

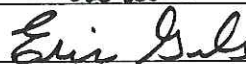
JOB NUMBER: 412-654
DATE: November 27, 2014

STRUCTURAL CALCULATIONS

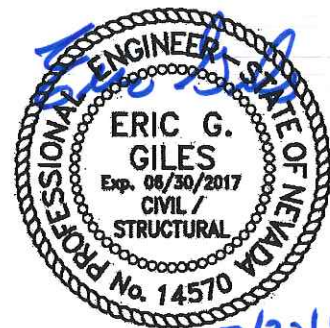
Centennial Parkway Channel West – CC215
Pioneer Way to US95
Drainage Structures

Prepared for:
City of Las Vegas Department of Public Works
333 N. Rancho Drive
Las Vegas, NV 89107

City of Las Vegas 100% Submittal

	<u>Name</u>	<u>Signature</u>	<u>Date</u>
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G. C. WALLACE COMPANIES
ENGINEERS | PLANNERS | SURVEYORS

SUBJECT Centennial Parkway Channel West – CC215

JOB NO. 412-654

CALCULATED BY DAT DATE 9/22/14

CLIENT City of Las Vegas

CHECKED BY _____ DATE _____

TABLE OF CONTENTS

<u>Description</u>	<u>page</u>
Project Description	1
Design Code	1
Design Parameters.....	1
Cast-In-Place RCB Culvers:	
22'x7' RCB with 10-ft Soil Cover.....	2
10'x5' RCB with 30-ft Soil Cover.....	43
(2)15'x7' RCB with 10-ft Soil Cover	78
(2)15'x7' RCB with 20-ft Soil Cover	119
(2)15'x7' RCB with 33-ft Soil Cover	159
(2)15'x7' RCB Headwall	195
Junction Structure – 10'x5' RCB into 22'x7' RCB	200
Junction Structure – 6'x5' RCB into 22'x7' RCB	205
Access Grate Inlet.....	210
6'x3' RCB Plug	217



Project Description:

Structural calculations and details are provided for various cast-in-place reinforced concrete storm drain structures for the *Centennial Parkway Channel West – CC215, Pioneer Way to US95* project located in the City of Las Vegas, Nevada. The contractor is permitted to provide precast structures instead of cast-in-place structures where applicable. The design and detailing of all precast structures shall be provided by the precast supplier.

Calculations are provided for the following:

1. Cast-In-Place Reinforced Concrete Box (RCB) Structures – The program BRASS-Culvert™ version 2.3.6 is used to design the following RCB sizes with soil cover as noted:
 - a. 22'x7' RCB with 10-ft max soil cover
 - b. 10'x5' RCB with 30-ft max soil cover
 - c. (2)15'x7' RCB with 10-ft max soil cover
 - d. (2)15'x7' RCB with 20-ft max soil cover
 - e. (2)15'x7' RCB with 33-ft max soil cover
2. Headwall for (2)15'x7' RCB – Headwall is designed to retain 4-ft of soil and span over RCB opening. Headwall is designed for traffic surcharge (240 psf) and seismic loading.
3. Junction Structure #1 - 10'x5' RCB entering side of 22'x7' RCB with 10-ft max soil cover. A beam is used to span the opening in the 22'x7' wall.
4. Junction Structure #2 – 6'x5' RCB entering side of 22'x7' RCB with 10-ft max soil cover. A beam is used to span the opening in the 22'x7' RCB.
5. Access Grate Inlet – 20'x10' metal grate supported by steel beams and concrete walls located in 22'x7' RCB to allow maintenance access. Grate structure is designed for HS20 wheel loading.
6. 6'x3' RCB Plug at Existing Headwall – Plug will be attached to outside face of existing headwall using epoxy anchors. Plug is designed for a maximum of 10-ft of soil cover.

Design Code:

AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2014

Concrete Junction Structures are designed for HS-20 Truck Loading.

Per Caltrans Bridge Design Specifications, Section 6 – “Culverts”, the RCBs were designed for a maximum equivalent lateral earth pressure of 100 pcf and a minimum pressure of 35 pcf.

A soil unit weight of 125 pcf was used for vertical earth pressure.

Design Parameters:

See General Structural Notes of Drawings

BRASS-CULVERT - 22'x7' RCB w/ 10' Soil Cover

BRASS-CULVERT(LRFD) Version 2.3.6

DATE : 10/24/2014

TIME : 15:12:54

PAGE 1

Input Filename : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.DAT
Output Filename : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.xml
Output Filename for Live Loads : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7_LL.OUT

The following filenames may be used in this run
Live Load Influence Values File name : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7_INF.OUT
Drawing File name : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.drw
Live Load Influence Ordinates File name : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.ill
Live Load Actions (w/o DF or IM) File name : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.oll
Intermediate Computations File name : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.ooo
Data Modelling File name : F:\Projects\400\412-
654\Division\Str1\Calcs\22x7RCB\Centennial 22x7.tmp

COMMENTS	THIS FILE WAS CREATED BY THE BRASS-CULVERT GUI.
COMMENTS	DO NOT EDIT THIS FILE!
COMMENTS	JOB DESCRIPTION:
TITLE	CENTENNIAL - 22 X 7 RCB
STRUCTID	
AGENCY	
COMMENTS	MAXIMUM 10-FEET OF FILL
UNITSIN	US
UNITSOUT	US
COMMENTS	ANALYSIS CONTROL:
TYPE	CIP
FUNCT	DESIGN
LRFR	NO
IRELEASE	NO
IDSN	LRFD
KBASE	FULL
KHACH	NO
EPOXY	NO
EDGE-STRIP	NO
LRFD-SHEAR	0
IFATIG	YES
DNEG	0.0000
COMMENTS	DESIGN CONTROL:
ISAMS	NO
ISAMW	NO
ADDS	1.0000
ADDW	1.0000
MAXSIZ	9
MINSIZ	4
SPCMAX	12.0000
SPCMIN	6.0000
ISPCGINC	MAX
PAS	0.012000
CUSTOM	STD
BAR_DE	US
COMMENTS	OUTPUT CONTROL:
MTEN	YES
IBSH	YES
IINFN	NO
LIVELO	NO

DEFAULTS	YES
LOOPS	NO
INTERMEDIATE	NO
COMMENTS	MATERIAL PROPERTIES:
FCONC	4000.000
CE	3644147.000
CWGT	150.000
ZEE	155.000
EXP_FACTOR	0.750
GAMMA_MIN_RE_1	1.600
GAMMA_MIN_RE_3	0.750
EWGT	125.000
AWGT	145.000
FYST	60000.000
CN	7.9580
COMMENTS	BOX GEOMETRY:
NBOX	1
NSPAN	22.0000
NHITE	7.0000
LENG	150.0000
BWIDTH	150.0000
CBWIDTH	0.0000
TSLAB	18.0000
KFXTS	F
BSLAB	18.0000
KFXBS	F
WALLR	14.0000
KFXW	F
COMMENTS	SKEW:
CSKEW	0.0000
LSKEW	90.0000
RSKEW	90.0000
COMMENTS	CONCRETE COVER:
COVS	2.0000
COVB	3.0000
COVW	2.0000
COVIN	2.0000
COMMENTS	DEAD LOADS:
PRESS	100.000
PMIN	35.000
PWAT	0.000

NFILL	10.0000
NWEAR	6.0000
FILLFA	1.1500
TYFILL	COMPACT
COMMENTS	LIVE LOADS:
LVLD	HL-93-TRUCK
LVLD	HL-93-TANDEM
LVOMT	YES
LLPATCH	PL
SURCH_USE	YES
LIMIT_DIST	NO
LRFDDE	YES

End of Input File No. 1

Note:

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

The first set are the variables defaulted from input and the second set are system variables.

Units

USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US

Design Variables

LRFDDF:	Use LRFD method for bot slab load distrib.	=	T
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDSN:	Design Method	=	LRFD
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESIGN
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	0.00
CUSTOM:	Default bar spacing and design check control	=	STD
ISAMS:	Design Same Top and Bottom Slab	=	F
ISAMW:	Design Same Interior-Exterior Wall	=	F

Output Control Variables

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

Standard Load Variables

LVLD:	Live Load Vehicle Name	=	HL-93-TRUCK
LVLD:	Live Load Vehicle Name	=	HL-93-TANDEM
LVOMT:	Neglect LL for Fill > 8Ft & Fill > Span	=	T

Uniform Dead Load Variable

EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (in)	=	6.0

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	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	100.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	35.0
PWAT:	Internal Water Pressure	=	0.0

Geometry - Box Dimension Variables

NBOX:	Number of Boxes (1 TO 4)	=	1
NSPAN:	Clear Span (Ft)	=	22.0
NHITE:	Clear Height (Ft)	=	7.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	10.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	150.0

Geometry - Slab Thickness Variables

TSLAB:	Minimum Value for Top Slab (In)	=	18.0
KFXTS:	Code for Top Slab(F=Fixed,V=Variable)	=	F
BSLAB:	Minimum Value for Bottom Slab(In)	=	18.0
KFXBS:	Code for Bottom Slab(F=Fixed,V=Variable)	=	F
WALLR:	Minimum Value for Exterior Wall (In)	=	14.0
KFXW:	Code for Exterior Wall(F=Fixed,V=Variable)	=	F

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)	=	0.0
BFILT:	Bottom Haunch (In)	=	0.0
KHACH:	Haunches used in Analysis (YES/NO)	=	NO

Geometry - Clear Concrete Cover

COVS:	Exterior Concrete Cover Top Slab (In)	=	2.0
COVB:	Exterior Concrete Cover Bottom Slab (In)	=	3.0
COVW:	Exterior Concrete Cover Walls (In)	=	2.0
COVIN:	Interior Concrete Cover (In)	=	2.0

Reinforcing Bar variables and Thickness Increment

SPCMAX:	Default Max. Bar Spacings (In)	=	12.0
SPCMIN:	Default Min. Bar Spacings (In)	=	6.0
MAXSIZ:	Default Bar Sizes(US)	=	9
MINSIZ:	Default Bar Sizes(US)	=	4
ISPCGINC:	Reinforcing Bar Minimum Increment	=	T
EPOXY:	Top Reinforcing Mat Epoxy Coated	=	F
ADDSD:	Added Slab Thickness Increment(In)	=	1.0
ADDWD:	Added Wall Thickness Increment(In)	=	1.0

Material Properties Variables

EWGT:	Weight of Soil (Pcf)	=	125.0
FYST:	Yield Strength of Reinf. Steel (Psi)	=	60000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi) (ASD)	=	36000.0
FCONC:	Compressive Strength of Concrete (Psi)	=	4000.0
FSHR:	Shear in Concrete (Psi) (ASD)	=	0.0
FSTIR:	Allowable Stress in Stirrups (Psi) (ASD)	=	0.0
CWGT:	Weight of Concrete (Pcf)	=	150.0
AWGT:	Weight of Wearing Surface (Pcf)	=	145.0

ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	8.0
CE:	Modulus of Elasticity of Concrete(ksi)	=	3644.1
ZEE:	Crack Width Parameter from AASHTO	=	0.9
CN:	Modular Ratio of Concrete	=	0.9
CE:	Modulus of Elasticity of Concrete(ksi)	=	
Service-I load and resistance factors			
EV:	Vertical Earth Pressure max-min	1.00	1.00
DC:	Components max-min	1.00	1.00
DW:	Wearing Surfaces max-min	1.00	1.00
EH:	Horizontal Earth Pressure At-Rest	1.00	
LS:	Live load surcharge	1.00	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.00	
Strength-I load and resistance factors			
EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.75	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.75	
Strength-II load and resistance factors			
EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.35	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.35	
Fatigue load and resistance factors			
EV:	Vertical Earth Pressure max-min	0.00	0.00
DC:	Components max-min	0.00	0.00
DW:	Wearing Surfaces max-min	0.00	0.00
EH:	Horizontal Earth Pressure At-Rest	0.00	
LS:	Live load surcharge	0.75	
WA:	Water load and stream pressure	0.00	
LL:	Vehicular live load	0.75	
BB:	Factor Load Factor Po and Pb AASHTO	=	0.80
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	0.0000
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
BB:	Factor Load Factor Po and Pb AASHTO	=	1.30
BETAD:	Dead Load Multiplier for Load Factor	=	
HAFBAR:	Assumed Half a Bar Dia. of #6 Bar (In)	=	0.375
I300:	A300 and A400 Bars to TRUE	=	T
I400:	A300 and A400 Bars to TRUE	=	T
ICHANG:	Initial Settings	=	F
ICUT:	Cut Bars Due to Skew	=	T
ICUTSM:	Bar Cuts Symmetrical	=	F
IFIXB:	Defaults for Slab Thickness Incrementing	=	F
IFIXI:	Defaults for Wall Thickness Incrementing	=	F
IFIXT:	Defaults for Slab Thickness Incrementing	=	F
IFIXW:	Defaults for Wall Thickness Incrementing	=	F

PAGE 8
DATE 10/24/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - 22 X 7 RCB

IFATIG:	Check Fatigue	=	F
IHAUCH:	Code for Considering Haunch in Analysis	=	F
ILES5:	Code for Span Less Than 5 ft	=	F
ISHR:	Code for Shear Stress Check	=	F

ILOOP:	Loop Counter for Design Iterations	=	0
INTERM SWITCH:	Turn on Intermediate Results Output	=	F
ISTORE:	Design Moments to Zero	=	0
KPASS:	Variable Dimen (use in fixed thickness design)	=	VAR
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
PAS:	Maximum AS/BD Desired	=	0.012

JOB DESCRIPTION

Title : CENTENNIAL - 22 X 7 RCB
Structure ID :
Agency name : STD

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	DESIGN	NO	FULL	0.00

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

Design Method	Limit State Ductility	Load and Resistance Redundant	Factors Operations
LOAD & RES.	1.0000	1.0500	1.00

DESIGN CONTROLS

Design Same Thickness Slabs	Design Same Thickness Walls	Round-up Thicknesses (In)	Increment Walls (In)	Bar Spacing File
NO	NO	1.00	1.00	Standard

Bar Spacing Max (In)	Min (In)	US-Bar Size Max	Bar Spacing Min	Increment
12.0	6.0	9	4	1 INCH

OUTPUT CONTROLS

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

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Gamma E (Kip/in)	Steel Fy (Psi)	Steel n
4000.	3644147.	0.75	60000.	7.96

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width coefficient is the coefficient in Eq. 5.7.3.4-2 for the crack width parameter Z

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	125.	145.

Note:

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

BOX GEOMETRY

Culvert Cells	Span Length (Ft)	Clear Height (Ft)	Centerline Length (Ft)
SINGLE	22.00	7.00	150.00

Bridge Width (Ft)	Number of Traffic Lanes
150.00	1 and 2 lanes investigated

Slab and Wall Information

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)
18.00 Fixed	18.00 Fixed	14.00 Fixed	0.00 n/a

LIVE LOADS

Vehicle Designation
 HL-93-TRUCK
 HL-93-TANDEM
 Live Load Control: YES
 (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. (Kips)	Dis. (Ft)	Wgt. (Kips)	Dis. (Ft)	Wgt. (Kips)	Dis. (Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil Pressure Max (Pcf)	Min (Pcf)	Water Density (Pcf)
****	35.0	0.0

Uniform Load (plf)	Wearing Surface	
	Thickness	Fill Height
	(in)	(Ft)
0.0	6.00	10.00

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)
0.0	0.0

CONCRETE COVER to face of bar

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)
2.00	3.00	2.00

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 10.00	ft.
Span Length	= 22.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.15	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 20.49 ft.

Final Distribution Factor = 1/Final Strip Width = **0.049** Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = **0.059**

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_c)$

$IM = 33(1.0 - 1.25(10.00))$

$IM = 0.0000$

Notes: Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.

1. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Number of cells	=	1
Top Slab thickness	=	18.0000 In.
Bottom Slab thickness	=	18.0000 In.
Exterior Wall thickness	=	14.0000 In.
Design Span(c-c walls)	=	23.1667 Ft.
Design Height(c-c slabs)	=	8.5000 Ft.
Fill Height(top of slab)	=	10.0000 Ft.
Wearing surface thickness	=	6.0000 In.
Loads based on 1 foot unit width		
Soil Structure Interaction Factor	=	1.0822
Earth Weight for fill computations	=	0.1353 Kcf
Weight of Fill without wearing surface	=	1.2851 Klf
Weight of Wearing Surface	=	0.0725 Klf
Weight of Top Slab	=	0.2250 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	1.5826 Klf
Weight of Walls divided by culvert width	=	0.1058 Klf
Uniform Dead Load on Bottom Slab	=	1.6884 Klf
Soil pressure at center of top slab	=	1.0750 Klf
Soil pressure at center of bottom slab	=	1.9250 Klf
Soil pressure due to live load surcharge	=	0.0700 Klf
Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000
Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0586
on Bottom Slab	=	0.0586

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 AASHTO LRFD 4.6.2.10 for fill depth less than 2 ft. and AASHTO LRFD 3.6.1.2.6 for fill depths over 2 ft. Also, see 3.6.1.3.3.

AASHTO Specifications state that no live load is to be used when the fill is greater than 8 feet and the fill is greater than the total span length

The fill is greater than 8 feet but less than the total span length of 23.17 feet

For a HL-93-TRUCK Vehicle
Description AASHTO LRFD HL-93 Design Truck (US)
The Number of axles = 3

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 = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 1
Fill = 10.00 ft.
Distribution slope = 1.15
LL Longitudinal Distribution Length = 12.33 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 2
Fill = 10.00 ft.
Distribution slope = 1.15
LL Longitudinal Distribution Length = 12.33 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 3
Fill = 10.00 ft.
Distribution slope = 1.15
LL Longitudinal Distribution Length = 12.33 ft.
[slope(fill) + longitudinal tire patch]

Redundancy 1.05
Operations 1.00

Design Iteration Loop Number 1

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill = 10.00 ft.
Span Length = 22.00 ft.
Truck Gage = 6.00 ft.
Soil Distribution Factor = 1.15
Tire Patch Width = 20.00 in.
Bridge Width = 150.00 ft.
Length = 150.00 ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 20.49 ft.

Final Distribution Factor = $1/\text{Final Strip Width} = 0.049$ Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.059

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(10.00))$

$IM = 0.0000$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Current Live Load: HL-93-TRUCK

Unfactored MOMENTS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-42.93	-4.01	-1.40	-0.19	0.00	0.00	-3.58
1- 1	-42.56	1.25	0.44	0.04	0.00	0.00	-3.56
1- 2	-42.20	5.17	1.81	0.22	0.00	0.00	-3.54
1- 3	-41.83	7.83	2.74	0.35	0.00	0.00	-3.52
1- 4	-41.46	9.28	3.25	0.42	0.00	0.00	-3.51
1- 5	-41.10	9.59	3.36	0.45	0.00	0.00	-3.49
1- 6	-40.73	8.81	3.08	0.42	0.00	0.00	-3.48
1- 7	-40.37	7.01	2.45	0.35	0.00	0.00	-3.46
1- 8	-40.00	4.25	1.49	0.22	0.00	0.00	-3.46
1- 9	-39.63	0.59	0.21	0.04	0.00	0.01	-3.48
1-10	-39.27	-3.91	-1.37	-0.18	0.00	0.06	-3.53
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-39.27	-3.91	-1.37	-0.18	0.00	0.06	-3.53
2- 1	-1.04	-3.90	-1.36	-0.18	0.00	0.69	-0.82
2- 2	28.69	-3.89	-1.36	-0.18	0.00	2.64	0.00
2- 3	49.94	-3.88	-1.36	-0.18	0.00	4.43	0.00
2- 4	62.68	-3.88	-1.36	-0.18	0.00	5.43	0.00
2- 5	66.94	-3.87	-1.35	-0.18	0.00	5.65	0.00
2- 6	62.70	-3.86	-1.35	-0.18	0.00	5.44	0.00
2- 7	49.96	-3.85	-1.35	-0.18	0.00	4.45	0.00
2- 8	28.73	-3.85	-1.35	-0.18	0.00	2.63	0.00
2- 9	-0.99	-3.84	-1.34	-0.18	0.00	0.70	-0.83
2-10	-39.20	-3.83	-1.34	-0.18	0.00	0.07	-3.54
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	-42.93	-4.01	-1.40	-0.19	0.00	0.00	-3.58
4- 1	-2.16	-4.02	-1.41	-0.19	0.00	0.23	-0.19
4- 2	29.55	-4.02	-1.41	-0.19	0.00	2.80	0.00
4- 3	52.20	-4.03	-1.41	-0.18	0.00	4.79	0.00
4- 4	65.78	-4.04	-1.41	-0.18	0.00	5.98	0.00
4- 5	70.31	-4.05	-1.42	-0.18	0.00	6.37	0.00
4- 6	65.77	-4.05	-1.42	-0.18	0.00	5.98	0.00
4- 7	52.17	-4.06	-1.42	-0.18	0.00	4.78	0.00
4- 8	29.51	-4.07	-1.42	-0.18	0.00	2.79	0.00
4- 9	-2.21	-4.07	-1.43	-0.18	0.00	0.25	-0.20
4-10	-42.99	-4.08	-1.43	-0.18	0.00	0.00	-3.59
BOTTOM SLAB RIGHT SIDE							

Current Live Load: HL-93-TRUCK

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	0.43	6.99	2.45	0.30	0.00	0.16	-0.16
1- 1	0.43	5.39	1.89	0.24	0.00	0.16	-0.16
1- 2	0.43	3.86	1.35	0.18	0.00	0.16	-0.16
1- 3	0.43	2.41	0.84	0.12	0.00	0.16	-0.16
1- 4	0.43	1.02	0.36	0.06	0.00	0.16	-0.16
1- 5	0.43	-0.29	-0.10	0.00	0.00	0.16	-0.16
1- 6	0.43	-1.53	-0.53	-0.06	0.00	0.16	-0.16
1- 7	0.43	-2.69	-0.94	-0.12	0.00	0.16	-0.16
1- 8	0.43	-3.79	-1.33	-0.18	0.00	0.16	-0.16
1- 9	0.43	-4.81	-1.68	-0.24	0.00	0.16	-0.16
1-10	0.43	-5.76	-2.02	-0.30	0.00	0.16	-0.16
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	18.33	0.00	0.00	-0.00	0.00	1.73	0.00
2- 1	14.67	0.00	0.00	-0.00	0.00	1.28	-0.02
2- 2	11.00	0.00	0.00	-0.00	0.00	0.99	-0.07
2- 3	7.34	0.00	0.00	-0.00	0.00	0.74	-0.15
2- 4	3.67	0.00	0.00	-0.00	0.00	0.53	-0.28
2- 5	0.00	0.00	0.00	-0.00	0.00	0.35	-0.44
2- 6	-3.66	0.00	0.00	-0.00	0.00	0.21	-0.64
2- 7	-7.33	0.00	0.00	-0.00	0.00	0.10	-0.87
2- 8	-11.00	0.00	0.00	-0.00	0.00	0.04	-1.13
2- 9	-14.66	0.00	0.00	-0.00	0.00	0.01	-1.43
2-10	-18.33	0.00	0.00	-0.00	0.00	0.00	-1.71
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	19.55	-0.00	-0.00	0.00	0.00	1.72	0.00
4- 1	15.64	-0.00	-0.00	0.00	0.00	1.37	0.00
4- 2	11.73	-0.00	-0.00	0.00	0.00	1.03	0.00
4- 3	7.82	-0.00	-0.00	0.00	0.00	0.69	0.00
4- 4	3.91	-0.00	-0.00	0.00	0.00	0.34	0.00
4- 5	-0.00	-0.00	-0.00	0.00	0.00	0.01	-0.01
4- 6	-3.91	-0.00	-0.00	0.00	0.00	0.00	-0.34
4- 7	-7.83	-0.00	-0.00	0.00	0.00	0.00	-0.69
4- 8	-11.74	-0.00	-0.00	0.00	0.00	0.00	-1.03
4- 9	-15.65	-0.00	-0.00	0.00	0.00	0.00	-1.38
4-10	-19.56	-0.00	-0.00	0.00	0.00	0.00	-1.72
BOTTOM SLAB RIGHT SIDE							

Current Live Load: HL-93-TRUCK

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 1	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 2	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 3	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 4	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 5	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 6	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 7	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 8	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1- 9	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
1-10	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.60
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 1	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 2	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 3	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 4	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 5	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 6	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 7	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 8	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2- 9	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
2-10	0.44	-5.86	-2.05	-0.30	0.00	0.16	-0.17
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 1	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 2	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 3	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 4	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 5	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 6	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 7	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 8	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4- 9	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
4-10	-0.42	-6.87	-2.40	-0.29	0.00	0.16	-0.16
BOTTOM SLAB RIGHT SIDE							

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

Fatigue Checks

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

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	Top	0.000	23.66	3.44	Pass
TOP SLAB	Left	0.000	23.66	3.36	Pass
TOP SLAB	Middle -	0.000	23.66	3.39	Pass

LRFD Crack Control Computation

AASHTO
(5.7.3.4)

Current Vehicle: AASHTO LRFD HL-93 Design Truck (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	0.75000000	14.00000000	2.50000000	1.31055903	6.97059631	6.00000000	36.39145279	33.46469879
Top slab, inside face	0.75000000	18.00000000	2.50000000	1.23041475	6.40567684	6.00000000	38.74279785	37.40991211
Bottom slab, outside corner	0.75000000	14.00000000	2.50000000	1.31055903	6.07031059	6.00000000	36.39145279	36.18619537
Bottom slab, inside face	0.75000000	18.00000000	2.56400013	1.23729312	8.31424618	6.00000000	38.09016418	31.56565857
Ext. wall, outside face	0.75000000	14.00000000	2.50000000	1.31055903	8.45223808	6.00000000	36.39145279	29.77886772
Ext. wall, inside face	0.8*f _t > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 23.167 feet
Percentage of main reinforcement required = 20.776% , less than or equal to 50%
Main reinforcement area (top slab) = 1.580 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 2.000 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE		Top slab CENTER	RIGHT SIDE		
area	1.5800 in ²	area	1.5800 in ²	area	1.5800 in ²
size	8 spaced at 6.00 in.	size	8 spaced at 6.00 in.	size	8 spaced at 6.00 in.

Exterior wall

TOP
area 1.5800 in²
size 8 spaced at 6.00 in.

OUTSIDE FACE
area 1.5800 in²
size 8 spaced at 6.00 in.

INSIDE FACE
area 0.5314 in²
size 5 spaced at 7.00 in.

BOTTOM
area 1.5800 in²
size 8 spaced at 6.00 in.

LEFT SIDE		Bottom slab CENTER	RIGHT SIDE		
area	1.5800 in ²	area	2.0000 in ²	area	1.5800 in ²
size	8 spaced at 6.00 in.	size	9 spaced at 6.00 in.	size	8 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	8	STR	0- 0	0		
BOT SLAB (Inside)	A200	300	9	STR	0- 0	0		
CORNER (Top)	A1	600	8	L-BAR	13- 7	21761	8-10	4- 9
CORNER (Bottom)	A2	600	8	L-BAR	10- 0	16020	5- 4	4- 8
EXTWALL (Inside)	B1	516	5	STR	7- 6	4036		
EXTWALL (Outside)	B2	600	8	STR	0- 0	0		
LONGITUD.(3)	C1	240	4	STR	51- 1	8195		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		
Total weight black bars						50012		
Total weight all bars						50012		

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2

Bottom slab(s) = 0.1100 in2

Exterior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	5	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-43.870	-71.135	-16.437	-26.951	11.332	6.706
1- 1	-37.894	-63.399	-16.439	-26.949	8.955	5.194
1- 2	-31.662	-59.153	-16.439	-26.949	6.680	3.750
1- 3	-27.320	-56.113	-16.439	-26.949	4.507	2.374
1- 4	-24.781	-54.215	-16.439	-26.949	2.437	1.067
1- 5	-23.958	-53.399	-16.439	-26.949	0.606	-0.309
1- 6	-24.765	-53.607	-16.439	-26.949	-0.565	-2.174
1- 7	-27.114	-54.782	-16.439	-26.949	-1.668	-3.937
1- 8	-30.917	-56.884	-16.439	-26.949	-2.702	-5.598
1- 9	-36.065	-59.886	-16.439	-26.949	-3.668	-7.156
1-10	-40.247	-65.906	-16.437	-26.951	-4.565	-8.612
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-40.247	-65.906	-4.832	-8.568	28.190	17.122
2- 1	-3.386	-8.781	-4.832	-8.568	22.352	13.666
2- 2	40.303	0.000	-4.643	-8.756	16.832	10.154
2- 3	72.574	0.000	-4.643	-8.756	11.374	6.576
2- 4	91.793	0.000	-4.643	-8.756	5.988	2.923
2- 5	98.007	0.000	-4.643	-8.756	0.657	-0.803
2- 6	91.846	0.000	-4.643	-8.756	-3.035	-6.170
2- 7	72.666	0.000	-4.643	-8.756	-6.651	-11.590
2- 8	40.382	0.000	-4.643	-8.756	-10.192	-17.075
2- 9	-3.258	-8.653	-4.832	-8.568	-13.675	-22.618
2-10	-40.099	-65.731	-4.832	-8.568	-17.110	-28.140
TOP SLAB RIGHT SIDE						
BOTTOM SLAB LEFT SIDE						
4- 0	-43.870	-71.135	-6.590	-11.133	29.821	18.254
4- 1	-5.387	-9.322	-6.590	-11.133	23.855	14.601
4- 2	41.640	0.000	-6.772	-10.951	17.890	10.949
4- 3	76.170	0.000	-6.772	-10.951	11.924	7.297
4- 4	96.880	0.000	-6.772	-10.951	5.959	3.645
4- 5	103.770	0.000	-6.772	-10.951	0.020	-0.034
4- 6	96.842	0.000	-6.772	-10.951	-3.658	-5.976
4- 7	76.096	0.000	-6.772	-10.951	-7.310	-11.941
4- 8	41.530	0.000	-6.772	-10.951	-10.962	-17.907
4- 9	-5.461	-9.505	-6.590	-11.133	-14.614	-23.872
4-10	-44.001	-71.349	-6.590	-11.133	-18.266	-29.838
BOTTOM SLAB RIGHT SIDE						

Output complete for a HL-93-TRUCK vehicle

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill = 10.00 ft.
Span Length = 22.00 ft.
Truck Gage = 6.00 ft.
Soil Distribution Factor = 1.15

Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 20.49 ft.

Final Distribution Factor = $1/\text{Final Strip Width} = 0.049$ Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.059

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(10.00))$

$IM = 0.0000$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

AASHTO Specifications state that no live load is to be used when the fill is greater than 8 feet and the fill is greater than the total span length

The fill is greater than 8 feet but less than the total span length of 23.17 feet

For a HL-93-TANDEM Vehicle
Description AASHTO LRFD HL-93 Design Tandem (US)
The Number of axles = 2

Axle Weights (kips)	Spacing (ft)
25.00	4.000
25.00	0.000
-----	-----
Totals 50.00	4.000

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 1
Fill = 10.00 ft.
Distribution slope = 1.15
LL Longitudinal Distribution Length = 12.33 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 2
Fill = 10.00 ft.
Distribution slope = 1.15
LL Longitudinal Distribution Length = 12.33 ft.
[slope(fill) + longitudinal tire patch]

For a HL-93-TANDEM Vehicle
Description AASHTO LRFD HL-93 Design Tandem (US)

The number of simulated axles based on fill = 16

The number of simulated axles is calculated based on the longitudinal distribution length of each axle divided by the simulated axle spacing of 1 foot and the simulated axle weights are calculated by dividing the vehicle axle weights by the number of simulated axles per vehicle axle.

Truck facing backwards		Truck facing forward	
Axle wts. (kips)	Spacing (ft)	Axle wts. (kips)	Spacing (ft)
2.08	0.000	2.08	0.000
2.08	1.000	2.08	1.000
2.08	1.000	2.08	1.000
2.08	1.000	2.08	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
4.17	1.000	4.17	1.000
2.08	1.000	2.08	1.000
2.08	1.000	2.08	1.000
2.08	1.000	2.08	1.000
2.08	1.000	2.08	1.000
Totals	50.00 15.000	50.00	15.000

Note: Impact or distribution is not included in the above table.

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

Design Iteration Loop Number 1

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill = 10.00 ft.
Span Length = 22.00 ft.
Truck Gage = 6.00 ft.
Soil Distribution Factor = 1.15
Tire Patch Width = 20.00 in.
Bridge Width = 150.00 ft.
Length = 150.00 ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 20.49 ft.

Final Distribution Factor = $1/\text{Final Strip Width} = 0.049$ Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.059

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(10.00))$

$IM = 0.0000$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Current Live Load: HL-93-TANDEM

Unfactored MOMENTS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-42.93	-4.01	-1.40	-0.19	0.00	0.00	-3.08
1- 1	-42.56	1.25	0.44	0.04	0.00	0.00	-3.09
1- 2	-42.20	5.17	1.81	0.22	0.00	0.00	-3.13
1- 3	-41.83	7.83	2.74	0.35	0.00	0.00	-3.30
1- 4	-41.46	9.28	3.25	0.42	0.00	0.00	-3.48
1- 5	-41.10	9.59	3.36	0.45	0.00	0.00	-3.67
1- 6	-40.73	8.81	3.08	0.42	0.00	0.00	-3.86
1- 7	-40.37	7.01	2.45	0.35	0.00	0.00	-4.05
1- 8	-40.00	4.25	1.49	0.22	0.00	0.00	-4.24
1- 9	-39.63	0.59	0.21	0.04	0.00	0.01	-4.43
1-10	-39.27	-3.91	-1.37	-0.18	0.00	0.06	-4.62
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-39.27	-3.91	-1.37	-0.18	0.00	0.06	-4.62
2- 1	-1.04	-3.90	-1.36	-0.18	0.00	1.01	-1.16
2- 2	28.69	-3.89	-1.36	-0.18	0.00	3.49	0.00
2- 3	49.94	-3.88	-1.36	-0.18	0.00	5.78	0.00
2- 4	62.68	-3.88	-1.36	-0.18	0.00	7.18	0.00
2- 5	66.94	-3.87	-1.35	-0.18	0.00	7.66	0.00
2- 6	62.70	-3.86	-1.35	-0.18	0.00	7.17	0.00
2- 7	49.96	-3.85	-1.35	-0.18	0.00	5.76	0.00
2- 8	28.73	-3.85	-1.35	-0.18	0.00	3.46	0.00
2- 9	-0.99	-3.84	-1.34	-0.18	0.00	1.01	-1.18
2-10	-39.20	-3.83	-1.34	-0.18	0.00	0.06	-4.64
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	-42.93	-4.01	-1.40	-0.19	0.00	0.00	-3.08
4- 1	-2.16	-4.02	-1.41	-0.19	0.00	0.33	-0.22
4- 2	29.55	-4.02	-1.41	-0.19	0.00	2.67	0.00
4- 3	52.20	-4.03	-1.41	-0.18	0.00	4.35	0.00
4- 4	65.78	-4.04	-1.41	-0.18	0.00	5.35	0.00
4- 5	70.31	-4.05	-1.42	-0.18	0.00	5.69	0.00
4- 6	65.77	-4.05	-1.42	-0.18	0.00	5.36	0.00
4- 7	52.17	-4.06	-1.42	-0.18	0.00	4.36	0.00
4- 8	29.51	-4.07	-1.42	-0.18	0.00	2.69	0.00
4- 9	-2.21	-4.07	-1.43	-0.18	0.00	0.35	-0.24
4-10	-42.99	-4.08	-1.43	-0.18	0.00	0.00	-3.07
BOTTOM SLAB RIGHT SIDE							

Current Live Load: HL-93-TANDEM

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	0.43	6.99	2.45	0.30	0.00	0.18	-0.23
1- 1	0.43	5.39	1.89	0.24	0.00	0.18	-0.23
1- 2	0.43	3.86	1.35	0.18	0.00	0.18	-0.23
1- 3	0.43	2.41	0.84	0.12	0.00	0.18	-0.23
1- 4	0.43	1.02	0.36	0.06	0.00	0.18	-0.23
1- 5	0.43	-0.29	-0.10	0.00	0.00	0.18	-0.23
1- 6	0.43	-1.53	-0.53	-0.06	0.00	0.18	-0.23
1- 7	0.43	-2.69	-0.94	-0.12	0.00	0.18	-0.23
1- 8	0.43	-3.79	-1.33	-0.18	0.00	0.18	-0.23
1- 9	0.43	-4.81	-1.68	-0.24	0.00	0.18	-0.23
1-10	0.43	-5.76	-2.02	-0.30	0.00	0.18	-0.23
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	18.33	0.00	0.00	-0.00	0.00	2.04	0.00
2- 1	14.67	0.00	0.00	-0.00	0.00	1.63	-0.03
2- 2	11.00	0.00	0.00	-0.00	0.00	1.34	-0.10
2- 3	7.34	0.00	0.00	-0.00	0.00	1.05	-0.23
2- 4	3.67	0.00	0.00	-0.00	0.00	0.77	-0.41
2- 5	0.00	0.00	0.00	-0.00	0.00	0.51	-0.64
2- 6	-3.66	0.00	0.00	-0.00	0.00	0.31	-0.91
2- 7	-7.33	0.00	0.00	-0.00	0.00	0.16	-1.20
2- 8	-11.00	0.00	0.00	-0.00	0.00	0.06	-1.49
2- 9	-14.66	0.00	0.00	-0.00	0.00	0.01	-1.77
2-10	-18.33	0.00	0.00	-0.00	0.00	0.00	-2.03
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	19.55	-0.00	-0.00	0.00	0.00	1.48	0.00
4- 1	15.64	-0.00	-0.00	0.00	0.00	1.19	0.00
4- 2	11.73	-0.00	-0.00	0.00	0.00	0.90	0.00
4- 3	7.82	-0.00	-0.00	0.00	0.00	0.60	0.00
4- 4	3.91	-0.00	-0.00	0.00	0.00	0.31	0.00
4- 5	-0.00	-0.00	-0.00	0.00	0.00	0.02	-0.02
4- 6	-3.91	-0.00	-0.00	0.00	0.00	0.00	-0.31
4- 7	-7.83	-0.00	-0.00	0.00	0.00	0.00	-0.60
4- 8	-11.74	-0.00	-0.00	0.00	0.00	0.00	-0.89
4- 9	-15.65	-0.00	-0.00	0.00	0.00	0.00	-1.19
4-10	-19.56	-0.00	-0.00	0.00	0.00	0.00	-1.48
BOTTOM SLAB RIGHT SIDE							

Current Live Load: HL-93-TANDEM

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 1	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 2	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 3	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 4	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 5	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 6	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 7	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 8	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1- 9	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
1-10	-17.60	-0.00	-0.00	0.00	0.00	0.00	-1.95
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 1	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 2	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 3	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 4	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 5	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 6	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 7	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 8	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2- 9	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
2-10	0.44	-5.86	-2.05	-0.30	0.00	0.18	-0.24
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 1	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 2	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 3	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 4	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 5	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 6	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 7	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 8	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4- 9	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
4-10	-0.42	-6.87	-2.40	-0.29	0.00	0.23	-0.17
BOTTOM SLAB RIGHT SIDE							

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

Fatigue Checks

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

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	Top	0.000	23.59	4.15	Pass
TOP SLAB	Left	0.000	23.56	4.42	Pass
TOP SLAB	Middle -	0.000	23.55	4.47	Pass

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Tandem (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	0.75000000	14.00000000	2.50000000	1.31055903	6.69864750	6.00000000	36.39145279	34.24262619
Top slab, inside face	0.75000000	18.00000000	2.56400013	1.23729312	8.68565941	6.00000000	38.09016418	30.71694183
Bottom slab, outside corner	0.75000000	14.00000000	2.50000000	1.31055903	6.17933559	6.00000000	36.39145279	35.83329391
Bottom slab, inside face	0.75000000	18.00000000	2.56400013	1.23729312	8.43750572	6.00000000	38.09016418	31.27884483
Ext. wall, outside face	0.75000000	14.00000000	2.50000000	1.31055903	8.45984173	6.00000000	36.39145279	29.76204491
Ext. wall, inside face	$0.8 * f_r > f_c$, therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 23.167 feet
Percentage of main reinforcement required = 20.776% , less than or equal to 50%
Main reinforcement area (top slab) = 2.000 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 2.000 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE area 1.5800 in² size 8 spaced at 6.00 in.	Top slab CENTER area 2.0000 in² size 9 spaced at 6.00 in.	RIGHT SIDE area 1.5800 in² size 8 spaced at 6.00 in.
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Exterior wall

TOP

area 1.5800 in²

size 8 spaced at 6.00 in.

