

Bridge Load Rating

Prepared for

Maine Department of Transportation

Monson

Piscataquis County

Bridge No. 6591

Route 6/15

REVISION 1

WIN: 022930.00

Date of Rating: June 5, 2019

Prepared By: Ian Riley, PE, SE



MaineDOT

REVIEWED

June 11th, 2019

THIS DOCUMENT HAS BEEN REVIEWED IN ACCORDANCE
WITH STATE OF MAINE STANDARD SPECIFICATIONS
SECTION 105.7 – WORKING DRAWINGS

Reviewed By:



Taylor Clark

All 107 pages

FOSCADH

[faw-skuh] CONSULTING ENGINEERS

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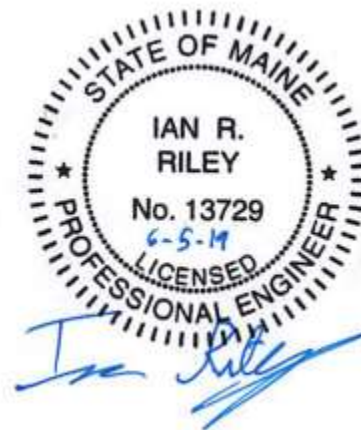


Superior Concrete, LLC

982 Minot Ave., Auburn, ME 04210

Phone: 207-784-1388

Stamp



Bridge No: 6591
 Town/City: Monson
 Route Carried: 6 / 15
 Crosses: _____

Bridge Name: _____
 Owner: _____
 Year Built: 2019
 Year(s) Rebuilt/Rehab: _____

SUMMARY OF BRIDGE RATING

Vehicle Type		Load Rating Factor	RT (TONS)	POSTING LOAD (TONS)
HL-93	INVENTORY	1.14	36.00	
	OPERATING	1.48	36.00	
HL-93 Modified (125%)	INVENTORY	1.03	45.00	
	OPERATING	1.33	45.00	
CONFIGURATION 1		N/A	50.00	
CONFIGURATION 2		N/A	47.00	
CONFIGURATION 3		N/A	44.00	
CONFIGURATION 4		N/A	44.00	
CONFIGURATION 5		N/A	44.00	
CONFIGURATION 6		1.06	37.95	
CONFIGURATION 7		N/A	29.50	
CONFIGURATION 8		N/A	18.70	

Group 1 Posting Analysis (Configuration 1)

Governing Posting: _____
 Governing Load Model: _____

Group 2 Posting Analysis (Configurations 2 – 5)

Governing Posting: _____
 Governing Load Model: _____

Group 3 Posting Analysis (Configurations 6 – 8)

Governing Posting: _____
 Governing Load Model: _____

LRFR Evaluation Factors:

Live Load Distribution Factor: 1.15
 Impact Factor: 1.268
 Governing Condition Factor, ϕ_c : 1.00
 System Factor, ϕ_s : 1.00
 ADTT (one-way): _____

Please check all the boxes that apply:

- ☐ Bridge load rating is governed by substructure rating
- ☐ Exterior girder controls load rating
- ☒ As-built load rating
- ☐ As-inspected load rating
- ☐ As-designed load rating
- ☐ One lane loaded
- ☐ Advanced analysis used
- ☐ Actual measurements taken
- ☐ Finite fatigue life ____ years

BREAKDOWN OF BRIDGE RATING

Town/City: Monson

Route Carried: 6 / 15

Bridge No: 6591

Crosses:

LOAD RATING POINTS OF INTEREST

<u>Bridge Component</u>	HL-93		HL-93 Modified		MaineDOT Truck Configurations							
	Inv. 72.0 kip	Oper. 72.0 kip	Inv. 90.0 kip	Oper. 90.0 kip	1 100.0 kip	2 94.0 kip	3 88.0 kip	4 88.0 kip	5 88.0 kip	6 75.9 kip	7 59.0 kip	8 37.4 kip
TOP SLAB FLEXURE STRENGTH I	1.14	1.48	1.03	1.33						1.15		
TOP SLAB SHEAR STRENGTH I	1.97	2.55	1.89	2.45						2.20		
BOTTOM SLAB FLEXURE STRENGTH I	1.35	1.74	1.39	1.80						1.06		
BOTTOM SLAB SHEAR STRENGTH I	3.30	4.27	3.38	4.38						2.44		
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
[COMPONENT] [LIMIT STATE] [ANALYZED CONDITION]												
CONTROLLING RATING FACTORS	1.14	1.48	1.03	1.33						1.06		

FOSCADH CONSULTING ENGINEERS

Project : Monson Box Culvert

Task : Box Culvert Design

Job No. : WIN: 22930.00

Client: American Concrete

File: Box Culvert - R1.etcx

Sht ____ of ____

By:IRR

Ck:

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Spec.: LRFD 8th ed.
Type of Culvert: Precast

Physical Dimensions

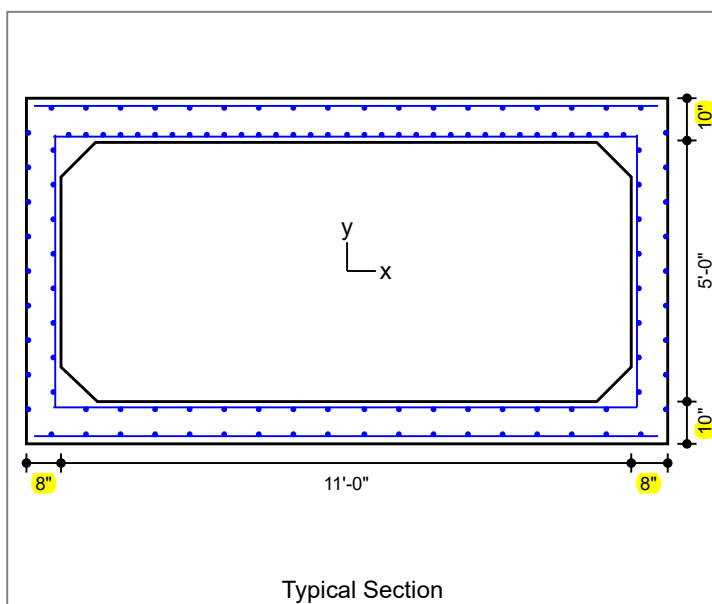
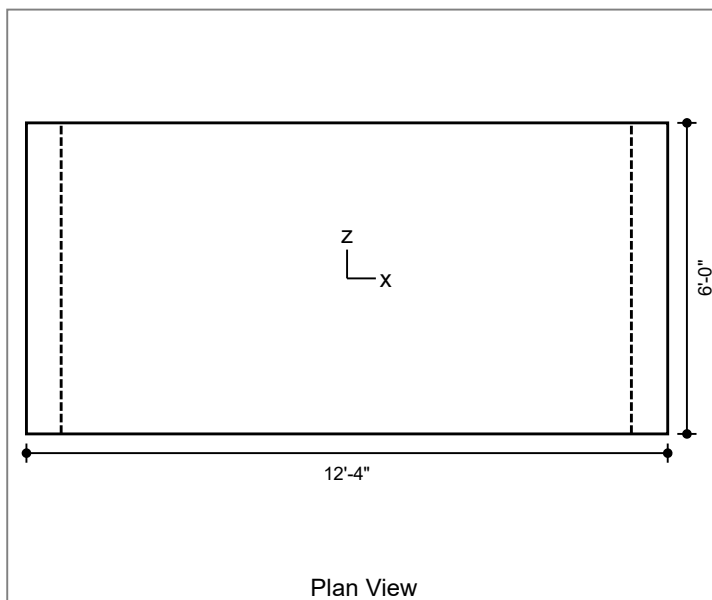
Clear Span:	11'-0"
Clear Height:	5'-0"
Top Slab:	10"
Bottom Slab:	10"
Ext. Wall:	8"
Fill Depth Range	
Maximum:	4.00 ft
Minimum:	1.50 ft
Increment:	0.50 ft
Length:	6'-0"
Skew Angle:	6.00 deg
Bottom Slab Support:	Full Slab
Top Haunch, Width:	8"
Top Haunch, Height:	8"
Bottom Haunch, Width:	8"
Bottom Haunch, Height:	8"

Material Properties

Concrete	
Strength, f'c:	5.000 ksi
Density:	0.150 kcf
Elasticity, Ec:	4287 ksi
Type:	Normal wt
Steel	
Yield, fy:	70 ksi
Allow Stress:	24 ksi
Elasticity, Es:	29000 ksi
Soil	
Density:	0.125 kcf
Exposure Factor	
Class 2 Exposure	
Reinforcement Covers	
Ext. Cover Top Slab:	2"
Ext. Cover Bottom Slab	2"
Ext. Cover Walls	2"
Int. Cover Walls	1 1/2"
Int. Top Slab	1 1/2"
Int. Cover Bottom Slab	1 1/2"

Loads

Live Load	
Vehicle Names:	125% HL-93 MaineDOT Config 6 HL-93
Traffic Direction:	Parallel
Eq. Height of Soil:	Calculated
Max No. of Lanes:	1
Dead Load	
Future Wearing Surface:	0.000 klf
Additional Dead Load:	0.000 klf
Concentrated Loads:	none
Lateral Soil Loads	
Eq. Fluid Press. Max:	93.70 pcf
Eq. Fluid Press. Min:	30.00 pcf
Consider Int. Water Press.:	no



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Sht ____ of ____

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Ck:_____

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Concrete Summary

Volume of Concrete: 1.041 cy/ft Total Volume of Concrete: 6.247 cy

Reinforcing Steel Bar Schedule (lb)

Location	Mark	Sheets Included	As Provided
Top Slab(Int)	A100	Top	0.624
Bot Slab(Int)	A200	Bot	0.624
Top Slab(Ext)	A300	Top	0.240
Bot Slab(Ext)	A400	Bot	0.240
Corner(Top)	A1	Top w/ nest	0.450
Corner(Bot)	A2	Bot w/ nest	0.450
Wall(Int)	B1	L&R	0.192
Longit. Top (Int)	C100	Top	0.240
Longit. Bot (Int)	C200	Bot	0.075
Longit. Top (Ext)	C1	Top	0.075
Longit. Bot (Ext)	C1	Bot	0.075
Longit. Wall (Ext)	C1	L&R	0.075
Longit. Wall (Int)	C1	L&R	0.075

Horiz. leg =
3'-0" (typ.)

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Live Load: Vehicle: (AA) 125% HL-93 - Design Vehicle
                Axle No.      weight(k)      Dist. From Previous(ft)
                    1           10.00            0.00
                    2           40.00           14.00
                    3           40.00           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: 0.64 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
                Combine: Truck Or Tandem Or 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) MaineDOT Config 6 - Legal Vehicle
                Axle No.      weight(k)      Dist. From Previous(ft)
                    1          11.90            0.00
                    2          21.30            9.00
                    3          21.40             4.00
                    4          21.30             4.00
                Gage width: 6.00 ft, Tread width: 20.00 in, Tread Length: 10.00 in
                Include Tandem: no
                Lane Load: 0.64 klf, P-Moment: 0.00 k, P-Shear: 0.00 k
                Combine: Truck Or Tandem Or Lane
                Rating Load Factor: 1.75
                Design Load Combinations: Strength I
                Override MPF: no
                Override DLA: no
Vehicle: (AC) 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: 0.64 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
Include Lane Load : no Max. No. of Lanes: Computed by Program

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Traffic Direction** : Lanes Parallel to Main Reinforcement
Neglect Live Load for Large Fill Depths: yes
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.: 93.70 pcf Min. Equiv. Fluid Press. : 30.00 pcf

Buoyancy Check : no

Fluid Pressures: Apply Water Press. : no

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
Ductility: 1.000 Importance: 1.000 Redundancy, non-earth: 1.000 Redundancy, earth: 1.050
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 1.5000 in
Walls : 2.0000 in 1.5000 in
Bot Slab: 2.0000 in 1.5000 in

Assigned reinforcement:
Location Mark Size Spacing (in) # of Layers
Top Slab Inside A100 (AS2) D10.4 2.0000 1
Bottom Slab Inside A200 (AS3) D10.4 2.0000 1
Top Slab Outside A300 (AS7) D8 4.0000 1
Bottom Slab Outside A400 (AS8) D8 4.0000 1
Top Corner A1 (AS1) D8 4.0000 1
Bottom Corner A2 (AS1) D8 4.0000 1
Ext. Wall Inside B1 (AS4) D6.4 4.0000 1
Longitudinal C1 (AS6) D5 8.0000 1
Top Distribution C100 (AS5) D8 4.0000 1
Bottom Distribution C200 D5 8.0000 1

Analysis Options

LL Analysis : Automatically Set Traffic Direction to Account for Skew Effects: yes (**will override previous)
Limit Distribution Width to Culvert Length for Fills < 2 ft: no
Limit Distribution Width to Culvert Length for Fills > 2 ft: no
Combine Longitudinal Axle Overlaps for Fills > 2 ft: yes
Combine Transverse Axle Overlaps for Fills > 2 ft: no
Axle Placement Increment for Moving Load Analysis: 20
Include Impact on Bottom Slab: yes
Always Distribute Wheel Load: yes
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: yes
Epoxy coat steel: no
Slenderness : checked K Factor: 2.00
Analysis Modeling : Use Haunches in the Structural Analysis Model: yes
Crit. Section: Consider Haunches when Selecting Critical Section Locations: yes
Extend Critical Section for Shear Beyond the End of the Haunch: no
Use Max. Moment with Max. Shear at the Critical Section for Shear: yes
Flexure : Ignore Axial Thrust: no
Use Eq. 12.10.4.2.4a-1: no
Shear : Always Check Iterative Beta Method
Environmental: Apply environmental durability factors: no
Live Load Deflection Criteria: 1/800

ANALYSIS RESULTS
 =====

Top Slab Thickness = 10.00 in
 Bottom Slab Thickness = 10.00 in
 Exterior Wall Thickness = 8.00 in

Modular Ratio (N) = 6.76 Max. Steel Ratio = 0.020
 Design Span = 11.67 ft Design Height = 5.83 ft

Volume of Concrete: 1.041 cy/ft

M dimension = 1.94 ft (method of equivalent capacity)
 = 4.06 ft (method of contraflexure - ASTM)

Reinforcing Steel Schedule

Location	Mat Mark	Sheets Included	Layers	As,prv (in2/ft)
Top slab (int)	A100 (AS2)	Top	1	0.624
Bot slab (int)	A200 (AS3)	Bot	1	0.624
Top slab (ext)	A300 (AS7)	Top	1	0.240
Bot slab (ext)	A400 (AS8)	Bot	1	0.240
Corner Top-U	A1 (AS1)	Top w/ nest	1	0.450
Corner Bottom-U	A2 (AS1)	Bot w/ nest	1	0.450
Ext wall (int)	B1 (AS4)	L&R	1	0.192
Top slab (int- 1)	C100 (AS5)	Top	1	0.240
Bot slab (int- 1)	C200	Bot	1	0.075
Temperature (1)	C1 (AS6)	Top	1	0.075
Temperature (1)	C1 (AS6)	Bot	1	0.075
Temperature (1)	C1 (AS6)	L&R	1	0.075
Temperature (1)	C1 (AS6)	L&R	1	0.075

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

AS Bar Marks

Location	Controlling Case	Prv Area in2/ft
Transverse Side Wall - Outside Face (AS1)	a	0.45
Transverse Top Slab - Inside Face (AS2)	a	0.624
Transverse Bottom Slab - Inside Face (AS3)	a	0.624
Transverse Side Wall - Inside Face (AS4)	c	0.192
Distribution Top Slab - Inside Face (AS5)		0.24
Distribution Top Slab - Outside Face (AS6)		0.075
Transverse Top Slab - Outside Face (AS7)	c	0.24
Transverse Bottom Slab - Outside Face (AS8)	c	0.24

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

Sheet Inventory

Interior sheets - 4 sheet layout with no laps

Sheet Loc.	Mat Mark	Zone	Size	Spac. (in)	Length (ft-in)	Area (in2/ft)	H leg (ft-in)	V leg (ft-in)	Mat Mark	Size	Spac. (in)	Area (in2/ft)	wgt (lbs)
Top	A100	Base	D10.4	2.00	11- 9	0.624			C100	D8	4.00	0.240	204
										(1) sheets, Total weight:			
L&R	B1	Base	D6.4	4.00	5- 9	0.192		5- 9	C1	D5	8.00	0.075	40
										(1) sheets, Total weight:			
Bot	A200	Base	D10.4	2.00	11- 9	0.624			C200	D5	8.00	0.075	168
										(1) sheets, Total weight:			

Exterior sheets - 4 sheet layout with laps located in the slab

Sheet Loc.	Mat Mark	Zone	Size	Spac. (in)	Length (ft-in)	Area (in2/ft)	H leg (ft-in)	V leg (ft-in)	Mat Mark	Size	Spac. (in)	Area (in2/ft)	wgt (lbs)
Top	A300	Base	D8	4.00	12- 0	0.240			C1	D5	8.00	0.075	59
										(1) sheets, Total weight:			
L&R	A1	Base	D8	4.00	12- 4	0.240	3- 0	6- 4	C1	D5	8.00	0.075	61
	A1	Nested	D7	4.00	7- 3	0.210	3- 6	3- 9					32
	A2	Base	D8	4.00	12- 4	0.240	3- 0	6- 4	C1	D5	8.00	0.075	---
	A2	Nested	D7	4.00	7- 1	0.210	3- 4	3- 9					31
										(2) sheets, Total weight:			
Bot	A400	Base	D8	4.00	12- 0	0.240			C1	D5	8.00	0.075	95

(1) sheets, Total weight: 95

Weight of Steel: 136 lb/ft

Total weight of all sheets: 814

Notes:

Epoxy coating may be needed for A1, A300, and some C1 reinforcement, check with governing agency.
 L&R - left and right, TC - top corner, BC - bottom corner, INT - interior walls, EXT - exterior walls
 Nested line wires are additive to the base line wires, but nested cross wires replace base cross wires.
 Adder sheets may require cross wires, check with mesh supplier.

Splice Lengths Table:

Bar Mark	Size	Splice Length (ft-in)
B1	D6.4	1- 4
C1	D5	1- 4
CE1	D5	0- 0
C100	D8	1- 4
C200	D5	1- 4

Summary of Ratings Table:

Truck	Flexure					Shear				
	Fill	Member	Location	IR	OR	Fill	Member	Location	IR	OR
(AA) 125% HL-	2.00	2	MID	1.03	1.33	1.50	2	LT	1.90	2.46
(AB) MaineDOT	2.00	4	MID	1.06	1.06	1.50	2	LT	2.21	2.21
(AC) HL-93	2.00	2	MID	1.14	1.48	1.50	2	LT	1.97	2.56

Critical Sections Summary: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings		Truck	Fill Depth (ft)
										IR	OR		
BOT	9.00	-13.64	11.48	14.52	5.84	15.49	0.90	0.45	6.14	1.20	1.20	AB	2.50
MID	35.00	1.36	1.68	6.97	6.36	6.64	0.90	0.19	6.14	NC	NC	AA	1.50
MID-	35.00	-12.88	12.52	14.52	5.84	15.71	0.90	0.45	6.14	1.28	1.28	AB	2.00
TOP	9.00	-12.40	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.36	1.76	AC	1.99

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 (in ²)	Mcr (k-ft)	Load Ratings		Truck	Fill Depth (ft)
										IR	OR		
LT	7.00	-9.57	3.73	32.90	12.84	30.38	0.90	0.45	9.59	3.84	4.98	AA	1.99
MID	70.00	25.19	-0.50	28.72	8.32	25.72	0.90	0.62	9.59	1.03	1.33	AA	2.00
RT	7.00	-9.57	3.73	32.90	12.84	30.38	0.90	0.45	9.59	3.84	4.98	AA	1.99

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 (in ²)	Mcr (k-ft)	Load Ratings		Truck	Fill Depth (ft)
										IR	OR		
LT	7.00	-9.34	4.84	32.90	12.84	30.61	0.90	0.45	9.59	4.68	4.68	AB	2.50
MID	70.00	24.90	0.79	28.72	8.32	26.04	0.90	0.62	9.59	1.06	1.06	AB	2.00
RT	7.00	-9.34	4.84	32.90	12.84	30.61	0.90	0.45	9.59	4.68	4.68	AB	2.50

Critical Sections Summary: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 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 (in ²)	Max. Spac (in)	Load Ratings		Truck	Fill Depth (ft)
												IR	OR		
BOT	10.76	3.47	-13.6	12.52	5.76	8.79	2.000	9.77b	0.00	0.00	0.00	4.08	4.08	AB	2.00
MID	35.00	0.94	1.2	2.01	6.23	16.73	3.521	18.59a	0.00	0.00	0.00	99.99	99.99	AA	2.00
MID-	35.00	0.94	-11.3	12.95	5.76	9.94	2.261	11.04a	0.00	0.00	0.00	21.01	27.23	AA	2.00
TOP	10.76	-2.90	-12.4	12.88	5.76	9.20	2.094	10.23a	0.00	0.00	0.00	4.27	5.54	AA	1.99

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 (in ²)	Max. Spac (in)	Load Ratings		Truck	Fill Depth (ft)
												IR	OR		
LT	14.52	11.05	-9.4	3.62	12.53	19.22	2.010	21.36a	0.00	0.00	0.00	1.90	2.46	AA	1.50
MID	70.00	4.39	24.9	-0.47	7.89	10.72	1.781	11.91a	0.00	0.00	0.00	2.44	3.17	AA	1.50
RT	14.52	11.05	-9.4	3.62	12.53	19.22	2.010	21.36a	0.00	0.00	0.00	1.90	2.46	AA	1.50

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

Design	Corr.	Corr.	Max.	Load Ratings	Fill

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 By:IRR Chk:____
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Loc	Dist. (in)	Shear (k)	Moment (k-ft)	A. F. (k)	Dv (in)	phi*Vn	Beta	Vc (k)	Vs (k)	Av (in2)	Spac (in)	IR	OR	Truck	Depth (ft)
LT	14.52	10.12	-8.8	4.68	12.53	20.13	2.105	22.36a	0.00	0.00	0.00	2.40	2.40	AB	1.99
MID	70.00	0.13	19.8	0.13	7.89	12.04	2.000	13.38b	0.00	0.00	0.00	94.45	99.99	AA	1.50
RT	14.52	10.12	-8.8	4.68	12.53	20.12	2.104	22.36a	0.00	0.00	0.00	2.40	2.40	AB	1.99

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

Analysis Results: Fill Depth = 1.50 ft

Load Parameters:

Fe = 1.02 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.726	0.180
Live Load Surcharge	0.315	0.315
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Mls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-1.14	0.00	-0.71	-0.47	0.00
1- 1	-1.48	-1.14	0.00	0.10	0.01	0.00
1- 2	-1.38	-1.14	0.00	0.69	0.39	0.00
1- 3	-1.28	-1.14	0.00	1.06	0.66	0.00
1- 4	-1.18	-1.14	0.00	1.25	0.82	0.00
1- 5	-1.08	-1.14	0.00	1.26	0.87	0.00
1- 6	-0.98	-1.14	0.00	1.12	0.82	0.00
1- 7	-0.88	-1.14	0.00	0.84	0.66	0.00
1- 8	-0.78	-1.14	0.00	0.45	0.39	0.00
1- 9	-0.68	-1.14	0.00	-0.05	0.01	0.00
1-10	-0.58	-1.14	0.00	-0.62	-0.47	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	1.60	0.92	0.00
1- 1	0.17	0.00	0.00	1.19	0.74	0.00
1- 2	0.17	0.00	0.00	0.82	0.55	0.00
1- 3	0.17	0.00	0.00	0.47	0.37	0.00
1- 4	0.17	0.00	0.00	0.16	0.18	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.37	-0.18	0.00
1- 7	0.17	0.00	0.00	-0.58	-0.37	0.00
1- 8	0.17	0.00	0.00	-0.77	-0.55	0.00
1- 9	0.17	0.00	0.00	-0.92	-0.74	0.00
1-10	0.17	0.00	0.00	-1.04	-0.92	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-1.14	0.00	-0.64	-0.47	0.00
2- 1	0.21	0.03	0.00	-0.64	-0.47	0.00
2- 2	0.81	0.95	0.00	-0.64	-0.47	0.00
2- 3	1.23	1.60	0.00	-0.64	-0.47	0.00
2- 4	1.49	1.99	0.00	-0.64	-0.47	0.00
2- 5	1.57	2.13	0.00	-0.64	-0.47	0.00
2- 6	1.49	1.99	0.00	-0.64	-0.47	0.00
2- 7	1.23	1.60	0.00	-0.64	-0.47	0.00
2- 8	0.81	0.95	0.00	-0.64	-0.47	0.00
2- 9	0.21	0.03	0.00	-0.64	-0.47	0.00
2-10	-0.58	-1.14	0.00	-0.64	-0.47	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	1.12	0.00	0.00	0.00	0.00
2- 1	0.58	0.90	0.00	0.00	0.00	0.00
2- 2	0.44	0.67	0.00	0.00	0.00	0.00
2- 3	0.29	0.45	0.00	0.00	0.00	0.00
2- 4	0.15	0.22	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.22	0.00	0.00	0.00	0.00
2- 7	-0.29	-0.45	0.00	0.00	0.00	0.00
2- 8	-0.44	-0.67	0.00	0.00	0.00	0.00
2- 9	-0.58	-0.90	0.00	0.00	0.00	0.00
2-10	-0.80	-1.12	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-1.14	0.00	-0.71	-0.47	0.00
4- 1	-0.13	0.03	0.00	-0.71	-0.47	0.00
4- 2	1.00	0.95	0.00	-0.71	-0.47	0.00
4- 3	1.80	1.60	0.00	-0.71	-0.47	0.00
4- 4	2.28	1.99	0.00	-0.71	-0.47	0.00
4- 5	2.44	2.13	0.00	-0.71	-0.47	0.00
4- 6	2.28	1.99	0.00	-0.71	-0.47	0.00
4- 7	1.80	1.60	0.00	-0.71	-0.47	0.00
4- 8	1.00	0.95	0.00	-0.71	-0.47	0.00
4- 9	-0.13	0.03	0.00	-0.71	-0.47	0.00
4-10	-1.58	-1.14	0.00	-0.71	-0.47	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	1.12	0.00	0.00	0.00	0.00
4- 1	1.10	0.90	0.00	0.00	0.00	0.00
4- 2	0.83	0.67	0.00	0.00	0.00	0.00
4- 3	0.55	0.45	0.00	0.00	0.00	0.00
4- 4	0.28	0.22	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.22	0.00	0.00	0.00	0.00
4- 7	-0.55	-0.45	0.00	0.00	0.00	0.00
4- 8	-0.83	-0.67	0.00	0.00	0.00	0.00
4- 9	-1.10	-0.90	0.00	0.00	0.00	0.00
4-10	-1.38	-1.12	0.00	0.00	0.00	0.00
Right						

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 1.50 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	1.12	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.04	0.92	0.00
4	0.17	0.00	0.00	1.60	0.92	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.638	2.56	
	2	2.553	2.56	14.00
	3	2.553	2.56	14.00
Tandem	1	1.596	2.56	

2 1.596 2.56

4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 4.66 ft
 Note: Distribution width is calculated for one wheel only.
 Impact Factor : 1.27
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.638 2.56 19.83
 2 2.553 2.56 5.83
 3 2.553 2.56 -8.17
 Maximum +Moment : 11.58 k-ft
 Corresponding Moment at End : -5.38 k-ft
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.638 2.56 15.28
 2 2.553 2.56 1.28
 3 2.553 2.56 -12.72
 Maximum +Shear : 5.87 k
 Corresponding Shear at Mid : -0.67 k
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum +Moment in Top Slab
 Tandem 1 1.596 2.56 6.80
 2 1.596 2.56 2.80
 Maximum +Moment : 10.05 k-ft
 Corresponding Moment at End : -5.67 k-ft
 Coincident Bottom Slab Load : 0.70 k/ft

Maximum +Shear in Top Slab
 Tandem 1 1.596 2.56 5.28
 2 1.596 2.56 1.28
 Maximum +Shear : 5.91 k
 Corresponding Shear at Mid : -1.09 k
 Coincident Bottom Slab Load : 0.70 k/ft

Maximum -Moment in Top Slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.638 2.56 19.36
 2 2.553 2.56 5.36
 3 2.553 2.56 -8.64
 Maximum -Moment : -5.43 k-ft
 Corresponding Moment at Mid : 11.34 k-ft
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.638 2.56 24.39
 2 2.553 2.56 10.39
 3 2.553 2.56 -3.61
 Maximum -Shear : -5.87 k
 Corresponding Shear at Mid : 0.67 k
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum -Moment in Top Slab
 Tandem 1 1.596 2.56 7.50
 2 1.596 2.56 3.50
 Maximum -Moment : -5.79 k-ft
 Corresponding Moment at Mid : 9.90 k-ft
 Coincident Bottom Slab Load : 0.70 k/ft

Maximum -Shear in Top Slab
 Tandem 1 1.596 2.56 10.39
 2 1.596 2.56 6.39
 Maximum -Shear : -5.91 k
 Corresponding Shear at Mid : 1.09 k
 Coincident Bottom Slab Load : 0.70 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-4.02	0.39	-0.42	0.00	-4.40	0.24	-0.33	0.00	0.00	0.00	0.00
1- 1	0.00	-3.80	0.39	-0.42	0.00	-4.41	0.24	-0.33	0.00	0.00	0.00	0.00
1- 2	0.00	-3.77	0.39	-0.42	0.00	-4.42	0.24	-0.33	0.00	0.00	0.00	0.00
1- 3	0.00	-3.87	0.39	-0.42	0.00	-4.53	0.24	-0.33	0.00	0.00	0.00	0.00
1- 4	0.00	-4.05	0.39	-0.42	0.00	-4.68	0.24	-0.33	0.00	0.00	0.00	0.00
1- 5	0.00	-4.26	0.39	-0.42	0.00	-4.86	0.24	-0.33	0.00	0.00	0.00	0.00
1- 6	0.00	-4.48	0.39	-0.42	0.00	-5.04	0.24	-0.33	0.00	0.00	0.00	0.00
1- 7	0.00	-4.71	0.39	-0.42	0.00	-5.22	0.24	-0.33	0.00	0.00	0.00	0.00
1- 8	0.00	-4.95	0.39	-0.42	0.00	-5.41	0.24	-0.33	0.00	0.00	0.00	0.00
1- 9	0.02	-5.19	0.39	-0.42	0.00	-5.60	0.24	-0.33	0.00	0.00	0.00	0.00
1-10	0.09	-5.43	0.39	-0.42	0.05	-5.79	0.24	-0.33	0.00	0.00	0.00	0.00
Top												
Member 2: (Top slab)												
Left												
2- 0	0.09	-5.43	5.87	0.00	0.05	-5.79	5.91	0.00	0.00	0.00	0.00	0.00
2- 1	3.41	-1.90	5.23	-0.14	2.13	-1.54	5.09	-0.09	0.00	0.00	0.00	0.00
2- 2	6.86	0.00	4.57	-0.55	5.38	0.00	4.24	-0.34	0.00	0.00	0.00	0.00
2- 3	9.45	0.00	3.89	-1.17	8.15	0.00	3.40	-0.73	0.00	0.00	0.00	0.00
2- 4	11.05	0.00	3.20	-1.83	9.73	0.00	2.56	-1.17	0.00	0.00	0.00	0.00
2- 5	11.58	0.00	2.51	-2.51	10.05	0.00	1.78	-1.78	0.00	0.00	0.00	0.00
2- 6	11.05	0.00	1.83	-3.20	9.73	0.00	1.17	-2.56	0.00	0.00	0.00	0.00
2- 7	9.45	0.00	1.17	-3.89	8.15	0.00	0.73	-3.40	0.00	0.00	0.00	0.00
2- 8	6.86	0.00	0.55	-4.57	5.33	0.00	0.34	-4.24	0.00	0.00	0.00	0.00

Sht:____of____
By:IRR Chk:____
6/5/2019 5:36:18 PM
Culvert p. 8 of 82
0.00
0.00

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.4	7.83	26.39	2.00	8.70
A2	Bot Corner Bar	-6.9	7.83	24.10	2.00	9.94
A100	Top Slab (int)	15.1	-0.23	38.24	2.00	7.29
A200	Bot Slab (int)	12.4	0.26	31.13	2.00	9.72

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-10.99	12.87	14.52	5.84	15.79	0.90	0.45	6.14	1.62	2.10
MID	35.00	1.36	1.68	6.97	6.36	6.64	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.89	12.87	14.52	5.84	15.79	0.90	0.45	6.14	1.56	2.02
TOP	9.00	-12.14	12.87	14.52	5.84	15.79	0.90	0.45	6.14	1.38	1.79

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
LT	7.00	-9.44	3.62	32.90	12.84	30.36	0.90	0.45	9.59	3.77	4.89
MID	70.00	24.88	-0.47	28.72	8.32	25.73	0.90	0.62	9.59	1.04	1.35
RT	7.00	-9.44	3.62	32.90	12.84	30.36	0.90	0.45	9.59	3.77	4.89

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
LT	7.00	-7.97	4.77	32.90	12.84	30.60	0.90	0.45	9.59	5.40	7.00
MID	70.00	19.80	0.13	28.72	8.32	25.88	0.90	0.62	9.59	1.43	1.85
RT	7.00	-7.97	4.77	32.90	12.84	30.60	0.90	0.45	9.59	5.40	7.00

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings	
													IR	OR
BOT	10.76	3.42	-11.0	12.87	5.76	9.69	2.205	36.43	10.77a	0.00	0.00	0.00	4.49	5.82
MID	35.00	0.85	1.4	1.68	6.23	15.73	3.311	31.73	17.48a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.85	-10.9	12.87	5.76	10.17	2.314	35.84	11.30a	0.00	0.00	0.00	13.47	17.47
TOP	10.76	-2.83	-12.1	12.87	5.76	9.30	2.116	36.97	10.33a	0.00	0.00	0.00	4.25	5.51

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings	
													IR	OR
LT	14.52	11.05	-9.4	3.62	12.53	19.22	2.010	43.17	21.36a	0.00	0.00	0.00	1.90	2.46
MID	70.00	4.39	24.9	-0.47	7.89	10.72	1.781	41.53	11.91a	0.00	0.00	0.00	2.44	3.17
RT	14.52	11.05	-9.4	3.62	12.53	19.22	2.010	43.17	21.36a	0.00	0.00	0.00	1.90	2.46

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings	
													IR	OR
LT	14.52	8.32	-8.0	4.77	12.53	22.04	2.304	40.95	24.49a	0.00	0.00	0.00	3.39	4.40
MID	70.00	0.13	19.8	0.13	7.89	12.04	2.000	45.00	13.38b	0.00	0.00	0.00	94.45	99.99
RT	14.52	8.32	-8.0	4.77	12.53	22.04	2.304	40.95	24.49a	0.00	0.00	0.00	3.39	4.40

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 1.50 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-3.825	-13.067	2.524	12.872	4.775	0.129
1- 1	-2.139	-11.085	1.677	12.872	3.875	-0.039
1- 2	-0.562	-10.738	1.677	12.872	3.020	-0.193
1- 3	0.530	-10.644	1.677	12.872	2.211	-0.335
1- 4	1.162	-10.714	1.677	12.872	1.446	-0.463
1- 5	1.363	-10.889	1.677	12.872	0.848	-0.699
1- 6	1.156	-11.137	1.677	12.872	0.746	-1.373
1- 7	0.570	-11.457	1.677	12.872	0.657	-2.002
1- 8	-0.369	-11.825	1.677	12.872	0.581	-2.586
1- 9	-1.636	-12.261	1.677	12.872	0.518	-3.124
1-10	-2.393	-14.128	2.524	12.872	0.468	-3.617
Top						
Member 2: (Top Slab)						
Left						
2- 0	-2.399	-14.150	-0.468	3.617	12.872	1.677
2- 1	6.019	-4.732	-0.468	3.617	11.113	1.293
2- 2	14.042	-0.183	-0.468	2.934	9.467	0.499
2- 3	20.011	0.760	-0.468	2.934	7.785	-1.079
2- 4	23.656	1.325	-0.468	2.934	6.086	-2.712
2- 5	24.876	1.514	-0.468	2.934	4.389	-4.389
2- 6	23.656	1.325	-0.468	2.934	2.712	-6.086
2- 7	20.011	0.760	-0.468	2.934	1.075	-7.785
2- 8	14.042	-0.183	-0.468	2.934	-0.499	-9.467
2- 9	5.994	-4.732	-0.468	3.617	-1.293	-11.113
2-10	-2.395	-14.150	-0.468	3.617	-1.677	-12.872
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-3.825	-13.067	0.129	4.775	10.473	2.202
4- 1	0.747	-2.879	0.129	4.775	8.394	1.761
4- 2	8.955	-0.119	0.129	4.031	6.315	1.321
4- 3	14.982	1.165	0.129	4.031	4.235	0.881
4- 4	18.599	1.936	0.129	4.031	2.156	0.440
4- 5	19.802	2.193	0.129	4.031	0.127	-0.127
4- 6	18.599	1.936	0.129	4.031	-0.440	-2.156
4- 7	14.982	1.165	0.129	4.031	-0.881	-4.235
4- 8	8.955	-0.119	0.129	4.031	-1.321	-6.315
4- 9	0.747	-2.879	0.129	4.775	-1.761	-8.394
4-10	-3.825	-13.067	0.129	4.775	-2.202	-10.473
Right						

----- Analysis Truck, MaineDOT Config 6 -----

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.759	2.56	
	2	1.359	2.56	9.00
	3	1.366	2.56	4.00
	4	1.359	2.56	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement

Distribution width : 4.66 ft

Note: Distribution width is calculated for one wheel only.

Impact Factor : 1.27

Distribution width : 0.00 ft

Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.759	2.56	18.86	Truck	1	0.759	2.56	18.72
	2	1.359	2.56	9.86		2	1.359	2.56	9.72
	3	1.366	2.56	5.86		3	1.366	2.56	5.72
	4	1.359	2.56	1.86		4	1.359	2.56	1.72

Maximum -Moment	:	-5.35	k-ft
Corresponding Moment at Mid	:	10.10	k-ft
Coincident Bottom Slab Load	:	0.90	k/ft
Maximum -Shear in Top Slab			
Truck	1	0.759	2.56
	2	1.359	2.56
	3	1.366	2.56
	4	1.359	2.56
Maximum -Shear	:	-5.72	k
Corresponding Shear at Mid	:	0.26	k
Coincident Bottom Slab Load	:	0.90	k/ft

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-5.35	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-5.34	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-5.33	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-5.33	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-5.33	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-5.33	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-5.33	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-5.34	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-5.34	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-5.34	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.05	-5.34	0.31	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.05	-5.34	5.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.82	-1.31	4.68	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	4.76	0.00	3.71	-0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	7.42	0.00	2.90	-0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	9.34	0.00	2.18	-1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	10.11	0.00	1.52	-1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	9.34	0.00	1.00	-2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	7.42	0.00	0.62	-2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	4.74	0.00	0.29	-3.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	1.81	-1.31	0.07	-4.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.05	-5.35	0.00	-5.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom slab)												
Left												
4- 0	0.00	-5.35	5.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.45	-0.29	4.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	4.44	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	7.48	0.00	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	9.31	0.00	1.05	0.00	0.00	0.						

