

February 2019 ABC-UTC Webinar Featured Presentation: Use of Longitudinal Full-Depth Precast Deck Panels on Boston's Commonwealth Avenue Bridge

#	Questions	Responses
	Design	
1	Why were longitudinal panels used compared to the transverse direction?	The severe skew was the main reason for the use of longitudinal deck panels. Skewed panels make it difficult to use post-tensioning for transverse panels.
2	If the panels are full-depth, does the superstructure still have an increased MOI/stiffness as in the CIP case (effective flange width)?	Research has shown that the behavior of the precast deck is the same as a cast-in-place concrete deck.
3	What is your recommendation for using precast concrete deck panels for freeze-thaw areas?	The deck concrete should meet all the requirements for a typical deck. Standard freeze-thaw durability provisions should be used.
	Construction	
4	What was the impact of accelerated bridge construction on the project schedule?	Conventional construction would have taken an estimated 5 years of staged construction with long duration shutdowns of the light rail. This project was completed in three with only two short duration impacts to all traffic.
5	Was there any staging construction?	There were two stages of construction for the superstructure which were used to accommodate utility relocations.
6	Were track outages required and, if so, how many were used during construction? Did lack of timely outages delay construction?	The contractor coordinated closely with both the commuter railroad and the MBTA. The railroad relaxed some of the more onerous requirements regarding crane operations, which was very beneficial to the aggressive project schedule.
7	Can you comment on the construction and reliability of the closure joints?	The durability of the joints was handled with the materials selected and the use of waterproofing membranes.
8	Was ultra-high performance concrete considered for the precast panel closure pours, and why was it not used?	Being a design-build contract, any material for closure joints was on the table. The contractor chose a more conventional high-early-strength concrete. UHPC could easily work with narrower joints.

9	What concrete strength was used in the longitudinal full-depth precast deck panels?	MassDOT required that their typical high performance concrete be used for precast deck panels. The design strength is 4 ksi.
10	How did you transport the panels, and how did you manage the construction sequence and loading of such a large bridge?	The MassDOT Bridge Manual includes provisions for handling calculations that follow the PCI Design Manual. This is also included in the 2018 AASHTO LRFD Guide Specifications for ABC. The Commonwealth Avenue Bridge was specifically designed with simple spans and link slabs, which allowed for any sequence of construction.
11	Can you comment on the difficulty and procedures involved in leveling the full-depth panels?	Leveling of the panels is normally not an issue. The design of leveling devices is typically left to the contractor (means and methods). A variety of methods have been successfully used throughout the country.
12	Discuss challenges presented by the severe skew and differences in camber of adjacent girders when setting the full-depth panels.	One of the benefits with the use of longitudinal deck panels is that they can easily accommodate large skews, so camber differences between adjacent girders is not an issue.
13	Were there any problems aligning the deck panels to the correct deck elevations?	There were minor issues at longitudinal joint interface between the Greenline and Westbound structures; however, the wearing surface was able to accommodate this issue.
14	Please comment on your success using precast overhangs in conjunction with longitudinal full-depth deck panels.	The fascia panels are similar to conventional precast deck panels. They were run transversely from the first interior girder to the overhang.
15	Were the barriers precast?	The parapets and sidewalks were cast-in-place due to the large width of the sidewalks.
16	Were panels cast "upside down" so that, when they were flipped over and installed, any minor or micro-tension cracks were in compression?	This was not considered.
17	How did the design/construction team deal with fabrication tolerances and fit-up issues in the field?	Longitudinal panels are much more forgiving due to the larger closure joints. Projecting reinforcing was detailed to allow for significant adjustment.

