

# **Culvert Load Capacity Assessment Report**

**Existing Culvert on SC 18  
Near I-85 Exit 95 Over  
Providence Branch**

**Project ID: P027114**

**Cherokee County, South Carolina**

**Prepared for:  
The South Carolina  
Department of Transportation**

**Report prepared by:**



Mead & Hunt, Inc.  
878 South Lake Dr.  
Lexington, SC 29072  
[www.meadhunt.com](http://www.meadhunt.com)

April 4, 2016

## **CULVERT INFORMATION**

The existing twin box culvert is located on SC 18 (N. Limestone St.) near the I-85 Exit 95/SC 18 (Gaffney) exit over Providence Branch in Cherokee County, South Carolina. The twin cast-in-place reinforced concrete culvert was originally constructed in the year 1937 and later was lengthened in the year 1970 with same size culvert. The length of twin culverts built in 1937 was 63 Ft. and the after extensions in the year 1970, the total length of culvert is 94 ft. The material properties of the original 1937 construction is unknown. Based on the Manual of Bridge Evaluation, for the twin box culvert constructed in the year 1937, a concrete  $f'_c$  value of 2.5 ksi & reinforcing steel  $F_y$  value of 33 ksi were assumed for the analysis and determination of moment and shear capacities of the twin box-culvert. The existing plans can be found in Appendix A.



**Figure 1 – SC 18 over culvert (looking south)**

The twin reinforced concrete box culvert has clear spans of 10'-0" and a clear rise of 10'-0". For the existing condition, the earth cover is 10' based on the original 1928 construction plans and the culvert widening plans of 1970 (top of grade – top of culvert = 640.65 – 630.66; say = 10 ft.).

The culvert is in generally good condition with minimal cracking noticed and minimal scour at the inlet and outlet. It was noted that there were some minor leaks and deteriorations (see Figures 5 & 6). Additionally, scour of bottom slab was noted in the north barrel floor. Ridges could be seen and felt where the rebar is located and it will not be too long before the rebar becomes exposed (see figure 7).





**Figure 2 – View from roadway (looking upstream)**



**Figure 3 – View from roadway (looking downstream)**





**Figure 4 – View of culvert outlet (looking upstream)**



**Figure 5 – Crack/leak in culvert wall**





**Figure 6 – Deterioration at Wall Base**



**Figure 7 – Rebar in bottom slab in north barrel**

For the proposed embankment condition, the earth cover is 16' based on the original 1928 construction plan and the proposed I-85 widening plans (Top of grade – Top of Culvert = 646.61 – 630.66; say = 16 Ft.). Unit weight of earth fill is assumed to be 120 lb./cu.ft. For the purpose of this study the effects of any additional earth pressure due to ground water is ignored.

## **METHODOLOGY**

A twin (2-cell) reinforced concrete box culvert was analyzed and forces and load capacities was determined using BRASS software. Load Factor method was utilized for determining the forces and capacities. The twin-box culvert was analyzed for forces due to live load caused by AASHTO HS 20 truck load. The wheel loads are distributed through fills according to AASHTO 6.4.1 as uniformly distributed over a rectangle area with one side equal to 1.75 times the depth of the fill plus the wheel width for two vehicles and the other side equal to 1.75 times the depth of the fill plus the wheel length. The load placement and calculation of maximum live load moment due to HS20 truck load are computed by BRASS.

In the BRASS program an at-rest pressure coefficient of 0.5 is used based on assumed medium dense sand or gravel backfill (see AASHTO LRFD Table 3.11.5.5.1). In addition, lateral earth pressure due to 2' of earth as live load surcharge is also included in the analysis.

The twin-box culverts were analyzed for both the existing earth cover of 10 Ft. and proposed earth cover for 16 Ft. due to new embankment construction on top of existing culverts. The reinforcement in the twin-box culvert lengthening constructed in the year 1970 is significantly more than the reinforcement utilized in the original twin-box culvert (see Appendix A). Thus the capacity of existing twin-box culvert is controlled by the original portion constructed in the year 1937.

The twin culverts are 10'x10'. All the side walls are 10" thick. The top slab has a variable thickness varying from 10" at the face of the exterior wall to 12" at the face of the interior wall. Because of this variation, at the maximum positive moment location thickness of top slab is about 10.8". As the top slab thickness varies, three different models were created for determining the actual capacities at the locations 1, 2, 3 in top slab and 4, 5 & 6 in bottom slab (see Appendix B). In addition, as the negative moment reinforcement for the top & bottom of exterior wall is not same as the negative moment reinforcement for the top & bottom slab at the exterior support, an additional model was created for determining moment capacity of exterior walls.

All these models were first analyzed for the existing condition with an earth cover of 10 ft. Similar to the aforementioned four BRASS models for existing earth cover of 10 Ft., four additional models were created for the proposed embankment condition with an earth cover of 16 ft. Even though the culvert reinforcement for the proposed embankment is same as the existing condition, since BRASS computes the moment capacity based on the beam-column action, the moment capacity is slightly more due to increased axial load caused by the additional fill.

The summary of factored moment and moment capacities and factored shear and shear capacities for various critical locations are presented in Appendix B. The factored moment and shear are due to combined factored effects due to dead load, earth pressure, HS20 truck live load, and live load surcharge. Also a twin-box culvert section with the locations of the critical section is included in Appendix B. The BRASS analysis and capacity check calculations for all the four models are given in Appendix C for existing condition and Appendix D for proposed embankment condition with 16 Ft. earth cover.

### **SUMMARY OF LOAD CAPACITY CHECK RESULTS**

Based on the BRASS culvert load capacity check and summary results provided in Appendix B, for the existing condition, the performance ratios for both moment and shear are less than 1.05 at all locations except at the top and bottom slab exterior support. At the exterior support of the top slab, due to a small reinforcement of #5@ 12" o.c., there is 22% overstress in the total factored moment. Similarly, at the exterior support of bottom slab, there is 11% over stress in the total factored moment. Based on the field visit, it appears the twin-culvert is in fair condition with no significant cracks as stated and shown above. As such, it appears that due to some moment redistribution to mid-span and interior support, the overstress in the top and bottom slab at the exterior support location may have been reduced reaching less than 5% overstress. Another possibility is that the reinforcement yield stress of the original culvert is higher than assumed providing additional capacity. These factors reflect that the existing culvert is adequate for the existing loading condition.

For the proposed condition, due to the 6 ft. of additional earth fill with new embankment, there is considerable overstress in the entire regions of both the top and bottom slab. The following table summarizes the calculated moment and shear in each overstressed location:

<b>Proposed Condition - Results Summary</b>		
Location	Moment	Shear
Top Slab Exterior Support	53% overstressed	13% overstressed
Top Slab Mid-span	47% overstressed	N/A
Top Slab Interior Support	20% overstressed	2% overstressed
Bottom Slab Exterior Support	37% overstressed	7% overstressed
Bottom Slab Mid-Span	51% overstressed	N/A
Bottom Slab Interior Support	43% overstressed	27% overstressed

**Table 1 – Moment/Shear Results Summary**

## **RECOMMENDATIONS**

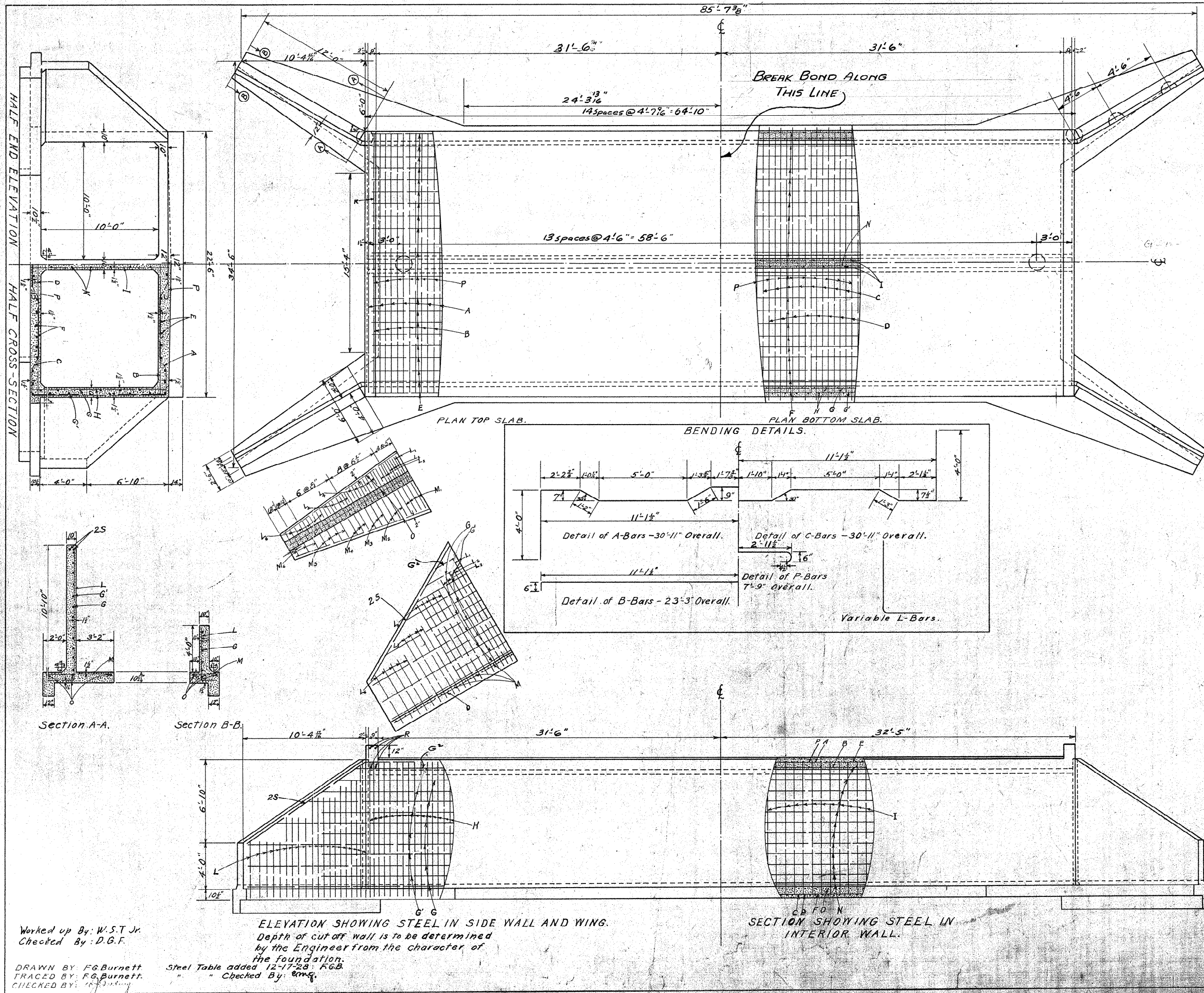
Due to the analysis of the culvert showing that the existing culvert is near its stress limit, along with its age, current condition of the culvert, and overstressing of the culvert with additional fill, it is recommended that the existing box-culvert be removed and replaced if any additional embankment is required above the culvert.

If replaced, the culvert shall be replaced with a structure that meets all hydraulic requirements and be designed per LRFD specifications. The replacement of the culvert will require a hydraulic analysis to be performed and FEMA coordination will be necessary as Providence Branch is a Zone AE FEMA detailed study area with base flood elevations established.



## **APPENDIX A**

### **EXISTING TWIN-BOX CULVERT PLANS (1928 & 1970 Construction)**



STEEL TABLE				
MARK	NO.	SIZE	LENGTH	SPACING
A	66	3/8"	30'-11"	12" C to C
B	64	"	23'-3"	"
C	66	"	30'-11"	"
D	64	"	23'-3"	"
E	40	2#	32'-0"	As Shown
F	40	"	32'-0"	"
G	20	"	37'-5"	Stagger 20" C to C
H	4	"	25'-11"	"
I	4	"	38'-11"	"
J	8	"	21'-11"	"
K	24	"	23'-0"	"
L	860	"	11'-3"	6" C to C
M	8	"	11'-6"	"
N	8	"	12'-4"	As Shown
O	8	"	11'-3"	"
P	20	"	10'-6"	"
Q	16	"	8'-6"	"
R	30	"	5'-3"	"
S	16	"	5'-0"	"
T	12	"	4'-6"	"
U	12	"	4'-0"	"
V	12	"	3'-8"	"
W	16	"	3'-0"	"
X	12	"	2'-3"	"
Y	24	"	32'-0"	Stagger 20" C to C
Z	12	"	14'-6"	As Shown
AA	128	3/8"	7'-9"	12" C to C
AB	8	"	22'-0"	As Shown
AC	8	1/2"	17'-0"	"
AD	4	"	34'-5"	"

Conc. in Caps = 3.52 cu. yd.  
 Filing (Unreduced) = 780 lin. ft.  
 Note: For Cap details see plan of Culvert Sta. 201+30.

APPROXIMATE QUANTITIES	
REINFORCING STEEL	18,687 Lbs.
CLASS "A" CONCRETE	180.34 Cu. Yds.
EXCAVATION 1'	75.69 Cu. Yds.

NOTES:-  
 All exposed edges are to be chamfered 1".  
 The parapet walls shall be poured at the same time as the top slab.  
 All dimensions relating to steel are to centers of bars. All reinforcing steel is to be deformed bars, square twisted bars not considered deformed.  
 All laps are to be at least 40 diameters of bar.  
 Forms for exposed surfaces shall be of dressed lumber.  
 Forms shall be removed when directed by the Engineer and exposed surfaces finished by rubbing with a carborundum brick. Top surfaces are to be tamped and trowelled so as to provide a smooth neat finish.  
 All steel to be used is to be furnished by Res. Eng. and concrete in pile caps added to quantities shown.

S.C. STATE HIGHWAY DEPARTMENT  
 COLUMBIA, S.C.

## CONCRETE CULVERT

REINFORCED BOX TYPE  
 DOUBLE 10'X10' XG3'

NOVEMBER 1928  
 SCALE 1/4" = 1'-0"  
 CORRECTED BY: [Signature]  
 APPROVED BY: [Signature]  
 STATE HIGHWAY ENGINEER

Worked up By: W.S.T. Jr.  
 Checked By: D.G.F.

DRAWN BY: F.G. Burnett  
 TRACED BY: F.G. Burnett  
 CHECKED BY: [Signature]

ELEVATION SHOWING STEEL IN SIDE WALL AND WING.  
 Depth of cut off wall is to be determined by the Engineer from the character of the foundation.  
 Steel Table added 12-17-28: F.G.B.  
 " " Checked By: [Signature]

SECTION SHOWING STEEL IN INTERIOR WALL.





FED. ROAD DIV. NO.	STATE	COUNTY	FILE NO.	ROUTE NO.	SHEET NO.	TOTAL SHEETS
3	S. C.	CHEROKEE	11,434	18	30	56

# STEEL SCHEDULE (1 END)

MARK	No. 2" in inches	SIZE	LENGTH	SPACING	LOCATION
A	(L/12)	5	29'-4"	8" C to C	T & B Slabs
B	(L/12)	5	22'-2"	"	"
C	(L/12)	6	9'-4"	"	"
D	5B	4	L-(0'-4")	As Shown	T & B Slabs
F <sub>1</sub> to F <sub>3</sub>	2 ea	4	2'-6" to 3'-4" vary by 5"	"	Wing Footings
F <sub>4</sub> to F <sub>18</sub>	2 ea	4	3'-8" to 6'-0" vary by 2"	"	"
G <sub>1</sub>	(L/12)	4	11'-4"	12" ea. Face	Side Wall
G <sub>2</sub>	(L/12)	4	11'-8"	8" Squ	Midwall
H <sub>1</sub> to H <sub>6</sub>	2 ea	4	L-(2'-0") to L-(10'-9") vary by 1'-9"	12" C. to C.	Side wall & Wings
H <sub>7</sub>	8	4	L-(11'-2")	"	"
H <sub>8</sub>	10	4	L-(10'-4")	12" Stag'd.	Midwall
I <sub>1</sub> to I <sub>10</sub>	2 ea	4	6'-1" to 12'-10" vary by 9"	As Shown	Wings & Footings
I <sub>11</sub>	10	4	5'-9"	"	"
J	4	5	16'-0"	"	Top of Wings
K	2	7	11'-0"	"	Headwall
L	8	4	15'-0"	"	Footings
L <sub>1</sub>	2	4	16'-0"	"	"
M	48	6	1'-6"	"	Dowels
H <sub>9</sub>	20	4	L+(2'-0")	12" C to C.	S. Walls & Wings

*Disregard Fractions	
Concrete P.F.L. Barrel	2.5129 CY
Concrete P.F.D. Cut-Off Wall (1 End)	1.3310 CY
Excavation P.F.L. P.F.D. Barrel	1.0185 CY
Reinforcing Steel P.F.L. Barrel	356.7 LBS

# QUANTITIES

STATION	LENGTH "L"	REINFORCING STEEL	CLASS "A" CONCRETE
78+09	Ext. 15'-0" Lt.	6068 LBS	47.3 CY
"	Ext. 16'-0" Rt.	6424 LBS	49.8 CY
		LBS	CY
		LBS	CY
		LBS	CY
		LBS	CY
TOTAL		12,492 LBS	97.1 CY

NOTE:  
Method used in figuring Quantities  
Reinforcing Steel = 717.1 + 356.7 L  
Class "A" Concrete = 9.609 + 2.5123 L

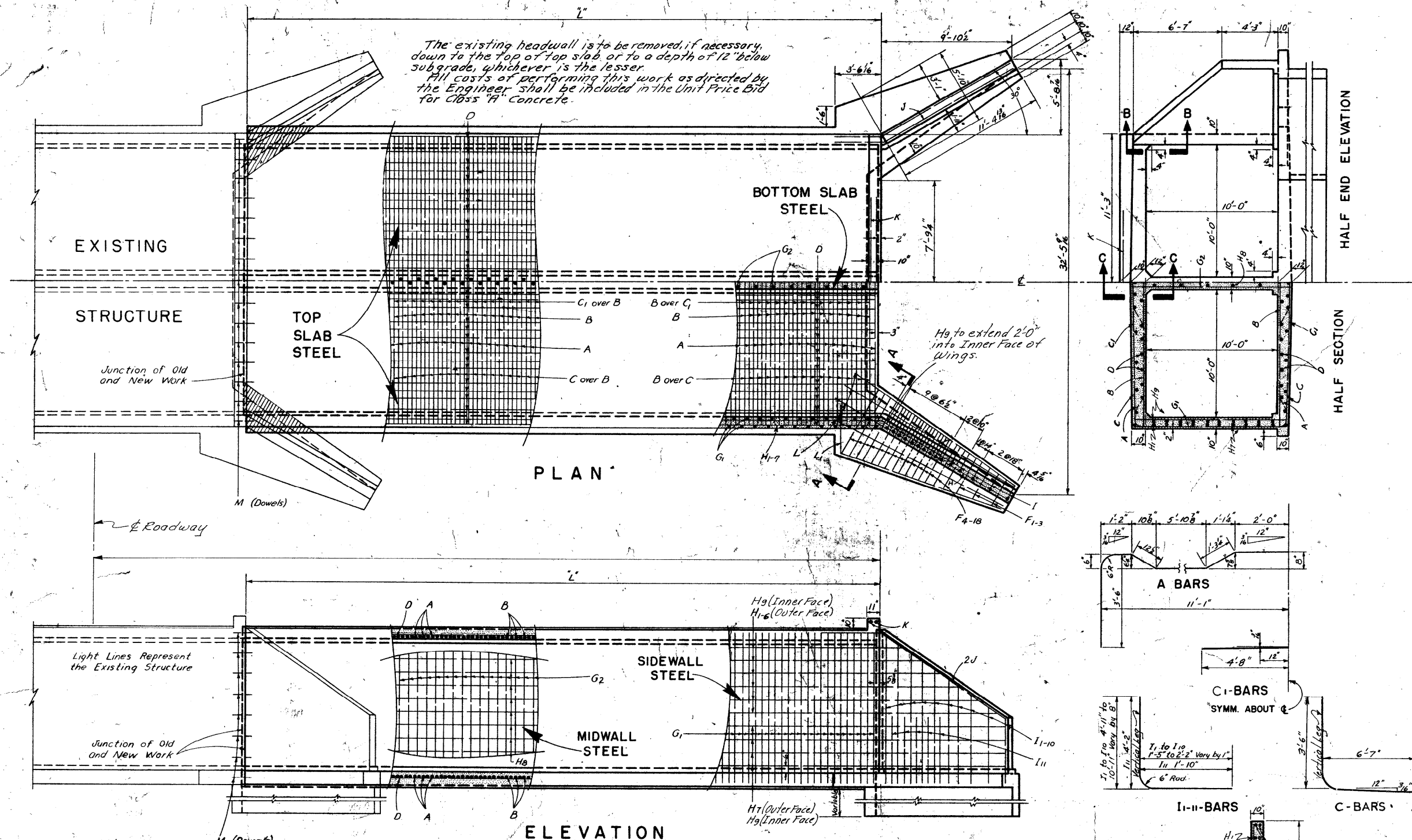
NOTE:  
CONSTRUCT UNTREATED TIMBER CUTOFF WALLS. SEE ACCOMPANYING SHEET

S.C. STATE HIGHWAY DEPARTMENT  
COLUMBIA

# CONCRETE CULVERT REINFORCED BOX TYPE DOUBLE IOXIO EXT.

S.G. FILE NO. COUNTY  
ROUTE NO. 18 DATE 5-17-70

B 2.1010 EXT.



Rev.	By	App'd	Date
1	G.K.B. W.B.B.	2-67	
2	Reinforcing		
3	W.B.B. R.P.B.	4-56	
4	A.O.W. R.P.B.	6-53	
5	A.O.W. R.P.B.	6-53	
6	A.O.W. R.P.B.	6-53	
7	A.O.W. R.P.B.	6-53	
8	A.O.W. R.P.B.	6-53	
9	A.O.W. R.P.B.	6-53	
10	A.O.W. R.P.B.	6-53	
11	A.O.W. R.P.B.	6-53	
12	A.O.W. R.P.B.	6-53	
13	A.O.W. R.P.B.	6-53	
14	A.O.W. R.P.B.	6-53	
15	A.O.W. R.P.B.	6-53	
16	A.O.W. R.P.B.	6-53	
17	A.O.W. R.P.B.	6-53	
18	A.O.W. R.P.B.	6-53	
19	A.O.W. R.P.B.	6-53	
20	A.O.W. R.P.B.	6-53	



IDENTIFICATION				Sufficiency Rating = 96.3	
(1) State Name - SOUTH CAROLINA	Code 454			Functionally Obsolete = NO	
(8) Structure Number	# 0001140001800200			Structurally Deficient = NO	
(5) Inventory Route (On/Under)	On - 141000181				
(2) State Highway Department District	4				
(3) County Code 21	(4) Place Code			CLASSIFICATION	
(6) Features Intersected PROVIDENCE CREEK				Code	
(7) Facility Carried SC 18				(112) NBIS Bridge Length -	YES
(9) Location 1.5 MI N OF GAFFNEY				(104) Highway System - NOT NHS	0
(11) Milepoint 17.100				(26) Functional Class - URBAN-MIN ART	14
(12) Base Highway Network -NOT PART OF NET	Code 0			(100) Strahnet Highway - NOT STRAH HWY	0
(13) LRS Inventory Route & Subroute				(101) Parallel Structure - NONE EXIST	N
(16) Latitude 35 Degrees 5 Minutes 57.00 Seconds				(102) Direction of Traffic - 2-WAY TRAFFIC	2
(17) Longitude 81 Degrees 37 Minutes 42.00 Seconds				(103) Temporary Structure -	
(98) Border Bridge State Code % SHARE %				(105) Federal Lands Highways -N/A	0
(99) Border Bridge Structure No. #				(110) Designated National Network -NO	0
STRUCTURE TYPE AND MATERIAL				(20) Toll - ON FREE ROAD	3
(43) Structure Type Main: MATERIAL -CONCRETE	Code 119			(21) Maintain - SCDOT	1
Type - CULVERT (INCL. FRAME CULV)				(22) Owner - SCDOT	1
(44) Structure Type Appr: MATERIAL -OTHER OR N/A	Code 000			(37) Historical Significance -NOT DETERMINABLE	4
Type - OTHER OR N/A				CONDITION	
(45) Number of Spans in Main Unit 2				(58) Deck - NOT APPLICABLE	N
(46) Number of Approach Spans 0				(59) Superstructure - NOT APPLICABLE	N
(107) Deck Structure Type -N/A	Code N			(60) Substructure - NOT APPLICABLE	N
(108) Wearing Surface / Protective System:				(61) Channel and Channel Protection-BNK SLUMPING	6
A) Type of Wearing Surface - N/A	Code N			(62) Culverts - DETERIORATION	6
B) Type of Membrane - N/A	Code N			LOAD RATING AND POSTING	
C) Type of Deck Protection - N/A	Code N			(31) Design Load - HS 20	5
AGE AND SERVICE				(64) Operating Rating - LF	99
(27) Year Built 1937				(66) Inventory Rating - LF	94
(106) Year Reconstructed 1970				(70) Bridge Posting - EQUAL/ABOVE LEGAL LOADS	5
(42) Type of Service On -HIGHWAY				(41) Structure Open, Posted or Closed -	A
Under - WATERWAY	Code 5			Description -OPEN, NO RESTRICT	
(28) Lanes: On Structure = 2 Under Structure = 0				APPRAISAL	
(29) Average Daily Traffic 9500				(67) Structure Evaluation - EQUAL TO MIN CRITERIA	6
(30) Year of ADT 2014 (109) Truck ADT 06 %				(68) Deck Geometry	9
(19) Bypass, Detour Length 1 MI				(69) Underclearances, Vertical and Horizontal	N
GEOMETRIC DATA				(71) Waterway Adequacy	8
(48) Length of Maximum Span 10 FT				(72) Approach Roadway Alignment	8
(49) Structure Length 23 FT				(36) Traffic Safety Features	0000
(50) Curb or Sidewalk: Left 5.0 FT Right 5.0 FT				(113) Scour Critical Bridges - CALC SCOUR ABOVE FOOT	8
(51) Bridge Roadway Width Curb to Curb 64 FT				PROPOSED IMPROVEMENTS	
(52) Deck Width Out to Out 100.0 FT				(75) Type of Work -	Code
(32) Approach Roadway Width (W/Shoulders) 64 FT				(76) Length of Structure Improvement	23.0 FT
(33) Bridge Median -NONE	Code 0			(94) Bridge Improvement Cost	\$0
(34) Skew 0 Deg (35) Structure Flared NO				(95) Roadway Improvement Costs	\$0
(10) Inventory Route Min Vert Clear 99 FT 99 IN				(96) Total Project Cost	\$0
(47) Inventory Route Total Horz Clear 64.0 FT				(97) Year of Improvement Cost Estimate	2015
(53) Min Vert Clear Over Bridge Roadway 99 FT 99 IN				(114) Future ADT	13395
(54) Min Vert Underclear Ref - NOT HWY OR RX 0 FT 0 IN				(115) Year of Future ADT	2034
(55) Min Lat Underclear Right Ref -NOT HWY OR RXR 99.9 FT				INSPECTIONS	
(56) Min Lat Underclear Left 0.0 FT				(90) Inspection Date 12/2015	(91) Frequency 24 Mo
NAVIGATION DATA				(92) Critical Feature Inspection:	(93) CFI Date
(38) Navigation Control -NONE	Code 0			A) Fracture Crit Detail NO Mo A)	
(111) Pier Protection -	Code			B) Underwater Insp NO Mo B)	
(39) Navigation Vertical Clearance FT				C) Other Special Insp NO Mo C)	
(116) Vert-Lift Bridge Nav Min Vert Clear FT					
(40) Navigation Horizontal Clearance FT					

