Box Culvert Design Calculations

Florida Blvd. Culvert Replacement

Bridge Culvert No. 724446

Duval County (72100)

Prepared for:

CITY OF
Neptune
Beach

Prepared by:

Parsons Transportation Group
1300 Riverplace Boulevard, Suite 200
Jacksonville, Florida 32207
Certification of Authorization: 1838
David A. Whong, P.E.
FL No. 66882

June 2020

David A Whong
2020.06.11 10:29:47 -04'00'

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Load Rating Summary Form

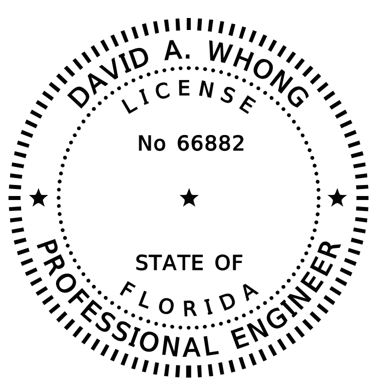
Bridge No.	724446	**Analysis Method:**	LRFR-LRFD	**FDOT Bridge Load Rating Summary Form (Page 1 of 1)**
Location	Florida Blvd & 5th St over Ditch, Neptune Beach (1200' west of SR A1A)			
Description	Double 7x6 Box Culvert; Bridge Length = 21'-11"			

Rating Type	Rating Type	Gross Axle Weight (tons)	Moment/Shear/Service		Dead Load Factor	Live Load Factor	Live Load Distrib. Factor (axles)	Rating Factor	Span No. - Girder No., Interior/Exterior, %Span Length	RF·Weight (tons)
Level	**Vehicle**	**Weight**	**Member Type**	**Limit**	**DC**	**LL**	**LLDF**	**RF**	**Governing Location**	**RATING**
Inventory	HL93	36	Reinf. Concrete	Strength, Moment	1.25/0.90	1.75	2.330	1.650	Ext. Wall Haunch, Bottom Slab	59.4
Operating	HL93	36	Reinf. Concrete	Strength, Moment	1.25/0.90	1.35	2.330	2.130	Ext. Wall Haunch, Bottom Slab	76.7
Permit	FL120	60	Reinf. Concrete	Strength, Moment	1.25/0.90	1.35	3.750	1.324	Ext. Wall Haunch, Bottom Slab	79.4
Permit Max Span	FL120	60	Reinf. Concrete	Strength, Moment	1.25/0.90	1.35	3.750	1.324	Ext. Wall Haunch, Bottom Slab	79.4
Legal	SU2	17	Member Type	Limit Test	NA	NA				-1
	SU3	33	Member Type	Limit Test	NA	NA				-1
	SU4	35	Member Type	Limit Test	NA	NA				-1
	C3	28	Member Type	Limit Test	NA	NA				-1
	C4	36.7	Member Type	Limit Test	NA	NA				-1
	C5	40	Member Type	Limit Test	NA	NA				-1
	ST5	40	Member Type	Limit Test	NA	NA				-1
Emergency Vehicle (EV)	EV2	28.75	Member Type	Limit Test	NA	NA				-1
	EV3	43	Member Type	Limit Test	NA	NA				-1

Original Design Load	HL93	
Rating Type, *Analysis*	LRFR-LRFD	
Distribution Method	AASHTO Formula	
Impact Factor	24.8%	(axle loading)
FL120 Gov. Span Length	7.8	(feet)
Minimum Span Length	7.8	(feet)
Recommended Posting	At/Above legal loads. Posting Not Required.	
Recommended SU Posting*	99	(tons)
Recommended C Posting	99	(tons)
Recommended ST5 Posting	99	(tons)
Owner	04 City or Municipal Highway Agency	
Location	Neither interstate traffic nor within 1 mile reasonable access to an interstate	
EV Posting	No. EV posting is not recommended. The FAST Act does not apply	
Floor Beam Present?	No	
Segmental Bridge?	No	
Project No. & Reason	NA	New Bridge
Plans Status	Design or Construction	

Performed by:	Raymond Helmbreck	Date:	10/29/19
Checked by:	David A. Whong	Date:	10/30/19
Sealed By:	David A. Whong	Date:	06/11/20
FL P.E. No.:	66882		
Cert. Auth. No.:	1838		
Phone & email:	904-596-1406; david.whong@parsons.com		
Company:	Parsons Transportation Group		
Address:	1300 Riverplace Blvd, Ste 200, Jacksonville, FL 32207		

P.E. Seal, Comments by the Engineer



David A Whong
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This 10-11-2019 summary follows the FDOT Bridge Load Rating Manual (BLRM), and the FDOT BMS Coding Guide.

*Recommended SU Posting levels for Florida SU trucks adequately restricts AASHTO SU trucks; see BLRM Chapter 7.

fdot.gov/maintenance/LoadRating.shtm

Bridge Description

BRIDGE DESCRIPTION

There is a long history of flooding in Duval County beach communities during major rain events and during minor rain events occurring with exceptionally high tides, especially areas east of 3rd Street. Each of the beaches communities have a major channel that converge in Hopkins Creek. A major hydrologic and hydraulic analysis of these systems was performed as part of a drainage improvement project by the FDOT for SR A1A. The studies document that the problem stems from drainage channels and culvert crossings that do not have the flow capacity to handle the current land development and design storms (Parsons, 2016).

For the City of Neptune Beach, the most significant bottleneck is the culvert crossing at Florida Blvd and 5th Street where the existing culvert is undersized, deteriorated, and partially full of sediment. Some of the impacts from this bottleneck may include surcharged inlets and water pooling in low lying areas east of 3rd Street.

The project is located along the main drainage channel of Neptune Beach, Florida. The channel herein is denoted CONB main channel or just channel. The project is in Section 21, Township 2 South, Range 29 East, in Duval County, Florida. The horizontal datum used for this project is NAD 1983, State Plane Zone Florida East. The vertical datum used for this project is NAVD 1988. The conversion from NGVD 1929 to NAVD 1988 is 1.06-ft in the project area, with NGVD 1929 higher than NAVD 1988.

The proposed reinforced concrete double 7' x 6' culvert will replace the existing hydraulically inadequate and deteriorated steel corrugated pipe culvert. The alignment of the proposed culvert will remain consistent with the existing culvert with a skew of approximately 45 degrees under an intersection of two 2-lane undivided urban sections with no medians, flush shoulders, some sidewalks, and partial curbs.

The governing manuals used in this report are FDOT's Structures Design Guidelines (SDG) dated January 2019 and FDOT's Bridge Load Rating Manual (BLRM) dated January 2019.

The load ratings are performed using FDOT's LRFD Box Culvert Program v4.0. The rating includes the HL93 Operating and the HL93 Inventory Limit States (Strength I and Service III), as well as the FL120 Permit Limit State (Strength II). Due to the HL93 Operating Rating Factor being greater than 1.3, Florida Legal Loads and the Emergency Vehicle were not required to be evaluated.

Box Culvert Design

Box Culvert Analysis:
Dimensions and Material Properties

STEP 1

New File Name (optional):

Refresh File List

Select File Below (required):

- 08x08Under4
- 10x06Under3
- 10x10Under6
- 12x08Under3
- 12x12Under6
- 15x12Under3
- 15x15Under6
- Neptune Beach

To Create a New File:
1. Enter new data file name above (path and .dat extension will be added automatically).
2. Select a source file from the file list on the left.
3. Press "Refresh File List". The new data file will be available for selection on the file list.

Calculate worksheet (CTRL+F9) to load data file selection.

Calculate Worksheet

Read In Data

data file currently in use: CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

This program uses design values from the CurrentDataFile *in use. It is generally **not** necessary to save the modified Mathcad worksheet since all the design values are saved in the* CurrentDataFile.

Only change new values. Calculate Worksheet (CTRL+F9) twice to save/view new values. If current data values are correct, leave (XX) *in the* newData *field.*

Project = "CONB - Double 7' x 6' Box Culvert"

newProject := "XX"

DesignedBy = "RLH"

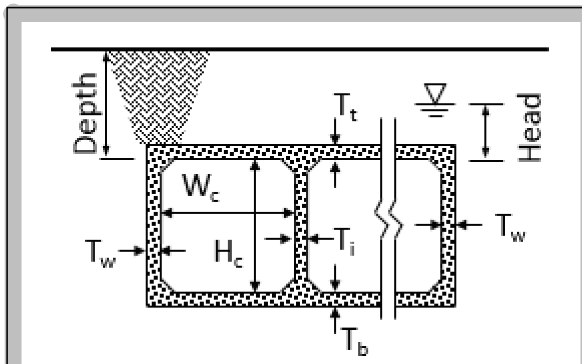
newDesignedBy := "XX"

CheckedBy = "DAW"

newCheckedBy := "XX"

Comment = "Double 7' x 6' Box Culvert"

newComment := "XX"



Box Section

Design Parameters

program analyzes a one foot wide cross section: $b_w = 1\,ft$

Geometry and Box Dimensions

to enter and/or change data values, change **XX**·dimension *values to the desired values*

number of cells:	*distance from top of opening to surface:*	*opening width of cell:*	*opening height of cell:*	*length of culvert along centerline:*
NoOfCells = 2	Depth = 3 ft	W_c = 7 ft	H_c = 6 ft	L_c = 150 ft
newNoOfCells := **XX**	newDepth := **XX**·ft	$newW_c$:= **XX**·ft	$newH_c$:= **XX**·ft	$newL_c$:= **150**·ft

(span-to-rise ratios exceeding 4-to-1 are not recommended) ***SDG 3.15.13***

top slab thickness: (8 inch min.) ***SDG 3.15.6***	*bottom slab thickness: (8 inch min.)*	*exterior wall thickness: (8 inch min.)*	*interior wall thickness: (8 inch min.)*	*water head at top of opening: (typically = 0.0)*
T_t = 12·in	T_b = 12·in	T_w = 12·in	T_i = 12·in	Head = 0 ft
$newT_t$:= **XX**·in	$newT_b$:= **XX**·in	$newT_w$:= **XX**·in	$newT_i$:= **XX**·in	newHead := **XX**·ft

depth of soil above top surface of slab:

SoilHeight := if(newDepth = **XX**·ft, Depth, newDepth) − if($newT_t$ = **XX**·in, T_t, $newT_t$)

SoilHeight = 2 ft

extension type:

0 - *new box (no extension)*
1- *left extension*
2 - *right extension*

Extension = 0

newExtension := XX

extension notes:
1.Two feet is added automatically to the length of culvert and corresponding rebar lengths for splicing to existing culvert per Index No. 289
2. When switching extension types, extension- specific variables require new user inputs (e.g. H_{start}, H_{end}, & L_{ww})

box end skew:

$$Skew_{box} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot deg$$

$$newSkew_{box} := \begin{pmatrix} \mathbf{XX} \cdot deg \\ \mathbf{XX} \cdot deg \end{pmatrix} \quad \begin{matrix} \textit{left} \\ \textit{right} \end{matrix}$$

(for left extensions the right end skew is zero and for right extensions the left end skew is zero)

Extension = 0

0 - *new box (no extension)*
1- *left extension*
2 - *right extension*

Headwall Dimensions

index for number of headwalls:

iwbeg := if(Extension ≠ 2, 0, 1)

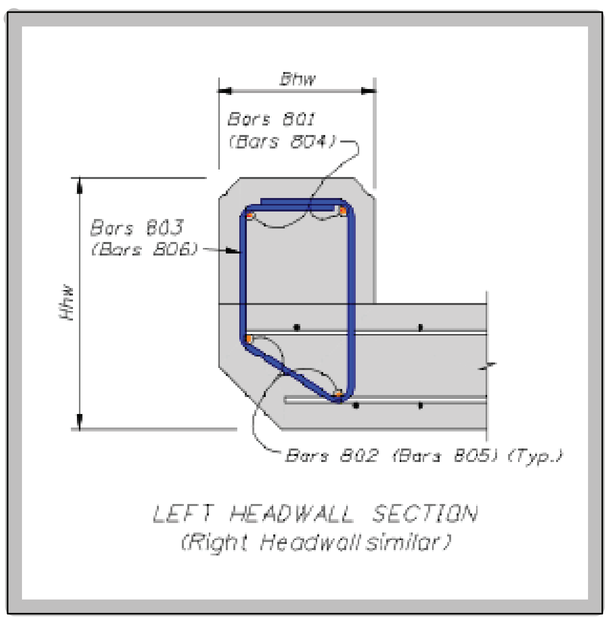
iwend := if(Extension ≠ 1, 1, 0)

iw := iwbeg .. iwend

Values currently being used by the program

left & right headwall height, H, and width, B:

iw =	$\frac{Hhw_{iw}}{in}$ =	$\frac{Bhw_{iw}}{in}$ =
0	36	12
1	36	12



Change Group values (colored); change individual values (white)

(headwall exceeding 2 feet above the top slab is beyond the intent of this program)

$newH_{hw}$:= **XX**·in

$newH_{hw.left}$:= **XX**·in

$newH_{hw.right}$:= **XX**·in

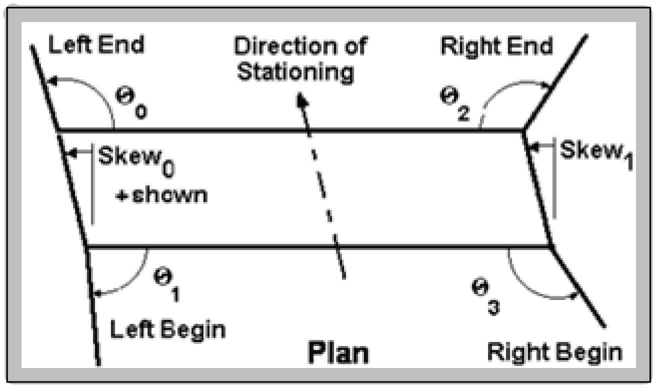
$newB_{hw}$:= **XX**·in

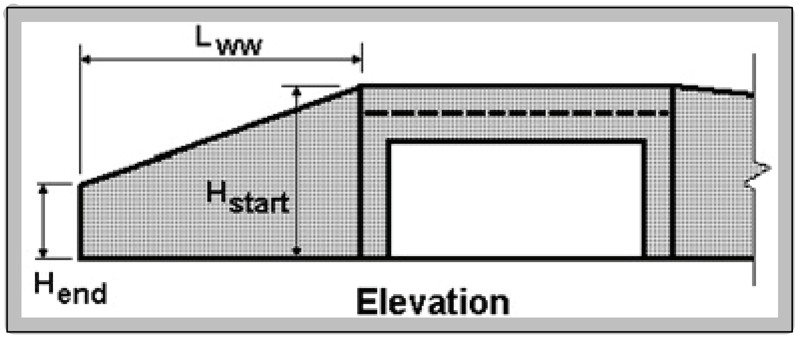
$newB_{hw.left}$:= **XX**·in

$newB_{hw.right}$:= **XX**·in

If New, Change Data

Wingwall Dimensions





wingwall geometry:

ibeg := if (Extension ≠ 2, 0, 2)   iend := if (Extension ≠ 1, 3, 1)   i := ibeg .. iend

$H_{start.default} := \max(H_{hw}) + \text{if}\left[(newH_c = \textbf{XX}\cdot ft), H_c, newH_c\right]$ $H_{start.default} = 9\,ft$

Values currently being used by the program   *Change Group values (colored); change individual values (white)*

	i =	H_{start_i} = (ft)	θ_i = (deg)
0-left end	0	9	90
1-left begin	1	9	90
2-right end	2	9	135
3-right begin	3	9	135

$newH_{start_i} := \textbf{XX}\cdot ft$

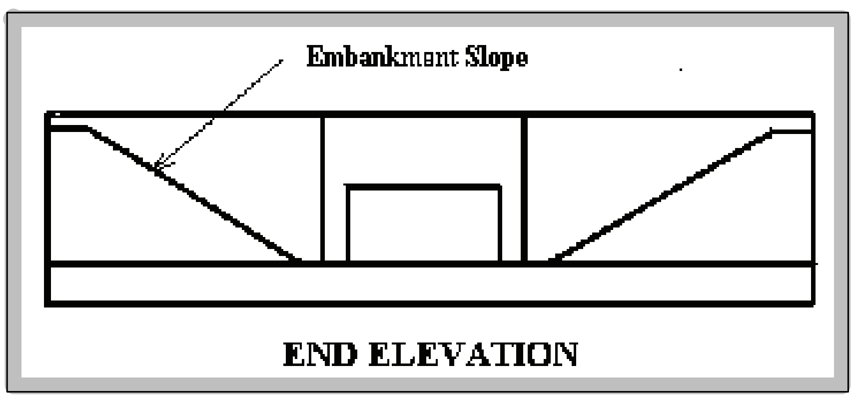
$new\theta_i := \textbf{XX}\cdot deg$

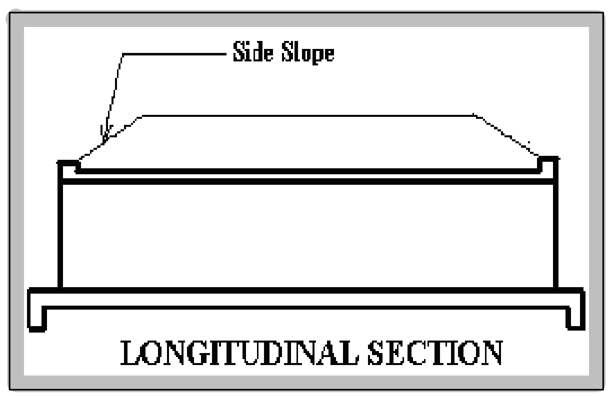
Enable the following to use default values (right click - Enable Eval.):

$newH_{start_i} := H_{start.default}$

k := 0 .. 3

$newH_{start.ww_k}$:=	$new\theta_{ww_k}$:=
XX·ft	XX·deg
XX·ft	XX·deg
XX·ft	XX·deg
XX·ft	XX·deg





Notes:
Box skew angles measured from square, counterclockwise positive. Wingwall angles θ *measured from box wall to wingwall. (allowable range for* θ *is 45 to 225 degrees).* EmbankmentSlope *is the slope of the soil below the top of the wingwall and used to calculate the wingwall length.* SideSlope *is the slope of the soil that goes downward perpendicular to the top of the headwall. If there are two headwalls and they are not parallel, default* $\beta_{sideslope}$ *has to be overridden using* β_{user} .

