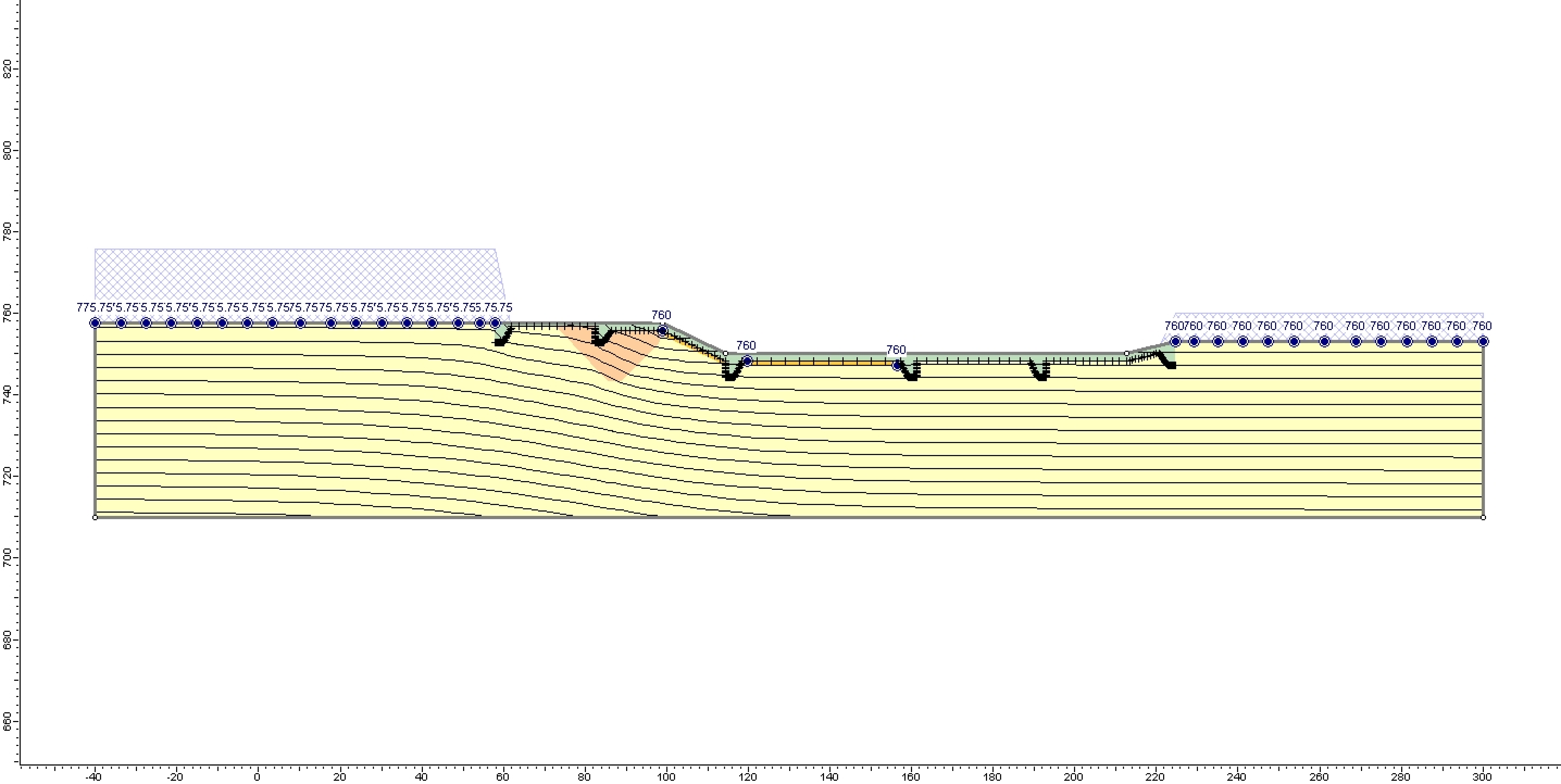
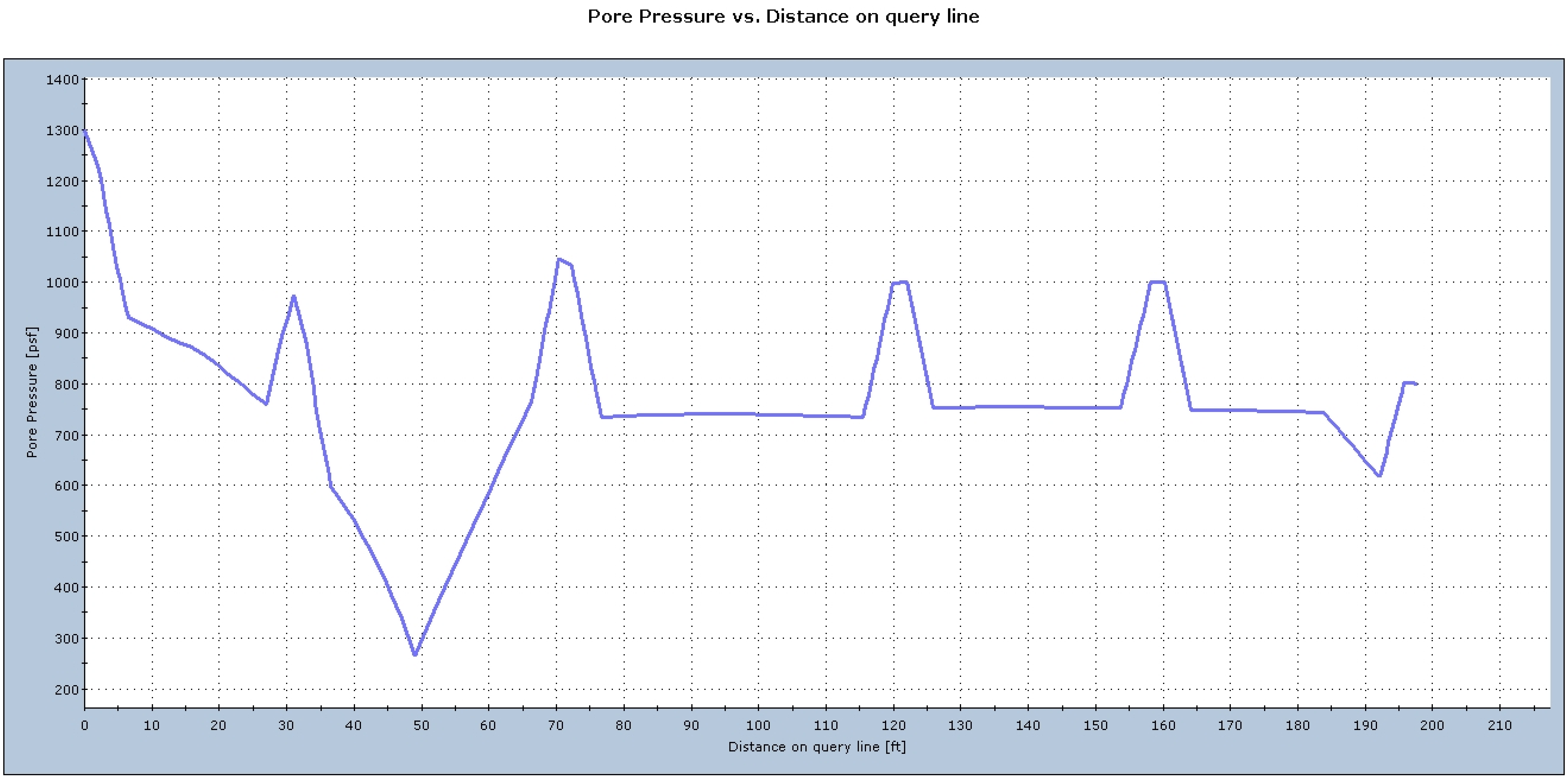
Structural



775.75'5.75'5.75'5.75'5.75'5.75'5.75'5.75'75.75'75.75'5.75'5.75'5.75'5.75'5.75'5.75'5.75.75
760
760
760
760760 760 760 760 760 760 760 760 760 760 760 760
820
800
780
760
740
720
700
680
660
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300



Pore Pressure vs. Distance on query line
Pore Pressure [psf]
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Distance on query line [ft]

Maximum Design Flood

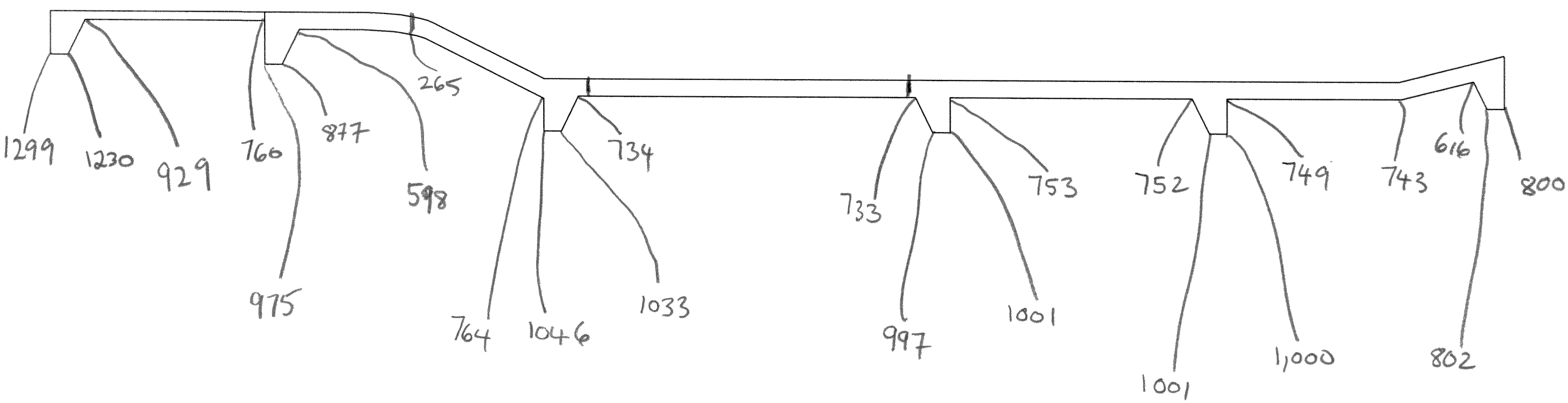
775'.75 Head

760' TAIL

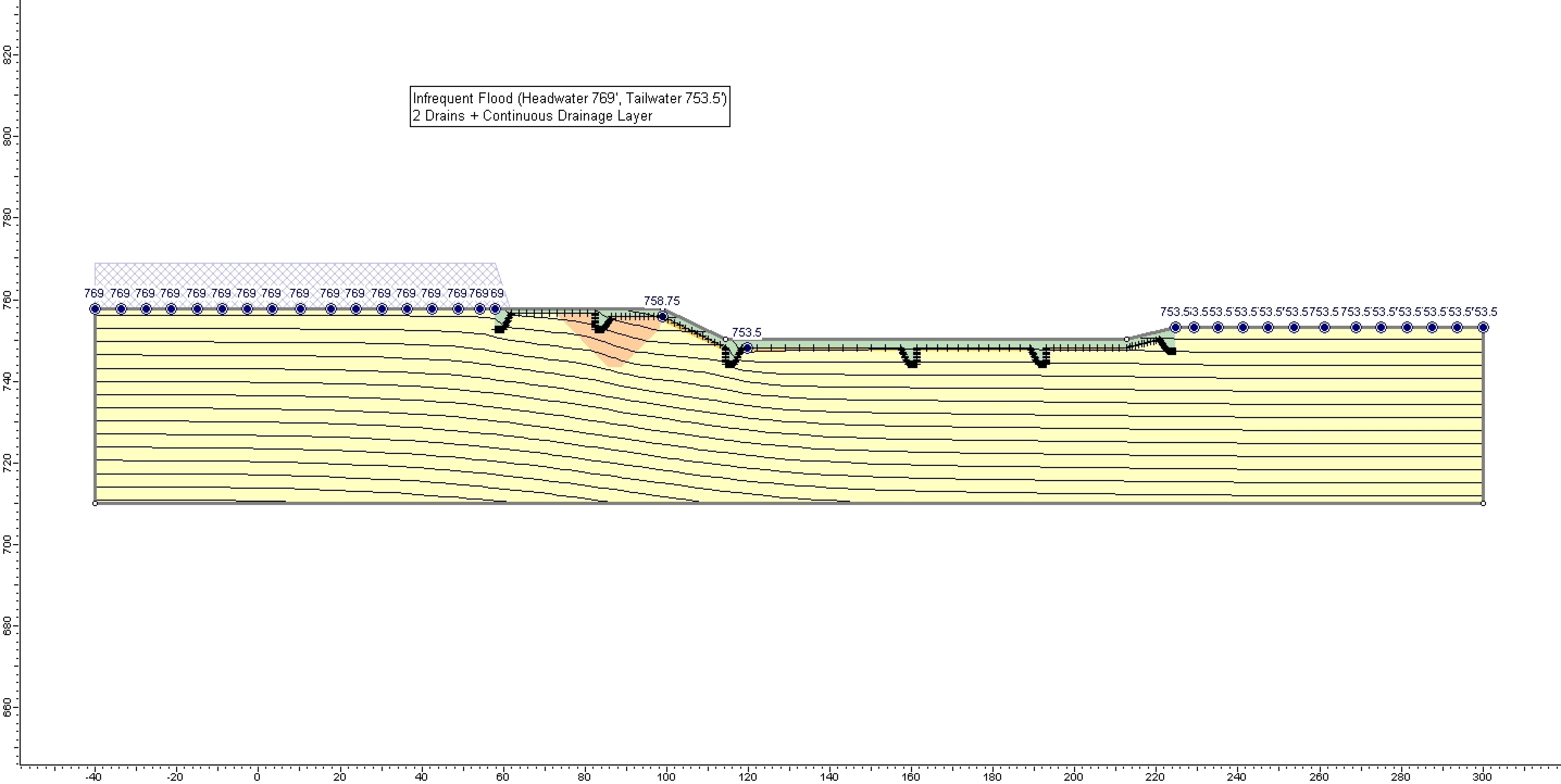
Water Pressure (psf)