## **APPENDIX B**

### **CULVERT LOAD CAPACITY RESULTS SUMMARY (Existing & Proposed Conditions)**

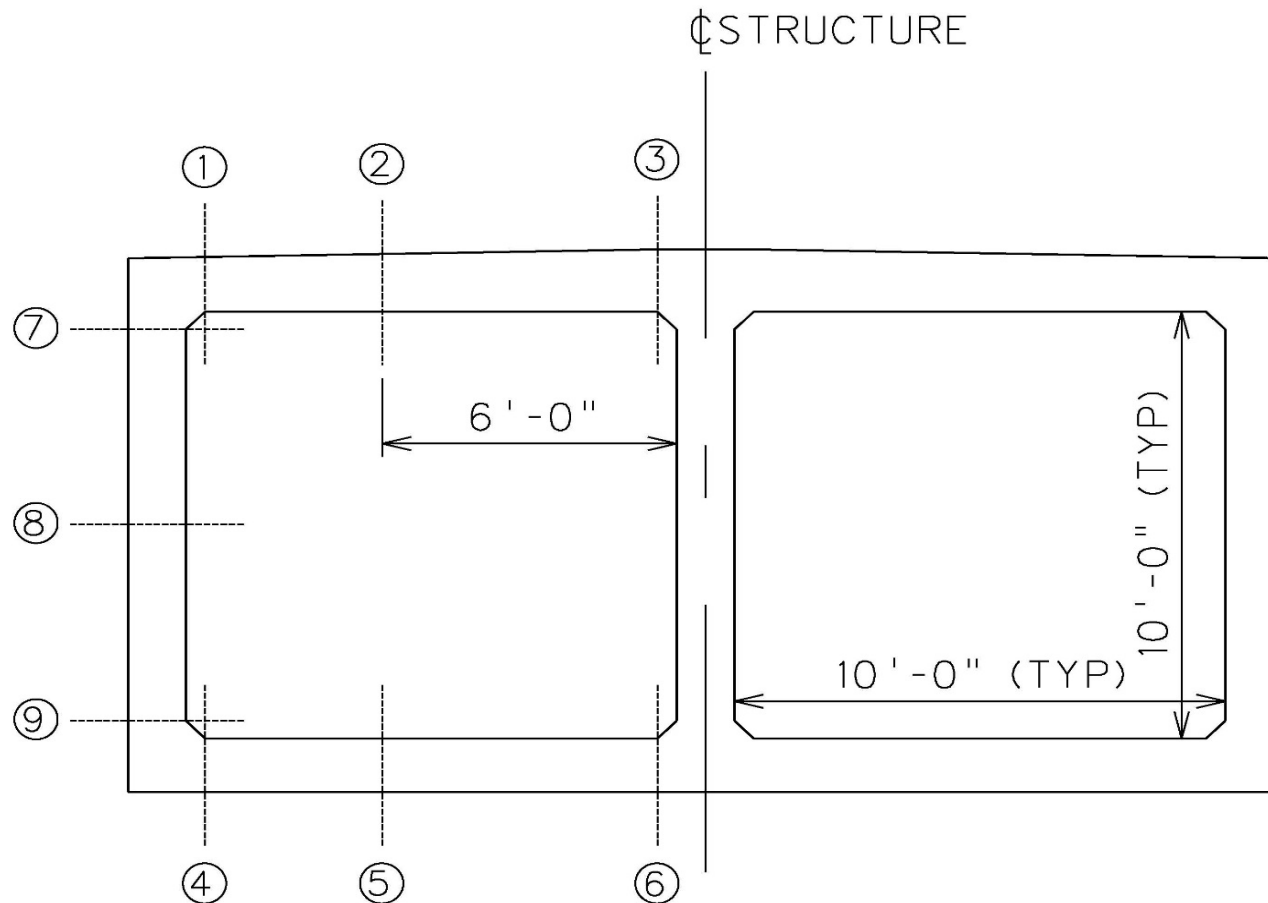


### Flexure Check

Location	Effective Depth (in)	Reinforcement	$A_{steel}$ (in <sup>2</sup> )	Load & Capacity - Existing Cover (10')				Load & Capacity - Proposed Cover (16')			
				Pu (kips)	Mu (k-ft)	$\phi Mn$ (k-ft)	Perf. Ratio	Pu (kips)	Mu (k-ft)	$\phi Mn$ (k-ft)	Perf. Ratio
1	8.19	#5 @ 12"	0.31	3.5	-8.2	-6.7	1.22	5.1	-10.7	-7.0	1.53
2	8.99	#5 @ 6"	0.62	3.4	14.2	13.7	1.04	4.9	20.5	13.9	1.47
3	10.06	#5 @ 12" + #7 @ 12"	0.91	3.3	-17.5	-21.6	0.81	4.8	-26.1	-21.8	1.20
4	8.69	#5 @ 12"	0.31	4.4	-8.1	-7.3	1.11	5.9	-10.4	-7.6	1.37
5	8.69	#5 @ 6"	0.62	4.5	13.4	13.4	1.00	6.1	20.6	13.6	1.51
6	8.56	#5 @ 12" + #7 @ 12"	0.91	4.7	-17.3	-18.3	0.95	6.4	-26.5	-18.5	1.43
7	8.19	#5 @ 12" + #4 @ 6"	0.71	9.0	-11.3	-14.7	0.77	14.5	-15.8	-15.4	1.03
8	8.25	#4 @ 6"	0.40	9.0	3.9	9.4	0.41	14.5	3.4	10.3	0.33
9	8.19	#5 @ 12" + #4 @ 6"	0.71	9.0	-10.2	-14.7	0.69	14.5	-14.7	-15.4	0.95

### Shear Check

Location	Effective Depth (in)	Load & Capacity - Existing Cover (10')			Load & Capacity - Proposed Cover (16')		
		Vu (k-ft)	$\phi Vn$ (k-ft)	Perf. Ratio	Vu (k-ft)	$\phi Vn$ (k-ft)	Perf. Ratio
1	8.19	8.1	10.1	0.80	11.4	10.1	1.13
3	10.06	10.2	14.5	0.70	14.8	14.5	1.02
4	8.69	7.7	10.7	0.72	11.5	10.7	1.07
6	8.56	10.0	12.1	0.83	15.2	12.0	1.27
7	8.19	4.8	10.1	0.48	6.3	10.0	0.63
9	8.19	5.3	10.4	0.51	6.7	10.2	0.66





## **APPENDIX C**

### **BRASS INPUT & OUTPUT FOR EXISTING CONDITION (Four Models)**

**BRASS-CULVERT**

BRASS-CULVERT Version 2.7

DATE : 3/ 6/2016

TIME : 15:34:20

PAGE 1

Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Exteri  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Exteri

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot

PAGE 2  
DATE 03/06/2016  
BRASS-CULVERT Version 2.7  
I-85 DESIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK

Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

Units

USSI\_UNITS: Input Units = US  
USSI\_UNITS OU: Output Units = US  
JOB DESCRIPTION: EXISTING COVER 10'  
CHECK TOP AND BOTTOM SLAB @ EXTERIOR SUPPORT FOR NEGATIVE MOMENT

Design Variables

LRFD: Use LRFD method for bot slab load distrib. = F  
CUTYPE: Precast(PC) or Cast in Place(CIP) Culvert = CIP  
IDSN: Load Factor(LF) Service Load (SL) Design = LF  
FUNCT: Design (DESIGN) or Design Review (DESREV) = DESREV  
IRELEASE: Moment Continuity Released (@ end of walls) = F  
DNEG: Distance to Neg. Moment Computation Point = 1.00

Output Control Variables

MTEN: Output Moment-Shears = T  
IINFN: Output Influence Line = F  
IBSH: Output Bar Schedule = F

Standard Load Variables

LVLD: Live Load Vehicle Name = HS20T  
LVOMT: Neglect LL for Fill > 8Ft & Fill > Span = F



PAGE 3  
DATE 03/06/2016  
BRASS-CULVERT Version 2.7  
I-85 DESIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK

Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	10.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	10.0
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCOnc:	Compressive Strength of Concrete (Psi)	= 2500.0
FSHR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
 ILESS: Code for Span Less Than 5 ft = F  
 ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL, FIXED, HINGED) = FULL  
 LDPASS: Bypass Live Load if no vehicle input = F  
 LONGB: Longitudinal Bar Code = F  
 MESSGE: Code for Message Printout = T

---

JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
 Structure ID : XIST CHECK  
 Agency name : MEAD &

Input units : US  
 Output units : US

---

ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
CAST-IN-PLACE	DESREV	NO	FULL	1.00

Consider Haunches in Analysis : YES  
 Perform Edge Beam reinforcement computations : NO  
 Use epoxy coated bars in top mat of reinforcement: NO  
 in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input

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BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
10.00 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

(Neglect Live Load if fill is greater than 8 ft.  
and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water
Pressure	Density
Max	Min
(Pcf)	(Pcf)
50.0	36.0
	0.0

	Wearing
Uniform	Surface
Load	Thickness
(plf)	(in)
0.0	0.00
	Fill
	Height
	(Ft)
	10.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in



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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches

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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

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Live Load Parameters for a HS20T vehicle

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Fill	= 10.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 35.16666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 35.16666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.05687
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	10.0000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.8542 Ft.
Fill Height(top of slab)	=	10.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.0889
Earth Weight for fill computations	=	0.1307 Kcf

Weight of Fill without wearing surface	=	1.3067 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1250 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	1.4317 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	1.6047 Klf

Soil pressure at center of top slab	=	0.5208 Klf
Soil pressure at center of bottom slab	=	1.0635 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
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Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0569
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000
-----	-----
Totals 72.00	28.000

Tire Contact Area = 40.00000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 2.000000 in.

Vehicle Axle number = 1  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 17.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 2  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 3  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]





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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.87	0.00	-3.83	-5.75	-0.70	0.00	0.08	-0.09	14.00	14.00
1- 1	-0.88	0.00	-3.84	-1.08	-0.16	0.00	0.02	-0.09	14.00	14.00
1- 2	-0.88	0.00	-3.85	2.40	0.25	0.00	0.00	-0.12	0.00	14.00
1- 3	-0.88	0.00	-3.86	4.76	0.56	0.00	0.00	-0.19	0.00	14.00
1- 4	-0.88	0.00	-3.86	6.06	0.74	0.00	0.00	-0.27	14.00	14.00
1- 5	-0.88	0.00	-3.87	6.36	0.80	0.00	0.02	-0.35	14.00	14.00
1- 6	-0.89	0.00	-3.88	5.72	0.75	0.00	0.04	-0.43	14.00	14.00
1- 7	-0.89	0.00	-3.89	4.22	0.58	0.00	0.06	-0.51	14.00	14.00
1- 8	-0.89	0.00	-3.90	1.91	0.29	0.00	0.08	-0.59	14.00	14.00
1- 9	-0.89	0.00	-3.91	-1.14	-0.11	0.00	0.10	-0.67	14.00	14.00
1-10	-0.89	0.00	-3.91	-4.87	-0.64	0.00	0.12	-0.75	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.89	0.00	-3.91	-4.87	-0.64	0.00	0.12	-0.75	14.00	14.00
2- 1	0.26	0.00	1.13	-4.14	-0.54	0.00	0.11	-0.07	14.00	14.00
2- 2	1.10	0.00	4.81	-3.41	-0.45	0.00	0.65	0.00	14.00	0.00
2- 3	1.63	0.00	7.13	-2.68	-0.35	0.00	1.01	-0.04	14.00	14.00
2- 4	1.84	0.00	8.07	-1.96	-0.26	0.00	1.19	-0.09	14.00	14.00
2- 5	1.74	0.00	7.65	-1.23	-0.16	0.00	1.18	-0.15	14.00	14.00
2- 6	1.34	0.00	5.86	-0.50	-0.07	0.00	0.98	-0.20	14.00	14.00
2- 7	0.61	0.00	2.70	0.22	0.03	0.00	0.61	-0.25	14.00	14.00
2- 8	-0.42	0.00	-1.83	0.95	0.12	0.00	0.17	-0.32	14.00	14.00
2- 9	-1.76	0.00	-7.73	1.68	0.22	0.00	0.00	-0.87	0.00	14.00
2-10	-3.42	0.00	-14.99	2.40	0.31	0.00	0.00	-1.73	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.13	-0.13	14.00	14.00
3- 1	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.07	-0.07	14.00	14.00
3- 2	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 3	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 4	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.10	-0.10	14.00	14.00
3- 5	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.15	-0.15	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.21	-0.21	14.00	14.00
3- 7	0.00	0.00	0.00	-0.01	0.00	0.00	0.26	-0.26	14.00	14.00
3- 8	0.00	0.00	0.00	-0.01	0.00	0.00	0.32	-0.32	14.00	14.00
3- 9	0.00	0.00	0.00	-0.02	0.00	0.00	0.37	-0.37	14.00	14.00
3-10	0.00	0.00	0.00	-0.02	0.00	0.00	0.43	-0.43	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-0.87	0.00	-3.83	-5.75	-0.70	0.00	0.08	-0.09	14.00	14.00
4- 1	0.39	0.00	1.73	-4.89	-0.60	0.00	0.21	-0.01	14.00	14.00
4- 2	1.31	0.00	5.75	-4.03	-0.49	0.00	0.32	0.00	0.00	14.00
4- 3	1.88	0.00	8.24	-3.16	-0.39	0.00	0.38	0.00	0.00	14.00
4- 4	2.10	0.00	9.20	-2.30	-0.28	0.00	0.40	0.00	0.00	14.00
4- 5	1.97	0.00	8.63	-1.44	-0.18	0.00	0.36	0.00	0.00	14.00
4- 6	1.49	0.00	6.52	-0.58	-0.07	0.00	0.27	0.00	0.00	14.00
4- 7	0.66	0.00	2.88	0.28	0.04	0.00	0.13	-0.03	14.00	14.00
4- 8	-0.52	0.00	-2.30	1.15	0.14	0.00	0.03	-0.14	14.00	14.00
4- 9	-2.06	0.00	-9.01	2.01	0.25	0.00	0.00	-0.38	14.00	0.00
4-10	-3.94	0.00	-17.25	2.87	0.35	0.00	0.00	-0.68	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.00	0.00	-0.01	4.87	0.55	0.00	0.02	-0.07	14.00	14.00
1- 1	-0.00	0.00	-0.01	3.75	0.44	0.00	0.02	-0.07	14.00	14.00
1- 2	-0.00	0.00	-0.01	2.68	0.33	0.00	0.02	-0.07	14.00	14.00
1- 3	-0.00	0.00	-0.01	1.67	0.22	0.00	0.02	-0.07	14.00	14.00
1- 4	-0.00	0.00	-0.01	0.73	0.11	0.00	0.02	-0.07	14.00	14.00
1- 5	-0.00	0.00	-0.01	-0.16	0.01	0.00	0.02	-0.07	14.00	14.00
1- 6	-0.00	0.00	-0.01	-0.99	-0.10	0.00	0.02	-0.07	14.00	14.00
1- 7	-0.00	0.00	-0.01	-1.77	-0.21	0.00	0.02	-0.07	14.00	14.00
1- 8	-0.00	0.00	-0.01	-2.48	-0.32	0.00	0.02	-0.07	14.00	14.00
1- 9	-0.00	0.00	-0.01	-3.13	-0.43	0.00	0.02	-0.07	14.00	14.00
1-10	-0.00	0.00	-0.01	-3.73	-0.54	0.00	0.02	-0.07	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.21	0.00	5.29	0.67	0.09	0.00	0.88	-0.05	14.00	14.00
2- 1	0.92	0.00	4.03	0.67	0.09	0.00	0.64	-0.05	14.00	14.00
2- 2	0.63	0.00	2.77	0.67	0.09	0.00	0.48	-0.05	14.00	14.00
2- 3	0.34	0.00	1.50	0.67	0.09	0.00	0.32	-0.06	14.00	14.00
2- 4	0.05	0.00	0.24	0.67	0.09	0.00	0.17	-0.11	14.00	14.00
2- 5	-0.23	0.00	-1.02	0.67	0.09	0.00	0.05	-0.26	14.00	14.00
2- 6	-0.52	0.00	-2.29	0.67	0.09	0.00	0.01	-0.42	14.00	14.00
2- 7	-0.81	0.00	-3.55	0.67	0.09	0.00	0.00	-0.58	0.00	14.00
2- 8	-1.10	0.00	-4.81	0.67	0.09	0.00	0.00	-0.73	0.00	14.00
2- 9	-1.39	0.00	-6.07	0.67	0.09	0.00	0.00	-0.88	0.00	14.00
2-10	-1.67	0.00	-7.34	0.67	0.09	0.00	0.00	-0.95	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 1	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 2	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 3	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 4	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 5	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 7	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 8	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 9	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3-10	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
INTERIOR WALL TOP										



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BOTTOM SLAB LEFT SIDE										
4- 0	1.33	0.00	5.84	0.80	0.10	0.00	0.18	0.00	0.00	14.00
4- 1	1.01	0.00	4.42	0.80	0.10	0.00	0.13	0.00	0.00	14.00
4- 2	0.69	0.00	3.01	0.80	0.10	0.00	0.09	0.00	0.00	14.00
4- 3	0.36	0.00	1.59	0.80	0.10	0.00	0.04	0.00	0.00	14.00
4- 4	0.04	0.00	0.18	0.80	0.10	0.00	0.00	-0.01	14.00	14.00
4- 5	-0.28	0.00	-1.24	0.80	0.10	0.00	0.00	-0.06	14.00	0.00
4- 6	-0.61	0.00	-2.65	0.80	0.10	0.00	0.00	-0.11	14.00	0.00
4- 7	-0.93	0.00	-4.07	0.80	0.10	0.00	0.00	-0.16	14.00	0.00
4- 8	-1.25	0.00	-5.49	0.80	0.10	0.00	0.00	-0.20	14.00	0.00
4- 9	-1.57	0.00	-6.90	0.80	0.10	0.00	0.00	-0.25	14.00	0.00
4-10	-1.90	0.00	-8.32	0.80	0.10	0.00	0.00	-0.30	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K		K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 1	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 2	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 3	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 4	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 5	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 6	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 7	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 8	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 9	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1-10	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 1	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 2	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 3	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 4	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 5	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 6	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 7	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 8	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 9	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2-10	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 1	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 2	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 3	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 4	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 5	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 6	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 7	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 8	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 9	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3-10	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB LEFT SIDE											
4- 0	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 1	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 2	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 3	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 4	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 5	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 6	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 7	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 8	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 9	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4-10	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-11.324	-15.310	-8.970	-11.375	7.550	4.385
1- 1	-7.090	-8.076	-8.970	-11.375	5.852	3.332
1- 2	-2.466	-4.151	-8.970	-11.375	4.231	2.335
1- 3	1.238	-2.114	-8.970	-11.375	2.687	1.392
1- 4	3.316	-1.079	-8.970	-11.375	1.219	0.504
1- 5	3.871	-0.983	-8.970	-11.375	-0.113	-0.388
1- 6	2.960	-1.766	-8.970	-11.375	-0.903	-1.690
1- 7	0.664	-3.363	-8.970	-11.375	-1.625	-2.928
1- 8	-2.933	-5.713	-8.970	-11.375	-2.292	-4.090
1- 9	-7.087	-9.419	-8.970	-11.375	-2.904	-5.175
1-10	-10.546	-15.589	-8.970	-11.375	-3.460	-6.183
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-10.546	-15.589	-3.460	-6.183	11.413	8.970
2- 1	-1.826	-4.907	-3.460	-6.183	8.887	6.954
2- 2	5.898	2.283	-3.460	-6.183	6.525	4.937
2- 3	11.064	7.036	-3.460	-6.183	4.164	2.895
2- 4	13.637	9.580	-3.460	-6.183	1.809	0.782
2- 5	13.606	9.939	-3.460	-6.183	-0.472	-1.569
2- 6	11.004	8.114	-3.460	-6.183	-2.558	-3.928
2- 7	5.983	3.960	-3.460	-6.183	-4.602	-6.284
2- 8	-1.048	-2.727	-3.460	-6.183	-6.619	-8.634
2- 9	-9.684	-12.654	-3.460	-6.183	-8.635	-10.976
2-10	-20.131	-25.445	-3.460	-6.183	-10.651	-13.151
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.301	-0.258	-21.689	-25.355	0.108	-0.116
3- 1	0.175	-0.141	-21.689	-25.355	0.108	-0.116
3- 2	0.050	-0.024	-21.689	-25.355	0.108	-0.116
3- 3	0.096	-0.079	-21.689	-25.355	0.108	-0.116
3- 4	0.212	-0.203	-21.689	-25.355	0.108	-0.116
3- 5	0.327	-0.327	-21.689	-25.355	0.108	-0.116
3- 6	0.444	-0.452	-21.689	-25.355	0.108	-0.116
3- 7	0.561	-0.577	-21.689	-25.355	0.108	-0.116
3- 8	0.678	-0.703	-21.689	-25.355	0.108	-0.116
3- 9	0.795	-0.828	-21.689	-25.355	0.108	-0.116
3-10	0.912	-0.954	-21.689	-25.355	0.108	-0.116
INTERIOR WALL TOP						

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BOTTOM SLAB LEFT SIDE						
4- 0	-11.324	-15.310	-4.385	-7.550	10.962	10.067
4- 1	-1.366	-4.906	-4.385	-7.550	8.599	7.807
4- 2	6.107	2.888	-4.385	-7.550	6.237	5.547
4- 3	11.032	8.214	-4.385	-7.550	3.875	3.287
4- 4	13.399	11.092	-4.385	-7.550	1.528	0.995
4- 5	13.203	11.522	-4.385	-7.550	-0.733	-1.364
4- 6	10.447	9.504	-4.385	-7.550	-2.993	-3.728
4- 7	5.309	4.787	-4.385	-7.550	-5.253	-6.093
4- 8	-1.822	-2.896	-4.385	-7.550	-7.513	-8.457
4- 9	-11.242	-13.338	-4.385	-7.550	-9.773	-10.822
4-10	-23.054	-26.343	-4.385	-7.550	-12.033	-13.187
BOTTOM SLAB RIGHT SIDE						

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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Bottom	0.00	23.93	0.66	Pass
EXTERIOR WALL	Middle -	0.00	23.85	1.49	Pass
EXTERIOR WALL	Top	0.00	23.59	4.13	Pass
TOP SLAB	Left	0.00	23.80	2.04	Pass
TOP SLAB	Middle +	0.00	23.69	3.10	Pass
INTERIOR WALL	Bottom	0.00	23.90	1.04	Pass
INTERIOR WALL	Middle	0.00	23.91	0.90	Pass
INTERIOR WALL	Top	0.00	23.54	4.65	Pass
BOTTOM SLAB	Left	0.00	23.90	0.98	Pass



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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

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Reinforcing Bar Stresses Sizes and Spacing

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Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	22.15	19.80	0.3100	0.3100	5	12.0	29	33
A2	24.82	19.80	0.3100	0.3100	5	12.0	29	33
A100	23.02	19.80	0.6200	0.6200	5	6.0		
A300	20.28	19.80	0.9000	0.9000	7	8.0		
A200	21.76	19.80	0.6200	0.6200	5	6.0		
A400	20.30	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

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## Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.62 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.62 (in)													
	Moment	Axial	Shear	Shear	Resistance												
		Force	Force	Cap	Po	Mu	Mbal	Pbal	Steel	Mom.	Des.	Design		Flexure		Shear	
	Kft	Kips	Kips	Kips	Cap	Cap	Cap	Cap	Area	Cap	Thk	Flx	Shr	Inv	Oper	Inv	Oper
BOT	-10.2*	9.0	5.3	9.6	185.2	6.1	20.5	82.9	0.3100	7.7	8.19	1.32	0.55	0.00	0.00	5.76	9.61
MID	3.9	9.0	0.1	9.8	187.1	7.9	21.1	81.5	0.4000	9.4	8.25	0.41	NA	4.07	6.79	NA	NA
MID-	-1.1	9.0	0.4	9.8	187.1	7.9	21.1	81.5	0.4000	9.4	8.25	0.12	NA	12.14	20.23	NA	NA
TOP	-11.3*	9.0	4.8	9.4	185.2	6.1	20.5	82.9	0.3100	7.7	8.19	1.47	0.51	0.00	0.00	5.58	9.30
Member No. = 2 TOP SLAB				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-8.2*	3.5	8.1	10.1	185.2	6.1	20.5	82.9	0.3100	6.7	8.19	1.22	0.80	0.21	0.35	2.42	4.04
MID	13.6*	3.5	0.5	11.4	191.9	11.9	22.4	75.7	0.6200	12.4	8.19	1.10	NA	0.40	0.66	NA	NA
RT	-16.6	3.5	10.2	11.4	198.0	16.7	23.9	67.9	0.9000	17.0	8.06	0.97	0.89	0.96	1.60	1.58	2.64
Member No. = 3 INTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.50 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.50 (in)													
BOT	-0.2	21.7	0.1	9.6	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.02	0.01	NA	NA	86.08	99.00
MID	0.3	21.7	0.1	9.6	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.04	NA	28.02	46.70	NA	NA
MID-	-0.3	21.7	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.04	NA	28.03	46.72	NA	NA
TOP	-0.9	21.7	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.09	0.01	10.83	18.05	81.62	99.00
Member No. = 4 BOTTOM SLAB				Thickness = 10.50 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-8.1*	4.4	7.7	10.7	194.1	6.5	22.5	88.4	0.3100	7.3	8.69	1.11	0.72	0.44	0.74	7.48	12.47
MID	13.4*	4.4	0.7	11.9	200.8	12.7	24.6	81.2	0.6200	13.4	8.69	1.00	NA	0.67	1.11	NA	NA
RT	-17.3	4.4	9.9	12.0	206.9	17.8	26.2	73.4	0.9000	18.3	8.56	0.95	0.83	1.28	2.14	4.69	7.82

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
 X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Exterior Support-Exist.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

---

Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

**BRASS-CULVERT**

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TIME : 15:51:56

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab MidSpa  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab MidSpa

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot



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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

---

Units  
USSI\_UNITS: Input Units = US  
USSI\_UNITS OU: Output Units = US  
JOB DESCRIPTION: EXISTING COVER 10'  
CHECK TOP AND BOTTOM SLAB @ MID-SPAN POSITIVE MOMENT

---

Design Variables  
LRFDDF: Use LRFD method for bot slab load distrib. = F  
CUTYPE: Precast(PC) or Cast in Place(CIP) Culvert = CIP  
IDSN: Load Factor(LF) Service Load (SL) Design = LF  
FUNCT: Design (DESIGN) or Design Review (DESREV) = DESREV  
IRELEASE: Moment Continuity Released (@ end of walls) = F  
DNEG: Distance to Neg. Moment Computation Point = 1.00

---

Output Control Variables  
MTEN: Output Moment-Shears = T  
IINFN: Output Influence Line = F  
IBSH: Output Bar Schedule = F

---

Standard Load Variables  
LVLD: Live Load Vehicle Name = HS20T  
LVOMT: Neglect LL for Fill > 8Ft & Fill > Span = F

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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	10.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	10.8
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCNC:	Compressive Strength of Concrete (Psi)	= 2500.0
FSHR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
 ILESS: Code for Span Less Than 5 ft = F  
 ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL, FIXED, HINGED) = FULL  
 LDPASS: Bypass Live Load if no vehicle input = F  
 LONGB: Longitudinal Bar Code = F  
 MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : ESIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
 Structure ID : XISTING CHECK  
 Agency name : MEAD &

Input units : US  
 Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
-------------------	---------------	----------------------------	--------------------------	--------------------------

CAST-IN-PLACE	DESREV	NO	FULL	1.00
---------------	--------	----	------	------

Consider Haunches in Analysis : YES  
 Perform Edge Beam reinforcement computations : NO  
 Use epoxy coated bars in top mat of reinforcement: NO  
 in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input



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BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
10.80 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

(Neglect Live Load if fill is greater than 8 ft.  
and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water
Pressure	Density
Max	Min
(Pcf)	(Pcf)
50.0	36.0
	0.0

	Wearing
Uniform	Surface
Load	Thickness
(plf)	(in)
0.0	0.00
	Fill
	Height
	(Ft)
	10.00

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SKEW

Skew Left (Deg)	Skew Right (Deg)	Skew Center (Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch Height (In)	Bottom Haunch Height (In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in

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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches

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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

---

Live Load Parameters for a HS20T vehicle

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Fill	= 10.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 35.16666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 35.16666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.05687
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	10.8000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.8875 Ft.
Fill Height(top of slab)	=	10.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.0889
Earth Weight for fill computations	=	0.1307 Kcf

Weight of Fill without wearing surface	=	1.3067 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1350 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	1.4417 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	1.6147 Klf

Soil pressure at center of top slab	=	0.5225 Klf
Soil pressure at center of bottom slab	=	1.0669 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
--	---	------------

Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0569
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000
-----	-----
Totals 72.00	28.000

Tire Contact Area = 40.00000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 2.000000 in.