$EmbankmentSlope := \frac{\textbf{1}}{\textbf{2}} \frac{rise}{run}$ $SideSlope := \frac{\textbf{1}}{\textbf{10}} \frac{rise}{run}$ *(if* SideSlope *varies, note that* $L_{ww.default}$ *wingwall length is based on* SideSlope*)*

If New, Change Data

default wingwall length: $\frac{L_{ww.default_i}}{ft} =$; *default wingwall end height:* $\frac{H_{end.default_i}}{ft} =$; $\frac{H_{start_i}}{ft} =$

i =		$\frac{L_{ww.default_i}}{ft}$	$\frac{H_{end.default_i}}{ft}$	$\frac{H_{start_i}}{ft}$
0	*0-left end*	20	9	9
1	*1-left begin*	20	9	9
2	*2-right end*	24	7.5	9
3	*3-right begin*	24	7.5	9

default value assumes roadway CL is parallel to headwalls

Values currently being used by the program

i =	$\frac{L_{ww_i}}{ft}$	$\frac{H_{end_i}}{ft}$	$\frac{\beta_{sideslope_i}}{deg}$
0	16.5	9	5.71
1	16.5	9	5.71
2	23	9	4.04
3	23	9	4.04

Override all values

$newL_{ww_i} := \mathbf{XX} \cdot ft$

$newH_{end_i} := \mathbf{XX} \cdot ft$

Enable the following to use default values (right click - Enable Eval.):

$newL_{ww_i} := L_{ww.default_i}$

$newH_{end_i} := H_{end.default_i}$

Override individual values (white)

$newL_{w.ww_k} :=$	$newH_{end.ww_k} :=$	$\beta_{user_k} :=$
$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot deg$
$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot deg$
$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot deg$
$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot ft$	$\mathbf{XX} \cdot deg$

Soil Properties

density of soil:
SDG 3.15.4

$\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$

$new\gamma_{soil} := \mathbf{XX} \cdot \frac{lbf}{ft^3}$

soil friction angle:

$\phi = 30 \cdot deg$

$new\phi := \mathbf{XX} \cdot deg$

modulus of subgrade reaction:

$k_s = 86500 \cdot \frac{lbf}{ft^3}$

$newk_s := \mathbf{XX} \cdot \frac{lbf}{ft^3}$

nominal bearing capacity:

$q_{nom} = 4444 \cdot \frac{lbf}{ft^2}$

$newq_{nom} := \mathbf{XX} \cdot \frac{lbf}{ft^2}$

nominal bearing capacity is allowable bearing pressure (typically from Geotech Engr) multiplied by factor of safety

Material Properties

environmental class:
SDG 1.3

$Env = 3$

$newEnv := \mathbf{XX}$

1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

reinforcing strength:
SDG 3.15.8

$F_y = 60 \cdot ksi$

$newF_y := \mathbf{XX} \cdot ksi$

density of concrete:
SDG 3.15.4B

$\gamma_{conc} = 150 \cdot \frac{lbf}{ft^3}$

$new\gamma_{conc} := \mathbf{XX} \cdot \frac{lbf}{ft^3}$

density of water:

$\gamma_w = 62.4 \cdot \frac{lbf}{ft^3}$

$new\gamma_w := \mathbf{XX} \cdot \frac{lbf}{ft^3}$

concrete strength preset for FDOT work:
SDG 3.15.7

$f_{c.fdot} := if(Env \le 1, 3.4 \cdot ksi, 5.5 \cdot ksi)$

$f_{c.fdot} = 5.5 \cdot ksi$

$f_c = 5.5 \cdot ksi$

$newf_c := f_{c.fdot}$

aggregate factor:

concrete modulus of elasticity:

SDG 1.4.1 and 3.15.7

AggFactor := **1**

0 - standard aggregate
1 - Florida aggregate

$E_{fdot} := \text{if}(\text{AggFactor} = 1, 1.0, 1.0)\left[2500\left(\frac{f_{c.fdot}}{ksi}\right)^{0.33}\right]\cdot ksi$

$E_{fdot} = 4387.93\cdot ksi$

$E = 4388\cdot ksi$

$newE := E_{fdot}$

modular ratio:

$n_{mod} = 6.61$

$newn_{mod} := \frac{29000ksi}{newE}$

Construction Vehicle Load (optional)

Applies wheel load assuming no soil cover.

construction wheel loads 1, 2, and 3:

ConWheel1 = 0·kip newConWheel1 := **XX**·kip

ConWheel2 = 0·kip newConWheel2 := **XX**·kip

ConWheel3 = 0·kip newConWheel3 := **XX**·kip

spacing between axles 1 and 2 & axles 2 and 3:

ConAxleSpacing1 = 16 ft newConAxleSpacing1 := **XX**·ft

ConAxleSpacing2 = 16 ft newConAxleSpacing2 := **XX**·ft

Headwall Loads

additional dead load if a barrier is located on top of the headwall:

$BarrierDL_{hw} = 0\cdot\frac{kip}{ft}$ $newBarrierDL_{hw} := \textbf{XX}\cdot\frac{kip}{ft}$

set whether a line of truck wheels is considered as a loading:

$ConsiderLL_{hw} = 1$ $newConsiderLL_{hw} := \textbf{XX}$

0 - not considered
1 - considered

end of data entry

Write Box Design Data to CurrentDataFile

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

assign the data read in to the data to be read out, then change only the new values using the fSwitchData *function:*

DataOut := DataIn

Write Out Data to File

Box Culvert Analysis:
Box & Headwall Load Cases

Project = "CONB - Double 7' x 6' Box Culvert"

DesignedBy = "RLH"
CheckedBy = "DAW"

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

Design Parameters

$b_w = 1\,ft$ *:program analyzes a one foot wide cross section*

number of cells:	*distance from top of opening to surface:*	*opening width of cell:*	*opening height of cell:*	*length of culvert along centerline:*
NoOfCells = 2	Depth = 3 ft	$W_c = 7\,ft$	$H_c = 6\,ft$	$L_c = 150\,ft$
top slab thickness:	*bottom slab thickness:*	*exterior wall thickness:*	*interior wall thickness:*	*water head at top of opening:*
$T_t = 12 \cdot in$	$T_b = 12 \cdot in$	$T_w = 12 \cdot in$	$T_i = 12 \cdot in$	Head = 0 ft

1:1 Haunch Dimension for shear force reduction

$H_{ts} := \mathbf{4} \cdot in$ *top slab* $H_{bs} := \mathbf{4} \cdot in$ *bottom slab*

1:1 Haunch Dimension for moment reduction

$H_{tm} := \mathbf{2} \cdot in$ *top slab* $H_{bm} := \mathbf{2} \cdot in$ *bottom slab*

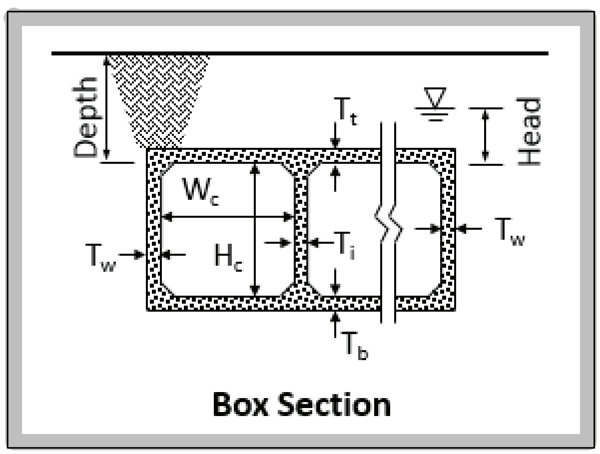
Excluding the haunch properties avoids potential for an unconservative moment design in the negative moment region caused by the change in section properties at critical location.

$Haunch_{toggle} :=$ include haunch properties

reinforced haunch width (default 2 inches per Standard Index No. 289):

$Haunch_{top} := H_{tm}$ $Haunch_{bot} := H_{bm}$

extension type:
Extension = 0
0 - *new box (no extension)*
1- *left extension*
2 - *right extension*



$HydraulicOpening := W_c \cdot H_c \cdot NoOfCells$

$HydraulicOpening = 84\,ft^2$

Soil properties

depth of soil above top surface of slab:	*density of soil:*	*soil friction angle:*	*modulus of subgrade reaction:*	*nominal bearing capacity:*
SoilHeight = 2 ft	$\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$	$\phi = 30 \cdot deg$	$k_s = 86500 \cdot \frac{lbf}{ft^3}$	$q_{nom} = 4444 \cdot \frac{lbf}{ft^2}$

Material properties

modular ratio:

$n_{mod} = 6.61$

environmental class:

$Env = 3$

1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

reinforcing strength:

$F_y = 60 \cdot ksi$

density of concrete:

$\gamma_{conc} = 150 \cdot \frac{lbf}{ft^3}$

concrete strength preset for FDOT work:

$f_c = 5.5 \cdot ksi$

density of water:

$\gamma_w = 62.4 \cdot \frac{lbf}{ft^3}$

concrete modulus of elasticity:

$E = 4388 \cdot ksi$

Construction Vehicle Loads (optional)

Applies wheel load assuming no soil cover.

construction wheel loads 1, 2, and 3:

$ConWheel1 = 0 \cdot kip$

$ConWheel2 = 0 \cdot kip$

$ConWheel3 = 0 \cdot kip$

spacing between axles 1 and 2 & axles 2 and 3:

$ConAxleSpacing1 = 16 ft$

$ConAxleSpacing2 = 16 ft$

Headwall Loads

additional dead load if a barrier is located on top of the headwall:

$BarrierDL_{hw} = 0 \cdot \frac{kip}{ft}$

set whether a line of truck wheels is considered as a loading:

$ConsiderLL_{hw} = 1$

0 - not considered
1 - considered

Generate Loads:

1. Press 'Calculate Worksheet' (or CTRL+F9) to run the entire worksheet and generate data for other worksheets to use. Repeat 'Calculate Worksheet' if changes are made.
2. Close this worksheet without saving and proceed to the next worksheet

Calculate Worksheet

2. Close this worksheet without saving and proceed to the next worksheet.

Box Culvert Design:

Section 1 - Box Loads, Approximately 75 pages

$Strength_{box}$ =

	0	1	2
0	6.44	6.22	-0.86
1	2.25	6.24	0
2	15.62	7	0
3	-1.06	0.53	0
4	13.18	0	0
5	5.65	0.39	6.22
6	2.44	0	6.24
7	12.05	-0.41	11.03
8	-0.34	0	3.98
9	8.86	0	10.71
10	3.74	0	1.83
11	4.96	0	12.99
12	-0.38	3.98	0
13	12.29	11.03	0
14	-0.94	-1	0
15	11.88	-8.75	0
16	10.68	0	0
17	7.3	8.41	0
18	-4.8	9.67	0
19	12.52	7.21	0
20	13.35	-5.57	0

$Service_{box}$ =

	0	1	2
0	3.49	4.24	0.43
1	1.05	3.21	0
2	8.15	3.97	0
3	0	0.69	0
4	6.61	0	0
5	2.95	1.26	4.24
6	1.21	0	3.21
7	6.26	-0.75	5.92
8	0	0	2.85
9	4.84	0	5.66
10	1.96	0	1.84
11	2.28	0	9.18
12	0	2.85	0
13	6.36	5.92	0
14	0	-1.21	0
15	7.43	-5.69	0
16	6.45	0	0
17	-2.69	4.99	0
18	3.54	5.85	0
19	6.06	4.11	0
20	8.22	-3.6	0

these are loads:
column 0 corresponds to moment,
column 1 to shear, and
column 2 to axial forces

The values of the final matrix are in units of feet, kips and radians.

Write Box Load Data to DataOut Variable

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

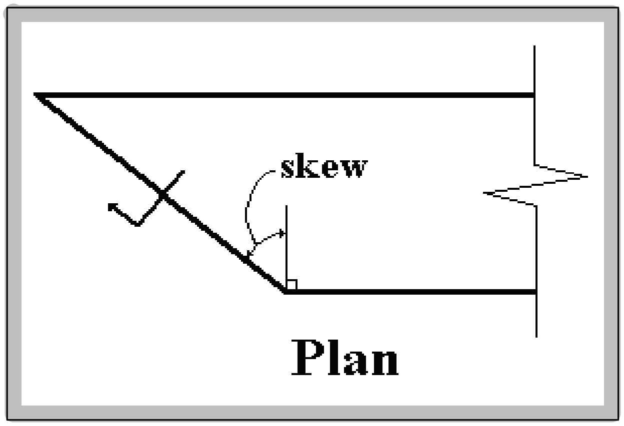
Section 2 - Write Box Load Data

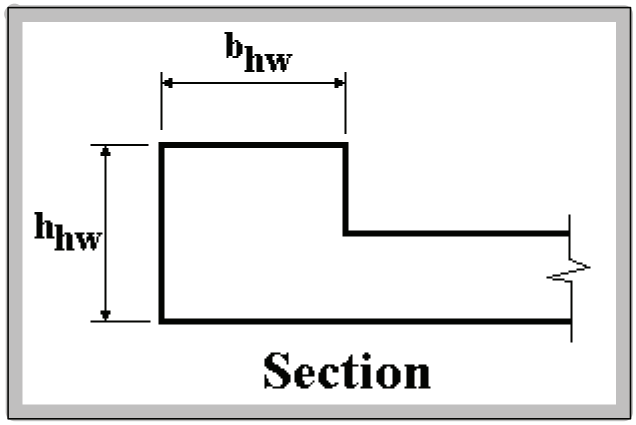
Headwall Design

Note: No lateral load analysis is performed on the headwall. If significant horizontal loads are anticipated, supplemental calculations are required.

$nc := NoOfCells$

Tributary Area for headwall design is defined in this file.





SkewDiagram

$iwbeg := if(Extension \neq 2, 0, 1)$ $iwend := if(Extension \neq 1, 1, 0)$ *index for walls:* $iw := iwbeg .. iwend$

Design parameters

index for number of headwalls:

$iw =$

0
1

left & right headwall height, H, and width, B:

$H_{hw} = \begin{pmatrix} 36 \\ 36 \end{pmatrix} \cdot in$ $B_{hw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

box end skew:

$Skew_{box} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot deg$ *left* *right*

additional dead load if a barrier is located on top of the headwall: $BarrierDL_{hw} = 0 \cdot \frac{kip}{ft}$

set whether a line of truck wheels is considered as a loading: $ConsiderLL_{hw} = 1$

0 - not considered
1 - considered

index for cells: $ic := 0 .. (nc - 1)$

number of cells: $NoOfCells = 2$

opening width of cell: $W_c = 7 ft$

opening height of cell: $H_c = 6 ft$

top slab thickness: $T_t = 12 \cdot in$

bottom slab thickness: $T_b = 12 \cdot in$

exterior wall thickness: $T_w = 12 \cdot in$

interior wall thickness: $T_i = 12 \cdot in$

modular ratio: $n_{mod} = 6.61$

concrete strength preset for FDOT work: $f_c = 5.5 \cdot ksi$

concrete modulus of elasticity: $E = 4388 \cdot ksi$

density of concrete: $\gamma_{conc} = 150 \cdot \frac{lbf}{ft^3}$

density of water: $\gamma_w = 62.4 \cdot \frac{lbf}{ft^3}$

depth of soil above top surface of slab: $SoilHeight = 2 ft$

density of soil: $\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$

reinforcing strength: $F_y = 60 \cdot ksi$

environmental class: $Env = 3$

1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

Calculate Worksheet

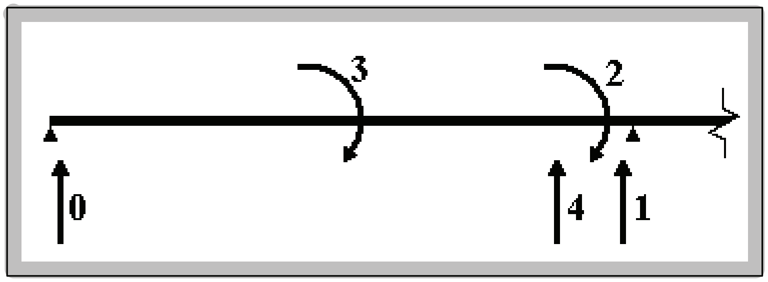
Calculate load combinations

Strength

$Strength_{hw} := 1.25 \cdot Force_{sw} + 1.35 \cdot Force_{ew} + 1.75 \cdot Force_{ll} \cdot ConsiderLL_{hw}$

Service

$Service_{hw} := 1.0 \cdot Force_{sw} + 1.0 \cdot Force_{ew} + 1.0 \cdot Force_{ll} \cdot ConsiderLL_{hw}$



*Due to the difference in the center-to-center span (model) versus clear span (actual) a reduction in the moment forces is allowed. For end moments, a reduction of 1/3*Vend*t is used and for midspan moments 1/6*Vend*t is used.*

$$Strength_{hw} = \begin{pmatrix} 29.83 & 23.59 & 34.53 & 45.61 & 36.32 \\ 29.83 & 23.59 & 34.53 & 45.61 & 36.32 \end{pmatrix} \qquad Service_{hw} = \begin{pmatrix} 17.56 & 14.33 & 21.1 & 26.75 & 21.61 \\ 17.56 & 14.33 & 21.1 & 26.75 & 21.61 \end{pmatrix}$$

$$Strength_{hw_{iw,2}} := Strength_{hw_{iw,2}} - \frac{1}{3} \cdot Strength_{hw_{iw,1}} \cdot \frac{T_w}{ft} \qquad Service_{hw_{iw,2}} := Service_{hw_{iw,2}} - \frac{1}{3} \cdot Service_{hw_{iw,1}} \cdot \frac{T_w}{ft}$$

$$Strength_{hw_{iw,3}} := Strength_{hw_{iw,3}} - \frac{1}{6} \cdot \left(\frac{4 \cdot Strength_{hw_{iw,3}}}{L_{hw_{iw,0}}} \right) \cdot \frac{T_w}{ft} \qquad Service_{hw_{iw,3}} := Service_{hw_{iw,3}} - \frac{1}{6} \cdot \left(\frac{4 \cdot Service_{hw_{iw,3}}}{L_{hw_{iw,0}}} \right) \cdot \frac{T_w}{ft}$$

$$Strength_{hw} = \begin{pmatrix} 29.83 & 23.59 & 26.66 & 41.81 & 36.32 \\ 29.83 & 23.59 & 26.66 & 41.81 & 36.32 \end{pmatrix} \qquad Service_{hw} = \begin{pmatrix} 17.56 & 14.33 & 16.32 & 24.52 & 21.61 \\ 17.56 & 14.33 & 16.32 & 24.52 & 21.61 \end{pmatrix}$$

Write Box and Headwall Load Data CurrentDataFile

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

assign the data read in to the data to be read out, then change only the new values using the fSwitchData *function:*

DataOut := DataIn

Setion 4 Write Out Data

Box Culvert Analysis:
Box Reinforcement Design

Project = "CONB - Double 7' x 6' Box Culvert"

DesignedBy = "RLH"

CheckedBy = "DAW"

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

1. Design Parameters

$b_w = 1\,ft$ *:program analyzes a one foot wide cross section*

number of cells:	*distance from top of opening to surface:*	*opening width of cell:*	*opening height of cell:*	*length of culvert along centerline:*
NoOfCells = 2	Depth = 3 ft	$W_c = 7\,ft$	$H_c = 6\,ft$	$L_c = 150\,ft$
top slab thickness:	*bottom slab thickness:*	*exterior wall thickness:*	*interior wall thickness:*	*water head at top of opening:*
$T_t = 12 \cdot in$	$T_b = 12 \cdot in$	$T_w = 12 \cdot in$	$T_i = 12 \cdot in$	Head = 0 ft

Extension = 0

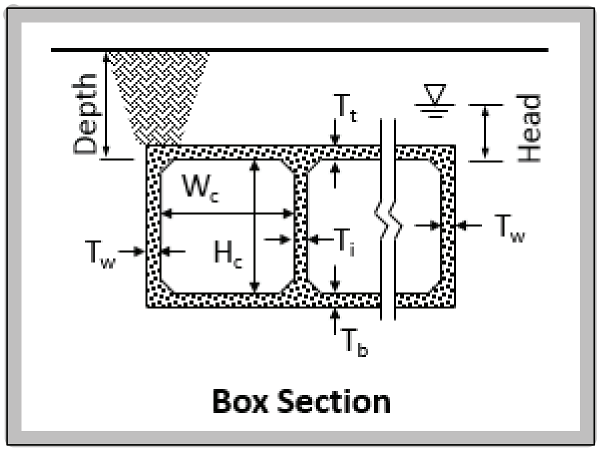
0 - *new box (no extension)*

1- *left extension*

2 - *right extension*

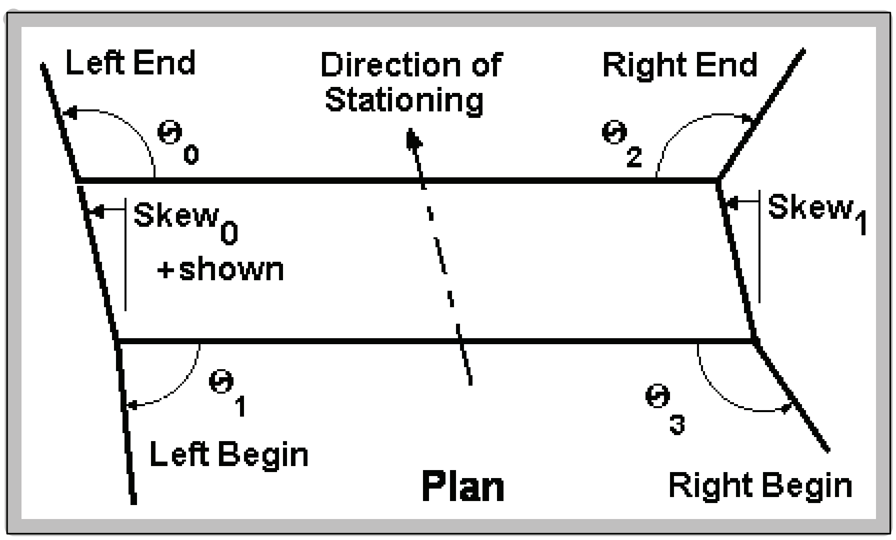
$HydraulicOpening := W_c \cdot H_c \cdot NoOfCells$

