APPENDIX G

Lackawanna Cut-Off Restoration – Passenger Rail Study

STRUCTURE INSPECTION REPORT

GPI

LACKAWANNA COUNTY - PNRRA

INSPECTION AND ANALYSIS REPORT

PNRRA OVER SLATEFORD CREEK &

STONE MASONRY RETAINING WALL ALONG S.R. 0611

NORTHAMPTON COUNTY

UPPER MOUNT BETHEL TOWNSHIP

Prepared By: **Michael J. Ergler, P.E., C.B.S.I.**

Inspection By: **Michael J. Ergler, P.E., C.B.S.I.**
Kris Harvey

Inspection Date: **May 24, 2019**

GPI

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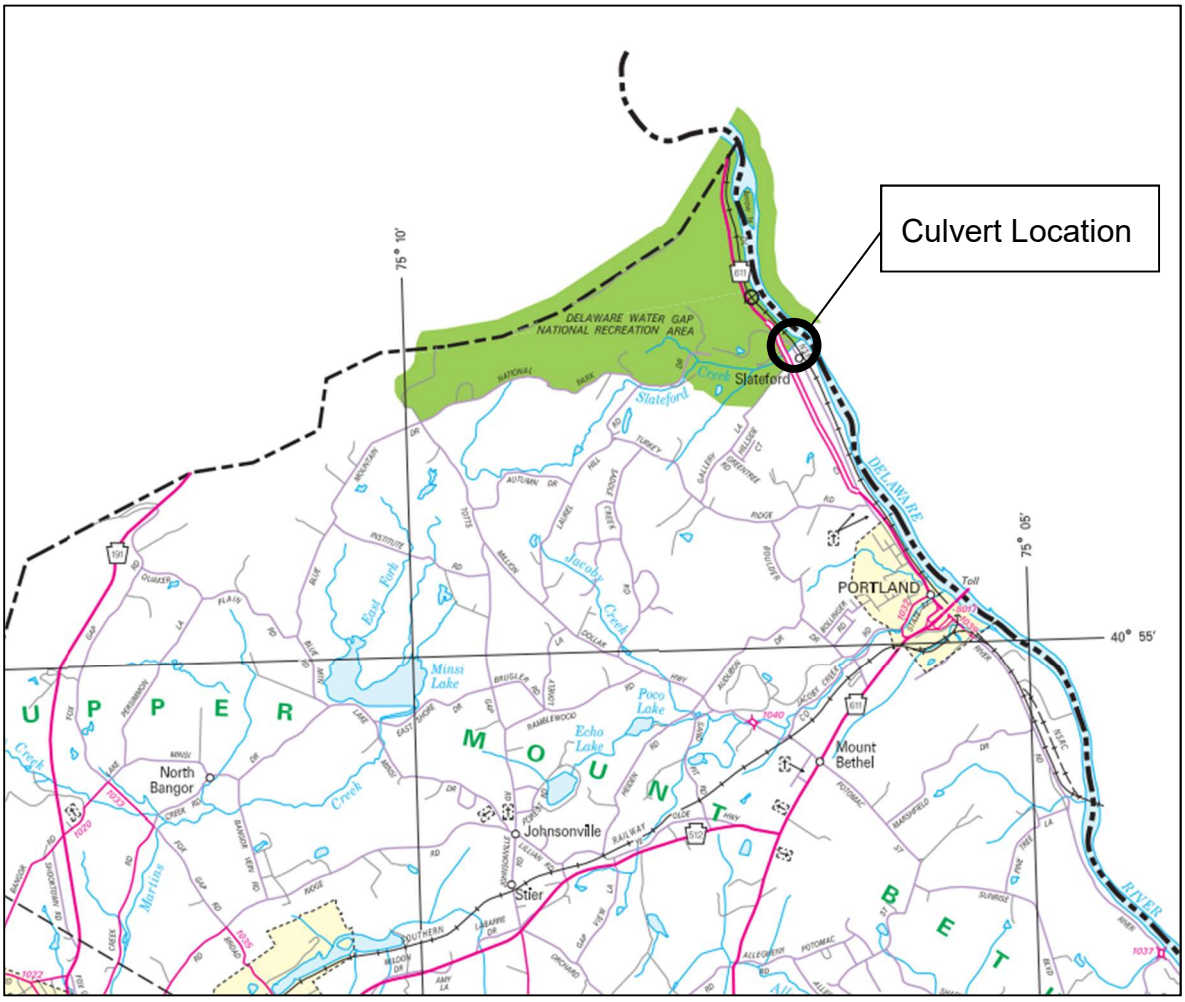
LOCATION MAP



Culvert Site:

Upper Mount Bethel Township
Northampton County, PA
Latitude: 40° 56' 50.0"
Longitude: -75° 6' 50.9"

Map Obtained From:
Northhampton County
Type 10 General Highway Map

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GENERAL INFORMATION

BRIDGE DESCRIPTION

Year Built:	1909
Rehabilitation Year:	N/A
Structure Type:	Twin Cell Cast-In-Place Reinforced Concrete Rigid Frame
Structure Length:	30'-6" (Two 14'-0" Spans)
Number of Spans:	2
Deck type:	N/A - Culvert Under Fill
Culvert Length:	59.3' (Out-to-Out, Railroad Section)
Underclearance:	9'-0" (Upstream Fascia)
	10'-6" (Downstream Fascia)

FIELD INSPECTION RESULTS

PNRRA RIGHT-OF-WAY

The PNRRA right-of-way on top of the culvert and in approach of the culvert is heavily vegetated and overgrown with tree growth (See Photos 3 to 5).

CULVERT

The cast-in-place concrete twin cell culvert is comprised of (2) distinct sections. The PNRRA culvert section was built in 1909 for railroad traffic and is in fair condition overall (See Photos 1 and 6 to13). The PennDOT culvert section was added in 1936 to support SR 0611 over Slateford Creek and is in poor condition overall (See Photos 2, 14, and 15). The below observations primarily concentrate on the downstream PNRRA section:

Top Slab:

The top slab has an area of fine map cracking with efflorescence and stalactites along the downstream end of both Spans 1 & 2 (See Photos 22 & 23). A few top slab construction joints along the culvert exhibit efflorescence with stalactites, active water seepage, and areas of scale.

The PennDOT extension section has failing drainage structures with unreinforced soil and loose rocks noted above the top slab of both culvert spans at the construction joint with the PNRRA section (See Photos 18 and 19). Both drainage inlets exhibit areas of severe scale and spalling concrete surrounding the opening with several exposed longitudinal and transverse reinforcing steel bars exhibiting severe corrosion and section loss (25% to 75% estimated section remaining). Both inlets are located

at the toe of the steep slope along the east side of SR 0611 and are partially covered with debris and railroad ties.

Sidewalls:

The cast-in-place reinforced concrete sidewalls of the PNRRA section exhibit areas of hairline to fine map cracking with some efflorescence and associated concrete delamination along the downstream ends of both spans. The walls also have areas of scale and shallow spalling along the haunches and adjacent to a few construction joints with some light water seepage (See Photos 20 and 21). The base of all walls exhibits a band of concrete scaling and abrasion with the worst area at the downstream end of the middle wall (1'-6" high by 6" deep).

Floor:

The cast-in-place concrete floor of the PNRRA section exhibits heavy concrete scale with exposed aggregate and a few 1/8" to ¼" wide cracks. A 1'-0" diameter by 6" deep spall is located at mid length of Span 1 in the PNRRA section.

Headwall:

The cast-in-place reinforced concrete headwall in the PNRRA section (downstream) exhibits several fine to 1/16" wide horizontal and scattered hairline cracks with light efflorescence.

The previously failed cast-in-place reinforced concrete headwall in the PennDOT section (upstream) has been replaced with gabion baskets (See Photo 2).

Wingwalls:

The northeast and northwest (downstream) non-integral cast-in-place reinforced concrete wingwalls in the PNRRA section exhibit a few fine scattered cracks with efflorescence.

The southwest (upstream) cast-in-place reinforced concrete integral wingwall in the PennDOT section exhibits severe scale along the interface with the culvert up to 12" deep and leans 7¼" toward the stream. This lean has been monitored on a 6-month inspection frequency since 2013 (See Photo 28).

CHANNEL

The channel flows from west to east with fair to poor alignment (See Photos 14 to 17). A large pile of debris directs flow primarily through Span 1 with minor scour along the inlet (See Photo 2). Heavy scour at the outlet undermines the cast-in-place concrete apron up to 1'-0" high and 1'-0" deep (See Photo 27). The stream banks are steep and heavily vegetated with rip rap protection lining the downstream channel.

MASONRY RETAINING WALL ALONG S.R. 0611

The masonry retaining wall along S.R. 0611 was constructed to support the steep slopes from the edge of the roadway down to the PNRRA right-of-way approximately ½ mile south of the Slateford Creek culvert. The overall length of the masonry retaining wall is approximately 950'-0" long and was constructed in (3) distinct

sections. The PennDOT as-built plans from 1936 denote that a 500'-0" masonry retaining wall was constructed along S.R. 0611 in this area. The northernmost section of the wall is round stacked stone, 3'-0" to 4'-0" high, and approximately 200'-0" long (See Photo 29). This section of the retaining wall is in fair condition overall and requires approximately 50 SF of reconstruction. The middle section of the wall is a stone masonry wall, 4'-0" to 7'-3" high, and is approximately 500'-0" long (See Photo 30). This section of the retaining wall is in satisfactory condition overall and requires approximately 200 LF to 300 LF of repointing. The southernmost section of the wall is stacked stone, 3'-0" to 4'-0" high, and approximately 250'-0" long (See Photo 31). This section of the retaining wall is in satisfactory condition overall and requires approximately 50 SF of reconstruction.

RATINGS SUMMARY

A rating analysis was performed for the Cooper E80 rail loading and provided in Appendix 2. As no records for the as-built condition of PNRRA culvert section were found, assumptions were made including but not limited to:

- PennDOT's BXLRFD program was used to rate the culvert using LRFD method.
- The PNRRA culvert section has the same reinforcing and dimensions as the PennDOT culvert section.
- The earth cover was assumed to be 2'-4" over the entire culvert.
- The structure was analyzed as a rigid frame on spread footings.
- The Cooper E80 live load was inputted as a Special Live Load.

The analysis showed an Inventory Rating (IR) of 0.61 and an Operating Rating (OP) of 0.79 for the PNRRA culvert.

MAINTENANCE RECOMMENDATIONS

PNRRA Culvert Critical, High Priority, & Priority Maintenance

- Clean and repair the heavily deteriorated top slab concrete adjacent to the drainage inlets in both spans at the construction joint between the PNRRA and PennDOT culvert sections: 2 SY @ $5,900.00
- Fill in the 3'-0" deep scour hole just downstream of the PNRRA culvert section apron that is undermining the apron: 10 CY @ $7,500.00

PNRRA Culvert Recommended Maintenance Items

- Repair the scaling concrete along the waterline throughout the PNRRA culvert section: 4 CY @ $11,500.00
- Repair the delaminated and cracked concrete at the construction joints and along the east fascia walls and top slab of the PNRRA culvert section: 25 SY @ $73,200.00
- Repave the heavily scaled concrete floor throughout both spans in the PNRRA culvert section: 185 SY @ $28,900.00

Total Repair Cost of Recommended Maintenance: $127,000.00
Note: Costs include a 25% contingency.

MAINTENANCE RECOMMENDATIONS TO BE COORDINATED WITH PENNDOT DISTRICT 5-0

Critical, High Priority, & Priority Maintenance

- Clear the drainage inlets and provide new drainage structures in both spans above the PennDOT culvert section at the construction joint with the PNRRA culvert section (2 Each).
- Clean and repair the heavily deteriorated top slab concrete adjacent to the drainage inlets in both spans at the construction joint between the PNRRA and PennDOT culvert sections (3 SY).

Culvert Recommended Maintenance Items

- Remove the heavy debris obstructing Span 2 just upstream of the PennDOT culvert section directing flow primarily through Span 1 (50 CY).

Masonry Retaining Wall Recommended Maintenance Items

- Reconstruct the missing and displaced stone along the northernmost section of the stacked stone retaining wall (50 SF).
- Repoint the loose and cracked mortar joints in the middle section of the stone masonry retaining wall (300 LF).

APPENDIX 1 – PHOTOGRAPHS

Photo 1 – Right (Downstream) elevation.

Photo 2 – Left (Upstream) elevation (PennDOT Section). Note the heavily deteriorated fascia with exposed and corroded reinforcement and a gabion basket headwall. Also, note the heavy debris accumulation obstructing Span 2.

Photo 3 – General view of the PNRRA right-of-way looking north from the culvert. Note the heavy tree and vegetation overgrowth.

Photo 4 – General view of the PNRRA right-of-way looking south from the culvert. Note the heavy tree and vegetation overgrowth.

Photo 5 – General view of top side from the northeast corner of the culvert looking southwest. Note the heavy tree and vegetation overgrowth.

Photo 6 – General underside view of Span 1 from the east fascia of the PNRRA section looking west.

Photo 7 – General underside view of Span 2 from the east fascia of the PNRRA section looking west.

Photo 8 – General view of the PNRRA south culvert wall in Span 1 looking southwest from the east facia.

Photo 9 – General view of the south face of the PNRRA middle culvert wall in Span 1 looking northwest from the east facia.

Photo 10 – General view of the north face of the PNRRA middle culvert wall in Span 2 looking southwest from the east facia.

Photo 11 – General view of the PNRRA north culvert wall in Span 2 looking northwest from the east facia.

Photo 12 – General view of the southeast wingwall at the outlet looking south. Note the heavy vegetation overgrowth.

Photo 13 – General view of the northeast wingwall at the outlet looking north. Note the heavy vegetation overgrowth.