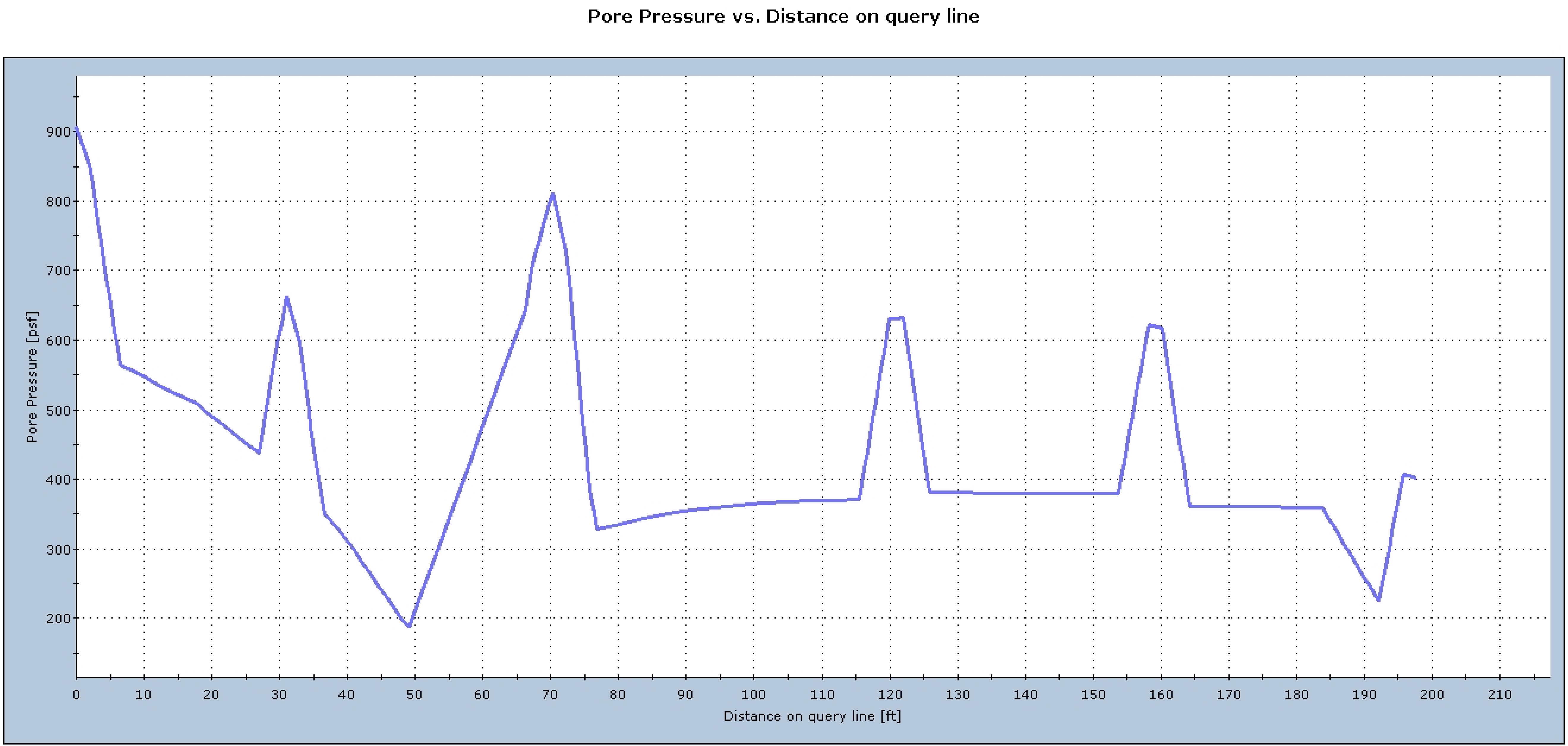
3 Drain outlet

Continuous Drainage Layer



1:5

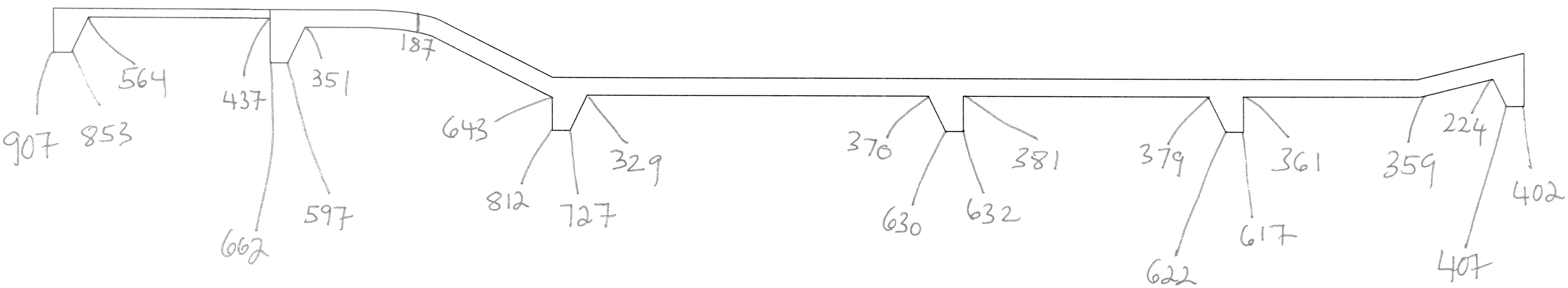

Infrequent Flood (Headwater 769', Tailwater 753.5')
2 Drains + Continuous Drainage Layer
769
758.75
753.5
820
800
780
760
740
720
700
680
660
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300


Pore Pressure vs. Distance on query line
Pore Pressure [psf]
900
800
700
600
500
400
300
200
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Distance on query line [ft]

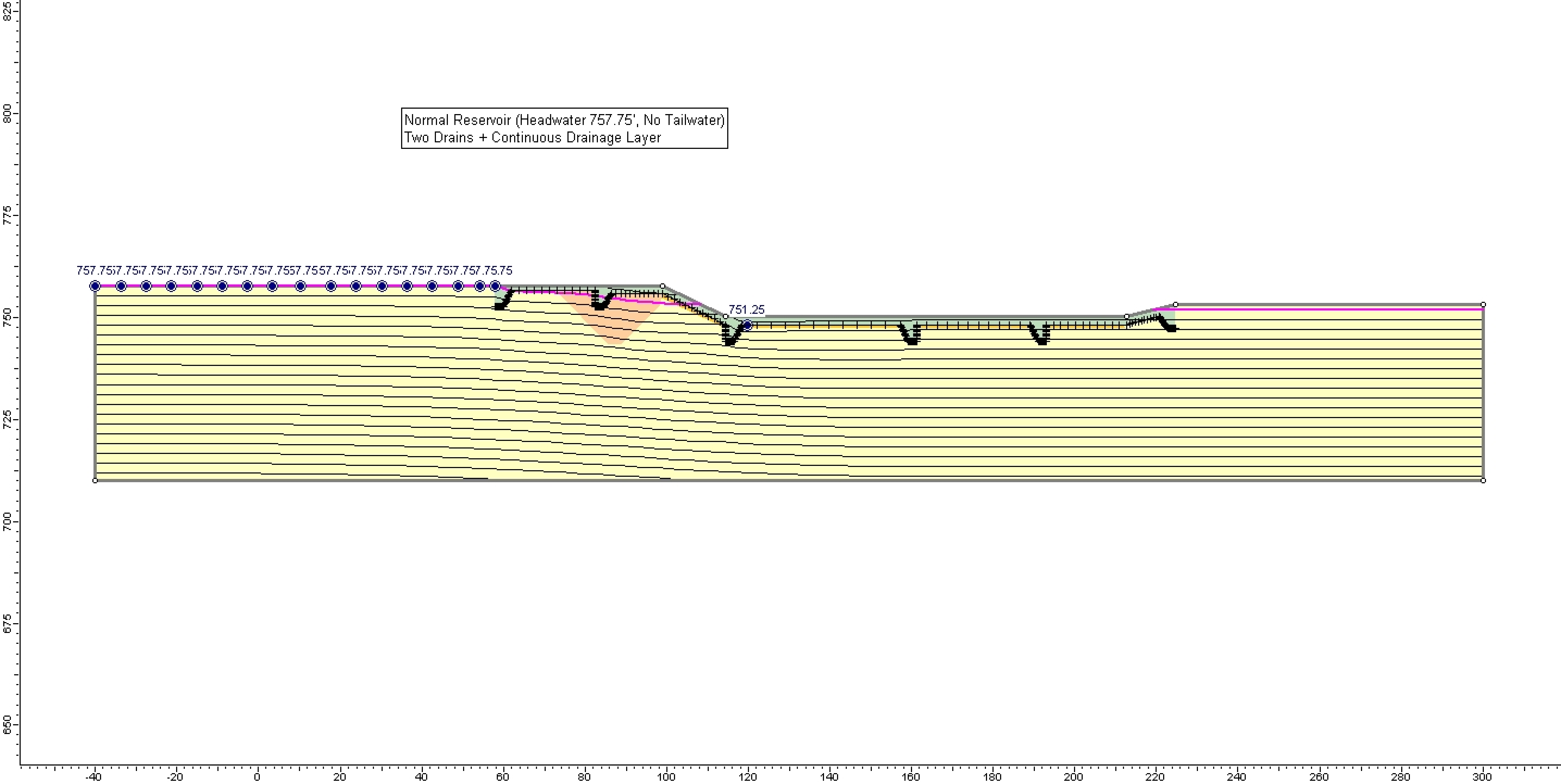
Infrequent Flood
Headwater 769' elev
Tailwater 753.5' elev

(uplift pressures in psf)

