditional concrete decks (less material, less waste, less noise). Recyclable since bridge is essentially all-steel construction. • No wet work on site which avoids the risk of contamination of the river. <p>Social Impact</p> <ul style="list-style-type: none"> • Bridge replacement (including substructure) was completed in 26 days which would have taken weeks using conventional

		construction. Residents, EMS, Fire experienced a short detour time which would have been crucial in a lifesaving scenario.
57	What level of environmental document was prepared? Does it involve both CEQA & NEPA.	The project received Nationwide Permit (NWP) 3 – Maintenance from Ohio DOT – Office of Environmental Services (OES) and the United States Army Corps of Engineers (USACE).