

Design Memorandum

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: November 30, 2015
SUBJECT: WSDOT Precast Concrete Culvert Standards

This Design Memorandum introduces the newly developed WSDOT Precast Concrete Culvert Series Shapes. The design requirements for buried structures shall be as specified in the July 31, 2015 Design Memorandum for use of buried structures.

For culverts with span lengths less than 20 feet, the Region PE Office may allow Contractor-Supplied design of the culverts while under contract. For clarity, the span length is measured from interior face to face of culvert along centerline roadway.

For culverts with span lengths equal or greater than 20 feet and less than 26 feet, the Region PE Office may utilize Contractor-Supplied design while under contract for any culverts meeting all of the following criteria:

1. Geotechnical Report foundation recommendation of spread footing support based on confirmed presence of competent soils at the site. No soft soil support embankment requiring lightweight fills or ground improvement, as confirmed by the Geotechnical Report
2. Peak Seismic Ground Accelerations at the project site of 0.3g or less, as shown in the Geotechnical Design manual M 46-03.11 - May 2015 Section 6.3.1, Figure 6-8
“Determination of Seismic Hazard Level, Peak Horizontal Acceleration (%G) for 7% Probability of Exceedance in 75 Years for Site Class B (Adapted From AASHTO 2012)
3. No liquefaction or lateral spread risks, as confirmed by the Geotechnical Report
4. Skew angle of waterway alignment limited to within 25 degrees of a normal 90-degree crossing of the roadway alignment if the soil fill is retained by headwalls
5. Not scour critical, as confirmed by the HQ Hydraulics Office

For culvert span lengths equal to or greater than 26 feet, or for any culverts with span lengths between 20 feet and 26 feet that do not meet all of the criteria above, the design of the culvert shall be completed prior to contract, with plans included as part of the Ad-copy PS&E. The design may be completed either by WSDOT staff or by a proprietary culvert supplier identified as a sole source by WSDOT. In lieu of sole source selection by WSDOT, design may be solicited from three proprietary culvert suppliers, with all three plan sets included as options in the Ad-Copy PS&E.

Culvert Preliminary Plans are required for any culvert with span lengths greater than 26 feet, or for any culverts with span lengths equal to or greater than 20 feet that do not meet all the criteria above. Culvert Preliminary Plans shall be prepared by the Bridge and Structures Office, with the site data submitted by the Region PE Office. The culvert Preliminary Plan will contain plan, elevation, and section details, defining geometrics, and a structure cost estimate.

Standard Culverts Design and Detailing Requirements:

The new WSDOT Precast Concrete Culvert Series Shapes will accommodate up to 30 feet of backfill and 20 to 60 feet clear span length. The geometry used for developing these precast concrete culvert shapes is shown in Figure 1.

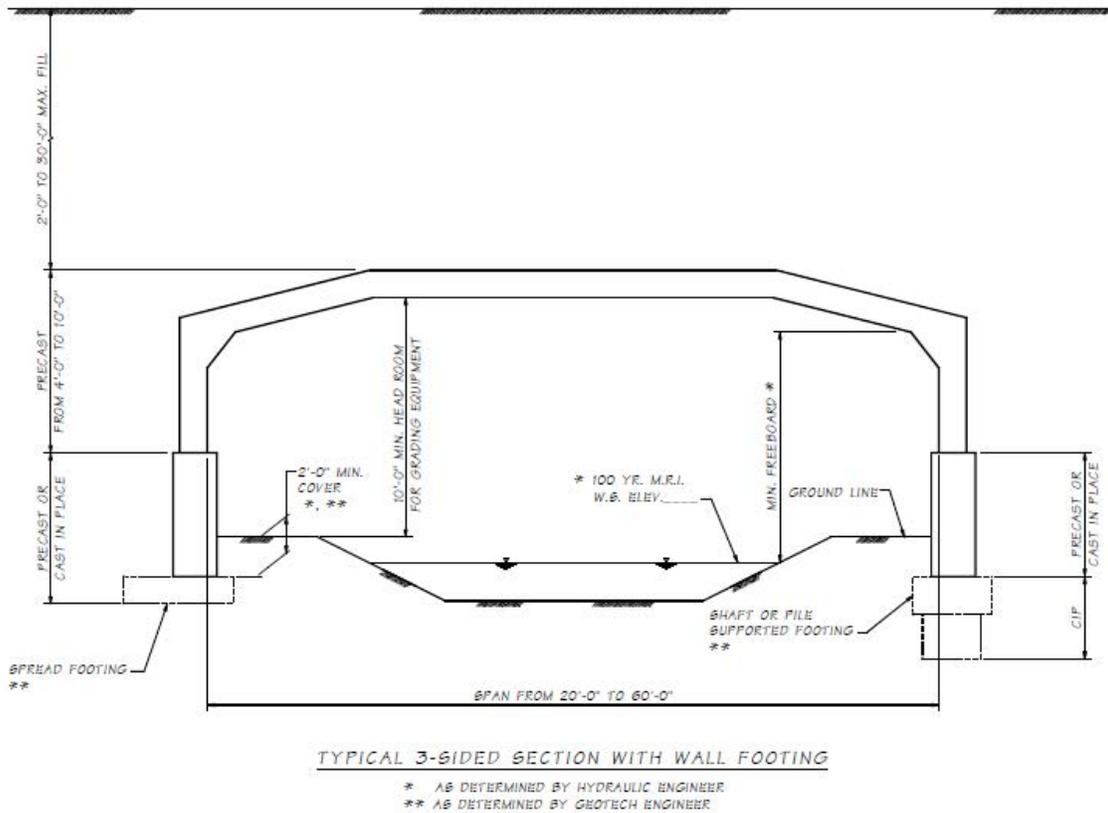
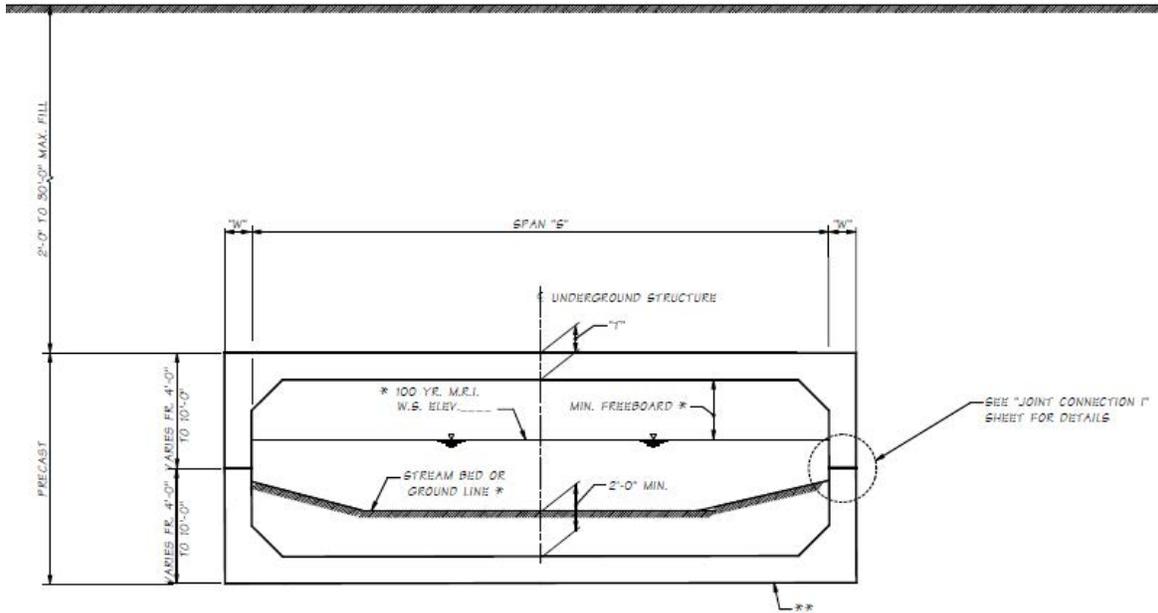


Figure 1: Precast Concrete Culvert Configuration

The foundation for these precast concrete culvert shapes may be spread footing, pile or drilled shaft as recommended in the geotechnical report. For span lengths less than 26 ft measured from interior face to face of culvert along centerline roadway, split box culvert configurations composed of these precast concrete culvert shapes on the top, and a cast-in-place or precast section on the bottom as shown in Figure 2 could be considered for poor soil conditions or as recommended in the geotechnical and hydraulic reports.