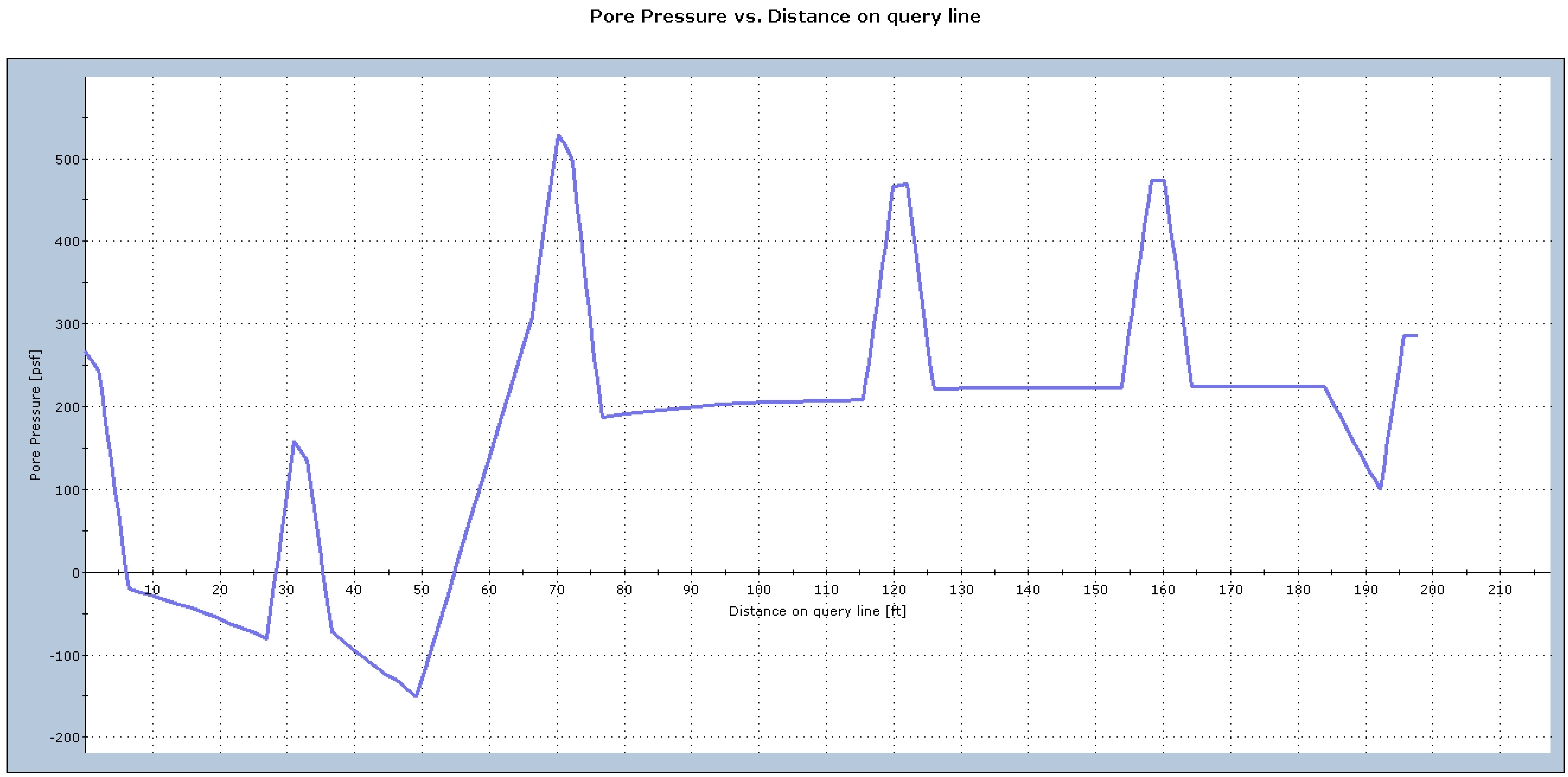
2 Drains + Drainage Layer.



1:5



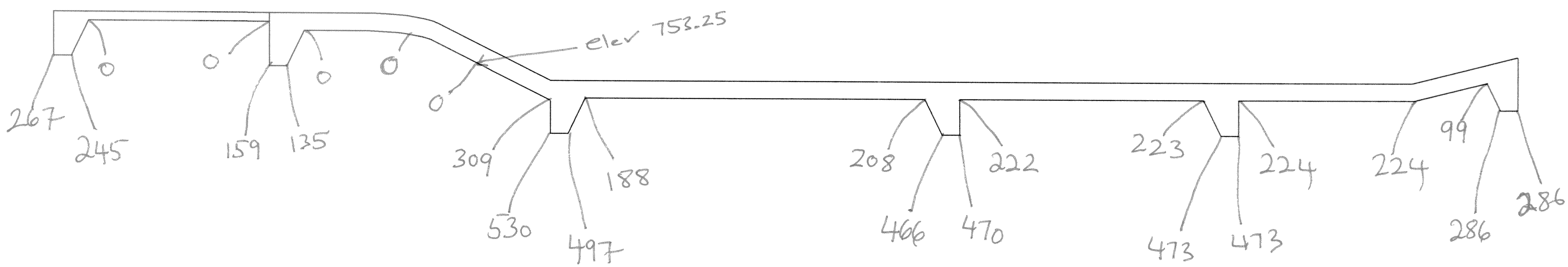
Normal Reservoir (Headwater 757.75', No Tailwater)
Two Drains + Continuous Drainage Layer
751.25
825
800
775
750
725
700
675
650
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300


Pore Pressure vs. Distance on query line
Pore Pressure [psf]
Distance on query line [ft]
500
400
300
200
100
0
-100
-200
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

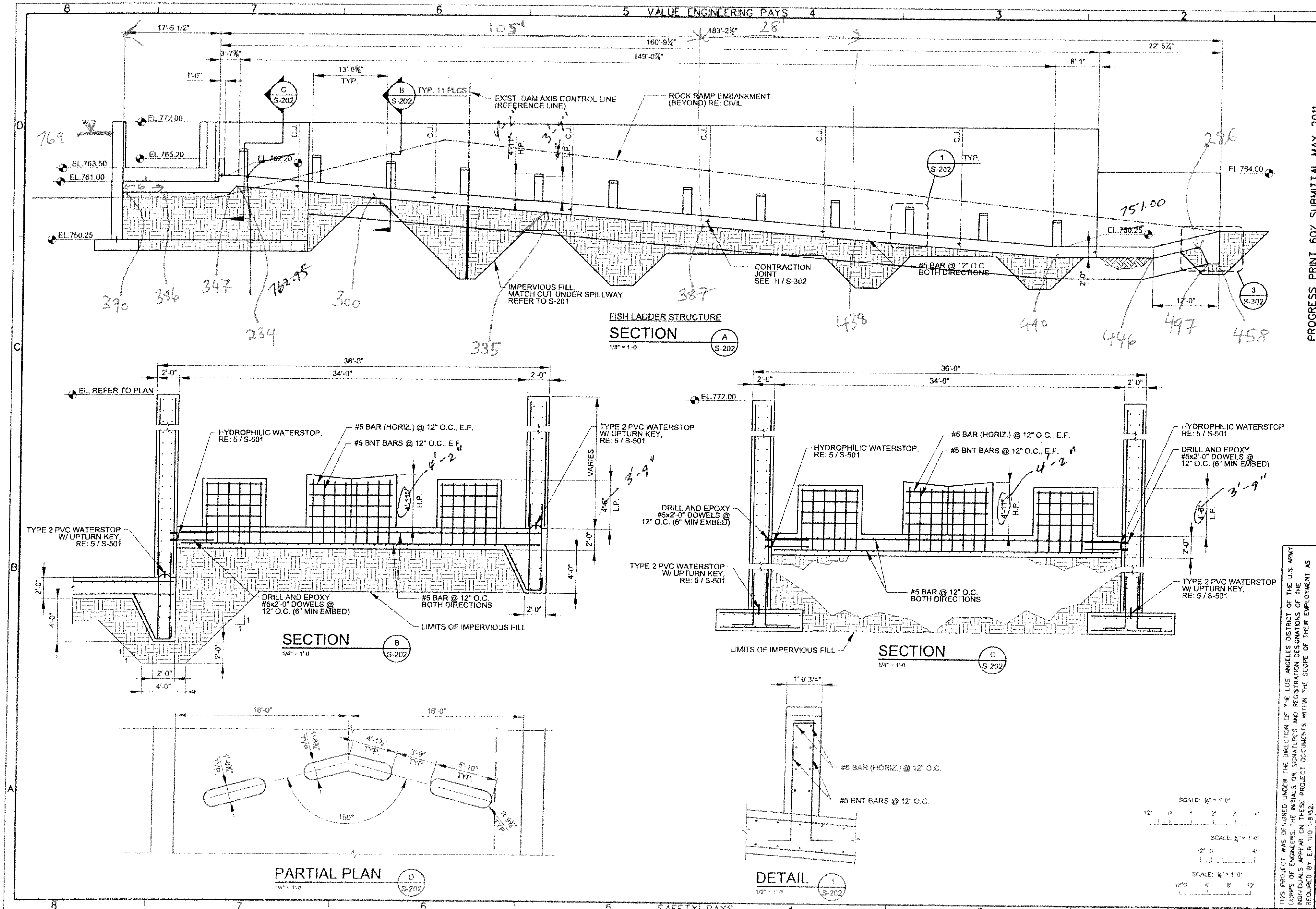
Normal Reservoir.
Headwater = 757.75' elev
No Tailwater.

(uplift pressures in psf)

2 Drains + Drainage Layer.



1:5



PROGRESS PRINT 60% SUBMITTAL MAY 2011

MATILIJA DAM ECOSYSTEM RESTORATION
VENTURA COUNTY, CALIFORNIA

ROBLES DIVERSION DAM MODIFICATION PROJECT
HFB STRUCTURAL CONCRETE OUTLINE ELEVATION & SECTIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: M.P.
DRAWN BY: B.F.
CHECKED BY: M.P.

SUBMITTED BY: | DATE: | APPROVED: | DATE:

CHIEF, DESIGN BRANCH | CHIEF, ENGINEERING DIVISION

SPEC. NO. | FILE NAME: S-201.DGN

PREPARED UNDER THE DIRECTION OF:
COL. THOMAS H. MAGNESS
DISTRICT ENGINEER
DISTRICT FILE NO. 214/

TETRA TECH

Scale: AS SHOWN
SHEET S-202

REVISIONS: SYMBOL | DESCRIPTIONS | DATE | APPROVAL

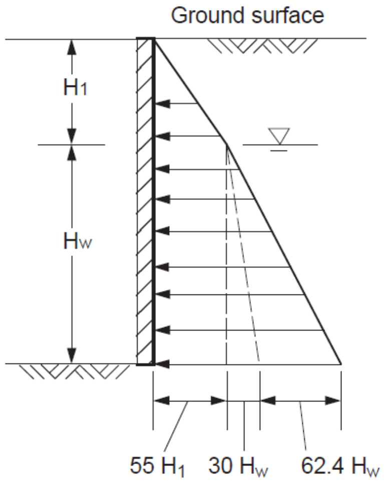
THIS PROJECT WAS DESIGNED UNDER THE DIRECTION OF THE LOS ANGELES DISTRICT OF THE U.S. ARMY CORPS OF ENGINEERS. THE INITIALS OR SIGNATURES AND REGISTRATION DESIGNATIONS OF THE INDIVIDUALS APPEAR ON THESE PROJECT DOCUMENTS WITHIN THE SCOPE OF THEIR EMPLOYMENT AS REQUIRED BY E.R. 1110-1-8152.

$h_w := 24ft$ $\quad \phi := 26.74$ $\quad k_o := 1 - \sin\left(\phi \cdot \frac{\pi}{180}\right) = 0.55$ $\quad ELP := k_o \cdot 100pcf = 55.006 \cdot pcf$ $\quad \gamma_m := 130pcf$

$PGA_{MDE} := 0.633$ $\quad k_h := \left(\frac{2}{3}\right) \cdot PGA_{MDE} = 0.422$

$F_{sr} := \gamma_m \cdot h_w \cdot k_h = 1.317 \times 10^3 \cdot psf$

From the AMEC getech report



Non-yielding (At Rest) Wall Pressure (psf)

a. Behavior of Backfills.