Photo 14 – General upstream view of Span 1 of the PennDOT section from the construction joint looking west.

Photo 15 – General upstream view of Span 2 of the PennDOT section from the construction joint looking west.

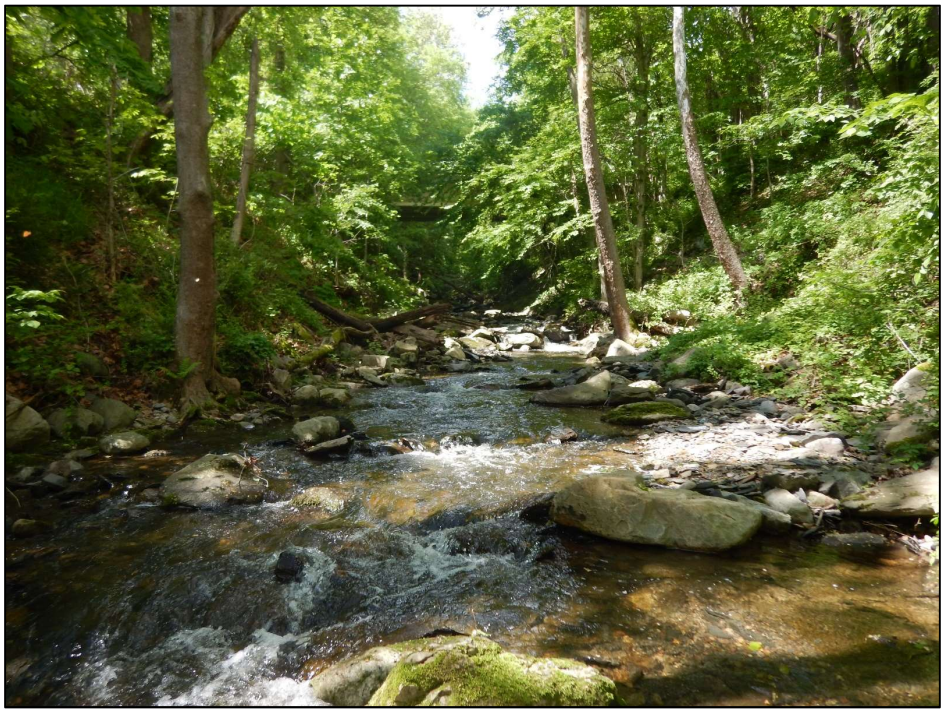

Photo 16 – Waterway looking upstream from the west fascia.

Photo 17 – Waterway looking downstream from the east fascia.

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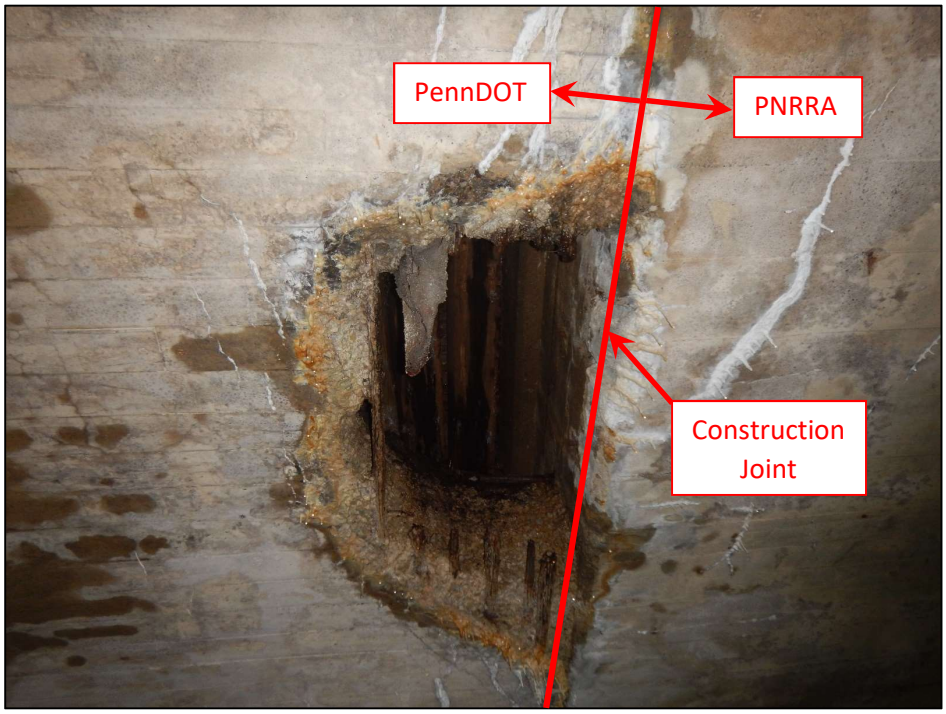

Photo 18 – Heavily deteriorated drainage inlet through the top slab in Span 1 of the PennDOT section at the construction joint.

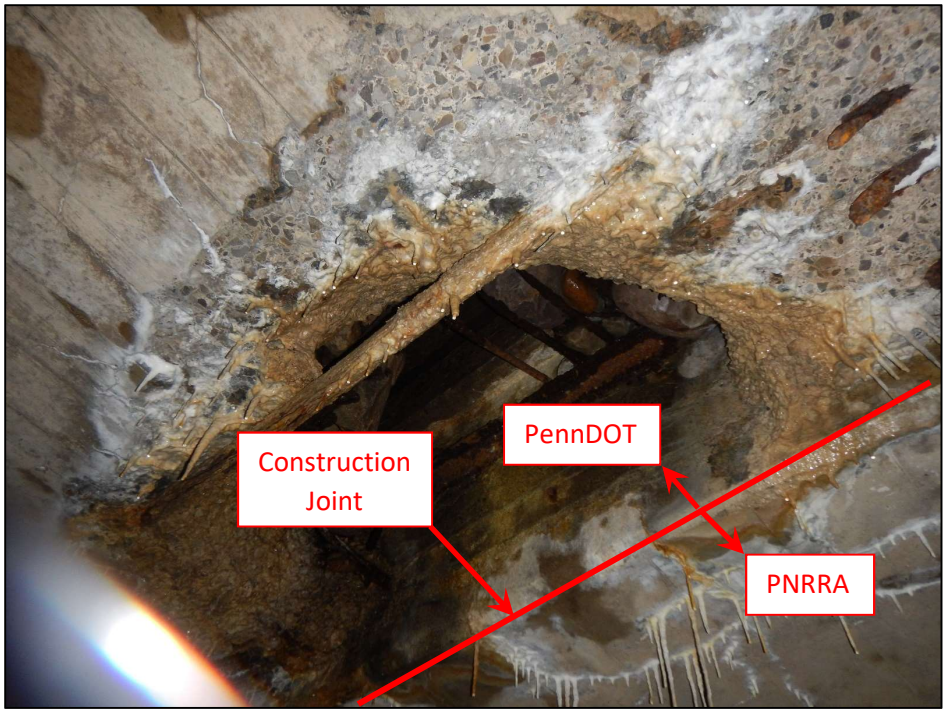

Photo 19 – Heavily deteriorated drainage inlet through the top slab in Span 2 of the PennDOT section at the construction joint.

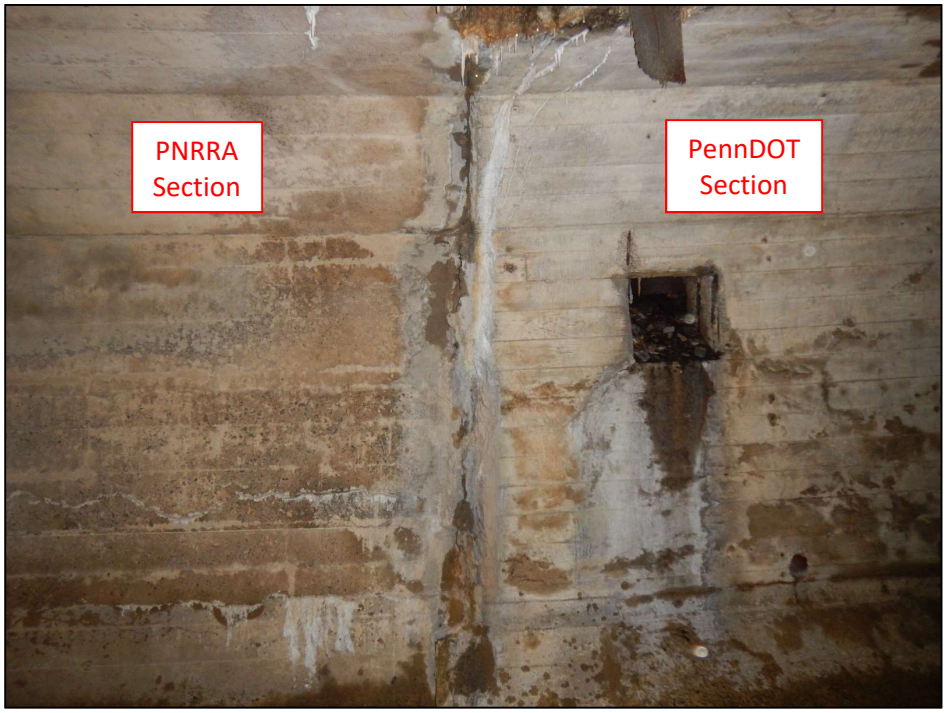

Photo 20 – Span 1 south wall construction joint between the sections with active water seepage and efflorescense.

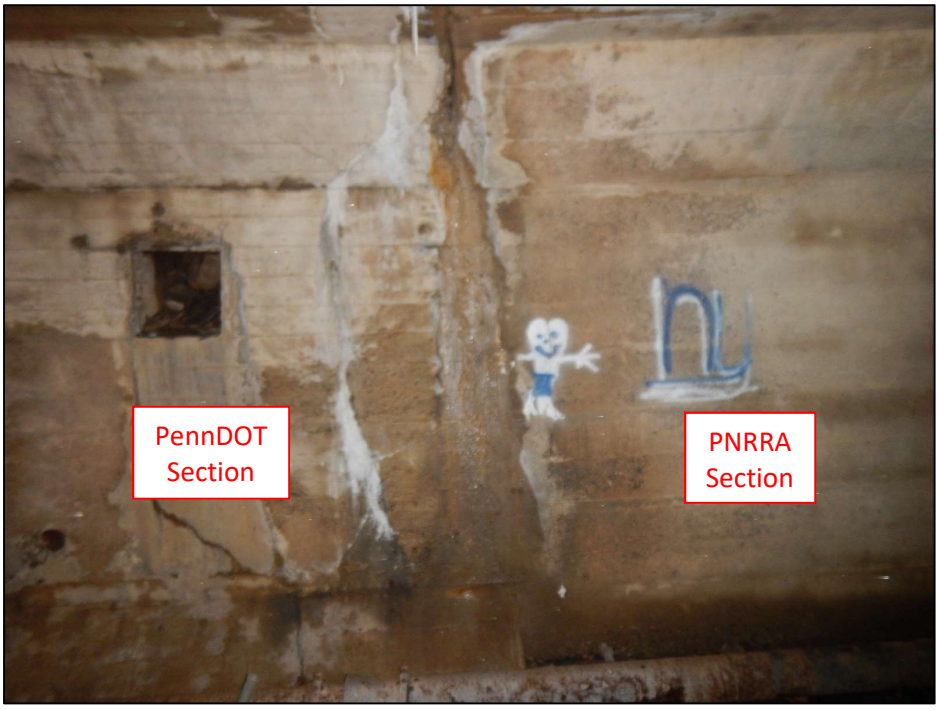

Photo 21 – Span 2 north wall construction joint between the sections with active water seepage and efflorescense.

Photo 22 – Close up view of the Span 1 east fascia and headwall. Note the heavy vegetation overgrowth and cracked concrete with efflorescense and stalactites in the top slab.

Photo 23 – Close up view of the Span 2 east fascia and headwall. Note the heavy vegetation overgrowth and cracked concrete with efflorescense and stalactites in the top slab.

Photo 24 – Abrasion and concrete scaling up to 1'-0" high and 3" deep along the waterline. Typical in both Spans.

Photo 25 – Abrasion and concrete scaling up to 1’-6” high and 4” deep along the middle culvert wall at the outlet.

Photo 26 – Heavy abrasion and concrete scaling along the concrete floor. Typical of both spans (Span 2 shown).

Photo 27 – The outlet apron is undermined up to 1’-0” deep by 1’-0” high in the 3’-0” deep scour hole just downstream.

Photo 28 – The southwest wingwall in the PennDOT section (upstream) exhibits severe scale along the interface with the culvert up to 12” deep and leans 7¼” toward the stream.

Photo 29 – The typical view of the round stacked stone retaining wall along S.R. 0611 (northernmost section).

Photo 30 – The typical view of the stone masonry retaining wall along S.R. 0611 (middle section).

Photo 29 – The typical view of the stacked stone retaining wall along S.R. 0611 (southernmost section).

