

**March 2022 ABC-UTC Monthly Webinar:  
Precast Concrete Culvert Standards for WSDOT Fish Passage Projects**

#	Questions	Responses
	<b>Policy</b>	
1	Does Washington State DOT tend to replace fish passage culverts with culverts? Oregon tends to use bridges to meet opening standards.	<p>We use both bridges and culverts. Our selection criteria for each are as follows:</p> <p><b>Buried Structures</b> These work for deep buried streams, they can be cost-effective, and they can be installed quickly. Box culverts require no foundation, they work well for shallow burial, and they work well in softer soils.</p> <p><b>Bridges</b> These work for shallow streams, unstable stream geometry, limited fish windows, construction outside of the stream banks, and if rock or debris is moving in the streams. They provide longer spans, large opening widths, and provide for stage construction.</p>
2	Is this a project you are working on in conjunction with Washington State DNR (Department of Natural Resources)?	As Washington State DNR is also part of the consent decree, the Washington State DOT coordinates with them on the Fish Passage Projects.
3	When these structures are redone, could they make them multifunctional, e.g., to also include solar arrays on the top side, or filtration / RO (reverse osmosis)?	Multifunctional uses are not included in the Fish Passage Projects at this time.
4	Are you eliminating fish baffles entirely?	In our corrections, we have eliminated most fish baffles for these projects.
	<b>Design</b>	
5	Are there scour issues at the approaches?	Yes, scour is considered at the approaches per the Bridge Design Manual (BDM).

6	What are the special Washington State seismic design requirements of large precast buried structures?	We require racking analysis, with Transient Ground Displacement (TGD), using pseudo-static or dynamic SSI (Soil-Structure Interaction) analysis. We also consider the Ground Motion Attenuation with Depth. The effect of vertical seismic motions is accounted for by applying a vertical pseudo-static loading for combinations of seismic effects at 1.0 EQH+0.3 EQV and 0.3 EQH+1.0 EQV. [EQH = EarthQuake, Horizontal; EQV = EarthQuake, Vertical]
7	What range of horizontal earth pressure is used in the design of the Washington box culverts?	The horizontal earth pressure is determined by using granular material backfill with effective angle of internal friction for backfill, $\phi = 34$ degrees, and drained internal angle of friction for subgrade under three-sided culverts, $\phi_{sub} = 30$ degrees. The at-rest lateral earth pressure coefficient for culverts is $K_o = 0.4450$ . The back slope behind the wingwalls is 2H:1V max.
8	How do you address settlement between precast segments? For example, with use of a bell joint?	The transverse differential settlements are considered for Service Limit State only (crack control in reinforced concrete members). The longitudinal differential settlements per allowable joint opening between precast units are calculated for a range of culvert configurations.
9	How do you prevent the precast culvert segments from settling independently?	Precast segments are tied together, acting as one unit.
10	How much settlement can precast box and split box structures tolerate? What joint connections are required for settlement?	Culverts are designed for the transverse differential settlements designed to tolerate a minimum 2-inch per 100-ft differential displacement, and longitudinal settlement per allowable joint opening between precast units calculated by using the formula: $\Delta Y = K_{max} \cdot W \cdot R$ , where $K_{max}$ is the maximum curvature, and W and R are length and height of the precast culvert units.
11	How do these designs compare to Pennsylvania standards?	We had some earlier discussions with PennDOT regarding their standard culverts. Their culvert manufacturers have apparently developed standard drawings meeting PennDOT requirements. This is a different approach than our standard plan development, which is not per a specific manufacturer's capability.