(1) Non-Yielding Backfills. For low intensity ground motions the backfill material may respond within the range of linear elastic deformations. Walls with non-yielding backfills can be expected to have dynamic soil pressures greater than those predicted by the Mononobe-Okabe method. The dynamic soil pressures and associated forces in the backfill may be analyzed as an elastic response using Wood's method as described in ITL 92-11 (Ebeling and Morrision, 1992). A reasonable estimate for determining the additional lateral seismic soil force against a soil retaining structure, for non-yielding backfill conditions, can be determined as

$$F_{sr} = \gamma\, h^2\, k_h$$

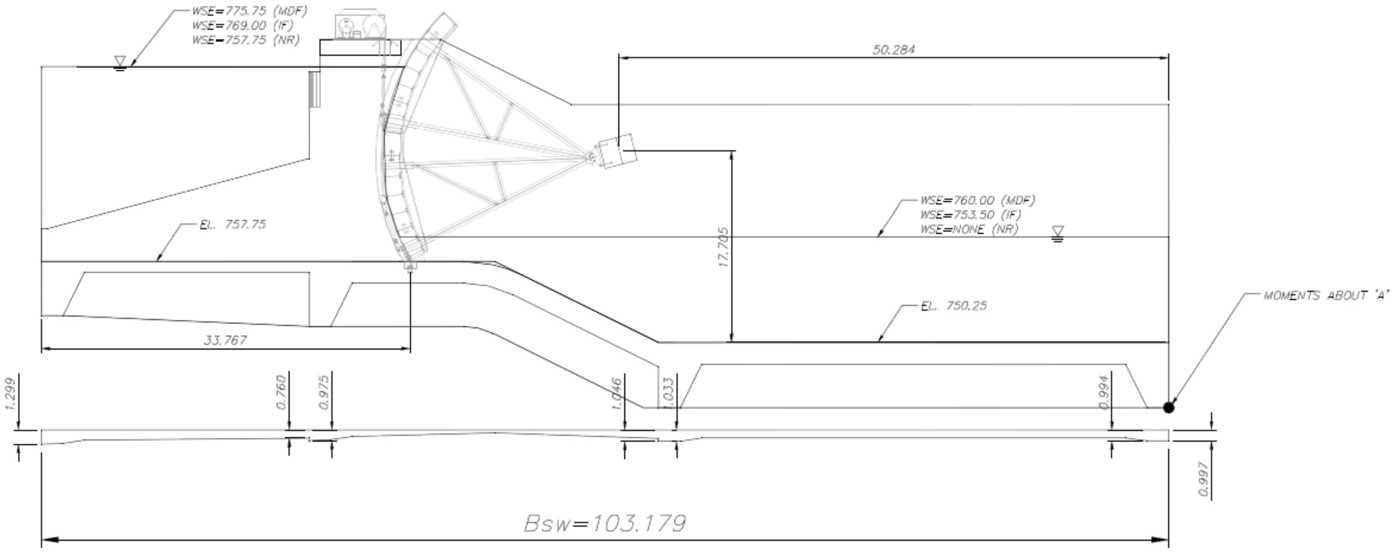
where: F_{sr} = Lateral seismic force representing dynamic soil pressure effects

γ = Unit weight of soil. Use moist or submerged unit weight when all soil is above or below the water table. For partially submerged soils the unit weight shall be proportioned by a weighted average.

h = Height of backfill

k_h = Effective peak ground acceleration, expressed as a decimal fraction of the acceleration of gravity

GEOMETRY OF HFB at SPILLWAY (SW)



CHECK FOR STABILITY FOR MAXIMUM DESIGN FLOOD (MDF)

Geometries (from AutoCAD Mass Properties)

$t_{wall} := 24in$ $A_{wall\_SW} := 2420.2695ft^2$ $A_{water\_SW} := 1141.6927ft^2$ $\gamma_c := 150pcf$

$L_{SW} := 30ft$ $A_{slab\_SW} := 232.9664ft^2$ $A_{up\_SW} := 74.7469klf$ $\gamma_w := 62.4pcf$

$B_{SW} := 103.18ft$ $A_{walk\_SW} := 11.25ft^2$ $Gate_{DL\_INCA} := 19kip$ $Gate_{mud\_INCA} := 3kip$

$A_{wall\_total} := 2420.2695ft^2$ $A_{water\_total} := 1742.9972ft^2$ $A_{slab\_total} := 382.8136ft^2$ $A_{up\_total} := 122.9672klf$

$A_{slab\_SB} := 149.8472ft^2$ $A_{water\_SB} := 601.1219ft^2$ $A_{up\_SB} := 47.9083klf$ $B_{SB} := 63.5ft$

$B_{total} := 166.6792ft$

$k_h := 0$

$EL_{lwr\_SB} := 750.25ft$ $EL_{upr\_SW} := 757.75ft$ $WSE_{hw} := 775.75ft$ $WSE_{tw} := 760.00ft$

$t_{apron} := 12in$ $t_{slab} := 24in$ $L_{SB} := 30ft$ $WSE_{tw\_FL} := 753.5ft$ $WSE_{hw\_FL} := 769.00ft$

$L_{SW\_SB} := 30ft$

Moment Arms (From AutoCAD Mass Properties)

$CG_{uplift\_SW} := 50.9460ft$ $CG_{walk\_SW} := 73.9500ft$ $CG_{slab\_SW} := 48.4651ft$ $CG_{gate\_trunion\_horz} := 50.284ft$

$CG_{wall\_SW} := 44.5923ft$ $CG_{gate\_trunion\_vert} := 17.7ft$ $CG_{water\_SW} := 58.6249ft$ $CG_{gate\_sill} := 33.676ft$

$CG_{uplift\_SB} := 32.0722ft$ $CG_{slab\_SB} := 33.8179ft$ $CG_{water\_SB} := 30.8559ft$

$CG_{wall\_total} := 108.0923ft$ $CG_{up\_total} := 83.1387ft$ $CG_{water\_total} := 91.2339ft$ $CG_{slab\_total} := 79.7565ft$

Notes: SW = Spillway portion of structure (upstream)
SB = Stilling Basin portion of structure (downstream)

Restoring Loads

$W_{wall\_SW} := t_{wall} \cdot A_{wall\_SW} \cdot \gamma_c = 726.081 \cdot kip$

$W_{water\_SW} := A_{water\_SW} \cdot \gamma_w \cdot L_{SW} = 2.137 \times 10^3 \cdot kip$

$W_{slab\_SW} := A_{slab\_SW} \cdot L_{SW} \cdot \gamma_c = 1.048 \times 10^3 \cdot kip$

$W_{walk\_SW} := A_{walk\_SW} \cdot L_{SW} \cdot \gamma_c = 50.625 \cdot kip$

$W_{slab\_SB} := A_{slab\_SB} \cdot L_{SB} \cdot \gamma_c = 674.312 \cdot kip$

$W_{water\_SB} := A_{water\_SB} \cdot \gamma_w \cdot L_{SB} = 1.125 \times 10^3 \cdot kip$

$W_{slab\_total} := A_{slab\_total} \cdot L_{SW} \cdot \gamma_c = 1.723 \times 10^3 \cdot kip$

$W_{wall\_total} := t_{wall} \cdot A_{wall\_total} \cdot \gamma_c = 726.081 \cdot kip$

$W_{gate} := \left(Gate_{DL\_INCA} + Gate_{mud\_INCA}\right) = 22 \cdot kip$

$W_{water\_total} := A_{water\_total} \cdot \gamma_w \cdot L_{SW} = 3.263 \times 10^3 \cdot kip$

$W_{total\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} + W_{walk\_SW} + W_{gate} = 3.984 \times 10^3 \cdot kip$

$W_{total\_SB} := W_{slab\_SB} + W_{water\_SB} = 1.8 \times 10^3 \cdot kip$

$W_{total} := W_{total\_SW} + W_{total\_SB} = 5.784 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{walk\_SW} + W_{gate} = 1.847 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SB} := W_{slab\_SB} = 674.312 \cdot kip$

$W_{Gate} := Gate_{DL\_INCA} + Gate_{mud\_INCA} = 22 \cdot kip$

$W_{EQ\_mass} := W_{EQ\_mass\_SW} + W_{EQ\_mass\_SB} = 2.521 \times 10^3 \cdot kip$

Driving Loads

$$H_{hydrostatic} := \frac{\gamma_w \cdot \left(WSE_{hw} - WSE_{tw}\right)^2 \cdot L_{SW}}{2} = 232.186 \cdot kip$$

Hydrodynamic loads are from trunion reactions

Uplift

$U_{SW} := A_{up\_SW} \cdot L_{SW} = 2.242 \times 10^3 \cdot kip$

STABILITY ANALYSIS OF HSB TAINTER GATE @ SPILLWAY (SW)

Overturning

$$M_{OT\_SW} := U_{SW} \cdot CG_{uplift\_SW} + \left[H_{hydrostatic} \cdot \frac{(WSE_{hw} - WSE_{tw})}{3} \right] = 1.155 \times 10^{5} \cdot kip \cdot ft$$

$$M_{R\_SW} := W_{wall\_SW} \cdot CG_{wall\_SW} + W_{slab\_SW} \cdot CG_{slab\_SW} + W_{walk\_SW} \cdot CG_{walk\_SW} + W_{water\_SW} \cdot CG_{water\_SW} + CG_{gate\_sill} \cdot W_{Gate}$$

$$M_{R\_SW} = 2.13 \times 10^{5} \cdot kip \cdot ft$$

$$SF_{OT\_SW} := \frac{M_{R\_SW}}{M_{OT\_SW}} = 1.844$$

Uplift Resistance

$$DL_{SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} = 3.912 \times 10^{3} \cdot kip$$

$$SF_{up\_SW} := \frac{DL_{SW}}{U_{SW}} = 1.744$$

Table 3-4 Required Factors of Safety for Flotation – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	1.3	1.2	1.1

$$e'\_SW := \frac{(M_{R\_SW} - M_{OT\_SW})}{DL_{SW}} = 24.927 \cdot ft$$

$$e_{SW} := \frac{B_{SW}}{2} - e'\_SW = 26.663 \cdot ft \qquad OT_{SW} := \frac{3 \cdot e'\_SW}{B_{SW}} = 72.476 \cdot \%$$

Table 3-5 Requirements for Location of the Resultant – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	100% of Base in Compression	75% of Base in Compression	Resultant Within Base

$$CHECK_{Uplift} := \begin{cases} \text{"SF > 1.2 for Usual LC; OK"} & \text{if } SF_{up\_SW} \geq 1.2 \\ \text{"SF < 1.2 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

$$CHECK_{OT} := \begin{cases} \text{"<75\% Base in Compression; OK"} & \text{if } OT_{SW} \geq 75\% \\ \text{">75\% Base in Compression; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT SPILLWAY ONLY:

$CHECK_{OT}$ = ">75% Base in Compression; NG"

$CHECK_{Uplift}$ = "SF > 1.2 for Usual LC; OK"

Base compression is slightly less then 75%; analysis does not consider wall friction to resist overturning, OK by inspection

SLIDING RESISTANCE ON TOTAL STRUCTURE

$\mu_{car} := .55$ $\mu_{cif} := .45$ $ht_{key} := 4ft$ $N_{key} := 6$ $c_{ohesion} := 0psf$ $L_{tot} := B_{total} \cdot L_{SW\_SB}$

$q1\_2_{water} := (WSE_{hw} - EL_{upr\_SW}) \cdot \gamma_w = 1.123 \times 10^3 \cdot psf$ $q3\_6_{water} := (WSE_{tw} - EL_{lwr\_SB}) \cdot \gamma_w = 608.4 \cdot psf$

$q1\_2_{B.O.key} := (t_{apron} + ht_{key}) \cdot \gamma_c = 750 \cdot psf$ $q3\_6_{B.O.key} := (t_{slab} + ht_{key}) \cdot \gamma_c = 900 \cdot psf$

$q1\_2_{T.O.key} := (t_{apron}) \cdot \gamma_c = 150 \cdot psf$ $q3\_6_{T.O.key} := (t_{slab}) \cdot \gamma_c = 300 \cdot psf$

Passive Pressure of Keys

$$pw1\_2_{B.O.key} := \frac{\left[267psf + 245psf + 159psf + 135psf + 4\gamma_w \cdot (ht_{key} - 4ft)\right]}{4} = 201.5 \cdot psf$$

$$pw1\_2_{T.O.key} := \frac{(0psf + 0psf + 0psf + 0psf)}{4} = 0 \cdot psf$$

$$pw3\_5_{B.O.key} := \frac{\left[530psf + 497psf + 466psf + 470psf + 473psf + 473psf + 6\gamma_w \cdot (ht_{key} - 4ft)\right]}{6} = 484.833 \cdot psf$$

$$pw3\_5_{T.O.key} := \frac{(309psf + 188psf + 208psf + 222psf + 223psf + 224psf)}{6} = 229 \cdot psf$$

$$pw6_{B.O.key} := \frac{\left[286psf + 286psf + 2\gamma_w \cdot (ht_{key} - 4ft)\right]}{2} = 286 \cdot psf$$

$$pw6_{T.O.key} := \frac{(94psf + 94psf)}{2} = 94 \cdot psf$$

$$p1\_2 := \frac{\left[(q1\_2_{water} + q1\_2_{B.O.key} - pw1\_2_{B.O.key}) + (q1\_2_{water} + q1\_2_{T.O.key} - pw1\_2_{T.O.key})\right]}{2} = 1.472 \times 10^3 \cdot psf$$

$$p3\_5 := \frac{\left[(q3\_6_{water} + q3\_6_{B.O.key} - pw3\_5_{B.O.key}) + (q3\_6_{water} + q3\_6_{T.O.key} - pw3\_5_{T.O.key})\right]}{2} = 851.483 \cdot psf$$

$$p6 := \frac{\left[\left(\frac{q3\_6_{water}}{2} + q3\_6_{B.O.key} - pw6_{B.O.key}\right) + \left(\frac{q3\_6_{water}}{2} + q3\_6_{T.O.key} - pw6_{T.O.key}\right)\right]}{2} = 714.2 \cdot psf$$

$$p_{avg} := \frac{2p1\_2 + 3p3\_5 + p6}{6} = 1.036 \times 10^3 \cdot psf$$

$$P_{keys} := (N_{key} \cdot p_{avg} \cdot ht_{key} \cdot L_{SW\_SB}) = 745.626 \cdot kip$$