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APPENDIX 2 – LIVE LOAD RATING

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JOB:	SCR-2019407.00		
SHEET NO.		OF	
CALCULATED BY:	AJK	DATE	6/21/19
CHECKED BY:	HF	DATE	7/1/19

Precast Reinforced Concrete Box Culvert

Loading Computations

Barrier Dead Load

Barrier Type	Headwall			
Additional Headwall Height	2	ft	(Enter Total Headwall Height if Barrier Type is a Headwall)	
Barrier Width	1	ft	(Enter Headwall Width if Barrier Type is a Headwall)	Assumed
Distribution Width	2	ft	(2*Barrier Width)	
Barrier Unit Weight	0.3	klf	1'-6" W X (Headwall Ht) X 0.150 klf	
Additional Headwall Weight	0.300	klf		
Total Barrier Weight	0.600	klf		
Barrier Dead Load	0.300	klf	(Total Barrier Weight) / (Distribution Width)	

Left Approach Slab Dead Load

Appr. Slab Width		ft	
Appr. Slab Length		ft	
Appr. Slab Thick.		ft	
Culvert Length		ft	
Appr. Slab Wt.	0	kips	(Appr. Slab Width) X (Appr. Slab Length) X (Appr. Slab Thick.) X 0.150 kcf
Distribution Factor	0.5		$^1/_2$ of DL to Culvert wall & $^1/_2$ of DL to Sleeper Slab
Approach Slab DL Left Wall		klf	(Appr. Slab Wt.) X (Distribution Factor) / (Culvert Length)

Left Approach Slab Live Load

Roadway Width		ft	
No. of Lanes Loaded	0		AASHTO 3.6.1.1.1
Multiple Presence Factor			AASHTO 3.6.1.1.2
Approach Slab Length		ft	
PHL-93 Lane Load	0.64	klf	AASHTO 3.6.1.2.4
Total Live Load		kips	
Distribution Factor	0.5		1/2 of LL to Culvert wall & 1/2 of LL to Sleeper Slab
Culvert Length		ft	
Approach Slab LL Left Wall		klf	(Total Live Load) X (Distribution Factor) / (Culvert Length)

Right Approach Slab Dead Load

Appr. Slab Width		ft	
Appr. Slab Length		ft	
Appr. Slab Thick.		ft	
Culvert Length		ft	
Appr. Slab Wt.	0	kips	(Appr. Slab Width) X (Appr. Slab Length) X (Appr. Slab Thick.) X 0.150 kcf
Distribution Factor	0.5		$^1/_2$ of DL to Culvert wall & $^1/_2$ of DL to Sleeper Slab
Approach Slab DL Right Wall		klf	(Appr. Slab Wt.) X (Distribution Factor) / (Culvert Length)

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Precast Reinforced Concrete Box Culvert

Right Approach Slab Live Load

Roadway Width		ft	
No. of Lanes Loaded	0		AASHTO 3.6.1.1.1
Multiple Presence Factor			AASHTO 3.6.1.1.2
Approach Slab Length		ft	
PHL-93 Lane Load	0.64	klf	AASHTO 3.6.1.2.4
Total Live Load		kips	
Distribution Factor	0.5		1/2 of LL to Culvert wall & 1/2 of LL to Sleeper Slab
Culvert Length		ft	
Approach Slab LL Right Wall		klf	(Total Live Load) X (Distribution Factor) / (Culvert Length)

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CHECKED BY:	HF	DATE	7/1/19
Precast Reinforced Concrete Box Culvert			

BXLRFD Assumptions

- **LL Rating based on LRFD method**
- **Dimensions match PennDOT section (other than not having a bottom haunch) and supplemented by inspection report field measurements**
- **Reinforcement matches PennDOT section**
- **Analyze structure as a rigid frame (as there are no haunches present, which doesn't match the other structure, and the opening height changes)**
- **Cooper E80 trailing load neglected**
- **Historic Values for Reinforcement and Concrete Strength (1909)**
- **Fill height set to 2'-4" (minimum) from inspection**
- **Footing dimensions assumed**
- **Loads assumed not transferred as per DM-4 3.6.1.5.2P**

BXLRFD Analysis Run Inputs

CTL			
System of Units	US		Default Value
Structure Type	2		1 - Single Celled Culvert, 2 - Twin Celled Culvert, U - U-channel
Type of Run	AR		See BXLRFD Commentary
Precast or CIP	C		
Bottom Slab	N		
Top Slab Support	M		M - Top slab is monolithic with walls, S - Top slab is simply supported on walls
Frame Support	F		Leave Blank for Culverts with Bottom Slab
MAT			
f'c for All Members	3	ksi	Historic Concrete Strength (1909)
f'c for Top Slab		ksi	Leave Blank to use f'c for All Members, or Enter f'c for Top Slab for CIP Culverts
Reinforcement Grade	33	ksi	Historic Rebar Strength (1909)
Reinforcement Type	B		W-Wire Mesh, B-Bars
Alpha	45		Leave blank for no shear reinforcement.
Rebar Size or Wire Dia.			Leave blank for analysis run.
Epoxy Coated Bars	N		As per existing Plans
Concrete Unit Weight for DL			Default (150 pcf)
Concrete Unit Weight for E			Default (145 pcf)
Reinforcement Ultimate Strength	50		
DIM			
Clear Span	14	ft	
Clear Height	10.5833	ft	
Top Slab Thickness	24	in	Enter Thickness for Analysis
Bottom Slab Thickness	26	in	Enter Thickness for Analysis
Left Wall Thickness	15	in	Enter Thickness for Analysis
Right Wall Thickness	15	in	Enter Thickness for Analysis
Interior Wall Thickness	30	in	Enter Thickness for Analysis
Fill Grade		%	
Top Slab Grade		%	
U-Channel Left Wall Ht.		ft	Enter Ht. for Analysis
U-Channel Right Wall Ht.		ft	Enter Ht. for Analysis
FTG			
Left Footing Length	66	ft	
Left Footing Thk.	24	ft	
Left Toe Projection	24	ft	
Left Footing Length	66	ft	
Left Footing Thk.	24	ft	
Left Toe Projection	24	ft	
Interior Footing Width	78	ft	
Interior Footing Thk.	24	ft	

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Precast Reinforced Concrete Box Culvert

LDC

Earth Weight Density		pcf	Default
Height of Fill	2.3333	ft	Set to 2'-4" min. from inspection
No. of Lanes	1	--	AASHTO 3.6.1.1.1 (Roadway Width/12)
LL Surcharge	0	ft	Default
Live Load	E	--	E - Special Live Load
Overlay Weight Density		pcf	Default
Overlay Thickness	0	in	
Future Wearing Surface	0	psf	30 psf for Culverts at Grade, 0 otherwise
Max. LL Distribution Length	82.5	ft	
Segment Length	82.5	ft	Use 165'/2 (Structure length from inspection report)
Multiple Presence Factor			Default, Leave "Blank" no longer used.
PA Traffic Factor			Default, Leave "Blank" no longer used.
Fatigue Dynamic Load Allow.			Default, Leave "Blank" no longer used.
Ductility Factor		--	Default, As per DM-4 Section 1.3.4, a factor other than 1.0 is not permitted
Redundancy Factor		--	Default, As per DM-4 Section 1.3.4, a factor other than 1.0 is not permitted
Importance Factor		--	Default, As per DM-4 Section 1.3.4, a factor other than 1.0 is not permitted
P-82 Max. Dynamic Load Allow.		--	Default, 1.2 per DM-4 Section 3.6.2
LL Override	1	--	Default
Min. Equiv. Fluid Pressure		pcf	Default, As per DM-4 Table 3.11.5.5-2P
Max. Equiv. Fluid Pressure		pcf	Default, As per DM-4 Table 3.11.5.5-2P
Barrier Dead Load	0.300	klf	See Loading Computations
Approach Slab DL Left Wall		klf	See Loading Computations
Approach Slab LL Left Wall		klf	See Loading Computations
Approach Slab DL Right Wall		klf	See Loading Computations
Approach Slab LL Right Wall		klf	See Loading Computations
Ratings without FWS	Y		Y-For Analysis Runs
Backfill Type			Default (O -Other Backfill Type)
Number of Precast Shear			Number of Precast Segements With Shear Transfer

SLL

Gage Distance	4.7083	ft
Passing Distance	0	ft
Axle Effect	N	
Lane Load	0	klf
Percent Increase	0	
Load Factor; STR I	1.75	
Load Factor; STR II	1.35	
Load Factor; SERV I	1	
Load Factor Fatigue	1.75	

SAL

Axle Load	40	kips
Axle Spacing	8	ft
Axle Load	80	kips
Axle Spacing	5	ft
Axle Load	80	kips
Axle Spacing	5	ft
Axle Load	80	kips
Axle Spacing	5	ft
Axle Load	80	kips
Axle Spacing	9	ft
Axle Load	52	kips
Axle Spacing	5	ft
Axle Load	52	kips
Axle Spacing	6	ft

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Precast Reinforced Concrete Box Culvert

Axle Load	52	kips
Axle Spacing	5	ft
Axle Load	52	kips
Axle Spacing	8	ft
Axle Load	40	kips
Axle Spacing	8	ft
Axle Load	80	kips
Axle Spacing	5	ft
Axle Load	80	kips
Axle Spacing	5	ft
Axle Load	80	kips
Axle Spacing	5	ft
Axle Load	80	kips
Axle Spacing	9	ft
Axle Load	52	kips
Axle Spacing	5	ft
Axle Load	52	kips
Axle Spacing	6	ft
Axle Load	52	kips
Axle Spacing	5	ft
Axle Load	52	kips
Axle Spacing		ft

HCH

Top Left X	18	in	
Top Left Y	18	in	
Top Right X	18	in	
Top Right Y	18	in	
Bot Left X		in	
Bot Left Y		in	
Bot Right X		in	
Bot Right Y		in	
Top Int X	18	in	
Top Int Y	18	in	
Bot Int X		in	Leave Blank for Single Cell Culverts
Bot Int Y		in	Leave Blank for Single Cell Culverts

CVR

Top Slab Top Cover	1.875	in	Default
Top Slab Bottom Cover	2	in	Default
Bottom Slab Top Cover	2	in	Default
Bottom Slab Bot Cover	1.875	in	Default
All Wall Covers	2.25	in	Default
Footing Top Cover		in	Default
Footing Bot Cover		in	Default

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Precast Reinforced Concrete Box Culvert

TSR

	Slab No.	1	
	Face	T	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	10	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Slab No.	2	
	Face	T	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	10	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Slab No.	1	
	Face	B	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	8	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Slab No.	2	
	Face	B	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	8	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

BSR

	Slab No.	1	
	Face	T	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	8	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

Greenman-Pedersen, Inc.
52 Glenmaura National Blvd, Suite 302
Scranton, PA 18505
(570) 342-3700 FAX (570) 342-4080

JOB:	SCR-2019407.00		
SHEET NO.		OF	
CALCULATED BY:	AJK	DATE	6/24/19
CHECKED BY:	HF	DATE	7/1/19

Precast Reinforced Concrete Box Culvert

	Slab No.	2	
	Face	T	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	8	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Slab No.	1	
	Face	B	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	10	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Slab No.	2	
	Face	B	
	Range Distance	14	ft
	Reinf. Size or Wire Dia.	10	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

WLR

	Wall No.	1	
	Face	L	
	Range Distance	10	ft
	Reinf. Size or Wire Dia.	8	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Wall No.	1	
	Face	R	
	Range Distance	10	ft
	Reinf. Size or Wire Dia.	4	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

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JOB:	SCR-2019407.00		
SHEET NO.		OF	
CALCULATED BY:	AJK	DATE	6/24/19
CHECKED BY:	HF	DATE	7/1/19

Precast Reinforced Concrete Box Culvert

	Wall No.	2	
	Face	L	
	Range Distance	10	ft
	Reinf. Size or Wire Dia.	4	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Wall No.	2	
	Face	R	
	Range Distance	10	ft
	Reinf. Size or Wire Dia.	4	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Wall No.	3	
	Face	L	
	Range Distance	10	ft
	Reinf. Size or Wire Dia.	4	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

	Wall No.	3	
	Face	R	
	Range Distance	10	ft
	Reinf. Size or Wire Dia.	8	
[2]	Spacing	12	in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
[3]	Spacing		in
	Range Distance		ft
	Reinf. Size or Wire Dia.		
	Spacing		in

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SHEET NO.		OF	
CALCULATED BY:	AJK	DATE	6/24/19
CHECKED BY:	HF	DATE	7/1/19

Precast Reinforced Concrete Box Culvert

FTR

Footing Number	1	
Face	T	
Reinf Size or Wire Dia.	8	
Spacing	12	in
Footing Number	1	
Face	B	
Reinf Size or Wire Dia.	10	
Spacing	12	in
Footing Number	2	
Face	T	
Reinf Size or Wire Dia.	8	
Spacing	12	in
Footing Number	2	
Face	B	
Reinf Size or Wire Dia.	10	
Spacing	12	in
Footing Number	3	
Face	T	
Reinf Size or Wire Dia.	8	
Spacing	12	in
Footing Number	3	
Face	B	
Reinf Size or Wire Dia.	10	
Spacing	12	in

TVA

	Slab Number	1	
	Region Start Distance	1.25	ft
	Region End Distance	1.25	ft
	Shear Rein. Area	1.27	in^2
[2]	Spacing	0	in
	Region Start Distance	12.75	ft
	Region End Distance	12.75	ft
	Shear Rein. Area	1.27	in^2
	Spacing	0	in
	Slab Number	2	
	Region Start Distance	1.25	ft
	Region End Distance	1.25	ft
	Shear Rein. Area	1.27	in^2
[2]	Spacing	0	in
	Region Start Distance	12.75	ft
	Region End Distance	12.75	ft
	Shear Rein. Area	1.27	in^2
	Spacing	0	in

BVA

	Slab Number	1	
	Region Start Distance	1.25	ft
	Region End Distance	1.25	ft
	Shear Rein. Area	1.27	in^2
[2]	Spacing	0	in
	Region Start Distance	12.75	ft
	Region End Distance	12.75	ft
	Shear Rein. Area	1.27	in^2
	Spacing	0	in

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JOB:	SCR-2019407.00		
SHEET NO.		OF	
CALCULATED BY:	AJK	DATE	6/24/19
CHECKED BY:	HF	DATE	7/1/19

