4M ENGINEERING
CIVIL – STRUCTURAL
6675 Purple Poppy Ln., Park City, UT 84098 801-380-0562

6/3/25

Washington State Department of Transportation

RE: Existing Box Culvert Evaluation

As part of the I-405, SR522 Vicinity to SR527 Express Toll Lanes Improvement Project, traffic from the I-405 will be shifted onto an existing concrete box culvert located in the median. The existing culvert was built in 1996. Since the available plans for the culvert do not match field conditions, the following information was determined based on field investigation:

- Configuration and materials: Single-cell precast concrete box culvert
- Geometry: Interior dimensions are 20’ wide x 9’ high, with 2’ chamfer at top and bottom. Wall and slab thicknesses are 10”.
- Depth of fill above culvert: Varies from 4’-6’
- Reinforcement:
    - Top Slab - Interior: #7 bars at 5” o.c. transverse and #5 bars at 10” o.c. longitudinal
    - Wall – Interior: #5 bars at 5” o.c. vertical with #5 bars at 10” o.c. horizontal
    - Wall – Exterior: #7 bars at 5” o.c. vertical with #5 bars at 10” o.c. horizontal

In order to analyze the culvert, the below assumptions were made:

- Concrete strength, f’c = 5000 psi. Typical for precast concrete.
- Reinforcing steel strength, fy = 60,000 psi
- Fill density above culvert: 127 pcf. This is a weighted average which includes 6” of asphalt at 140 pcf with compacted or saturated soils below at 125 pcf.
- Reinforcement:
    - Corner bars are assumed equivalent to vertical exterior wall bars (#7 at 5” o.c.) as is standard practice. These bars are often combined into one single U-shaped bar.
    - Bottom slab reinforcement is taken to be equal to the top slab reinforcement. Standard practice is equivalent or better.
    - Top and bottom slab exterior reinforcement is taken to be #5 bars at 10” o.c. in both directions, matching the top slab longitudinal rebar and the horizontal wall rebar. Standard practice is equivalent or better.
    - Additional bars were added around the riser/access openings, to account for the opening, which provide the same level of strength as uninterrupted bars. This assumption is based on typical details for openings in similar box culverts (provided on Page 75).

The culvert parameters outlined above were analyzed in the Erikkson Culvert software, the program indicated for box culvert design and analysis per the WSDOT Bridge Design Manual (BDM). The software inputs can be viewed on Pages 5-6. Input values that were confirmed by field investigations are highlighted for reference.

To evaluate the ability of the culvert to support traffic loading, load ratings were determined for HL-93 loads and the additional rating trucks outlined in Chapter 13 of the BDM. It was determined that the culvert

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could support the various truck loadings with ratings greater than 1.0 for all loadings except HL-93 (see Page 9). Although there are two lanes of traffic above the culvert running parallel to the centerline of the culvert, one of these lanes is an express lane and not likely to be subject to truck loadings. However, to ensure HL-93 truck loadings could be supported in both lanes simultaneously, temporary shoring has been conservatively added to the center of the culvert. The shoring is designed to carry the HL-93 Live Load only. To approximate load ratings for this condition, the culvert was modeled as a double box culvert with a center stem. The corresponding load ratings can be found on Pages 3 and 22. Minimum controlling HL-93 inventory and operating ratings are 1.26 and 1.63 respectively, demonstrating that the culvert can safely support the worst-case traffic loadings which could occur during construction.

Additionally, the concrete riser and steel plate cover strength was evaluated under HL-93 LL and soil DL and found to be acceptable (see Pages 36-39).

6-3-25

BRIDGE RATING SUMMARY:
EXISTING CULVERT (WITH SHORING)

6-3-25

Bridge Name:	Drainage Vault
Bridge Number:	V001
SID Number:	XG180500
Span Types:	N/A
Bridge Length:	285 ft
Design Load:	HL-93
Engineering Firm/Agency:	4M Engineering
Rated By:	Jessica Merrell
Checked By:	Forrest Megargel
Date:	6/3/2025

Inspection Report Date:	3/13/2025	Deck Condition	N/A
Rating Method:	LRFR	Superstructure Condition	N/A
Overlay Thickness:	N/A	Substructure Condition	N/A

Truck	RF	γ	Controlling Point
AASHTO 1 (Type 3)	2.08	2.0	Shear @ bottom slab
AASHTO 2 (Type 3S2)	2.28	2.0	Shear @ bottom slab
AASHTO 3 (Type 3-3)	2.21	2.0	Shear @ bottom slab
Legal Lane	2.73	2.0	Shear @ bottom slab
NRL	2.08	2.0	Shear @ bottom slab
LGL-105	2.08	2.0	Shear @ bottom slab
OL-1	3.44	1.20	Shear @ top slab
OL-2	3.36	1.20	Shear @ top slab
EV2	2.04	1.30	Shear @ top slab
EV3	2.20	1.30	Shear @ top slab

SNBI Rating	RF	γ	Controlling Point
Inventory (HL-93)	1.26	1.75	Shear @ bottom slab
Operating (HL-93)	1.63	1.35	Shear @ bottom slab

Remarks:

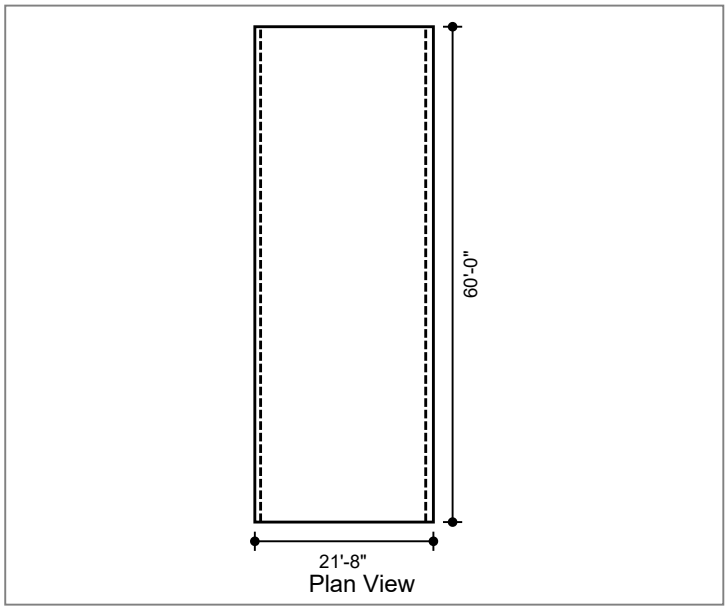
Per inspection report, concrete culvert is 20'x9' in good condition.

Existing Culvert Analysis (Unshored)

Spec.: LRFD 9th ed.
Type of Culvert: Precast

Physical Dimensions

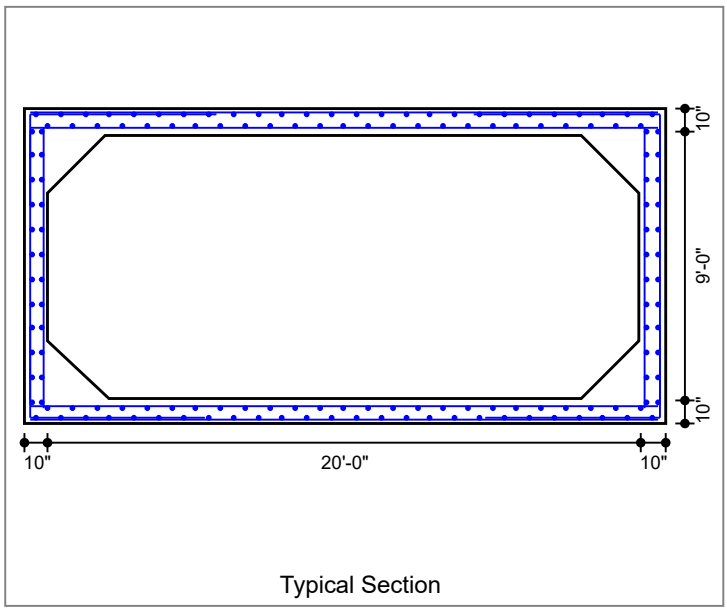
Clear Span:	20'-0"
Clear Height:	9'-0"
Top Slab:	10"
Bottom Slab:	10"
Ext. Wall:	10"
Fill Depth Range	
Maximum:	6.00 ft
Minimum:	4.00 ft
Increment:	0.50 ft
Length:	60'-0"
Skew Angle:	0.00 deg
Bottom Slab Support:	Full Slab
Top Haunch, Width:	2'-0"
Top Haunch, Height:	2'-0"
Bottom Haunch, Width:	2'-0"
Bottom Haunch, Height:	2'-0"



Plan View

Material Properties

Concrete	
Strength, f'c:	5.000 ksi
Density:	0.155 kcf
Elasticity, Ec:	4903 ksi
Type:	Normal wt
Steel	
Yield, fy:	60 ksi
Allow Stress:	36 ksi
Elasticity, Es:	29000 ksi
Soil	
Density:	0.127 kcf
Exposure Factor	
User-Defined:	1.00
Reinforcement Covers	
Ext. Cover Top Slab:	2"
Ext. Cover Bottom Slab	2"
Ext. Cover Walls	2"
Int. Cover Walls	2"
Int. Cover Top Slab	2"
Int. Cover Bottom Slab	2"



Typical Section

Controlling Ratings

Inventory Rating: 0.75
Operating Rating: 0.97

Loads

Live Load

Vehicle Names:	HL-93	NRL	Type 3
	Type 3S2	Type 3-3	Overload 1
	Overload 2	EV 2	EV 3
	NRL - Legal Lane	WA-105	
Traffic Direction:	Perpendicular		
Eq. Height of Soil:	Calculated		
Max No. of Lanes:	2		

Dead Load

Future Wearing Surface:	0.000 klf
Additional Dead Load:	0.000 klf
Concentrated Loads:	none

Lateral Soil Loads

Eq. Fluid Press. Max:	60.00 pcf
Eq. Fluid Press. Min:	30.00 pcf

Interior Water Pressure:	no
Exterior Water Pressure:	no

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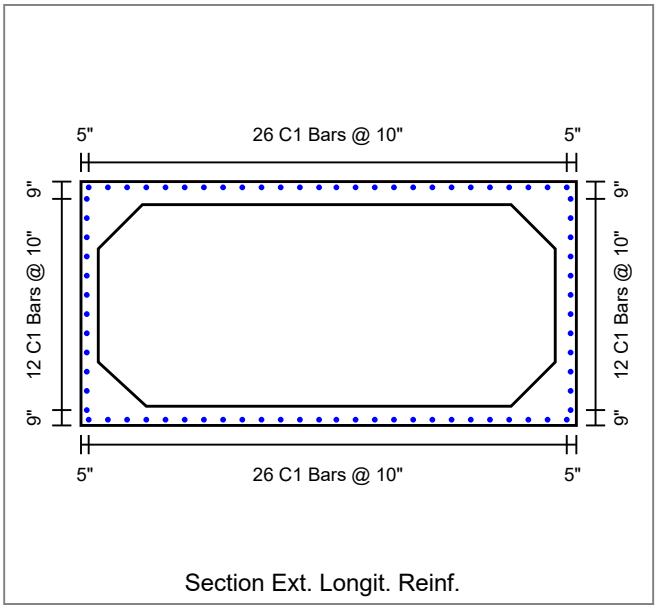
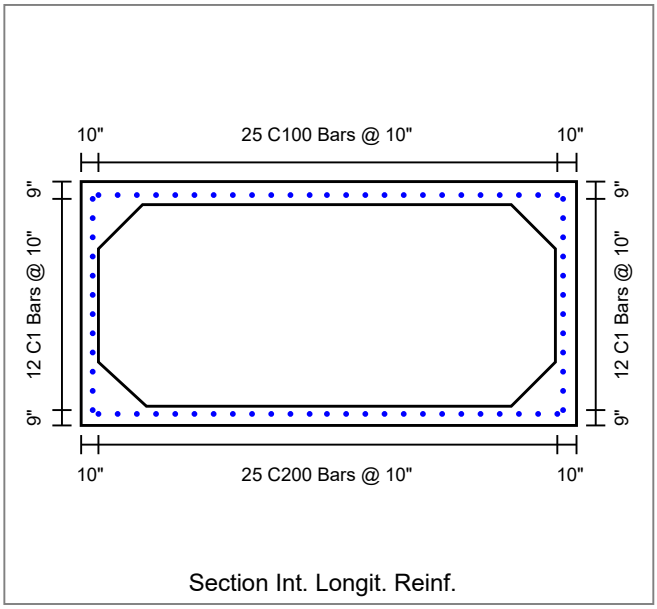
Concrete Summary
Volume of Concrete: 2.189 cy/ft Total Volume of Concrete: 131.358 cy

Reinforcing Steel Bar Schedule (lb)

Location	Mark	Qty	Size	Spacing	Type	Length	Hor.Leg	Ver.Leg	Tot.Weight
Top Slab(Int)	A100 (AS2)	144	7	5"	S	21'-3"	--	--	6255.0
Bot Slab(Int)	A200 (AS3)	144	7	5"	S	21'-3"	--	--	6255.0
Top Slab(Ext)	A300 (AS7)	72	5	10"	S	21'-3"	--	--	1596.0
Bot Slab(Ext)	A400 (AS8)	72	5	10"	S	21'-3"	--	--	1596.0
Corner(Top)	A1 (AS1)	288	7	5"	L	9'-5"	6'-4"	3'-1"	5543.0
Corner(Bot)	A2 (AS1)	288	7	5"	L	9'-0"	5'-11"	3'-1"	5298.0
Wall(Int)	B1 (AS4)	288	5	5"	S	9'-6"	--	--	2854.0
Wall(Ext)	B2 (AS1)	288	7	5"	S	9'-0"	--	--	5298.0
Longit. Top (Int)	C100 (AS5)	25	5	10"	S	59'-11"	--	--	1562.0
Longit. Bot (Int)	C200	25	5	10"	S	59'-11"	--	--	1562.0
Longit. Top (Ext)	C1 (AS6)	26	5	10"	S	59'-11"	--	--	1624.7
Longit. Bot (Ext)	C1 (AS6)	26	5	10"	S	59'-11"	--	--	1624.7
Longit. Wall (Ext)	C1 (AS6)	24	5	10"	S	59'-11"	--	--	1499.8
Longit. Wall (Int)	C1 (AS6)	24	5	10"	S	59'-11"	--	--	1499.8
									44068



Section Ext. Longit. Reinf.



Section Int. Longit. Reinf.

Notes:
-Field verified values are highlighted.
-A1, A2, and B2 are often combined into one U-bar, or same sizes used. A1 and A2 are assumed to match B2.
-Bottom slab interior rebar typically matches or exceeds top slab interior rebar (assumed to match top slab rebar)
-Other bars are conservatively assumed to be #5 @ 10" o.c.

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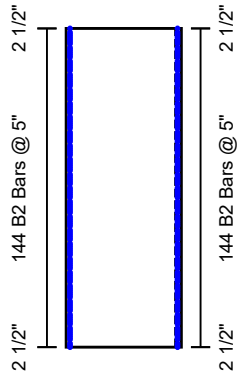
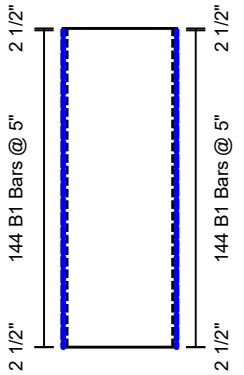
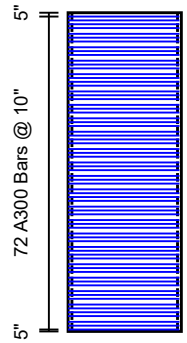


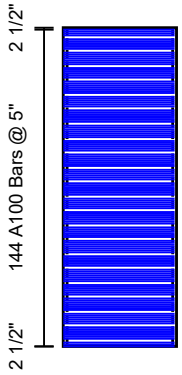
Ext. Wall Reinf.



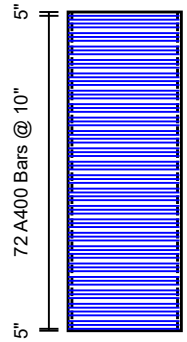
Int. Wall Reinf.



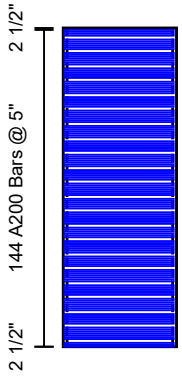
Top Slab Ext. Reinf.



Top Slab Int. Reinf.



Bottom Slab Ext. Reinf.



Bottom Slab Int. Reinf.

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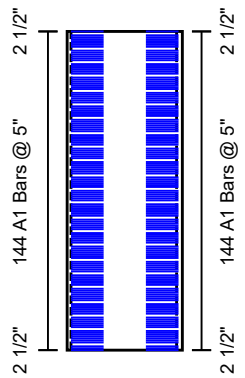
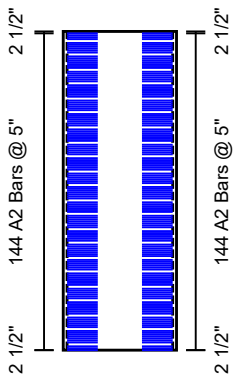


Top Slab Corner Reinf.



Bottom Slab Corner Reinf.

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RATINGS SUMMARY
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	Flexure			Shear		
Truck	RF(INV)	RF(OP)	Controlling Point	RF(INV)	RF(OP)	Controlling Point
(AA) HL-93	0.75	0.97	Ext Wall, BOT	0.83	1.08	Bottom Slab, RT
(AB) NRL	1.17	1.17	Ext Wall, BOT	1.37	1.37	Bottom Slab, LT
(AC) Type 3	1.17	1.17	Ext Wall, BOT	1.37	1.37	Bottom Slab, LT
(AD) Type 3S2	1.27	1.27	Ext Wall, BOT	1.50	1.50	Bottom Slab, LT
(AE) Type 3-3	1.24	1.24	Ext Wall, BOT	1.45	1.45	Bottom Slab, LT
(AF) Overload	2.11	2.11	Ext Wall, BOT	2.56	2.56	Top Slab, LT
(AG) Overload	2.06	2.06	Ext Wall, BOT	2.50	2.50	Top Slab, LT
(AH) EV 2	1.29	1.29	Ext Wall, BOT	1.54	1.54	Top Slab, RT
(AI) EV 3	1.38	1.38	Ext Wall, BOT	1.64	1.64	Top Slab, LT
(AJ) NRL - Le	1.47	1.47	Ext Wall, BOT	1.74	1.74	Bottom Slab, LT
(AK) WA-105	1.17	1.17	Ext Wall, BOT	1.37	1.37	Bottom Slab, LT

REINFORCEMENT SUMMARY
=====================

M dimension = 5' 3" (method of equivalent capacity)
= 6' 12" (method of contraflexure - ASTM)

Reinforcing Steel Schedule

Location	Bar Mark	Qty	Size	Type	Spacing (in)	As,prv (in2/ft)	Length (ft-in)	Wgt (lbs)	H Leg (ft-in)	V Leg (ft-in)
Top Slab (int)	A100 (AS2)	144	7	STR	5.00	1.440	21- 3	6255		
Bot Slab (int)	A200 (AS3)	144	7	STR	5.00	1.440	21- 3	6255		
Top Slab (ext)	A300 (AS7)	72	5	STR	10.00	0.372	21- 3	1596		
Bot Slab (ext)	A400 (AS8)	72	5	STR	10.00	0.372	21- 3	1596		
Corner (Top)	A1 (AS1)	288	7	L-BAR	5.00	1.440	9- 5	5543	6- 4	3- 1
Corner (Bottom)	A2 (AS1)	288	7	L-BAR	5.00	1.440	9- 0	5298	5-11	3- 1
Ext Wall (int)	B1 (AS4)	288	5	STR	5.00	0.744	9- 6	2854		
Ext Wall (ext)	B2 (AS1)	288	7	STR	5.00	1.440	9- 0	5298		
Top Slab (int- 1)	C100 (AS5)	25	5	STR	10.00	0.372	59-11	1562		
Bot Slab (int- 1)	C200	25	5	STR	10.00	0.372	59-11	1562		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
							Total	44068		

Note: A denotes flexural steel, B denotes vertical steel, C denotes longitudinal steel

AS Bar Marks

Location	As prv in2/ft
Transverse Side Wall - Outside Face (AS1)	1.440
Transverse Top Slab - Inside Face (AS2)	1.440
Transverse Bottom Slab - Inside Face (AS3)	1.440
Transverse Side Wall - Inside Face (AS4)	0.744
Distribution Top Slab - Inside Face (AS5)	0.372
Distribution Top Slab - OutSide Face (AS6)	0.372
Transverse Top Slab - Outside Face (AS7)	0.372
Transverse Bottom Slab - Outside Face (AS8)	0.372

Notes: 1.) Final areas of steel provided must be checked in analysis mode

Project: Bothell to Swamp Creek
Task : Box Culvert Evaluation
Client : Skanska
Job No.:

CULVERT PROPERTIES
==========
Type of Culvert: Precast Specification : LRFD 9th Edition
Operating Mode : Analysis

Physical Dimensions

No. of Boxes: 1 Name: BoxCulvert
Clear Span : 20.0000 ft
Clear Height: 9.0000 ft Skew Angle : 0.00 deg
Length : 60.0000 ft Bottom Slab Support: Full Slab
Fill Depth Range: Maximum : 6.00 ft Minimum : 4.00 ft Increment : 0.50 ft
Haunches: Top, Length: 24.0000 in Height: 24.0000 in
Bottom, Length: 24.0000 in Height: 24.0000 in
Member Thicknesses: Top Slab: 10.0000 in Bot Slab: 10.0000 in
Ext Wall: 10.0000 in
Wall Joint: None