At Rest Pressure of Keys for Sidewall Friction

$p_{p\_slide\_\gamma sub} := 30pcf$ $\quad L_{slide\mu} := B_{SB} + B_{SW} = 166.68 \cdot ft$ $\quad n_{\mu\_key\_slide\_face} := 2$ $\quad n_{\mu\_wall\_slide\_face} := 2$

$p_{p\_slide\_\gamma moist} := 55pcf$ $\quad ht_{wall\_slide\_face} := 10ft$

$$P_{\mu\_slide\_wall} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma moist} \cdot ht_{wall\_slide\_face} + p_{p\_slide\_\gamma sub} \cdot (ht_{key} + t_{slab}) \right] \cdot (ht_{wall\_slide\_face} + ht_{key} + t_{slab})}{2} \cdot n_{\mu\_wall\_slid}\right.$$

$$P_{\mu\_slide\_key} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma sub} \cdot (ht_{key} + t_{slab})^2 \right]}{2} \cdot n_{\mu\_key\_slide\_face} \cdot L_{slide\mu} \right] = 81.006 \cdot kip$$

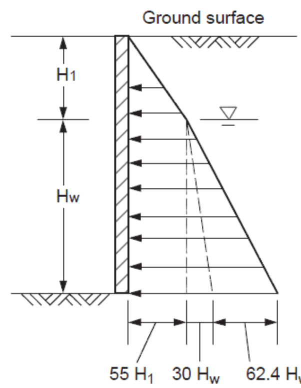
$$P_{\mu DL} := \mu_{car} \cdot (W_{total} - U_{total}) = 1.152 \times 10^6 \, lbf$$

$$P_R := P_{\mu DL} + P_{keys} + P_{\mu\_slide\_key} + P_{\mu\_slide\_wall} = 2.855 \times 10^3 \cdot kip$$

$$H_D := k_h \cdot W_{EQ\_mass} + H_{hydrostatic} = 232.186 \cdot kip$$

$$FS_{sliding} := \frac{P_R + c_{ohesion} \cdot L_{tot}}{H_D} = 12.296$$

$$CHECK_{sliding} := \begin{cases} \text{"SF > 1.2 for Unusual LC; OK"} & \text{if } FS_{sliding} \ge 1.2 \\ \text{"SF < 1.2 for Unusual LC; NG"} & \text{otherwise} \end{cases}$$

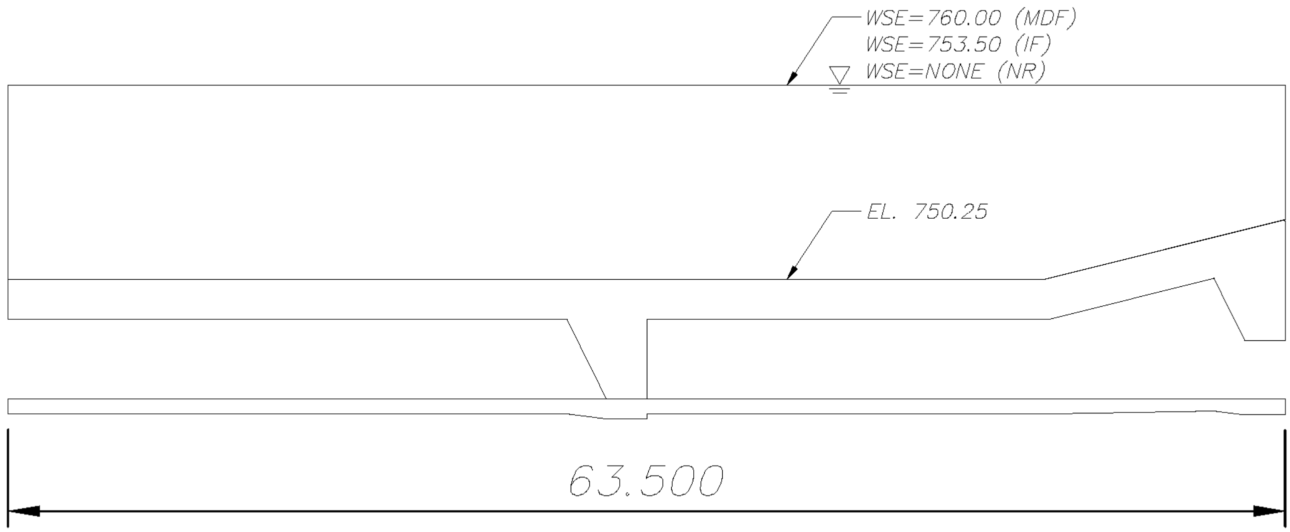


Non-yielding (At Rest) Wall Pressure (psf)

$CHECK_{sliding}$ = "SF > 1.2 for Unusual LC; OK"

Table 3-3 Required Factors of Safety for Sliding - Normal Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
Well Defined	1.4	1.2	1.1
Ordinary	1.5	1.3	1.1
Limited	3.0	2.6	2.2



STABILITY ANALYSIS OF STILLING BASIN (SB)

$U_{SB} := A_{up\_SB} \cdot L_{SW} = 1.437 \times 10^{3} \cdot kip$

$DL_{SB} := W_{slab\_SB} + W_{water\_SB} = 1.8 \times 10^{3} \cdot kip$

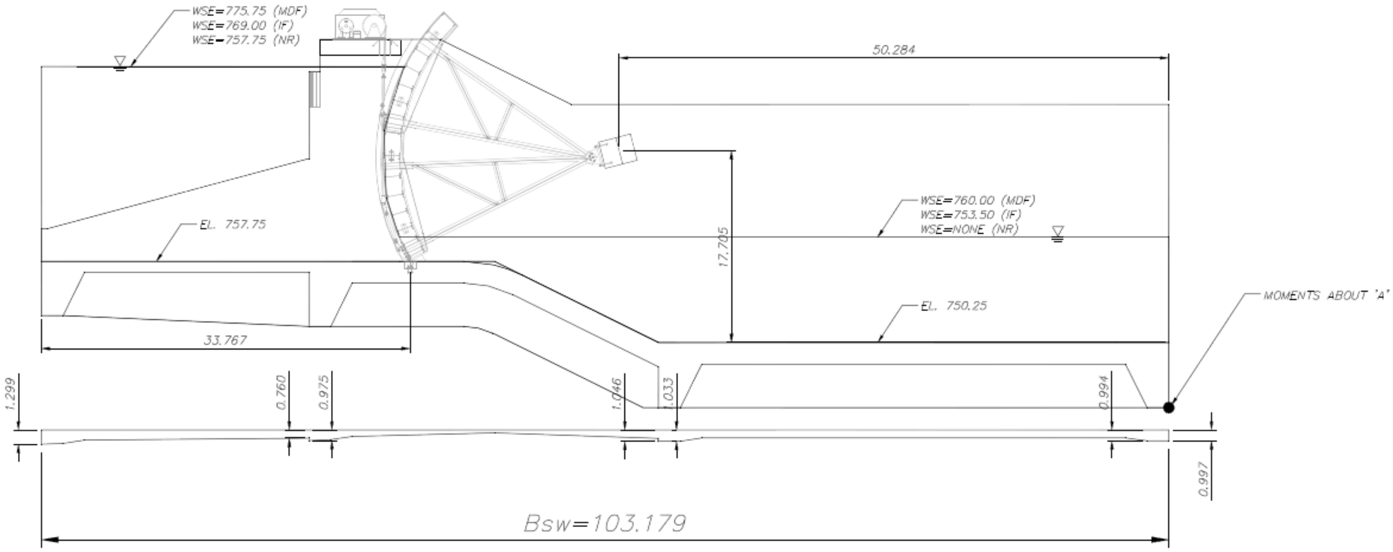
$$SF_{up\_SB} := \frac{DL_{SB}}{U_{SB}} = 1.252$$

$$CHECK_{Uplift\_SB} := \begin{cases} \text{"SF > 1.2 for Usual LC; OK"} & \text{if } SF_{up\_SB} \geq 1.2 \\ \text{"SF < 1.2 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT STILLING BASIN

$CHECK_{Uplift\_SB}$ = "SF > 1.2 for Usual LC; OK"

GEOMETRY OF HFB at SPILLWAY (SW)



CHECK FOR STABILITY FOR INFREQUENT DESIGN FLOOD (IF)

Geometries (from AutoCAD Mass Properties)

$t_{wall} := 24in$ | $A_{wall\_SW} := 2420.2695ft^2$ | $A_{water\_SW} := 524.9954ft^2$ | $\gamma_c := 150pcf$

$L_{SW} := 30ft$ | $A_{slab\_SW} := 232.9664ft^2$ | $A_{up\_SW} := 43.7167klf$ | $\gamma_w := 62.4pcf$

$B_{SW} := 103.18ft$ | $A_{walk\_SW} := 11.25ft^2$ | $Gate_{DL\_INCA} := 19kip$ | $Gate_{mud\_INCA} := 3kip$

$A_{wall\_total} := 2420.2695ft^2$ | $A_{water\_total} := 713.3164ft^2$ | $A_{slab\_total} := 382.8136ft^2$ | $A_{up\_total} := 67.3852klf$

$A_{slab\_SB} := 149.8472ft^2$ | $A_{water\_SB} := 188.3081ft^2$ | $A_{up\_SB} := 23.6685klf$ | $B_{SB} := 63.5ft$

$B_{total} := 166.6792ft$ | $t_{wall\_FL} := 24in$ | $L_{FL} := 16ft$ | $A_{up\_FL} := 76.9295klf$

$B_{FL} := 202.6134ft$ | $A_{wall\_FL} := 3934.7354ft^2$ | $A_{water\_FL} := 1388.7740ft^2$ | $A_{slab\_FL} := 436.3768ft^2$

$k_h := 0$ | $A_{gate\_wall\_FL} := 420ft^2$ | $t_{ftg\_FL} := 24in$ | $A_{ftg\_plan\_FL} := 758.2628ft^2$

$EL_{lwr\_SB} := 750.25ft$ | $EL_{upr\_SW} := 757.75ft$ | $WSE_{hw} := 769.00ft$ | $WSE_{tw} := 753.50ft$

$t_{apron} := 12in$ | $t_{slab} := 24in$ | $L_{SB} := 30ft$ | $WSE_{tw\_FL} := 753.5ft$ | $WSE_{hw\_FL} := 769.00ft$

$L_{SW\_SB} := 30ft$

Moment Arms (From AutoCAD Mass Properties)

$CG_{uplift\_SW} := 55.0720ft$ | $CG_{walk\_SW} := 73.9500ft$ | $CG_{slab\_SW} := 48.4651ft$ | $CG_{gate\_trunion\_horz} := 50.284ft$

$CG_{wall\_SW} := 44.5923ft$ | $CG_{gate\_trunion\_vert} := 17.7ft$ | $CG_{water\_SW} := 67.8334ft$ | $CG_{gate\_sill} := 33.676ft$

$CG_{uplift\_SB} := 32.0722ft$ | $CG_{slab\_SB} := 33.8179ft$ | $CG_{water\_SB} := 30.8559ft$

$CG_{wall\_total} := 108.0923ft$ | $CG_{up\_total} := 88.4464ft$ | $CG_{water\_total} := 105.7450ft$ | $CG_{slab\_total} := 79.7565ft$

$CG_{wall\_FL} := 103.3428ft$ | $CG_{uplift\_FL} := 89.8235ft$ | $CG_{water\_FL} := 106.3740ft$ | $CG_{slab\_FL} := 95.9967ft$

$CG_{ftg\_FL} := 188.4996ft$ | $CG_{gate\_wall\_FL} := 150ft$

Notes: FL = Fish Ladder structure
SW = Spillway portion of structure (upstream)
SB = Stilling Basin portion of structure (downstream)