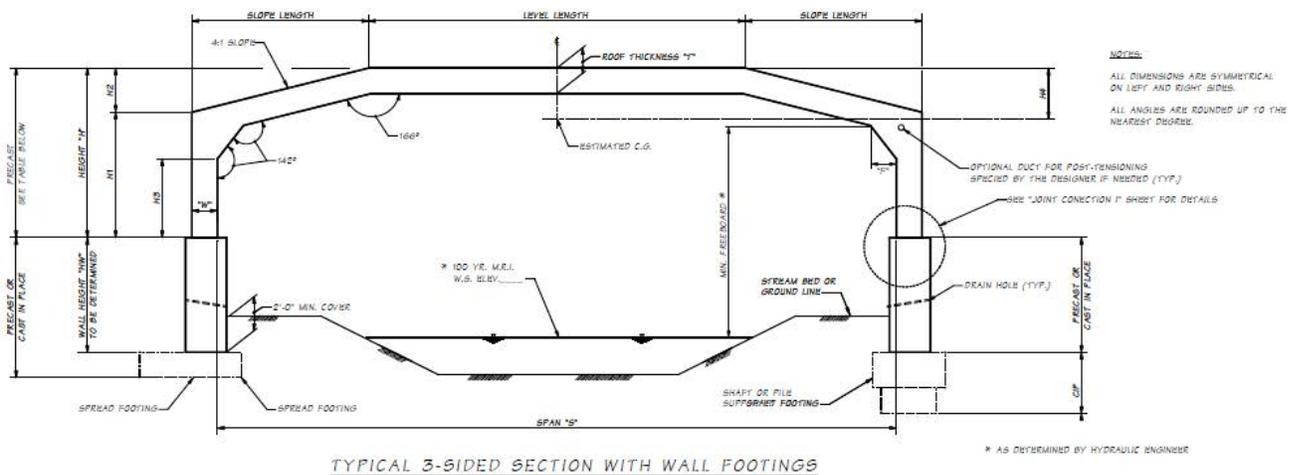


TYPICAL SPLIT BOX CULVERT

SEE "SECTION DETAILS AND TABLE" SHEET FOR DIMENSIONS
 * TO BE DETERMINED BY THE HYDRAULIC ENGINEER
 ** TO BE DETERMINED BY THE GEOTECH ENGINEER

Figure 2: Precast Concrete Split Box Culvert Configuration

The typical section for these precast concrete culvert shapes is shown in Figure 3, and the span capability is shown in Table 1. The span capabilities of these precast concrete culvert shapes are based on 6.0 ksi compressive strength of concrete, and grade 60.0 ksi reinforcement. The design is based on the unit weight of concrete of 0.16 kcf, unit weight of soil of 0.125 kcf, and 0.14 for unit weight of HMA overlay.



TYPICAL 3-SIDED SECTION WITH WALL FOOTINGS

Figure 3: Typical Section of Precast Concrete Culvert Series

PRECAST CULVERT GEOMETRY TABLE																	
SERIES	TYPES	CASES	SPAN		WALL HEIGHTS			LEVEL	SLOPE		ROOF THICK.	WALL THICK.		RILLET	SEGMENT	SEGMENT	C.G. **
			'S'	'W'	H1	H2	H3	LENGTH	LENGTH(2)	'T'	'W'	OR 'F'	LENGTH **	WEIGHT **	FROM TOP		
			FT.	FT.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.	KIPS	FT.
'SB20'	SPLIT BOX (1)	FLAT TOP	20	10 (3)	-	-	-	22'-2"	-	1'-2"	1'-2"	1'-4"	5'-0"	36	2.72		
'SB25'	SPLIT BOX (1)	FLAT TOP	25	10 (3)	-	-	-	27'-4"	-	1'-4"	1'-2"	1'-4"	5'-0"	47	2.83		
'FC20'	3-SIDED	FLAT TOP	20	10 (3)	-	-	-	22'-2"	-	1'-2"	1'-1"	1'-4"	5'-0"	36	2.72		
'FC25'	3-SIDED	FLAT TOP	25	10 (3)	-	-	-	27'-4"	-	1'-4"	1'-2"	1'-4"	5'-0"	47	2.83		
'FC30'	3-SIDED	FIXED SLOPE LENGTH	30	10	7'-4 1/2"	2'-7 1/2"	4'-8 1/2"	12'-2"	10'-8"	1'-8"	1'-8"	1'-7"	5'-0"	50	2.94		
'FC35'	3-SIDED	FIXED SLOPE LENGTH	35	10	7'-4 1/2"	2'-7 1/2"	4'-8 1/2"	17'-2"	10'-8"	1'-8"	1'-8"	1'-7"	5'-0"	60	2.99		
'FC40'	3-SIDED	FIXED SLOPE LENGTH	40	10	7'-4 1/2"	2'-7 1/2"	4'-8 1/2"	22'-2"	10'-8"	1'-8"	1'-8"	1'-7"	5'-0"	69	2.66		
'VC45'	3-SIDED	VARIABLE SLOPE LENGTH	45	10	7'-1 1/2"	2'-10 1/2"	4'-3 1/2"	22'-2"	15'-1"	1'-7"	1'-8"	1'-10"	4'-0"	68	2.81		
'VC50'	3-SIDED	VARIABLE SLOPE LENGTH	50	10	6'-1"	3'-11"	3'-0 1/2"	22'-2"	15'-8"	1'-7"	1'-8"	1'-10"	4'-0"	68	2.98		
'VC55'	3-SIDED	VARIABLE SLOPE LENGTH	55	10	5'-8"	4'-8"	2'-4 1/2"	22'-2"	18'-3"	1'-7"	1'-10"	2'-0"	4'-0"	72	3.09		
'VC60'	3-SIDED	VARIABLE SLOPE LENGTH	60	10	4'-0"	5'-3"	1'-7 1/2"	22'-2"	20'-11"	1'-7"	2'-0"	2'-0"	3'-0"	68	3.24		

Table 1: Precast Culvert Span Capability Charts

The connection between the precast concrete culvert base and supporting stem wall or footing could be bearing, shear key, or pinned as shown in Figure 4.

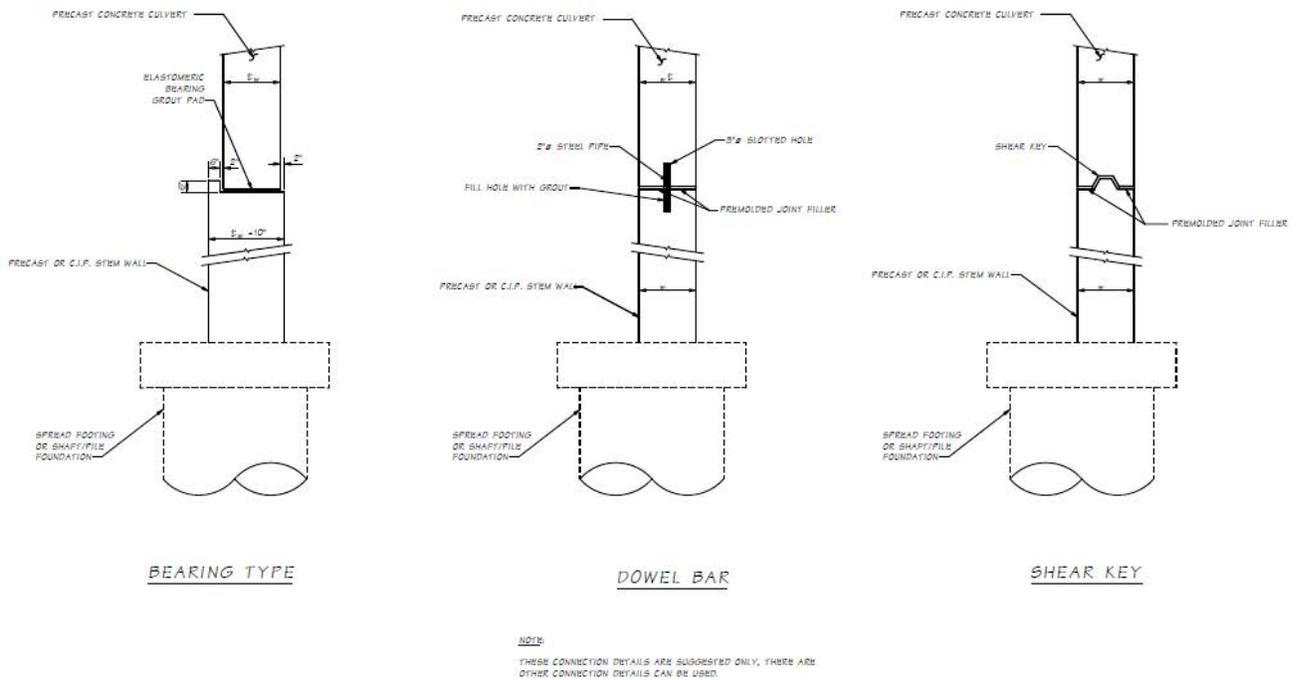


Figure 4: Precast Segment Base Details

The connection between the precast concrete segments could be cast-in-place concrete joints or tight joint with waterproofing membrane as shown in Figure 5.