Material Properties

Concrete: Strength,f'c : 5.000 ksi Density : 0.155 kcf Elasticity,Ec: 4903 ksi
Type : Normal Weight Density Modification Factor : 1.00
Fr Factor : 0.24 Gamma1 : 1.60 Gamma3 : 1.00 (user defined)
Steel: Yield,fy : 60.00 ksi fss Limit : 0.60fy Elasticity,Es: 29000 ksi
Yield,fyv : 60.00 ksi Diameter : 1.000 in Type : Rebar
Soil: Density : 0.127 kcf Slope Factor: 1.150
Poisson's : 0.5
Fe Factor : 1.000 (User Defined)
Serviceability, Gamma-e: 1.00

Loads

Live Load: Vehicle: (AA) HL-93 - Design Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	8.00	0.00
2	32.00	14.00
3	32.00	14.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: yes
Tandem: Axle 1: 25.00 k, Axle 2: 25.00 k, Axle Spacing: 4.00 ft
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Inventory Rating Load Factor: 1.75 Operating Rating Load Factor: 1.35
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AB) NRL - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	8.00	0.00
2	8.00	4.00
3	8.00	4.00
4	17.00	4.00
5	17.00	4.00
6	8.00	4.00
7	8.00	4.00
8	6.00	6.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AC) Type 3 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	17.00	0.00
2	17.00	4.00
3	16.00	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I

Override MPF: no
Override DLA: no

Vehicle: (AD) Type 3S2 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	15.50	0.00
2	15.50	4.00
3	15.50	22.00
4	15.50	4.00
5	10.00	11.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AE) Type 3-3 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	14.00	0.00
2	14.00	4.00
3	16.00	16.00
4	12.00	15.00
5	12.00	4.00
6	12.00	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AF) Overload 1 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	21.50	0.00
2	21.50	4.00
3	21.50	12.00
4	21.50	4.00
5	10.00	10.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 1.2
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AG) Overload 2 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	22.00	0.00
2	21.50	6.00
3	21.50	4.00
4	22.00	14.00
5	21.50	6.00
6	21.50	4.00
7	22.00	16.00
8	21.50	6.00
9	21.50	4.00
10	12.00	10.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 1.2
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AH) EV 2 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	24.00	0.00
2	33.50	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck Or Tandem Or Lane
Rating Load Factor: 1.3
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AI) EV 3 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)

1	24.00	0.00
2	31.00	15.00
3	31.00	4.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck Or Tandem Or Lane
Rating Load Factor: 1.3
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AJ) NRL - Legal Lane - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	10.50	0.00
2	10.50	4.00
3	12.00	16.00
4	9.00	15.00
5	9.00	4.00
6	9.00	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.20 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AK) WA-105 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	14.00	0.00
2	14.00	4.00
3	17.00	10.00
4	17.00	32.00
5	17.00	4.00
6	7.00	4.00
7	7.00	4.00
8	12.50	11.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Include Lane Load : yes Max. No. of Lanes: 2
Traffic Direction : Lanes Perpendicular to Main Reinforcement
Neglect Live Load if: Fill > 8 ft and Fill > Clear Span
Apply Surcharge at Fill Depths > 2 ft : yes
Compute Surcharge Depth: yes

Dead Load: Future Wearing Surface : 0.00 klf Add. Dead Load : 0.00 klf
Concentrated Loads : none

Lateral Soil Loads: Max. Equiv. Fluid Press.: 60.00 pcf Min. Equiv. Fluid Press. : 30.00 pcf
Include Additional Uniform Horiz. Load: no
Include Additional Uniform Vert. Load: no
Buoyancy Check : no
Fluid Pressures : Apply Water Press. : no
Foundation Model : Uniform Loads
Seismic Analysis : Do not include

Load and Resistance Factors

	Max	Min
DC:	1.250	0.900
DW:	1.500	0.650
EV:	1.300	0.900
EH:	1.350	0.900
WA:	1.000	
EQ:	1.000	

LL I : 1.750 LL II : 1.350 LL Legal : 2.000 LL Extreme : 0.500
Ductility: 1.000 Importance: 1.000 Redundancy, non-earth: 1.000 Redundancy, earth: 1.000
Condition: 1.000 System : 1.000
Phi Shear: 0.900 Phi Moment: 1.000 PM Compression: 0.750 PM Tension : 0.900
Load Factor Multipliers, Design Mode: 1.00 Analysis Mode: 1.00

Reinforcement

Reinforcement Covers :	Exterior	Interior
Top Slab:	2.0000 in	2.0000 in
Walls :	2.0000 in	2.0000 in
Bot Slab:	2.0000 in	2.0000 in

Assigned reinforcement:

Location	Mark	Size	Spacing (in)
Top Slab Inside	A100 (AS2)	7	5.0000
Bottom Slab Inside	A200 (AS3)	7	5.0000
Top Slab Outside	A300 (AS7)	5	10.0000
Bottom Slab Outside	A400 (AS8)	5	10.0000
Top Corner	A1 (AS1)	7	5.0000
Bottom Corner	A2 (AS1)	7	5.0000
Ext. Wall Inside	B1 (AS4)	5	5.0000
Ext. Wall Outside	B2 (AS1)	7	5.0000
Longitudinal	C1 (AS6)	5	10.0000
Top Distribution	C100 (AS5)	5	10.0000
Bottom Distribution	C200	5	10.0000

Analysis Options

LL Analysis : Automatically Set Traffic Direction to Account for Skew Effects: no
Limit LL Distribution Width to Culvert Length for: None
Combine Longitudinal Axle Distribution Overlaps: No
Combine Transverse Axle Distribution Overlaps: No
Axle Placement Increment for Moving Load Analysis: 20
Include Impact on Bottom Slab: yes
Always Distribute Wheel Load: yes
Deflection Criteria : 1/800
Approach Slab will be Used: no

Reinforcement : Always Include Distribution Steel: no
Distribution Slab Provided: no
User Defined Longitudinal Steel: yes
Max. As used in Vc Calcs: 2.00 in2/ft
Distribute Minimum Reinforcement per Face: yes
Use individual Member Thicknesses for Min Steel: no
Epoxy coat steel: no
Use M-dimension for bar length calcs.: no

Slenderness : Checked K Factor: 2.00

Analysis Modeling : Use Haunches in the Structural Analysis Model: yes

Critical Sections : Flexure critical section location: 1.5 member depth
Shear critical section location: dv beyond support
Use Max. Moment with Max. Shear at the Critical Section for Shear: no
Include depth of haunch for critical sections: no

Flexure : Ignore Axial Thrust: no
Use Eq. 12.10.4.2.4a-1: yes Nu Multiplier: 1.00

Shear : Always Check Iterative Beta Method

Environmental : Apply duribility factors: no

Load Combinations : LRFD min/min: no

ANALYSIS RESULTS
==========

Top Slab Thickness = 10.00 in
Bottom Slab Thickness = 10.00 in
Exterior Wall Thickness = 10.00 in

Modular Ratio (N) = 5.91 Max. Steel Ratio = 0.025
Design Span = 20.83 ft Design Height = 9.83 ft

Volume of Concrete: 2.189 cy/ft Weight of Steel: 734 lb/ft

Note: Design and analysis results do not include force effects from stipping and handling stages

M dimension = 5' 3" (method of equivalent capacity)
= 6' 12" (method of contraflexure - ASTM)

Reinforcing Steel Schedule

Location	Bar Mark	Qty	Size	Type	Spacing (in)	As,prv (in2/ft)	Length (ft-in)	Wgt (lbs)	H Leg (ft-in)	V Leg (ft-in)
Top Slab (int)	A100 (AS2)	144	7	STR	5.00	1.440	21- 3	6255		
Bot Slab (int)	A200 (AS3)	144	7	STR	5.00	1.440	21- 3	6255		
Top Slab (ext)	A300 (AS7)	72	5	STR	10.00	0.372	21- 3	1596		
Bot Slab (ext)	A400 (AS8)	72	5	STR	10.00	0.372	21- 3	1596		
Corner (Top)	A1 (AS1)	288	7	L-BAR	5.00	1.440	9- 5	5543	6- 4	3- 1
Corner (Bottom)	A2 (AS1)	288	7	L-BAR	5.00	1.440	9- 0	5298	5-11	3- 1
Ext Wall (int)	B1 (AS4)	288	5	STR	5.00	0.744	9- 6	2854		
Ext Wall (ext)	B2 (AS1)	288	7	STR	5.00	1.440	9- 0	5298		
Top Slab (int- 1)	C100 (AS5)	25	5	STR	10.00	0.372	59-11	1562		
Bot Slab (int- 1)	C200	25	5	STR	10.00	0.372	59-11	1562		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
							Total	44068		

Note: A denotes flexural steel, B denotes vertical steel, C denotes longitudinal steel

AS Bar Marks

Location	As prv in2/ft
Transverse Side Wall - Outside Face (AS1)	1.440
Transverse Top Slab - Inside Face (AS2)	1.440
Transverse Bottom Slab - Inside Face (AS3)	1.440
Transverse Side Wall - Inside Face (AS4)	0.744
Distribution Top Slab - Inside Face (AS5)	0.372
Distribution Top Slab - OutSide Face (AS6)	0.372
Transverse Top Slab - Outside Face (AS7)	0.372
Transverse Bottom Slab - Outside Face (AS8)	0.372

Notes: 1.) Final areas of steel provided must be checked in analysis mode

Summary of Ratings Table:

Truck	ILF	OLF	Flexure Fill	Flexure Member	Flexure Location	Flexure IR	Flexure OR	Shear Fill	Shear Member	Shear Location	Shear IR	Shear OR
(AA)HL-93	1.75	1.35	6.00	1	BOT	0.75	0.97	6.00	4	RT	0.83	1.08
(AB)NRL	2.00	2.00	6.00	1	BOT	1.17	1.17	6.00	4	LT	1.37	1.37
(AC)Type 3	2.00	2.00	6.00	1	BOT	1.17	1.17	6.00	4	LT	1.37	1.37
(AD)Type 3	2.00	2.00	6.00	1	BOT	1.27	1.27	6.00	4	LT	1.50	1.50
(AE)Type 3	2.00	2.00	6.00	1	BOT	1.24	1.24	6.00	4	LT	1.45	1.45
(AF)Overlo	1.20	1.20	6.00	1	BOT	2.11	2.11	4.00	2	LT	2.56	2.56
(AG)Overlo	1.20	1.20	6.00	1	BOT	2.06	2.06	4.00	2	LT	2.50	2.50
(AH)EV 2	1.30	1.30	6.00	1	BOT	1.29	1.29	4.00	2	RT	1.54	1.54
(AI)EV 3	1.30	1.30	6.00	1	BOT	1.38	1.38	4.00	2	LT	1.64	1.64
(AJ)NRL -	2.00	2.00	6.00	1	BOT	1.47	1.47	6.00	4	LT	1.74	1.74
(AK)WA-105	2.00	2.00	6.00	1	BOT	1.17	1.17	6.00	4	LT	1.37	1.37

Critical Sections Summary: Flexure

Member 1: (Exterior Wall), Thickness = 10.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	Load Ratings IR	Load Ratings OR	Load Ratings Truck	Fill Depth (ft)
BOT	24.00	-58.07	19.07	48.35	7.56	53.31*	1.00	1.44	14.31	0.75	0.97	15AA	6.00

MID	59.00	0.00	6.37	26.97	7.69	29.13	1.00	0.74	14.31	NC	NC	AA	4.00
MID-	59.00	-55.33	19.07	48.35	7.56	53.31*	1.00	1.44	14.31	0.89	1.15	AA	6.00
TOP	24.00	-55.25	19.07	48.35	7.56	53.31*	1.00	1.44	14.31	0.90	1.17	AA	6.00

Member 2: (Top Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	24.00	-25.93	4.75	48.35	7.56	49.64	1.00	1.44	14.31	3.40	4.40	AA	6.00
MID	125.00	39.58	0.88	48.35	7.56	48.59	1.00	1.44	14.31	1.67	2.16	AA	6.00
MID-	125.00	0.37	4.49	13.89	7.69	15.58	1.00	0.37	14.31	NC	NC	AA	6.00
RT	24.00	-25.93	4.75	48.35	7.56	49.64	1.00	1.44	14.31	3.40	4.40	AA	6.00

Member 4: (Bottom Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	24.00	-28.60	7.42	48.35	7.56	50.35	1.00	1.44	14.31	3.70	4.79	AA	6.00
MID	125.00	41.27	2.89	48.35	7.56	49.14	1.00	1.44	14.31	1.63	2.12	AA	6.00
MID-	125.00	0.58	6.95	13.89	7.69	16.49	1.00	0.37	14.31	NC	NC	AA	6.00
RT	24.00	-28.60	7.42	48.35	7.56	50.35	1.00	1.44	14.31	3.70	4.79	AA	6.00

Critical Sections Summary: Vertical Shear

Member 1: (Exterior Wall), Thickness = 10.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
BOT	12.20	5.88	60.3	19.07	7.20	10.99	2.000	12.21 b	0.00	0.00	0.00	5.23	6.78	AA	6.00
MID	59.00	0.93	15.2	8.15	7.25	13.39	2.420	14.88 a	0.00	0.00	0.00	41.52	53.83	AA	5.50
MID-	59.00	0.29	51.0	16.59	7.20	10.99	2.000	12.21 b	0.00	0.00	0.00	13.61	17.64	AA	4.00
TOP	12.20	-3.93	56.1	19.07	7.20	10.99	2.000	12.21 b	0.00	0.00	0.00	4.80	6.22	AA	6.00

Member 2: (Top Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	12.20	17.13	42.3	4.75	7.56	17.31	n/a	19.24 c	0.00	0.00	0.00	1.03	1.34	AA	6.00
MID	125.00	2.03	36.5	0.35	7.56	17.31	n/a	19.24 c	0.00	0.00	0.00	8.52	11.04	AA	4.00
MID-	125.00	2.32	11.2	3.80	7.69	17.60	n/a	19.56 c	0.00	0.00	0.00	7.60	9.85	AA	4.00
RT	12.20	17.35	42.3	4.75	7.56	17.31*	n/a	19.24 c	0.00	0.00	0.00	0.99	1.29	AA	6.00

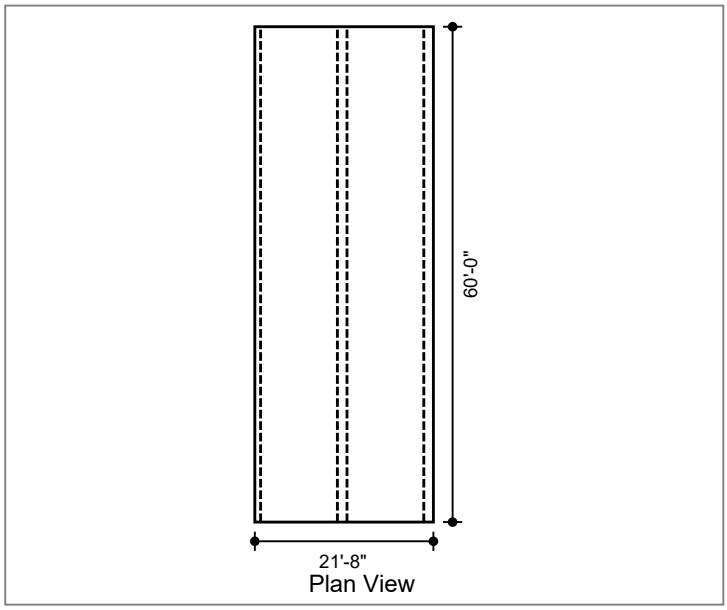
Member 4: (Bottom Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	12.20	17.86	46.5	7.42	7.56	17.31*	n/a	19.24 c	0.00	0.00	0.00	0.89	1.16	AA	6.00
MID	125.00	0.15	37.5	2.35	7.56	17.31	n/a	19.24 c	0.00	0.00	0.00	NC	NC	AA	4.00
MID-	125.00	0.17	0.0	6.25	7.69	23.39	5.052	25.99 a	0.00	0.00	0.00	NC	NC	AA	4.00
RT	12.20	18.24	46.5	7.42	7.56	17.31*	n/a	19.24 c	0.00	0.00	0.00	0.83	1.08	AA	6.00

Vc Calculation By: a - Iterative Beta, b - Constant Beta, c - Box Culvert, d - Standard/Arema

Existing Culvert Analysis (Shored)

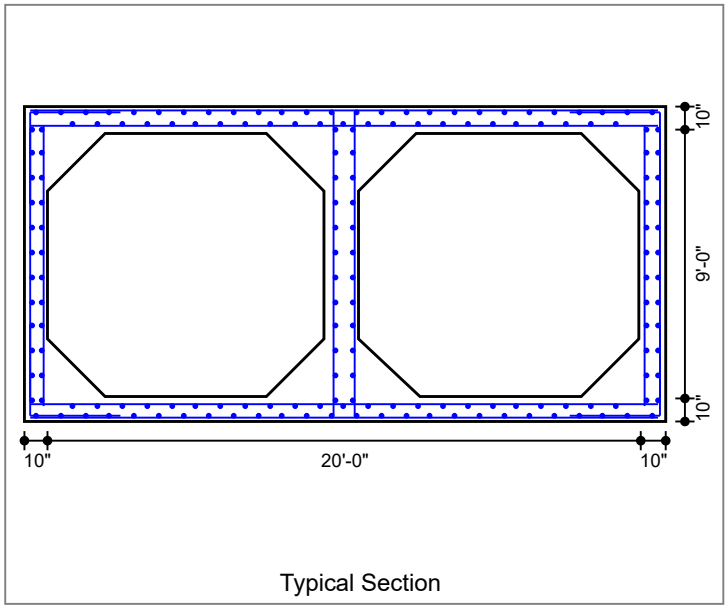
Spec.: LRFD 9th ed.
Type of Culvert: Precast



Plan View

Physical Dimensions

Clear Span:	9'-6"
Clear Height:	9'-0"
Top Slab:	10"
Bottom Slab:	10"
Ext. Wall:	10"
Int. Wall:	1'-0"
Fill Depth Range	
Maximum:	6.00 ft
Minimum:	4.00 ft
Increment:	0.50 ft
Length:	60'-0"
Skew Angle:	0.00 deg
Bottom Slab Support:	Full Slab
Top Haunch, Width:	2'-0"
Top Haunch, Height:	2'-0"
Bottom Haunch, Width:	2'-0"
Bottom Haunch, Height:	2'-0"



Typical Section

Material Properties

Concrete	
Strength, f'c:	5.000 ksi
Density:	0.155 kcf
Elasticity, Ec:	4903 ksi
Type:	Normal wt
Steel	
Yield, fy:	60 ksi
Allow Stress:	36 ksi
Elasticity, Es:	29000 ksi
Soil	
Density:	0.127 kcf
Exposure Factor	
User-Defined:	1.00
Reinforcement Covers	
Ext. Cover Top Slab:	2"
Ext. Cover Bottom Slab	2"
Ext. Cover Walls	2"
Int. Cover Walls	2"
Int. Cover Top Slab	2"
Int. Cover Bottom Slab	2"

Controlling Ratings

Inventory Rating: 1.26
Operating Rating: 1.63

Loads

Live Load

Vehicle Names:	HL-93	EV 2	EV 3
	NRL - Legal Lane	NRL	Oveload 1
	Oveload 2	Type 3-3	Type 3
	Type 3S2	WA-105	
Traffic Direction:	Perpendicular		
Eq. Height of Soil:	Calculated		
Max No. of Lanes:	2		

Dead Load

Future Wearing Surface:	0.000 klf
Additional Dead Load:	0.000 klf
Concentrated Loads:	none

Lateral Soil Loads

Eq. Fluid Press. Max:	60.00 pcf
Eq. Fluid Press. Min:	30.00 pcf

Interior Water Pressure:	no
Exterior Water Pressure:	no

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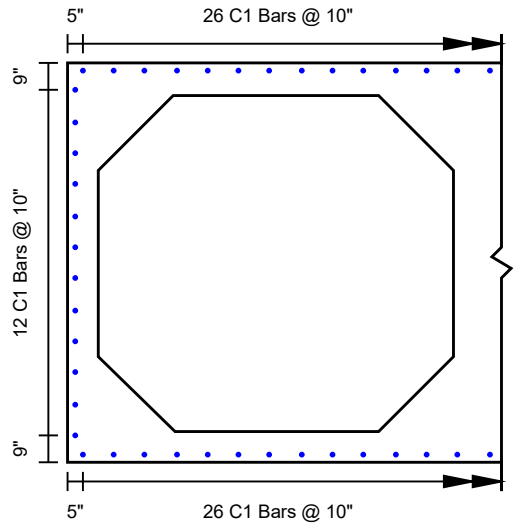
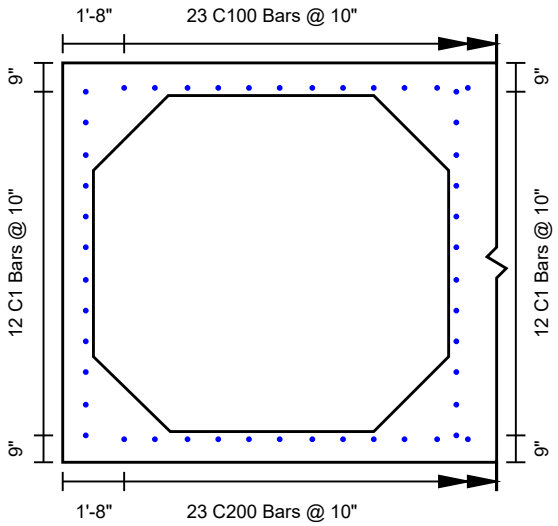
Concrete Summary
Volume of Concrete: 2.819 cy/ft Total Volume of Concrete: 169.136 cy

Reinforcing Steel Bar Schedule (lb)

Location	Mark	Qty	Size	Spacing	Type	Length	Hor.Leg	Ver.Leg	Tot.Weight
Top Slab(Int)	A100 (AS2)	144	7	5"	S	21'-3"	--	--	6255.0
Bot Slab(Int)	A200 (AS3)	144	7	5"	S	21'-3"	--	--	6255.0
Top Slab(Ext)	A300 (AS7)	72	5	10"	S	21'-3"	--	--	1596.0
Bot Slab(Ext)	A400 (AS8)	72	5	10"	S	21'-3"	--	--	1596.0
Corner(Top)	A1 (AS1)	288	7	5"	L	6'-2"	3'-1"	3'-1"	3630.0
Corner(Bot)	A2 (AS1)	288	7	5"	L	6'-2"	3'-1"	3'-1"	3630.0
Wall(Int)	B1 (AS4)	288	5	5"	S	9'-6"	--	--	2854.0
Wall(Ext)	B2 (AS1)	288	7	5"	S	9'-0"	--	--	5298.0
Int Wall	B3	288	5	5"	S	10'-3"	--	--	3079.0
Longit. Top (Int)	C100 (AS5)	23	5	10"	S	59'-11"	--	--	1437.0
Longit. Bot (Int)	C200	23	5	10"	S	59'-11"	--	--	1437.0
Longit. Top (Ext)	C1 (AS6)	26	5	10"	S	59'-11"	--	--	1624.8
Longit. Bot (Ext)	C1 (AS6)	26	5	10"	S	59'-11"	--	--	1624.8
Longit. Wall (Ext)	C1 (AS6)	24	5	10"	S	59'-11"	--	--	1499.8
Longit. Wall (Int)	C1 (AS6)	24	5	10"	S	59'-11"	--	--	1499.8
Longit. Int	C1 (AS6)	24	5	10"	S	59'-11"	--	--	1374.8
									44691



Section Ext. Longit. Reinf.