Restoring Loads

$W_{wall\_SW} := t_{wall} \cdot A_{wall\_SW} \cdot \gamma_c = 726.081 \cdot kip$

$W_{water\_SW} := A_{water\_SW} \cdot \gamma_w \cdot L_{SW} = 982.791 \cdot kip$

$W_{slab\_SW} := A_{slab\_SW} \cdot L_{SW} \cdot \gamma_c = 1.048 \times 10^3 \cdot kip$

$W_{walk\_SW} := A_{walk\_SW} \cdot L_{SW} \cdot \gamma_c = 50.625 \cdot kip$

$W_{slab\_SB} := A_{slab\_SB} \cdot L_{SB} \cdot \gamma_c = 674.312 \cdot kip$

$W_{water\_SB} := A_{water\_SB} \cdot \gamma_w \cdot L_{SB} = 352.513 \cdot kip$

$W_{slab\_total} := A_{slab\_total} \cdot L_{SW} \cdot \gamma_c = 1.723 \times 10^3 \cdot kip$

$W_{wall\_total} := t_{wall} \cdot A_{wall\_total} \cdot \gamma_c = 726.081 \cdot kip$

$W_{gate} := \left(Gate_{DL\_INCA} + Gate_{mud\_INCA}\right) = 22 \cdot kip$

$W_{water\_total} := A_{water\_total} \cdot \gamma_w \cdot L_{SW} = 1.335 \times 10^3 \cdot kip$

$W_{wall\_FL} := t_{wall\_FL} \cdot A_{wall\_FL} \cdot \gamma_c = 1.18 \times 10^3 \cdot kip$

$W_{water\_FL} := A_{water\_FL} \cdot \gamma_w \cdot L_{FL} = 1.387 \times 10^3 \cdot kip$

$W_{slab\_FL} := A_{slab\_FL} \cdot L_{FL} \cdot \gamma_c = 1.047 \times 10^3 \cdot kip$

$W_{ftg\_FL} := A_{ftg\_plan\_FL} \cdot t_{ftg\_FL} \cdot \gamma_c = 227.479 \cdot kip$

$W_{gate\_wall\_FL} := A_{gate\_wall\_FL} \cdot t_{wall\_FL} \cdot \gamma_c = 126 \cdot kip$

$W_{total\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} + W_{walk\_SW} + W_{gate} = 2.83 \times 10^3 \cdot kip$

$W_{total\_SB} := W_{slab\_SB} + W_{water\_SB} = 1.027 \times 10^3 \cdot kip$

$W_{total} := W_{total\_SW} + W_{total\_SB} = 3.857 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{walk\_SW} + W_{gate} = 1.847 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SB} := W_{slab\_SB} = 674.312 \cdot kip$

$W_{Gate} := Gate_{DL\_INCA} + Gate_{mud\_INCA} = 22 \cdot kip$

$W_{EQ\_mass} := W_{EQ\_mass\_SW} + W_{EQ\_mass\_SB} = 2.521 \times 10^3 \cdot kip$

Driving Loads

$$H_{hydrostatic} := \frac{\gamma_w \cdot \left(WSE_{hw} - WSE_{tw}\right)^2 \cdot L_{SW}}{2} = 224.874 \cdot kip$$

$$H_{hydrostatic\_FL} := \frac{\gamma_w \cdot \left(WSE_{hw} - WSE_{tw\_FL}\right)^2 \cdot L_{FL}}{2} = 119.933 \cdot kip$$

Hydrodynamic loads are from trunion reactions

Uplift

$U_{SW} := A_{up\_SW} \cdot L_{SW} = 1.312 \times 10^3 \cdot kip$

$U_{FL} := A_{up\_FL} \cdot L_{FL} = 1.231 \times 10^3 \cdot kip$

STABILITY ANALYSIS OF HSB TAINTER GATE @ SPILLWAY (SW)

Overturning

$$M_{OT\_SW} := U_{SW} \cdot CG_{uplift\_SW} + \left[H_{hydrostatic} \cdot \frac{(WSE_{hw} - WSE_{tw})}{3} \right] = 7.339 \times 10^4 \cdot kip \cdot ft$$

$$M_{R\_SW} := W_{wall\_SW} \cdot CG_{wall\_SW} + W_{slab\_SW} \cdot CG_{slab\_SW} + W_{walk\_SW} \cdot CG_{walk\_SW} + W_{water\_SW} \cdot CG_{water\_SW} + CG_{gate\_sill} \cdot W_{Gate}$$

$$M_{R\_SW} = 1.543 \times 10^5 \cdot kip \cdot ft$$

$$SF_{OT\_SW} := \frac{M_{R\_SW}}{M_{OT\_SW}} = 2.103$$

Uplift Resistance

$$DL_{SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} = 2.757 \times 10^3 \cdot kip$$

$$SF_{up\_SW} := \frac{DL_{SW}}{U_{SW}} = 2.102$$

Table 3-4 Required Factors of Safety for Flotation – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	1.3	1.2	1.1

$$e'\_SW := \frac{(M_{R\_SW} - M_{OT\_SW})}{DL_{SW}} = 29.358 \cdot ft$$

$$e_{SW} := \frac{B_{SW}}{2} - e'\_SW = 22.232 \cdot ft \qquad OT_{SW} := \frac{3 \cdot e'\_SW}{B_{SW}} = 85.361 \cdot \%$$

Table 3-5 Requirements for Location of the Resultant – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	100% of Base in Compression	75% of Base in Compression	Resultant Within Base

$$CHECK_{Uplift} := \begin{cases} \text{"SF > 1.2 for Usual LC; OK"} & \text{if } SF_{up\_SW} \geq 1.2 \\ \text{"SF < 1.2 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

$$CHECK_{OT} := \begin{cases} \text{"<75\% Base in Compression; OK"} & \text{if } OT_{SW} \geq 75\% \\ \text{">75\% Base in Compression; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT SPILLWAY ONLY:

$CHECK_{OT}$ = "<75% Base in Compression; OK"

$CHECK_{Uplift}$ = "SF > 1.2 for Usual LC; OK"

SLIDING RESISTANCE ON TOTAL STRUCTURE

$\mu_{car} := .55$ $\quad \mu_{cif} := .45$ $\quad ht_{key} := 4ft$ $\quad N_{key} := 6$ $\quad c_{ohesion} := 0psf$ $\quad L_{tot} := B_{total} \cdot L_{SW\_SB}$

$q1\_2_{water} := \left(WSE_{hw} - EL_{upr\_SW}\right) \cdot \gamma_w = 702 \cdot psf$ $\quad q3\_6_{water} := \left(WSE_{tw} - EL_{lwr\_SB}\right) \cdot \gamma_w = 202.8 \cdot psf$

$q1\_2_{B.O.key} := \left(t_{apron} + ht_{key}\right) \cdot \gamma_c = 750 \cdot psf$ $\quad q3\_6_{B.O.key} := \left(t_{slab} + ht_{key}\right) \cdot \gamma_c = 900 \cdot psf$

$q1\_2_{T.O.key} := \left(t_{apron}\right) \cdot \gamma_c = 150 \cdot psf$ $\quad q3\_6_{T.O.key} := \left(t_{slab}\right) \cdot \gamma_c = 300 \cdot psf$

Passive Pressure of Keys

$$pw1\_2_{B.O.key} := \frac{\left[267psf + 245psf + 159psf + 135psf + 4\gamma_w \cdot \left(ht_{key} - 4ft\right)\right]}{4} = 201.5 \cdot psf$$

$$pw1\_2_{T.O.key} := \frac{(0psf + 0psf + 0psf + 0psf)}{4} = 0 \cdot psf$$

$$pw3\_5_{B.O.key} := \frac{\left[530psf + 497psf + 466psf + 470psf + 473psf + 473psf + 6\gamma_w \cdot \left(ht_{key} - 4ft\right)\right]}{6} = 484.833 \cdot psf$$

$$pw3\_5_{T.O.key} := \frac{(309psf + 188psf + 208psf + 222psf + 223psf + 224psf)}{6} = 229 \cdot psf$$

$$pw6_{B.O.key} := \frac{\left[286psf + 286psf + 2\gamma_w \cdot \left(ht_{key} - 4ft\right)\right]}{2} = 286 \cdot psf$$

$$pw6_{T.O.key} := \frac{(94psf + 94psf)}{2} = 94 \cdot psf$$

$$p1\_2 := \frac{\left[\left(q1\_2_{water} + q1\_2_{B.O.key} - pw1\_2_{B.O.key}\right) + \left(q1\_2_{water} + q1\_2_{T.O.key} - pw1\_2_{T.O.key}\right)\right]}{2} = 1.051 \times 10^3 \cdot psf$$

$$p3\_5 := \frac{\left[\left(q3\_6_{water} + q3\_6_{B.O.key} - pw3\_5_{B.O.key}\right) + \left(q3\_6_{water} + q3\_6_{T.O.key} - pw3\_5_{T.O.key}\right)\right]}{2} = 445.883 \cdot psf$$

$$p6 := \frac{\left[\left(\frac{q3\_6_{water}}{2} + q3\_6_{B.O.key} - pw6_{B.O.key}\right) + \left(\frac{q3\_6_{water}}{2} + q3\_6_{T.O.key} - pw6_{T.O.key}\right)\right]}{2} = 511.4 \cdot psf$$

$$p_{avg} := \frac{2p1\_2 + 3p3\_5 + p6}{6} = 658.592 \cdot psf$$

$$P_{keys} := \left(N_{key} \cdot p_{avg} \cdot ht_{key} \cdot L_{SW\_SB}\right) = 474.186 \cdot kip$$

At Rest Pressure of Keys for Sidewall Friction

$p_{p\_slide\_\gamma sub} := 30pcf$ $\quad L_{slide\mu} := B_{SB} + B_{SW} = 166.68 \cdot ft$ $\quad n_{\mu\_key\_slide\_face} := 2$ $\quad n_{\mu\_wall\_slide\_face} := 2$

$p_{p\_slide\_\gamma moist} := 55pcf$ $\quad ht_{wall\_slide\_face} := 10ft$

$$P_{\mu\_slide\_wall} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma moist} \cdot ht_{wall\_slide\_face} + p_{p\_slide\_\gamma sub} \cdot (ht_{key} + t_{slab}) \right] \cdot (ht_{wall\_slide\_face} + ht_{key} + t_{slab})}{2} \cdot n_{\mu\_wall\_slid}\right.$$

$$P_{\mu\_slide\_key} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma sub} \cdot (ht_{key} + t_{slab})^2 \right]}{2} \cdot n_{\mu\_key\_slide\_face} \cdot L_{slide\mu} \right] = 81.006 \cdot kip$$

$$P_{\mu DL} := \mu_{car} \cdot (W_{total} - U_{total}) = 1.009 \times 10^6 \, lbf$$

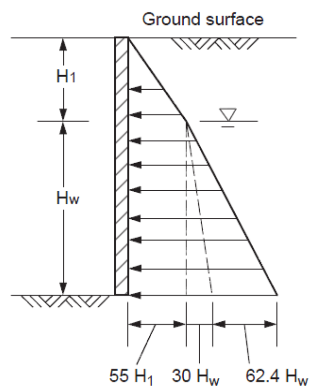
$$P_R := P_{\mu DL} + P_{keys} + P_{\mu\_slide\_key} + P_{\mu\_slide\_wall} = 2.441 \times 10^3 \cdot kip$$

$$H_D := k_h \cdot W_{EQ\_mass} + H_{hydrostatic} = 224.874 \cdot kip$$

$$FS_{sliding} := \frac{P_R + c_{ohesion} \cdot L_{tot}}{H_D} = 10.853$$

$CHECK_{sliding} :=$ | "SF > 1.2 for Unusual LC; OK" if $FS_{sliding} \ge 1.2$
| "SF < 1.2 for Unusual LC; NG" otherwise