Vehicle Axle number = 1  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 17.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 2  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 3  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]





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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.96	0.00	-4.06	-5.65	-0.68	0.00	0.07	-0.10	14.00	14.00
1- 1	-0.93	0.00	-3.96	-1.00	-0.15	0.00	0.02	-0.09	14.00	14.00
1- 2	-0.91	0.00	-3.87	2.45	0.26	0.00	0.00	-0.12	0.00	14.00
1- 3	-0.89	0.00	-3.78	4.76	0.55	0.00	0.00	-0.18	0.00	14.00
1- 4	-0.87	0.00	-3.68	6.00	0.73	0.00	0.00	-0.25	14.00	14.00
1- 5	-0.85	0.00	-3.59	6.23	0.78	0.00	0.02	-0.31	14.00	14.00
1- 6	-0.82	0.00	-3.50	5.52	0.72	0.00	0.04	-0.38	14.00	14.00
1- 7	-0.80	0.00	-3.40	3.94	0.54	0.00	0.06	-0.45	14.00	14.00
1- 8	-0.78	0.00	-3.31	1.54	0.24	0.00	0.08	-0.52	14.00	14.00
1- 9	-0.76	0.00	-3.21	-1.61	-0.18	0.00	0.10	-0.59	14.00	14.00
1-10	-0.74	0.00	-3.12	-5.44	-0.71	0.00	0.12	-0.66	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.74	0.00	-3.12	-5.44	-0.71	0.00	0.12	-0.66	14.00	14.00
2- 1	0.43	0.00	1.82	-4.63	-0.61	0.00	0.18	-0.01	14.00	14.00
2- 2	1.27	0.00	5.39	-3.82	-0.50	0.00	0.72	0.00	14.00	0.00
2- 3	1.79	0.00	7.58	-3.00	-0.39	0.00	1.07	-0.05	14.00	14.00
2- 4	1.98	0.00	8.41	-2.19	-0.29	0.00	1.24	-0.11	14.00	14.00
2- 5	1.86	0.00	7.88	-1.38	-0.18	0.00	1.21	-0.17	14.00	14.00
2- 6	1.41	0.00	5.97	-0.57	-0.07	0.00	1.01	-0.22	14.00	14.00
2- 7	0.63	0.00	2.69	0.24	0.03	0.00	0.63	-0.28	14.00	14.00
2- 8	-0.46	0.00	-1.96	1.06	0.14	0.00	0.19	-0.34	14.00	14.00
2- 9	-1.88	0.00	-7.97	1.87	0.24	0.00	0.00	-0.89	0.00	14.00
2-10	-3.62	0.00	-15.36	2.68	0.35	0.00	0.00	-1.75	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.00	0.03	0.00	0.00	0.11	-0.11	14.00	14.00
3- 1	0.00	0.00	0.00	0.02	0.00	0.00	0.06	-0.06	14.00	14.00
3- 2	0.00	0.00	0.00	0.02	0.00	0.00	0.01	-0.01	14.00	14.00
3- 3	0.00	0.00	0.00	0.01	0.00	0.00	0.04	-0.04	14.00	14.00
3- 4	0.00	0.00	0.00	0.01	0.00	0.00	0.08	-0.08	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.13	-0.13	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.18	-0.18	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.23	-0.23	14.00	14.00
3- 8	-0.00	0.00	-0.00	-0.02	-0.00	0.00	0.28	-0.28	14.00	14.00
3- 9	-0.00	0.00	-0.00	-0.02	-0.00	0.00	0.33	-0.33	14.00	14.00
3-10	-0.00	0.00	-0.00	-0.03	-0.00	0.00	0.38	-0.38	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-0.96	0.00	-4.06	-5.65	-0.68	0.00	0.07	-0.10	14.00	14.00
4- 1	0.36	0.00	1.54	-4.80	-0.58	0.00	0.18	-0.01	14.00	14.00
4- 2	1.32	0.00	5.59	-3.95	-0.48	0.00	0.30	0.00	0.00	14.00
4- 3	1.91	0.00	8.12	-3.11	-0.38	0.00	0.37	0.00	0.00	14.00
4- 4	2.15	0.00	9.11	-2.26	-0.27	0.00	0.38	0.00	0.00	14.00
4- 5	2.02	0.00	8.57	-1.41	-0.17	0.00	0.35	0.00	0.00	14.00
4- 6	1.53	0.00	6.49	-0.57	-0.07	0.00	0.26	0.00	0.00	14.00
4- 7	0.68	0.00	2.89	0.28	0.03	0.00	0.12	-0.03	14.00	14.00
4- 8	-0.53	0.00	-2.26	1.13	0.14	0.00	0.02	-0.13	14.00	14.00
4- 9	-2.11	0.00	-8.93	1.97	0.24	0.00	0.00	-0.37	14.00	0.00
4-10	-4.04	0.00	-17.14	2.82	0.34	0.00	0.00	-0.67	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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 I-85 DESIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK

Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	0.02	0.00	0.09	4.84	0.54	0.00	0.02	-0.06	14.00	14.00
1- 1	0.02	0.00	0.09	3.71	0.43	0.00	0.02	-0.06	14.00	14.00
1- 2	0.02	0.00	0.09	2.63	0.32	0.00	0.02	-0.06	14.00	14.00
1- 3	0.02	0.00	0.09	1.62	0.22	0.00	0.02	-0.06	14.00	14.00
1- 4	0.02	0.00	0.09	0.67	0.11	0.00	0.02	-0.06	14.00	14.00
1- 5	0.02	0.00	0.09	-0.23	-0.00	0.00	0.02	-0.06	14.00	14.00
1- 6	0.02	0.00	0.09	-1.06	-0.11	0.00	0.02	-0.06	14.00	14.00
1- 7	0.02	0.00	0.09	-1.84	-0.22	0.00	0.02	-0.06	14.00	14.00
1- 8	0.02	0.00	0.09	-2.56	-0.33	0.00	0.02	-0.06	14.00	14.00
1- 9	0.02	0.00	0.09	-3.21	-0.44	0.00	0.02	-0.06	14.00	14.00
1-10	0.02	0.00	0.09	-3.81	-0.55	0.00	0.02	-0.06	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.22	0.00	5.19	0.75	0.10	0.00	0.87	-0.05	14.00	14.00
2- 1	0.93	0.00	3.93	0.75	0.10	0.00	0.63	-0.05	14.00	14.00
2- 2	0.63	0.00	2.66	0.75	0.10	0.00	0.47	-0.05	14.00	14.00
2- 3	0.33	0.00	1.40	0.75	0.10	0.00	0.31	-0.06	14.00	14.00
2- 4	0.03	0.00	0.13	0.75	0.10	0.00	0.16	-0.11	14.00	14.00
2- 5	-0.27	0.00	-1.13	0.75	0.10	0.00	0.04	-0.27	14.00	14.00
2- 6	-0.56	0.00	-2.39	0.75	0.10	0.00	0.01	-0.43	14.00	14.00
2- 7	-0.86	0.00	-3.66	0.75	0.10	0.00	0.00	-0.59	0.00	14.00
2- 8	-1.16	0.00	-4.92	0.75	0.10	0.00	0.00	-0.74	0.00	14.00
2- 9	-1.46	0.00	-6.18	0.75	0.10	0.00	0.00	-0.89	0.00	14.00
2-10	-1.76	0.00	-7.45	0.75	0.10	0.00	0.00	-0.96	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 1	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 2	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 3	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 4	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 8	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3- 9	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
3-10	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.04	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	1.38	0.00	5.87	0.78	0.09	0.00	0.19	0.00	0.00	14.00
4- 1	1.05	0.00	4.45	0.78	0.09	0.00	0.14	0.00	0.00	14.00
4- 2	0.72	0.00	3.04	0.78	0.09	0.00	0.09	0.00	0.00	14.00
4- 3	0.38	0.00	1.62	0.78	0.09	0.00	0.04	0.00	0.00	14.00
4- 4	0.05	0.00	0.21	0.78	0.09	0.00	0.00	-0.01	14.00	14.00
4- 5	-0.28	0.00	-1.21	0.78	0.09	0.00	0.00	-0.06	14.00	0.00
4- 6	-0.62	0.00	-2.62	0.78	0.09	0.00	0.00	-0.11	14.00	0.00
4- 7	-0.95	0.00	-4.04	0.78	0.09	0.00	0.00	-0.15	14.00	0.00
4- 8	-1.29	0.00	-5.45	0.78	0.09	0.00	0.00	-0.20	14.00	0.00
4- 9	-1.62	0.00	-6.87	0.78	0.09	0.00	0.00	-0.25	14.00	0.00
4-10	-1.95	0.00	-8.29	0.78	0.09	0.00	0.00	-0.30	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K		K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 1	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 2	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 3	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 4	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 5	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 6	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 7	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 8	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1- 9	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
1-10	-1.22	0.00	-5.19	-0.75	-0.54	-0.10	0.00	0.05	-0.85	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 1	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 2	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 3	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 4	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 5	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 6	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 7	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 8	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2- 9	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
2-10	0.02	0.00	0.09	-3.81	-2.75	-0.55	0.00	0.02	-0.06	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 1	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 2	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 3	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 4	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 5	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 6	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 7	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 8	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3- 9	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
3-10	-3.51	0.00	-14.90	1.49	1.08	0.20	0.00	0.00	-1.66	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB LEFT SIDE											
4- 0	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 1	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 2	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 3	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 4	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 5	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 6	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 7	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 8	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4- 9	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
4-10	-0.02	0.00	-0.09	-4.84	-3.48	-0.54	0.00	0.06	-0.02	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-11.661	-15.550	-8.925	-11.366	7.644	4.530
1- 1	-7.269	-8.200	-8.925	-11.366	5.936	3.470
1- 2	-2.476	-4.190	-8.925	-11.366	4.306	2.466
1- 3	1.315	-2.009	-8.925	-11.366	2.752	1.518
1- 4	3.462	-0.836	-8.925	-11.366	1.276	0.625
1- 5	4.077	-0.611	-8.925	-11.366	-0.035	-0.301
1- 6	3.212	-1.274	-8.925	-11.366	-0.817	-1.623
1- 7	0.950	-2.758	-8.925	-11.366	-1.544	-2.869
1- 8	-2.623	-5.002	-8.925	-11.366	-2.215	-4.037
1- 9	-6.460	-8.914	-8.925	-11.366	-2.830	-5.128
1-10	-9.853	-15.055	-8.925	-11.366	-3.391	-6.142
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-9.853	-15.055	-3.391	-6.142	11.406	8.925
2- 1	-1.022	-4.436	-3.391	-6.142	8.862	6.895
2- 2	6.631	2.608	-3.391	-6.142	6.486	4.864
2- 3	11.699	7.309	-3.391	-6.142	4.113	2.809
2- 4	14.152	9.806	-3.391	-6.142	1.745	0.669
2- 5	13.985	10.102	-3.391	-6.142	-0.539	-1.702
2- 6	11.235	8.199	-3.391	-6.142	-2.638	-4.074
2- 7	6.062	3.939	-3.391	-6.142	-4.688	-6.442
2- 8	-1.051	-2.899	-3.391	-6.142	-6.719	-8.804
2- 9	-9.850	-12.990	-3.391	-6.142	-8.749	-11.158
2-10	-20.428	-25.962	-3.391	-6.142	-10.779	-13.346
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.281	-0.213	-21.568	-26.130	0.092	-0.105
3- 1	0.167	-0.112	-21.568	-26.130	0.092	-0.105
3- 2	0.053	-0.012	-21.568	-26.130	0.092	-0.105
3- 3	0.092	-0.065	-21.568	-26.130	0.092	-0.105
3- 4	0.190	-0.177	-21.568	-26.130	0.092	-0.105
3- 5	0.289	-0.289	-21.568	-26.130	0.092	-0.105
3- 6	0.389	-0.403	-21.568	-26.130	0.092	-0.105
3- 7	0.489	-0.517	-21.568	-26.130	0.092	-0.105
3- 8	0.590	-0.631	-21.568	-26.130	0.092	-0.105
3- 9	0.690	-0.745	-21.568	-26.130	0.092	-0.105
3-10	0.790	-0.858	-21.568	-26.130	0.092	-0.105
INTERIOR WALL TOP						

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## BOTTOM SLAB LEFT SIDE

4- 0	-11.661	-15.550	-4.530	-7.644	11.053	10.162
4- 1	-1.626	-5.056	-4.530	-7.644	8.675	7.888
4- 2	5.934	2.809	-4.530	-7.644	6.298	5.613
4- 3	10.933	8.189	-4.530	-7.644	3.922	3.339
4- 4	13.356	11.105	-4.530	-7.644	1.556	1.041
4- 5	13.202	11.558	-4.530	-7.644	-0.719	-1.333
4- 6	10.471	9.548	-4.530	-7.644	-2.993	-3.711
4- 7	5.339	4.843	-4.530	-7.644	-5.267	-6.089
4- 8	-1.821	-2.849	-4.530	-7.644	-7.541	-8.468
4- 9	-11.266	-13.310	-4.530	-7.644	-9.815	-10.847
4-10	-23.131	-26.350	-4.530	-7.644	-12.089	-13.226

## BOTTOM SLAB RIGHT SIDE



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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Bottom	0.00	23.94	0.64	Pass
EXTERIOR WALL	Middle -	0.00	23.87	1.34	Pass
EXTERIOR WALL	Top	0.00	23.63	3.66	Pass
TOP SLAB	Left	0.00	23.83	1.74	Pass
TOP SLAB	Middle +	0.00	23.71	2.90	Pass
INTERIOR WALL	Bottom	0.00	23.91	0.92	Pass
INTERIOR WALL	Middle	0.00	23.92	0.79	Pass
INTERIOR WALL	Top	0.00	23.59	4.08	Pass
BOTTOM SLAB	Left	0.00	23.91	0.89	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

---

Reinforcing Bar Stresses Sizes and Spacing

---

Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	24.86	19.80	0.3100	0.3100	5	12.0	29	34
A2	25.55	19.80	0.3100	0.3100	5	12.0	29	33
A100	21.72	19.80	0.6200	0.6200	5	6.0		
A300	18.85	19.80	0.9000	0.9000	7	8.0		
A200	21.61	19.80	0.6200	0.6200	5	6.0		
A400	20.23	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

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Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.62 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.62 (in)													
	Moment	Coin. Axial	Shear Force	Shear Force	Resistance				Steel	Mom.	Des.	Design Ratio		Flexure Ratings		Shear Ratings	
	Kft	Kips	Kips	Cap Kips	Po Cap Kips	Mu Cap Kft	Mbal Cap Kft	Pbal Cap Kips	Area In2	Cap Kft	Thk in	Flx	Shr	Inv	Oper	Inv	Oper
BOT	-10.3*	8.9	5.4	9.6	185.2	6.1	20.5	82.9	0.3100	7.7	8.19	1.35	0.56	0.00	0.00	5.74	9.57
MID	4.1	8.9	0.0	9.8	187.1	7.9	21.1	81.5	0.4000	9.4	8.25	0.44	NA	4.03	6.72	NA	NA
MID-	-0.8	8.9	0.3	9.8	187.1	7.9	21.1	81.5	0.4000	9.4	8.25	0.09	NA	13.70	22.84	NA	NA
TOP	-10.6*	8.9	4.7	9.5	185.2	6.1	20.5	82.9	0.3100	7.7	8.19	1.39	0.50	0.00	0.00	5.74	9.57
Member No. = 2 TOP SLAB				Thickness = 10.80 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-7.7*	3.4	7.9	11.0	199.5	6.7	23.8	91.7	0.3100	7.4	8.99	1.04	0.72	0.82	1.37	3.17	5.29
MID	14.2*	3.4	0.5	12.2	206.2	13.2	26.0	84.5	0.6200	13.7	8.99	1.03	NA	0.74	1.23	NA	NA
RT	-17.0	3.4	10.2	12.7	212.2	18.4	27.7	76.7	0.9000	18.9	8.86	0.90	0.81	1.50	2.51	2.25	3.76
Member No. = 3 INTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.50 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.50 (in)													
BOT	-0.1	21.6	0.1	9.5	184.3	5.3	20.3	84.6	0.2667	9.1	8.25	0.02	0.01	NA	NA	97.40	99.00
MID	0.3	21.6	0.1	9.5	184.3	5.3	20.3	84.6	0.2667	9.1	8.25	0.03	NA	31.63	52.72	NA	NA
MID-	-0.3	21.6	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.1	8.25	0.03	NA	31.65	52.76	NA	NA
TOP	-0.8	21.6	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.1	8.25	0.08	0.01	12.27	20.46	93.00	99.00
Member No. = 4 BOTTOM SLAB				Thickness = 10.50 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-8.3*	4.5	7.8	10.7	194.1	6.5	22.5	88.4	0.3100	7.3	8.69	1.13	0.73	0.32	0.54	7.33	12.22
MID	13.4	4.5	0.7	11.9	200.8	12.7	24.6	81.2	0.6200	13.4	8.69	1.00	NA	0.70	1.16	NA	NA
RT	-17.3	4.5	9.9	12.0	206.9	17.8	26.2	73.4	0.9000	18.3	8.56	0.95	0.83	1.34	2.23	4.74	7.90

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab MidSpan-Exist.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

**BRASS-CULVERT**

BRASS-CULVERT Version 2.7

DATE : 3/ 6/2016

TIME : 16:30: 5

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Interi  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Interi

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot

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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

Units

USSI\_UNITS: Input Units = US  
USSI\_UNITS OU: Output Units = US  
JOB DESCRIPTION: EXISTING COVER 10'  
CHECK TOP AND BOTTOM SLAB @ INTERIOR SUPPORT NEGATIVE MOMENT

Design Variables

LRFDDE: Use LRFD method for bot slab load distrib. = F  
CUTYPE: Precast(PC) or Cast in Place(CIP) Culvert = CIP  
IDSN: Load Factor(LF) Service Load (SL) Design = LF  
FUNCT: Design (DESIGN) or Design Review (DESREV) = DESREV  
IRELEASE: Moment Continuity Released (@ end of walls) = F  
DNEG: Distance to Neg. Moment Computation Point = 1.00

Output Control Variables

MTEN: Output Moment-Shears = T  
IINFN: Output Influence Line = F  
IBSH: Output Bar Schedule = F

Standard Load Variables

LVLD: Live Load Vehicle Name = HS20T  
LVOMT: Neglect LL for Fill > 8Ft & Fill > Span = F



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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	10.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	12.0
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCOVC:	Compressive Strength of Concrete (Psi)	= 2500.0
FSCR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
 ILESS: Code for Span Less Than 5 ft = F  
 ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL,FIXED,HINGED) = FULL  
 LDPASS: Bypass Live Load if no vehicle input = F  
 LONGB: Longitudinal Bar Code = F  
 MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
 Structure ID : XISTING CHECK  
 Agency name : MEAD &

Input units : US  
 Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
-------------------	---------------	----------------------------	--------------------------	--------------------------

CAST-IN-PLACE	DESREV	NO	FULL	1.00
---------------	--------	----	------	------

Consider Haunches in Analysis : YES  
 Perform Edge Beam reinforcement computations : NO  
 Use epoxy coated bars in top mat of reinforcement: NO  
 in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input

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 BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
12.00 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

 LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

 (Neglect Live Load if fill is greater than 8 ft.  
 and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

 DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water
Pressure	Density
Max	Min
(Pcf)	(Pcf)
50.0	36.0
	0.0

	Wearing
Uniform	Surface
Load	Thickness
(plf)	(in)
0.0	0.00
	Fill
	Height
	(Ft)
	10.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in

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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches



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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

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Live Load Parameters for a HS20T vehicle

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Fill	= 10.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 35.16666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 35.16666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.05687
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	12.0000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.9375 Ft.
Fill Height(top of slab)	=	10.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.0889
Earth Weight for fill computations	=	0.1307 Kcf

Weight of Fill without wearing surface	=	1.3067 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1500 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	1.4567 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	1.6297 Klf

Soil pressure at center of top slab	=	0.5250 Klf
Soil pressure at center of bottom slab	=	1.0719 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
--	---	------------

Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0569
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000
-----	-----
Totals 72.00	28.000

Tire Contact Area = 40.00000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 2.000000 in.