Section Int. Longit. Reinf.

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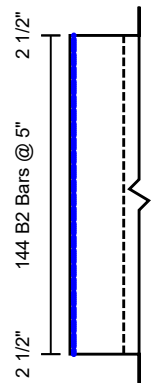
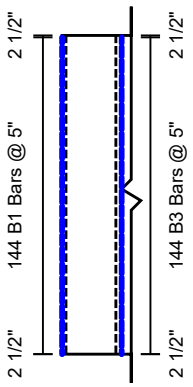
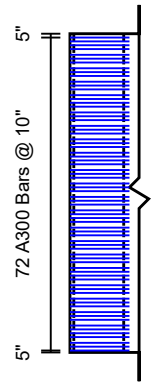


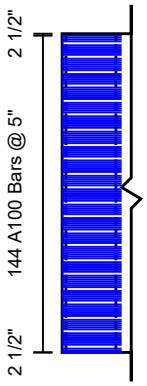
Ext. Wall Reinf.



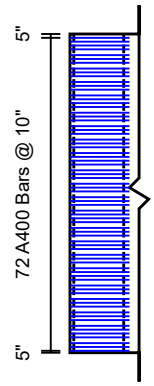
Int. Wall Reinf.



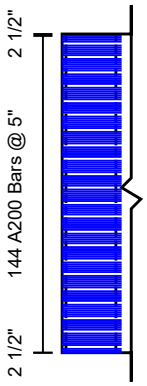
Top Slab Ext. Reinf.



Top Slab Int. Reinf.



Bottom Slab Ext. Reinf.



Bottom Slab Int. Reinf.

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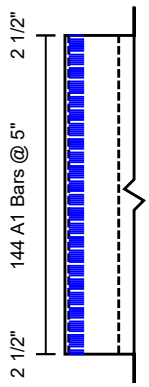
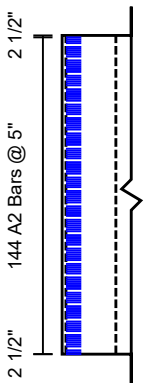


Top Slab Corner Reinf.



Bottom Slab Corner Reinf.

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RATINGS SUMMARY
==========

	Flexure			Shear		
Truck	RF(INV)	RF(OP)	Controlling Point	RF(INV)	RF(OP)	Controlling Point
(AA) HL-93	1.45	1.88	Bottom Slab, RT	1.26	1.63	Bottom Slab, RT
(AB) EV 2	2.31	2.31	Bottom Slab, RT	2.04	2.04	Top Slab, RT
(AC) EV 3	2.49	2.49	Bottom Slab, RT	2.20	2.20	Top Slab, RT
(AD) NRL - Le	3.10	3.10	Bottom Slab, RT	2.73	2.73	Bottom Slab, RT
(AE) NRL	2.36	2.36	Bottom Slab, RT	2.08	2.08	Bottom Slab, RT
(AF) Oveload	3.86	3.86	Bottom Slab, RT	3.44	3.44	Top Slab, RT
(AG) Oveload	3.78	3.78	Bottom Slab, RT	3.36	3.36	Top Slab, RT
(AH) Type 3-3	2.51	2.51	Bottom Slab, RT	2.21	2.21	Bottom Slab, RT
(AI) Type 3	2.36	2.36	Bottom Slab, RT	2.08	2.08	Bottom Slab, RT
(AJ) Type 3S2	2.59	2.59	Bottom Slab, RT	2.28	2.28	Bottom Slab, RT
(AK) WA-105	2.36	2.36	Bottom Slab, RT	2.08	2.08	Bottom Slab, RT

REINFORCEMENT SUMMARY
=====================

M dimension = 2' 5" (method of equivalent capacity)
= 6' 1" (method of contraflexure - ASTM)

Reinforcing Steel Schedule

Location	Bar Mark	Qty	Size	Type	Spacing (in)	As,prv (in2/ft)	Length (ft-in)	Wgt (lbs)	H Leg (ft-in)	V Leg (ft-in)
Top Slab (int)	A100 (AS2)	144	7	STR	5.00	1.440	21- 3	6255		
Bot Slab (int)	A200 (AS3)	144	7	STR	5.00	1.440	21- 3	6255		
Top Slab (ext)	A300 (AS7)	72	5	STR	10.00	0.372	21- 3	1596		
Bot Slab (ext)	A400 (AS8)	72	5	STR	10.00	0.372	21- 3	1596		
Corner (Top)	A1 (AS1)	288	7	L-BAR	5.00	1.440	6- 2	3630	3- 1	3- 1
Corner (Bottom)	A2 (AS1)	288	7	L-BAR	5.00	1.440	6- 2	3630	3- 1	3- 1
Ext Wall (int)	B1 (AS4)	288	5	STR	5.00	0.744	9- 6	2854		
Ext Wall (ext)	B2 (AS1)	288	7	STR	5.00	1.440	9- 0	5298		
Int Wall	B3	288	5	STR	5.00	0.744	10- 3	3079		
Top Slab (int- 1)	C100 (AS5)	23	5	STR	10.00	0.372	59-11	1437		
Bot Slab (int- 1)	C200	23	5	STR	10.00	0.372	59-11	1437		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1375		
						Total		44691		

Note: A denotes flexural steel, B denotes vertical steel, C denotes longitudinal steel

AS Bar Marks

Location	As prv in2/ft
Transverse Side Wall - Outside Face (AS1)	1.440
Transverse Top Slab - Inside Face (AS2)	1.440
Transverse Bottom Slab - Inside Face (AS3)	1.440
Transverse Side Wall - Inside Face (AS4)	0.744
Distribution Top Slab - Inside Face (AS5)	0.372
Distribution Top Slab - OutSide Face (AS6)	0.372
Transverse Top Slab - Outside Face (AS7)	0.372
Transverse Bottom Slab - Outside Face (AS8)	0.372

Notes: 1.) Final areas of steel provided must be checked in analysis mode

Project: Bothell to Swamp Creek
Task : Box Culvert Evaluation
Client : Skanska
Job No.:

CULVERT PROPERTIES
==========
Type of Culvert: Precast Specification : LRFD 9th Edition
Operating Mode : Analysis

Physical Dimensions

No. of Boxes: 2 Name: BoxCulvert
Clear Span : 9.5000 ft
Clear Height: 9.0000 ft Skew Angle : 0.00 deg
Length : 60.0000 ft Bottom Slab Support: Full Slab
Fill Depth Range: Maximum : 6.00 ft Minimum : 4.00 ft Increment : 0.50 ft
Haunches: Top, Length: 24.0000 in Height: 24.0000 in
Bottom, Length: 24.0000 in Height: 24.0000 in
Member Thicknesses: Top Slab: 10.0000 in Bot Slab: 10.0000 in
Ext Wall: 10.0000 in Int Wall: 12.0000 in
Wall Joint: None

Material Properties

Concrete: Strength,f'c : 5.000 ksi Density : 0.155 kcf Elasticity,Ec: 4903 ksi
Type : Normal Weight Density Modification Factor : 1.00
Fr Factor : 0.24 Gamma1 : 1.60 Gamma3 : 1.00 (user defined)
Steel: Yield,fy : 60.00 ksi fss Limit : 0.60fy Elasticity,Es: 29000 ksi
Yield,fyv : 60.00 ksi Diameter : 1.000 in Type : Rebar
Soil: Density : 0.127 kcf Slope Factor: 1.150
Poisson's : 0.5
Fe Factor : 1.000 (User Defined)
Serviceability, Gamma-e: 1.00

Loads

Live Load: Vehicle: (AA) HL-93 - Design Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	8.00	0.00
2	32.00	14.00
3	32.00	14.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: yes
Tandem: Axle 1: 25.00 k, Axle 2: 25.00 k, Axle Spacing: 4.00 ft
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Inventory Rating Load Factor: 1.75 Operating Rating Load Factor: 1.35
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AB) EV 2 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	24.00	0.00
2	33.50	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck Or Tandem Or Lane
Rating Load Factor: 1.3
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AC) EV 3 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	24.00	0.00
2	31.00	15.00
3	31.00	4.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck Or Tandem Or Lane
Rating Load Factor: 1.3
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AD) NRL - Legal Lane - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	10.50	0.00
2	10.50	4.00

3	12.00	16.00
4	9.00	15.00
5	9.00	4.00
6	9.00	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.20 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AE) NRL - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	8.00	0.00
2	8.00	4.00
3	8.00	4.00
4	17.00	4.00
5	17.00	4.00
6	8.00	4.00
7	8.00	4.00
8	6.00	6.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AF) Oveload 1 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	21.50	0.00
2	21.50	4.00
3	21.50	12.00
4	21.50	4.00
5	10.00	10.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 1.2
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AG) Oveload 2 - Permit Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	22.00	0.00
2	21.50	6.00
3	21.50	4.00
4	22.00	14.00
5	21.50	6.00
6	21.50	4.00
7	22.00	16.00
8	21.50	6.00
9	21.50	4.00
10	12.00	10.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 1.2
Design Load Combinations: Strength II
Override MPF: no
Override DLA: no

Vehicle: (AH) Type 3-3 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	14.00	0.00
2	14.00	4.00
3	16.00	16.00
4	12.00	15.00
5	12.00	4.00
6	12.00	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AI) Type 3 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	17.00	0.00
2	17.00	4.00
3	16.00	15.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AJ) Type 3S2 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	15.50	0.00
2	15.50	4.00
3	15.50	22.00
4	15.50	4.00
5	10.00	11.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Vehicle: (AK) WA-105 - Legal Vehicle

Axle No.	Weight(k)	Dist. From Previous(ft)
1	14.00	0.00
2	14.00	4.00
3	17.00	10.00
4	17.00	32.00
5	17.00	4.00
6	7.00	4.00
7	7.00	4.00
8	12.50	11.00

Gage Width: 6.00 ft, Tread Width: 20.00 in, Tread Length: 10.00 in
Include Tandem: no
Lane Load: 0.00 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
Combine: Truck + Lane Or Tandem + Lane
Rating Load Factor: 2
Design Load Combinations: Strength I
Override MPF: no
Override DLA: no

Include Lane Load : yes Max. No. of Lanes: 2
Traffic Direction : Lanes Perpendicular to Main Reinforcement
Neglect Live Load if: Fill > 8 ft and Fill > Clear Span
Apply Surcharge at Fill Depths > 2 ft : yes
Compute Surcharge Depth: yes
Dead Load: Future Wearing Surface : 0.00 klf Add. Dead Load : 0.00 klf
Concentrated Loads : none
Lateral Soil Loads: Max. Equiv. Fluid Press.: 60.00 pcf Min. Equiv. Fluid Press. : 30.00 pcf
Include Additional Uniform Horiz. Load: no
Include Additional Uniform Vert. Load: no
Buoyancy Check : no
Fluid Pressures : Apply Water Press. : no
Foundation Model : Uniform Loads
Seismic Analysis : Do not include

Load and Resistance Factors

	Max	Min
DC:	1.250	0.900
DW:	1.500	0.650
EV:	1.300	0.900
EH:	1.350	0.900
WA:	1.000	
EQ:	1.000	

LL I : 1.750 LL II : 1.350 LL Legal : 1.750 LL Extreme : 0.500
Ductility: 1.000 Importance: 1.000 Redundancy, non-earth: 1.000 Redundancy, earth: 1.000
Condition: 1.000 System : 1.000
Phi Shear: 0.900 Phi Moment: 1.000 PM Compression: 0.750 PM Tension : 0.900
Load Factor Multipliers, Design Mode: 1.00 Analysis Mode: 1.00

Reinforcement

Reinforcement Covers :	Exterior	Interior
Top Slab:	2.0000 in	2.0000 in
Walls :	2.0000 in	2.0000 in
Bot Slab:	2.0000 in	2.0000 in

Assigned reinforcement:

Location	Mark	Size	Spacing (in)
Top Slab Inside	A100 (AS2)	7	5.0000
Bottom Slab Inside	A200 (AS3)	7	5.0000
Top Slab Outside	A300 (AS7)	5	10.0000
Bottom Slab Outside	A400 (AS8)	5	10.0000
Top Corner	A1 (AS1)	7	5.0000
Bottom Corner	A2 (AS1)	7	5.0000
Ext. Wall Inside	B1 (AS4)	5	5.0000
Ext. Wall Outside	B2 (AS1)	7	5.0000
Interior Wall	B3	5	5.0000
Longitudinal	C1 (AS6)	5	10.0000
Top Distribution	C100 (AS5)	5	10.0000
Bottom Distribution	C200	5	10.0000

Analysis Options

LL Analysis : Automatically Set Traffic Direction to Account for Skew Effects: no
Limit LL Distribution Width to Culvert Length for: None
Combine Longitudinal Axle Distribution Overlaps: No
Combine Transverse Axle Distribution Overlaps: No
Axle Placement Increment for Moving Load Analysis: 20
Include Impact on Bottom Slab: yes
Always Distribute Wheel Load: yes
Deflection Criteria : 1/800
Approach Slab will be Used: no

Reinforcement : Always Include Distribution Steel: no
Distribution Slab Provided: no
User Defined Longitudinal Steel: yes
Max. As used in Vc Calcs: 2.00 in2/ft
Distribute Minimum Reinforcement per Face: yes
Use individual Member Thicknesses for Min Steel: no
Epoxy coat steel: no
Use M-dimension for bar length calcs.: no

Slenderness : Checked K Factor: 2.00

Analysis Modeling : Use Haunches in the Structural Analysis Model: yes

Critical Sections : Flexure critical section location: 1.5 member depth
Shear critical section location: dv beyond support
Use Max. Moment with Max. Shear at the Critical Section for Shear: no
Include depth of haunch for critical sections: no

Flexure : Ignore Axial Thrust: no
Use Eq. 12.10.4.2.4a-1: yes Nu Multiplier: 1.00

Shear : Always Check Iterative Beta Method

Environmental : Apply duribility factors: no

Load Combinations : LRFD min/min: no

ANALYSIS RESULTS
==========

Top Slab Thickness = 10.00 in
Bottom Slab Thickness = 10.00 in
Exterior Wall Thickness = 10.00 in
Interior Wall Thickness = 12.00 in

Modular Ratio (N) = 5.91 Max. Steel Ratio = 0.025
Design Span = 10.42 ft Design Height = 9.83 ft

Volume of Concrete: 2.819 cy/ft Weight of Steel: 745 lb/ft

Note: Design and analysis results do not include force effects from stipping and handling stages

M dimension = 2' 5" (method of equivalent capacity)
= 6' 1" (method of contraflexure - ASTM)

Reinforcing Steel Schedule

Location	Bar Mark	Qty	Size	Type	Spacing (in)	As,prv (in2/ft)	Length (ft-in)	Wgt (lbs)	H Leg (ft-in)	V Leg (ft-in)
Top Slab (int)	A100 (AS2)	144	7	STR	5.00	1.440	21- 3	6255		
Bot Slab (int)	A200 (AS3)	144	7	STR	5.00	1.440	21- 3	6255		
Top Slab (ext)	A300 (AS7)	72	5	STR	10.00	0.372	21- 3	1596		
Bot Slab (ext)	A400 (AS8)	72	5	STR	10.00	0.372	21- 3	1596		
Corner (Top)	A1 (AS1)	288	7	L-BAR	5.00	1.440	6- 2	3630	3- 1	3- 1
Corner (Bottom)	A2 (AS1)	288	7	L-BAR	5.00	1.440	6- 2	3630	3- 1	3- 1
Ext Wall (int)	B1 (AS4)	288	5	STR	5.00	0.744	9- 6	2854		
Ext Wall (ext)	B2 (AS1)	288	7	STR	5.00	1.440	9- 0	5298		
Int Wall	B3	288	5	STR	5.00	0.744	10- 3	3079		
Top Slab (int- 1)	C100 (AS5)	23	5	STR	10.00	0.372	59-11	1437		
Bot Slab (int- 1)	C200	23	5	STR	10.00	0.372	59-11	1437		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	26	5	STR	10.00	0.372	59-11	1625		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1500		
Temperature (1)	C1 (AS6)	24	5	STR	10.00	0.372	59-11	1375		
							Total	44691		

Note: A denotes flexural steel, B denotes vertical steel, C denotes longitudinal steel

AS Bar Marks

Location	As prv in2/ft
Transverse Side Wall - Outside Face (AS1)	1.440
Transverse Top Slab - Inside Face (AS2)	1.440
Transverse Bottom Slab - Inside Face (AS3)	1.440
Transverse Side Wall - Inside Face (AS4)	0.744
Distribution Top Slab - Inside Face (AS5)	0.372
Distribution Top Slab - OutSide Face (AS6)	0.372
Transverse Top Slab - Outside Face (AS7)	0.372
Transverse Bottom Slab - Outside Face (AS8)	0.372

Notes: 1.) Final areas of steel provided must be checked in analysis mode

Summary of Ratings Table:

Truck	ILF	OLF	Flexure Fill	Flexure Member	Flexure Location	Flexure IR	Flexure OR	Shear Fill	Shear Member	Shear Location	Shear IR	Shear OR
(AA)HL-93	1.75	1.35	4.00	4	RT	1.45	1.88	4.00	4	RT	1.26	1.63
(AB)EV 2	1.30	1.30	4.00	4	RT	2.31	2.31	4.00	2	RT	2.04	2.04
(AC)EV 3	1.30	1.30	4.00	4	RT	2.49	2.49	4.00	2	RT	2.20	2.20
(AD)NRL -	2.00	2.00	4.00	4	RT	3.10	3.10	4.00	4	RT	2.73	2.73
(AE)NRL	2.00	2.00	4.00	4	RT	2.36	2.36	4.00	4	RT	2.08	2.08
(AF)Oveloa	1.20	1.20	4.00	4	RT	3.86	3.86	4.00	2	RT	3.44	3.44
(AG)Oveloa	1.20	1.20	4.00	4	RT	3.78	3.78	4.00	2	RT	3.36	3.36
(AH)Type 3	2.00	2.00	4.00	4	RT	2.51	2.51	4.00	4	RT	2.21	2.21
(AI)Type 3	2.00	2.00	4.00	4	RT	2.36	2.36	4.00	4	RT	2.08	2.08
(AJ)Type 3	2.00	2.00	4.00	4	RT	2.59	2.59	4.00	4	RT	2.28	2.28
(AK)WA-105	2.00	2.00	4.00	4	RT	2.36	2.36	4.00	4	RT	2.08	2.08

Critical Sections Summary: Flexure

Member 1: (Exterior Wall), Thickness = 10.00 in

Design	Corr.	Load Ratings	28	Fill

Loc	Dist. (in)	Moment (k-ft)	A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	IR	OR	Truck	Depth (ft)
BOT	24.00	-5.65	10.35	48.35	7.56	51.12	1.00	1.44	14.31	18.53	24.02	AA	4.00
MID	59.00	2.50	3.71	26.97	7.69	28.23	1.00	0.74	14.31	19.94	25.85	AA	4.00
MID-	59.00	-4.32	9.55	48.35	7.56	50.91	1.00	1.44	14.31	15.25	19.77	AA	4.00
TOP	24.00	-7.28	10.35	48.35	7.56	51.12	1.00	1.44	14.31	10.26	13.30	AA	4.00