$HydraulicOpening = 84\,ft^2$



box end skew:

$Skew_{box} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot deg$ *left* *right*



Soil properties

depth of soil above top surface of slab:

SoilHeight = 2 ft

density of soil:

$\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$

soil friction angle:

$\phi = 30 \cdot deg$

modulus of subgrade reaction:

$k_s = 86500 \cdot \frac{lbf}{ft^3}$

nominal bearing capacity:

$q_{nom} = 4444 \cdot \frac{lbf}{ft^2}$

Material properties

modular ratio:

$n_{mod} = 6.609$

environmental class:

Env = 3

1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

reinforcing strength:

$F_y = 60 \cdot ksi$

density of concrete:

$\gamma_{conc} = 150 \cdot \frac{lbf}{ft^3}$

concrete strength preset for FDOT work:

$f_c = 5.5 \cdot ksi$

density of water:

$\gamma_w = 62.4 \cdot \frac{lbf}{ft^3}$

concrete modulus of elasticity:

$E = 4388 \cdot ksi$

Construction vehicle loads (optional)

Applies wheel load assuming no soil cover.

construction wheel loads 1, 2, and 3:

ConWheel1 = 0·kip

ConWheel2 = 0·kip

ConWheel3 = 0·kip

spacing between axles 1 and 2 & axles 2 and 3:

ConAxleSpacing1 = 16 ft

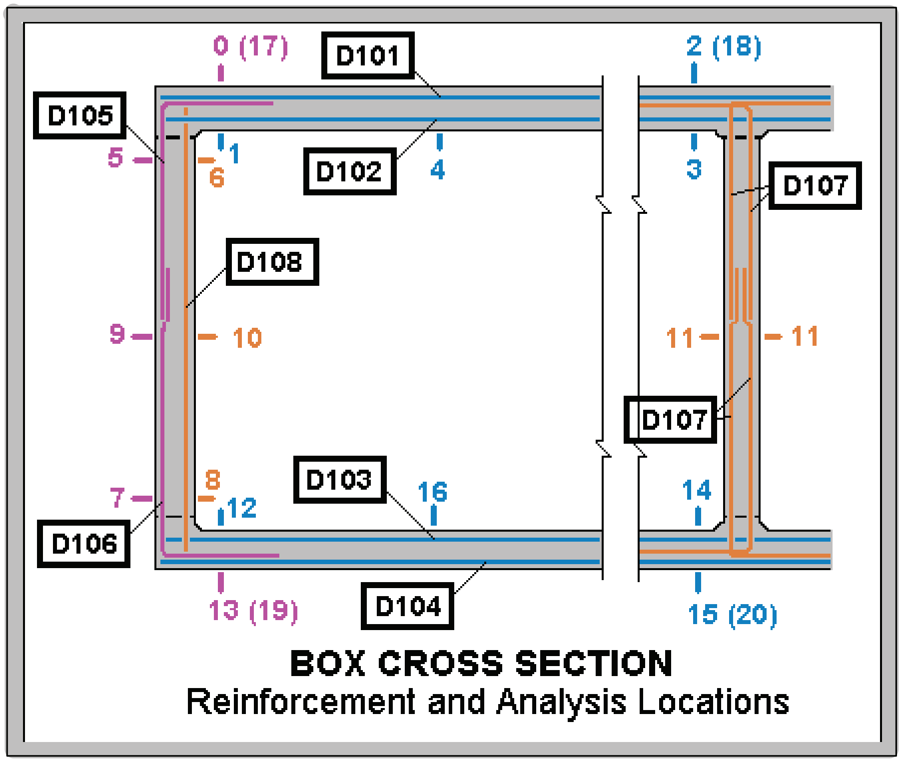
ConAxleSpacing2 = 16 ft

2. Design and Check Main Reinforcing

it := 0 .. 20 *index for transverse sections*

$BarSize_{box_{it}} := 0$ $\qquad S_{box_{it}} := 12\cdot in$

Cross Section Notes:
1. Bars shown with the same color are combined as Bar Groups.
2. Colored numbers indicate moment analysis locations.
3. Colored numbers in parenthesis indicate shear analysis locations.
4. Black numbers refer to bar designations.



Enter Box Transverse Reinforcing

Generally, reinforcement should be at least a #3 bar and spacing should not exceed 12 inches.

Note: Shear generally controls slab and wall thicknesses and cracking generally controls reinforcement areas

Bar Designation (section number) *Bar Sizes & Spacings used in analysis* *Change Bar Group values (color) or change individual Bars (white)*

D101(2)
D102(1,3,4)
D103(12,14,16)
D104(15)

$$BarSize_{slabs} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix} \qquad S_{slabs} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix}\cdot in$$

$newBarSize_{slabs} :=$ **XX**

$newS_{slabs} :=$ **XX**$\cdot in$

BarSizeD1$_{01}$:= **XX** $\qquad$ SD1$_{01}$:= **XX**$\cdot$in
BarSizeD1$_{02}$:= **XX** $\qquad$ SD1$_{02}$:= **XX**$\cdot$in
BarSizeD1$_{03}$:= **XX** $\qquad$ SD1$_{03}$:= **XX**$\cdot$in
BarSizeD1$_{04}$:= **XX** $\qquad$ SD1$_{04}$:= **XX**$\cdot$in

D105(9,0,5)
D106(9,7,13)

$$BarSize_{corners} = \begin{pmatrix} 4 \\ 4 \end{pmatrix} \qquad S_{corners} = \begin{pmatrix} 6 \\ 6 \end{pmatrix}\cdot in$$

$newBarSize_{corners} :=$ **XX**

$newS_{corners} :=$ **XX**$\cdot in$

BarSizeD1$_{05}$:= **XX** $\qquad$ SD1$_{05}$:= **XX**$\cdot$in
BarSizeD1$_{06}$:= **XX** $\qquad$ SD1$_{06}$:= **XX**$\cdot$in

D107(11)
D108(6,8,10)

$$BarSize_{walls} = \begin{pmatrix} 5 \\ 5 \end{pmatrix} \qquad S_{walls} = \begin{pmatrix} 12 \\ 12 \end{pmatrix}\cdot in$$

$newBarSize_{walls} :=$ **XX**

$newS_{walls} :=$ **XX**$\cdot in$

BarSizeD1$_{07}$:= **XX** $\qquad$ SD1$_{07}$:= **XX**$\cdot$in
BarSizeD1$_{08}$:= **XX** $\qquad$ SD1$_{08}$:= **XX**$\cdot$in

Check Box Main Reinforcement

$checkShear_{box}$ =

	0
0	0
1	0
2	0
3	0
4	0
5	0.03
6	0
7	0.03
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0.54
18	0.59
19	0.49
20	0.38

$CheckShear_{box}$ =

	0
0	"ok"
1	"ok"
2	"ok"
3	"ok"
4	"ok"
5	"ok"
6	"ok"
7	"ok"
8	"ok"
9	"ok"
10	"ok"
11	"ok"
12	"ok"
13	"ok"
14	"ok"
15	"ok"
16	"ok"
17	"ok"
18	"ok"
19	"ok"
20	"ok"

$checkCracking_{box}$ =

	0
0	0.35
1	0.1
2	0.59
3	0
4	0.45
5	0.11
6	0.1
7	0.22
8	0.03
9	0.18
10	0.09
11	0.17
12	0
13	0.78
14	0
15	0.51
16	0.44

$CheckCracking_{box}$ =

	0
0	"ok"
1	"ok"
2	"ok"
3	"ok"
4	"ok"
5	"ok"
6	"ok"
7	"ok"
8	"ok"
9	"ok"
10	"ok"
11	"ok"
12	"ok"
13	"ok"
14	"ok"
15	"ok"
16	"ok"

$checkM_{box}$ =

	0
0	0.43
1	0.13
2	0.67
3	0.05
4	0.57
5	0.32
6	0.22
7	0.61
8	0.03
9	0.45
10	0.3
11	0.29
12	0.02
13	0.8
14	0.04
15	0.51
16	0.46

$CheckM_{box}$ =

	0
0	"ok"
1	"ok"
2	"ok"
3	"ok"
4	"ok"
5	"ok"
6	"ok"
7	"ok"
8	"ok"
9	"ok"
10	"ok"
11	"ok"
12	"ok"
13	"ok"
14	"ok"
15	"ok"
16	"ok"

checkMinStl =

	0
0	0.57
1	0.18
2	0.62
3	0.06
4	0.62
5	0.42
6	0.29
7	0.73
8	0.04
9	0.6
10	0.39
11	0.38
12	0.03
13	0.94
14	0.05
15	0.62
16	0.61

CheckMinStl =

	0
0	"OK"
1	"OK"
2	"OK"
3	"OK"
4	"OK"
5	"OK"
6	"OK"
7	"OK"
8	"OK"
9	"OK"
10	"OK"
11	"OK"
12	"OK"
13	"OK"
14	"OK"
15	"OK"
16	"OK"

$Summary(CheckShear_{box})$ = "OK"

$Summary(CheckCracking_{box})$ = "OK"

$Summary(CheckM_{box})$ = "OK"

Summary(CheckMinStl) = "OK"

$Summary(CheckAll_{box})$ = "OK"

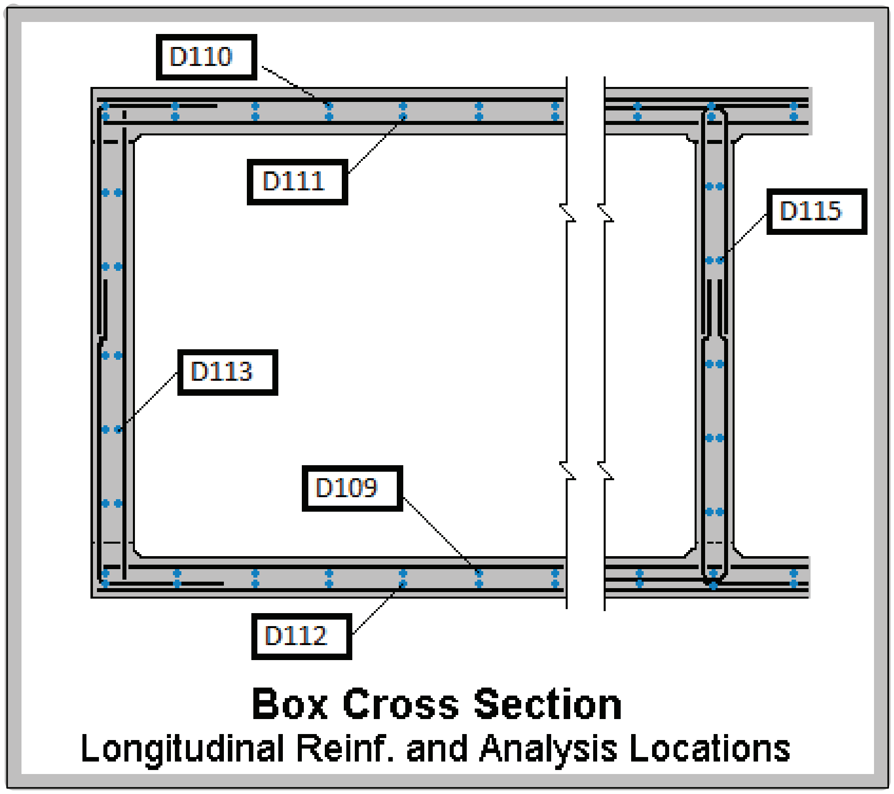
Calculate Worksheet

3. Design and Check Box Longitudinal Reinforcing

To meet LRFD temperature and shrinkage requirements, reinforcement spacing should not exceed 12 inches.

index for longitudinal sections: $il := 0..4$

0: D109
1: D110
2: D111
3: D112
4: D113,114,115...



Enter Box Longitudinal Reinforcing

Bar Sizes & Spacings used in analysis

$$BarSize_{long} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \\ 4 \end{pmatrix} \qquad S_{long} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$$

Change Bar Group (color) values or change individual Bars (white)

$newBarSize_{long} := \mathbf{XX}$

$newS_{long} := \mathbf{XX} \cdot in$

$BarSizeD1_{09} := \mathbf{XX}$	$SD1_{09} := \mathbf{XX} \cdot in$
$BarSizeD1_{10} := \mathbf{XX}$	$SD1_{10} := \mathbf{XX} \cdot in$
$BarSizeD1_{11} := \mathbf{XX}$	$SD1_{11} := \mathbf{XX} \cdot in$
$BarSizeD1_{12} := \mathbf{XX}$	$SD1_{12} := \mathbf{XX} \cdot in$
$BarSizeD1_{13} := \mathbf{XX}$	$SD1_{13} := \mathbf{XX} \cdot in$

Check Box Longitudinal Reinforcement

$CheckAs_{temp.box}^{T} = (\text{"ok"} \quad \text{"ok"} \quad \text{"ok"} \quad \text{"ok"} \quad \text{"ok"})$

$Summary(CheckAs_{temp.box}) = \text{"OK"}$

$Summary(CheckAll_{box}) = \text{"OK"}$

Calculate Worksheet

Write Box Design Data to CurrentDataFile

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

assign the data read in to the data to be read out, then change only the new values using the fSwitchData *function:*

DataOut := DataIn

Write Data to File

Box Culvert Analysis:
Cutoff Wall & Headwall Design

Project = "CONB - Double 7' x 6' Box Culvert"

DesignedBy = "RLH"
CheckedBy = "DAW"

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

Design Parameters

$b_w = 1\,ft$ *:program analyzes a one foot wide cross section*

Geometry and Box Dimensions

Extension = 0
0 - *new box (no extension)*
1- *left extension*
2 - *right extension*

box end skew:

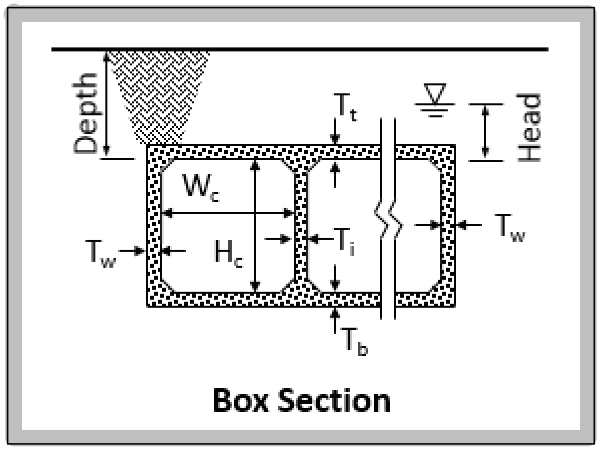
$Skew_{box} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot deg$ *left* / *right*

top slab thickness:

$T_t = 12 \cdot in$

bottom slab thickness:

$T_b = 12 \cdot in$



Material Properties

modular ratio:

$n_{mod} = 6.609$

reinforcing strength:

$F_y = 60 \cdot ksi$

concrete strength preset for FDOT work:

$f_c = 5.5 \cdot ksi$

concrete modulus of elasticity:

$E = 4388 \cdot ksi$

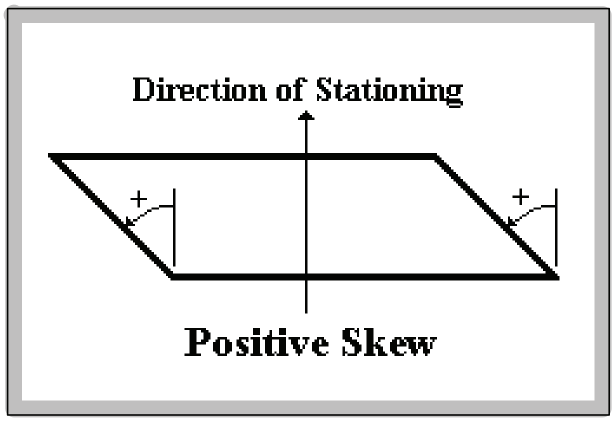
environmental class:

Env = 3

1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

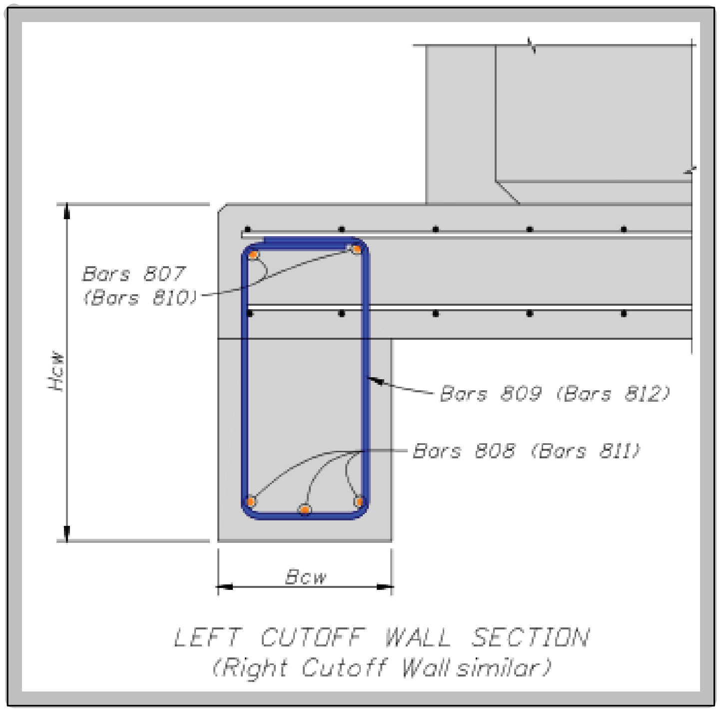
density of concrete:

$\gamma_{conc} = 150 \cdot pcf$



4. Design and Check Cutoff Wall Reinforcing

$Skew_{box} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot deg$ *left Headwall*
right Headwall



index for number of cutoff walls:

$iwbeg := if(Extension \neq 2, 0, 1)$

$iwend := if(Extension \neq 1, 1, 0)$

$iw := iwbeg .. iwend$ $iw =$

0
1

Enter Cutoff Wall Dimensions

Note: changes in height or width of the Cutoff Wall or Headwall requires a recalculation of the Loads file (2Box&HeadwallLoads.mcd). Height of Cutoff Wall includes the thickness of the bottom slab. Cutoff walls exceeding 2 feet below the bottom slab is beyond the intent of this program.

Values currently being used by the program   *Change Group values (colored); change individual values (white)*

row 0 = left & row 1 = right
cutoff wall height, H, and width, B:

$H_{cw} = \begin{pmatrix} 24 \\ 24 \end{pmatrix} \cdot in$ $B_{cw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

Note: Height of Cutoff Wall includes the thickness of the bottom slab.