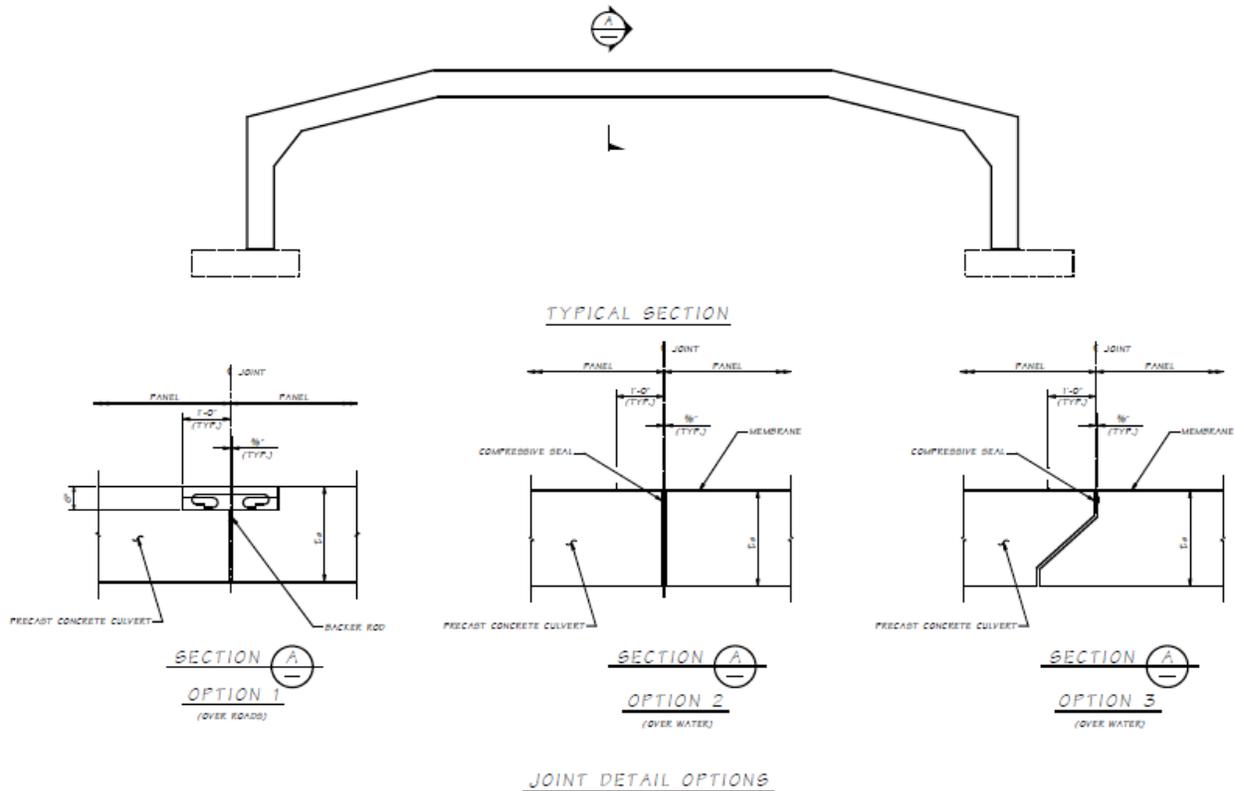


Figure 5: Precast Segment Joint Details

Shipping and Handling:

The shipping configuration and the location of lifting loops shall be carefully studied so that the precast segments are stable during shipping and handling. The maximum height of the precast segments is 10 feet. For vertical culvert openings beyond 10 feet, a cast-in-place or precast stem wall as part of the culvert foundation should be considered. The maximum shipping weight of precast segments may vary depending on the size of precast segments. The shipping weight shall meet the legal axle load limits set by the RCW, but in no case shall the maximum shipping weight exceed 70 kips.

A complete set of CAD drawings used in the memorandum are attached for clarity.

Background:

The foundation types for precast concrete culvert series shapes could be spread footing, pile or drilled shaft as recommended in the geotechnical report. In case of poor soil conditions, split box culvert configurations composed of a precast concrete culvert shape on the top, and a cast-in-place or precast section on the bottom could be considered. This will be similar or alternative to 4-sided box culverts that are used for poor soil conditions.

Three types of support connections and three types of connections between the precast concrete segments are introduced and could be used as in accordance with project requirements. Soil lateral pressure, seismic racking, and culverts over roadway or waterway could be basis for connection type selection.

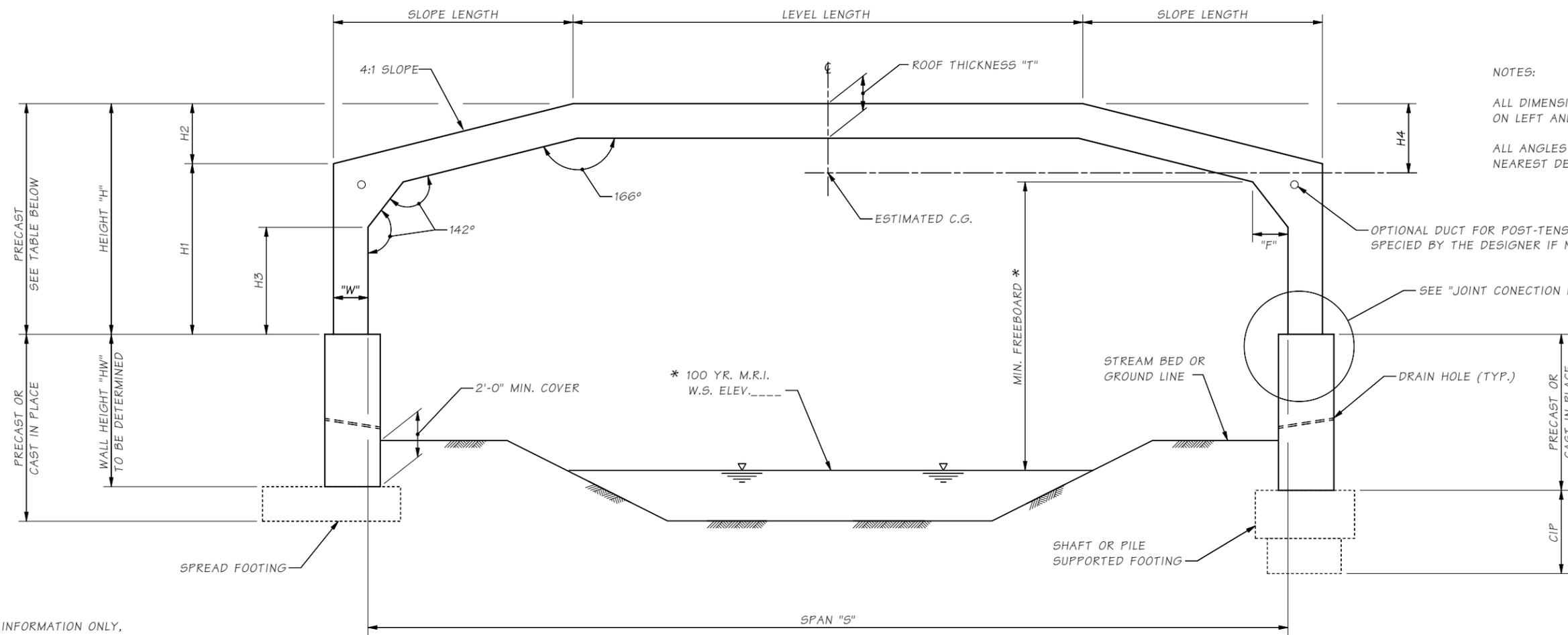
Fish passage structures are usually scour critical except those supported on deep foundation.