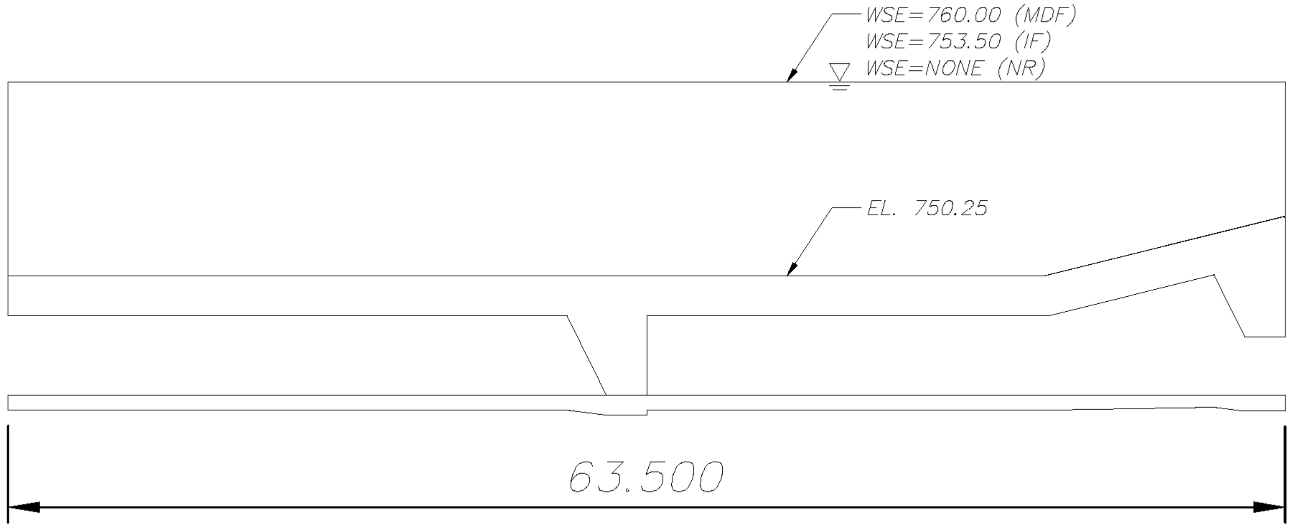
$CHECK_{sliding}$ = "SF > 1.2 for Unusual LC; OK"



Non-yielding (At Rest) Wall Pressure (psf)

Table 3-3 Required Factors of Safety for Sliding - Normal Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
Well Defined	1.4	1.2	1.1
Ordinary	1.5	1.3	1.1
Limited	3.0	2.6	2.2



STABILITY ANALYSIS OF STILLING BASIN (SB)

$U_{SB} := A_{up\_SB} \cdot L_{SW} = 710.055 \cdot kip$

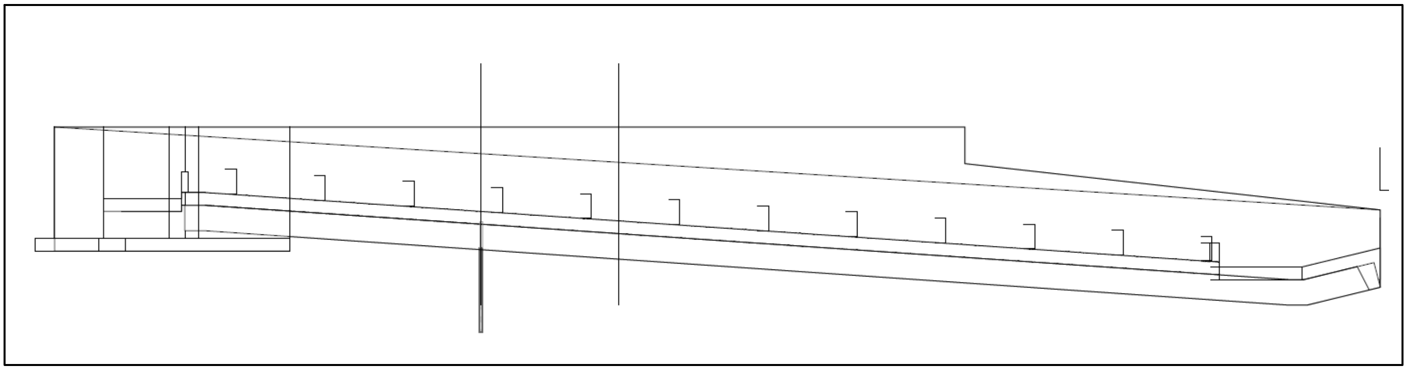
$DL_{SB} := W_{slab\_SB} + W_{water\_SB} = 1.027 \times 10^{3} \cdot kip$

$$SF_{up\_SB} := \frac{DL_{SB}}{U_{SB}} = 1.446$$

$$CHECK_{Uplift\_SB} := \begin{cases} \text{"SF > 1.2 for Usual LC; OK"} & \text{if } SF_{up\_SB} \geq 1.2 \\ \text{"SF < 1.2 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT STILLING BASIN

$CHECK_{Uplift\_SB}$ = "SF > 1.2 for Usual LC; OK"



STABILITY ANALYSIS OF FISH LADDER (FL)

Uplift $U_{FL} = 1.231 \times 10^{3} \cdot kip$

Uplift Resistance $DL_{total\_FL} := W_{wall\_FL} + W_{slab\_FL} + W_{ftg\_FL} + W_{gate\_wall\_FL} + W_{water\_FL} = 3.968 \times 10^{3} \cdot kip$

$$SF_{up\_FL} := \frac{DL_{total\_FL}}{U_{FL}} = 3.224$$

Overturning

$$M_{OT\_FL} := U_{FL} \cdot CG_{uplift\_FL} + H_{hydrostatic\_FL} \cdot \frac{\left(WSE_{hw\_FL} - WSE_{tw\_FL}\right)}{3} = 1.112 \times 10^{5} \cdot kip \cdot ft$$

$$M_{R\_FL} := W_{slab\_FL} \cdot CG_{slab\_FL} + W_{ftg\_FL} \cdot CG_{ftg\_FL} + W_{water\_FL} \cdot CG_{water\_FL} + W_{gate\_wall\_FL} \cdot CG_{gate\_wall\_FL} = 3.098 \times 10^{5} \cdot ki$$

$$SF_{OT\_FL} := \frac{M_{R\_FL}}{M_{OT\_FL}} = 2.787$$

$$e'\_FL := \frac{\left(M_{R\_FL} - M_{OT\_FL}\right)}{DL_{total\_FL}} = 50.061 \cdot ft$$

$$e_{ftg\_FL} := \frac{B_{FL}}{2} - e'\_FL = 51.246 \cdot ft \qquad OT_{FL} := \frac{3 \cdot e'\_FL}{B_{FL}} = 74.123 \cdot \%$$

$CHECK_{Uplift\_FL} :=$ | "SF > 1.2 for Usual LC; OK" if $SF_{up\_FL} \geq 1.2$
| "SF < 1.2 for Usual LC; NG" otherwise

$CHECK_{OT\_FL} :=$ | "<75% Base in Compression; OK for Usual LC" if $OT_{FL} \geq 75\%$
| ">75% Base in Compression; NG for Usual LC" otherwise

STABILITY RESULTS AT TOTAL STRUCTURE

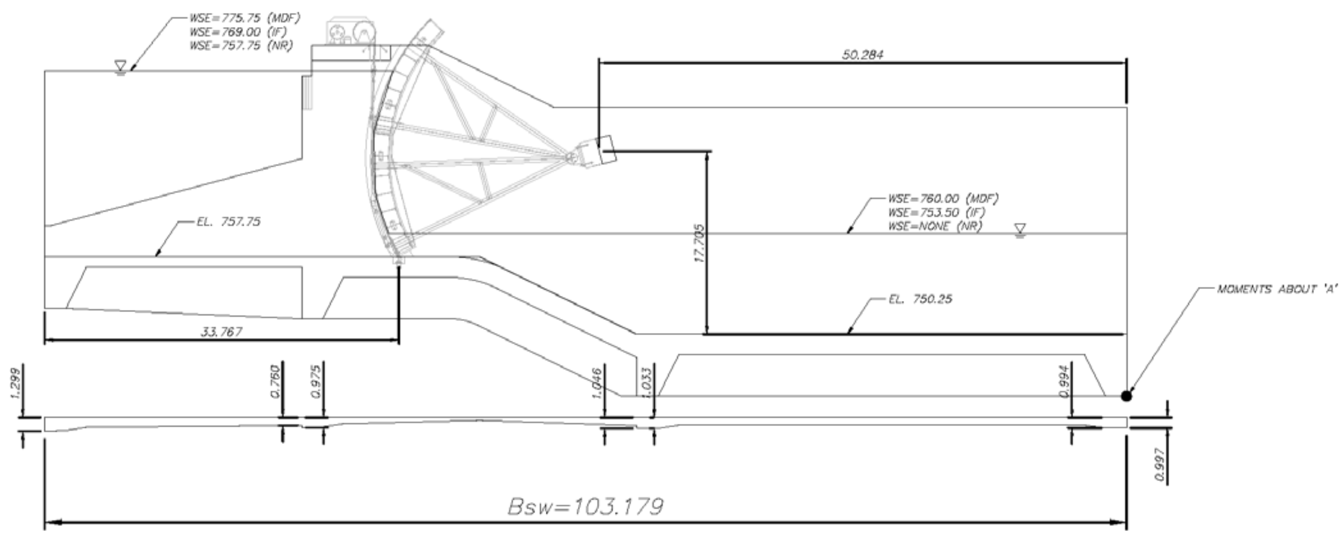
$CHECK_{Uplift\_FL}$ = "SF > 1.2 for Usual LC; OK"

$CHECK_{OT\_FL}$ = ">75% Base in Compression; NG for Usual LC"

Base compression is slightly less then 75%; analysis does not consider wall friction to resist overturning, OK by inspection

IF controls the stability desing because during MDF event the structured is entirely covered with water

GEOMETRY OF HFB (SPILLWAY)



CHECK FOR STABILITY FOR MDE EARTHQUAKE

Material and Seismic Properties)

$PGA := 0.633$ $\quad k_h := \left(\frac{2}{3}\right)\cdot PGA = 0.422$ $\quad \gamma_{moist} := 130pcf$ $\quad \gamma_w := 62.4pcf$ $\quad \gamma_c := 150pcf$

$$K_o := \frac{55pcf}{\gamma_{moist}} = 0.423$$

HFB Geometries

$t_{wall} := 24in$ $\quad L_{SW\_SB} := 30ft$ $\quad B_{SW} := 103.18ft$ $\quad B_{total} := 166.6792ft$

$t_{apron} := 12in$ $\quad t_{slab} := 24in$ $\quad B_{SB} := 63.5ft$

$EL_{lwr\_SB} := 750.25ft$ $\quad EL_{upr\_SW} := 757.75ft$ $\quad WSE_{hw} := 757.75ft$ $\quad WSE_{tw} := 750.25ft$

Geometries (from AutoCAD Mass Properties)

$A_{slab\_SB} := 149.8472ft^2$ $\quad A_{wall\_SW} := 2790.1071ft^2$ $\quad A_{water\_SW} := 0ft^2$ $\quad Gate_{mud\_INCA} := 3kip$

$A_{water\_SB} := 0ft^2$ $\quad A_{slab\_SW} := 232.9664ft^2$ $\quad A_{up\_SW} := 13.5008klf$

$A_{up\_SB} := 14.4997klf$ $\quad A_{walk\_SW} := 11.25ft^2$ $\quad Gate_{DL\_INCA} := 19kip$

Moment Arms (From AutoCAD Mass Properties)

$CG_{uplift\_SWx} := 52.3887ft$ $CG_{walk\_SWx} := 73.9500ft$ $CG_{slab\_SWx} := 48.4651ft$ $CG_{gate\_trunion\_horz} := 50.284ft$

$CG_{wall\_SWx} := 49.2553ft$ $CG_{gate\_trunion\_vert} := 17.7ft$ $CG_{water\_SW} := 58.6249ft$ $CG_{gate\_sill} := 33.676ft$

$CG_{uplift\_SB} := 51.6426ft$ $CG_{slab\_SB} := 33.8179ft$ $CG_{water\_SB} := 30.8559ft$ $CG_{slab\_total} := 0ft$

$CG_{wall\_SWy} := 13.9221ft$ $CG_{slab\_SWy} := 7.6986ft$ $CG_{walk\_SWy} := 33.2501ft$

Restoring Loads

$W_{wall\_SW} := t_{wall} \cdot A_{wall\_SW} \cdot \gamma_c = 837.032 \cdot kip$

$W_{water\_SW} := A_{water\_SW} \cdot \gamma_w \cdot L_{SW\_SB} = 0 \cdot kip$

$W_{slab\_SW} := A_{slab\_SW} \cdot L_{SW\_SB} \cdot \gamma_c = 1.048 \times 10^3 \cdot kip$

$W_{walk\_SW} := A_{walk\_SW} \cdot L_{SW\_SB} \cdot \gamma_c = 50.625 \cdot kip$