OUTSIDE FACE

area 1.5800 in²

size 8 spaced at 6.00 in.

INSIDE FACE

area 0.5314 in²

size 5 spaced at 7.00 in.

BOTTOM

area 1.5800 in²

size 8 spaced at 6.00 in.

				Bottom slab				
LEFT SIDE area 1.5800 in² size 8 spaced at 6.00 in.	CENTER area 2.0000 in² size 9 spaced at 6.00 in.	RIGHT SIDE area 1.5800 in² size 8 spaced at 6.00 in.						

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	9	STR	0- 0	0		
BOT SLAB (Inside)	A200	300	9	STR	0- 0	0		
CORNER (Top)	A1	600	8	L-BAR	13- 7	21761	8-10	4- 9

CORNER (Bottom)	A2	600	8	L-BAR	10- 0	16020	5- 4	4- 8
EXTWALL (Inside)	B1	516	5	STR	7- 6	4036		
EXTWALL (Outside)	B2	600	8	STR	0- 0	0		
LONGITUD.(3)	C1	240	4	STR	51- 1	8195		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		

Total weight black bars	50012
Total weight all bars	50012

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2

Bottom slab(s) = 0.1100 in2

Exterior wall(s) = 0.1100 in2

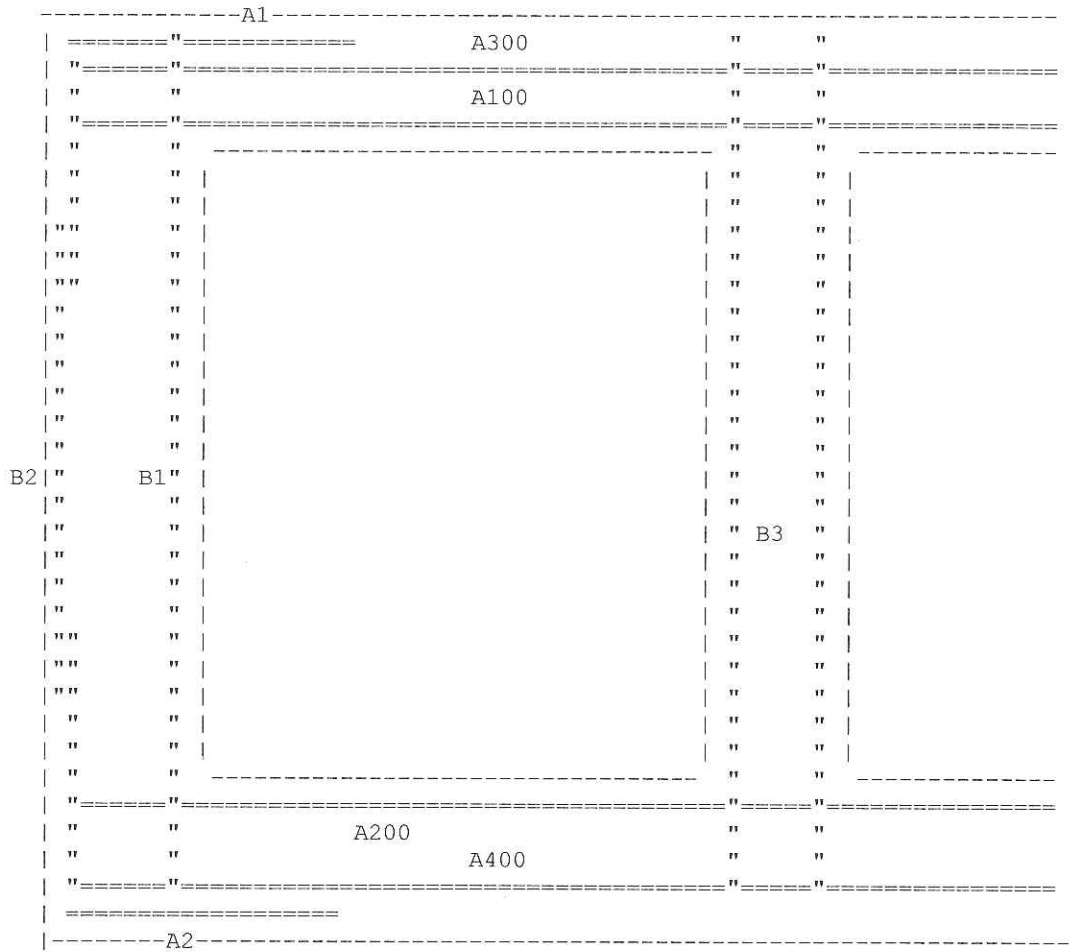
Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	5	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-43.870	-70.227	-16.437	-27.597	11.367	6.578
1- 1	-37.894	-62.546	-16.439	-27.596	8.989	5.066
1- 2	-31.662	-58.405	-16.439	-27.596	6.714	3.623
1- 3	-27.320	-55.701	-16.439	-27.596	4.542	2.247
1- 4	-24.781	-54.172	-16.439	-27.596	2.471	0.940
1- 5	-23.958	-53.726	-16.439	-27.596	0.640	-0.436
1- 6	-24.765	-54.310	-16.439	-27.596	-0.531	-2.301
1- 7	-27.114	-55.859	-16.439	-27.596	-1.633	-4.064
1- 8	-30.917	-58.317	-16.439	-27.596	-2.667	-5.725
1- 9	-36.070	-61.625	-16.439	-27.596	-3.633	-7.283
1-10	-40.254	-67.908	-16.437	-27.597	-4.531	-8.739
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-40.254	-67.908	-4.797	-8.700	28.748	17.122
2- 1	-2.801	-9.422	-4.797	-8.700	23.010	13.647
2- 2	41.862	0.000	-4.608	-8.888	17.478	10.091
2- 3	75.053	0.000	-4.608	-8.888	11.933	6.428
2- 4	95.006	0.000	-4.608	-8.888	6.423	2.670
2- 5	101.701	0.000	-4.608	-8.888	0.949	-1.170
2- 6	95.032	0.000	-4.608	-8.888	-2.843	-6.659
2- 7	75.075	0.000	-4.608	-8.888	-6.546	-12.199
2- 8	41.914	0.000	-4.608	-8.888	-10.155	-17.738
2- 9	-2.694	-9.302	-4.797	-8.700	-13.669	-23.255
2-10	-40.113	-67.768	-4.797	-8.700	-17.110	-28.719
TOP SLAB RIGHT SIDE						
BOTTOM SLAB LEFT SIDE						
4- 0	-43.870	-70.227	-6.463	-11.167	29.385	18.254
4- 1	-5.207	-9.386	-6.463	-11.167	23.513	14.601
4- 2	41.396	0.000	-6.644	-10.985	17.640	10.949
4- 3	75.358	0.000	-6.644	-10.985	11.768	7.297
4- 4	95.730	0.000	-6.644	-10.985	5.896	3.645
4- 5	102.513	0.000	-6.644	-10.985	0.032	-0.046
4- 6	95.711	0.000	-6.644	-10.985	-3.658	-5.908
4- 7	75.320	0.000	-6.644	-10.985	-7.310	-11.780
4- 8	41.336	0.000	-6.644	-10.985	-10.962	-17.653
4- 9	-5.268	-9.563	-6.463	-11.167	-14.614	-23.525
4-10	-44.001	-70.389	-6.463	-11.167	-18.266	-29.397
BOTTOM SLAB RIGHT SIDE						

Output complete for a HL-93-TANDEM vehicle



Serviceability, Fatigue, and Other Checks

→ Based on crack control check
AASHTO 5.7.3.4 LRFD

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 Required (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	34.24	36.39	1.5242	1.5800	8	6.0	106	57
A2	35.83	36.39	1.5711	1.5800	8	6.0	64	56
A100	30.72	38.09	1.6843	2.0000	9	6.0		
A200	31.28	38.09	1.6218	2.0000	9	6.0		
B1	<u>0.00</u>	35.19	0.5188	0.5314	5	<u>12"</u> 7.0		
B2	29.76	36.39	1.2929	1.5800	8	6.0		

USE #8+#9@12"
 $A_s = 1.79 \text{ in}^2$

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.

Output at Critical Sections (per unit design width)

Member No. = 1 EXTERIOR WALL

Thickness	=	14.00 (in)
Clear cover at end	=	3.00 (in)
Clear cover at middle	=	2.00 (in)
Bar diameter (bot)	=	1.00 (in)
Bar diameter (mid+)	=	1.13 (in)
Bar diameter (mid-)	=	1.00 (in)
Bar diameter (top)	=	1.00 (in)

Design Ratio	Moment Kft	Coin.	Resistance					Steel Area In2	Mom. Cap	Des.	
		Axial	Shear	Shear	Po	Mu	Mbal				
		Force	Force	Cap	Cap	Cap	Cap				
		Kips	Kips	Kips	Kips	Kft	Kft	Kips		Kft	in
BOT	-71.1	16.4	6.6	14.0	396.4	73.6	93.1	113.0	1.5800	73.6	11.50
MID	-24.8	16.4	0.6	18.9	360.8	27.5	74.9	166.4	0.5314	27.5	11.69
MID-	-54.2	16.4	0.4	17.1	396.4	73.6	93.1	113.0	1.5800	73.6	11.50
TOP	-67.9	16.4	5.6	14.5	396.4	73.6	93.1	113.0	1.5800	73.6	11.50

Member No. = 2 TOP SLAB

Thickness	=	18.00 (in)
Clear cover at end	=	3.00 (in)
Clear cover at middle	=	2.00 (in)
Bar diameter (lt)	=	1.00 (in)
Bar diameter (mid)	=	1.13 (in)
Bar diameter (rt)	=	1.00 (in)

LT	-67.9	4.8	24.0	30.0	494.3	102.1	149.3	178.7	1.5800	102.1	15.50	0.7
MID	101.7	4.8	0.9	29.9	508.6	125.9	159.6	157.5	2.0000	125.9	15.44	0.8
RT	-67.8	4.6	24.0	30.0	494.3	102.1	149.3	178.7	1.5800	102.1	15.50	0.7

Member No. = 4 BOTTOM SLAB

Thickness	=	18.00 (in)
Clear cover at end	=	3.00 (in)
Clear cover at middle	=	2.00 (in)
Bar diameter (lt)	=	1.00 (in)
Bar diameter (mid)	=	1.13 (in)
Bar diameter (rt)	=	1.00 (in)

LT	-71.1	6.6	25.1	28.0	494.3	95.1	141.0	162.2	1.5800	95.1	14.50	0.7
MID	103.8	6.6	0.0	30.0	508.6	126.0	159.6	157.5	2.0000	126.0	15.44	0.8
RT	-71.3	6.8	25.1	28.0	494.3	95.1	141.0	162.2	1.5800	95.1	14.50	0.8

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.

Volume of Concrete and Weight of Reinforcing Steel

Thickness				Volume	Steel
Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)		
18.00	18.00	14.00	0.00 n/a	3.309	803

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	9	STR	24- 0	24477		
BOT SLAB (Inside)	A200	300	9	STR	24- 0	24477		
CORNER (Top)	A1	600	8	L-BAR	13- 7	21761	8-10	4- 9
CORNER (Bottom)	A2	600	8	L-BAR	10- 0	16020	5- 4	4- 8
EXTWALL (Inside)	B1	516	5	STR	7- 6	4036		
EXTWALL (Outside)	B2	600	8	STR	7- 0	11214		
LONGITUD. (3)	C1	240	4	STR	51- 1	8195		
LONGITUD. (3)	C100	69	4	STR	51- 1	2356		
LONGITUD. (3)	C200	69	4	STR	51- 1	2356		

Total weight black bars	114892
Total weight all bars	114892

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2
Bottom slab(s) = 0.1100 in2
Exterior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	5	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Job No.	412-654	By	DAT	Subject	22'x7' RCB	Sheet
Date		Checked				Of

Distribution Reinforcing (AASHTO LRFD 9.7.3.2)

Use distribution steel in top slab to account for construction loading when fill is less than 2-ft.

For primary reinforcement perpendicular to traffic:

Effective Span, $S =$ ft

% Distribution Reinforcing = $220 / S^{0.5}$
=

Primary Reinforcing = #8 + #9 @ 12"
Area of Steel = 1.79 in²/ft

Min Distribution Reinforcing = 0.84 in²/ft

BRASS-CULVERT

10'x5' RCB w/ Max 30' of F.II

BRASS-CULVERT(LRFD) Version 2.3.6

DATE : 10/24/2014

TIME : 15:47: 9

PAGE 1

Input Filename : F:\Projects\400\412-654\Division\Strl\Calcs\Centennial 10x5 -
 30 feet.DAT
 Output Filename : F:\Projects\400\412-654\Division\Strl\Calcs\Centennial 10x5 -
 30 feet.xml
 Output Filename for Live Loads : F:\Projects\400\412-654\Division\Strl\Calcs\Centennial 10x5 -
 30 feet_LL.OUT

The following filenames may be used in this run

Live Load Influence Values File name : F:\Projects\400\412-
 654\Division\Strl\Calcs\Centennial 10x5 - 30 feet_INF.OUT
 Drawing File name : F:\Projects\400\412-
 654\Division\Strl\Calcs\Centennial 10x5 - 30 feet.drw
 Live Load Influence Ordinates File name : F:\Projects\400\412-
 654\Division\Strl\Calcs\Centennial 10x5 - 30 feet.ill
 Live Load Actions (w/o DF or IM) File name : F:\Projects\400\412-
 654\Division\Strl\Calcs\Centennial 10x5 - 30 feet.oll
 Intermediate Computations File name : F:\Projects\400\412-
 654\Division\Strl\Calcs\Centennial 10x5 - 30 feet.ooo
 Data Modelling File name : F:\Projects\400\412-
 654\Division\Strl\Calcs\Centennial 10x5 - 30 feet.tmp

COMMENTS THIS FILE WAS CREATED BY THE BRASS-CULVERT GUI.
 COMMENTS DO NOT EDIT THIS FILE!
 COMMENTS JOB DESCRIPTION:
 TITLE CENTENNIAL - 10' X 5' RCB
 STRUCTID
 AGENCY
 COMMENTS MAXIMUM 30-FEET OF FILL
 UNITSIN US
 UNITSOUT US
 COMMENTS ANALYSIS CONTROL:
 TYPE CIP
 FUNCT DESIGN
 LRFR NO
 IRELEASE NO
 IDSN LRFD
 KBASE FULL
 KHACH NO
 EPOXY NO
 EDGE-STRIP NO
 LRFD-SHEAR 0
 IFATIG YES
 DNEG 0.0000
 COMMENTS DESIGN CONTROL:
 ISAMS NO
 ISAMW NO
 ADDS 1.0000
 ADDW 1.0000
 MAXSIZ 8
 MINSIZ 4
 SPCMAX 12.0000
 SPCMIN 6.0000
 ISPCGINC MAX
 PAS 0.012000
 CUSTOM STD
 BAR_DE US
 COMMENTS OUTPUT CONTROL:
 MTEN YES
 IBSH YES
 IINFN NO
 LIVELO NO

DEFAULTS	YES
LOOPS	NO
INTERMEDIATE	NO
COMMENTS	MATERIAL PROPERTIES:
FCONC	4000.000
CE	3644147.000
CWGT	150.000
ZEE	155.000
EXP_FACTOR	0.750
GAMMA_MIN_RE_1	1.600
GAMMA_MIN_RE_3	0.750
EWGT	125.000
AWGT	145.000
FYST	60000.000
CN	7.9580
COMMENTS	BOX GEOMETRY:
NBOX	1
NSPAN	10.0000
NHITE	5.0000
LENG	150.0000
BWIDTH	150.0000
CBWIDTH	0.0000
TSLAB	14.0000
KFXTS	F
BSLAB	15.0000
KFXBS	F
WALLR	12.0000
KFXW	F
COMMENTS	SKEW:
CSKEW	0.0000
LSKEW	90.0000
RSKEW	90.0000
COMMENTS	CONCRETE COVER:
COVS	2.0000
COVB	3.0000
COVW	2.0000
COVIN	2.0000
COMMENTS	DEAD LOADS:
PRESS	100.000
PMIN	35.000
PWAT	0.000

NFILL	30.0000
NWEAR	6.0000
FILLFA	1.1500
TYFILL	COMPACT
COMMENTS	LIVE LOADS:
LVLD	HL-93-TRUCK
LVLD	HL-93-TANDEM
LVOMT	YES
LLPATCH	PL
SURCH_USE	YES
LIMIT_DIST	NO
LRFDDF	YES

End of Input File No. 1

Note:

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

The first set are the variables defaulted from input and the second set are system variables.

Units			
USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US

Design Variables			
LRFDDF:	Use LRFD method for bot slab load distrib.	=	T
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDSN:	Design Method	=	LRFD
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESIGN
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	0.00
CUSTOM:	Default bar spacing and design check control	=	STD
ISAMS:	Design Same Top and Bottom Slab	=	F
ISAMW:	Design Same Interior-Exterior Wall	=	F

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

Standard Load Variables			
LVLD:	Live Load Vehicle Name	=	HL-93-TRUCK
LVLD:	Live Load Vehicle Name	=	HL-93-TANDEM
LVOMT:	Neglect LL for Fill & 8Ft & Fill & Span	=	T

Uniform Dead Load Variable

EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (in)	=	6.0

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	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	100.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	35.0
PWAT:	Internal Water Pressure	=	0.0

Geometry - Box Dimension Variables

NBOX:	Number of Boxes (1 TO 4)	=	1
NSPAN:	Clear Span (Ft)	=	10.0
NHITE:	Clear Height (Ft)	=	5.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	30.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	150.0

Geometry - Slab Thickness Variables

TSLAB:	Minimum Value for Top Slab (In)	=	14.0
KFXTS:	Code for Top Slab(F=Fixed,V=Variable)	=	F
BSLAB:	Minimum Value for Bottom Slab(In)	=	15.0
KFXBS:	Code for Bottom Slab(F=Fixed,V=Variable)	=	F
WALLR:	Minimum Value for Exterior Wall (In)	=	12.0
KFXW:	Code for Exterior Wall(F=Fixed,V=Variable)	=	F

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)	=	0.0
BFILT:	Bottom Haunch (In)	=	0.0
KHACH:	Haunches used in Analysis (YES/NO)	=	NO

Geometry - Clear Concrete Cover

COVS:	Exterior Concrete Cover Top Slab (In)	=	2.0
COVB:	Exterior Concrete Cover Bottom Slab (In)	=	3.0
COVW:	Exterior Concrete Cover Walls (In)	=	2.0
COVIN:	Interior Concrete Cover (In)	=	2.0

Reinforcing Bar variables and Thickness Increment

SPCMAX:	Default Max. Bar Spacings (In)	=	12.0
SPCMIN:	Default Min. Bar Spacings (In)	=	6.0
MAXSIZ:	Default Bar Sizes(US)	=	8
MINSIZ:	Default Bar Sizes(US)	=	4
ISPCGINC:	Reinforcing Bar Minimum Increment	=	T
EPOXY:	Top Reinforcing Mat Epoxy Coated	=	F
ADD:	Added Slab Thickness Increment(In)	=	1.0
ADDW:	Added Wall Thickness Increment(In)	=	1.0

Material Properties Variables

EWGT:	Weight of Soil (Pcf)	=	125.0
FYST:	Yield Strength of Reinf. Steel (Psi)	=	60000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi)(ASD)	=	36000.0
FCONC:	Compressive Strength of Concrete (Psi)	=	4000.0
FSHR:	Shear in Concrete (Psi)(ASD)	=	0.0
FSTIR:	Allowable Stress in Stirrups (Psi)(ASD)	=	0.0
CWGT:	Weight of Concrete (Pcf)	=	150.0
AWGT:	Weight of Wearing Surface (Pcf)	=	145.0

PAGE 7
DATE 10/24/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	8.0
CE:	Modulus of Elasticity of Concrete(ksi)	=	3644.1
ZEE:	Crack Width Parameter from AASHTO	=	0.9
CN:	Modular Ratio of Concrete	=	0.9
CE:	Modulus of Elasticity of Concrete(ksi)	=	
Service-I load and resistance factors			
EV:	Vertical Earth Pressure max-min	1.00	1.00
DC:	Components max-min	1.00	1.00
DW:	Wearing Surfaces max-min	1.00	1.00
EH:	Horizontal Earth Pressure At-Rest	1.00	
LS:	Live load surcharge	1.00	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.00	
Strength-I load and resistance factors			
EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.75	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.75	
Strength-II load and resistance factors			
EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.35	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.35	
Fatigue load and resistance factors			
EV:	Vertical Earth Pressure max-min	0.00	0.00
DC:	Components max-min	0.00	0.00
DW:	Wearing Surfaces max-min	0.00	0.00
EH:	Horizontal Earth Pressure At-Rest	0.00	
LS:	Live load surcharge	0.75	
WA:	Water load and stream pressure	0.00	
LL:	Vehicular live load	0.75	
BB:	Factor Load Factor Po and Pb AASHTO	=	0.80
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	0.0000
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500
BB:	Factor Load Factor Po and Pb AASHTO	=	1.30
BETAD:	Dead Load Multiplier for Load Factor	=	
HAFBAR:	Assumed Half a Bar Dia. of #6 Bar (In)	=	0.375
I300:	A300 and A400 Bars to TRUE	=	T
I400:	A300 and A400 Bars to TRUE	=	T
ICHANG:	Initial Settings	=	F
ICUT:	Cut Bars Due to Skew	=	T
ICUTSM:	Bar Cuts Symmetrical	=	F
IFIXB:	Defaults for Slab Thickness Incrementing	=	F
IFIXI:	Defaults for Wall Thickness Incrementing	=	F
IFIXT:	Defaults for Slab Thickness Incrementing	=	F
IFIXW:	Defaults for Wall Thickness Incrementing	=	F

PAGE 8
DATE 10/24/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

IFATIG:	Check Fatigue	=	F
IHAUCH:	Code for Considering Haunch in Analysis	=	F
ILES5:	Code for Span Less Than 5 ft	=	F
ISHR:	Code for Shear Stress Check	=	F

ILOOP:	Loop Counter for Design Iterations	=	0
INTERM_SWITCH:	Turn on Intermediate Results Output	=	F
ISTORE:	Design Moments to Zero	=	0
KPASS:	Variable Dimen (use in fixed thickness design)	=	VAR
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
PAS:	Maximum AS/BD Desired	=	0.012

JOB DESCRIPTION

Title : CENTENNIAL - 10' X 5' RCB
Structure ID :
Agency name : STD

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	DESIGN	NO	FULL	0.00

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

Design Method	Limit State Ductility	Load and Resistance Redundant	Factors Operations
LOAD & RES.	1.0000	1.0500	1.00

DESIGN CONTROLS

Design Same Thickness Slabs	Design Same Thickness Walls	Round-up Thicknesses (In)	Increment Walls (In)	Bar Spacing File
NO	NO	1.00	1.00	Standard

Bar Spacing Max (In)	Min (In)	US-Bar Size Max	Min	Bar Spacing Increment
12.0	6.0	8	4	1 INCH

OUTPUT CONTROLS

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

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Gamma E (Kip/in)	Steel Fy (Psi)	Steel n
4000.	3644147.	0.75	60000.	7.96

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width coefficient is the coefficient in Eq. 5.7.3.4-2 for the crack width parameter Z

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	125.	145.

Note:

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

BOX GEOMETRY

Culvert Cells	Span Length (Ft)	Clear Height (Ft)	Centerline Length (Ft)
SINGLE	10.00	5.00	150.00

Bridge Width (Ft)	Number of Traffic Lanes
150.00	1 and 2 lanes investigated

Slab and Wall Information

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)
14.00 Fixed	15.00 Fixed	12.00 Fixed	0.00 n/a

LIVE LOADS

Vehicle Designation
HL-93-TRUCK
HL-93-TANDEM
Live Load Control: YES
(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. (Kips)	Dis. (Ft)	Wgt. (Kips)	Dis. (Ft)	Wgt. (Kips)	Dis. (Ft)
0.0	0.0	0.0	0.0	0.0	0.0

Soil Pressure		Water Density
Max (Pcf)	Min (Pcf)	(Pcf)
****	35.0	0.0

Uniform Load (plf)	Wearing Surface	Fill
	Thickness (in)	Height (Ft)
0.0	6.00	30.00

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)
0.0	0.0

CONCRETE COVER to face of bar

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)
2.00	3.00	2.00

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 30.00	ft.
Span Length	= 10.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.15	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 42.77 ft.

Final Distribution Factor = 1/Final Strip Width = **0.023** Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = **0.028**

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(30.00))$

$IM = 0.0000$ Notes: Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.

1. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
2. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Number of cells	=	1
Top Slab thickness	=	14.0000 In.
Bottom Slab thickness	=	15.0000 In.
Exterior Wall thickness	=	12.0000 In.
Design Span(c-c walls)	=	11.0000 Ft.
Design Height(c-c slabs)	=	6.2083 Ft.
Fill Height(top of slab)	=	30.0000 Ft.
Wearing surface thickness	=	6.0000 In.
Loads based on 1 foot unit width		
Soil Structure Interaction Factor	=	1.1500
Earth Weight for fill computations	=	0.1437 Kcf
Weight of Fill without wearing surface	=	4.2406 Klf
Weight of Wearing Surface	=	0.0725 Klf
Weight of Top Slab	=	0.1750 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	4.4881 Klf
Weight of Walls divided by culvert width	=	0.1364 Klf
Uniform Dead Load on Bottom Slab	=	4.6245 Klf
Soil pressure at center of top slab	=	3.0583 Klf
Soil pressure at center of bottom slab	=	3.6792 Klf
Soil pressure due to live load surcharge	=	0.0700 Klf
Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000
Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0281
on Bottom Slab	=	0.0281

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 AASHTO LRFD 4.6.2.10 for fill depth less than 2 ft. and AASHTO LRFD 3.6.1.2.6 for fill depths over 2 ft. Also, see 3.6.1.3.3.

No live load used
Fill greater than 8 feet and span length
Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

PAGE 13
DATE 10/24/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Current Live Load: HL-93-TRUCK

Unfactored MOMENTS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-21.78	-5.86	-2.05	-0.12	0.00	0.00	0.00
1- 1	-22.02	0.22	0.08	0.00	0.00	0.00	0.00
1- 2	-22.27	4.90	1.72	0.10	0.00	0.00	0.00
1- 3	-22.51	8.22	2.88	0.17	0.00	0.00	0.00
1- 4	-22.76	10.18	3.56	0.21	0.00	0.00	0.00
1- 5	-23.00	10.83	3.79	0.23	0.00	0.00	0.00
1- 6	-23.25	10.17	3.56	0.21	0.00	0.00	0.00
1- 7	-23.49	8.24	2.89	0.17	0.00	0.00	0.00
1- 8	-23.74	5.06	1.77	0.11	0.00	0.00	0.00
1- 9	-23.98	0.66	0.23	0.02	0.00	0.00	0.00
1-10	-24.23	-4.95	-1.73	-0.10	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-24.23	-4.95	-1.73	-0.10	0.00	0.00	0.00
2- 1	0.21	-4.95	-1.73	-0.10	0.00	0.00	0.00
2- 2	19.21	-4.95	-1.73	-0.10	0.00	0.00	0.00
2- 3	32.78	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 4	40.92	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 5	43.63	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 6	40.91	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 7	32.76	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 8	19.18	-4.93	-1.73	-0.10	0.00	0.00	0.00
2- 9	0.16	-4.93	-1.73	-0.10	0.00	0.00	0.00
2-10	-24.28	-4.93	-1.73	-0.10	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	-21.78	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 1	3.41	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 2	23.00	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 3	36.99	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 4	45.39	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 5	48.19	-5.87	-2.05	-0.12	0.00	0.00	0.00
4- 6	45.40	-5.87	-2.05	-0.12	0.00	0.00	0.00
4- 7	37.01	-5.87	-2.05	-0.12	0.00	0.00	0.00
4- 8	23.03	-5.87	-2.06	-0.12	0.00	0.00	0.00
4- 9	3.45	-5.88	-2.06	-0.12	0.00	0.00	0.00
4-10	-21.73	-5.88	-2.06	-0.12	0.00	0.00	0.00
BOTTOM SLAB RIGHT SIDE							

PAGE 14
DATE 10/24/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Current Live Load: HL-93-TRUCK

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-0.39	10.92	3.82	0.22	0.00	0.00	0.00
1- 1	-0.39	8.66	3.03	0.18	0.00	0.00	0.00
1- 2	-0.39	6.43	2.25	0.13	0.00	0.00	0.00
1- 3	-0.39	4.25	1.49	0.09	0.00	0.00	0.00
1- 4	-0.39	2.10	0.73	0.05	0.00	0.00	0.00
1- 5	-0.39	-0.01	-0.01	0.00	0.00	0.00	0.00
1- 6	-0.39	-2.09	-0.73	-0.04	0.00	0.00	0.00
1- 7	-0.39	-4.12	-1.44	-0.08	0.00	0.00	0.00
1- 8	-0.39	-6.12	-2.14	-0.13	0.00	0.00	0.00
1- 9	-0.39	-8.07	-2.83	-0.17	0.00	0.00	0.00
1-10	-0.39	-9.99	-3.50	-0.21	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	24.68	0.00	0.00	-0.00	0.00	0.00	0.00
2- 1	19.74	0.00	0.00	-0.00	0.00	0.00	0.00
2- 2	14.81	0.00	0.00	-0.00	0.00	0.00	0.00
2- 3	9.87	0.00	0.00	-0.00	0.00	0.00	0.00
2- 4	4.93	0.00	0.00	-0.00	0.00	0.00	0.00
2- 5	-0.00	0.00	0.00	-0.00	0.00	0.00	0.00
2- 6	-4.94	0.00	0.00	-0.00	0.00	0.00	0.00
2- 7	-9.88	0.00	0.00	-0.00	0.00	0.00	0.00
2- 8	-14.82	0.00	0.00	-0.00	0.00	0.00	0.00
2- 9	-19.75	0.00	0.00	-0.00	0.00	0.00	0.00
2-10	-24.69	0.00	0.00	-0.00	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	25.44	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 1	20.35	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 2	15.27	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 3	10.18	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 4	5.09	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 5	0.00	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 6	-5.08	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 7	-10.17	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 8	-15.26	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 9	-20.34	-0.00	-0.00	0.00	0.00	0.00	0.00
4-10	-25.43	-0.00	-0.00	0.00	0.00	0.00	0.00
BOTTOM SLAB RIGHT SIDE							

PAGE 15
DATE 10/24/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Current Live Load: HL-93-TRUCK

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 1	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 2	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 3	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 4	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 5	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 6	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 7	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 8	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 9	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1-10	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 1	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 2	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 3	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 4	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 5	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 6	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 7	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 8	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 9	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2-10	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 1	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 2	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 3	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 4	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 5	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 6	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 7	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 8	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 9	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4-10	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
BOTTOM SLAB RIGHT SIDE							

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

PAGE 16
DATE 10/24/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

No Fatigue Checks Required for this Live Load

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Truck (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	0.75000000	12.00000000	2.43750000	1.36414564	6.78432369	6.00000000	35.36943436	33.00845337
Top slab, inside face	0.75000000	14.00000000	2.50000000	1.31055903	8.39441967	6.00000000	36.39145279	29.90740967
Bottom slab, outside corner	0.75000000	12.00000000	2.43750000	1.36414564	7.42597294	6.00000000	35.36943436	31.28665352
Bottom slab, inside face	0.75000000	15.00000000	2.50000000	1.28571427	8.50884724	6.00000000	37.08995438	30.22710228
Ext. wall, inside face	0.8*f _t > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 11.000 feet
Percentage of main reinforcement required = 30.151% , less than or equal to 50%
Main reinforcement area (top slab) = 1.580 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 1.580 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE	Top slab CENTER	RIGHT SIDE
area 1.2000 in ²	area 1.5800 in ²	area 1.2000 in ²
size 7 spaced at 6.00 in.	size 8 spaced at 6.00 in.	size 7 spaced at 6.00 in.

Exterior wall

TOP
area 1.2000 in²
size 7 spaced at 6.00 in.

OUTSIDE FACE

area 1.2000 in²
size 7 spaced at 6.00 in.

INSIDE FACE

area 0.2667 in²
size 4 spaced at 9.00 in.

BOTTOM

area 1.2000 in²
size 7 spaced at 6.00 in.

LEFT SIDE	Bottom slab CENTER	RIGHT SIDE
area 1.2000 in ²	area 1.5800 in ²	area 1.2000 in ²
size 7 spaced at 6.00 in.	size 8 spaced at 6.00 in.	size 7 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	8	STR	0- 0	0		
BOT SLAB (Inside)	A200	300	8	STR	0- 0	0		
CORNER (Top)	A1	600	7	L-BAR	9- 6	11649	4- 9	4- 9
CORNER (Bottom)	A2	600	7	L-BAR	8- 2	10014	3- 5	4- 9
EXTWALL (Inside)	B1	400	4	STR	5- 6	1470		
LONGITUD.(3)	C1	138	4	STR	51- 1	4712		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		

Total weight black bars	27845
Total weight all bars	27845

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in²

Bottom slab(s) = 0.1100 in²

Exterior wall(s) = 0.1100 in²

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-26.023	-38.243	-22.861	-33.159	15.518	9.785
1- 1	-20.403	-29.845	-22.861	-33.159	12.228	7.644
1- 2	-13.818	-25.754	-22.861	-33.159	8.992	5.540
1- 3	-9.226	-22.958	-22.861	-33.159	5.811	3.473
1- 4	-6.592	-21.434	-22.861	-33.159	2.685	1.442
1- 5	-5.881	-21.160	-22.861	-33.159	-0.380	-0.560
1- 6	-7.061	-22.113	-22.861	-33.159	-2.344	-3.571
1- 7	-10.097	-24.270	-22.861	-33.159	-4.265	-6.534
1- 8	-14.955	-27.609	-22.861	-33.159	-6.151	-9.442
1- 9	-21.601	-32.108	-22.861	-33.159	-8.000	-12.295
1-10	-27.473	-40.271	-22.861	-33.159	-9.812	-15.094
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-27.473	-40.271	-9.647	-14.840	33.685	23.223
2- 1	-4.396	-7.011	-9.812	-14.675	26.947	18.578
2- 2	21.539	0.000	-9.812	-14.675	20.209	13.933
2- 3	40.063	0.000	-9.812	-14.675	13.472	9.287
2- 4	51.175	0.000	-9.812	-14.675	6.734	4.642
2- 5	54.876	0.000	-9.812	-14.675	-0.002	-0.005
2- 6	51.165	0.000	-9.812	-14.675	-4.647	-6.742
2- 7	40.042	0.000	-9.812	-14.675	-9.292	-13.480
2- 8	21.508	0.000	-9.812	-14.675	-13.937	-20.218
2- 9	-4.437	-7.027	-9.812	-14.675	-18.582	-26.956
2-10	-27.503	-40.314	-9.647	-14.840	-23.227	-33.693
TOP SLAB RIGHT SIDE						
BOTTOM SLAB LEFT SIDE						
4- 0	-26.023	-38.243	-9.924	-15.308	34.717	23.933
4- 1	-0.884	-5.319	-9.758	-15.475	27.774	19.146
4- 2	25.850	0.000	-9.758	-15.475	20.832	14.360
4- 3	44.946	0.000	-9.758	-15.475	13.889	9.574
4- 4	56.406	0.000	-9.758	-15.475	6.947	4.788
4- 5	60.229	0.000	-9.758	-15.475	0.004	0.001
4- 6	56.415	0.000	-9.758	-15.475	-4.784	-6.939
4- 7	44.965	0.000	-9.758	-15.475	-9.570	-13.881
4- 8	25.878	0.000	-9.758	-15.475	-14.356	-20.824
4- 9	-0.846	-5.306	-9.758	-15.475	-19.142	-27.766
4-10	-25.997	-38.205	-9.924	-15.308	-23.929	-34.709
BOTTOM SLAB RIGHT SIDE						

Output complete for a HL-93-TRUCK vehicle

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill = 30.00 ft.
Span Length = 10.00 ft.
Truck Gage = 6.00 ft.
Soil Distribution Factor = 1.15

Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 42.77 ft.