If you have any questions regarding this policy memorandum, please contact Richard.Zeldenrust@wsdot.wa.gov at 705-7196, or Luong.Tran@wsdot.wa.gov at 705-7195, Jim.Wei@wsdot.wa.gov at 705-7169 or Bijan.Khaleghi@wsdot.wa.gov at 705-7181.

cc: Mark Gaines, Bridge Construction – 47354
Craig Boone, Bridge and Structures – 47340



UNDERGROUND
STRUCTURES.CPJ - C



NOTES:
 ALL DIMENSIONS ARE SYMMETRICAL ON LEFT AND RIGHT SIDES.
 ALL ANGLES ARE ROUNDED UP TO THE NEAREST DEGREE.

** FOR INFORMATION ONLY, NOT USED FOR DESIGN OR FABRICATION
 (1) SPLIT BOX CONSISTS OF TWO "FC20" OR TWO "FC25"
 (2) EACH SIDE
 (3) 4'-0" MIN. HEIGHT

TYPICAL 3-SIDED SECTION WITH WALL FOOTINGS

* AS DETERMINED BY HYDRAULIC ENGINEER

PRECAST CULVERT GEOMETRY TABLE

SERIES	TYPES	CASES	SPAN	HEIGHT	WALL HEIGHTS			LEVEL LENGTH	SLOPE LENGTH(2)	ROOF THICK.	WALL THICK.	FILLET OR "F"	SEGMENT LENGTH **	SEGMENT WEIGHT **	C.G. **
					H1	H2	H3								
			FT.	FT.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.-IN.	FT.	KIPS	FT.
"SB20"	SPLIT BOX (1)	FLAT TOP	20	10 (3)	-	-	-	22'-2"	-	1'-2"	1'-1"	1'-4"	5'-0"	38	2.75
"SB25"	SPLIT BOX (1)	FLAT TOP	25	10 (3)	-	-	-	27'-4"	-	1'-4"	1'-2"	1'-4"	5'-0"	47	2.83
"FC20"	3-SIDED	FLAT TOP	20	10 (3)	-	-	-	22'-2"	-	1'-2"	1'-1"	1'-4"	5'-0"	38	2.75
"FC25"	3-SIDED	FLAT TOP	25	10 (3)	-	-	-	27'-4"	-	1'-4"	1'-2"	1'-4"	5'-0"	47	2.83
"FC30"	3-SIDED	FIXED SLOPE LENGTH	30	10	7'-4 3/4"	2'-7 1/4"	4'-7 3/4"	12'-2"	10'-5"	1'-6"	1'-6"	1'-6 3/8"	5'-0"	50	2.67
"FC35"	3-SIDED	FIXED SLOPE LENGTH	35	10	7'-4 3/4"	2'-7 1/4"	4'-7 3/4"	17'-2"	10'-5"	1'-6"	1'-6"	1'-6 3/8"	5'-0"	60	2.59
"FC40"	3-SIDED	FIXED SLOPE LENGTH	40	10	7'-4 3/4"	2'-7 1/4"	4'-7 3/4"	22'-2"	10'-5"	1'-6"	1'-6"	1'-6 3/8"	5'-0"	69	2.66
"VC45"	3-SIDED	VARIED SLOPE LENGTH	45	10	6'-8 3/4"	3'-3 1/4"	3'-6 1/8"	22'-2"	13'-1"	1'-7"	1'-8"	1'-11 1/4"	4'-6"	68	2.83
"VC50"	3-SIDED	VARIED SLOPE LENGTH	50	10	6'-1"	3'-11"	2'-10 9/8"	22'-2"	15'-8"	1'-7"	1'-9"	1'-11 1/4"	4'-0"	68	3.00
"VC55"	3-SIDED	VARIED SLOPE LENGTH	55	10	5'-5 1/4"	4'-0 3/4"	2'-3 1/8"	22'-2"	18'-3"	1'-7"	1'-10"	1'-11 1/4"	4'-0"	72	3.00
"VC60"	3-SIDED	VARIED SLOPE LENGTH	60	10	4'-9 1/4"	5'-2 3/4"	1'-7 5/8"	22'-2"	20'-11"	1'-7"	2'-0"	1'-11 1/4"	3'-6"	66	3.25

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Bridge Projects Engr.										
Prelim. Plan By										
Architect/Specialist										
DATE		REVISION		BY	APPD					

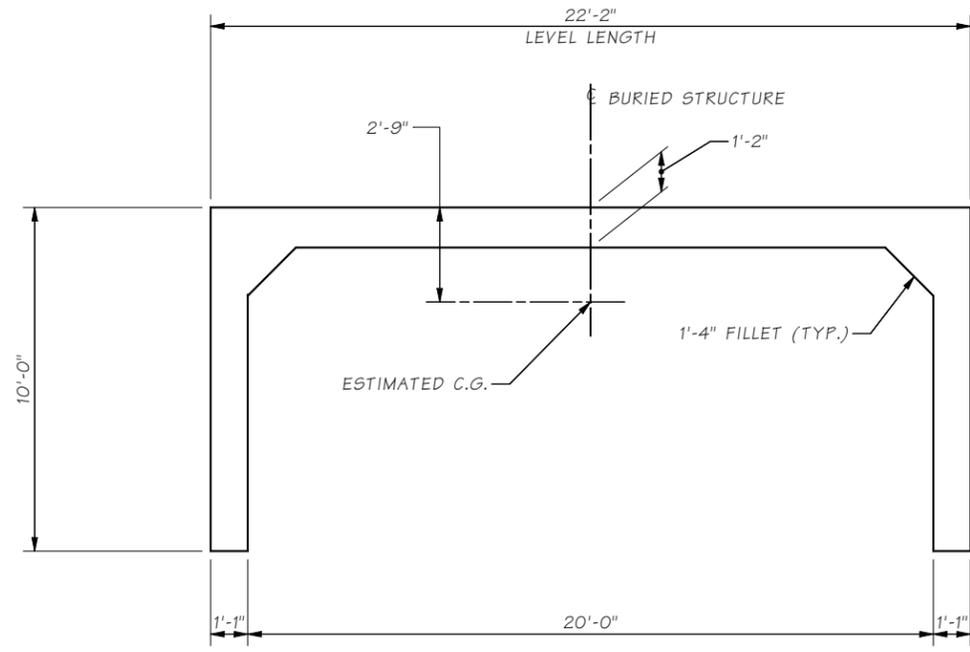
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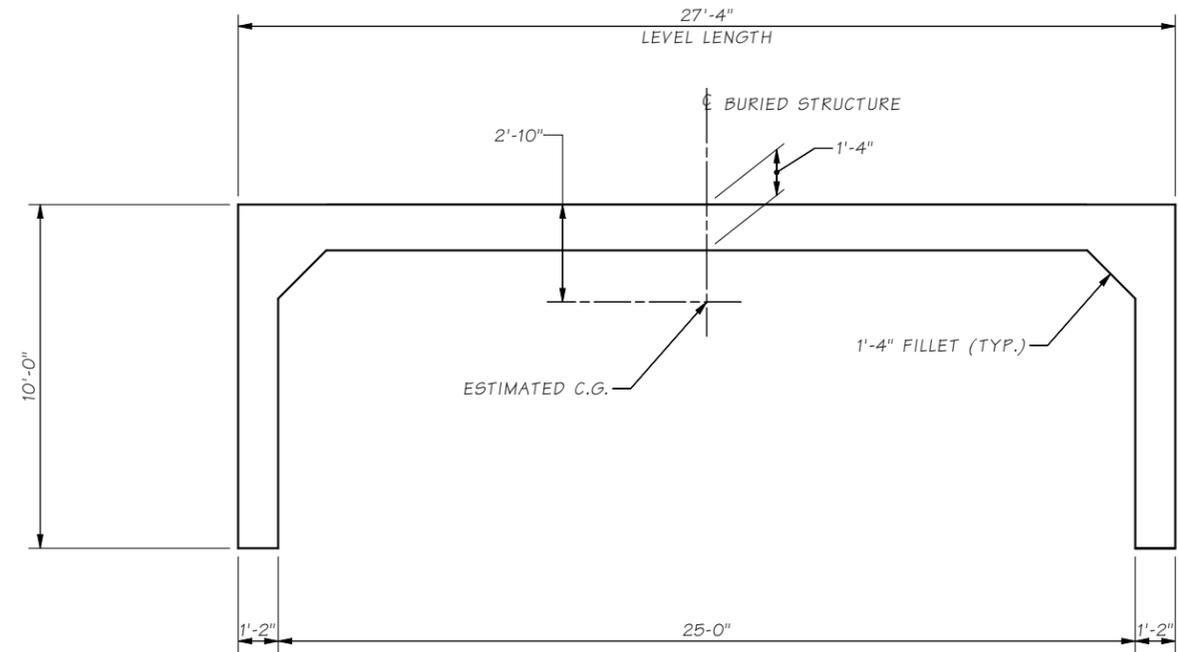
PRELIMINARY
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 NOT FOR CONSTRUCTION