Precast Reinforced Concrete Box Culvert

	Slab Number	2	
	Region Start Distance	1.25	ft
	Region End Distance	1.25	ft
	Shear Rein. Area	1.27	in^2
[2]	Spacing	0	in
	Region Start Distance	12.75	ft
	Region End Distance	12.75	ft
	Shear Rein. Area	1.27	in^2
	Spacing	0	

Program Title	LRFD Box Culvert Design and Rating
Program Name	BXLRFD
Version	2.8.0.0
Last Updated	10/12/2018
Documentation	09/2018
License No.	333687

SLATEFORD PRELIMINARY CULVERT RATING
RIGID FRAME RUN

DONE: AJK DATE: 06/24/19
CHCK: HF DATE: 07/01/19

SLATEFORD PRELIMINARY CULVERT RATING
SUMMARY OF INPUT FILE

COMMAND: CTL

SYSTEM OF UNITS	US		
STRUCTURE TYPE	2		
TYPE OF RUN	AR		
PRECAST OR CAST-IN-PLACE	C		
BOTTOM SLAB	N		
TOP SLAB SUPPORT	M		
FRAME SUPPORT	F		

COMMAND: MAT

f'c FOR ALL MEMBERS	3	ksi	
f'c FOR TOP SLAB AT GRADE	*	ksi	(computed, if necessary)
REINFORCEMENT GRADE	33	ksi	
REINFORCEMENT TYPE	B		
ALPHA	45	degrees	
REBAR SIZE OR WIRE DIAM	*	*	(computed, if necessary)
EPOXY COATED	N		
DENSITY OF CONC. FOR DL	150.0	lb/ft^3	(default)
DENSITY OF CONC. FOR E	145.0	lb/ft^3	(default)
REINF ULT TENS STRENGTH	50	ksi	

COMMAND: DIM

CLEAR SPAN	14	ft	
CLEAR HEIGHT	10.5833	ft	
TOP SLAB THICKNESS	24	in	
BOTTOM SLAB THICKNESS	26	in	
LEFT WALL THICKNESS	15	in	
RIGHT WALL THICKNESS	15	in	
INTERIOR WALL THICKNESS	30	in	
FILL GRADE	0.0		(default)
TOP SLAB GRADE	0.0		(default)
UCHNL LEFT WALL HEIGHT	*	ft	(computed, if necessary)
UCHNL RIGHT WALL HEIGHT	*	ft	(computed, if necessary)

COMMAND: FTG

LEFT FOOTING WIDTH	66	in	
LEFT FOOTING THICKNESS	24	in	
LEFT TOE PROJECTION	24	in	
RIGHT FOOTING WIDTH	66	in	
RIGHT FOOTING THICKNESS	24	in	
RIGHT TOE PROJECTION	24	in	
INTERIOR FTG WIDTH	78	in	
INTERIOR FTG THICKNESS	24	in	

COMMAND: LDC

EARTH WEIGHT/DENSITY	140.0	lbf/ft^3	(default)
HEIGHT OF FILL	2.3333	ft	
NUMBER OF LANES	1		
LIVE LOAD SURCHARGE	0	ft	
LIVE LOAD	E		
OVERLAY WEIGHT/DENSITY	150.0	lbf/ft^3	(default)
OVERLAY THICKNESS	0	in	
FUTURE WEARING SURFACE	0	lbf/ft^2	
LL DISTRIBUTION LENGTH	82.5	ft	
SEGMENT LENGTH	82.5	ft	
MULTIPLE PRESENCE REDUCT	1.0		(default)
PA TRAFFIC FACTOR	*		(computed, if necessary)
FATIGUE DYN. LOAD ALLOW.	*		(computed, if necessary)
DUCTILITY FACTOR	1.0		(default)
REDUNDANCY FACTOR	1.0		(default)
IMPORTANCE FACTOR	1.0		(default)
PERMIT DYN. LOAD ALLOW.	1.20		(default)
LIVE LOAD OVERRIDE	1		
MIN EQUIV FLUID PRESS	45.0	lbf/ft^3	(default)
MAX EQUIV FLUID PRESS	70.0	lbf/ft^3	(default)
BARRIER DEAD LOAD	0.3	kip/ft	
APPROACH SLAB DL-LEFT	0	kip	(default)
APPROACH SLAB LL-LEFT	0	kip	(default)
APPROACH SLAB DL-RIGHT	0	kip	(default)
APPROACH SLAB LL-RIGHT	0	kip	(default)
RATINGS W/O FWS	Y		
BACKFILL TYPE	*		(computed, if necessary)
NO. PC SHEAR TRNS SEG	2		(default)

SLATEFORD PRELIMINARY CULVERT RATING
SUMMARY OF INPUT FILE (cont.)

COMMAND: SLL

GAGE DISTANCE	4.7083	ft	
PASSING DISTANCE	0	ft	
AXLE EFFECT	N		
LANE LOAD	0	Kip/ft	
PERCENT INCREASE	0		
LOAD FACTOR STRENGTH I	1.75		
LOAD FACTOR STRENGTH II	1.35		
LOAD FACTOR SERVICE I	1		
LOAD FACTOR FATIGUE	1.75		

COMMAND: SAL

AXLE LOAD	40	kip	
AXLE SPACING	8	ft	
AXLE LOAD	80	kip	
AXLE SPACING	5	ft	
AXLE LOAD	80	kip	
AXLE SPACING	5	ft	
AXLE LOAD	80	kip	
AXLE SPACING	5	ft	
AXLE LOAD	80	kip	
AXLE SPACING	9	ft	
AXLE LOAD	52	kip	
AXLE SPACING	5	ft	
AXLE LOAD	52	kip	
AXLE SPACING	6	ft	
AXLE LOAD	52	kip	
AXLE SPACING	5	ft	
AXLE LOAD	52	kip	
AXLE SPACING	8	ft	
AXLE LOAD	40	kip	
AXLE SPACING	8	ft	
AXLE LOAD	80	kip	
AXLE SPACING	5	ft	
AXLE LOAD	80	kip	
AXLE SPACING	5	ft	
AXLE LOAD	80	kip	
AXLE SPACING	5	ft	
AXLE LOAD	80	kip	
AXLE SPACING	9	ft	
AXLE LOAD	52	kip	
AXLE SPACING	5	ft	
AXLE LOAD	52	kip	
AXLE SPACING	6	ft	
AXLE LOAD	52	kip	
AXLE SPACING	5	ft	
AXLE LOAD	52	kip	
AXLE SPACING	*	ft	(computed, if necessary)

COMMAND: HCH

TOP LEFT X	18	in	
TOP LEFT Y	18	in	
TOP RIGHT X	18	in	
TOP RIGHT Y	18	in	
BOTTOM LEFT X	*	in	(computed, if necessary)
BOTTOM LEFT Y	*	in	(computed, if necessary)
BOTTOM RIGHT X	*	in	(computed, if necessary)
BOTTOM RIGHT Y	*	in	(computed, if necessary)
TOP INTERIOR X	18	in	
TOP INTERIOR Y	18	in	
BOTTOM INTERIOR X	*	in	(computed, if necessary)
BOTTOM INTERIOR X	*	in	(computed, if necessary)

SLATEFORD PRELIMINARY CULVERT RATING
SUMMARY OF INPUT FILE (cont.)

COMMAND: CVR

TOP SLAB - TOP COVER	1.875 in
TOP SLAB - BOTTOM COVER	2 in
BOTTOM SLAB - TOP COVER	2 in
BOTTOM SLAB - BOTTOM CVR	1.875 in
ALL WALL COVERS	2.25 in
FOOTING - TOP COVER	2 in
FOOTING - BOTTOM COVER	3 in

COMMAND: TSR

SLAB NUMBER	1
FACE	T
RANGE DISTANCE	14 ft
BAR SIZE OR WIRE DIAM	10 *
SPACING	12 in

COMMAND: TSR

SLAB NUMBER	2
FACE	T
RANGE DISTANCE	14 ft
BAR SIZE OR WIRE DIAM	10 *
SPACING	12 in

COMMAND: TSR

SLAB NUMBER	1
FACE	B
RANGE DISTANCE	14 ft
BAR SIZE OR WIRE DIAM	8 *
SPACING	12 in

COMMAND: TSR

SLAB NUMBER	2
FACE	B
RANGE DISTANCE	14 ft
BAR SIZE OR WIRE DIAM	8 *
SPACING	12 in

COMMAND: WLR

WALL NUMBER	1
FACE	L
RANGE DISTANCE	10.5833 ft
BAR SIZE/WIRE DIAM	8 *
SPACING	12 in

COMMAND: WLR

WALL NUMBER	1
FACE	R
RANGE DISTANCE	10.5833 ft
BAR SIZE/WIRE DIAM	4 *
SPACING	12 in

COMMAND: WLR

WALL NUMBER	2
FACE	L
RANGE DISTANCE	10.5833 ft
BAR SIZE/WIRE DIAM	4 *
SPACING	12 in

COMMAND: WLR

WALL NUMBER	2
FACE	R
RANGE DISTANCE	10.5833 ft
BAR SIZE/WIRE DIAM	4 *
SPACING	12 in

SLATEFORD PRELIMINARY CULVERT RATING
SUMMARY OF INPUT FILE (cont.)

```
COMMAND:  WLR
  WALL NUMBER                        3
  FACE                               L
  RANGE DISTANCE               10.5833 ft
  BAR SIZE/WIRE DIAM                 4 *
  SPACING                           12 in

COMMAND:  WLR
  WALL NUMBER                        3
  FACE                               R
  RANGE DISTANCE               10.5833 ft
  BAR SIZE/WIRE DIAM                 8 *
  SPACING                           12 in

COMMAND:  FTR
  FOOTING NUMBER                     1
  FACE                               T
  BAR SIZE OR WIRE DIAM              8 *
  SPACING                           12 in

COMMAND:  FTR
  FOOTING NUMBER                     1
  FACE                               B
  BAR SIZE OR WIRE DIAM             10 *
  SPACING                           12 in

COMMAND:  FTR
  FOOTING NUMBER                     2
  FACE                               T
  BAR SIZE OR WIRE DIAM              8 *
  SPACING                           12 in

COMMAND:  FTR
  FOOTING NUMBER                     2
  FACE                               B
  BAR SIZE OR WIRE DIAM             10 *
  SPACING                           12 in

COMMAND:  FTR
  FOOTING NUMBER                     3
  FACE                               T
  BAR SIZE OR WIRE DIAM              8 *
  SPACING                           12 in

COMMAND:  FTR
  FOOTING NUMBER                     3
  FACE                               B
  BAR SIZE OR WIRE DIAM             10 *
  SPACING                           12 in

COMMAND:  TVA
  SLAB NUMBER                        1
  REGION START DISTANCE           1.25 ft
  REGION END   DISTANCE           1.25 ft
  SHEAR REINFORCEMENT AREA        1.27 in^2
  SPACING                            0 in
  REGION START DISTANCE          12.75 ft
  REGION END   DISTANCE          12.75 ft
  SHEAR REINFORCEMENT AREA        1.27 in^2
  SPACING                            0 in

COMMAND:  TVA
  SLAB NUMBER                        2
  REGION START DISTANCE           1.25 ft
  REGION END   DISTANCE           1.25 ft
  SHEAR REINFORCEMENT AREA        1.27 in^2
  SPACING                            0 in
  REGION START DISTANCE          12.75 ft
  REGION END   DISTANCE          12.75 ft
  SHEAR REINFORCEMENT AREA        1.27 in^2
  SPACING                            0 in
```

SLATEFORD PRELIMINARY CULVERT RATING
SUMMARY OF INPUT FILE (cont.)

```
 COMMAND:  OIN
   INPUT FILE ECHO                    0
   INPUT COMMANDS                     1
   INPUT SUMMARY                      0

 COMMAND:  OUR
   SECTION PROPERTIES                 *        (computed, if necessary)
   LIVE LOAD RATING                   1
   RATING SUMMARY                     1
   DL EFFECTS & CAPACITIES            *        (computed, if necessary)
   FLEXURAL REINFORCEMENT             *        (computed, if necessary)
   SHEAR DESIGN                       *        (computed, if necessary)
   FOUNDATION PRESSURE                0            (default)
   QUANTITIES                         *        (computed, if necessary)
   SERVICEABILITY TABLE               *        (computed, if necessary)
   SERVICEABILITY SUMMARY             1            (default)
   FOUNDATION PRESS SUMMARY           1            (default)
   MIN. REINFORCEMENT CHECK           1            (default)
          %WARNING - <Bar and wire clear covers>:
              Top slab, top cover less than lower limit.
              Verify input on the CVR card.
          %WARNING - <Inconsistent Data>:
              The Fatigue limit state is no longer
              analyzed by the program.
              Load Factor for Fatigue will be ignored.
              Please verify input on the SLL card.

 Note: Wall distances begin at the bottom of the wall and slab distances
       begin at the left side of the slab.
```

SLATEFORD PRELIMINARY CULVERT RATING
ADDITIONAL INFORMATION

COMPUTED VALUES

Input Reinf Grade (ksi)	Computed Flexure Reinf Grade (ksi)	Computed Axial Reinf Grade (ksi)	Computed Shear Reinf Grade (ksi)	Computed Development Reinf Grade (ksi)
33.000	33.000	33.000	33.000	33.000

ADDITIONAL GEOMETRY

Final Component Thickness

Top Slab #1	:	24.00 in
Top Slab #2	:	24.00 in
Wall #1	:	15.00 in
Wall #2	:	30.00 in
Wall #3	:	15.00 in

Final Strip Footing Projections

Left Wall Toe Projection	:	24.00 in
Left Wall Heel Projection	:	27.00 in
Center Wall Projection	:	24.00 in
Right Wall Toe Projection	:	24.00 in
Right Wall Heel Projection	:	27.00 in