Final Distribution Factor = $1/\text{Final Strip Width} = 0.023$ Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.028

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(30.00))$

$IM = 0.0000$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

No live load used

Fill greater than 8 feet and span length

Factors for Ductility	1.00
Redundancy	1.05
Operations	1.00

Design Iteration Loop Number	1
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PAGE 21
DATE 10/24/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Current Live Load: HL-93-TANDEM

Unfactored MOMENTS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-21.78	-5.86	-2.05	-0.12	0.00	0.00	0.00
1- 1	-22.02	0.22	0.08	0.00	0.00	0.00	0.00
1- 2	-22.27	4.90	1.72	0.10	0.00	0.00	0.00
1- 3	-22.51	8.22	2.88	0.17	0.00	0.00	0.00
1- 4	-22.76	10.18	3.56	0.21	0.00	0.00	0.00
1- 5	-23.00	10.83	3.79	0.23	0.00	0.00	0.00
1- 6	-23.25	10.17	3.56	0.21	0.00	0.00	0.00
1- 7	-23.49	8.24	2.89	0.17	0.00	0.00	0.00
1- 8	-23.74	5.06	1.77	0.11	0.00	0.00	0.00
1- 9	-23.98	0.66	0.23	0.02	0.00	0.00	0.00
1-10	-24.23	-4.95	-1.73	-0.10	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-24.23	-4.95	-1.73	-0.10	0.00	0.00	0.00
2- 1	0.21	-4.95	-1.73	-0.10	0.00	0.00	0.00
2- 2	19.21	-4.95	-1.73	-0.10	0.00	0.00	0.00
2- 3	32.78	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 4	40.92	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 5	43.63	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 6	40.91	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 7	32.76	-4.94	-1.73	-0.10	0.00	0.00	0.00
2- 8	19.18	-4.93	-1.73	-0.10	0.00	0.00	0.00
2- 9	0.16	-4.93	-1.73	-0.10	0.00	0.00	0.00
2-10	-24.28	-4.93	-1.73	-0.10	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	-21.78	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 1	3.41	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 2	23.00	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 3	36.99	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 4	45.39	-5.86	-2.05	-0.12	0.00	0.00	0.00
4- 5	48.19	-5.87	-2.05	-0.12	0.00	0.00	0.00
4- 6	45.40	-5.87	-2.05	-0.12	0.00	0.00	0.00
4- 7	37.01	-5.87	-2.05	-0.12	0.00	0.00	0.00
4- 8	23.03	-5.87	-2.06	-0.12	0.00	0.00	0.00
4- 9	3.45	-5.88	-2.06	-0.12	0.00	0.00	0.00
4-10	-21.73	-5.88	-2.06	-0.12	0.00	0.00	0.00
BOTTOM SLAB RIGHT SIDE							

PAGE 22
DATE 10/24/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Current Live Load: HL-93-TANDEM

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-0.39	10.92	3.82	0.22	0.00	0.00	0.00
1- 1	-0.39	8.66	3.03	0.18	0.00	0.00	0.00
1- 2	-0.39	6.43	2.25	0.13	0.00	0.00	0.00
1- 3	-0.39	4.25	1.49	0.09	0.00	0.00	0.00
1- 4	-0.39	2.10	0.73	0.05	0.00	0.00	0.00
1- 5	-0.39	-0.01	-0.01	0.00	0.00	0.00	0.00
1- 6	-0.39	-2.09	-0.73	-0.04	0.00	0.00	0.00
1- 7	-0.39	-4.12	-1.44	-0.08	0.00	0.00	0.00
1- 8	-0.39	-6.12	-2.14	-0.13	0.00	0.00	0.00
1- 9	-0.39	-8.07	-2.83	-0.17	0.00	0.00	0.00
1-10	-0.39	-9.99	-3.50	-0.21	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	24.68	0.00	0.00	-0.00	0.00	0.00	0.00
2- 1	19.74	0.00	0.00	-0.00	0.00	0.00	0.00
2- 2	14.81	0.00	0.00	-0.00	0.00	0.00	0.00
2- 3	9.87	0.00	0.00	-0.00	0.00	0.00	0.00
2- 4	4.93	0.00	0.00	-0.00	0.00	0.00	0.00
2- 5	-0.00	0.00	0.00	-0.00	0.00	0.00	0.00
2- 6	-4.94	0.00	0.00	-0.00	0.00	0.00	0.00
2- 7	-9.88	0.00	0.00	-0.00	0.00	0.00	0.00
2- 8	-14.82	0.00	0.00	-0.00	0.00	0.00	0.00
2- 9	-19.75	0.00	0.00	-0.00	0.00	0.00	0.00
2-10	-24.69	0.00	0.00	-0.00	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	25.44	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 1	20.35	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 2	15.27	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 3	10.18	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 4	5.09	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 5	0.00	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 6	-5.08	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 7	-10.17	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 8	-15.26	-0.00	-0.00	0.00	0.00	0.00	0.00
4- 9	-20.34	-0.00	-0.00	0.00	0.00	0.00	0.00
4-10	-25.43	-0.00	-0.00	0.00	0.00	0.00	0.00
BOTTOM SLAB RIGHT SIDE							

PAGE 23
DATE 10/24/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Current Live Load: HL-93-TANDEM

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 1	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 2	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 3	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 4	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 5	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 6	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 7	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 8	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1- 9	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
1-10	-24.30	-0.00	-0.00	0.00	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 1	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 2	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 3	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 4	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 5	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 6	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 7	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 8	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2- 9	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
2-10	-0.39	-9.82	-3.44	-0.21	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
BOTTOM SLAB LEFT SIDE							
4- 0	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 1	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 2	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 3	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 4	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 5	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 6	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 7	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 8	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4- 9	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
4-10	0.39	-10.89	-3.81	-0.22	0.00	0.00	0.00
BOTTOM SLAB RIGHT SIDE							

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

PAGE 24
DATE 10/24/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

No Fatigue Checks Required for this Live Load

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Tandem (US)

Location	γ_e	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	0.75000000	12.00000000	2.43750000	1.36414564	6.78432369	6.00000000	35.36943436	33.00845337
Top slab, inside face	0.75000000	14.00000000	2.50000000	1.31055903	8.39441967	6.00000000	36.39145279	29.90740967
Bottom slab, outside corner	0.75000000	12.00000000	2.43750000	1.36414564	7.42597294	6.00000000	35.36943436	31.28665352
Bottom slab, inside face	0.75000000	15.00000000	2.50000000	1.28571427	8.50884724	6.00000000	37.08995438	30.22710228
Ext. wall, inside face	$0.8 * f_r > f_c$, therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 11.000 feet
Percentage of main reinforcement required = 30.151% , less than or equal to 50%
Main reinforcement area (top slab) = 1.580 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 1.580 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE	Top slab CENTER	RIGHT SIDE
area 1.2000 in ²	area 1.5800 in ²	area 1.2000 in ²
size 7 spaced at 6.00 in.	size 8 spaced at 6.00 in.	size 7 spaced at 6.00 in.

Exterior wall

TOP
area 1.2000 in²
size 7 spaced at 6.00 in.

OUTSIDE FACE

area 1.2000 in²
size 7 spaced at 6.00 in.

INSIDE FACE

area 0.2667 in²
size 4 spaced at 9.00 in.

BOTTOM

area 1.2000 in²
size 7 spaced at 6.00 in.

LEFT SIDE	Bottom slab CENTER	RIGHT SIDE
area 1.2000 in ²	area 1.5800 in ²	area 1.2000 in ²
size 7 spaced at 6.00 in.	size 8 spaced at 6.00 in.	size 7 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	8	STR	0- 0	0		
BOT SLAB (Inside)	A200	300	8	STR	0- 0	0		
CORNER (Top)	A1	600	7	L-BAR	9- 6	11649	4- 9	4- 9

CORNER (Bottom)	A2	600	7	L-BAR	8- 2	10014	3- 5	4- 9
EXTWALL (Inside)	B1	400	4	STR	5- 6	1470		
LONGITUD. (3)	C1	138	4	STR	51- 1	4712		
LONGITUD. (3)	C100	0	4	STR	51- 1	0		
LONGITUD. (3)	C200	0	4	STR	51- 1	0		

Total weight black bars	27845
Total weight all bars	27845

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2
 Bottom slab(s) = 0.1100 in2
 Exterior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

PAGE 27
DATE 10/24/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - 10' X 5' RCB

Factored Actions for Load and Resistance 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	-26.023	-38.243	-22.861	-33.159	15.518	9.785
1- 1	-20.403	-29.845	-22.861	-33.159	12.228	7.644
1- 2	-13.818	-25.754	-22.861	-33.159	8.992	5.540
1- 3	-9.226	-22.958	-22.861	-33.159	5.811	3.473
1- 4	-6.592	-21.434	-22.861	-33.159	2.685	1.442
1- 5	-5.881	-21.160	-22.861	-33.159	-0.380	-0.560
1- 6	-7.061	-22.113	-22.861	-33.159	-2.344	-3.571
1- 7	-10.097	-24.270	-22.861	-33.159	-4.265	-6.534
1- 8	-14.955	-27.609	-22.861	-33.159	-6.151	-9.442
1- 9	-21.601	-32.108	-22.861	-33.159	-8.000	-12.295
1-10	-27.473	-40.271	-22.861	-33.159	-9.812	-15.094
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-27.473	-40.271	-9.647	-14.840	33.685	23.223
2- 1	-4.396	-7.011	-9.812	-14.675	26.947	18.578
2- 2	21.539	0.000	-9.812	-14.675	20.209	13.933
2- 3	40.063	0.000	-9.812	-14.675	13.472	9.287
2- 4	51.175	0.000	-9.812	-14.675	6.734	4.642
2- 5	54.876	0.000	-9.812	-14.675	-0.002	-0.005
2- 6	51.165	0.000	-9.812	-14.675	-4.647	-6.742
2- 7	40.042	0.000	-9.812	-14.675	-9.292	-13.480
2- 8	21.508	0.000	-9.812	-14.675	-13.937	-20.218
2- 9	-4.437	-7.027	-9.812	-14.675	-18.582	-26.956
2-10	-27.503	-40.314	-9.647	-14.840	-23.227	-33.693
TOP SLAB RIGHT SIDE						
BOTTOM SLAB LEFT SIDE						
4- 0	-26.023	-38.243	-9.924	-15.308	34.717	23.933
4- 1	-0.884	-5.319	-9.758	-15.475	27.774	19.146
4- 2	25.850	0.000	-9.758	-15.475	20.832	14.360
4- 3	44.946	0.000	-9.758	-15.475	13.889	9.574
4- 4	56.406	0.000	-9.758	-15.475	6.947	4.788
4- 5	60.229	0.000	-9.758	-15.475	0.004	0.001
4- 6	56.415	0.000	-9.758	-15.475	-4.784	-6.939
4- 7	44.965	0.000	-9.758	-15.475	-9.570	-13.881
4- 8	25.878	0.000	-9.758	-15.475	-14.356	-20.824
4- 9	-0.846	-5.306	-9.758	-15.475	-19.142	-27.766
4-10	-25.997	-38.205	-9.924	-15.308	-23.929	-34.709
BOTTOM SLAB RIGHT SIDE						

Output complete for a HL-93-TANDEM vehicle

Serviceability, Fatigue, and Other Checks

→ Based on crack control check
AASHTO 5.7.3.4 LRFD

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		Size US Bars	Spacing (In)	H (In)	V (In)
			Required (In2)	Provided (In2)				
A1	33.01	35.37	1.1199	1.2000	7	6.0	57	57
A2	31.29	35.37	1.0615	1.2000	7	6.0	41	57
A100	29.91	36.39	1.1524	1.5800	8	6.0		
A200	30.23	37.09	1.1642	1.5800	8	6.0		
B1	0.00	29.16	0.2014	0.2667	4	9.0		

} Use #7 @ 6" ($A_s = 1.28 \text{ in}^2/\text{ft}$)

No B2 bars selected for culverts less than 6 feet high. A1 bars extended.

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 it if should, this will control yielding under service loads.
5. For culverts less than 6 feet high and with moment continuity, no rebar is selected for the exterior face of the exterior wall. The rebar from the upper exterior corner (A1) is called out to cover the entire exterior face of the exterior wall (B2).

Output at Critical Sections (per unit design width)

Member No. = 1 EXTERIOR WALL

Thickness	=	12.00 (in)
Clear cover at end	=	3.00 (in)
Clear cover at middle	=	2.00 (in)
Bar diameter (bot)	=	0.88 (in)
Bar diameter (mid+)	=	1.00 (in)
Bar diameter (mid-)	=	0.88 (in)
Bar diameter (top)	=	0.88 (in)

Design Ratio	Moment	Coin.	Shear	Shear	Resistance				Steel	Mom.	Des.	
		Axial			Po	Mu	Mbal	Pbal				
		Force			Cap	Cap	Cap	Cap				Area
	Kft	Kips	Kips	Kips	Kips	Kft	Kft	Kips	In2	Kft	in	
BOT	-38.2	22.9	7.9	13.5	334.5	47.0	64.1	99.4	1.2000	47.0	9.56	0.8
MID	-6.6	22.9	0.4	45.1	302.8	12.2	51.3	147.3	0.2667	12.2	9.75	0.5
MID-	-21.4	22.9	0.6	19.8	334.5	47.0	64.1	99.4	1.2000	47.0	9.56	0.5
TOP	-40.3	22.9	8.6	13.1	334.5	47.0	64.1	99.4	1.2000	47.0	9.56	0.9

Member No. = 2 TOP SLAB

Thickness	=	14.00 (in)
Clear cover at end	=	3.00 (in)
Clear cover at middle	=	2.00 (in)
Bar diameter (lt)	=	0.88 (in)
Bar diameter (mid)	=	1.00 (in)
Bar diameter (rt)	=	0.88 (in)

LT	-40.3	9.6	24.5*	22.4	383.5	58.0	86.6	132.3	1.2000	58.0	11.56	0.7
MID	54.9	9.8	0.0	22.2	396.4	73.9	93.1	113.0	1.5800	73.9	11.50	0.7
RT	-40.3	9.8	24.5*	22.4	383.5	58.0	86.6	132.3	1.2000	58.0	11.56	0.7

Member No. = 4 BOTTOM SLAB

Thickness	=	15.00 (in)
Clear cover at end	=	3.00 (in)
Clear cover at middle	=	2.00 (in)
Bar diameter (lt)	=	0.88 (in)
Bar diameter (mid)	=	1.00 (in)
Bar diameter (rt)	=	0.88 (in)

LT	-38.2	9.9	25.2*	22.4	408.0	58.0	92.1	132.3	1.2000	58.0	11.56	0.7
MID	60.2	9.8	0.0	24.2	420.9	81.0	106.1	129.4	1.5800	81.0	12.50	0.7
RT	-38.2	9.8	25.2*	22.4	408.0	58.0	92.1	132.3	1.2000	58.0	11.56	0.7

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.

Volume of Concrete and Weight of Reinforcing Steel

Top Slab (In)	Thickness		Interior Wall (In)	Volume (Cy/Ft)	Steel (Lb/Ft)
	Bottom Slab (In)	Exterior Wall (In)			
14.00	15.00	12.00	0.00 n/a	1.444	383

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	8	STR	11- 8	9345		
BOT SLAB (Inside)	A200	300	8	STR	11- 8	9345		
CORNER (Top)	A1	600	7	L-BAR	9- 6	11649	4- 9	4- 9
CORNER (Bottom)	A2	600	7	L-BAR	8- 2	10014	3- 5	4- 9
EXTWALL (Inside)	B1	400	4	STR	5- 6	1470		
LONGITUD. (3)	C1	138	4	STR	51- 1	4712		
LONGITUD. (3)	C100	33	4	STR	51- 1	1127		
LONGITUD. (3)	C200	33	4	STR	51- 1	1127		

Total weight black bars	48789
Total weight all bars	48789

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2
Bottom slab(s) = 0.1100 in2
Exterior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Job No.	412-654	By	DAT	Subject	10'x5' RCB	Sheet
Date		Checked				Of

Distribution Reinforcing (AASHTO LRFD 9.7.3.2)

Use distribution steel in top slab to account for construction loading when fill is less than 2-ft.

For primary reinforcement perpendicular to traffic:

Effective Span, $S =$ ft

% Distribution Reinforcing = $220 / S^{0.5} < 67\%$
 =

Primary Reinforcing = #7 @ 6"
 Area of Steel = 1.2 in²/ft

Min Distribution Reinforcing = 0.80 in²/ft

BRASS-CULVERT (2) 15' x 7' RCB w/ 10' Max Soil Cover

BRASS-CULVERT(LRFD) Version 2.3.6

DATE : 10/27/2014

TIME : 8: 9:35

PAGE 1

Input Filename : F:\Projects\400\412-654\Division\Str1\Calcs\Centennial Double
15x7 - 10feet.DAT
Output Filename : F:\Projects\400\412-654\Division\Str1\Calcs\Centennial Double
15x7 - 10feet.xml
Output Filename for Live Loads : F:\Projects\400\412-654\Division\Str1\Calcs\Centennial Double
15x7 - 10feet_LL.OUT

The following filenames may be used in this run

Live Load Influence Values File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 10feet_INF.OUT
Drawing File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 10feet.drw
Live Load Influence Ordinates File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 10feet.ill
Live Load Actions (w/o DF or IM) File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 10feet.oll
Intermediate Computations File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 10feet.ooo
Data Modelling File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 10feet.tmp

COMMENTS THIS FILE WAS CREATED BY THE BRASS-CULVERT GUI.
COMMENTS DO NOT EDIT THIS FILE!
COMMENTS JOB DESCRIPTION:
TITLE CENTENNIAL - DOUBLE 15' X 7' RCB
STRUCTID
AGENCY
COMMENTS 10' MAX FILL ABOVE
UNITSIN US
UNITSOUT US
COMMENTS ANALYSIS CONTROL:
TYPE CIP
FUNCT DESIGN
LRFR NO
IRELEASE NO
IDSN LRFD
KBASE FULL
KHACH NO
EPOXY NO
EDGE-STRIP NO
LRFD-SHEAR 0
IFATIG YES
DNEG 0.0000
COMMENTS DESIGN CONTROL:
ISAMS NO
ISAMW NO
ADDS 1.0000
ADDW 1.0000
MAXSIZ 9
MINSIZ 4
SPCMAX 12.0000
SPCMIN 6.0000
ISPCGINC MAX
PAS 0.012000
CUSTOM STD
BAR_DE US
COMMENTS OUTPUT CONTROL:
MTEN YES
IBSH YES
IINFN NO
LIVELO NO

DEFAULTS	YES
LOOPS	NO
INTERMEDIATE	NO
COMMENTS	MATERIAL PROPERTIES:
FCONC	4000.000
CE	3644147.000
CWGT	150.000
ZEE	155.000
EXP_FACTOR	0.750
GAMMA_MIN_RE_1	1.600
GAMMA_MIN_RE_3	0.750
EWGT	125.000
AWGT	145.000
FYST	60000.000
CN	7.9580
COMMENTS	BOX GEOMETRY:
NBOX	2
NSPAN	15.0000
NHITE	7.0000
LENG	150.0000
BWIDTH	150.0000
CBWIDTH	0.0000
TSLAB	14.0000
KFXTS	F
BSLAB	15.0000
KFXBS	F
WALLR	10.0000
KFXW	F
IWALLR	8.0000
KFXI	F
COMMENTS	SKEW:
CSKEW	0.0000
LSKEW	90.0000
RSKEW	90.0000
COMMENTS	CONCRETE COVER:
COVS	2.0000
COVB	3.0000
COVW	2.0000
COVIN	2.0000
COMMENTS	DEAD LOADS:
PRESS	100.000

PMIN	35.000
PWAT	0.000
NFILL	10.0000
NWEAR	6.0000
FILLFA	1.1000
TYFILL	COMPACT
COMMENTS	LIVE LOADS:
LVLD	HL-93-TRUCK
LVLD	HL-93-TANDEM
LVOMT	YES
LLPATCH	PL
SURCH_USE	YES
LIMIT_DIST	NO
LRFDDF	YES

End of Input File No. 1

Note:

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

The first set are the variables defaulted from input and the second set are system variables.

Units

USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US

Design Variables

LRFDFF:	Use LRFD method for bot slab load distrib.	=	T
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDSN:	Design Method	=	LRFD
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESIGN
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	0.00
CUSTOM:	Default bar spacing and design check control	=	STD
ISAMS:	Design Same Top and Bottom Slab	=	F
ISAMW:	Design Same Interior-Exterior Wall	=	F

Output Control Variables

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

Standard Load Variables

LVLD:	Live Load Vehicle Name	=	HL-93-TRUCK
LVLD:	Live Load Vehicle Name	=	HL-93-TANDEM
LVOMT:	Neglect LL for Fill > 8Ft & Fill > Span	=	T

Uniform Dead Load Variable

EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (in)	=	6.0

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	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	100.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	35.0
PWAT:	Internal Water Pressure	=	0.0

Geometry - Box Dimension Variables

NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	15.0
NHITE:	Clear Height (Ft)	=	7.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	10.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	150.0

Geometry - Slab Thickness Variables

TSLAB:	Minimum Value for Top Slab (In)	=	14.0
KFXTS:	Code for Top Slab(F=Fixed,V=Variable)	=	F
BSLAB:	Minimum Value for Bottom Slab(In)	=	15.0
KFXBS:	Code for Bottom Slab(F=Fixed,V=Variable)	=	F
WALLR:	Minimum Value for Exterior Wall (In)	=	10.0
KFXW:	Code for Exterior Wall(F=Fixed,V=Variable)	=	F
IWALLR:	Minimum Value for Interior Wall(In)	=	8.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F
IWALLR:	Minimum Value for Interior Wall(In)	=	8.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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)	=	0.0
BFILT:	Bottom Haunch (In)	=	0.0
KHACH:	Haunches used in Analysis (YES/NO)	=	NO

Geometry - Clear Concrete Cover

COVS:	Exterior Concrete Cover Top Slab (In)	=	2.0
COVB:	Exterior Concrete Cover Bottom Slab (In)	=	3.0
COVW:	Exterior Concrete Cover Walls (In)	=	2.0
COVIN:	Interior Concrete Cover (In)	=	2.0

Reinforcing Bar variables and Thickness Increment

SPCMAX:	Default Max. Bar Spacings (In)	=	12.0
SPCMIN:	Default Min. Bar Spacings (In)	=	6.0
MAXSIZ:	Default Bar Sizes(US)	=	9
MINSIZ:	Default Bar Sizes(US)	=	4
ISPCGINC:	Reinforcing Bar Minimum Increment	=	T
EPOXY:	Top Reinforcing Mat Epoxy Coated	=	F
ADDS:	Added Slab Thickness Increment(In)	=	1.0
ADDW:	Added Wall Thickness Increment(In)	=	1.0

Material Properties Variables

EWGT:	Weight of Soil (Pcf)	=	125.0
FYST:	Yield Strength of Reinf. Steel (Psi)	=	60000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi)(ASD)	=	36000.0
FCONC:	Compressive Strength of Concrete (Psi)	=	4000.0
FSHR:	Shear in Concrete (Psi)(ASD)	=	0.0
FSTIR:	Allowable Stress in Stirrups (Psi)(ASD)	=	0.0
CWGT:	Weight of Concrete (Pcf)	=	150.0
AWGT:	Weight of Wearing Surface (Pcf)	=	145.0

ZEE:	Crack Width Parameter from AASHTO	=	155.0
CN:	Modular Ratio of Concrete	=	8.0
CE:	Modulus of Elasticity of Concrete(ksi)	=	3644.1

ZEE:	Crack Width Parameter from AASHTO	=	0.9
CN:	Modular Ratio of Concrete	=	0.9
CE:	Modulus of Elasticity of Concrete(ksi)	=	

Service-I load and resistance factors

EV:	Vertical Earth Pressure max-min	1.00	1.00
DC:	Components max-min	1.00	1.00
DW:	Wearing Surfaces max-min	1.00	1.00
EH:	Horizontal Earth Pressure At-Rest	1.00	
LS:	Live load surcharge	1.00	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.00	

Strength-I load and resistance factors

EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.75	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.75	

Strength-II load and resistance factors

EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.35	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.35	

Fatigue load and resistance factors

EV:	Vertical Earth Pressure max-min	0.00	0.00
DC:	Components max-min	0.00	0.00
DW:	Wearing Surfaces max-min	0.00	0.00
EH:	Horizontal Earth Pressure At-Rest	0.00	
LS:	Live load surcharge	0.75	
WA:	Water load and stream pressure	0.00	
LL:	Vehicular live load	0.75	

BB:	Factor Load Factor Po and Pb AASHTO	=	0.80
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	0.0000
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500

BB:	Factor Load Factor Po and Pb AASHTO	=	1.30
BETAD:	Dead Load Multiplier for Load Factor	=	

HAFBAR:	Assumed Half a Bar Dia. of #6 Bar (In)	=	0.375
I300:	A300 and A400 Bars to TRUE	=	T
I400:	A300 and A400 Bars to TRUE	=	T
ICHANG:	Initial Settings	=	F
ICUT:	Cut Bars Due to Skew	=	T
ICUTSM:	Bar Cuts Symmetrical	=	F
IFIXB:	Defaults for Slab Thickness Incrementing	=	F
IFIXI:	Defaults for Wall Thickness Incrementing	=	F
IFIXT:	Defaults for Slab Thickness Incrementing	=	F
IFIXW:	Defaults for Wall Thickness Incrementing	=	F

PAGE 8
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

IFATIG:	Check Fatigue	=	F
IHAUCH:	Code for Considering Haunch in Analysis	=	F
ILES5:	Code for Span Less Than 5 ft	=	F
ISHR:	Code for Shear Stress Check	=	F

ILOOP:	Loop Counter for Design Iterations	=	0
INTERM_SWITCH:	Turn on Intermediate Results Output	=	F
ISTORE:	Design Moments to Zero	=	0
KPASS:	Variable Dimen (use in fixed thickness design)	=	VAR
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
PAS:	Maximum AS/BD Desired	=	0.012

JOB DESCRIPTION

Title : CENTENNIAL - DOUBLE 15' X 7' RCB
Structure ID :
Agency name : STD

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	DESIGN	NO	FULL	0.00

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

Design Method	Limit State Ductility	Load and Resistance Redundant	Factors Operations
LOAD & RES.	1.0000	1.0500	1.00

DESIGN CONTROLS

Design Same Thickness Slabs	Design Same Thickness Walls	Round-up Thicknesses (In)	Increment Walls (In)	Bar Spacing File
NO	NO	1.00	1.00	Standard

Bar Spacing Max (In)	Min (In)	US-Bar Size Max	Min	Bar Spacing Increment
12.0	6.0	9	4	1 INCH

OUTPUT CONTROLS

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

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Gamma E (Kip/in)	Steel Fy (Psi)	Steel n
4000.	3644147.	0.75	60000.	7.96

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width coefficient is the coefficient in Eq. 5.7.3.4-2 for the crack width parameter Z

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	125.	145.

Note:

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

BOX GEOMETRY

Culvert Cells	Span Length (Ft)	Clear Height (Ft)	Centerline Length (Ft)
DOUBLE	15.00	7.00	150.00

Bridge Width (Ft)	Number of Traffic Lanes
150.00	1 and 2 lanes investigated

Slab and Wall Information

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)
14.00 Fixed	15.00 Fixed	10.00 Fixed	8.00 Fixed

LIVE LOADS

Vehicle Designation
HL-93-TRUCK
HL-93-TANDEM
Live Load Control: YES
(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 Pressure Max	Water Density Min
(Pcf)	(Pcf)
****	35.0
	0.0

Uniform Load (plf)	Wearing Surface Thickness (in)	Fill Height (Ft)
0.0	6.00	10.00

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)
0.0	0.0

CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
2.00	3.00	2.00	2.00

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 10.00	ft.
Span Length	= 15.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.10	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 19.57 ft.

Final Distribution Factor = 1/Final Strip Width = **0.051** Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = **0.061**

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(10.00))$

$IM = 0.0000$

Notes: Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.

1. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
2. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Number of cells	=	2
Top Slab thickness	=	14.0000 In.
Bottom Slab thickness	=	15.0000 In.
Exterior Wall thickness	=	10.0000 In.
Interior wall thickness	=	8.00 In.
Design Span(c-c walls)	=	15.7500 Ft.
Design Height(c-c slabs)	=	8.2083 Ft.
Fill Height(top of slab)	=	10.0000 Ft.
Wearing surface thickness	=	6.0000 In.
Loads based on 1 foot unit width		
Soil Structure Interaction Factor	=	1.0619
Earth Weight for fill computations	=	0.1327 Kcf
Weight of Fill without wearing surface	=	1.2610 Klf
Weight of Wearing Surface	=	0.0725 Klf
Weight of Top Slab	=	0.1750 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	1.5085 Klf
Weight of Walls divided by culvert width	=	0.0778 Klf
Uniform Dead Load on Bottom Slab	=	1.5862 Klf
Soil pressure at center of top slab	=	1.0583 Klf
Soil pressure at center of bottom slab	=	1.8792 Klf
Soil pressure due to live load surcharge	=	0.0720 Klf
Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000
Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0613
on Bottom Slab	=	0.0613

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 AASHTO LRFD 4.6.2.10 for fill depth less than 2 ft. and AASHTO LRFD 3.6.1.2.6 for fill depths over 2 ft. Also, see 3.6.1.3.3.

AASHTO Specifications state that no live load is to be used when the fill is greater than 8 feet and the fill is greater than the total span length

The fill is greater than 8 feet but less than the total span length of 31.50 feet

Axle Weights (kips)	Spacing (ft)
8.00	14.000
32.00	14.000
32.00	0.000

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

```
Vehicle Axle number = 1
Fill = 10.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 11.83 ft.
[slope(fill) + longitudinal tire patch]
```

```
Tire Contact Area =      200.0000      sq.in.
Tire patch Width  =      20.00000     in.
Tire Patch Length =      10.00000     in.
```

```
Vehicle Axle number = 2
Fill = 10.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 11.83 ft.
[slope(fill) + longitudinal tire patch]
```

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

```
Vehicle Axle number = 3
Fill = 10.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 11.83 ft.
[slope(fill) + longitudinal tire patch]
```


LRFD Live Load Distribution Factor Computation**Input Values**

Depth of Fill	=	10.00	ft.
Span Length	=	15.00	ft.
Truck Gage	=	6.00	ft.
Soil Distribution Factor	=	1.10	
Tire Patch Width	=	20.00	in.
Bridge Width	=	150.00	ft.
Length	=	150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 19.57 ft.

Final Distribution Factor = 1/Final Strip Width = **0.051** Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = **0.061**

Dynamic Load Allowance Calculation - Article 3.6.2.2

$$IM = 33(1.0 - 1.25 D_e)$$

$$IM = 33(1.0 - 1.25(10.00))$$

$$IM = 0.0000$$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

PAGE 15
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored MOMENTS (per unit design width) due to Dead and Live Loads including Distribution and Impact							
M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-6.76	-6.76	-2.37	-0.32	0.00	0.12	-0.67
1- 1	-6.96	-1.88	-0.66	-0.10	0.00	0.00	-0.61
1- 2	-7.15	1.79	0.63	0.07	0.00	0.00	-0.59
1- 3	-7.35	4.31	1.51	0.20	0.00	0.00	-0.62
1- 4	-7.55	5.73	2.01	0.27	0.00	0.00	-0.68
1- 5	-7.75	6.10	2.14	0.30	0.00	0.02	-0.76
1- 6	-7.94	5.49	1.92	0.28	0.00	0.11	-0.90
1- 7	-8.14	3.94	1.38	0.21	0.00	0.21	-1.05
1- 8	-8.34	1.51	0.53	0.09	0.00	0.31	-1.21
1- 9	-8.54	-1.75	-0.61	-0.08	0.00	0.42	-1.38
1-10	-8.73	-5.77	-2.02	-0.29	0.00	0.52	-1.54
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-8.73	-5.77	-2.02	-0.29	0.00	0.52	-1.54
2- 1	4.77	-4.91	-1.72	-0.25	0.00	0.68	-0.23
2- 2	14.54	-4.04	-1.42	-0.20	0.00	1.61	0.00
2- 3	20.56	-3.18	-1.11	-0.16	0.00	2.46	-0.20
2- 4	22.84	-2.32	-0.81	-0.12	0.00	2.95	-0.43
2- 5	21.38	-1.46	-0.51	-0.07	0.00	3.04	-0.67
2- 6	16.17	-0.59	-0.21	-0.03	0.00	2.74	-0.90
2- 7	7.23	0.27	0.09	0.01	0.00	2.04	-1.14
2- 8	-5.46	1.13	0.40	0.06	0.00	0.99	-1.40
2- 9	-21.89	1.99	0.70	0.10	0.00	0.22	-2.48
2-10	-42.06	2.86	1.00	0.14	0.00	0.00	-4.40
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	-0.01	0.03	0.01	0.00	0.00	0.28	-0.28
3- 1	-0.01	0.03	0.01	0.00	0.00	0.18	-0.18
3- 2	-0.01	0.02	0.01	0.00	0.00	0.08	-0.08
3- 3	-0.01	0.01	0.00	0.00	0.00	0.02	-0.02
3- 4	-0.00	0.01	0.00	0.00	0.00	0.12	-0.12
3- 5	-0.00	0.00	0.00	-0.00	0.00	0.22	-0.22
3- 6	0.00	-0.01	-0.00	-0.00	0.00	0.32	-0.32
3- 7	0.01	-0.01	-0.00	-0.00	0.00	0.42	-0.42
3- 8	0.01	-0.02	-0.01	-0.00	0.00	0.52	-0.52
3- 9	0.01	-0.03	-0.01	-0.00	0.00	0.62	-0.62
3-10	0.01	-0.03	-0.01	-0.00	0.00	0.72	-0.72
INTERIOR WALL TOP							

PAGE 16
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	-6.76	-6.76	-2.37	-0.32	0.00	0.12	-0.67
4- 1	7.04	-5.75	-2.01	-0.27	0.00	0.70	0.00
4- 2	16.91	-4.73	-1.66	-0.23	0.00	1.51	0.00
4- 3	22.84	-3.72	-1.30	-0.18	0.00	1.99	0.00
4- 4	24.84	-2.71	-0.95	-0.13	0.00	2.15	0.00
4- 5	22.90	-1.69	-0.59	-0.08	0.00	1.99	0.00
4- 6	17.03	-0.68	-0.24	-0.03	0.00	1.50	0.00
4- 7	7.22	0.34	0.12	0.02	0.00	0.69	0.00
4- 8	-6.52	1.35	0.47	0.06	0.00	0.00	-0.48
4- 9	-24.20	2.37	0.83	0.11	0.00	0.00	-1.91
4-10	-45.81	3.38	1.18	0.16	0.00	0.00	-3.68

BOTTOM SLAB RIGHT SIDE

PAGE 17
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-0.24	6.71	2.35	0.30	0.00	0.14	-0.20
1- 1	-0.24	5.20	1.82	0.24	0.00	0.14	-0.20
1- 2	-0.24	3.76	1.32	0.18	0.00	0.14	-0.20
1- 3	-0.24	2.39	0.84	0.12	0.00	0.14	-0.20
1- 4	-0.24	1.08	0.38	0.06	0.00	0.14	-0.20
1- 5	-0.24	-0.16	-0.06	0.00	0.00	0.14	-0.20
1- 6	-0.24	-1.33	-0.47	-0.06	0.00	0.14	-0.20
1- 7	-0.24	-2.44	-0.85	-0.11	0.00	0.14	-0.20
1- 8	-0.24	-3.47	-1.22	-0.17	0.00	0.14	-0.20
1- 9	-0.24	-4.44	-1.56	-0.23	0.00	0.14	-0.20
1-10	-0.24	-5.35	-1.87	-0.29	0.00	0.14	-0.20
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	9.76	0.55	0.19	0.03	0.00	1.31	-0.15
2- 1	7.39	0.55	0.19	0.03	0.00	0.98	-0.15
2- 2	5.01	0.55	0.19	0.03	0.00	0.77	-0.20
2- 3	2.64	0.55	0.19	0.03	0.00	0.57	-0.28
2- 4	0.26	0.55	0.19	0.03	0.00	0.40	-0.39
2- 5	-2.12	0.55	0.19	0.03	0.00	0.26	-0.54
2- 6	-4.49	0.55	0.19	0.03	0.00	0.15	-0.71
2- 7	-6.87	0.55	0.19	0.03	0.00	0.07	-0.92
2- 8	-9.24	0.55	0.19	0.03	0.00	0.03	-1.15
2- 9	-11.62	0.55	0.19	0.03	0.00	0.00	-1.36
2-10	-13.99	0.55	0.19	0.03	0.00	0.00	-1.46
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 1	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 2	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 3	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 4	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 5	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 6	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 7	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 8	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3- 9	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
3-10	0.00	-0.01	-0.00	-0.00	0.00	0.12	-0.12
INTERIOR WALL TOP							

PAGE 18
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	10.01	0.64	0.23	0.03	0.00	0.83	0.00
4- 1	7.51	0.64	0.23	0.03	0.00	0.63	0.00
4- 2	5.02	0.64	0.23	0.03	0.00	0.42	0.00
4- 3	2.52	0.64	0.23	0.03	0.00	0.22	0.00
4- 4	0.02	0.64	0.23	0.03	0.00	0.02	-0.01
4- 5	-2.48	0.64	0.23	0.03	0.00	0.00	-0.21
4- 6	-4.98	0.64	0.23	0.03	0.00	0.00	-0.41
4- 7	-7.48	0.64	0.23	0.03	0.00	0.00	-0.62
4- 8	-9.97	0.64	0.23	0.03	0.00	0.00	-0.82
4- 9	-12.47	0.64	0.23	0.03	0.00	0.00	-1.03
4-10	-14.97	0.64	0.23	0.03	0.00	0.00	-1.23

BOTTOM SLAB RIGHT SIDE

PAGE 19
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 1	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 2	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 3	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 4	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 5	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 6	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 7	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 8	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1- 9	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
1-10	-9.32	-0.52	-0.18	-0.03	0.00	0.14	-1.25
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 1	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 2	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 3	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 4	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 5	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 6	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 7	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 8	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2- 9	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
2-10	-0.23	-5.13	-1.79	-0.28	0.00	0.13	-0.19
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 1	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 2	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 3	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 4	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 5	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 6	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 7	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 8	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3- 9	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
3-10	-25.22	0.98	0.34	0.05	0.00	0.00	-2.36
INTERIOR WALL TOP							

PAGE 20
 DATE 10/27/2014
 BRASS-CULVERT(LRFD) Version 2.3.6
 CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 1	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 2	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 3	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 4	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 5	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 6	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 7	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 8	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4- 9	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13
4-10	0.24	-6.76	-2.37	-0.30	0.00	0.20	-0.13

BOTTOM SLAB RIGHT SIDE

Factors for Ductility 1.00
 Redundancy 1.05
 Operations 1.00

Fatigue Checks

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

where:

f_s = actual stress range in the reinforcement

f_t = maximum allowable stress range

Member	Location	$f_{\min}$ (kip)	f_t (kip)	f_s (kip)	Result
EXTERIOR WALL	Bottom	0.000	23.76	2.35	Pass
EXTERIOR WALL	Middle -	0.000	23.43	5.70	Pass
EXTERIOR WALL	Top	0.000	23.45	5.52	Pass
TOP SLAB	Left	0.000	23.46	5.36	Pass
TOP SLAB	Middle +	0.000	23.45	5.46	Pass
BOTTOM SLAB	Left	0.000	23.80	1.99	Pass

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Truck (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	0.75000000	10.00000000	2.37500000	1.44496489	6.81401157	6.00000000	33.78597641	31.41908264
Top slab, inside face	0.75000000	14.00000000	2.37500000	1.29185867	8.28988361	6.00000000	37.76679611	31.16524887
Top slab, outside face	0.75000000	14.00000000	2.50000000	1.31055903	7.34649181	6.00000000	36.39145279	32.44585037
Bottom slab, outside corner	0.75000000	10.00000000	2.37500000	1.44496489	8.26050854	6.00000000	33.78597641	27.92593575
Bottom slab, inside face	0.75000000	15.00000000	2.37500000	1.26874113	7.17320156	7.00000000	35.19797897	34.70510864
Bottom slab, outside face	0.75000000	15.00000000	3.56400013	1.44521070	6.04276562	6.00000000	27.62027931	27.58145142
Ext. wall, outside face	0.8*f _t > f _c , therefore no check necessary.							
Ext. wall, inside face	0.8*f _t > f _c , therefore no check necessary.							
Interior wall	0.8*f _t > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 15.750 feet
Percentage of main reinforcement required = 25.198% , less than or equal to 50%
Main reinforcement area (top slab) = 0.880 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 0.754 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE	Top slab CENTER	RIGHT SIDE
area 0.8800 in ²	area 0.8800 in ²	area 1.5800 in ²
size 6 spaced at 6.00 in.	size 6 spaced at 6.00 in.	size 8 spaced at 6.00 in.