BURIED STRUCTURES
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 3-SIDED PRECAST CULVERT SECTION DETAILS AND TABLE

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SB20, FC20

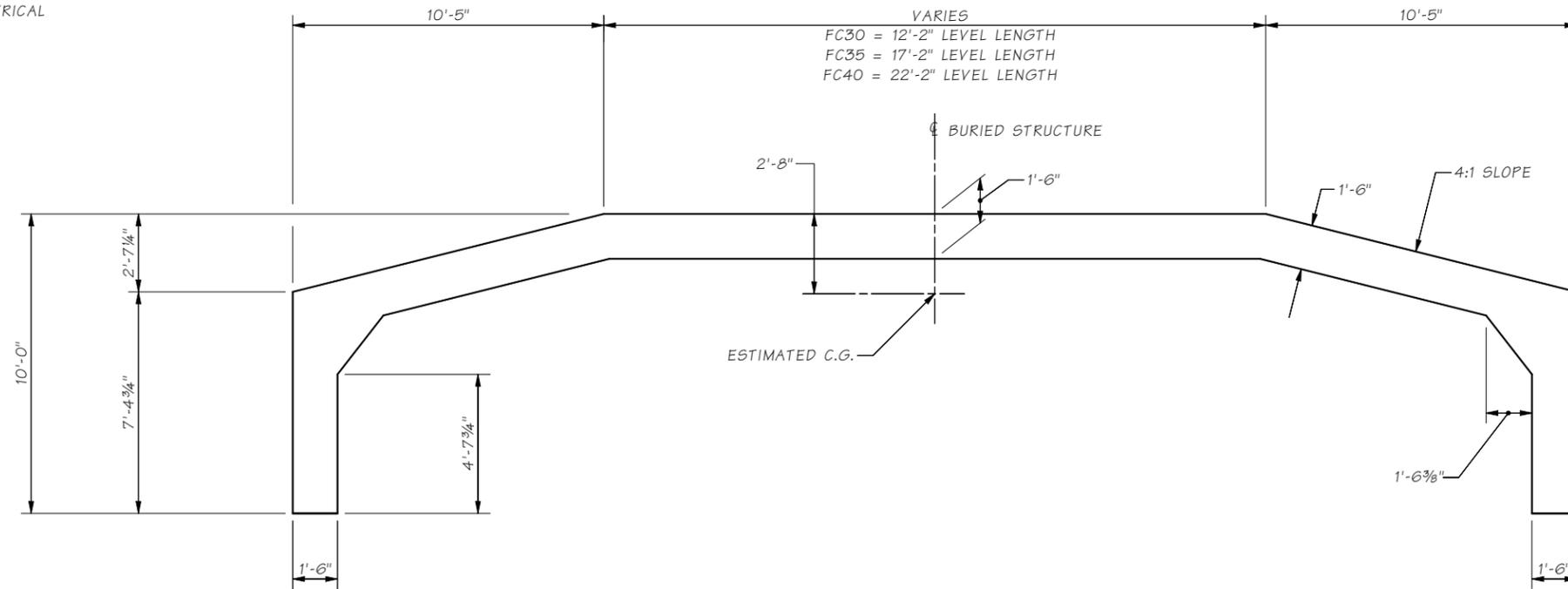


SB25, FC25

FOR SPANS BETWEEN FC25 TO FC30, USE THE SECTION BELOW WITH VARIED MIDDLE DECK SEGMENT

NOTE:

ALL DIMENSIONS ARE SYMMETRICAL ON LEFT AND RIGHT SIDES



FC30, FC35, FC40

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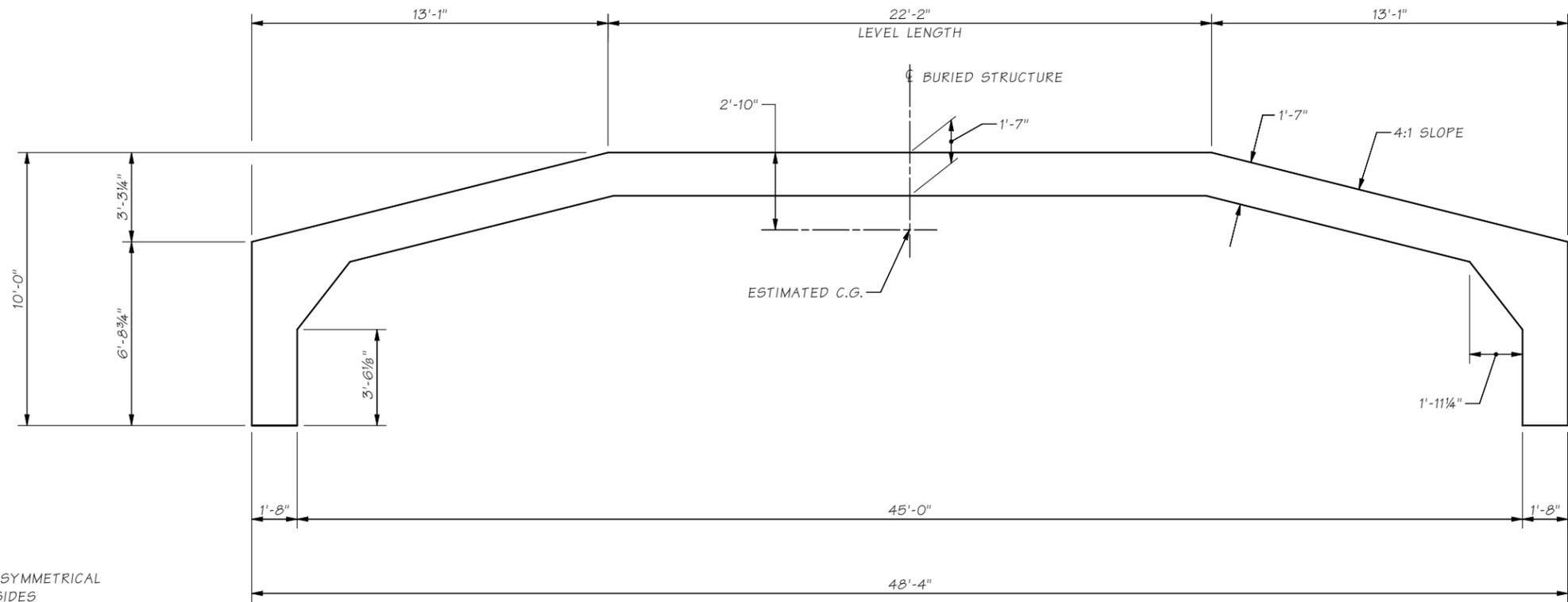
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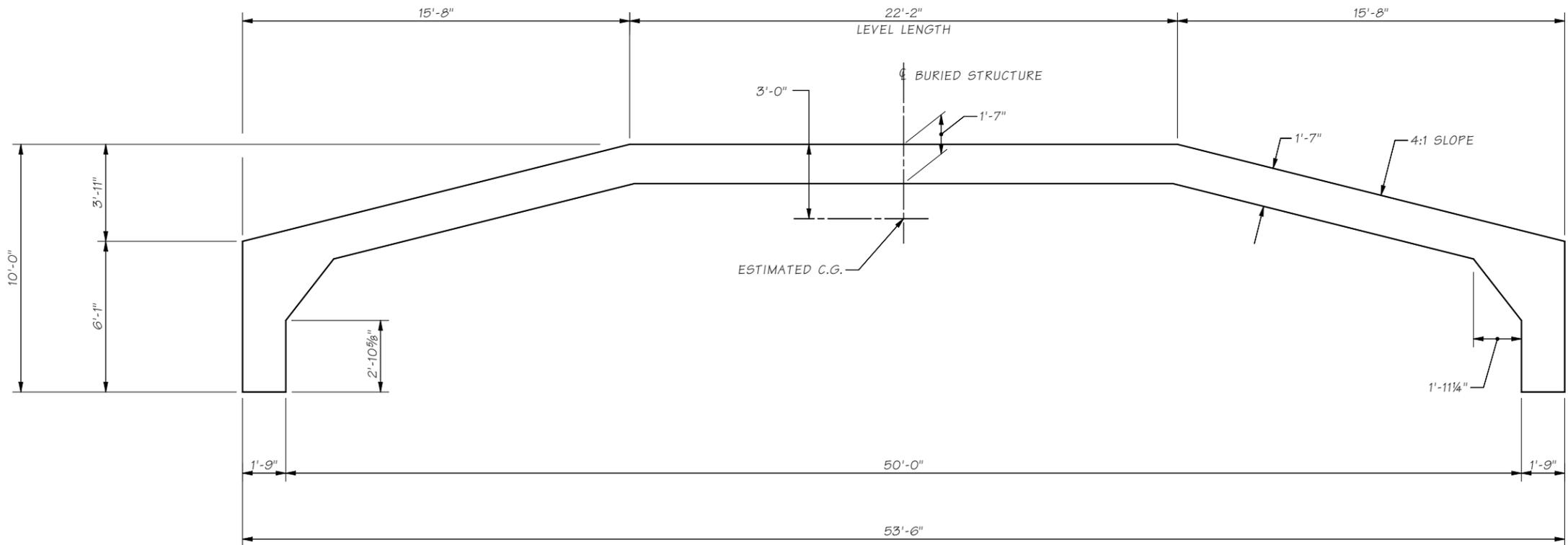
3-SIDED PRECAST CULVERT
 SERIES FC20 TO FC40