Member 2: (Top Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	24.00	-3.20	5.20	48.35	7.56	49.76	1.00	1.44	14.31	36.28	47.03	AA	6.00
MID	50.00	8.90	0.75	48.35	7.56	48.56	1.00	1.44	14.31	7.72	10.00	AA	4.00
MID-	50.00	0.40	4.86	13.89	7.69	15.72	1.00	0.37	14.31	NC	NC	AA	6.00
RT	25.00	-10.13	1.90	13.66	7.56	14.38	1.00	0.37	14.31	1.72	2.23	AA	4.00

Member 3: (Interior Wall), Thickness = 12.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	Load Ratings IR	OR	Truck	Fill Depth (ft)
BOT	23.00	-2.33	23.26	34.41	9.69	43.90	1.00	0.74	20.61	NC	NC	AA	4.50
MID	59.00	3.04	11.48	34.41	9.69	39.20	1.00	0.74	20.61	12.88	16.69	AA	4.00
TOP	23.00	-6.35	24.55	34.41	9.69	44.40	1.00	0.74	20.61	6.99	9.06	AA	4.00

Member 4: (Bottom Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in2)	Mcr (k-ft)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	24.00	-3.60	6.96	48.35	7.56	50.23	1.00	1.44	14.31	37.19	48.21	AA	6.00
MID	50.00	8.05	1.82	48.35	7.56	48.85	1.00	1.44	14.31	10.76	13.95	AA	4.00
MID-	50.00	0.55	6.58	13.89	7.69	16.36	1.00	0.37	14.31	NC	NC	AA	6.00
RT	25.00	-12.01	2.96	13.66	7.56	14.78	1.00	0.37	14.31	1.45	1.88	AA	4.00

Critical Sections Summary: Vertical Shear

Member 1: (Exterior Wall), Thickness = 10.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
BOT	12.20	5.42	9.7	9.61	7.20	18.77	3.416	20.85 a	0.00	0.00	0.00	11.34	14.70	AA	6.00
MID	59.00	0.62	2.5	3.71	7.25	23.36	4.223	25.96 a	0.00	0.00	0.00	41.25	53.48	AA	4.00
MID-	59.00	0.66	4.3	9.55	7.20	25.17	4.581	27.97 a	0.00	0.00	0.00	41.98	54.41	AA	4.00
TOP	12.20	-4.38	10.4	9.61	7.20	18.64	3.393	20.71 a	0.00	0.00	0.00	11.26	14.59	AA	6.00

Member 2: (Top Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	12.20	7.98	6.7	4.70	7.56	19.92	3.451	22.13 a	0.00	0.00	0.00	3.51	4.55	AA	4.00
MID	62.50	0.33	7.6	0.75	7.56	20.87	3.616	23.19 a	0.00	0.00	0.00	38.12	49.41	AA	4.00
MID-	62.50	2.72	0.6	4.70	7.69	21.88	3.730	24.32 a	0.00	0.00	0.00	11.39	14.76	AA	4.00
RT	13.20	11.06	19.5	1.90	7.56	12.89	n/a	14.33 c	0.00	0.00	0.00	1.28	1.66	AA	4.00

Member 3: (Interior Wall), Thickness = 12.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
BOT	13.64	1.10	1.2	22.94	9.25	35.60	5.043	39.56 a	0.00	0.00	0.00	32.29	41.86	AA	4.00
MID	59.00	1.10	3.0	11.48	9.25	34.86	4.939	38.74 a	0.00	0.00	0.00	31.63	41.00	AA	4.00
TOP	13.64	1.10	7.2	24.55	9.25	34.97	4.953	38.85 a	0.00	0.00	0.00	31.72	41.12	AA	4.00

Member 4: (Bottom Slab), Thickness = 10.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR	Truck	Fill Depth (ft)
LT	12.20	7.46	7.7	6.96	7.56	19.90	3.448	22.11 a	0.00	0.00	0.00	7.15	9.27	AA	6.00
MID	62.50	0.24	6.6	1.82	7.56	21.78	3.774	24.20 a	0.00	0.00	0.00	60.23	78.08	AA	4.00
MID-	62.50	2.56	0.0	5.89	7.69	23.39	4.042	25.99 a	0.00	0.00	0.00	64.83	84.04	AA	4.00
RT	13.20	11.42	22.3	2.96	7.56	12.84	n/a	14.27 c	0.00	0.00	0.00	1.26	1.63	AA	4.00

Vc Calculation By: a - Iterative Beta, b - Constant Beta, c - Box Culvert, d - Standard/Arema

Culvert Shoring Calculations

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 4.00 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.79	1.92	0.00	0.69	0.19	0.00
2	-0.18	0.02	0.00	2.22	0.74	0.00
3	2.92	6.74	0.00	-1.37	-0.39	0.00
4	0.18	-0.02	0.00	3.28	0.75	0.00

---------- Analysis Truck, HL-93 ----------

HL-93 load distribution on box culvert

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.495	6.27	
	2	0.495	6.27	6.00
	3	0.495	6.27	4.00
	4	0.495	6.27	6.00
Tandem	1	0.387	6.27	
	2	0.387	6.27	6.00
	3	0.387	6.27	4.00
	4	0.387	6.27	6.00

Live Load Parameters:

Traffic Direction is Perpendicular to Main Reinforcement
Distribution Width : 6.00 ft
Impact Factor : 1.17
Truck MPF : 1.20 Tandem MPF : 1.20
Lane Load Distribution Width : 15.17 ft
Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab

Vehicle	Axle No.	Weight (klf)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.495	6.27	11.97
	2	0.495	6.27	5.97
	3	0.495	6.27	1.97
	4	0.495	6.27	-4.03

Maximum +Moment : 3.37 k-ft
Corresponding Moment at End : -3.02 k-ft
Coincident Bottom Slab Load : 0.42 k/ft

Maximum -Moment in Top Slab

Vehicle	Axle No.	Weight (klf)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.495	6.27	14.95
	2	0.495	6.27	8.95
	3	0.495	6.27	4.95
	4	0.495	6.27	-1.05

Maximum -Moment : -10.73 k-ft
Corresponding Moment at Mid : 2.30 k-ft
Coincident Bottom Slab Load : 0.50 k/ft

Maximum +Shear in Top Slab

Truck	1	0.495	6.27	9.13
	2	0.495	6.27	3.13
	3	0.495	6.27	-0.87
	4	0.495	6.27	-6.87

Maximum +Shear : 3.20 k
Corresponding Shear at Mid : -0.50 k
Coincident Bottom Slab Load : 0.35 k/ft

Maximum -Shear in Top Slab

Truck	1	0.495	6.27	17.28
	2	0.495	6.27	11.28
	3	0.495	6.27	7.28
	4	0.495	6.27	1.28

Maximum -Shear : -4.43 k
Corresponding Shear at Mid : -0.72 k
Coincident Bottom Slab Load : 0.55 k/ft

Maximum +Moment in Top Slab

Tandem	1	0.387	6.27	11.97
	2	0.387	6.27	5.97
	3	0.387	6.27	1.97
	4	0.387	6.27	-4.03

Maximum +Moment : 2.64 k-ft
Corresponding Moment at End : -2.36 k-ft
Coincident Bottom Slab Load : 0.33 k/ft

Maximum -Moment in Top Slab

Tandem	1	0.387	6.27	14.95
	2	0.387	6.27	8.95
	3	0.387	6.27	4.95
	4	0.387	6.27	-1.05

Maximum -Moment : -8.39 k-ft
Corresponding Moment at Mid : 1.79 k-ft
Coincident Bottom Slab Load : 0.39 k/ft

Maximum +Shear in Top Slab

Tandem	1	0.387	6.27	9.13
	2	0.387	6.27	3.13
	3	0.387	6.27	-0.87
	4	0.387	6.27	-6.87

Maximum +Shear : 2.50 k
Corresponding Shear at Mid : -0.39 k
Coincident Bottom Slab Load : 0.27 k/ft

Maximum -Shear in Top Slab

Tandem	1	0.387	6.27	17.28
	2	0.387	6.27	11.28
	3	0.387	6.27	7.28
	4	0.387	6.27	1.28

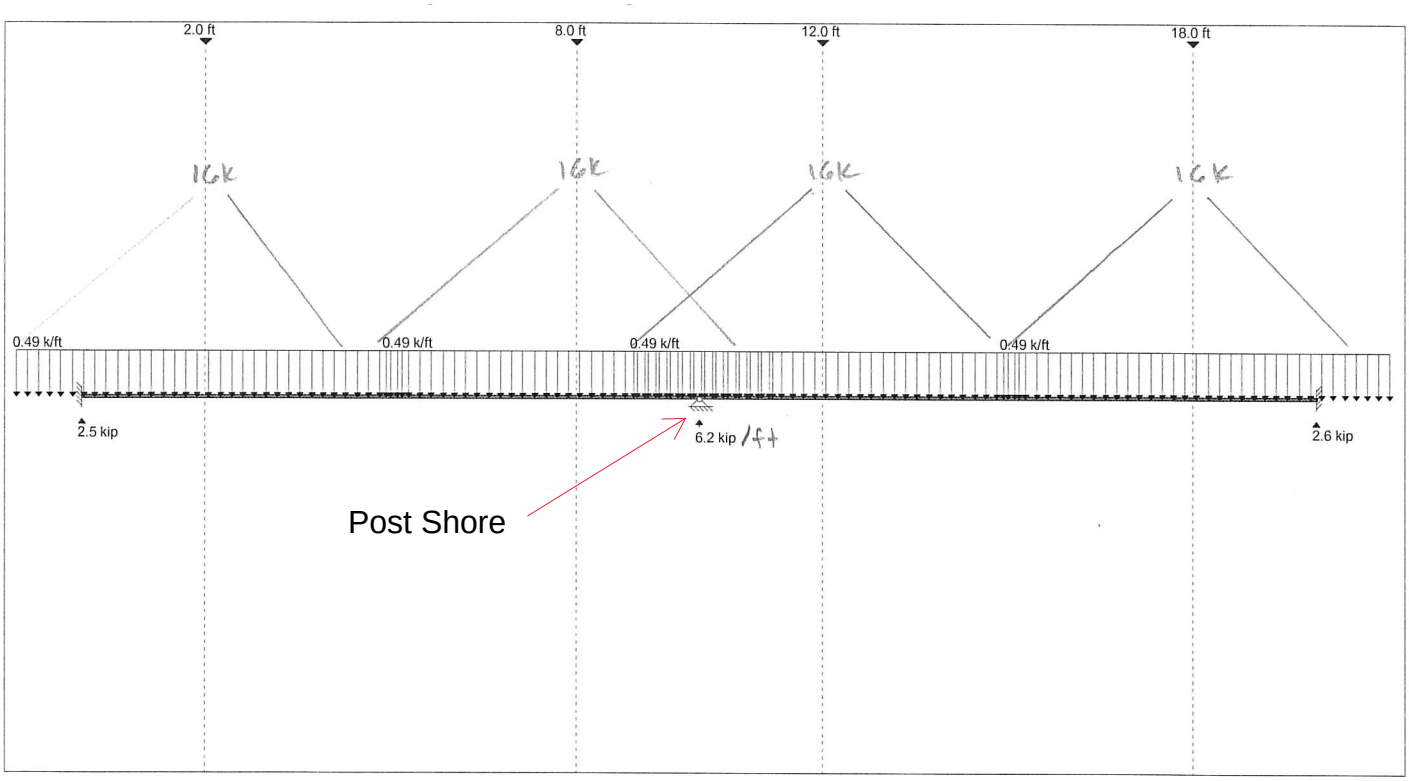
Maximum -Shear : -3.46 k
Corresponding Shear at Mid : -0.56 k
Coincident Bottom Slab Load : 0.43 k/ft

Unfactored Moments and Shears due to Truck Loads: (k-ft, k)

	Truck				Tandem				Lane			
M-PT	Mll+	Mll-	Vll+	Vll-	Mll+	Mll-	Vll+	Vll-	Mll+	Mll-	Vll+	Vll-

Member 1: (Exterior Wall)

HL-93 Wheel Load on Box Culvert



Beam Parameters: Length = 20.0 ft, [redacted]

Shore capacity = 8.5 kips
Shore max spacing = 8.5/6.2 = 1.37' = 16"

4M ENGINEERING
CIVIL - STRUCTURAL

Project Name: Bothell Culvert
Calculated By: FM
Date: 6-2-25

Check Punching Shear at Slab

f'c	5000	psi		
d	7.69	in		
Load Factor, LF	1.0		Max LF for LL	
Load, P	8.5	kips	Load per shore	
c1	5	in	Dimensions of Jack Base Bracket	
c2	5	in		
$b_0 = 2(c1+d)+2(c2+d)$	50.75	in	Critical Shear perimeter	
ϕ	0.75			
Vu = P*LF	9	kips		
ϕVc $\phi(4*f'c^{0.5}*b_0*d)$	83	kips	OK	ACI Eq 11-33

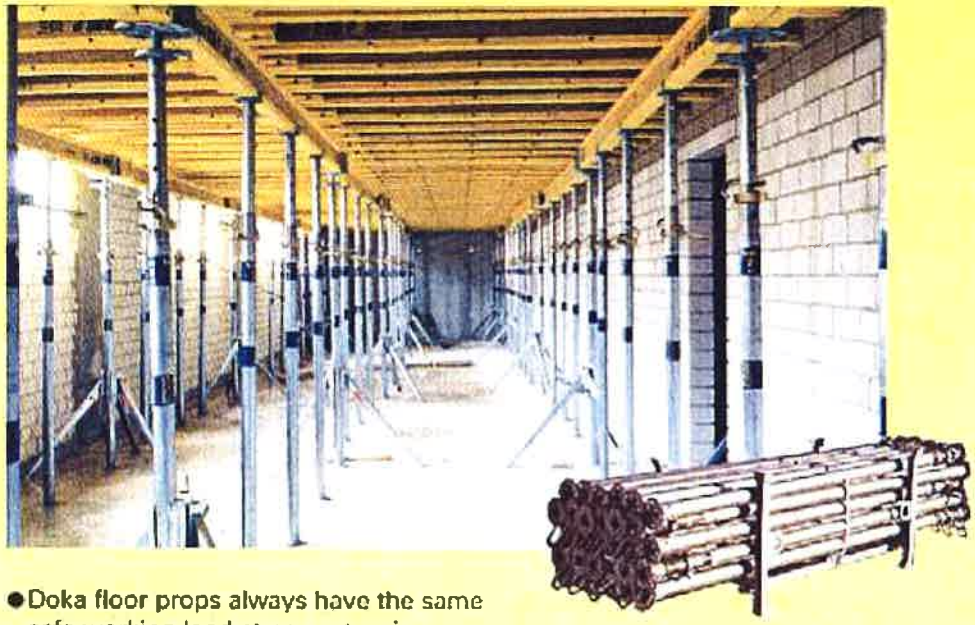
Check Shear at Slab

ϕ	0.75		
b	12	in	
d	7.69	in	
f'c	5000	psi	
$\phi Vc = \phi(2*f'c^{0.5}*b*d)$	9785	lbs per ft	
Vu = wl/2	7215	lbs	OK

Check Longitudinal Slab Bending Between Shoring Posts

f'c	5000	psi	
fy	60000	psi	
b	12	in	
No. Bar	5		
db	0.625	in	
As per bar	0.31	in^2/bar	
Spacing	10	in	
As per width "b"	0.37	in^2/ft	
Slab Thickness, t	10	in	
d = t - 2" cover - 0.5*db	7.69	in	
a = As*fy / (0.85*f'c*b)	0.44	in	
ϕ	0.9		
$\phi Mn = \phi As*fy*(d-a/2)$	12503	lb-ft /ft	
w (Strength I, factored)	10850	plf	
Span, l	1.33	ft	
M = wl^2/8	2399.1	lb-ft	OK

The best possible "support" on your site – Doka floor props



- Doka floor props always have the same safe working load at any extension eliminating field calculation
- Doka floor props are light weight
- Doka floor props are galvanized – no rust
- Doka floor props come with accessories for both H20 and Alu beams

The numbered holes are a convenient feature that makes for quicker and easier height adjustments.

Eurex 30

8.5 kips (*)

(*) over entire extension range

Eurex 30 floor props						
Type	Article Number	closed	extended	weight	Safe working load	safetey factor
Eurex 30 250	586092000	5' - 0"	8' - 2"	33 lbs	8,5 kips (37,8 kN) (**)	3 : 1
Eurex 30 300	586093000	5' - 8"	9' - 10"	37 lbs		3 : 1
Eurex 30 350	586094000	6' - 6"	11' - 5"	45 lbs		3 : 1
Eurex 30 400	586095000	7' - 6"	13' - 1"	55 lbs		3 : 1

(**) according to DOKA TEST REPORT on compressions test for Doka-post-shores EUREX 30 8,5 kips, Nr.: 861/01, Date: 27.09.2001 and US-Standards

doka
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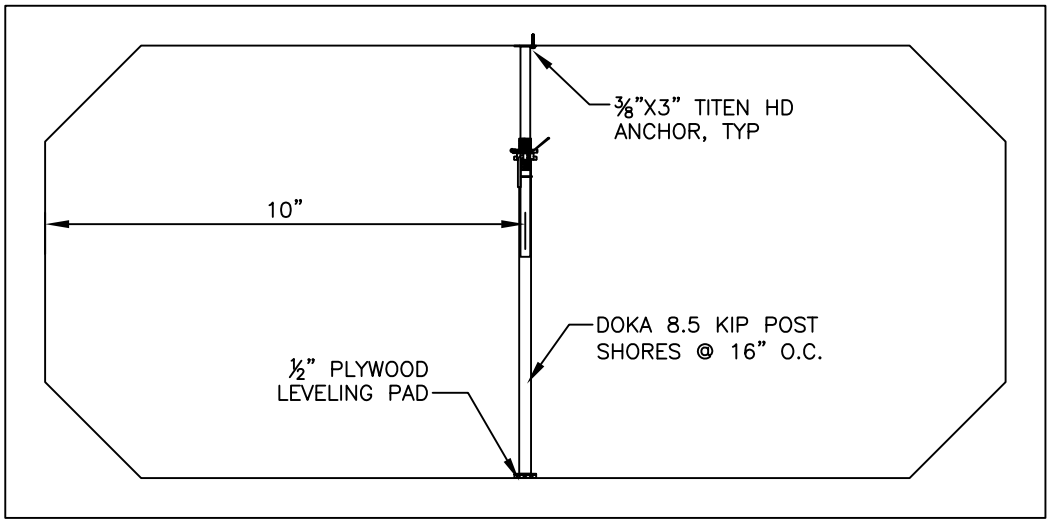
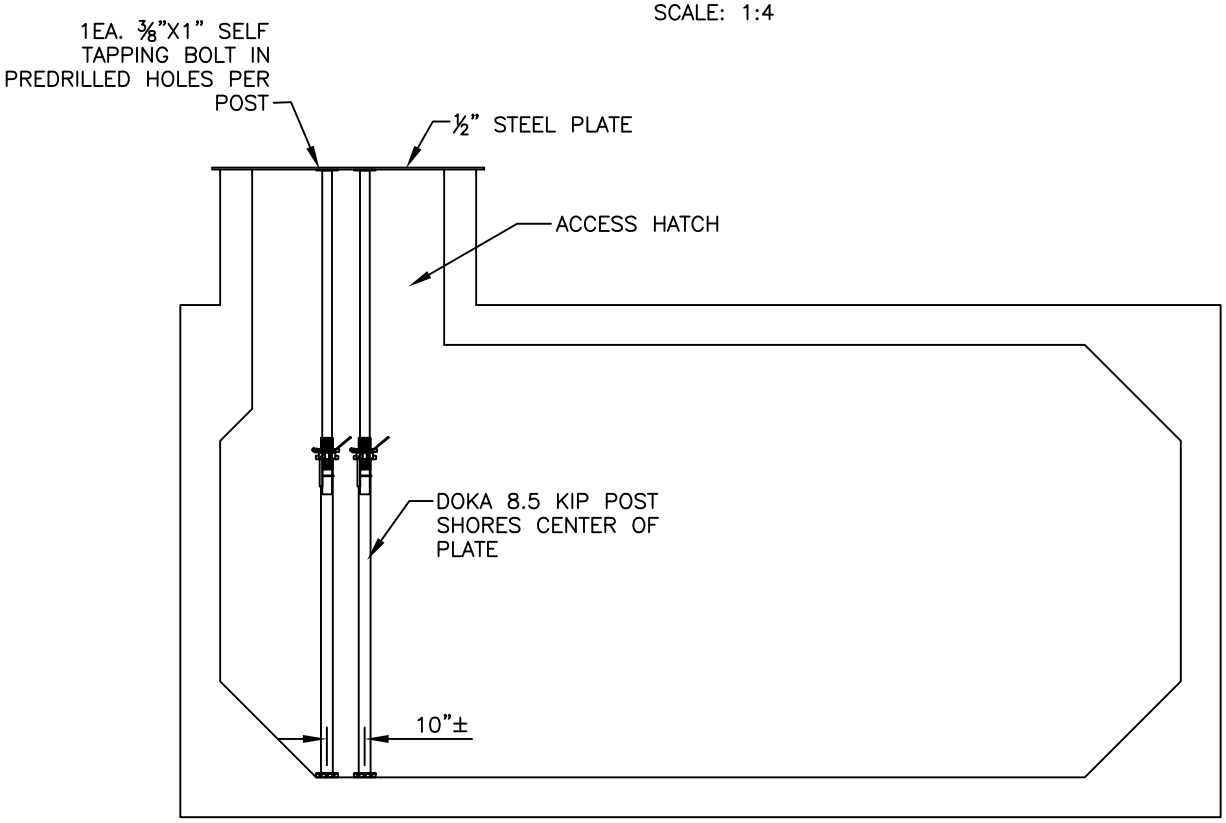