Vehicle Axle number = 1  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 17.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 2  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 3  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]



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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-1.08	0.00	-4.35	-5.52	-0.66	0.00	0.05	-0.10	14.00	14.00
1- 1	-1.02	0.00	-4.12	-0.90	-0.14	0.00	0.01	-0.10	14.00	14.00
1- 2	-0.96	0.00	-3.90	2.51	0.26	0.00	0.00	-0.12	0.00	14.00
1- 3	-0.91	0.00	-3.67	4.76	0.55	0.00	0.00	-0.17	0.00	14.00
1- 4	-0.85	0.00	-3.45	5.93	0.71	0.00	0.00	-0.22	0.00	14.00
1- 5	-0.80	0.00	-3.22	6.07	0.76	0.00	0.02	-0.27	14.00	14.00
1- 6	-0.74	0.00	-3.00	5.26	0.68	0.00	0.03	-0.32	14.00	14.00
1- 7	-0.68	0.00	-2.77	3.56	0.49	0.00	0.05	-0.37	14.00	14.00
1- 8	-0.63	0.00	-2.54	1.04	0.18	0.00	0.07	-0.43	14.00	14.00
1- 9	-0.57	0.00	-2.32	-2.24	-0.26	0.00	0.09	-0.48	14.00	14.00
1-10	-0.52	0.00	-2.09	-6.22	-0.81	0.00	0.11	-0.53	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.52	0.00	-2.09	-6.22	-0.81	0.00	0.11	-0.53	14.00	14.00
2- 1	0.67	0.00	2.71	-5.29	-0.69	0.00	0.28	0.00	14.00	0.00
2- 2	1.52	0.00	6.13	-4.36	-0.57	0.00	0.81	-0.01	14.00	14.00
2- 3	2.02	0.00	8.19	-3.44	-0.45	0.00	1.15	-0.07	14.00	14.00
2- 4	2.19	0.00	8.87	-2.51	-0.33	0.00	1.30	-0.13	14.00	14.00
2- 5	2.02	0.00	8.19	-1.59	-0.21	0.00	1.26	-0.20	14.00	14.00
2- 6	1.52	0.00	6.13	-0.66	-0.09	0.00	1.04	-0.26	14.00	14.00
2- 7	0.67	0.00	2.70	0.26	0.03	0.00	0.65	-0.32	14.00	14.00
2- 8	-0.52	0.00	-2.10	1.19	0.15	0.00	0.22	-0.38	14.00	14.00
2- 9	-2.04	0.00	-8.26	2.12	0.27	0.00	0.00	-0.94	0.00	14.00
2-10	-3.91	0.00	-15.80	3.04	0.40	0.00	0.00	-1.78	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.01	0.03	0.00	0.00	0.09	-0.09	14.00	14.00
3- 1	0.00	0.00	0.01	0.03	0.00	0.00	0.05	-0.05	14.00	14.00
3- 2	0.00	0.00	0.01	0.02	0.00	0.00	0.01	-0.01	14.00	14.00
3- 3	0.00	0.00	0.00	0.01	0.00	0.00	0.03	-0.03	14.00	14.00
3- 4	0.00	0.00	0.00	0.01	0.00	0.00	0.07	-0.07	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.11	-0.11	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.15	-0.15	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.19	-0.19	14.00	14.00
3- 8	-0.00	0.00	-0.01	-0.02	-0.00	0.00	0.23	-0.23	14.00	14.00
3- 9	-0.00	0.00	-0.01	-0.03	-0.00	0.00	0.27	-0.27	14.00	14.00
3-10	-0.00	0.00	-0.01	-0.03	-0.00	0.00	0.31	-0.31	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-1.08	0.00	-4.35	-5.52	-0.66	0.00	0.05	-0.10	14.00	14.00
4- 1	0.32	0.00	1.29	-4.69	-0.56	0.00	0.15	-0.01	14.00	14.00
4- 2	1.33	0.00	5.39	-3.86	-0.46	0.00	0.27	0.00	0.00	14.00
4- 3	1.97	0.00	7.96	-3.04	-0.37	0.00	0.35	0.00	0.00	14.00
4- 4	2.22	0.00	8.99	-2.21	-0.27	0.00	0.37	0.00	0.00	14.00
4- 5	2.10	0.00	8.50	-1.38	-0.17	0.00	0.34	0.00	0.00	14.00
4- 6	1.60	0.00	6.46	-0.56	-0.07	0.00	0.25	0.00	0.00	14.00
4- 7	0.72	0.00	2.90	0.27	0.03	0.00	0.12	-0.02	14.00	14.00
4- 8	-0.54	0.00	-2.20	1.10	0.13	0.00	0.01	-0.12	14.00	14.00
4- 9	-2.18	0.00	-8.83	1.93	0.23	0.00	0.00	-0.36	14.00	0.00
4-10	-4.20	0.00	-17.00	2.75	0.33	0.00	0.00	-0.65	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	0.05	0.00	0.21	4.80	0.53	0.00	0.02	-0.05	14.00	14.00
1- 1	0.05	0.00	0.21	3.66	0.42	0.00	0.02	-0.05	14.00	14.00
1- 2	0.05	0.00	0.21	2.58	0.31	0.00	0.02	-0.05	14.00	14.00
1- 3	0.05	0.00	0.21	1.55	0.21	0.00	0.02	-0.05	14.00	14.00
1- 4	0.05	0.00	0.21	0.59	0.10	0.00	0.02	-0.05	14.00	14.00
1- 5	0.05	0.00	0.21	-0.31	-0.01	0.00	0.02	-0.05	14.00	14.00
1- 6	0.05	0.00	0.21	-1.16	-0.12	0.00	0.02	-0.05	14.00	14.00
1- 7	0.05	0.00	0.21	-1.94	-0.23	0.00	0.02	-0.05	14.00	14.00
1- 8	0.05	0.00	0.21	-2.66	-0.34	0.00	0.02	-0.05	14.00	14.00
1- 9	0.05	0.00	0.21	-3.33	-0.45	0.00	0.02	-0.05	14.00	14.00
1-10	0.05	0.00	0.21	-3.93	-0.56	0.00	0.02	-0.05	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.25	0.00	5.06	0.85	0.11	0.00	0.86	-0.06	14.00	14.00
2- 1	0.94	0.00	3.80	0.85	0.11	0.00	0.62	-0.06	14.00	14.00
2- 2	0.63	0.00	2.53	0.85	0.11	0.00	0.46	-0.06	14.00	14.00
2- 3	0.31	0.00	1.26	0.85	0.11	0.00	0.30	-0.07	14.00	14.00
2- 4	-0.00	0.00	-0.00	0.85	0.11	0.00	0.15	-0.13	14.00	14.00
2- 5	-0.31	0.00	-1.27	0.85	0.11	0.00	0.04	-0.29	14.00	14.00
2- 6	-0.63	0.00	-2.53	0.85	0.11	0.00	0.00	-0.44	0.00	14.00
2- 7	-0.94	0.00	-3.80	0.85	0.11	0.00	0.00	-0.60	0.00	14.00
2- 8	-1.25	0.00	-5.06	0.85	0.11	0.00	0.00	-0.75	0.00	14.00
2- 9	-1.56	0.00	-6.33	0.85	0.11	0.00	0.00	-0.90	0.00	14.00
2-10	-1.88	0.00	-7.59	0.85	0.11	0.00	0.00	-0.97	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 1	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 2	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 3	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 4	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 8	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 9	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3-10	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	1.46	0.00	5.91	0.76	0.09	0.00	0.19	0.00	0.00	14.00
4- 1	1.11	0.00	4.50	0.76	0.09	0.00	0.14	0.00	0.00	14.00
4- 2	0.76	0.00	3.08	0.76	0.09	0.00	0.09	0.00	0.00	14.00
4- 3	0.41	0.00	1.66	0.76	0.09	0.00	0.05	0.00	0.00	14.00
4- 4	0.06	0.00	0.25	0.76	0.09	0.00	0.00	-0.01	14.00	14.00
4- 5	-0.29	0.00	-1.17	0.76	0.09	0.00	0.00	-0.05	14.00	0.00
4- 6	-0.64	0.00	-2.58	0.76	0.09	0.00	0.00	-0.10	14.00	0.00
4- 7	-0.99	0.00	-4.00	0.76	0.09	0.00	0.00	-0.15	14.00	0.00
4- 8	-1.34	0.00	-5.41	0.76	0.09	0.00	0.00	-0.20	14.00	0.00
4- 9	-1.69	0.00	-6.83	0.76	0.09	0.00	0.00	-0.25	14.00	0.00
4-10	-2.04	0.00	-8.24	0.76	0.09	0.00	0.00	-0.29	14.00	0.00
BOTTOM SLAB RIGHT SIDE										



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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K		K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 1	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 2	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 3	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 4	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 5	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 6	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 7	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 8	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1- 9	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
1-10	-1.25	0.00	-5.06	-0.85	-0.62	-0.11	0.00	0.06	-0.84	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 1	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 2	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 3	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 4	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 5	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 6	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 7	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 8	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2- 9	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
2-10	0.05	0.00	0.21	-3.93	-2.83	-0.56	0.00	0.02	-0.05	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 1	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 2	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 3	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 4	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 5	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 6	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 7	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 8	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3- 9	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
3-10	-3.75	0.00	-15.19	1.70	1.23	0.22	0.00	0.00	-1.68	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB LEFT SIDE											
4- 0	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 1	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 2	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 3	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 4	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 5	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 6	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 7	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 8	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4- 9	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
4-10	-0.05	0.00	-0.21	-4.80	-3.46	-0.53	0.00	0.05	-0.02	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-12.121	-15.892	-8.883	-11.371	7.772	4.724
1- 1	-7.514	-8.379	-8.883	-11.371	6.050	3.654
1- 2	-2.491	-4.244	-8.883	-11.371	4.406	2.641
1- 3	1.421	-1.869	-8.883	-11.371	2.839	1.684
1- 4	3.661	-0.514	-8.883	-11.371	1.350	0.782
1- 5	4.351	-0.119	-8.883	-11.371	0.082	-0.206
1- 6	3.543	-0.625	-8.883	-11.371	-0.708	-1.539
1- 7	1.321	-1.964	-8.883	-11.371	-1.441	-2.795
1- 8	-2.230	-4.074	-8.883	-11.371	-2.119	-3.973
1- 9	-5.656	-8.265	-8.883	-11.371	-2.740	-5.073
1-10	-8.968	-14.380	-8.883	-11.371	-3.306	-6.095
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-8.968	-14.380	-3.306	-6.095	11.414	8.882
2- 1	0.032	-3.983	-3.306	-6.095	8.844	6.831
2- 2	7.605	3.010	-3.306	-6.095	6.447	4.780
2- 3	12.556	7.676	-3.306	-6.095	4.054	2.704
2- 4	14.859	10.119	-3.306	-6.095	1.667	0.520
2- 5	14.518	10.339	-3.306	-6.095	-0.623	-1.873
2- 6	11.575	8.336	-3.306	-6.095	-2.752	-4.265
2- 7	6.198	3.941	-3.306	-6.095	-4.803	-6.652
2- 8	-1.028	-3.105	-3.306	-6.095	-6.855	-9.033
2- 9	-10.053	-13.446	-3.306	-6.095	-8.906	-11.406
2-10	-20.812	-26.626	-3.306	-6.095	-10.958	-13.613
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.256	-0.155	-21.929	-26.668	0.072	-0.091
3- 1	0.157	-0.077	-21.929	-26.668	0.072	-0.091
3- 2	0.058	0.002	-21.929	-26.668	0.072	-0.091
3- 3	0.086	-0.047	-21.929	-26.668	0.072	-0.091
3- 4	0.162	-0.144	-21.929	-26.668	0.072	-0.091
3- 5	0.239	-0.240	-21.929	-26.668	0.072	-0.091
3- 6	0.317	-0.339	-21.929	-26.668	0.072	-0.091
3- 7	0.396	-0.439	-21.929	-26.668	0.072	-0.091
3- 8	0.475	-0.538	-21.929	-26.668	0.072	-0.091
3- 9	0.554	-0.637	-21.929	-26.668	0.072	-0.091
3-10	0.632	-0.737	-21.929	-26.668	0.072	-0.091
INTERIOR WALL TOP						

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## BOTTOM SLAB LEFT SIDE

4- 0	-12.121	-15.892	-4.724	-7.772	11.186	10.298
4- 1	-1.972	-5.259	-4.724	-7.772	8.786	8.003
4- 2	5.714	2.706	-4.724	-7.772	6.387	5.708
4- 3	10.813	8.163	-4.724	-7.772	3.990	3.413
4- 4	13.313	11.134	-4.724	-7.772	1.599	1.102
4- 5	13.213	11.618	-4.724	-7.772	-0.701	-1.293
4- 6	10.514	9.616	-4.724	-7.772	-2.996	-3.692
4- 7	5.386	4.923	-4.724	-7.772	-5.291	-6.092
4- 8	-1.820	-2.790	-4.724	-7.772	-7.586	-8.492
4- 9	-11.309	-13.288	-4.724	-7.772	-9.881	-10.892
4-10	-23.258	-26.387	-4.724	-7.772	-12.177	-13.292

## BOTTOM SLAB RIGHT SIDE

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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Bottom	0.00	23.94	0.62	Pass
EXTERIOR WALL	Middle -	0.00	23.89	1.14	Pass
EXTERIOR WALL	Top	0.00	23.70	3.03	Pass
TOP SLAB	Left	0.00	23.84	1.59	Pass
TOP SLAB	Middle +	0.00	23.74	2.64	Pass
INTERIOR WALL	Bottom	0.00	23.92	0.75	Pass
INTERIOR WALL	Middle	0.00	23.93	0.66	Pass
INTERIOR WALL	Top	0.00	23.66	3.36	Pass
BOTTOM SLAB	Left	0.00	23.92	0.77	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

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Reinforcing Bar Stresses Sizes and Spacing

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Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	21.34	19.80	0.3100	0.3100	5	12.0	29	35
A2	26.58	19.80	0.3100	0.3100	5	12.0	29	33
A100	20.05	19.80	0.6200	0.6200	5	6.0		
A300	17.04	19.80	0.9000	0.9000	7	8.0		
A200	21.43	19.80	0.6200	0.6200	5	6.0		
A400	20.17	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

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Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness		= 10.00 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (bot )		= 0.62 (in)											
				Bar diameter (mid+)		= 0.50 (in)											
				Bar diameter (mid-)		= 0.50 (in)											
				Bar diameter (top )		= 0.62 (in)											
	Moment	Axial	Shear	Shear	Resistance												
		Force	Force	Cap	Po	Mu	Mbal	Pbal	Steel	Mom.	Des.	Design		Flexure		Shear	
	Kft	Kips	Kips	Kips	Cap	Cap	Cap	Cap	Area	Cap	Thk	Flx	Shr	Inv	Oper	Inv	Oper
BOT	-10.6*	8.9	5.5	9.6	185.2	6.1	20.5	82.9	0.3100	7.7	8.19	1.38	0.57	0.00	0.00	5.71	9.51
MID	4.4	8.9	0.1	9.8	187.1	7.9	21.1	81.5	0.4000	9.3	8.25	0.47	NA	3.97	6.62	NA	NA
MID-	-0.5	8.9	0.2	9.8	187.1	7.9	21.1	81.5	0.4000	9.3	8.25	0.05	NA	15.32	25.55	NA	NA
TOP	-9.7*	8.9	4.6	9.5	185.2	6.1	20.5	82.9	0.3100	7.7	8.19	1.27	0.49	0.00	0.00	5.97	9.95
Member No. = 2 TOP SLAB				Thickness		= 12.00 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (lt )		= 0.62 (in)											
				Bar diameter (mid )		= 0.62 (in)											
				Bar diameter (rt )		= 0.88 (in)											
LT	-7.2	3.3	7.6	12.3	220.9	7.7	29.2	104.9	0.3100	8.3	10.19	0.86	0.62	1.60	2.67	4.33	7.22
MID	14.9	3.3	0.6	13.5	227.6	15.0	31.7	97.7	0.6200	15.6	10.19	0.95	NA	1.22	2.04	NA	NA
RT	-17.5	3.3	10.2	14.5	233.7	21.1	33.8	89.9	0.9000	21.6	10.06	0.81	0.70	2.31	3.85	3.26	5.43
Member No. = 3 INTERIOR WALL				Thickness		= 10.00 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (bot )		= 0.50 (in)											
				Bar diameter (mid+)		= 0.50 (in)											
				Bar diameter (mid-)		= 0.50 (in)											
				Bar diameter (top )		= 0.50 (in)											
BOT	-0.1	21.9	0.1	9.4	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.01	0.01	NA	NA	99.00	99.00
MID	0.2	21.9	0.1	9.4	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.03	NA	38.44	64.07	NA	NA
MID-	-0.2	21.9	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.03	NA	38.46	64.11	NA	NA
TOP	-0.7	21.9	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.07	0.01	14.97	24.95	99.00	99.00
Member No. = 4 BOTTOM SLAB				Thickness		= 10.50 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (lt )		= 0.62 (in)											
				Bar diameter (mid )		= 0.62 (in)											
				Bar diameter (rt )		= 0.88 (in)											
LT	-8.5*	4.7	7.9	10.7	194.1	6.5	22.5	88.4	0.3100	7.4	8.69	1.16	0.74	0.15	0.26	7.09	11.82
MID	13.3	4.7	0.7	11.9	200.8	12.7	24.6	81.2	0.6200	13.4	8.69	0.99	NA	0.72	1.21	NA	NA
RT	-17.3	4.7	10.0	12.1	206.9	17.8	26.2	73.4	0.9000	18.3	8.56	0.95	0.83	1.39	2.32	4.78	7.97

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.



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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
 X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Interior Support-Exist.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support Exist.DAT  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support Exist.xml

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support

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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

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Units

USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US
JOB DESCRIPTION: EXISTING COVER 10'			
CHECK EXTERIOR WALLS			

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Design Variables

LRFD:	Use LRFD method for bot slab load distrib.	=	F
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDS:	Load Factor(LF) Service Load (SL) Design	=	LF
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESREV
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	1.00

---

Output Control Variables

MTEN:	Output Moment-Shears	=	T
IINF:	Output Influence Line	=	F
IBSH:	Output Bar Schedule	=	F

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Standard Load Variables

LVLD:	Live Load Vehicle Name	=	HS20T
LVOMT:	Neglect LL for Fill > 8Ft & Fill > Span	=	F

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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	10.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	10.0
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCOnc:	Compressive Strength of Concrete (Psi)	= 2500.0
FSHR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

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B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
 ILESS: Code for Span Less Than 5 ft = F  
 ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL, FIXED, HINGED) = FULL  
 LDPASS: Bypass Live Load if no vehicle input = F  
 LONGB: Longitudinal Bar Code = F  
 MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
 Structure ID : XISTING CHECK  
 Agency name : MEAD &

Input units : US  
 Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
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CAST-IN-PLACE	DESREV	NO	FULL	1.00
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Consider Haunches in Analysis : YES  
 Perform Edge Beam reinforcement computations : NO  
 Use epoxy coated bars in top mat of reinforcement: NO  
 in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85



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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input

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BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
10.00 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

(Neglect Live Load if fill is greater than 8 ft.  
and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water	
Pressure	Density	
Max	Min	
(Pcf)	(Pcf)	(Pcf)
50.0	36.0	0.0

	Wearing	
Uniform	Surface	Fill
Load	Thickness	Height
(plf)	(in)	(Ft)
0.0	0.00	10.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in

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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance  
  
Required Thickness is 7.00 Inches

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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

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Live Load Parameters for a HS20T vehicle

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Fill	= 10.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 35.16666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 35.16666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.05687
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	10.0000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.8542 Ft.
Fill Height(top of slab)	=	10.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.0889
Earth Weight for fill computations	=	0.1307 Kcf

Weight of Fill without wearing surface	=	1.3067 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1250 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	1.4317 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	1.6047 Klf

Soil pressure at center of top slab	=	0.5208 Klf
Soil pressure at center of bottom slab	=	1.0635 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
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Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0569
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000
-----	-----
Totals 72.00	28.000

Tire Contact Area = 40.00000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 2.000000 in.

Vehicle Axle number = 1  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 17.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 2  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 3  
 Fill = 10.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 18.17 ft.  
 [slope(fill) + longitudinal tire patch]





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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.87	0.00	-3.83	-5.75	-0.70	0.00	0.08	-0.09	14.00	14.00
1- 1	-0.88	0.00	-3.84	-1.08	-0.16	0.00	0.02	-0.09	14.00	14.00
1- 2	-0.88	0.00	-3.85	2.40	0.25	0.00	0.00	-0.12	0.00	14.00
1- 3	-0.88	0.00	-3.86	4.76	0.56	0.00	0.00	-0.19	0.00	14.00
1- 4	-0.88	0.00	-3.86	6.06	0.74	0.00	0.00	-0.27	14.00	14.00
1- 5	-0.88	0.00	-3.87	6.36	0.80	0.00	0.02	-0.35	14.00	14.00
1- 6	-0.89	0.00	-3.88	5.72	0.75	0.00	0.04	-0.43	14.00	14.00
1- 7	-0.89	0.00	-3.89	4.22	0.58	0.00	0.06	-0.51	14.00	14.00
1- 8	-0.89	0.00	-3.90	1.91	0.29	0.00	0.08	-0.59	14.00	14.00
1- 9	-0.89	0.00	-3.91	-1.14	-0.11	0.00	0.10	-0.67	14.00	14.00
1-10	-0.89	0.00	-3.91	-4.87	-0.64	0.00	0.12	-0.75	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.89	0.00	-3.91	-4.87	-0.64	0.00	0.12	-0.75	14.00	14.00
2- 1	0.26	0.00	1.13	-4.14	-0.54	0.00	0.11	-0.07	14.00	14.00
2- 2	1.10	0.00	4.81	-3.41	-0.45	0.00	0.65	0.00	14.00	0.00
2- 3	1.63	0.00	7.13	-2.68	-0.35	0.00	1.01	-0.04	14.00	14.00
2- 4	1.84	0.00	8.07	-1.96	-0.26	0.00	1.19	-0.09	14.00	14.00
2- 5	1.74	0.00	7.65	-1.23	-0.16	0.00	1.18	-0.15	14.00	14.00
2- 6	1.34	0.00	5.86	-0.50	-0.07	0.00	0.98	-0.20	14.00	14.00
2- 7	0.61	0.00	2.70	0.22	0.03	0.00	0.61	-0.25	14.00	14.00
2- 8	-0.42	0.00	-1.83	0.95	0.12	0.00	0.17	-0.32	14.00	14.00
2- 9	-1.76	0.00	-7.73	1.68	0.22	0.00	0.00	-0.87	0.00	14.00
2-10	-3.42	0.00	-14.99	2.40	0.31	0.00	0.00	-1.73	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.13	-0.13	14.00	14.00
3- 1	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.07	-0.07	14.00	14.00
3- 2	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 3	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 4	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.10	-0.10	14.00	14.00
3- 5	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.15	-0.15	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.21	-0.21	14.00	14.00
3- 7	0.00	0.00	0.00	-0.01	0.00	0.00	0.26	-0.26	14.00	14.00
3- 8	0.00	0.00	0.00	-0.01	0.00	0.00	0.32	-0.32	14.00	14.00
3- 9	0.00	0.00	0.00	-0.02	0.00	0.00	0.37	-0.37	14.00	14.00
3-10	0.00	0.00	0.00	-0.02	0.00	0.00	0.43	-0.43	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-0.87	0.00	-3.83	-5.75	-0.70	0.00	0.08	-0.09	14.00	14.00
4- 1	0.39	0.00	1.73	-4.89	-0.60	0.00	0.21	-0.01	14.00	14.00
4- 2	1.31	0.00	5.75	-4.03	-0.49	0.00	0.32	0.00	0.00	14.00
4- 3	1.88	0.00	8.24	-3.16	-0.39	0.00	0.38	0.00	0.00	14.00
4- 4	2.10	0.00	9.20	-2.30	-0.28	0.00	0.40	0.00	0.00	14.00
4- 5	1.97	0.00	8.63	-1.44	-0.18	0.00	0.36	0.00	0.00	14.00
4- 6	1.49	0.00	6.52	-0.58	-0.07	0.00	0.27	0.00	0.00	14.00
4- 7	0.66	0.00	2.88	0.28	0.04	0.00	0.13	-0.03	14.00	14.00
4- 8	-0.52	0.00	-2.30	1.15	0.14	0.00	0.03	-0.14	14.00	14.00
4- 9	-2.06	0.00	-9.01	2.01	0.25	0.00	0.00	-0.38	14.00	0.00
4-10	-3.94	0.00	-17.25	2.87	0.35	0.00	0.00	-0.68	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.00	0.00	-0.01	4.87	0.55	0.00	0.02	-0.07	14.00	14.00
1- 1	-0.00	0.00	-0.01	3.75	0.44	0.00	0.02	-0.07	14.00	14.00
1- 2	-0.00	0.00	-0.01	2.68	0.33	0.00	0.02	-0.07	14.00	14.00
1- 3	-0.00	0.00	-0.01	1.67	0.22	0.00	0.02	-0.07	14.00	14.00
1- 4	-0.00	0.00	-0.01	0.73	0.11	0.00	0.02	-0.07	14.00	14.00
1- 5	-0.00	0.00	-0.01	-0.16	0.01	0.00	0.02	-0.07	14.00	14.00
1- 6	-0.00	0.00	-0.01	-0.99	-0.10	0.00	0.02	-0.07	14.00	14.00
1- 7	-0.00	0.00	-0.01	-1.77	-0.21	0.00	0.02	-0.07	14.00	14.00
1- 8	-0.00	0.00	-0.01	-2.48	-0.32	0.00	0.02	-0.07	14.00	14.00
1- 9	-0.00	0.00	-0.01	-3.13	-0.43	0.00	0.02	-0.07	14.00	14.00
1-10	-0.00	0.00	-0.01	-3.73	-0.54	0.00	0.02	-0.07	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.21	0.00	5.29	0.67	0.09	0.00	0.88	-0.05	14.00	14.00
2- 1	0.92	0.00	4.03	0.67	0.09	0.00	0.64	-0.05	14.00	14.00
2- 2	0.63	0.00	2.77	0.67	0.09	0.00	0.48	-0.05	14.00	14.00
2- 3	0.34	0.00	1.50	0.67	0.09	0.00	0.32	-0.06	14.00	14.00
2- 4	0.05	0.00	0.24	0.67	0.09	0.00	0.17	-0.11	14.00	14.00
2- 5	-0.23	0.00	-1.02	0.67	0.09	0.00	0.05	-0.26	14.00	14.00
2- 6	-0.52	0.00	-2.29	0.67	0.09	0.00	0.01	-0.42	14.00	14.00
2- 7	-0.81	0.00	-3.55	0.67	0.09	0.00	0.00	-0.58	0.00	14.00
2- 8	-1.10	0.00	-4.81	0.67	0.09	0.00	0.00	-0.73	0.00	14.00
2- 9	-1.39	0.00	-6.07	0.67	0.09	0.00	0.00	-0.88	0.00	14.00
2-10	-1.67	0.00	-7.34	0.67	0.09	0.00	0.00	-0.95	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 1	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 2	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 3	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 4	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 5	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 7	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 8	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3- 9	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
3-10	0.00	0.00	0.00	-0.00	0.00	0.00	0.05	-0.05	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	1.33	0.00	5.84	0.80	0.10	0.00	0.18	0.00	0.00	14.00
4- 1	1.01	0.00	4.42	0.80	0.10	0.00	0.13	0.00	0.00	14.00
4- 2	0.69	0.00	3.01	0.80	0.10	0.00	0.09	0.00	0.00	14.00
4- 3	0.36	0.00	1.59	0.80	0.10	0.00	0.04	0.00	0.00	14.00
4- 4	0.04	0.00	0.18	0.80	0.10	0.00	0.00	-0.01	14.00	14.00
4- 5	-0.28	0.00	-1.24	0.80	0.10	0.00	0.00	-0.06	14.00	0.00
4- 6	-0.61	0.00	-2.65	0.80	0.10	0.00	0.00	-0.11	14.00	0.00
4- 7	-0.93	0.00	-4.07	0.80	0.10	0.00	0.00	-0.16	14.00	0.00
4- 8	-1.25	0.00	-5.49	0.80	0.10	0.00	0.00	-0.20	14.00	0.00
4- 9	-1.57	0.00	-6.90	0.80	0.10	0.00	0.00	-0.25	14.00	0.00
4-10	-1.90	0.00	-8.32	0.80	0.10	0.00	0.00	-0.30	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K		K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 1	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 2	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 3	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 4	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 5	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 6	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 7	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 8	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1- 9	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
1-10	-1.21	0.00	-5.29	-0.67	-0.48	-0.09	0.00	0.05	-0.86	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 1	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 2	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 3	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 4	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 5	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 6	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 7	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 8	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2- 9	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
2-10	-0.00	0.00	-0.01	-3.73	-2.68	-0.54	0.00	0.02	-0.07	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 1	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 2	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 3	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 4	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 5	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 6	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 7	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 8	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3- 9	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
3-10	-3.35	0.00	-14.67	1.34	0.96	0.18	0.00	0.00	-1.64	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB LEFT SIDE											
4- 0	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 1	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 2	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 3	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 4	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 5	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 6	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 7	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 8	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4- 9	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
4-10	0.00	0.00	0.01	-4.87	-3.51	-0.55	0.00	0.07	-0.02	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-11.324	-15.310	-8.970	-11.375	7.550	4.385
1- 1	-7.090	-8.076	-8.970	-11.375	5.852	3.332
1- 2	-2.466	-4.151	-8.970	-11.375	4.231	2.335
1- 3	1.238	-2.114	-8.970	-11.375	2.687	1.392
1- 4	3.316	-1.079	-8.970	-11.375	1.219	0.504
1- 5	3.871	-0.983	-8.970	-11.375	-0.113	-0.388
1- 6	2.960	-1.766	-8.970	-11.375	-0.903	-1.690
1- 7	0.664	-3.363	-8.970	-11.375	-1.625	-2.928
1- 8	-2.933	-5.713	-8.970	-11.375	-2.292	-4.090
1- 9	-7.087	-9.419	-8.970	-11.375	-2.904	-5.175
1-10	-10.546	-15.589	-8.970	-11.375	-3.460	-6.183
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-10.546	-15.589	-3.460	-6.183	11.413	8.970
2- 1	-1.826	-4.907	-3.460	-6.183	8.887	6.954
2- 2	5.898	2.283	-3.460	-6.183	6.525	4.937
2- 3	11.064	7.036	-3.460	-6.183	4.164	2.895
2- 4	13.637	9.580	-3.460	-6.183	1.809	0.782
2- 5	13.606	9.939	-3.460	-6.183	-0.472	-1.569
2- 6	11.004	8.114	-3.460	-6.183	-2.558	-3.928
2- 7	5.983	3.960	-3.460	-6.183	-4.602	-6.284
2- 8	-1.048	-2.727	-3.460	-6.183	-6.619	-8.634
2- 9	-9.684	-12.654	-3.460	-6.183	-8.635	-10.976
2-10	-20.131	-25.445	-3.460	-6.183	-10.651	-13.151
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.301	-0.258	-21.689	-25.355	0.108	-0.116
3- 1	0.175	-0.141	-21.689	-25.355	0.108	-0.116
3- 2	0.050	-0.024	-21.689	-25.355	0.108	-0.116
3- 3	0.096	-0.079	-21.689	-25.355	0.108	-0.116
3- 4	0.212	-0.203	-21.689	-25.355	0.108	-0.116
3- 5	0.327	-0.327	-21.689	-25.355	0.108	-0.116
3- 6	0.444	-0.452	-21.689	-25.355	0.108	-0.116
3- 7	0.561	-0.577	-21.689	-25.355	0.108	-0.116
3- 8	0.678	-0.703	-21.689	-25.355	0.108	-0.116
3- 9	0.795	-0.828	-21.689	-25.355	0.108	-0.116
3-10	0.912	-0.954	-21.689	-25.355	0.108	-0.116
INTERIOR WALL TOP						