Exterior wall
TOP
area 0.8800 in²
size 6 spaced at 6.00 in.

Interior wall
TOP
area 0.2000 in²
size 4 spaced at 12.00 in.

INSIDE FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

EACH FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

OUTSIDE FACE
area 0.2667 in²
size 4 spaced at 9.00

BOTTOM
area 0.8800 in²
size 6 spaced at 6.00 in.

BOTTOM
area 0.2000 in²
size 4 spaced at 12.00 in.

LEFT SIDE	Bottom slab CENTER	RIGHT SIDE
area 0.8800 in ²	area 0.7543 in ²	area 2.0000 in ²
size 6 spaced at 6.00 in.	size 6 spaced at 7.00 in.	size 9 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	6	STR	0- 0	0		
BOT SLAB (Inside)	A200	258	6	STR	0- 0	0		
TOP SLAB (Outside)	A300	300	8	STR	0- 0	0		
BOT SLAB (Outside)	A400	300	9	STR	0- 0	0		
CORNER (Top)	A1	600	6	L-BAR	5- 8	5108	2- 8	3- 0
CORNER (Bottom)	A2	600	6	L-BAR	5- 8	5108	2- 8	3- 0
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	400	4	STR	0- 0	0		
INTWALL	B3	300	4	STR	0- 0	0		
LONGITUD.(3)	C1	336	4	STR	51- 1	11472		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		
Total weight black bars						23192		
Total weight all bars						23192		

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2

Bottom slab(s) = 0.1100 in2

Exterior wall(s) = 0.1100 in2

Interior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

PAGE 25
DATE 10/27/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Factored Actions for Load and Resistance 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	-12.482	-20.653	-8.925	-15.815	10.087	5.646
1- 1	-8.261	-13.471	-8.925	-15.815	7.840	4.220
1- 2	-4.001	-9.154	-9.221	-15.520	5.688	2.858
1- 3	-0.387	-7.102	-9.221	-15.520	3.631	1.559
1- 4	1.579	-6.145	-9.221	-15.520	1.671	0.324
1- 5	2.007	-6.211	-9.221	-15.520	-0.119	-0.922
1- 6	1.075	-7.324	-9.221	-15.520	-1.234	-2.685
1- 7	-1.251	-9.341	-9.221	-15.520	-2.278	-4.359
1- 8	-4.909	-12.200	-9.221	-15.520	-3.258	-5.938
1- 9	-8.853	-16.810	-8.925	-15.815	-4.174	-7.421
1-10	-12.639	-23.477	-8.925	-15.815	-5.027	-8.809
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-12.639	-23.477	-4.824	-8.448	16.569	9.351
2- 1	3.136	-3.388	-4.924	-8.348	12.721	7.134
2- 2	19.002	0.000	-4.924	-8.348	9.084	4.832
2- 3	29.610	0.000	-4.924	-8.348	5.473	2.467
2- 4	34.436	0.000	-4.924	-8.348	1.909	0.040
2- 5	33.421	0.000	-4.924	-8.348	-0.672	-3.358
2- 6	26.567	0.000	-4.924	-8.348	-3.087	-6.923
2- 7	14.032	0.000	-7.860	-5.411	-5.442	-10.557
2- 8	-1.572	-8.968	-7.760	-5.511	-7.746	-14.218
2- 9	-17.010	-32.579	-7.760	-5.511	-10.006	-17.859
2-10	-34.925	-62.844	-7.760	-5.511	-12.230	-21.285
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.547	-0.501	-22.044	-37.867	0.220	-0.231
3- 1	0.357	-0.320	-22.044	-37.867	0.220	-0.231
3- 2	0.167	-0.140	-22.044	-37.867	0.220	-0.231
3- 3	0.053	-0.037	-22.044	-37.867	0.220	-0.231
3- 4	0.227	-0.218	-23.072	-37.867	0.220	-0.231
3- 5	0.403	-0.403	-33.059	-37.776	0.220	-0.231
3- 6	0.583	-0.592	-33.523	-26.388	0.220	-0.231
3- 7	0.764	-0.782	-33.523	-26.388	0.220	-0.231
3- 8	0.944	-0.972	-33.523	-26.388	0.220	-0.231
3- 9	1.125	-1.162	-33.523	-26.388	0.220	-0.231
3-10	1.305	-1.351	-33.523	-26.388	0.220	-0.231
INTERIOR WALL TOP						

BOTTOM SLAB LEFT SIDE

4- 0	-12.482	-20.653	-5.799	-10.051	16.179	9.950
4- 1	5.476	-2.084	-5.694	-10.156	12.389	7.619
4- 2	21.395	0.000	-5.694	-10.156	8.599	5.288
4- 3	31.347	0.000	-5.694	-10.156	4.809	2.958
4- 4	35.329	0.000	-5.694	-10.156	1.030	0.601
4- 5	33.342	0.000	-5.694	-10.156	-1.343	-3.157
4- 6	25.388	0.000	-5.694	-10.156	-3.674	-6.947
4- 7	11.654	0.000	-9.443	-6.406	-6.005	-10.737
4- 8	-4.045	-8.502	-9.549	-6.301	-8.336	-14.528
4- 9	-19.010	-34.334	-9.549	-6.301	-10.667	-18.318
4-10	-37.646	-66.140	-9.549	-6.301	-12.998	-22.108

BOTTOM SLAB RIGHT SIDE

Output complete for a HL-93-TRUCK
vehicle

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 10.00	ft.
Span Length	= 15.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.10	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 19.57 ft.

Final Distribution Factor = 1/Final Strip Width = 0.051 Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.061

Dynamic Load Allowance Calculation - Article 3.6.2.2

$$IM = 33(1.0 - 1.25 D_e)$$

$$IM = 33(1.0 - 1.25(10.00))$$

$$IM = 0.0000$$

Notes:

Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.

1. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
2. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6. AASHTO Specifications state that no live load is to be used when the fill is greater than 8 feet and the fill is greater than the total span length. The fill is greater than 8 feet but less than the total span length of 31.50 feet.

For a HL-93-TANDEM Vehicle
Description AASHTO LRFD HL-93 Design Tandem (US)
The Number of axles = 2

Axle Weights (kips)	Spacing (ft)
25.00	4.000
25.00	0.000

	-----	-----
Totals	50.00	4.000

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 1
Fill = 10.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 11.83 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 2
Fill = 10.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 11.83 ft.
[slope(fill) + longitudinal tire patch]

For a HL-93-TANDEM Vehicle

Description AASHTO LRFD HL-93 Design Tandem (US)

The number of simulated axles based on fill = 15

The number of simulated axles is calculated based on the longitudinal distribution length of each axle divided by the simulated axle spacing of 1 foot and the simulated axle weights are calculated by dividing the vehicle axle weights by the number of simulated axles per vehicle axle.

Truck facing backwards		Truck facing forward	
Axle wts. (kips)	Spacing (ft)	Axle wts. (kips)	Spacing (ft)
2.27	0.000	2.27	0.000
2.27	1.000	2.27	1.000
2.27	1.000	2.27	1.000
2.27	1.000	2.27	1.000
4.55	1.000	4.55	1.000
4.55	1.000	4.55	1.000
4.55	1.000	4.55	1.000
4.55	1.000	4.55	1.000
4.55	1.000	4.55	1.000
4.55	1.000	4.55	1.000
4.55	1.000	4.55	1.000
2.27	1.000	2.27	1.000
2.27	1.000	2.27	1.000
2.27	1.000	2.27	1.000
2.27	1.000	2.27	1.000
-----	-----	-----	-----
Totals 50.00	14.000	50.00	14.000

Note: Impact or distribution is not included in the above table.

Factors for Ductility 1.00
 Redundancy 1.05
 Operations 1.00

Fatigue Checks

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

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	Bottom	0.000	23.71	2.90	Pass
EXTERIOR WALL	Middle -	0.000	23.27	7.30	Pass
EXTERIOR WALL	Top	0.000	23.27	7.28	Pass
TOP SLAB	Left	0.000	23.23	7.70	Pass
TOP SLAB	Middle +	0.000	23.26	7.36	Pass
INTERIOR WALL	Bottom	0.000	22.94	10.64	Pass
INTERIOR WALL	Middle	0.000	23.62	3.84	Pass
INTERIOR WALL	Top	0.000	22.02	19.77	Pass
BOTTOM SLAB	Left	0.000	23.76	2.43	Pass

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Tandem (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	0.75000000	10.00000000	2.37500000	1.44496489	6.37376785	6.00000000	33.78597641	32.66255188
Top slab, inside face	0.75000000	14.00000000	2.37500000	1.29185867	7.63441563	6.00000000	37.76679611	32.81472397
Top slab, outside face	0.75000000	14.00000000	2.50000000	1.31055903	7.54732323	6.00000000	36.39145279	31.92652512
Bottom slab, outside corner	0.75000000	10.00000000	2.37500000	1.44496489	8.18540287	6.00000000	33.78597641	28.08807945
Bottom slab, inside face	0.75000000	15.00000000	2.37500000	1.26874113	7.28146744	7.00000000	35.19797897	34.39281082
Bottom slab, outside face	0.75000000	15.00000000	3.56400013	1.44521070	6.23833179	6.00000000	27.62027931	27.17789841
Ext. wall, outside face	0.75000000	10.00000000	2.25000000	1.41474652	7.25353909	7.00000000	32.08890152	31.57272148
Ext. wall, inside face	0.8*f _t > f _c , therefore no check necessary.							
Interior wall	0.8*f _t > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 15.750 feet
Percentage of main reinforcement required = 25.198% , less than or equal to 50%
Main reinforcement area (top slab) = 0.880 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 0.754 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE	Top slab CENTER	RIGHT SIDE
area 0.8800 in ²	area 0.8800 in ²	area 1.5800 in ²
size 6 spaced at 6.00 in.	size 6 spaced at 6.00 in.	size 8 spaced at 6.00 in.

Exterior wall
TOP
area 0.8800 in²
size 6 spaced at 6.00 in.

Interior wall
TOP
area 0.3000 in²
size 4 spaced at 8.00 in.

INSIDE FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

EACH FACE
area 0.3000 in²
size 4 spaced at 8.00 in.

OUTSIDE FACE
area 0.3429 in²
size 4 spaced at 7.00

BOTTOM
area 0.8800 in²
size 6 spaced at 6.00 in.

BOTTOM
area 0.3000 in²
size 4 spaced at 8.00 in.

LEFT SIDE	Bottom slab CENTER	RIGHT SIDE
area 0.8800 in ²	area 0.7543 in ²	area 2.0000 in ²
size 6 spaced at 6.00 in.	size 6 spaced at 7.00 in.	size 9 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	6	STR	0- 0	0		
BOT SLAB (Inside)	A200	258	6	STR	0- 0	0		
TOP SLAB (Outside)	A300	300	8	STR	0- 0	0		

BOT SLAB (Outside)	A400	300	9	STR	0- 0	0		
CORNER (Top)	A1	600	6	L-BAR	5- 8	5108	2- 8	3- 0
CORNER (Bottom)	A2	600	6	L-BAR	5- 8	5108	2- 8	3- 0
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	516	4	STR	0- 0	0		
INTWALL	B3	450	4	STR	0- 0	0		
LONGITUD. (3)	C1	336	4	STR	51- 1	11472		
LONGITUD. (3)	C100	0	4	STR	51- 1	0		
LONGITUD. (3)	C200	0	4	STR	51- 1	0		

Total weight black bars	23192
Total weight all bars	23192

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2

Bottom slab(s) = 0.1100 in2

Exterior wall(s) = 0.1100 in2

Interior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-12.365	-20.809	-8.813	-16.537	10.174	5.496
1- 1	-8.257	-13.472	-8.813	-16.537	7.926	4.070
1- 2	-4.000	-8.928	-9.109	-16.242	5.775	2.708
1- 3	-0.386	-7.062	-9.109	-16.242	3.718	1.409
1- 4	1.579	-6.405	-9.109	-16.242	1.757	0.174
1- 5	2.026	-6.736	-9.109	-16.242	-0.032	-1.072
1- 6	1.156	-8.003	-9.109	-16.242	-1.147	-2.835
1- 7	-1.093	-10.154	-9.109	-16.242	-2.191	-4.509
1- 8	-4.668	-13.143	-9.109	-16.242	-3.171	-6.088
1- 9	-8.529	-17.876	-8.813	-16.537	-4.087	-7.571
1-10	-12.238	-24.665	-8.813	-16.537	-4.940	-8.959
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-12.238	-24.665	-4.639	-8.437	17.446	9.233
2- 1	3.162	-3.605	-4.738	-8.339	13.449	7.017
2- 2	20.241	0.000	-4.738	-8.339	9.695	4.800
2- 3	31.598	0.000	-4.738	-8.339	5.957	2.551
2- 4	36.866	0.000	-4.738	-8.339	2.272	0.018
2- 5	35.997	0.000	-4.738	-8.339	-0.428	-3.495
2- 6	28.827	0.000	-4.738	-8.339	-2.946	-7.189
2- 7	15.705	0.000	-7.619	-5.458	-5.365	-10.933
2- 8	-0.646	-9.980	-7.521	-5.556	-7.721	-14.695
2- 9	-16.785	-32.230	-7.521	-5.556	-10.001	-18.455
2-10	-34.923	-61.507	-7.521	-5.556	-12.230	-21.950
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.762	-0.716	-22.043	-38.146	0.314	-0.326
3- 1	0.495	-0.458	-22.043	-38.146	0.314	-0.326
3- 2	0.228	-0.200	-22.043	-38.146	0.314	-0.326
3- 3	0.071	-0.054	-22.043	-38.146	0.314	-0.326
3- 4	0.323	-0.314	-23.072	-38.146	0.314	-0.326
3- 5	0.576	-0.576	-32.968	-38.146	0.314	-0.326
3- 6	0.833	-0.842	-33.523	-26.667	0.314	-0.326
3- 7	1.091	-1.109	-33.523	-26.667	0.314	-0.326
3- 8	1.349	-1.376	-33.523	-26.667	0.314	-0.326
3- 9	1.607	-1.644	-33.523	-26.667	0.314	-0.326
3-10	1.865	-1.911	-33.523	-26.667	0.314	-0.326
INTERIOR WALL TOP						

PAGE 33
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	-12.365	-20.809	-5.537	-9.958	15.808	9.950
4- 1	5.846	-2.082	-5.433	-10.061	12.113	7.619
4- 2	21.349	0.000	-5.433	-10.061	8.418	5.288
4- 3	31.033	0.000	-5.433	-10.061	4.723	2.957
4- 4	34.899	0.000	-5.433	-10.061	1.029	0.588
4- 5	32.944	0.000	-5.433	-10.061	-1.344	-3.089
4- 6	25.171	0.000	-5.433	-10.061	-3.674	-6.784
4- 7	11.770	0.000	-9.113	-6.382	-6.005	-10.479
4- 8	-4.046	-8.719	-9.216	-6.279	-8.336	-14.174
4- 9	-19.011	-33.870	-9.216	-6.279	-10.667	-17.869
4-10	-37.647	-64.841	-9.216	-6.279	-12.998	-21.564

BOTTOM SLAB RIGHT SIDE

Output complete for a HL-93-TANDEM vehicle

-----A1-----			
	=====	A300	" "
	"=====		"=====
	" "	A100	" "
	"=====		"=====
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
B2	B1 "		" "
	" "		" "
	" "		" "
	" "		" B3 "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	" "		" "
	"=====		"=====
	" "	A200	" "
	" "	A400	" "
	"=====		"=====
	=====		=====
	-----A2-----		

Serviceability, Fatigue, and Other Checks

→ Based on crack control check
 AASHTO 5.7.3.4 LRFD

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 Required (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	32.66	33.79	0.8507	0.8800	6	6.0	32	36
A2	28.09	33.79	0.7316	0.8800	6	6.0	32	36
A100	32.81	37.77	0.7939	0.8800	6	6.0		
A300*	31.93	36.39	1.3209	1.5800	8	6.0		
A200	34.39	35.20	0.6814	0.7543	6	7.0		
A400*	27.18	27.62	1.3906	2.0000	9	6.0		
B1	0.00	22.36	0.0774	0.2000	4	12.0		
B2	31.57	32.09	0.3374	0.3429	4	7.0		
B3	7.64	26.90	0.2808	0.3000	4	8.0		

* FOR A300 AND A400, use (1)-#7@12" + (1)-#8@12"

$$A_s = 0.79 \text{ in}^2 + 0.60 \text{ in}^2$$

$$= 1.39 \text{ in}^2$$

Note that the maximum moments are at the center of the wall. Hence the moment at face of wall will be less. Designs are a little conservative.

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 it if should, this will control yielding under service loads.

Output at Critical Sections (per unit design width)

Member No. = 1 EXTERIOR WALL												
				Thickness	= 10.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (bot)	= 0.75 (in)							
				Bar diameter (mid+)	= 0.75 (in)							
				Bar diameter (mid-)	= 1.13 (in)							
				Bar diameter (top)	= 0.50 (in)							
	Moment	Coin.		Resistance								
	Kft	Axial	Shear	Shear	Po	Mu	Mbal	Pbal	Steel	Mom.	Des.	Design
		Force	Force	Cap	Cap	Cap	Cap	Cap	Area	Cap	Thk	Ratio
		Kips	Kips	Kips	Kips	Kft	Kft	Kips	In2	Kft	in	
BOT	-20.8	8.8	6.7	10.7	274.7	27.9	41.4	83.0	0.8800	27.9	7.62	0.7
MID	2.0	8.8	0.0	28.5	251.6	7.0	34.6	117.7	0.2000	7.0	7.75	0.3
MID-	-6.7	9.1	1.1	15.3	256.4	11.7	36.1	110.8	0.3429	11.7	7.75	0.6
TOP	-24.7	9.1	6.8	9.8	274.7	27.9	41.4	83.0	0.8800	27.9	7.62	0.9
Member No. = 2 TOP SLAB												
				Thickness	= 14.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (lt)	= 0.75 (in)							
				Bar diameter (mid)	= 0.75 (in)							
				Bar diameter (rt)	= 1.13 (in)							
LT	-24.7	4.6	13.9	17.9	372.6	43.6	81.1	148.6	0.8800	43.6	11.62	0.6
MID	36.9	4.7	0.4	16.1	372.6	43.6	81.1	148.6	0.8800	43.6	11.62	0.8
RT	-62.8	4.9	19.0*	17.6	396.4	73.7	93.1	113.0	1.5800	73.7	11.50	0.9
Member No. = 3 INTERIOR WALL												
				Thickness	= 8.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (bot)	= 0.75 (in)							
				Bar diameter (mid+)	= 0.75 (in)							
				Bar diameter (mid-)	= 1.13 (in)							
				Bar diameter (top)	= 0.50 (in)							
BOT	-0.7	22.0	0.3	26.8	206.0	8.2	22.2	80.0	0.3000	8.2	5.75	0.1
MID	0.6	22.0	0.3	26.8	206.0	8.2	22.2	80.0	0.3000	8.2	5.75	0.1
MID-	-0.6	22.0	0.3	26.8	206.0	8.2	22.2	80.0	0.3000	8.2	5.75	0.1
TOP	-1.9	22.0	0.3	27.0	206.0	8.2	22.2	80.0	0.3000	8.2	5.75	0.2
Member No. = 4 BOTTOM SLAB												
				Thickness	= 15.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (lt)	= 0.75 (in)							
				Bar diameter (mid)	= 0.75 (in)							
				Bar diameter (rt)	= 1.13 (in)							
LT	-20.8	5.5	12.5	18.0	397.1	43.6	87.3	148.6	0.8800	43.6	11.62	0.5
MID	35.3	5.7	1.3	17.5	392.8	41.1	90.2	171.1	0.7543	41.1	12.62	0.9
RT	-66.1	5.7	18.9*	18.0	435.1	84.2	103.8	91.8	2.0000	84.2	11.44	0.8

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.

Volume of Concrete and Weight of Reinforcing Steel

Thickness				Volume	Steel
Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)		
14.00	15.00	10.00	8.00	3.499	797

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	300	6	STR	32- 0	14423		
BOT SLAB (Inside)	A200	258	6	STR	32- 0	12404		
TOP SLAB (Outside)	A300	300	8	STR	32- 0	25632		
BOT SLAB (Outside)	A400	300	9	STR	32- 0	32636		
CORNER (Top)	A1	600	6	L-BAR	5- 8	5108	2- 8	3- 0
CORNER (Bottom)	A2	600	6	L-BAR	5- 8	5108	2- 8	3- 0
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	516	4	STR	7- 0	2414		
INTWALL	B3	450	4	STR	9- 0	2707		
LONGITUD. (3)	C1	336	4	STR	51- 1	11472		
LONGITUD. (3)	C100	93	4	STR	51- 1	3175		
LONGITUD. (3)	C200	93	4	STR	51- 1	3175		

Total weight black bars	119758
Total weight all bars	119758

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2
Bottom slab(s) = 0.1100 in2
Exterior wall(s) = 0.1100 in2

Interior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Job No.	412-654	By	DAT	Subject	(2)-15'x7' RCB	Sheet	
Date		Checked				Of	

Distribution Reinforcing (AASHTO LRFD 9.7.3.2)

Use distribution steel in top slab to account for construction loading when fill is less than 2-ft.

For primary reinforcement perpendicular to traffic:

Effective Span, $S =$ ft

% Distribution Reinforcing = $220 / S^{0.5} < 67\%$
 =

Primary Reinforcing = #6 @ 6"
 Area of Steel = 0.88 in²/ft

Min Distribution Reinforcing = 0.50 in²/ft

BRASS-CULVERT - (2) 15'x7' RCB w/ 20' Max Soil Cover

BRASS-CULVERT(LRFD) Version 2.3.6

DATE : 10/27/2014

TIME : 9:13:51

PAGE 1

Input Filename : F:\Projects\400\412-654\Division\Str1\Calcs\Centennial Double
15x7 - 20 feet.DAT
Output Filename : F:\Projects\400\412-654\Division\Str1\Calcs\Centennial Double
15x7 - 20 feet.xml
Output Filename for Live Loads : F:\Projects\400\412-654\Division\Str1\Calcs\Centennial Double
15x7 - 20 feet_LL.OUT

The following filenames may be used in this run

Live Load Influence Values File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 20 feet_INF.OUT
Drawing File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 20 feet.drw
Live Load Influence Ordinates File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 20 feet.ill
Live Load Actions (w/o DF or IM) File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 20 feet.oll
Intermediate Computations File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 20 feet.ooo
Data Modelling File name : F:\Projects\400\412-
654\Division\Str1\Calcs\Centennial Double 15x7 - 20 feet.tmp

COMMENTS THIS FILE WAS CREATED BY THE BRASS-CULVERT GUI.
COMMENTS DO NOT EDIT THIS FILE!
COMMENTS JOB DESCRIPTION:
TITLE CENTENNIAL - DOUBLE 15' X 7' RCB

STRUCTID

AGENCY

COMMENTS 20' MAX FILL ABOVE

UNITSIN US

UNITSOUT US

COMMENTS ANALYSIS CONTROL:

TYPE CIP

FUNCT DESIGN

LRFR NO

IRELEASE NO

IDSN LRFD

KBASE FULL

KHACH NO

EPOXY NO

EDGE-STRIP NO

LRFD-SHEAR 0

IFATIG YES

DNEG 0.0000

COMMENTS DESIGN CONTROL:

ISAMS NO

ISAMW NO

ADDS 1.0000

ADDW 1.0000

MAXSIZ 10

MINSIZ 4

SPCMAX 12.0000

SPCMIN 6.0000

ISPCGINC MAX

PAS 0.012000

CUSTOM STD

BAR_DE US

COMMENTS OUTPUT CONTROL:

MTEN YES

IBSH YES

IINFN NO

LIVELO NO

DEFAULTS	YES
LOOPS	NO
INTERMEDIATE	NO
COMMENTS	MATERIAL PROPERTIES:
FCONC	4000.000
CE	3644147.000
CWGT	150.000
COMMENTS	THE IGNORE CRACK CONTROL OPTION WAS SPECIFIED.
COMMENTS	THEREFORE, Z WILL BE SET TO A LARGE VALUE SO
COMMENTS	CRACK CONTROL WILL NOT BE CRITICAL
ZEE	20000.0
COMMENTS	THE IGNORE CRACK CONTROL OPTION WAS SPECIFIED.
COMMENTS	THEREFORE, EXPOSURE FACTOR WILL BE SET TO A LARGE
COMMENTS	VALUE SO CRACK CONTROL WILL NOT BE CRITICAL
EXP_FACTOR	120.0
GAMMA_MIN_RE_1	1.600
GAMMA_MIN_RE_3	0.750
EWGT	125.000
AWGT	145.000
FYST	60000.000
CN	7.9580
COMMENTS	BOX GEOMETRY:
NBOX	2
NSPAN	15.0000
NHITE	7.0000
LENG	150.0000
BWIDTH	150.0000
CBWIDTH	0.0000
TSLAB	16.0000
KFXTS	F
BSLAB	18.0000
KFXBS	F
WALLR	12.0000
KFXW	F
IWALLR	12.0000
KFXI	F
COMMENTS	SKEW:
CSKEW	0.0000
LSKEW	90.0000
RSKEW	90.0000
COMMENTS	CONCRETE COVER:

PAGE 3
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

COVS	2.0000
COVB	3.0000
COVW	2.0000
COVIN	2.0000
COMMENTS	DEAD LOADS:
PRESS	100.000
PMIN	35.000
PWAT	0.000
NFILL	20.0000
NWEAR	6.0000
FILLFA	1.1000
TYFILL	COMPACT
COMMENTS	LIVE LOADS:
LVLD	HL-93-TRUCK
LVLD	HL-93-TANDEM
LVOMT	YES
LLPATCH	PL
SURCH_USE	YES
LIMIT_DIST	NO
LRFDFF	YES

End of Input File No. 1

=====

Note:

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

The first set are the variables defaulted from input and the second set are system variables.

Units

USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US

Design Variables

LRFDFF:	Use LRFD method for bot slab load distrib.	=	T
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDSN:	Design Method	=	LRFD
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESIGN
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	0.00
CUSTOM:	Default bar spacing and design check control	=	STD
ISAMS:	Design Same Top and Bottom Slab	=	F
ISAMW:	Design Same Interior-Exterior Wall	=	F

Output Control Variables

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

Standard Load Variables

LVLD:	Live Load Vehicle Name	=	HL-93-TRUCK
LVLD:	Live Load Vehicle Name	=	HL-93-TANDEM
LVOMT:	Neglect LL for Fill > 8Ft & Fill > Span	=	T

Uniform Dead Load Variable

EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (in)	=	6.0

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	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	100.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	35.0
PWAT:	Internal Water Pressure	=	0.0

Geometry - Box Dimension Variables

NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	15.0
NHITE:	Clear Height (Ft)	=	7.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	20.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	150.0

Geometry - Slab Thickness Variables

TSLAB:	Minimum Value for Top Slab (In)	=	16.0
KFXTS:	Code for Top Slab(F=Fixed,V=Variable)	=	F
BSLAB:	Minimum Value for Bottom Slab(In)	=	18.0
KFXBS:	Code for Bottom Slab(F=Fixed,V=Variable)	=	F
WALLR:	Minimum Value for Exterior Wall (In)	=	12.0
KFXW:	Code for Exterior Wall(F=Fixed,V=Variable)	=	F
IWALLR:	Minimum Value for Interior Wall(In)	=	12.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F
IWALLR:	Minimum Value for Interior Wall(In)	=	12.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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)	=	0.0
BFILT:	Bottom Haunch (In)	=	0.0
KHACH:	Haunches used in Analysis (YES/NO)	=	NO

Geometry - Clear Concrete Cover

COVS:	Exterior Concrete Cover Top Slab (In)	=	2.0
COVB:	Exterior Concrete Cover Bottom Slab (In)	=	3.0
COVW:	Exterior Concrete Cover Walls (In)	=	2.0
COVIN:	Interior Concrete Cover (In)	=	2.0

Reinforcing Bar variables and Thickness Increment

SPCMAX:	Default Max. Bar Spacings (In)	=	12.0
SPCMIN:	Default Min. Bar Spacings (In)	=	6.0
MAXSIZ:	Default Bar Sizes(US)	=	10
MINSIZ:	Default Bar Sizes(US)	=	4
ISPCGINC:	Reinforcing Bar Minimum Increment	=	T
EPOXY:	Top Reinforcing Mat Epoxy Coated	=	F
ADDS:	Added Slab Thickness Increment(In)	=	1.0
ADDW:	Added Wall Thickness Increment(In)	=	1.0

Material Properties Variables

EWGT:	Weight of Soil (Pcf)	=	125.0
FYST:	Yield Strength of Reinf. Steel (Psi)	=	60000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi)(ASD)	=	36000.0
FCONC:	Compressive Strength of Concrete (Psi)	=	4000.0
FSHR:	Shear in Concrete (Psi)(ASD)	=	0.0
FSTIR:	Allowable Stress in Stirrups (Psi)(ASD)	=	0.0
CWGT:	Weight of Concrete (Pcf)	=	150.0
AWGT:	Weight of Wearing Surface (Pcf)	=	145.0

ZEE:	Crack Width Parameter from AASHTO	=	20000.0
CN:	Modular Ratio of Concrete	=	8.0
CE:	Modulus of Elasticity of Concrete(ksi)	=	3644.1

ZEE:	Crack Width Parameter from AASHTO	=	0.9
CN:	Modular Ratio of Concrete	=	0.9
CE:	Modulus of Elasticity of Concrete(ksi)	=	

Service-I load and resistance factors

EV: Vertical Earth Pressure max-min	1.00	1.00
DC: Components max-min	1.00	1.00
DW: Wearing Surfaces max-min	1.00	1.00
EH: Horizontal Earth Pressure At-Rest	1.00	
LS: Live load surcharge	1.00	
WA: Water load and stream pressure	1.00	
LL: Vehicular live load	1.00	

Strength-I load and resistance factors

EV: Vertical Earth Pressure max-min	1.30	0.90
DC: Components max-min	1.25	0.90
DW: Wearing Surfaces max-min	1.50	0.65
EH: Horizontal Earth Pressure At-Rest	1.35	
LS: Live load surcharge	1.75	
WA: Water load and stream pressure	1.00	
LL: Vehicular live load	1.75	

Strength-II load and resistance factors

EV: Vertical Earth Pressure max-min	1.30	0.90
DC: Components max-min	1.25	0.90
DW: Wearing Surfaces max-min	1.50	0.65
EH: Horizontal Earth Pressure At-Rest	1.35	
LS: Live load surcharge	1.35	
WA: Water load and stream pressure	1.00	
LL: Vehicular live load	1.35	

Fatigue load and resistance factors

EV: Vertical Earth Pressure max-min	0.00	0.00
DC: Components max-min	0.00	0.00
DW: Wearing Surfaces max-min	0.00	0.00
EH: Horizontal Earth Pressure At-Rest	0.00	
LS: Live load surcharge	0.75	
WA: Water load and stream pressure	0.00	
LL: Vehicular live load	0.75	

BB: Factor Load Factor Po and Pb AASHTO	=	0.80
BETAD: Dead Load Multiplier for Load Factor	=	1.0000
BETAL: Live Load Multiplier for Load Factor	=	0.0000
PHIMOM: Phi Factor for Moment	=	0.9000
PHISHR: Phi Factor for Shear	=	0.8500

BB: Factor Load Factor Po and Pb AASHTO	=	1.30
BETAD: Dead Load Multiplier for Load Factor	=	

HAFBAR: Assumed Half a Bar Dia. of #6 Bar (In)	=	0.375
I300: A300 and A400 Bars to TRUE	=	T
I400: A300 and A400 Bars to TRUE	=	T
ICHANG: Initial Settings	=	F
ICUT: Cut Bars Due to Skew	=	T
ICUTSM: Bar Cuts Symmetrical	=	F
IFIXB: Defaults for Slab Thickness Incrementing	=	F
IFIXI: Defaults for Wall Thickness Incrementing	=	F
IFIXT: Defaults for Slab Thickness Incrementing	=	F
IFIXW: Defaults for Wall Thickness Incrementing	=	F

PAGE 8
DATE 10/27/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

IFATIG:	Check Fatigue	=	F
IHAUCH:	Code for Considering Haunch in Analysis	=	F
ILES5:	Code for Span Less Than 5 ft	=	F
ISHR:	Code for Shear Stress Check	=	F

ILOOP:	Loop Counter for Design Iterations	=	0
INTERM_SWITCH:	Turn on Intermediate Results Output	=	F
ISTORE:	Design Moments to Zero	=	0
KPASS:	Variable Dimen (use in fixed thickness design)	=	VAR
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
PAS:	Maximum AS/BD Desired	=	0.012

JOB DESCRIPTION

Title : CENTENNIAL - DOUBLE 15' X 7' RCB
Structure ID :
Agency name : STD

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	DESIGN	NO	FULL	0.00

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

Design Method	Limit State Ductility	Load and Resistance Redundant	Factors Operations
LOAD & RES.	1.0000	1.0500	1.00

DESIGN CONTROLS

Design Same Thickness Slabs	Design Same Thickness Walls	Round-up Thicknesses (In)	Increment Walls (In)	Bar Spacing File
NO	NO	1.00	1.00	Standard

Bar Spacing Max (In)	US-Bar Size Min (In)	Bar Spacing Max (In)	Increment Min
12.0	6.0	10	4
1 INCH			

OUTPUT CONTROLS

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

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Gamma E (Kip/in)	Steel Fy (Psi)	Steel n
4000.	3644147.	****	60000.	7.96

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width coefficient is the coefficient in Eq. 5.7.3.4-2 for the crack width parameter Z

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	125.	145.

Note:

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

BOX GEOMETRY

Culvert	Span	Clear	Centerline
Cells	Length	Height	Length
	(Ft)	(Ft)	(Ft)
DOUBLE	15.00	7.00	150.00

Bridge	Number of
Width	Traffic Lanes
(Ft)	
150.00	1 and 2 lanes investigated

Slab and Wall Information

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
16.00 Fixed	18.00 Fixed	12.00 Fixed	12.00 Fixed

LIVE LOADS

Vehicle Designation
 HL-93-TRUCK
 HL-93-TANDEM
 Live Load Control: YES
 (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)
****	35.0
	0.0

Uniform	Wearing	Fill
Load	Surface	Height
(plf)	Thickness	(Ft)
0.0	6.00	20.00

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)
0.0	0.0

CONCRETE COVER to face of bar

Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
2.00	3.00	2.00	2.00

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 20.00	ft.
Span Length	= 15.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.10	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 30.57 ft.