BOX CULVERT TEMP SHORING

SCALE: 1:4



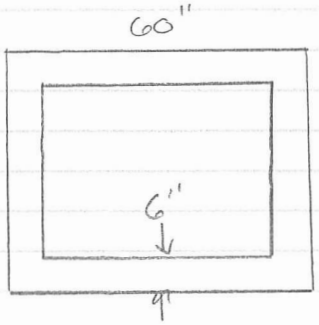
HATCH LID TEMP SHORING

SCALE: 1:4

6-3-25

Access Riser Calculations

Concrete Riser



Area = 108 in²

Assume min steel = 12 no. 3's

Riser Load = HL-93 wheel load + Soil DL

= 1.75 (16,000) + 1.25 (2'·127)(5²) = 35,938 lbs

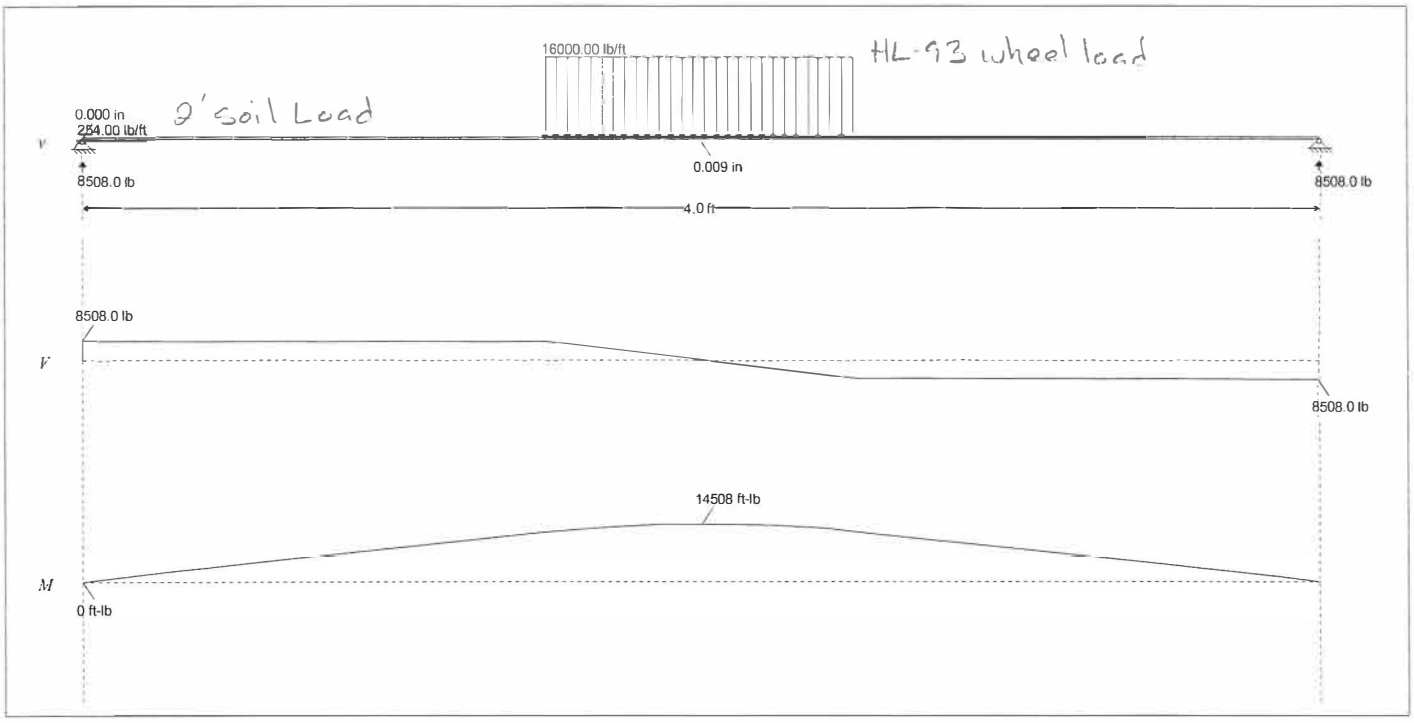
Compressive stress = $\frac{35938 \text{ lbs}}{108 \text{ in}^2}$ = 333 psi

4M ENGINEERING
CIVIL – STRUCTURAL

Project Name: Box Culvert
Date: 5-28-25

Check Concrete Risers as Concrete Columns

Dead Load	6.35	kips		
Live Load	16.0	kips		
Design Load (Vertical)	36	kips		1.25 DL + 1.75LL
Lateral Load	0	kips		
Divided over 4 supports (Lateral)	0	kips		
f'c	3.5	ksi		
fy	60	ksi		
ρ_trial	0.03			
Ag_trial	17.0	sq in		
	4.1	in		
Check w/ #3 bars				
Bar Number	3			
Number of Bars	12			
db	0.375	in		
As per bar	0.11	sq in		
Ast (total)	1.32	sq in		
Length	60	in		
Width	60	in		
Int width	48	in		
Ag	108	sq in		
ρ = Ast/Ag	0.012			Per ACI 10.9, Must be between 0.01 to 0.08
ϕ	0.7			
ϕ*Pn = 0.8∗ϕ*[0.85*f'c*(Ag-Ast)+fy*Ast)]	222	kips	OK	ACI-318 Eq. 10-2
Rating Factor RF	7.6			AASHTO eqn 13.1.1A-1
Check Slenderness Effects				
Effective length factor, k	2			
Unsupported length, lu	4.5	ft		
Radius of gyration, r	76.8	in		Per ACI 10.10.1.2, equal to 0.3x dimension
Check k*lu/r < 22	1.41		OK	ACI-318 Eq. 10-6
Check Concrete for Shear				
ϕ	0.75			
b	60	in		
d	57.81	in		
f'c	3500	psi		
ϕVc = ϕ[2*(1+Nu/2000Ag)*f'c^0.5*b*d]	309	kips	OK	ACI-318 Eq. 11-4



Beam Parameters: Length = 4.0 ft, E = 29000.0 ksi, I = 140.0 in^4, A = 6.0 in^2

A36 plate F_y = 36 ksi, f_y = 22 ksi (ASD)

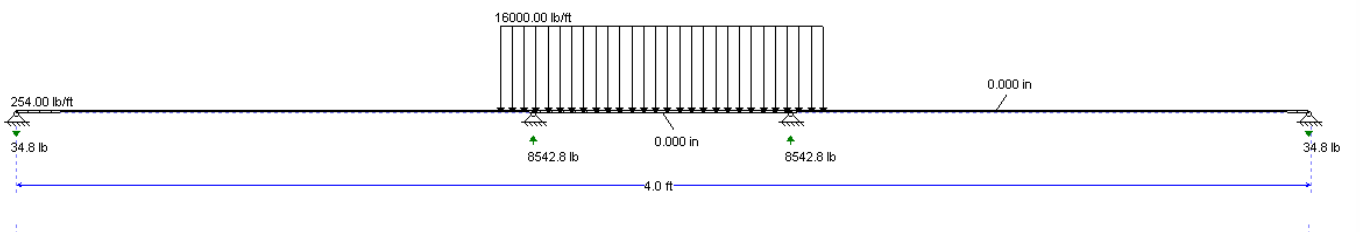
$f_b = \frac{M}{S}$ $S_{min} = \frac{M}{f_b} = \frac{14508}{22000} \cdot 12 = 7.91\ in^3$

4'x4' plate

find req'd thickness

$S = \frac{bh^2}{6}$ $h = \frac{7.91(6)}{48''} = .99'' \Rightarrow$ 1" plate req'd

Note: steel plates as-built are 1/2" thick. 2ea. 8.5 kip shoring posts will be implemented rather than replacing 1/2" plates with 1" plates.



APPENDIX

Inspection

Printed On: 3/18/2025

CD Guid: 119f214d-5bdd-451a-87b6-c08671b799fb

Agency: Washington State | Program Mgr: Sonia L. Lowry | CD Status: Work | Release Date:

Structure No. V001 **SID** XG180500 **Structure Name** Drainge vault

Carrying **Route On** **Mile Post**

Intersecting **Route Under** **Mile Post**

2/9/2028 — Inspector's Signature JJL Cert # G1805 Cert Exp Date

3/18/2028 — Co-Inspector's Signature

Current Inspections Performed

Report Type	Subtype	Rsk Mthd	Begin Date	Comp Date	Interval	Due Date	Hours	Inspector	Cert No	Co-Insp
Initial		1	3/13/2025	3/13/2025			1.0	JJL	G1805	
Routine Bridge		1	3/13/2025	3/13/2025			1.0	JJL	G1805	

Component Condition Ratings

	G	Overall Condition Classification	(BC12)
	N	FHWA Deck Overall	(BC01)
	N	WSDOT Deck Overall	(WC01)
	N	Bridge Railings	(BC05)
	N	Bridge Railing Transitions	(BC06)
	N	Bridge Joints	(BC08)
	N	Superstructure Overall	(BC02)
	N	NSTM Inspection	(BC14)
	N	Bridge Bearings	(BC07)
	N	Substructure Overall	(BC03)
	N	UW Inspection	(BC15)
	8	Culvert Overall	(BC04)
	N	Scour Condition	(BC11)
	N	Channel Condition	(BC09)
	N	Channel Protection	(BC10)
		Chan/Prot (NBI Disc)	(1677)
		Pier/Abut/Prot (NBI Disc)	(1679)

Appraisal

		Scour Critical (NBI Disc)	(1680)
	N	Scour Vulnerability	(BAP03)
	X	Scour Plan of Action	(BAP04)
		Waterway (NBI Disc)	(1662)
	N	Overtopping Likelihood	(BAP02)
		Appr Roadway Align	(BAP01)
		Fatigue Details	(BIR02)
		Seismic Vulnerability	(BAP05)

Optional Condition Ratings

	6	Drain Condition	(LP01)
	9	Retaining Wall Condition	(LP02)

Miscellaneous Fields

	1996	Year Built	(BW01)
		Asphalt Depth	(WIE30)
	0.00	Design Curb Height	(WIE31)
	0.00	Bridge Rail Height	(WIE32)
	1	Number of Utilities	(WIE33)
	Y	Subject to NBIS	(WIE34)
	03/17/2025	Inspn QA Date	(BIE09)

Inspection Flags

		Soundings	(WIE20)
		Clearance	(WIE21)
		Revise Rating	(WIE22)
	P	PhotosFlag	(WIE23)
	Y	Roadside Hardware Flag	(WIE25)
	Y	QA Flag	(WIE24)

BMS Elements

Element	Element Description	Total	Units	CS 1	CS 2	CS 3	CS 4
	Culvert Elements						
241	Concrete Culvert	285	LF	285	0	0	0

Notes

Culvert Notes

241 This is a drainage detention vault running along the median area of I-405 near Exist 26, north of 228th St. SE., Bothell, WA . The actual length of culvert is approximately 285 feet, and the vault interior width and height are approximately 20 x 9 feet . The inspection was performed by entering the vault through one of the hatches at night around 11:30 pm on March 12, with one lane I-405 closure. The ground above the vault was not inspected due to the night condition. At the hatch opening, the ground is about 4 feet above the vault. The vault bottom has standing water due to rain on the inspection day. The vault is an active drainage structure with three cells, an inlet chamber, a settling chamber, and an outlet chamber connecting to outfall. the structure condition is good, with typical longitudinal hairline cracks at each expansion joint. The expansion joint spaces at 10 feet, all expansion joints and hatches leak significantly.

CD Guid: 119f214d-5bdd-451a-87b6-c08671b799fb

Agency: Washington State | Program Mgr: Sonia L. Lowry | CD Status: Work | Release Date:

Structure No. V001 **SID** XG180500 **Structure Name** Drainge vault

Carrying **Route On** **Mile Post**

Intersecting **Route Under** **Mile Post**

Repairs

Repair No	Pr	R	Repair Descriptions	BMS	Noted	Maint	Verified
			(No repairs for this structure)				

All Inspections and Resources Required

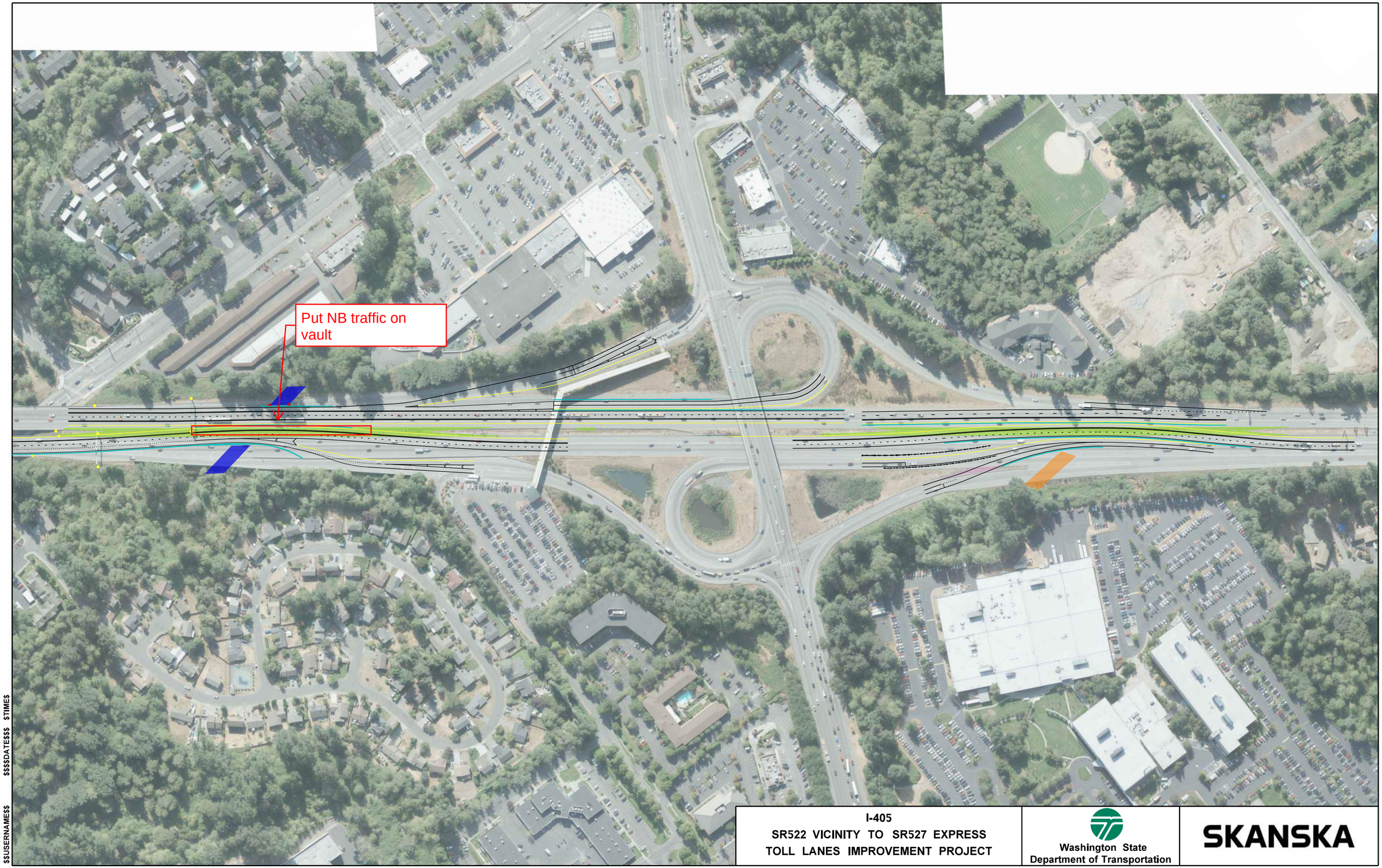
Report Type	Subtype	Rsk Mthd	Begin Date	Comp Date	Interval	Due Date	Hours	Inspector	Cert No	Co-Insp
Initial		N	3/13/2025	3/13/2025			1.0	JJL	G1805	

Inspection Note	Late Inspection Explanation	Late PM Resp Date	Late PM Approval	Insp QC Date	Inspn Data Update Date
Mid night underground inspection, rainy					

Report Type	Subtype	Rsk Mthd	Begin Date	Comp Date	Interval	Due Date	Hours	Inspector	Cert No	Co-Insp
Routine Bridge		N	3/13/2025	3/13/2025			1.0	JJL	G1805	

Inspection Note	Late Inspection Explanation	Late PM Resp Date	Late PM Approval	Insp QC Date	Inspn Data Update Date
Mid night underground inspection, rainy					

Plans



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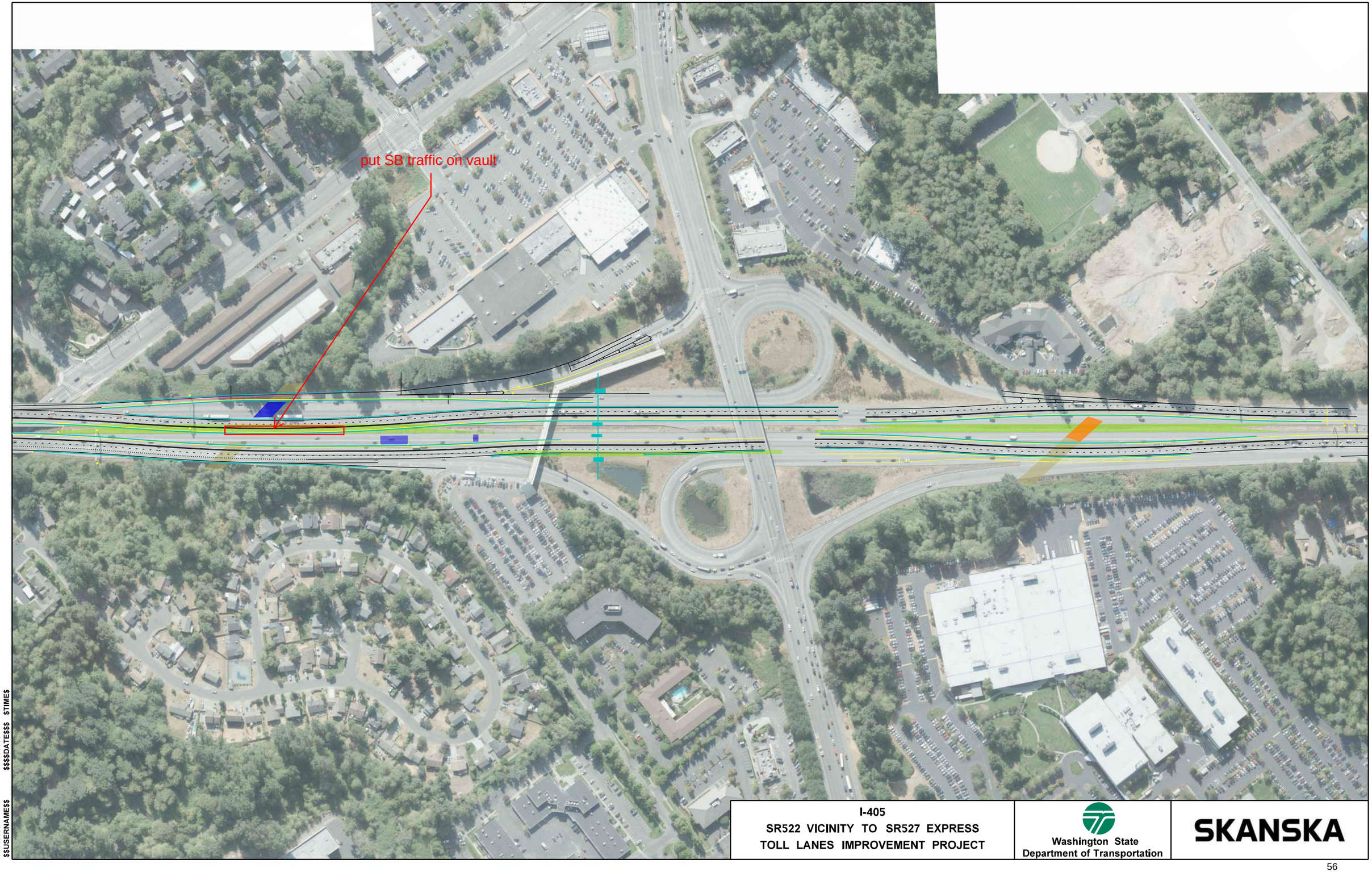
I-405
SR522 VICINITY TO SR527 EXPRESS TOLL LANES IMPROVEMENT PROJECT