SLATEFORD PRELIMINARY CULVERT RATING
LIVE LOAD ELAT & IM TABLE

Dynamic Load Allowance

Fill Height (ft)	IM	Permit IM
2.33	1.28	N/A

Case 1 - On Deck Loading

No. of Lanes Loaded	c-c Culvert Span (ft)	MPF *	Calc Elat (ft)	Calc Elat --------- MPF (ft)	Seg Length (ft)	Elat Used (ft)
1	15.88	1.20	9.90	8.25	82.5	8.25

Case 2 - Thru Fill Loading

No. of Lanes Loaded	Fill Height (ft)	LL Distribution Length (ft)	MPF *	Total Width (LANE(i)) (ft)	Elat Used (ft)
1	2.33	82.5	1.20	11.56	9.63

* Includes Multiple Presence Reduction Factor

SLATEFORD PRELIMINARY CULVERT RATING
SERVICEABILITY SPACING SUMMARY

Location	Minimum Primary Spacing	Maximum Primary Spacing	Temp/ Shrink Spacing	Crack Control Spacing
Top Slab No. 1	OK	OK	OK	OK
Top Slab No. 2	OK	OK	OK	OK
Wall No. 1	OK	OK	OK	OK
Wall No. 2	OK	OK	OK	OK
Wall No. 3	OK	OK	OK	OK
STRIP FOOTING: Wall No. 1	OK	OK	OK	OK
STRIP FOOTING: Wall No. 2	OK	OK	OK	OK
STRIP FOOTING: Wall No. 3	OK	OK	OK	OK

SLATEFORD PRELIMINARY CULVERT RATING
LIVE LOAD RATING W/O FWS

SPECIAL Loading: Top Slab No. 1

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
1.50	DL+E	2.84	1.90		46.05 F1	TN	2.22		0.79 B	0.57	0.90
	LL+I	19.45	2.36								
	DL+E	2.84	1.90		46.05 F1	TN		2.88	0.79 B	0.57	0.90
	LL+I	15.00	1.82								
2.80	DL+E	8.21	1.90		44.36 F1	TN	1.07		0.79 B	0.81 **	0.90
	LL+I	33.81	2.56								
	DL+E	8.21	1.90		44.36 F1	TN		1.39	0.79 B	0.81 **	0.90
	LL+I	26.08	1.98								
3.29	DL+E	9.72	1.90	-3.73	44.82 F1	TN	0.93		0.79 B	0.81 **	0.90
	LL+I	37.74	3.68	-12.97	-28.60 V6		1.91		0.00		
	DL+E	9.72	1.90	-3.73	44.82 F1	TN		1.21	0.79 B	0.81 **	0.90
	LL+I	29.11	2.84	-10.00	-28.68 V6			2.47	0.00		
4.20	DL+E	11.76	1.90	-2.65	44.42 F1	TN	0.73		0.79 B	0.81 **	0.90
	LL+I	44.98	3.90	-10.19	-27.60 V6		2.45		0.00		
	DL+E	11.76	1.90	-2.65	44.42 F1	TN		0.94	0.79 B	0.81 **	0.90
	LL+I	34.70	3.01	-7.86	-27.60 V6			3.17	0.00		
5.60	DL+E	13.00	1.90	-0.06	44.12 F1	TN	0.61		0.79 B	0.81 **	0.90
	LL+I	51.17	3.93	7.27	26.67 V5		3.72		0.00		
	DL+E	13.00	1.90	-0.06	44.12 F1	TN		0.79	0.79 B	0.81 **	0.90
	LL+I	39.48	3.03	5.61	26.58 V5			4.82	0.00		
7.00	DL+E	11.92	1.90	1.60	44.25 F1	TN	0.65		0.79 B	0.81 **	0.90
	LL+I	50.09	4.01	10.86	27.46 V5		2.40		0.00		
	DL+E	11.92	1.90	1.60	44.25 F1	TN		0.84	0.79 B	0.81 **	0.90
	LL+I	38.64	3.09	8.38	27.37 V5			3.11	0.00		
8.40	DL+E	8.53	1.90	3.25	44.87 F1	TN	0.89		0.79 B	0.81 **	0.90
	LL+I	41.05	3.94	14.99	28.77 V5		1.70		0.00		
	DL+E	8.53	1.90	3.25	44.87 F1	TN		1.15	0.79 B	0.81 **	0.90
	LL+I	31.66	3.04	11.56	28.77 V5			2.21	0.00		
9.80	DL+E	3.54	5.24	4.90	49.76 F1	TN	1.90		0.79 B	0.71	0.90
	LL+I	24.33	3.88	19.11	28.77 V5		1.25		0.00		
	DL+E	3.54	5.24	4.90	49.76 F1	TN		2.46	0.79 B	0.71	0.90
	LL+I	18.77	2.99	14.74	28.77 V5			1.62	0.00		
10.71	DL+E	-2.12	1.90	5.98	-67.84 F2	TN	2.94		1.27 T	0.62	0.90
	LL+I	-22.36	0.62	21.90	30.63 V5		1.13		0.00		
	DL+E	-2.12	1.90	5.98	-67.84 F2	TN		3.81	1.27 T	0.62	0.90
	LL+I	-17.25	0.48	16.90	30.63 V5			1.46	0.00		
11.20	DL+E	-5.20	1.90		-67.64 F2	TN	2.20		1.27 T	0.81	0.90
	LL+I	-28.41	0.69								
	DL+E	-5.20	1.90		-67.64 F2	TN		2.85	1.27 T	0.81	0.90
	LL+I	-21.92	0.53								
12.50	DL+E	-14.72	1.90		-67.21 F2	TN	1.13		1.27 T	0.81	0.90
	LL+I	-46.59	0.76								
	DL+E	-14.72	1.90		-67.21 F2	TN		1.46	1.27 T	0.81	0.90
	LL+I	-35.94	0.59								

SPECIAL Loading: Top Slab No. 2

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
1.50	DL+E	-14.72	1.90		-67.21 F2	TN	1.13		1.27 T	0.81	0.90
	LL+I	-46.58	0.76								
	DL+E	-14.72	1.90		-67.21 F2	TN		1.46	1.27 T	0.81	0.90
	LL+I	-35.94	0.58								
2.80	DL+E	-5.20	1.90		-67.63 F2	TN	2.20		1.27 T	0.81	0.90
	LL+I	-28.41	0.68								
	DL+E	-5.20	1.90		-67.63 F2	TN		2.85	1.27 T	0.81	0.90
	LL+I	-21.92	0.52								
3.29	DL+E	-2.12	1.90	-5.98	-67.82 F2	TN	2.94		1.27 T	0.62	0.90
	LL+I	-22.36	0.61	-22.04	-30.63 V6		1.12		0.00		
	DL+E	-2.12	1.90	-5.98	-67.82 F2	TN		3.81	1.27 T	0.62	0.90
	LL+I	-17.25	0.47	-17.00	-30.63 V6			1.45	0.00		
4.20	DL+E	3.54	5.24	-4.90	49.77 F1	TN	1.90		0.79 B	0.71	0.90
	LL+I	24.33	3.88	-19.20	-28.77 V6		1.24		0.00		
	DL+E	3.54	5.24	-4.90	49.77 F1	TN		2.46	0.79 B	0.71	0.90
	LL+I	18.77	2.99	-14.82	-28.77 V6			1.61	0.00		

SLATEFORD PRELIMINARY CULVERT RATING
LIVE LOAD RATING W/O FWS (cont.)

SPECIAL Loading: Top Slab No. 2 (cont.)

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
5.60	DL+E	8.53	1.90	-3.25	44.87 F1	TN	0.89		0.79 B	0.81 **	0.90
	LL+I	41.04	3.95	-14.83	-28.77 V6		1.72		0.00		
	DL+E	8.53	1.90	-3.25	44.87 F1	TN		1.15	0.79 B	0.81 **	0.90
	LL+I	31.66	3.05	-11.44	-28.77 V6			2.23	0.00		
7.00	DL+E	11.92	1.90	-1.60	44.25 F1	TN	0.65		0.79 B	0.81 **	0.90
	LL+I	50.10	4.00	-10.94	-27.48 V6		2.39		0.00		
	DL+E	11.92	1.90	-1.60	44.25 F1	TN		0.84	0.79 B	0.81 **	0.90
	LL+I	38.65	3.09	-8.44	-27.39 V6			3.09	0.00		
8.40	DL+E	13.00	1.90	0.06	44.11 F1	TN	0.61		0.79 B	0.81 **	0.90
	LL+I	51.17	3.92	-7.09	-26.66 V6		3.82		0.00		
	DL+E	13.00	1.90	0.06	44.11 F1	TN		0.79	0.79 B	0.81 **	0.90
	LL+I	39.48	3.02	-5.47	-26.57 V6			4.95	0.00		
9.80	DL+E	11.76	1.90	2.65	44.42 F1	TN	0.73		0.79 B	0.81 **	0.90
	LL+I	44.98	3.90	10.18	27.61 V5		2.45		0.00		
	DL+E	11.76	1.90	2.65	44.42 F1	TN		0.94	0.79 B	0.81 **	0.90
	LL+I	34.70	3.01	7.85	27.61 V5			3.18	0.00		
10.71	DL+E	9.72	1.90	3.73	44.83 F1	TN	0.93		0.79 B	0.81 **	0.90
	LL+I	37.74	3.69	12.93	28.60 V5		1.91		0.00		
	DL+E	9.72	1.90	3.73	44.83 F1	TN		1.21	0.79 B	0.81 **	0.90
	LL+I	29.11	2.85	9.97	28.67 V5			2.48	0.00		
11.20	DL+E	8.21	1.90		44.38 F1	TN	1.07		0.79 B	0.81 **	0.90
	LL+I	33.82	2.59								
	DL+E	8.21	1.90		44.38 F1	TN		1.39	0.79 B	0.81 **	0.90
	LL+I	26.09	2.00								
12.50	DL+E	2.84	1.90		46.11 F1	TN	2.23		0.79 B	0.57	0.90
	LL+I	19.44	2.39								
	DL+E	2.84	1.90		46.11 F1	TN		2.89	0.79 B	0.57	0.90
	LL+I	15.00	1.85								

SPECIAL Loading: Wall No. 1

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
0.00	DL+E	-0.36	10.12		53.04 F1	TR	4.05		0.20 R	0.54 **	0.90
	LL+I	13.17	24.26								
	DL+E	-0.36	10.12		53.04 F1	TR		5.25	0.20 R	0.54 **	0.90
	LL+I	10.16	18.72								
1.06	DL+E	0.00	10.58	-0.93	48.86 F4	CM	5.60		0.20 R	0.43 **	0.90
	LL+I	8.73	27.29	4.03	13.84 V5		3.67		0.00		
	DL+E	0.00	10.58	-0.93	48.86 F4	CM		7.25	0.20 R	0.43 **	0.90
	LL+I	6.74	21.05	3.11	13.84 V5			4.75	0.00		
2.12	DL+E	2.79	10.33	-0.36	36.32 F4	CM	7.35		0.20 R	0.33 **	0.90
	LL+I	4.56	27.29	4.03	13.84 V5		3.52		0.00		
	DL+E	2.79	10.33	-0.36	36.32 F4	CM		9.53	0.20 R	0.33 **	0.90
	LL+I	3.52	21.05	3.11	13.84 V5			4.57	0.00		
3.17	DL+E	4.22	10.09	0.17	8.11 F4	CM	9.86		0.20 R	0.27 **	0.90
	LL+I	0.39	27.29	4.03	13.84 V5		3.39		0.00		
	DL+E	4.22	10.09	0.17	8.11 F4	CM		12.78	0.20 R	0.27 **	0.90
	LL+I	0.30	21.05	3.11	13.84 V5			4.40	0.00		
4.23	DL+E	4.72	7.36	0.65	6.02 F1	TN	3.83		0.20 R	0.27 **	0.90
	LL+I	0.34	-1.95	4.03	13.20 V2		3.12		0.00		
	DL+E	4.72	7.36	0.65	6.02 F1	TN		4.97	0.20 R	0.27 **	0.90
	LL+I	0.26	-1.50	3.11	13.20 V2			4.04	0.00		
5.29	DL+E	4.05	7.18	1.39	7.31 F1	TN	2.27		0.20 R	0.27 **	0.90
	LL+I	1.44	-2.02	4.03	13.20 V5		2.93		0.00		
	DL+E	4.05	7.18	1.39	7.31 F1	TN		2.94	0.20 R	0.27 **	0.90
	LL+I	1.11	-1.56	3.11	13.20 V5			3.80	0.00		
6.35	DL+E	2.35	7.00	2.30	7.48 F1	TN	2.00		0.20 R	0.27 **	0.90
	LL+I	2.57	-2.01	4.03	13.20 V5		2.71		0.00		
	DL+E	2.35	7.00	2.30	7.48 F1	TN		2.59	0.20 R	0.27 **	0.90
	LL+I	1.98	-1.55	3.11	13.20 V5			3.51	0.00		
7.41	DL+E	-0.25	6.82	3.10	7.35 F1	TN	2.05		0.20 R	0.27 **	0.90
	LL+I	3.70	-2.01	4.03	13.20 V5		2.51		0.00		
	DL+E	-0.25	6.82	3.10	7.35 F1	TN		2.66	0.20 R	0.27 **	0.90
	LL+I	2.86	-1.55	3.11	13.20 V5			3.25	0.00		

SLATEFORD PRELIMINARY CULVERT RATING
LIVE LOAD RATING W/O FWS (cont.)

SPECIAL Loading: Wall No. 1 (cont.)