Final Distribution Factor = 1/Final Strip Width = 0.033 Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.039

Dynamic Load Allowance Calculation - Article 3.6.2.2

IM = 33(1.0 - 1.25 D_e)

IM = 33(1.0 - 1.25(20.00))

IM = 0.0000

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Number of cells	=	2
Top Slab thickness	=	16.0000 In.
Bottom Slab thickness	=	18.0000 In.
Exterior Wall thickness	=	12.0000 In.
Interior wall thickness	=	12.00 In.
Design Span(c-c walls)	=	16.0000 Ft.
Design Height(c-c slabs)	=	8.4167 Ft.
Fill Height(top of slab)	=	20.0000 Ft.
Wearing surface thickness	=	6.0000 In.
Loads based on 1 foot unit width		
Soil Structure Interaction Factor	=	1.1212
Earth Weight for fill computations	=	0.1402 Kcf
Weight of Fill without wearing surface	=	2.7330 Klf
Weight of Wearing Surface	=	0.0725 Klf
Weight of Top Slab	=	0.2000 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	3.0055 Klf
Weight of Walls divided by culvert width	=	0.0984 Klf
Uniform Dead Load on Bottom Slab	=	3.1039 Klf
Soil pressure at center of top slab	=	2.0667 Klf
Soil pressure at center of bottom slab	=	2.9083 Klf
Soil pressure due to live load surcharge	=	0.0700 Klf
Impact Factor on Top Slab & Walls	=	0.0000
Impact Factor on Bottom Slab	=	0.0000
Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0393
on Bottom Slab	=	0.0393

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 AASHTO LRFD 4.6.2.10 for fill depth less than 2 ft. and AASHTO LRFD 3.6.1.2.6 for fill depths over 2 ft. Also, see 3.6.1.3.3.

AASHTO Specifications state that no live load is to be used when the fill is greater than 8 feet and the fill is greater than the total span length

The fill is greater than 8 feet but less than the total span length of 32.00 feet

For a HL-93-TRUCK Vehicle
Description AASHTO LRFD HL-93 Design Truck (US)
The Number of axles = 3

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 = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 1
Fill = 20.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 22.83 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 2
Fill = 20.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 22.83 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 3
Fill = 20.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 22.83 ft.
[slope(fill) + longitudinal tire patch]

For a HL-93-TRUCK Vehicle
Description AASHTO LRFD HL-93 Design Truck (US)

The number of simulated axles based on fill = 50

The number of simulated axles is calculated based on the longitudinal distribution length of each axle divided by the simulated axle spacing of 1 foot and the simulated axle weights are calculated by dividing the vehicle axle weights by the number of simulated axles per vehicle axle.

Truck facing backwards		Truck facing forward	
Axle wts. (kips)	Spacing (ft)	Axle wts. (kips)	Spacing (ft)
0.36	0.000	1.45	0.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
0.36	1.000	1.45	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.82	1.000	2.91	1.000
1.45	1.000	1.45	1.000
1.45	1.000	1.45	1.000
1.45	1.000	1.45	1.000
1.45	1.000	1.45	1.000
1.45	1.000	1.45	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
2.91	1.000	1.82	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000
1.45	1.000	0.36	1.000

	1.45	1.000	0.36	1.000
	1.45	1.000	0.36	1.000
	1.45	1.000	0.36	1.000
	1.45	1.000	0.36	1.000
Totals	72.00	49.000	72.00	49.000

Note: Impact or distribution is not included in the above table.

Factors for Ductility 1.00
 Redundancy 1.05
 Operations 1.00

Design Iteration Loop Number 1

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill = 20.00 ft.
 Span Length = 15.00 ft.
 Truck Gage = 6.00 ft.
 Soil Distribution Factor = 1.10
 Tire Patch Width = 20.00 in.
 Bridge Width = 150.00 ft.
 Length = 150.00 ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 30.57 ft.

Final Distribution Factor = $1/\text{Final Strip Width} = 0.033$ Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.039

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(20.00))$

$IM = 0.0000$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

PAGE 15
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored MOMENTS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-12.54	-12.25	-4.29	-0.34	0.00	0.09	-0.37
1- 1	-13.35	-3.71	-1.30	-0.11	0.00	0.00	-0.33
1- 2	-14.15	2.83	0.99	0.07	0.00	0.00	-0.34
1- 3	-14.96	7.42	2.60	0.20	0.00	0.00	-0.35
1- 4	-15.76	10.14	3.55	0.28	0.00	0.00	-0.42
1- 5	-16.57	11.04	3.86	0.31	0.00	0.01	-0.50
1- 6	-17.37	10.17	3.56	0.29	0.00	0.06	-0.59
1- 7	-18.18	7.60	2.66	0.22	0.00	0.11	-0.69
1- 8	-18.99	3.39	1.19	0.11	0.00	0.17	-0.80
1- 9	-19.79	-2.40	-0.84	-0.06	0.00	0.24	-0.91
1-10	-20.60	-9.72	-3.40	-0.28	0.00	0.30	-1.01
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-20.60	-9.72	-3.40	-0.28	0.00	0.30	-1.01
2- 1	7.57	-8.27	-2.89	-0.24	0.00	0.33	-0.19
2- 2	28.04	-6.82	-2.39	-0.19	0.00	0.96	0.00
2- 3	40.81	-5.36	-1.88	-0.15	0.00	1.49	-0.09
2- 4	45.89	-3.91	-1.37	-0.11	0.00	1.79	-0.21
2- 5	43.28	-2.46	-0.86	-0.07	0.00	1.83	-0.34
2- 6	32.98	-1.01	-0.35	-0.03	0.00	1.63	-0.46
2- 7	14.98	0.44	0.16	0.01	0.00	1.17	-0.59
2- 8	-10.72	1.90	0.66	0.05	0.00	0.54	-0.75
2- 9	-44.10	3.35	1.17	0.10	0.00	0.11	-1.27
2-10	-85.19	4.80	1.68	0.14	0.00	0.00	-2.40
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	-0.13	-0.02	-0.01	-0.00	0.00	0.27	-0.28
3- 1	-0.10	-0.02	-0.01	-0.00	0.00	0.17	-0.17
3- 2	-0.08	-0.01	-0.00	-0.00	0.00	0.06	-0.06
3- 3	-0.05	-0.01	-0.00	-0.00	0.00	0.05	-0.05
3- 4	-0.03	-0.00	-0.00	-0.00	0.00	0.16	-0.16
3- 5	-0.00	-0.00	-0.00	-0.00	0.00	0.27	-0.27
3- 6	0.02	0.00	0.00	0.00	0.00	0.38	-0.37
3- 7	0.05	0.01	0.00	0.00	0.00	0.48	-0.48
3- 8	0.07	0.01	0.00	0.00	0.00	0.59	-0.59
3- 9	0.10	0.02	0.01	0.00	0.00	0.70	-0.70
3-10	0.13	0.02	0.01	0.00	0.00	0.81	-0.81
INTERIOR WALL TOP							

PAGE 16
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	-12.54	-12.25	-4.29	-0.34	0.00	0.09	-0.37
4- 1	15.17	-10.42	-3.65	-0.29	0.00	0.45	0.00
4- 2	34.93	-8.58	-3.00	-0.24	0.00	0.88	0.00
4- 3	46.74	-6.74	-2.36	-0.19	0.00	1.16	0.00
4- 4	50.61	-4.90	-1.71	-0.14	0.00	1.27	0.00
4- 5	46.54	-3.06	-1.07	-0.08	0.00	1.18	0.00
4- 6	34.51	-1.22	-0.43	-0.03	0.00	0.90	0.00
4- 7	14.55	0.62	0.22	0.02	0.00	0.43	0.00
4- 8	-13.37	2.46	0.86	0.07	0.00	0.02	-0.31
4- 9	-49.23	4.29	1.50	0.12	0.00	0.00	-1.15
4-10	-93.04	6.13	2.15	0.17	0.00	0.00	-2.20

BOTTOM SLAB RIGHT SIDE

PAGE 17
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-0.96	11.36	3.98	0.30	0.00	0.08	-0.13
1- 1	-0.96	8.95	3.13	0.24	0.00	0.08	-0.13
1- 2	-0.96	6.61	2.31	0.18	0.00	0.08	-0.13
1- 3	-0.96	4.33	1.52	0.13	0.00	0.08	-0.13
1- 4	-0.96	2.13	0.75	0.07	0.00	0.08	-0.13
1- 5	-0.96	0.01	0.00	0.01	0.00	0.08	-0.13
1- 6	-0.96	-2.05	-0.72	-0.05	0.00	0.08	-0.13
1- 7	-0.96	-4.04	-1.41	-0.11	0.00	0.08	-0.13
1- 8	-0.96	-5.96	-2.08	-0.17	0.00	0.08	-0.13
1- 9	-0.96	-7.80	-2.73	-0.23	0.00	0.08	-0.13
1-10	-0.96	-9.58	-3.35	-0.29	0.00	0.08	-0.13
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	20.01	0.91	0.32	0.03	0.00	0.80	-0.08
2- 1	15.20	0.91	0.32	0.03	0.00	0.60	-0.08
2- 2	10.39	0.91	0.32	0.03	0.00	0.47	-0.10
2- 3	5.58	0.91	0.32	0.03	0.00	0.35	-0.13
2- 4	0.77	0.91	0.32	0.03	0.00	0.24	-0.20
2- 5	-4.04	0.91	0.32	0.03	0.00	0.16	-0.29
2- 6	-8.85	0.91	0.32	0.03	0.00	0.09	-0.41
2- 7	-13.65	0.91	0.32	0.03	0.00	0.04	-0.54
2- 8	-18.46	0.91	0.32	0.03	0.00	0.02	-0.67
2- 9	-23.27	0.91	0.32	0.03	0.00	0.00	-0.80
2-10	-28.08	0.91	0.32	0.03	0.00	0.00	-0.87
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 1	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 2	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 3	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 4	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 5	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 6	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 7	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 8	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3- 9	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
3-10	0.03	0.00	0.00	0.00	0.00	0.13	-0.13
INTERIOR WALL TOP							

PAGE 18
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	19.80	1.15	0.40	0.03	0.00	0.48	0.00
4- 1	14.83	1.15	0.40	0.03	0.00	0.36	0.00
4- 2	9.87	1.15	0.40	0.03	0.00	0.24	0.00
4- 3	4.90	1.15	0.40	0.03	0.00	0.12	0.00
4- 4	-0.06	1.15	0.40	0.03	0.00	0.01	-0.01
4- 5	-5.03	1.15	0.40	0.03	0.00	0.00	-0.12
4- 6	-10.00	1.15	0.40	0.03	0.00	0.00	-0.24
4- 7	-14.96	1.15	0.40	0.03	0.00	0.00	-0.36
4- 8	-19.93	1.15	0.40	0.03	0.00	0.00	-0.48
4- 9	-24.90	1.15	0.40	0.03	0.00	0.00	-0.60
4-10	-29.86	1.15	0.40	0.03	0.00	0.00	-0.72

BOTTOM SLAB RIGHT SIDE

PAGE 19
DATE 10/27/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 1	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 2	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 3	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 4	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 5	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 6	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 7	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 8	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1- 9	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
1-10	-20.11	-0.91	-0.32	-0.03	0.00	0.08	-0.81
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 1	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 2	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 3	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 4	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 5	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 6	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 7	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 8	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2- 9	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
2-10	-1.02	-10.18	-3.56	-0.31	0.00	0.08	-0.13
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 1	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 2	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 3	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 4	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 5	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 6	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 7	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 8	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3- 9	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
3-10	-56.70	1.84	0.64	0.05	0.00	0.00	-1.55
INTERIOR WALL TOP							

PAGE 20
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 1	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 2	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 3	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 4	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 5	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 6	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 7	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 8	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4- 9	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08
4-10	0.96	-11.40	-3.99	-0.30	0.00	0.12	-0.08

BOTTOM SLAB RIGHT SIDE

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

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	0.000	23.92	0.81	Pass
EXTERIOR WALL	Middle -	0.000	23.77	2.33	Pass
EXTERIOR WALL	Top	0.000	23.81	1.87	Pass
TOP SLAB	Left	0.000	23.82	1.82	Pass
TOP SLAB	Middle +	0.000	23.82	1.84	Pass
BOTTOM SLAB	Left	0.000	23.93	0.68	Pass

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Truck (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	120.00000000	12.00000000	2.50000000	1.37593985	1676.09985352	8.00000000	4682.55517578	36.31502533
Top slab, inside face	120.00000000	16.00000000	2.50000000	1.26455021	1785.92846680	8.00000000	5086.09326172	37.09069443
Top slab, outside face	120.00000000	16.00000000	2.63500023	1.28165257	1972.71386719	6.00000000	5812.67919922	33.13494110
Bottom slab, outside corner	120.00000000	12.00000000	2.43750000	1.36414564	1838.49743652	7.00000000	5159.46044922	33.40453720
Bottom slab, inside face	120.00000000	18.00000000	2.50000000	1.23041475	1740.38708496	9.00000000	4858.95068359	39.11434174
Bottom slab, outside face	120.00000000	18.00000000	3.63500023	1.36149371	1843.56848145	6.00000000	4636.71972656	33.33459091
Ext. wall, outside face	120.00000000	12.00000000	2.25000000	1.32967031	1270.48193359	7.00000000	5491.66796875	49.54858780
Ext. wall, inside face	0.8*f _r > f _c , therefore no check necessary.							
Interior wall	0.8*f _r > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 16.000 feet
Percentage of main reinforcement required = 25.000% , less than or equal to 50%
Main reinforcement area (top slab) = 1.185 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 1.053 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE		Top slab CENTER	RIGHT SIDE		
area	1.1850 in ²	area	1.1850 in ²	area	2.5400 in ²
size	8 spaced at 8.00 in.	size	8 spaced at 8.00 in.	size	10 spaced at 6.00 in.

Exterior wall
TOP
area 1.1850 in²
size 8 spaced at 8.00 in.

Interior wall
TOP
area 0.2000 in²
size 4 spaced at 12.00 in.

INSIDE FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

EACH FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

OUTSIDE FACE
area 0.3429 in²
size 4 spaced at 7.00

BOTTOM
area 1.0286 in²
size 7 spaced at 7.00 in.

BOTTOM
area 0.2000 in²
size 4 spaced at 12.00 in.

LEFT SIDE		Bottom slab CENTER	RIGHT SIDE		
area	1.0286 in ²	area	1.0533 in ²	area	2.5400 in ²
size	7 spaced at 7.00 in.	size	8 spaced at 9.00 in.	size	10 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	225	8	STR	0- 0	0		
BOT SLAB (Inside)	A200	200	8	STR	0- 0	0		
TOP SLAB (Outside)	A300	300	10	STR	0- 0	0		
BOT SLAB (Outside)	A400	300	10	STR	0- 0	0		
CORNER (Top)	A1	450	8	L-BAR	10- 2	12215	5- 7	4- 7
CORNER (Bottom)	A2	516	7	L-BAR	7- 3	7645	3- 5	3-10
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	516	4	STR	0- 0	0		
INTWALL	B3	300	4	STR	0- 0	0		
LONGITUD.(3)	C1	342	4	STR	51- 1	11677		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		
Total weight black bars						33041		
Total weight all bars						33041		

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2
Bottom slab(s) = 0.1100 in2
Exterior wall(s) = 0.1100 in2

Interior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-23.193	-35.798	-19.592	-30.262	15.898	9.194
1- 1	-16.031	-24.291	-19.592	-30.262	12.370	6.914
1- 2	-9.154	-17.260	-20.071	-29.783	8.942	4.702
1- 3	-3.152	-14.049	-20.071	-29.783	5.615	2.556
1- 4	0.092	-12.700	-20.071	-29.783	2.389	0.477
1- 5	0.676	-13.093	-20.071	-29.783	-0.737	-1.535
1- 6	-1.255	-15.190	-20.071	-29.783	-2.699	-4.544
1- 7	-5.673	-18.905	-20.071	-29.783	-4.577	-7.470
1- 8	-12.505	-24.177	-20.071	-29.783	-6.388	-10.295
1- 9	-20.421	-32.195	-19.592	-30.262	-8.132	-13.019
1-10	-27.977	-44.263	-19.592	-30.262	-9.810	-15.643
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-27.977	-44.263	-10.434	-16.611	30.116	19.496
2- 1	3.124	-5.398	-10.867	-16.178	23.172	14.979
2- 2	33.593	0.000	-10.867	-16.178	16.372	10.437
2- 3	53.364	0.000	-10.867	-16.178	9.592	5.863
2- 4	62.231	0.000	-10.867	-16.178	2.838	1.216
2- 5	60.118	0.000	-10.867	-16.178	-2.167	-5.190
2- 6	47.047	0.000	-10.867	-16.178	-6.804	-11.967
2- 7	23.244	0.000	-16.237	-10.808	-11.405	-18.763
2- 8	-6.288	-14.213	-15.804	-11.241	-15.972	-25.570
2- 9	-36.274	-59.361	-15.804	-11.241	-20.511	-32.384
2-10	-72.920	-116.135	-15.804	-11.241	-25.029	-39.071
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.363	-0.722	-51.495	-77.521	0.287	-0.203
3- 1	0.192	-0.481	-51.495	-77.521	0.287	-0.203
3- 2	0.022	-0.239	-51.495	-77.521	0.287	-0.203
3- 3	0.033	-0.181	-51.495	-77.521	0.287	-0.203
3- 4	0.260	-0.337	-51.495	-77.521	0.287	-0.203
3- 5	0.488	-0.493	-54.680	-77.521	0.287	-0.203
3- 6	0.729	-0.663	-74.682	-54.334	0.287	-0.203
3- 7	0.970	-0.834	-74.682	-54.334	0.287	-0.203
3- 8	1.212	-1.005	-74.682	-54.334	0.287	-0.203
3- 9	1.454	-1.176	-74.682	-54.334	0.287	-0.203
3-10	1.695	-1.347	-74.682	-54.334	0.287	-0.203
INTERIOR WALL TOP						

For a HL-93-TANDEM Vehicle
Description AASHTO LRFD HL-93 Design Tandem (US)
The Number of axles = 2

Axle Weights (kips)	Spacing (ft)
25.00	4.000
25.00	0.000

Totals 50.00	4.000

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 1
Fill = 20.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 22.83 ft.
[slope(fill) + longitudinal tire patch]

Tire Contact Area = 200.0000 sq.in.
Tire patch Width = 20.00000 in.
Tire Patch Length = 10.00000 in.

Vehicle Axle number = 2
Fill = 20.00 ft.
Distribution slope = 1.10
LL Longitudinal Distribution Length = 22.83 ft.
[slope(fill) + longitudinal tire patch]

The number of simulated axles is calculated based on the longitudinal distribution length of each axle divided by the simulated axle spacing of 1 foot and the simulated axle weights are calculated by dividing the vehicle axle weights by the number of simulated axles per vehicle axle.

Note: Impact or distribution is not included in the above table.

147

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	0.000	23.92	0.81	Pass
EXTERIOR WALL	Middle -	0.000	23.78	2.24	Pass
EXTERIOR WALL	Top	0.000	23.83	1.75	Pass
TOP SLAB	Left	0.000	23.83	1.69	Pass
TOP SLAB	Middle +	0.000	23.84	1.63	Pass
BOTTOM SLAB	Left	0.000	23.93	0.67	Pass

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Tandem (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	120.00000000	12.00000000	2.50000000	1.37593985	1681.43798828	8.00000000	4682.55517578	36.20007324
Top slab, inside face	120.00000000	16.00000000	2.50000000	1.26455021	1795.23742676	8.00000000	5086.09326172	36.89889908
Top slab, outside face	120.00000000	16.00000000	2.63500023	1.28165257	1980.21936035	6.00000000	5812.67919922	33.00968552
Bottom slab, outside corner	120.00000000	12.00000000	2.43750000	1.36414564	1838.66735840	7.00000000	5159.46044922	33.40145874
Bottom slab, inside face	120.00000000	18.00000000	2.50000000	1.23041475	1746.26831055	9.00000000	4858.95068359	38.98298264
Bottom slab, outside face	120.00000000	18.00000000	3.63500023	1.36149371	1850.88781738	6.00000000	4636.71972656	33.20328522
Ext. wall, outside face	120.00000000	12.00000000	2.25000000	1.32967031	1273.58178711	7.00000000	5491.66796875	49.42841339
Ext. wall, inside face	0.8*f _r > f _c , therefore no check necessary.							
Interior wall	0.8*f _r > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 16.000 feet
Percentage of main reinforcement required = 25.000% , less than or equal to 50%
Main reinforcement area (top slab) = 1.185 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 1.053 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.
Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE		Top slab CENTER	RIGHT SIDE		
area	1.1850 in ²	area	1.1850 in ²	area	2.5400 in ²
size	8 spaced at 8.00 in.	size	8 spaced at 8.00 in.	size	10 spaced at 6.00 in.

Exterior wall TOP		Interior wall TOP	
area	1.1850 in ²	area	0.2000 in ²
size	8 spaced at 8.00 in.	size	4 spaced at 12.00 in.

INSIDE FACE		EACH FACE	
area	0.2000 in ²	area	0.2000 in ²
size	4 spaced at 12.00 in.	size	4 spaced at 12.00 in.

OUTSIDE FACE
area 0.3429 in²
size 4 spaced at 7.00

BOTTOM		BOTTOM	
area	1.0286 in ²	area	0.2000 in ²
size	7 spaced at 7.00 in.	size	4 spaced at 12.00 in.

LEFT SIDE		Bottom slab CENTER	RIGHT SIDE		
area	1.0286 in ²	area	1.0533 in ²	area	2.5400 in ²
size	7 spaced at 7.00 in.	size	8 spaced at 9.00 in.	size	10 spaced at 6.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	225	8	STR	0- 0	0		
BOT SLAB (Inside)	A200	200	8	STR	0- 0	0		
TOP SLAB (Outside)	A300	300	10	STR	0- 0	0		

BOT SLAB (Outside)	A400	300	10	STR	0- 0	0		
CORNER (Top)	A1	450	8	L-BAR	10- 2	12215	5- 7	4- 7
CORNER (Bottom)	A2	516	7	L-BAR	7- 3	7645	3- 5	3-10
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	516	4	STR	0- 0	0		
INTWALL	B3	300	4	STR	0- 0	0		
LONGITUD.(3)	C1	342	4	STR	51- 1	11677		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		

Total weight black bars	33041
Total weight all bars	33041

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in²

Bottom slab(s) = 0.1100 in²

Exterior wall(s) = 0.1100 in²

Interior wall(s) = 0.1100 in²

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-23.221	-35.797	-19.604	-30.082	15.897	9.223
1- 1	-16.028	-24.264	-19.604	-30.082	12.369	6.943
1- 2	-9.151	-17.154	-20.082	-29.604	8.942	4.730
1- 3	-3.150	-13.975	-20.082	-29.604	5.615	2.584
1- 4	0.093	-12.639	-20.082	-29.604	2.388	0.505
1- 5	0.673	-13.035	-20.082	-29.604	-0.738	-1.507
1- 6	-1.273	-15.107	-20.082	-29.604	-2.700	-4.515
1- 7	-5.699	-18.797	-20.082	-29.604	-4.578	-7.441
1- 8	-12.533	-24.044	-20.082	-29.604	-6.389	-10.266
1- 9	-20.453	-32.033	-19.604	-30.082	-8.133	-12.990
1-10	-28.011	-44.075	-19.604	-30.082	-9.811	-15.614
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-28.011	-44.075	-9.855	-15.681	29.935	19.508
2- 1	2.958	-5.333	-10.266	-15.271	23.007	14.993
2- 2	33.276	0.000	-10.266	-15.271	16.222	10.478
2- 3	52.985	0.000	-10.266	-15.271	9.466	5.919
2- 4	61.793	0.000	-10.266	-15.271	2.742	1.299
2- 5	59.676	0.000	-10.266	-15.271	-2.230	-5.069
2- 6	46.644	0.000	-10.266	-15.271	-6.840	-11.800
2- 7	22.919	0.000	-15.340	-10.197	-11.422	-18.563
2- 8	-6.498	-14.036	-14.929	-10.607	-15.978	-25.350
2- 9	-36.318	-58.976	-14.929	-10.607	-20.511	-32.160
2-10	-72.917	-115.543	-14.929	-10.607	-25.029	-38.853
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	0.321	-0.665	-51.494	-77.413	0.264	-0.183
3- 1	0.166	-0.443	-51.494	-77.413	0.264	-0.183
3- 2	0.012	-0.221	-51.494	-77.413	0.264	-0.183
3- 3	0.029	-0.170	-51.494	-77.413	0.264	-0.183
3- 4	0.238	-0.311	-51.494	-77.413	0.264	-0.183
3- 5	0.447	-0.452	-54.679	-77.413	0.264	-0.183
3- 6	0.668	-0.605	-74.681	-54.226	0.264	-0.183
3- 7	0.890	-0.760	-74.681	-54.226	0.264	-0.183
3- 8	1.112	-0.914	-74.681	-54.226	0.264	-0.183
3- 9	1.334	-1.068	-74.681	-54.226	0.264	-0.183
3-10	1.556	-1.223	-74.681	-54.226	0.264	-0.183
INTERIOR WALL TOP						

PAGE 33
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	-23.221	-35.797	-9.086	-14.624	29.442	19.675
4- 1	11.628	-1.053	-8.700	-15.011	22.483	15.012
4- 2	41.012	0.000	-8.700	-15.011	15.525	10.350
4- 3	59.304	0.000	-8.700	-15.011	8.566	5.687
4- 4	66.466	0.000	-8.700	-15.011	1.638	0.985
4- 5	62.494	0.000	-8.700	-15.011	-3.036	-5.962
4- 6	47.389	0.000	-8.700	-15.011	-7.699	-12.920
4- 7	21.515	0.000	-14.292	-9.419	-12.361	-19.879
4- 8	-8.925	-16.494	-14.678	-9.033	-17.024	-26.837
4- 9	-39.916	-64.924	-14.678	-9.033	-21.687	-33.796
4-10	-78.344	-124.550	-14.678	-9.033	-26.349	-40.754

BOTTOM SLAB RIGHT SIDE

Output complete for a HL-93-TANDEM

vehicle

Serviceability, Fatigue, and Other Checks

→ Based on crack control check
AASHTO 5.7.3.4 LRFD

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 Required (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	36.20	60.00	1.1238	1.1850	8	8.0	67	55
A2	33.40	60.00	0.9078	1.0286	7	7.0	41	46
A100	36.90	60.00	1.1140	1.1850	8	8.0		
A300	33.01	60.00	2.2960	2.5400	10	6.0		
A200	38.98	60.00	1.0415	1.0533	8	9.0		
A400	33.20	60.00	2.3052	2.5400	10	6.0		
B1	0.00	60.00	0.0106	0.2000	4	12.0		
B2	49.43	60.00	0.3309	0.3429	4	7.0		
B3	2.54	60.00	0.0010	0.2000	4	12.0		

USE #706"
 $A_s = 1.20 \text{ in}^2/\text{ft}$

USE #706" $A_s = 1.20 \text{ in}^2/\text{ft}$

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 it if should, this will control yielding under service loads.

Output at Critical Sections (per unit design width)

Member No. = 1 EXTERIOR WALL												
				Thickness	= 12.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (bot)	= 0.88 (in)							
				Bar diameter (mid+)	= 1.00 (in)							
				Bar diameter (mid-)	= 1.27 (in)							
				Bar diameter (top)	= 0.50 (in)							
	Moment	Coin. Axial	Shear	Shear	Po	Mu	Mbal	Pbal	Steel	Mom.	Des.	Design
	Kft	Force	Force	Cap	Cap	Cap	Cap	Cap	Area	Cap	Thk	Ratio
		Kips	Kips	Kips	Kips	Kft	Kft	Kips	In2	Kft	in	
BOT	-35.8	19.6	9.3	12.7	328.7	41.6	61.7	107.6	1.0286	41.6	9.56	0.9
MID	0.7	19.6	0.7	45.2	300.6	9.2	50.3	150.5	0.2000	9.2	9.75	0.1
MID-	-13.1	20.1	1.5	19.7	305.4	15.3	52.5	143.6	0.3429	15.3	9.75	0.9
TOP	-44.3	20.1	10.9	11.7	334.0	46.7	63.5	99.1	1.1850	46.7	9.50	0.9
Member No. = 2 TOP SLAB												
				Thickness	= 16.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (lt)	= 0.88 (in)							
				Bar diameter (mid)	= 1.00 (in)							
				Bar diameter (rt)	= 1.27 (in)							
LT	-44.3	10.4	22.9*	21.3	431.9	67.7	111.1	164.8	1.1850	67.7	13.50	0.7
MID	62.2	10.9	2.2	18.8	431.9	67.7	111.1	164.8	1.1850	67.7	13.50	0.9
RT	-116.1	10.9	32.1*	21.5	477.9	118.4	139.3	97.5	2.5400	118.4	13.36	1.0
Member No. = 3 INTERIOR WALL												
				Thickness	= 12.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (bot)	= 0.88 (in)							
				Bar diameter (mid+)	= 1.00 (in)							
				Bar diameter (mid-)	= 1.27 (in)							
				Bar diameter (top)	= 0.50 (in)							
BOT	-0.7	51.5	0.3	57.9	300.6	12.1	50.3	150.5	0.2000	12.1	9.75	0.1
MID	0.5	51.5	0.3	57.9	300.6	12.1	50.3	150.5	0.2000	12.1	9.75	0.0
MID-	-0.5	51.5	0.3	57.9	300.6	12.1	50.3	150.5	0.2000	12.1	9.75	0.0
TOP	-1.3	51.5	0.2	554.6	300.6	12.1	50.3	150.5	0.2000	12.1	9.75	0.1
Member No. = 4 BOTTOM SLAB												
				Thickness	= 18.00 (in)							
				Clear cover at end	= 3.00 (in)							
				Clear cover at middle	= 2.00 (in)							
				Bar diameter (lt)	= 0.88 (in)							
				Bar diameter (mid)	= 1.00 (in)							
				Bar diameter (rt)	= 1.27 (in)							
LT	-35.8	9.6	21.9	23.0	475.6	64.2	129.2	189.7	1.0286	64.2	14.56	0.6
MID	66.8	9.2	3.0	21.6	476.4	70.1	135.6	203.9	1.0533	70.1	15.50	1.0
RT	-125.2	9.2	33.3*	23.0	526.9	132.9	160.4	114.0	2.5400	132.9	14.36	0.9

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.

Volume of Concrete and Weight of Reinforcing Steel

Thickness				Volume (Cy/Ft)	Steel (Lb/Ft)
Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)		
16.00	18.00	12.00	12.00		

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	225	8	STR	32- 8	19625		
BOT SLAB (Inside)	A200	200	8	STR	32- 8	17444		
TOP SLAB (Outside)	A300	300	10	STR	32- 8	42171		
BOT SLAB (Outside)	A400	300	10	STR	32- 8	42171		
CORNER (Top)	A1	450	8	L-BAR	10- 2	12215	5- 7	4- 7
CORNER (Bottom)	A2	516	7	L-BAR	7- 3	7645	3- 5	3-10
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	516	4	STR	7- 0	2414		
INTWALL	B3	300	4	STR	9- 5	1888		
LONGITUD. (3)	C1	342	4	STR	51- 1	11677		
LONGITUD. (3)	C100	93	4	STR	51- 1	3175		
LONGITUD. (3)	C200	93	4	STR	51- 1	3175		

Total weight black bars	165104
Total weight all bars	165104

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in²
Bottom slab(s) = 0.1100 in²
Exterior wall(s) = 0.1100 in²

Interior wall(s) = 0.1100 in²

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

BRASS-CULVERT - (2) 15'x7' RCB w/ 33' Max Soil Cover

BRASS-CULVERT(LRFD) Version 2.3.6

DATE : 10/27/2014

TIME : 14:10:26

PAGE 1

Input Filename : F:\Projects\400\412-654\Division\Strl\Calcs\Centennial Double
15x7 - 33 feet.DAT
Output Filename : F:\Projects\400\412-654\Division\Strl\Calcs\Centennial Double
15x7 - 33 feet.xml
Output Filename for Live Loads : F:\Projects\400\412-654\Division\Strl\Calcs\Centennial Double
15x7 - 33 feet_LL.OUT

The following filenames may be used in this run

Live Load Influence Values File name : F:\Projects\400\412-
654\Division\Strl\Calcs\Centennial Double 15x7 - 33 feet_INF.OUT
Drawing File name : F:\Projects\400\412-
654\Division\Strl\Calcs\Centennial Double 15x7 - 33 feet.drw
Live Load Influence Ordinates File name : F:\Projects\400\412-
654\Division\Strl\Calcs\Centennial Double 15x7 - 33 feet.ill
Live Load Actions (w/o DF or IM) File name : F:\Projects\400\412-
654\Division\Strl\Calcs\Centennial Double 15x7 - 33 feet.oll
Intermediate Computations File name : F:\Projects\400\412-
654\Division\Strl\Calcs\Centennial Double 15x7 - 33 feet.ooo
Data Modelling File name : F:\Projects\400\412-
654\Division\Strl\Calcs\Centennial Double 15x7 - 33 feet.tmp

COMMENTS THIS FILE WAS CREATED BY THE BRASS-CULVERT GUI.
COMMENTS DO NOT EDIT THIS FILE!
COMMENTS JOB DESCRIPTION:
TITLE CENTENNIAL - DOUBLE 15' X 7' RCB
STRUCTID
AGENCY
COMMENTS 33' MAX SOIL COVER
UNITSIN US
UNITSOUT US
COMMENTS ANALYSIS CONTROL:
TYPE CIP
FUNCT DESIGN
LRFR NO
IRELEASE NO
IDSN LRFD
KBASE FULL
KHACH NO
EPOXY NO
EDGE-STRIP NO
LRFD-SHEAR 0
IFATIG YES
DNEG 0.0000
COMMENTS DESIGN CONTROL:
ISAMS NO
ISAMW NO
ADDS 1.0000
ADDW 1.0000
MAXSIZ 11
MINSIZ 4
SPCMAX 12.0000
SPCMIN 6.0000
ISPCGINC MAX
PAS 0.012000
CUSTOM STD
BAR_DE US
COMMENTS OUTPUT CONTROL:
MTEN YES
IBSH YES
IINFN NO
LIVELO NO

DEFAULTS	YES
LOOPS	NO
INTERMEDIATE	NO
COMMENTS	MATERIAL PROPERTIES:
FCONC	4500.000
CE	3865202.000
CWGT	150.000
COMMENTS	THE IGNORE CRACK CONTROL OPTION WAS SPECIFIED.
COMMENTS	THEREFORE, Z WILL BE SET TO A LARGE VALUE SO
COMMENTS	CRACK CONTROL WILL NOT BE CRITICAL
ZEE	20000.0
COMMENTS	THE IGNORE CRACK CONTROL OPTION WAS SPECIFIED.
COMMENTS	THEREFORE, EXPOSURE FACTOR WILL BE SET TO A LARGE
COMMENTS	VALUE SO CRACK CONTROL WILL NOT BE CRITICAL
EXP_FACTOR	120.0
GAMMA_MIN_RE_1	1.600
GAMMA_MIN_RE_3	0.750
EWGT	125.000
AWGT	145.000
FYST	60000.000
CN	7.5028
COMMENTS	BOX GEOMETRY:
NBOX	2
NSPAN	15.0000
NHITE	7.0000
LENG	150.0000
BWIDTH	150.0000
CBWIDTH	0.0000
TSLAB	20.0000
KFXTS	F
BSLAB	22.0000
KFXBS	F
WALLR	15.0000
KFXW	F
IWALLR	12.0000
KFXI	F
COMMENTS	SKEW:
CSKEW	0.0000
LSKEW	90.0000
RSKEW	90.0000
COMMENTS	CONCRETE COVER:

COVS	2.0000
COVB	3.0000
COVW	2.0000
COVIN	2.0000
COMMENTS	DEAD LOADS:
PRESS	100.000
PMIN	35.000
PWAT	0.000
NFILL	33.0000
NWEAR	6.0000
FILLFA	1.1000
TYFILL	COMPACT
COMMENTS	LIVE LOADS:
LVLD	HL-93-TRUCK
LVLD	HL-93-TANDEM
LVOMT	YES
LLPATCH	PL
SURCH_USE	YES
LIMIT_DIST	NO
LRFDDE	YES

End of Input File No. 1

=====

Note:

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

The first set are the variables defaulted from input and the second set are system variables.