$newB_{cw} := \mathbf{XX} \cdot in$

$newH_{cw} := \mathbf{XX} \cdot in$

$newB_{cw.left} := \mathbf{XX} \cdot in$

$newB_{cw.right} := \mathbf{XX} \cdot in$

$newH_{cw.left} := \mathbf{XX} \cdot in$

$newH_{cw.right} := \mathbf{XX} \cdot in$

Enter Cutoff Wall, CW, Reinforcing

row 0 = left CW, top; row 1 = left CW, bot;
row 2 = right CW, top; row 3 = right CW, bot:

$BarSize_{cw} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $Num_{cw} = \begin{pmatrix} 2 \\ 2 \\ 2 \\ 2 \end{pmatrix}$

$newBarSize_{cw} := \mathbf{XX}$

$newNum_{cw} := \mathbf{XX}$

$BarSizeD8_{07} := \mathbf{XX}$ $NumD8_{07} := \mathbf{XX}$

$BarSizeD8_{08} := \mathbf{XX}$ $NumD8_{08} := \mathbf{XX}$

$BarSizeD8_{10} := \mathbf{XX}$ $NumD8_{10} := \mathbf{XX}$

$BarSizeD8_{11} := \mathbf{XX}$ $NumD8_{11} := \mathbf{XX}$

row 0 = left CW & row 1 = right CW:

$StirSize_{cw} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$ $S_{stirrup.cw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

$newStirSize_{cw} := \mathbf{XX}$

$newS_{stirrup.cw} := \mathbf{XX} \cdot in$

$BarSizeD8_{09} := \mathbf{XX}$ $SD8_{09} := \mathbf{XX} \cdot in$

$BarSizeD8_{12} := \mathbf{XX}$ $SD8_{12} := \mathbf{XX} \cdot in$

Cutoff Wall Reinforcement Checks

Shear generally controls wall size

cracking generally controls reinforcement area

$CheckV_{midspan.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$checkCracking_{midspan.cw} = \begin{pmatrix} 0.14 \\ 0.14 \end{pmatrix}$

$CheckCracking_{midspan.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckV_{support.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$checkCracking_{support.cw} = \begin{pmatrix} 0.16 \\ 0.16 \end{pmatrix}$

$CheckCracking_{support.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

Moment, minimum steel, and spacing checks

$CheckM_{midspan.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckAs_{min.top.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckS_{top.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckS_{stirrup.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckM_{support.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckAs_{min.bot.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

$CheckS_{bot.cw} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \end{pmatrix}$

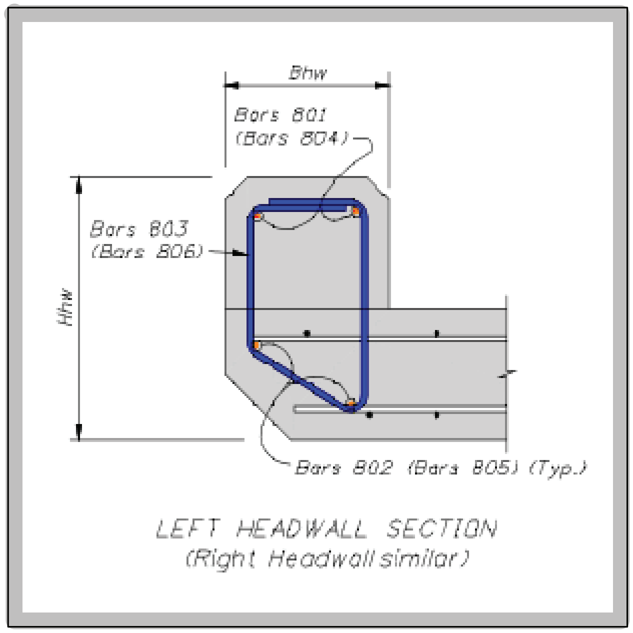
$Summary(CheckAll_{cw}) = \text{"OK"}$

Calculate Worksheet

5. Design and Check Headwall

Enter Design Dimensions and Parameters

Note: No lateral load analysis is performed on the headwall. If significant horizontal loads are anticipated, supplemental calculations are required. Height of Headwall includes the thickness of the top slab. Headwalls exceeding 2 feet above the top slab is beyond the intent of this program.



iw =

0
1

$Skew_{box} = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \cdot deg$ *left Headwall* / *right Headwall*

$BarrierDL_{hw} = 0 \cdot \frac{kip}{ft}$ *Additional dead load if a barrier is located on top of the headwall*

$ConsiderLL_{hw} = 1$ *This variable sets whether a line of truck wheels is considered as a loading. A 1 value means it is considered and a 0 means it is not*

Note: Height of Headwall includes the thickness of the top slab

Enter Headwall Dimensions

Values currently being used by the program

row 0 = left & row 1 = right
headwall height, H, and width, B:

$H_{hw} = \begin{pmatrix} 36 \\ 36 \end{pmatrix} \cdot in$ $B_{hw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

Enter Headwall, HW, Reinforcing

Change Group values (colored); change individual values (white)

row 0 = left HW, top; row 1 = left HW, bot;
row 2 = right HW, top; row 3 = right HW, bot:

$BarSize_{hw} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix}$ $Num_{hw} = \begin{pmatrix} 2 \\ 2 \\ 2 \\ 2 \end{pmatrix}$

$BarSizeD8_{01} :=$ **XX** $NumD8_{01} :=$ **XX**

$newBarSize_{hw} :=$ **XX** $BarSizeD8_{02} :=$ **XX** $NumD8_{02} :=$ **XX**

$newNum_{hw} :=$ **XX** $BarSizeD8_{04} :=$ **XX** $NumD8_{04} :=$ **XX**

$BarSizeD8_{05} :=$ **XX** $NumD8_{05} :=$ **XX**

row 0 = left HW & row 1 = right HW:

$StirSize_{hw} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$ $S_{stirrup.hw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

$newStirSize_{hw} :=$ **XX** $BarSizeD8_{03} :=$ **XX** $SD8_{03} :=$ **XX**$\cdot in$

$newS_{stirrup.hw} :=$ **XX**$\cdot in$ $BarSizeD8_{06} :=$ **XX** $SD8_{06} :=$ **XX**$\cdot in$

Headwall Reinforement Checks

Shear generally controls wall size

$CheckV_{ext.support.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$

$CheckV_{int.support.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$

cracking generally controls reinforcement area

$checkCracking_{midspan.hw} = \begin{pmatrix} 0.22 \\ 0.22 \end{pmatrix}$ $CheckCracking_{midspan.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$

$checkCracking_{support.hw} = \begin{pmatrix} 0.13 \\ 0.13 \end{pmatrix}$ $CheckCracking_{support.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$

Moment, minimum steel, and spacing checks

$CheckM_{midspan.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$ $CheckAs_{min.bot.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$ $CheckS_{bot.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$ $CheckS_{stirrup.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$

$CheckM_{support.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$ $CheckAs_{min.top.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$ $CheckS_{top.hw} = \begin{pmatrix} "ok" \\ "ok" \end{pmatrix}$ $Summary(CheckAll_{hw}) = "OK"$

Calculate Worksheet

$checkV_{ext.support.hw} = \begin{pmatrix} 0.31 \\ 0.31 \end{pmatrix}$ $checkCracking_{midspan.hw} = \begin{pmatrix} 0.22 \\ 0.22 \end{pmatrix}$

$checkV_{int.support.hw} = \begin{pmatrix} 0.35 \\ 0.35 \end{pmatrix}$ $checkCracking_{support.hw} = \begin{pmatrix} 0.13 \\ 0.13 \end{pmatrix}$

Moment, minimum steel, and spacing checks

$checkM_{midspan.hw} = \begin{pmatrix} 0.50 \\ 0.50 \end{pmatrix}$ $checkAs_{min.bot.hw} = \begin{pmatrix} 0.67 \\ 0.67 \end{pmatrix}$

$checkM_{support.hw} = \begin{pmatrix} 0.3 \\ 0.3 \end{pmatrix}$ $checkAs_{min.top.hw} = \begin{pmatrix} 0.4 \\ 0.4 \end{pmatrix}$

Write Box Design Data to CurrentDataFile

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

assign the data read in to the data to be read out, then change only the new values using the fSwitchData *function:*

DataOut := DataIn

Write Out Data to FIle

Box Culvert Analysis:
Wing Wall Design

Project = "CONB - Double 7' x 6' Box Culvert"

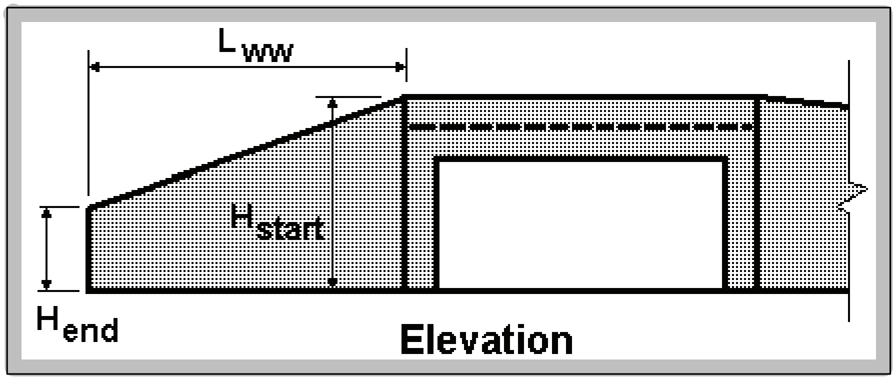
DesignedBy = "RLH"

CheckedBy = "DAW"

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

6. Design and Check Wing Walls

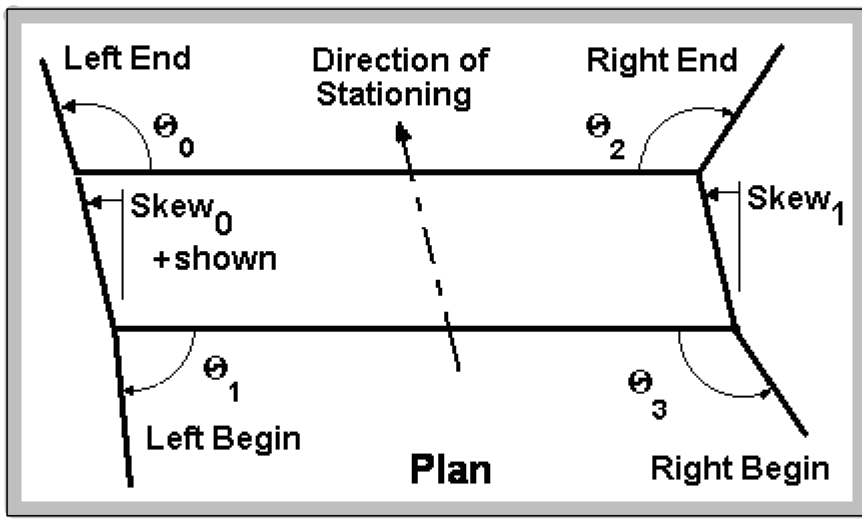


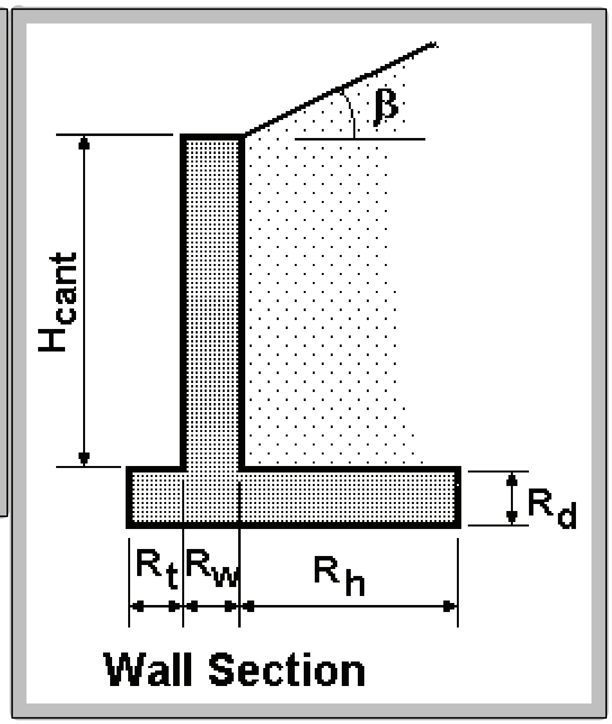
Wingwall Length and Height

ibeg := if (Extension = 2, 2, 0)

iend := if (Extension = 1, 1, 3)

i := ibeg .. iend





nominal bearing capacity:

$q_{nom} = 4444 \cdot \frac{lbf}{ft^2}$

nominal bearing capacity is allowable bearing pressure(typically from Geotech Engr) multiplied by factor of safety

Wingwall angles, lengths and heights

$\beta_{default}$ *is calculated using the embankment slope value, or is the user override value, in the* **Box Culvert Data.**

i =

0
1
2
3

0-left end
1-left begin
2-right end
3-right begin

$\theta = \begin{pmatrix} 90 \\ 90 \\ 135 \\ 135 \end{pmatrix} \cdot deg$ $L_{ww} = \begin{pmatrix} 16.5 \\ 16.5 \\ 23 \\ 23 \end{pmatrix} ft$ $H_{start} = \begin{pmatrix} 9 \\ 9 \\ 9 \\ 9 \end{pmatrix} ft$ $H_{end} = \begin{pmatrix} 9 \\ 9 \\ 9 \\ 9 \end{pmatrix} ft$

set whether live load surcharge is considered as a loading:

$ConsiderLLSurcharge_{ww} = 1$

$newConsiderLLSurcharge_{ww} := \textbf{XX}$

0 - not considered
1 - considered

Enter wall sizes

Note: as a general rule, R_h *is usually 3 to 4 times* R_t

Note: R_w *must be less than 16 in,* ***LRFD 5.8.3.3-3***

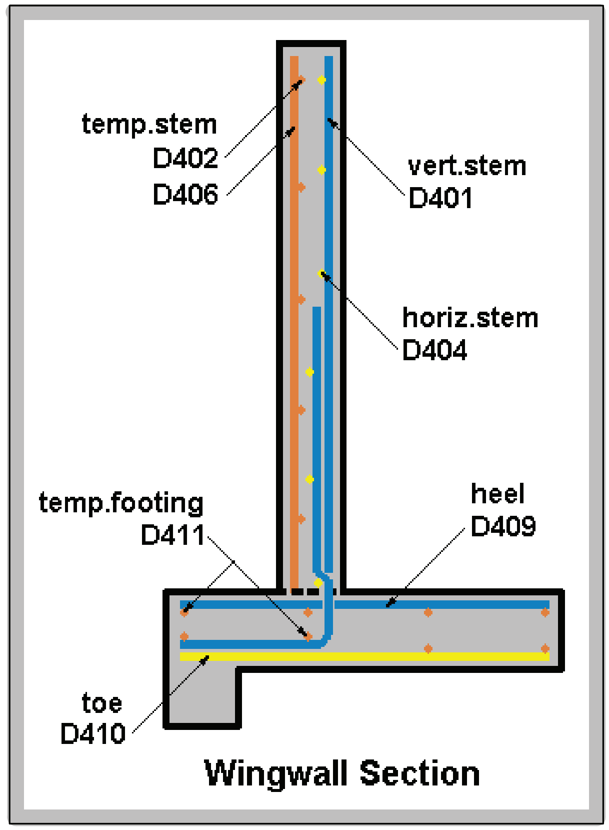
$\frac{R_{t_i}}{in} =$	$\frac{R_{w_i}}{in} =$	$\frac{R_{h_i}}{ft} =$	$\frac{R_{d_i}}{in} =$	$\frac{\beta_i}{deg} =$
21	12	6	12	5.711
21	12	6	12	5.711
21	12	6	12	4.038
21	12	6	12	4.038

$newR_t := \textbf{21} \cdot in$ $newR_w := \textbf{XX} \cdot in$ $newR_h := \textbf{6} \cdot ft$ $newR_d := \textbf{XX} \cdot in$ $new\beta := \textbf{XX} \cdot deg$

$newR_{t.ww_i} :=$	$newR_{w.ww_i} :=$	$newR_{h.ww_i} :=$	$newR_{d.ww_i} :=$	$new\beta_{ww_i} :=$
XX·in	**XX**·in	**XX**·ft	**XX**·in	**XX**·deg
XX·in	**XX**·in	**XX**·ft	**XX**·in	**XX**·deg
XX·in	**XX**·in	**XX**·ft	**XX**·in	**XX**·deg
XX·in	**XX**·in	**XX**·ft	**XX**·in	**XX**·deg

Wing Wall Stability Checks

$$L_{ww} = \begin{pmatrix} 16.5 \\ 16.5 \\ 23 \\ 23 \end{pmatrix} ft \qquad H_{start} = \begin{pmatrix} 9 \\ 9 \\ 9 \\ 9 \end{pmatrix} ft \qquad H_{end} = \begin{pmatrix} 9 \\ 9 \\ 9 \\ 9 \end{pmatrix} ft$$



$$checkPressure = \begin{pmatrix} 0.77 & 0.91 & 0.73 & 0.65 \\ 0.77 & 0.91 & 0.73 & 0.65 \\ 0.76 & 0.91 & 0.72 & 0.65 \\ 0.76 & 0.91 & 0.72 & 0.65 \end{pmatrix}$$

$$CheckPressure = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$CheckReaction1 = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix} \qquad CheckReaction2 = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

Calculate Worksheet

7. Design and Check Wing Wall Reinforcing

To meet LRFD temperature and shrinkage requirements, wall reinforcement spacing should not exceed 12 inches.

Enter Wingwall reinforcing

$Cover_{ww} = 3 \cdot in$

Note: Bars D403 & D405 are varies bars based on Bars D402 & D404 respectively.

row 0 = left begin; row 1 = left end; row 2 = right begin; row 3 = right end:

$BarSize_{vert.stem} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix}$ $S_{vert.stem} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix} \cdot in$

$newBarSize_{vert.stem} := XX$

$newS_{vert.stem} := 6 \cdot in$

$BarSizeD4_{01} := XX$ $SD4_{01} := XX \cdot in$

$BarSizeD5_{01} := XX$ $SD5_{01} := XX \cdot in$

$BarSizeD6_{01} := XX$ $SD6_{01} := XX \cdot in$

$BarSizeD7_{01} := XX$ $SD7_{01} := XX \cdot in$

$BarSize_{horiz.stem} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $S_{horiz.stem} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$

$newBarSize_{horiz.stem} := XX$

$newS_{horiz.stem} := XX \cdot in$

$BarSizeD4_{04} := XX$ $SD4_{04} := XX \cdot in$

$BarSizeD5_{04} := XX$ $SD5_{04} := XX \cdot in$

$BarSizeD6_{04} := XX$ $SD6_{04} := XX \cdot in$

$BarSizeD7_{04} := XX$ $SD7_{04} := XX \cdot in$

$BarSize_{temp.stem} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $S_{temp.stem} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$

$newBarSize_{temp.stem} := XX$

$newS_{temp.stem} := XX \cdot in$

$BarSizeD4_{02} := XX$ $SD4_{02} := XX \cdot in$

$BarSizeD5_{02} := XX$ $SD5_{02} := XX \cdot in$

$BarSizeD6_{02} := XX$ $SD6_{02} := XX \cdot in$

$BarSizeD7_{02} := XX$ $SD7_{02} := XX \cdot in$

Note: Temp. bars D-06 use bar size and spacing of bars D-02.