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
8.06	DL+E	-2.26	6.71	3.55	7.22 F1	TN	2.15		0.20 R	0.27 **	0.90
	LL+I	4.40	-2.00	4.03	13.20 V5		2.40		0.00		
	DL+E	-2.26	6.71	3.55	7.22 F1	TN		2.79	0.20 R	0.27 **	0.90
	LL+I	3.40	-1.54	3.11	13.20 V5			3.11	0.00		
8.47	DL+E	-5.01	8.84		-47.16 F2	TN	2.01		0.79 L	0.56	0.90
	LL+I	-20.92	23.56								
	DL+E	-5.01	8.84		-47.16 F2	TN		2.61	0.79 L	0.56	0.90
	LL+I	-16.14	18.18								
9.08	DL+E	-7.47	8.70		-41.43 F2	TN	1.45		0.79 L	0.56	0.90
	LL+I	-23.40	23.56								
	DL+E	-7.47	8.70		-41.43 F2	TN		1.88	0.79 L	0.56	0.90
	LL+I	-18.05	18.18								

SPECIAL Loading: Wall No. 2

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
0.00	DL+E	-0.00	27.16		-3.37 F4	CM	8.21		0.20 L	0.49 **	0.90
	LL+I	-0.41	64.21								
	DL+E	-0.00	27.16		-3.37 F4	CM		10.64	0.20 L	0.49 **	0.90
	LL+I	-0.32	49.54								
1.06	DL+E	-0.00	26.67		0.21 F4	CM	8.22		0.20 R	0.49 **	0.90
	LL+I	0.03	64.21								
	DL+E	-0.00	26.67		0.21 F4	CM		10.65	0.20 R	0.49 **	0.90
	LL+I	0.02	49.54								
2.12	DL+E	-0.00	26.17		3.80 F4	CM	8.23		0.20 R	0.49 **	0.90
	LL+I	0.46	64.21								
	DL+E	-0.00	26.17		3.80 F4	CM		10.66	0.20 R	0.49 **	0.90
	LL+I	0.36	49.54								
2.29	DL+E	-0.00	26.09	0.00	4.39 F4	CM	8.23		0.20 R	0.49 **	0.90
	LL+I	0.53	64.21	5.00	30.58 V5		6.11		0.00		
	DL+E	-0.00	26.09	0.00	4.39 F4	CM		10.67	0.20 R	0.49 **	0.90
	LL+I	0.41	49.54	3.86	30.58 V5			7.92	0.00		
3.17	DL+E	-0.00	25.68	0.00	7.39 F4	CM	8.23		0.20 R	0.49 **	0.90
	LL+I	0.90	64.21	5.00	30.58 V5		6.11		0.00		
	DL+E	-0.00	25.68	0.00	7.39 F4	CM		10.67	0.20 R	0.49 **	0.90
	LL+I	0.69	49.54	3.86	30.58 V5			7.92	0.00		
4.23	DL+E	-0.00	25.18	0.00	11.00 F4	CM	8.24		0.20 R	0.49 **	0.90
	LL+I	1.33	64.21	5.00	30.58 V5		6.11		0.00		
	DL+E	-0.00	25.18	0.00	11.00 F4	CM		10.68	0.20 R	0.49 **	0.90
	LL+I	1.03	49.54	3.86	30.58 V5			7.92	0.00		
5.29	DL+E	-0.00	24.68	0.00	14.60 F4	CM	8.25		0.20 R	0.49 **	0.90
	LL+I	1.77	64.21	5.00	30.58 V5		6.11		0.00		
	DL+E	-0.00	24.68	0.00	14.60 F4	CM		10.69	0.20 R	0.49 **	0.90
	LL+I	1.37	49.54	3.86	30.58 V5			7.92	0.00		
6.35	DL+E	-0.00	22.77	0.00	201.70 F1	CM	7.77		0.20 R	0.51 **	0.90
	LL+I	25.96	41.77	5.00	30.58 V5		6.11		0.00		
	DL+E	-0.00	22.77	0.00	201.70 F1	CM		10.07	0.20 R	0.51 **	0.90
	LL+I	20.03	32.22	3.86	30.58 V5			7.92	0.00		
6.79	DL+E	-0.00	22.57	0.00	209.72 F1	CM	7.45		0.20 R	0.56 **	0.90
	LL+I	28.17	41.77	5.00	30.58 V2		6.11		0.00		
	DL+E	-0.00	22.57	0.00	209.72 F1	CM		9.65	0.20 R	0.56 **	0.90
	LL+I	21.73	32.22	3.86	30.58 V2			7.92	0.00		
7.41	DL+E	-0.00	22.28		218.15 F1	TR	6.98		0.20 R	0.62 **	0.90
	LL+I	31.25	41.77								
	DL+E	-0.00	22.28		218.15 F1	TR		9.05	0.20 R	0.62 **	0.90
	LL+I	24.11	32.22								
8.47	DL+E	-0.00	21.78		219.01 F1	TR	5.99		0.20 R	0.73 **	0.90
	LL+I	36.55	41.77								
	DL+E	-0.00	21.78		219.01 F1	TR		7.77	0.20 R	0.73 **	0.90
	LL+I	28.19	32.22								
9.08	DL+E	-0.00	21.49		219.42 F1	TR	5.54		0.20 R	0.79 **	0.90
	LL+I	39.63	41.77								
	DL+E	-0.00	21.49		219.42 F1	TR		7.18	0.20 R	0.79 **	0.90
	LL+I	30.57	32.22								

SLATEFORD PRELIMINARY CULVERT RATING
LIVE LOAD RATING W/O FWS (cont.)

SPECIAL Loading: Wall No. 2 (cont.)

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor

SPECIAL Loading: Wall No. 3

Dist (ft)		Fact Moment (kips-ft)	Fact Thrust (kips)	Fact Shear (kips)	Fact Resist (kips-ft) (kips)	Zone	Rating Factor IR STR-I	Rating Factor OR STR-II	Prov Reinf (in^2)	Min Reinf (in^2)	Phi Factor
0.00	DL+E	0.36	10.12		-52.96 F2	TR	4.05		0.20 L	0.54 **	0.90
	LL+I	-13.18	23.84								
	DL+E	0.36	10.12		-52.96 F2	TR		5.25	0.20 L	0.54 **	0.90
	LL+I	-10.16	18.39								
1.06	DL+E	-0.00	10.58	0.93	-48.83 F4	CM	5.57		0.20 L	0.43 **	0.90
	LL+I	-8.76	27.43	-4.03	-13.84 V6		3.67		0.00		
	DL+E	-0.00	10.58	0.93	-48.83 F4	CM		7.22	0.20 L	0.43 **	0.90
	LL+I	-6.76	21.16	-3.11	-13.84 V6			4.75	0.00		
2.12	DL+E	-2.79	10.33	0.36	-36.30 F4	CM	7.32		0.20 L	0.33 **	0.90
	LL+I	-4.58	27.43	-4.03	-13.84 V6		3.52		0.00		
	DL+E	-2.79	10.33	0.36	-36.30 F4	CM		9.48	0.20 L	0.33 **	0.90
	LL+I	-3.53	21.16	-3.11	-13.84 V6			4.57	0.00		
3.17	DL+E	-4.22	10.09	-0.17	-8.10 F4	CM	9.81		0.20 L	0.27 **	0.90
	LL+I	-0.40	27.43	-4.03	-13.84 V6		3.39		0.00		
	DL+E	-4.22	10.09	-0.17	-8.10 F4	CM		12.71	0.20 L	0.27 **	0.90
	LL+I	-0.31	21.16	-3.11	-13.84 V6			4.40	0.00		
4.23	DL+E	-4.72	7.36	-0.65	-6.03 F2	TN	3.84		0.20 L	0.27 **	0.90
	LL+I	-0.34	-1.94	-4.03	-13.20 V1		3.12		0.00		
	DL+E	-4.72	7.36	-0.65	-6.03 F2	TN		4.98	0.20 L	0.27 **	0.90
	LL+I	-0.26	-1.50	-3.11	-13.20 V1			4.04	0.00		
5.29	DL+E	-4.05	7.18	-1.39	-7.31 F2	TN	2.27		0.20 L	0.27 **	0.90
	LL+I	-1.44	-2.02	-4.03	-13.20 V6		2.93		0.00		
	DL+E	-4.05	7.18	-1.39	-7.31 F2	TN		2.94	0.20 L	0.27 **	0.90
	LL+I	-1.11	-1.56	-3.11	-13.20 V6			3.80	0.00		
6.35	DL+E	-2.35	7.00	-2.30	-7.48 F2	TN	2.00		0.20 L	0.27 **	0.90
	LL+I	-2.57	-2.01	-4.03	-13.20 V6		2.71		0.00		
	DL+E	-2.35	7.00	-2.30	-7.48 F2	TN		2.59	0.20 L	0.27 **	0.90
	LL+I	-1.98	-1.55	-3.11	-13.20 V6			3.51	0.00		
7.41	DL+E	0.25	6.82	-3.10	-7.35 F2	TN	2.05		0.20 L	0.27 **	0.90
	LL+I	-3.70	-2.00	-4.03	-13.20 V6		2.51		0.00		
	DL+E	0.25	6.82	-3.10	-7.35 F2	TN		2.66	0.20 L	0.27 **	0.90
	LL+I	-2.86	-1.55	-3.11	-13.20 V6			3.25	0.00		
8.04	DL+E	2.20	6.71	-3.53	-7.22 F2	TN	2.15		0.20 L	0.27 **	0.90
	LL+I	-4.38	-2.00	-4.03	-13.20 V6		2.40		0.00		
	DL+E	2.20	6.71	-3.53	-7.22 F2	TN		2.78	0.20 L	0.27 **	0.90
	LL+I	-3.38	-1.55	-3.11	-13.20 V6			3.11	0.00		
8.47	DL+E	5.01	8.84		47.62 F1	TN	2.04		0.79 R	0.56	0.90
	LL+I	20.92	23.84								
	DL+E	5.01	8.84		47.62 F1	TN		2.64	0.79 R	0.56	0.90
	LL+I	16.14	18.39								
9.08	DL+E	7.47	8.70		41.73 F1	TN	1.46		0.79 R	0.56	0.90
	LL+I	23.40	23.84								
	DL+E	7.47	8.70		41.73 F1	TN		1.90	0.79 R	0.56	0.90
	LL+I	18.05	18.39								

** Warning: The provided area of steel is less than the required minimum area of steel.

SLATEFORD PRELIMINARY CULVERT RATING
LIVE LOAD RATING W/O FWS (cont.)

F or V reported after the Fact Resist indicates whether the Rating is for Flexure (F) or Shear (V). The numerical code reported after F or V corresponds to the governing Maximum Effect Case for the Rating Factor.

Maximum Effect Cases:

1	Maximum Positive	Moment and Concurrent Thrust
2	Maximum Negative	Moment and Concurrent Thrust
3	Maximum Tension	Thrust and Concurrent Moment
4	Maximum Compression	Thrust and Concurrent Moment
5	Maximum Positive	Shear and Concurrent Moment
6	Maximum negative	Shear and Concurrent Moment

T, B, L, or R reported after the Reinforcement (Reinf) indicates the location of the flexural reinforcement reported:

T	Top	steel in a slab
B	Bottom	steel in a slab
L	Left	steel in a wall
R	Right	steel in a wall

Zone Code Descriptions
TN - Tension controlled section
TR - Transition section
CM - Compression controlled section

Phi Factor Epsilon (cl) = 0.00200
Phi Factor Epsilon (tl) = 0.00500

Note: Wall distances begin at the bottom of the wall and slab distances begin at the left side of the slab.

SLATEFORD PRELIMINARY CULVERT RATING
STRIP FOOTING PERFORMANCE RATIOS W/O FWS

Wall No. 1

Dist (ft)	Flexure Loading Code A B C D	Fact Moment (kips-ft)	Moment Resist (kips-ft)	Phi Factor	Moment Perf Ratio	Shear Loading Code A B C D	Fact Shear (kips)	Shear Resist (kips)	Shear Perf Ratio
1.66L						1 1 7 2	-5.23	-21.42	4.10
0.00LT	1 1 7 2	20.31	39.25	0.90	1.93	1 6 7 2	4.35	21.42	4.92
LB	1 1 7 2	20.31	39.25	0.90	1.93				
0.00RT	1 4 7 2	12.42	39.25	0.90	3.16				
RB	1 4 7 2	12.42	39.25	0.90	3.16				
1.66R						1 2 7 2	1.55	21.42	13.77

Wall No. 2

Dist (ft)	Flexure Loading Code A B C D	Fact Moment (kips-ft)	Moment Resist (kips-ft)	Phi Factor	Moment Perf Ratio	Shear Loading Code A B C D	Fact Shear (kips)	Shear Resist (kips)	Shear Perf Ratio
1.66L						1 5 7 2	-4.30	-21.42	4.98
0.00LT	1 4 7 2	27.84	39.25	0.90	1.41				
LB	1 4 7 2	27.84	39.25	0.90	1.41				
0.00RT	1 4 7 2	28.39	39.25	0.90	1.38				
RB	1 4 7 2	28.39	39.25	0.90	1.38				
1.66R						1 6 7 2	4.31	21.42	4.97

Wall No. 3

Dist (ft)	Flexure Loading Code A B C D	Fact Moment (kips-ft)	Moment Resist (kips-ft)	Phi Factor	Moment Perf Ratio	Shear Loading Code A B C D	Fact Shear (kips)	Shear Resist (kips)	Shear Perf Ratio
1.66L						1 1 7 2	-1.55	-21.42	13.78
0.00LT	1 4 7 2	12.45	39.25	0.90	3.15				
LB	1 4 7 2	12.45	39.25	0.90	3.15				
0.00RT	1 2 7 2	20.14	39.25	0.90	1.95	1 5 7 2	-4.35	-21.42	4.92
RB	1 2 7 2	20.14	39.25	0.90	1.95				
1.66R						1 2 7 2	5.19	21.42	4.13

L or R after the distance indicates the Left or Right side of the strip footing.