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.2	7.64	25.61	2.00	9.10
A2	Bot Corner Bar	-7.8	7.64	28.91	2.00	7.56
A100	Top Slab (int)	13.6	-0.15	34.47	2.00	8.45
A200	Bot Slab (int)	14.3	0.45	35.60	2.00	8.08

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-12.60	12.53	14.52	5.84	15.71	0.90	0.45	6.14	1.33	1.33
MID	35.00	1.36	1.68	6.97	6.36	6.64	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.84	12.53	14.52	5.84	15.71	0.90	0.45	6.14	1.41	1.41
TOP	9.00	-11.77	12.53	14.52	5.84	15.71	0.90	0.45	6.14	1.42	1.42

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
LT	7.00	-8.54	3.28	32.90	12.84	30.29	0.90	0.45	9.59	4.27	4.27
MID	70.00	22.31	-0.33	28.72	8.32	25.76	0.90	0.62	9.59	1.20	1.20
RT	7.00	-8.55	3.28	32.90	12.84	30.29	0.90	0.45	9.59	4.27	4.27

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
LT	7.00	-8.58	4.64	32.90	12.84	30.57	0.90	0.45	9.59	4.82	4.82
MID	70.00	23.02	0.47	28.72	8.32	25.96	0.90	0.62	9.59	1.17	1.17
RT	7.00	-8.58	4.64	32.90	12.84	30.57	0.90	0.45	9.59	4.82	4.82

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.28	-12.6	12.53	5.76	9.07	2.063	37.33	10.08a	0.00	0.00	0.00	4.48	4.48
MID	35.00	0.71	1.4	1.68	6.23	15.97	3.361	31.57	17.74a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.71	-11.8	12.53	5.76	9.66	2.198	36.47	10.74a	0.00	0.00	0.00	23.37	23.37
TOP	10.76	-2.50	-11.8	12.53	5.76	9.44	2.146	36.77	10.48a	0.00	0.00	0.00	7.53	7.53

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	10.06	-8.5	3.28	12.53	19.85	2.075	42.63	22.05a	0.00	0.00	0.00	2.21	2.21
MID	70.00	2.65	22.3	-0.33	7.89	10.82	1.797	41.41	12.02a	0.00	0.00	0.00	4.08	4.08
RT	14.52	10.06	-8.5	3.28	12.53	19.85	2.075	42.63	22.05a	0.00	0.00	0.00	2.21	2.21

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.83	-8.6	4.64	12.53	20.36	2.129	42.20	22.62a	0.00	0.00	0.00	2.45	2.45
MID	70.00	0.07	23.0	0.47	7.89	12.04	2.000	45.00	13.38b	0.00	0.00	0.00	99.99	99.99
RT	14.52	9.83	-8.6	4.64	12.53	20.36	2.128	42.21	22.62a	0.00	0.00	0.00	2.45	2.45

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 1.50 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-3.825	-14.715	2.524	12.534	4.638	0.465
1- 1	-2.139	-12.709	1.677	12.534	3.738	0.298
1- 2	-0.562	-12.333	1.677	12.534	2.884	0.143
1- 3	0.530	-12.047	1.677	12.534	2.074	0.001
1- 4	1.162	-11.844	1.677	12.534	1.310	-0.127
1- 5	1.363	-11.719	1.677	12.534	0.712	-0.363
1- 6	1.156	-11.658	1.677	12.534	0.609	-1.037
1- 7	0.570	-11.652	1.677	12.534	0.520	-1.666
1- 8	-0.369	-11.694	1.677	12.534	0.444	-2.249
1- 9	-1.636	-11.801	1.677	12.534	0.382	-2.788
1-10	-2.463	-13.338	2.524	12.534	0.332	-3.281
Top						
Member 2: (Top Slab)						
Left						
2- 0	-2.469	-13.360	-0.332	3.281	12.534	1.677
2- 1	3.228	-3.712	-0.332	3.281	10.139	1.293
2- 2	10.380	-0.183	-0.332	2.934	7.965	0.950
2- 3	16.445	0.760	-0.332	2.934	6.050	-0.118
2- 4	20.663	1.325	-0.332	2.934	4.312	-1.258
2- 5	22.306	1.514	-0.332	2.934	2.654	-2.654
2- 6	20.663	1.325	-0.332	2.934	1.257	-4.315
2- 7	16.445	0.760	-0.332	2.934	0.116	-6.050
2- 8	10.338	-0.183	-0.332	2.934	-0.950	-7.965
2- 9	3.214	-3.712	-0.332	3.281	-1.293	-10.139
2-10	-2.467	-13.381	-0.332	3.281	-1.677	-12.534
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-3.825	-14.715	0.465	4.638	12.399	2.202
4- 1	0.376	-2.451	0.465	4.638	9.920	1.761
4- 2	10.013	-0.119	0.465	4.031	7.440	1.321
4- 3	17.239	1.165	0.465	4.031	4.961	0.881
4- 4	21.573	1.936	0.465	4.031	2.482	0.440
4- 5	23.017	2.193	0.465	4.031	0.068	-0.068
4- 6	21.569	1.936	0.465	4.031	-0.440	-2.484
4- 7	17.228	1.165	0.465	4.031	-0.881	-4.964
4- 8	9.994	-0.119	0.465	4.031	-1.321	-7.443
4- 9	0.376	-2.451	0.465	4.638	-1.761	-9.922
4-10	-3.825	-14.715	0.465	4.638	-2.202	-12.402
Right						

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

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.511	2.56	
	2	2.042	2.56	14.00
	3	2.042	2.56	14.00
Tandem	1	1.596	2.56	
	2	1.596	2.56	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 4.66 ft
 Note: Distribution width is calculated for one wheel only.
 Impact Factor : 1.27
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.511	2.56	19.83	Truck	1	0.511	2.56	19.36
	2	2.042	2.56	5.83		2	2.042	2.56	5.36

3	2.042	2.56	-8.64
Maximum -Moment	:	-4.34	k-ft
Corresponding Moment at Mid	:	9.07	k-ft
Coincident Bottom Slab Load	:	0.45	k/ft

Maximum -Shear in Top Slab			
Truck	1	0.511	2.56
	2	2.042	2.56
	3	2.042	2.56
Maximum -Shear	:		-4.69 k
Corresponding Shear at Mid	:		0.53 k
Coincident Bottom Slab Load	:		0.45 k/ft

Maximum -Moment in Top Slab			
Tandem	1	1.596	2.56 7.50
	2	1.596	2.56 3.50
Maximum -Moment	:		-5.79 k-ft
Corresponding Moment at Mid	:		9.90 k-ft
Coincident Bottom Slab Load	:		0.70 k/ft

Maximum -Shear in Top Slab			
Tandem	1	1.596	2.56 10.39
	2	1.596	2.56 6.39
Maximum -Shear	:		-5.91 k
Corresponding Shear at Mid	:		1.09 k
Coincident Bottom Slab Load	:		0.70 k/ft

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.22	0.31	-0.34	0.00	-4.40	0.24	-0.33	0.00	0.00	0.00	0.00
1- 1	0.00	-3.04	0.31	-0.34	0.00	-4.41	0.24	-0.33	0.00	0.00	0.00	0.00
1- 2	0.00	-3.01	0.31	-0.34	0.00	-4.42	0.24	-0.33	0.00	0.00	0.00	0.00
1- 3	0.00	-3.10	0.31	-0.34	0.00	-4.53	0.24	-0.33	0.00	0.00	0.00	0.00
1- 4	0.00	-3.24	0.31	-0.34	0.00	-4.68	0.24	-0.33	0.00	0.00	0.00	0.00
1- 5	0.00	-3.41	0.31	-0.34	0.00	-4.86	0.24	-0.33	0.00	0.00	0.00	0.00
1- 6	0.00	-3.59	0.31	-0.34	0.00	-5.04	0.24	-0.33	0.00	0.00	0.00	0.00
1- 7	0.00	-3.77	0.31	-0.34	0.00	-5.22	0.24	-0.33	0.00	0.00	0.00	0.00
1- 8	0.00	-3.96	0.31	-0.34	0.00	-5.41	0.24	-0.33	0.00	0.00	0.00	0.00
1- 9	0.01	-4.15	0.31	-0.34	0.00	-5.60	0.24	-0.33	0.00	0.00	0.00	0.00
1-10	0.07	-4.34	0.31	-0.34	0.05	-5.79	0.24	-0.33	0.00	0.00	0.00	0.00
Top												
Member 2: (Top slab)												
Left												
2- 0	0.07	-4.34	4.69	0.00	0.05	-5.79	5.91	0.00	0.00	0.00	0.00	0.00
2- 1	2.73	-1.52	4.19	-0.11	2.13	-1.54	5.09	-0.09	0.00	0.00	0.00	0.00
2- 2	5.49	0.00	3.66	-0.44	5.38	0.00	4.24	-0.34	0.00	0.00	0.00	0.00
2- 3	7.56	0.00	3.11	-0.94	8.15	0.00	3.40	-0.73	0.00	0.00	0.00	0.00
2- 4	8.84	0.00	2.56	-1.46	9.73	0.00	2.56	-1.17	0.00	0.00	0.00	0.00
2- 5	9.27	0.00	2.01	-2.01	10.05	0.00	1.78	-1.78	0.00	0.00	0.00	0.00
2- 6	8.84	0.00	1.46	-2.56	9.73	0.00	1.17	-2.56	0.00	0.00	0.00	0.00
2- 7	7.56	0.00	0.94	-3.11	8.15	0.00	0.73	-3.40	0.00	0.00	0.00	0.00
2- 8	5.49	0.00	0.44	-3.66	5.33	0.00	0.34	-4.24	0.00	0.00	0.00	0.00
2- 9	2.72	-1.52	0.11	-4.19	2.12	-1.54	0.09	-5.09	0.00	0.00	0.00	0.00
2-10	0.07	-4.34	0.00	-4.69	0.06	-5.79	0.00	-5.91	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom slab)												
Left												
4- 0	0.00	-3.22	2.67	0.00	0.00	-4.40	4.13	0.00	0.00	0.00	0.00	0.00
4- 1	0.53	-0.43	2.15	0.00	0.53	-0.33	3.31	0.00	0.00	0.00	0.00	0.00
4- 2	2.62	0.00	1.63	0.00	3.83	0.00	2.49	0.00	0.00	0.00	0.00	0.00
4- 3	4.11	0.00	1.10	0.00	6.19	0.00	1.68	0.00	0.00	0.00	0.00	0.00
4- 4	5.00	0.00	0.58	0.00	7.61	0.00	0.86	0.00	0.00	0.00	0.00	0.00
4- 5	5.30	0.00	0.06	-0.06	8.08	0.00	0.05	-0.05	0.00	0.00	0.00	0.00
4- 6	5.00	0.00	0.00	-0.58	7.61	0.00	0.00	-0.86	0.00	0.00	0.00	0.00
4- 7	4.11	0.00	0.00	-1.10	6.19	0.00	0.00	-1.68	0.00	0.00	0.00	0.00
4- 8	2.62	0.00	0.00	-1.63	3.83	0.00	0.00	-2.49	0.0			

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.4	7.83	26.39	2.00	8.70
A2	Bot Corner Bar	-6.9	7.83	24.10	2.00	9.94
A100	Top Slab (int)	13.5	-0.15	34.31	2.00	8.51
A200	Bot Slab (int)	12.4	0.34	31.05	2.00	9.75

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-10.99	12.87	14.52	5.84	15.79	0.90	0.45	6.14	1.62	2.10
MID	35.00	1.36	1.68	6.97	6.36	6.64	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.89	12.87	14.52	5.84	15.79	0.90	0.45	6.14	1.56	2.02
TOP	9.00	-12.14	12.87	14.52	5.84	15.79	0.90	0.45	6.14	1.38	1.79

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
LT	7.00	-9.13	3.47	32.90	12.84	30.33	0.90	0.45	9.59	3.93	5.09
MID	70.00	22.20	-0.33	28.72	8.32	25.76	0.90	0.62	9.59	1.20	1.56
RT	7.00	-9.13	3.47	32.90	12.84	30.33	0.90	0.45	9.59	3.93	5.09

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
LT	7.00	-7.88	4.64	32.90	12.84	30.57	0.90	0.45	9.59	5.50	7.12
MID	70.00	19.80	0.28	28.72	8.32	25.92	0.90	0.62	9.59	1.43	1.86
RT	7.00	-7.88	4.64	32.90	12.84	30.57	0.90	0.45	9.59	5.50	7.12

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings	
													IR	OR
BOT	10.76	3.28	-11.0	12.87	5.76	9.72	2.210	36.40	10.80a	0.00	0.00	0.00	4.87	6.32
MID	35.00	0.71	1.4	1.68	6.23	15.97	3.361	31.57	17.74a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.71	-10.9	12.87	5.76	10.19	2.319	35.81	11.33a	0.00	0.00	0.00	16.88	21.88
TOP	10.76	-2.69	-12.1	12.87	5.76	9.32	2.120	36.95	10.35a	0.00	0.00	0.00	4.63	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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings	
													IR	OR
LT	14.52	10.78	-9.1	3.47	12.53	19.38	2.027	43.03	21.54a	0.00	0.00	0.00	1.97	2.56
MID	70.00	3.51	22.2	-0.33	7.89	10.77	1.788	41.48	11.96a	0.00	0.00	0.00	3.07	3.98
RT	14.52	10.78	-9.1	3.47	12.53	19.38	2.027	43.03	21.54a	0.00	0.00	0.00	1.97	2.56

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings	
													IR	OR
LT	14.52	8.32	-7.9	4.64	12.53	21.99	2.299	40.99	24.43a	0.00	0.00	0.00	3.38	4.39
MID	70.00	0.10	19.8	0.28	7.89	12.04	2.000	45.00	13.38b	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.32	-7.9	4.64	12.53	21.99	2.299	40.99	24.43a	0.00	0.00	0.00	3.38	4.39

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

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
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Bottom						
1- 0	-3.825	-13.067	2.524	12.872	4.638	0.278
1- 1	-2.139	-11.085	1.677	12.872	3.738	0.110
1- 2	-0.562	-10.738	1.677	12.872	2.883	-0.045
1- 3	0.530	-10.644	1.677	12.872	2.074	-0.186
1- 4	1.162	-10.714	1.677	12.872	1.310	-0.315
1- 5	1.363	-10.889	1.677	12.872	0.711	-0.551
1- 6	1.156	-11.137	1.677	12.872	0.609	-1.225
1- 7	0.570	-11.457	1.677	12.872	0.520	-1.853
1- 8	-0.369	-11.825	1.677	12.872	0.444	-2.437
1- 9	-1.636	-12.261	1.677	12.872	0.381	-2.975
1-10	-2.423	-14.128	2.524	12.872	0.332	-3.468
Top						

Left	1	2	3	4	5	6
2- 0	-2.429	-14.150	-0.332	3.468	12.872	1.677
2- 1	4.825	-4.105	-0.332	3.468	10.852	1.293
2- 2	11.642	-0.183	-0.332	2.934	8.888	0.692
2- 3	17.726	0.760	-0.332	2.934	6.920	-0.668
2- 4	21.341	1.325	-0.332	2.934	4.971	-2.072
2- 5	22.197	1.514	-0.332	2.934	3.511	-3.511
2- 6	21.341	1.325	-0.332	2.934	2.072	-4.975
2- 7	17.726	0.760	-0.332	2.934	0.665	-6.920
2- 8	11.642	-0.183	-0.332	2.934	-0.692	-8.888
2- 9	4.805	-4.105	-0.332	3.468	-1.293	-10.852
2-10	-2.426	-14.150	-0.332	3.468	-1.677	-12.872
Right						

Left						
4- 0	-3.825	-13.067	0.278	4.638	10.473	2.202
4- 1	0.516	-2.692	0.278	4.638	8.394	1.761
4- 2	8.955	-0.119	0.278	4.031	6.315	1.321
4- 3	14.982	1.165	0.278	4.031	4.235	0.881
4- 4	18.599	1.936	0.278	4.031	2.156	0.440
4- 5	19.802	2.193	0.278	4.031	0.102	-0.102
4- 6	18.599	1.936	0.278	4.031	-0.440	-2.156
4- 7	14.982	1.165	0.278	4.031	-0.881	-4.235
4- 8	8.955	-0.119	0.278	4.031	-1.321	-6.315
4- 9	0.516	-2.692	0.278	4.638	-1.761	-8.394
4-10	-3.825	-13.067	0.278	4.638	-2.202	-10.473
Right						

Analysis Results: Fill Depth = 1.99 ft

Load Parameters:

Fe = 1.03 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.772	0.226
Live Load Surcharge	0.306	0.306
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Pls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-1.53	0.00	-0.78	-0.46	0.00
1- 1	-1.48	-1.53	0.00	0.11	0.01	0.00
1- 2	-1.38	-1.53	0.00	0.75	0.38	0.00
1- 3	-1.28	-1.53	0.00	1.16	0.64	0.00
1- 4	-1.18	-1.53	0.00	1.37	0.80	0.00
1- 5	-1.08	-1.53	0.00	1.39	0.85	0.00
1- 6	-0.98	-1.53	0.00	1.24	0.80	0.00
1- 7	-0.88	-1.53	0.00	0.94	0.64	0.00
1- 8	-0.78	-1.53	0.00	0.50	0.38	0.00
1- 9	-0.68	-1.53	0.00	-0.05	0.01	0.00
1-10	-0.58	-1.53	0.00	-0.69	-0.46	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	1.73	0.89	0.00
1- 1	0.17	0.00	0.00	1.30	0.71	0.00
1- 2	0.17	0.00	0.00	0.90	0.54	0.00
1- 3	0.17	0.00	0.00	0.53	0.36	0.00
1- 4	0.17	0.00	0.00	0.19	0.18	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.40	-0.18	0.00
1- 7	0.17	0.00	0.00	-0.64	-0.36	0.00
1- 8	0.17	0.00	0.00	-0.85	-0.54	0.00
1- 9	0.17	0.00	0.00	-1.03	-0.71	0.00
1-10	0.17	0.00	0.00	-1.18	-0.89	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-1.53	0.00	-0.70	-0.46	0.00
2- 1	0.21	0.05	0.00	-0.70	-0.46	0.00
2- 2	0.81	1.27	0.00	-0.70	-0.46	0.00
2- 3	1.23	2.14	0.00	-0.70	-0.46	0.00
2- 4	1.49	2.67	0.00	-0.70	-0.46	0.00
2- 5	1.57	2.84	0.00	-0.70	-0.46	0.00
2- 6	1.49	2.67	0.00	-0.70	-0.46	0.00
2- 7	1.23	2.14	0.00	-0.70	-0.46	0.00
2- 8	0.81	1.27	0.00	-0.70	-0.46	0.00
2- 9	0.21	0.05	0.00	-0.70	-0.46	0.00
2-10	-0.58	-1.53	0.00	-0.70	-0.46	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	1.50	0.00	0.00	0.00	0.00
2- 1	0.58	1.20	0.00	0.00	0.00	0.00
2- 2	0.44	0.90	0.00	0.00	0.00	0.00
2- 3	0.29	0.60	0.00	0.00	0.00	0.00
2- 4	0.15	0.30	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.30	0.00	0.00	0.00	0.00
2- 7	-0.29	-0.60	0.00	0.00	0.00	0.00
2- 8	-0.44	-0.90	0.00	0.00	0.00	0.00
2- 9	-0.58	-1.20	0.00	0.00	0.00	0.00
2-10	-0.80	-1.50	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-1.53	0.00	-0.78	-0.46	0.00
4- 1	-0.13	0.05	0.00	-0.78	-0.46	0.00
4- 2	1.00	1.27	0.00	-0.78	-0.46	0.00
4- 3	1.80	2.14	0.00	-0.78	-0.46	0.00
4- 4	2.28	2.67	0.00	-0.78	-0.46	0.00
4- 5	2.44	2.84	0.00	-0.78	-0.46	0.00
4- 6	2.28	2.67	0.00	-0.78	-0.46	0.00
4- 7	1.80	2.14	0.00	-0.78	-0.46	0.00
4- 8	1.00	1.27	0.00	-0.78	-0.46	0.00
4- 9	-0.13	0.05	0.00	-0.78	-0.46	0.00
4-10	-1.58	-1.53	0.00	-0.78	-0.46	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	1.50	0.00	0.00	0.00	0.00
4- 1	1.10	1.20	0.00	0.00	0.00	0.00
4- 2	0.83	0.90	0.00	0.00	0.00	0.00
4- 3	0.55	0.60	0.00	0.00	0.00	0.00
4- 4	0.28	0.30	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.30	0.00	0.00	0.00	0.00
4- 7	-0.55	-0.60	0.00	0.00	0.00	0.00
4- 8	-0.83	-0.90	0.00	0.00	0.00	0.00
4- 9	-1.10	-1.20	0.00	0.00	0.00	0.00
4-10	-1.38	-1.50	0.00	0.00	0.00	0.00
Right						

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 1.99 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	1.50	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.18	0.89	0.00
4	0.17	0.00	0.00	1.73	0.89	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.515	3.12	
	2	2.059	3.12	14.00
	3	2.059	3.12	14.00
Tandem	1	1.287	3.12	

2 1.287 3.12

4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 4.66 ft
 Note: Distribution width is calculated for one wheel only.
 Impact Factor : 1.25
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.515 3.12 19.83
 2 2.059 3.12 5.83
 3 2.059 3.12 -8.17
 Maximum +Moment : 11.00 k-ft
 Corresponding Moment at End : -5.24 k-ft
 Coincident Bottom Slab Load : 0.55 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.515 3.12 15.56
 2 2.059 3.12 1.56
 3 2.059 3.12 -12.44
 Maximum +Shear : 5.62 k
 Corresponding Shear at Mid : -0.80 k
 Coincident Bottom Slab Load : 0.55 k/ft

Maximum +Moment in Top Slab
 Tandem 1 1.287 3.12 7.11
 2 1.287 3.12 3.11
 Maximum +Moment : 9.85 k-ft
 Corresponding Moment at End : -5.59 k-ft
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum +Shear in Top Slab
 Tandem 1 1.287 3.12 5.56
 2 1.287 3.12 1.56
 Maximum +Shear : 5.62 k
 Corresponding Shear at Mid : -0.75 k
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum -Moment in Top Slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.515 3.12 19.25
 2 2.059 3.12 5.25
 3 2.059 3.12 -8.75
 Maximum -Moment : -5.29 k-ft
 Corresponding Moment at Mid : 10.71 k-ft
 Coincident Bottom Slab Load : 0.55 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.515 3.12 24.11
 2 2.059 3.12 10.11
 3 2.059 3.12 -3.89
 Maximum -Shear : -5.62 k
 Corresponding Shear at Mid : 0.80 k
 Coincident Bottom Slab Load : 0.55 k/ft

Maximum -Moment in Top Slab
 Tandem 1 1.287 3.12 7.50
 2 1.287 3.12 3.50
 Maximum -Moment : -5.64 k-ft
 Corresponding Moment at Mid : 9.81 k-ft
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum -Shear in Top Slab
 Tandem 1 1.287 3.12 10.11
 2 1.287 3.12 6.11
 Maximum -Shear : -5.62 k
 Corresponding Shear at Mid : 0.75 k
 Coincident Bottom Slab Load : 0.69 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.90	0.31	-0.41	0.00	-4.26	0.20	-0.32	0.00	0.00	0.00	0.00
1- 1	0.00	-3.72	0.31	-0.41	0.00	-4.30	0.20	-0.32	0.00	0.00	0.00	0.00
1- 2	0.00	-3.69	0.31	-0.41	0.00	-4.34	0.20	-0.32	0.00	0.00	0.00	0.00
1- 3	0.00	-3.80	0.31	-0.41	0.00	-4.44	0.20	-0.32	0.00	0.00	0.00	0.00
1- 4	0.00	-3.97	0.31	-0.41	0.00	-4.58	0.20	-0.32	0.00	0.00	0.00	0.00
1- 5	0.00	-4.17	0.31	-0.41	0.00	-4.75	0.20	-0.32	0.00	0.00	0.00	0.00
1- 6	0.00	-4.38	0.31	-0.41	0.00	-4.92	0.20	-0.32	0.00	0.00	0.00	0.00
1- 7	0.00	-4.60	0.31	-0.41	0.00	-5.10	0.20	-0.32	0.00	0.00	0.00	0.00
1- 8	0.00	-4.83	0.31	-0.41	0.00	-5.28	0.20	-0.32	0.00	0.00	0.00	0.00
1- 9	0.01	-5.06	0.31	-0.41	0.00	-5.46	0.20	-0.32	0.00	0.00	0.00	0.00
1-10	0.11	-5.29	0.31	-0.41	0.04	-5.64	0.20	-0.32	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.11	-5.29	5.62	0.00	0.04	-5.64	5.62	0.00	0.00	0.00	0.00	0.00
2- 1	3.00	-1.82	4.99	-0.11	1.88	-1.46	4.80	-0.07	0.00	0.00	0.00	0.00
2- 2	6.41	0.00	4.34	-0.44	5.10	0.00	3.97	-0.28	0.00	0.00	0.00	0.00
2- 3	8.92	0.00	3.66	-1.01	7.84	0.00	3.14	-0.63	0.00	0.00	0.00	0.00
2- 4	10.47	0.00	2.98	-1.64	9.45	0.00	2.33	-1.05	0.00	0.00	0.00	0.00
2- 5	11.00	0.00	2.31	-2.31	9.85	0.00	1.61	-1.61	0.00	0.00	0.00	0.00
2- 6	10.47	0.00	1.64	-2.98	9.45	0.00	1.05	-2.33	0.00	0.00	0.00	0.00
2- 7	8.92	0.00	1.01	-3.66	7.84	0.00	0.63	-3.14	0.00	0.00	0.00	0.00
2- 8	6.41	0.00	0.44	-4.34	5.05	0.00	0.28	-3.97	0.00	0.00	0.00	0.00

Sht:____of____
By:IRR Chk:____
6/5/2019 5:36:19 PM
Culvert p. 19 of 82
0.00
0.00

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.6	7.92	27.44	2.00	8.20
A2	Bot Corner Bar	-7.2	7.92	25.35	2.00	9.23
A100	Top Slab (int)	15.2	-0.11	38.41	2.00	7.24
A200	Bot Slab (int)	13.0	0.32	32.47	2.00	9.18

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.33	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.59	2.06
MID	35.00	1.17	2.00	6.97	6.36	6.71	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.18	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.54	2.00
TOP	9.00	-12.40	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.36	1.76

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-9.57	3.73	32.90	12.84	30.38	0.90	0.45	9.59	3.84	4.98
MID	70.00	24.80	-0.28	28.72	8.32	25.78	0.90	0.62	9.59	1.05	1.36
RT	7.00	-9.57	3.73	32.90	12.84	30.38	0.90	0.45	9.59	3.84	4.98

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.11	4.78	32.90	12.84	30.60	0.90	0.45	9.59	5.56	7.21
MID	70.00	20.50	0.21	28.72	8.32	25.90	0.90	0.62	9.59	1.39	1.80
RT	7.00	-8.11	4.78	32.90	12.84	30.60	0.90	0.45	9.59	5.56	7.21

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.38	-11.3	12.88	5.76	9.53	2.168	36.63	10.59a	0.00	0.00	0.00	4.77	6.18
MID	35.00	0.71	1.2	2.00	6.23	17.10	3.600	30.75	19.01a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.71	-11.2	12.88	5.76	10.05	2.286	35.99	11.16a	0.00	0.00	0.00	13.87	17.98
TOP	10.76	-2.90	-12.4	12.88	5.76	9.20	2.094	37.12	10.23a	0.00	0.00	0.00	4.27	5.54

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	11.04	-9.6	3.73	12.53	19.26	2.014	43.14	21.40a	0.00	0.00	0.00	1.95	2.52
MID	70.00	4.04	24.8	-0.28	7.89	10.72	1.781	41.53	11.91a	0.00	0.00	0.00	2.66	3.44
RT	14.52	11.04	-9.6	3.73	12.53	19.26	2.014	43.14	21.40a	0.00	0.00	0.00	1.95	2.52

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.63	-8.1	4.78	12.53	21.70	2.269	41.20	24.11a	0.00	0.00	0.00	3.32	4.30
MID	70.00	0.12	20.5	0.21	7.89	12.04	2.000	45.00	13.38b	0.00	0.00	0.00	99.56	99.99
RT	14.52	8.63	-8.1	4.78	12.53	21.70	2.269	41.20	24.11a	0.00	0.00	0.00	3.32	4.30

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 1.99 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.379	-13.418	3.039	12.878	4.784	0.214
1- 1	-2.467	-11.417	2.000	12.878	3.855	0.035
1- 2	-0.832	-11.096	2.000	12.878	2.972	-0.130
1- 3	0.302	-10.969	2.000	12.878	2.134	-0.283
1- 4	0.960	-11.019	2.000	12.878	1.341	-0.422
1- 5	1.168	-11.175	2.000	12.878	0.714	-0.669
1- 6	0.954	-11.414	2.000	12.878	0.601	-1.372
1- 7	0.343	-11.723	2.000	12.878	0.501	-2.029
1- 8	-0.639	-12.089	2.000	12.878	0.414	-2.641
1- 9	-1.964	-12.528	2.000	12.878	0.340	-3.208
1-10	-2.900	-14.452	3.039	12.878	0.279	-3.730
Top						
Member 2: (Top Slab)						
Left						
2- 0	-2.907	-14.474	-0.279	3.730	12.878	2.000
2- 1	5.287	-4.661	-0.279	3.730	11.104	1.552
2- 2	13.668	0.018	-0.279	3.077	9.364	0.995
2- 3	19.791	1.150	-0.279	3.077	7.594	-0.580
2- 4	23.538	1.829	-0.279	3.077	5.812	-2.285
2- 5	24.797	2.055	-0.279	3.077	4.036	-4.036
2- 6	23.538	1.829	-0.279	3.077	2.285	-5.812
2- 7	19.791	1.150	-0.279	3.077	0.577	-7.594
2- 8	13.668	0.018	-0.279	3.077	-0.995	-9.364
2- 9	5.287	-4.661	-0.279	3.730	-1.552	-11.104
2-10	-2.903	-14.474	-0.279	3.730	-2.000	-12.878
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.379	-13.418	0.214	4.784	10.868	2.525
4- 1	0.688	-2.809	0.214	4.784	8.708	2.020
4- 2	9.228	0.082	0.214	4.174	6.549	1.515
4- 3	15.494	1.555	0.214	4.174	4.389	1.010
4- 4	19.252	2.439	0.214	4.174	2.230	0.505
4- 5	20.505	2.734	0.214	4.174	0.121	-0.121
4- 6	19.252	2.439	0.214	4.174	-0.505	-2.230
4- 7	15.494	1.555	0.214	4.174	-1.010	-4.389
4- 8	9.228	0.082	0.214	4.174	-1.515	-6.549
4- 9	0.688	-2.809	0.214	4.784	-2.020	-8.708
4-10	-4.379	-13.418	0.214	4.784	-2.525	-10.868
Right						

----- Analysis Truck, MaineDOT Config 6 -----

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.612	3.12	
	2	1.096	3.12	9.00
	3	1.101	3.12	4.00
	4	1.096	3.12	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement

Distribution width : 4.66 ft

Note: Distribution width is calculated for one wheel only.

Impact Factor : 1.25

Distribution width : 0.00 ft

Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.612	3.12	19.02	Truck	1	0.612	3.12	18.83
	2	1.096	3.12	10.02		2	1.096	3.12	9.83
	3	1.101	3.12	6.02		3	1.101	3.12	5.83
	4	1.096	3.12	2.02		4	1.096	3.12	1.83

Sht: ___ of ___
By: IRR Chk: ___
6/5/2019 5:36:20 PM
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Maximum -Moment	:	-5.20	k-ft
Corresponding Moment at Mid	:	9.76	k-ft
Coincident Bottom Slab Load	:	0.88	k/ft
Maximum -Shear in Top Slab			
Truck	1	0.612	3.12
	2	1.096	3.12
	3	1.101	3.12
	4	1.096	3.12
Maximum -Shear	:	-5.38	k
Corresponding Shear at Mid	:	0.06	k
Coincident Bottom Slab Load	:	0.88	k/ft

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-5.25	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-5.25	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-5.24	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-5.24	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-5.23	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-5.23	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-5.22	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-5.22	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-5.21	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-5.21	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.04	-5.20	0.26	-0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.04	-5.20	5.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.60	-1.25	4.37	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	4.54	0.00	3.47	-0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	7.25	0.00	2.68	-0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	9.06	0.00	1.99	-0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	9.77	0.00	1.37	-1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	9.09	0.00	0.89	-1.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	7.21	0.00	0.54	-2.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	4.50	0.00	0.24	-3.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	1.60	-1.23	0.06	-4.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.04	-5.20	0.00	-5.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom slab)												
Left												
4- 0	0.00	-5.25	5.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.42	-0.25	4.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	4.35	0.00	3.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	7.35	0.00	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	9.15	0.00	1.03	0.00	0.00	0.0						

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.4	7.67	26.78	2.00	8.51
A2	Bot Corner Bar	-8.1	7.67	30.28	2.00	7.03
A100	Top Slab (int)	14.0	-0.05	35.27	2.00	8.18
A200	Bot Slab (int)	14.8	0.54	36.85	2.00	7.69

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-12.96	12.46	14.52	5.84	15.70	0.90	0.45	6.14	1.30	1.30
MID	35.00	1.17	2.00	6.97	6.36	6.71	0.90	0.19	6.14	NC	NC
MID-	35.00	-12.15	12.46	14.52	5.84	15.70	0.90	0.45	6.14	1.39	1.39
TOP	9.00	-12.06	12.46	14.52	5.84	15.70	0.90	0.45	6.14	1.40	1.40

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
LT	7.00	-8.68	3.35	32.90	12.84	30.30	0.90	0.45	9.59	4.36	4.36
MID	70.00	22.66	-0.18	28.72	8.32	25.80	0.90	0.62	9.59	1.18	1.18
RT	7.00	-8.66	3.35	32.90	12.84	30.30	0.90	0.45	9.59	4.37	4.37

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
LT	7.00	-8.80	4.68	32.90	12.84	30.58	0.90	0.45	9.59	4.88	4.88
MID	70.00	23.67	0.60	28.72	8.32	26.00	0.90	0.62	9.59	1.14	1.14
RT	7.00	-8.82	4.68	32.90	12.84	30.58	0.90	0.45	9.59	4.86	4.86

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.28	-13.0	12.46	5.76	8.94	2.034	37.53	9.93a	0.00	0.00	0.00	4.70	4.70
MID	35.00	0.61	1.2	2.00	6.23	17.29	3.639	30.62	19.21a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.61	-12.2	12.46	5.76	9.51	2.164	36.66	10.57a	0.00	0.00	0.00	28.39	28.39
TOP	10.76	-2.52	-12.1	12.46	5.76	9.33	2.122	36.93	10.36a	0.00	0.00	0.00	7.54	7.54

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.94	-8.7	3.35	12.53	19.95	2.086	42.54	22.17a	0.00	0.00	0.00	2.32	2.32
MID	70.00	2.40	22.7	-0.18	7.89	10.77	1.788	41.48	11.96a	0.00	0.00	0.00	4.48	4.48
RT	14.52	9.94	-8.7	3.35	12.53	19.95	2.086	42.54	22.17a	0.00	0.00	0.00	2.32	2.32

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	10.12	-8.8	4.68	12.53	20.13	2.105	42.39	22.36a	0.00	0.00	0.00	2.40	2.40
MID	70.00	0.07	23.7	0.60	7.89	12.04	2.000	45.00	13.38b	0.00	0.00	0.00	99.99	99.99
RT	14.52	10.12	-8.8	4.68	12.53	20.12	2.104	42.39	22.36a	0.00	0.00	0.00	2.40	2.40

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 1.99 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.379	-15.149	3.039	12.456	4.682	0.598
1- 1	-2.467	-13.071	2.000	12.456	3.753	0.419
1- 2	-0.832	-12.674	2.000	12.456	2.870	0.253
1- 3	0.302	-12.370	2.000	12.456	2.032	0.101
1- 4	0.960	-12.152	2.000	12.456	1.239	-0.039
1- 5	1.168	-12.010	2.000	12.456	0.612	-0.286
1- 6	0.954	-11.939	2.000	12.456	0.499	-0.988
1- 7	0.343	-11.930	2.000	12.456	0.399	-1.646
1- 8	-0.639	-11.976	2.000	12.456	0.312	-2.258
1- 9	-1.964	-12.090	2.000	12.456	0.238	-2.825
1-10	-3.032	-13.689	3.039	12.456	0.177	-3.347
Top						
Member 2: (Top Slab)						
Left						
2- 0	-3.038	-13.711	-0.177	3.347	12.456	2.000
2- 1	2.832	-3.651	-0.177	3.347	10.016	1.552
2- 2	10.402	0.018	-0.177	3.077	7.841	1.164
2- 3	16.861	1.150	-0.177	3.077	5.878	0.244
2- 4	21.063	1.829	-0.177	3.077	4.066	-0.974
2- 5	22.659	2.055	-0.177	3.077	2.405	-2.405
2- 6	21.117	1.829	-0.177	3.077	0.974	-4.066
2- 7	16.784	1.150	-0.177	3.077	-0.246	-5.878
2- 8	10.323	0.018	-0.177	3.077	-1.164	-7.841
2- 9	2.832	-3.616	-0.177	3.347	-1.552	-10.016
2-10	-3.036	-13.711	-0.177	3.347	-2.000	-12.462
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.379	-15.149	0.598	4.682	12.766	2.525
4- 1	0.306	-2.447	0.598	4.682	10.213	2.020
4- 2	10.263	0.082	0.598	4.174	7.660	1.515
4- 3	17.710	1.555	0.598	4.174	5.107	1.010
4- 4	22.178	2.439	0.598	4.174	2.553	0.505
4- 5	23.667	2.734	0.598	4.174	0.066	-0.066
4- 6	22.178	2.439	0.598	4.174	-0.505	-2.558
4- 7	17.710	1.555	0.598	4.174	-1.010	-5.111
4- 8	10.262	0.082	0.598	4.174	-1.515	-7.664
4- 9	0.283	-2.447	0.598	4.682	-2.020	-10.217
4-10	-4.379	-15.194	0.598	4.682	-2.525	-12.771
Right						