12	What are the recommended dimensions for a fish passage?	<p>Recommended dimensions for fish passages are as follows:</p> <p><b>Split box structure configurations</b></p> <ul style="list-style-type: none"> <li>- Precast U-shape bottom with 10-ft walls plus flat top slab</li> <li>- Precast U-shape bottom with 10-ft walls plus U-shape top with 5-ft walls</li> <li>- Precast U-shape bottom with 10-ft walls plus U-shape top with 10-ft walls</li> </ul> <p><b>Three-sided structure configurations</b></p> <ul style="list-style-type: none"> <li>- Precast U-shape top with 10-ft walls on precast or CIP strip footings (structure inside height about 10 ft)</li> <li>- Precast U-shape top with 10-ft walls on 5-ft tall precast or CIP stem walls (structure inside height about 15 ft)</li> <li>- Precast U-shape top with 10-ft walls on 10-ft tall precast or CIP stem walls (structure inside height about 20 ft)</li> </ul>
13	What are the implications / complications of building a bridge with a skew greater than 30 degrees?	Skew is defined by the plan geometry. Skews greater than 30 degrees are challenging but can be done. We have many bridges with skews over 30 degrees.
14	What is the most challenging part of this project?	The most challenging part of the Fish Passage Projects is the coordination between the Hydraulics, Geotechnical, Structural, and the Project Offices. For the construction, the most challenging part is providing competent bedding and getting proper erection of the culvert segments.
<b>Construction</b>		
15	Who are the primary suppliers for this product in your state?	The primary suppliers are Columbia Precast, Concrete Pipe NW, Contech, EnCon Northwest, Granite Precast, H2 Precast, Northwest Precast, Oldcastle, Shope Concrete, Wilbert Precast, Olympian Precast, Inc.
16	Are the fish passage devices installed during initial fabrication or post installation? What are the constructability / water handling issues involved with the fish passages?	There are no fish passage devices installed during initial fabrication or post installation. Streams are usually re-routed during box culvert construction. Streams for 3-sided culverts can be re-routed or built per the fish window depending on the bank width and size of the structure.

	Questions during Webinar	
17	What kind of foundation was the Loutsis Creek culvert built on? Were there any scour concerns for this site?	Cast-in-place concrete spread footings with stem walls were used for this project. The top of the foundation was below the scour depth per the BDM (Bridge Design Manual).
18	Are the wing walls precast also?	Wingwalls can be precast or cast in place. The precast option is preferred for speed of construction.
19	It appears that you are increasing flow areas to reduce velocities and improve fish passage. Will these improvements increase flooding downstream?	No, all fish passage crossings are designed with hydraulic models and extensive survey both upstream and downstream of the crossing. Part of the design process is evaluating flood hazards to make sure that the project does not impact public health or safety.
20	Bijan noted that box culverts require no foundation. This is true for a four-sided box culvert on competent soil. For 3-sided box culverts, do you use a foundation? If not, how do you account for load distribution into the soil?	A box culvert for us is a 4-sided structure that does not require a foundation. A 3-sided culvert always requires a foundation, either spread footings or deep foundations.
21	Does Washington State DOT try to limit the roadway outage to four or five weeks?	The decision to limit the roadway outage is done by the project offices on a case-by-case basis. We have the capability to meet accelerated construction with the use of prefabricated culverts.
22	The wing wall foundation is 2 ft below the 500-year scour elevation. What kind of backfill material is used to ensure it doesn't scour down to that depth?	The backfill is granular material per the Standard Specifications with back slopes behind the wingwalls of 2H:1V.
23	Are there any design / constructability concerns for 3-sided rigid frames installed in stages? Are there any issues with tying the units together?	The 3-sided structures have fewer design and constructability concerns because they are installed on footings or stem walls. They can be installed in stages and can be tied together for installation. Stage construction due to traffic requirements can also be challenging for deeper structures.
24	For fish passage structures, do you need to use 3-sided boxes with a natural stream bottom, or do you use precast floor slabs?	Our practice is to use the natural stream bottom for 3-sided boxes. Precast floor slabs are not used for our 3-sided structures.