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## BOTTOM SLAB LEFT SIDE

4- 0	-11.324	-15.310	-4.385	-7.550	10.962	10.067
4- 1	-1.366	-4.906	-4.385	-7.550	8.599	7.807
4- 2	6.107	2.888	-4.385	-7.550	6.237	5.547
4- 3	11.032	8.214	-4.385	-7.550	3.875	3.287
4- 4	13.399	11.092	-4.385	-7.550	1.528	0.995
4- 5	13.203	11.522	-4.385	-7.550	-0.733	-1.364
4- 6	10.447	9.504	-4.385	-7.550	-2.993	-3.728
4- 7	5.309	4.787	-4.385	-7.550	-5.253	-6.093
4- 8	-1.822	-2.896	-4.385	-7.550	-7.513	-8.457
4- 9	-11.242	-13.338	-4.385	-7.550	-9.773	-10.822
4-10	-23.054	-26.343	-4.385	-7.550	-12.033	-13.187

## BOTTOM SLAB RIGHT SIDE



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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Bottom	0.00	23.97	0.30	Pass
EXTERIOR WALL	Middle -	0.00	23.85	1.49	Pass
EXTERIOR WALL	Top	0.00	23.81	1.86	Pass
TOP SLAB	Left	0.00	23.91	0.92	Pass
TOP SLAB	Middle +	0.00	23.69	3.10	Pass
INTERIOR WALL	Bottom	0.00	23.90	1.04	Pass
INTERIOR WALL	Middle	0.00	23.91	0.90	Pass
INTERIOR WALL	Top	0.00	23.54	4.65	Pass
BOTTOM SLAB	Left	0.00	23.96	0.44	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

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Reinforcing Bar Stresses Sizes and Spacing

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Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	9.69	19.80	0.7086	0.7086	5	5.2	29	33
A2	10.86	19.80	0.7086	0.7086	5	5.2	29	33
A100	23.02	19.80	0.6200	0.6200	5	6.0		
A300	20.28	19.80	0.9000	0.9000	7	8.0		
A200	21.76	19.80	0.6200	0.6200	5	6.0		
A400	20.30	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

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Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness			= 10.00 (in)										
				Clear cover at end			= 1.50 (in)										
				Clear cover at middle			= 1.50 (in)										
				Bar diameter (bot )			= 0.62 (in)										
				Bar diameter (mid+)			= 0.50 (in)										
				Bar diameter (mid-)			= 0.50 (in)										
				Bar diameter (top )			= 0.62 (in)										
	Moment	Coin. Axial Force	Shear Force	Shear Cap	Resistance			Pbal	Steel Area	Mom. Cap	Des. Thk	Design Ratio		Flexure Ratings		Shear Ratings	
	Kft	Kips	Kips	Kips	Po Kips	Mu Kft	Mbal Kft	Kips	In2	Kft	in	Flx	Shr	Inv	Oper	Inv	Oper
BOT	-10.2	9.0	5.3	10.4	193.8	13.6	22.9	73.7	0.7086	14.7	8.19	0.69	0.50	6.11	10.19	6.69	11.15
MID	3.9	9.0	0.1	9.8	187.1	7.9	21.1	81.5	0.4000	9.4	8.25	0.41	NA	4.07	6.79	NA	NA
MID-	-1.1	9.0	0.4	9.8	187.1	7.9	21.1	81.5	0.4000	9.4	8.25	0.12	NA	12.14	20.23	NA	NA
TOP	-11.3	9.0	4.8	10.1	193.8	13.6	22.9	73.7	0.7086	14.7	8.19	0.77	0.48	2.60	4.33	6.20	10.33
Member No. = 2 TOP SLAB				Thickness			= 10.00 (in)										
				Clear cover at end			= 1.50 (in)										
				Clear cover at middle			= 1.50 (in)										
				Bar diameter (lt )			= 0.62 (in)										
				Bar diameter (mid )			= 0.62 (in)										
				Bar diameter (rt )			= 0.88 (in)										
LT	-8.2	3.5	8.1	11.7	193.8	13.6	22.9	73.7	0.7086	14.0	8.19	0.59	0.69	4.13	6.88	3.49	5.81
MID	13.6*	3.5	0.5	11.4	191.9	11.9	22.4	75.7	0.6200	12.4	8.19	1.10	NA	0.40	0.66	NA	NA
RT	-16.6	3.5	10.2	11.4	198.0	16.7	23.9	67.9	0.9000	17.0	8.06	0.97	0.89	0.96	1.60	1.58	2.64
Member No. = 3 INTERIOR WALL				Thickness			= 10.00 (in)										
				Clear cover at end			= 1.50 (in)										
				Clear cover at middle			= 1.50 (in)										
				Bar diameter (bot )			= 0.50 (in)										
				Bar diameter (mid+)			= 0.50 (in)										
				Bar diameter (mid-)			= 0.50 (in)										
				Bar diameter (top )			= 0.50 (in)										
BOT	-0.2	21.7	0.1	9.6	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.02	0.01	NA	NA	86.08	99.00
MID	0.3	21.7	0.1	9.6	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.04	NA	28.02	46.70	NA	NA
MID-	-0.3	21.7	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.04	NA	28.03	46.72	NA	NA
TOP	-0.9	21.7	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	9.2	8.25	0.09	0.01	10.83	18.05	81.62	99.00
Member No. = 4 BOTTOM SLAB				Thickness			= 10.50 (in)										
				Clear cover at end			= 1.50 (in)										
				Clear cover at middle			= 1.50 (in)										
				Bar diameter (lt )			= 0.62 (in)										
				Bar diameter (mid )			= 0.62 (in)										
				Bar diameter (rt )			= 0.88 (in)										
LT	-8.1	4.4	7.7	12.3	202.7	14.4	25.2	79.2	0.7086	15.0	8.69	0.54	0.63	5.82	9.70	10.84	18.08
MID	13.4*	4.4	0.7	11.9	200.8	12.7	24.6	81.2	0.6200	13.4	8.69	1.00	NA	0.67	1.11	NA	NA
RT	-17.3	4.4	9.9	12.0	206.9	17.8	26.2	73.4	0.9000	18.3	8.56	0.95	0.83	1.28	2.14	4.69	7.82

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
 X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support Exist.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 2  
CONTROLLING POINT : Center  
RATING FACTOR : 0.40  
LOAD RATING : 14.35 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 2  
CONTROLLING POINT : Center  
RATING FACTOR : 0.66  
LOAD RATING : 23.92 (TONS)  
ACTION TYPE : Flexure

## **APPENDIX D**

### **BRASS INPUT & OUTPUT FOR PROPOSED CONDITION WITH NEW EMBANKMENT (Four Models)**

**BRASS-CULVERT**

BRASS-CULVERT Version 2.7

DATE : 3/ 6/2016

TIME : 15:40:22

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Exteri  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Exteri

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot



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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

---

Units

USSI\_UNITS: Input Units = US  
USSI\_UNITS OU: Output Units = US  
JOB DESCRIPTION: PROPOSED COVER 16'  
CHECK TOP AND BOTTOM SLAB @ EXTERIOR SUPPORT FOR NEGATIVE MOMENT

---

Design Variables

LRFD: Use LRFD method for bot slab load distrib. = F  
CUTYPE: Precast(PC) or Cast in Place(CIP) Culvert = CIP  
IDSN: Load Factor(LF) Service Load (SL) Design = LF  
FUNCT: Design (DESIGN) or Design Review (DESREV) = DESREV  
IRELEASE: Moment Continuity Released (@ end of walls) = F  
DNEG: Distance to Neg. Moment Computation Point = 1.00

---

Output Control Variables

MTEN: Output Moment-Shears = T  
IINFN: Output Influence Line = F  
IBSH: Output Bar Schedule = F

---

Standard Load Variables

LVLD: Live Load Vehicle Name = HS20T  
LVOMT: Neglect LL for Fill > 8Ft & Fill > Span = F

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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	16.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	10.0
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCOVC:	Compressive Strength of Concrete (Psi)	= 2500.0
FSCR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
ILES5: Code for Span Less Than 5 ft = F  
ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL, FIXED, HINGED) = FULL  
LDPASS: Bypass Live Load if no vehicle input = F  
LONGB: Longitudinal Bar Code = F  
MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
Structure ID : ROPOSED CHECK  
Agency name : MEAD &

Input units : US  
Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
-------------------	---------------	----------------------------	--------------------------	--------------------------

CAST-IN-PLACE	DESREV	NO	FULL	1.00
---------------	--------	----	------	------

Consider Haunches in Analysis : YES  
Perform Edge Beam reinforcement computations : NO  
Use epoxy coated bars in top mat of reinforcement: NO  
in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input

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BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
10.00 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

(Neglect Live Load if fill is greater than 8 ft.  
and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water
Pressure	Density
Max	Min
(Pcf)	(Pcf)
50.0	36.0
	0.0

	Wearing
Uniform	Surface
Load	Thickness
(plf)	(in)
0.0	0.00
	Fill
	Height
	(Ft)
	16.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in



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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches

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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

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Live Load Parameters for a HS20T vehicle

---

Fill	= 16.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 45.66666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 45.66666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.04380
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	10.0000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.8542 Ft.
Fill Height(top of slab)	=	16.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.1422
Earth Weight for fill computations	=	0.1371 Kcf

Weight of Fill without wearing surface	=	2.1931 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1250 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	2.3181 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	2.4911 Klf

Soil pressure at center of top slab	=	0.8208 Klf
Soil pressure at center of bottom slab	=	1.3635 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
--	---	------------

Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0438
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000
-----	-----
Totals 72.00	28.000

Tire Contact Area = 40.00000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 2.000000 in.

Vehicle Axle number = 1  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 2  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 3  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]





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I-85 DESIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK

Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.86	0.00	-6.31	-7.85	-0.70	0.00	0.03	-0.09	14.00	14.00
1- 1	-0.87	0.00	-6.38	-1.57	-0.16	0.00	0.01	-0.10	14.00	14.00
1- 2	-0.88	0.00	-6.44	3.17	0.25	0.00	0.00	-0.11	0.00	14.00
1- 3	-0.88	0.00	-6.51	6.43	0.56	0.00	0.00	-0.15	0.00	14.00
1- 4	-0.89	0.00	-6.57	8.27	0.74	0.00	0.00	-0.20	0.00	14.00
1- 5	-0.90	0.00	-6.64	8.77	0.80	0.00	0.01	-0.24	14.00	14.00
1- 6	-0.91	0.00	-6.70	7.98	0.75	0.00	0.02	-0.29	14.00	14.00
1- 7	-0.92	0.00	-6.77	5.96	0.58	0.00	0.03	-0.33	14.00	14.00
1- 8	-0.93	0.00	-6.83	2.79	0.29	0.00	0.04	-0.38	14.00	14.00
1- 9	-0.94	0.00	-6.90	-1.48	-0.11	0.00	0.05	-0.43	14.00	14.00
1-10	-0.95	0.00	-6.96	-6.78	-0.64	0.00	0.06	-0.47	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.95	0.00	-6.96	-6.78	-0.64	0.00	0.06	-0.47	14.00	14.00
2- 1	0.26	0.00	1.89	-5.77	-0.54	0.00	0.05	-0.02	14.00	14.00
2- 2	1.14	0.00	8.35	-4.75	-0.45	0.00	0.36	0.00	14.00	0.00
2- 3	1.69	0.00	12.42	-3.74	-0.35	0.00	0.60	-0.02	14.00	14.00
2- 4	1.91	0.00	14.08	-2.73	-0.26	0.00	0.72	-0.05	14.00	14.00
2- 5	1.82	0.00	13.36	-1.72	-0.16	0.00	0.72	-0.07	14.00	14.00
2- 6	1.39	0.00	10.24	-0.70	-0.07	0.00	0.60	-0.10	14.00	14.00
2- 7	0.64	0.00	4.72	0.31	0.03	0.00	0.37	-0.13	14.00	14.00
2- 8	-0.43	0.00	-3.19	1.32	0.12	0.00	0.08	-0.23	14.00	14.00
2- 9	-1.83	0.00	-13.49	2.34	0.22	0.00	0.00	-0.57	0.00	14.00
2-10	-3.56	0.00	-26.19	3.35	0.31	0.00	0.00	-1.16	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.06	-0.06	14.00	14.00
3- 1	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 2	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.01	-0.01	14.00	14.00
3- 3	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 4	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.05	-0.05	14.00	14.00
3- 5	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.07	-0.07	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.10	-0.10	14.00	14.00
3- 7	0.00	0.00	0.00	-0.01	0.00	0.00	0.13	-0.13	14.00	14.00
3- 8	0.00	0.00	0.00	-0.01	0.00	0.00	0.16	-0.16	14.00	14.00
3- 9	0.00	0.00	0.00	-0.02	0.00	0.00	0.19	-0.18	14.00	14.00
3-10	0.00	0.00	0.00	-0.02	0.00	0.00	0.21	-0.21	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-0.86	0.00	-6.31	-7.85	-0.70	0.00	0.03	-0.09	14.00	14.00
4- 1	0.41	0.00	3.00	-6.68	-0.60	0.00	0.13	-0.00	14.00	14.00
4- 2	1.32	0.00	9.74	-5.50	-0.49	0.00	0.25	0.00	0.00	14.00
4- 3	1.89	0.00	13.90	-4.32	-0.39	0.00	0.31	0.00	0.00	14.00
4- 4	2.11	0.00	15.49	-3.14	-0.28	0.00	0.33	0.00	0.00	14.00
4- 5	1.97	0.00	14.51	-1.97	-0.18	0.00	0.31	0.00	0.00	14.00
4- 6	1.49	0.00	10.95	-0.79	-0.07	0.00	0.23	0.00	0.00	14.00
4- 7	0.66	0.00	4.82	0.39	0.04	0.00	0.11	-0.01	14.00	14.00
4- 8	-0.53	0.00	-3.88	1.57	0.14	0.00	0.01	-0.11	14.00	14.00
4- 9	-2.06	0.00	-15.16	2.75	0.25	0.00	0.00	-0.32	14.00	0.00
4-10	-3.94	0.00	-29.02	3.92	0.35	0.00	0.00	-0.59	14.00	0.00
BOTTOM SLAB RIGHT SIDE										



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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.01	0.00	-0.06	6.52	0.55	0.00	0.01	-0.04	14.00	14.00
1- 1	-0.01	0.00	-0.06	5.07	0.44	0.00	0.01	-0.04	14.00	14.00
1- 2	-0.01	0.00	-0.06	3.68	0.33	0.00	0.01	-0.04	14.00	14.00
1- 3	-0.01	0.00	-0.06	2.34	0.22	0.00	0.01	-0.04	14.00	14.00
1- 4	-0.01	0.00	-0.06	1.07	0.11	0.00	0.01	-0.04	14.00	14.00
1- 5	-0.01	0.00	-0.06	-0.15	0.01	0.00	0.01	-0.04	14.00	14.00
1- 6	-0.01	0.00	-0.06	-1.30	-0.10	0.00	0.01	-0.04	14.00	14.00
1- 7	-0.01	0.00	-0.06	-2.40	-0.21	0.00	0.01	-0.04	14.00	14.00
1- 8	-0.01	0.00	-0.06	-3.44	-0.32	0.00	0.01	-0.04	14.00	14.00
1- 9	-0.01	0.00	-0.06	-4.42	-0.43	0.00	0.01	-0.04	14.00	14.00
1-10	-0.01	0.00	-0.06	-5.34	-0.54	0.00	0.01	-0.04	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.26	0.00	9.28	0.93	0.09	0.00	0.54	-0.02	14.00	14.00
2- 1	0.96	0.00	7.07	0.93	0.09	0.00	0.37	-0.02	14.00	14.00
2- 2	0.66	0.00	4.86	0.93	0.09	0.00	0.27	-0.02	14.00	14.00
2- 3	0.36	0.00	2.65	0.93	0.09	0.00	0.16	-0.03	14.00	14.00
2- 4	0.06	0.00	0.44	0.93	0.09	0.00	0.06	-0.05	14.00	14.00
2- 5	-0.24	0.00	-1.78	0.93	0.09	0.00	0.02	-0.14	14.00	14.00
2- 6	-0.54	0.00	-3.99	0.93	0.09	0.00	0.01	-0.23	14.00	14.00
2- 7	-0.84	0.00	-6.20	0.93	0.09	0.00	0.00	-0.33	0.00	14.00
2- 8	-1.14	0.00	-8.41	0.93	0.09	0.00	0.00	-0.44	0.00	14.00
2- 9	-1.44	0.00	-10.62	0.93	0.09	0.00	0.00	-0.55	0.00	14.00
2-10	-1.74	0.00	-12.83	0.93	0.09	0.00	0.00	-0.60	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 1	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 2	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 3	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 4	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 5	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 7	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 8	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 9	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3-10	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	1.33	0.00	9.78	1.09	0.10	0.00	0.17	0.00	0.00	14.00
4- 1	1.01	0.00	7.41	1.09	0.10	0.00	0.13	0.00	0.00	14.00
4- 2	0.68	0.00	5.03	1.09	0.10	0.00	0.09	0.00	0.00	14.00
4- 3	0.36	0.00	2.66	1.09	0.10	0.00	0.04	0.00	0.00	14.00
4- 4	0.04	0.00	0.28	1.09	0.10	0.00	0.00	-0.01	14.00	14.00
4- 5	-0.28	0.00	-2.10	1.09	0.10	0.00	0.00	-0.05	14.00	0.00
4- 6	-0.61	0.00	-4.47	1.09	0.10	0.00	0.00	-0.09	14.00	0.00
4- 7	-0.93	0.00	-6.85	1.09	0.10	0.00	0.00	-0.14	14.00	0.00
4- 8	-1.25	0.00	-9.22	1.09	0.10	0.00	0.00	-0.18	14.00	0.00
4- 9	-1.58	0.00	-11.60	1.09	0.10	0.00	0.00	-0.22	14.00	0.00
4-10	-1.90	0.00	-13.98	1.09	0.10	0.00	0.00	-0.27	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K	K	K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 1	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 2	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 3	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 4	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 5	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 6	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 7	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 8	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 9	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1-10	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 1	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 2	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 3	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 4	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 5	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 6	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 7	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 8	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 9	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2-10	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 1	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 2	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 3	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 4	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 5	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 6	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 7	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 8	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 9	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3-10	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB LEFT SIDE											
4- 0	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 1	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 2	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 3	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 4	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 5	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 6	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 7	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 8	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 9	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4-10	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-16.602	-21.237	-14.523	-16.248	9.596	5.916
1- 1	-10.875	-12.022	-14.523	-16.248	7.475	4.559
1- 2	-4.844	-6.793	-14.523	-16.248	5.430	3.256
1- 3	-0.050	-3.927	-14.523	-16.248	3.463	2.009
1- 4	2.650	-2.386	-14.523	-16.248	1.571	0.816
1- 5	3.355	-2.116	-14.523	-16.248	-0.190	-0.374
1- 6	2.137	-3.053	-14.523	-16.248	-1.285	-2.100
1- 7	-0.924	-5.137	-14.523	-16.248	-2.311	-3.761
1- 8	-5.746	-8.305	-14.523	-16.248	-3.283	-5.346
1- 9	-11.461	-13.283	-14.523	-16.248	-4.200	-6.854
1-10	-16.492	-21.506	-14.523	-16.248	-5.061	-8.286
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-16.492	-21.506	-5.062	-8.286	16.273	14.523
2- 1	-2.486	-5.920	-5.062	-8.286	12.655	11.258
2- 2	8.671	5.183	-5.062	-8.286	9.153	7.994
2- 3	16.125	12.667	-5.062	-8.286	5.652	4.717
2- 4	19.800	16.597	-5.062	-8.286	2.181	1.404
2- 5	19.680	16.990	-5.062	-8.286	-1.166	-2.041
2- 6	15.761	13.847	-5.062	-8.286	-4.468	-5.502
2- 7	8.239	6.991	-5.062	-8.286	-7.745	-8.984
2- 8	-2.535	-3.957	-5.062	-8.286	-11.009	-12.490
2- 9	-16.413	-18.970	-5.062	-8.286	-14.274	-15.988
2-10	-33.645	-38.065	-5.062	-8.286	-17.539	-19.366
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.158	-0.124	-35.463	-38.309	0.053	-0.059
3- 1	0.094	-0.067	-35.463	-38.309	0.053	-0.059
3- 2	0.030	-0.010	-35.463	-38.309	0.053	-0.059
3- 3	0.051	-0.038	-35.463	-38.309	0.053	-0.059
3- 4	0.107	-0.100	-35.463	-38.309	0.053	-0.059
3- 5	0.162	-0.162	-35.463	-38.309	0.053	-0.059
3- 6	0.219	-0.225	-35.463	-38.309	0.053	-0.059
3- 7	0.276	-0.289	-35.463	-38.309	0.053	-0.059
3- 8	0.334	-0.353	-35.463	-38.309	0.053	-0.059
3- 9	0.391	-0.417	-35.463	-38.309	0.053	-0.059
3-10	0.448	-0.481	-35.463	-38.309	0.053	-0.059
INTERIOR WALL TOP						

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BOTTOM SLAB LEFT SIDE						
4- 0	-16.602	-21.237	-5.916	-9.595	16.446	15.464
4- 1	-1.525	-5.547	-5.916	-9.595	12.842	11.956
4- 2	9.771	6.169	-5.916	-9.595	9.239	8.448
4- 3	17.167	14.077	-5.916	-9.595	5.635	4.939
4- 4	20.660	18.184	-5.916	-9.595	2.039	1.418
4- 5	20.248	18.490	-5.916	-9.595	-1.471	-2.182
4- 6	15.932	14.996	-5.916	-9.595	-4.980	-5.786
4- 7	7.939	7.459	-5.916	-9.595	-8.488	-9.390
4- 8	-3.375	-4.502	-5.916	-9.595	-11.997	-12.994
4- 9	-18.292	-20.518	-5.916	-9.595	-15.505	-16.598
4-10	-36.989	-40.447	-5.916	-9.595	-19.013	-20.201
BOTTOM SLAB RIGHT SIDE						

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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Bottom	0.00	23.95	0.55	Pass
EXTERIOR WALL	Middle -	0.00	23.90	1.00	Pass
EXTERIOR WALL	Top	0.00	23.74	2.56	Pass
TOP SLAB	Left	0.00	23.89	1.11	Pass
TOP SLAB	Middle +	0.00	23.81	1.90	Pass
INTERIOR WALL	Bottom	0.00	23.95	0.52	Pass
INTERIOR WALL	Middle	0.00	23.96	0.44	Pass
INTERIOR WALL	Top	0.00	23.77	2.31	Pass
BOTTOM SLAB	Left	0.00	23.94	0.64	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

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Reinforcing Bar Stresses Sizes and Spacing

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Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	29.78	19.80	0.3100	0.3100	5	12.0	29	33
A2	35.80	19.80	0.3100	0.3100	5	12.0	29	33
A100	35.18	19.80	0.6200	0.6200	5	6.0		
A300	31.66	19.80	0.9000	0.9000	7	8.0		
A200	34.65	19.80	0.6200	0.6200	5	6.0		
A400	32.07	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