Washington State Department of Transportation

SKANSKA



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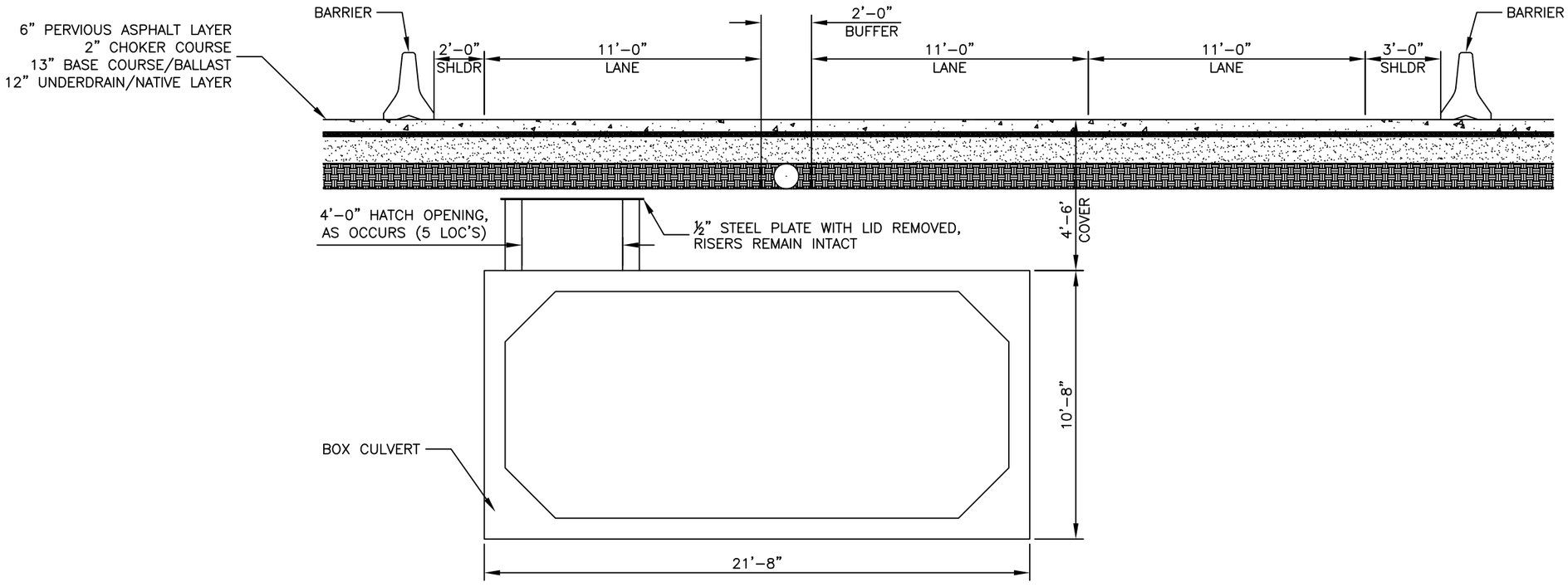
I-405
SR522 VICINITY TO SR527 EXPRESS TOLL LANES IMPROVEMENT PROJECT

Washington State Department of Transportation

SKANSKA



TYP SECTION THROUGH VAULT NW–12
SCALE: 1:5

#	DATE	DESCRIPTION
0	5–16–25	ISSUED FOR CONSTRUCTION

REVISIONS

STATE OF WASHINGTON
JEFFREY G. MEGARGEL
REGISTERED PROFESSIONAL ENGINEER
20100237

6/3/25

PLANS PREPARED BY
4M ENGINEERING
CIVIL - STRUCTURAL
6675 PURPLE POPPY LN., PARK CITY, UT 84098
801–380–0562
WWW.4MENGINEERS.COM

DESIGNED BY: JESSICA MERRELL

PLANS PREPARED FOR:
SKANSKA USA CIVIL
18911 NORTH CREEK PKWY, STE 300

PROJECT INFORMATION
PROJECT TITLE:
I–405 BRICKYARD TO SR527

OWNER: WASH DOT

DIST	COUNTY	ROUTE	POST MILE
–	SNOHOMISH	405	–

CONTRACT NO.: 9727

SHEET NAME:
TYP SECTION @ VAULT NW–12

STR NAME: VAULT NW–12

SHEET 1 OF 1

STR NO.: VAULT NW–12

FILE: Bothell culvert section.dwg

Field Investigations

Outlook

Re: Box Culvert Findings

From Lucarelli, Zachary <Zachary.Lucarelli@skanska.com>
Date Tue 4/15/2025 2:50 PM
To Forrest Megargel <forrestm@4mengineers.com>
Cc Jessica Merrell <jessicam@4mengineers.com>

Forrest,

Our superintendent verified the following today:

"The wall portion is #5 bar 5" OC vertical and #5 bar 10" OC horizontal. The lid portion looks to be #7 bar transverse at 5" OC, and #5 bar longitudinal at 10" OC."

Thanks!

Zach

From: Lucarelli, Zachary
Sent: Monday, April 14, 2025 1:47 PM
To: Forrest Megargel
Cc: Jessica Merrell
Subject: Re: Box Culvert Findings

Forrest,

Some photos attached.

Thanks,

Zach

From: Forrest Megargel <forrestm@4mengineers.com>
Sent: Wednesday, April 2, 2025 6:24 AM
To: Lucarelli, Zachary <Zachary.Lucarelli@skanska.com>
Cc: Jessica Merrell <jessicam@4mengineers.com>
Subject: Box Culvert Findings

Outlook

Re: Box Culvert

From Lucarelli, Zachary <Zachary.Lucarelli@skanska.com>
Date Thu 4/24/2025 9:49 AM
To Forrest Megargel <forrestm@4mengineers.com>
Cc Jessica Merrell <jessicam@4mengineers.com>

Forrest,

The exterior mat of the walls is #7 verticals at 5" OC, and #5 horizontals at 10" OC.

Thanks,

Zach

From: Forrest Megargel <forrestm@4mengineers.com>
Sent: Thursday, April 17, 2025 7:49 AM
To: Lucarelli, Zachary <Zachary.Lucarelli@skanska.com>
Cc: Jessica Merrell <jessicam@4mengineers.com>
Subject: Box Culvert

Zach,

Based on as-built the bar information we recommend adding shoring to the box culvert, unless the exterior bars in the walls can be verified as #7's or larger. I don't know how practical getting that information would be.

Forrest Megargel, P.E.

4M ENGINEERING
CIVIL - STRUCTURAL

6675 Purple Poppy Ln
Park City, Utah, 84098
801-380-0562

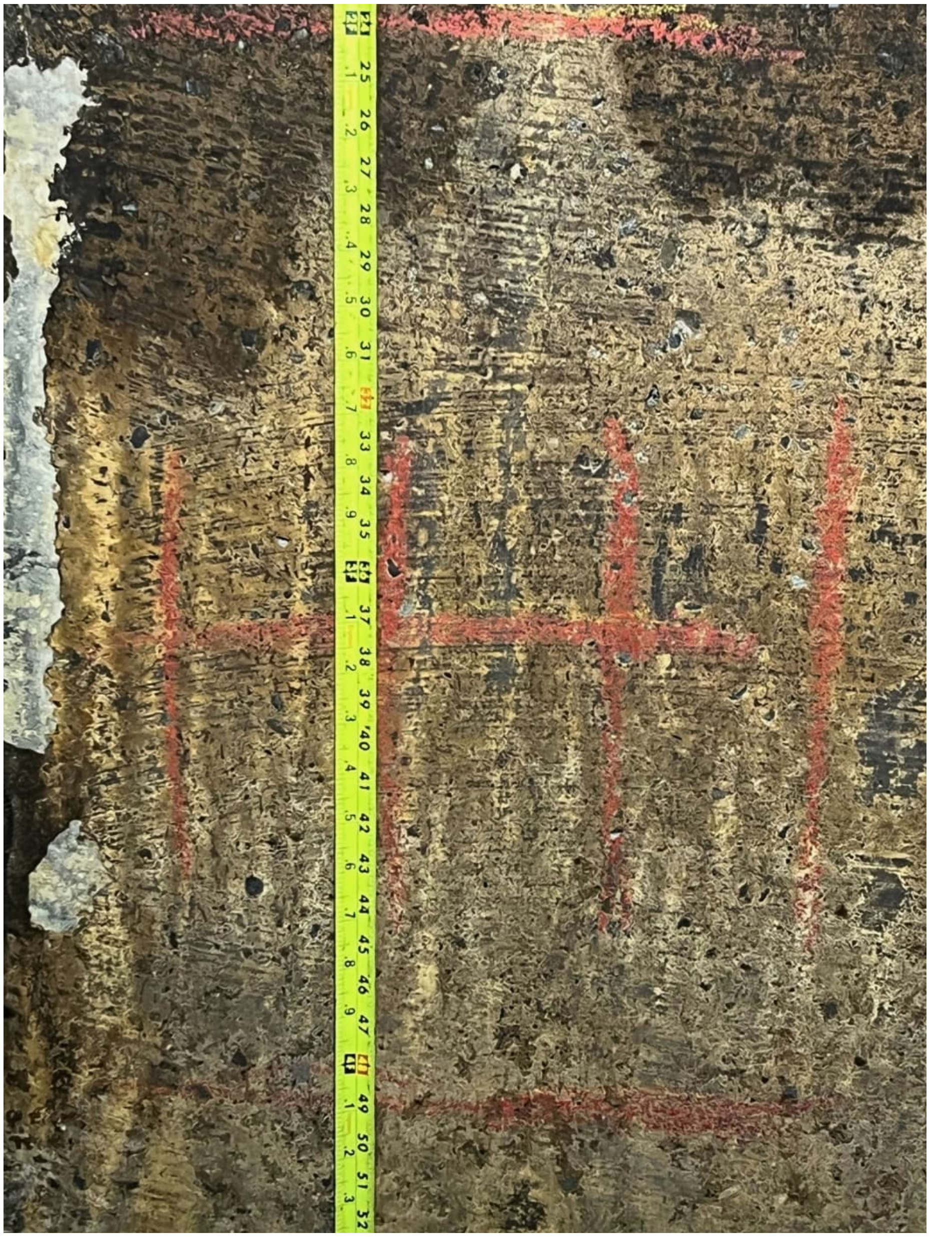
Ceiling Rebar

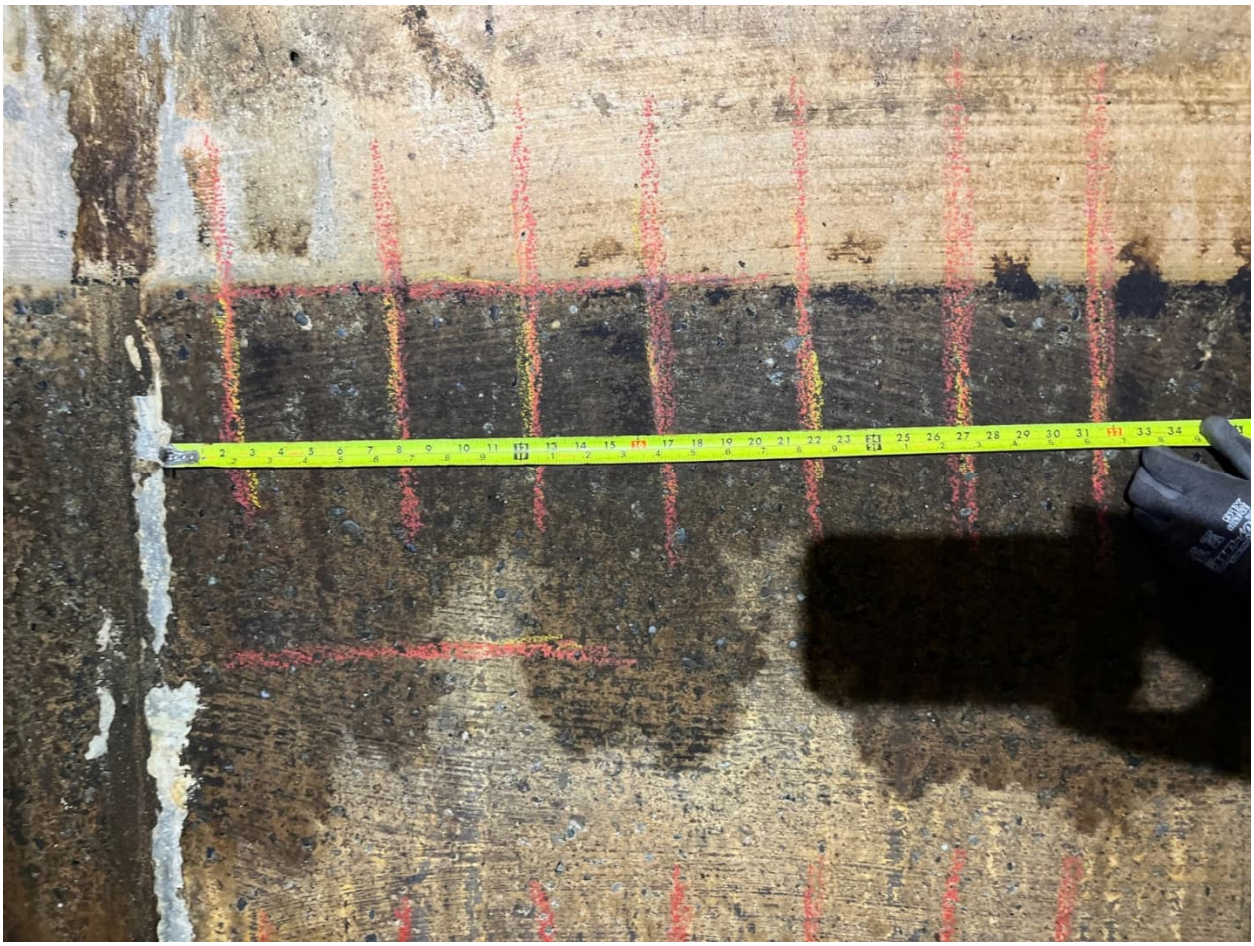

Network:Mar 13, 2025 at 1:14:08 AM PDT
Local:Mar 13, 2025 at 1:14:08 AM PDT
N 47° 47' 33.121", W 122° 12' 35.475"
I-405 S
Bothell WA 98021
United States

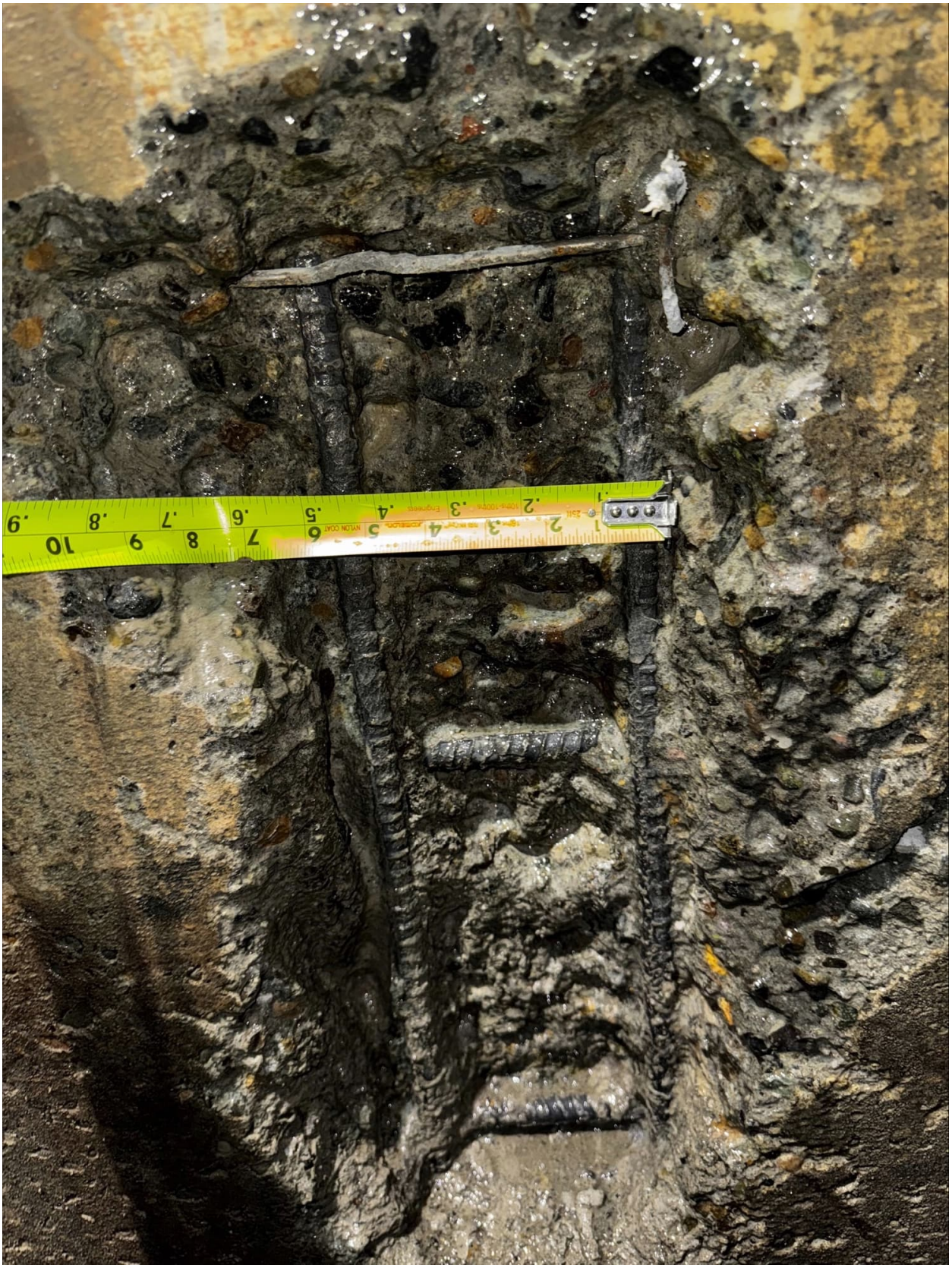

DEWALT


DEWALT

Wall Rebar







Sample Plans

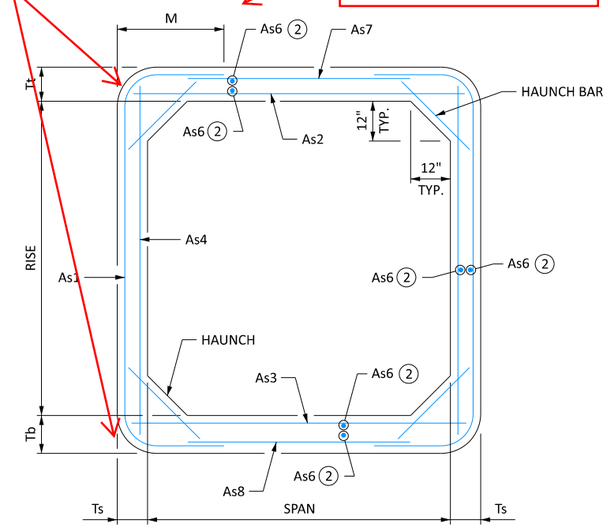
As3 exceeds As2

As7 and As8 bars exceed longitudinal bars

Corner bars match exterior wall rebar (one bar used)

