

## July 2021 ABC-UTC Monthly Webinar: South Dakota ABC and Monolithic Precast Box Culverts

#	Questions	Responses
	<b>Design</b>	
1	What type of hydraulic and hydrological modeling was used? Was there any pushback from the Department of Natural Resources on replacing a bridge with a culvert?	HEC-RAS modeling was used. No "pushback" was received from the various environmental agencies.
2	Is it more efficient to replace a bridge with a culvert?	Bridge versus box culvert economics is site specific; however, generally it is more economical to install a box versus a bridge when feasible.
3	Is the new box culvert extended beyond the clear zone? Do you have any safety information for box culverts without bridge guardrails?	The new box culvert extends beyond the clear zone so guardrails are not required.
4	Were "split boxes" considered (top / bottom precast separately, with wall closure pour) for longer spans with no internal walls?	Our experience is that interior walls have not been a problem, have provided excellent service life, and are more economical to build than clear span boxes. These boxes have 8 or 9 feet of fill over the top, which would have made for overly thick and expensive slabs.
5	What is the rationale behind requiring the box culvert sections to act monolithically?	Our state has expansive soils that move over time and have caused significant problems with our roads and structures. Our field-cast boxes are tied together from end to end, and they have performed very well against the expansive soils. This change was an attempt to cause a precast structure to act like our field-cast boxes.
6	What are the seismic criteria used for the design of precast concrete box? Can you share any details for sealing the precast concrete box at the joints?	We are in an area for low to no seismic activity and do not design for it. The box joints are sealed at the bottom with a rope-type joint compound. The sides and tops have a wide layer of heavyweight filter fabric to keep the soil on the outside of the joint. The common walls in this case were sealed with concrete.

<b>Construction</b>		
7	How are the differential settlement and unevenness of the bedding considered in the design?	There is a minimum of two feet of granular bedding material below the structure. This material is either trimmed with a screed board or finished with a laser controlled piece of equipment. This provides a uniform support across the bottom of the structure.
8	How did you address Maintenance of Traffic? How were you able to cope with environmental requirements for this project?	We typically build a small detour around box sites that is topped with recycled asphalt and has proper signage per Manual on Uniform Traffic Control Devices (MUTCD) requirements.
9	Was lightweight concrete considered when designing the large precast elements to reduce the weight for transport and handling?	The additional cost of lightweight concrete would be more than the savings in freight. In addition, the precaster needs to achieve a high concrete strength within one day of time so they can reuse their forms to make another piece.
10	What are your preferences for the forms for precast box culverts? (We are form manufacturers.)	It is up to the precaster to use forms that produce box pieces that meet AASHTO specifications. We have learned that large double cell pieces are hard to produce in a way that meets these specifications. In this case, the choice was made to go with single cell box pieces that were longer than a double cell so the joints would be within specifications and the pieces could be handled with a crane that did not need to be on the box bed when setting the pieces.
11	What size facility is required to cast these boxes? Are they able to be done by state department maintenance forces?	The precaster for this project has indoor and outdoor production. The size of these pieces caused the precaster to make the pieces outside. They are cast on a concrete slab. The South Dakota DOT does not have maintenance forces or equipment for making precast box culvert sections.
<b>Maintenance</b>		
12	Can you talk about the maintenance aspects and pros and cons of using a box culvert versus a bridge?	Our maintenance records have proven that maintenance of box culverts is far less than that of a bridge. In addition, boxes generally have a lower first cost than a bridge.

Cost		
13	What cost estimate values were used for this solution? How did the cost estimate compare to the alternatives?	The initial value engineering change proposal pricing is included in the presentation. The purpose of this change was more about determining a method to make precast boxes monolithic than saving money. The money savings will show up when this option is allowed in the future.
14	What were the size and cost of the boxes?	The sizes and costs are in the presentation material. Basically, the precast option originally bid was a line of double 13-ft span by 12-ft rise set next to a single 13-ft span by 12-ft rise with straight end sections. The final structures were a triple line of 12-ft by 12-ft single cell boxes set side by side with monolithic flared inlet wall sections and a floating inlet apron slab.
Questions during Webinar		
15	Who designs South Dakota's projects, consultants or the SDDOT? Do you verify load rating for AASHTO and DOT vehicles?	The SDDOT Bridge Office designs most of their field cast box culverts with a few designed by consultants. The precast boxes are structurally designed by the precaster or engineering firm they hire. In this case, the precaster hired a structural engineer to redesign the boxes, and they did their own detailing for replacement plan sheets per their proposal. All precast box culverts are rated in accordance with the AASHTO Manual for Bridge Evaluation, 2018 Edition with the latest Interim Revisions using the LRFR method. The rating will include evaluation of the Design HL-93 truck at both Inventory and Operating levels and a Legal Load rating for the three South Dakota (SD) legal trucks (Type 3, 3S2, and 3-2) as well as the notional rating load and four specialized hauling vehicles. The structure will also be evaluated for the emergency vehicles, EV2 and EV3, at the legal load rating level. All sections of the box culvert will rate at HL-93 or better (Inventory Level). The three SD Legal Loads, the notional rating load, the four specialized hauling vehicles, and two emergency vehicles will rate greater than 1.0 at legal load rating level. AASHTOWare Bridge Rating (BrR) is required to be used to rate the box culvert.