Enter footing reinforcing

row 0 = left begin; row 1 = left end; row 2 = right begin; row 3 = right end:

$BarSize_{heel} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix}$ $S_{heel} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix} \cdot in$

$newBarSize_{heel} := \mathbf{XX}$

$newS_{heel} := \mathbf{6} \cdot in$

$BarSizeD4_{09} := \mathbf{XX}$ $SD4_{09} := \mathbf{XX} \cdot in$

$BarSizeD5_{09} := \mathbf{XX}$ $SD5_{09} := \mathbf{XX} \cdot in$

$BarSizeD6_{09} := \mathbf{XX}$ $SD6_{09} := \mathbf{XX} \cdot in$

$BarSizeD7_{09} := \mathbf{XX}$ $SD7_{09} := \mathbf{XX} \cdot in$

$BarSize_{toe} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $S_{toe} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$

$newBarSize_{toe} := \mathbf{XX}$

$newS_{toe} := \mathbf{XX} \cdot in$

typically, $S_{toe} = S_{vert.stem}$

$BarSizeD4_{10} := \mathbf{XX}$ $SD4_{10} := \mathbf{XX} \cdot in$

$BarSizeD5_{10} := \mathbf{XX}$ $SD5_{10} := \mathbf{XX} \cdot in$

$BarSizeD6_{10} := \mathbf{XX}$ $SD6_{10} := \mathbf{XX} \cdot in$

$BarSizeD7_{10} := \mathbf{XX}$ $SD7_{10} := \mathbf{XX} \cdot in$

$BarSize_{temp.footing} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $S_{temp.footing} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$

$newBarSize_{temp.footing} := \mathbf{XX}$

$newS_{temp.footing} := \mathbf{XX} \cdot in$

$BarSizeD4_{11} := \mathbf{XX}$ $SD4_{11} := \mathbf{XX} \cdot in$

$BarSizeD5_{11} := \mathbf{XX}$ $SD5_{11} := \mathbf{XX} \cdot in$

$BarSizeD6_{11} := \mathbf{XX}$ $SD6_{11} := \mathbf{XX} \cdot in$

$BarSizeD7_{11} := \mathbf{XX}$ $SD7_{11} := \mathbf{XX} \cdot in$

Footing Reinforement Checks

$$\text{CheckCracking}_{vert} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckCracking}_{horiz} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckM}_{vert.stem} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckV}_{vert.stem} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckV}_{horiz.stem} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckLong}_{stem} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckM}_{horiz.stem} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.vert} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.horiz} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.temp.vert} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.temp.horiz} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.temp.stem} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckCracking}_{heel} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckM}_{heel} = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$\text{CheckV}_{heel} = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.temp.heel} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.heel} = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$\text{CheckCracking}_{toe} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckM}_{toe} = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$\text{CheckV}_{toe} = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.temp.toe} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.toe} = \begin{pmatrix} \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \\ \text{"ok"} & \text{"ok"} & \text{"ok"} & \text{"ok"} \end{pmatrix}$$

$$\text{CheckHookDevelopment} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{CheckAs}_{min.temp.footing} = \begin{pmatrix} \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \\ \text{"ok"} \end{pmatrix}$$

$$\text{Summary}\left(\text{SumCheckAll}_{ww}\right) = \text{"OK"}$$

Calculate Worksheet

$$checkCracking_{vert} = \begin{pmatrix} 0.56 \\ 0.56 \\ 0.55 \\ 0.55 \end{pmatrix} \quad checkCracking_{horiz} = \begin{pmatrix} 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \end{pmatrix} \quad checkM_{vert.stem} = \begin{pmatrix} 0.62 \\ 0.62 \\ 0.62 \\ 0.62 \end{pmatrix}$$

$$checkV_{vert.stem} = \begin{pmatrix} 0.27 \\ 0.27 \\ 0.27 \\ 0.27 \end{pmatrix} \quad checkV_{horiz.stem} = \begin{pmatrix} 0.07 \\ 0.07 \\ 0.07 \\ 0.07 \end{pmatrix} \quad checkLong_{stem} = \begin{pmatrix} 0.71 \\ 0.71 \\ 0.7 \\ 0.7 \end{pmatrix}$$

$$checkM_{horiz.stem} = \begin{pmatrix} 0.22 \\ 0.22 \\ 0.21 \\ 0.21 \end{pmatrix} \quad checkAs_{min.vert} = \begin{pmatrix} 0.62 \\ 0.62 \\ 0.62 \\ 0.62 \end{pmatrix} \quad checkAs_{min.horiz} = \begin{pmatrix} 0.29 \\ 0.29 \\ 0.29 \\ 0.29 \end{pmatrix}$$

$$checkAs_{min.temp.vert} = \begin{pmatrix} 0.18 & 0.5 & 0.5 \\ 0.18 & 0.5 & 0.5 \\ 0.18 & 0.5 & 0.5 \\ 0.18 & 0.5 & 0.5 \end{pmatrix} \quad checkAs_{min.temp.horiz} = \begin{pmatrix} 0.55 & 1.00 & 1.00 \\ 0.55 & 1.00 & 1.00 \\ 0.55 & 1.00 & 1.00 \\ 0.55 & 1.00 & 1.00 \end{pmatrix}$$

$$checkCracking_{heel} = \begin{pmatrix} 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \end{pmatrix} \quad checkM_{heel} = \begin{pmatrix} 0.49 & 0.47 & 0.27 & 0.28 \\ 0.49 & 0.47 & 0.27 & 0.28 \\ 0.49 & 0.47 & 0.26 & 0.28 \\ 0.49 & 0.47 & 0.26 & 0.28 \end{pmatrix} \quad checkV_{heel} = \begin{pmatrix} 0.22 & 0.23 & 0.14 & 0.14 \\ 0.22 & 0.23 & 0.14 & 0.14 \\ 0.22 & 0.23 & 0.14 & 0.14 \\ 0.22 & 0.23 & 0.14 & 0.14 \end{pmatrix}$$

$$checkAs_{min.temp.heel} = \begin{pmatrix} 0.18 & 0.17 & 0.5 \\ 0.18 & 0.17 & 0.5 \\ 0.18 & 0.17 & 0.5 \\ 0.18 & 0.17 & 0.5 \end{pmatrix} \quad checkAs_{min.heel} = \begin{pmatrix} 0.62 & 0.62 & 0.35 & 0.38 \\ 0.62 & 0.62 & 0.35 & 0.38 \\ 0.62 & 0.62 & 0.35 & 0.38 \\ 0.62 & 0.62 & 0.35 & 0.38 \end{pmatrix}$$

$$checkCracking_{toe} = \begin{pmatrix} 0.26 \\ 0.26 \\ 0.26 \\ 0.26 \end{pmatrix} \quad checkM_{toe} = \begin{pmatrix} 0.2 & 0.23 & 0.17 & 0.16 \\ 0.2 & 0.23 & 0.17 & 0.16 \\ 0.2 & 0.23 & 0.17 & 0.16 \\ 0.2 & 0.23 & 0.17 & 0.16 \end{pmatrix} \quad checkV_{toe} = \begin{pmatrix} 0.22 & 0.25 & 0.19 & 0.17 \\ 0.22 & 0.25 & 0.19 & 0.17 \\ 0.22 & 0.25 & 0.19 & 0.17 \\ 0.22 & 0.25 & 0.19 & 0.17 \end{pmatrix}$$

$$checkAs_{min.temp.toe} = \begin{pmatrix} 0.55 & 0.33 & 1 \\ 0.55 & 0.33 & 1 \\ 0.55 & 0.33 & 1 \\ 0.55 & 0.33 & 1 \end{pmatrix} \quad checkAs_{min.toe} = \begin{pmatrix} 0.27 & 0.30 & 0.23 & 0.21 \\ 0.27 & 0.30 & 0.23 & 0.21 \\ 0.27 & 0.30 & 0.23 & 0.21 \\ 0.27 & 0.30 & 0.23 & 0.21 \end{pmatrix}$$

$$checkHookDevelopment = \begin{pmatrix} 0.93 \\ 0.93 \\ 0.93 \\ 0.93 \end{pmatrix} \quad checkAs_{min.temp.footing} = \begin{pmatrix} 0.55 & 0.33 & 1.00 \\ 0.55 & 0.33 & 1.00 \\ 0.55 & 0.33 & 1.00 \\ 0.55 & 0.33 & 1.00 \end{pmatrix} \quad Summary\left(SumCheckAll_{ww}\right) = \text{"OK"}$$

End of section 8

Write Wing Wall Design Data to CurrentDataFile

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

assign the data read in to the data to be read out, then change only the new values using the fSwitchData *function:*

DataOut := DataIn

Write Out Data to File

Box Culvert Analysis:
Estimate of Quantities

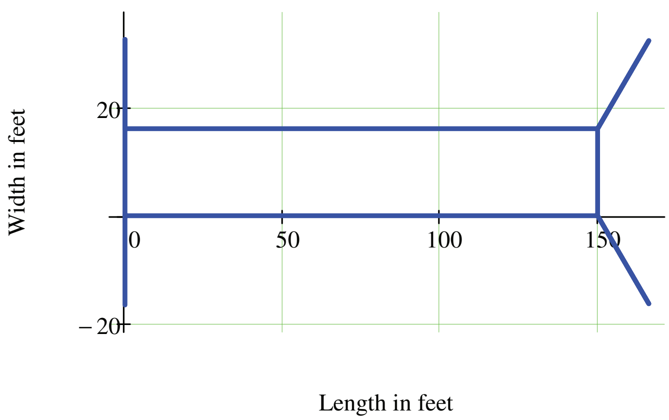
Project = "CONB - Double 7' x 6' Box Culvert"

DesignedBy = "RLH"

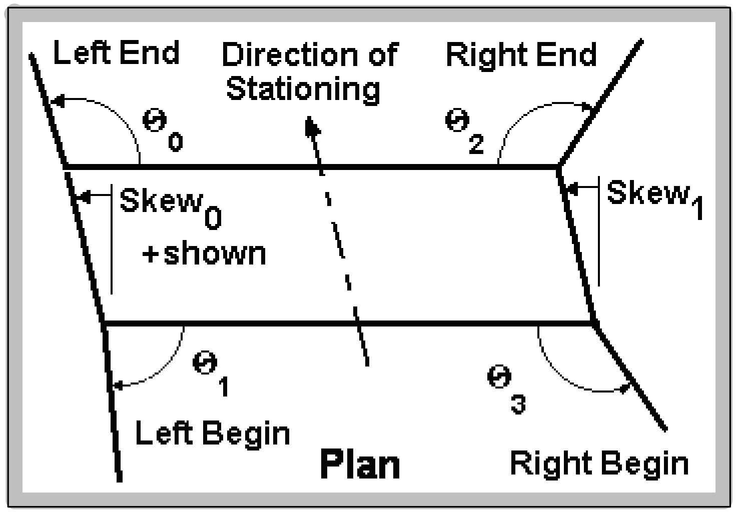
CheckedBy = "DAW"

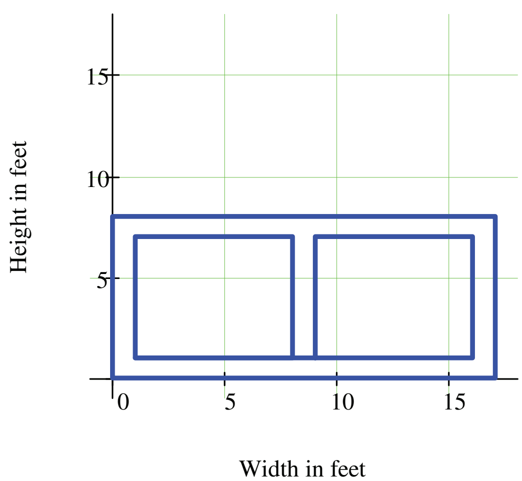
CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

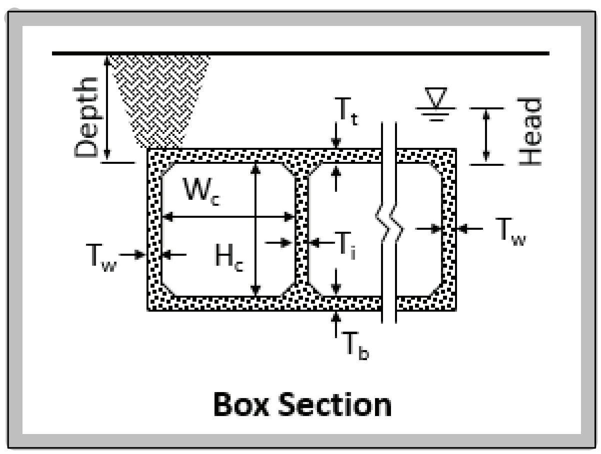


Plan - Box Culvert





Cross Section - Box Culvert



Box Dimensions

HydraulicOpening := $W_c \cdot H_c \cdot NoOfCells$

HydraulicOpening = $84\,ft^2$

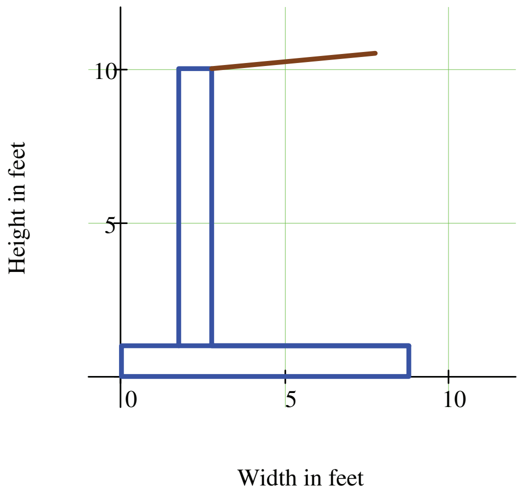
SoilHeight = 2 ft

NoOfCells = 2	W_c = 7 ft	H_c = 6 ft	L_c = 150 ft	θ^T = (90 90 135 135)·deg	Head = 0 ft
T_t = 12·in	T_b = 12·in	T_w = 12·in	T_i = 12·in	Cover = 3·in	Depth = 3 ft

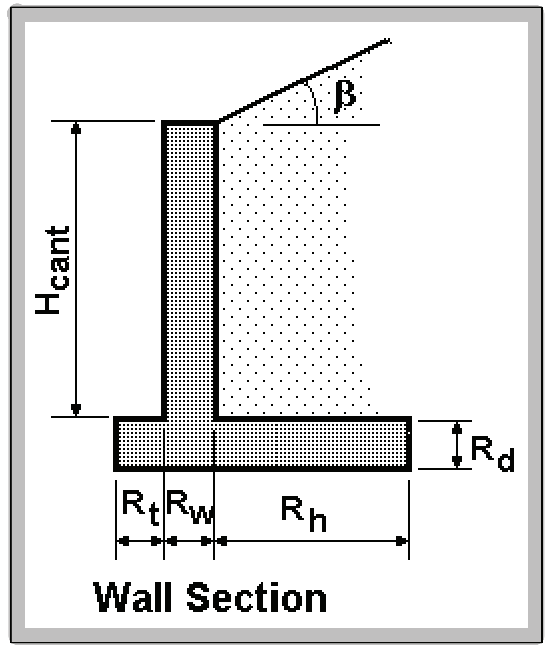
Cutoff wall and Headwall Dimensions

$Skew_{left}$ = 0·deg	B_{lhw} = 12·in	H_{lhw} = 36·in	B_{lcw} = 12·in	H_{lcw} = 24·in
$Skew_{right}$ = 0·deg	B_{rhw} = 12·in	H_{rhw} = 36·in	B_{rcw} = 12·in	H_{rcw} = 24·in

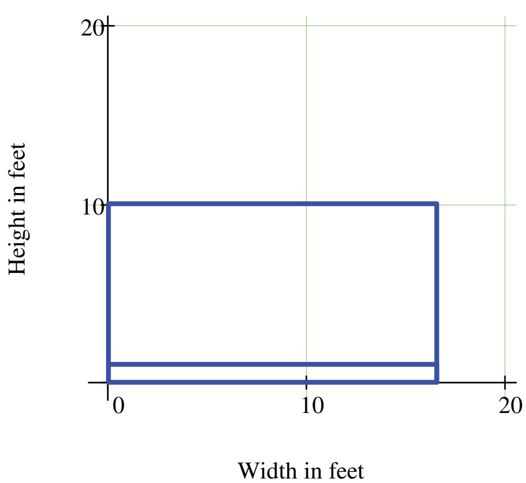
Wingwall Dimensions



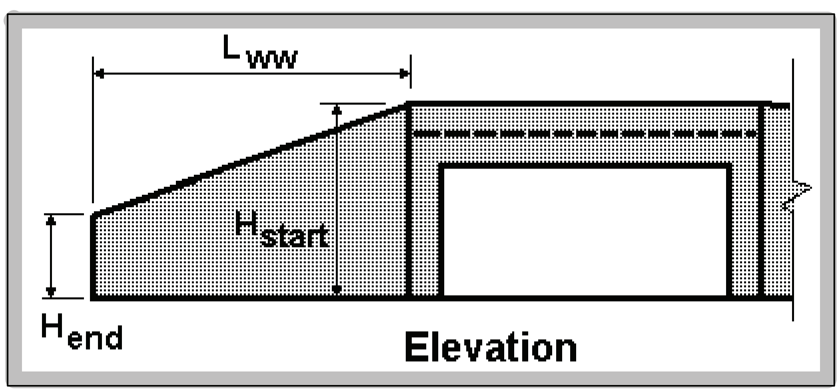
Cross Section - First Wingwall



$R_t = \begin{pmatrix} 21 \\ 21 \\ 21 \\ 21 \end{pmatrix} \cdot in$ $R_w = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$ $R_h = \begin{pmatrix} 72 \\ 72 \\ 72 \\ 72 \end{pmatrix} \cdot in$ $R_d = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$ $\beta = \begin{pmatrix} 5.71 \\ 5.71 \\ 4.04 \\ 4.04 \end{pmatrix} \cdot deg$



Elevation - First Wingwall



$H_{end} = \begin{pmatrix} 9 \\ 9 \\ 9 \\ 9 \end{pmatrix} ft$ $H_{start} = \begin{pmatrix} 9 \\ 9 \\ 9 \\ 9 \end{pmatrix} ft$ $L_{ww} = \begin{pmatrix} 16.5 \\ 16.5 \\ 23 \\ 23 \end{pmatrix} ft$ $\theta = \begin{pmatrix} 90 \\ 90 \\ 135 \\ 135 \end{pmatrix} \cdot deg$

Summary of Concrete Quantities

$Vol_{cw.left} = 0.63 \cdot yd^3$ $Vol_{cw.right} = 0.63 \cdot yd^3$

$Vol_{bot.slab} = 96.33 \cdot yd^3$ $Vol_{walls} = 100 \cdot yd^3$ $Vol_{top.slab} = 94.44 \cdot yd^3$

$Vol_{hw.left} = 1.26 \cdot yd^3$ $Vol_{hw.right} = 1.26 \cdot yd^3$

$$Vol_{wall} = \begin{pmatrix} 5.5 \\ 5.5 \\ 7.67 \\ 7.67 \end{pmatrix} \cdot yd^3 \quad Vol_{ww.cowall} = \begin{pmatrix} 0.6111 \\ 0.6111 \\ 0.8519 \\ 0.8519 \end{pmatrix} \cdot yd^3 \quad Vol_{footing} = \begin{pmatrix} 5.35 \\ 5.35 \\ 7.45 \\ 7.45 \end{pmatrix} \cdot yd^3 \quad TotalVol_{wingwall} = \begin{pmatrix} 11.46 \\ 11.46 \\ 15.97 \\ 15.97 \end{pmatrix} \cdot yd^3$$

$Vol_{box} = 295.17 \cdot yd^3$ $\sum Vol_{wall} = 26.33 \cdot yd^3$ $\sum TotalVol_{footing} = 28.53 \cdot yd^3$ $TotalVolume = 350.03 \cdot yd^3$

Summary of Soil and Miscellaneous Values

$E = 4388 \cdot ksi$ $f_c = 5.5 \cdot ksi$ $Extension = 0$ $Env = 3$

0 - *new box (no extension)*
1- *left extension*
2 - *right extension*

Environmental Class
1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

$F_y = 60 \cdot ksi$ $n_{mod} = 6.609$

$ConsiderLLSurcharge_{ww} = 1$ *0 - No* *1 - Yes*

$ConsiderLL_{hw} = 1$ *0 - No* *1 - Yes*

$BarrierDL_{hw} = 0 \cdot \frac{kip}{ft}$

$\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$ $k_s = 86500 \cdot \frac{lbf}{ft^3}$ $\phi = 30 \cdot deg$ $q_{nom} = 4444 \cdot \frac{lbf}{ft^2}$

Summary of Reinforcement Check Values

$Check_{box} = "OK"$ $Check_{cw} = "OK"$ $Check_{hw} = "OK"$ $Check_{ww} = "OK"$ $TotalCheck = "OK"$

$$BarSize_{slabs} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix} \quad S_{slabs} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix} \cdot in$$

top slab, top mat
top slab, bot mat
bot slab, top mat
bot slab, bot mat

$$BarSize_{long} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \\ 4 \end{pmatrix} \quad S_{long} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$$

top slab, top mat
top slab, bot mat
interior wall(s)
exterior walls
bot slab, both m.

$$BarSize_{walls} = \begin{pmatrix} 5 \\ 5 \end{pmatrix} \quad S_{walls} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$$

interior wall(s)
exterior walls

$$BarSize_{corners} = \begin{pmatrix} 4 \\ 4 \end{pmatrix} \quad S_{corners} = \begin{pmatrix} 6 \\ 6 \end{pmatrix} \cdot in$$

top corner
bot corner

$$BarSize_{cw} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix} \quad Num_{cw} = \begin{pmatrix} 2 \\ 2 \\ 2 \\ 2 \end{pmatrix}$$

top bar, left cw
bot bar, left cw
top bar, right cw
bot bar, right cw

$$StirSize_{cw} = \begin{pmatrix} 4 \\ 4 \end{pmatrix} \quad S_{stirrup.cw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$$

$$BarSize_{hw} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix} \quad Num_{hw} = \begin{pmatrix} 2 \\ 2 \\ 2 \\ 2 \end{pmatrix}$$

top bar, left hw
bot bar, left hw
top bar, right hw
bot bar, right hw

$$StirSize_{hw} = \begin{pmatrix} 4 \\ 4 \end{pmatrix} \quad S_{stirrup.hw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$$

Reinforcement List - Main Box

click table below to reveal scroll bar...