BRIDGE SHEET NO. 0 OF SHEETS



NOTE:
ALL DIMENSIONS ARE SYMMETRICAL
ON LEFT AND RIGHT SIDES

VC45



VC50

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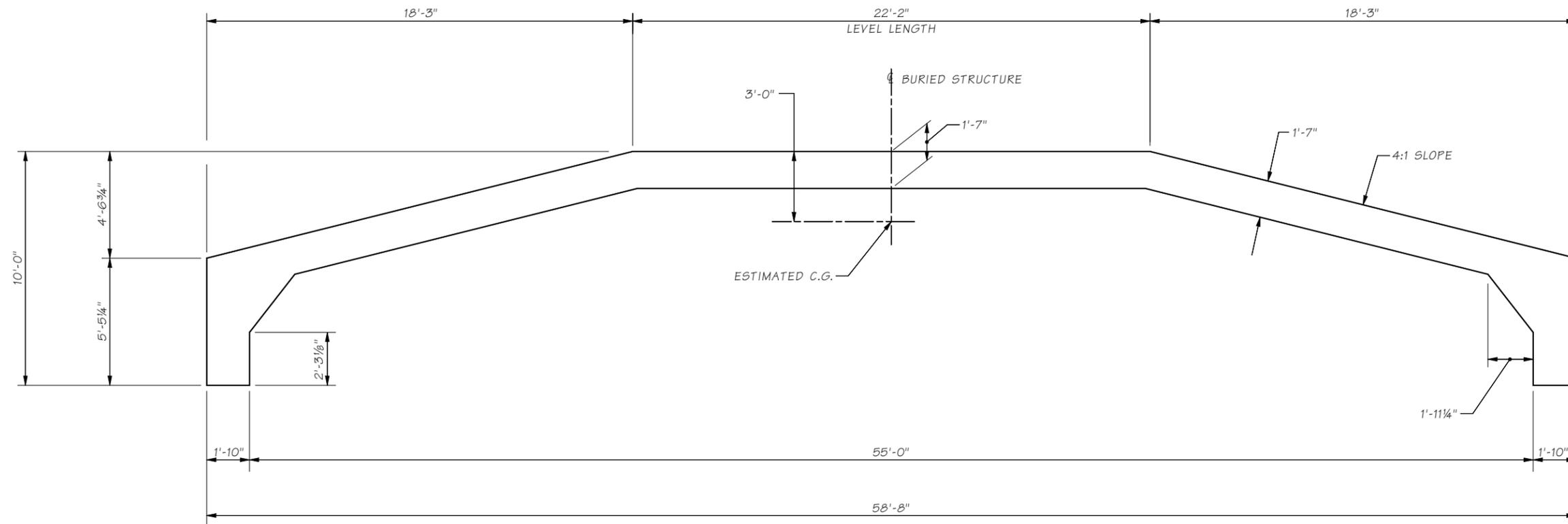
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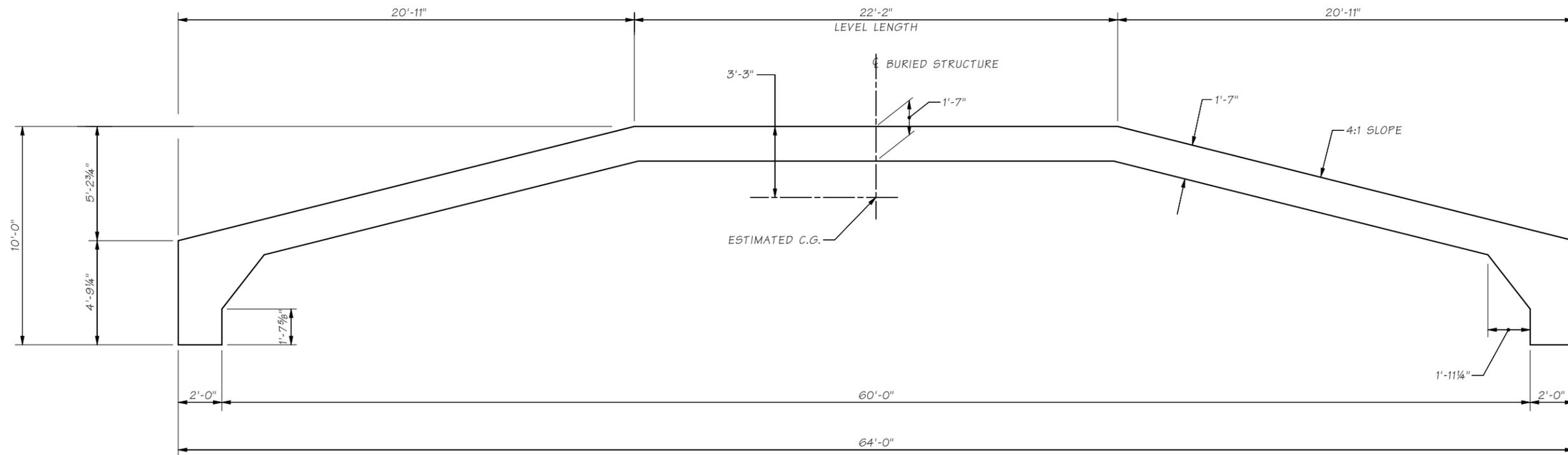
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PRELIMINARY PLANS
3-SIDED PRECAST CULVERT
SERIES VC45 TO VC50