\*\* THE HEIGHT OF C.H.C.U. \*\* BOTTOM SLAB = 7.00 IN



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## Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness		= 10.00 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (bot )		= 0.62 (in)											
				Bar diameter (mid+)		= 0.50 (in)											
				Bar diameter (mid-)		= 0.50 (in)											
				Bar diameter (top )		= 0.62 (in)											
	Moment	Axial Force	Shear Force	Shear Cap	Resistance				Steel Area	Mom. Cap	Des. Thk	Design Ratio		Flexure Ratings		Shear Ratings	
	Kft	Kips	Kips	Kips	Po Cap	Mu Cap	Mbal Cap	Pbal Cap	In2	Kft	in	Flx	Shr	Inv	Oper	Inv	Oper
BOT	-14.7*	14.5	6.7	9.5	185.2	6.1	20.5	82.9	0.3100	8.6	8.19	1.70	0.71	0.00	0.00	4.09	6.82
MID	3.4	14.5	0.2	9.7	187.1	7.9	21.1	81.5	0.4000	10.3	8.25	0.33	NA	4.93	8.22	NA	NA
MID-	-2.4	14.5	0.4	9.7	187.1	7.9	21.1	81.5	0.4000	10.3	8.25	0.23	NA	16.58	27.65	NA	NA
TOP	-15.8*	14.5	6.3	9.4	185.2	6.1	20.5	82.9	0.3100	8.6	8.19	1.83	0.67	0.00	0.00	4.24	7.07
Member No. = 2 TOP SLAB				Thickness		= 10.00 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (lt )		= 0.62 (in)											
				Bar diameter (mid )		= 0.62 (in)											
				Bar diameter (rt )		= 0.88 (in)											
LT	-10.7*	5.1	11.4*	10.1	185.2	6.1	20.5	82.9	0.3100	7.0	8.19	1.53	1.13	0.00	0.00	0.00	0.00
MID	19.8*	5.1	1.2	11.4	191.9	11.9	22.4	75.7	0.6200	12.6	8.19	1.57	NA	0.00	0.00	NA	NA
RT	-24.8*	5.1	14.8*	11.3	198.0	16.7	23.9	67.9	0.9000	17.2	8.06	1.44	1.30	0.00	0.00	0.00	0.00
Member No. = 3 INTERIOR WALL				Thickness		= 10.00 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (bot )		= 0.50 (in)											
				Bar diameter (mid+)		= 0.50 (in)											
				Bar diameter (mid-)		= 0.50 (in)											
				Bar diameter (top )		= 0.50 (in)											
BOT	-0.1	35.5	0.1	9.5	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	0.01	NA	NA	99.00	99.00
MID	0.2	35.5	0.1	9.5	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	NA	NA	NA	NA	NA
MID-	-0.2	35.5	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	NA	NA	NA	NA	NA
TOP	-0.4	35.5	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.04	0.01	27.69	46.16	99.00	99.00
Member No. = 4 BOTTOM SLAB				Thickness		= 10.50 (in)											
				Clear cover at end		= 1.50 (in)											
				Clear cover at middle		= 1.50 (in)											
				Bar diameter (lt )		= 0.62 (in)											
				Bar diameter (mid )		= 0.62 (in)											
				Bar diameter (rt )		= 0.88 (in)											
LT	-10.4*	5.9	11.5*	10.7	194.1	6.5	22.5	88.4	0.3100	7.6	8.69	1.37	1.07	0.00	0.00	0.00	0.00
MID	20.7*	5.9	1.5	11.9	200.8	12.7	24.6	81.2	0.6200	13.6	8.69	1.52	NA	0.00	0.00	NA	NA
RT	-26.6*	5.9	15.2*	12.0	206.9	17.8	26.2	73.4	0.9000	18.5	8.56	1.44	1.27	0.00	0.00	0.00	0.00

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Exterior Support-Prop.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

**BRASS-CULVERT**

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab MidSpa  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab MidSpa

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot

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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

---

Units

USSI\_UNITS: Input Units = US  
USSI\_UNITS OU: Output Units = US  
JOB DESCRIPTION: PROPOSED COVER 16'  
CHECK TOP AND BOTTOM SLAB @ MID-SPAN POSITIVE MOMENT

---

Design Variables

LRFD: Use LRFD method for bot slab load distrib. = F  
CUTYPE: Precast(PC) or Cast in Place(CIP) Culvert = CIP  
IDSN: Load Factor(LF) Service Load (SL) Design = LF  
FUNCT: Design (DESIGN) or Design Review (DESREV) = DESREV  
IRELEASE: Moment Continuity Released (@ end of walls) = F  
DNEG: Distance to Neg. Moment Computation Point = 1.00

---

Output Control Variables

MTEN: Output Moment-Shears = T  
IINFN: Output Influence Line = F  
IBSH: Output Bar Schedule = F

---

Standard Load Variables

LVLD: Live Load Vehicle Name = HS20T  
LVOMT: Neglect LL for Fill > 8Ft & Fill > Span = F

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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	16.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	10.8
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCNC:	Compressive Strength of Concrete (Psi)	= 2500.0
FSHR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
 ILESS: Code for Span Less Than 5 ft = F  
 ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL, FIXED, HINGED) = FULL  
 LDPASS: Bypass Live Load if no vehicle input = F  
 LONGB: Longitudinal Bar Code = F  
 MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
 Structure ID : ROPOSED CHECK  
 Agency name : MEAD &

Input units : US  
 Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
CAST-IN-PLACE	DESREV	NO	FULL	1.00

Consider Haunches in Analysis : YES  
 Perform Edge Beam reinforcement computations : NO  
 Use epoxy coated bars in top mat of reinforcement: NO  
 in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input

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BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
10.80 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

(Neglect Live Load if fill is greater than 8 ft.  
and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water	
Pressure	Density	
Max	Min	
(Pcf)	(Pcf)	(Pcf)
50.0	36.0	0.0

	Wearing	
Uniform	Surface	Fill
Load	Thickness	Height
(plf)	(in)	(Ft)
0.0	0.00	16.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in

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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches

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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

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Live Load Parameters for a HS20T vehicle

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Fill	= 16.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 45.66666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 45.66666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.04380
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	10.8000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.8875 Ft.
Fill Height(top of slab)	=	16.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.1422
Earth Weight for fill computations	=	0.1371 Kcf

Weight of Fill without wearing surface	=	2.1931 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1350 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	2.3281 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	2.5011 Klf

Soil pressure at center of top slab	=	0.8225 Klf
Soil pressure at center of bottom slab	=	1.3669 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
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Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0438
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.



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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)	
8.00	14.000	
32.00	14.000	
32.00	0.000	
-----	-----	
Totals 72.00	28.000	
Tire Contact Area =	40.00000	sq.in.
Tire patch Width =	20.00000	in.
Tire Patch Length =	2.000000	in.

Vehicle Axle number = 1  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area =	160.0000	sq.in.
Tire patch Width =	20.00000	in.
Tire Patch Length =	8.000000	in.

Vehicle Axle number = 2  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area =	160.0000	sq.in.
Tire patch Width =	20.00000	in.
Tire Patch Length =	8.000000	in.

Vehicle Axle number = 3  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]





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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.94	0.00	-6.71	-7.70	-0.68	0.00	0.02	-0.10	14.00	14.00
1- 1	-0.93	0.00	-6.59	-1.46	-0.15	0.00	0.00	-0.10	14.00	14.00
1- 2	-0.91	0.00	-6.48	3.22	0.26	0.00	0.00	-0.11	0.00	14.00
1- 3	-0.89	0.00	-6.37	6.41	0.55	0.00	0.00	-0.15	0.00	14.00
1- 4	-0.88	0.00	-6.26	8.18	0.73	0.00	0.00	-0.18	0.00	14.00
1- 5	-0.86	0.00	-6.14	8.58	0.78	0.00	0.01	-0.22	14.00	14.00
1- 6	-0.85	0.00	-6.03	7.69	0.72	0.00	0.02	-0.26	14.00	14.00
1- 7	-0.83	0.00	-5.92	5.56	0.54	0.00	0.03	-0.30	14.00	14.00
1- 8	-0.82	0.00	-5.81	2.26	0.24	0.00	0.04	-0.34	14.00	14.00
1- 9	-0.80	0.00	-5.69	-2.14	-0.18	0.00	0.05	-0.37	14.00	14.00
1-10	-0.78	0.00	-5.58	-7.58	-0.71	0.00	0.06	-0.41	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.78	0.00	-5.58	-7.58	-0.71	0.00	0.06	-0.41	14.00	14.00
2- 1	0.43	0.00	3.08	-6.44	-0.61	0.00	0.09	-0.00	14.00	14.00
2- 2	1.31	0.00	9.34	-5.31	-0.50	0.00	0.41	0.00	14.00	0.00
2- 3	1.85	0.00	13.20	-4.18	-0.39	0.00	0.64	-0.03	14.00	14.00
2- 4	2.06	0.00	14.68	-3.05	-0.29	0.00	0.75	-0.05	14.00	14.00
2- 5	1.93	0.00	13.75	-1.92	-0.18	0.00	0.75	-0.08	14.00	14.00
2- 6	1.47	0.00	10.43	-0.79	-0.07	0.00	0.62	-0.11	14.00	14.00
2- 7	0.66	0.00	4.71	0.34	0.03	0.00	0.38	-0.14	14.00	14.00
2- 8	-0.48	0.00	-3.40	1.47	0.14	0.00	0.10	-0.25	14.00	14.00
2- 9	-1.95	0.00	-13.91	2.60	0.24	0.00	0.00	-0.58	0.00	14.00
2-10	-3.77	0.00	-26.81	3.73	0.35	0.00	0.00	-1.18	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.00	0.03	0.00	0.00	0.05	-0.06	14.00	14.00
3- 1	0.00	0.00	0.00	0.02	0.00	0.00	0.03	-0.03	14.00	14.00
3- 2	0.00	0.00	0.00	0.02	0.00	0.00	0.01	-0.01	14.00	14.00
3- 3	0.00	0.00	0.00	0.01	0.00	0.00	0.02	-0.02	14.00	14.00
3- 4	0.00	0.00	0.00	0.01	0.00	0.00	0.04	-0.04	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.07	-0.07	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.09	-0.09	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.11	-0.11	14.00	14.00
3- 8	-0.00	0.00	-0.00	-0.02	-0.00	0.00	0.14	-0.14	14.00	14.00
3- 9	-0.00	0.00	-0.00	-0.02	-0.00	0.00	0.16	-0.16	14.00	14.00
3-10	-0.00	0.00	-0.00	-0.03	-0.00	0.00	0.19	-0.19	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-0.94	0.00	-6.71	-7.70	-0.68	0.00	0.02	-0.10	14.00	14.00
4- 1	0.37	0.00	2.66	-6.55	-0.58	0.00	0.12	-0.00	14.00	14.00
4- 2	1.33	0.00	9.46	-5.39	-0.48	0.00	0.24	0.00	0.00	14.00
4- 3	1.92	0.00	13.68	-4.24	-0.38	0.00	0.30	0.00	0.00	14.00
4- 4	2.15	0.00	15.33	-3.08	-0.27	0.00	0.33	0.00	0.00	14.00
4- 5	2.02	0.00	14.41	-1.93	-0.17	0.00	0.30	0.00	0.00	14.00
4- 6	1.53	0.00	10.91	-0.77	-0.07	0.00	0.23	0.00	0.00	14.00
4- 7	0.68	0.00	4.84	0.38	0.03	0.00	0.11	-0.01	14.00	14.00
4- 8	-0.53	0.00	-3.81	1.54	0.14	0.00	0.01	-0.10	14.00	14.00
4- 9	-2.11	0.00	-15.03	2.69	0.24	0.00	0.00	-0.31	14.00	0.00
4-10	-4.05	0.00	-28.82	3.85	0.34	0.00	0.00	-0.58	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	0.01	0.00	0.10	6.46	0.54	0.00	0.01	-0.04	14.00	14.00
1- 1	0.01	0.00	0.10	5.01	0.43	0.00	0.01	-0.04	14.00	14.00
1- 2	0.01	0.00	0.10	3.61	0.32	0.00	0.01	-0.04	14.00	14.00
1- 3	0.01	0.00	0.10	2.27	0.22	0.00	0.01	-0.04	14.00	14.00
1- 4	0.01	0.00	0.10	0.99	0.11	0.00	0.01	-0.04	14.00	14.00
1- 5	0.01	0.00	0.10	-0.24	-0.00	0.00	0.01	-0.04	14.00	14.00
1- 6	0.01	0.00	0.10	-1.40	-0.11	0.00	0.01	-0.04	14.00	14.00
1- 7	0.01	0.00	0.10	-2.50	-0.22	0.00	0.01	-0.04	14.00	14.00
1- 8	0.01	0.00	0.10	-3.54	-0.33	0.00	0.01	-0.04	14.00	14.00
1- 9	0.01	0.00	0.10	-4.53	-0.44	0.00	0.01	-0.04	14.00	14.00
1-10	0.01	0.00	0.10	-5.45	-0.55	0.00	0.01	-0.04	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.28	0.00	9.10	1.04	0.10	0.00	0.53	-0.03	14.00	14.00
2- 1	0.97	0.00	6.89	1.04	0.10	0.00	0.37	-0.03	14.00	14.00
2- 2	0.66	0.00	4.67	1.04	0.10	0.00	0.26	-0.03	14.00	14.00
2- 3	0.35	0.00	2.46	1.04	0.10	0.00	0.15	-0.03	14.00	14.00
2- 4	0.04	0.00	0.25	1.04	0.10	0.00	0.05	-0.06	14.00	14.00
2- 5	-0.28	0.00	-1.96	1.04	0.10	0.00	0.02	-0.14	14.00	14.00
2- 6	-0.59	0.00	-4.17	1.04	0.10	0.00	0.00	-0.23	14.00	14.00
2- 7	-0.90	0.00	-6.38	1.04	0.10	0.00	0.00	-0.33	0.00	14.00
2- 8	-1.21	0.00	-8.59	1.04	0.10	0.00	0.00	-0.45	0.00	14.00
2- 9	-1.52	0.00	-10.81	1.04	0.10	0.00	0.00	-0.55	0.00	14.00
2-10	-1.83	0.00	-13.02	1.04	0.10	0.00	0.00	-0.61	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 1	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 2	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 3	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 4	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 8	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 9	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
3-10	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.02	-0.02	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	1.38	0.00	9.84	1.07	0.09	0.00	0.18	0.00	0.00	14.00
4- 1	1.05	0.00	7.46	1.07	0.09	0.00	0.13	0.00	0.00	14.00
4- 2	0.71	0.00	5.09	1.07	0.09	0.00	0.09	0.00	0.00	14.00
4- 3	0.38	0.00	2.71	1.07	0.09	0.00	0.04	0.00	0.00	14.00
4- 4	0.05	0.00	0.33	1.07	0.09	0.00	0.00	-0.00	14.00	14.00
4- 5	-0.29	0.00	-2.04	1.07	0.09	0.00	0.00	-0.05	14.00	0.00
4- 6	-0.62	0.00	-4.42	1.07	0.09	0.00	0.00	-0.09	14.00	0.00
4- 7	-0.95	0.00	-6.79	1.07	0.09	0.00	0.00	-0.13	14.00	0.00
4- 8	-1.29	0.00	-9.17	1.07	0.09	0.00	0.00	-0.18	14.00	0.00
4- 9	-1.62	0.00	-11.54	1.07	0.09	0.00	0.00	-0.22	14.00	0.00
4-10	-1.96	0.00	-13.92	1.07	0.09	0.00	0.00	-0.27	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K		K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 1	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 2	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 3	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 4	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 5	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 6	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 7	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 8	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1- 9	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
1-10	-1.28	0.00	-9.10	-1.04	-0.75	-0.10	0.00	0.03	-0.52	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 1	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 2	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 3	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 4	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 5	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 6	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 7	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 8	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2- 9	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
2-10	0.01	0.00	0.10	-5.45	-3.93	-0.55	0.00	0.01	-0.04	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 1	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 2	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 3	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 4	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 5	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 6	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 7	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 8	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3- 9	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
3-10	-3.66	0.00	-26.03	2.08	1.50	0.20	0.00	0.00	-1.19	0.00	14.00
INTERIOR WALL TOP											



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BOTTOM SLAB LEFT SIDE											
4- 0	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 1	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 2	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 3	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 4	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 5	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 6	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 7	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 8	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4- 9	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
4-10	-0.01	0.00	-0.10	-6.46	-4.65	-0.54	0.00	0.04	-0.01	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-17.098	-21.648	-14.407	-16.183	9.755	6.124
1- 1	-11.139	-12.229	-14.407	-16.183	7.623	4.759
1- 2	-4.861	-6.842	-14.407	-16.183	5.568	3.450
1- 3	0.092	-3.760	-14.407	-16.183	3.590	2.195
1- 4	2.933	-2.015	-14.407	-16.183	1.689	0.996
1- 5	3.761	-1.550	-14.407	-16.183	-0.044	-0.238
1- 6	2.653	-2.304	-14.407	-16.183	-1.132	-1.985
1- 7	-0.314	-4.213	-14.407	-16.183	-2.164	-3.654
1- 8	-5.056	-7.217	-14.407	-16.183	-3.141	-5.247
1- 9	-10.332	-12.410	-14.407	-16.183	-4.062	-6.763
1-10	-15.232	-20.562	-14.407	-16.183	-4.928	-8.201
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-15.232	-20.562	-4.929	-8.201	16.209	14.407
2- 1	-1.275	-5.131	-4.929	-8.201	12.577	11.128
2- 2	9.758	5.855	-4.929	-8.201	9.061	7.850
2- 3	17.040	13.232	-4.929	-8.201	5.546	4.559
2- 4	20.527	17.050	-4.929	-8.201	2.061	1.230
2- 5	20.202	17.316	-4.929	-8.201	-1.292	-2.237
2- 6	16.063	14.030	-4.929	-8.201	-4.607	-5.712
2- 7	8.322	7.000	-4.929	-8.201	-7.894	-9.209
2- 8	-2.627	-4.197	-4.929	-8.201	-11.173	-12.730
2- 9	-16.713	-19.444	-4.929	-8.201	-14.451	-16.242
2-10	-34.145	-38.818	-4.929	-8.201	-17.730	-19.633
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.161	-0.089	-35.469	-39.227	0.043	-0.056
3- 1	0.100	-0.043	-35.469	-39.227	0.043	-0.056
3- 2	0.040	0.003	-35.469	-39.227	0.043	-0.056
3- 3	0.055	-0.026	-35.469	-39.227	0.043	-0.056
3- 4	0.099	-0.084	-35.469	-39.227	0.043	-0.056
3- 5	0.143	-0.143	-35.469	-39.227	0.043	-0.056
3- 6	0.189	-0.204	-35.469	-39.227	0.043	-0.056
3- 7	0.236	-0.265	-35.469	-39.227	0.043	-0.056
3- 8	0.282	-0.326	-35.469	-39.227	0.043	-0.056
3- 9	0.329	-0.387	-35.469	-39.227	0.043	-0.056
3-10	0.375	-0.447	-35.469	-39.227	0.043	-0.056
INTERIOR WALL TOP						

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BOTTOM SLAB LEFT SIDE						
4- 0	-17.098	-21.648	-6.124	-9.755	16.557	15.583
4- 1	-1.916	-5.829	-6.124	-9.755	12.939	12.061
4- 2	9.491	5.981	-6.124	-9.755	9.321	8.538
4- 3	16.983	13.965	-6.124	-9.755	5.703	5.016
4- 4	20.556	18.134	-6.124	-9.755	2.090	1.485
4- 5	20.209	18.487	-6.124	-9.755	-1.436	-2.129
4- 6	15.943	15.024	-6.124	-9.755	-4.958	-5.747
4- 7	7.977	7.515	-6.124	-9.755	-8.480	-9.365
4- 8	-3.337	-4.426	-6.124	-9.755	-12.003	-12.983
4- 9	-18.262	-20.440	-6.124	-9.755	-15.525	-16.601
4-10	-36.989	-40.381	-6.124	-9.755	-19.048	-20.219
BOTTOM SLAB RIGHT SIDE						

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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Middle -	0.00	23.91	0.91	Pass
EXTERIOR WALL	Top	0.00	23.77	2.26	Pass
TOP SLAB	Left	0.00	23.90	0.98	Pass
TOP SLAB	Middle +	0.00	23.82	1.78	Pass
INTERIOR WALL	Bottom	0.00	23.95	0.46	Pass
INTERIOR WALL	Middle	0.00	23.96	0.39	Pass
INTERIOR WALL	Top	0.00	23.80	2.02	Pass
BOTTOM SLAB	Left	0.00	23.94	0.60	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

---

Reinforcing Bar Stresses Sizes and Spacing

---

Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	34.86	19.80	0.3100	0.3100	5	12.0	29	34
A2	37.07	19.80	0.3100	0.3100	5	12.0	29	33
A100	33.17	19.80	0.6200	0.6200	5	6.0		
A300	29.40	19.80	0.9000	0.9000	7	8.0		
A200	34.32	19.80	0.6200	0.6200	5	6.0		
A400	31.88	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

\*\* THE HEIGHT OF C.H.C.U. \*\* BOTTOM SLAB = 7.00 IN

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## Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.62 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.62 (in)													
	Moment	Coin. Axial Force	Shear Force	Shear Cap	Resistance				Steel Area	Mom. Cap	Des. Thk	Design Ratio		Flexure Ratings		Shear Ratings	
	Kft	Kips	Kips	Kips	Po Cap Kips	Mu Cap Kft	Mbal Cap Kft	Pbal Cap Kips	In2			Flx	Shr	Inv	Oper	Inv	Oper
BOT	-15.0*	14.4	6.9	9.5	185.2	6.1	20.5	82.9	0.3100	8.6	8.19	1.74	0.73	0.00	0.00	3.97	6.61
MID	3.8	14.4	0.0	9.7	187.1	7.9	21.1	81.5	0.4000	10.2	8.25	0.37	NA	4.78	7.97	NA	NA
MID-	-2.0	14.4	0.2	9.7	187.1	7.9	21.1	81.5	0.4000	10.2	8.25	0.20	NA	19.32	32.20	NA	NA
TOP	-14.7*	14.4	6.2	9.4	185.2	6.1	20.5	82.9	0.3100	8.6	8.19	1.70	0.66	0.00	0.00	4.42	7.37
Member No. = 2 TOP SLAB				Thickness = 10.80 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-9.9*	4.9	11.1*	11.0	199.5	6.7	23.8	91.7	0.3100	7.7	8.99	1.29	1.01	0.00	0.00	0.87	1.44
MID	20.5*	4.9	1.3	12.2	206.2	13.2	26.0	84.5	0.6200	13.9	8.99	1.47	NA	0.00	0.00	NA	NA
RT	-25.4*	4.9	14.8*	12.6	212.2	18.4	27.7	76.7	0.9000	19.0	8.86	1.33	1.18	0.00	0.00	0.00	0.00
Member No. = 3 INTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.50 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.50 (in)													
BOT	-0.1	35.5	0.0	9.4	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.00	0.00	NA	NA	99.00	99.00
MID	0.1	35.5	0.0	9.4	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	NA	NA	NA	NA	NA
MID-	-0.1	35.5	0.0	9.1	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	NA	NA	NA	NA	NA
TOP	-0.4	35.5	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.03	0.01	31.43	52.40	99.00	99.00
Member No. = 4 BOTTOM SLAB				Thickness = 10.50 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-10.7*	6.1	11.5*	10.7	194.1	6.5	22.5	88.4	0.3100	7.6	8.69	1.40	1.08	0.00	0.00	0.00	0.00
MID	20.6*	6.1	1.4	11.9	200.8	12.7	24.6	81.2	0.6200	13.6	8.69	1.51	NA	0.00	0.00	NA	NA
RT	-26.6*	6.1	15.2*	12.0	206.9	17.8	26.2	73.4	0.9000	18.5	8.56	1.44	1.27	0.00	0.00	0.00	0.00

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab MidSpan-Prop.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

**BRASS-CULVERT**

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TIME : 16:24:26

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Interi  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Interi

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot

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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

---

Units

USSI\_UNITS: Input Units = US  
USSI\_UNITS OU: Output Units = US  
JOB DESCRIPTION: PROPOSED COVER 16'  
CHECK TOP AND BOTTOM SLAB @ INTERIOR SUPPORT NEGATIVE MOMENT

---

Design Variables

LRFD: Use LRFD method for bot slab load distrib. = F  
CUTYPE: Precast(PC) or Cast in Place(CIP) Culvert = CIP  
IDSN: Load Factor(LF) Service Load (SL) Design = LF  
FUNCT: Design (DESIGN) or Design Review (DESREV) = DESREV  
IRELEASE: Moment Continuity Released (@ end of walls) = F  
DNEG: Distance to Neg. Moment Computation Point = 1.00

---

Output Control Variables

MTEN: Output Moment-Shears = T  
IINFN: Output Influence Line = F  
IBSH: Output Bar Schedule = F

---

Standard Load Variables

LVLD: Live Load Vehicle Name = HS20T  
LVOMT: Neglect LL for Fill > 8Ft & Fill > Span = F

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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	16.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	12.0
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCNC:	Compressive Strength of Concrete (Psi)	= 2500.0
FSHR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
ILES5: Code for Span Less Than 5 ft = F  
ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL,FIXED,HINGED) = FULL  
LDPASS: Bypass Live Load if no vehicle input = F  
LONGB: Longitudinal Bar Code = F  
MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
Structure ID : ROPOSED CHECK  
Agency name : MEAD &

Input units : US  
Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
-------------------	---------------	----------------------------	--------------------------	--------------------------

CAST-IN-PLACE	DESREV	NO	FULL	1.00
---------------	--------	----	------	------

Consider Haunches in Analysis : YES  
Perform Edge Beam reinforcement computations : NO  
Use epoxy coated bars in top mat of reinforcement: NO  
in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input



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 BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
12.00 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

 LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

 (Neglect Live Load if fill is greater than 8 ft.  
 and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

 DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water
Pressure	Density
Max	Min
(Pcf)	(Pcf)
50.0	36.0
	0.0

	Wearing
Uniform	Surface
Load	Thickness
(plf)	(in)
0.0	0.00
	Fill
	Height
	(Ft)
	16.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

## HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

## CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:

Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:

Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in

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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches

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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

---

Live Load Parameters for a HS20T vehicle

---

Fill	= 16.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 45.66666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 45.66666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.04380
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	12.0000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.9375 Ft.
Fill Height(top of slab)	=	16.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.1422
Earth Weight for fill computations	=	0.1371 Kcf

Weight of Fill without wearing surface	=	2.1931 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1500 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	2.3431 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	2.5161 Klf

Soil pressure at center of top slab	=	0.8250 Klf
Soil pressure at center of bottom slab	=	1.3719 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
--	---	------------

Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0438
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)	
8.00	14.000	
32.00	14.000	
32.00	0.000	
-----	-----	
Totals 72.00	28.000	
Tire Contact Area =	40.00000	sq.in.
Tire patch Width =	20.00000	in.
Tire Patch Length =	2.000000	in.