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

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.412	3.12	
	2	1.647	3.12	14.00
	3	1.647	3.12	14.00
Tandem	1	1.287	3.12	
	2	1.287	3.12	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 4.66 ft
 Note: Distribution width is calculated for one wheel only.
 Impact Factor : 1.25
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.412	3.12	19.83	Truck	1	0.412	3.12	19.25
	2	1.647	3.12	5.83		2	1.647	3.12	5.25

3	1.647	3.12	-8.75
Maximum -Moment	:	-4.23	k-ft
Corresponding Moment at Mid	:	8.57	k-ft
Coincident Bottom Slab Load	:	0.44	k/ft

Maximum -Shear in Top Slab				
Truck	1	0.412	3.12	24.11
	2	1.647	3.12	10.11
	3	1.647	3.12	-3.89
Maximum -Shear	:		-4.50	k
Corresponding Shear at Mid	:		0.64	k
Coincident Bottom Slab Load	:		0.44	k/ft

Maximum -Moment in Top Slab			
Tandem	1	1.287	3.12 7.50
	2	1.287	3.12 3.50
Maximum -Moment	:	-5.64	k-ft
Corresponding Moment at Mid	:	9.81	k-ft
Coincident Bottom Slab Load	:	0.69	k/ft

Maximum -Shear in Top Slab			
Tandem	1	1.287	3.12 10.11
	2	1.287	3.12 6.11
Maximum -Shear			: -5.62 k
Corresponding Shear at Mid			: 0.75 k
Coincident Bottom Slab Load			: 0.69 k/ft

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.12	0.25	-0.33	0.00	-4.26	0.20	-0.32	0.00	0.00	0.00	0.00
1- 1	0.00	-2.98	0.25	-0.33	0.00	-4.30	0.20	-0.32	0.00	0.00	0.00	0.00
1- 2	0.00	-2.95	0.25	-0.33	0.00	-4.34	0.20	-0.32	0.00	0.00	0.00	0.00
1- 3	0.00	-3.04	0.25	-0.33	0.00	-4.44	0.20	-0.32	0.00	0.00	0.00	0.00
1- 4	0.00	-3.17	0.25	-0.33	0.00	-4.58	0.20	-0.32	0.00	0.00	0.00	0.00
1- 5	0.00	-3.33	0.25	-0.33	0.00	-4.75	0.20	-0.32	0.00	0.00	0.00	0.00
1- 6	0.00	-3.50	0.25	-0.33	0.00	-4.92	0.20	-0.32	0.00	0.00	0.00	0.00
1- 7	0.00	-3.68	0.25	-0.33	0.00	-5.10	0.20	-0.32	0.00	0.00	0.00	0.00
1- 8	0.00	-3.86	0.25	-0.33	0.00	-5.28	0.20	-0.32	0.00	0.00	0.00	0.00
1- 9	0.01	-4.05	0.25	-0.33	0.00	-5.46	0.20	-0.32	0.00	0.00	0.00	0.00
1-10	0.09	-4.23	0.25	-0.33	0.04	-5.64	0.20	-0.32	0.00	0.00	0.00	0.00
Top												
Member 2: (Top slab)												
Left												
2- 0	0.09	-4.23	4.50	0.00	0.04	-5.64	5.62	0.00	0.00	0.00	0.00	0.00
2- 1	2.40	-1.46	3.99	-0.09	1.88	-1.46	4.80	-0.07	0.00	0.00	0.00	0.00
2- 2	5.13	0.00	3.47	-0.36	5.10	0.00	3.97	-0.28	0.00	0.00	0.00	0.00
2- 3	7.14	0.00	2.93	-0.81	7.84	0.00	3.14	-0.63	0.00	0.00	0.00	0.00
2- 4	8.38	0.00	2.39	-1.31	9.45	0.00	2.33	-1.05	0.00	0.00	0.00	0.00
2- 5	8.80	0.00	1.85	-1.85	9.85	0.00	1.61	-1.61	0.00	0.00	0.00	0.00
2- 6	8.38	0.00	1.31	-2.39	9.45	0.00	1.05	-2.33	0.00	0.00	0.00	0.00
2- 7	7.14	0.00	0.80	-2.93	7.84	0.00	0.63	-3.14	0.00	0.00	0.00	0.00
2- 8	5.13	0.00	0.36	-3.47	5.05	0.00	0.28	-3.97	0.00	0.00	0.00	0.00
2- 9	2.40	-1.46	0.09	-3.99	1.88	-1.44	0.07	-4.80	0.00	0.00	0.00	0.00
2-10	0.09	-4.23	0.00	-4.50	0.04	-5.64	0.00	-5.62	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom slab)												
Left												
4- 0	0.00	-3.12	2.63	0.00	0.00	-4.26	4.06	0.00	0.00	0.00	0.00	0.00
4- 1	0.51	-0.37	2.11	0.00	0.50	-0.29	3.25	0.00	0.00	0.00	0.00	0.00
4- 2	2.57	0.00	1.60	0.00	3.76	0.00	2.45	0.00	0.00	0.00	0.00	0.00
4- 3	4.03	0.00	1.08	0.00	6.08	0.00	1.65	0.00	0.00	0.00	0.00	0.00
4- 4	4.91	0.00	0.57	0.00	7.47	0.00	0.84	0.00	0.00	0.00	0.00	0.00
4- 5	5.21	0.00	0.06	-0.06	7.94	0.00	0.04	-0.04	0.00	0.00	0.00	0.00
4- 6	4.91	0.00	0.00	-0.57	7.47	0.00	0.00	-0.84	0.00	0.00	0.00	0.00
4- 7	4.03	0.00	0.00	-1.08	6.08	0.00	0.00	-1.65	0.00	0.00	0.00	0.00
4- 8	2.57	0.00	0.00	-1.60	3.76	0.00	0.00	-2.45	0.00			

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.6	7.92	27.44	2.00	8.20
A2	Bot Corner Bar	-7.2	7.92	25.35	2.00	9.23
A100	Top Slab (int)	14.0	-0.05	35.47	2.00	8.12
A200	Bot Slab (int)	13.0	0.40	32.40	2.00	9.21

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-11.33	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.59	2.06
MID	35.00	1.17	2.00	6.97	6.36	6.71	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.18	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.54	2.00
TOP	9.00	-12.40	12.88	14.52	5.84	15.79	0.90	0.45	6.14	1.36	1.76

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
LT	7.00	-9.25	3.59	32.90	12.84	30.35	0.90	0.45	9.59	4.01	5.20
MID	70.00	22.79	-0.17	28.72	8.32	25.80	0.90	0.62	9.59	1.18	1.52
RT	7.00	-9.25	3.59	32.90	12.84	30.35	0.90	0.45	9.59	4.01	5.20

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
LT	7.00	-8.03	4.67	32.90	12.84	30.58	0.90	0.45	9.59	5.65	7.32
MID	70.00	20.50	0.36	28.72	8.32	25.94	0.90	0.62	9.59	1.39	1.80
RT	7.00	-8.03	4.67	32.90	12.84	30.58	0.90	0.45	9.59	5.65	7.32

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.27	-11.3	12.88	5.76	9.55	2.172	36.61	10.61a	0.00	0.00	0.00	5.12	6.64
MID	35.00	0.60	1.2	2.00	6.23	17.30	3.642	30.61	19.23a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.60	-11.2	12.88	5.76	10.07	2.290	35.97	11.18a	0.00	0.00	0.00	17.37	22.51
TOP	10.76	-2.76	-12.4	12.88	5.76	9.22	2.097	37.10	10.24a	0.00	0.00	0.00	4.65	6.03

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	10.70	-9.2	3.59	12.53	19.47	2.036	42.96	21.63a	0.00	0.00	0.00	2.05	2.66
MID	70.00	3.23	22.8	-0.17	7.89	10.72	1.781	41.53	11.91a	0.00	0.00	0.00	3.32	4.31
RT	14.52	10.70	-9.2	3.59	12.53	19.47	2.036	42.96	21.63a	0.00	0.00	0.00	2.05	2.66

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.63	-8.0	4.67	12.53	21.66	2.265	41.23	24.07a	0.00	0.00	0.00	3.31	4.29
MID	70.00	0.10	20.5	0.36	7.89	12.04	2.000	45.00	13.38b	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.63	-8.0	4.67	12.53	21.66	2.265	41.23	24.07a	0.00	0.00	0.00	3.31	4.29

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

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
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M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.379	-13.418	3.039	12.877	4.674	0.357
1- 1	-2.467	-11.417	2.000	12.877	3.745	0.178
1- 2	-0.832	-11.096	2.000	12.877	2.862	0.012
1- 3	0.302	-10.969	2.000	12.877	2.024	-0.140
1- 4	0.960	-11.019	2.000	12.877	1.231	-0.280
1- 5	1.168	-11.175	2.000	12.877	0.604	-0.527
1- 6	0.954	-11.414	2.000	12.877	0.491	-1.229
1- 7	0.343	-11.723	2.000	12.877	0.391	-1.887
1- 8	-0.639	-12.089	2.000	12.877	0.304	-2.499
1- 9	-1.964	-12.528	2.000	12.877	0.230	-3.066
1-10	-2.940	-14.452	3.039	12.877	0.169	-3.587
Top						
Member 2: (Top slab)						
Left						
2- 0	-2.946	-14.474	-0.169	3.587	12.877	2.000
2- 1	4.237	-4.025	-0.169	3.587	10.771	1.552
2- 2	11.425	0.018	-0.169	3.077	8.727	1.151
2- 3	17.895	1.150	-0.169	3.077	6.684	-0.228
2- 4	21.743	1.829	-0.169	3.077	4.768	-1.710
2- 5	22.795	2.055	-0.169	3.077	3.229	-3.229
2- 6	21.743	1.829	-0.169	3.077	1.710	-4.768
2- 7	17.895	1.150	-0.169	3.077	0.225	-6.684
2- 8	11.425	0.018	-0.169	3.077	-1.151	-8.727
2- 9	4.237	-4.023	-0.169	3.587	-1.552	-10.771
2-10	-2.943	-14.474	-0.169	3.587	-2.000	-12.877
Right						
Member 4: (Bottom slab)						
Left						
4- 0	-4.379	-13.418	0.357	4.674	10.868	2.525
4- 1	0.466	-2.647	0.357	4.674	8.708	2.020
4- 2	9.228	0.082	0.357	4.174	6.549	1.515
4- 3	15.494	1.555	0.357	4.174	4.389	1.010
4- 4	19.252	2.439	0.357	4.174	2.230	0.505
4- 5	20.505	2.734	0.357	4.174	0.097	-0.097
4- 6	19.252	2.439	0.357	4.174	-0.505	-2.230
4- 7	15.494	1.555	0.357	4.174	-1.010	-4.389
4- 8	9.228	0.082	0.357	4.174	-1.515	-6.549
4- 9	0.466	-2.647	0.357	4.674	-2.020	-8.708
4-10	-4.379	-13.418	0.357	4.674	-2.525	-10.868
Right						

Analysis Results: Fill Depth = 2.00 ft

Load Parameters:

Fe = 1.03 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.773	0.226
Live Load Surcharge	0.306	0.306
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Pls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-1.54	0.00	-0.78	-0.46	0.00
1- 1	-1.48	-1.54	0.00	0.11	0.01	0.00
1- 2	-1.38	-1.54	0.00	0.75	0.38	0.00
1- 3	-1.28	-1.54	0.00	1.16	0.64	0.00
1- 4	-1.18	-1.54	0.00	1.37	0.79	0.00
1- 5	-1.08	-1.54	0.00	1.39	0.85	0.00
1- 6	-0.98	-1.54	0.00	1.24	0.79	0.00
1- 7	-0.88	-1.54	0.00	0.94	0.64	0.00
1- 8	-0.78	-1.54	0.00	0.50	0.38	0.00
1- 9	-0.68	-1.54	0.00	-0.05	0.01	0.00
1-10	-0.58	-1.54	0.00	-0.69	-0.46	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	1.74	0.89	0.00
1- 1	0.17	0.00	0.00	1.30	0.71	0.00
1- 2	0.17	0.00	0.00	0.90	0.54	0.00
1- 3	0.17	0.00	0.00	0.53	0.36	0.00
1- 4	0.17	0.00	0.00	0.19	0.18	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.40	-0.18	0.00
1- 7	0.17	0.00	0.00	-0.64	-0.36	0.00
1- 8	0.17	0.00	0.00	-0.85	-0.54	0.00
1- 9	0.17	0.00	0.00	-1.03	-0.71	0.00
1-10	0.17	0.00	0.00	-1.18	-0.89	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-1.54	0.00	-0.71	-0.46	0.00
2- 1	0.21	0.05	0.00	-0.71	-0.46	0.00
2- 2	0.81	1.28	0.00	-0.71	-0.46	0.00
2- 3	1.23	2.15	0.00	-0.71	-0.46	0.00
2- 4	1.49	2.68	0.00	-0.71	-0.46	0.00
2- 5	1.57	2.86	0.00	-0.71	-0.46	0.00
2- 6	1.49	2.68	0.00	-0.71	-0.46	0.00
2- 7	1.23	2.15	0.00	-0.71	-0.46	0.00
2- 8	0.81	1.28	0.00	-0.71	-0.46	0.00
2- 9	0.21	0.05	0.00	-0.71	-0.46	0.00
2-10	-0.58	-1.54	0.00	-0.71	-0.46	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	1.51	0.00	0.00	0.00	0.00
2- 1	0.58	1.20	0.00	0.00	0.00	0.00
2- 2	0.44	0.90	0.00	0.00	0.00	0.00
2- 3	0.29	0.60	0.00	0.00	0.00	0.00
2- 4	0.15	0.30	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.30	0.00	0.00	0.00	0.00
2- 7	-0.29	-0.60	0.00	0.00	0.00	0.00
2- 8	-0.44	-0.90	0.00	0.00	0.00	0.00
2- 9	-0.58	-1.20	0.00	0.00	0.00	0.00
2-10	-0.80	-1.51	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-1.54	0.00	-0.78	-0.46	0.00
4- 1	-0.13	0.05	0.00	-0.78	-0.46	0.00
4- 2	1.00	1.28	0.00	-0.78	-0.46	0.00
4- 3	1.80	2.15	0.00	-0.78	-0.46	0.00
4- 4	2.28	2.68	0.00	-0.78	-0.46	0.00
4- 5	2.44	2.86	0.00	-0.78	-0.46	0.00
4- 6	2.28	2.68	0.00	-0.78	-0.46	0.00
4- 7	1.80	2.15	0.00	-0.78	-0.46	0.00
4- 8	1.00	1.28	0.00	-0.78	-0.46	0.00
4- 9	-0.13	0.05	0.00	-0.78	-0.46	0.00
4-10	-1.58	-1.54	0.00	-0.78	-0.46	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	1.51	0.00	0.00	0.00	0.00
4- 1	1.10	1.20	0.00	0.00	0.00	0.00
4- 2	0.83	0.90	0.00	0.00	0.00	0.00
4- 3	0.55	0.60	0.00	0.00	0.00	0.00
4- 4	0.28	0.30	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.30	0.00	0.00	0.00	0.00
4- 7	-0.55	-0.60	0.00	0.00	0.00	0.00
4- 8	-0.83	-0.90	0.00	0.00	0.00	0.00
4- 9	-1.10	-1.20	0.00	0.00	0.00	0.00
4-10	-1.38	-1.51	0.00	0.00	0.00	0.00
Right						

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 2.00 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	1.51	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.18	0.89	0.00
4	0.17	0.00	0.00	1.74	0.89	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.516	3.13	
	2	2.065	3.13	14.00
	3	2.065	3.13	14.00
Tandem	1	1.291	3.13	

2 1.291 3.13

4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution Width : 4.63 ft
 Impact Factor : 1.25
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.516 3.13 19.83
 2 2.065 3.13 5.83
 3 2.065 3.13 -8.17
 Maximum +Moment : 11.21 k-ft
 Corresponding Moment at End : -5.13 k-ft
 Coincident Bottom Slab Load : 0.65 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.516 3.13 15.57
 2 2.065 3.13 1.57
 3 2.065 3.13 -12.43
 Maximum +Shear : 5.66 k
 Corresponding Shear at Mid : -0.81 k
 Coincident Bottom Slab Load : 0.65 k/ft

Maximum +Moment in Top Slab
 Tandem 1 1.291 3.13 8.48
 2 1.291 3.13 4.48
 Maximum +Moment : 10.10 k-ft
 Corresponding Moment at End : -5.28 k-ft
 Coincident Bottom Slab Load : 0.81 k/ft

Maximum +Shear in Top Slab
 Tandem 1 1.291 3.13 5.57
 2 1.291 3.13 1.57
 Maximum +Shear : 5.66 k
 Corresponding Shear at Mid : -0.75 k
 Coincident Bottom Slab Load : 0.81 k/ft

Maximum -Moment in Top slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.516 3.13 19.25
 2 2.065 3.13 5.25
 3 2.065 3.13 -8.75
 Maximum -Moment : -5.18 k-ft
 Corresponding Moment at Mid : 10.92 k-ft
 Coincident Bottom Slab Load : 0.65 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.516 3.13 24.10
 2 2.065 3.13 10.10
 3 2.065 3.13 -3.90
 Maximum -Shear : -5.66 k
 Corresponding Shear at Mid : 0.81 k
 Coincident Bottom Slab Load : 0.65 k/ft

Maximum -Moment in Top slab
 Tandem 1 1.291 3.13 7.50
 2 1.291 3.13 3.50
 Maximum -Moment : -5.49 k-ft
 Corresponding Moment at Mid : 10.06 k-ft
 Coincident Bottom Slab Load : 0.81 k/ft

Maximum -Shear in Top slab
 Tandem 1 1.291 3.13 10.10
 2 1.291 3.13 6.10
 Maximum -Shear : -5.66 k
 Corresponding Shear at Mid : 0.75 k
 Coincident Bottom Slab Load : 0.81 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)												
Bottom												
1- 0	0.00	-4.36	0.44	-0.27	0.00	-4.55	0.28	-0.14	0.00	0.00	0.00	0.00
1- 1	0.00	-4.02	0.44	-0.27	0.00	-4.42	0.28	-0.14	0.00	0.00	0.00	0.00
1- 2	0.00	-3.98	0.44	-0.27	0.00	-4.38	0.28	-0.14	0.00	0.00	0.00	0.00
1- 3	0.00	-4.10	0.44	-0.27	0.00	-4.49	0.28	-0.14	0.00	0.00	0.00	0.00
1- 4	0.00	-4.29	0.44	-0.27	0.00	-4.65	0.28	-0.14	0.00	0.00	0.00	0.00
1- 5	0.00	-4.47	0.44	-0.27	0.00	-4.83	0.28	-0.14	0.00	0.00	0.00	0.00
1- 6	0.00	-4.60	0.44	-0.27	0.00	-5.02	0.28	-0.14	0.00	0.00	0.00	0.00
1- 7	0.00	-4.74	0.44	-0.27	0.00	-5.22	0.28	-0.14	0.00	0.00	0.00	0.00
1- 8	0.00	-4.88	0.44	-0.27	0.00	-5.34	0.28	-0.14	0.00	0.00	0.00	0.00
1- 9	0.02	-5.03	0.44	-0.27	0.00	-5.42	0.28	-0.14	0.00	0.00	0.00	0.00
1-10	0.15	-5.18	0.44	-0.27	0.06	-5.49	0.28	-0.14	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.15	-5.18	5.66	0.00	0.06	-5.49	5.66	0.00	0.00	0.00	0.00	0.00
2- 1	3.16	-1.69	5.02	-0.11	1.97	-1.29	4.83	-0.07	0.00	0.00	0.00	0.00
2- 2	6.60	0.00	4.36	-0.45	5.31	0.00	4.00	-0.28	0.00	0.00	0.00	0.00
2- 3	9.12	0.00	3.69	-1.01	8.07	0.00	3.16	-0.63	0.00	0.00	0.00	0.00
2- 4	10.68	0.00	3.00	-1.65	9.69	0.00	2.34	-1.05	0.00	0.00	0.00	0.00
2- 5	11.21	0.00	2.32	-2.32	10.10	0.00	1.62	-1.62	0.00	0.00	0.00	0.00
2- 6	10.68	0.00	1.65	-3.00	9.69	0.00	1.05	-2.34	0.00	0.00	0.00	0.00
2- 7	9.12	0.00	1.01	-3.69	8.07	0.00	0.63	-3.16	0.00	0.00	0.00	0.00
2- 8	6.59	0.00	0.45	-4.36	5.26	0.00	0.28	-4.00	0.00	0.00	0.00	0.00
2- 9	3.16	-1.69	0.11	-5.02	1.97	-1.26	0.07	-4.83	0.00	0.00	0.00	0.00

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 2-10 0.15 -5.18 0.00 -5.66 0.06 -5.49 0.00 -5.66 0.00 0.00 0.00
 Right

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:20 PM
 Culvert p. 30 of 82
 0.00

Member 4: (Bottom Slab)

Left												
4- 0	0.00	-4.36	3.51	0.00	0.00	-4.55	4.06	0.00	0.00	0.00	0.00	0.00
4- 1	0.51	-0.59	2.82	0.00	0.34	-0.37	3.26	0.00	0.00	0.00	0.00	0.00
4- 2	3.46	0.00	2.14	0.00	3.80	0.00	2.46	0.00	0.00	0.00	0.00	0.00
4- 3	5.41	0.00	1.45	0.00	6.12	0.00	1.65	0.00	0.00	0.00	0.00	0.00
4- 4	6.58	0.00	0.77	0.00	7.51	0.00	0.85	0.00	0.00	0.00	0.00	0.00
4- 5	6.97	0.00	0.07	-0.07	7.97	0.00	0.04	-0.04	0.00	0.00	0.00	0.00
4- 6	6.58	0.00	0.00	-0.77	7.51	0.00	0.00	-0.85	0.00	0.00	0.00	0.00
4- 7	5.41	0.00	0.00	-1.45	6.12	0.00	0.00	-1.65	0.00	0.00	0.00	0.00
4- 8	3.46	0.00	0.00	-2.14	3.80	0.00	0.00	-2.46	0.00	0.00	0.00	0.00
4- 9	0.51	-0.59	0.00	-2.82	0.34	-0.37	0.00	-3.26	0.00	0.00	0.00	0.00
4-10	0.00	-4.36	0.00	-3.51	0.00	-4.55	0.00	-4.06	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 2.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.6	7.96	27.37	2.00	8.23
A2	Bot Corner Bar	-7.3	7.96	25.83	2.00	8.98
A100	Top Slab (int)	15.4	-0.24	39.09	2.00	7.06
A200	Bot Slab (int)	13.0	0.46	32.47	2.00	9.18

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-11.51	12.95	14.52	5.84	15.80	0.90	0.45	6.14	1.56	2.02
MID	35.00	1.16	2.01	6.97	6.36	6.71	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.33	12.95	14.52	5.84	15.80	0.90	0.45	6.14	1.51	1.96
TOP	9.00	-12.39	12.95	14.52	5.84	15.80	0.90	0.45	6.14	1.36	1.77

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
LT	7.00	-9.33	3.49	32.90	12.84	30.33	0.90	0.45	9.59	3.97	5.14
MID	70.00	25.19	-0.50	28.72	8.32	25.72	0.90	0.62	9.59	1.03	1.33
RT	7.00	-9.33	3.49	32.90	12.84	30.33	0.90	0.45	9.59	3.97	5.14

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
LT	7.00	-8.48	5.01	32.90	12.84	30.65	0.90	0.45	9.59	5.19	6.73
MID	70.00	20.58	0.46	28.72	8.32	25.96	0.90	0.62	9.59	1.39	1.80
RT	7.00	-8.49	5.01	32.90	12.84	30.65	0.90	0.45	9.59	5.19	6.72

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.61	-11.5	12.95	5.76	9.44	2.147	36.77	10.48a	0.00	0.00	0.00	4.14	5.37
MID	35.00	0.94	1.2	2.01	6.23	16.73	3.521	31.02	18.59a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.94	-11.3	12.95	5.76	9.94	2.261	36.12	11.04a	0.00	0.00	0.00	21.01	27.23
TOP	10.76	-2.66	-12.4	12.95	5.76	9.24	2.102	37.07	10.27a	0.00	0.00	0.00	7.46	9.67

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	11.10	-9.3	3.49	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.09	4.01
MID	70.00	4.06	25.2	-0.50	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	4.69	6.08
RT	14.52	11.10	-9.3	3.49	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.09	4.01

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.65	-8.5	5.01	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.06
MID	70.00	0.12	20.6	0.46	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.65	-8.5	5.01	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.05

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 2.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.390	-13.927	3.050	12.951	5.012	0.463
1- 1	-2.474	-11.642	2.007	12.951	4.083	0.284
1- 2	-0.837	-11.181	2.007	12.951	3.199	0.118
1- 3	0.297	-11.072	2.007	12.951	2.360	-0.035
1- 4	0.956	-11.143	2.007	12.951	1.567	-0.175
1- 5	1.164	-11.328	2.007	12.951	0.939	-0.422
1- 6	0.950	-11.599	2.007	12.951	0.826	-1.125
1- 7	0.338	-11.942	2.007	12.951	0.725	-1.783
1- 8	-0.644	-12.210	2.007	12.951	0.638	-2.396
1- 9	-1.971	-12.468	2.007	12.951	0.564	-2.963
1-10	-2.843	-14.212	3.050	12.951	0.503	-3.486
Top						
Member 2: (Top Slab)						
Left						
2- 0	-2.850	-14.234	-0.503	3.486	12.951	2.007
2- 1	5.565	-4.428	-0.503	3.486	11.166	1.557
2- 2	14.002	0.022	-0.503	3.080	9.417	0.999
2- 3	20.152	1.158	-0.503	3.080	7.637	-0.582
2- 4	23.923	1.839	-0.503	3.080	5.844	-2.297
2- 5	25.189	2.066	-0.503	3.080	4.058	-4.058
2- 6	23.923	1.839	-0.503	3.080	2.297	-5.844
2- 7	20.152	1.158	-0.503	3.080	0.579	-7.637
2- 8	13.995	0.022	-0.503	3.080	-0.999	-9.417
2- 9	5.565	-4.428	-0.503	3.486	-1.557	-11.166
2-10	-2.846	-14.234	-0.503	3.486	-2.007	-12.951
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.390	-13.927	0.463	5.012	10.889	2.532
4- 1	0.469	-3.039	0.463	5.012	8.728	2.025
4- 2	9.315	0.087	0.463	4.177	6.567	1.519
4- 3	15.577	1.563	0.463	4.177	4.405	1.013
4- 4	19.333	2.450	0.463	4.177	2.244	0.506
4- 5	20.584	2.745	0.463	4.177	0.122	-0.122
4- 6	19.333	2.450	0.463	4.177	-0.506	-2.244
4- 7	15.577	1.563	0.463	4.177	-1.013	-4.406
4- 8	9.315	0.087	0.463	4.177	-1.519	-6.567
4- 9	0.469	-3.039	0.463	5.012	-2.025	-8.728
4-10	-4.390	-13.933	0.463	5.012	-2.532	-10.890
Right						

----- Analysis Truck, MaineDOT Config 6 -----

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.614	3.13	
	2	1.100	3.13	9.00
	3	1.105	3.13	4.00
	4	1.100	3.13	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 4.63 ft
 Impact Factor : 1.25
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.614	3.13	19.02	Truck	1	0.614	3.13	18.83
	2	1.100	3.13	10.02		2	1.100	3.13	9.83
	3	1.105	3.13	6.02		3	1.105	3.13	5.83
	4	1.100	3.13	2.02		4	1.100	3.13	1.83
Maximum +Moment : 10.07 k-ft					Maximum -Moment : -5.00 k-ft				

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 Filename: Box Culvert - R1.etcx
 Corresponding Moment at End : -4.96 k-ft
 Coincident Bottom Slab Load : 1.04 k/ft

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:20 PM
 Culvert p. 33 of 82

Corresponding Moment at Mid : 10.06 k-ft
 Coincident Bottom Slab Load : 1.04 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.614 3.13 18.57
 2 1.100 3.13 9.57
 3 1.105 3.13 5.57
 4 1.100 3.13 1.57

Maximum +Shear : 5.41 k
 Corresponding Shear at Mid : -0.06 k
 Coincident Bottom Slab Load : 1.04 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.614 3.13 19.10
 2 1.100 3.13 10.10
 3 1.105 3.13 6.10
 4 1.100 3.13 2.10

Maximum -Shear : -5.42 k
 Corresponding Shear at Mid : 0.06 k
 Coincident Bottom Slab Load : 1.04 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-5.69	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-5.64	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-5.59	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-5.62	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-5.64	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-5.66	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-5.56	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-5.42	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-5.28	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-5.14	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.05	-5.00	0.37	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												

Member 2: (Top Slab)												
Left												
2- 0	0.05	-5.00	5.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.68	-1.10	4.40	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	4.80	0.00	3.49	-0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	7.53	0.00	2.70	-0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	9.35	0.00	2.00	-0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	10.07	0.00	1.38	-1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	9.38	0.00	0.90	-2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	7.48	0.00	0.54	-2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	4.76	0.00	0.24	-3.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	1.68	-1.08	0.06	-4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.05	-5.00	0.00	-5.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												

Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-5.69	5.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.28	-0.36	4.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	4.68	0.00	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	7.88	0.00	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	9.80	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 5	10.44	0.00	0.04	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	9.80	0.00	0.00	-1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 7	7.88	0.00	0.00	-2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 8	4.68	0.00	0.00	-3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 9	0.26	-0.36	0.00	-4.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-10	0.00	-5.70	0.00	-5.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 2.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.4	7.71	26.64	2.00	8.58
A2	Bot Corner Bar	-8.5	7.71	32.17	2.00	6.36
A100	Top Slab (int)	14.3	-0.16	36.15	2.00	7.90
A200	Bot Slab (int)	15.5	0.65	38.53	2.00	7.21

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings	
										IR	OR
BOT	9.00	-13.64	12.52	14.52	5.84	15.71	0.90	0.45	6.14	1.21	1.21
MID	35.00	1.16	2.01	6.97	6.36	6.71	0.90	0.19	6.14	NC	NC
MID-	35.00	-12.88	12.52	14.52	5.84	15.71	0.90	0.45	6.14	1.28	1.28
TOP	9.00	-12.02	12.52	14.52	5.84	15.71	0.90	0.45	6.14	1.41	1.41

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 (in ²)	Mcr (k-ft)	Load Ratings	
										IR	OR
LT	7.00	-8.39	3.16	32.90	12.84	30.26	0.90	0.45	9.59	4.57	4.57
MID	70.00	23.20	-0.37	28.72	8.32	25.75	0.90	0.62	9.59	1.15	1.15
RT	7.00	-8.37	3.16	32.90	12.84	30.26	0.90	0.45	9.59	4.58	4.58

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 (in ²)	Mcr (k-ft)	Load Ratings	
										IR	OR
LT	7.00	-9.28	4.88	32.90	12.84	30.62	0.90	0.45	9.59	4.51	4.51
MID	70.00	24.90	0.79	28.72	8.32	26.04	0.90	0.62	9.59	1.06	1.06
RT	7.00	-9.28	4.88	32.90	12.84	30.62	0.90	0.45	9.59	4.50	4.50

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings	
													IR	OR
BOT	10.76	3.47	-13.6	12.52	5.76	8.79	2.000	45.00	9.77b	0.00	0.00	0.00	4.08	4.08
MID	35.00	0.81	1.2	2.01	6.23	16.96	3.571	30.85	18.85a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.81	-12.9	12.52	5.76	9.24	2.102	37.07	10.27a	0.00	0.00	0.00	65.55	65.55
TOP	10.76	-2.33	-12.0	12.52	5.76	9.37	2.131	36.87	10.41a	0.00	0.00	0.00	7.57	7.57

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings	
													IR	OR
LT	14.52	9.99	-8.4	3.16	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.54	3.54
MID	70.00	2.42	23.2	-0.37	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	7.88	7.88
RT	14.52	9.99	-8.4	3.16	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.54	3.54

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings	
													IR	OR
LT	14.52	10.60	-9.3	4.88	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.47	3.47
MID	70.00	0.07	24.9	0.79	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	10.60	-9.3	4.88	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.47	3.47

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 2.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.390	-15.930	3.050	12.523	4.879	0.790
1- 1	-2.474	-13.771	2.007	12.523	3.950	0.611
1- 2	-0.837	-13.302	2.007	12.523	3.066	0.445
1- 3	0.297	-13.047	2.007	12.523	2.227	0.292
1- 4	0.956	-12.877	2.007	12.523	1.434	0.152
1- 5	1.164	-12.786	2.007	12.523	0.806	-0.095
1- 6	0.950	-12.544	2.007	12.523	0.693	-0.798
1- 7	0.338	-12.299	2.007	12.523	0.592	-1.456
1- 8	-0.644	-12.110	2.007	12.523	0.505	-2.069
1- 9	-1.971	-11.989	2.007	12.523	0.431	-2.636
1-10	-3.018	-13.354	3.050	12.523	0.370	-3.159
Top						
Member 2: (Top Slab)						
Left						
2- 0	-3.024	-13.376	-0.370	3.159	12.523	2.007
2- 1	2.980	-3.394	-0.370	3.159	10.069	1.557
2- 2	10.864	0.022	-0.370	3.080	7.882	1.168
2- 3	17.359	1.158	-0.370	3.080	5.909	0.245
2- 4	21.594	1.839	-0.370	3.080	4.086	-0.980
2- 5	23.195	2.066	-0.370	3.080	2.417	-2.417
2- 6	21.645	1.839	-0.370	3.080	0.979	-4.086
2- 7	17.279	1.158	-0.370	3.080	-0.246	-5.909
2- 8	10.786	0.022	-0.370	3.080	-1.168	-7.882
2- 9	2.980	-3.358	-0.370	3.159	-1.557	-10.069
2-10	-3.022	-13.376	-0.370	3.159	-2.007	-12.528
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.390	-15.930	0.790	4.879	13.374	2.532
4- 1	0.069	-2.627	0.790	4.879	10.700	2.025
4- 2	10.858	0.087	0.790	4.177	8.026	1.519
4- 3	18.657	1.563	0.790	4.177	5.352	1.013
4- 4	23.336	2.450	0.790	4.177	2.679	0.506
4- 5	24.895	2.745	0.790	4.177	0.067	-0.067
4- 6	23.336	2.450	0.790	4.177	-0.506	-2.680
4- 7	18.657	1.563	0.790	4.177	-1.013	-5.354
4- 8	10.858	0.087	0.790	4.177	-1.519	-8.028
4- 9	0.040	-2.627	0.790	4.879	-2.025	-10.701
4-10	-4.390	-15.943	0.790	4.879	-2.532	-13.375
Right						

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

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.413	3.13	
	2	1.652	3.13	14.00
	3	1.652	3.13	14.00
Tandem	1	1.291	3.13	
	2	1.291	3.13	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution Width : 4.63 ft
 Impact Factor : 1.25
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.413	3.13	19.83	Truck	1	0.413	3.13	19.25
	2	1.652	3.13	5.83		2	1.652	3.13	5.25
	3	1.652	3.13	-8.17		3	1.652	3.13	-8.75

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 Maximum +Moment : 8.97 k-ft
 Corresponding Moment at End : -4.10 k-ft
 Coincident Bottom Slab Load : 0.52 k/ft

Sht:____of____
 By:IRR Chk:____
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Maximum +Shear in Top Slab
 Truck 1 0.413 3.13 15.57
 2 1.652 3.13 1.57
 3 1.652 3.13 -12.43
 Maximum +Shear : 4.53 k
 Corresponding Shear at Mid : -0.65 k
 Coincident Bottom Slab Load : 0.52 k/ft

Maximum +Moment in Top Slab
 Tandem 1 1.291 3.13 8.48
 2 1.291 3.13 4.48
 Maximum +Moment : 10.10 k-ft
 Corresponding Moment at End : -5.28 k-ft
 Coincident Bottom Slab Load : 0.81 k/ft

Maximum +Shear in Top Slab
 Tandem 1 1.291 3.13 5.57
 2 1.291 3.13 1.57
 Maximum +Shear : 5.66 k
 Corresponding Shear at Mid : -0.75 k
 Coincident Bottom Slab Load : 0.81 k/ft

Maximum -Moment : -4.14 k-ft
 Corresponding Moment at Mid : 8.74 k-ft
 Coincident Bottom Slab Load : 0.52 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.413 3.13 24.10
 2 1.652 3.13 10.10
 3 1.652 3.13 -3.90

Maximum -Shear : -4.53 k
 Corresponding Shear at Mid : 0.65 k
 Coincident Bottom Slab Load : 0.52 k/ft

Maximum -Moment in Top Slab
 Tandem 1 1.291 3.13 7.50
 2 1.291 3.13 3.50

Maximum -Moment : -5.49 k-ft
 Corresponding Moment at Mid : 10.06 k-ft
 Coincident Bottom Slab Load : 0.81 k/ft

Maximum -Shear in Top Slab
 Tandem 1 1.291 3.13 10.10
 2 1.291 3.13 6.10

Maximum -Shear : -5.66 k
 Corresponding Shear at Mid : 0.75 k
 Coincident Bottom Slab Load : 0.81 k/ft

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

M-PT	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.48	0.35	-0.21	0.00	-4.55	0.28	-0.14	0.00	0.00	0.00	0.00
1- 1	0.00	-3.22	0.35	-0.21	0.00	-4.42	0.28	-0.14	0.00	0.00	0.00	0.00
1- 2	0.00	-3.19	0.35	-0.21	0.00	-4.38	0.28	-0.14	0.00	0.00	0.00	0.00
1- 3	0.00	-3.28	0.35	-0.21	0.00	-4.49	0.28	-0.14	0.00	0.00	0.00	0.00
1- 4	0.00	-3.43	0.35	-0.21	0.00	-4.65	0.28	-0.14	0.00	0.00	0.00	0.00
1- 5	0.00	-3.58	0.35	-0.21	0.00	-4.83	0.28	-0.14	0.00	0.00	0.00	0.00
1- 6	0.00	-3.68	0.35	-0.21	0.00	-5.02	0.28	-0.14	0.00	0.00	0.00	0.00
1- 7	0.00	-3.79	0.35	-0.21	0.00	-5.22	0.28	-0.14	0.00	0.00	0.00	0.00
1- 8	0.00	-3.91	0.35	-0.21	0.00	-5.34	0.28	-0.14	0.00	0.00	0.00	0.00
1- 9	0.01	-4.02	0.35	-0.21	0.00	-5.42	0.28	-0.14	0.00	0.00	0.00	0.00
1-10	0.12	-4.14	0.35	-0.21	0.06	-5.49	0.28	-0.14	0.00	0.00	0.00	0.00
Top												