BRIDGE SHEET NO. 0 OF SHEETS



NOTE:
ALL DIMENSIONS ARE SYMMETRICAL
ON LEFT AND RIGHT SIDES

VC55



VC60

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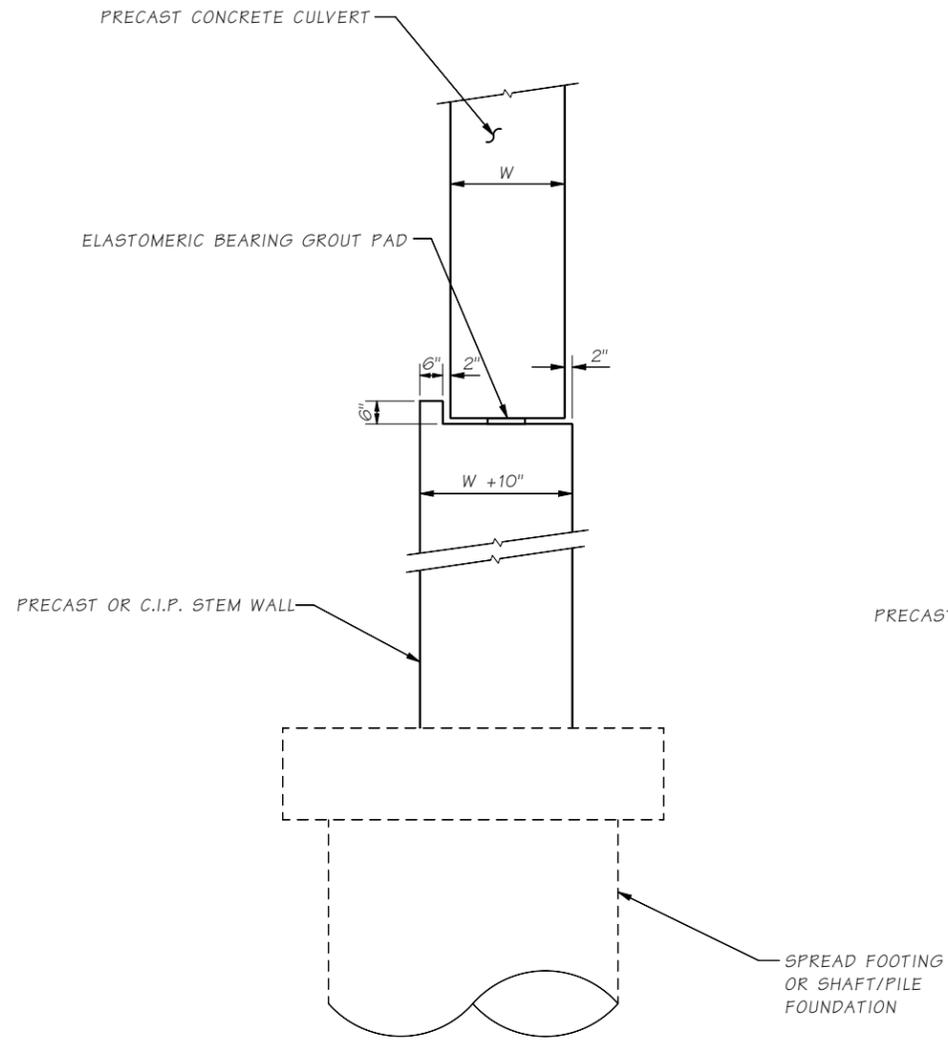
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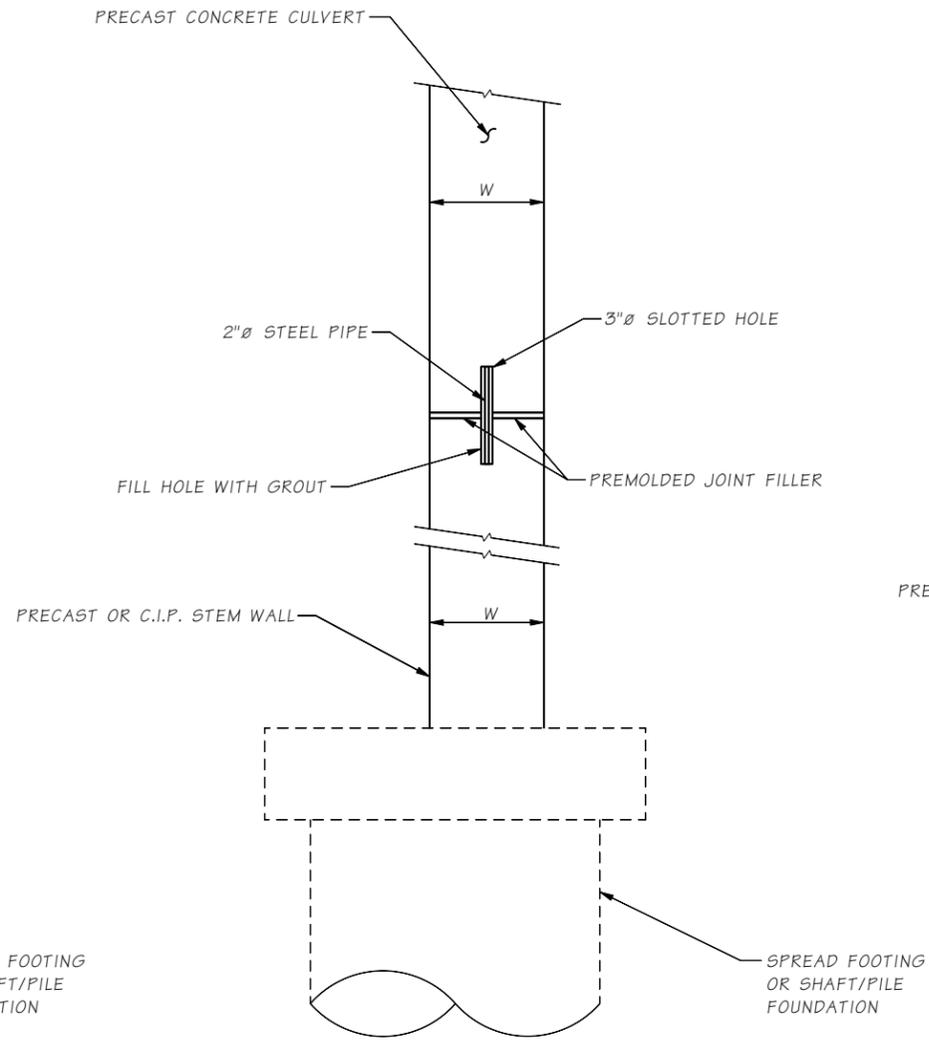
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PRELIMINARY PLANS

3-SIDED PRECAST CULVERT
SERIES VC55 TO VC60

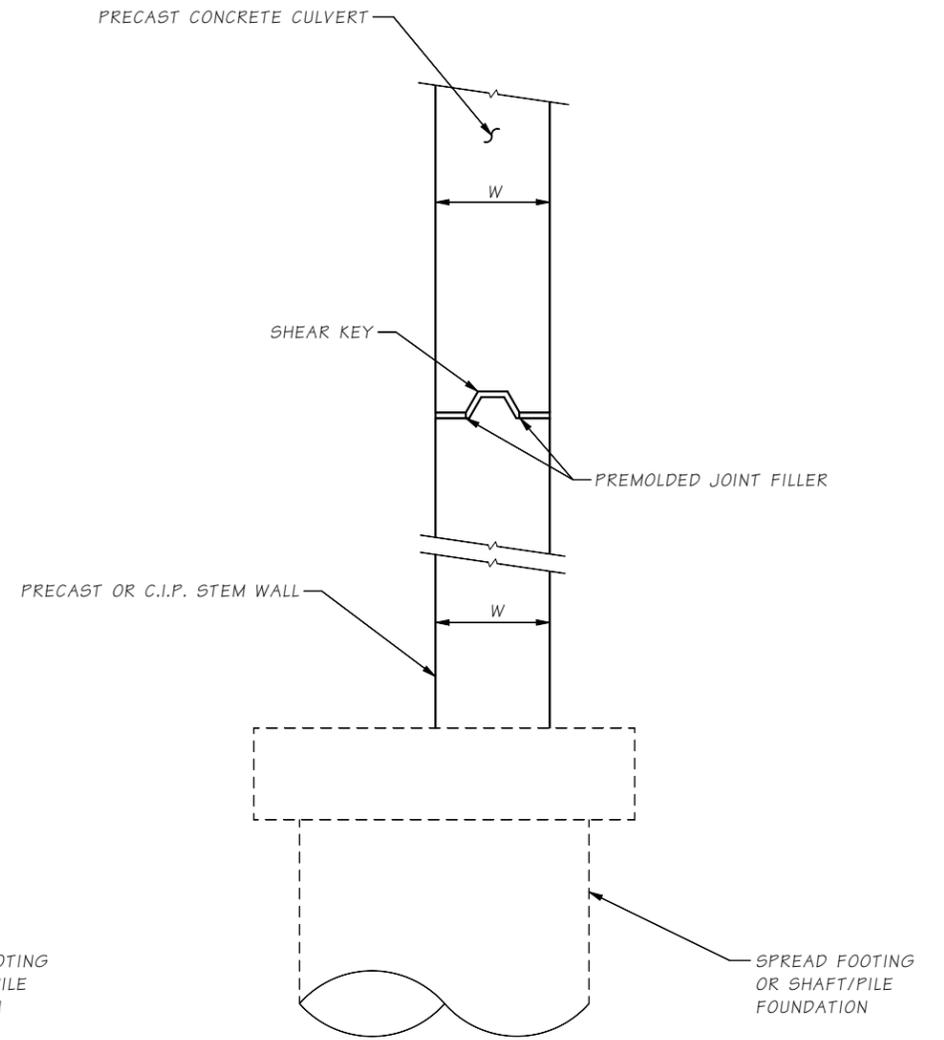
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BEARING TYPE



DOWEL BAR



SHEAR KEY

NOTE:

THESE CONNECTION DETAILS ARE SUGGESTED ONLY, THERE ARE OTHER CONNECTION DETAILS CAN BE USED.