Vehicle Axle number = 1  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area =	160.0000	sq.in.
Tire patch Width =	20.00000	in.
Tire Patch Length =	8.000000	in.

Vehicle Axle number = 2  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area =	160.0000	sq.in.
Tire patch Width =	20.00000	in.
Tire Patch Length =	8.000000	in.

Vehicle Axle number = 3  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]







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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft	Kft	Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-1.06	0.00	-7.22	-7.51	-0.66	0.00	0.01	-0.11	14.00	14.00
1- 1	-1.01	0.00	-6.88	-1.32	-0.14	0.00	0.00	-0.11	0.00	14.00
1- 2	-0.96	0.00	-6.53	3.30	0.26	0.00	0.00	-0.12	0.00	14.00
1- 3	-0.91	0.00	-6.19	6.41	0.55	0.00	0.00	-0.14	0.00	14.00
1- 4	-0.86	0.00	-5.85	8.07	0.71	0.00	0.00	-0.16	0.00	14.00
1- 5	-0.81	0.00	-5.50	8.35	0.76	0.00	0.00	-0.19	14.00	14.00
1- 6	-0.76	0.00	-5.16	7.32	0.68	0.00	0.01	-0.22	14.00	14.00
1- 7	-0.71	0.00	-4.82	5.04	0.49	0.00	0.03	-0.25	14.00	14.00
1- 8	-0.66	0.00	-4.48	1.57	0.18	0.00	0.04	-0.28	14.00	14.00
1- 9	-0.61	0.00	-4.13	-3.01	-0.26	0.00	0.05	-0.30	14.00	14.00
1-10	-0.56	0.00	-3.79	-8.64	-0.81	0.00	0.06	-0.33	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.56	0.00	-3.79	-8.64	-0.81	0.00	0.06	-0.33	14.00	14.00
2- 1	0.68	0.00	4.62	-7.36	-0.69	0.00	0.14	0.00	14.00	0.00
2- 2	1.57	0.00	10.63	-6.07	-0.57	0.00	0.47	-0.00	14.00	14.00
2- 3	2.10	0.00	14.24	-4.78	-0.45	0.00	0.69	-0.03	14.00	14.00
2- 4	2.28	0.00	15.46	-3.49	-0.33	0.00	0.80	-0.06	14.00	14.00
2- 5	2.10	0.00	14.28	-2.21	-0.21	0.00	0.78	-0.10	14.00	14.00
2- 6	1.58	0.00	10.70	-0.92	-0.09	0.00	0.65	-0.13	14.00	14.00
2- 7	0.70	0.00	4.73	0.37	0.03	0.00	0.40	-0.16	14.00	14.00
2- 8	-0.54	0.00	-3.64	1.65	0.15	0.00	0.11	-0.27	14.00	14.00
2- 9	-2.12	0.00	-14.41	2.94	0.27	0.00	0.00	-0.60	0.00	14.00
2-10	-4.06	0.00	-27.57	4.23	0.40	0.00	0.00	-1.20	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.01	0.03	0.00	0.00	0.05	-0.05	14.00	14.00
3- 1	0.00	0.00	0.01	0.03	0.00	0.00	0.03	-0.03	14.00	14.00
3- 2	0.00	0.00	0.01	0.02	0.00	0.00	0.01	-0.01	14.00	14.00
3- 3	0.00	0.00	0.01	0.01	0.00	0.00	0.01	-0.01	14.00	14.00
3- 4	0.00	0.00	0.00	0.01	0.00	0.00	0.03	-0.03	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.00	-0.00	0.00	0.05	-0.05	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.07	-0.07	14.00	14.00
3- 7	-0.00	0.00	-0.01	-0.01	-0.00	0.00	0.09	-0.09	14.00	14.00
3- 8	-0.00	0.00	-0.01	-0.02	-0.00	0.00	0.12	-0.11	14.00	14.00
3- 9	-0.00	0.00	-0.01	-0.03	-0.00	0.00	0.14	-0.13	14.00	14.00
3-10	-0.00	0.00	-0.01	-0.04	-0.00	0.00	0.16	-0.15	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-1.06	0.00	-7.22	-7.51	-0.66	0.00	0.01	-0.11	14.00	14.00
4- 1	0.33	0.00	2.23	-6.38	-0.56	0.00	0.10	-0.00	14.00	14.00
4- 2	1.34	0.00	9.10	-5.26	-0.46	0.00	0.22	0.00	0.00	14.00
4- 3	1.97	0.00	13.40	-4.13	-0.37	0.00	0.29	0.00	0.00	14.00
4- 4	2.23	0.00	15.13	-3.01	-0.27	0.00	0.32	0.00	0.00	14.00
4- 5	2.10	0.00	14.28	-1.88	-0.17	0.00	0.29	0.00	0.00	14.00
4- 6	1.60	0.00	10.86	-0.75	-0.07	0.00	0.22	0.00	0.00	14.00
4- 7	0.72	0.00	4.86	0.37	0.03	0.00	0.10	-0.00	14.00	14.00
4- 8	-0.55	0.00	-3.71	1.50	0.13	0.00	0.00	-0.09	14.00	14.00
4- 9	-2.19	0.00	-14.85	2.62	0.23	0.00	0.00	-0.30	14.00	0.00
4-10	-4.21	0.00	-28.57	3.75	0.33	0.00	0.00	-0.57	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	0.05	0.00	0.31	6.40	0.53	0.00	0.01	-0.03	14.00	14.00
1- 1	0.05	0.00	0.31	4.93	0.42	0.00	0.01	-0.03	14.00	14.00
1- 2	0.05	0.00	0.31	3.52	0.31	0.00	0.01	-0.03	14.00	14.00
1- 3	0.05	0.00	0.31	2.17	0.21	0.00	0.01	-0.03	14.00	14.00
1- 4	0.05	0.00	0.31	0.88	0.10	0.00	0.01	-0.03	14.00	14.00
1- 5	0.05	0.00	0.31	-0.35	-0.01	0.00	0.01	-0.03	14.00	14.00
1- 6	0.05	0.00	0.31	-1.52	-0.12	0.00	0.01	-0.03	14.00	14.00
1- 7	0.05	0.00	0.31	-2.64	-0.23	0.00	0.01	-0.03	14.00	14.00
1- 8	0.05	0.00	0.31	-3.69	-0.34	0.00	0.01	-0.03	14.00	14.00
1- 9	0.05	0.00	0.31	-4.68	-0.45	0.00	0.01	-0.03	14.00	14.00
1-10	0.05	0.00	0.31	-5.61	-0.56	0.00	0.01	-0.03	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.31	0.00	8.87	1.19	0.11	0.00	0.52	-0.03	14.00	14.00
2- 1	0.98	0.00	6.65	1.19	0.11	0.00	0.36	-0.03	14.00	14.00
2- 2	0.65	0.00	4.44	1.19	0.11	0.00	0.25	-0.03	14.00	14.00
2- 3	0.33	0.00	2.23	1.19	0.11	0.00	0.14	-0.03	14.00	14.00
2- 4	0.00	0.00	0.02	1.19	0.11	0.00	0.05	-0.06	14.00	14.00
2- 5	-0.32	0.00	-2.19	1.19	0.11	0.00	0.02	-0.15	14.00	14.00
2- 6	-0.65	0.00	-4.41	1.19	0.11	0.00	0.00	-0.24	0.00	14.00
2- 7	-0.98	0.00	-6.62	1.19	0.11	0.00	0.00	-0.34	0.00	14.00
2- 8	-1.30	0.00	-8.83	1.19	0.11	0.00	0.00	-0.45	0.00	14.00
2- 9	-1.63	0.00	-11.04	1.19	0.11	0.00	0.00	-0.56	0.00	14.00
2-10	-1.95	0.00	-13.26	1.19	0.11	0.00	0.00	-0.61	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 1	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 2	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 3	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 4	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 5	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 6	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 7	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 8	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 9	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3-10	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	1.46	0.00	9.91	1.04	0.09	0.00	0.18	0.00	0.00	14.00
4- 1	1.11	0.00	7.53	1.04	0.09	0.00	0.13	0.00	0.00	14.00
4- 2	0.76	0.00	5.16	1.04	0.09	0.00	0.09	0.00	0.00	14.00
4- 3	0.41	0.00	2.78	1.04	0.09	0.00	0.05	0.00	0.00	14.00
4- 4	0.06	0.00	0.41	1.04	0.09	0.00	0.00	-0.00	14.00	14.00
4- 5	-0.29	0.00	-1.97	1.04	0.09	0.00	0.00	-0.04	14.00	0.00
4- 6	-0.64	0.00	-4.35	1.04	0.09	0.00	0.00	-0.09	14.00	0.00
4- 7	-0.99	0.00	-6.72	1.04	0.09	0.00	0.00	-0.13	14.00	0.00
4- 8	-1.34	0.00	-9.10	1.04	0.09	0.00	0.00	-0.18	14.00	0.00
4- 9	-1.69	0.00	-11.47	1.04	0.09	0.00	0.00	-0.22	14.00	0.00
4-10	-2.04	0.00	-13.85	1.04	0.09	0.00	0.00	-0.26	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K		K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 1	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 2	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 3	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 4	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 5	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 6	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 7	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 8	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1- 9	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
1-10	-1.31	0.00	-8.87	-1.19	-0.86	-0.11	0.00	0.03	-0.51	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 1	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 2	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 3	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 4	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 5	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 6	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 7	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 8	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2- 9	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
2-10	0.05	0.00	0.31	-5.61	-4.04	-0.56	0.00	0.01	-0.03	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 1	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 2	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 3	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 4	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 5	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 6	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 7	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 8	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3- 9	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
3-10	-3.91	0.00	-26.52	2.37	1.71	0.22	0.00	0.00	-1.21	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB	LEFT SIDE										
4- 0	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 1	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 2	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 3	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 4	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 5	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 6	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 7	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 8	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4- 9	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
4-10	-0.05	0.00	-0.31	-6.40	-4.61	-0.53	0.00	0.03	-0.01	14.00	14.00
BOTTOM SLAB	RIGHT SIDE										

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-17.764	-22.207	-14.276	-16.119	9.969	6.401
1- 1	-11.488	-12.510	-14.276	-16.119	7.820	5.024
1- 2	-4.882	-6.907	-14.276	-16.119	5.749	3.704
1- 3	0.284	-3.540	-14.276	-16.119	3.756	2.439
1- 4	3.313	-1.525	-14.276	-16.119	1.841	1.231
1- 5	4.300	-0.805	-14.276	-16.119	0.160	-0.079
1- 6	3.330	-1.321	-14.276	-16.119	-0.936	-1.839
1- 7	0.479	-3.007	-14.276	-16.119	-1.977	-3.521
1- 8	-4.169	-5.801	-14.276	-16.119	-2.962	-5.126
1- 9	-8.878	-11.291	-14.276	-16.119	-3.890	-6.653
1-10	-13.615	-19.366	-14.276	-16.119	-4.763	-8.102
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-13.615	-19.366	-4.763	-8.102	16.145	14.276
2- 1	0.314	-4.168	-4.763	-8.102	12.492	10.976
2- 2	11.193	6.723	-4.763	-8.102	8.955	7.676
2- 3	18.261	13.982	-4.763	-8.102	5.419	4.365
2- 4	21.512	17.666	-4.763	-8.102	1.914	1.003
2- 5	20.927	17.774	-4.763	-8.102	-1.449	-2.486
2- 6	16.506	14.307	-4.763	-8.102	-4.788	-5.983
2- 7	8.475	7.058	-4.763	-8.102	-8.088	-9.503
2- 8	-2.703	-4.465	-4.763	-8.102	-11.388	-13.045
2- 9	-17.067	-20.025	-4.763	-8.102	-14.688	-16.578
2-10	-34.766	-39.764	-4.763	-8.102	-17.987	-19.991
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.166	-0.046	-35.990	-39.945	0.030	-0.052
3- 1	0.109	-0.014	-35.990	-39.945	0.030	-0.052
3- 2	0.052	0.019	-35.990	-39.945	0.030	-0.052
3- 3	0.058	-0.011	-35.990	-39.945	0.030	-0.052
3- 4	0.088	-0.065	-35.990	-39.945	0.030	-0.052
3- 5	0.118	-0.120	-35.990	-39.945	0.030	-0.052
3- 6	0.150	-0.177	-35.990	-39.945	0.030	-0.052
3- 7	0.183	-0.234	-35.990	-39.945	0.030	-0.052
3- 8	0.216	-0.291	-35.990	-39.945	0.030	-0.052
3- 9	0.248	-0.348	-35.990	-39.945	0.030	-0.052
3-10	0.281	-0.406	-35.990	-39.945	0.030	-0.052
INTERIOR WALL TOP						

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BOTTOM SLAB LEFT SIDE						
4- 0	-17.764	-22.207	-6.401	-9.969	16.714	15.751
4- 1	-2.431	-6.206	-6.401	-9.969	13.075	12.208
4- 2	9.130	5.734	-6.401	-9.969	9.436	8.664
4- 3	16.753	13.827	-6.401	-9.969	5.797	5.121
4- 4	20.434	18.080	-6.401	-9.969	2.160	1.573
4- 5	20.173	18.495	-6.401	-9.969	-1.389	-2.061
4- 6	15.969	15.071	-6.401	-9.969	-4.933	-5.700
4- 7	8.033	7.596	-6.401	-9.969	-8.476	-9.339
4- 8	-3.287	-4.328	-6.401	-9.969	-12.020	-12.978
4- 9	-18.235	-20.353	-6.401	-9.969	-15.563	-16.617
4-10	-37.014	-40.322	-6.401	-9.969	-19.107	-20.256
BOTTOM SLAB RIGHT SIDE						



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### Fatigue Checks

$$f_s \leq f_f = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_f$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_f$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Top	0.00	23.81	1.86	Pass
TOP SLAB	Left	0.00	23.91	0.90	Pass
TOP SLAB	Middle +	0.00	23.84	1.64	Pass
INTERIOR WALL	Middle	0.00	23.97	0.33	Pass
INTERIOR WALL	Top	0.00	23.83	1.66	Pass
BOTTOM SLAB	Left	0.00	23.95	0.54	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

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Reinforcing Bar Stresses Sizes and Spacing

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Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	29.20	19.80	0.3100	0.3100	5	12.0	29	35
A2	38.77	19.80	0.3100	0.3100	5	12.0	29	33
A100	30.59	19.80	0.6200	0.6200	5	6.0		
A300	26.52	19.80	0.9000	0.9000	7	8.0		
A200	33.92	19.80	0.6200	0.6200	5	6.0		
A400	31.67	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

\*\* THE HEIGHT OF C.H.C.U. \*\* BOTTOM SLAB = 7.00 IN

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## Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.

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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.62 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.62 (in)													
	Moment	Axial Force	Shear Force	Shear Cap	Resistance				Steel Area	Mom. Cap	Des. Thk	Design Ratio		Flexure Ratings		Shear Ratings	
	Kft	Kips	Kips	Kips	Po Kips	Mu Kft	Mbal Kft	Pbal Kips	In2			Flx	Shr	Inv	Oper	Inv	Oper
BOT	-15.4*	14.3	7.1	9.5	185.2	6.1	20.5	82.9	0.3100	8.6	8.19	1.79	0.75	0.00	0.00	3.80	6.33
MID	4.3	14.3	0.2	9.7	187.1	7.9	21.1	81.5	0.4000	10.2	8.25	0.42	NA	4.58	7.63	NA	NA
MID-	-1.5	14.3	0.1	9.7	187.1	7.9	21.1	81.5	0.4000	10.2	8.25	0.15	NA	23.93	39.89	NA	NA
TOP	-13.2*	14.3	6.0	9.5	185.2	6.1	20.5	82.9	0.3100	8.6	8.19	1.54	0.64	0.00	0.00	4.68	7.81
Member No. = 2 TOP SLAB				Thickness = 12.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-8.8*	4.8	10.7	12.3	220.9	7.7	29.2	104.9	0.3100	8.6	10.19	1.02	0.87	0.89	1.48	2.78	4.63
MID	21.5*	4.8	1.4	13.5	227.6	15.0	31.7	97.7	0.6200	15.8	10.19	1.36	NA	0.00	0.00	NA	NA
RT	-26.1*	4.8	14.8*	14.5	233.7	21.1	33.8	89.9	0.9000	21.8	10.06	1.20	1.02	0.00	0.00	0.41	0.68
Member No. = 3 INTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.50 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.50 (in)													
BOT	-0.0	36.0	0.0	9.2	184.3	5.3	20.3	84.6	0.2667	11.7	8.25	0.00	0.00	NA	NA	99.00	99.00
MID	0.1	36.0	0.0	9.2	184.3	5.3	20.3	84.6	0.2667	11.7	8.25	0.01	NA	NA	NA	NA	NA
MID-	-0.1	36.0	0.0	9.1	184.3	5.3	20.3	84.6	0.2667	11.7	8.25	0.01	NA	NA	NA	NA	NA
TOP	-0.4	36.0	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	11.7	8.25	0.03	0.01	38.26	63.78	99.00	99.00
Member No. = 4 BOTTOM SLAB				Thickness = 10.50 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-11.1*	6.4	11.7*	10.7	194.1	6.5	22.5	88.4	0.3100	7.7	8.69	1.45	1.09	0.00	0.00	0.00	0.00
MID	20.4*	6.4	1.4	11.9	200.8	12.7	24.6	81.2	0.6200	13.7	8.69	1.50	NA	0.00	0.00	NA	NA
RT	-26.5*	6.4	15.2*	12.0	206.9	17.8	26.2	73.4	0.9000	18.5	8.56	1.43	1.26	0.00	0.00	0.00	0.00

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
 X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Top and Bot Slab Interior Support-Prop.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 1  
CONTROLLING POINT : Bottom  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

**BRASS-CULVERT**

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Input Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support Prop.DAT  
 Output Filename : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support Prop.xml

The following filenames may be used in this run

Live Load Influence Values	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Drawing	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Live Load Influence Ordinates	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Live Load Actions (w/o DF or IM)	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Intermediate Computations	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support
Data Modelling	File name : X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support

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Note:

The following list of variables are used in the application. They are shown in US units because that is the internal computational mode.

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Units

USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US
JOB DESCRIPTION: PROPOSED COVER 16'			
CHECK EXTERIOR WALLS			

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Design Variables

LRFDDE:	Use LRFD method for bot slab load distrib.	=	F
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDSN:	Load Factor(LF) Service Load (SL) Design	=	LF
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESREV
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	1.00

---

Output Control Variables

MTEN:	Output Moment-Shears	=	T
IINFN:	Output Influence Line	=	F
IBSH:	Output Bar Schedule	=	F

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Standard Load Variables

LVLD:	Live Load Vehicle Name	=	HS20T
LVOMT:	Neglect LL for Fill > 8Ft & Fill > Span	=	F



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Uniform Dead Load Variable			
EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (In)	=	0.0
Concentrated Dead Load Variables			
EDLC1:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX1:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC2:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX2:	Position of Load from CL of Left Wall (Ft)	=	0.0
EDLC3:	Extra Concentrated Dead Load (Lbs)	=	0.0
EDLX3:	Position of Load from CL of Left Wall (Ft)	=	0.0
Soil and Water Pressure Variables			
SURCH:	Depth of Surcharge (Ft)	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	50.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	36.0
PWAT:	Internal Water Pressure (Pcf)	=	0.0
Geometry - Box Dimension Variables			
NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	10.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	16.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	94.0
Geometry - Slab Thickness Variables			
TSLAB:	Thickness of top Slab (In)	=	10.0
BSLAB:	Thickness of Bottom Slab(In)	=	10.5
WALLR:	Thickness of Exterior Wall (In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
IWALLR:	Minimum Value for Interior Wall(In)	=	10.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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Geometry - Skew and Haunch Variables		
LSKEW:	Left End Skew Angle(Deg)	= 90.0
RSKEW:	Right End Skew Angle (Deg)	= 90.0
CSKEW:	Culvert Skew Angle (Deg)	= 0.0
TFILT:	Top Haunch (In)	= 4.0
BFILT:	Bottom Haunch (In)	= 4.0
KHACH:	Haunches used in Analysis	= YES

---

Geometry - Clear Concrete Cover		
COVS:	Exterior Concrete Cover Top Slab (In)	= 1.5
COVB:	Exterior Concrete Cover Bottom Slab (In)	= 1.5
COVW:	Exterior Concrete Cover Walls (In)	= 1.5
COVIN:	Interior Concrete Cover (In)	= 1.5

---

Material Properties Variables		
EWGT:	Unit Weight of Soil (Pcf)	= 120.0
FYST:	Yield Strength of Reinf. Steel (Psi)	= 33000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	= 0.0
FCOnc:	Compressive Strength of Concrete (Psi)	= 2500.0
FSHR:	Shear in Concrete (Psi) (ASD)	= 0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	= 0.0
CWGT:	Unit Weight of Concrete (w/ rebar) (Pcf)	= 150.0
AWGT:	Unit Weight of Wearing Surface (Pcf)	= 145.0

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ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	7.9
CE:	Modulus of Elasticity of Concrete (Ksi)	=	3653.3

---

B1:	Ratio Depth Compressive Zone AASHTO 8.16.2.7	=	0.85
BB:	Factor Load Factor Po and Pb AASHTO 8.16.1.2.2	=	0.70
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	1.6670
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
GAMMA:	Load Factor Actions Multiplier	=	1.3000

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IFATIG: Check Fatigue = T  
 ILESS: Code for Span Less Than 5 ft = F  
 ISHR: Code for Shear Stress Check = T

KBASE: Bottom Slab Support Code(FULL, FIXED, HINGED) = FULL  
 LDPASS: Bypass Live Load if no vehicle input = F  
 LONGB: Longitudinal Bar Code = F  
 MESSGE: Code for Message Printout = T

#### JOB DESCRIPTION

Title : EIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK  
 Structure ID : ROPOSED CHECK  
 Agency name : MEAD &

Input units : US  
 Output units : US

#### ANALYSIS CONTROL

Construction Type	Design/Review	Moment Continuity Released	Bottom Slab Support Code	Negative Moment Position
CAST-IN-PLACE	DESREV	NO	FULL	1.00

Consider Haunches in Analysis : YES  
 Perform Edge Beam reinforcement computations : NO  
 Use epoxy coated bars in top mat of reinforcement: NO  
 in top slab

Design Method	Load Factors		Resistance Factors	
	Dead Load	Live Load	Moment	Shear
LOAD FACTOR	1.0000	1.6670	0.90	0.85

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OUTPUT CONTROLS

Drawing File:	NO
Actions at tenth Points:	YES
Bar Schedule:	NO
Live Load Influence Ordinates:	NO
Live Load Actions Envelope:	YES
Default Output:	YES
Intermediate Design Iteration Computations:	NO
Intermediate Computations	NO

---

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Parameter Z	Steel Fy	Steel n	(Kip/in)	(Psi)
2500.	3653288.	155.	33000.	7.94		

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width parameter Z is used by AASHTO Sec. 8.16.8.4, Eq. 8-61 for computing the reinforcing stress strength

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	120.	145.

Note:

1. The Soil Structure Interaction Factor from AASHTO is computed and applied to the weight of earth input

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BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	10.00	10.00	94.00

## Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
10.00 Fixed	10.50 Fixed	10.00 Fixed	10.00 Fixed

---

LIVE LOADS

Vehicle Designation

HS20T

Live Load Control: NO

(Neglect Live Load if fill is greater than 8 ft.  
and fill is greater than culvert span)

Tire application model: patch load

Live Load Surcharge: 2.0 Ft

---

DEAD LOADS

Concentrated Loads					
Wgt.	Dis.	Wgt.	Dis.	Wgt.	Dis.
(Kips)	(Ft)	(Kips)	(Ft)	(Kips)	(Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil	Water
Pressure	Density
Max	Min
(Pcf)	(Pcf)
50.0	36.0
	0.0

	Wearing
Uniform	Surface
Load	Thickness
(plf)	(in)
0.0	0.00
	Fill
	Height
	(Ft)
	16.00

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SKEW

Skew	Skew	Skew
Left	Right	Center
(Deg)	(Deg)	(Deg)
90.0	90.0	0.0

---

HAUNCHES

Top Haunch	Bottom Haunch
Height	Height
(In)	(In)
4.0	4.0

---

CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
1.50	1.50	1.50	1.50

Cover requirements of article 16.7.3 not met for:  
Top Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Top Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Corner  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Bottom Slab, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Exterior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Exterior Wall, Interior  
minimum required cover = 2.00 in  
specified cover = 1.50 in

Cover requirements of article 16.7.3 not met for:  
Interior Wall  
minimum required cover = 2.00 in  
specified cover = 1.50 in

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EXTERIOR WALL Minimum Thickness Based on Cover and Layer Clearance  
AASHTO 8.21.3 (minimum thickness)  
Equation 2 = exterior wall cover plus the diameter of two #6 bars and  
two #4 bars plus the inside wall/slab cover plus 1 in clearance

Required Thickness is 7.00 Inches



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Span length	10.833
Center line skew	0.0
Equiv. strip width = $(4+0.06*\text{SPAN})$	4.65000

---

Live Load Parameters for a HS20T vehicle

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Fill	= 16.00000 Ft.
Tire patch width	= 20.00000 In.
Equiv. strip width = $\text{FILL}*1.75+\text{TPATW}/12+16$	= 45.66666 Ft.
Lay length (precast -- two wheels check)	= 94.000 Ft.
Wheel factor	= 2.00000
Controlling strip width	= 45.66666 Ft.
Wheel factor	= 2.00000
Distr. factor top & walls = $\text{wheel\_factor}/(\text{Ctrl Strip})$	= 0.04380
Distr. factor bottom	= wheel factor
$((\text{Ctrl Strip})+2*\text{cellhgt})$	= 0.02028

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Number of cells	=	2
Top Slab thickness	=	10.0000 In.
Bottom Slab thickness	=	10.5000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	10.00 In.
Design Span(c-c walls)	=	10.8333 Ft.
Design Height(c-c slabs)	=	10.8542 Ft.
Fill Height(top of slab)	=	16.0000 Ft.
Wearing surface thickness	=	0.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor (embank)	=	1.1422
Earth Weight for fill computations	=	0.1371 Kcf

Weight of Fill without wearing surface	=	2.1931 Klf
Weight of Wearing Surface	=	0.0000 Klf
Weight of Top Slab	=	0.1250 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	2.3181 Klf

Weight of Walls divided by culvert width	=	0.1731 Klf
Uniform Dead Load on Bottom Slab	=	2.4911 Klf

Soil pressure at center of top slab	=	0.8208 Klf
Soil pressure at center of bottom slab	=	1.3635 Klf

Soil pressure due to live load surcharge	=	0.1000 Klf
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Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0438
on Bottom Slab	=	0.0203

Note:

1. The weight of the walls is computed by taking the interior wall thickness plus twice the exterior wall thickness and multiplying by the clear height of the culvert and the weight of concrete. That result is divided by the span length times the number of cells plus the wall thicknesses.
2. The soil pressure computations use the fill height and the culvert height for appropriate values for lateral earth pressures. Wearing surface, fill height, and slab thickness are used in vertical dead load computations.
3. The distribution width and associated distribution factor for the top slab is computed according to 3.24.3.2 for fill depth less than 2 ft. and 6.4 for fill depths over 2 ft.