Member 2: (Top Slab)												
Left												
2- 0	0.12	-4.14	4.53	0.00	0.06	-5.49	5.66	0.00	0.00	0.00	0.00	0.00
2- 1	2.53	-1.35	4.02	-0.09	1.97	-1.29	4.83	-0.07	0.00	0.00	0.00	0.00
2- 2	5.28	0.00	3.49	-0.36	5.31	0.00	4.00	-0.28	0.00	0.00	0.00	0.00
2- 3	7.30	0.00	2.95	-0.81	8.07	0.00	3.16	-0.63	0.00	0.00	0.00	0.00
2- 4	8.55	0.00	2.40	-1.32	9.69	0.00	2.34	-1.05	0.00	0.00	0.00	0.00
2- 5	8.97	0.00	1.86	-1.86	10.10	0.00	1.62	-1.62	0.00	0.00	0.00	0.00
2- 6	8.55	0.00	1.32	-2.40	9.69	0.00	1.05	-2.34	0.00	0.00	0.00	0.00
2- 7	7.30	0.00	0.81	-2.95	8.07	0.00	0.63	-3.16	0.00	0.00	0.00	0.00
2- 8	5.27	0.00	0.36	-3.49	5.26	0.00	0.28	-4.00	0.00	0.00	0.00	0.00
2- 9	2.53	-1.35	0.09	-4.02	1.97	-1.26	0.07	-4.83	0.00	0.00	0.00	0.00
2-10	0.12	-4.14	0.00	-4.53	0.06	-5.49	0.00	-5.66	0.00	0.00	0.00	0.00
Right												

Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-3.48	2.81	0.00	0.00	-4.55	4.06	0.00	0.00	0.00	0.00	0.00
4- 1	0.41	-0.47	2.26	0.00	0.34	-0.37	3.26	0.00	0.00	0.00	0.00	0.00
4- 2	2.77	0.00	1.71	0.00	3.80	0.00	2.46	0.00	0.00	0.00	0.00	0.00
4- 3	4.33	0.00	1.16	0.00	6.12	0.00	1.65	0.00	0.00	0.00	0.00	0.00
4- 4	5.26	0.00	0.61	0.00	7.51	0.00	0.85	0.00	0.00	0.00	0.00	0.00
4- 5	5.57	0.00	0.06	-0.06	7.97	0.00	0.04	-0.04	0.00	0.00	0.00	0.00
4- 6	5.26	0.00	0.00	-0.61	7.51	0.00	0.00	-0.85	0.00	0.00	0.00	0.00
4- 7	4.33	0.00	0.00	-1.16	6.12	0.00	0.00	-1.65	0.00	0.00	0.00	0.00
4- 8	2.77	0.00	0.00	-1.71	3.80	0.00	0.00	-2.46	0.00	0.00	0.00	0.00
4- 9	0.41	-0.47	0.00	-2.26	0.34	-0.37	0.00	-3.26	0.00	0.00	0.00	0.00
4-10	0.00	-3.49	0.00	-2.81	0.00	-4.55	0.00	-4.06	0.00	0.00	0.00	0.00
Right												

Note: unfactored live load results computed at 2.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.6	7.96	27.37	2.00	8.23
A2	Bot Corner Bar	-7.3	7.96	25.83	2.00	8.98
A100	Top Slab (int)	14.3	-0.15	36.22	2.00	7.88
A200	Bot Slab (int)	13.0	0.51	32.43	2.00	9.20

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.51	12.95	14.52	5.84	15.80	0.90	0.45	6.14	1.56	2.02
MID	35.00	1.16	2.01	6.97	6.36	6.71	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.33	12.95	14.52	5.84	15.80	0.90	0.45	6.14	1.51	1.96
TOP	9.00	-12.39	12.95	14.52	5.84	15.80	0.90	0.45	6.14	1.36	1.77

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-9.04	3.39	32.90	12.84	30.31	0.90	0.45	9.59	4.14	5.36
MID	70.00	23.25	-0.35	28.72	8.32	25.76	0.90	0.62	9.59	1.14	1.48
RT	7.00	-9.04	3.39	32.90	12.84	30.31	0.90	0.45	9.59	4.14	5.36

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.38	4.86	32.90	12.84	30.61	0.90	0.45	9.59	5.29	6.85
MID	70.00	20.58	0.56	28.72	8.32	25.99	0.90	0.62	9.59	1.39	1.80
RT	7.00	-8.38	4.86	32.90	12.84	30.61	0.90	0.45	9.59	5.28	6.85

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.45	-11.5	12.95	5.76	9.45	2.151	36.74	10.50a	0.00	0.00	0.00	4.53	5.87
MID	35.00	0.78	1.2	2.01	6.23	17.00	3.579	30.83	18.89a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.78	-11.3	12.95	5.76	9.97	2.267	36.09	11.07a	0.00	0.00	0.00	26.33	34.13
TOP	10.76	-2.57	-12.4	12.95	5.76	9.25	2.104	37.05	10.28a	0.00	0.00	0.00	7.47	9.68

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	10.75	-9.0	3.39	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.22	4.17
MID	70.00	3.25	23.3	-0.35	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	5.87	7.60
RT	14.52	10.75	-9.0	3.39	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.22	4.17

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.65	-8.4	4.86	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.06
MID	70.00	0.10	20.6	0.56	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.65	-8.4	4.86	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.05

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 2.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.390	-13.927	3.050	12.948	4.857	0.556
1- 1	-2.474	-11.642	2.007	12.948	3.928	0.377
1- 2	-0.837	-11.181	2.007	12.948	3.044	0.211
1- 3	0.297	-11.072	2.007	12.948	2.205	0.058
1- 4	0.956	-11.143	2.007	12.948	1.412	-0.082
1- 5	1.164	-11.328	2.007	12.948	0.784	-0.329
1- 6	0.950	-11.599	2.007	12.948	0.671	-1.032
1- 7	0.338	-11.942	2.007	12.948	0.570	-1.690
1- 8	-0.644	-12.210	2.007	12.948	0.483	-2.303
1- 9	-1.971	-12.468	2.007	12.948	0.409	-2.870
1-10	-2.896	-14.212	3.050	12.948	0.348	-3.392
Top						
Member 2: (Top Slab)						
Left						
2- 0	-2.903	-14.234	-0.348	3.392	12.948	2.007
2- 1	4.459	-3.837	-0.348	3.392	10.830	1.557
2- 2	11.757	0.022	-0.348	3.080	8.774	1.155
2- 3	18.316	1.158	-0.348	3.080	6.719	-0.228
2- 4	22.189	1.839	-0.348	3.080	4.794	-1.719
2- 5	23.251	2.066	-0.348	3.080	3.246	-3.246
2- 6	22.189	1.839	-0.348	3.080	1.719	-4.794
2- 7	18.316	1.158	-0.348	3.080	0.226	-6.719
2- 8	11.687	0.022	-0.348	3.080	-1.155	-8.774
2- 9	4.459	-3.837	-0.348	3.392	-1.557	-10.830
2-10	-2.900	-14.234	-0.348	3.392	-2.007	-12.948
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.390	-13.927	0.556	4.857	10.889	2.532
4- 1	0.290	-2.832	0.556	4.857	8.728	2.025
4- 2	9.315	0.087	0.556	4.177	6.567	1.519
4- 3	15.577	1.563	0.556	4.177	4.405	1.013
4- 4	19.333	2.450	0.556	4.177	2.244	0.506
4- 5	20.584	2.745	0.556	4.177	0.097	-0.097
4- 6	19.333	2.450	0.556	4.177	-0.506	-2.244
4- 7	15.577	1.563	0.556	4.177	-1.013	-4.406
4- 8	9.315	0.087	0.556	4.177	-1.519	-6.567
4- 9	0.290	-2.832	0.556	4.857	-2.025	-8.728
4-10	-4.390	-13.933	0.556	4.857	-2.532	-10.890
Right						

Analysis Results: Fill Depth = 2.50 ft

Load Parameters:

Fe = 1.04 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.820	0.273
Live Load Surcharge	0.297	0.297
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Mls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-1.93	0.00	-0.85	-0.44	0.00
1- 1	-1.48	-1.93	0.00	0.11	0.01	0.00
1- 2	-1.38	-1.93	0.00	0.80	0.37	0.00
1- 3	-1.28	-1.93	0.00	1.26	0.62	0.00
1- 4	-1.18	-1.93	0.00	1.49	0.77	0.00
1- 5	-1.08	-1.93	0.00	1.52	0.82	0.00
1- 6	-0.98	-1.93	0.00	1.36	0.77	0.00
1- 7	-0.88	-1.93	0.00	1.04	0.62	0.00
1- 8	-0.78	-1.93	0.00	0.56	0.37	0.00
1- 9	-0.68	-1.93	0.00	-0.04	0.01	0.00
1-10	-0.58	-1.93	0.00	-0.76	-0.44	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	1.87	0.87	0.00
1- 1	0.17	0.00	0.00	1.41	0.69	0.00
1- 2	0.17	0.00	0.00	0.98	0.52	0.00
1- 3	0.17	0.00	0.00	0.58	0.35	0.00
1- 4	0.17	0.00	0.00	0.21	0.17	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.42	-0.17	0.00
1- 7	0.17	0.00	0.00	-0.69	-0.35	0.00
1- 8	0.17	0.00	0.00	-0.93	-0.52	0.00
1- 9	0.17	0.00	0.00	-1.14	-0.69	0.00
1-10	0.17	0.00	0.00	-1.32	-0.87	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-1.93	0.00	-0.78	-0.44	0.00
2- 1	0.21	0.06	0.00	-0.78	-0.44	0.00
2- 2	0.81	1.61	0.00	-0.78	-0.44	0.00
2- 3	1.23	2.71	0.00	-0.78	-0.44	0.00
2- 4	1.49	3.38	0.00	-0.78	-0.44	0.00
2- 5	1.57	3.60	0.00	-0.78	-0.44	0.00
2- 6	1.49	3.38	0.00	-0.78	-0.44	0.00
2- 7	1.23	2.71	0.00	-0.78	-0.44	0.00
2- 8	0.81	1.61	0.00	-0.78	-0.44	0.00
2- 9	0.21	0.06	0.00	-0.78	-0.44	0.00
2-10	-0.58	-1.93	0.00	-0.78	-0.44	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	1.90	0.00	0.00	0.00	0.00
2- 1	0.58	1.52	0.00	0.00	0.00	0.00
2- 2	0.44	1.14	0.00	0.00	0.00	0.00
2- 3	0.29	0.76	0.00	0.00	0.00	0.00
2- 4	0.15	0.38	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.38	0.00	0.00	0.00	0.00
2- 7	-0.29	-0.76	0.00	0.00	0.00	0.00
2- 8	-0.44	-1.14	0.00	0.00	0.00	0.00
2- 9	-0.58	-1.52	0.00	0.00	0.00	0.00
2-10	-0.80	-1.90	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-1.93	0.00	-0.85	-0.44	0.00
4- 1	-0.13	0.06	0.00	-0.85	-0.44	0.00
4- 2	1.00	1.61	0.00	-0.85	-0.44	0.00
4- 3	1.80	2.71	0.00	-0.85	-0.44	0.00
4- 4	2.28	3.38	0.00	-0.85	-0.44	0.00
4- 5	2.44	3.60	0.00	-0.85	-0.44	0.00
4- 6	2.28	3.38	0.00	-0.85	-0.44	0.00
4- 7	1.80	2.71	0.00	-0.85	-0.44	0.00
4- 8	1.00	1.61	0.00	-0.85	-0.44	0.00
4- 9	-0.13	0.06	0.00	-0.85	-0.44	0.00
4-10	-1.58	-1.93	0.00	-0.85	-0.44	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	1.90	0.00	0.00	0.00	0.00
4- 1	1.10	1.52	0.00	0.00	0.00	0.00
4- 2	0.83	1.14	0.00	0.00	0.00	0.00
4- 3	0.55	0.76	0.00	0.00	0.00	0.00
4- 4	0.28	0.38	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.38	0.00	0.00	0.00	0.00
4- 7	-0.55	-0.76	0.00	0.00	0.00	0.00
4- 8	-0.83	-1.14	0.00	0.00	0.00	0.00
4- 9	-1.10	-1.52	0.00	0.00	0.00	0.00
4-10	-1.38	-1.90	0.00	0.00	0.00	0.00
Right						

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 2.50 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	1.90	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.32	0.87	0.00
4	0.17	0.00	0.00	1.87	0.87	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.382	3.71	
	2	1.526	3.71	14.00
	3	1.526	3.71	14.00
Tandem	1	0.954	3.71	

2 0.954 3.71

4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution Width : 5.20 ft
 Impact Factor : 1.23
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.382 3.71 19.83
 2 1.526 3.71 5.83
 3 1.526 3.71 -8.17
 Maximum +Moment : 9.44 k-ft
 Corresponding Moment at End : -4.45 k-ft
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.382 3.71 15.85
 2 1.526 3.71 1.85
 3 1.526 3.71 -12.15
 Maximum +Shear : 4.81 k
 Corresponding Shear at Mid : -0.85 k
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum +Moment in Top Slab
 Tandem 1 0.954 3.71 8.08
 2 0.954 3.71 4.08
 Maximum +Moment : 8.83 k-ft
 Corresponding Moment at End : -4.70 k-ft
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum +Shear in Top Slab
 Tandem 1 0.954 3.71 5.85
 2 0.954 3.71 1.85
 Maximum +Shear : 4.77 k
 Corresponding Shear at Mid : -0.52 k
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum -Moment in Top slab
 Vehicle Axle Weight Length Dist. From
 No. (k) (ft) Left End (ft)
 Truck 1 0.382 3.71 19.35
 2 1.526 3.71 5.35
 3 1.526 3.71 -8.65
 Maximum -Moment : -4.49 k-ft
 Corresponding Moment at Mid : 9.30 k-ft
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.382 3.71 23.81
 2 1.526 3.71 9.81
 3 1.526 3.71 -4.19
 Maximum -Shear : -4.81 k
 Corresponding Shear at Mid : 0.85 k
 Coincident Bottom Slab Load : 0.56 k/ft

Maximum -Moment in Top slab
 Tandem 1 0.954 3.71 8.08
 2 0.954 3.71 4.08
 Maximum -Moment : -4.76 k-ft
 Corresponding Moment at Mid : 8.83 k-ft
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum -Shear in Top slab
 Tandem 1 0.954 3.71 9.81
 2 0.954 3.71 5.81
 Maximum -Shear : -4.77 k
 Corresponding Shear at Mid : 0.52 k
 Coincident Bottom Slab Load : 0.69 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)												
Bottom												
1- 0	0.00	-3.91	0.31	-0.24	0.00	-4.35	0.20	-0.13	0.00	0.00	0.00	0.00
1- 1	0.00	-3.73	0.31	-0.24	0.00	-4.33	0.20	-0.13	0.00	0.00	0.00	0.00
1- 2	0.00	-3.63	0.31	-0.24	0.00	-4.31	0.20	-0.13	0.00	0.00	0.00	0.00
1- 3	0.00	-3.66	0.31	-0.24	0.00	-4.30	0.20	-0.13	0.00	0.00	0.00	0.00
1- 4	0.00	-3.74	0.31	-0.24	0.00	-4.35	0.20	-0.13	0.00	0.00	0.00	0.00
1- 5	0.00	-3.85	0.31	-0.24	0.00	-4.41	0.20	-0.13	0.00	0.00	0.00	0.00
1- 6	0.00	-3.97	0.31	-0.24	0.00	-4.48	0.20	-0.13	0.00	0.00	0.00	0.00
1- 7	0.00	-4.10	0.31	-0.24	0.00	-4.54	0.20	-0.13	0.00	0.00	0.00	0.00
1- 8	0.00	-4.23	0.31	-0.24	0.00	-4.61	0.20	-0.13	0.00	0.00	0.00	0.00
1- 9	0.00	-4.36	0.31	-0.24	0.00	-4.68	0.20	-0.13	0.00	0.00	0.00	0.00
1-10	0.11	-4.49	0.31	-0.24	0.04	-4.76	0.20	-0.13	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.11	-4.49	4.81	0.00	0.04	-4.76	4.77	0.00	0.00	0.00	0.00	0.00
2- 1	2.43	-1.44	4.25	-0.08	1.52	-1.09	4.05	-0.05	0.00	0.00	0.00	0.00
2- 2	5.46	0.00	3.67	-0.33	4.41	0.00	3.32	-0.21	0.00	0.00	0.00	0.00
2- 3	7.62	0.00	3.08	-0.75	6.96	0.00	2.59	-0.47	0.00	0.00	0.00	0.00
2- 4	8.98	0.00	2.48	-1.31	8.38	0.00	1.89	-0.83	0.00	0.00	0.00	0.00
2- 5	9.44	0.00	1.88	-1.88	8.83	0.00	1.30	-1.30	0.00	0.00	0.00	0.00
2- 6	8.98	0.00	1.31	-2.48	8.38	0.00	0.83	-1.89	0.00	0.00	0.00	0.00
2- 7	7.62	0.00	0.75	-3.08	6.90	0.00	0.47	-2.59	0.00	0.00	0.00	0.00
2- 8	5.43	0.00	0.33	-3.67	4.41	0.00	0.21	-3.32	0.00	0.00	0.00	0.00
2- 9	2.43	-1.44	0.08	-4.25	1.52	-1.08	0.05	-4.05	0.00	0.00	0.00	0.00

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 2-10 0.11 -4.49 0.00 -4.81 0.04 -4.76 0.00 -4.77 0.00 0.00 0.00
 Right

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:21 PM
 Culvert p. 41 of 82
 0.00

Member 4: (Bottom Slab)

Left												
4- 0	0.00	-3.91	3.30	0.00	0.00	-4.35	4.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.44	-0.44	2.65	0.00	0.30	-0.28	3.21	0.00	0.00	0.00	0.00	0.00
4- 2	3.05	0.00	2.00	0.00	3.59	0.00	2.42	0.00	0.00	0.00	0.00	0.00
4- 3	4.90	0.00	1.35	0.00	5.94	0.00	1.63	0.00	0.00	0.00	0.00	0.00
4- 4	6.02	0.00	0.71	0.00	7.34	0.00	0.84	0.00	0.00	0.00	0.00	0.00
4- 5	6.39	0.00	0.06	-0.06	7.81	0.00	0.04	-0.04	0.00	0.00	0.00	0.00
4- 6	6.02	0.00	0.00	-0.71	7.34	0.00	0.00	-0.84	0.00	0.00	0.00	0.00
4- 7	4.90	0.00	0.00	-1.35	5.94	0.00	0.00	-1.63	0.00	0.00	0.00	0.00
4- 8	3.05	0.00	0.00	-2.00	3.59	0.00	0.00	-2.42	0.00	0.00	0.00	0.00
4- 9	0.44	-0.44	0.00	-2.65	0.30	-0.28	0.00	-3.21	0.00	0.00	0.00	0.00
4-10	0.00	-3.91	0.00	-3.30	0.00	-4.35	0.00	-4.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 2.50 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.3	7.50	26.29	2.00	8.75
A2	Bot Corner Bar	-7.6	7.50	27.93	2.00	7.98
A100	Top Slab (int)	14.4	-0.06	36.29	2.00	7.86
A200	Bot Slab (int)	13.6	0.53	33.83	2.00	8.68

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-11.90	12.00	14.52	5.84	15.60	0.90	0.45	6.14	1.49	1.93
MID	35.00	0.96	2.34	6.97	6.36	6.79	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.12	12.00	14.52	5.84	15.60	0.90	0.45	6.14	1.57	2.03
TOP	9.00	-11.65	12.00	14.52	5.84	15.60	0.90	0.45	6.14	1.49	1.93

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
LT	7.00	-8.81	3.58	32.90	12.84	30.35	0.90	0.45	9.59	4.48	5.80
MID	70.00	23.07	-0.22	28.72	8.32	25.79	0.90	0.62	9.59	1.17	1.51
RT	7.00	-8.81	3.58	32.90	12.84	30.35	0.90	0.45	9.59	4.48	5.80

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
LT	7.00	-8.52	4.93	32.90	12.84	30.63	0.90	0.45	9.59	5.45	7.06
MID	70.00	21.29	0.57	28.72	8.32	25.99	0.90	0.62	9.59	1.34	1.74
RT	7.00	-8.52	4.93	32.90	12.84	30.63	0.90	0.45	9.59	5.45	7.06

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.48	-11.9	12.00	5.76	9.24	2.103	37.06	10.27a	0.00	0.00	0.00	4.60	5.96
MID	35.00	0.71	1.0	2.34	6.23	18.43	3.879	29.85	20.48a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.71	-11.1	12.00	5.76	9.97	2.268	36.09	11.08a	0.00	0.00	0.00	23.60	30.60
TOP	10.76	-2.71	-11.7	12.00	5.76	9.41	2.140	36.81	10.45a	0.00	0.00	0.00	7.73	10.02

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	10.18	-8.8	3.58	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.60	4.66
MID	70.00	3.30	23.1	-0.22	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	5.77	7.48
RT	14.52	10.18	-8.8	3.58	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.60	4.66

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.98	-8.5	4.93	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.06
MID	70.00	0.10	21.3	0.57	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.98	-8.5	4.93	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.06

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 2.50 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.963	-14.211	3.584	12.004	4.933	0.569
1- 1	-2.814	-12.024	2.342	12.004	3.974	0.379
1- 2	-1.117	-11.571	2.342	12.004	3.061	0.201
1- 3	0.060	-11.251	2.342	12.004	2.194	0.037
1- 4	0.744	-11.121	2.342	12.004	1.371	-0.114
1- 5	0.961	-11.087	2.342	12.004	0.714	-0.372
1- 6	0.737	-11.139	2.342	12.004	0.590	-1.104
1- 7	0.100	-11.269	2.342	12.004	0.478	-1.791
1- 8	-0.924	-11.461	2.342	12.004	0.380	-2.433
1- 9	-2.310	-11.730	2.342	12.004	0.294	-3.030
1-10	-3.485	-13.540	3.584	12.004	0.222	-3.581
Top						
Member 2: (Top Slab)						
Left						
2- 0	-3.491	-13.562	-0.222	3.581	12.004	2.342
2- 1	4.277	-4.057	-0.222	3.581	10.242	1.826
2- 2	12.436	0.232	-0.222	3.226	8.524	1.369
2- 3	18.261	1.563	-0.222	3.226	6.784	0.081
2- 4	21.862	2.362	-0.222	3.226	5.036	-1.590
2- 5	23.071	2.628	-0.222	3.226	3.299	-3.299
2- 6	21.862	2.362	-0.222	3.226	1.587	-5.036
2- 7	18.261	1.563	-0.222	3.226	-0.081	-6.784
2- 8	12.388	0.232	-0.222	3.226	-1.369	-8.524
2- 9	4.277	-4.057	-0.222	3.581	-1.826	-10.242
2-10	-3.496	-13.562	-0.222	3.581	-2.342	-12.004
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.963	-14.211	0.569	4.933	11.306	2.867
4- 1	0.335	-2.836	0.569	4.933	9.061	2.294
4- 2	9.365	0.296	0.569	4.323	6.816	1.720
4- 3	15.991	1.969	0.569	4.323	4.571	1.147
4- 4	19.966	2.972	0.569	4.323	2.326	0.573
4- 5	21.290	3.307	0.569	4.323	0.101	-0.101
4- 6	19.966	2.972	0.569	4.323	-0.573	-2.327
4- 7	15.991	1.969	0.569	4.323	-1.147	-4.572
4- 8	9.365	0.296	0.569	4.323	-1.720	-6.816
4- 9	0.335	-2.836	0.569	4.933	-2.294	-9.061
4-10	-4.963	-14.211	0.569	4.933	-2.867	-11.306
Right						

----- Analysis Truck, MaineDOT Config 6 -----

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.454	3.71	
	2	0.813	3.71	9.00
	3	0.817	3.71	4.00
	4	0.813	3.71	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 5.20 ft
 Impact Factor : 1.23
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.454	3.71	18.85	Truck	1	0.454	3.71	18.25
	2	0.813	3.71	9.85		2	0.813	3.71	9.25
	3	0.817	3.71	5.85		3	0.817	3.71	5.25
	4	0.813	3.71	1.85		4	0.813	3.71	1.25
Maximum +Moment : 8.63 k-ft					Maximum -Moment : -4.36 k-ft				

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 Filename: Box Culvert - R1.etcx
 Corresponding Moment at End : -4.33 k-ft
 Coincident Bottom Slab Load : 0.89 k/ft

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:21 PM
 Culvert p. 44 of 82

Maximum +Shear in Top Slab
 Truck 1 0.454 3.71 18.85
 2 0.813 3.71 9.85
 3 0.817 3.71 5.85
 4 0.813 3.71 1.85
 Maximum +Shear : 4.51 k
 Corresponding Shear at Mid : 0.00 k
 Coincident Bottom Slab Load : 0.89 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.454 3.71 18.81
 2 0.813 3.71 9.81
 3 0.817 3.71 5.81
 4 0.813 3.71 1.81
 Maximum -Shear : -4.51 k
 Corresponding Shear at Mid : 0.00 k
 Coincident Bottom Slab Load : 0.89 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-5.47	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-5.35	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-5.24	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-5.12	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-5.01	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-4.90	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-4.78	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-4.67	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-4.55	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-4.45	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.04	-4.36	0.26	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.04	-4.36	4.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.29	-0.93	3.66	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	3.99	0.00	2.89	-0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	6.49	0.00	2.21	-0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	8.07	0.00	1.61	-0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	8.63	0.00	1.11	-1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	8.07	0.00	0.71	-1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	6.49	0.00	0.40	-2.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	3.99	0.00	0.18	-2.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	1.29	-0.93	0.04	-3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.04	-4.36	0.00	-4.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-5.47	5.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.22	-0.26	4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	4.18	0.00	3.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	7.19	0.00	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	9.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 5	9.61	0.00	0.03	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	9.00	0.00	0.00	-1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 7	7.19	0.00	0.00	-2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 8	4.18	0.00	0.00	-3.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 9	0.22	-0.26	0.00	-4.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-10	0.00	-5.47	0.00	-5.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 2.50 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.1	7.21	25.76	2.00	9.02
A2	Bot Corner Bar	-8.6	7.21	33.26	2.00	6.01
A100	Top Slab (int)	13.6	-0.01	34.20	2.00	8.55
A200	Bot Slab (int)	15.4	0.70	38.21	2.00	7.30

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-13.64	11.48	14.52	5.84	15.49	0.90	0.45	6.14	1.20	1.20
MID	35.00	0.96	2.34	6.97	6.36	6.79	0.90	0.19	6.14	NC	NC
MID-	35.00	-12.27	11.48	14.52	5.84	15.49	0.90	0.45	6.14	1.37	1.37
TOP	9.00	-11.33	11.48	14.52	5.84	15.49	0.90	0.45	6.14	1.53	1.53

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
LT	7.00	-8.01	3.29	32.90	12.84	30.29	0.90	0.45	9.59	5.12	5.12
MID	70.00	21.66	-0.13	28.72	8.32	25.82	0.90	0.62	9.59	1.28	1.28
RT	7.00	-8.01	3.29	32.90	12.84	30.29	0.90	0.45	9.59	5.12	5.12

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
LT	7.00	-9.34	4.84	32.90	12.84	30.61	0.90	0.45	9.59	4.68	4.68
MID	70.00	24.43	0.86	28.72	8.32	26.06	0.90	0.62	9.59	1.10	1.10
RT	7.00	-9.34	4.84	32.90	12.84	30.61	0.90	0.45	9.59	4.68	4.68

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.39	-13.6	11.48	5.76	8.79	2.000	45.00	9.77b	0.00	0.00	0.00	4.59	4.59
MID	35.00	0.62	1.0	2.34	6.23	18.70	3.937	29.70	20.78a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.62	-12.3	11.48	5.76	9.38	2.135	36.85	10.43a	0.00	0.00	0.00	74.61	74.61
TOP	10.76	-2.42	-11.3	11.48	5.76	9.52	2.165	36.65	10.57a	0.00	0.00	0.00	7.83	7.83

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.12	-8.0	3.29	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.19	4.19
MID	70.00	1.95	21.7	-0.13	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	9.79	9.79
RT	14.52	9.12	-8.0	3.29	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.19	4.19

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	10.59	-9.3	4.84	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.63	3.63
MID	70.00	0.06	24.4	0.86	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	10.59	-9.3	4.84	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.63	3.63

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 2.50 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-4.963	-16.156	3.584	11.481	4.837	0.861
1- 1	-2.814	-13.811	2.342	11.481	3.879	0.670
1- 2	-1.117	-13.200	2.342	11.481	2.966	0.493
1- 3	0.060	-12.688	2.342	11.481	2.098	0.329
1- 4	0.744	-12.269	2.342	11.481	1.276	0.178
1- 5	0.961	-11.934	2.342	11.481	0.619	-0.080
1- 6	0.737	-11.675	2.342	11.481	0.494	-0.813
1- 7	0.100	-11.485	2.342	11.481	0.383	-1.500
1- 8	-0.924	-11.357	2.342	11.481	0.284	-2.141
1- 9	-2.310	-11.316	2.342	11.481	0.199	-2.738
1-10	-3.617	-12.854	3.584	11.481	0.127	-3.290
Top						
Member 2: (Top Slab)						
Left						
2- 0	-3.623	-12.876	-0.127	3.290	11.481	2.342
2- 1	2.288	-3.152	-0.127	3.290	9.197	1.826
2- 2	9.864	0.232	-0.127	3.226	7.151	1.369
2- 3	16.278	1.563	-0.127	3.226	5.266	0.698
2- 4	20.279	2.362	-0.127	3.226	3.524	-0.545
2- 5	21.659	2.628	-0.127	3.226	1.946	-1.946
2- 6	20.279	2.362	-0.127	3.226	0.542	-3.524
2- 7	16.278	1.563	-0.127	3.226	-0.698	-5.271
2- 8	9.864	0.232	-0.127	3.226	-1.369	-7.151
2- 9	2.288	-3.152	-0.127	3.290	-1.826	-9.197
2-10	-3.622	-12.876	-0.127	3.290	-2.342	-11.481
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-4.963	-16.156	0.861	4.837	13.356	2.867
4- 1	-0.044	-2.522	0.861	4.837	10.685	2.294
4- 2	10.403	0.296	0.861	4.323	8.014	1.720
4- 3	18.193	1.969	0.861	4.323	5.342	1.147
4- 4	22.868	2.972	0.861	4.323	2.671	0.573
4- 5	24.426	3.307	0.861	4.323	0.059	-0.059
4- 6	22.868	2.972	0.861	4.323	-0.573	-2.671
4- 7	18.193	1.969	0.861	4.323	-1.147	-5.342
4- 8	10.403	0.296	0.861	4.323	-1.720	-8.014
4- 9	-0.044	-2.522	0.861	4.837	-2.294	-10.685
4-10	-4.963	-16.156	0.861	4.837	-2.867	-13.356
Right						

Analysis Truck, HL-93				
Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.305	3.71	
	2	1.221	3.71	14.00
	3	1.221	3.71	14.00
Tandem	1	0.954	3.71	
	2	0.954	3.71	4.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution Width : 5.20 ft
 Impact Factor : 1.23
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.305	3.71	19.83	Truck	1	0.305	3.71	19.35
	2	1.221	3.71	5.83		2	1.221	3.71	5.35
	3	1.221	3.71	-8.17		3	1.221	3.71	-8.65

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 Filename: Box Culvert - R1.etcx
 Maximum +Moment : 7.55 k-ft
 Corresponding Moment at End : -3.56 k-ft
 Coincident Bottom Slab Load : 0.44 k/ft

Sht: ____ of ____
 By: IRR Chk: ____
 6/5/2019 5:36:21 PM
 Culvert p. 47 of 82

Maximum +Shear in Top Slab
 Truck 1 0.305 3.71 15.85
 2 1.221 3.71 1.85
 3 1.221 3.71 -12.15

Maximum +Shear : 3.85 k
 Corresponding Shear at Mid : -0.68 k
 Coincident Bottom Slab Load : 0.44 k/ft

Maximum +Moment in Top Slab
 Tandem 1 0.954 3.71 8.08
 2 0.954 3.71 4.08

Maximum +Moment : 8.83 k-ft
 Corresponding Moment at End : -4.70 k-ft
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum +Shear in Top Slab
 Tandem 1 0.954 3.71 5.85
 2 0.954 3.71 1.85

Maximum +Shear : 4.77 k
 Corresponding Shear at Mid : -0.52 k
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum -Moment : -3.59 k-ft
 Corresponding Moment at Mid : 7.44 k-ft
 Coincident Bottom Slab Load : 0.44 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.305 3.71 23.81
 2 1.221 3.71 9.81
 3 1.221 3.71 -4.19

Maximum -Shear : -3.85 k
 Corresponding Shear at Mid : 0.68 k
 Coincident Bottom Slab Load : 0.44 k/ft

Maximum -Moment in Top Slab
 Tandem 1 0.954 3.71 8.08
 2 0.954 3.71 4.08

Maximum -Moment : -4.76 k-ft
 Corresponding Moment at Mid : 8.83 k-ft
 Coincident Bottom Slab Load : 0.69 k/ft

Maximum -Shear in Top Slab
 Tandem 1 0.954 3.71 9.81
 2 0.954 3.71 5.81

Maximum -Shear : -4.77 k
 Corresponding Shear at Mid : 0.52 k
 Coincident Bottom Slab Load : 0.69 k/ft

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

M-PT	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.12	0.25	-0.19	0.00	-4.35	0.20	-0.13	0.00	0.00	0.00	0.00
1- 1	0.00	-2.98	0.25	-0.19	0.00	-4.33	0.20	-0.13	0.00	0.00	0.00	0.00
1- 2	0.00	-2.91	0.25	-0.19	0.00	-4.31	0.20	-0.13	0.00	0.00	0.00	0.00
1- 3	0.00	-2.93	0.25	-0.19	0.00	-4.30	0.20	-0.13	0.00	0.00	0.00	0.00
1- 4	0.00	-2.99	0.25	-0.19	0.00	-4.35	0.20	-0.13	0.00	0.00	0.00	0.00
1- 5	0.00	-3.08	0.25	-0.19	0.00	-4.41	0.20	-0.13	0.00	0.00	0.00	0.00
1- 6	0.00	-3.17	0.25	-0.19	0.00	-4.48	0.20	-0.13	0.00	0.00	0.00	0.00
1- 7	0.00	-3.28	0.25	-0.19	0.00	-4.54	0.20	-0.13	0.00	0.00	0.00	0.00
1- 8	0.00	-3.38	0.25	-0.19	0.00	-4.61	0.20	-0.13	0.00	0.00	0.00	0.00
1- 9	0.00	-3.49	0.25	-0.19	0.00	-4.68	0.20	-0.13	0.00	0.00	0.00	0.00
1-10	0.09	-3.59	0.25	-0.19	0.04	-4.76	0.20	-0.13	0.00	0.00	0.00	0.00
Top												

Member 2: (Top Slab)

Left												
2- 0	0.09	-3.59	3.85	0.00	0.04	-4.76	4.77	0.00	0.00	0.00	0.00	0.00
2- 1	1.94	-1.16	3.40	-0.07	1.52	-1.09	4.05	-0.05	0.00	0.00	0.00	0.00
2- 2	4.37	0.00	2.94	-0.26	4.41	0.00	3.32	-0.21	0.00	0.00	0.00	0.00
2- 3	6.10	0.00	2.46	-0.60	6.96	0.00	2.59	-0.47	0.00	0.00	0.00	0.00
2- 4	7.18	0.00	1.98	-1.05	8.38	0.00	1.89	-0.83	0.00	0.00	0.00	0.00
2- 5	7.55	0.00	1.51	-1.51	8.83	0.00	1.30	-1.30	0.00	0.00	0.00	0.00
2- 6	7.18	0.00	1.05	-1.98	8.38	0.00	0.83	-1.89	0.00	0.00	0.00	0.00
2- 7	6.10	0.00	0.60	-2.46	6.90	0.00	0.47	-2.59	0.00	0.00	0.00	0.00
2- 8	4.35	0.00	0.26	-2.94	4.41	0.00	0.21	-3.32	0.00	0.00	0.00	0.00
2- 9	1.94	-1.16	0.07	-3.40	1.52	-1.08	0.05	-4.05	0.00	0.00	0.00	0.00
2-10	0.09	-3.59	0.00	-3.85	0.04	-4.76	0.00	-4.77	0.00	0.00	0.00	0.00
Right												

Member 4: (Bottom Slab)

Left												
4- 0	0.00	-3.12	2.64	0.00	0.00	-4.35	4.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.35	-0.35	2.12	0.00	0.30	-0.28	3.21	0.00	0.00	0.00	0.00	0.00
4- 2	2.44	0.00	1.60	0.00	3.59	0.00	2.42	0.00	0.00	0.00	0.00	0.00
4- 3	3.92	0.00	1.08	0.00	5.94	0.00	1.63	0.00	0.00	0.00	0.00	0.00
4- 4	4.81	0.00	0.56	0.00	7.34	0.00	0.84	0.00	0.00	0.00	0.00	0.00
4- 5	5.11	0.00	0.05	-0.05	7.81	0.00	0.04	-0.04	0.00	0.00	0.00	0.00
4- 6	4.81	0.00	0.00	-0.56	7.34	0.00	0.00	-0.84	0.00	0.00	0.00	0.00
4- 7	3.92	0.00	0.00	-1.08	5.94	0.00	0.00	-1.63	0.00	0.00	0.00	0.00
4- 8	2.44	0.00	0.00	-1.60	3.59	0.00	0.00	-2.42	0.00	0.00	0.00	0.00
4- 9	0.35	-0.35	0.00	-2.12	0.30	-0.28	0.00	-3.21	0.00	0.00	0.00	0.00
4-10	0.00	-3.12	0.00	-2.64	0.00	-4.35	0.00	-4.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 2.50 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.3	7.46	26.35	2.00	8.72
A2	Bot Corner Bar	-7.6	7.46	27.99	2.00	7.96
A100	Top Slab (int)	13.8	0.00	34.70	2.00	8.37
A200	Bot Slab (int)	13.6	0.58	33.79	2.00	8.69

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.90	11.93	14.52	5.84	15.59	0.90	0.45	6.14	1.49	1.93
MID	35.00	0.96	2.34	6.97	6.36	6.79	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.12	11.93	14.52	5.84	15.59	0.90	0.45	6.14	1.57	2.03
TOP	9.00	-11.65	11.93	14.52	5.84	15.59	0.90	0.45	6.14	1.48	1.92

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.56	3.50	32.90	12.84	30.33	0.90	0.45	9.59	4.66	6.05
MID	70.00	22.01	-0.11	28.72	8.32	25.82	0.90	0.62	9.59	1.25	1.62
RT	7.00	-8.56	3.50	32.90	12.84	30.33	0.90	0.45	9.59	4.66	6.05