Cost		
18	Please comment on the cost comparison between different methods of bridge construction (conventional versus different ABC methods).	There is no simple answer on ABC costs. ABC costs are affected by a number of factors including construction speed, need for specialized materials, and site constraints. This site had many constraints, which led to a very high cost. Also, costs in metropolitan Boston are very high due to the site congestion and complexity of delivery of materials. The costs may have been higher if conventional construction was used due to the high cost of managing a complex project over 5 years. The owner understood this at the start of the project and accepted the cost in order to minimize impacts.
19	Did you have any claims related to the project?	There are no claims on the project that MassDOT or CME are aware of.
General		
20	What would you do differently the next time?	Honestly, nothing. It may not have been possible to build it any other way.
Questions during Webinar		
21	Were the new girders erected out of plumb due to the skew of the structure?	Yes. In 2017 the girders were actually erected in pairs for the most part, but they were erected singly in 2018. By using pairs, they were able to set the out-of plumb geometry prior to erection via the cross frames. The girders were erected out of plumb in order to achieve plumbness under full dead load. HDR is one of the leaders in the US regarding highly skewed steel bridge design and erection. They led this design effort for the DB Team.
22	Was the construction 24 hours a day and 7 days a week?	Yes. During the two shutdown periods of 18 and 16 days, construction was 24/7.
23	What was the weight of the largest panel?	Believe the largest panel approx. weight was 8.5 tons.

24	Was the substructure retrofit in order to use the longitudinal panels?	No, the substructure was rated a 4 prior to the project, so the substructure project needed to be performed regardless of the method of the superstructure replacement. The abutments were converted to semi-integral, which required modifications. The deck panels had no impact on other substructure features.
25	Why did you use loop bars from the precast panels in the closure strips?	Being a design-build project, the contractor could have suggested other details. The loop bars allow for shorter splice lengths which worked well within the relatively narrow closure joints.
26	What were the maximum panel dimensions used? Any issues with crane picks?	Believe the largest typical longitudinal deck panel was ~20' x 8'-10" (fascia panel). There may have been larger one-off panels at the BU or Essex Street framing.
27	Slide 52: Did the cost include the foundation work? Do you have an average sq ft cost for the completed deck?	The cost did not include the substructure project. The approximate cost is \$1,500 / square foot for the superstructure. See previous response above regarding the unit cost for this project.
28	What was the joint preparation prior to casting the high-early-strength concrete?	The Specifications called for Saturated Surface Dry condition. This project was performed prior to the research regarding exposed aggregate surface conditions. The exposed aggregate surface condition is being incorporated into the next edition of the Mass Bridge Manual.
29	What was the bridge deck area (for \$95M)?	The deck area was approximately 64,000 square feet, resulting in an approximate cost of \$1,500 / square foot. See previous response above regarding the unit cost for this project.
30	Did the panel placement sequence have to be considered, similar to how a deck pour sequence is considered in cast-in-place decks?	The Commonwealth Avenue bridge was specifically designed with simple spans and link slabs (no continuity), which allowed for any sequence of deck panel erection (all positive moment regions).

31	Is there a concern with locating all closures over the tops of the beams?	Research has shown that the behavior of the precast deck with closure pours is the same as a cast-in-place concrete deck. The joint over the girders is designed as a full-moment connection using the same forces as a cast-in-place concrete deck. Additionally, locating all closures over the tops of the beams is one of the advantages for longitudinal deck panels with regards to minimizing formwork efforts.
32	What was the skew angle?	The skew angle was 62.5 degrees.
33	What limited the size of the deck panels?	Crane picks limited the size of some of the deck panels. Given the significant span lengths and skew, some panels were located remotely from feasible crane locations.
34	During the substructure project, what type of foundation was used, i.e., the existing one or a new one?	The existing pier footings were reused for the substructure project.
35	How were the tracks on the bridge deck integrated with the precast panels?	A second pour of concrete with blockouts to accommodate the rails was necessary for the Greenline reservation replacement. A high durometer material was then used to set the rails within the rail pockets.
36	Were life cycle costs considered when deciding to utilize a membrane and overlay rather than an exposed concrete deck?	MassDOT typically uses a high-quality membrane waterproofing system and asphalt overlay for bridges. There is a long history of good performance of these systems in the Northeast. An exposed concrete deck was not considered.
37	From the picture, it seems there is exposed aggregates or shear key on the panels. How did you meet the 1/4-inch amplitude requirements?	Exposed aggregate finish was not specified for this project; however, it will be included in the upcoming Bridge Manual revisions. It is important to note that 1/4-inch amplitude is not required. The goal of exposed aggregate is to improve bond. The 1/4-inch amplitude specification is normally used for horizontal shear transfer between precast girders to CIP decks. Horizontal shear is not an issue with a deck closure joint; therefore, the 1/4-inch amplitude is not required. The 2018 AASHTO LRFD ABC Guide Specification specifically states this.