$Reinf_{box}$ =

	0	1	2	3	4
0	"Bar Location"	"Size"	"Desig"	"Len"	"Num"
1	"top face, top slab"	5	101	16.5	300
2	"bot face, top slab"	5	102	16.5	300
3	"top face, bot slab"	5	103	16.5	306
4	"bot face, bot slab"	5	104	16.5	306
5	"top ext corner"	4	105	5.87	598
6	"bot ext corner"	4	106	5.87	598
7	"each corner, int wall"	5	107	5.46	600
8	"inside face, ext wall"	5	108	7.5	300
9	long top face, bot slab"	4	109	155.32	18
10	long top face, top slab"	4	110	152.32	18
11	long bot face, top slab"	4	111	151.67	18
12	long bot face, bot slab"	4	112	155.32	18
13	ng each face, ext wall"	4	113	152.32	14
14	ng each face, ext wall"	4	114	152.32	14
15	ong each face, int wall"	4	115	151.67	...
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					

Reinforcement Lists - Left Begin and Left End Wingwalls

Rw_0 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"wall vert, soil side"	5	401	8.75	33	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall horiz, front side"	4	402	16	10	1	0	0	16	0	0	0	0	0	0	0	0
"wall horiz, soil side"	4	404	16	10	1	0	0	16	0	0	0	0	0	0	0	0
"wall vert, front side"	4	406	8.75	17	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall vert, soil side"	5	407	4.73	33	10	0	0	2.25	2.48	0	0	0	0	0	0	0
"top footing heel"	5	409	8.25	33	1	0	0	8.25	0	0	0	0	0	0	0	0
"bot footing toe"	4	410	8.25	17	1	0	0	8.25	0	0	0	0	0	0	0	0
"temp footing"	4	411	16	20	1	0	0	16	0	0	0	0	0	0	0	0
"wall to box ties"	5	412	2	14	1	0	0	2	0	0	0	0	0	0	0	0

Rw_1 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"wall vert, soil side"	5	501	8.75	33	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall horiz, front side"	4	502	16	10	1	0	0	16	0	0	0	0	0	0	0	0
"wall horiz, soil side"	4	504	16	10	1	0	0	16	0	0	0	0	0	0	0	0
"wall vert, front side"	4	506	8.75	17	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall vert, soil side"	5	507	4.73	33	10	0	0	2.25	2.48	0	0	0	0	0	0	0
"top footing heel"	5	509	8.25	33	1	0	0	8.25	0	0	0	0	0	0	0	0
"bot footing toe"	4	510	8.25	17	1	0	0	8.25	0	0	0	0	0	0	0	0
"temp footing"	4	511	16	20	1	0	0	16	0	0	0	0	0	0	0	0
"wall to box ties"	5	512	2	14	1	0	0	2	0	0	0	0	0	0	0	0

Reinforcement Lists - Right Begin and Right End Wingwalls

Rw_2 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"wall vert, soil side"	5	601	8.75	46	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall horiz, front side"	4	602	22.5	10	1	0	0	22.5	0	0	0	0	0	0	0	0
"wall horiz, soil side"	4	604	22.5	10	1	0	0	22.5	0	0	0	0	0	0	0	0
"wall vert, front side"	4	606	8.75	24	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall vert, soil side"	5	607	4.73	46	10	0	0	2.25	2.48	0	0	0	0	0	0	0
"top footing heel"	5	609	8.25	46	1	0	0	8.25	0	0	0	0	0	0	0	0
"bot footing toe"	4	610	8.25	24	1	0	0	8.25	0	0	0	0	0	0	0	0
"temp footing"	4	611	22.5	20	1	0	0	22.5	0	0	0	0	0	0	0	0
"wall to box ties"	5	612	2	14	1	0	0	2	0	0	0	0	0	0	0	0

Rw_3 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"wall vert, soil side"	5	701	8.75	46	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall horiz, front side"	4	702	22.5	10	1	0	0	22.5	0	0	0	0	0	0	0	0
"wall horiz, soil side"	4	704	22.5	10	1	0	0	22.5	0	0	0	0	0	0	0	0
"wall vert, front side"	4	706	8.75	24	1	0	0	8.75	0	0	0	0	0	0	0	0
"wall vert, soil side"	5	707	4.73	46	10	0	0	2.25	2.48	0	0	0	0	0	0	0
"top footing heel"	5	709	8.25	46	1	0	0	8.25	0	0	0	0	0	0	0	0
"bot footing toe"	4	710	8.25	24	1	0	0	8.25	0	0	0	0	0	0	0	0
"temp footing"	4	711	22.5	20	1	0	0	22.5	0	0	0	0	0	0	0	0
"wall to box ties"	5	712	2	14	1	0	0	2	0	0	0	0	0	0	0	0

Reinforcement Lists - Headwalls and Cutoff Walls

Rh_1 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	5	801	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"bottom"	5	802	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"stirrups"	4	803	6.15	17	27	0	0	2.45	0.5	0	0.38	2.07	0.5	0.5	0	0

Rh_2 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	5	804	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"bottom"	5	805	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"stirrups"	4	806	6.15	17	27	0	0	2.45	0.5	0	0.38	2.07	0.5	0.5	0	0

Rc_1 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	4	807	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"bottom"	4	808	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"stirrups"	4	809	4.4	17	7	0	0	1.45	0.5	0.5	0.5	0	0	0	0	0

Rc_2 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	4	810	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"bottom"	4	811	16.5	2	1	0	0	16.5	0	0	0	0	0	0	0	0
"stirrups"	4	812	4.4	17	7	0	0	1.45	0.5	0.5	0.5	0	0	0	0	0

No variables are modified in this file: CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Box Culvert Analysis:
Design Load Rating (LRFD)

Project = "CONB - Double 7' x 6' Box Culvert"

DesignedBy = "RLH"
CheckedBy = "DAW"

CurrentDataFile = "\Data Files CIP\Neptune Beach.dat"

Comment = "Double 7' x 6' Box Culvert"

Design Parameters

$b_w = 1\,ft$ *:program analyzes a one foot wide cross section*

number of cells: NoOfCells = 2

distance from top of opening to surface: Depth = 3 ft

opening width of cell: $W_c = 7\,ft$

opening height of cell: $H_c = 6\,ft$

length of culvert along centerline: $L_c = 150\,ft$

top slab thickness: $T_t = 12 \cdot in$

bottom slab thickness: $T_b = 12 \cdot in$

exterior wall thickness: $T_w = 12 \cdot in$

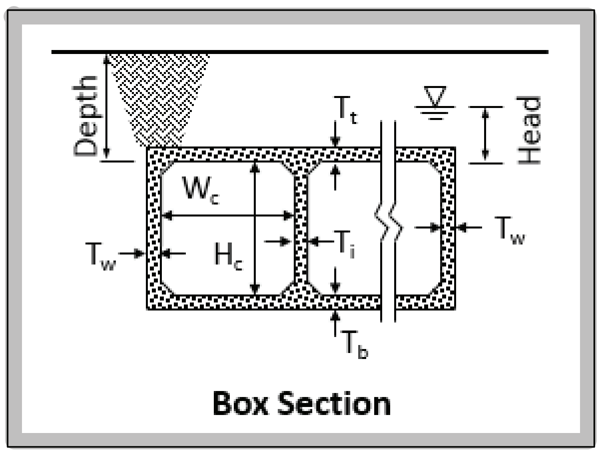
interior wall thickness: $T_i = 12 \cdot in$

water head at top of opening: Head = 0 ft

Extension = 0
0 - *new box (no extension)*
1- *left extension*
2 - *right extension*

HydraulicOpening := $W_c \cdot H_c \cdot$ NoOfCells

HydraulicOpening = $84\,ft^2$



Soil properties

depth of soil above top surface of slab: SoilHeight = 2 ft

density of soil: $\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$

soil friction angle: $\phi = 30 \cdot deg$

modulus of subgrade reaction: $k_s = 86500 \cdot \frac{lbf}{ft^3}$

nominal bearing capacity: $q_{nom} = 4444 \cdot \frac{lbf}{ft^2}$

Material properties

modular ratio: $n_{mod} = 6.61$

environmental class: Env = 3
1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

reinforcing strength: $F_y = 60 \cdot ksi$

density of concrete: $\gamma_{conc} = 150 \cdot \frac{lbf}{ft^3}$

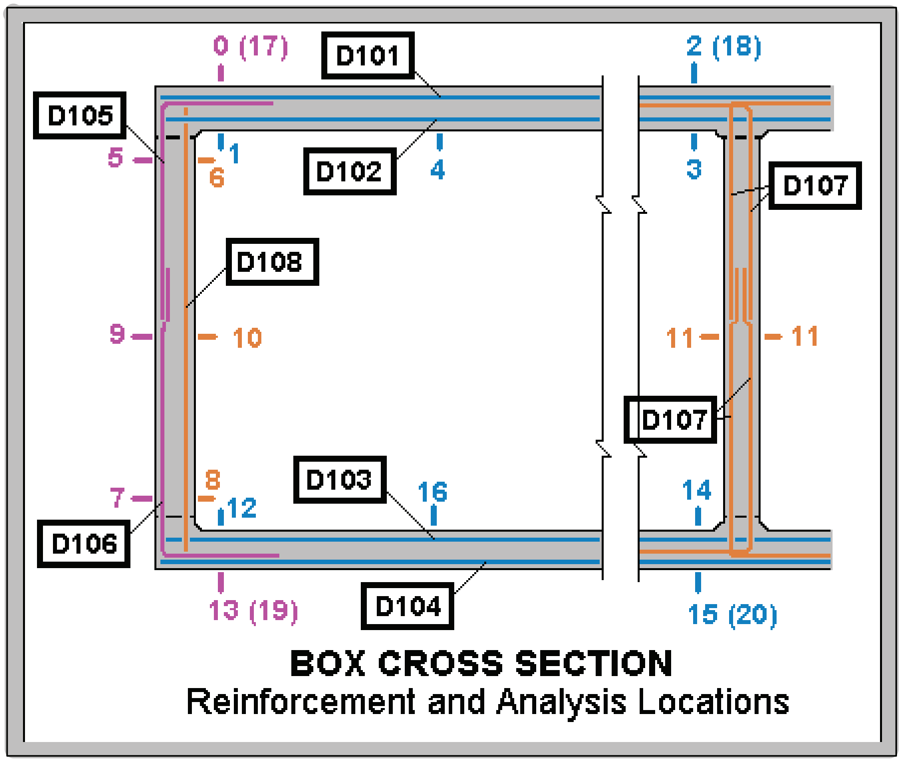
density of water: $\gamma_w = 62.4 \cdot \frac{lbf}{ft^3}$

concrete strength preset for FDOT work: $f_c = 5.5 \cdot ksi$

concrete modulus of elasticity: $E = 4388 \cdot ksi$

Main Reinforcing Summary:

Cross Section Notes:
1. Bars shown with the same color are combined as Bar Groups.
2. Colored numbers indicate moment analysis locations.
3. Colored numbers in parenthesis indicate shear analysis locations.
4. Black numbers refer to bar designations.



Reinforcing bar size and spacing

Generally, reinforcement should be at least a #3 bar and spacing should not exceed 12 inches.

Note: Shear generally controls slab and wall thicknesses and cracking generally controls reinforcement areas

$S_{box} := Sbox \cdot ft$ $As_{it} := A_{s_{it}} \cdot ft^2$

Bar Designation (section number) *Bar Sizes & Spacings used in analysis*

D101(2)
D102(1,3,4)
D103(12,14,16)
D104(15)

$BarSize_{slabs} = \begin{pmatrix} 5 \\ 5 \\ 5 \\ 5 \end{pmatrix}$ $S_{slabs} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix} \cdot in$

D105(9,0,5)
D106(9,7,13)

$BarSize_{corners} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$ $S_{corners} = \begin{pmatrix} 6 \\ 6 \end{pmatrix} \cdot in$

D107(11)
D108(6,8,10)

$BarSize_{walls} = \begin{pmatrix} 5 \\ 5 \end{pmatrix}$ $S_{walls} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

Reinforcing Bar Size Per Location:

$BarSizeBox^T =$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	4	5	5	5	5	4	5	4	5	4	5	5	5	4	5	5	5	4	5	4	5

Reinforcing Bar Spacing Per Location (in):

$\frac{S_{box}{}^T}{in} =$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	6	6	6	6	6	6	12	6	12	6	12	12	6	6	6	6	6	6	6	6	6

Area of Reinforcing Steel Per Unit Width Per Location (in^2)   Note: Unit Width Set to 1ft Default:

$\frac{As^T}{in^2} =$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0.4	0.44	0.62	0.62	0.62	0.4	0.22	0.4	0.22	0.4	0.31	0.31	0.44	0.4	0.62	0.62	0.62	0.4	0.62	0.4	0.62

Load Components:

Import Box Load Data (generated in Worksheet 2)

$Force_{trk} := Force_{trk.box}$ *HL-93 design truck*

$Force_{ev} := Force_{ev.box}$ *vertical earth pressure*

$Force_{es} := Force_{es.box}$ *earth surcharge*

$Force_{dc} := Force_{dc.box}$ *self weight (concrete)*

$Force_{HL93} := Force_{ll.box}$ *HL-93 design truck or tandem (governing)*

$Force_{eh} := Force_{eh.box}$ *horizontal earth pressure*

$Force_{wa} := Force_{wa.box}$ *water*

$Force_{ls} := Force_{ls.box}$ *live load surcharge*

Generate FL-120 Permit Live Load

$Force_{FL120} := 1.67 Force_{trk}$ *FL-120 permit load is scalable to HL-93 design truck*

Design Load Rating: Strength I *(Inventory)* Combinations, HL-93:

Strength I-A *max V, min H*

$$Strength_A := 1.25 \cdot Force_{dc} + 1.05 \cdot 1.30 \cdot Force_{ev} + 0.5 \cdot \left(Force_{eh} + Force_{es}\right) + 1.75 \cdot Force_{HL93} + 1.0 \cdot Force_{wa}$$

Strength I-B *min V, max H*

$$Strength_B := 0.9 \cdot Force_{dc} + 0.9 \cdot Force_{ev} + 1.05 \cdot 1.35 \cdot \left(Force_{eh} + Force_{es}\right) + 1.75 \cdot Force_{ls}$$

Strength I-C *max V, max H*

$$Strength_C := 1.25 \cdot Force_{dc} + 1.05 \cdot 1.30 \cdot Force_{ev} + 1.05 \cdot 1.35 \cdot \left(Force_{eh} + Force_{es}\right) + 1.75 \cdot Force_{ls} + 1.75 \cdot Force_{HL93}$$

Strength I Inventory Load Rating Calculations

Governing Load Rating Factor Per Location:

$RFdisplay_{design.inventory}^{T} =$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	2.9	7.7	2.1	28.5	2.5	3.9	4.8	2.3	6.5	3.2	4.6	4.4	10.0	1.6	21.7	2.3	2.7	2.0	1.8	2.8	3.6

Design Load Rating Factor for Strength I (Inventory), HL-93: $\min\left(RF_{design.inventory}\right) = 1.65$

Design Load Rating:Strength I *(Operating)* Combinations, HL-93:

Strength I-A *max V, min H*

$$Strength_A := 1.25 \cdot Force_{dc} + 1.05 \cdot 1.30 \cdot Force_{ev} + 0.5 \cdot \left(Force_{eh} + Force_{es}\right) + 1.35 \cdot Force_{HL93} + 1.0 \cdot Force_{wa}$$

Strength I-B *min V, max H*

$$Strength_B := 0.9 \cdot Force_{dc} + 0.9 \cdot Force_{ev} + 1.05 \cdot 1.35 \cdot \left(Force_{eh} + Force_{es}\right) + 1.35 \cdot Force_{ls}$$

Strength I-C *max V, max H*

$$Strength_C := 1.25 \cdot Force_{dc} + 1.05 \cdot 1.30 \cdot Force_{ev} + 1.05 \cdot 1.35 \cdot \left(Force_{eh} + Force_{es}\right) + 1.35 \cdot Force_{ls} + 1.35 \cdot Force_{HL93}$$

Strength I Operating Load Rating Calculations

Governing Load Rating Factor Per Location:

$RFdisplay_{design.operating}^{T} =$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	3.8	9.9	2.7	37.0	3.2	4.9	6.1	2.8	8.4	4.0	6.0	5.4	12.9	2.1	28.1	2.9	3.5	2.6	2.4	3.6	4.6

Design Load Rating Factor for Strength I (Operating), HL-93: $\min\left(RF_{design.operating}\right) = 2.13$

Permit Load Rating: Strength II Combinations, FL-120:

Strength II-A *max V, min*

$$Strength_A := 1.25 \cdot Force_{dc} + 1.05 \cdot 1.30 \cdot Force_{ev} + 0.5 \cdot \left(Force_{eh} + Force_{es}\right) + 1.35 \cdot Force_{FL120} + 1.0 \cdot Force_{wa}$$

Strength II-B *min V, max*

$$Strength_B := 0.9 \cdot Force_{dc} + 0.9 \cdot Force_{ev} + 1.05 \cdot 1.35 \cdot \left(Force_{eh} + Force_{es}\right) + 1.35 \cdot Force_{ls}$$

Strength II-C *max V, max*

$$Strength_C := 1.25 \cdot Force_{dc} + 1.05 \cdot 1.30 \cdot Force_{ev} + 1.05 \cdot 1.35 \cdot \left(Force_{eh} + Force_{es}\right) + 1.35 \cdot Force_{ls} + 1.35 \cdot Force_{FL120}$$

StrengthII FL120 Load Rating Calculations

Governing Load Rating Factor Per Location:

$RFdisplay_{design.permit}^{T} =$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	2.58	5.94	1.62	25.14	1.93	3.44	3.91	1.84	5.34	2.56	3.99	3.42	8.17	1.32	25.95	2.31	2.57	2.12	1.96	2.42	4.09

Permit Load Rating Factor for Strength II, FL-120: $\min\left(RF_{design.permit}\right) = 1.32$

Load Rating Summary Tables:

Load Rating Summary Table Calculations

General Load Factors & Weight:

LRFR =

"Limit State"	"Vehicle"	"Weight(tons)"	"LL"	"DC min/max"	"EV min/max"	"EH min/max"
"Str. I (Inv.)"	"HL-93"	"N/A"	1.75	"0.9/1.25"	"0.9/1.05x1.30"	"0.5/1.05x1.35"
"Str. I (Op.)"	"HL-93"	"N/A"	1.35	"0.9/1.25"	"0.9/1.05x1.30"	"0.5/1.05x1.35"
"Str. II"	"FL-120"	60	1.35	"0.9/1.25"	"0.9/1.05x1.30"	"0.5/1.05x1.35"

Moment (Strength):

$LRFR_{moment}$ =

"Limit State"	"Vehicle"	"LL/(*PL)"	"Rating Factor"	"Tons"	"Location (see below)"
"Str. I (Inv.)"	"HL-93"	2.33	1.65	"NA"	13
"Str. I (Op.)"	"HL-93"	2.33	2.13	"NA"	13
"Str. II"	"FL-120"	3.75	1.32	79.47	13

Shear (Strength):

$LRFR_{shear}$ =

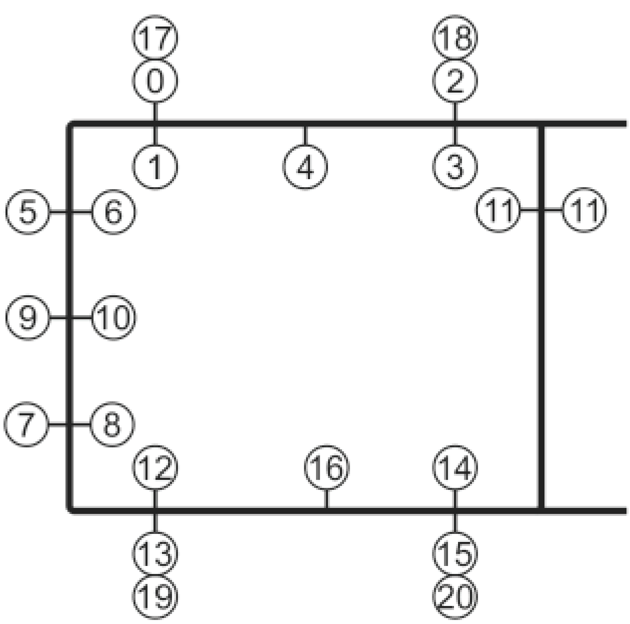
"Limit State"	"Vehicle"	"LL/(*PL)"	"Rating Factor"	"Tons"	"Location (see below)"
"Str. I (Inv.)"	"HL-93"	3.97	1.84	"NA"	18
"Str. I (Op.)"	"HL-93"	3.97	2.38	"NA"	18
"Str. II"	"FL-120"	4.83	1.96	117.46	18

**PL-permanent loads (including water)*

Governing Rating Factor:

Summary =

"Limit State"	"Vehicle"	"Weight(tons)"	"Rating Factor"	"Governing Mode"	"Location (see below)"
"Str. II"	"FL-120"	79.47	1.32	"Moment"	13



Section Locations

Dimensions X, Y, & Z:

distance along centerline culvert from outside exterior wall face to...