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.45	4.82	32.90	12.84	30.61	0.90	0.45	9.59	5.53	7.17
MID	70.00	21.29	0.65	28.72	8.32	26.01	0.90	0.62	9.59	1.35	1.74
RT	7.00	-8.45	4.82	32.90	12.84	30.61	0.90	0.45	9.59	5.53	7.17

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.37	-11.9	11.93	5.76	9.25	2.104	37.05	10.28a	0.00	0.00	0.00	4.95	6.41
MID	35.00	0.60	1.0	2.34	6.23	18.75	3.946	29.67	20.83a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.60	-11.1	11.93	5.76	9.98	2.270	36.08	11.09a	0.00	0.00	0.00	29.53	38.28
TOP	10.76	-2.63	-11.7	11.93	5.76	9.41	2.141	36.80	10.46a	0.00	0.00	0.00	7.73	10.02

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.81	-8.6	3.50	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.79	4.91
MID	70.00	2.64	22.0	-0.11	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	7.22	9.36
RT	14.52	9.81	-8.6	3.50	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	3.79	4.91

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.98	-8.4	4.82	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.06
MID	70.00	0.08	21.3	0.65	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.98	-8.4	4.82	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.67	6.06

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

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
------	---------	---------	--------	--------	--------	--------

Bottom	1- 0	1- 1	1- 2	1- 3	1- 4	1- 5	1- 6	1- 7	1- 8	1- 9	1-10	Top
	-4.963	-2.814	-1.117	0.060	0.744	0.961	0.737	0.100	-0.924	-2.310	-3.524	
	-14.211	-12.024	-11.571	-11.251	-11.121	-11.087	-11.139	-11.269	-11.461	-11.730	-13.540	
	3.584	2.342	2.342	2.342	2.342	2.342	2.342	2.342	2.342	2.342	3.584	
	11.931	11.931	11.931	11.931	11.931	11.931	11.931	11.931	11.931	11.931	11.931	
	4.823	3.864	2.951	2.084	1.261	0.604	0.480	0.368	0.270	0.184	0.112	
	0.652	0.462	0.285	0.121	-0.030	-0.289	-1.021	-1.708	-2.350	-2.947	-3.498	

Left	2-0	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	Right
	-3.530	3.426	10.606	17.097	20.815	22.011	20.815	16.997	10.606	3.426	-3.535	
	-13.562	-3.551	0.232	1.563	2.362	2.628	2.362	1.563	0.232	-3.551	-13.562	
	-0.112	-0.112	-0.112	-0.112	-0.112	-0.112	-0.112	-0.112	-0.112	-0.112	-0.112	
	3.498	3.498	3.226	3.226	3.226	3.226	3.226	3.226	3.226	3.498	3.498	
	11.931	9.882	7.903	5.931	4.169	2.639	1.129	-0.344	-1.369	-1.826	-2.342	
	2.342	1.826	1.369	0.344	-1.132	-2.639	-4.169	-5.936	-7.903	-9.882	-11.931	

Left						
4- 0	-4.963	-14.211	0.652	4.823	11.306	2.867
4- 1	0.181	-2.681	0.652	4.823	9.061	2.294
4- 2	9.365	0.296	0.652	4.323	6.816	1.720
4- 3	15.991	1.969	0.652	4.323	4.571	1.147
4- 4	19.966	2.972	0.652	4.323	2.326	0.573
4- 5	21.290	3.307	0.652	4.323	0.081	-0.081
4- 6	19.966	2.972	0.652	4.323	-0.573	-2.327
4- 7	15.991	1.969	0.652	4.323	-1.147	-4.572
4- 8	9.365	0.296	0.652	4.323	-1.720	-6.816
4- 9	0.181	-2.681	0.652	4.823	-2.294	-9.061
4-10	-4.963	-14.211	0.652	4.823	-2.867	-11.306
Right						

Analysis Results: Fill Depth = 3.00 ft

Load Parameters:

Fe = 1.05 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.867	0.320
Live Load Surcharge	0.287	0.287
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Mls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-2.34	0.00	-0.92	-0.43	0.00
1- 1	-1.48	-2.34	0.00	0.11	0.01	0.00
1- 2	-1.38	-2.34	0.00	0.86	0.35	0.00
1- 3	-1.28	-2.34	0.00	1.36	0.60	0.00
1- 4	-1.18	-2.34	0.00	1.61	0.75	0.00
1- 5	-1.08	-2.34	0.00	1.65	0.79	0.00
1- 6	-0.98	-2.34	0.00	1.48	0.75	0.00
1- 7	-0.88	-2.34	0.00	1.13	0.60	0.00
1- 8	-0.78	-2.34	0.00	0.62	0.35	0.00
1- 9	-0.68	-2.34	0.00	-0.04	0.01	0.00
1-10	-0.58	-2.34	0.00	-0.83	-0.43	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	2.01	0.84	0.00
1- 1	0.17	0.00	0.00	1.52	0.67	0.00
1- 2	0.17	0.00	0.00	1.06	0.50	0.00
1- 3	0.17	0.00	0.00	0.64	0.34	0.00
1- 4	0.17	0.00	0.00	0.24	0.17	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.45	-0.17	0.00
1- 7	0.17	0.00	0.00	-0.75	-0.34	0.00
1- 8	0.17	0.00	0.00	-1.02	-0.50	0.00
1- 9	0.17	0.00	0.00	-1.25	-0.67	0.00
1-10	0.17	0.00	0.00	-1.45	-0.84	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-2.34	0.00	-0.85	-0.43	0.00
2- 1	0.21	0.07	0.00	-0.85	-0.43	0.00
2- 2	0.81	1.94	0.00	-0.85	-0.43	0.00
2- 3	1.23	3.28	0.00	-0.85	-0.43	0.00
2- 4	1.49	4.08	0.00	-0.85	-0.43	0.00
2- 5	1.57	4.35	0.00	-0.85	-0.43	0.00
2- 6	1.49	4.08	0.00	-0.85	-0.43	0.00
2- 7	1.23	3.28	0.00	-0.85	-0.43	0.00
2- 8	0.81	1.94	0.00	-0.85	-0.43	0.00
2- 9	0.21	0.07	0.00	-0.85	-0.43	0.00
2-10	-0.58	-2.34	0.00	-0.85	-0.43	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	2.29	0.00	0.00	0.00	0.00
2- 1	0.58	1.84	0.00	0.00	0.00	0.00
2- 2	0.44	1.38	0.00	0.00	0.00	0.00
2- 3	0.29	0.92	0.00	0.00	0.00	0.00
2- 4	0.15	0.46	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.46	0.00	0.00	0.00	0.00
2- 7	-0.29	-0.92	0.00	0.00	0.00	0.00
2- 8	-0.44	-1.38	0.00	0.00	0.00	0.00
2- 9	-0.58	-1.84	0.00	0.00	0.00	0.00
2-10	-0.80	-2.29	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-2.34	0.00	-0.92	-0.43	0.00
4- 1	-0.13	0.07	0.00	-0.92	-0.43	0.00
4- 2	1.00	1.94	0.00	-0.92	-0.43	0.00
4- 3	1.80	3.28	0.00	-0.92	-0.43	0.00
4- 4	2.28	4.08	0.00	-0.92	-0.43	0.00
4- 5	2.44	4.35	0.00	-0.92	-0.43	0.00
4- 6	2.28	4.08	0.00	-0.92	-0.43	0.00
4- 7	1.80	3.28	0.00	-0.92	-0.43	0.00
4- 8	1.00	1.94	0.00	-0.92	-0.43	0.00
4- 9	-0.13	0.07	0.00	-0.92	-0.43	0.00
4-10	-1.58	-2.34	0.00	-0.92	-0.43	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	2.29	0.00	0.00	0.00	0.00
4- 1	1.10	1.84	0.00	0.00	0.00	0.00
4- 2	0.83	1.38	0.00	0.00	0.00	0.00
4- 3	0.55	0.92	0.00	0.00	0.00	0.00
4- 4	0.28	0.46	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.46	0.00	0.00	0.00	0.00
4- 7	-0.55	-0.92	0.00	0.00	0.00	0.00
4- 8	-0.83	-1.38	0.00	0.00	0.00	0.00
4- 9	-1.10	-1.84	0.00	0.00	0.00	0.00
4-10	-1.38	-2.29	0.00	0.00	0.00	0.00
Right						

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 3.00 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	2.29	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.45	0.84	0.00
4	0.17	0.00	0.00	2.01	0.84	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.293	4.28	
	2	1.170	4.28	14.00
	3	1.170	4.28	14.00
Tandem	1	0.756	8.28	

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 Member 4: (Bottom Slab)

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:22 PM
 Culvert p. 52 of 82

Left												
4- 0	0.00	-3.35	2.88	0.00	0.00	-3.74	3.56	0.00	0.00	0.00	0.00	0.00
4- 1	0.38	-0.33	2.31	0.00	0.24	-0.21	2.85	0.00	0.00	0.00	0.00	0.00
4- 2	2.66	0.00	1.74	0.00	3.12	0.00	2.14	0.00	0.00	0.00	0.00	0.00
4- 3	4.28	0.00	1.18	0.00	5.17	0.00	1.44	0.00	0.00	0.00	0.00	0.00
4- 4	5.25	0.00	0.61	0.00	6.40	0.00	0.73	0.00	0.00	0.00	0.00	0.00
4- 5	5.58	0.00	0.05	-0.05	6.81	0.00	0.03	-0.03	0.00	0.00	0.00	0.00
4- 6	5.25	0.00	0.00	-0.61	6.40	0.00	0.00	-0.73	0.00	0.00	0.00	0.00
4- 7	4.28	0.00	0.00	-1.18	5.17	0.00	0.00	-1.44	0.00	0.00	0.00	0.00
4- 8	2.66	0.00	0.00	-1.75	3.12	0.00	0.00	-2.14	0.00	0.00	0.00	0.00
4- 9	0.38	-0.33	0.00	-2.31	0.24	-0.21	0.00	-2.85	0.00	0.00	0.00	0.00
4-10	0.00	-3.35	0.00	-2.88	0.00	-3.74	0.00	-3.56	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 3.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.0	7.23	25.50	2.00	9.15
A2	Bot Corner Bar	-7.4	7.23	27.36	2.00	8.24
A100	Top Slab (int)	13.7	0.02	34.53	2.00	8.43
A200	Bot Slab (int)	13.3	0.60	33.09	2.00	8.95

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-11.41	11.36	14.52	5.84	15.47	0.90	0.45	6.14	1.62	2.10
MID	35.00	0.75	2.68	6.97	6.36	6.86	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.62	11.36	14.52	5.84	15.47	0.90	0.45	6.14	1.71	2.22
TOP	9.00	-11.09	11.36	14.52	5.84	15.47	0.90	0.45	6.14	1.62	2.10

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
LT	7.00	-8.41	3.68	32.90	12.84	30.37	0.90	0.45	9.59	5.04	6.54
MID	70.00	21.62	-0.09	28.72	8.32	25.82	0.90	0.62	9.59	1.30	1.68
RT	7.00	-8.41	3.68	32.90	12.84	30.37	0.90	0.45	9.59	5.04	6.54

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
LT	7.00	-8.23	5.01	32.90	12.84	30.64	0.90	0.45	9.59	6.20	8.04
MID	70.00	20.54	0.67	28.72	8.32	26.02	0.90	0.62	9.59	1.46	1.89
RT	7.00	-8.23	5.01	32.90	12.84	30.64	0.90	0.45	9.59	6.20	8.04

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.51	-11.4	11.36	5.76	9.35	2.127	36.90	10.39a	0.00	0.00	0.00	4.91	6.36
MID	35.00	0.64	0.8	2.68	6.23	20.53	4.322	28.66	22.81a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.64	-10.6	11.36	5.76	10.16	2.311	35.85	11.29a	0.00	0.00	0.00	27.26	35.34
TOP	10.76	-2.76	-11.1	11.36	5.76	9.56	2.176	36.59	10.63a	0.00	0.00	0.00	8.00	10.37

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.53	-8.4	3.68	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.14	5.36
MID	70.00	2.70	21.6	-0.09	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	7.05	9.14
RT	14.52	9.53	-8.4	3.68	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.14	5.36

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.79	-8.2	5.01	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.17	6.70
MID	70.00	0.08	20.5	0.67	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.79	-8.2	5.01	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.17	6.70

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 3.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-5.477	-13.764	2.682	11.365	5.007	0.674
1- 1	-3.158	-11.538	2.682	11.365	4.019	0.472
1- 2	-1.403	-11.100	2.682	11.365	3.077	0.284
1- 3	-0.183	-10.768	2.682	11.365	2.180	0.109
1- 4	0.526	-10.620	2.682	11.365	1.328	-0.054
1- 5	0.752	-10.571	2.682	11.365	0.642	-0.323
1- 6	0.520	-10.609	2.682	11.365	0.506	-1.085
1- 7	-0.142	-10.724	2.682	11.365	0.384	-1.801
1- 8	-1.210	-10.906	2.682	11.365	0.274	-2.472
1- 9	-2.655	-11.169	2.682	11.365	0.177	-3.098
1-10	-4.173	-13.037	4.126	11.365	0.094	-3.679
Top						
Member 2: (Top Slab)						
Left						
2- 0	-4.179	-13.059	-0.094	3.679	11.365	2.682
2- 1	3.271	-3.761	-0.094	3.679	9.598	2.098
2- 2	11.397	0.446	-0.094	3.372	7.885	1.573
2- 3	16.975	1.975	-0.094	3.372	6.154	0.606
2- 4	20.457	2.893	-0.094	3.372	4.421	-1.010
2- 5	21.625	3.199	-0.094	3.372	2.701	-2.701
2- 6	20.457	2.893	-0.094	3.372	1.006	-4.421
2- 7	16.975	1.975	-0.094	3.372	-0.606	-6.154
2- 8	11.235	0.446	-0.094	3.372	-1.573	-7.885
2- 9	3.271	-3.761	-0.094	3.679	-2.098	-9.598
2-10	-4.177	-13.059	-0.094	3.679	-2.682	-11.365
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-5.477	-13.764	4.469	5.007	11.083	3.207
4- 1	0.222	-2.699	0.674	5.007	8.874	2.566
4- 2	8.978	0.510	0.674	4.469	6.665	1.924
4- 3	15.401	2.381	0.674	4.469	4.457	1.283
4- 4	19.252	3.504	0.674	4.469	2.248	0.641
4- 5	20.539	3.878	0.674	4.469	0.081	-0.084
4- 6	19.252	3.504	0.674	4.469	-0.641	-2.248
4- 7	15.401	2.381	0.674	4.469	-1.283	-4.457
4- 8	8.978	0.510	0.674	4.469	-1.924	-6.665
4- 9	0.222	-2.699	0.674	5.007	-2.566	-8.874
4-10	-5.477	-13.764	4.469	5.007	-3.207	-11.083
Right						

Analysis Truck, MaineDOT Config 6				
Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.348	4.28	
	2	0.623	4.28	9.00
	3	0.646	8.28	6.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 5.78 ft
 Impact Factor : 1.21
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.348	4.28	19.73	Truck	1	0.348	4.28	17.92
	2	0.623	4.28	10.73		2	0.623	4.28	8.92
	3	0.646	8.28	4.72		3	0.646	8.28	2.92
Maximum +Moment : 7.47 k-ft					Maximum -Moment : -3.83 k-ft				
Corresponding Moment at End : -3.59 k-ft					Corresponding Moment at Mid : 7.40 k-ft				
Coincident Bottom Slab Load : 0.70 k/ft					Coincident Bottom Slab Load : 0.70 k/ft				

Maximum +Shear in Top Slab
 Truck 1 0.348 4.28 18.33
 2 0.623 4.28 9.33
 3 0.646 8.28 3.33
 Maximum +Shear : 3.81 k
 Corresponding Shear at Mid : 0.05 k
 Coincident Bottom Slab Load : 0.73 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.348 4.28 19.73
 2 0.623 4.28 10.73
 3 0.646 8.28 4.72
 Maximum -Shear : -3.85 k
 Corresponding Shear at Mid : 0.03 k
 Coincident Bottom Slab Load : 0.70 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-4.51	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-4.44	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-4.37	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-4.30	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-4.23	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-4.15	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-4.08	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-4.01	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-3.94	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-3.88	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.03	-3.83	0.20	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.03	-3.83	3.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.12	-0.78	3.08	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	3.41	0.00	2.42	-0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	5.64	0.00	1.83	-0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	6.99	0.00	1.33	-0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	7.47	0.00	0.91	-0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	7.07	0.00	0.58	-1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	5.78	0.00	0.32	-1.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	3.52	0.00	0.14	-2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	1.03	-0.81	0.03	-3.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.03	-3.83	0.00	-3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-4.51	4.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.18	-0.22	3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	3.53	0.00	2.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	6.04	0.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	7.55	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 5	8.05	0.00	0.03	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	7.55	0.00	0.00	-0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 7	6.04	0.00	0.00	-1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 8	3.52	0.00	0.00	-2.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 9	0.19	-0.20	0.00	-3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-10	0.00	-4.52	0.00	-4.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 3.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-6.9	6.90	25.25	2.00	9.29
A2	Bot Corner Bar	-8.1	6.90	31.16	2.00	6.71
A100	Top Slab (int)	13.1	0.09	33.04	2.00	8.97
A200	Bot Slab (int)	14.6	0.75	36.09	2.00	7.92

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-12.61	10.80	14.52	5.84	15.35	0.90	0.45	6.14	1.36	1.36
MID	35.00	-0.75	2.68	6.97	6.36	6.86	0.90	0.19	6.14	NC	NC
MID-	35.00	-11.40	10.80	14.52	5.84	15.35	0.90	0.45	6.14	1.53	1.53
TOP	9.00	-10.86	10.80	14.52	5.84	15.35	0.90	0.45	6.14	1.66	1.66

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
LT	7.00	-7.77	3.42	32.90	12.84	30.32	0.90	0.45	9.59	5.71	5.71
MID	70.00	20.63	0.03	28.72	8.32	25.85	0.90	0.62	9.59	1.40	1.40
RT	7.00	-7.79	3.42	32.90	12.84	30.32	0.90	0.45	9.59	5.68	5.68

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
LT	7.00	-8.81	4.88	32.90	12.84	30.62	0.90	0.45	9.59	5.47	5.47
MID	70.00	22.71	0.93	28.72	8.32	26.08	0.90	0.62	9.59	1.24	1.24
RT	7.00	-8.80	4.88	32.90	12.84	30.62	0.90	0.45	9.59	5.47	5.47

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.39	-12.6	10.80	5.76	8.91	2.028	37.57	9.90a	0.00	0.00	0.00	5.03	5.03
MID	35.00	0.52	0.8	2.68	6.23	21.10	4.441	28.41	23.44a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.52	-11.4	10.80	5.76	9.71	2.209	36.41	10.79a	0.00	0.00	0.00	87.53	87.53
TOP	10.76	-2.50	-10.9	10.80	5.76	9.66	2.197	36.47	10.73a	0.00	0.00	0.00	8.09	8.09

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.55	-7.8	3.42	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.90	4.90
MID	70.00	1.60	20.6	0.03	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	11.92	11.92
RT	14.52	8.62	-7.8	3.42	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.83	4.83

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.82	-8.8	4.88	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.28	4.28
MID	70.00	0.05	22.7	0.93	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	9.83	-8.8	4.88	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.27	4.27

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 3.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-5.477	-15.111	2.682	10.801	4.882	0.932
1- 1	-3.158	-12.765	2.682	10.801	3.895	0.730
1- 2	-1.403	-12.206	2.682	10.801	2.953	0.542
1- 3	-0.183	-11.753	2.682	10.801	2.056	0.366
1- 4	0.526	-11.398	2.682	10.801	1.204	0.204
1- 5	0.752	-11.134	2.682	10.801	0.518	-0.066
1- 6	0.520	-10.955	2.682	10.801	0.382	-0.827
1- 7	-0.142	-10.852	2.682	10.801	0.259	-1.543
1- 8	-1.210	-10.817	2.682	10.801	0.150	-2.214
1- 9	-2.655	-10.872	2.682	10.801	0.053	-2.840
1-10	-4.213	-12.553	4.126	10.801	-0.030	-3.421
Top						
Member 2: (Top Slab)						
Left						
2- 0	-4.219	-12.575	0.030	3.421	10.801	2.682
2- 1	1.973	-2.957	0.030	3.421	8.620	2.098
2- 2	9.276	0.446	0.030	3.372	6.653	1.573
2- 3	15.542	1.975	0.030	3.372	4.814	1.049
2- 4	19.327	2.893	0.030	3.372	3.136	-0.180
2- 5	20.629	3.199	0.030	3.372	1.598	-1.588
2- 6	19.457	2.893	0.030	3.372	0.200	-3.140
2- 7	15.789	1.975	0.030	3.372	-1.049	-4.832
2- 8	9.475	0.446	0.030	3.372	-1.573	-6.661
2- 9	1.810	-3.006	0.030	3.421	-2.098	-8.699
2-10	-4.220	-12.570	0.030	3.421	-2.682	-10.863
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-5.477	-15.111	4.469	4.882	12.395	3.207
4- 1	-0.131	-2.502	0.932	4.882	9.915	2.566
4- 2	9.698	0.510	0.932	4.469	7.436	1.924
4- 3	16.927	2.381	0.932	4.469	4.957	1.283
4- 4	21.263	3.504	0.932	4.469	2.477	0.641
4- 5	22.707	3.878	0.932	4.469	0.053	-0.051
4- 6	21.259	3.504	0.932	4.469	-0.641	-2.481
4- 7	16.917	2.381	0.932	4.469	-1.283	-4.961
4- 8	9.683	0.510	0.932	4.469	-1.924	-7.440
4- 9	-0.112	-2.472	0.932	4.882	-2.566	-9.920
4-10	-5.477	-15.135	4.469	4.882	-3.207	-12.399
Right						

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

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.234	4.28	
	2	0.936	4.28	14.00
	3	0.936	4.28	14.00
Tandem	1	0.756	8.28	

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution Width : 5.78 ft
 Impact Factor : 1.21
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.234	4.28	19.83	Truck	1	0.234	4.28	20.23
	2	0.936	4.28	5.83		2	0.936	4.28	6.23
	3	0.936	4.28	-8.17		3	0.936	4.28	-7.77
Maximum +Moment : 6.43 k-ft					Maximum -Moment : -3.14 k-ft				

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 Corresponding Moment at End : -3.12 k-ft
 Coincident Bottom Slab Load : 0.39 k/ft

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:22 PM
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Corresponding Moment at Mid : 6.38 k-ft
 Coincident Bottom Slab Load : 0.39 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.234 4.28 16.14
 2 0.936 4.28 2.14
 3 0.936 4.28 -11.86

Maximum +Shear : 3.31 k
 Corresponding Shear at Mid : -0.70 k
 Coincident Bottom Slab Load : 0.39 k/ft

Maximum +Moment in Top Slab
 Tandem 1 0.756 8.28 5.83
 Maximum +Moment : 7.68 k-ft
 Corresponding Moment at End : -4.11 k-ft
 Coincident Bottom Slab Load : 0.61 k/ft

Maximum +Shear in Top Slab
 Tandem 1 0.756 8.28 4.14
 Maximum +Shear : 4.06 k
 Corresponding Shear at Mid : -0.35 k
 Coincident Bottom Slab Load : 0.61 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.234 4.28 23.52
 2 0.936 4.28 9.52
 3 0.936 4.28 -4.48

Maximum -Shear : -3.31 k
 Corresponding Shear at Mid : 0.70 k
 Coincident Bottom Slab Load : 0.39 k/ft

Maximum -Moment in Top Slab
 Tandem 1 0.756 8.28 5.89
 Maximum -Moment : -4.11 k-ft
 Corresponding Moment at Mid : 7.68 k-ft
 Coincident Bottom Slab Load : 0.61 k/ft

Maximum -Shear in Top Slab
 Tandem 1 0.756 8.28 7.52
 Maximum -Shear : -4.06 k
 Corresponding Shear at Mid : 0.35 k
 Coincident Bottom Slab Load : 0.61 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-2.68	0.22	-0.17	0.00	-3.74	0.15	-0.10	0.00	0.00	0.00	0.00
1- 1	0.00	-2.59	0.22	-0.17	0.00	-3.74	0.15	-0.10	0.00	0.00	0.00	0.00
1- 2	0.00	-2.53	0.22	-0.17	0.00	-3.74	0.15	-0.10	0.00	0.00	0.00	0.00
1- 3	0.00	-2.55	0.22	-0.17	0.00	-3.73	0.15	-0.10	0.00	0.00	0.00	0.00
1- 4	0.00	-2.61	0.22	-0.17	0.00	-3.78	0.15	-0.10	0.00	0.00	0.00	0.00
1- 5	0.00	-2.69	0.22	-0.17	0.00	-3.83	0.15	-0.10	0.00	0.00	0.00	0.00
1- 6	0.00	-2.77	0.22	-0.17	0.00	-3.89	0.15	-0.10	0.00	0.00	0.00	0.00
1- 7	0.00	-2.86	0.22	-0.17	0.00	-3.94	0.15	-0.10	0.00	0.00	0.00	0.00
1- 8	0.00	-2.95	0.22	-0.17	0.00	-3.99	0.15	-0.10	0.00	0.00	0.00	0.00
1- 9	0.00	-3.05	0.22	-0.17	0.00	-4.05	0.15	-0.10	0.00	0.00	0.00	0.00
1-10	0.04	-3.14	0.22	-0.17	0.03	-4.11	0.15	-0.10	0.00	0.00	0.00	0.00
Top												

Member 2: (Top Slab)												
Left												
2- 0	0.04	-3.14	3.31	0.00	0.03	-4.11	4.06	0.00	0.00	0.00	0.00	0.00
2- 1	1.49	-0.99	2.91	-0.05	1.20	-0.92	3.42	-0.04	0.00	0.00	0.00	0.00
2- 2	3.70	0.00	2.50	-0.20	3.82	0.00	2.78	-0.16	0.00	0.00	0.00	0.00
2- 3	5.17	0.00	2.07	-0.46	6.11	0.00	2.14	-0.37	0.00	0.00	0.00	0.00
2- 4	6.11	0.00	1.65	-0.83	7.38	0.00	1.56	-0.67	0.00	0.00	0.00	0.00
2- 5	6.43	0.00	1.23	-1.23	7.68	0.00	1.07	-1.07	0.00	0.00	0.00	0.00
2- 6	6.11	0.00	0.83	-1.65	7.24	0.00	0.67	-1.56	0.00	0.00	0.00	0.00
2- 7	5.17	0.00	0.46	-2.07	5.91	0.00	0.37	-2.14	0.00	0.00	0.00	0.00
2- 8	3.62	0.00	0.20	-2.50	3.70	0.00	0.16	-2.78	0.00	0.00	0.00	0.00
2- 9	1.49	-0.99	0.05	-2.91	1.20	-0.92	0.04	-3.42	0.00	0.00	0.00	0.00
2-10	0.04	-3.14	0.00	-3.31	0.03	-4.11	0.00	-4.06	0.00	0.00	0.00	0.00
Right												

Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-2.68	2.30	0.00	0.00	-3.74	3.56	0.00	0.00	0.00	0.00	0.00
4- 1	0.31	-0.27	1.85	0.00	0.24	-0.21	2.85	0.00	0.00	0.00	0.00	0.00
4- 2	2.13	0.00	1.40	0.00	3.12	0.00	2.14	0.00	0.00	0.00	0.00	0.00
4- 3	3.43	0.00	0.94	0.00	5.17	0.00	1.44	0.00	0.00	0.00	0.00	0.00
4- 4	4.20	0.00	0.49	0.00	6.40	0.00	0.73	0.00	0.00	0.00	0.00	0.00
4- 5	4.46	0.00	0.04	-0.04	6.81	0.00	0.03	-0.03	0.00	0.00	0.00	0.00
4- 6	4.20	0.00	0.00	-0.49	6.40	0.00	0.00	-0.73	0.00	0.00	0.00	0.00
4- 7	3.43	0.00	0.00	-0.94	5.17	0.00	0.00	-1.44	0.00	0.00	0.00	0.00
4- 8	2.13	0.00	0.00	-1.40	3.12	0.00	0.00	-2.14	0.00	0.00	0.00	0.00
4- 9	0.31	-0.27	0.00	-1.85	0.24	-0.21	0.00	-2.85	0.00	0.00	0.00	0.00
4-10	0.00	-2.68	0.00	-2.30	0.00	-3.74	0.00	-3.56	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 3.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.0	7.15	25.60	2.00	9.10
A2	Bot Corner Bar	-7.4	7.15	27.46	2.00	8.19
A100	Top Slab (int)	13.3	0.08	33.58	2.00	8.77
A200	Bot Slab (int)	13.3	0.65	33.05	2.00	8.96

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.41	11.24	14.52	5.84	15.44	0.90	0.45	6.14	1.62	2.09
MID	35.00	0.75	2.68	6.97	6.36	6.86	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.62	11.24	14.52	5.84	15.44	0.90	0.45	6.14	1.71	2.21
TOP	9.00	-11.09	11.24	14.52	5.84	15.44	0.90	0.45	6.14	1.62	2.10

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.19	3.61	32.90	12.84	30.35	0.90	0.45	9.59	5.25	6.81
MID	70.00	21.00	0.00	28.72	8.32	25.85	0.90	0.62	9.59	1.36	1.76
RT	7.00	-8.19	3.61	32.90	12.84	30.35	0.90	0.45	9.59	5.25	6.81

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.17	4.91	32.90	12.84	30.62	0.90	0.45	9.59	6.28	8.14
MID	70.00	20.54	0.75	28.72	8.32	26.03	0.90	0.62	9.59	1.46	1.89
RT	7.00	-8.17	4.91	32.90	12.84	30.62	0.90	0.45	9.59	6.28	8.14

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.42	-11.4	11.24	5.76	9.35	2.127	36.90	10.39a	0.00	0.00	0.00	5.24	6.80
MID	35.00	0.55	0.8	2.68	6.23	20.97	4.414	28.47	23.30a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.55	-10.6	11.24	5.76	10.16	2.311	35.85	11.29a	0.00	0.00	0.00	34.08	44.17
TOP	10.76	-2.69	-11.1	11.24	5.76	9.56	2.175	36.60	10.62a	0.00	0.00	0.00	8.00	10.36

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.15	-8.2	3.61	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.40	5.71
MID	70.00	2.16	21.0	0.00	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	8.81	11.43
RT	14.52	9.15	-8.2	3.61	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.40	5.71

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.79	-8.2	4.91	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.17	6.70
MID	70.00	0.07	20.5	0.75	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.79	-8.2	4.91	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.17	6.70

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

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
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M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-5.477	-13.764	2.682	11.236	4.911	0.747
1- 1	-3.158	-11.538	2.682	11.236	3.924	0.546
1- 2	-1.403	-11.100	2.682	11.236	2.981	0.357
1- 3	-0.183	-10.768	2.682	11.236	2.084	0.182
1- 4	0.526	-10.620	2.682	11.236	1.233	0.020
1- 5	0.752	-10.571	2.682	11.236	0.547	-0.250
1- 6	0.520	-10.609	2.682	11.236	0.411	-1.011
1- 7	-0.142	-10.724	2.682	11.236	0.288	-1.728
1- 8	-1.210	-10.906	2.682	11.236	0.178	-2.399
1- 9	-2.655	-11.169	2.682	11.236	0.082	-3.025
1-10	-4.191	-13.037	4.126	11.236	-0.002	-3.605
Top						
Member 2: (Top slab)						
Left						
2- 0	-4.197	-13.059	0.002	3.605	11.236	2.682
2- 1	2.619	-3.326	0.002	3.605	9.223	2.098
2- 2	10.004	0.446	0.002	3.372	7.286	1.573
2- 3	16.371	1.975	0.002	3.372	5.359	0.808
2- 4	19.992	2.893	0.002	3.372	3.699	-0.646
2- 5	20.997	3.199	0.002	3.372	2.161	-2.161
2- 6	19.750	2.893	0.002	3.372	0.643	-3.699
2- 7	16.016	1.975	0.002	3.372	-0.808	-5.359
2- 8	9.794	0.446	0.002	3.372	-1.573	-7.286
2- 9	2.619	-3.326	0.002	3.605	-2.098	-9.223
2-10	-4.195	-13.059	0.002	3.605	-2.682	-11.236
Right						
Member 4: (Bottom slab)						
Left						
4- 0	-5.477	-13.764	4.469	4.911	11.083	3.207
4- 1	0.088	-2.583	0.747	4.911	8.874	2.566
4- 2	8.978	0.510	0.747	4.469	6.665	1.924
4- 3	15.401	2.381	0.747	4.469	4.457	1.283
4- 4	19.252	3.504	0.747	4.469	2.248	0.641
4- 5	20.539	3.878	0.747	4.469	0.065	-0.067
4- 6	19.252	3.504	0.747	4.469	-0.641	-2.248
4- 7	15.401	2.381	0.747	4.469	-1.283	-4.457
4- 8	8.978	0.510	0.747	4.469	-1.924	-6.665
4- 9	0.088	-2.583	0.747	4.911	-2.566	-8.874
4-10	-5.477	-13.764	4.469	4.911	-3.207	-11.083
Right						

Analysis Results: Fill Depth = 3.50 ft

Load Parameters:

Fe = 1.06 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.914	0.367
Live Load Surcharge	0.280	0.280
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Pls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-2.75	0.00	-0.99	-0.42	0.00
1- 1	-1.48	-2.75	0.00	0.11	0.01	0.00
1- 2	-1.38	-2.75	0.00	0.92	0.35	0.00
1- 3	-1.28	-2.75	0.00	1.46	0.58	0.00
1- 4	-1.18	-2.75	0.00	1.74	0.73	0.00
1- 5	-1.08	-2.75	0.00	1.78	0.77	0.00
1- 6	-0.98	-2.75	0.00	1.60	0.73	0.00
1- 7	-0.88	-2.75	0.00	1.23	0.58	0.00
1- 8	-0.78	-2.75	0.00	0.68	0.35	0.00
1- 9	-0.68	-2.75	0.00	-0.04	0.01	0.00
1-10	-0.58	-2.75	0.00	-0.90	-0.42	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	2.15	0.82	0.00
1- 1	0.17	0.00	0.00	1.63	0.65	0.00
1- 2	0.17	0.00	0.00	1.14	0.49	0.00
1- 3	0.17	0.00	0.00	0.69	0.33	0.00
1- 4	0.17	0.00	0.00	0.27	0.16	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.48	-0.16	0.00
1- 7	0.17	0.00	0.00	-0.80	-0.33	0.00
1- 8	0.17	0.00	0.00	-1.10	-0.49	0.00
1- 9	0.17	0.00	0.00	-1.36	-0.65	0.00
1-10	0.17	0.00	0.00	-1.59	-0.82	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-2.75	0.00	-0.91	-0.42	0.00
2- 1	0.21	0.08	0.00	-0.91	-0.42	0.00
2- 2	0.81	2.28	0.00	-0.91	-0.42	0.00
2- 3	1.23	3.86	0.00	-0.91	-0.42	0.00
2- 4	1.49	4.80	0.00	-0.91	-0.42	0.00
2- 5	1.57	5.12	0.00	-0.91	-0.42	0.00
2- 6	1.49	4.80	0.00	-0.91	-0.42	0.00
2- 7	1.23	3.86	0.00	-0.91	-0.42	0.00
2- 8	0.81	2.28	0.00	-0.91	-0.42	0.00
2- 9	0.21	0.08	0.00	-0.91	-0.42	0.00
2-10	-0.58	-2.75	0.00	-0.91	-0.42	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	2.70	0.00	0.00	0.00	0.00
2- 1	0.58	2.16	0.00	0.00	0.00	0.00
2- 2	0.44	1.62	0.00	0.00	0.00	0.00
2- 3	0.29	1.08	0.00	0.00	0.00	0.00
2- 4	0.15	0.54	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.54	0.00	0.00	0.00	0.00
2- 7	-0.29	-1.08	0.00	0.00	0.00	0.00
2- 8	-0.44	-1.62	0.00	0.00	0.00	0.00
2- 9	-0.58	-2.16	0.00	0.00	0.00	0.00
2-10	-0.80	-2.70	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-2.75	0.00	-0.99	-0.42	0.00
4- 1	-0.13	0.08	0.00	-0.99	-0.42	0.00
4- 2	1.00	2.28	0.00	-0.99	-0.42	0.00
4- 3	1.80	3.86	0.00	-0.99	-0.42	0.00
4- 4	2.28	4.80	0.00	-0.99	-0.42	0.00
4- 5	2.44	5.12	0.00	-0.99	-0.42	0.00
4- 6	2.28	4.80	0.00	-0.99	-0.42	0.00
4- 7	1.80	3.86	0.00	-0.99	-0.42	0.00
4- 8	1.00	2.28	0.00	-0.99	-0.42	0.00
4- 9	-0.13	0.08	0.00	-0.99	-0.42	0.00
4-10	-1.58	-2.75	0.00	-0.99	-0.42	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	2.70	0.00	0.00	0.00	0.00
4- 1	1.10	2.16	0.00	0.00	0.00	0.00
4- 2	0.83	1.62	0.00	0.00	0.00	0.00
4- 3	0.55	1.08	0.00	0.00	0.00	0.00
4- 4	0.28	0.54	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.54	0.00	0.00	0.00	0.00
4- 7	-0.55	-1.08	0.00	0.00	0.00	0.00
4- 8	-0.83	-1.62	0.00	0.00	0.00	0.00
4- 9	-1.10	-2.16	0.00	0.00	0.00	0.00
4-10	-1.38	-2.70	0.00	0.00	0.00	0.00
Right						

Unfactored Thrusts due to All Loads: (k) (Fill Depth = 3.50 ft)

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	2.70	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.59	0.82	0.00
4	0.17	0.00	0.00	2.15	0.82	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.237	4.86	
	2	0.948	4.86	14.00
	3	0.948	4.86	14.00
Tandem	1	0.650	8.86	

Left	2-0	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	Right
	0.04	-3.59	3.69	0.00	0.02	-3.70	3.59	0.00	0.00	0.00	0.00	0.00
	1.47	-1.13	3.23	-0.05	1.01	-0.84	3.00	-0.03	0.00	0.00	0.00	0.00
	3.98	0.00	2.75	-0.20	3.28	0.00	2.41	-0.14	0.00	0.00	0.00	0.00
	5.64	0.00	2.26	-0.47	5.33	0.00	1.84	-0.32	0.00	0.00	0.00	0.00
	6.70	0.00	1.78	-0.85	6.50	0.00	1.34	-0.58	0.00	0.00	0.00	0.00
	7.07	0.00	1.31	-1.31	6.82	0.00	0.92	-0.92	0.00	0.00	0.00	0.00
	6.70	0.00	0.85	-1.78	6.33	0.00	0.58	-1.34	0.00	0.00	0.00	0.00
	5.64	0.00	0.47	-2.26	5.14	0.00	0.32	-1.84	0.00	0.00	0.00	0.00
	3.88	0.00	0.20	-2.75	3.15	0.00	0.14	-2.42	0.00	0.00	0.00	0.00
	1.47	-1.13	0.05	-3.23	1.01	-0.84	0.03	-3.00	0.00	0.00	0.00	0.00
	0.04	-3.59	0.00	-3.69	0.03	-3.70	0.00	-3.59	0.00	0.00	0.00	0.00