38	Did diaphragm spacing require adjustments during design due to the location of the precast panel joints?	No, this was not a consideration. The design of the steel framing was the same as if the deck were CIP concrete. The transverse closure joints were not connected to cross frames below.
39	Was stainless steel considered for the rebar? Stainless steel rebar is generally a small percentage of the overall cost, with great benefits for the longevity of the deck.	There is more than one way to provide durability. Stainless steel with a bare concrete deck is one approach, but there are others. MassDOT typically uses epoxy-coated bars combined with high-performance concrete, high-quality waterproofing membranes, and asphalt overlays. This approach has been used effectively for many years in the Northeast and in Europe.
40	How were the edges of the precast panels prepared for the closure pours, e.g., pre-wetting, sand blasting?	The Specifications called for Saturated Surface Dry condition on a formed shear key surface. This project was delivered prior to the research regarding the use of exposed aggregate surface condition. The exposed aggregate surface condition is being incorporated into the next edition of the Mass Bridge Manual.
41	Are there any specific concerns/procedures regarding future deck repairs?	At the end of the day, this deck is a reinforced concrete deck. No special repair procedures would ever be required. It can be treated as a CIP deck.
42	Could you share more details on the substructure evaluation?	<p>The West Abutment and West Pier footings are on piles, and testing was performed to load test the existing piles. The East Pier and Abutment are on spread footings.</p> <p>A detailed load comparison was performed during the substructure project assuming the BTC superstructure weights (i.e., the steel girder weights decreased due to shallower beams and 50 ksi girders, but the sidewalk widths increased). A re-evaluation of the substructure footings was performed by CME and the Geotech Nobis during the substructure project. The allowable loads were included in the DB procurement provisions. Exceeding these loads would require a re-evaluation of the foundations by the DB team.</p> <p>The use of simple spans with link slabs also played into this approach. The existing bridge had simple spans. Making the new spans continuous would lead to higher girder reactions at the piers, which would have been problematic.</p>

43	Why don't the studs have a coating for corrosion, in comparison with panel reinforcement?	<p>In most of the northeast, studs are installed in the field after erection. The studs are placed after the deck forms are installed, which eliminates tripping hazards and the potential for snagging of lanyards during erection. This has been standard practice for decades.</p> <p>The corrosion of the studs is not a problem due to the depth of the studs from the top of the deck (well below the top mat of rebar). This provides significant cover for the migration of chlorides. Removal of 60-year-old decks has shown that corrosion of studs is a non-issue.</p>
44	What was the magnitude of the longitudinal post-tensioning in the deck panels?	There was no longitudinal post-tensioning in the deck panels. The connection of deck panels was made through reinforced concrete closure joints.
45	What is the new girder spacing?	The new girder spacing was 6'-4" for the EB and WB Commonwealth Avenue girders. For the Greenline girders, during preliminary and final design the goal was to have a girder beneath each rail for simplicity of design, so the beam spacing mirrored the rail spacing on the Greenline (spaced at 5'-0").
46	How is the bridge deck drainage handled for this bridge?	There is a significant vertical curve to the bridge. The shoulders were able to accommodate the gutter flow. Therefore, all drainage structures were located off the bridge deck.
47	What was the clear cover used on the panels?	The clear cover of the panels was 2.5 inches.
48	Given the total cost of the project, would you prefer to use narrower joints with UHPC?	Being a design-build contract, any material for closure joints was on the table. The contractor chose a more conventional high-early-strength concrete. UHPC could easily work with narrower joints. However, given the larger spans, narrower joints may not have accommodated the necessary shear connectors.
49	Can you speak to dealing with the railroad company on this project?	The contractor coordinated closely with both the Commuter Railroad and the MBTA. The railroad relaxed some of the more onerous requirements regarding crane operations, which was very beneficial to the aggressive project schedule.
50	The framing plans have many cross-frames. Did you look at simplifying the cross-framing?	Several bays carried utilities, so a significant number of the cross-frames shown in the framing plan in the presentation are actually utility supports. The design was based on minimizing cross frames where feasible in order to accelerated girder erection.