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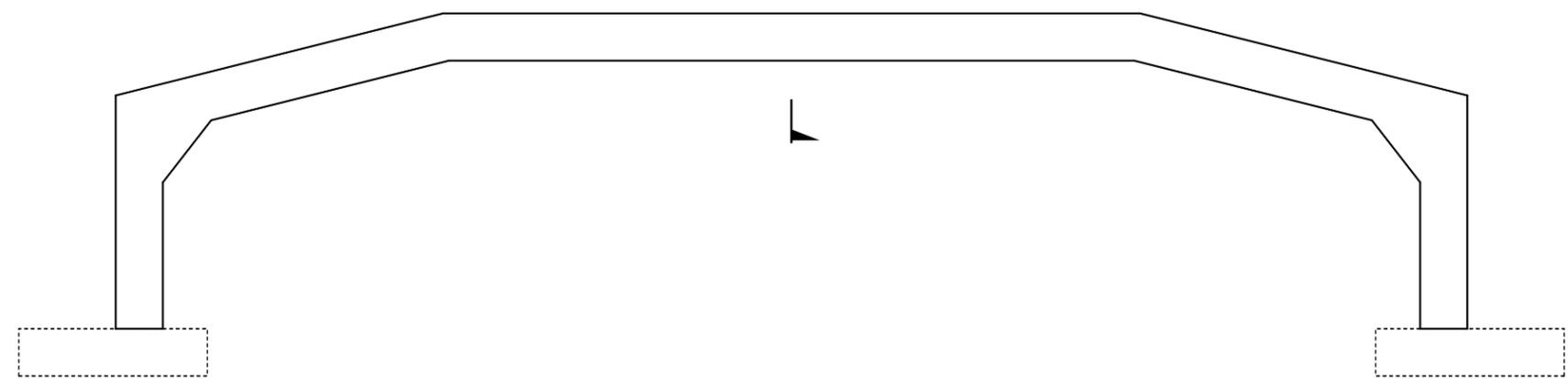
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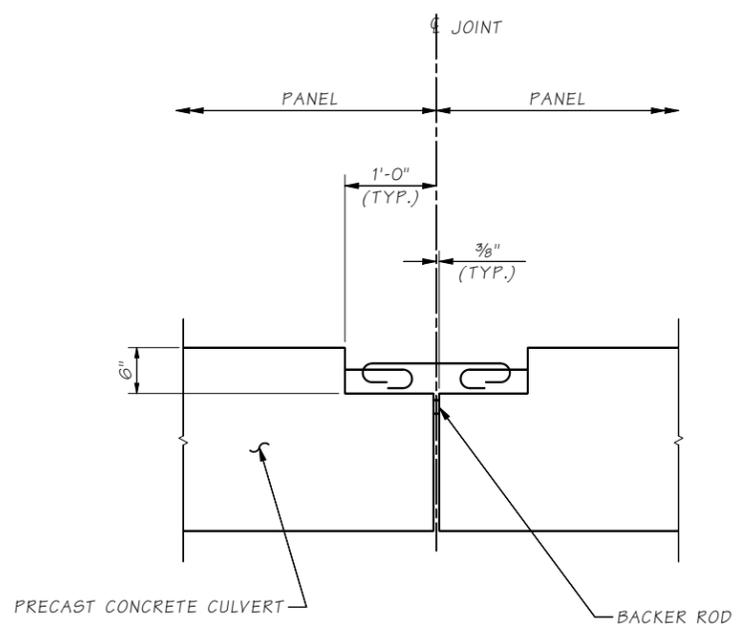
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 JOINT CONNECTION 1
 BETWEEN PRECAST AND FOOTING



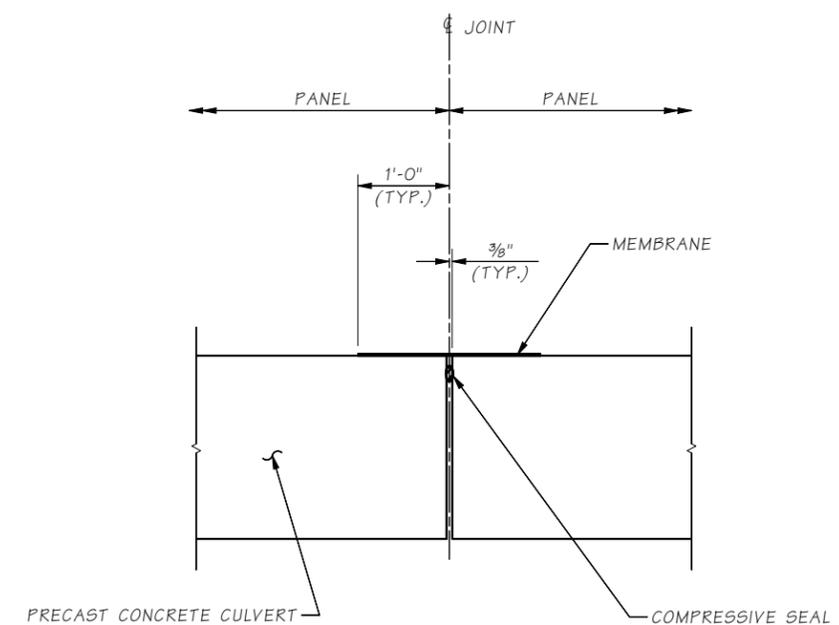
TYPICAL SECTION



SECTION A

OPTION 1

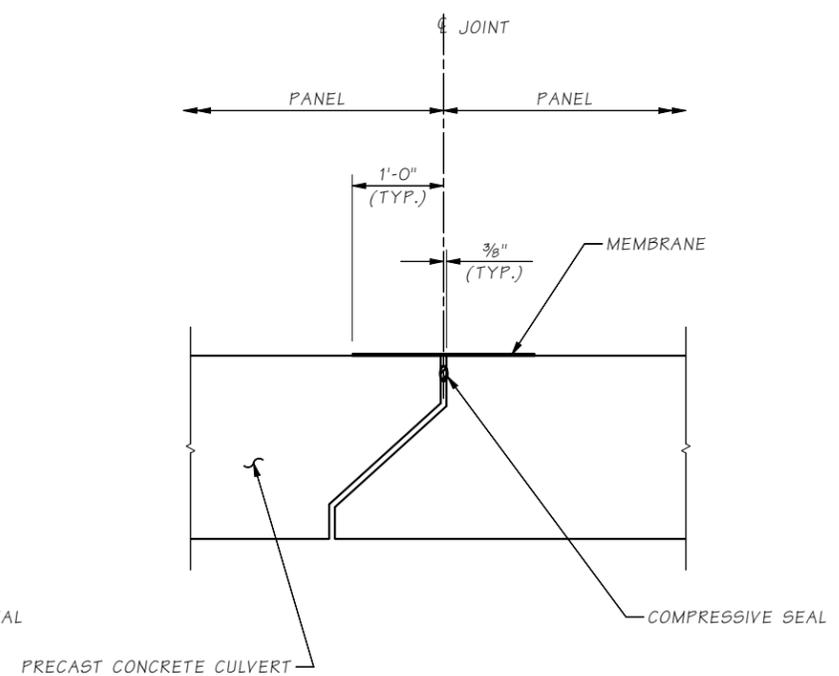
(OVER ROADS)
WATER PROOFING MEMBRANE MIGHT BE REQUIRED



SECTION A

OPTION 2

(OVER WATER)



SECTION A

OPTION 3

(OVER WATER)

JOINT DETAIL OPTIONS

THESE CONNECTION DETAILS ARE SUGGESTED ONLY, THERE ARE OTHER CONNECTION DETAILS CAN BE USED.

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Bridge Projects Engr.								
Prelim. Plan By								
Architect/Specialist	DATE	REVISION	BY	APP'D				

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BURIED STRUCTURES
PRELIMINARY PLANS
CONNECTION DETAIL II
CONNECTION BETWEEN PANELS

BRIDGE SHEET NO. 0 OF SHEETS