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 Member 4: (Bottom Slab)

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:23 PM
 Culvert p. 63 of 82

Left												
4- 0	0.00	-2.81	2.47	0.00	0.00	-3.13	3.06	0.00	0.00	0.00	0.00	0.00
4- 1	0.37	-0.24	1.99	0.00	0.24	-0.16	2.45	0.00	0.00	0.00	0.00	0.00
4- 2	2.33	0.00	1.50	0.00	2.71	0.00	1.84	0.00	0.00	0.00	0.00	0.00
4- 3	3.73	0.00	1.01	0.00	4.48	0.00	1.23	0.00	0.00	0.00	0.00	0.00
4- 4	4.57	0.00	0.53	0.00	5.54	0.00	0.62	0.00	0.00	0.00	0.00	0.00
4- 5	4.84	0.00	0.04	-0.04	5.89	0.00	0.03	-0.03	0.00	0.00	0.00	0.00
4- 6	4.57	0.00	0.00	-0.53	5.54	0.00	0.00	-0.62	0.00	0.00	0.00	0.00
4- 7	3.73	0.00	0.00	-1.01	4.48	0.00	0.00	-1.23	0.00	0.00	0.00	0.00
4- 8	2.33	0.00	0.00	-1.50	2.71	0.00	0.00	-1.84	0.00	0.00	0.00	0.00
4- 9	0.37	-0.24	0.00	-1.99	0.23	-0.16	0.00	-2.45	0.00	0.00	0.00	0.00
4-10	0.00	-2.81	0.00	-2.47	0.00	-3.13	0.00	-3.06	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 3.50 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.0	7.18	25.47	2.00	9.17
A2	Bot Corner Bar	-7.3	7.18	26.64	2.00	8.57
A100	Top Slab (int)	13.5	0.09	33.91	2.00	8.65
A200	Bot Slab (int)	13.1	0.63	32.62	2.00	9.12

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-10.98	11.13	14.52	5.84	15.42	0.90	0.45	6.14	1.80	2.33
MID	35.00	0.55	3.03	6.97	6.36	6.94	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.26	11.13	14.52	5.84	15.42	0.90	0.45	6.14	1.86	2.41
TOP	9.00	-10.90	11.13	14.52	5.84	15.42	0.90	0.45	6.14	1.72	2.23

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
LT	7.00	-8.31	3.86	32.90	12.84	30.41	0.90	0.45	9.59	5.46	7.08
MID	70.00	20.95	0.01	28.72	8.32	25.85	0.90	0.62	9.59	1.40	1.81
RT	7.00	-8.31	3.86	32.90	12.84	30.41	0.90	0.45	9.59	5.46	7.08

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
LT	7.00	-7.97	5.11	32.90	12.84	30.67	0.90	0.45	9.59	7.17	9.30
MID	70.00	19.95	0.70	28.72	8.32	26.02	0.90	0.62	9.59	1.59	2.06
RT	7.00	-7.97	5.11	32.90	12.84	30.67	0.90	0.45	9.59	7.17	9.30

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.57	-11.0	11.13	5.76	9.47	2.155	36.71	10.52a	0.00	0.00	0.00	5.16	6.69
MID	35.00	0.59	0.5	3.03	6.23	23.58	4.964	27.36	26.20a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.59	-10.3	11.13	5.76	10.32	2.348	35.65	11.47a	0.00	0.00	0.00	25.79	33.43
TOP	10.76	-2.90	-10.9	11.13	5.76	9.61	2.186	36.54	10.68a	0.00	0.00	0.00	8.13	10.54

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.25	-8.3	3.86	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.59	5.95
MID	70.00	2.28	20.9	0.01	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	8.34	10.81
RT	14.52	9.25	-8.3	3.86	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.59	5.95

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.53	-8.0	5.11	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.92	7.67
MID	70.00	0.07	19.9	0.70	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.53	-8.0	5.11	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.92	7.67

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 3.50 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-5.908	-13.342	3.028	11.130	5.111	0.703
1- 1	-3.508	-11.097	3.028	11.130	4.093	0.490
1- 2	-1.690	-10.695	3.028	11.130	3.120	0.290
1- 3	-0.425	-10.413	3.028	11.130	2.192	0.104
1- 4	0.311	-10.260	3.028	11.130	1.310	-0.070
1- 5	0.546	-10.239	3.028	11.130	0.593	-0.351
1- 6	0.305	-10.307	3.028	11.130	0.446	-1.143
1- 7	-0.385	-10.457	3.028	11.130	0.312	-1.890
1- 8	-1.497	-10.682	3.028	11.130	0.191	-2.592
1- 9	-3.005	-10.993	3.028	11.130	0.083	-3.248
1-10	-4.789	-12.960	4.676	11.130	-0.012	-3.860
Top						
Member 2: (Top Slab)						
Left						
2- 0	-4.795	-12.982	0.012	3.860	11.130	3.028
2- 1	2.575	-3.630	0.012	3.860	9.318	2.374
2- 2	10.709	0.660	0.012	3.525	7.565	1.781
2- 3	16.295	2.391	0.012	3.525	5.799	1.017
2- 4	19.768	3.430	0.012	3.525	4.034	-0.562
2- 5	20.950	3.776	0.012	3.525	2.284	-2.286
2- 6	19.768	3.430	0.012	3.525	0.562	-4.034
2- 7	16.295	2.391	0.012	3.525	-1.017	-5.799
2- 8	10.536	0.660	0.012	3.525	-1.781	-7.565
2- 9	2.575	-3.630	0.012	3.860	-2.374	-9.318
2-10	-4.793	-12.982	0.012	3.860	-3.028	-11.130
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-5.908	-13.342	4.622	5.111	10.755	3.553
4- 1	0.192	-2.597	0.703	5.111	8.610	2.842
4- 2	8.704	0.724	0.703	4.622	6.464	2.132
4- 3	14.950	2.797	0.703	4.622	4.318	1.421
4- 4	18.698	4.040	0.703	4.622	2.172	0.711
4- 5	19.947	4.455	0.703	4.622	0.070	-0.072
4- 6	18.698	4.040	0.703	4.622	-0.711	-2.172
4- 7	14.950	2.797	0.703	4.622	-1.421	-4.318
4- 8	8.700	0.724	0.703	4.622	-2.132	-6.464
4- 9	0.192	-2.597	0.703	5.111	-2.842	-8.610
4-10	-5.908	-13.342	4.622	5.111	-3.553	-10.755
Right						

Analysis Truck, MaineDOT Config 6				
Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.282	4.86	
	2	0.505	4.86	9.00
	3	0.555	8.86	6.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution Width : 12.35 ft
 Impact Factor : 1.19
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	Weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.282	4.86	17.75	Truck	1	0.282	4.86	17.92
	2	0.505	4.86	8.75		2	0.505	4.86	8.92
	3	0.555	8.86	2.75		3	0.555	8.86	2.92
Maximum +Moment : 6.70 k-ft					Maximum -Moment : -3.53 k-ft				
Corresponding Moment at End : -3.53 k-ft					Corresponding Moment at Mid : 6.70 k-ft				
Coincident Bottom Slab Load : 0.58 k/ft					Coincident Bottom Slab Load : 0.59 k/ft				

Maximum +Shear in Top Slab
 Truck 1 0.282 4.86 17.75
 2 0.505 4.86 8.75
 3 0.555 8.86 2.75
 Maximum +Shear : 3.37 k
 Corresponding Shear at Mid : 0.13 k
 Coincident Bottom Slab Load : 0.58 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.282 4.86 21.35
 2 0.505 4.86 12.35
 3 0.555 8.86 6.35
 Maximum -Shear : -3.50 k
 Corresponding Shear at Mid : 0.12 k
 Coincident Bottom Slab Load : 0.53 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.66	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-3.64	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-3.62	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-3.60	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-3.58	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-3.57	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-3.55	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-3.54	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-3.53	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-3.52	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.02	-3.53	0.15	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.02	-3.53	3.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.08	-0.71	2.73	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	3.04	0.00	2.09	-0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	4.88	0.00	1.57	-0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	6.17	0.00	1.14	-0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	6.70	0.00	0.78	-0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	6.45	0.00	0.50	-1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	5.28	0.00	0.27	-1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	3.31	0.00	0.12	-2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	0.86	-0.79	0.03	-2.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.02	-3.53	0.00	-3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-3.66	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.19	-0.18	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	3.01	0.00	2.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	5.09	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	6.34	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 5	6.75	0.00	0.03	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	6.33	0.00	0.00	-0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 7	5.07	0.00	0.00	-1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 8	2.98	0.00	0.00	-2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 9	0.22	-0.14	0.00	-2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-10	0.00	-3.70	0.00	-3.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 3.50 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-6.9	6.87	25.46	2.00	9.18
A2	Bot Corner Bar	-7.7	6.87	29.32	2.00	7.40
A100	Top Slab (int)	13.1	0.18	32.90	2.00	9.02
A200	Bot Slab (int)	14.0	0.79	34.65	2.00	8.39

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.78	10.58	14.52	5.84	15.30	0.90	0.45	6.14	1.55	1.55
MID	35.00	0.55	3.03	6.97	6.36	6.94	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.78	10.58	14.52	5.84	15.30	0.90	0.45	6.14	1.72	1.72
TOP	9.00	-10.76	10.58	14.52	5.84	15.30	0.90	0.45	6.14	1.74	1.74

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-7.79	3.58	32.90	12.84	30.35	0.90	0.45	9.59	6.08	6.08
MID	70.00	20.30	0.17	28.72	8.32	25.89	0.90	0.62	9.59	1.48	1.48
RT	7.00	-7.86	3.58	32.90	12.84	30.35	0.90	0.45	9.59	5.99	5.99

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.37	4.95	32.90	12.84	30.63	0.90	0.45	9.59	6.46	6.46
MID	70.00	21.45	0.98	28.72	8.32	26.09	0.90	0.62	9.59	1.39	1.39
RT	7.00	-8.38	4.95	32.90	12.84	30.63	0.90	0.45	9.59	6.45	6.45

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.41	-11.8	10.58	5.76	9.17	2.087	37.17	10.19a	0.00	0.00	0.00	5.58	5.58
MID	35.00	0.43	0.5	3.03	6.23	24.17	5.087	27.11	26.85a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.43	-10.8	10.58	5.76	10.01	2.278	36.03	11.13a	0.00	0.00	0.00	84.04	84.04
TOP	10.76	-2.62	-10.8	10.58	5.76	9.66	2.198	36.47	10.74a	0.00	0.00	0.00	8.19	8.19

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.37	-7.8	3.58	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.45	5.45
MID	70.00	1.37	20.3	0.17	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	13.87	13.87
RT	14.52	8.70	-7.9	3.58	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.09	5.09

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.24	-8.4	4.95	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.07	5.07
MID	70.00	0.05	21.4	0.98	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	9.25	-8.4	4.95	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.06	5.06

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 3.50 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-5.908	-14.256	3.028	10.579	4.953	0.980
1- 1	-3.508	-11.923	3.028	10.579	3.934	0.767
1- 2	-1.690	-11.433	3.028	10.579	2.962	0.567
1- 3	-0.425	-11.056	3.028	10.579	2.034	0.381
1- 4	0.311	-10.784	3.028	10.579	1.151	0.207
1- 5	0.546	-10.615	3.028	10.579	0.434	-0.074
1- 6	0.305	-10.540	3.028	10.579	0.287	-0.866
1- 7	-0.385	-10.548	3.028	10.579	0.153	-1.613
1- 8	-1.497	-10.631	3.028	10.579	0.032	-2.315
1- 9	-3.005	-10.807	3.028	10.579	-0.076	-2.971
1-10	-4.815	-12.659	4.676	10.579	-0.170	-3.583
Top						
Member 2: (Top Slab)						
Left						
2- 0	-4.821	-12.681	0.170	3.583	10.579	3.028
2- 1	1.897	-2.898	0.170	3.583	8.444	2.374
2- 2	9.078	0.660	0.170	3.525	6.419	1.781
2- 3	14.968	2.391	0.170	3.525	4.585	1.187
2- 4	18.829	3.430	0.170	3.525	2.919	0.113
2- 5	20.301	3.776	0.170	3.525	1.373	-1.346
2- 6	19.332	3.430	0.170	3.525	-0.052	-2.928
2- 7	15.662	2.391	0.170	3.525	-1.187	-4.658
2- 8	9.549	0.660	0.170	3.525	-1.781	-6.772
2- 9	1.507	-3.032	0.170	3.583	-2.374	-8.773
2-10	-4.824	-12.683	0.170	3.583	-3.028	-10.807
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-5.908	-14.256	4.622	4.953	11.657	3.553
4- 1	-0.120	-2.488	0.980	4.953	9.324	2.842
4- 2	9.224	0.724	0.980	4.622	6.992	2.132
4- 3	16.020	2.797	0.980	4.622	4.659	1.421
4- 4	20.094	4.040	0.980	4.622	2.326	0.711
4- 5	21.447	4.455	0.980	4.622	0.049	-0.044
4- 6	20.079	4.040	0.980	4.622	-0.711	-2.339
4- 7	15.989	2.797	0.980	4.622	-1.421	-4.672
4- 8	9.178	0.724	0.980	4.622	-2.132	-7.005
4- 9	-0.067	-2.424	0.980	4.953	-2.842	-9.337
4-10	-5.908	-14.332	4.622	4.953	-3.553	-11.670
Right						

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

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.190	4.86	
	2	0.759	4.86	14.00
	3	0.759	4.86	14.00
Tandem	1	0.650	8.86	

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 12.35 ft
 Impact Factor : 1.19
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.190	4.86	19.83	Truck	1	0.190	4.86	19.35
	2	0.759	4.86	5.83		2	0.759	4.86	5.35
	3	0.759	4.86	-8.17		3	0.759	4.86	-8.65
Maximum +Moment : 5.66 k-ft					Maximum -Moment : -2.88 k-ft				

Corresponding Moment at End : -2.85 k-ft
 Coincident Bottom Slab Load : 0.33 k/ft

Corresponding Moment at Mid : 5.59 k-ft
 Coincident Bottom Slab Load : 0.33 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.190 4.86 16.43
 2 0.759 4.86 2.43
 3 0.759 4.86 -11.57

Maximum -Shear in Top Slab
 Truck 1 0.190 4.86 23.24
 2 0.759 4.86 9.24
 3 0.759 4.86 -4.76

Maximum +Shear : 2.95 k
 Corresponding Shear at Mid : -0.74 k
 Coincident Bottom Slab Load : 0.33 k/ft

Maximum -Shear : -2.95 k
 Corresponding Shear at Mid : 0.74 k
 Coincident Bottom Slab Load : 0.33 k/ft

Maximum +Moment in Top Slab
 Tandem 1 0.650 8.86 5.25
 Maximum +Moment : 6.82 k-ft
 Corresponding Moment at End : -3.46 k-ft
 Coincident Bottom Slab Load : 0.52 k/ft

Maximum -Moment in Top Slab
 Tandem 1 0.650 8.86 5.60
 Maximum -Moment : -3.70 k-ft
 Corresponding Moment at Mid : 6.72 k-ft
 Coincident Bottom Slab Load : 0.52 k/ft

Maximum +Shear in Top Slab
 Tandem 1 0.650 8.86 4.43
 Maximum +Shear : 3.59 k
 Corresponding Shear at Mid : -0.20 k
 Coincident Bottom Slab Load : 0.52 k/ft

Maximum -Shear in Top Slab
 Tandem 1 0.650 8.86 7.24
 Maximum -Shear : -3.59 k
 Corresponding Shear at Mid : 0.20 k
 Coincident Bottom Slab Load : 0.52 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-2.25	0.20	-0.18	0.00	-3.13	0.11	-0.12	0.00	0.00	0.00	0.00
1- 1	0.00	-2.20	0.20	-0.18	0.00	-3.17	0.11	-0.12	0.00	0.00	0.00	0.00
1- 2	0.00	-2.17	0.20	-0.18	0.00	-3.20	0.11	-0.12	0.00	0.00	0.00	0.00
1- 3	0.00	-2.22	0.20	-0.18	0.00	-3.23	0.11	-0.12	0.00	0.00	0.00	0.00
1- 4	0.00	-2.29	0.20	-0.18	0.00	-3.28	0.11	-0.12	0.00	0.00	0.00	0.00
1- 5	0.00	-2.38	0.20	-0.18	0.00	-3.35	0.11	-0.12	0.00	0.00	0.00	0.00
1- 6	0.00	-2.47	0.20	-0.18	0.00	-3.42	0.11	-0.12	0.00	0.00	0.00	0.00
1- 7	0.00	-2.57	0.20	-0.18	0.00	-3.49	0.11	-0.12	0.00	0.00	0.00	0.00
1- 8	0.00	-2.67	0.20	-0.18	0.00	-3.56	0.11	-0.12	0.00	0.00	0.00	0.00
1- 9	0.00	-2.77	0.20	-0.18	0.00	-3.63	0.11	-0.12	0.00	0.00	0.00	0.00
1-10	0.03	-2.88	0.20	-0.18	0.02	-3.70	0.11	-0.12	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.03	-2.88	2.95	0.00	0.02	-3.70	3.59	0.00	0.00	0.00	0.00	0.00
2- 1	1.18	-0.91	2.58	-0.04	1.01	-0.84	3.00	-0.03	0.00	0.00	0.00	0.00
2- 2	3.18	0.00	2.20	-0.16	3.28	0.00	2.41	-0.14	0.00	0.00	0.00	0.00
2- 3	4.51	0.00	1.81	-0.37	5.33	0.00	1.84	-0.32	0.00	0.00	0.00	0.00
2- 4	5.36	0.00	1.42	-0.68	6.50	0.00	1.34	-0.58	0.00	0.00	0.00	0.00
2- 5	5.66	0.00	1.04	-1.05	6.82	0.00	0.92	-0.92	0.00	0.00	0.00	0.00
2- 6	5.36	0.00	0.68	-1.42	6.33	0.00	0.58	-1.34	0.00	0.00	0.00	0.00
2- 7	4.51	0.00	0.37	-1.81	5.14	0.00	0.32	-1.84	0.00	0.00	0.00	0.00
2- 8	3.10	0.00	0.16	-2.20	3.15	0.00	0.14	-2.42	0.00	0.00	0.00	0.00
2- 9	1.18	-0.91	0.04	-2.58	1.01	-0.84	0.03	-3.00	0.00	0.00	0.00	0.00
2-10	0.03	-2.88	0.00	-2.95	0.03	-3.70	0.00	-3.59	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-2.25	1.98	0.00	0.00	-3.13	3.06	0.00	0.00	0.00	0.00	0.00
4- 1	0.30	-0.19	1.59	0.00	0.24	-0.16	2.45	0.00	0.00	0.00	0.00	0.00
4- 2	1.87	0.00	1.20	0.00	2.71	0.00	1.84	0.00	0.00	0.00	0.00	0.00
4- 3	2.98	0.00	0.81	0.00	4.48	0.00	1.23	0.00	0.00	0.00	0.00	0.00
4- 4	3.65	0.00	0.42	0.00	5.54	0.00	0.62	0.00	0.00	0.00	0.00	0.00
4- 5	3.88	0.00	0.03	-0.03	5.89	0.00	0.03	-0.03	0.00	0.00	0.00	0.00
4- 6	3.65	0.00	0.00	-0.42	5.54	0.00	0.00	-0.62	0.00	0.00	0.00	0.00
4- 7	2.98	0.00	0.00	-0.81	4.48	0.00	0.00	-1.23	0.00	0.00	0.00	0.00
4- 8	1.87	0.00	0.00	-1.20	2.71	0.00	0.00	-1.84	0.00	0.00	0.00	0.00
4- 9	0.30	-0.19	0.00	-1.59	0.23	-0.16	0.00	-2.45	0.00	0.00	0.00	0.00
4-10	0.00	-2.25	0.00	-1.98	0.00	-3.13	0.00	-3.06	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 3.50 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.0	7.08	25.60	2.00	9.10
A2	Bot Corner Bar	-7.3	7.08	26.77	2.00	8.51
A100	Top Slab (int)	13.2	0.14	33.22	2.00	8.90
A200	Bot Slab (int)	13.1	0.68	32.58	2.00	9.14

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-10.98	10.95	14.52	5.84	15.38	0.90	0.45	6.14	1.79	2.32
MID	35.00	0.55	3.03	6.97	6.36	6.94	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.26	10.95	14.52	5.84	15.38	0.90	0.45	6.14	1.85	2.40
TOP	9.00	-10.90	10.95	14.52	5.84	15.38	0.90	0.45	6.14	1.71	2.22

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.11	3.78	32.90	12.84	30.39	0.90	0.45	9.59	5.68	7.37
MID	70.00	20.50	0.10	28.72	8.32	25.87	0.90	0.62	9.59	1.45	1.88
RT	7.00	-8.11	3.78	32.90	12.84	30.39	0.90	0.45	9.59	5.68	7.37

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-7.93	5.03	32.90	12.84	30.65	0.90	0.45	9.59	7.25	9.40
MID	70.00	19.95	0.78	28.72	8.32	26.04	0.90	0.62	9.59	1.59	2.06
RT	7.00	-7.93	5.03	32.90	12.84	30.65	0.90	0.45	9.59	7.25	9.40

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.48	-11.0	10.95	5.76	9.47	2.154	36.72	10.52a	0.00	0.00	0.00	5.49	7.12
MID	35.00	0.51	0.5	3.03	6.23	24.01	5.053	27.18	26.68a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.51	-10.3	10.95	5.76	10.32	2.347	35.66	11.46a	0.00	0.00	0.00	32.21	41.75
TOP	10.76	-2.82	-10.9	10.95	5.76	9.60	2.184	36.55	10.67a	0.00	0.00	0.00	8.12	10.53

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.85	-8.1	3.78	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.94	6.41
MID	70.00	1.83	20.5	0.10	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	10.42	13.51
RT	14.52	8.85	-8.1	3.78	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.94	6.41

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.53	-7.9	5.03	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.92	7.67
MID	70.00	0.06	19.9	0.78	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.53	-7.9	5.03	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.92	7.67

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

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
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M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-5.908	-13.342	3.028	10.955	5.025	0.782
1- 1	-3.508	-11.097	3.028	10.955	4.007	0.569
1- 2	-1.690	-10.695	3.028	10.955	3.034	0.369
1- 3	-0.425	-10.413	3.028	10.955	2.107	0.183
1- 4	0.311	-10.260	3.028	10.955	1.224	0.009
1- 5	0.546	-10.239	3.028	10.955	0.507	-0.272
1- 6	0.305	-10.307	3.028	10.955	0.360	-1.064
1- 7	-0.385	-10.457	3.028	10.955	0.226	-1.811
1- 8	-1.497	-10.682	3.028	10.955	0.105	-2.513
1- 9	-3.005	-10.993	3.028	10.955	-0.003	-3.169
1-10	-4.801	-12.960	4.676	10.955	-0.097	-3.781
Top						
Member 2: (Top slab)						
Left						
2- 0	-4.808	-12.982	0.097	3.781	10.955	3.028
2- 1	2.060	-3.234	0.097	3.781	8.924	2.374
2- 2	9.481	0.660	0.097	3.525	6.973	1.781
2- 3	15.757	2.391	0.097	3.525	5.054	1.181
2- 4	19.413	3.430	0.097	3.525	3.411	-0.266
2- 5	20.504	3.776	0.097	3.525	1.827	-1.829
2- 6	19.114	3.430	0.097	3.525	0.266	-3.411
2- 7	15.421	2.391	0.097	3.525	-1.181	-5.054
2- 8	9.260	0.660	0.097	3.525	-1.781	-6.994
2- 9	2.060	-3.234	0.097	3.781	-2.374	-8.924
2-10	-4.806	-12.982	0.097	3.781	-3.028	-10.955
Right						
Member 4: (Bottom slab)						
Left						
4- 0	-5.908	-13.342	4.622	5.025	10.755	3.553
4- 1	0.062	-2.514	0.782	5.025	8.610	2.842
4- 2	8.704	0.724	0.782	4.622	6.464	2.132
4- 3	14.950	2.797	0.782	4.622	4.318	1.421
4- 4	18.698	4.040	0.782	4.622	2.172	0.711
4- 5	19.947	4.455	0.782	4.622	0.056	-0.058
4- 6	18.698	4.040	0.782	4.622	-0.711	-2.172
4- 7	14.950	2.797	0.782	4.622	-1.421	-4.318
4- 8	8.700	0.724	0.782	4.622	-2.132	-6.464
4- 9	0.062	-2.514	0.782	5.025	-2.842	-8.610
4-10	-5.908	-13.342	4.622	5.025	-3.553	-10.755
Right						

Analysis Results: Fill Depth = 4.00 ft

Load Parameters:

Fe = 1.06 Surcharge Depth : 2.93 ft

Applied Horizontal Loads: (k/ft)

Load Description	Bottom of wall	Top of wall
Horizontal Earth Load	0.960	0.414
Live Load Surcharge	0.275	0.275
Internal Water Pressure	0.000	0.000

Unfactored Moments due to All Loads: (k-ft)

M-PT	Mdc	Mev	Mdw	Meh	Mls	Mwa
Member 1: (Exterior wall)						
Bottom						
1- 0	-1.58	-3.17	0.00	-1.06	-0.41	0.00
1- 1	-1.48	-3.17	0.00	0.11	0.01	0.00
1- 2	-1.38	-3.17	0.00	0.98	0.34	0.00
1- 3	-1.28	-3.17	0.00	1.55	0.57	0.00
1- 4	-1.18	-3.17	0.00	1.86	0.71	0.00
1- 5	-1.08	-3.17	0.00	1.91	0.76	0.00
1- 6	-0.98	-3.17	0.00	1.73	0.71	0.00
1- 7	-0.88	-3.17	0.00	1.33	0.57	0.00
1- 8	-0.78	-3.17	0.00	0.73	0.34	0.00
1- 9	-0.68	-3.17	0.00	-0.04	0.01	0.00
1-10	-0.58	-3.17	0.00	-0.97	-0.41	0.00
Top						

Unfactored Shears due to All Loads: (k)

M-PT	Vdc	Vev	Vdw	Veh	Vls	Vwa
Member 1: (Exterior wall)						
Bottom						
1- 0	0.17	0.00	0.00	2.28	0.80	0.00
1- 1	0.17	0.00	0.00	1.74	0.64	0.00
1- 2	0.17	0.00	0.00	1.23	0.48	0.00
1- 3	0.17	0.00	0.00	0.75	0.32	0.00
1- 4	0.17	0.00	0.00	0.30	0.16	0.00
1- 5	0.17	0.00	0.00	-0.12	0.00	0.00
1- 6	0.17	0.00	0.00	-0.50	-0.16	0.00
1- 7	0.17	0.00	0.00	-0.86	-0.32	0.00
1- 8	0.17	0.00	0.00	-1.18	-0.48	0.00
1- 9	0.17	0.00	0.00	-1.47	-0.64	0.00
1-10	0.17	0.00	0.00	-1.73	-0.80	0.00
Top						

Member 2: (Top Slab)

Left						
2- 0	-0.58	-3.17	0.00	-0.98	-0.41	0.00
2- 1	0.21	0.09	0.00	-0.98	-0.41	0.00
2- 2	0.81	2.63	0.00	-0.98	-0.41	0.00
2- 3	1.23	4.44	0.00	-0.98	-0.41	0.00
2- 4	1.49	5.53	0.00	-0.98	-0.41	0.00
2- 5	1.57	5.89	0.00	-0.98	-0.41	0.00
2- 6	1.49	5.53	0.00	-0.98	-0.41	0.00
2- 7	1.23	4.44	0.00	-0.98	-0.41	0.00
2- 8	0.81	2.63	0.00	-0.98	-0.41	0.00
2- 9	0.21	0.09	0.00	-0.98	-0.41	0.00
2-10	-0.58	-3.17	0.00	-0.98	-0.41	0.00
Right						

Member 2: (Top Slab)

Left						
2- 0	0.80	3.11	0.00	0.00	0.00	0.00
2- 1	0.58	2.48	0.00	0.00	0.00	0.00
2- 2	0.44	1.86	0.00	0.00	0.00	0.00
2- 3	0.29	1.24	0.00	0.00	0.00	0.00
2- 4	0.15	0.62	0.00	0.00	0.00	0.00
2- 5	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	-0.15	-0.62	0.00	0.00	0.00	0.00
2- 7	-0.29	-1.24	0.00	0.00	0.00	0.00
2- 8	-0.44	-1.86	0.00	0.00	0.00	0.00
2- 9	-0.58	-2.48	0.00	0.00	0.00	0.00
2-10	-0.80	-3.11	0.00	0.00	0.00	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-1.58	-3.17	0.00	-1.06	-0.41	0.00
4- 1	-0.13	0.09	0.00	-1.06	-0.41	0.00
4- 2	1.00	2.63	0.00	-1.06	-0.41	0.00
4- 3	1.80	4.44	0.00	-1.06	-0.41	0.00
4- 4	2.28	5.53	0.00	-1.06	-0.41	0.00
4- 5	2.44	5.89	0.00	-1.06	-0.41	0.00
4- 6	2.28	5.53	0.00	-1.06	-0.41	0.00
4- 7	1.80	4.44	0.00	-1.06	-0.41	0.00
4- 8	1.00	2.63	0.00	-1.06	-0.41	0.00
4- 9	-0.13	0.09	0.00	-1.06	-0.41	0.00
4-10	-1.58	-3.17	0.00	-1.06	-0.41	0.00
Right						

Member 4: (Bottom Slab)

Left						
4- 0	1.38	3.11	0.00	0.00	0.00	0.00
4- 1	1.10	2.48	0.00	0.00	0.00	0.00
4- 2	0.83	1.86	0.00	0.00	0.00	0.00
4- 3	0.55	1.24	0.00	0.00	0.00	0.00
4- 4	0.28	0.62	0.00	0.00	0.00	0.00
4- 5	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	-0.28	-0.62	0.00	0.00	0.00	0.00
4- 7	-0.55	-1.24	0.00	0.00	0.00	0.00
4- 8	-0.83	-1.86	0.00	0.00	0.00	0.00
4- 9	-1.10	-2.48	0.00	0.00	0.00	0.00
4-10	-1.38	-3.11	0.00	0.00	0.00	0.00
Right						

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

Member	Pdc	Pev	Pdw	Peh	Pls	Pwa
1	0.80	3.11	0.00	0.00	0.00	0.00
2	-0.17	0.00	0.00	1.73	0.80	0.00
4	0.17	0.00	0.00	2.28	0.80	0.00

Analysis Truck, 125% HL-93

Vehicle	Axle No.	Weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.199	5.43	
	2	0.796	5.43	14.00
	3	0.796	5.43	14.00
Tandem	1	0.573	9.43	

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 Member 4: (Bottom Slab)

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:23 PM
 Culvert p. 74 of 82

Left												
4- 0	0.00	-2.58	2.31	0.00	0.00	-2.91	2.86	0.00	0.00	0.00	0.00	0.00
4- 1	0.33	-0.22	1.86	0.00	0.20	-0.14	2.29	0.00	0.00	0.00	0.00	0.00
4- 2	2.17	0.00	1.40	0.00	2.51	0.00	1.72	0.00	0.00	0.00	0.00	0.00
4- 3	3.48	0.00	0.95	0.00	4.17	0.00	1.15	0.00	0.00	0.00	0.00	0.00
4- 4	4.26	0.00	0.49	0.00	5.16	0.00	0.58	0.00	0.00	0.00	0.00	0.00
4- 5	4.53	0.00	0.04	-0.04	5.49	0.00	0.03	-0.03	0.00	0.00	0.00	0.00
4- 6	4.26	0.00	0.00	-0.49	5.16	0.00	0.00	-0.58	0.00	0.00	0.00	0.00
4- 7	3.48	0.00	0.00	-0.95	4.17	0.00	0.00	-1.15	0.00	0.00	0.00	0.00
4- 8	2.17	0.00	0.00	-1.40	2.50	0.00	0.00	-1.72	0.00	0.00	0.00	0.00
4- 9	0.33	-0.23	0.00	-1.86	0.20	-0.14	0.00	-2.29	0.00	0.00	0.00	0.00
4-10	0.00	-2.58	0.00	-2.31	0.00	-2.92	0.00	-2.86	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 4.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.1	7.26	25.70	2.00	9.05
A2	Bot Corner Bar	-7.4	7.26	27.45	2.00	8.20
A100	Top Slab (int)	13.5	0.15	34.04	2.00	8.60
A200	Bot Slab (int)	13.5	0.70	33.45	2.00	8.81

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.14	11.10	14.52	5.84	15.41	0.90	0.45	6.14	1.83	2.37
MID	35.00	0.35	3.38	6.97	6.36	7.01	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.33	11.10	14.52	5.84	15.41	0.90	0.45	6.14	1.93	2.50
TOP	9.00	-10.87	11.10	14.52	5.84	15.41	0.90	0.45	6.14	1.80	2.33

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.24	3.99	32.90	12.84	30.43	0.90	0.45	9.59	5.91	7.66
MID	70.00	20.79	0.09	28.72	8.32	25.87	0.90	0.62	9.59	1.46	1.89
RT	7.00	-8.24	3.99	32.90	12.84	30.43	0.90	0.45	9.59	5.91	7.66

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.12	5.25	32.90	12.84	30.70	0.90	0.45	9.59	7.53	9.76
MID	70.00	20.28	0.80	28.72	8.32	26.05	0.90	0.62	9.59	1.60	2.07
RT	7.00	-8.14	5.25	32.90	12.84	30.70	0.90	0.45	9.59	7.50	9.72

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.66	-11.1	11.10	5.76	9.40	2.140	36.82	10.45a	0.00	0.00	0.00	5.18	6.71
MID	35.00	0.57	0.3	3.38	6.23	24.21	5.096	27.10	26.90a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.57	-10.3	11.10	5.76	10.29	2.341	35.69	11.43a	0.00	0.00	0.00	28.93	37.50
TOP	10.76	-2.97	-10.9	11.10	5.76	9.61	2.187	36.53	10.68a	0.00	0.00	0.00	8.14	10.55

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.16	-8.2	3.99	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.99	6.47
MID	70.00	1.96	20.8	0.09	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	9.71	12.59
RT	14.52	9.16	-8.2	3.99	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	4.99	6.47

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.69	-8.1	5.25	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	6.22	8.06
MID	70.00	0.06	20.3	0.80	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.70	-8.1	5.25	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	6.21	8.05

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 4.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-6.352	-13.606	3.378	11.104	5.255	0.803
1- 1	-3.863	-11.267	3.378	11.104	4.203	0.579
1- 2	-1.975	-10.836	3.378	11.104	3.196	0.368
1- 3	-0.661	-10.524	3.378	11.104	2.234	0.170
1- 4	0.105	-10.326	3.378	11.104	1.317	-0.014
1- 5	0.349	-10.271	3.378	11.104	0.567	-0.307
1- 6	0.099	-10.311	3.378	11.104	0.408	-1.133
1- 7	-0.621	-10.441	3.378	11.104	0.263	-1.914
1- 8	-1.782	-10.651	3.378	11.104	0.131	-2.650
1- 9	-3.360	-10.950	3.378	11.104	0.012	-3.340
1-10	-5.327	-12.973	3.378	11.104	-0.094	-3.986
Top						
Member 2: (Top Slab)						
Left						
2- 0	-5.349	-12.995	3.695	3.986	11.104	3.378
2- 1	2.150	-3.490	0.094	3.986	9.225	2.655
2- 2	10.354	0.870	0.094	3.695	7.409	1.991
2- 3	16.069	2.806	0.094	3.695	5.585	1.327
2- 4	19.596	3.967	0.094	3.695	3.764	-0.213
2- 5	20.786	4.354	0.094	3.695	1.961	-1.966
2- 6	19.596	3.967	0.094	3.695	0.213	-3.764
2- 7	16.054	2.806	0.094	3.695	-1.327	-5.584
2- 8	10.188	0.870	0.094	3.695	-1.991	-7.409
2- 9	2.150	-3.490	0.094	3.986	-2.655	-9.225
2-10	-5.349	-12.995	3.695	3.986	-3.378	-11.104
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-6.352	-13.606	4.792	5.255	10.966	3.903
4- 1	0.109	-2.644	0.803	5.255	8.776	3.123
4- 2	8.792	0.935	0.803	4.792	6.586	2.342
4- 3	15.170	3.212	0.803	4.792	4.396	1.561
4- 4	19.000	4.578	0.803	4.792	2.206	0.781
4- 5	20.276	5.033	0.803	4.792	0.062	-0.062
4- 6	19.000	4.578	0.803	4.792	-0.781	-2.209
4- 7	15.168	3.212	0.803	4.792	-1.561	-4.399
4- 8	8.782	0.935	0.803	4.792	-2.342	-6.589
4- 9	0.109	-2.646	0.803	5.255	-3.123	-8.779
4-10	-6.352	-13.629	4.792	5.255	-3.903	-10.969
Right						

Analysis Truck, MaineDOT Config 6				
Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.237	5.43	
	2	0.424	5.43	9.00
	3	0.490	9.43	6.00

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 12.93 ft
 Impact Factor : 1.17
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.237	5.43	17.37	Truck	1	0.237	5.43	18.50
	2	0.424	5.43	8.37		2	0.424	5.43	9.50
	3	0.490	9.43	2.37		3	0.490	9.43	3.50
Maximum +Moment : 6.30 k-ft					Maximum -Moment : -3.27 k-ft				
Corresponding Moment at End : -3.26 k-ft					Corresponding Moment at Mid : 6.15 k-ft				
Coincident Bottom Slab Load : 0.52 k/ft					Coincident Bottom Slab Load : 0.55 k/ft				