25	Is there any particular reason for using the concrete option for the buried structures? Is the concrete option found to be more cost- and schedule-effective compared to the metal culvert option by Washington State DOT?	Our BDM (Bridge Design Manual) allows concrete, metal, and composite materials for buried structures. The precast concrete option for the buried structures is found to be more cost-effective and schedule-friendly. We use metal and composite materials on a case-by-case basis as suitable to the site and schedule.
26	The precast members seem to come to the field off the truck with significant cracking. What are the criteria for rejection if necessary and/or to assure they are designed with proper crack control? Does this give you satisfactory criteria for a 75-year service life? What are the comparisons between the heavy concrete systems and the alternative corrugated steel or stiffened aluminum arch systems that are available for stream crossings?	The precast members are supposed to come to the site and be installed without any cracking beyond what is allowed in the Standard Specifications. Members are designed per crack control requirements. Members with significant cracks will be rejected or repaired to meet the long-term durability requirements. Criteria for rejection is defined by Bridge Construction. All precast members are designed per AASHTO for a 75-year design life. Use of heavy concrete culvert systems may not be suitable in sites with shipping and handling restrictions, long spans, or sites with limited bearing capacity. In these cases, the alternative corrugated steel or stiffened aluminum arch systems that are advantageous for culvert and for stream crossings are used.
27	What measure(s) is Washington State DOT using to determine success of this large-scale replacement initiative?	All the effort is focused on the completion date of 2030. To achieve this goal, WSDOT employs different contracting methods such as DBB (Design-Bid-Build), DB (Design-Build), PDB (Progressive Design-Build), CSD (Contractor Supplied Designs), and Project Bundling.
28	Did you encounter any fish ladder requirements, on the top of the bottom slab, in any of the culverts? If so, were they fabricated from cast concrete, fastened metal, or something else?	To date, fish ladders are not considered in our designs and construction.
29	How is water management typically done during construction? What return period of flows / water levels are used during construction for water management?	Water management during construction is typically done by diverting the stream through temporary culverts or structures. Normal water levels are used during construction for water management.

30	For the structure that had 100 ft of fill, was that replaced with a bridge or another culvert?	For the structure that had 100 ft of fill, a buried structure was used. Buried structures are usually cost effective, unless other situations such as rock or debris moving in the stream, longer spans, large opening widths, or stage construction make the bridge option more advantageous.
31	How are you calculating scour for 3-sided structures? Are you using the NCHRP abutment scour equation plus contraction scour, or are you using the open bottom culvert contraction scour equation?	Scour calculations for 3-sided structures are per the BDM (Bridge Design Manual). The BDM requirements are based on AASHTO and FHWA's HEC 23 document for using the open bottom culvert contraction scour equation as modified by geotechnical and hydraulic engineers.
32	For 4-sided structures, is there a recommended minimum depth the bottom slab should be below the stream bed?	The minimum depth of the bottom slab below the stream bed is 12 inches.
33	How are streambed materials inside the culverts designed / sized? Are there standards, or are the materials at each site specifically designed for the site?	Streambed materials inside the culverts are designed and sized to match the current upstream and downstream bed material.
34	Do you use any kind of shear key to prevent your wing walls from sliding?	There is no shear key to prevent the wing walls from sliding. The wingwalls are supported on their foundations and are designed with a factor of safety of 1.5 against sliding.
35	Are you sometimes using post-tensioning to connect precast segments together?	We have not used post-tensioning to connect precast segments together.
36	If you use hinges at the mid-height of the walls of very large culverts, how do you justify these hinges from a seismic standpoint?	Hinges at the mid-height of the walls of very large culverts are designed and detailed to transfer the lateral seismic loads. The joints are seismic shear resistant.
37	How is the embankment protected from erosion?	A combination of wingwalls, retaining walls, and 2H:1V backslopes behind the walls provide protection from erosion.

38	We have seen early deterioration of precast units due to leakage through the top slab joints. Have concrete overlays or distribution slabs been considered as a cost-effective measure to prevent this?	Five-inch-thick concrete slabs, concrete overlays, or distribution slabs are considered for improved performance and durability. All these options bear some minor increase in costs but improve the longevity and service life of buried structures.
39	Are the limited construction window restrictions dependent on stream classification, and is that window usually noted on the drawings?	The limited construction window restrictions are dependent on stream classification. The construction window is covered in the Contract Document and is not necessarily in the drawings.
40	Can we get a copy of the presentation for academic purposes?	Definitely, a copy of the presentation is available on the ABC-UTC website in the March 2022 Monthly Webinar Archives.