SIZE SPAN x RISE (ft.)	CLASS	f'c (psi)	FILL HEIGHT RANGE (ft.)	Tt (in.)	Tb (in.)	Ts (in.)	WEIGHT (lbs./ft.)	REINFORCEMENT REQUIREMENTS ①									
								As1			As2		As3		As4		As7/As8	
								As	LENGTH	M	As	LENGTH	As	LENGTH	As	LENGTH	As	LENGTH
16x4	1	5000	<3	10	11	9	5800	1.33	16'-11"	5'-10"	0.87	16'-6"	0.81	16'-6"	0.22	4'-6"	0.27	10'-5"
	2	5000	3 - 6	10	11	9	5800	1.24	15'-7"	5'-2"	0.83	16'-6"	0.81	16'-6"	0.22	4'-6"	0.27	11'-5"
	3	5000	6 - 10	10	11	10	5950	1.48	17'-4"	6'-1"	1.01	16'-6"	1.00	16'-6"	0.24	4'-6"	0.27	10'-5"
	4	6000	10 - 16	12	12	11	6750	1.85	16'-8"	5'-7"	1.30	16'-6"	1.32	16'-6"	0.27	4'-6"	0.29	11'-1"
16x5	1	5000	<3	10	11	9	6025	1.23	17'-7"	5'-8"	0.95	16'-6"	0.90	16'-6"	0.22	5'-6"	0.27	10'-5"
	2	5000	3 - 6	10	11	9	6025	1.14	16'-3"	5'-0"	0.91	16'-6"	0.90	16'-6"	0.22	5'-6"	0.27	11'-5"
	3	5000	6 - 10	10	11	10	6200	1.36	17'-4"	5'-7"	1.09	16'-6"	1.11	16'-6"	0.24	5'-6"	0.27	11'-3"
	4	6000	10 - 16	12	12	10	6850	1.84	15'-10"	4'-8"	1.55	16'-6"	1.57	16'-6"	0.24	5'-6"	0.29	12'-9"
16x6	1	5000	<3	10	11	9	6250	1.15	17'-3"	5'-0"	1.01	16'-6"	0.98	16'-6"	0.22	6'-6"	0.27	11'-5"
	2	5000	3 - 6	10	11	9	6250	1.06	17'-0"	4'-11"	0.98	16'-6"	0.98	16'-6"	0.22	6'-6"	0.27	11'-5"
	3	5000	6 - 10	10	11	9	6250	1.38	18'-1"	5'-5"	1.27	16'-6"	1.32	16'-6"	0.22	6'-6"	0.27	11'-5"
	4	6000	10 - 16	12	12	10	7100	1.69	16'-10"	4'-8"	1.66	16'-6"	1.69	16'-6"	0.24	6'-6"	0.29	12'-9"
16x7	1	5000	<3	10	11	8	6250	1.13	16'-10"	4'-4"	1.17	16'-6"	1.16	16'-6"	0.20	7'-6"	0.27	12'-9"
	2	5000	3 - 6	10	11	8	6250	1.05	16'-6"	4'-2"	1.14	16'-6"	1.16	16'-6"	0.20	7'-6"	0.27	12'-10"
	3	5000	6 - 10	10	11	9	6475	1.29	17'-5"	4'-7"	1.34	16'-6"	1.41	16'-6"	0.22	7'-6"	0.27	12'-10"
	4	6000	10 - 16	12	12	10	7350	1.57	17'-10"	4'-8"	1.76	16'-6"	1.80	16'-6"	0.24	7'-6"	0.29	12'-9"
16x8	1	5000	<3	10	11	8	6450	1.05	17'-6"	4'-2"	1.23	16'-6"	1.23	16'-6"	0.20	8'-6"	0.27	12'-9"
	2	5000	3 - 6	10	11	8	6450	0.97	17'-2"	4'-0"	1.20	16'-6"	1.23	16'-6"	0.20	8'-6"	0.27	12'-9"
	3	5000	6 - 10	10	11	9	6700	1.20	18'-2"	4'-6"	1.41	16'-6"	1.50	16'-6"	0.22	8'-6"	0.27	12'-10"
	4	6000	10 - 16	12	12	10	7600	1.47	18'-10"	4'-8"	1.84	16'-6"	1.89	16'-6"	0.24	8'-6"	0.29	12'-9"
16x9	1	5000	<3	10	11	8	6650	0.98	18'-4"	4'-1"	1.29	16'-6"	1.28	16'-6"	0.20	9'-6"	0.27	12'-9"
	2	5000	3 - 6	10	11	8	6650	0.90	17'-11"	3'-10"	1.24	16'-6"	1.28	16'-6"	0.20	9'-6"	0.27	12'-9"
	3	5000	6 - 10	10	11	9	6925	1.13	18'-11"	4'-4"	1.53	16'-6"	1.57	16'-6"	0.22	9'-6"	0.27	12'-9"
	4	6000	10 - 16	12	12	10	7850	1.36	19'-8"	4'-7"	1.90	16'-6"	1.97	16'-6"	0.24	9'-6"	0.29	12'-9"
16x10	1	5000	<3	10	11	8	6850	0.93	19'-1"	3'-11"	1.34	16'-6"	1.34	16'-6"	0.20	10'-6"	0.27	12'-9"
	2	5000	3 - 6	10	11	8	6850	0.84	18'-9"	3'-9"	1.29	16'-6"	1.34	16'-6"	0.20	10'-6"	0.27	12'-9"
	3	5000	6 - 10	10	11	9	7150	1.07	19'-8"	4'-3"	1.58	16'-6"	1.64	16'-6"	0.22	10'-6"	0.27	12'-10"
	4	6000	10 - 16	12	12	10	8100	1.29	20'-6"	4'-6"	1.96	16'-6"	2.06	16'-6"	0.24	10'-6"	0.29	12'-9"
16x11	1	5000	<3	10	11	8	7050	0.91	20'-0"	3'-11"	1.39	16'-6"	1.39	16'-6"	0.20	11'-6"	0.27	12'-9"
	2	5000	3 - 6	10	11	8	7050	0.83	19'-8"	3'-9"	1.33	16'-6"	1.39	16'-6"	0.20	11'-6"	0.27	12'-9"
	3	5000	6 - 10	10	11	9	7375	1.02	20'-6"	4'-2"	1.63	16'-6"	1.70	16'-6"	0.22	11'-6"	0.27	12'-9"
	4	6000	10 - 16	12	12	10	8350	1.23	21'-3"	4'-5"	2.03	16'-6"	2.12	16'-6"	0.24	11'-6"	0.29	12'-9"
16x12	1	5000	<3	10	11	8	7250	0.90	21'-1"	3'-11"	1.43	16'-6"	1.44	16'-6"	0.24	12'-6"	0.27	12'-7"
	2	5000	3 - 6	10	11	8	7250	0.83	20'-9"	3'-9"	1.37	16'-6"	1.44	16'-6"	0.24	12'-6"	0.27	12'-9"
	3	5000	6 - 10	10	11	9	7600	0.99	22'-7"	4'-8"	1.67	16'-6"	1.75	16'-6"	0.24	12'-6"	0.27	11'-7"
	4	6000	10 - 16	12	12	11	8950	1.20	22'-2"	4'-4"	1.92	16'-6"	2.02	16'-6"	0.24	12'-6"	0.29	12'-11"

Note: all longitudinal bars are equivalent



BOX CULVERT CROSS SECTION

GENERAL NOTES

SEE STANDARD FIG. 5-395.100(A) FOR BASIS OF DESIGN. FILL HEIGHT IS DEFINED AS THE DISTANCE FROM THE TOP OF THE CULVERT TO THE TOP OF THE PAVEMENT OR TO TOP OF FILL IF THERE IS NO PAVEMENT.

DESIGNS FOR FILL HEIGHTS GREATER THAN SHOWN IN THE TABLES ARE AVAILABLE FROM THE MnDOT BRIDGE OFFICE.

SEE STANDARD FIG. 5-395.101(A) AND FIG. 5-397.101(B) FOR ADDITIONAL INFORMATION. TRANSVERSE REINFORCEMENT IS PARALLEL TO THE CULVERT SPAN. LONGITUDINAL REINFORCEMENT IS PERPENDICULAR TO THE CULVERT SPAN.

IF THE FILL HEIGHT RANGE EXTENDS INTO MORE THAN ONE CLASS, USE THE CLASS WITH THE LARGEST REINFORCEMENT AREAS. CHECK MAXIMUM AND MINIMUM FILL HEIGHTS OVER THE FULL AREA OF ROADWAY AND SHOULDERS.

ROADWAY OR SHOULDER FILL HEIGHTS OF LESS THAN 2'-0" REQUIRE A DISTRIBUTION SLAB. EXTEND THE WIDTH OF THE DISTRIBUTION SLAB TO THE OUTSIDE EDGES OF THE ROADWAY SHOULDERS UNLESS DIRECTED BY THE ENGINEER.

USE CONCRETE MIX 3S52 FOR THE DISTRIBUTION SLAB.

PLACE 6" THICK CAST-IN-PLACE DISTRIBUTION SLAB WITH NO. 5 BARS AT 1'-0" TRANSVERSELY AND NO. 5 BARS AT 1'-0" LONGITUDINALLY. EPOXY COAT ALL DISTRIBUTION SLAB REINFORCEMENT. CENTER DISTRIBUTION SLAB JOINTS OVER BARREL SEGMENTS. PROVIDE 3" MINIMUM GRANULAR MATERIAL IN ACCORDANCE WITH SPEC. 3149.2B BETWEEN BARREL AND DISTRIBUTION SLAB.

PRECAST DISTRIBUTION SLABS WITH THE SAME REINFORCEMENT MAY BE USED FOR FILL HEIGHTS OVER 1'-0". CENTER DISTRIBUTION SLAB JOINTS OVER BARREL SEGMENTS. PROVIDE 6" MIN GRANULAR MATERIAL IN ACCORDANCE WITH SPEC. 3149.2B BETWEEN BARREL AND DISTRIBUTION SLAB.

REDESIGN DISTRIBUTION SLAB PER THE MnDOT PAVEMENT DESIGN MANUAL IF IT IS USED AS PAVEMENT SURFACE.

CULVERT WEIGHT IS BASED ON 150 P.C.F. WITH A HAUNCH SIZE OF 12 INCHES.

① REINFORCEMENT AREAS ARE IN SQUARE INCHES PER LINEAL FOOT OF BARREL. ALL REINFORCEMENT LENGTHS AND AREAS ARE MINIMUM REQUIREMENTS. REINFORCEMENT REQUIREMENTS ARE FOR WELDED WIRE REINFORCEMENT WITH MINIMUM SPECIFIED YIELD STRESS OF 65 ksi. IF BAR REINFORCEMENT IS SUBSTITUTED FOR WELDED WIRE REINFORCEMENT, INCREASE THE AREA OF REINFORCEMENT BY 8%, AND SUBMIT DESIGN CALCULATIONS VERIFYING COMPLIANCE WITH AASHTO 5.7.3.4 "CONTROL OF CRACKING BY DISTRIBUTION OF REINFORCEMENT".

② PLACE LONGITUDINAL REINFORCEMENT DENOTED AS As6 IN ALL SLABS AND WALLS WITH A MINIMUM OF 0.06 IN^2/FT.

MnDOT

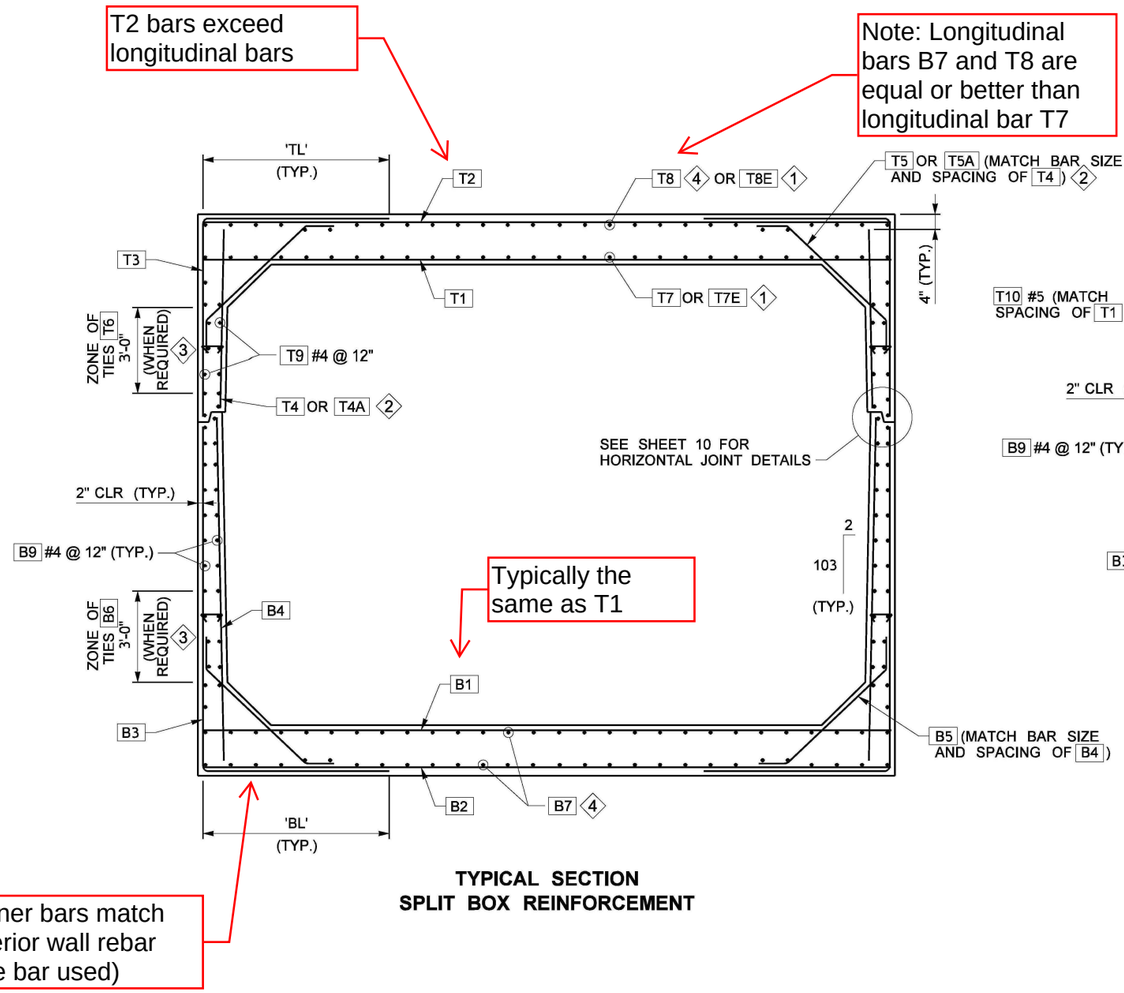
REVISION: AUGUST 21, 2024

APPROVED: MARCH 24, 2011
Nancy Daubenberger
STATE BRIDGE ENGINEER

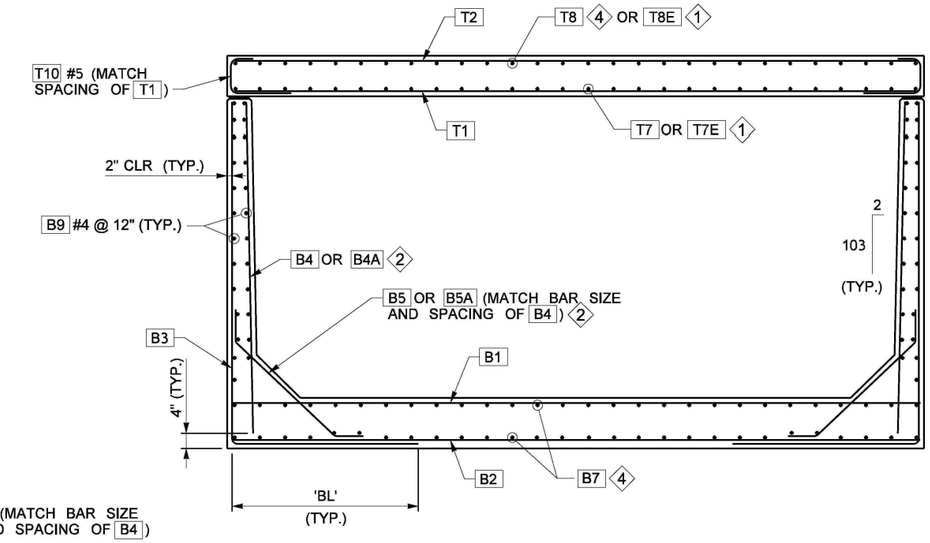
DO NOT INCLUDE TABLES WITH PLAN

FIG. 5-395.100(E)

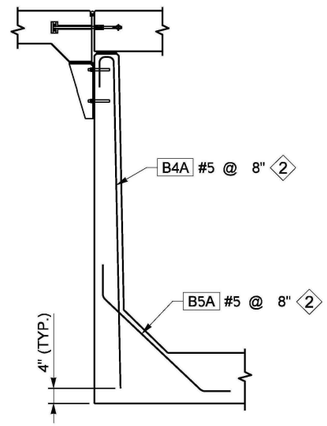
TITLE: PRECAST CONCRETE BOX CULVERT TABLES



TYPICAL SECTION
SPLIT BOX REINFORCEMENT

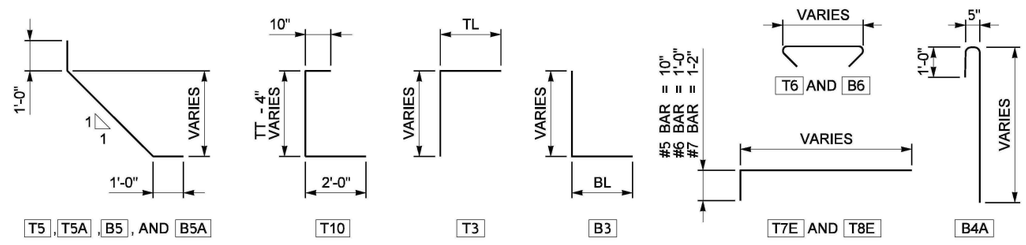


TYPICAL SECTION
SPLIT BOX ~ SLAB REINFORCEMENT



SPLIT BOX ~ SLAB ADDITIONAL REINFORCEMENT WHEN APPROACH SLAB SEAT IS PRESENT

BENDING DIAGRAM



(ALL DIMENSIONS ARE OUT TO OUT)

KEY NOTES

1. BARS T7E AND T8E SHALL BE INSTALLED IN THE END SEGMENTS. ROTATE 90° HOOK AS NECESSARY TO PROVIDE THE SPECIFIED CLEARANCE.

   SIZE AND SPACING OF BARS T7E SHALL MATCH T7.

   BARS T8E SHALL BE AS FOLLOWS:

   END SEGMENT WITHOUT HEADWALL OR TRAFFIC BARRIER: #5 @ 12"
   END SEGMENT WITH UP TO 2'-0" HEADWALL: #6 @ 12"
   END SEGMENT WITH UP TO 4'-0" HEADWALL: #6 @ 6"
   END SEGMENT WITH TRAFFIC BARRIER: #7 @ 6"
   FOR ADDITIONAL END SEGMENT DETAILS SEE SHEET 11.

2. WHEN AN APPROACH SLAB SEAT IS PRESENT, ADDITIONAL REINFORCEMENT IS REQUIRED AS FOLLOWS:

   FOR SPLIT BOX ~ SLAB STRUCTURES:
   ADD B4A #5 @ 8" AND B5A #5 @ 8". BUNDLE WITH TYPICAL B4 AND B5 RESPECTIVELY.

   FOR SPLIT BOX STRUCTURES:
   ADD T4A #5 @ 8" AND T5A #5 @ 8". BUNDLE WITH TYPICAL T4 AND T5 RESPECTIVELY.

3. TIES T6 #4 AND B6 #4 SHALL BE SPACED AT 6" MAX. VERTICALLY AND AT 2'-0" MAX. HORIZONTALLY. EACH TIE SHALL BE HOOKED AROUND LONGITUDINAL BARS T9 OR B9. ADDITIONAL BARS T9 AND B9 MAY BE ADDED TO FACILITATE PLACEMENT OF TIES AS REQUIRED.

4. BARS B7 AND T8 SHALL BE #4 @ 12" WHEN CORRESPONDING SLAB THICKNESS ≤ 20 INCHES, AND #4 @ 9" FOR THICKER SLABS.

GEOFFREY D. SWETT
STATE OF WASHINGTON
32820
STRUCTURAL ENGINEER
PROFESSIONAL ENGINEER
Sep 12, 2023

BURIED STRUCTURE
SPLIT BOX
STANDARD PLAN E-20.10-00

SHEET 4 OF 17 SHEETS

APPROVED FOR PUBLICATION
Mark A Gaines Sep 12, 2023
STATE DESIGN ENGINEER
Washington State Department of Transportation

DESIGN TABLE ~ CLASS I STRUCTURES ~ SPANS 12', 15' AND 18'