Maximum +Shear in Top Slab
 Truck 1 0.237 5.43 17.17
 2 0.424 5.43 8.17
 3 0.490 9.43 2.17
 Maximum +Shear : 3.07 k
 Corresponding Shear at Mid : 0.05 k
 Coincident Bottom Slab Load : 0.51 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.237 5.43 21.95
 2 0.424 5.43 12.95
 3 0.490 9.43 6.95
 Maximum -Shear : -3.33 k
 Corresponding Shear at Mid : 0.13 k
 Coincident Bottom Slab Load : 0.47 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-3.31	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 1	0.00	-3.29	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 2	0.00	-3.28	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 3	0.00	-3.26	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 4	0.00	-3.25	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 5	0.00	-3.25	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 6	0.00	-3.25	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 7	0.00	-3.25	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 8	0.00	-3.25	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1- 9	0.00	-3.25	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-10	0.02	-3.26	0.14	-0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Top												
Member 2: (Top Slab)												
Left												
2- 0	0.02	-3.26	3.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 1	1.05	-0.63	2.50	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 2	2.93	0.00	1.93	-0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 3	4.58	0.00	1.38	-0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 4	5.77	0.00	1.01	-0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 5	6.30	0.00	0.69	-0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 6	6.03	0.00	0.44	-1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 7	4.96	0.00	0.24	-1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 8	3.18	0.00	0.11	-2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2- 9	0.76	-0.74	0.03	-2.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-10	0.02	-3.27	0.00	-3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												
Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-3.31	3.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 1	0.17	-0.16	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 2	2.75	0.00	1.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 3	4.64	0.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 4	5.77	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 5	6.15	0.00	0.03	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 6	5.76	0.00	0.00	-0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 7	4.61	0.00	0.00	-1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 8	2.71	0.00	0.00	-1.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4- 9	0.21	-0.12	0.00	-2.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-10	0.00	-3.38	0.00	-3.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 4.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.1	6.97	25.99	2.00	8.90
A2	Bot Corner Bar	-7.8	6.97	29.51	2.00	7.32
A100	Top Slab (int)	13.4	0.24	33.72	2.00	8.72
A200	Bot Slab (int)	14.1	0.84	34.98	2.00	8.28

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 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
BOT	9.00	-11.74	10.61	14.52	5.84	15.31	0.90	0.45	6.14	1.62	1.62
MID	35.00	0.35	3.38	6.97	6.36	7.01	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.72	10.61	14.52	5.84	15.31	0.90	0.45	6.14	1.81	1.81
TOP	9.00	-10.84	10.61	14.52	5.84	15.31	0.90	0.45	6.14	1.79	1.79

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
LT	7.00	-7.85	3.75	32.90	12.84	30.38	0.90	0.45	9.59	6.46	6.46
MID	70.00	20.62	0.26	28.72	8.32	25.91	0.90	0.62	9.59	1.48	1.48
RT	7.00	-7.95	3.75	32.90	12.84	30.38	0.90	0.45	9.59	6.32	6.32

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
LT	7.00	-8.41	5.09	32.90	12.84	30.66	0.90	0.45	9.59	6.94	6.94
MID	70.00	21.42	1.04	28.72	8.32	26.11	0.90	0.62	9.59	1.44	1.44
RT	7.00	-8.44	5.09	32.90	12.84	30.66	0.90	0.45	9.59	6.89	6.89

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.50	-11.7	10.61	5.76	9.18	2.088	37.16	10.20a	0.00	0.00	0.00	5.69	5.69
MID	35.00	0.40	0.3	3.38	6.23	24.22	5.099	27.09	26.92a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.40	-10.7	10.61	5.76	10.05	2.287	35.98	11.17a	0.00	0.00	0.00	88.90	88.90
TOP	10.76	-2.73	-10.8	10.61	5.76	9.61	2.186	36.54	10.68a	0.00	0.00	0.00	8.13	8.13

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.42	-7.8	3.75	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.84	5.84
MID	70.00	1.21	20.6	0.26	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	15.73	15.73
RT	14.52	8.91	-7.9	3.75	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.24	5.24

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in2)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	9.23	-8.4	5.09	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.48	5.48
MID	70.00	0.05	21.4	1.04	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	9.25	-8.4	5.09	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.46	5.46

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

Load Combination Results at Tenth Points: (k-ft, k)(Fill Depth = 4.00 ft)

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
Member 1: (Exterior wall)						
Bottom						
1- 0	-6.352	-14.297	3.378	10.605	5.092	1.042
1- 1	-3.863	-11.885	3.378	10.605	4.040	0.818
1- 2	-1.975	-11.380	3.378	10.605	3.033	0.607
1- 3	-0.661	-10.994	3.378	10.605	2.071	0.409
1- 4	0.105	-10.722	3.378	10.605	1.154	0.224
1- 5	0.349	-10.571	3.378	10.605	0.404	-0.068
1- 6	0.099	-10.521	3.378	10.605	0.245	-0.894
1- 7	-0.621	-10.560	3.378	10.605	0.100	-1.675
1- 8	-1.782	-10.680	3.378	10.605	-0.032	-2.411
1- 9	-3.360	-10.897	3.378	10.605	-0.151	-3.101
1-10	-5.327	-12.852	3.378	10.605	-0.257	-3.747
Top						
Member 2: (Top Slab)						
Left						
2- 0	-5.349	-12.874	3.695	3.747	10.605	3.378
2- 1	1.825	-2.823	0.257	3.747	8.492	2.655
2- 2	9.319	0.870	0.257	3.695	6.463	1.991
2- 3	15.214	2.806	0.257	3.695	4.483	1.327
2- 4	19.091	3.967	0.257	3.695	2.794	0.353
2- 5	20.620	4.354	0.257	3.695	1.211	-1.161
2- 6	19.558	3.967	0.257	3.695	-0.266	-2.795
2- 7	15.873	2.806	0.257	3.695	-1.327	-4.804
2- 8	9.754	0.870	0.257	3.695	-1.991	-6.911
2- 9	1.316	-3.007	0.257	3.747	-2.655	-8.990
2-10	-5.349	-12.885	3.695	3.747	-3.378	-11.066
Right						
Member 4: (Bottom Slab)						
Left						
4- 0	-6.352	-14.297	4.792	5.092	11.644	3.903
4- 1	-0.169	-2.533	1.042	5.092	9.313	3.123
4- 2	9.215	0.935	1.042	4.792	6.982	2.342
4- 3	16.001	3.212	1.042	4.792	4.651	1.561
4- 4	20.068	4.578	1.042	4.792	2.320	0.781
4- 5	21.416	5.033	1.042	4.792	0.046	-0.038
4- 6	20.044	4.578	1.042	4.792	-0.781	-2.341
4- 7	15.952	3.212	1.042	4.792	-1.561	-4.672
4- 8	9.141	0.935	1.042	4.792	-2.342	-7.003
4- 9	-0.094	-2.464	1.042	5.092	-3.123	-9.334
4-10	-6.352	-14.420	4.792	5.092	-3.903	-11.665
Right						

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

Vehicle	Axle No.	weight (k/ft)	Length (ft)	Dist. From Previous (ft)
Truck	1	0.159	5.43	
	2	0.637	5.43	14.00
	3	0.637	5.43	14.00
Tandem	1	0.573	9.43	

***Distributed loads may have been intensified due to axle overlap between lanes

Live Load Parameters:

Traffic Direction is Parallel to Main Reinforcement
 Distribution width : 12.93 ft
 Impact Factor : 1.17
 Distribution width : 0.00 ft
 Lane Load: 0.000 k/ft

Truck Positions That Cause Maximum Results:

Maximum +Moment in Top Slab					Maximum -Moment in Top Slab				
Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)	Vehicle	Axle No.	weight (k)	Length (ft)	Dist. From Left End (ft)
Truck	1	0.159	5.43	19.83	Truck	1	0.159	5.43	20.22
	2	0.637	5.43	5.83		2	0.637	5.43	6.22
	3	0.637	5.43	-8.17		3	0.637	5.43	-7.78
Maximum +Moment : 5.11 k-ft					Maximum -Moment : -2.65 k-ft				

Eriksson Culvert v4.2.3
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 Filename: Box Culvert - R1.etcx
 Corresponding Moment at End : -2.63 k-ft
 Coincident Bottom Slab Load : 0.31 k/ft

Sht:____of____
 By:IRR Chk:____
 6/5/2019 5:36:24 PM
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Corresponding Moment at Mid : 5.08 k-ft
 Coincident Bottom Slab Load : 0.31 k/ft

Maximum +Shear in Top Slab
 Truck 1 0.159 5.43 16.72
 2 0.637 5.43 2.72
 3 0.637 5.43 -11.28

Maximum +Shear : 2.68 k
 Corresponding Shear at Mid : -0.78 k
 Coincident Bottom Slab Load : 0.31 k/ft

Maximum +Moment in Top Slab
 Tandem 1 0.573 9.43 5.30
 Maximum +Moment : 6.19 k-ft
 Corresponding Moment at End : -3.06 k-ft
 Coincident Bottom Slab Load : 0.49 k/ft

Maximum +Shear in Top Slab
 Tandem 1 0.573 9.43 4.72
 Maximum +Shear : 3.23 k
 Corresponding Shear at Mid : -0.11 k
 Coincident Bottom Slab Load : 0.49 k/ft

Maximum -Shear in Top Slab
 Truck 1 0.159 5.43 22.95
 2 0.637 5.43 8.95
 3 0.637 5.43 -5.05

Maximum -Shear : -2.68 k
 Corresponding Shear at Mid : 0.78 k
 Coincident Bottom Slab Load : 0.31 k/ft

Maximum -Moment in Top Slab
 Tandem 1 0.573 9.43 5.88
 Maximum -Moment : -3.33 k-ft
 Corresponding Moment at Mid : 6.06 k-ft
 Coincident Bottom Slab Load : 0.49 k/ft

Maximum -Shear in Top Slab
 Tandem 1 0.573 9.43 6.95
 Maximum -Shear : -3.23 k
 Corresponding Shear at Mid : 0.11 k
 Coincident Bottom Slab Load : 0.49 k/ft

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

M-PT	Truck				Tandem				Lane			
	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-	M11+	M11-	V11+	V11-
Member 1: (Exterior wall)												
Bottom												
1- 0	0.00	-2.07	0.18	-0.16	0.00	-2.91	0.10	-0.09	0.00	0.00	0.00	0.00
1- 1	0.00	-2.04	0.18	-0.16	0.00	-2.94	0.10	-0.09	0.00	0.00	0.00	0.00
1- 2	0.00	-2.02	0.18	-0.16	0.00	-2.97	0.10	-0.09	0.00	0.00	0.00	0.00
1- 3	0.00	-2.06	0.18	-0.16	0.00	-2.99	0.10	-0.09	0.00	0.00	0.00	0.00
1- 4	0.00	-2.13	0.18	-0.16	0.00	-3.02	0.10	-0.09	0.00	0.00	0.00	0.00
1- 5	0.00	-2.21	0.18	-0.16	0.00	-3.08	0.10	-0.09	0.00	0.00	0.00	0.00
1- 6	0.00	-2.29	0.18	-0.16	0.00	-3.13	0.10	-0.09	0.00	0.00	0.00	0.00
1- 7	0.00	-2.38	0.18	-0.16	0.00	-3.18	0.10	-0.09	0.00	0.00	0.00	0.00
1- 8	0.00	-2.47	0.18	-0.16	0.00	-3.23	0.10	-0.09	0.00	0.00	0.00	0.00
1- 9	0.00	-2.56	0.18	-0.16	0.00	-3.28	0.10	-0.09	0.00	0.00	0.00	0.00
1-10	0.02	-2.65	0.18	-0.16	0.02	-3.33	0.10	-0.09	0.00	0.00	0.00	0.00
Top												

Member 2: (Top Slab)												
Left												
2- 0	0.02	-2.65	2.68	0.00	0.02	-3.33	3.23	0.00	0.00	0.00	0.00	0.00
2- 1	0.99	-0.81	2.33	-0.03	0.89	-0.74	2.68	-0.03	0.00	0.00	0.00	0.00
2- 2	2.82	0.00	1.97	-0.14	2.92	0.00	2.13	-0.12	0.00	0.00	0.00	0.00
2- 3	4.06	0.00	1.61	-0.31	4.79	0.00	1.62	-0.28	0.00	0.00	0.00	0.00
2- 4	4.84	0.00	1.25	-0.57	5.88	0.00	1.18	-0.51	0.00	0.00	0.00	0.00
2- 5	5.11	0.00	0.90	-0.90	6.19	0.00	0.81	-0.81	0.00	0.00	0.00	0.00
2- 6	4.84	0.00	0.57	-1.25	5.72	0.00	0.51	-1.18	0.00	0.00	0.00	0.00
2- 7	4.05	0.00	0.31	-1.61	4.60	0.00	0.28	-1.62	0.00	0.00	0.00	0.00
2- 8	2.74	0.00	0.14	-1.97	2.79	0.00	0.12	-2.13	0.00	0.00	0.00	0.00
2- 9	0.99	-0.81	0.03	-2.33	0.89	-0.74	0.03	-2.68	0.00	0.00	0.00	0.00
2-10	0.02	-2.65	0.00	-2.68	0.02	-3.33	0.00	-3.23	0.00	0.00	0.00	0.00
Right												

Member 4: (Bottom Slab)												
Left												
4- 0	0.00	-2.07	1.85	0.00	0.00	-2.91	2.86	0.00	0.00	0.00	0.00	0.00
4- 1	0.26	-0.18	1.49	0.00	0.20	-0.14	2.29	0.00	0.00	0.00	0.00	0.00
4- 2	1.73	0.00	1.12	0.00	2.51	0.00	1.72	0.00	0.00	0.00	0.00	0.00
4- 3	2.78	0.00	0.76	0.00	4.17	0.00	1.15	0.00	0.00	0.00	0.00	0.00
4- 4	3.41	0.00	0.39	0.00	5.16	0.00	0.58	0.00	0.00	0.00	0.00	0.00
4- 5	3.62	0.00	0.03	-0.03	5.49	0.00	0.03	-0.03	0.00	0.00	0.00	0.00
4- 6	3.41	0.00	0.00	-0.39	5.16	0.00	0.00	-0.58	0.00	0.00	0.00	0.00
4- 7	2.78	0.00	0.00	-0.76	4.17	0.00	0.00	-1.15	0.00	0.00	0.00	0.00
4- 8	1.73	0.00	0.00	-1.12	2.50	0.00	0.00	-1.72	0.00	0.00	0.00	0.00
4- 9	0.26	-0.18	0.00	-1.49	0.20	-0.14	0.00	-2.29	0.00	0.00	0.00	0.00
4-10	0.00	-2.07	0.00	-1.85	0.00	-2.92	0.00	-2.86	0.00	0.00	0.00	0.00
Right												

Note: Unfactored live load results computed at 4.00 ft and 0 ft fill depths, per LRFD 3.6.1.2.6

Serviceability Check: Crack Control

Bar Mark	Location	Moment (k-ft)	Thrust (k)	Fss (ksi)	Spacing (in)	Allow (in)
A1	Top Corner Bar	-7.1	7.13	25.86	2.00	8.96
A2	Bot Corner Bar	-7.4	7.13	27.61	2.00	8.12
A100	Top Slab (int)	13.3	0.20	33.50	2.00	8.80
A200	Bot Slab (int)	13.5	0.74	33.42	2.00	8.82

Strength Limit State at Critical Sections: Flexure

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Moment (k-ft)	Corr. A. F. (k)	Mu (k-ft)	ds (in)	Ma (k-ft)	phi	As (in ²)	Mcr (k-ft)	Load Ratings IR	OR
BOT	9.00	-11.14	10.89	14.52	5.84	15.37	0.90	0.45	6.14	1.82	2.36
MID	35.00	0.35	3.38	6.97	6.36	7.01	0.90	0.19	6.14	NC	NC
MID-	35.00	-10.33	10.89	14.52	5.84	15.37	0.90	0.45	6.14	1.92	2.49
TOP	9.00	-10.87	10.89	14.52	5.84	15.37	0.90	0.45	6.14	1.79	2.32

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.07	3.92	32.90	12.84	30.42	0.90	0.45	9.59	6.15	7.97
MID	70.00	20.44	0.17	28.72	8.32	25.89	0.90	0.62	9.59	1.50	1.95
RT	7.00	-8.07	3.92	32.90	12.84	30.42	0.90	0.45	9.59	6.15	7.97

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 (in ²)	Mcr (k-ft)	Load Ratings IR	OR
LT	7.00	-8.09	5.17	32.90	12.84	30.68	0.90	0.45	9.59	7.61	9.86
MID	70.00	20.28	0.87	28.72	8.32	26.06	0.90	0.62	9.59	1.60	2.08
RT	7.00	-8.10	5.17	32.90	12.84	30.68	0.90	0.45	9.59	7.58	9.83

Notes: Mu - Resisting moment under pure flexure, Ma - Allowable moment under applied axial load

Strength Limit State at Critical Sections: Vertical Shear

Member 1: (Exterior wall), Thickness = 8.00 in

Loc	Dist. (in)	Design Shear (k)	Corr. Moment (k-ft)	Corr. A. F. (k)	Dv (in)	phi*Vn (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
BOT	10.76	3.58	-11.1	10.89	5.76	9.40	2.138	36.83	10.44a	0.00	0.00	0.00	5.49	7.12
MID	35.00	0.49	0.3	3.38	6.23	24.22	5.097	27.09	26.91a	0.00	0.00	0.00	99.99	99.99
MID-	35.00	0.49	-10.3	10.89	5.76	10.28	2.338	35.71	11.42a	0.00	0.00	0.00	36.11	46.81
TOP	10.76	-2.90	-10.9	10.89	5.76	9.60	2.184	36.55	10.67a	0.00	0.00	0.00	8.12	10.53

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.74	-8.1	3.92	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.44	7.05
MID	70.00	1.57	20.4	0.17	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	12.14	15.74
RT	14.52	8.74	-8.1	3.92	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	5.44	7.05

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 (k)	Beta	Theta	Vc (k)	Vs (k)	Av (in ²)	Max. Spac (in)	Load Ratings IR	OR
LT	14.52	8.69	-8.1	5.17	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	6.22	8.06
MID	70.00	0.05	20.3	0.87	8.32	19.04	n/a	n/a	21.16c	0.00	0.00	0.00	99.99	99.99
RT	14.52	8.70	-8.1	5.17	12.84	29.40	n/a	n/a	32.66c	0.00	0.00	0.00	6.21	8.05

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

M-PT	+Moment	-Moment	+Axial	-Axial	+Shear	-Shear
------	---------	---------	--------	--------	--------	--------

Member 1: (Exterior wall)

Bottom	1- 0	1- 1	1- 2	1- 3	1- 4	1- 5	1- 6	1- 7	1- 8	1- 9	1-10	Top
	-6.352	-3.863	-1.975	-0.661	0.105	0.349	0.099	-0.621	-1.782	-3.360	-5.327	
	-13.606	-11.267	-10.836	-10.524	-10.326	-10.271	-10.311	-10.441	-10.651	-10.950	-12.973	
	3.378	3.378	3.378	3.378	3.378	3.378	3.378	3.378	3.378	3.378	3.378	
	10.888	10.888	10.888	10.888	10.888	10.888	10.888	10.888	10.888	10.888	10.888	
	5.174	4.122	3.115	2.153	1.237	0.486	0.328	0.182	0.050	-0.069	-0.175	
	0.873	0.649	0.438	0.240	0.056	-0.237	-1.063	-1.844	-2.580	-3.270	-3.916	

Member 2: (Top Slab)

Left						
2- 0	-5.349	-12.995	3.695	3.916	10.888	3.378
2- 1	1.717	-3.136	0.175	3.916	8.811	2.655
2- 2	9.311	0.870	0.175	3.695	6.818	1.991
2- 3	15.587	2.806	0.175	3.695	4.897	1.327
2- 4	19.296	3.967	0.175	3.695	3.217	0.036
2- 5	20.438	4.354	0.175	3.695	1.568	-1.573
2- 6	19.013	3.967	0.175	3.695	-0.036	-3.217
2- 7	15.256	2.806	0.175	3.695	-1.327	-4.897
2- 8	9.069	0.870	0.175	3.695	-1.991	-6.818
2- 9	1.717	-3.136	0.175	3.916	-2.655	-8.811
2-10	-5.349	-12.995	3.695	3.916	-3.378	-10.888
Right						

Member 4: (Bottom Slab)

Left						
4- 0	-6.352	-13.606	4.792	5.174	10.966	3.903
4- 1	-0.007	-2.565	0.873	5.174	8.776	3.123
4- 2	8.792	0.935	0.873	4.792	6.586	2.342
4- 3	15.170	3.212	0.873	4.792	4.396	1.561
4- 4	19.000	4.578	0.873	4.792	2.206	0.781
4- 5	20.276	5.033	0.873	4.792	0.050	-0.050
4- 6	19.000	4.578	0.873	4.792	-0.781	-2.209
4- 7	15.168	3.212	0.873	4.792	-1.561	-4.399
4- 8	8.782	0.935	0.873	4.792	-2.342	-6.589
4- 9	-0.007	-2.567	0.873	5.174	-3.123	-8.779
4-10	-6.352	-13.629	4.792	5.174	-3.903	-10.969
Right						

CULVERT DESIGN FOR BOX CULVERTS AND 3-SIDED CULVERTS PER AASHTO LRFD BRIDGE DESIGN SPECIFICATION, 8th ED.

Includes 2016 Interim Revisions to AASHTO LRFD Bridge Design Specifications, 8th Edition

CULVERT LOCATION AND PROJECT NUMBER

Culvert description:	Monson Piscataquis County	5.0	X	11.0
Project number:	WIN: 22930.00	(height)	X	(span)
Date of design:	Wednesday, June 5, 2019			
Designed By:	Ian Riley, P.E., S.E. Foscadh Consulting Engineers			

CALCULATION GUIDE AND LAYOUT

These calculations are designed to be both an efficient design tool and an effective guide to the calculations for summary review. The calculations are arranged in 6 sections:

- SECTION 1 - GENERAL DESIGN INFORMATION
- SECTION 2 - FACTORED LOADS PER AASHTO ARTICLE 3.4
- SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR
- SECTION 4 - DESIGN OF CULVERT WALLS FOR COMBINED LOADING
- SECTION 5 - DESIGN OF BOTTOM SLAB or DESIGN OF 3-SIDED CULVERT FOOTING
- SECTION 6 - RISA-3D STRUCTURE MODEL REPORT

Section 1 shows the general design inputs and gives a summary of the designed culvert reinforcement sizes and loads. Section 2 shows the calculation of the factored loads to be input into the RISA-3D model. Section 3 shows the design of the top slab of the culvert. Section 4 shows the design of the walls of the culvert. Section 5 shows the design of the bottom slab or the 3-sided culvert footing (depending on which is applicable) with Section 5a showing footing sliding (if applicable). Section 6 shows the output from the RISA-3D model showing load locations and values.

SECTION 1 - GENERAL DESIGN INFORMATION

This culvert design spreadsheet is programmed to simplify design calculations for box and 3-sided culverts designed per AASHTO LRFD bridge specs. It is designed to take dimension and load inputs, which are applied to a RISA-3D.pro model with given load factors, and output design checks for all structural members per AASHTO specifications. It will only design single span culverts with traffic parallel to the span. It is advised that the user of this spreadsheet verify all calculations and inputs for errors or limitations. Design assumptions are also made and must be verified by the user as acceptable for the design. Additional design checks may be required for unusual culvert designs.

The following cell is an input cell, to be modified by the user: SAMPLE INPUT CELL (units)

SECTION 1 - GENERAL DESIGN INFORMATION

The following cell is a calculation cell, to be verified by the user: **SAMPLE CALC CELL** (units)

GENERAL INPUTS FOR CULVERT TO BE DESIGNED

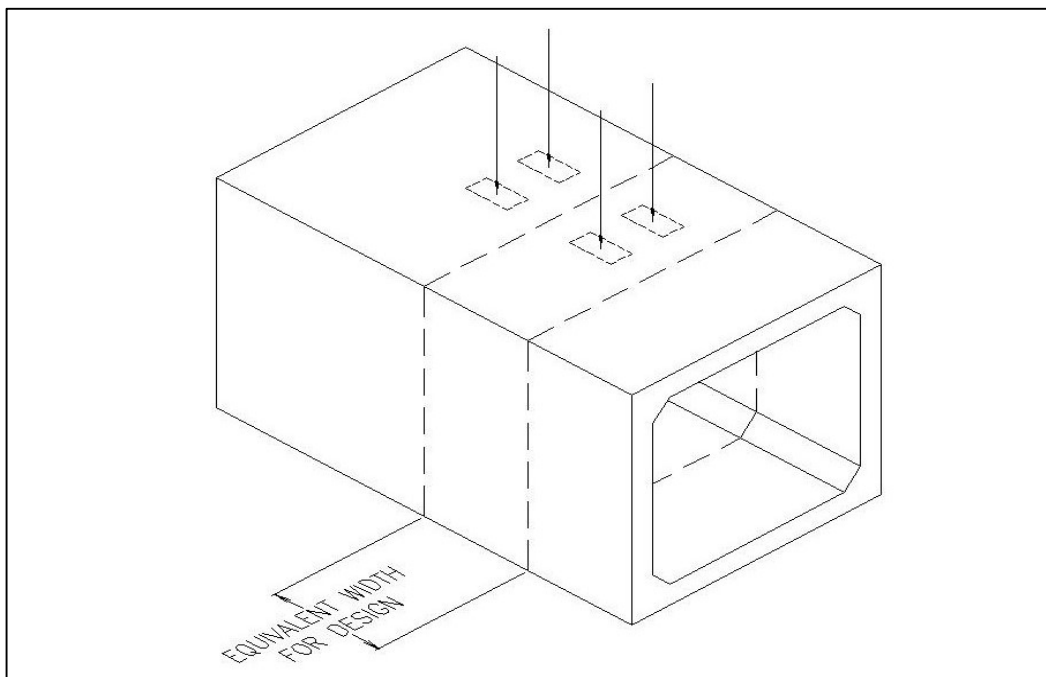
Location and soil information:

γ_s	Weight of soil:	Use 125 pcf for typical soils if weight is unknown.		125	pcf
H_{min}			MIN	MAX	
$\& H$	Soil cover over culvert:	1.5	4.0		ft
D_w	Depth of water table (typically assume top of culvert):		4.0		ft
Q_{serv}	Allowable SERVICE soil bearing pressure		2,000		psf
Q_{str}	Allowable STRENGTH soil bearing pressure		3,500		psf

Designed culvert dimensions:

S	Span (clear span from wall to wall):	11	ft
H_c	Height of culvert walls (clear height, slab to slab):	5	ft
t	Top slab thickness:	10	in
tw	Wall thickness:	8	in
tb or tbf	Bottom slab or 3-sided footing thickness:	10	in
	WARNING! Culvert span greater than 10 ft. and is considered a minor span.		
tf	Corner fillet width/height:	8	in
LS	Culvert segment length:	6.00	ft
E	Equivalent width of slab for design (calculated):	55.92	in

The culvert will be divided into "equivalent width" sections and designed for those sections. Each section will be calculated as the area of culvert "engaged" per wheel load. See Section 2 for calculations of E.



SECTION 1 - GENERAL DESIGN INFORMATION

Basic culvert component information:

F_c	28 day compressive strength of concrete:	5,000	psi
F_y	Yield strength of reinforcement:	70,000	psi
		Inside face	Outside face
d_{ci} & d_{co}	Reinforcement cover from edge of bar to face of concrete:	1.5	2.0 in
			2.0 in (top)
Minimum cover to the outside face is 2 in (if $H < 2$ ft) per Article 12.11.4.4.			
Minimum cover to the outside face is 2.5 in if top slab is used as a driving surface per Article 5.12.3			

DESIGN SUMMARY OF CULVERT

The following is a summary of the dimensions, thickness, and rebar sizes and spacings for the culvert.

Culvert dimensions:

Span:	11 ft	Development length per Article 5.11.2.1 and calculated in each individual section.
Height:	5 ft	
Top slab thickness:	10 in	
Wall thickness:	8 in	
Bottom slab/footing thickness:	10 in	

Top slab reinforcement:

	Trans. Spacing	Long. Spacing	Wire Size/Wire Size	Development Length Required
Interior (positive) rebar:	A-100	Wire Mesh: 2 x 4	D10.4/D8 WWR	12 inches
Exterior (negative) rebar:	A-300	Wire Mesh: 4 x 8	D15/D5 WWR	12 inches
Longitudinal (T&S) rebar:	C-100	Longitudinal bars of A-100/300	WWR	12 inches

SUMMARY OF CULVERT FACTORED LOADS FROM RISA-3D MODEL

The designed culvert will be modeled in RISA-3D as a concrete frame with fixed member ends and pin-roller connections at the base. The culvert is loaded with the loads calculated in the next section of this spreadsheet. These loads are added into RISA-3D as individual, unfactored loads. We then use three sets of load combinations to calculate the maximum stresses in the culvert.

The first set of load cases are the combined unfactored Service I cases, used to check for deflection limits.

The second set of load cases are the combined, factored Strength I cases, used to check for stress limits.

The third set of load cases are also combined, factored Strength I cases, but are used to check for maximum shear.

These load cases are analyzed in RISA-3D and the worst case of both the STRENGTH I and SERVICE I AASHTO load cases are chosen for each member. The maximum factored moments of the top and bottom slabs and walls used for design are listed below. For further details please see the RISA-3D output report following these spreadsheets (Section 6).

Top slab factored loads:

Mup (Positive FACTORED moment)	118,592	lb-ft
Mun (Negative FACTORED moment)	24,963	lb-ft
Vu (FACTORED shear load in slab)	46,169	lb
Vu (FACTORED shear load in fillet)	46,169	lb

SECTION 2 - FACTORED LOADS PER AASHTO ARTICLE 3.4

APPLIED LIVE LOADS PER 3.6

LOADS ARE PER EQUIVALENT WIDTH (PER WHEEL) OF CULVERT LENGTH

$$\text{EQUIVALENT WIDTH} = E = 55.9 \text{ in} = 4.660 \text{ ft}$$

Equivalent width is calculated in Section 3 (Top Slab Design)

Live loads applied, see Article 3.6.1.2.2 for HL-93 loading

Axle load (2x wheel load) per Article 3.6.1.2.2	Single axle load:	32.0	kip
Width between wheel loads per Article 3.6.1.2.2	Typical axle width:	6.0	ft
Design tandem load per Article 3.6.1.2.3	Design tandem axle load:	25.0	kip
Tandem spacing per Article 3.6.1.2.3	Design tandem axle spacing:	4.0	ft spacing
Per MDOT Section 534.30:	Configuration 6:	21.3	kip
<i>Include an 11.9 kip axle (9 ft. spacing) for long spans</i>		21.4	kip
<i>Lane load does not apply per Article 3.6.1.3.3</i>		21.3	kip
	Manual live load increase factor (applied to HL-93 loads only):	1.25	(unitless)
Bd = width of excavation trench, for earth vertical load below	Bd:	17.33333	ft

Load factors per Article 3.4.1:

AASHTO Article	Description	Factor
1.3.2.1	η_i - Load modifier for ductility and redundancy	1.00 (unitless)
Table 3.4.1-1	γ_l - Live load (and related loads)	1.75 (unitless)
<i>Fatigue loading is not required per Article 5.5.3.1</i>		
Table 3.4.1-2	γ_p - Components	Max: 1.25, Min: 0.90 (unitless)
<i>These AASHTO load factors should not need to be modified unless desired.</i>		
	γ_p - At-rest earth pressure	1.35 (unitless)
	γ_p - Vertical earth pressure	1.30 (unitless)
	WA - Water load	1.00 (unitless)
Table 3.6.1.1.2-1	m - Multiple presence factor	1.2 (unitless)
<i>Culverts shall be designed for single lane loading per Article 12.11.2.1.</i>		
Table 3.6.2.1-1	IM - Impact factor	1.33 (unitless)
3.6.2.2	IMb - Modified impact factor for buried components	1.268 (unitless)
<i>Seismic loads are not required for single span bridges and culverts.</i>		

Factored load and general design methodology per Article 3.4.1

Total factored load shall be: $Q = \sum \eta_i \gamma_i Q_i$

Culverts shall be designed for Strength I loads, checked for deflection and bearing under Service I

SECTION 2 - FACTORED LOADS PER AASHTO ARTICLE 3.4

loads. Fatigue design is not required per Article 5.5.3.1. See Risa-3D output for all designed load cases.

Design limit states: Per Article 1.3.2.1: $Q = \sum \eta_i \gamma_i Q_i \leq \phi R_n = R_r$

Deflection limit per Article 2.5.2.6.2

The deflection limits in AASHTO are meant for above-grade bridges and not **buried culverts**. Therefore we shall limit **buried culvert live load deflections** to **L/360** unless otherwise required. For culverts with **less than 4 feet of cover** deflections shall be limited to **L/800** unless there are pedestrian loads applied directly to the culvert (and then shall be **L/1000**) per Article 2.5.2.6.2.

Live Load Deflection limit: $S / \boxed{800} = \boxed{0.165}$ in
Total Service Deflection limit: $S / \boxed{360} = \boxed{0.366667}$ in

Top slab deflections shall be checked per Article 2.5.2.6.2 and also per the Risa-3D model calculated deflections. See section 3 for top slab deflection calculations.

CALCULATE SOIL PRESSURE ON CULVERT

This program will not check for pressure from ice, seismic, swelling & temperature changes as they typically will not control the design. Perform additional calculations if required.

γ_w (density of water, typically 62.4 pcf) $\gamma_w = \boxed{62.4}$ pcf
 K_o (at-rest earth pressure coefficient, use 0.500 if unknown) $K_o = \boxed{0.500}$ (unitless)
 $K_o = 0.5$ is a conservative value. Alternatively, calculate per Article 3.11.5.2.
At-rest earth pressure is assumed over active pressure as culvert is a buried, rigid structure.

Live load surcharge per Article 3.11.6.4

Height of culvert wall (outside face) $H_w = H + (t+tb)/12$ $H_w = \boxed{6.67}$ ft
Earth surcharge due to live load per Table 3.11.6.4-1 $heq = \boxed{3.67}$ ft
Live load can be neglected at depths greater than 8 ft and the span length per Article 3.6.1.2.6.
 $\Delta p = k_o \gamma_s heq$ (eq. 3.11.6.4-1) $\Delta p = \boxed{229.1667}$ psf

Vertical earth pressure per Article 12.11.2.2

For embankment installations, per Article 12.11.2.2.1

$B_c = S + 2 \cdot t_w$ Assumed compacted fill, thus $F_e \leq 1.15$. $B_c = \boxed{12.333}$ ft
 $F_e = 1 + 0.20 \cdot (H/B_c) < \text{or} = 1.15$ (eq. 12.11.2.2.1-2) $F_e = \boxed{1.065}$ (unitless)
 $W_E = F_e \gamma_s B_c H$ (eq. 12.11.2.2.1-1) W_e (embankment) = $\boxed{6,567}$ lb/ft

For trench installations, per Article 12.11.2.2.1

$C_d = \frac{1 - e^{-2K_\mu' \frac{H}{B_d}}}{2K_\mu'}$ (see Figure 12.11.2.2.1-3) $C_d = \boxed{0.223983}$ (unitless)
 B_d (width of trench) $B_d = \boxed{17.33333}$ ft
We will assume that $B_d = B_c + 5$ ft (more is conservative)

SECTION 2 - FACTORED LOADS PER AASHTO ARTICLE 3.4

$$F_t = \frac{C_d B_d^2}{H B_c} \leq F_s$$

$K\mu'$ (see Figure 12.11.2.2.1-3) $K\mu' = 0.130$ (unitless)
We will assume that $K\mu' = 0.130$ (conservative)
 (eq. 12.11.2.2.1-4) $F_t = 1.065$ (unitless)

$$W_E = F_t \gamma_s B_c H$$

(eq. 12.11.2.2.1-3) W_E (trench) = 6,567 lb/ft

Selected W_E for design, input W_E if installation conditions are known

As installation conditions are rarely known we will assume the worst case of the above calculated values. If installation conditions are known then one can manually select the W_E from above and input it below.

W_E (maximum of values calculated above) $W_E' = 6,567$ lb/ft width
 W_E is in lb/ft of width of culvert, multiply by E and divide by B_c to get lb/ft along span.

Distributed vertical soil load on top slab of culvert: $W_E = 2,623$ lb/ft

Lateral pressure per Article 3.11

Lateral earth pressure per Article 3.11.5.1

z = depth below surface, take as $H_w + H$ $z = 10.67$ ft
 $p = k \gamma_s z$ with $k = 0.500$ and $\gamma_s = 125$ pcf $p = 666.6667$ psf
 (eq. 3.11.5.1-1) (at bottom of culvert wall)

Hydrostatic pressure per Article 3.11.3

Water table depth (from general inputs) $D_w = 4$ ft
 $P_w = \gamma_w ((H_w + H) - D_w)$ (at bottom of culvert wall) $P_w = 416$ psf

In load cases where we combine hydrostatic pressure with the horizontal earth pressure we will reduce the horizontal earth pressure by the density of water. See Figure C3.11.3-1.

Buoyancy is assumed to not control the design and will be checked separately.

UNFACTORED LOADS FOR RISA-3D MODEL

FOLLOWING LOADS WILL BE INPUT INTO THE CULVERT MODEL IN RISA-3D

LOADS ARE PER EQUIVALENT WIDTH (PER WHEEL) OF CULVERT LENGTH

EQUIVALENT WIDTH = 55.92 in = 4.660 ft

DEAD LOADS:

UNFACTORED - SERVICE I

ALL COMPONENTS:

Self-weight of concrete:

Self-weight load

Selfweight

Self-weight load is calculated in Risa-3D or entered in Risa-3D manually.

TOP SLAB:

SECTION 2 - FACTORED LOADS PER AASHTO ARTICLE 3.4

Vertical soil pressure:

Distributed load

$$W_e = 2622.9 \text{ lb/ft}$$

WALLS:

Lateral earth pressure:

Linear varying load

Lateral earth pressure reduced for hydrostatic pressure:

Exterior lateral hydrostatic pressure:

Linear varying load

Interior lateral hydrostatic pressure:

Linear varying load

$$EH/E_{hw} \text{ Ratio: } 0.501$$

	BOTTOM	TOP
EH =	3106.7	1165.0
E _{hw} =	1555.8	583.4
W _w =	1938.6	0.0
W _w =	1453.9	0
	lb/ft	lb/ft

BOTTOM SLAB:

Vertical water pressure:

Distributed load

$$W_w = 2180.9 \text{ lb/ft}$$

Add internal soil load manually if present.