$Dim_{X.top} = 1.17\,ft$ *locations 0, 1, & 17*

$Dim_{X.bot} = 1.17\,ft$ *locations 12,13 & 19*

$Dim_{Y} = 4.5\,ft$ *locations 4 & 16*

$Dim_{Z.top} = 7.83\,ft$ *locations 2, 3, & 18*

$Dim_{Z.bot} = 7.83\,ft$ *locations 14, 15, & 20*

note: Dimensions assume default haunch width of 2 inches per Index No 289. To change haunch widths, see Sheet 2.

Geotechnical Data

5.0 DESIGN RECOMMENDATIONS

5.1 General

The following evaluation and recommendations are based on the provided project information as presented in this report, results of the field exploration and laboratory testing performed, and the construction techniques recommended in Section 6.0 below. If the described project conditions are incorrect or changed after this report, or subsurface conditions encountered during construction are different from those reported, MAE should be notified so these recommendations can be re-evaluated and revised, if necessary. We recommend that MAE review the foundation plans and earthwork specifications to verify that the recommendations in this report have been properly interpreted and implemented.

5.2 Culvert Foundation Support Recommendations

Based on the results of the subsurface explorations, laboratory testing, and provided information, as included in this report, we consider the subsurface conditions at the site adaptable for supporting the planned culverts when constructed upon properly prepared subgrade soils. Provided the site is prepared in accordance with the recommendations presented in this report, the following parameters may be used for design of the planned culvert.

5.2.1 Bearing Pressure

The maximum allowable net soil bearing pressure for use in foundation design for the culvert should not exceed 2,000 psf. Net bearing pressure is defined as the soil bearing pressure at the foundation bearing level in excess of the natural overburden pressure at that level. The foundations should be designed based on the maximum load that could be imposed by all loading conditions.

5.2.2 Bearing Material

The culvert foundation should bear on the compacted structural backfill or compacted native sandy soils. The bearing level soils, after compaction, should exhibit densities equivalent to 98 percent of the modified Proctor maximum dry density (AASHTO T 180), to a depth of at least one foot below the foundation bearing levels.

We note that sands containing few amounts of organic fines were encountered at both boring locations. These soils were encountered between approximate depths of 6 and 8 feet below the existing ground surface. We consider these soils unsuitable for use as bedding or backfill material. If these soils are encountered within 2 feet of the culvert bearing elevation, they should be removed and replaced with suitable fill material as described in Section 6.4 of this report. In addition, these excavated soils should not be reused as backfill.

5.2.3 Settlement Estimates

Post-construction settlement of the culvert structure will be influenced by several interrelated factors, such as (1) subsurface stratification and strength compressibility characteristics; (2) culvert size, bearing levels, applied loads, and resulting bearing pressures beneath the culvert; and (3) site preparation and earthwork construction techniques used by the contractor. Any deviation from these recommendations could result in an increase in the estimated post construction settlements of the structure.

Due to the sandy nature of the surficial soils and granular nature of the recommended backfill soils, we expect the majority of settlement to occur in an elastic manner, relatively concurrent with loading. Using the recommended maximum bearing pressure, recommended in this report and the field and laboratory tests and site preparation techniques data that we have correlated to geotechnical strength and compressibility characteristics of the subsurface soils, we estimate that total settlement of the culvert could be on the order of one inch or less.

Differential settlements result from differences in applied bearing pressures and variations in the compressibility characteristics of the subsurface soils. Based on the recommended foundation design for the culvert and the site preparation and earthwork construction techniques outlined in Section 6.0, we estimate the differential settlement along the length of the culvert to be one-half inch or less.

Provided the site preparation and earthwork construction recommendations outlined in Section 6.0 of this report are performed, the following parameters may be used for design.

5.2.4 Lateral Earth Pressure Soil Parameters

In general, walls that have adjacent compacted fill will be subjected to lateral earth pressures. The wing walls for the culverts, assumed to not be restrained at the top and that sufficient movement is anticipated, will be subjected to active earth pressures. Surcharge effects for sloped backfill, point or area loads behind the walls, and adequate drainage provisions should be incorporated in the wall design. Passive resistance, resulting from footing embedment at the wall toe, could be neglected for safer design.

The following soil parameters can be used for the project where soils are placed adjacent to the culvert wing walls:

- Retained Soil Unit Weight, Saturated (γ_{sat}) = 120 pcf
- Retained Soil Unit Weight, Moist (γ_m) = 110 pcf
- Retained Soil Angle of Internal Friction (ϕ) = 30 degrees
- Coefficient of Active Earth Pressure, k_a = 0.33
- Coefficient of Passive Earth Pressure, k_p = 3.0
- Foundation Soil Unit Weight, Saturated (γ_{sat}) = 125 pcf
- Foundation Soil Angle of Internal Friction (ϕ) = 30 degrees

The above parameters are based on clean sand backfill (SP) placed and compacted behind the walls as discussed in Section 6.4, and on compaction of the wall foundation soils as discussed in Section 6.3. A coefficient of friction for poured in-place concrete of 0.45 may be used in the wall design. The walls should be designed to include all temporary construction and permanent traffic and surcharge loads acting on the walls.

5.2.5 Hydrostatic Uplift Resistance

It is anticipated that the buried structures will exert little or no net downward pressure on the soils, rather, the structures may be subject to hydrostatic uplift pressure when empty. Below grade structures should be designed to resist hydrostatic uplift pressures appropriate for their depth below existing grade and the normal seasonal high groundwater table. Hydrostatic uplift forces can be resisted in several ways including:

- Addition of dead weight to the structure.
- Mobilizing the dead weight of the soil surrounding the structure through extension of footings outside the perimeter of the structure.

A moist compacted soil unit weight of 110 lb/ft^3 may be used in designing structures to resist buoyancy.

5.3 Environmental Classification

A total of 2 soil corrosion series tests were performed on soil samples obtained from both borings adjacent to the existing culvert system to determine the environmental classification of the soils. The samples were classified in accordance with FDOT procedures contained in Chapter 1.3.2.1 of the January 2019 edition of the FDOT Structures Design Guidelines. Based on the results of these tests, the encountered soils were classified as Slightly Aggressive. Sample locations and test results are shown on the *Corrosion Series Test Results* included in Appendix C and are summarized on Figure 3.

6.0 SITE PREPARATION AND EARTHWORK RECOMMENDATIONS

Site preparation as outlined in this section should be performed to provide more uniform foundation bearing conditions, to reduce the potential for post-construction settlements of the planned structure.

6.1 Clearing and Stripping

Prior to construction, the location of existing underground utility lines within the construction area should be established. Provisions should then be made to relocate interfering utilities to appropriate locations. It should be noted that, if underground pipes are not properly removed or plugged, they may serve as conduits for subsurface erosion, which may subsequently lead to excessive settlement of overlying structure.

Although not recorded on our field logs, it was observed that a surficial topsoil layer is present at the site. Therefore, it should be anticipated that up to about 6 inches of topsoil and soils containing significant amounts of organic materials may be encountered in this area. The actual depths of topsoil should be determined by MAE using visual observation and judgment during earthwork operations. These unsuitable materials should not be reused as backfill material within the planned culvert structure excavations. However, topsoil may be stockpiled and used subsequently in areas to be grassed.

6.2 Temporary Groundwater Control

The groundwater level was encountered at each of the boring locations and recorded at the time of our exploration. At B-1 and B-2 locations, the groundwater was measured at a depth of 5.5 and 6.5 feet (respectively) below the existing ground surface. Because of the need for excavation to the bottom elevation of the culverts, followed by compaction of the bedding and backfill soils, it may be necessary to install temporary groundwater control measures to dewater the area to facilitate the excavation and compaction processes.

The groundwater control measures should be determined by the contractor but can consist of sumps or wellpoints (or a combination of these or other methods) capable of lowering the groundwater level to at least 2 feet below the required depth of excavation. The dewatering system should not be decommissioned until excavation, compaction, and fill placement is complete, and sufficient deadweight exists on the culvert structure to prevent uplift.

Note that discharge of produced groundwater to surface waters of the state from dewatering operations or other site activities is regulated and requires a permit from the State of Florida Department of Environmental Protection (FDEP). This permit is termed a *Generic Permit for the Discharge of Produced Groundwater From Any Non-Contaminated Site Activity*. If discharge of produced groundwater is anticipated, we recommend sampling and testing of the groundwater early in the site design phase to prevent project delays during construction. MAE can provide the sampling, testing, and professional consulting required to evaluate compliance with the regulations.

6.3 Compaction

After completing the clearing and stripping operations and installing the temporary groundwater control measures (if required), the exposed surface area should be compacted with hand-held compaction equipment. Typically, the material should exhibit moisture contents within ±2 percent of the modified Proctor optimum moisture content (ASTM D 1557) during the compaction operations. Compaction should continue until densities of at least 98 percent of the modified Proctor maximum dry density (ASTM D 1557) have been achieved within the upper 1 foot of the compacted natural soils at the site.

Should the bearing level soils experience pumping and soil strength loss during the compaction operations, compaction work should be immediately terminated. The disturbed soils should be removed and backfilled with dry structural fill soils, which are then compacted, or the excess moisture content within the disturbed soils should be allowed to dissipate before recompacting.

Care should be exercised to avoid damaging any nearby structures while the compaction operation is underway. Prior to commencing compaction, occupants of adjacent structures should be notified, and the existing conditions of the structures should be documented with photographs and survey (if deemed necessary). Compaction should cease if deemed detrimental to adjacent structures, and MAE should be contacted immediately.

6.4 Structural Backfill and Fill Soils

Any structural backfill or fill required for site development should be placed in loose lifts not exceeding 6 inches in thickness and compacted by the use of hand-held compaction equipment.

Structural fill is defined as a non-plastic, inorganic, granular soil having less than 12 percent material passing the No. 200 mesh sieve and containing less than 4 percent organic material. The fine sand and slightly silty fine sand, without roots, as encountered in the borings, are suitable as fill materials and, with proper moisture control, should densify using conventional compaction methods. It should be noted that soils with more than 12 percent passing the No. 200 sieve will be more difficult to compact, due to their nature to retain soil moisture, and may require drying. Typically, the material should exhibit moisture contents within ±2 percent of the modified Proctor optimum moisture content (ASTM D 1557) during the compaction operations. Compaction should continue until densities of at least 98 percent of the modified Proctor maximum dry density (ASTM D 1557) have been achieved within each lift of the compacted structural fill.

To avoid damage to the culvert wingwalls during the compaction process, heavy compaction equipment should not be used within 5 feet of the walls. Hand-held compaction equipment should be used in these areas. The fill material within 5 feet of the wall should be placed in thin lifts (6 inches or less) and compacted as discussed above. Excessive compaction should be avoided as it can result in overstressing of the walls.

We note that soils containing few amounts of organic fines were encountered at boring both boring locations between approximate depths of 6 and 8 feet below the existing grade. We consider these soils unsuitable for use as bedding and/or backfill. Organic laden soils should be removed and clearly separated from the soils intended for reuse as backfill material. They can, however, be used in landscape areas.

We recommend that material excavated from the cross-drain trench that will be reused as backfill be stockpiled a safe distance from the excavation and in such a manner that promotes runoff away from the open trench and limits saturation of the materials.

6.5 Excavation Protection

Excavation work for the culvert construction will be required to meet OSHA Excavation Standard Subpart P regulations for Type C Soils. The use of excavation support systems will be necessary where there is not sufficient space to allow the side slopes of the excavation to be laidback to at least 2H:1V (2 horizontal to 1 vertical) to provide a safe and stable working area and to facilitate adequate compaction along the sides of the excavation.

The method of excavation support should be determined by the contractor but can consist of a trench box, drilled-in soldier piles with lagging, interlocking steel sheeting or other methods. The support structure should be designed according to OSHA sheeting and bracing requirements by a Florida registered Professional Engineer.

7.0 QUALITY CONTROL TESTING

A representative number of field in-place density tests should be made in the upper 2 feet of compacted natural soils, in each lift of compacted backfill and fill, and in the upper 12 inches below the bearing levels in the culvert excavations. The density tests are considered necessary to verify that satisfactory compaction operations have been performed. We recommend density testing be performed at one location on each side of the planned culvert crossing.

8.0 REPORT LIMITATIONS

This report has been prepared for the exclusive use of Parsons Transportation Group and the City of Neptune Beach for specific application to the design and construction of the *TWO 04 Florida Boulevard Culvert Crossing* project. An electronically signed and sealed version, and a version of our report that is signed and sealed in blue ink, may be considered an original of the report. Copies of an original should not be relied on unless specifically allowed by MAE in writing. Our work for this project was performed in accordance with generally accepted geotechnical engineering practice. No warranty, express or implied, is made.

The analyses and recommendations contained in this report are based on the data obtained from this project. This testing indicates subsurface conditions only at the specific locations and times, and only to the depths explored. These results do not reflect subsurface variations that may exist away from the boring locations and/or at depths below the boring termination depths. Subsurface conditions and water levels at other locations may differ from conditions occurring at the tested locations. In addition, it should be understood that the passage of time may result in a change in the conditions at the tested locations. If variations in subsurface conditions from those described in this report are observed during construction, the recommendations in this report must be re-evaluated.

The scope of our services did not include any environmental assessment or testing for the presence or absence of hazardous or toxic materials in the soil, groundwater, or surface water within or beyond the subject site. Any statements made in this report, and/or notations made on the generalized soil profiles or boring logs, regarding odors or other potential environmental concerns are based on observations made during execution of our scope of services and as such are strictly for the information of our client. No opinion of any environmental concern of such observations is made or implied. Unless complete environmental information regarding the site is already available, an environmental assessment is recommended.

If changes in the design or location of the planned culvert crossing occur, the conclusions and recommendations contained in this report may need to be modified. We recommend that these changes be provided to us for our consideration. MAE is not responsible for conclusions, interpretations, opinions or recommendations made by others based on the data contained in this report.

Whong, David

From: Brett H. Harbison, PE <bharbison@meskelengineering.com>
Sent: Tuesday, October 08, 2019 3:18 PM
To: Tina D. Meskel; Gyorog, Tom
Cc: Whong, David; Helmbreck, Raymond; Rodney Mank
Subject: [EXTERNAL] RE: CONB TO4 Culvert - Geotech

Tom and David,

The following parameters can be used assuming backfill compaction has been performed in accordance with Section 6 of our report:

- Backfill total unit weight = 120 pcf
- Angle of internal friction of backfill soils = 30 degrees
- Modulus of subgrade reaction = 86,500 pcf (50 pci)

Thanks!
Brett

Brett Harbison, P.E.
Meskel & Associates Engineering
Email: bharbison@meskelengineering.com

Jacksonville Office: 904-519-6990
Tampa Office: 813-252-5585
www.meskelengineering.com [meskelengineering.com]

TEN YEARS MAE Meskel & Associates Engineering
Facebook [facebook.com] | Twitter [twitter.com] | YouTube [youtube.com] | LinkedIn [linkedin.com]

From: Tina D. Meskel <tina@meskelengineering.com>
Sent: Tuesday, October 8, 2019 11:54 AM
To: Gyorog, Tom <Tom.Gyorog@parsons.com>
Cc: Whong, David <David.Whong@parsons.com>; Helmbreck, Raymond <Raymond.Helmbreck@parsons.com>; Brett H. Harbison, PE <bharbison@meskelengineering.com>; Rodney Mank <rodney@meskelengineering.com>
Subject: RE: CONB TO4 Culvert - Geotech

Hi, Tom, hope all is good with you.

We can definitely provide the parameter you need. We do not have any budget left to go back to the field. Do you need us to prepare a proposal?

Tina Meskel, P.E.
Principal, President
Meskel & Associates Engineering

Email: tina@meskelengineering.com
Cell: 904-945-2580

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Jacksonville Office: 904-519-6990
Tampa Office: 813-252-5585
www.meskelengineering.com [meskelengineering.com]

From: Gyorog, Tom <Tom.Gyorog@parsons.com>
Sent: Tuesday, October 08, 2019 10:15 AM
To: Tina D. Meskel <tina@meskelengineering.com>
Cc: Whong, David <David.Whong@parsons.com>; Helmbreck, Raymond <Raymond.Helmbreck@parsons.com>
Subject: FW: CONB TO4 Culvert - Geotech

Tina,

Would you provide this parameter?

Do you have any budget left to do some wall borings in the adjacent park?

Thanks,
Tom Gyorog, P.E.
Project Manager
1300 Riverplace Blvd, Suite 200 - Jacksonville, FL 32207
tom.gyorog@parsons.com - P: +1 904.596.1412

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From: Whong, David <David.Whong@parsons.com>
Sent: Tuesday, October 8, 2019 10:09 AM
To: Gyorog, Tom <Tom.Gyorog@parsons.com>
Cc: Helmbreck, Raymond <Raymond.Helmbreck@parsons.com>
Subject: CONB TO4 Culvert - Geotech

Tom,

Can you please contact Meskel? We need the modulus of subgrade reaction for the culvert; I have not been able to locate this value in their report dated 03/14/19 (MAE Project No. 0018-0003B).