DESIGN SPAN S ◇1	DESIGN HEIGHT			FILL DEPTH FD ◇2	MEMBER THICKNESS			TOP UNIT REINFORCEMENT ◇3											BOTTOM UNIT REINFORCEMENT ◇3									MATERIAL QUANTITIES				STR. I BEARING DEMAND (PSF) ◇4	REQ'D HORIZ. JOINT TYPE ◇6
	TOTAL H	TOP UNIT WALL HT	BOT. UNIT WALL HB		WALLS TW	TOP SLAB TT	BOT. SLAB TB	T1 (SLAB INTERIOR)		T2 (SLAB EXTERIOR)		T3 (CORNER)			T4 (WALL INTERIOR)		T6 (TIES) ◇7	T7 (BOT.)		B1 (SLAB INTERIOR)		B2 (SLAB EXTERIOR)		B3 (CORNER)			B4 (WALL INTERIOR)		B6 (TIES) ◇7	TOP UNIT ◇8		BOTTOM UNIT ◇10			
								SIZE	SPA.	SIZE	SPA.	SIZE	SPA.	TL	SIZE	SPA.		SIZE	SPA.	SIZE	SPA.	SIZE	SPA.	SIZE	SPA.	BL	SIZE	SPA.		CONC. (CY/FT)	STEEL (LBS/FT)	CONC. (CY/FT)	STEEL (LBS/FT)		
12'	10'	N/A	10'	0' ≤ FD < 2'	10"	12"	10"	#7	6"	#5	12"	N/A			#4	8"	N/A	#5	10"	#6	6"	#7	5"	#7	5"	3'-2"	#4	8"	N/A	0.58	106.1	1.06	322.5	2397	2
				2'≤ FD ≤ 4'	10"	12"	10"	#7	6"	#5	12"				#4	8"		#4	12"	#6	6"	#7	5"	#7	5"	3'-2"	#4	8"		0.58	98.4	1.06	322.5	2490	2
				4'< FD ≤ 6'	12"	12"	12"	#8	6"	#5	12"				#4	8"		#4	12"	#6	6"	#6	5"	#7	5"	4'-3"	#4	8"		0.59	112.8	1.28	318.9	2901	2
				6'< FD ≤ 8'	12"	12"	12"	#8	6"	#5	12"				#4	8"		#4	12"	#6	6"	#7	5"	#7	5"	3'-4"	#4	8"		0.59	112.8	1.28	327.7	3255	2
				8'< FD ≤ 10'	12"	12"	12"	#9	6"	#5	12"				#4	8"		#6	10"	#7	6"	#7	5"	#8	5"	3'-8"	#4	8"		0.59	150.3	1.28	382.2	3631	2
	10'	N/A	10'	0' ≤ FD < 2'	10"	12"	10"	#9	6"	#5	12"				#4	8"		#4	12"	#8	6"	#6	5"	#7	5"	3'-11"	#4	8"		0.69	157.2	1.15	361.0	2269	2
				2'≤ FD ≤ 4'	10"	12"	10"	#8	6"	#5	12"	N/A			#4	8"	N/A	#4	12"	#8	6"	#6	5"	#7	5"	5'-1"	#4	8"	N/A	0.69	138.3	1.15	378.8	2313	2
				4'< FD ≤ 8'	12"	14"	12"	#9	6"	#5	10"				#4	8"		#4	12"	#9	6"	#6	5"	#7	5"	4'-1"	#4	8"		0.81	163.6	1.39	399.5	3147	2
				8'< FD ≤ 10'	12"	16"	14"	#9	6"	#6	12"				#4	8"		#5	10"	#8	6"	#6	5"	#8	5"	3'-7"	#4	8"		0.91	183.0	1.50	422.7	3625	2
				0' ≤ FD < 2'	10"	12"	10"	#9	6"	#6	7"	#6	7"	3'-0"	#4	8"		#5	9"	#8	6"	#5	10"	#6	5"	4'-4"	#4	8"		0.99	272.1	1.15	301.1	2030	1
				2'≤ FD ≤ 4'	10"	12"	10"	#9	6"	#6	7"	#6	7"	3'-0"	#4	8"		#4	12"	#8	6"	#5	12"	#6	6"	4'-9"	#4	8"		0.99	260.1	1.15	282.2	1992	1
				4'< FD ≤ 8'	10"	14"	12"	#9	6"	#5	10"	#5	5"	5'-2"	#4	8"		#4	12"	#9	6"	#5	10"	#6	5"	3'-9"	#4	8"		1.09	244.9	1.26	315.9	2792	1
15'	12'	5'	7'	8'< FD ≤ 12'	12"	16"	14"	#10	6"	#6	12"	#5	6"	3'-10"	#4	8"	N/A	#4	12"	#9	6"	#6	12"	#7	6"	3'-5"	#4	8"	N/A	1.27	273.3	1.50	342.9	3739	1
	TO 15'		TO 10'	12'< FD ≤ 16'	12"	18"	16"	#10	6"	#6	12"	#6	6"	3'-9"	#4	8"		#4	12"	#9	6"	#6	10"	#7	5"	3'-7"	#4	8"		1.38	292.3	1.60	375.3	4436	1
				16'< FD ≤ 20'	12"	20"	18"	#10	6"	#5	6"	#6	6"	3'-9"	#4	8"		#4	12"	#10	6"	#6	12"	#8	6"	3'-9"	#4	8"		1.48	303.5	1.71	417.2	5372	1
				20'< FD ≤ 24'	12"	22"	22"	#10	6"	#6	10"	#6	5"	3'-11"	#4	8"	Y	#4	12"	#10	6"	#6	9"	#8	6"	3'-11"	#4	8"	Y	1.59	327.1	1.92	443.4	6342	1
				24'< FD ≤ 28'	12"	22"	22"	#11	6"	#6	10"	#7	5"	3'-11"	#4	8"	Y	#4	12"	#10	6"	#6	10"	#8	5"	3'-11"	#4	8"	Y	1.59	387.9	1.92	473.0	7209	1
				28'< FD ≤ 32'	12"	24"	24"	#11	6"	#7	10"	#7	5"	4'-1"	#4	8"	Y	#4	12"	#11	6"	#7	10"	#8	5"	4'-1"	#4	8"	Y	1.69	402.5	2.02	522.3	8145	1
				32'< FD ≤ 38'	12"	24"	24"	#11	5"	#7	10"	#8	5"	4'-1"	#4	8"	Y	#4	12"	#11	6"	#7	10"	#8	5"	4'-1"	#4	8"	Y	1.69	470.2	2.02	522.3	9445	1
				0' ≤ FD < 2'	10"	16"	12"	#8	6"	#6	12"				#4	8"		#4	12"	#9	6"	#6	5"	#7	5"	3'-2"	#4	8"		1.04	164.2	1.37	422.3	2259	2
				2'≤ FD ≤ 4'	10"	14"	12"	#9	6"	#5	10"				#4	8"		#4	12"	#9	6"	#6	5"	#7	5"	3'-2"	#4	8"		0.92	188.0	1.37	420.7	2348	2
	10'	N/A	10'	4'< FD ≤ 6'	12"	16"	14"	#9	6"	#6	12"	N/A			#4	8"	N/A	#4	12"	#10	6"	#7	10"	#7	5"	4'-3"	#4	8"	N/A	1.06	195.9	1.63	449.0	2731	2
				6'< FD ≤ 8'	12"	18"	16"	#9	6"	#6	12"				#4	8"		#4	12"	#9	6"	#7	10"	#7	5"	3'-10"	#4	8"		1.18	196.3	1.75	412.6	3165	2
				8'< FD ≤ 10'	12"	18"	16"	#10	6"	#6	12"				#4	8"		#4	12"	#9	6"	#6	5"	#8	5"	3'-6"	#4	8"		1.18	196.3	1.75	483.8	3576	2
				0' ≤ FD < 2'	10"	14"	12"	#9	6"	#6	9"	#6	9"	3'-1"	#4	8"		#5	8"	#8	6"	#6	10"	#6	5"	3'-1"	#4	8"		1.22	290.0	1.37	328.2	1877	1
				2'≤ FD ≤ 4'	10"	14"	12"	#9	6"	#5	8"	#6	8"	4'-0"	#4	8"		#4	12"	#9	6"	#6	10"	#6	5"	3'-1"	#4	8"		1.22	272.9	1.37	356.4	2001	1
18'	12'	5'	7'	4'< FD ≤ 6'	10"	16"	14"	#9	6"	#5	9"	#5	6"	3'-8"	#4	8"	N/A	#4	12"	#9	6"	#5	10"	#7	5"	3'-6"	#4	8"	N/A	1.34	261.4	1.49	381.6	2349	1
	TO 15'		TO 10'	6'< FD ≤ 10'	10"	18"	16"	#10	6"	#6	12"	#6	6"	3'-5"	#4	8"		#4	12"	#10	6"	#6	10"	#7	5"	3'-5"	#4	8"		1.47	316.1	1.61	428.4	3198	1
				10'< FD ≤ 14'	12"	20"	18"	#11	6"	#5	6"	#5	6"	3'-9"	#4	8"		#4	12"	#10	6"	#6	10"	#7	5"	3'-9"	#4	8"		1.67	360.8	1.87	444.3	3984	1
				14'< FD ≤ 18'	12"	22"	22"	#11	6"	#5	7"	#6	7"	3'-11"	#4	8"	Y	#4	12"	#10	6"	#6	10"	#7	5"	3'-11"	#4	8"	Y	1.79	380.4	2.12	461.9	4973	1
				18'< FD ≤ 22'	12"	22"	22"	#11	5"	#6	10"	#6	5"	3'-11"	#4	8"	Y	#4	12"	#11	6"	#6	10"	#8	5"	3'-11"	#4	8"	Y	1.79	443.9	2.12	548.0	5841	1
				22'< FD ≤ 30'	12"	24"	24"	#10 ◇9	4"	#7	10"	#6	5"	4'-1"	#4	8"	Y	#4	12"	#10 ◇9	4"	#7	10"	#8	5"	4'-1"	#4	8"	Y	1.92	462.7	2.24	610.4	7643	1

KEY NOTES

◇1 DESIGN SPAN 'S', SHALL BE TAKEN EQUAL TO THE HORIZONTAL DISTANCE BETWEEN INSIDE FACE OF WALLS AT THE CORNER BETWEEN THE FILLET AND THE WALL AS SHOWN ON SHEET 1. FOR SEGMENTS WITH A SKEW SEE GRAPHICAL CLARIFICATION OF DESIGN SPAN ON SHEET 3. IF THE DESIGN SPAN FALLS IN BETWEEN A DESIGN SPAN VALUE IN THE TABLES, USE REINFORCEMENT FOR THE LONGER SPAN. CLASS 1 STRUCTURES WITH SPANS GREATER THAN 18 FEET AND LESS THAN 20 FEET SHALL USE GEOMETRY AND REINFORCEMENT FOR 21 FOOT SPAN CLASS 2 STRUCTURES WITH A PGA = 0.32G.

◇2 THE MAXIMUM FILL DEPTH OVER THE ENTIRE BURIED STRUCTURE SHALL BE USED WHEN SELECTING DESIGN FILL DEPTH.

◇3 FOR REINFORCING DETAILS SEE SHEET 4.

◇4 MAXIMUM REQUIRED BEARING RESISTANCE FOR STRENGTH LIMIT STATE.

◇5 THESE STRUCTURES HAVE BEEN DESIGNED FOR A TRAVERSE DIFFERENTIAL SETTLEMENT DISPLACEMENT EQUAL TO 2 INCHES PER 100 FEET OF STRUCTURAL SPAN (DESIGN SPAN + 1.0 FOOT).

◇6 FOR HORIZONTAL JOINT TYPE DETAILS SEE SHEET 10.

◇7 WALL TIES T6 AND B6 ARE REQUIRED WHEN INDICATED BY LETTER 'Y'.

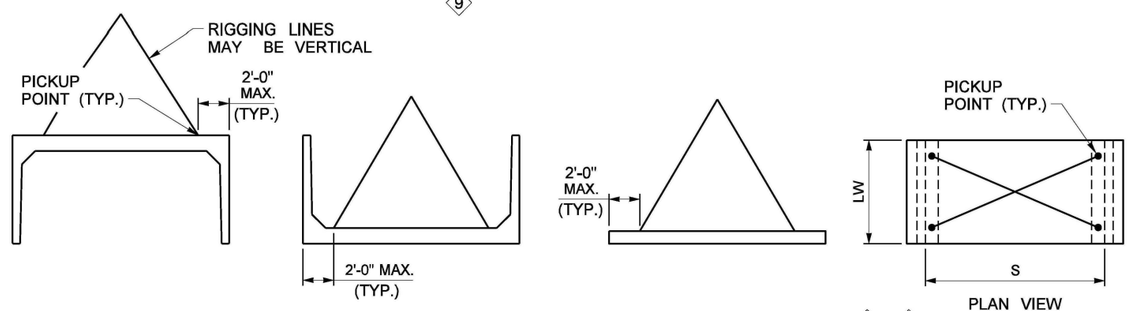
◇8 MATERIAL QUANTITIES ARE FOR A TYPICAL INTERIOR SEGMENT. STEEL WEIGHT DOES NOT INCLUDE ADDITIONAL REINFORCING REQUIRED FOR APPROACH SLAB SEAT.

◇9 SINGLE BARS SPACED AT 4 INCHES MAY BE SUBSTITUTED BY TWO-BAR BUNDLES SPACED AT 8".

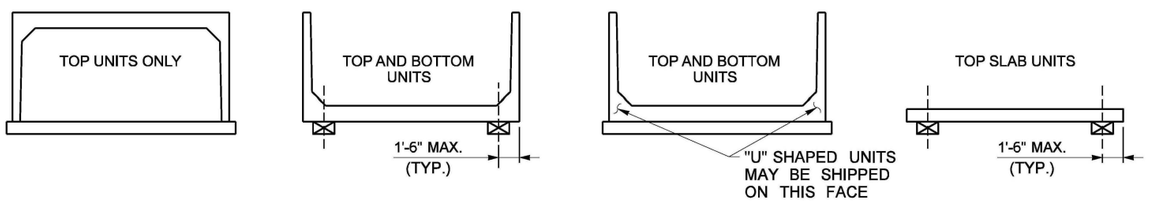
◇10 QUANTITIES OF BOTTOM UNIT CORRESPOND TO 'HB' = 10'-0".

◇11 REINFORCING OF PRECAST UNITS HAVE BEEN DESIGNED FOR HANDLING AND SHIPPING ORIENTATIONS PRESENTED ON THIS SHEET. ALTERNATE SHIPPING OR HANDLING ORIENTATIONS SHALL BE ANALYZED BY THE CONTRACTOR.

◇12 CONCRETE COMPRESSIVE STRENGTH SHALL BE AT LEAST F'CI = 3.5 KSI FOR HANDLING AND F'C = 7.0 KSI FOR SHIPPING.



HANDLING ORIENTATIONS FOR TOP AND BOTTOM UNITS ◇11, ◇12



SHIPPING ORIENTATIONS ◇11, ◇12

GEOFFREY D. SWETT — STATE OF WASHINGTON — 32820 — STRUCTURAL ENGINEER — PROFESSIONAL ENGINEER

Sep 12, 2023

BURIED STRUCTURE SPLIT BOX

STANDARD PLAN E-20.10-00

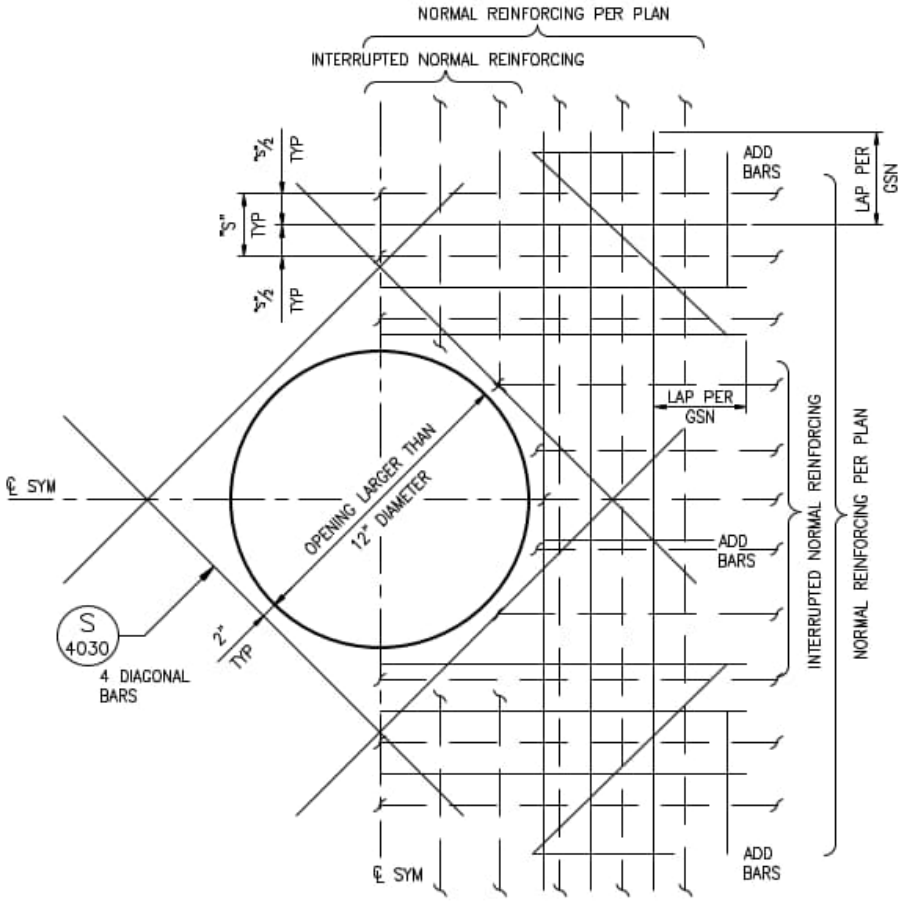
SHEET 5 OF 17 SHEETS

APPROVED FOR PUBLICATION

Mark A Peaires Sep 12, 2023

STATE DESIGN ENGINEER

Washington State Department of Transportation



NOTES:

1. THIS DETAIL TO BE USED FOR OPENINGS LARGER THAN 12"ø AND WHEN CALLED FOR ON THE DRAWINGS OR WHEN NO OTHER ADDITIONAL REINFORCING IS SPECIFIED. FOR OPENINGS SMALLER THAN 12"ø, USE DETAIL S/4030.

2. FOR OPENINGS LESS THAN 60": AREA OF ADD BARS AT EACH EDGE OF OPENING IN EACH DIRECTION SHALL MATCH ½ THE CROSS SECTIONAL AREA OF THE INTERRUPTED BARS. BARS UP TO TWO BAR SIZES LARGER THAN NORMAL REINFORCING MAY BE USED. FIT ADD BARS WITHIN A DISTANCE OF 2X WALL/SLAB THICKNESS FROM EDGE OF OPENING.

   FOR OPENINGS 60" AND LARGER: OMIT VERTICAL AND HORIZONTAL ADD BARS AND USE (4) #6 BARS FOR DIAGONAL BARS SIMILAR TO DETAIL S/4030.

3. CUT NORMAL REINFORCING 2" CLEAR OF OPENING.

4. PROVIDE STANDARD ACI HOOKS ON BARS/DOWELS IF STRAIGHT EXTENSION PAST THE OPENING CANNOT BE ACHIEVED.

5. PLACE ADD BARS IN SAME PLANES AS NORMAL REINFORCING INDICATED.

6. PLACE #5 ADD DIAGONAL CORNER BARS UNDER NORMAL REINFORCING INDICATED.

7. WHEN AN INTERSECTING SLAB OR WALL OCCURS WITHIN ONE WALL/SLAB THICKNESS OF THE EDGE OF OPENING, NO ADD BARS ARE REQUIRED ON THAT SIDE.

ADDITIONAL REINFORCING AT CIRCULAR OPENINGS IN WALLS/SLABS

NOT TO SCALE

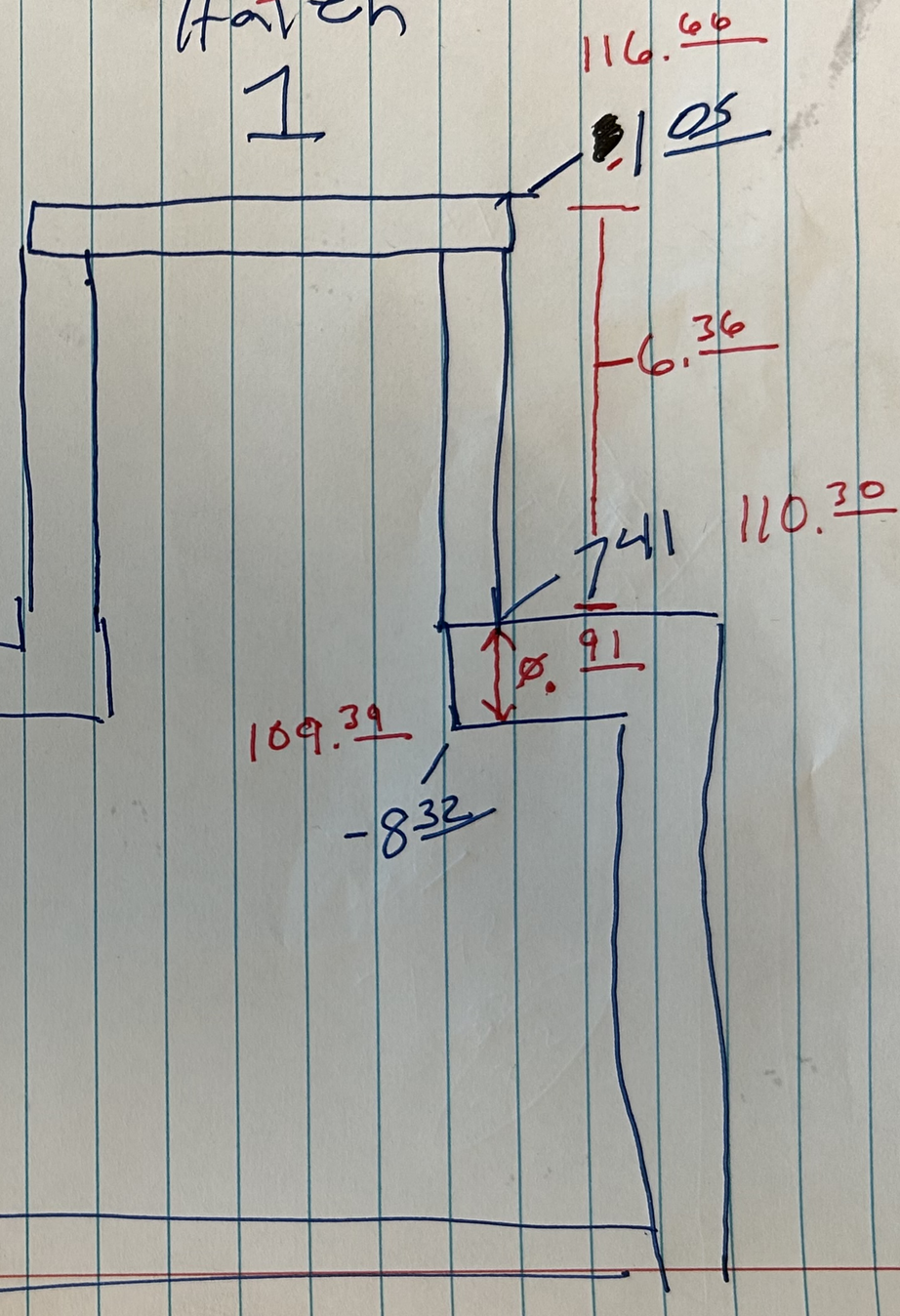
S 4036

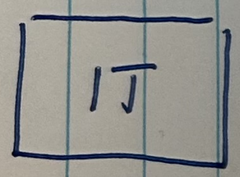

I-405 NB
ITS #103
1
2
3
4
5
6
7
I-405 SB

North End

Hatch

1





117.71

250317 PRKER 120

Hatch 6

115.38 per survey shot

0.00

ITS

25031 7PRKER_103

.10

115.48

Rim @ Grade

6.10

Grade rings

109.38

Top structure

-6.00

Ø.90

-6.90

108.48

Vault Ceiling

May 15, 2025 at 2:00:35 AM
I-405 S
Bothell WA 98021
United States