T or B after the distance indicates the location of the flexural reinforcement reported:
T Top steel in footing
B Bottom steel in footing

Flexure/Shear Loading Codes:

Code A	Code B		Code C	Code D
1 Strength-I	1 Maximum Positive	Moment	1 PHL-93	1 On Deck
2 Strength-II	2 Maximum Negative	Moment	2 HL-93	2 Thru Fill
3 Strength-IA	3 Maximum Tension	Thrust	3 P-82	
	4 Maximum Compression	Thrust	4 ML-80	
	5 Maximum Positive	Shear	5 HS-20	
	6 Maximum Negative	Shear	6 H-20	
			7 SLL	
			8 TK527	
			9 EV2	
			Z EV3	
			Y SU6TV	
			X PA2016-13	

SLATEFORD PRELIMINARY CULVERT RATING
RATING SUMMARY W/O FWS

Loading: SPECIAL

Member	No.	Dist (ft)	Dist/ Span Ratio	IR Rating Factor STR-I		IR Rating Tonnage (ton)	Dist (ft)	Dist/ Span Ratio	OR Rating Factor STR-II		OR Rating Tonnage (ton)
Top Slab	1	5.60	0.40	0.61	F	345.43	5.60	0.40	0.79	F	447.78
Top Slab	2	8.40	0.60	0.61	F	345.40	8.40	0.60	0.79	F	447.74
Wall	1	9.08	0.86	1.45	F	824.29	9.08	0.86	1.88	F	999.99
Wall	2	9.08	0.86	5.54	F	999.99	9.08	0.86	7.18	F	999.99
Wall	3	9.08	0.86	1.46	F	831.46	9.08	0.86	1.90	F	999.99

The Minimum Inventory Rating is governed by FLEXURE.
The Minimum Inventory Rating Factor is 0.61 at Distance 8.40 (ft)
in: Top Slab 2

The Minimum Operating Rating is governed by FLEXURE.
The Minimum Operating Rating Factor is 0.79 at Distance 8.40 (ft)
in: Top Slab 2

F or V reported after the Rating Factor indicates whether the Rating
is for Flexure (F) or Shear (V).

Note: Wall distances begin at the bottom of the wall and slab distances
begin at the left side of the slab.

SLATEFORD PRELIMINARY CULVERT RATING
RATING SUMMARY W/O FWS (cont.)

C O M B I N E D
R A T I N G S U M M A R Y

INVENTORY RATING (IR)	Member	SPECIAL Top Slab 2
	Dist. (ft)	8.40
	Limit State	STR-I
	Rating	0.61 F
	Rating Tons	345.40
OPERATING RATING (OR)	Member	SPECIAL Top Slab 2
	Dist. (ft)	8.40
	Limit State	STR-II
	Rating	0.79 F
	Rating Tons	447.74

All ratings are based on the exclusion of the design future wearing surface.

F or V reported after the Rating Factor indicates whether the Rating is for Flexure (F) or Shear (V).

SLATEFORD PRELIMINARY CULVERT RATING
MINIMUM REINFORCEMENT CHECK

Top Slab No. 1 - Top Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
1.50	42.14+	-7.64	0.14	0.45*	N/A	0.900	1.270	
2.80	42.14+	-0.78	0.01	0.45*	N/A	0.900	1.270	
3.29	42.14+			0.45*	N/A		1.270	
4.20	42.14+			0.45*	N/A		1.270	
5.60	42.14+			0.45*	N/A		1.270	
7.00	42.14+	-1.11	0.02	0.45*	N/A	0.900	1.270	
8.40	42.14+	-6.11	0.12	0.45*	N/A	0.900	1.270	
9.80	42.14+	-14.27	0.27	0.45*	N/A	0.900	1.270	
10.71	42.14+	-32.65	0.62*	0.45	N/A	0.900	1.270	
11.20	42.14	-44.81+	0.81*	0.45	N/A	0.900	1.270	
12.50	42.14	-81.75+	0.81*	0.45	N/A	0.900	1.270	

Top Slab No. 1 - Bottom Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
1.50	42.14+	29.72	0.57*	0.45	N/A	0.900	0.790	
2.80	42.14	56.02+	0.81*	0.45	N/A	0.900	0.790	A
3.29	42.14	63.27+	0.81*	0.45	N/A	0.900	0.790	A
4.20	42.14	75.65+	0.81*	0.45	N/A	0.900	0.790	A
5.60	42.14	85.56+	0.81*	0.45	N/A	0.900	0.790	A
7.00	42.14	82.68+	0.81*	0.45	N/A	0.900	0.790	A
8.40	42.14	66.10+	0.81*	0.45	N/A	0.900	0.790	A
9.80	42.14+	37.16	0.71*	0.45	N/A	0.900	0.790	
10.71	42.14+	14.21	0.27	0.45*	N/A	0.900	0.790	
11.20	42.14+	5.25	0.10	0.45*	N/A	0.900	0.790	
12.50	42.14+			0.45*	N/A		0.790	

Top Slab No. 2 - Top Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
1.50	42.14	-81.74+	0.81*	0.45	N/A	0.900	1.270	
2.80	42.14	-44.82+	0.81*	0.45	N/A	0.900	1.270	
3.29	42.14+	-32.64	0.62*	0.45	N/A	0.900	1.270	
4.20	42.14+	-14.26	0.27	0.45*	N/A	0.900	1.270	
5.60	42.14+	-6.11	0.12	0.45*	N/A	0.900	1.270	
7.00	42.14+	-1.11	0.02	0.45*	N/A	0.900	1.270	
8.40	42.14+			0.45*	N/A		1.270	
9.80	42.14+			0.45*	N/A		1.270	
10.71	42.14+			0.45*	N/A		1.270	
11.20	42.14+	-0.78	0.01	0.45*	N/A	0.900	1.270	
12.50	42.14+	-7.64	0.14	0.45*	N/A	0.900	1.270	

Top Slab No. 2 - Bottom Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
1.50	42.14+			0.45*	N/A		0.790	
2.80	42.14+	5.26	0.10	0.45*	N/A	0.900	0.790	
3.29	42.14+	14.22	0.27	0.45*	N/A	0.900	0.790	
4.20	42.14+	37.17	0.71*	0.45	N/A	0.900	0.790	
5.60	42.14	66.10+	0.81*	0.45	N/A	0.900	0.790	A
7.00	42.14	82.69+	0.81*	0.45	N/A	0.900	0.790	A
8.40	42.14	85.56+	0.81*	0.45	N/A	0.900	0.790	A
9.80	42.14	75.65+	0.81*	0.45	N/A	0.900	0.790	A
10.71	42.14	63.27+	0.81*	0.45	N/A	0.900	0.790	A
11.20	42.14	56.03+	0.81*	0.45	N/A	0.900	0.790	A
12.50	42.14+	29.71	0.57*	0.45	N/A	0.900	0.790	

SLATEFORD PRELIMINARY CULVERT RATING
MINIMUM REINFORCEMENT CHECK (cont.)

Top Slab No. 2 - Bottom Face (cont.)

Wall No. 1 - Left Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
0.00	16.46+	-12.39	0.42*	0.27	N/A	0.900	0.790	
1.06	16.46+	-4.86	0.16	0.27*	N/A	0.900	0.790	
2.12	16.46+	-0.85	0.03	0.27*	N/A	0.900	0.790	
3.17	16.46+			0.27*	N/A		0.790	
4.23	16.46+	-3.46	0.11	0.27*	N/A	0.900	0.790	
5.29	16.46+	-10.37	0.35*	0.27	N/A	0.900	0.790	
6.35	16.46	-17.86+	0.56*	0.27	N/A	0.900	0.790	
7.41	16.46	-25.87+	0.56*	0.27	N/A	0.900	0.790	
8.06	16.46	-31.06+	0.56*	0.27	N/A	0.900	0.790	
8.47	16.46	-34.57+	0.56*	0.27	N/A	0.900	0.790	
9.08	16.46	-41.16+	0.56*	0.27	N/A	0.900	0.790	

Wall No. 1 - Right Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
0.00	16.46	17.09+	0.54*	0.27	N/A	0.900	0.200	A
1.06	16.46+	13.15	0.43*	0.27	N/A	0.900	0.200	A
2.12	16.46+	9.92	0.33*	0.27	N/A	0.900	0.200	A
3.17	16.46+	6.35	0.21	0.27*	N/A	0.900	0.200	A
4.23	16.46+	6.75	0.22	0.27*	N/A	0.900	0.200	A
5.29	16.46+	7.32	0.24	0.27*	N/A	0.900	0.200	A
6.35	16.46+	6.56	0.21	0.27*	N/A	0.900	0.200	A
7.41	16.46+	4.60	0.15	0.27*	N/A	0.900	0.200	A
8.06	16.46+	2.85	0.09	0.27*	N/A	0.900	0.200	A
8.47	16.46+	1.82	0.06	0.27*	N/A	0.900	0.200	A
9.08	16.46+	1.10	0.04	0.27*	N/A	0.900	0.200	A

Wall No. 2 - Left Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
0.00	65.85+	-8.48	0.12	0.49*	N/A	0.900	0.200	A
1.06	65.85+	-2.70	0.04	0.49*	N/A	0.900	0.200	A
2.12	65.85+	-6.68	0.10	0.49*	N/A	0.900	0.200	A
2.29	65.85+	-7.76	0.11	0.49*	N/A	0.900	0.200	A
3.17	65.85+	-13.45	0.20	0.49*	N/A	0.900	0.200	A
4.23	65.85+	-20.50	0.30	0.49*	N/A	0.900	0.200	A
5.29	65.85+	-27.55	0.41	0.49*	N/A	0.900	0.200	A
6.35	65.85+	-34.61	0.51*	0.49	N/A	0.900	0.200	A
6.79	65.85+	-37.56	0.56*	0.49	N/A	0.900	0.200	A
7.41	65.85+	-41.67	0.62*	0.49	N/A	0.900	0.200	A
8.47	65.85+	-48.73	0.73*	0.49	N/A	0.900	0.200	A
9.08	65.85+	-52.84	0.79*	0.49	N/A	0.900	0.200	A

Wall No. 2 - Right Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
0.00	65.85+	8.48	0.12	0.49*	N/A	0.900	0.200	A
1.06	65.85+	2.70	0.04	0.49*	N/A	0.900	0.200	A
2.12	65.85+	6.68	0.10	0.49*	N/A	0.900	0.200	A
2.29	65.85+	7.76	0.11	0.49*	N/A	0.900	0.200	A
3.17	65.85+	13.45	0.20	0.49*	N/A	0.900	0.200	A
4.23	65.85+	20.50	0.30	0.49*	N/A	0.900	0.200	A
5.29	65.85+	27.55	0.41	0.49*	N/A	0.900	0.200	A
6.35	65.85+	34.61	0.51*	0.49	N/A	0.900	0.200	A

SLATEFORD PRELIMINARY CULVERT RATING
MINIMUM REINFORCEMENT CHECK (cont.)

Wall No. 2 - Right Face (cont.)

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
6.79	65.85+	37.56	0.56*	0.49	N/A	0.900	0.200	A
7.41	65.85+	41.67	0.62*	0.49	N/A	0.900	0.200	A
8.47	65.85+	48.73	0.73*	0.49	N/A	0.900	0.200	A
9.08	65.85+	52.84	0.79*	0.49	N/A	0.900	0.200	A

Wall No. 3 - Left Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
0.00	16.46	-17.09+	0.54*	0.27	N/A	0.900	0.200	A
1.06	16.46+	-13.15	0.43*	0.27	N/A	0.900	0.200	A
2.12	16.46+	-9.92	0.33*	0.27	N/A	0.900	0.200	A
3.17	16.46+	-6.35	0.21	0.27*	N/A	0.900	0.200	A
4.23	16.46+	-6.75	0.22	0.27*	N/A	0.900	0.200	A
5.29	16.46+	-7.32	0.24	0.27*	N/A	0.900	0.200	A
6.35	16.46+	-6.56	0.21	0.27*	N/A	0.900	0.200	A
7.41	16.46+	-4.60	0.15	0.27*	N/A	0.900	0.200	A
8.04	16.46+	-2.92	0.09	0.27*	N/A	0.900	0.200	A
8.47	16.46+	-1.82	0.06	0.27*	N/A	0.900	0.200	A
9.08	16.46+	-1.10	0.04	0.27*	N/A	0.900	0.200	A

Wall No. 3 - Right Face

Dist (ft)	Cracking Moment M(cr) (kip-ft)	4/3*M(u) (kip-ft)	Rho Min Area (in^2)	Temp Shrink Area (in^2)	0.002 Ag (in^2)	Phi Factor (in^2)	Area Prov/ Width (in^2)	Status Code
0.00	16.46+	12.39	0.42*	0.27	N/A	0.900	0.790	
1.06	16.46+	4.86	0.16	0.27*	N/A	0.900	0.790	
2.12	16.46+	0.85	0.03	0.27*	N/A	0.900	0.790	
3.17	16.46+			0.27*	N/A		0.790	
4.23	16.46+	3.46	0.11	0.27*	N/A	0.900	0.790	
5.29	16.46+	10.37	0.35*	0.27	N/A	0.900	0.790	
6.35	16.46	17.87+	0.56*	0.27	N/A	0.900	0.790	
7.41	16.46	25.88+	0.56*	0.27	N/A	0.900	0.790	
8.04	16.46	30.89+	0.56*	0.27	N/A	0.900	0.790	
8.47	16.46	34.58+	0.56*	0.27	N/A	0.900	0.790	
9.08	16.46	41.16+	0.56*	0.27	N/A	0.900	0.790	

Status Code Descriptions
+ - Controlling moment for Rho Min Area calculation
* - Controlling minimum area of steel
A - Area provided smaller than required minimum area of steel

SLATEFORD PRELIMINARY CULVERT RATING
STRIP FOOTING BEARING PRESSURE

Wall No. 1

Live Load	Locn	STR-I e/B Ratio	STR-I Bearing Pressure (ksf)	STR-II e/B Ratio	STR-II Bearing Pressure (ksf)	SER-I e/B Ratio	SER-I Bearing Pressure (ksf)
SPECIAL	L	-0.16 *	12.38	-0.13	10.55	-0.09	7.50
	R		6.00		5.65		4.24

L Left edge of the footing
R Right edge of the footing

A maximum value for qb of 9.67 (ksf) (qb = N/Be) occurs for the STR-I limit state, SPECIAL live load, maximum effect case 1. For this reported condition, Be is 4.40 (ft). This average pressure is used in the calculation of settlement for soils.