Thanks,

David Whong, PE
1300 Riverplace Blvd, Suite 200
Jacksonville, FL 32207
david.whong@parsons.com - P: +1 904.596.1406 M: +1 904.210.6125

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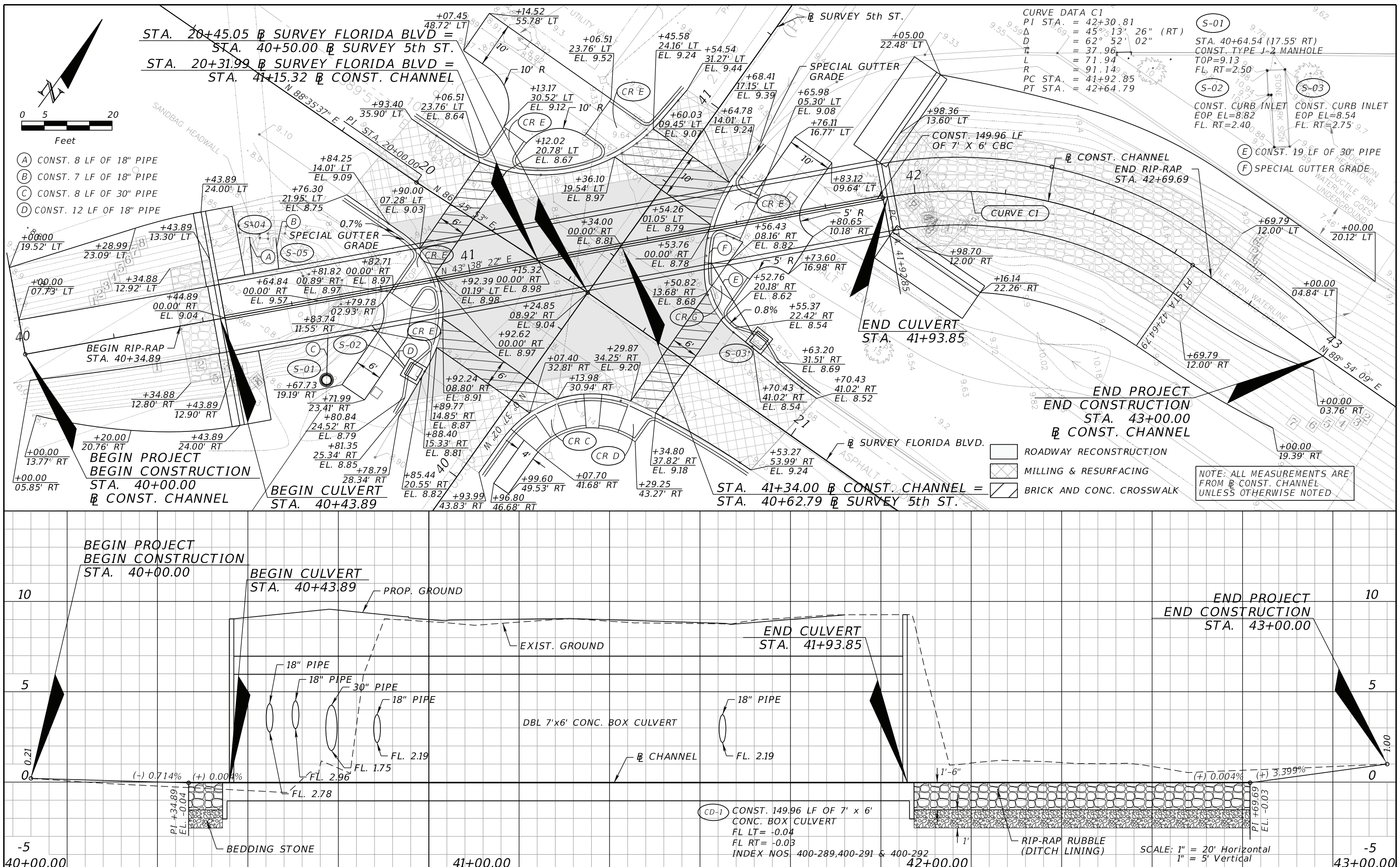

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

THOMAS J GYOROG, P.E.
P.E. NO.: 46612
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1300 RIVERPLACE BLVD. SUITE 200
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CERTIFICATE OF AUTHORIZATION: 1838

57

CITY OF NEPTUNE BEACH
DEPARTMENT OF PUBLIC WORKS

ROAD	COUNTY	FINANCIAL PROJECT ID
FLORIDA BLVD	DUVAL	648931

CULVERT PLAN-PROFILE

SHEET NO.

p001545D 10/31/2019 5:04:32 PM Default P:\648931 CNB GEC\Task Orders\TO4\roadway\PLPRRD01.dgn

BOX CULVERT DATA TABLES

BOX, HEADWALL AND CUTOFF WALL DATA TABLE (inches unless shown otherwise)																				Table Date 7-01-09
LOCATION	STRUCTURE /BRIDGE NUMBER	BOX									HEADWALL AND CUTOFF WALL									
		Wc(ft)	Hc(ft)	Tt	Tw	Tb	Ti	#cells	Lc(ft)	Cover	Blhw	Hlhw	Brhw	Hrhw	Blcw	Hlcw	Brcw	Hrcw	SL(deg)	SR(deg)
20+31.99	724446	7	6	12	12	12	12	2	150	3	12	36	12	36	12	24	12	24	0	0

LEFT SIDE WINGWALLS DATA TABLE (inches unless shown otherwise)																		Table Date 01-01-11
STRUCTURE /BRIDGE NUMBER	LEFT END WINGWALL									LEFT BEGIN WINGWALL								
	Rt	Rw	Rh	Rd	SW(deg)	β (deg)	He(ft)	Hs(ft)	Lw(ft)	Rt	Rw	Rh	Rd	SW(deg)	β (deg)	He(ft)	Hs(ft)	Lw(ft)
724446	21	12	72	12	90	5.71	9	9	16.5	21	12	72	12	90	5.71	9	9	16.5

RIGHT SIDE WINGWALLS DATA TABLE (inches unless shown otherwise)																		Table Date 01-01-11
STRUCTURE /BRIDGE NUMBER	RIGHT END WINGWALL									RIGHT BEGIN WINGWALL								
	Rt	Rw	Rh	Rd	SW(deg)	β (deg)	He(ft)	Hs(ft)	Lw(ft)	Rt	Rw	Rh	Rd	SW(deg)	β (deg)	He(ft)	Hs(ft)	Lw(ft)
724446	21	12	72	12	135	4.04	9	9	23	21	12	72	12	135	4.04	9	9	23

ESTIMATED CONCRETE QUANTITIES (CY)																				Table Date 7-01-13
STRUCTURE /BRIDGE NUMBER	BOX								LEFT END WINGWALL			LEFT BEGIN WINGWALL			RIGHT END WINGWALL			RIGHT BEGIN WINGWALL		
	Left Cutoff Wall	Right Cutoff Wall	Bottom Slab	Walls	Top Slab	Left Head Wall	Right Head Wall	Sub Total	Footing	Wall	Sub Total	Footing	Wall	Sub Total	Footing	Wall	Sub Total	Footing	Wall	Sub Total
724446	0.63	0.63	96.3	100	94.4	1.26	1.26	295	5.96	5.5	11.5	5.96	5.5	11.5	8.31	7.67	16	8.31	7.67	16

MAIN STEEL REINFORCEMENT SPACING (inches)																			Table Date 7-01-09
STRUCTURE /BRIDGE NUMBER	BOX														HEADWALLS		CUTOFF WALLS		
	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115, 116...	803	806	809	812
724446	6	6	6	6	6	6	12	12	12	12	12	12	12	12	12	12	12	12	12

WINGWALL STEEL REINFORCEMENT SPACING (inches)																												Table Date 7-01-09
STRUCTURE /BRIDGE NUMBER	LEFT END WINGWALL							LEFT BEGIN WINGWALL							RIGHT END WINGWALL							RIGHT BEGIN WINGWALL						
	401 407(8)	402 (403)	404 (405)	406	409	410	411	501 507(8)	502 (503)	504 (505)	506	509	510	511	601 607(8)	602 (603)	604 (605)	606	609	610	611	701 707(8)	702 (703)	704 (705)	706	709	710	711
724446	6	12	12	12	6	12	12	6	12	12	12	6	12	12	6	12	12	12	6	12	12	6	12	12	12	6	12	12

WINGWALL NOTE: Bar designations in "( )" are only required for variable height wingwalls.

NOTES [Notes Date 7-01-14]:

1. Environmental Class: Extremely Aggressive
2. Reinforcing Steel, Grade 60
3. Concrete Class IV f'c = 5.5 ksi
4. Soil Properties:
   Friction Angle: 30 degrees
   Modulus of Subgrade Reaction: 50 pci
   Nominal Bearing Resistance: 2,000 psf
5. Work this Drawing with Standard Plans Index 400-289
6. Settlement criteria for Precast Box Culvert option (Index 400-291):
   Long Term Differential Settlement (ΔY) = 0.04 ft.
   Effective Length for Settlement (L) = 150 ft.

BRIDGE CULVERT NO. 724446

Designed By : RLH 10-19
Checked By : DAW 10-19

Drawn By : DAW 10-19
Checked By : RLH 10-19

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

ENGINEER OF RECORD
DAVID A. WHONG, P.E.
P.E. NO.: 66882
PARSONS TRANSPORTATION GROUP
1300 RIVERPLACE BLVD. SUITE 200
JACKSONVILLE, FL. 32207
CERTIFICATE OF AUTHORIZATION: 1838

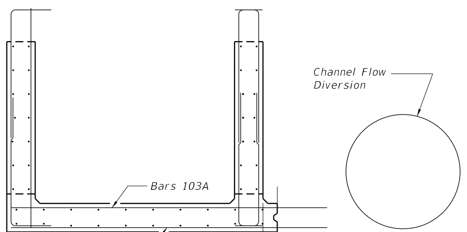
CITY OF NEPTUNE BEACH
DEPARTMENT OF PUBLIC WORKS

ROAD	COUNTY	FINANCIAL PROJECT ID
FLORIDA BLVD	DUVAL	648931

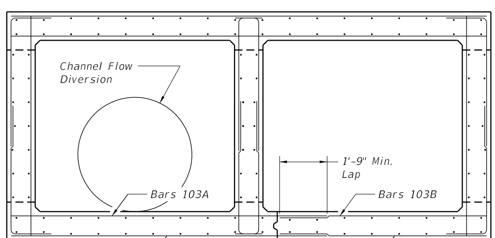
BOX CULVERT CD-1 DATA TABLES

SHEET NO.

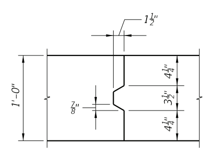
$USER$ $DATE$ $TIME$ $FILE$



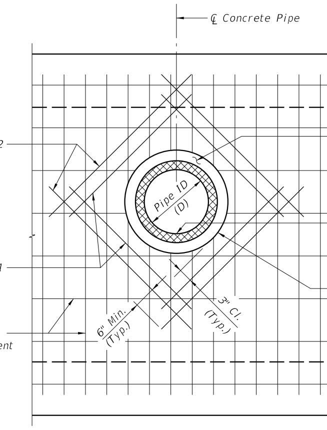
CULVERT - PHASE I



CULVERT - PHASE II



KEYED CONSTRUCTION JOINT DETAIL



PIPE PENETRATION DETAIL

PIPE PENETRATION NOTES:

1. Pipe blockout diameter to be 6" greater than pipe outside diameter.
2. Cut box culvert reinforcement as required to maintain 3" cover.
3. Place 900-series bars between wall reinforcing mats.
4. See Culvert Plan-Profile for size, placement, and invert elevation.

BRIDGE CULVERT NO. 724446

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

ENGINEER OF RECORD

DAVID A. WHONG, P.E.
P.E. NO.: 66882
PARSONS TRANSPORTATION GROUP
1300 RIVERPLACE BLVD, SUITE 200
JACKSONVILLE, FL. 32207
CERTIFICATE OF AUTHORIZATION: 1838

59

CITY OF NEPTUNE BEACH
DEPARTMENT OF PUBLIC WORKS

ROAD	COUNTY	FINANCIAL PROJECT ID
FLORIDA BLVD	DUVAL	648931

BOX CULVERT CD-1
CULVERT DETAILS

SHEET NO.

$USER$ $DATE$ $TIME$ $FILE$

Designed By : RLH 10-19
Checked By : DAW 10-19

Drawn By : DAW 10-19
Checked By : RLH 10-19

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

MARK SIZE	MARK DES	LENGTH FT IN	NO BARS	TYP BAR	STY A	STY G	B FT IN FR	C FT IN FR	D FT IN FR	E FT IN FR	F FT IN FR	H FT IN FR	J FT IN FR	K FT IN FR	N NO	Ø ANG
LOCATION MAIN BOX											NO. REQUIRED = 1					
5	101	16- 6	296	1			16- 6									
5	102	16- 6	296	1			16- 6									
5	103A	11- 2	302	1			11- 2									
5	103B	7- 2	302	1			7- 2									
5	104A	11- 2	302	1			11- 2									
5	104B	7- 2	302	1			7- 2									
4	105	5-11	590	10			1- 5	4- 5 1/2								
4	106	5-11	590	10			1- 5	4- 5 1/2								
5	107	5- 6	592	10			0-10	4- 7 1/2								
5	108	7- 6	296	1			7- 6									
4	109	153- 4	18	2			1- 5	150- 6							2	
4	110	150- 4	18	2			1- 5	147- 6							2	
4	111	149- 8	18	2			1- 5	146- 9 1/2							2	
4	112	153- 4	18	2			1- 5	150- 6							2	
4	113	150- 4	14	2			1- 5	147- 6							2	
4	114	150- 4	14	2			1- 5	147- 6							2	
4	115	149- 8	14	2			1- 5	146- 9 1/2							2	
LOCATION LEFT END WINGWALL											NO. REQUIRED = 1					
5	401	8- 9	27	1			8- 9									
4	402	16- 0	10	1			16- 0									
4	404	16- 0	10	1			16- 0									
4	406	8- 9	17	1			8- 9									
5	407	4- 6	27	10			2- 0	2- 5 3/4								
5	409	7- 6	27	1			7- 6									
4	410	7- 6	17	1			7- 6									
4	411	16- 0	18	1			16- 0									
5	412	2- 0	14	1			2- 0									
LOCATION LEFT BEGIN WINGWALL											NO. REQUIRED = 1					
5	501	8- 9	27	1			8- 9									
4	502	16- 0	10	1			16- 0									
4	504	16- 0	10	1			16- 0									
4	506	8- 9	17	1			8- 9									
5	507	4- 6	27	10			2- 0	2- 5 3/4								
5	509	7- 6	27	1			7- 6									
4	510	7- 6	17	1			7- 6									
4	511	16- 0	18	1			16- 0									
5	512	2- 0	14	1			2- 0									
LOCATION RIGHT END WINGWALL											NO. REQUIRED = 1					
5	601	8- 9	37	1			8- 9									
4	602	22- 6	10	1			22- 6									
4	604	22- 6	10	1			22- 6									
4	606	8- 9	24	1			8- 9									
5	607	4- 6	37	10			2- 0	2- 5 3/4								
5	609	7- 6	37	1			7- 6									
4	610	7- 6	24	1			7- 6									
4	611	22- 6	18	1			22- 6									
5	612	2- 0	14	1			2- 0									

Designed By : RLH 10-19
Checked By : DAW 10-19

Drawn By : DAW 10-19
Checked By : RLH 10-19

BRIDGE CULVERT NO. 724446

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

ENGINEER OF RECORD
DAVID A. WHONG, P.E.
P.E. NO.: 66882
PARSONS TRANSPORTATION GROUP
1300 RIVERPLACE BLVD, SUITE 200
JACKSONVILLE, FL. 32207
CERTIFICATE OF AUTHORIZATION: 1838

CITY OF NEPTUNE BEACH
DEPARTMENT OF PUBLIC WORKS

ROAD	COUNTY	FINANCIAL PROJECT ID
FLORIDA BLVD	DUVAL	648931

BOX CULVERT CD-1
REINFORCING BAR LIST (1 OF 2)

SHEET NO.

$USER$ $DATE$ $TIME$ $FILE$

MARK SIZE	MARK DES	LENGTH FT-IN	NO BARS	TYP BAR	STY A	STY G	B	C	D	E	F	H	J	K	N NO	Ø ANG
LOCATION			RIGHT BEGIN WINGWALL							NO. REQUIRED = 1						
5	701	8- 9	46	1			8- 9									
4	702	22- 6	10	1			22- 6									
4	704	22- 6	10	1			22- 6									
4	706	8- 9	24	1			8- 9									
5	707	4- 9	46	10			2- 3	2- 5 ¾								
5	709	8- 3	46	1			8- 3									
4	710	8- 3	24	1			8- 3									
4	711	22- 6	20	1			22- 6									
5	712	2- 0	14	1			2- 0									
LOCATION			LEFT HEADWALL							NO. REQUIRED = 1						
5	801	16- 6	2	1			16- 6									
5	802	16- 6	2	1			16- 6									
4	803	6- 2	17	27			2- 5 ½	0- 6		0- 4 ½	2- 1	0- 6	0- 6			
LOCATION			RIGHT HEADWALL							NO. REQUIRED = 1						
5	804	16- 6	2	1			16- 6									
5	805	16- 6	2	1			16- 6									
4	806	6- 2	17	27			2- 5 ½	0- 6		0- 4 ½	2- 1	0- 6	0- 6			
LOCATION			LEFT CUTOFF WALL							NO. REQUIRED = 1						
4	807	16- 6	2	1			16- 6									
4	808	16- 6	2	1			16- 6									
4	809	4- 5	17	7			1- 5 ½	0- 6	0- 6	0- 6						
LOCATION			RIGHT CUTOFF WALL							NO. REQUIRED = 1						
4	810	16- 6	2	1			16- 6									
4	811	16- 6	2	1			16- 6									
4	812	4- 5	17	7			1- 5 ½	0- 6	0- 6	0- 6						
LOCATION			18" PIPE PENETRATION							NO. REQUIRED = 3						
4	901	4- 1	8	1			4- 1									
4	902	4-10	8	1			4-10									
LOCATION			30" PIPE PENETRATION							NO. REQUIRED = 1						
4	903	5- 3	8	1			5- 3									
4	904	6- 0	8	1			6- 0									

BRIDGE CULVERT NO. 724446

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

ENGINEER OF RECORD
DAVID A. WHONG, P.E.
P.E. NO.: 66882
PARSONS TRANSPORTATION GROUP
1300 RIVERPLACE BLVD. SUITE 200
JACKSONVILLE, FL. 32207
CERTIFICATE OF AUTHORIZATION: 1838

CITY OF NEPTUNE BEACH
DEPARTMENT OF PUBLIC WORKS

ROAD	COUNTY	FINANCIAL PROJECT ID
FLORIDA BLVD	DUVAL	648931

BOX CULVERT CD-1
REINFORCING BAR LIST (2 OF 2)

SHEET NO.

$USER$ $DATE$ $TIME$ $FILE$

Designed By : RLH 10-19
Checked By : DAW 10-19

Drawn By : DAW 10-19
Checked By : RLH 10-19

Load Rating Summary Details for Reinforced Concrete Bridge Culverts (Box and Three-Sided Culvert)

Table Date 01-01-11

Table 2 - LRFR

Level	Limit State	Vehicle	Weight (tons)	Load Factors			Moment (Strength)					Shear (Strength)					
				LL	DC	DW	Unfactored Ratio LL / Permanent Loads	Rating Factor	Tons	Location	Dimension	Unfactored Ratio LL / Permanent Loads	Rating Factor	Tons	Location	Dimension	Comments: Wheel load distribution method if other than LRFD. Other appropriate comments.
Design Load Rating	Strength I (Inv)	HL-93	N/A	1.75	1.25	1.50	2.33	1.65	N/A	A	1.17	3.97	1.84	N/A	B	7.83	
Design Load Rating	Strength I (Op)	HL-93	N/A	1.35	1.25	1.50	2.33	2.13	N/A	A	1.17	3.97	2.38	N/A	B	7.83	
Permit Load Rating	Strength II	FL120	60.0	1.35	1.25	1.50	3.75	1.32	79.47	A	1.17	4.83	1.96	117.46	B	7.83	

General Notes:

1. This table is based on the requirements established in the January 2019 "Structures Manual".

Table 2 Notes:

1. Permit capacity is determined by using the permit vehicle in all lanes.
2. Does the depth of fill above the top slab exceed the span length between the inside faces of the end walls (Bridge Culvert Total Span Length)? ☐ Yes ☒ No

   If Yes then the live load may be neglected per LRFD 3.6.1.2.6.

3. Software: FDOT Box Culvert v4.0

Designed By : RLH 10-19
Checked By : DAW 10-19

Drawn By : DAW 10-19
Checked By : RLH 10-19

Abbreviations:

DL - Dead Load (LFR)

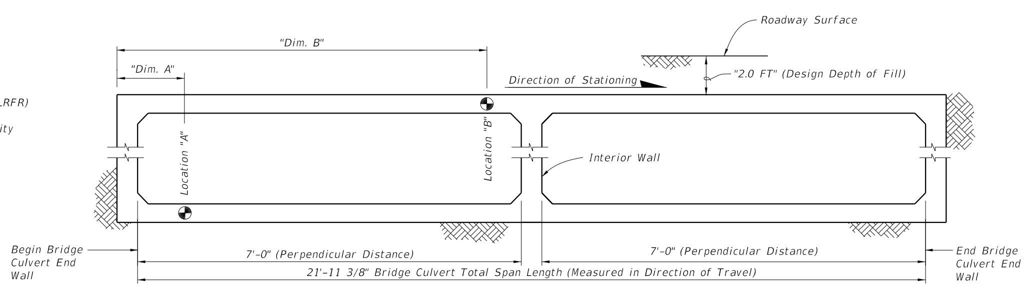
DC - Component Dead Load (LRFR)

DW - Wearing Surface & Utility Dead Load (LRFR)

LL - Live Load

Inv - Inventory

Op - Operating



RATING LOCATIONS

BRIDGE CULVERT NO. 724446

THE OFFICIAL RECORD OF THIS SHEET IS THE ELECTRONIC FILE DIGITALLY SIGNED AND SEALED UNDER RULE 61G15-23.004, F.A.C.

REVISIONS				ENGINEER OF RECORD					
DATE	DESCRIPTION	DATE	DESCRIPTION	DAVID A. WHONG, P.E. P.E. NO.: 66882 PARSONS TRANSPORTATION GROUP 1300 RIVERPLACE BLVD, SUITE 200 JACKSONVILLE, FL. 32207 CERTIFICATE OF AUTHORIZATION: 1838	CITY OF NEPTUNE BEACH DEPARTMENT OF PUBLIC WORKS			BRIDGE CULVERT CD-1 BRIDGE LOAD RATING SUMMARY	SHEET NO.
					ROAD	COUNTY	FINANCIAL PROJECT ID		
					FLORIDA BLVD	DUVAL	648931		

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