Units

USSI_UNITS:	Input Units	=	US
USSI_UNITS_OU:	Output Units	=	US

Design Variables

LRFDFF:	Use LRFD method for bot slab load distrib.	=	T
CUTYPE:	Precast(PC) or Cast in Place(CIP) Culvert	=	CIP
IDSN:	Design Method	=	LRFD
FUNCT:	Design (DESIGN) or Design Review (DESREV)	=	DESIGN
IRELEASE:	Moment Continuity Released (@ end of walls)	=	F
DNEG:	Distance to Neg. Moment Computation Point	=	0.00
CUSTOM:	Default bar spacing and design check control	=	STD
ISAMS:	Design Same Top and Bottom Slab	=	F
ISAMW:	Design Same Interior-Exterior Wall	=	F

Output Control Variables

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

Standard Load Variables

LVLD:	Live Load Vehicle Name	=	HL-93-TRUCK
LVLD:	Live Load Vehicle Name	=	HL-93-TANDEM
LVOMT:	Neglect LL for Fill > 8Ft & Fill > Span	=	T

Uniform Dead Load Variable

EDLU:	Extra Uniform Dead Load (Lbs/Ft)	=	0.0
NWEAR:	Thickness of Wearing Surface (in)	=	6.0

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	=	2.0
PRESS:	Maximum Soil Equiv. Fluid Pressure(Pcf)	=	100.0
PMIN:	Minimum Soil Equiv. Fluid Pressure(Pcf)	=	35.0
PWAT:	Internal Water Pressure	=	0.0

Geometry - Box Dimension Variables

NBOX:	Number of Boxes (1 TO 4)	=	2
NSPAN:	Clear Span (Ft)	=	15.0
NHITE:	Clear Height (Ft)	=	7.0
NFILL:	Design Fill Measured from Top of Top Slab(Ft)	=	33.0
LENG:	Section length(PC)-Culvert Length(CIP) (Ft)	=	150.0

Geometry - Slab Thickness Variables

TSLAB:	Minimum Value for Top Slab (In)	=	20.0
KFXTS:	Code for Top Slab(F=Fixed,V=Variable)	=	F
BSLAB:	Minimum Value for Bottom Slab(In)	=	22.0
KFXBS:	Code for Bottom Slab(F=Fixed,V=Variable)	=	F
WALLR:	Minimum Value for Exterior Wall (In)	=	15.0
KFXW:	Code for Exterior Wall(F=Fixed,V=Variable)	=	F
IWALLR:	Minimum Value for Interior Wall(In)	=	12.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F
IWALLR:	Minimum Value for Interior Wall(In)	=	12.0
KFXI:	Code for Interior Wall(F=Fixed,V=Variable)	=	F

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)	=	0.0
BFILT:	Bottom Haunch (In)	=	0.0
KHACH:	Haunches used in Analysis (YES/NO)	=	NO

Geometry - Clear Concrete Cover

COVS:	Exterior Concrete Cover Top Slab (In)	=	2.0
COVB:	Exterior Concrete Cover Bottom Slab (In)	=	3.0
COVW:	Exterior Concrete Cover Walls (In)	=	2.0
COVIN:	Interior Concrete Cover (In)	=	2.0

Reinforcing Bar variables and Thickness Increment

SPCMAX:	Default Max. Bar Spacings (In)	=	12.0
SPCMIN:	Default Min. Bar Spacings (In)	=	6.0
MAXSIZ:	Default Bar Sizes(US)	=	11
MINSIZ:	Default Bar Sizes(US)	=	4
ISPCGINC:	Reinforcing Bar Minimum Increment	=	T
EPOXY:	Top Reinforcing Mat Epoxy Coated	=	F
ADDS:	Added Slab Thickness Increment(In)	=	1.0
ADDW:	Added Wall Thickness Increment(In)	=	1.0

Material Properties Variables

EWGT:	Weight of Soil (Pcf)	=	125.0
FYST:	Yield Strength of Reinf. Steel (Psi)	=	60000.0
FSTL:	Allowable Stress of Reinf. Steel(Psi)(ASD)	=	36000.0
FCONC:	Compressive Strength of Concrete (Psi)	=	4500.0
FSHR:	Shear in Concrete (Psi)(ASD)	=	0.0
FSTIR:	Allowable Stress in Stirrups (Psi)(ASD)	=	0.0
CWGT:	Weight of Concrete (Pcf)	=	150.0
AWGT:	Weight of Wearing Surface (Pcf)	=	145.0

ZEE:	Crack Width Parameter from AASHTO	=	20000.0
CN:	Modular Ratio of Concrete	=	7.5
CE:	Modulus of Elasticity of Concrete(ksi)	=	3865.2

ZEE:	Crack Width Parameter from AASHTO	=	0.9
CN:	Modular Ratio of Concrete	=	0.9
CE:	Modulus of Elasticity of Concrete(ksi)	=	

Service-I load and resistance factors

EV:	Vertical Earth Pressure max-min	1.00	1.00
DC:	Components max-min	1.00	1.00
DW:	Wearing Surfaces max-min	1.00	1.00
EH:	Horizontal Earth Pressure At-Rest	1.00	
LS:	Live load surcharge	1.00	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.00	

Strength-I load and resistance factors

EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.75	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.75	

Strength-II load and resistance factors

EV:	Vertical Earth Pressure max-min	1.30	0.90
DC:	Components max-min	1.25	0.90
DW:	Wearing Surfaces max-min	1.50	0.65
EH:	Horizontal Earth Pressure At-Rest	1.35	
LS:	Live load surcharge	1.35	
WA:	Water load and stream pressure	1.00	
LL:	Vehicular live load	1.35	

Fatigue load and resistance factors

EV:	Vertical Earth Pressure max-min	0.00	0.00
DC:	Components max-min	0.00	0.00
DW:	Wearing Surfaces max-min	0.00	0.00
EH:	Horizontal Earth Pressure At-Rest	0.00	
LS:	Live load surcharge	0.75	
WA:	Water load and stream pressure	0.00	
LL:	Vehicular live load	0.75	

BB:	Factor Load Factor Po and Pb AASHTO	=	0.80
BETAD:	Dead Load Multiplier for Load Factor	=	1.0000
BETAL:	Live Load Multiplier for Load Factor	=	0.0000
PHIMOM:	Phi Factor for Moment	=	0.9000
PHISHR:	Phi Factor for Shear	=	0.8500

BB:	Factor Load Factor Po and Pb AASHTO	=	1.30
BETAD:	Dead Load Multiplier for Load Factor	=	

HAFBAR:	Assumed Half a Bar Dia. of #6 Bar (In)	=	0.375
I300:	A300 and A400 Bars to TRUE	=	T
I400:	A300 and A400 Bars to TRUE	=	T
ICHANG:	Initial Settings	=	F
ICUT:	Cut Bars Due to Skew	=	T
ICUTSM:	Bar Cuts Symmetrical	=	F
IFIXB:	Defaults for Slab Thickness Incrementing	=	F
IFIXI:	Defaults for Wall Thickness Incrementing	=	F
IFIXT:	Defaults for Slab Thickness Incrementing	=	F
IFIXW:	Defaults for Wall Thickness Incrementing	=	F

PAGE 8
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

IFATIG:	Check Fatigue	=	F
IHAUCH:	Code for Considering Haunch in Analysis	=	F
ILES5:	Code for Span Less Than 5 ft	=	F
ISHR:	Code for Shear Stress Check	=	F

ILOOP:	Loop Counter for Design Iterations	=	0
INTERM_SWITCH:	Turn on Intermediate Results Output	=	F
ISTORE:	Design Moments to Zero	=	0
KPASS:	Variable Dimen (use in fixed thickness design)	=	VAR
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
PAS:	Maximum AS/BD Desired	=	0.012

JOB DESCRIPTION

Title : CENTENNIAL - DOUBLE 15' X 7' RCB
Structure ID :
Agency name : STD

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	DESIGN	NO	FULL	0.00

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

Design Method	Limit State Ductility	Load and Resistance Redundant	Factors Operations
LOAD & RES.	1.0000	1.0500	1.00

DESIGN CONTROLS

Design Same Thickness Slabs	Design Same Thickness Walls	Round-up Thicknesses (In)	Increment Walls (In)	Bar Spacing File
NO	NO	1.00	1.00	Standard

Bar Spacing Max (In)	US-Bar Size Min (In)	Bar Spacing Max (In)	Min (In)	Increment
12.0	6.0	11	4	1 INCH

OUTPUT CONTROLS

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

MATERIAL PROPERTIES

Concrete f'c (Psi)	Concrete Ec (Psi)	Crack Width Gamma E (Kip/in)	Steel Fy (Psi)	Steel n
4500.	3865202.	****	60000.	7.50

Note:

1. The concrete unit weight used for the Ec computation is 5 pcf less than used for load computations
2. The crack width coefficient is the coefficient in Eq. 5.7.3.4-2 for the crack width parameter Z

Unit Weights

Concrete (Pcf)	Soil Fill (Pcf)	Wearing Surface (Pcf)
150.	125.	145.

Note:

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

BOX GEOMETRY

Culvert Cells	Span Length (Ft)	Clear Height (Ft)	Centerline Length (Ft)
DOUBLE	15.00	7.00	150.00

Bridge Width (Ft)	Number of Traffic Lanes
150.00	1 and 2 lanes investigated

Slab and Wall Information

Top Slab (In)	Bottom Slab (In)	Exterior Wall (In)	Interior Wall (In)
20.00 Fixed	22.00 Fixed	15.00 Fixed	12.00 Fixed

LIVE LOADS

Vehicle Designation
HL-93-TRUCK
HL-93-TANDEM
Live Load Control: YES
(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 Pressure Max (Pcf) ****	Min (Pcf) 35.0	Water Density (Pcf) 0.0
--	----------------------	----------------------------------

Uniform Load (plf) 0.0	Wearing Surface Thickness (in) 6.00	Fill Height (Ft) 33.00
---------------------------------	---	---------------------------------

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)
0.0	0.0

CONCRETE COVER to face of bar			
Top	Bottom	Exterior	Interior
Slab	Slab	Wall	Wall
(In)	(In)	(In)	(In)
2.00	3.00	2.00	2.00

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 33.00	ft.
Span Length	= 15.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.10	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 44.87 ft.

Final Distribution Factor = $1/\text{Final Strip Width} = 0.022$ Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.027

Dynamic Load Allowance Calculation - Article 3.6.2.2

$IM = 33(1.0 - 1.25 D_e)$

$IM = 33(1.0 - 1.25(33.00))$

$IM = 0.0000$

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

Number of cells	=	2
Top Slab thickness	=	20.0000 In.
Bottom Slab thickness	=	22.0000 In.
Exterior Wall thickness	=	15.0000 In.
Interior wall thickness	=	12.00 In.
Design Span(c-c walls)	=	16.1250 Ft.
Design Height(c-c slabs)	=	8.7500 Ft.
Fill Height(top of slab)	=	33.0000 Ft.
Wearing surface thickness	=	6.0000 In.

Loads based on 1 foot unit width		
Soil Structure Interaction Factor	=	1.1500
Earth Weight for fill computations	=	0.1437 Kcf

Weight of Fill without wearing surface	=	4.6719 Klf
Weight of Wearing Surface	=	0.0725 Klf
Weight of Top Slab	=	0.2500 Klf
Weight of Extra Uniform Dead Load	=	0.0000 Klf
Uniform Dead Load on Top Slab	=	4.9944 Klf

Weight of Walls divided by culvert width	=	0.1140 Klf
Uniform Dead Load on Bottom Slab	=	5.1083 Klf

Soil pressure at center of top slab	=	3.3833 Klf
Soil pressure at center of bottom slab	=	4.2583 Klf
Soil pressure due to live load surcharge	=	0.0700 Klf

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

Axle Load Distribution Factor on:		
Top Slab & Walls	=	0.0267
on Bottom Slab	=	0.0267

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 AASHTO LRFD 4.6.2.10 for fill depth less than 2 ft. and AASHTO LRFD 3.6.1.2.6 for fill depths over 2 ft. Also, see 3.6.1.3.3.

No live load used
Fill greater than 8 feet and span length

Factors for Ductility	1.00
Redundancy	1.05
Operations	1.00

Design Iteration Loop Number 1

PAGE 13
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored MOMENTS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load Kft	Soil Press (Max) Kft	Soil Press (Min) Kft	Surch Hgt. Kft	Water Press (Max) Kft	LIVE Pos Kft	LOADS Neg Kft
EXTERIOR WALL BOTTOM							
1- 0	-21.97	-20.00	-7.00	-0.36	0.00	0.00	0.00
1- 1	-23.22	-6.08	-2.13	-0.12	0.00	0.00	0.00
1- 2	-24.47	4.65	1.63	0.08	0.00	0.00	0.00
1- 3	-25.72	12.26	4.29	0.22	0.00	0.00	0.00
1- 4	-26.97	16.81	5.88	0.30	0.00	0.00	0.00
1- 5	-28.21	18.36	6.43	0.34	0.00	0.00	0.00
1- 6	-29.46	16.99	5.95	0.32	0.00	0.00	0.00
1- 7	-30.71	12.76	4.47	0.24	0.00	0.00	0.00
1- 8	-31.96	5.74	2.01	0.11	0.00	0.00	0.00
1- 9	-33.21	-4.01	-1.40	-0.07	0.00	0.00	0.00
1-10	-34.46	-16.41	-5.74	-0.30	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-34.46	-16.41	-5.74	-0.30	0.00	0.00	0.00
2- 1	13.15	-13.96	-4.89	-0.26	0.00	0.00	0.00
2- 2	47.78	-11.52	-4.03	-0.21	0.00	0.00	0.00
2- 3	69.42	-9.07	-3.18	-0.17	0.00	0.00	0.00
2- 4	78.07	-6.63	-2.32	-0.12	0.00	0.00	0.00
2- 5	73.73	-4.18	-1.46	-0.08	0.00	0.00	0.00
2- 6	56.41	-1.73	-0.61	-0.03	0.00	0.00	0.00
2- 7	26.11	0.71	0.25	0.01	0.00	0.00	0.00
2- 8	-17.19	3.16	1.11	0.06	0.00	0.00	0.00
2- 9	-73.46	5.60	1.96	0.10	0.00	0.00	0.00
2-10	-142.73	8.05	2.82	0.15	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	-0.17	-0.06	-0.02	-0.00	0.00	0.00	0.00
3- 1	-0.14	-0.05	-0.02	-0.00	0.00	0.00	0.00
3- 2	-0.10	-0.03	-0.01	-0.00	0.00	0.00	0.00
3- 3	-0.07	-0.02	-0.01	-0.00	0.00	0.00	0.00
3- 4	-0.03	-0.01	-0.00	-0.00	0.00	0.00	0.00
3- 5	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
3- 6	0.03	0.01	0.00	0.00	0.00	0.00	0.00
3- 7	0.07	0.02	0.01	0.00	0.00	0.00	0.00
3- 8	0.10	0.03	0.01	0.00	0.00	0.00	0.00
3- 9	0.13	0.05	0.02	0.00	0.00	0.00	0.00
3-10	0.17	0.06	0.02	0.00	0.00	0.00	0.00
INTERIOR WALL TOP							

PAGE 14
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	-21.97	-20.00	-7.00	-0.36	0.00	0.00	0.00
4- 1	24.49	-17.00	-5.95	-0.31	0.00	0.00	0.00
4- 2	57.67	-14.00	-4.90	-0.25	0.00	0.00	0.00
4- 3	77.57	-11.00	-3.85	-0.20	0.00	0.00	0.00
4- 4	84.19	-8.00	-2.80	-0.15	0.00	0.00	0.00
4- 5	77.52	-5.00	-1.75	-0.09	0.00	0.00	0.00
4- 6	57.57	-2.00	-0.70	-0.04	0.00	0.00	0.00
4- 7	24.34	1.00	0.35	0.02	0.00	0.00	0.00
4- 8	-22.17	4.00	1.40	0.07	0.00	0.00	0.00
4- 9	-81.97	7.00	2.45	0.13	0.00	0.00	0.00
4-10	-155.05	10.00	3.50	0.18	0.00	0.00	0.00

BOTTOM SLAB RIGHT SIDE

PAGE 15
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored SHEARS (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-1.43	17.77	6.22	0.31	0.00	0.00	0.00
1- 1	-1.43	14.08	4.93	0.25	0.00	0.00	0.00
1- 2	-1.43	10.47	3.66	0.19	0.00	0.00	0.00
1- 3	-1.43	6.93	2.43	0.13	0.00	0.00	0.00
1- 4	-1.43	3.47	1.22	0.07	0.00	0.00	0.00
1- 5	-1.43	0.09	0.03	0.01	0.00	0.00	0.00
1- 6	-1.43	-3.21	-1.12	-0.05	0.00	0.00	0.00
1- 7	-1.43	-6.44	-2.25	-0.12	0.00	0.00	0.00
1- 8	-1.43	-9.59	-3.36	-0.18	0.00	0.00	0.00
1- 9	-1.43	-12.67	-4.43	-0.24	0.00	0.00	0.00
1-10	-1.43	-15.67	-5.48	-0.30	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	33.55	1.52	0.53	0.03	0.00	0.00	0.00
2- 1	25.50	1.52	0.53	0.03	0.00	0.00	0.00
2- 2	17.45	1.52	0.53	0.03	0.00	0.00	0.00
2- 3	9.39	1.52	0.53	0.03	0.00	0.00	0.00
2- 4	1.34	1.52	0.53	0.03	0.00	0.00	0.00
2- 5	-6.71	1.52	0.53	0.03	0.00	0.00	0.00
2- 6	-14.77	1.52	0.53	0.03	0.00	0.00	0.00
2- 7	-22.82	1.52	0.53	0.03	0.00	0.00	0.00
2- 8	-30.87	1.52	0.53	0.03	0.00	0.00	0.00
2- 9	-38.93	1.52	0.53	0.03	0.00	0.00	0.00
2-10	-46.98	1.52	0.53	0.03	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 1	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 2	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 3	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 4	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 5	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 6	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 7	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 8	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3- 9	0.04	0.01	0.00	0.00	0.00	0.00	0.00
3-10	0.04	0.01	0.00	0.00	0.00	0.00	0.00
INTERIOR WALL TOP							

DATE 10/27/2014

BRASS-CULVERT(LRFD) Version 2.3.6

CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	32.93	1.86	0.65	0.03	0.00	0.00	0.00
4- 1	24.70	1.86	0.65	0.03	0.00	0.00	0.00
4- 2	16.46	1.86	0.65	0.03	0.00	0.00	0.00
4- 3	8.22	1.86	0.65	0.03	0.00	0.00	0.00
4- 4	-0.02	1.86	0.65	0.03	0.00	0.00	0.00
4- 5	-8.25	1.86	0.65	0.03	0.00	0.00	0.00
4- 6	-16.49	1.86	0.65	0.03	0.00	0.00	0.00
4- 7	-24.73	1.86	0.65	0.03	0.00	0.00	0.00
4- 8	-32.96	1.86	0.65	0.03	0.00	0.00	0.00
4- 9	-41.20	1.86	0.65	0.03	0.00	0.00	0.00
4-10	-49.44	1.86	0.65	0.03	0.00	0.00	0.00

BOTTOM SLAB RIGHT SIDE

PAGE 17
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Current Live Load: HL-93-TRUCK

Unfactored AXIAL FORCES (per unit design width)
due to Dead and Live Loads including Distribution and Impact

M-PT	Dead Load K	Soil Press (Max) K	Soil Press (Min) K	Surch Hgt. K	Water Press (Max) K	LIVE Pos K	LOADS Neg K
EXTERIOR WALL BOTTOM							
1- 0	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 1	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 2	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 3	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 4	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 5	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 6	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 7	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 8	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1- 9	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
1-10	-32.52	-1.47	-0.51	-0.03	0.00	0.00	0.00
EXTERIOR WALL TOP							
TOP SLAB LEFT SIDE							
2- 0	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 1	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 2	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 3	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 4	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 5	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 6	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 7	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 8	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2- 9	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
2-10	-1.51	-16.60	-5.81	-0.32	0.00	0.00	0.00
TOP SLAB RIGHT SIDE							
INTERIOR WALL BOTTOM							
3- 0	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 1	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 2	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 3	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 4	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 5	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 6	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 7	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 8	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3- 9	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
3-10	-87.01	2.82	0.99	0.05	0.00	0.00	0.00
INTERIOR WALL TOP							

PAGE 18
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

BOTTOM SLAB LEFT SIDE

4- 0	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 1	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 2	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 3	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 4	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 5	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 6	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 7	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 8	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4- 9	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00
4-10	1.36	-16.94	-5.93	-0.30	0.00	0.00	0.00

BOTTOM SLAB RIGHT SIDE

Factors for Ductility 1.00
Redundancy 1.05
Operations 1.00

PAGE 19
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

No Fatigue Checks Required for this Live Load

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Truck (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	120.00000000	15.00000000	2.56400013	1.29453659	1828.53771973	8.00000000	4923.64306641	35.38708496
Top slab, inside face	120.00000000	20.00000000	2.56399918	1.21007431	1869.49865723	8.00000000	5258.37988281	37.02989197
Top slab, outside face	120.00000000	20.00000000	2.70499992	1.22343373	1741.70520020	7.00000000	5530.77441406	39.29861832
Bottom slab, outside corner	120.00000000	15.00000000	2.50000000	1.28571427	1778.25708008	8.00000000	5004.37451172	36.63708115
Bottom slab, inside face	120.00000000	22.00000000	2.56399918	1.18845725	1764.89855957	9.00000000	4982.17480469	39.93152618
Bottom slab, outside face	120.00000000	22.00000000	3.70499992	1.28930616	1614.25048828	7.00000000	4510.86621094	40.17568207
Ext. wall, outside face	120.00000000	15.00000000	2.31250000	1.26038003	1276.83349609	9.00000000	4873.67675781	52.00836945
Ext. wall, inside face	0.8*f _t > f _c , therefore no check necessary.							
Interior wall	0.8*f _t > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 16.125 feet
Percentage of main reinforcement required = 24.903% , less than or equal to 50%
Main reinforcement area (top slab) = 1.500 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 1.333 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE	Top slab CENTER	RIGHT SIDE
area 1.5000 in ²	area 1.5000 in ²	area 2.6743 in ²
size 9 spaced at 8.00 in.	size 9 spaced at 8.00 in.	size 11 spaced at 7.00 in.

Exterior wall
TOP
area 1.5000 in²
size 9 spaced at 8.00 in.

Interior wall
TOP
area 0.2000 in²
size 4 spaced at 12.00 in.

INSIDE FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

EACH FACE
area 0.2000 in²
size 4 spaced at 12.00 in.

OUTSIDE FACE
area 0.4133 in²
size 5 spaced at 9.00

BOTTOM
area 1.1850 in²
size 8 spaced at 8.00 in.

BOTTOM
area 0.2000 in²
size 4 spaced at 12.00 in.

LEFT SIDE	Bottom slab CENTER	RIGHT SIDE
area 1.1850 in ²	area 1.3333 in ²	area 2.6743 in ²
size 8 spaced at 8.00 in.	size 9 spaced at 9.00 in.	size 11 spaced at 7.00 in.

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	225	9	STR	0- 0	0		
BOT SLAB (Inside)	A200	200	9	STR	0- 0	0		
TOP SLAB (Outside)	A300	258	11	STR	0- 0	0		
BOT SLAB (Outside)	A400	258	11	STR	0- 0	0		
CORNER (Top)	A1	450	9	L-BAR	12- 4	18868	6- 9	5- 7
CORNER (Bottom)	A2	450	8	L-BAR	9- 0	10814	4- 3	4- 9
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	400	5	STR	0- 0	0		
INTWALL	B3	300	4	STR	0- 0	0		
LONGITUD.(3)	C1	351	4	STR	51- 1	11985		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		

Total weight black bars	43171
Total weight all bars	43171

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2

Bottom slab(s) = 0.1100 in2

Exterior wall(s) = 0.1100 in2

Interior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

PAGE 23
DATE 10/27/2014
BRASS-CULVERT(LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

Factored Actions for Load and Resistance 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	-39.585	-59.000	-31.998	-46.496	24.414	14.841
1- 1	-27.601	-40.510	-31.998	-46.496	19.074	11.356
1- 2	-16.295	-28.984	-32.742	-45.751	13.843	7.944
1- 3	-6.432	-23.500	-32.742	-45.751	8.720	4.603
1- 4	-1.003	-20.907	-32.742	-45.751	3.706	1.336
1- 5	0.085	-21.142	-32.742	-45.751	-1.200	-1.860
1- 6	-3.072	-24.141	-32.742	-45.751	-4.380	-6.601
1- 7	-10.379	-29.841	-32.742	-45.751	-7.430	-11.290
1- 8	-21.741	-38.179	-32.742	-45.751	-10.409	-15.870
1- 9	-35.046	-51.110	-31.998	-46.496	-13.315	-20.342
1-10	-47.941	-70.826	-31.998	-46.496	-16.149	-24.705
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-47.941	-70.826	-17.110	-26.175	47.976	33.016
2- 1	4.748	-7.886	-17.749	-25.536	36.989	25.435
2- 2	54.296	0.000	-17.749	-25.536	26.002	17.855
2- 3	86.127	0.000	-17.749	-25.536	15.015	10.274
2- 4	100.242	0.000	-17.749	-25.536	4.028	2.694
2- 5	96.641	0.000	-17.749	-25.536	-4.119	-7.727
2- 6	75.324	0.000	-17.749	-25.536	-11.699	-18.713
2- 7	36.651	0.000	-26.175	-17.110	-19.279	-29.700
2- 8	-11.592	-20.460	-25.536	-17.749	-26.860	-40.687
2- 9	-61.015	-94.926	-25.536	-17.749	-34.440	-51.674
2-10	-122.662	-187.108	-25.536	-17.749	-42.021	-62.661
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	-0.213	-0.316	-79.234	-114.607	0.072	0.048
3- 1	-0.170	-0.253	-79.234	-114.607	0.072	0.048
3- 2	-0.128	-0.190	-79.234	-114.607	0.072	0.048
3- 3	-0.086	-0.127	-79.234	-114.607	0.072	0.048
3- 4	-0.043	-0.064	-79.234	-114.607	0.072	0.048
3- 5	-0.001	-0.001	-82.614	-114.607	0.072	0.048
3- 6	0.062	0.000	-114.607	-79.234	0.072	0.048
3- 7	0.125	0.000	-114.607	-79.234	0.072	0.048
3- 8	0.188	0.000	-114.607	-79.234	0.072	0.048
3- 9	0.250	0.000	-114.607	-79.234	0.072	0.048
3-10	0.313	0.000	-114.607	-79.234	0.072	0.048
INTERIOR WALL TOP						

BOTTOM SLAB LEFT SIDE

4- 0	-39.585	-59.000	-14.730	-22.709	47.628	32.757
4- 1	17.344	-1.619	-14.154	-23.285	36.391	25.004
4- 2	65.446	0.000	-14.154	-23.285	25.153	17.250
4- 3	95.427	0.000	-14.154	-23.285	13.916	9.497
4- 4	107.288	0.000	-14.154	-23.285	2.685	1.737
4- 5	101.029	0.000	-14.154	-23.285	-5.069	-9.501
4- 6	76.649	0.000	-14.154	-23.285	-12.822	-20.738
4- 7	34.653	0.000	-22.709	-14.730	-20.575	-31.976
4- 8	-15.071	-26.473	-23.285	-14.154	-28.329	-43.213
4- 9	-67.003	-105.214	-23.285	-14.154	-36.082	-54.451
4-10	-131.436	-202.076	-23.285	-14.154	-43.836	-65.688

BOTTOM SLAB RIGHT SIDE

Output complete for a HL-93-TRUCK vehicle

LRFD Live Load Distribution Factor Computation

Input Values

Depth of Fill	= 33.00	ft.
Span Length	= 15.00	ft.
Truck Gage	= 6.00	ft.
Soil Distribution Factor	= 1.10	
Tire Patch Width	= 20.00	in.
Bridge Width	= 150.00	ft.
Length	= 150.00	ft.

Fill greater than 2 feet - Article 3.6.1.2.6

Use greater strip width between 4.6.2.10 and 3.6.1.2.6 (use better distribution)

Controlling Distribution Factor

Final Strip Width = 44.87 ft.

Final Distribution Factor = 1/Final Strip Width = 0.022 Lanes per ft. of width

Multiple Presence Factor = 1.20

Distribution Factor * Multiple Presence Factor = 0.027

Dynamic Load Allowance Calculation - Article 3.6.2.2

IM = 33(1.0 - 1.25 D_e)

IM = 33(1.0 - 1.25(33.00))

IM = 0.0000

Notes:

1. Only the one lane loaded case is considered for 4.6.2.10, which provides an upper bound on the distribution plus multiple presence factor for all cases. The one lane loaded multiple presence factor is used. See 12.11.2.1, 3.6.1.3.3, and 4.6.2.10.
2. Lane loads are not applied. See 3.6.1.3.3. This applies to all approximate strip methods.
3. The distribution factor for fills of 2 feet or greater is bounded by the distribution factor computed in 4.6.2.10. See 3.6.1.2.6.

No live load used

Fill greater than 8 feet and span length

Factors for Ductility	1.00
Redundancy	1.05
Operations	1.00

PAGE 25
DATE 10/27/2014
BRASS-CULVERT (LRFD) Version 2.3.6
CENTENNIAL - DOUBLE 15' X 7' RCB

No Fatigue Checks Required for this Live Load

LRFD Crack Control Computation

Current Vehicle: AASHTO LRFD HL-93 Design Tandem (US)

Location	γ_c	h (in.)	d_c (in.)	β_s	Max Spacing (in.)	Current Spacing (in.)	Allowable Stress (kip)	Actual Stress (kip)
Top slab, outside corner	120.00000000	15.00000000	2.56400013	1.29453659	1828.53771973	8.00000000	4923.64306641	35.38708496
Top slab, inside face	120.00000000	20.00000000	2.56399918	1.21007431	1869.49865723	8.00000000	5258.37988281	37.02989197
Top slab, outside face	120.00000000	20.00000000	2.70499992	1.22343373	2023.64831543	6.00000000	6013.72216797	33.83797073
Bottom slab, outside corner	120.00000000	15.00000000	2.50000000	1.28571427	1778.25708008	8.00000000	5004.37451172	36.63708115
Bottom slab, inside face	120.00000000	22.00000000	2.56399918	1.18845725	1764.89855957	9.00000000	4982.17480469	39.93152618
Bottom slab, outside face	120.00000000	22.00000000	3.70499992	1.28930616	1876.03454590	6.00000000	4841.38427734	34.59157944
Ext. wall, outside face	120.00000000	15.00000000	2.31250000	1.26038003	1276.83349609	9.00000000	4873.67675781	52.00836945
Ext. wall, inside face	0.8*f _r > f _c , therefore no check necessary.							
Interior wall	0.8*f _r > f _c , therefore no check necessary.							

Lateral Distribution Steel:

Span Length = 16.125 feet
Percentage of main reinforcement required = 24.903% , less than or equal to 50%
Main reinforcement area (top slab) = 1.500 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C100) = # 4
Spacing (C100) = 12.000 in
Area of steel (C100) = 0.200 in²
Main reinforcement area (bottom slab) = 1.333 in²
Required lateral distribution area = 0.000 in²
Because the required area is less than the minimum, an area of steel of 0.200 in² is used.

Bar size (C200) = # 4
Spacing (C200) = 12.000 in
Area of steel (C200) = 0.200 in²

Bar sizes and spacings with computed areas of steel

Areas of steel are in in²/ft

LEFT SIDE area 1.5000 in² size 9 spaced at 8.00 in.	Top slab CENTER area 1.5000 in² size 9 spaced at 8.00 in.	RIGHT SIDE area 3.1200 in² size 11 spaced at 6.00 in.
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Exterior wall

TOP

area 1.5000 in²

size 9 spaced at 8.00 in.

Interior wall

TOP

area 0.2000 in²

size 4 spaced at 12.00 in.

INSIDE FACE

area 0.2000 in²

size 4 spaced at 12.00 in.

EACH FACE

area 0.2000 in²

size 4 spaced at 12.00 in.

OUTSIDE FACE

area 0.4133 in²

size 5 spaced at 9.00

BOTTOM

area 1.1850 in²

size 8 spaced at 8.00 in.

BOTTOM

area 0.2000 in²

size 4 spaced at 12.00 in.

			Bottom slab					
LEFT SIDE area 1.1850 in² size 8 spaced at 8.00 in.	CENTER area 1.3333 in² size 9 spaced at 9.00 in.	RIGHT SIDE area 3.1200 in² size 11 spaced at 6.00 in.						

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	225	9	STR	0- 0	0		
BOT SLAB (Inside)	A200	200	9	STR	0- 0	0		
TOP SLAB (Outside)	A300	300	11	STR	0- 0	0		

BOT SLAB (Outside)	A400	300	11	STR	0- 0	0		
CORNER (Top)	A1	450	9	L-BAR	12- 4	18868	6- 9	5- 7
CORNER (Bottom)	A2	450	8	L-BAR	9- 0	10814	4- 3	4- 9
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	400	5	STR	0- 0	0		
INTWALL	B3	300	4	STR	0- 0	0		
LONGITUD.(3)	C1	351	4	STR	51- 1	11985		
LONGITUD.(3)	C100	0	4	STR	51- 1	0		
LONGITUD.(3)	C200	0	4	STR	51- 1	0		

Total weight black bars	43171
Total weight all bars	43171

The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in2
 Bottom slab(s) = 0.1100 in2
 Exterior wall(s) = 0.1100 in2

Interior wall(s) = 0.1100 in2

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533

Factored Actions for Load and Resistance 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	-39.585	-59.000	-31.998	-46.496	24.414	14.841
1- 1	-27.601	-40.510	-31.998	-46.496	19.074	11.356
1- 2	-16.295	-28.984	-32.742	-45.751	13.843	7.944
1- 3	-6.432	-23.500	-32.742	-45.751	8.720	4.603
1- 4	-1.003	-20.907	-32.742	-45.751	3.706	1.336
1- 5	0.085	-21.142	-32.742	-45.751	-1.200	-1.860
1- 6	-3.072	-24.141	-32.742	-45.751	-4.380	-6.601
1- 7	-10.379	-29.841	-32.742	-45.751	-7.430	-11.290
1- 8	-21.741	-38.179	-32.742	-45.751	-10.409	-15.870
1- 9	-35.046	-51.110	-31.998	-46.496	-13.315	-20.342
1-10	-47.941	-70.826	-31.998	-46.496	-16.149	-24.705
EXTERIOR WALL TOP						
TOP SLAB LEFT SIDE						
2- 0	-47.941	-70.826	-17.110	-26.175	47.976	33.016
2- 1	4.748	-7.886	-17.749	-25.536	36.989	25.435
2- 2	54.296	0.000	-17.749	-25.536	26.002	17.855
2- 3	86.127	0.000	-17.749	-25.536	15.015	10.274
2- 4	100.242	0.000	-17.749	-25.536	4.028	2.694
2- 5	96.641	0.000	-17.749	-25.536	-4.119	-7.727
2- 6	75.324	0.000	-17.749	-25.536	-11.699	-18.713
2- 7	36.651	0.000	-26.175	-17.110	-19.279	-29.700
2- 8	-11.592	-20.460	-25.536	-17.749	-26.860	-40.687
2- 9	-61.015	-94.926	-25.536	-17.749	-34.440	-51.674
2-10	-122.662	-187.108	-25.536	-17.749	-42.021	-62.661
TOP SLAB RIGHT SIDE						
INTERIOR WALL BOTTOM						
3- 0	-0.213	-0.316	-79.234	-114.607	0.072	0.048
3- 1	-0.170	-0.253	-79.234	-114.607	0.072	0.048
3- 2	-0.128	-0.190	-79.234	-114.607	0.072	0.048
3- 3	-0.086	-0.127	-79.234	-114.607	0.072	0.048
3- 4	-0.043	-0.064	-79.234	-114.607	0.072	0.048
3- 5	-0.001	-0.001	-82.614	-114.607	0.072	0.048
3- 6	0.062	0.000	-114.607	-79.234	0.072	0.048
3- 7	0.125	0.000	-114.607	-79.234	0.072	0.048
3- 8	0.188	0.000	-114.607	-79.234	0.072	0.048
3- 9	0.250	0.000	-114.607	-79.234	0.072	0.048
3-10	0.313	0.000	-114.607	-79.234	0.072	0.048
INTERIOR WALL TOP						

BOTTOM SLAB LEFT SIDE

4- 0	-39.585	-59.000	-14.730	-22.709	47.628	32.757
4- 1	17.344	-1.619	-14.154	-23.285	36.391	25.004
4- 2	65.446	0.000	-14.154	-23.285	25.153	17.250
4- 3	95.427	0.000	-14.154	-23.285	13.916	9.497
4- 4	107.288	0.000	-14.154	-23.285	2.685	1.737
4- 5	101.029	0.000	-14.154	-23.285	-5.069	-9.501
4- 6	76.649	0.000	-14.154	-23.285	-12.822	-20.738
4- 7	34.653	0.000	-22.709	-14.730	-20.575	-31.976
4- 8	-15.071	-26.473	-23.285	-14.154	-28.329	-43.213
4- 9	-67.003	-105.214	-23.285	-14.154	-36.082	-54.451
4-10	-131.436	-202.076	-23.285	-14.154	-43.836	-65.688

BOTTOM SLAB RIGHT SIDE

Output complete for a HL-93-TANDEM vehicle

Serviceability, Fatigue, and Other Checks

→ Based on crack control check
AASHTO 5.7.3.4 LRFD

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 Required (In2)	Area steel Provided (In2)	Size US Bars	Spacing (In)	H (In)	V (In)
A1	35.39	60.00	1.3694	1.5000	9	8.0	81	67
A2	36.64	60.00	1.1397	1.1850	8	8.0	51	57
A100 *	37.03	60.00	1.3862	1.5000	9	8.0		
A300 **	33.84	60.00	2.5964	3.1200	11	6.0		
A200 *	39.93	60.00	1.3317	1.3333	9	9.0		
A400 **	34.59	60.00	2.6529	3.1200	11	6.0		
B1	0.00	60.00	0.0026	0.2000	4	12.0		
B2	52.01	60.00	0.4072	0.4133	5	9.0		
B3	0.24	60.00	0.0010	0.2000	4	12.0		

} Use #8 @ 6"
 $A_s = 1.57 \text{ in}^2/\text{ft}$

* For A100 and A200, Use #8 @ 12" + #7 @ 12"

$$A_s = 0.79 + 0.60 = 1.39 \text{ in}^2/\text{ft}$$

** For A300 and A400, Use #11 @ 12" + #10 @ 12"

$$A_s = 1.56 + 1.27 = 2.83 \text{ in}^2/\text{ft} - \text{SEE CALC}$$

ON FOLLOWING
PAGE

Concrete Beam Design

Used to determine reinforcing requirements

Factored Moment, Mu =	202.70	k*ft
Depth of beam or thickness of slab =	22.0	inches
Width of Beam, b =	12.0	inches
Size of Rebar =	11	
Clearance to Reinforcing =	3.0	inches

$$d = 18.295 \text{ inches}$$

$$\phi = 0.90$$

$$f_c = 4000 \text{ psi}$$

$$f_y = 60000 \text{ psi}$$

$$R = Mu / (\phi * b * d^2)$$

$$= (202.70 * 12000) / (0.9 * 12 * 18.30^2)$$

$$= 672.89$$

$$m = f_y / 0.85 * f_c$$

$$= 60000 / 0.85 * 4000$$

$$= 17.65$$

$$\rho = 1/m (1 - \sqrt{1 - 2mR / f_y})$$

$$= (1 / 17.65) * (1 - \sqrt{1 - (2 * 17.65 * 672.89 / 60000)})$$

$$= 0.01262$$

$$\text{Min } \rho = 3 * \sqrt{f_c} / f_y \text{ but not less than } 200 / f_y \quad (\text{Eq. 10-3})$$

$$= 0.00333$$

$$\text{Instead of } \rho \text{ min, you can use } 4/3 \rho = 4/3 * 0.0126 \quad (10.5.3)$$

$$= 0.0168$$

$$\text{Use } \rho = 0.01262$$

$$\text{Required } A_s = \rho * b * d$$

$$= 0.0126 * 12 * 18.295$$

$$= 2.77 \text{ sq. inches}$$

$$\text{Use } A_s = 2.83 \text{ sq. inches}$$

$$T = f_y * A_s$$

$$= 169.8 \text{ kips}$$

$$a = T / (0.85 * f_c * b)$$

$$= 4.16176 \text{ inches}$$

$$\phi M_n = \phi * T (d - a/2)$$

$$\phi M_n = 206.49 \text{ k*ft}$$

$$\begin{aligned} & \text{--- (1) \#11 BAR} = 1.56 \text{ in}^2 \\ & + \text{(1) \#10 BAR} = 1.27 \text{ in}^2 \\ & \leq 2.83 \text{ in}^2 \end{aligned}$$

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.