HL-93 SINGLE AXLE LOAD:

UNFACTORED - SERVICE I

TOP SLAB:

Centered on span

HL-93 wheel load:

Distributed at

START

STOP

54.7

85.4

in

in

$$W_l = 7930.9 \text{ lb/ft}$$

WALLS:

Taking 0 at bottom of wall

Live load surcharge:

Distributed at

START

STOP

0.0

70.0

in

in

$$W_l = 1354.3 \text{ lb/ft}$$

HL-93 TANDEM AXLE LOAD:

UNFACTORED - SERVICE I

TOP SLAB:

First wheel load:

Distributed at

START

STOP

42.7

73.4

in

in

$$W_l = 6196.1 \text{ lb/ft}$$

Second wheel load:

Distributed at

90.7

121.4

in

in

$$W_l = 6196.1 \text{ lb/ft}$$

WALLS:

Taking 0 at bottom of wall

Live load surcharge:

Distributed at

START

STOP

0.0

70.0

in

in

$$W_l = 1354.3 \text{ lb/ft}$$

MDOT TRI-AXLE LOAD:

UNFACTORED - SERVICE I

TOP SLAB:

First wheel load:

Distributed at

START

STOP

6.7

37.4

in

in

$$W_l = 5279.0 \text{ lb/ft}$$

Second wheel load:

Distributed at

54.7

85.4

in

in

$$W_l = 5303.8 \text{ lb/ft}$$

Third wheel load:

Distributed at

102.7

133.4

in

in

$$W_l = 5279.0 \text{ lb/ft}$$

WALLS:

Taking 0 at bottom of wall

Live load surcharge:

Distributed at

START

STOP

0.0

70.0

in

in

$$W_l = 1354.3 \text{ lb/ft}$$

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

This program has the following limitations:

1. This program does not compute selfweight, it must be added to the dead loads manually
2. This program limits the beam design to tension-controlled only for maximum ductility
3. This program will not design shear reinforcement (but will indicate if it's required)
4. This program is for precast culverts only, modify minimum reinforcement spacing for cast-in-place.

INPUT TOP SLAB FACTORED LOADS FROM RISA-3D OUTPUT

Input factored loads only! This program will not factor the loads that are input.

Negative moments shall be taken at the intersection of the walls and slabs at haunches per Article 12.11.4.2.

Mup (Positive FACTORED moment)	118,592	lb-ft	(See RISA-3D output)
Mun (Negative FACTORED moment)	24,963	lb-ft	(See RISA-3D output)
Vu (FACTORED shear load in slab)	46,169	lb	(See RISA-3D output)
Vu (FACTORED shear load in fillet)	46,169	lb	(See RISA-3D output)
Mp (Positive UNFACTORED moment)	64,221	lb-ft	For crack control calculation.
Mnp (Negative UNFACTORED end moment from Mp's load case)	33,286	lb-ft	
Mdnpc (Positive dead load moment)	19,912	lb-ft	For deflection calculations.
Mnd (Negative UNFACTORED dead load end moment, from Mp's case)	10,086	lb-ft	
Mnp and Mnd are to be taken from the load case of Mp above, for deflection calculations.			
Mn (Negative UNFACTORED moment)	13,299	lb-ft	For crack control calculation.

INPUT REINFORCEMENT SIZES AND SPACING

$$\text{EQUIVALENT WIDTH} = E = 55.9 \text{ in} = 4.660 \text{ ft}$$

Interior (positive moment) reinforcement:

Area of steel:	$\left(\frac{E}{\text{spacing}}\right) A_{\text{bar}} =$	2.908 in ² /E	Diameter:	0.364 in
	Stress ratio:	88.6% < 1.0 OK!	Spacing:	2.0 in
Basic development length:		12.00 in	Max. spacing =	8.14 in
Required length past cutoff =		12.00 in	development length is calculated elsewhere	

Exterior (negative moment) reinforcement:

Area of steel:	$\left(\frac{E}{\text{spacing}}\right) A_{\text{bar}} =$	2.097 in ² /E	Diameter:	0.437 in
	Stress ratio:	27.3% < 1.0 OK!	Spacing:	4.0 in
Basic development length:		12.00 in	Max. spacing =	15.00 in
Required length past cutoff =		12.00 in	development length is calculated elsewhere	

Temperature and shrinkage (longitudinal) distribution reinforcement:

		Top	Bottom
Area of steel per span	3.780 in ²	Diameter:	0.252 0.320 in

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

Area of steel required: in² Spacing: in
 Basic development length: in Max. spacing = in
development length is calculated elsewhere

CALCULATE EQUIVALENT STRIP WIDTH PER WHEEL

Tire contact area per Article 3.6.1.2.5:

Tire contact area is entered for HL-93 loads. Modify if other than the typical contact area for the design truck wheel load.

Length: in
 Width: in

Load distribution per Article 3.6.1.2.6:

LLDF per Table 3.6.1.2.6a-1:

LLDF = unitless

Minimum height of soil cover = H = ft

Minimum axle spacing used (conservative):

s_a = axle spacing = ft

$$H_{int-t} = \frac{s_w - \frac{w_t}{12} - \frac{0.06D_i}{12}}{LLDF}$$

s_w = wheel spacing = ft

l_t = tire patch length = in

$$H_{int-p} = \frac{s_a - \frac{l_t}{12}}{LLDF}$$

w_t = tire patch width = in

D_i = clear span of culvert = in

H_{int-t} = wheel interaction depth transverse to culvert span = ft

H_{int-p} = wheel interaction depth parallel to culvert span = ft

Check if equation 3.6.1.2.6b-2 or 3.6.1.2.6b-3 applies:

Is $H < H_{int-t}$?

ww per equation 3.6.1.2.6b-2:

Perp. to span:

Width of distributed load applied to top slab = w_w = ft

Check if equation 3.6.1.2.6b-5 or 3.6.1.2.6b-6 applies:

Is $H < H_{int-p}$?

lw per equation 3.6.1.2.6b-5:

Along span:

Length of distributed load parallel to span = l_w = ft

Equivalent width per Article 4.6.2.10:

This equivalent width is for both wheel loads on an axle.

$E = 96 + 1.44S$ (eq. 4.6.2.10.2-1)

Per axle:

$E =$ in

$E_{span} = L_T + LLDF(H)$

$E_{span} =$ in

Check if AASHTO article 3.6.1.2.6 applies:

Is depth of soil cover 2 ft or greater?

If 'yes' then use AASHTO Article 3.6.1.2.6, otherwise use Article 4.6.2.10:

Equivalent width and length for design calculated for single wheel load:

$l_w =$ in

$w_w =$ in

This design will be based off of a single wheel load, NOT for the full axle load and width.

Check for overlap of loaded widths:

Do wheel loads overlap?

Reduction for overlap, if any: in

All structural calculations will use this equivalent width.

Equivalent width to use for design:

$E =$ in

SHEAR DESIGN PER ARTICLE 5.7

Vu (FACTORED shear load) at ds away from the end of the fillet

Vu @ dv from start of fillet (from inputs above)

Vu for slab design = 46.17 kip

We will check the shear at a distance dv away from the start of the fillet.

Design for shear at ds away from the end of the fillet

Use the lesser of:

$$V_n = V_c + V_s + V_p \quad (\text{eq. 5.7.3.3-1})$$

or

$$V_n = 0.25f'_c b_v d_v + V_p \quad (\text{eq. 5.7.3.3-2})$$

Use the procedure for shear in slabs of box culverts per Article 5.12.7.3.

Otherwise use the simplified procedure of Article 5.6.7.1:

Is the culvert soil cover less than 24 in. per Article 5.12.7.3:

YES

Per Article 5.7.2.8:

b = bv = E = 55.92 in

No transverse reinforcement is needed per Article 5.7.2.3.

SQRT(F'c) = 2.236 ksi

Per Article 5.12.7.3:

As = 2.908 in²

$$V_c = \left(0.0676\sqrt{f'_c} + 4.6 \frac{A_s V_u d_s}{b d_s M_u} \right) b d_s \quad (\text{eq. 5.12.7.3-1})$$

Mu (below) = 1423.1 kip-in

$$d_e = \frac{A_s f_y d_s}{A_s f_y} \quad (\text{eq. 5.7.2.8-2})$$

de = 8.32 in

$$d_v = \frac{M_n}{A_y f_y} \geq \text{MAX}(0.9d_e \text{ or } 0.72h) \quad (\text{eq. C5.7.2.8-1})$$

(Vu*de)/Mu not greater than 1.0

dv = 7.89 in

(Vu*de)/Mu = 3.238 unitless

Vc = 83.69 kip

Therefore, take (Vu*de)/Mu = 1.0

For single cell box culvert slabs cast monolithic with walls per 5.12.7.3:

Vc need not be less than 0.0948*SQRT(f'c)*bv*de

Vc min = 98.60 kip

Vc not to exceed 0.126*SQRT(f'c)*bv*de

Vc max = 131.05 kip

Simplified procedure per Article 5.6.7.1 (not used if soil cover is 2 ft or more):

Check that thickness < 16 in for simplified design:

YES

Simplified shear design shall be used per 5.12.7.3.

Per Article 5.6.7.1:

β = 2.0 (unitless)

θ = 45 degrees

$$V_c = 0.0316\beta\sqrt{f'_c} b_v d_v \quad (\text{eq. 5.7.3.3-3})$$

Vc = 62.35 kip

Vc to be used = 62.35 kip

Vn (from the lesser of eq. 5.7.3.3-1 and 5.7.3.3-2)

Vn = 62.35 kip

φ = 0.9 (unitless) Per Table 12.5.5-1

Vr = φVn = 56.11 kip

OK! One-way shear strength in slab is sufficient.

Vu (FACTORED shear load) though fillet at distance ds from wall face

Vu @ dv from face of wall (from inputs above)

Vu for fillet design = 46.17 kip

We will check the shear at a distance dv away from the face of the support.

Design for shear through corner fillets

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

No transverse reinforcement is needed per Article 5.7.2.3.

$$d_v = \left\{ \begin{array}{l} (d_s + t_{haunch}) - \left(\frac{C}{2}\right) \geq \\ \text{MAX}[0.9(d_e + t_{haunch}) \\ \text{or } (0.72t + t_{haunch})] \end{array} \right\}$$

Per Article 5.6.7.1:

$$V_c = 0.0316\beta\sqrt{f'_c}b_vd_v \quad (\text{eq. 5.7.3.3-3})$$

Vn (from the lesser of eq. 5.7.3.3-1 and 5.7.3.3-2)

$$\phi = 0.9 \text{ (unitless) Per Table 12.5.5-1}$$

OK! One-way shear strength in fillet is sufficient.

$$\begin{array}{ll} b_v = & 55.92 \text{ in} \\ d_s \text{ (below)} = & 8.318 \text{ in} \\ d_v = & 15.783 \text{ in} \\ \beta = & 2.0 \text{ (unitless)} \\ \theta = & 45 \text{ degrees} \end{array}$$

$$\begin{array}{ll} V_c = & 124.72 \text{ kip} \\ V_n = & 124.72 \text{ kip} \\ V_r = \phi V_n = & 112.25 \text{ kip} \end{array}$$

FLEXURAL DESIGN PER ARTICLE 5.6

Mup (FACTORED positive moment)

Mup (from inputs above)

$$M_{up} = 118,592 \text{ lb-ft}$$

Mun (FACTORED negative moment)

Mun (from inputs above)

$$M_{un} = 24,963 \text{ lb-ft}$$

β_1 (Ratio of depth of the rectangular stress block) per Article 5.6.2.2

f'_c (ksi)	β_1
$2.2 \leq f'_c \leq 4.0$	0.85
$4.0 < f'_c < 8.0$	$0.85 - 0.05(f'_c - 4)$
$8.0 \leq f'_c$	0.65

$$\beta_1 = 0.800 \text{ (unitless)}$$

Compute the POSITIVE moment capacity for the selected reinforcement per Article 5.6.3.2

Take compression force to equal tension force.

$$C = (0.85 \cdot f'_c) \cdot b \cdot a \quad \text{and} \quad T = A_s \cdot f_s$$

C = T

Therefore:

$$a = \frac{A_s f_s}{0.85 f'_c b}$$

$$\frac{c}{d_s} \leq \frac{0.003}{0.003 + \epsilon_{cl}} \quad \text{eq. 5.6.2.1-1}$$

$$\epsilon_{cl} = 0.003 \text{ in/in}$$

$$0.003 / (0.003 + \epsilon_{cl}) = 0.545 \text{ in/in}$$

Assume $f_s = f_y$

$$a = 0.856471 \text{ in}$$

with

$$f_s = f_y = 70,000 \text{ psi}$$

Per Article 5.6.3.2.2:

$$a = \beta_1 c$$

Therefore: $c = a / \beta_1$

$$c = 1.070588 \text{ in}$$

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

$$d_s = 8.32 \text{ in (extreme compression fiber to centroid of steel)}$$

$$c/d_s = 0.13 \text{ (unitless)}$$

OK! $c/d_s < \text{or} = \text{eq. 5.6.2.1-1}$, use F_y for F_s .

Per Article 5.6.3.2.3 we can use eq. 5.6.3.2.1-1 and eq. 5.6.3.2.2-1 with $b_w = b$.

We will ignore the negative moment reinforcement and the compressive forces (conservative).

$$M_n = A_s f_s \left(d_s - \frac{a}{2} \right) \quad (\text{eq. 5.6.3.2.1-1}) \quad M_n = 133,829 \text{ ft-lb}$$

$$M_r = \phi M_n \quad (\text{eq. 5.6.3.2.1-1}) \quad \text{Per Table 12.5.5-1:} \quad \phi = 1.00 \text{ (unitless)}$$

We will assume that the section is tension controlled. This assumption is to have an efficient and ductile section and will be checked below.

$$M_r = 133,829 \text{ ft-lb} \quad \text{OK! Positive moment capacity is sufficient.}$$

Check for tension controlled section (assumed above)

$$a = \beta_1 c \quad c = 1.070588 \quad \epsilon_c = 0.003 \quad \text{Per Article 5.6.2.1}$$

$$\epsilon_t = \frac{d_s - c}{c} \epsilon_c \quad d_s \text{ (calculated above)} = 8.32 \text{ in} \quad \epsilon_t = 0.020 \text{ (unitless)}$$

$$f_y = 70 \text{ ksi}$$

$$\epsilon_{ti} = 0.005 \text{ (unitless)}$$

Assumption OK if $\epsilon_t \geq \epsilon_{ti}$ *etl per Table C5.6.2.1-1*

OK! Section is tension controlled.

Check minimum required steel per Article 5.6.3.3

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 f_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right] \quad (\text{eq. 5.6.3.3-1})$$

fcpe = comp. stress due to prestress	No prestress.	fcpe = 0 ksi
fr = modulus of rupture	Per Article 5.4.2.6:	fr = 0.24*SQRT(Fc) = 0.54 ksi
Snc = section modulus for non-composit section		Snc = 932 in^3
Sc = Snc per article 5.6.3.3 for non-composite flexure		Sc = Snc = 932 in^3
Mdnc = total unfactored dead load moment, from above		Mdnc = N/A kip-in
γ1 = flexural cracking variability factor	For precast sections	γ1 = 1.20 (unitless)
γ2 = prestress variability factor	For bonded tendons	γ2 = N/A (unitless)
γ3 = Fy/Fu of reinforcement	For A1064, grade 70	γ3 = 0.875 (unitless)

$$M_r \geq \text{MIN}(M_{cr}, 1.33 * M_{up})$$

$$M_{cr} = 43,764 \text{ lb-ft}$$

$$1.33 * M_{up} = 157,727 \text{ lb-ft}$$

$$M_r = 133,829 \text{ lb-ft} \quad A_{smin} = 1.057 \text{ in}^2 \text{ (min. area of steel)}$$

OK! reinforcement area more than minimum required.

Check minimum reinforcement spacing per Article 5.10.3.1

$$\text{Diameter of selected bar} \quad d_{bar} = 0.364 \text{ in}$$

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

Selected spacing of reinforcement
Maximum size of course aggregate
Min. spacing (per Article 5.10.3.1.2)

Spacing = 1.92 in
Max size of aggregate = 0.75 in
Min. spacing = 1.36 in

This is for precast sections only, modify if using cast-in-place.

OK! Reinforcement spacing > min. bar spacing.

Check maximum reinforcement spacing per Article 5.10.3.2 and Article 5.6.7

Selected spacing of bars
Max. spacing (per Article 5.10.3.2)

Spacing = 1.92 in
Max. spacing = 15.00 in

Also, check maximum spacing for crack control per Article 5.6.7:

$$\beta_s = 1 + \frac{d_c}{0.7(h - d_c)}$$

d_c need not be taken > 2 in. + $d_b/2$

$d_c = 1.682$ in
 $\beta_s = 1.2889$ (unitless)

Calculate f_{ss} : Assume $j = 0.9$

$$f_{ss} = \frac{M}{\phi A_s j d_s}$$

$f_{ss} = 35.4$ ksi

Max. spacing (per Article 5.6.7)

$$s \leq \frac{700\gamma_e}{\beta_s f_{ss}} - 2d_c$$

$\gamma_e = 0.75$ for Class 2 exposure (corrosion)

(eq. 5.6.7-1)

Max. spacing for crack control = 8.14 in

max. spacing, s , need not be taken < 5 in.

OK! Bar spacing < max. bar spacing.

Max. spacing = 8.14 in

POSITIVE flexural reinforcement development length per Article 5.10.8.2.1

Basic tension development length per Article 5.10.8.2.1a:

development length calculated elsewhere

From inputs above:

Minimum cutoff length of 12 inches, $15d_{bar}$, $(1/20)$ span, and d_s

Required reinforcement length past theoretical cutoff:

$d_{bar} = 0.364$ in
 $A_{bar} = 0.1$ in²
 $l_d = 12.00$ in
 $l_{cutoff} = 12.00$ in

Compute the NEGATIVE moment capacity for the selected reinforcement per Article 5.6.3.2

Take compression force to equal tension force.

$$C = (0.85f'_c)b \cdot a \quad \text{and} \quad T = A_s f_s$$

$C = T$

Therefore:

$$a = \frac{A_s f_s}{0.85 f'_c b}$$

$$\frac{c}{d_s} \leq \frac{0.003}{0.003 + \epsilon_{cl}} \quad \text{eq. 5.6.2.1-1}$$

$\epsilon_{cl} = 0.003$ in/in

$0.003 / (0.003 + \epsilon_{cl}) = 0.545$ in/in

Assume $f_s = f_y$

$a = 0.617647$ in

with

$f_s = f_y = 70,000$ psi

Per Article 5.6.3.2.2:

$$a = \beta_1 c$$

Therefore: $c = a / \beta_1$

$c = 0.772059$ in

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

$$d_s = 7.78 \text{ in (extreme compression fiber to centroid of steel)}$$

$$c/d_s = 0.10 \text{ (unitless)}$$

OK! $c/d_s < \text{or} = \text{eq. 5.6.2.1-1}$, use F_y for F_s .

We will ignore the negative moment reinforcement and the compressive forces (conservative).

Per Article 5.6.3.2.3 we can use eq. 5.6.3.2.1-1 and eq. 5.6.3.2.2-1 with $b_w = b$.

$$M_n = A_s f_s \left(d_s - \frac{a}{2} \right) \quad (\text{eq. 5.6.3.2.1-1}) \quad M_n = 91,410 \text{ ft-lb}$$

$$M_r = \phi M_n \quad (\text{eq. 5.6.3.2.1-1}) \quad \text{Per Table 12.5.5-1:} \quad \phi = 1.00 \text{ (unitless)}$$

We will assume that the section is tension controlled. This assumption is to have an efficient and ductile section and will be checked below.

$$M_r = 91,410 \text{ ft-lb} \quad \text{OK! Negative moment capacity is sufficient.}$$

Check for tension controlled section (assumed above)

$$\alpha = \beta_1 c \quad c = 0.772059 \quad \epsilon_c = 0.003 \quad \text{Per Article 5.6.2.1}$$

$$\epsilon_t = \frac{d_s - c}{c} \epsilon_c \quad d_s \text{ (calculated above)} = 7.78 \text{ in} \quad \epsilon_t = 0.027 \text{ (unitless)}$$

$$f_y = 70 \text{ ksi}$$

$$\epsilon_{ti} = 0.005 \text{ (unitless)}$$

Assumption OK if $\epsilon_t \geq \epsilon_{ti}$ *etl per Table C5.6.2.1-1*

OK! Section is tension controlled.

Check minimum required steel per Article 5.6.3.3

$$M_{cr} = \gamma_3 \left[(\gamma_1 f_r + \gamma_2 f_{cpe}) S_c - M_{dnc} \left(\frac{S_c}{S_{nc}} - 1 \right) \right] \quad (\text{eq. 5.6.3.3-1})$$

fcpe = comp. stress due to prestress	No prestress.	fcpe = N/A ksi
fr = modulus of rupture	Per Article 5.4.2.6:	fr = 0.24*SQRT(Fc) = 0.54 ksi
Snc = section modulus for non-composit section		Snc = 932 in^3
Sc = Snc per article 5.6.3.3 for non-composite flexure		Sc = Snc = 932 in^3
Mdnc = total unfactored dead load moment, from above		Mdnc = N/A kip-in
γ1 = flexural cracking variability factor	For precast sections	γ1 = 1.20 (unitless)
γ2 = prestress variability factor	For bonded tendons	γ2 = N/A (unitless)
γ3 = Fy/Fu of reinforcement	For A1064, grade 70	γ3 = 0.875 (unitless)

$$M_r \geq \text{or} = \text{MIN}(M_{cr}, 1.33 * M_{un})$$

$$M_{cr} = 43,764 \text{ lb-ft}$$

$$1.33 * M_{un} = 33,200 \text{ lb-ft}$$

$$M_r = 91,410 \text{ lb-ft} \quad A_{smin} = 0.846 \text{ in}^2 \text{ (min. area of steel)}$$

OK! reinforcement area more than minimum required.

Check minimum reinforcement spacing per Article 5.10.3.1

$$\text{Diameter of selected bar} \quad d_{bar} = 0.437 \text{ in}$$

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

Selected spacing of reinforcement
Maximum size of course aggregate
Min. spacing (per Article 5.10.3.1.2)

Spacing = 4.00 in
Max size of aggregate = 0.75 in
Min. spacing = 1.44 in

This is for precast sections only, modify if using cast-in-place.

OK! Reinforcement spacing > min. bar spacing.

Check maximum bar spacing per Article 5.10.3.2 and Article 5.6.7

Selected spacing of bars
Max. spacing (per Article 5.10.3.2)

Spacing = 4.00 in
Max. spacing = 15.00 in

Also, check maximum spacing for crack control per Article 5.6.7:

$$\beta_s = 1 + \frac{d_c}{0.7(h - d_c)}$$

d_c need not be taken > 2 in. + $d_b/2$

d_c = 2.219 in
 β_s = 1.4073 (unitless)

Calculate f_{ss} : Assume $j = 0.9$

$$f_{ss} = \frac{M}{\phi A_s j d_s}$$

f_{ss} = 10.9 ksi

Max. spacing (per Article 5.6.7)

$$s \leq \frac{700\gamma_e}{\beta_s f_{ss}} - 2d_c$$

$\gamma_e = 0.75$ for Class 2 exposure (corrosion)

(eq. 5.6.7-1)

Max. spacing for crack control = 29.89 in

max. spacing, s , need not be taken < 5 in.

OK! Bar spacing < max. bar spacing.

Max. spacing = 15.00 in

NEGATIVE flexural reinforcement development length per Article 5.10.8.2.1

Basic tension development length per Article 5.10.8.2.1a:

development length calculated elsewhere

From inputs above:

Minimum cutoff length of 12 inches, $12d_{bar}$, (1/16)span, and d_s

Required reinforcement length past theoretical cutoff:

d_{bar} = 0.437 in
 A_{bar} = 0.15 in²
 l_d = 12.00 in
 l_{cutoff} = 12.00 in

DESIGN SLAB FOR PUNCHING SHEAR

Check two-way shear of slab @ $d_s/2$ away from loaded area per Article 5.12.8.6.3

Does two-way shear apply?

YES

(Will apply if loaded width + $d_s < E$)

V_u = Maximum factored wheel load

Per Table 12.5.5-1:

b_0 (length of shear perimeter) = $2*(ww + lw + (2*d_s))$

β_c = long side of load/short side of load

V_n per eq. 5.12.8.6.3-1:

$$V_n = \left(0.002 + 0.126 \sqrt{f_{c'}} \right) \sqrt{f_{c'}} b_0 d_s \leq 0.126 \sqrt{f_{c'}} b_0 d_s$$

Culvert segment length = 72 in

V_u = 53.26125 kip

ϕ = 0.9 (unitless)

b_0 = 206.512 in

β_c = 1.8214984 (unitless)

d_v = 8.318 in

V_n = 483.97 kip

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

$$V_n = \left(0.063 + \frac{1}{\beta_c} \right) \sqrt{f'_c} b_o d_v \leq 0.126 \sqrt{f'_c} b_o d_v$$

$$\phi V_n = 435.57 \text{ kip}$$

OK! Two-way shear capacity is sufficient.

SELECT MINIMUM TEMPERATURE AND SHRINKAGE STEEL

Per Article 5.10.6, for $f_y \leq 75$ ksi:

$$A_s \geq \frac{1.30bh}{2(b+h)f_y}$$

$$0.11 \leq A_s \leq 0.60$$

$$b = 148 \text{ in}$$

$$h = 10 \text{ in}$$

$$\text{As required per face} = 0.110 \text{ in}^2/\text{ft}$$

$$\text{Total As required, both faces} = 2.713 \text{ in}^2$$

As_t = selected area of steel

$$\text{As}_t \text{ selected} = 3.780 \text{ in}^2$$

OK! Temp. & shrinkage steel is acceptable.

Check minimum distribution reinforcement per Article 9.7.3.2

For primary reinforcement parallel to traffic:

$$100/\sqrt{S} = 30.15\% \text{ percent}$$

$$\text{Required percentage of positive reinforcement area} = A_{sp} * 0.3015 = 0.1881431 \text{ in}^2/\text{ft}$$

Percent area need not be more than 50%.

$$\text{As}_t \text{ selected} = 0.24 \text{ in}^2/\text{ft}$$

The selected area of steel only considers the interior reinforcement.

OK! Distribution steel is acceptable.

Check minimum reinforcement spacing per Article 5.10.3.1

Diameter of selected bottom bar

$$d_{\text{bar}} (\text{interior}) = 0.320 \text{ in}$$

Selected spacing of reinforcement

$$\text{Spacing} = 4.00 \text{ in}$$

Maximum size of course aggregate

$$\text{Max size of aggregate} = 0.75 \text{ in}$$

Min. spacing (per Article 5.10.3.1.2)

$$\text{Min. spacing} = 1.32 \text{ in}$$

Diameter of selected top bar

$$d_{\text{bar}} (\text{exterior}) = 0.252 \text{ in}$$

Selected spacing of reinforcement

$$\text{Spacing} = 8.00 \text{ in}$$

Maximum size of course aggregate

$$\text{Max size of aggregate} = 0.75 \text{ in}$$

Min. spacing (per Article 5.10.3.1.2)

$$\text{Min. spacing} = 1.25 \text{ in}$$

This is for precast sections only, modify if using cast-in-place.

OK! Reinforcement spacing > min. bar spacing.

Check maximum reinforcement spacing per Article 5.10.3.2

Selected spacing of reinforcement

$$\text{Spacing} = 8.00 \text{ in}$$

Max. spacing (per Article 5.10.3.2)

$$\text{Max. spacing} = 15.00 \text{ in}$$

OK! Reinforcement spacing < max. bar spacing.

Longitudinal reinforcement development length per Article 5.10.8.2.1

Basic tension development length per Article 5.10.8.2.1a:

$$d_{\text{bar}} = 0.320 \text{ in}$$

development length calculated elsewhere

$$A_{\text{bar}} = 0.080 \text{ in}^2$$

From inputs above:

$$l_d = 12.00 \text{ in}$$

CHECK FOR EDGE BEAM OR EDGE SHEAR REQUIREMENT PER ARTICLE 12.11.2

For cast-in-place box culverts or for precast box culverts with top slabs having span to thickness ratios (s/t) > 18 or segment lengths < 4.0 ft, edge beams OR shear transfer between sections shall be provided as specified in Article 4.6.2.10.4 as follows:

--

At ends of culvert runs where wheel loads travel within 24.0 in. from the end of culvert,

-- At expansion joints of cast-in-place culverts where wheel loads travel over or adjacent to the expansion joint.

$S/t =$ (unitless) Segment length = ft

OK! Edge beams are not required per Article 4.6.2.10.4

CHECK FOR DEFLECTION IN TOP SLAB PER ARTICLE 2.5.2.6.2

Deflection limit from Section 2:

Deflection limit = Span/800 = in

We will check deflections per AASHTO article 5.6.3.5.

$$E_c = 33,000 K_1 w_c^{1.5} \sqrt{f'_c} \quad \text{Per Article 5.4.2.4}$$

$$E_c =$$
 ksi

$$\text{Modular ratio} = E_s / E_c = n \quad E_s = 29,000 \text{ ksi}$$

$$n =$$
 (unitless)

Transformed areas of steel for calculating gross moment of inertia:

Transformed area = $(n - 1) \times \text{area of steel}$

Bottom: $A_{sp \text{ trans}} =$ in²

Top: $A_{sn \text{ trans}} =$ in²

$$\text{Gross moment of inertia of concrete only} = I_g = (E \times t^3) / 12$$

$$I_{g \text{ conc}} =$$
 in⁴

Calculate gross moment of inertia of the transformed section:

Part	Area (in ²)	y_{top} (in)	Ay_{top} (in ³)	y (in)	I_{self} (in ⁴)	Ay^2 (in ⁴)	I_{part} (in ⁴)
Concrete	559.20	5.00	2796	-0.037	4660	0.78	4660.8
Top Steel	12.075	2.22	26.79	-2.819	-	95.94	95.94
Bottom Steel	16.743	8.32	139.27	3.281	-	180.20	180.20
Σ (total) =		588.0 (in ²)	2962 (in ³)			$\Sigma I_{\text{part}} = I_g$ (in ⁴) =	4936.9

Centroid of uncracked section:

$$y_{\text{uncr}} = \Sigma Ay_{\text{top}} / \Sigma \text{Area}$$

$$y_{\text{uncr}} =$$
 in

Transformed areas of steel for calculating gross moment of inertia:

Transformed area in cracked section = $(n) \times A_s$

$$A_{sp \text{ trans}} =$$
 in²

Transformed area in uncracked section = $(n - 1) \times A_s$

$$A_{sn \text{ trans}} =$$
 in²

We will assume that the bottom steel is in a cracked area and the top steel is not.

Calculate properties of the cracked, transformed section:

SECTION 3 - DESIGN OF TOP SLAB FOR FLEXURE AND SHEAR

Part	Area (in ²)	y _{top} (in)	Ay _{top} (in ³)	y (in)	I _{self} (in ⁴)	Ay (in ³)	I _{part} (in ⁴)
Concrete	-	5.00	-	1.051	43.3	123.55	173.2
Top Steel	12.075	2.22	26.79	-0.116	-	-1.41	0.16
Bottom Steel	19.651	8.32	163.46	-6.216	-	-122.15	759.27

$$\Sigma \text{ (total)} = 31.73 \text{ (in}^2\text{)} \quad 190.25 \text{ (in}^3\text{)} \quad \Sigma I_{\text{part}} = I_{\text{cr}} \text{ (in}^4\text{)} = \mathbf{932.6}$$

Depth to the neutral axis = c *c is solved for with $\Sigma Ay = 0$.*

OK! ΣAy is equal to or near zero. Use calculated value of c.

$$\Sigma Ay = \mathbf{0.00} \text{ in}^3$$

$$c = \frac{-\Sigma A_s \pm \sqrt{(\Sigma A_s)^2 + 2(E)(\Sigma Ay_{\text{top}})}}{E}$$

$$c = \mathbf{2.1021} \text{ in}$$

Calculate the dead load deflection:

Cracking moment for positive moment (calculated above):

$$M_{\text{cr}} = \mathbf{43764} \text{ lb-ft}$$

$$I_e = \left(\frac{M_{\text{cr}}}{M_a} \right)^3 I_g + \left[1 - \left(\frac{M_{\text{cr}}}{M_a} \right)^3 \right] I_{\text{cr}}$$

$$M_a = \text{positive dead load moment} = \mathbf{19911.8} \text{ lb-ft}$$

$$I_e \leq I_g$$

$$I_e = \mathbf{4937} \text{ in}^4$$

eq. 5.6.3.5.2-1 and 5.6.3.5.2-2

$$\Delta_{\text{MIDSPAN}} = \frac{5}{48} \frac{l_n^2}{EI} [M_{\text{mid}} + 0.1(2M_{\text{end}})]$$

$$M_{\text{mid}} = \mathbf{19912} \text{ lb-ft}$$

$$M_{\text{end}} = \mathbf{-10086} \text{ lb-ft}$$

$$\Delta D_{\text{midspan}} = \mathbf{0.018} \text{ in}$$

Calculate the total dead + live load deflection:

Cracking moment for positive moment (calculated above):

$$M_{\text{cr}} = \mathbf{43764} \text{ lb-ft}$$

$$I_e = \left(\frac{M_{\text{cr}}}{M_a} \right)^3 I_g + \left[1 - \left(\frac{M_{\text{cr}}}{M_a} \right)^3 \right] I_{\text{cr}}$$

$$M_a = \text{total positive moment} = \mathbf{64220.7} \text{ lb-ft}$$

$$I_e \leq I_g$$

$$I_e = \mathbf{2200} \text{ in}^4$$

eq. 5.6.3.5.2-1 and 5.6.3.5.2-2

$$\Delta_{\text{MIDSPAN}} = \frac{5}{48} \frac{l_n^2}{EI} [M_{\text{mid}} + 0.1(2M_{\text{end}})]$$

$$M_{\text{mid}} = \mathbf{64221} \text{ lb-ft}$$

$$M_{\text{end}} = \mathbf{-33286} \text{ lb-ft}$$

$$\Delta D+L_{\text{midspan}} = \mathbf{0.133} \text{ in}$$

Calculate the total long term deflection:

$$\Delta D_{\text{midspan}} = \mathbf{0.018} \text{ in}$$

$$\Delta L_{\text{midspan}} = \Delta D+L - \Delta D = \mathbf{0.114} \text{ in}$$

$$\Delta \text{Total} = [(M_D / M_{D+L}) * \Delta D+L] + \Delta D+L$$

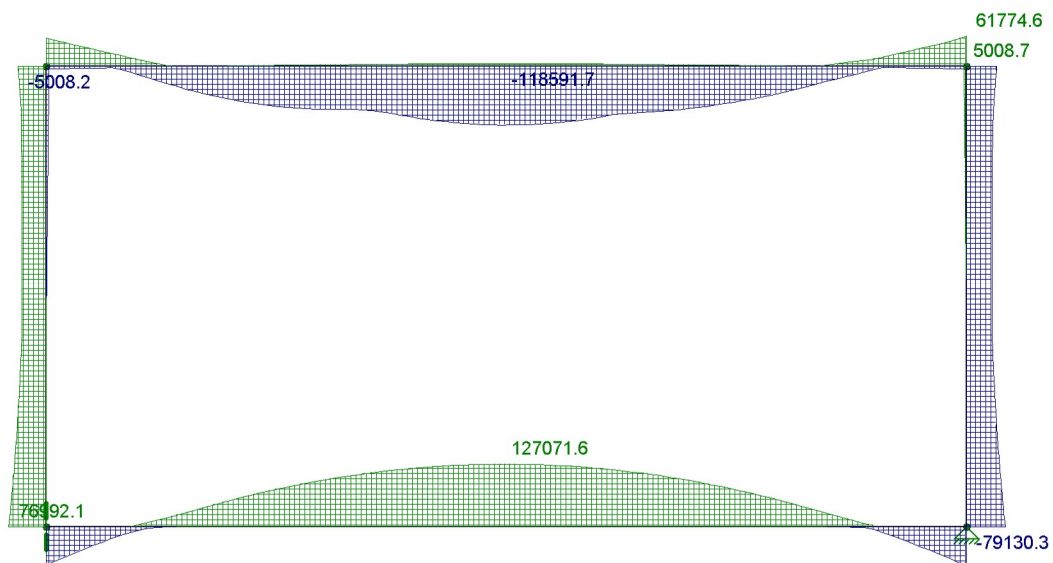
$$\Delta \text{Total} = \mathbf{0.174} \text{ in}$$

$$\text{Live Load Deflection limit} = \text{Span}/800 = \mathbf{0.165} \text{ in}$$

$$\text{Total Service Load Deflection limit} = \text{Span}/360 = \mathbf{0.367} \text{ in}$$

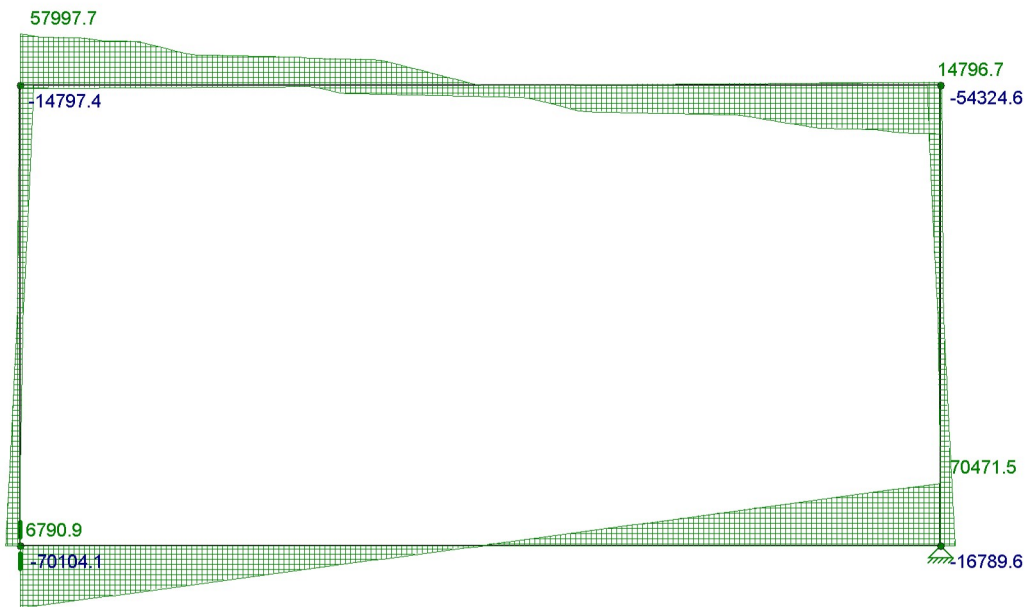
OK! Live load deflection of top slab is within allowable limits.

OK! Total service load deflection of top slab is within allowable limits.



Member z Bending Moments (lb-ft) (Enveloped)

American Concrete Industri...	Box Culvert Envelope of STRENGTH 1 flexure load cases	SK - 3
Ian Riley, PE, SE		May 24, 2019 at 4:44 PM
WIN: 22930.00		Box Culvert Model.r3d



Member y Shear Forces (lb) (Enveloped)

American Concrete Industri...	Box Culvert Envelope of STRENGTH I shear load cases	SK - 4
Ian Riley, PE, SE		May 24, 2019 at 4:44 PM
WIN: 22930.00		Box Culvert Model.r3d