16	What live load factor for EVs (Emergency Vehicles) was used, 1.3 for bridges or 2 for buried structures?	The live load factor for Emergency Vehicles was 2.
17	For a live load factor of 2 for EVs (Emergency Vehicles), most of our culverts fail for EV3 which was passed for HL-93. Do you have this issue in your DOT?	Yes, this is a concern for SDDOT. We are now requiring EV3 ratings to be greater than or equal to 1.0.
18	Are the wing walls designed to work as a retaining wall, i.e., is there moment-resisting steel going between the footing and the wall? If not, how was the overturning moment resisted?	Yes, the wingwalls are designed as a retaining wall with moment resisting steel between the footing and the wall.
19	Is the closure pour between sections some type of epoxy grout?	There was no epoxy grout used on the project. All closure pours were with concrete that met our structural concrete requirements. In this case, the field-cast concrete was designed to achieve full strength within a few days.
20	Was any post tensioning used in the box sections?	There was no post tensioning of the box sections.
21	Can you give any information about waterproofing of the structure?	We have received excellent service life from box culverts without waterproofing, so there was no water proofing applied to any of the concrete surfaces.
22	Are corners of the boxes doubly reinforced?	The corners of the boxes were not doubly reinforced.
23	Can you provide some cost data and comparison of bridge versus culvert costs?	N/A for this project.
24	What materials were used for the closure pour?	All closure pours were with concrete that met our structural concrete requirements. In this case, the field-cast concrete was designed to achieve full strength within a few days.
25	If the dimensions of the precast cells generate a weight that exceeds the limit for the transportation of the segment, how do you proceed in that case?	The contractor and precaster worked together to design the box unit wall thicknesses, steel area, and laying length to accommodate shipment and handling in the field.

26	Was there any reason for not using epoxy-coated reinforcement in the project?	Epoxy-coated steel is used in installations where corrosion has proven to be a problem, e.g., bridge decks, etc. Service life of uncoated steel in box culverts has been more than satisfactory.
27	Do you prefabricate arch concrete cells or just "rectangular" cells for culverts?	There are times when we have used arch cells, but we have found the box structures more site-friendly for length, flared ends, skewed ends, and final cost.
28	What is the maximum casting length for the bigger boxes?	South Dakota has four precast box producers. Some have 6-ft forms and some have 8-ft forms. One precaster has the ability to make small opening pieces in lengths greater than 8 ft. The large double cell pieces are typically cast to a shorter length than 6 ft for shipping and handling reasons mentioned earlier. The large pieces typically have more joint fit issues because of the large span and the type of forms used.
29	Is the reinforcing between the wing and wing footing grouted in place to make the moment connection?	The connection between the wing and wing footing were cast with a construction joint, similar to what is done with field-cast production.
30	Can you review the difference in hydraulic capacity for flared versus square headwalls/wingwalls, and how that was considered in the comparison between cast-in-place concrete and precast?	Flared box culvert wing walls are hydraulically more efficient than straight wing walls. The increase in efficiency varies with size of box, number of barrels, etc.
31	Did you divert the water when building the project? Where does the water go during construction?	There was no need to divert water for this project.
32	What is the gap width between the boxes?	The gap between the lines was 6 inches and was filled with reinforced concrete.
33	Was any consideration given for future widening or extending the culvert?	These structures are on very low ADT (Average Daily Traffic) roads with a very low probability of being widened in the future. We have widened similar box structures in the past and simply remove the end sections and extend the structure.

34	What is the service life of the box culvert, in years?	Our oldest precast box culvert has been in service for approximately 40 years. We hope to achieve a service life of at least 75 years.
35	How do you accommodate utilities carried on and parallel to the longitudinal axis of the culvert?	Generally we have no need to accommodate utilities on box culvert structures.