Output at Critical Sections (per unit design width)

Member No. = 1 EXTERIOR WALL				Thickness		= 15.00 (in)						
				Clear cover at end		= 3.00 (in)						
				Clear cover at middle		= 2.00 (in)						
				Bar diameter (bot)		= 1.00 (in)						
				Bar diameter (mid+)		= 1.13 (in)						
				Bar diameter (mid-)		= 1.41 (in)						
				Bar diameter (top)		= 0.50 (in)						
	Moment	Coin.		Resistance								
		Axial	Shear	Shear	Po	Mu	Mbal	Pbal	Steel	Mom.	Des.	Design
	Kft	Force	Force	Cap	Cap	Cap	Cap	Cap	Area	Cap	Thk	Ratio
		Kips	Kips	Kips	Kips	Kft	Kft	Kips	In2	Kft	in	
BOT	-59.0	32.0	12.4	18.0	453.0	64.5	106.8	167.2	1.1850	64.5	12.50	0.9
MID	-1.0	32.0	1.2	63.5	419.8	12.7	87.8	219.0	0.2000	12.7	12.75	0.1
MID-	-21.1	32.7	1.9	32.9	427.0	24.6	92.0	207.6	0.4133	24.6	12.69	0.9
TOP	-70.8	32.7	15.0	17.4	463.7	79.6	112.6	151.0	1.5000	79.6	12.44	0.9
Member No. = 2 TOP SLAB				Thickness		= 20.00 (in)						
				Clear cover at end		= 3.00 (in)						
				Clear cover at middle		= 2.00 (in)						
				Bar diameter (lt)		= 1.00 (in)						
				Bar diameter (mid)		= 1.13 (in)						
				Bar diameter (rt)		= 1.41 (in)						
LT	-70.8	17.1	33.5*	29.5	601.4	111.9	194.2	240.6	1.5000	111.9	17.44	0.6
MID	100.2	17.7	4.1	25.9	601.4	112.0	194.2	240.6	1.5000	112.0	17.44	0.9
RT	-187.1	17.7	49.0*	29.2	640.9	188.5	227.3	181.7	3.1200	188.5	17.30	1.0
Member No. = 3 INTERIOR WALL				Thickness		= 12.00 (in)						
				Clear cover at end		= 3.00 (in)						
				Clear cover at middle		= 2.00 (in)						
				Bar diameter (bot)		= 1.00 (in)						
				Bar diameter (mid+)		= 1.13 (in)						
				Bar diameter (mid-)		= 1.41 (in)						
				Bar diameter (top)		= 0.50 (in)						
BOT	-0.3	79.2	0.1	75.8	337.2	16.3	55.7	165.2	0.2000	16.3	9.75	0.0
MID	-0.0	79.2	0.1	75.8	337.2	16.3	55.7	165.2	0.2000	16.3	9.75	0.0
MID-	-0.1	79.2	0.1	75.8	337.2	16.3	55.7	165.2	0.2000	16.3	9.75	0.0
TOP	0.0	79.2	-0.0	3269.6	337.2	16.3	55.7	165.2	0.2000	16.3	9.75	0.0
Member No. = 4 BOTTOM SLAB				Thickness		= 22.00 (in)						
				Clear cover at end		= 3.00 (in)						
				Clear cover at middle		= 2.00 (in)						
				Bar diameter (lt)		= 1.00 (in)						
				Bar diameter (mid)		= 1.13 (in)						
				Bar diameter (rt)		= 1.41 (in)						
LT	-59.0	14.7	32.2*	30.9	645.8	95.1	214.8	274.8	1.1850	95.1	18.50	0.6
MID	107.3	14.2	5.1	28.8	650.8	112.0	226.6	284.5	1.3333	112.0	19.44	1.0
RT	-202.1*	14.2	51.2*	31.2	696.0	200.2	256.6	199.6	3.1200	200.2	18.30	1.0

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.

Volume of Concrete and Weight of Reinforcing Steel

Top Slab (In)	Thickness		Interior Wall (In)	Volume (Cy/Ft)	Steel (Lb/Ft)
	Bottom Slab (In)	Exterior Wall (In)			
20.00	22.00	15.00	12.00	5.250	1388

Reinforcing Steel Bar Schedule

Location	Mark	Qty	Size	Type	Length (Ft-In)	Wgt (Lbs)	H Leg (Ft-In)	V Leg (Ft-In)
TOP SLAB (Inside)	A100	225	9	STR	33- 2	25370		
BOT SLAB (Inside)	A200	200	9	STR	33- 2	22551		
TOP SLAB (Outside)	A300	300	11	STR	33- 2	52870		
BOT SLAB (Outside)	A400	300	11	STR	33- 2	52870		
CORNER (Top)	A1	450	9	L-BAR	12- 4	18868	6- 9	5- 7
CORNER (Bottom)	A2	450	8	L-BAR	9- 0	10814	4- 3	4- 9
EXTWALL (Inside)	B1	300	4	STR	7- 6	1504		
EXTWALL (Outside)	B2	400	5	STR	7- 0	2920		
INTWALL	B3	300	4	STR	10- 1	2022		
LONGITUD. (3)	C1	351	4	STR	51- 1	11985		
LONGITUD. (3)	C100	93	4	STR	51- 1	3175		
LONGITUD. (3)	C200	93	4	STR	51- 1	3175		

Total weight black bars	208124
Total weight all bars	208124

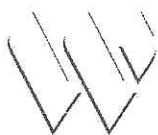
The minimum temperature and shrinkage steel for the:

Top slab(s) = 0.1100 in²
Bottom slab(s) = 0.1100 in²
Exterior wall(s) = 0.1100 in²

Interior wall(s) = 0.1100 in²

Splice Lengths Chart

Mark	Size	Splice (Ft-In)	Length (m)
B1	4	1- 9	0.533
B3	4	1- 9	0.533
C1	4	1- 9	0.533
C100	4	1- 9	0.533
C200	4	1- 9	0.533



G. C. WALLACE, INC.
1555 S. Rainbow Blvd.
Las Vegas, NV 89146
T: (702)804-2000
F: (702)804-2299

Title Headwall 4.0 (G)
Job # 412-654 Dsgnr: DAT Page: 28 SEP 2014
Description....
4'-0" Headwall with traffic surcharge load (240 psf)

This Wall in File: f:\projects\400\412-654\division\str\calcs\headwall.RPX

RetainPro 10 (c) 1987-2014, Build 10.14.8.13
License : KW-06057302
License To : G. C. WALLACE, INC.

Cantilevered Retaining Wall Design

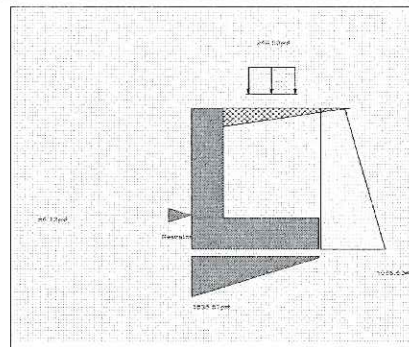
Code: IBC 2012, ACI 318-11, ACI 530-11

Criteria

Retained Height	=	4.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	45.0 psf/ft
Passive Pressure	=	250.0 psf/ft
Soil Density, Heel	=	120.00 pcf
Soil Density, Toe	=	0.00 pcf
Footings Soil Friction	=	0.250
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

Surcharge Over Heel	=	240.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
The above lateral load has been increased by a factor of		1.00
Wind on Exposed Stem	=	0.0 psf

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Design Summary

Wall Stability Ratios		
Overturning	=	3.18 OK
Slab Resists All Sliding !		
Total Bearing Load	=	3,460 lbs
...resultant ecc.	=	7.13 in
Soil Pressure @ Toe	=	1,636 psf OK
Soil Pressure @ Heel	=	94 psf OK
Allowable	=	2,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	1,963 psf
ACI Factored @ Heel	=	113 psf
Footing Shear @ Toe	=	0.0 psi OK
Footing Shear @ Heel	=	7.9 psi OK
Allowable	=	75.0 psi
Sliding Calcs		Slab Resists All Sliding !
Lateral Sliding Force	=	1,065.6 lbs

Stem Construction

Design Height Above Ftg	ft =	0.00
Wall Material Above "Ht"	=	Concrete
Thickness	=	12.00
Rebar Size	=	# 5
Rebar Spacing	=	12.00
Rebar Placed at	=	9.69 i
Design Data		
fb/FB + fa/Fa	=	0.148
Total Force @ Section	lbs =	1,152.0
Moment....Actual	ft-# =	1,920.0
Moment....Allowable	=	13,007.3
Shear.....Actual	psi =	9.9
Shear.....Allowable	psi =	75.0
Wall Weight	=	150.0
Rebar Depth 'd'	in =	9.69
LAP SPLICE IF ABOVE	in =	23.40
LAP SPLICE IF BELOW	in =	
HOOK EMBED INTO FTG	in =	6.00

Masonry Data

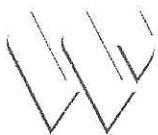
f _m	psi =	
F _s	psi =	
Solid Grouting	=	
Modular Ratio 'n'	=	
Short Term Factor	=	
Equiv. Solid Thick.	=	
Masonry Block Type	=	Medium Weight
Masonry Design Method	=	ASD

Concrete Data

f _c	psi =	2,500.0
F _y	psi =	60,000.0

Load Factors

Building Code	IBC 2012, ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.000
Seismic, E	1.000



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T: (702)804-2000
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Title Headwall 4.0 (G)
Job # 412:654 Dsgnr: DAT
Description....
4'-0" Headwall with traffic surcharge load (240 psf)

Page: _____
Date: 28 SEP 2014

This Wall in File: f:\projects\400\412-654\division\strl\calcs\headwall.RPX

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License : KW-06057302
License To : G. C. WALLACE, INC.

Cantilevered Retaining Wall Design

Code: IBC 2012, ACI 318-11, ACI 530-11

Footing Dimensions & Strengths

Toe Width = 0.00 ft
Heel Width = 4.00
Total Footing Width = 4.00
Footing Thickness = 14.00 in
Key Width = 0.00 in
Key Depth = 0.00 in
Key Distance from Toe = 0.00 ft
f_c = 2,500 psi F_y = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top 2.00 @ Btm. = 3.00 in

Footing Design Results

	Toe	Heel
Factored Pressure	1,963	113 psf
Mu' : Upward	0	2,590 ft-#
Mu' : Downward	0	5,265 ft-#
Mu: Design	0	2,675 ft-#
Actual 1-Way Shear	0.00	7.90 psi
Allow 1-Way Shear	0.00	75.00 psi
Toe Reinforcing	None Spec'd	
Heel Reinforcing	None Spec'd	
Key Reinforcing	None Spec'd	

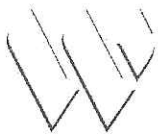
Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined

Summary of Overturning & Resisting Forces & Moments

Item	OVERTURNING.....				RESISTING.....				
	Force lbs	Distance ft	Moment ft-#		Force lbs	Distance ft	Moment ft-#		
Heel Active Pressure	=	600.6	1.72	1,034.4	Soil Over Heel	=	1,440.0	2.50	3,600.0
Surcharge over Heel	=	465.0	2.58	1,201.3	Sloped Soil Over Heel	=			
Surcharge Over Toe	=				Surcharge Over Heel	=	720.0	2.50	1,800.0
Adjacent Footing Load	=				Adjacent Footing Load	=			
Added Lateral Load	=				Axial Dead Load on Stem	=			
Load @ Stem Above Soil	=				* Axial Live Load on Stem	=			
	=				Soil Over Toe	=			
					Surcharge Over Toe	=			
					Stem Weight(s)	=	600.0	0.50	300.0
					Earth @ Stem Transitions	=			
					Footing Weight	=	700.0	2.00	1,400.0
					Key Weight	=			
					Vert. Component	=			

* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.



G. C. WALLACE, INC.
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Title Headwall 4.0 (S)
Job # 412-654 Dsgnr: DAT
Description....
4'-0" Headwall with seismic load

Page: _____
Date: 28 SEP 2014

This Wall in File: f:\projects\400\412-654\division\str\calcs\headwall.RPX

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Cantilevered Retaining Wall Design

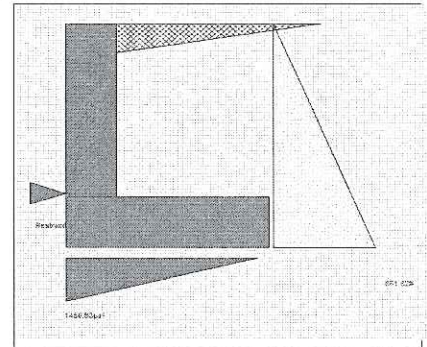
Code: IBC 2012, ACI 318-11, ACI 530-11

Criteria

Retained Height = 4.00 ft
Wall height above soil = 0.00 ft
Slope Behind Wall = 0.00 : 1
Height of Soil over Toe = 0.00 in
Water height over heel = 0.0 ft

Soil Data

Allow Soil Bearing = 2,000.0 psf
Equivalent Fluid Pressure Method
Heel Active Pressure = 45.0 psf/ft
Passive Pressure = 250.0 psf/ft
Soil Density, Heel = 120.00 pcf
Soil Density, Toe = 0.00 pcf
Footing||Soil Friction = 0.250
Soil height to ignore
for passive pressure = 12.00 in



Surcharge Loads

Surcharge Over Heel = 0.0 psf
Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
Used for Sliding & Overturning

Axial Load Applied to Stem

Axial Dead Load = 0.0 lbs
Axial Live Load = 0.0 lbs
Axial Load Eccentricity = 0.0 in

Earth Pressure Seismic Load

Design Kh = 0.200 g

Using Mononobe-Okabe / Seed-Whitman procedure

Stem Weight Seismic Load

Lateral Load Applied to Stem

Lateral Load = 0.0 #/ft
...Height to Top = 0.00 ft
...Height to Bottom = 0.00 ft
The above lateral load
has been increased
by a factor of 1.00
Wind on Exposed Stem = 0.0 psf

Kae for seismic earth pressure = 0.488
Ka for static earth pressure = 0.330
Difference: Kae - Ka = 0.158

F_p / W_p Weight Multiplier = 0.200 g

Adjacent Footing Load

Adjacent Footing Load = 0.0 lbs
Footing Width = 0.00 ft
Eccentricity = 0.00 in
Wall to Ftg CL Dist = 0.00 ft
Footing Type Line Load
Base Above/Below Soil = 0.0 ft
at Back of Wall
Poisson's Ratio = 0.300

Added seismic base force 177.2 lbs

Added seismic base force 84.0 lbs



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Cantilevered Retaining Wall Design

Code: IBC 2012, ACI 318-11, ACI 530-11

Design Summary

Wall Stability Ratios
Overturning = 2.87 OK
Slab Resists All Sliding !

Total Bearing Load = 2,740 lbs
...resultant ecc. = 8.89 in

Soil Pressure @ Toe = 1,451 psf OK
Soil Pressure @ Heel = 0 psf OK
Allowable = 2,000 psf
Soil Pressure Less Than Allowable
ACI Factored @ Toe = 1,741 psf
ACI Factored @ Heel = 0 psf
Footing Shear @ Toe = 0.0 psi OK
Footing Shear @ Heel = 4.2 psi OK
Allowable = 75.0 psi
Sliding Calcs Slab Resists All Sliding !
Lateral Sliding Force = 861.8 lbs

Stem Construction

Design Height Above Ftc ft = 0.00
Wall Material Above "Ht" = Concrete
Thickness = 12.00
Rebar Size = # 5
Rebar Spacing = 12.00
Rebar Placed at = 9.69 i
Design Data
fb/FB + fa/Fa = 0.105
Total Force @ Section lbs = 847.7
Moment.....Actual ft-# = 1,372.1
Moment.....Allowable = 13,007.3
Shear.....Actual psi = 6.0
Shear.....Allowable psi = 75.0
Wall Weight = 150.0
Rebar Depth 'd' in = 9.69
LAP SPLICE IF ABOVE in = 23.40
LAP SPLICE IF BELOW in =
HOOK EMBED INTO FTG in = 6.00

Top Stem

Stem OK

Masonry Data

fm psi =
Fs psi =
Solid Grouting =

Hook embedment reduced by stress ratio

Modular Ratio 'n' =
Short Term Factor =
Equiv. Solid Thick. =
Masonry Block Type = Medium Weight
Masonry Design Method = ASD

Concrete Data

f'c psi = 2,500.0
Fy psi = 60,000.0

Load Factors

Building Code IBC 2012, ACI
Dead Load 1.200
Live Load 1.600
Earth, H 1.600
Wind, W 1.000
Seismic, E 1.000

Footing Dimensions & Strengths

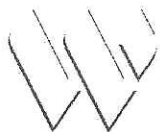
Toe Width = 0.00 ft
Heel Width = 4.00
Total Footing Width = 4.00
Footing Thickness = 14.00 in
Key Width = 0.00 in
Key Depth = 0.00 in
Key Distance from Toe = 0.00 ft
f'c = 2,500 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top 2.00 @ Btm = 3.00 in

Footing Design Results

	Toe	Heel
Factored Pressure	1,741	0 psf
Mu' : Upward	0	1,646 ft-#
Mu' : Downward	0	3,537 ft-#
Mu: Design	0	1,891 ft-#
Actual 1-Way Shear	0.00	4.21 psi
Allow 1-Way Shear	0.00	75.00 psi
Toe Reinforcing	None Spec'd	
Heel Reinforcing	None Spec'd	
Key Reinforcing	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined



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Title Headwall 4.0 (S)
Job # 412-654 Dsgnr: DAT
Description....
4'-0" Headwall with seismic load

Page: _____
Date: 28 SEP 2014

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Cantilevered Retaining Wall Design

Code: IBC 2012, ACI 318-11, ACI 530-11

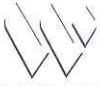
Summary of Overturning & Resisting Forces & Moments

Item	OVERTURNING.....		
	Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	= 600.6	1.72	1,034.4
Surcharge over Heel	=		
Surcharge Over Toe	=		
Adjacent Footing Load	=		
Added Lateral Load	=		
Load @ Stem Above Soil	=		
Seismic Earth Load	= 177.2	3.10	549.3
Seismic Stem Self Wt	= 84.0	3.17	266.0
Total	861.8	O.T.M.	1,849.7
	=	=	
Resisting/Overturning Ratio		=	2.87
Vertical Loads used for Soil Pressure	=	2,740.0 lbs	

If seismic is included, the OTM and sliding ratios
be 1.1 per section 1807.2.3 of IBC 2009 or IBC 201

	RESISTING.....		
	Force lbs	Distance ft	Moment ft-#
Soil Over Heel	= 1,440.0	2.50	3,600.0
Sloped Soil Over Heel	=		
Surcharge Over Heel	=		
Adjacent Footing Load	=		
Axial Dead Load on Stem	=		
* Axial Live Load on Stem	=		
Soil Over Toe	=		
Surcharge Over Toe	=		
Stem Weight(s)	= 600.0	0.50	300.0
Earth @ Stem Transitions	=		
Footing Weight	= 700.0	2.00	1,400.0
Key Weight	=		
Vert. Component	=		
Total	= 2,740.0 lbs	R.M.=	5,300.0

* Axial live load NOT included in total displayed, or used for overturning
resistance, but is included for soil pressure calculation.



Design Beam Over 10'x5' RCB Coming Into Side of 22'x7' RCB

Loads:

$$22' \times 7' \text{ RCB Top Slab} = (150 \text{ pcf}) (1'-8") (2' + 11') = 3.26 \text{ klf}$$

$$10' \text{ Soil Cover} = (125 \text{ pcf}) (10') (2' + 11') = 16.3 \text{ klf}$$

$$\text{Truck Surcharge} = 200 \text{ pcf} (2' + 11') = 2.6 \text{ klf}$$

$$10' \times 5' \text{ RCB Top Slab} = (150 \text{ pcf}) (1') (5') = 0.75 \text{ klf}$$

$$13' \text{ Soil Cover} = (125 \text{ pcf}) (13') (5') = 8.13 \text{ klf}$$

$$\text{Truck Surcharge} = 200 \text{ pcf} (5') = 1.0 \text{ klf}$$

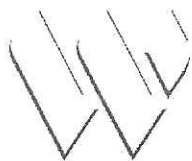
$$\text{Total DL} = 4.0 \text{ klf}$$

$$\text{Total Soil} = 24.4 \text{ klf}$$

$$\text{Total Surcharge} = 3.6 \text{ klf}$$

Span Length Over Opening = 12'-0" Each Side of Column Support

⇒ Use 6 #9 Bars In Beams w/ Support Column Mid-Span



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Engineer:
Project Descr:

Project ID:

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ENERCALC, INC. 1983-2013, Build:6.13.8.31, Ver:6.13.12.31

Licensee : G.C. WALLACE, INC.

Concrete Beam

Lic. #: KW-06002262

Description: 10'x5' RCB Penetration Into 22'x7' RCB - Beam Spanning Over Opening

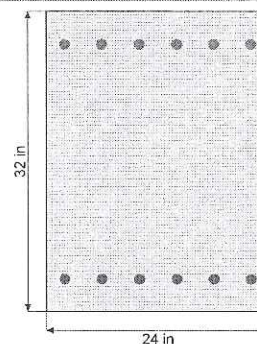
CODE REFERENCES

Calculations per ACI 318-08, IBC 2009, ASCE 7-10

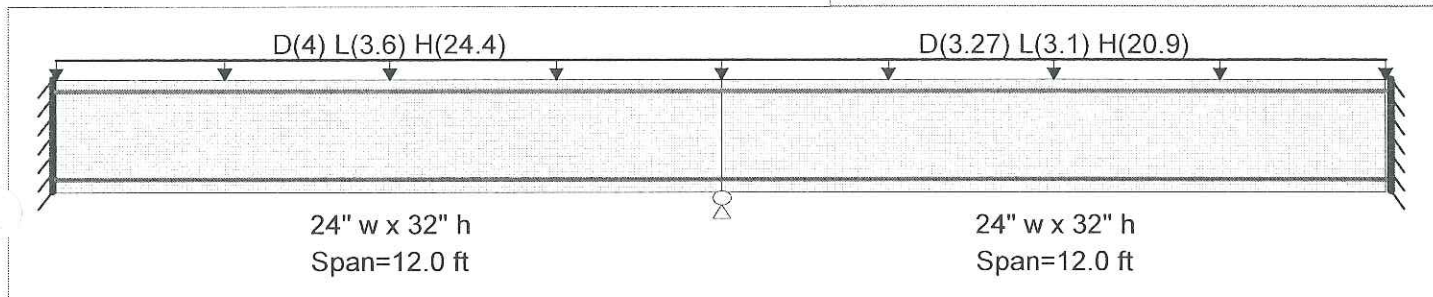
Load Combination Set : IBC 2009

Material Properties

f'_c	=	4.50 ksi	ϕ Phi Values	Flexure :	0.90
$f_r = f'_c^{1/2} * 7.50$	=	503.12 psi		Shear :	0.750
Ψ Density	=	145.0 pcf	β_1	=	0.8250
λ LtWt Factor	=	1.0			
Elastic Modulus	=	3,122.0 ksi	F_y - Stirrups	=	60.0 ksi
f_y - Main Rebar	=	60.0 ksi	E - Stirrups	=	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #	=	# 5
			Number of Resisting Legs Per Stirrup	=	2



Load Combination IBC 2009



Cross Section & Reinforcing Details

Rectangular Section, Width = 24.0 in, Height = 32.0 in

Span #1 Reinforcing....

6-#9 at 3.50 in from Bottom, from 0.0 to 12.0 ft in this span

Span #2 Reinforcing....

6-#9 at 3.50 in from Bottom, from 0.0 to 12.0 ft in this span

6-#9 at 3.50 in from Top, from 0.0 to 12.0 ft in this span

6-#9 at 3.50 in from Top, from 0.0 to 12.0 ft in this span

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Load for Span Number 1

Uniform Load : D = 4.0, L = 3.60, H = 24.40 k/ft, Tributary Width = 1.0 ft

Load for Span Number 2

Uniform Load : D = 3.270, L = 3.10, H = 20.90 k/ft, Tributary Width = 1.0 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.768 : 1	Maximum Deflection	
Section used for this span	Typical Section	Max Downward L+Lr+S Deflection	0.002 in Ratio = 82182
M_u : Applied	-550.39 k-ft	Max Upward L+Lr+S Deflection	0.000 in Ratio = 0 < 360
$M_n * \Phi$: Allowable	716.98 k-ft	Max Downward Total Deflection	0.015 in Ratio = 9795
Load Combination	+1.250D+0.50Lr+1.750L+1.350H	Max Upward Total Deflection	0.000 in Ratio = 999 < 180
Location of maximum on span	0.000 ft		
Span # where maximum occurs	Span # 1		

Vertical Reactions - Unfactored

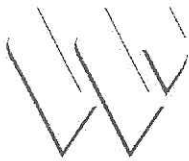
Support notation : Far left is #1

Load Combination	Support 1	Support 2	Support 3
Overall MAXimum	148.186	271.686	123.728
D Only	24.547	43.621	19.072
L Only	21.975	40.201	18.225
D+L	46.522	83.821	37.297
H Only	148.186	271.686	123.728

Shear Stirrup Requirements

Between 0.00 to 1.26 ft, $V_s > (4bd'f_c^{0.5})$ ACI 11.5.3, Req'd V_s = 138.070, use stirrups spaced at 4.000 in
Between 1.31 to 4.40 ft, $\Phi V_c < V_u$, Req'd V_s = 0.6885, use stirrups spaced at 5.000 in
Between 4.46 to 5.31 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd V_s = Min 11.4.5.1, use stirrups spaced at 14.000 in
Between 5.37 to 6.86 ft, $V_u < \Phi V_c/2$, Req'd V_s = Not Req'd, use stirrups spaced at 0.000 in
Between 6.91 to 7.77 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd V_s = Min 11.4.5.1, use stirrups spaced at 14.000 in

Note: TYP Wall Reinf is Used Plus #506"



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Engineer:
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Project ID:

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ENERCALC, INC. 1983-2013, Build:6.13.8.31, Ver:6.13.12.31

Concrete Beam

Lic. #: KW-06002262

Licensee: G.C. WALLACE, INC.

Description: 10'x5' RCB Penetration Into 22'x7' RCB - Beam Spanning Over Opening

Shear Stirrup Requirements

Between 7.83 to 10.91 ft, $\Phi V_c < V_u$, Req'd $V_s = 135.892$, use stirrups spaced at 5.000 in
Between 10.97 to 12.40 ft, $V_s > (4bd'f_c^{.5})$ ACI 11.5.5.3, Req'd $V_s = 139.527$, use stirrups spaced at 4.000 in
Between 12.46 to 16.06 ft, $\Phi V_c < V_u$, Req'd $V_s = 1.552$, use stirrups spaced at 5.000 in
Between 16.11 to 17.20 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd $V_s = \text{Min } 11.4.5.1$, use stirrups spaced at 14.000 in
Between 17.26 to 19.03 ft, $V_u < \Phi V_c/2$, Req'd $V_s = \text{Not Req'd}$, use stirrups spaced at 0.000 in
Between 19.09 to 20.11 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd $V_s = \text{Min } 11.4.5.1$, use stirrups spaced at 14.000 in
Between 20.17 to 23.94 ft, $V_s > (4bd'f_c^{.5})$ ACI 11.5.5.3, Req'd $V_s = 144.842$, use stirrups spaced at 5.000 in

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
H Only	1	0.0147	6.200	D+L	-0.0000	12.200
H Only	2	0.0100	6.200		0.0000	12.200

Design Top Slab - 10' x 5' RCB Slab @ Junction

Design top slab as simply supported beam with L = 10.5 ft

f'_c =	4000 psi
f_y =	60000 psi
Length of Span =	10.50 ft
Thickness of Top Slab =	12 inches
Soil Cover Depth over Slab =	10.0 ft
Truck Load =	250 psf
Soil Unit Weight =	125 psf
Soil-Structure Interaction Factor =	1.15 (Per Eq. 12.11.2.2.1-2)

Unfactored Loads

Wt of Concrete =	150 psf	Dead Load, DC
Wt of Soil =	1437.5 psf	Earth Load, EV
Wt of HS-20 Truck =	250 psf	Live Load, LL

AASHTO LRFD Load Factors Per Table 3.4.1-1

$$= \gamma_{DC}(DC) + \gamma_{EV}(EV) + \gamma_{LL}(LL)$$

$$\gamma_{DC} = 1.25$$

$$\gamma_{EV} = 1.30$$

$$\gamma_{LL} = 1.75$$

$$\begin{aligned} \text{Factored Load, } w &= 2.494 \text{ ksf} \\ \text{Tributary width} &= 1.00 \text{ ft} \\ \text{Use } w &= 2.49 \text{ k/ft} \\ \text{Factored Moment, } M_U &= wL^2 / 8 \\ &= 34.37 \text{ k*ft/ft} \\ \text{Divide by 2 for 2-way slab design} &= N \\ \text{Factored Moment, } M_U &= 34.37 \text{ k*ft/ft} \\ \text{Bar Size to Use} &= 5 \\ \text{diameter of bar} &= 0.625 \text{ in} \\ d &= 9.6875 \text{ inches} \\ b &= 12 \text{ inches} \\ R &= M_U / (.9bd^2) \\ &= 406.889 \end{aligned}$$

$$m = f_y / (f'_c * 0.85)$$

$$= 17.65$$

$$p = 1/m [1 - \sqrt{1 - (2mR/f_y)}]$$

$$= 0.00724$$

Greater than p min

$$\text{Area of Steel Required} = pbd$$

$$= 0.84 \text{ sq. inches}$$

Use #6 @ 6", $A_s = 0.88 \text{ sq. inches}$

Check Shear

$$V_u = w * (\text{Clear Span}) / 2$$

$$= 11.85 \text{ kips}$$

Per AASTHO 8.16.6.7

$$\phi V_c = 3 * \phi * \sqrt{f'_c} * b * d$$

$$= 18.75 \text{ kips}$$

Shear OK

Bottom Slab

Use the same reinforcing as the top slab. Loads to the bottom slab will be about the same as the top slab since wheel loads will distribute out.

Design Walls

Design walls to span vertically. Length of wall = 6 feet

$f_c = 4000$ psi
 $f_y = 60000$ psi
 Wall Height = 6 ft
 Thickness of Wall = 12 inches
 Soil Cover Depth over Slab = 13 ft
 Thickness of Top Slab = 12 inches
 Surcharge load = 2' of soil = 240 psf (AASHTO Table 3.11.6.4-2)
 EFP at Rest = 60 psf (per AASHTO 3.11.5)

Pressure at top of wall = EFP * (Soil Cover + Top Slab Thickness) + .5(Truck Surcharge)
 = 960 psf

Pressure at bottom of wall = EFP * (Soil Cover + Top Slab Thick+Wall Height) + .5(Truck Surch.)
 = 1320 psf

AASHTO LRFD Load Factors (Table 3.4.1-1 - Strength 1)

= 1.50 * EH (Could use 1.35 for EH and 1.5 for ES)

Conservatively use 1.5 for both

Load Factor = 1.50

Wall is designed as pinned at top and bottom

Factored pressure at top = 1.44 ksf

Factored Pressure at bottom = 1.98 ksf

Factored Moment, $M_u = [wL^2 / 8] + .1283WL$

$W = 1/2 (1.98 - 1.44)(6)$

= 1.62 k

$w = 1.44$ k/ft

Factored Moment, $M_u = 7.73$ k*ft/ft

Bar Size to Use = 4

diameter of bar = 0.5 in

Center Reinforcing in Wall (Y or N) = n

$d = 9.75$ inches

$b = 12$ inches

$R = M_u / (.9bd^2)$

= 90.31574

$m = f_y / (f_c * 0.85)$

= 17.65

$p = 1/m [1 - \sqrt{1 - (2mR/f_y)}]$

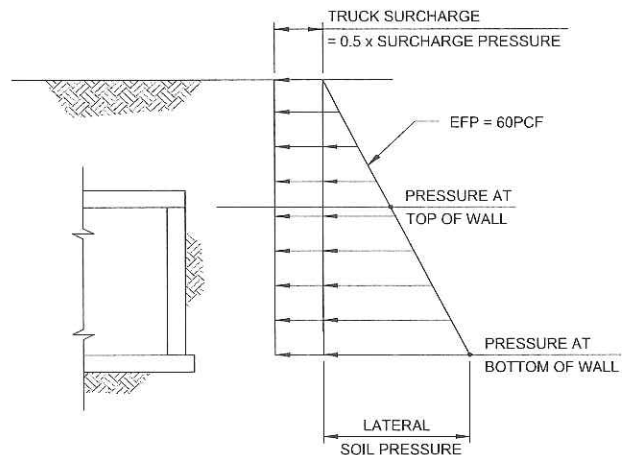
= 0.00153

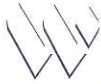
Less than min. Use 4/3 p

Area of Steel Required = 4/3 pbd

= 0.24 sq. inches

Use #5 @ 12" O.C.
 $A_s = 0.31$ sq. inches.





G. C. WALLACE COMPANIES
ENGINEERS | PLANNERS | SURVEYORS

DATE: _____ SHEET NO. _____ OF _____

SUBJECT: _____ JOB NO. _____

CLIENT: _____ CHECKED BY _____ CALC BY _____

Design Beam Over 6' x 5' RCB Coming Into Side of 22' x 7' RCB

Loads:

$$22' \times 7' \text{ RCB Top Slab} = (150 \text{ pcf})(11'-6")\left(\frac{14"}{12} + \frac{22'}{12}\right) = 2.74 \text{ klf}$$

$$10' \text{ Soil Cover Over } 22' \times 7' = (125 \text{ pcf})(10')\left(\frac{14"}{12} + \frac{22'}{12}\right) = 15.2 \text{ klf}$$

$$\text{Truck Surcharge} = 200 \text{ pcf}\left(\frac{14"}{12} + \frac{22'}{12}\right) = 2.4 \text{ klf}$$

$$6' \times 5' \text{ RCB Top Slab} = (150 \text{ pcf})(1') (3.5') = 0.53 \text{ klf}$$

$$13' \text{ Soil Cover over } 6' \times 5' \text{ RCB} = (125)(13')(3.5') = 5.69 \text{ klf}$$

$$\text{Truck Surcharge} = 200 \text{ pcf}(3.5') = 0.70 \text{ klf}$$

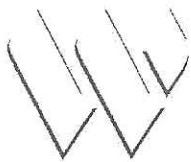
$$\text{Total DL} = 3.27 \text{ klf}$$

$$\text{Total Soil} = 20.9 \text{ klf}$$

$$\text{Total Surcharge} = 3.1 \text{ klf}$$

Span Length Over 6' x 5' RCB Opening = 14'-6"

For Span = 14'-6" Use 6-#9 Bars Top & Bottom



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Engineer:
Project Descr:

Project ID:

Printed: 14 OCT 2014, 8:27AM

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ENERCALC, INC. 1983-2013, Build:6.13.8.31, Ver:6.13.12.31

Licensee : G.C. WALLACE, INC.