Wall No. 2

Live Load	Locn	STR-I e/B Ratio	STR-I Bearing Pressure (ksf)	STR-II e/B Ratio	STR-II Bearing Pressure (ksf)	SER-I e/B Ratio	SER-I Bearing Pressure (ksf)
SPECIAL	L	-0.04	14.26	-0.04	12.04	-0.04	9.10
	R		14.61 *		12.31 *		9.30 *

L Left edge of the footing
R Right edge of the footing

A maximum value for qb of 14.49 (ksf) (qb = N/Be) occurs for the STR-I limit state, SPECIAL live load, maximum effect case 4. For this reported condition, Be is 6.47 (ft). This average pressure is used in the calculation of settlement for soils.

Wall No. 3

Live Load	Locn	STR-I e/B Ratio	STR-I Bearing Pressure (ksf)	STR-II e/B Ratio	STR-II Bearing Pressure (ksf)	SER-I e/B Ratio	SER-I Bearing Pressure (ksf)
SPECIAL	L	0.16	6.01	0.13 *	5.66	0.09 *	4.25
	R		12.31		10.50		7.47

L Left edge of the footing
R Right edge of the footing

A maximum value for qb of 9.61 (ksf) (qb = N/Be) occurs for the STR-I limit state, SPECIAL live load, maximum effect case 6. For this reported condition, Be is 4.39 (ft). This average pressure is used in the calculation of settlement for soils.

* Indicates the maximum e/B Ratio and Footing Pressure, among all maximum effect cases, for each limit state.

SLATEFORD PRELIMINARY CULVERT RATING
QUANTITIES

Volume of Concrete

Based on a segment length of: 82.50 ft.

Top Slab:	201.67	(yd^3)
Left Wall:	40.42	(yd^3)
Interior Wall:	80.84	(yd^3)
Right Wall:	40.42	(yd^3)
Haunches:	13.75*	(yd^3)
Strip Footing:	99.31	(yd^3)
TOTAL:	476.41	(yd^3)

* All haunches are included only in this total

SLATEFORD PRELIMINARY CULVERT RATING

Table of Contents

History of Reinforcing Steel

Reinforcing Steel Timeline

Historical Resources (http://resources.crsi.org/resources-search/?tag=Historical)

Year	Event
1910	First reinforcing bar specifications issued.
1911	ASTM A15 published with grades 33 and 50.
1914	ASTM A15 revised by adding grade 40.
1924	The American Association of State Highway Officials (AASHO) issued its first standard for concrete reinforcement, AASHO M 31.
1928	First hot-dip galvanized reinforcing bar specifications published, ASTM A123.
1947	ASTM A305 published; it included rebar deformation patterns.
1953	U.S. Navy uses galvanized rebar in a bridge in Bermuda.
1957	ASTM A408 published; it covered large diameter bars (no.14 and no.18 bars) in three different grades.
1958	ASTM A431 published; it included grade 75 rebar.
1959	ASTM A432 published; it included grade 60 rebar.
1968	ASTM A305, ASTM A408, ASTM A431, and ASTM A432 withdrawn. ASTM A615 published (replaced ASTM A15, ASTM A408, ASTM A431, ASTM A432, and portions of ASTM A305) with grades 40, 60, and 75.
1969	ASTM A15 withdrawn.
1972	ASTM A615 revised, removing grade 75 rebar.
1973	Epoxy-coated rebar first used in a U.S. bridge.
1974	ASTM A706 published for rebars with improved weldability.
1979	ASTM A767 published for zinc-coated (galvanized) rebars.
1981	ASTM A775 for epoxy-coated rebars and ASTM D3963 for handling of epoxycoated bars published.

1982 The American Association of State Highway and Transportation Officials (AASHTO) published the metric version of standard M31, known as AASHTO M 31M.

1983 Stainless steel rebar first used in U.S. bridges.

1987 ASTM A615 revised, reinstating grade 75. AASHTO published M 284 for epoxy-coated rebars.

1989 ASTM A775/A775M revised to change damage threshold and add anchor profile.

1990 ASTM A775/A775M revised with provisions for repairing damaged coating.
FHWA memorandum issued on certification programs.

1991 The Concrete Reinforcing Steel Institute (CRSI) began a certification program for epoxy-coating applicator plants.

1992 ASTM A775/A775M revised to change the coating thickness.

1994 ASTM A775/A775M revised to change the bend tests.

1995 ASTM A934/A934M published for prefabricated epoxy-coated rebar. ASTM A775/A75M revised to allow a chemical wash for surface preparation.

1996 ASTM A955/A955M published for stainless steel rebars.

1997 Cathodic debonding introduced in ASTM A775/A775M and A934/A934M.

2001 AASHTO issued AASHTO M 317M/M 317.

2003 ASTM A995 revised.

2004 ASTM A1035/A1035M published.
ASTM A615/A615M renamed.
ASTM A775/775M revised.
AASHTO MP 13M/MP 13 published.

2007 ASTM A955 revised.

2008 ASTM A1055 published for zinc and epoxy dual coated rebars.

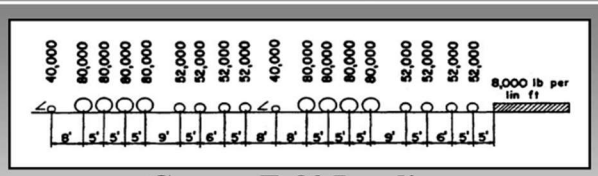
2009 STM A615/A615M revised, adding grade 80.
ASTM A706/A706M revised, adding grade 80.
AASHTO MP 18M/MP 18 published.

2012 AASHTO discontinued AASHTO M 284M/M 284. It was replaced by ASTM A775/A775M.
AASHTO discontinued AASHTO M 317M/M 317. It was replaced by ASTM D3963/D3963M.

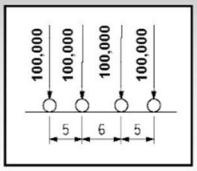
2015 ASTM A615/A615M revised, adding grade 100.
ASTM A1035/A1035M revised.
ASTM A1094/A1094M published for continuous hot-dip galvanized steel rebars.
AASHTO updated AASHTO MP 18M/MP 18.

NOTE: Information based on FHWA Publication No.: FHWA-HRT-16-012

Loading



Cooper E-80 Loading



One E-80 (Locomotive) Axle = Highway Truck (HS-20)!

Alternate Live Load

AREMA

Standard gauge [edit]

Main article: Standard-gauge railway

In common usage the term "standard gauge" refers to 1,435 mm (4 ft 8½ in).

Concrete @ your Fingertips

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Strength of historic concrete

The strength of the concrete in historic structures is likely to be very variable. The only sure way of determining it is to carry out appropriate tests (see **Testing/Hardened concrete/Core testing for strength**). However, if design information is available, guidance on the likely minimum concrete strength may be obtained from the Codes of Practice current at the time.

CP 114, *Structural use of reinforced concrete in buildings*, which was first published in 1948, specified three nominal concrete mixes on the basis of cement: fine aggregate: coarse aggregate ratios by volume, namely 1:1:2, 1:1½:3 and 1:2:4. Minimum 28-day cube strengths for the three mixes were given as 4500, 3750 and 3000lb/sq. inch respectively (i.e. approximately 31, 26 and 21N/mm^2).

CP 115, *The structural use of prestressed concrete in buildings*, which was first published in 1959, specified minimum 28-day cube strengths of 6000lb/sq. inch (approximately 41N/mm^2) for pre-tensioned concrete and 4500lb/sq. inch (approximately 31N/mm^2) for post-tensioned concrete.

CP 116, *The structural use of precast concrete*, published in 1965, specified 5 grades of concrete ranging from Grade A (3000lb/sq. inch or approximately 21N/mm^2) to Grade E (7500lb/sq. inch or approximately 52N/mm^2).

CP110, *The structural use of concrete*, was published in 1972. Described as “The Unified Code” it brought together the separate codes relating to reinforced, prestressed and precast concrete. Design in CP 110 (and all subsequent Codes) was based on specified concrete grades. Minimum concrete grades were specified for different types of element: 20N/mm^2 for reinforced concrete, 30N/mm^2 for post-tensioned prestressed concrete and 40N/mm^2 for pre-tensioned prestressed concrete.

Further information may be found in Concrete Society Technical Report 70, *Historical approaches to the design of concrete buildings and structures*, which also includes information on likely steel strengths, allowable materials etc.

Other references:Scott, WL, Glanville, W and Thomas, FG. *Explanatory handbook on the BS Code of Practice for reinforced concrete*, 1950 (revised 1957)

Walley, F and Bate, SCC. *A guide to the BS Code of Practice for prestressed concrete CP 115: 1959*, 1961

Bate, SCC et al. *Handbook to the unified Code for structural concrete (CP110: 1972)*, 1972.

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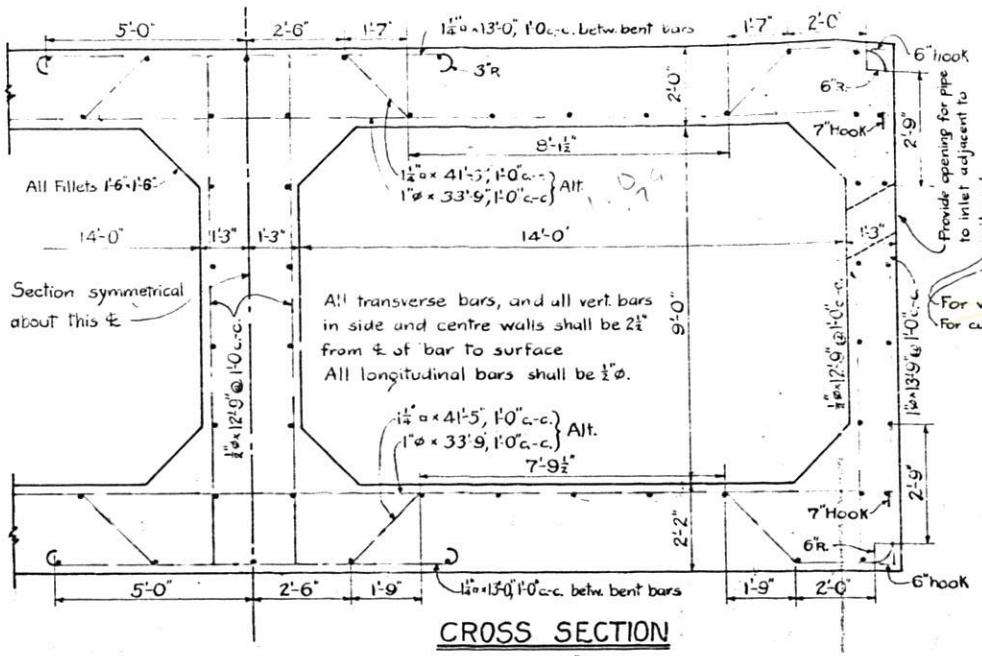
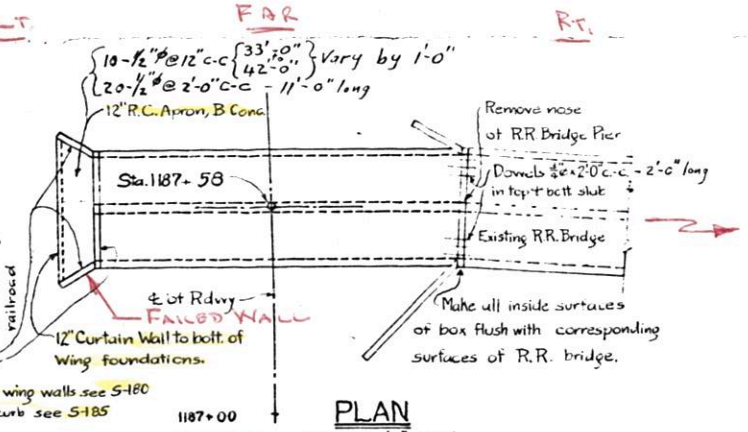


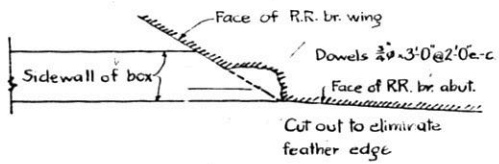
CROSS SECTION

SCALE: ⅜" = 1'-0"



PLAN

SCALE: 1/30 = 1'-0"



JOINT DETAILS

SCALE: ⅜" = 1'-0"

Box shall be Class A Concrete

QUANTITIES

7.1 C.Y. Class A Concrete per lineal foot.

915 Lbs Plain Steel Bars " " "

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF HIGHWAYS

R.C. DOUBLE BOX CULVERT

2 - 14'-0" SPANS 9'-0" CLEAR

STA. 1187+58 R 166-8 NORTHAMPTON CO.

SCALES AS SHOWN

DESIGNED BY H.E.K.

CHECKED BY C.E.P.M. 10-14-35

L-352

BMS 48-0611-0660-1282