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Varying axle spacing from 14.0 feet to 30.0 feet by 1 foot increments.

For a HS20T / No Lane Vehicle, Variable Axle Spacing  
 Description AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
 The Number of axles = 3  
 Beginning rear axle spacing = 14.00

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000
-----	-----
Totals 72.00	28.000

Tire Contact Area = 40.00000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 2.000000 in.

Vehicle Axle number = 1  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.17 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 2  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]

Tire Contact Area = 160.0000 sq.in.  
 Tire patch Width = 20.00000 in.  
 Tire Patch Length = 8.000000 in.

Vehicle Axle number = 3  
 Fill = 16.00 ft.  
 Distribution slope = 1.75  
 LL Longitudinal Distribution Length = 28.67 ft.  
 [slope(fill) + longitudinal tire patch]





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Current Live Load: HS20T / No Lane

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) Kft	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	Kft	Kft	Kft	Kft	Kft		Kft	Kft	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.86	0.00	-6.31	-7.85	-0.70	0.00	0.03	-0.09	14.00	14.00
1- 1	-0.87	0.00	-6.38	-1.57	-0.16	0.00	0.01	-0.10	14.00	14.00
1- 2	-0.88	0.00	-6.44	3.17	0.25	0.00	0.00	-0.11	0.00	14.00
1- 3	-0.88	0.00	-6.51	6.43	0.56	0.00	0.00	-0.15	0.00	14.00
1- 4	-0.89	0.00	-6.57	8.27	0.74	0.00	0.00	-0.20	0.00	14.00
1- 5	-0.90	0.00	-6.64	8.77	0.80	0.00	0.01	-0.24	14.00	14.00
1- 6	-0.91	0.00	-6.70	7.98	0.75	0.00	0.02	-0.29	14.00	14.00
1- 7	-0.92	0.00	-6.77	5.96	0.58	0.00	0.03	-0.33	14.00	14.00
1- 8	-0.93	0.00	-6.83	2.79	0.29	0.00	0.04	-0.38	14.00	14.00
1- 9	-0.94	0.00	-6.90	-1.48	-0.11	0.00	0.05	-0.43	14.00	14.00
1-10	-0.95	0.00	-6.96	-6.78	-0.64	0.00	0.06	-0.47	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	-0.95	0.00	-6.96	-6.78	-0.64	0.00	0.06	-0.47	14.00	14.00
2- 1	0.26	0.00	1.89	-5.77	-0.54	0.00	0.05	-0.02	14.00	14.00
2- 2	1.14	0.00	8.35	-4.75	-0.45	0.00	0.36	0.00	14.00	0.00
2- 3	1.69	0.00	12.42	-3.74	-0.35	0.00	0.60	-0.02	14.00	14.00
2- 4	1.91	0.00	14.08	-2.73	-0.26	0.00	0.72	-0.05	14.00	14.00
2- 5	1.82	0.00	13.36	-1.72	-0.16	0.00	0.72	-0.07	14.00	14.00
2- 6	1.39	0.00	10.24	-0.70	-0.07	0.00	0.60	-0.10	14.00	14.00
2- 7	0.64	0.00	4.72	0.31	0.03	0.00	0.37	-0.13	14.00	14.00
2- 8	-0.43	0.00	-3.19	1.32	0.12	0.00	0.08	-0.23	14.00	14.00
2- 9	-1.83	0.00	-13.49	2.34	0.22	0.00	0.00	-0.57	0.00	14.00
2-10	-3.56	0.00	-26.19	3.35	0.31	0.00	0.00	-1.16	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.06	-0.06	14.00	14.00
3- 1	-0.00	0.00	-0.00	0.02	-0.00	0.00	0.04	-0.04	14.00	14.00
3- 2	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.01	-0.01	14.00	14.00
3- 3	-0.00	0.00	-0.00	0.01	-0.00	0.00	0.02	-0.02	14.00	14.00
3- 4	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.05	-0.05	14.00	14.00
3- 5	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.07	-0.07	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.10	-0.10	14.00	14.00
3- 7	0.00	0.00	0.00	-0.01	0.00	0.00	0.13	-0.13	14.00	14.00
3- 8	0.00	0.00	0.00	-0.01	0.00	0.00	0.16	-0.16	14.00	14.00
3- 9	0.00	0.00	0.00	-0.02	0.00	0.00	0.19	-0.18	14.00	14.00
3-10	0.00	0.00	0.00	-0.02	0.00	0.00	0.21	-0.21	14.00	14.00
INTERIOR WALL TOP										

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BOTTOM SLAB LEFT SIDE										
4- 0	-0.86	0.00	-6.31	-7.85	-0.70	0.00	0.03	-0.09	14.00	14.00
4- 1	0.41	0.00	3.00	-6.68	-0.60	0.00	0.13	-0.00	14.00	14.00
4- 2	1.32	0.00	9.74	-5.50	-0.49	0.00	0.25	0.00	0.00	14.00
4- 3	1.89	0.00	13.90	-4.32	-0.39	0.00	0.31	0.00	0.00	14.00
4- 4	2.11	0.00	15.49	-3.14	-0.28	0.00	0.33	0.00	0.00	14.00
4- 5	1.97	0.00	14.51	-1.97	-0.18	0.00	0.31	0.00	0.00	14.00
4- 6	1.49	0.00	10.95	-0.79	-0.07	0.00	0.23	0.00	0.00	14.00
4- 7	0.66	0.00	4.82	0.39	0.04	0.00	0.11	-0.01	14.00	14.00
4- 8	-0.53	0.00	-3.88	1.57	0.14	0.00	0.01	-0.11	14.00	14.00
4- 9	-2.06	0.00	-15.16	2.75	0.25	0.00	0.00	-0.32	14.00	0.00
4-10	-3.94	0.00	-29.02	3.92	0.35	0.00	0.00	-0.59	14.00	0.00
BOTTOM SLAB RIGHT SIDE										

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Current Live Load: HS20T / No Lane

Unfactored SHEARS (per unit design width) due to Dead and Live Loads including Distribution and Impact										
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max)	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg
	K	K	K	K	K	K	K	K	ft	ft
EXTERIOR WALL BOTTOM										
1- 0	-0.01	0.00	-0.06	6.52	0.55	0.00	0.01	-0.04	14.00	14.00
1- 1	-0.01	0.00	-0.06	5.07	0.44	0.00	0.01	-0.04	14.00	14.00
1- 2	-0.01	0.00	-0.06	3.68	0.33	0.00	0.01	-0.04	14.00	14.00
1- 3	-0.01	0.00	-0.06	2.34	0.22	0.00	0.01	-0.04	14.00	14.00
1- 4	-0.01	0.00	-0.06	1.07	0.11	0.00	0.01	-0.04	14.00	14.00
1- 5	-0.01	0.00	-0.06	-0.15	0.01	0.00	0.01	-0.04	14.00	14.00
1- 6	-0.01	0.00	-0.06	-1.30	-0.10	0.00	0.01	-0.04	14.00	14.00
1- 7	-0.01	0.00	-0.06	-2.40	-0.21	0.00	0.01	-0.04	14.00	14.00
1- 8	-0.01	0.00	-0.06	-3.44	-0.32	0.00	0.01	-0.04	14.00	14.00
1- 9	-0.01	0.00	-0.06	-4.42	-0.43	0.00	0.01	-0.04	14.00	14.00
1-10	-0.01	0.00	-0.06	-5.34	-0.54	0.00	0.01	-0.04	14.00	14.00
EXTERIOR WALL TOP										
TOP SLAB LEFT SIDE										
2- 0	1.26	0.00	9.28	0.93	0.09	0.00	0.54	-0.02	14.00	14.00
2- 1	0.96	0.00	7.07	0.93	0.09	0.00	0.37	-0.02	14.00	14.00
2- 2	0.66	0.00	4.86	0.93	0.09	0.00	0.27	-0.02	14.00	14.00
2- 3	0.36	0.00	2.65	0.93	0.09	0.00	0.16	-0.03	14.00	14.00
2- 4	0.06	0.00	0.44	0.93	0.09	0.00	0.06	-0.05	14.00	14.00
2- 5	-0.24	0.00	-1.78	0.93	0.09	0.00	0.02	-0.14	14.00	14.00
2- 6	-0.54	0.00	-3.99	0.93	0.09	0.00	0.01	-0.23	14.00	14.00
2- 7	-0.84	0.00	-6.20	0.93	0.09	0.00	0.00	-0.33	0.00	14.00
2- 8	-1.14	0.00	-8.41	0.93	0.09	0.00	0.00	-0.44	0.00	14.00
2- 9	-1.44	0.00	-10.62	0.93	0.09	0.00	0.00	-0.55	0.00	14.00
2-10	-1.74	0.00	-12.83	0.93	0.09	0.00	0.00	-0.60	0.00	14.00
TOP SLAB RIGHT SIDE										
INTERIOR WALL BOTTOM										
3- 0	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 1	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 2	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 3	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 4	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 5	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 6	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 7	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 8	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3- 9	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
3-10	0.00	0.00	0.00	-0.00	0.00	0.00	0.03	-0.03	14.00	14.00
INTERIOR WALL TOP										



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BOTTOM SLAB	LEFT SIDE									
4- 0	1.33	0.00	9.78	1.09	0.10	0.00	0.17	0.00	0.00	14.00
4- 1	1.01	0.00	7.41	1.09	0.10	0.00	0.13	0.00	0.00	14.00
4- 2	0.68	0.00	5.03	1.09	0.10	0.00	0.09	0.00	0.00	14.00
4- 3	0.36	0.00	2.66	1.09	0.10	0.00	0.04	0.00	0.00	14.00
4- 4	0.04	0.00	0.28	1.09	0.10	0.00	0.00	-0.01	14.00	14.00
4- 5	-0.28	0.00	-2.10	1.09	0.10	0.00	0.00	-0.05	14.00	0.00
4- 6	-0.61	0.00	-4.47	1.09	0.10	0.00	0.00	-0.09	14.00	0.00
4- 7	-0.93	0.00	-6.85	1.09	0.10	0.00	0.00	-0.14	14.00	0.00
4- 8	-1.25	0.00	-9.22	1.09	0.10	0.00	0.00	-0.18	14.00	0.00
4- 9	-1.58	0.00	-11.60	1.09	0.10	0.00	0.00	-0.22	14.00	0.00
4-10	-1.90	0.00	-13.98	1.09	0.10	0.00	0.00	-0.27	14.00	0.00
BOTTOM SLAB	RIGHT SIDE									

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Current Live Load: HS20T / No Lane

Unfactored AXIAL FORCES (per unit design width) due to Dead and Live Loads including Distribution and Impact											
M-PT	DC	DW	EV	Soil Press	Surch Hgt.	Water Press (Max) K	LIVE Pos	LOADS Neg	Rear Axle Pos	Spacing Neg	
	K	K	K	K	K	K	K	K	ft	ft	
EXTERIOR WALL BOTTOM											
1- 0	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 1	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 2	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 3	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 4	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 5	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 6	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 7	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 8	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1- 9	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
1-10	-1.26	0.00	-9.28	-0.93	-0.67	-0.09	0.00	0.02	-0.53	14.00	14.00
EXTERIOR WALL TOP											
TOP SLAB LEFT SIDE											
2- 0	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 1	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 2	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 3	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 4	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 5	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 6	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 7	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 8	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2- 9	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
2-10	-0.01	0.00	-0.06	-5.34	-3.84	-0.54	0.00	0.01	-0.04	14.00	14.00
TOP SLAB RIGHT SIDE											
INTERIOR WALL BOTTOM											
3- 0	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 1	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 2	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 3	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 4	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 5	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 6	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 7	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 8	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3- 9	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
3-10	-3.49	0.00	-25.66	1.87	1.34	0.18	0.00	0.00	-1.18	0.00	14.00
INTERIOR WALL TOP											

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BOTTOM SLAB LEFT SIDE											
4- 0	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 1	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 2	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 3	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 4	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 5	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 6	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 7	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 8	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4- 9	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
4-10	0.01	0.00	0.06	-6.52	-4.69	-0.55	0.00	0.04	-0.01	14.00	14.00
BOTTOM SLAB RIGHT SIDE											

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Factored Actions for Load Factor Design at Tenth Points (per unit design width)						
M-Pt	+Moment (Kft)	-Moment (Kft)	+A.F. (Kips)	-A.F. (Kips)	+Shear (Kips)	-Shear (Kips)
EXTERIOR WALL BOTTOM						
1- 0	-16.602	-21.237	-14.523	-16.248	9.596	5.916
1- 1	-10.875	-12.022	-14.523	-16.248	7.475	4.559
1- 2	-4.844	-6.793	-14.523	-16.248	5.430	3.256
1- 3	-0.050	-3.927	-14.523	-16.248	3.463	2.009
1- 4	2.650	-2.386	-14.523	-16.248	1.571	0.816
1- 5	3.355	-2.116	-14.523	-16.248	-0.190	-0.374
1- 6	2.137	-3.053	-14.523	-16.248	-1.285	-2.100
1- 7	-0.924	-5.137	-14.523	-16.248	-2.311	-3.761
1- 8	-5.746	-8.305	-14.523	-16.248	-3.283	-5.346
1- 9	-11.461	-13.283	-14.523	-16.248	-4.200	-6.854
1-10	-16.492	-21.506	-14.523	-16.248	-5.061	-8.286
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-16.492	-21.506	-5.062	-8.286	16.273	14.523
2- 1	-2.486	-5.920	-5.062	-8.286	12.655	11.258
2- 2	8.671	5.183	-5.062	-8.286	9.153	7.994
2- 3	16.125	12.667	-5.062	-8.286	5.652	4.717
2- 4	19.800	16.597	-5.062	-8.286	2.181	1.404
2- 5	19.680	16.990	-5.062	-8.286	-1.166	-2.041
2- 6	15.761	13.847	-5.062	-8.286	-4.468	-5.502
2- 7	8.239	6.991	-5.062	-8.286	-7.745	-8.984
2- 8	-2.535	-3.957	-5.062	-8.286	-11.009	-12.490
2- 9	-16.413	-18.970	-5.062	-8.286	-14.274	-15.988
2-10	-33.645	-38.065	-5.062	-8.286	-17.539	-19.366
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.158	-0.124	-35.463	-38.309	0.053	-0.059
3- 1	0.094	-0.067	-35.463	-38.309	0.053	-0.059
3- 2	0.030	-0.010	-35.463	-38.309	0.053	-0.059
3- 3	0.051	-0.038	-35.463	-38.309	0.053	-0.059
3- 4	0.107	-0.100	-35.463	-38.309	0.053	-0.059
3- 5	0.162	-0.162	-35.463	-38.309	0.053	-0.059
3- 6	0.219	-0.225	-35.463	-38.309	0.053	-0.059
3- 7	0.276	-0.289	-35.463	-38.309	0.053	-0.059
3- 8	0.334	-0.353	-35.463	-38.309	0.053	-0.059
3- 9	0.391	-0.417	-35.463	-38.309	0.053	-0.059
3-10	0.448	-0.481	-35.463	-38.309	0.053	-0.059
INTERIOR WALL TOP						

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BOTTOM SLAB LEFT SIDE						
4- 0	-16.602	-21.237	-5.916	-9.595	16.446	15.464
4- 1	-1.525	-5.547	-5.916	-9.595	12.842	11.956
4- 2	9.771	6.169	-5.916	-9.595	9.239	8.448
4- 3	17.167	14.077	-5.916	-9.595	5.635	4.939
4- 4	20.660	18.184	-5.916	-9.595	2.039	1.418
4- 5	20.248	18.490	-5.916	-9.595	-1.471	-2.182
4- 6	15.932	14.996	-5.916	-9.595	-4.980	-5.786
4- 7	7.939	7.459	-5.916	-9.595	-8.488	-9.390
4- 8	-3.375	-4.502	-5.916	-9.595	-11.997	-12.994
4- 9	-18.292	-20.518	-5.916	-9.595	-15.505	-16.598
4-10	-36.989	-40.447	-5.916	-9.595	-19.013	-20.201
BOTTOM SLAB RIGHT SIDE						

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### Fatigue Checks

$$f_s \leq f_r = 24 - 0.33f_{\min} \quad (5.5.3.2-1)$$

where:

$f_s$  = actual stress range in the reinforcement

$f_r$  = maximum allowable stress range

Member	Location	$f_{\min}$ ( kip )	$f_r$ ( kip )	$f_s$ ( kip )	Result
EXTERIOR WALL	Bottom	0.00	23.98	0.25	Pass
EXTERIOR WALL	Middle -	0.00	23.90	1.00	Pass
EXTERIOR WALL	Top	0.00	23.88	1.15	Pass
TOP SLAB	Left	0.00	23.95	0.50	Pass
TOP SLAB	Middle +	0.00	23.81	1.90	Pass
INTERIOR WALL	Bottom	0.00	23.95	0.52	Pass
INTERIOR WALL	Middle	0.00	23.96	0.44	Pass
INTERIOR WALL	Top	0.00	23.77	2.31	Pass
BOTTOM SLAB	Left	0.00	23.97	0.29	Pass

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Serviceability, Fatigue, and Other Checks

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Based on crack control check  
AASHTO 16.6.4.7  
Factor Z = 155. k/in for precast or cast-in-place  
modified by a depth factor for CIP.

Slenderness check on walls passed  
Eccentricity check on walls passed

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Reinforcing Bar Stresses Sizes and Spacing

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Note: Bar stresses are based on bending and axial stress only  
Stresses are in ksi  
Area of steel in square inches per ft  
Spacing and H and V legs are in inches

Bar Mark	Description
A1	Top Corner Outside face Max Neg Moment
A100	Top Slab Inside face Max Pos Moment
A300	Top Slab Outside face Max Neg Moment Interior support
A2	Bottom Corner Outside face Max Neg Moment
A200	Bottom Slab Inside face Max Pos Moment
A400	Bottom Slab Outside face Max Neg Moment Interior support
B2	Exterior Wall Outside face Max Neg Moment
B1	Exterior Wall Inside face Max Pos Moment
B3	Interior Wall Both faces

Bar Type	Fs Act. (Ksi)	Fs All. (Ksi)	Area steel Input (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	13.03	19.80	0.7086	0.7086	5	5.2	29	33
A2	15.66	19.80	0.7086	0.7086	5	5.2	29	33
A100	35.18	19.80	0.6200	0.6200	5	6.0		
A300	31.66	19.80	0.9000	0.9000	7	8.0		
A200	34.65	19.80	0.6200	0.6200	5	6.0		
A400	32.07	19.80	0.9000	0.9000	7	8.0		
B1	0.00	19.80	0.4000	0.4000	4	6.0		
B2	0.00	19.80	0.4000	0.4000	4	6.0		
B3	0.00	19.80	0.2667	0.2667	4	9.0		

\*\* THE HEIGHT OF C.H.C.U. \*\* BOTTOM SLAB = 7.00 IN

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## Notes:

1. Area of steel is the maximum required for all limit states. The strength computations are shown in the results at critical sections table.
2. Design thickness shown in the following table is based on the appropriate cover minus half the diameter of the bar in the above table or one-half the diameter of a #6 bar. The actual half bar diameter is used once the steel has been selected and the #6 bar is used in design iterations.
3. For a Design review run the actual bar stresses shown can be the stress at either side of a member corner or the stress at the middle of the slab for a multiple cell group. The required  $A_s$  is actual in a Design review.
4. If the user wishes to ignore crack control the allowable steel stress is set at  $0.95 F_y$ . This limit will likely not control the design, but if it should, this will control yielding under service loads.



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Output at Critical Sections (per unit design width)																	
Member No. = 1 EXTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.62 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.62 (in)													
	Moment	Coin. Axial	Shear Force	Shear Force	Resistance				Steel	Mom.	Des.	Design Ratio		Flexure Ratings		Shear Ratings	
	Kft	Kips	Kips	Kips	Po	Mu	Mbal	Pbal	Area	Cap	Thk	Flx	Shr	Inv	Oper	Inv	Oper
BOT	-14.7	14.5	6.7	10.2	193.8	13.6	22.9	73.7	0.7086	15.4	8.19	0.95	0.66	1.79	2.99	4.88	8.14
MID	3.4	14.5	0.2	9.7	187.1	7.9	21.1	81.5	0.4000	10.3	8.25	0.33	NA	4.93	8.22	NA	NA
MID-	-2.4	14.5	0.4	9.7	187.1	7.9	21.1	81.5	0.4000	10.3	8.25	0.23	NA	16.58	27.65	NA	NA
TOP	-15.8*	14.5	6.3	10.0	193.8	13.6	22.9	73.7	0.7086	15.4	8.19	1.03	0.64	0.73	1.22	4.86	8.09
Member No. = 2 TOP SLAB				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-10.7	5.1	11.4	11.7	193.8	13.6	22.9	73.7	0.7086	14.2	8.19	0.75	0.98	3.20	5.33	1.29	2.14
MID	19.8*	5.1	1.2	11.4	191.9	11.9	22.4	75.7	0.6200	12.6	8.19	1.57	NA	0.00	0.00	NA	NA
RT	-24.8*	5.1	14.8*	11.3	198.0	16.7	23.9	67.9	0.9000	17.2	8.06	1.44	1.30	0.00	0.00	0.00	0.00
Member No. = 3 INTERIOR WALL				Thickness = 10.00 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (bot ) = 0.50 (in) Bar diameter (mid+) = 0.50 (in) Bar diameter (mid-) = 0.50 (in) Bar diameter (top ) = 0.50 (in)													
BOT	-0.1	35.5	0.1	9.5	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	0.01	NA	NA	99.00	99.00
MID	0.2	35.5	0.1	9.5	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	NA	NA	NA	NA	NA
MID-	-0.2	35.5	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.01	NA	NA	NA	NA	NA
TOP	-0.4	35.5	0.1	9.1	184.3	5.3	20.3	84.6	0.2667	11.6	8.25	0.04	0.01	27.69	46.16	99.00	99.00
Member No. = 4 BOTTOM SLAB				Thickness = 10.50 (in) Clear cover at end = 1.50 (in) Clear cover at middle = 1.50 (in) Bar diameter (lt ) = 0.62 (in) Bar diameter (mid ) = 0.62 (in) Bar diameter (rt ) = 0.88 (in)													
LT	-10.4	5.9	11.5	12.3	202.7	14.4	25.2	79.2	0.7086	15.2	8.69	0.68	0.94	4.41	7.35	2.75	4.59
MID	20.7*	5.9	1.5	11.9	200.8	12.7	24.6	81.2	0.6200	13.6	8.69	1.52	NA	0.00	0.00	NA	NA
RT	-26.6*	5.9	15.2*	12.0	206.9	17.8	26.2	73.4	0.9000	18.5	8.56	1.44	1.27	0.00	0.00	0.00	0.00

## Warnings:

- For exterior corners, BRASS-CULVERT does not perform a check on both the exterior wall and top or bottom slab. BRASS-CULVERT only checks the location that it has determined requires a greater area of steel. Because of this, BRASS-CULVERT may check one location for a particular culvert (e.g. top of the wall) and a different location (e.g. left end of top slab) for the same culvert with a different depth of fill.
- If the flexural resistance is zero and rebar has been entered, it could be due to the axial load being higher than the tensile capacity of the rebar provide. For example, the axial load is greater than the area of steel times the yield strength of the bars.

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## Notes:

1. Flexure rating value of n/a indicates no live load effect on the member
2. SS value adjacent to steel area indicates a simply supported culvert and a steel area is not required
3. AASHTO 8.16.4.2
  - Po -- Axial capacity at zero eccentricity (no moment)
  - Mu -- Flexural Capacity without an axial load
  - Pbal -- Axial load at balanced strain
  - Mbal -- Moment at balanced state of strain
4. The phi factors are included
5. Coin. is the coincident axial force
6. The plane of computation for shear is a "d" distance from the face of the supporting member
7. The plane of computation for moment if haunches are used is based on AASHTO 8.8.2
8. The plane of computation for moment if haunches are not used is based on the user input
9. An asterisk next to the Design Moment indicates the Moment is greater than the All Mom. Value
10. An asterisk next to the Shear Value indicates the Shear is greater than the Allowable Shear
11. Rating factors computations consider the effect of axial force. The Allowable Moment value is used with the maximum soil pressure.
12. The load combinations and envelope of critical action combinations are shown in the  
 X:\3286900\141416.01\XXXXX (SCDOT Number)\structures\Culvert Load Rating\Results\Wall-Support Prop.ooo file.
13. For fills less than 2.0 feet, Article 3.24.4 applies, and shear is assumed to adequate because the section has been designed for moment.

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Output complete for a HS20T                      vehicle

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DATE 03/06/2016  
BRASS-CULVERT Version 2.7  
I-85 DESIGN BUILD - EMBANKMENT OVER EXISTING CULVERT CHECK

\*\* LOAD RATING SUMMARY \*\*

\*INVENTORY RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 2  
CONTROLLING POINT : Center  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure

\*OPERATING RATING\*

LOAD NO. 1: AASHTO HS20-44 (MS 18) TRUCK (US)/ No Lane Specified  
TOTAL VEHICLE WT. : 36.00 (TONS)  
CONTROLLING MEMBER : 2  
CONTROLLING POINT : Center  
RATING FACTOR : 0.00  
LOAD RATING : 0.00 (TONS)  
ACTION TYPE : Flexure