Concrete Beam

Lic. #: KW-06002262

Description: 6'x5' RCB Penetration Into 22'x7' RCB - Beam Spanning Over Opening

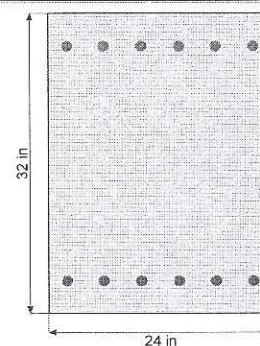
CODE REFERENCES

Calculations per ACI 318-08, IBC 2009, ASCE 7-10

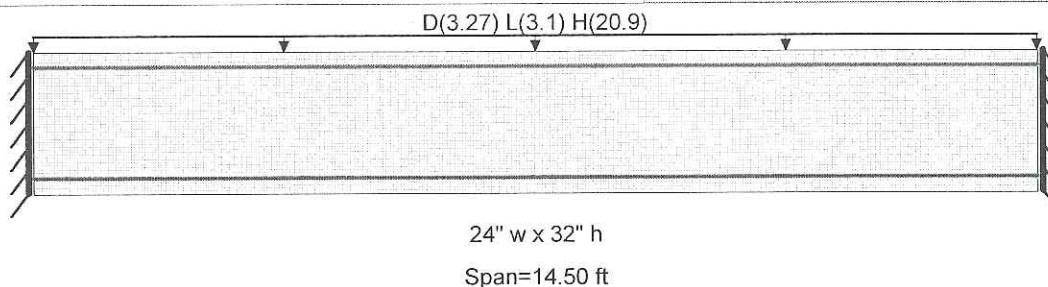
Load Combination Set : IBC 2009

Material Properties

f'_c	=	4.50 ksi	ϕ Phi Values	Flexure :	0.90
$f_r = f'_c^{1/2} * 7.50$	=	503.12 psi		Shear :	0.750
Ψ Density	=	145.0 pcf	β_1	=	0.8250
λ LtWt Factor	=	1.0			
Elastic Modulus	=	3,122.0 ksi	F_y - Stirrups	=	60.0 ksi
f_y - Main Rebar	=	60.0 ksi	E - Stirrups	=	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #	=	# 5
			Number of Resisting Legs Per Stirrup	=	2



Load Combination IBC 2009



Cross Section & Reinforcing Details

Rectangular Section, Width = 24.0 in, Height = 32.0 in

Span #1 Reinforcing....

6-#9 at 3.50 in from Bottom, from 0.0 to 14.50 ft in this span

6-#9 at 3.50 in from Top, from 0.0 to 14.50 ft in this span

Service loads entered. Load Factors will be applied for calculations.

Applied Loads

Load for Span Number 1

Uniform Load : D = 3.270, L = 3.10, H = 20.90 k/ft, Tributary Width = 1.0 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio	=	0.922 : 1	Maximum Deflection		
Section used for this span		Typical Section	Max Downward L+Lr+S Deflection	0.003 in	Ratio = 57818
M_u : Applied		-661.0 k-ft	Max Upward L+Lr+S Deflection	0.000 in	Ratio = 0 < 360
$M_n * \Phi$: Allowable		716.98 k-ft	Max Downward Total Deflection	0.028 in	Ratio = 6161
Load Combination		+1.250D+0.50Lr+1.750L+1.350H	Max Upward Total Deflection	0.000 in	Ratio = 999 < 180
Location of maximum on span		0.000 ft			
Span # where maximum occurs		Span # 1			

Vertical Reactions - Unfactored

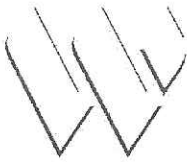
Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	151.525	151.525
D Only	23.708	23.708
L Only	22.475	22.475
D+L	46.183	46.183
H Only	151.525	151.525

Shear Stirrup Requirements

Between 0.00 to 1.55 ft, $V_s > (4bd\phi^{\wedge}.5)$ ACI 11.5.5.3, Req'd V_s = 138.538, use stirrups spaced at 4.000 in
Between 1.58 to 5.32 ft, $\Phi V_c < V_u$, Req'd V_s = 0.05980, use stirrups spaced at 5.000 in
Between 5.35 to 6.32 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd V_s = Min 11.4.5.1, use stirrups spaced at 14.000 in
Between 6.35 to 8.15 ft, $V_u < \Phi V_c/2$, Req'd V_s = Not Req'd, use stirrups spaced at 0.000 in
Between 8.18 to 9.15 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd V_s = Min 11.4.5.1, use stirrups spaced at 14.000 in
Between 9.18 to 12.92 ft, $\Phi V_c < V_u$, Req'd V_s = 137.322, use stirrups spaced at 5.000 in
Between 12.95 to 14.47 ft, $V_s > (4bd\phi^{\wedge}.5)$ ACI 11.5.5.3, Req'd V_s = 197.083, use stirrups spaced at 4.000 in

Note: Typ Wall Reinf is Used + #5 @ 6" Ties



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ENERCALC, INC. 1983-2013, Build:6.13.8.31, Ver:6.13.12.31

Concrete Beam

Lic. # : KW-06002262

Licensee : G.C. WALLACE, INC.

Description : 6'x5' RCB Penetration Into 22'x7' RCB - Beam Spanning Over Opening

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
H Only	1	0.0282	7.105		0.0000	0.000

Design Top Slab - 6'x5' RC Slab @ Junction

Design top slab as simply supported beam with L = 7 ft

f_c =	4000 psi
f_y =	60000 psi
Length of Span =	7.00 ft
Thickness of Top Slab =	12 inches
Soil Cover Depth over Slab =	10.0 ft
Truck Load =	250 psf
Soil Unit Weight =	125 psf
Soil-Structure Interaction Factor =	1.15 (Per Eq. 12.11.2.2.1-2)

Unfactored Loads

Wt of Concrete =	150 psf	Dead Load, DC
Wt of Soil =	1437.5 psf	Earth Load, EV
Wt of HS-20 Truck =	250 psf	Live Load, LL

AASHTO LRFD Load Factors Per Table 3.4.1-1

$$= \gamma_{DC}(DC) + \gamma_{EV}(EV) + \gamma_{LL}(LL)$$

γ_{DC} =	1.25
γ_{EV} =	1.30
γ_{LL} =	1.75

Factored Load, w =	2.494 ksf
Tributary width =	1.00 ft
Use w =	2.49 k/ft
Factored Moment, M_U =	$wL^2 / 8$
	= 15.27 k*ft/ft
Divide by 2 for 2-way slab design =	N
Factored Moment, M_U =	15.27 k*ft/ft
Bar Size to Use =	5
diameter of bar =	0.625 in
d =	9.6875 inches
b =	12 inches
$R = M_U / (.9bd^2)$	
	= 180.839

$$m = f_y / (f_c * 0.85)$$

$$= 17.65$$

$$p = 1/m [1 - \sqrt{1 - (2mR/f_y)}]$$

$$= 0.0031$$

Less than p min, Use 4/3 p

$$\text{Area of Steel Required} = 4/3 p b d$$

$$= 0.48 \text{ sq. inches}$$

Use #5 @ 6", $A_s = 0.61 \text{ sq. inches}$

Check Shear

$$V_u = w * (\text{Clear Span}) / 2$$

$$= 7.48 \text{ kips}$$

Per AASTHO 8.16.6.7

$$\phi V_c = 3 * \phi * \sqrt{f_c} * b * d$$

$$= 18.75 \text{ kips}$$

Shear OK

Bottom Slab

Use the same reinforcing as the top slab. Loads to the bottom slab will be about the same as the top slab since wheel loads will distribute out.

Design Walls

Design walls to span vertically. Length of wall = 6 feet

$f'_c = 4000$ psi
 $f_y = 60000$ psi
 Wall Height = 6 ft
 Thickness of Wall = 12 inches
 Soil Cover Depth over Slab = 13 ft
 Thickness of Top Slab = 12 inches
 Surcharge load = 2' of soil = 240 psf (AASHTO Table 3.11.6.4-2)
 EFP at Rest = 60 psf (per AASHTO 3.11.5)

Pressure at top of wall = $EFP * (\text{Soil Cover} + \text{Top Slab Thickness}) + .5(\text{Truck Surcharge})$
 = 960 psf

Pressure at bottom of wall = $EFP * (\text{Soil Cover} + \text{Top Slab Thick} + \text{Wall Height}) + .5(\text{Truck Surch.})$
 = 1320 psf

AASHTO LRFD Load Factors (Table 3.4.1-1 - Strength 1)

= $1.50 * EH$ (Could use 1.35 for EH and 1.5 for ES)

Conservatively use 1.5 for both

Load Factor = 1.50

Wall is designed as pinned at top and bottom

Factored pressure at top = 1.44 ksf

Factored Pressure at bottom = 1.98 ksf

Factored Moment, $M_U = [wL^2 / 8] + .1283WL$

$W = 1/2 (1.98 - 1.44)(6)$

= 1.62 k

$w = 1.44$ k/ft

Factored Moment, $M_U = 7.73$ k*ft/ft

Bar Size to Use = 4

diameter of bar = 0.5 in

Center Reinforcing in Wall (Y or N) = n

$d = 9.75$ inches

$b = 12$ inches

$R = M_U / (.9bd^2)$

= 90.31574

$m = f_y / (f'_c * 0.85)$

= 17.65

$p = 1/m [1 - \sqrt{1 - (2mR/f_y)}]$

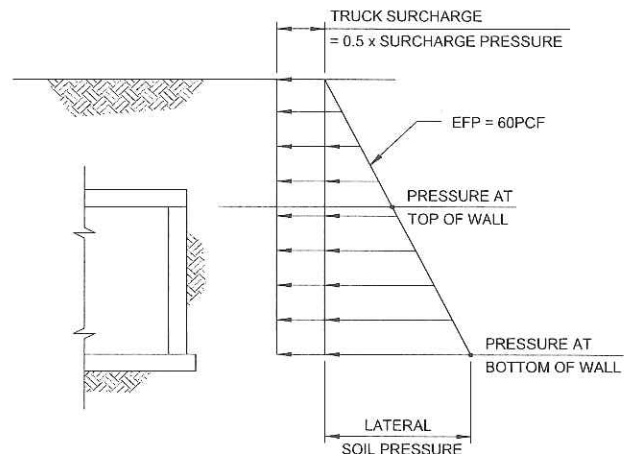
= 0.00153

Less than min. Use $4/3 p$

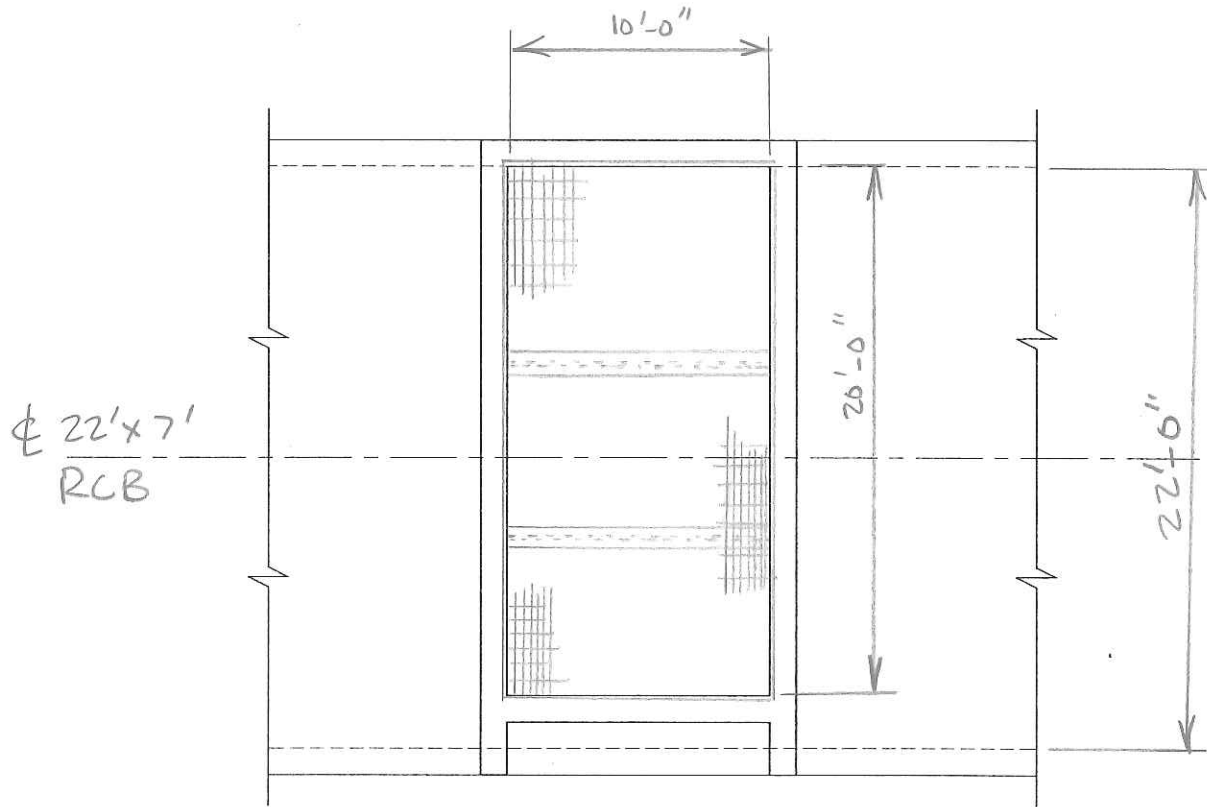
Area of Steel Required = $4/3 pbd$

= 0.24 sq. inches

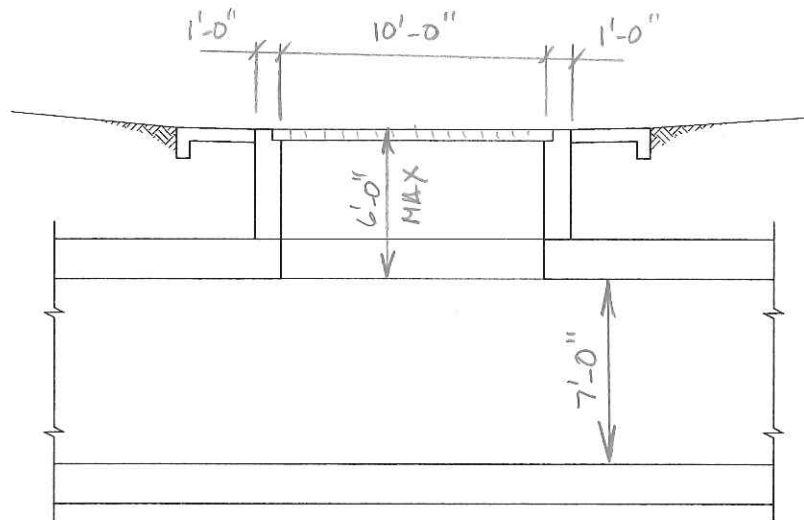
Use #5 @ 12" O.C.
 $A_s = 0.31$ sq. inches.



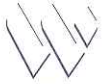
DESIGN 20'x10' ACCESS OPENING WITH GRATE
INTO TOP OF 22'x7' RCB



PLAN



ELEVATION



G. C. WALLACE COMPANIES
ENGINEERS | PLANNERS | SURVEYORS

DATE: 9/25/14

SHEET NO. _____ OF _____

SUBJECT: _____

JOB NO. _____

CLIENT: _____

CHECKED BY _____

CALC BY EGG

DESIGN GIRATE

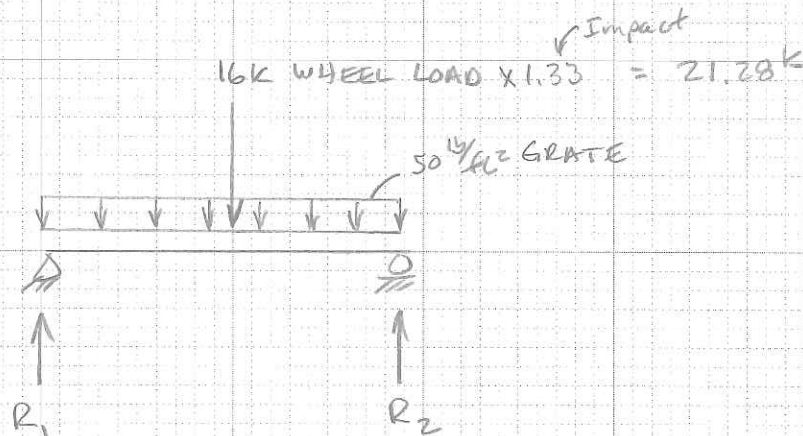
USE 5" DEEP X $\frac{3}{8}$ " WIDE MAIN BARS @ $1\frac{3}{8}$ " C-C SPACING

SPAN = 6'-8"

CAPACITY = 13,500 lb - OK - SEE LOAD TABLE ON FOLLOWING PAGE

- WHILE THIS IS NOT A 16K WHEEL LOAD A SHORT TERM INCREASE DURATION WOULD MAKE IT WORK AND IF DEFLECTION IS NOT AN ISSUE THAN OK.

DESIGN BEAM



$$R_1 = R_2 = \frac{[(16K) + 10(50)]}{2} = 8.25K$$

The computer program Enercalc was used to design beam
SEE OUTPUT

USE W12 X 30 BEAM

Heavy-Duty Steel Grating

22-H-4 & 22-H-2 (continued)

LOAD TABLE

Bar Size	Symbol	Approx. Weight per sq	Sec. Mod Per Ft. Of Width	SPAN (Length of Bearing Bar)											
				2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	7'-0"	8'-0"	
3" x 1/4"	22-4-124	24.5	3.273	U	10,909	6,982	4,848	3,562	2,727	2,155	1,745	1,443	1,212	891	682
	22-2-124	26.0		C	10,909	8,727	7,273	6,234	5,455	4,848	4,364	3,967	3,636	3,117	2,727
3" x 5/16"	22-4-125	30.7	4.091	U	13,636	8,727	6,061	4,453	3,409	2,694	2,182	1,803	1,515	1,113	852
	22-2-125	32.7		C	13,636	10,909	9,091	7,792	6,818	6,061	5,455	4,959	4,545	3,896	3,409
3" x 3/8"	22-4-126	36.4	4.909	U	16,364	10,473	7,273	5,343	4,091	3,232	2,618	2,164	1,818	1,336	1,023
	22-2-126	38.4		C	16,364	13,091	10,909	9,351	8,182	7,273	6,545	5,950	5,455	4,675	4,091
3-1/4" x 1/4"	22-4-134	26.4	3.841	U	12,803	8,194	5,690	4,181	3,201	2,529	2,048	1,693	1,423	1,045	800
	22-2-134	27.9		C	12,803	10,242	8,535	7,316	6,402	5,690	5,121	4,656	4,268	3,658	3,201
3-1/4" x 5/16"	22-4-135	33.1	4.801	U	16,004	10,242	7,113	5,226	4,001	3,161	2,561	2,116	1,778	1,306	1,000
	22-2-135	35.1		C	16,004	12,803	10,669	9,145	8,002	7,113	6,402	5,820	5,335	4,573	4,001
3-1/4" x 3/8"	22-4-136	39.2	5.761	U	19,205	12,291	8,535	6,271	4,801	3,793	3,073	2,539	2,134	1,568	1,200
	22-2-136	41.3		C	19,205	15,364	12,803	10,974	9,602	8,535	7,682	6,983	6,402	5,487	4,801
3-1/2" x 1/4"	22-4-144	28.3	4.455	U	14,848	9,503	6,599	4,848	3,712	2,933	2,376	1,963	1,650	1,212	928
	22-2-144	29.8		C	14,848	11,879	9,899	8,485	7,424	6,599	5,939	5,399	4,949	4,242	3,712
3-1/2" x 5/16"	22-4-145	35.5	5.568	U	18,561	11,879	8,249	6,061	4,640	3,666	2,970	2,454	2,062	1,515	1,160
	22-2-145	37.5		C	18,561	14,848	12,374	10,606	9,280	8,249	7,424	6,749	6,187	5,303	4,640
3-1/2" x 3/8"	22-4-146	42.1	6.682	U	22,273	14,255	9,899	7,273	5,568	4,400	3,564	2,945	2,475	1,818	1,392
	22-2-146	44.1		C	22,273	17,818	14,848	12,727	11,136	9,899	8,909	8,099	7,424	6,364	5,568
4" x 1/4"	22-4-164	32.1	5.818	U	19,394	12,412	8,620	6,333	4,848	3,831	3,103	2,564	2,155	1,583	1,212
	22-2-164	33.6		C	19,394	15,515	12,929	11,082	9,697	8,620	7,758	7,052	6,465	5,541	4,848
4" x 5/16"	22-4-165	40.2	7.273	U	24,242	15,515	10,774	7,916	6,061	4,789	3,879	3,206	2,694	1,979	1,515
	22-2-165	42.3		C	24,242	19,394	16,162	13,853	12,121	10,774	9,697	8,815	8,081	6,926	6,061
4" x 3/8"	22-4-166	47.8	8.727	U	29,091	18,618	12,929	9,499	7,273	5,746	4,655	3,847	3,232	2,375	1,818
	22-2-166	49.8		C	29,091	23,273	19,394	16,623	14,545	12,929	11,636	10,579	9,697	8,312	7,273
4-1/2" x 1/4"	22-4-184	35.9	7.364	U	24,545	15,709	10,909	8,015	6,136	4,848	3,927	3,246	2,727	2,004	1,534
	22-2-184	37.4		C	24,545	19,636	16,364	14,026	12,273	10,909	9,818	8,926	8,182	7,013	6,136
4-1/2" x 5/16"	22-4-185	45.0	9.205	U	30,682	19,636	13,636	10,019	7,670	6,061	4,909	4,057	3,409	2,505	1,918
	22-2-185	47.0		C	30,682	24,545	20,455	17,532	15,341	13,636	12,273	11,157	10,227	8,786	7,670
4-1/2" x 3/8"	22-4-186	53.5	11.045	U	36,818	23,564	16,364	12,022	9,205	7,273	5,891	4,869	4,091	3,006	2,301
	22-2-186	55.5		C	36,818	29,455	24,545	21,039	18,409	16,364	14,727	13,388	12,273	10,519	9,205
5" x 1/4"	22-4-204	39.8	9.091	U	30,303	19,394	13,468	9,895	7,576	5,986	4,848	4,007	3,367	2,474	1,894
	22-2-204	41.3		C	30,303	24,242	20,202	17,316	15,152	13,468	12,121	11,019	10,101	8,658	7,576
5" x 5/16"	22-4-205	49.8	11.364	U	37,879	24,242	16,835	12,369	9,470	7,482	6,061	5,009	4,209	3,092	2,367
	22-2-205	51.8		C	37,879	30,303	25,253	21,645	18,939	16,835	15,152	13,774	12,626	10,823	9,470
5" x 3/8"	22-4-206	59.2	13.636	U	45,455	29,091	20,202	14,842	11,364	8,979	7,273	6,011	5,051	3,711	2,841
	22-2-206	61.3		C	45,455	36,364	30,303	25,974	22,727	20,202	18,182	16,529	15,152	12,987	11,364
6" x 1/4"	22-4-244	47.4	13.091	U	43,636	27,927	19,394	14,249	10,909	8,620	6,982	5,770	4,848	3,562	2,727
	22-2-244	48.9		C	43,636	34,909	29,091	24,935	21,818	19,394	17,455	15,868	14,545	12,468	10,909
6" x 5/16"	22-4-245	59.3	16.364	U	54,545	34,909	24,242	17,811	13,636	10,774	8,727	7,213	6,061	4,453	3,409
	22-2-245	61.4		C	54,545	43,636	36,364	31,169	27,273	24,242	21,818	19,835	18,182	15,584	13,636
6" x 3/8"	22-4-246	70.7	19.636	U	65,455	41,891	29,091	21,373	16,364	12,929	10,473	8,655	7,273	5,343	4,091
	22-2-246	72.7		C	65,455	52,364	43,636	37,403	32,727	29,091	26,182	23,802	21,818	18,701	16,364

H-22 PANEL WIDTH (inches)

Note: H-Heavy Duty cross rods may extend 1/8" each side. Panel widths do not include these extensions.

No. of Bars	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1/4" Bar	15/8	3	43/8	53/4	71/8	81/2	97/8	111/4	125/8	14	153/8	163/4	181/8	191/2	207/8	221/4	235/8	25	263/8
5/16" Bar	111/16	31/16	47/16	513/16	73/16	89/16	915/16	115/16	1211/16	141/16	157/16	1613/16	183/16	199/16	2015/16	225/16	2311/16	251/16	267/16
3/8" Bar	13/4	31/8	41/2	57/8	71/4	85/8	10	113/8	123/4	141/8	151/2	167/8	181/4	195/8	21	223/8	233/4	251/8	261/2
No. of Bars	21	22	23	24	25	26	27												
1/4" Bar	273/4	291/8	301/2	317/8	331/4	345/8	36												
5/16" Bar	2713/16	293/16	309/16	3115/16	335/16	3411/16	361/16												
3/8" Bar	277/8	291/4	305/8	32	333/8	343/4	361/8												



G.C. Wallace, Inc.
1555 South Rainbow Blvd
Las Vegas, NV 89146
(702) 804-2000

Project Title:
Engineer: Eric G.
Project Descr:

Project ID:

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ENERCALC, INC. 1983-2013, Build:6.13.8.31, Ver:6.13.12.31

Steel Beam

Lic. #: KW-06002262

Licensee: G.C. WALLACE, INC.

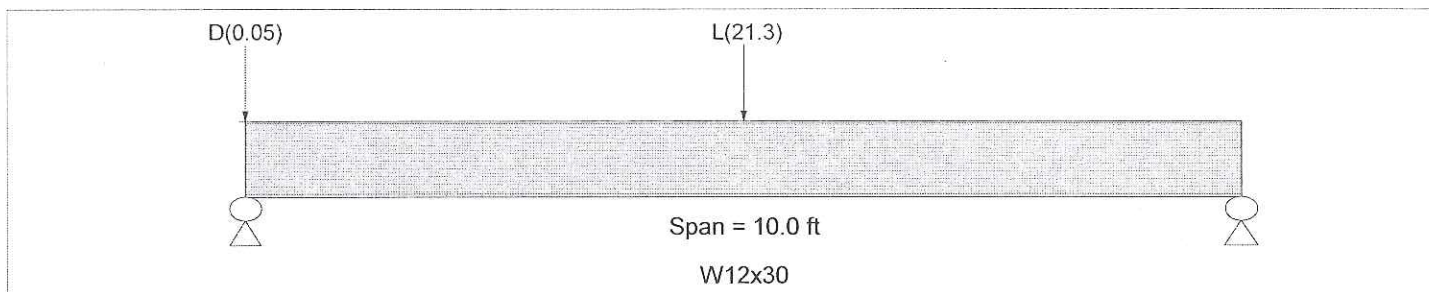
Description: Grate Support Beam

CODE REFERENCES

Material Properties

Analysis Method: Allowable Strength Design
Beam Bracing: Completely Unbraced
Bending Axis: Major Axis Bending
Load Combination: ASCE 7-02

Fy: Steel Yield: 50.0 ksi
E: Modulus: 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loads
Load(s) for Span Number 1
Point Load: D = 0.050 k @ 0.0 ft, (Dead Load)
Point Load: L = 21.30 k @ 5.0 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.499 : 1	Maximum Shear Stress Ratio =	0.169 : 1
Section used for this span	W12x30	Section used for this span	W12x30
Ma: Applied	53.624 k-ft	Va: Applied	10.80 k
Mn / Omega: Allowable	107.535 k-ft	Vn / Omega: Allowable	63.960 k
Load Combination	+D+L+H	Load Combination	+D+L+H
Location of maximum on span	5.000 ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1
Maximum Deflection			
Max Downward L+Lr+S Deflection	0.112 in	Ratio =	1,072
Max Upward L+Lr+S Deflection	0.000 in	Ratio =	0 < 360
Max Downward Total Deflection	0.113 in	Ratio =	1063
Max Upward Total Deflection	0.000 in	Ratio =	0 < 180

Maximum Forces & Stresses for Load Combinations

Load Combination		Max Stress Ratios		Summary of Moment Values							Summary of Shear Values		
Segment Length	Span #	M	V	Mmax +	Mmax -	Ma - Max	Mnx	Mnx/Omega	Cb	Rm	Va Max	Vnx	Vnx/Omega
D Only													
Dsgn. L = 10.00 ft	1	0.004	0.002	0.37		0.37	169.59	101.55	1.14	1.00	0.15	95.94	63.96
+D+L+H													
Dsgn. L = 10.00 ft	1	0.499	0.169	53.62		53.62	179.58	107.53	1.31	1.00	10.80	95.94	63.96

Overall Maximum Deflections - Unfactored Loads

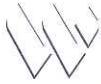
Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D+L	1	0.1129	5.050		0.0000	0.000

Vertical Reactions - Unfactored

Support notation: Far left is #1

Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	10.850	10.800
D Only	0.200	0.150
L Only	10.650	10.650
D+L	10.850	10.800



G. C. WALLACE COMPANIES
ENGINEERS | PLANNERS | SURVEYORS

DATE: _____ SHEET NO. _____ OF _____
SUBJECT: _____ JOB NO. _____
CLIENT: _____ CHECKED BY _____ CALC BY _____

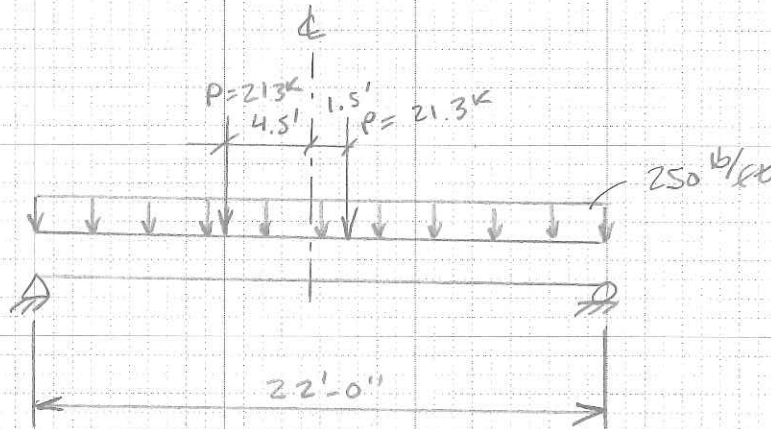
DESIGN BEAM TO CARRY GRATE

$$\text{WT OF GRATE } (50 \text{ lb/ft}^2) \left(10 \frac{1}{2} \right) = 250 \text{ lb/ft}$$

$$\text{WT OF W12 BEAM} = 10 \frac{1}{2} (30 \text{ lb/ft}) = 150 \text{ lb/ft}$$

$$\text{TRUCK} = 16 \text{ k WHEEL LOAD} \times 1.33 = 21.28 \text{ k} \cdot \text{ft}$$

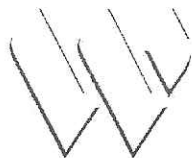
↑ IMPACT



SEE ENERCALC DESIGN

THE RCB HAS #9 @ 12" ALTERNATING W/ #8 @ 12"

$$\begin{aligned} \text{AS FOR 1' WIDE AREA} &= 2.0 \text{ in}^2 + 0.79 \text{ in}^2 \\ &= 2.79 \text{ in}^2 \quad \underline{\underline{OK}} \end{aligned}$$



G.C. Wallace, Inc.
1555 South Rainbow Blvd
Las Vegas, NV 89146
(702) 804-2000

Project Title:
Engineer: Eric G.
Project Descr:

Project ID:

Concrete Beam

File = c:\MyFiles\ERICGI-1\EGGFI-1\EnerCalc\2014\451-00-1.EC6
ENERCALC, INC. 1983-2013, Build:6.13.8.31, Ver:6.13.12.31

Lic. #: KW-06002262

Licensee: G.C. WALLACE, INC.

Description: Concrete Beam to Support Gate

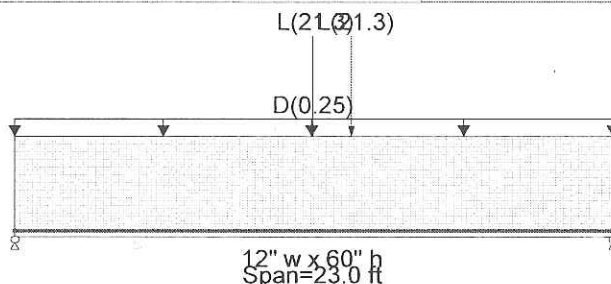
CODE REFERENCES

Material Properties

f'_c	=	4.0 ksi	ϕ Phi Values	Flexure :	0.90
$f_r = f'_c^{1/2}$	=	474.342 psi		Shear :	0.750
Ψ Density	=	145.0 pcf	β_1	=	0.850
λ LtWt Factor	=	1.0			
Elastic Modulus	=	3,605.0 ksi	F_y - Stirrups	=	40.0 ksi
f_y - Main Rebar	=	60.0 ksi	E - Stirrups	=	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #	=	# 4
			Number of Resisting Legs Per Stirrup	=	2



Load Combination ASCE 7-02



Cross Section & Reinforcing Details

Rectangular Section, Width = 12.0 in, Height = 60.0 in

Span #1 Reinforcing....

3-#9 at 3.0 in from Bottom, from 0.0 to 23.0 ft in this span

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loads

Load for Span Number 1

Uniform Load : D = 0.250 k/ft, Tributary Width = 1.0 ft, (Dead Load)

Point Load : L = 21.30 k @ 13.0 ft, (Wheel Load 1)

Point Load : L = 21.30 k @ 11.50 ft, (Wheel Load 2)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.600 : 1	Maximum Deflection	
Section used for this span	Typical Section	Max Downward L+Lr+S Deflection	0.024 in Ratio = 11424
M_u : Applied	443.726 k-ft	Max Upward L+Lr+S Deflection	0.000 in Ratio = 0 < 360
M_n * Phi : Allowable	739.72 k-ft	Max Downward Total Deflection	0.032 in Ratio = 8615
Load Combination	+1.20D+0.50Lr+1.60L+1.60H	Max Upward Total Deflection	0.000 in Ratio = 999
Location of maximum on span	11.500 ft		
Span # where maximum occurs	Span # 1		

Vertical Reactions - Unfactored

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	31.123	33.902
D Only	11.212	11.212
L Only	19.911	22.689
D+L	31.123	33.902

Shear Stirrup Requirements

Between 0.00 to 11.50 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd V_s = Min 11.5.6.3, use stirrups spaced at 24.000 in

Between 11.55 to 12.98 ft, $V_u < \Phi V_c/2$, Req'd V_s = Not Req'd, use stirrups spaced at 0.000 in

Between 13.03 to 22.95 ft, $\Phi V_c/2 < V_u \leq \Phi V_c$, Req'd V_s = Min 11.5.6.3, use stirrups spaced at 24.000 in

Maximum Forces & Stresses for Load Combinations

Concrete Beam Design

Used to determine reinforcing requirements

Factored Moment, Mu =	443.70	k*ft
Depth of beam or thickness of slab =	60.0	inches
Width of Beam, b =	12.0	inches
Size of Rebar =	6	
Clearance to Reinforcing =	3.0	inches

$$d = 56.625 \text{ inches}$$

$$\phi = 0.90$$

$$f_c = 4000 \text{ psi}$$

$$f_y = 60000 \text{ psi}$$

$$R = Mu / (\phi * b * d^2)$$

$$= (443.70 * 12000) / (0.9 * 12 * 56.63^2)$$

$$= 153.76$$

$$m = f_y / 0.85 * f_c$$

$$= 60000 / 0.85 * 4000$$

$$= 17.65$$

$$\rho = 1/m (1 - \sqrt{1 - 2mR / f_y})$$

$$= (1 / 17.65) * (1 - \sqrt{1 - (2 * 17.65 * 153.76 / 60000)})$$

$$= 0.00262$$

$$\text{Min } \rho = 3 * \sqrt{f_c} / f_y \text{ but not less than } 200 / f_y \quad (\text{Eq. 10-3})$$

$$= 0.00333$$

Instead of ρ min, you can use $4/3 \rho = 4/3 * 0.0026$ (10.5.3)

$$= 0.0035$$

$$\text{Use } \rho = 0.00333$$

$$\text{Required } A_s = \rho * b * d$$

$$= 0.0033 * 12 * 56.625$$

$$= 2.27 \text{ sq. inches}$$

$$\text{Use } A_s = 2.79 \text{ sq. inches}$$

$$T = f_y * A_s$$

$$= 167.4 \text{ kips}$$

$$a = T / (0.85 * f_c * b)$$

$$= 4.10294 \text{ inches}$$

$$\phi M_n = \phi * T (d - a/2)$$

$$\phi M_n = 685.17 \text{ k*ft}$$

(2) - #9 BARS
 + (1) - #8 BAR

 $\Sigma = 2.79 \text{ in}^2$

Design 6'x3' RCB Plug

Design walls to span vertically. Length of wall = 4 feet

$f_c = 4000$ psi
 $f_y = 60000$ psi
 Wall Height = 4 ft
 Thickness of Wall = 8 inches
 Soil Cover Depth over Slab = 10 ft
 Thickness of Top Slab = 0 inches
 Surcharge load = 2' of soil = 250 psf (AASHTO Table 3.11.6.4-2)
 EFP at Rest = 60 psf (per AASHTO 3.11.5)

Pressure at top of wall = $EFP * (\text{Soil Cover} + \text{Top Slab Thickness}) + .5(\text{Truck Surcharge})$
 = 725 psf

Pressure at bottom of wall = $EFP * (\text{Soil Cover} + \text{Top Slab Thick} + \text{Wall Height}) + .5(\text{Truck Surch.})$
 = 965 psf

AASHTO LRFD Load Factors (Table 3.4.1-1 - Strength 1)

= 1.50 * EH (Could use 1.35 for EH and 1.5 for ES)

Conservatively use 1.5 for both

Load Factor = 1.50

Wall is designed as pinned at top and bottom

Factored pressure at top = 1.09 ksf

Factored Pressure at bottom = 1.45 ksf

Factored Moment, $M_u = [wL^2 / 8] + .1283WL$

$W = 1/2 (1.45 - 1.09)(4)$

= 0.72 k

$w = 1.09$ k/ft

Factored Moment, $M_u = 2.54$ k*ft/ft

Bar Size to Use = 4

diameter of bar = 0.5 in

Center Reinforcing in Wall (Y or N) = N

$d = 5.75$ inches

$b = 12$ inches

$R = M_u / (.9bd^2)$

= 85.51158

$m = f_y / (f_c * 0.85)$

= 17.65

$p = 1/m [1 - \sqrt{1 - (2mR/f_y)}]$

= 0.00144

Less than min. Use 4/3 p

Area of Steel Required = 4/3 pbd

= 0.13 sq. inches

Use #4 @ 12" O.C.
 $A_s = 0.20$ sq. inches.