$W_{slab\_SB} := A_{slab\_SB} \cdot L_{SW\_SB} \cdot \gamma_c = 674.312 \cdot kip$

$W_{water\_SB} := A_{water\_SB} \cdot \gamma_w \cdot L_{SW\_SB} = 0 \cdot kip$

$W_{gate} := (Gate_{DL\_INCA} + Gate_{mud\_INCA}) = 22 \cdot kip$

$W_{total\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} + W_{walk\_SW} + W_{gate} = 1.958 \times 10^3 \cdot kip$

$W_{total\_SB} := W_{slab\_SB} + W_{water\_SB} = 674.312 \cdot kip$

$W_{total} := W_{total\_SW} + W_{total\_SB} = 2.632 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{walk\_SW} + W_{gate} = 1.958 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SB} := W_{slab\_SB} = 674.312 \cdot kip$

$W_{EQ\_mass} := W_{EQ\_mass\_SW} + W_{EQ\_mass\_SB} = 2.632 \times 10^3 \cdot kip$

Driving Lateral Loads

$$H_{PGA\_SW} := k_h \cdot W_{EQ\_mass\_SW} = 826.279 \cdot kip$$

$$H_{PGA\_SB} := k_h \cdot W_{EQ\_mass\_SB} = 284.56 \cdot kip$$

$$H_{hydrostatic} := \frac{\gamma_w \cdot \left(WSE_{hw} - WSE_{tw}\right)^2 \cdot L_{SW\_SB}}{2} = 52.65 \cdot kip$$

Hydrodynamic loading is ignored due to shallow water in the basin and with sloped walls

Uplift

$$U_{SW} := A_{up\_SW} \cdot L_{SW\_SB} = 405.024 \cdot kip$$

$$U_{SB} := A_{up\_SB} \cdot L_{SW\_SB} = 434.991 \cdot kip$$

$$U_{total} := U_{SW} + U_{SB} = 840.015 \cdot kip$$

STABILITY ANALYSIS OF HSB (TAINTER GATE @ SPILLWAY)

Overturning Driving at Spillway

$$M_{OT\_PGA} := k_h \cdot \left(W_{wall\_SW} \cdot CG_{wall\_SWy} + W_{walk\_SW} \cdot CG_{walk\_SWy} + W_{slab\_SW} \cdot CG_{slab\_SWy}\right) = 9.034 \times 10^3 \cdot kip \cdot ft$$

$$M_{OT\_SW} := U_{SW} \cdot CG_{uplift\_SWx} + \left[H_{hydrostatic} \cdot \frac{\left(WSE_{hw} - WSE_{tw}\right)}{3}\right] = 2.135 \times 10^4 \cdot kip \cdot ft$$

Table 3-5 Requirements for Location of the Resultant – All Structures

Site Information Category	Usual	Unusual	Extreme
	Load Condition Categories		
All Categories	100% of Base in Compression	75% of Base in Compression	Resultant Within Base

Overturning Resisting at Spillway

$$M_{R\_SW} := W_{wall\_SW} \cdot CG_{wall\_SWx} + W_{slab\_SW} \cdot CG_{slab\_SWx} + W_{walk\_SW} \cdot CG_{walk\_SWx} + W_{water\_SW} \cdot CG_{water\_SW} = 9.578 \times 10^4 \cdot kip \cdot$$

$$SF_{OT\_SW} := \frac{M_{R\_SW}}{\left(M_{OT\_SW} + M_{OT\_PGA}\right)} = 3.152$$

Table 3-4 Required Factors of Safety for Flotation – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	1.3	1.2	1.1

Uplift Resistance at Spillway

$DL_{SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} = 1.885 \times 10^{3} \cdot kip$

$SF_{up\_SW} := \dfrac{DL_{SW}}{U_{SW}} = 4.655$

$e'\_SW := \dfrac{(M_{R\_SW} - M_{OT\_SW} - M_{OT\_PGA})}{DL_{SW}} = 34.686 \cdot ft$

$e_{SW} := \dfrac{B_{SW}}{2} - e'\_SW = 16.904 \cdot ft$

$OT_{SW} := \dfrac{3 \cdot e'\_SW}{B_{SW}} = 100.851 \cdot \%$

$CHECK_{OT} :=$ | "<Resultant within base for extreme LC; OK" if $OT_{SW} \geq 0\%$
| ">Resultant not within base for extreme LC; NG" otherwise

$CHECK_{Uplift} :=$ | "SF > 1.3 for Usual LC; OK" if $SF_{up\_SW} \geq 1.3$
| "SF < 1.3 for Usual LC; NG" otherwise

STABILITY RESULTS AT SPILLWAY ONLY:

$CHECK_{OT}$ = "<Resultant within base for extreme LC; OK"

$CHECK_{Uplift}$ = "SF > 1.3 for Usual LC; OK"

SLIDING RESISTANCE ON TOTAL STRUCTURE

$\mu_{car} := .55$ $\mu_{cif} := .45$ $ht_{key} := 4ft$ $N_{key} := 6$ $c_{ohesion} := 0psf$ $L_{tot} := B_{total} \cdot L_{SW\_SB}$

$q1\_2_{water} := (WSE_{hw} - EL_{upr\_SW}) \cdot \gamma_w = 0 \cdot psf$

$q3\_6_{water} := (WSE_{tw} - EL_{lwr\_SB}) \cdot \gamma_w = 0 \cdot psf$

$q1\_2_{B.O.key} := (t_{apron} + ht_{key}) \cdot \gamma_c = 750 \cdot psf$

$q3\_6_{B.O.key} := (t_{slab} + ht_{key}) \cdot \gamma_c = 900 \cdot psf$

$q1\_2_{T.O.key} := (t_{apron}) \cdot \gamma_c = 150 \cdot psf$

$q3\_6_{T.O.key} := (t_{slab}) \cdot \gamma_c = 300 \cdot psf$

Passive Pressure of Keys

$$pw1\_2_{B.O.key} := \frac{[267psf + 245psf + 159psf + 135psf + 4\gamma_w \cdot (ht_{key} - 4ft)]}{4} = 201.5 \cdot psf$$

$$pw1\_2_{T.O.key} := \frac{(0psf + 0psf + 0psf + 0psf)}{4} = 0 \cdot psf$$

$$pw3\_5_{B.O.key} := \frac{[530psf + 497psf + 466psf + 470psf + 473psf + 473psf + 6\gamma_w \cdot (ht_{key} - 4ft)]}{6} = 484.833 \cdot psf$$

$$pw3\_5_{T.O.key} := \frac{(309psf + 188psf + 208psf + 222psf + 223psf + 224psf)}{6} = 229 \cdot psf$$

$$pw6_{B.O.key} := \frac{[286psf + 286psf + 2\gamma_w \cdot (ht_{key} - 4ft)]}{2} = 286 \cdot psf$$

$$pw6_{T.O.key} := \frac{(94psf + 94psf)}{2} = 94 \cdot psf$$

$$p1\_2 := \frac{[(q1\_2_{water} + q1\_2_{B.O.key} - pw1\_2_{B.O.key}) + (q1\_2_{water} + q1\_2_{T.O.key} - pw1\_2_{T.O.key})]}{2} = 349.25 \cdot psf$$

$$p3\_5 := \frac{[(q3\_6_{water} + q3\_6_{B.O.key} - pw3\_5_{B.O.key}) + (q3\_6_{water} + q3\_6_{T.O.key} - pw3\_5_{T.O.key})]}{2} = 243.083 \cdot psf$$

$$p6 := \frac{\left[\left(\frac{q3\_6_{water}}{2} + q3\_6_{B.O.key} - pw6_{B.O.key}\right) + \left(\frac{q3\_6_{water}}{2} + q3\_6_{T.O.key} - pw6_{T.O.key}\right)\right]}{2} = 410 \cdot psf$$

$$p_{avg} := \frac{2p1\_2 + 3p3\_5 + p6}{6} = 306.292 \cdot psf$$

$$P_{keys} := (N_{key} \cdot p_{avg} \cdot ht_{key} \cdot L_{SW\_SB}) = 220.53 \cdot kip$$

At Rest Pressure of Keys for Sidewall Friction

$p_{p\_slide\_\gamma sub} := 30pcf$ $\quad L_{slide\mu} := B_{SB} + B_{SW} = 166.68\,ft$ $\quad n_{\mu\_key\_slide\_face} := 2$ $\quad n_{\mu\_wall\_slide\_face} := 2$

$p_{p\_slide\_\gamma moist} := 55pcf$ $\quad ht_{wall\_slide\_face} := 10ft$

$$P_{\mu\_slide\_wall} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma moist} \cdot ht_{wall\_slide\_face} + p_{p\_slide\_\gamma sub} \cdot \left(ht_{key} + t_{slab}\right)\right] \cdot \left(ht_{wall\_slide\_face} + ht_{key} + t_{slab}\right)}{2} \cdot n_{\mu\_wall\_slid}\right.$$

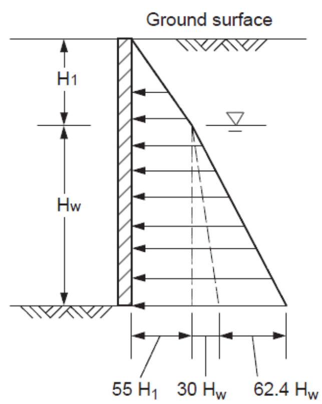
$$P_{\mu\_slide\_key} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma sub} \cdot \left(ht_{key} + t_{slab}\right)^2\right]}{2} \cdot n_{\mu\_key\_slide\_face} \cdot L_{slide\mu} \right] = 81.006 \cdot kip$$

$$P_{\mu DL} := \mu_{car} \cdot \left(W_{total} - U_{total}\right) = 9.858 \times 10^5\,lbf$$

$$P_R := P_{\mu DL} + P_{keys} + P_{\mu\_slide\_key} + P_{\mu\_slide\_wall} = 2.163 \times 10^3 \cdot kip$$

$$H_D := k_h \cdot W_{EQ\_mass} = 1.111 \times 10^3 \cdot kip$$

$$FS_{sliding} := \frac{P_R + c_{ohesion} \cdot L_{tot}}{H_D} = 1.948$$



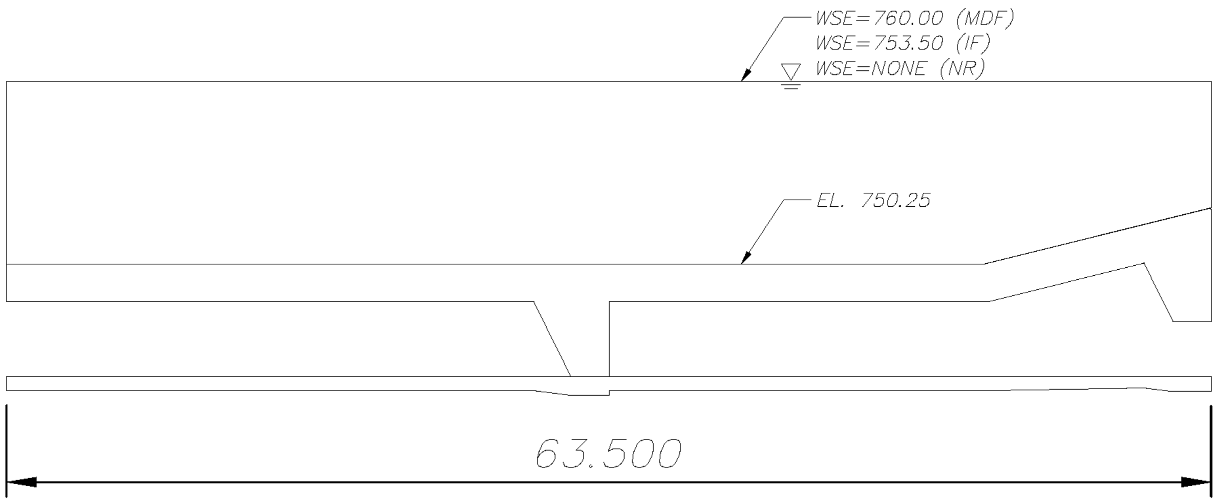
Non-yielding (At Rest) Wall Pressure (psf)

Table 3-3 Required Factors of Safety for Sliding - Normal Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
Well Defined	1.4	1.2	1.1
Ordinary	1.5	1.3	1.1
Limited	3.0	2.6	2.2

$CHECK_{sliding} :=$ "SF > 1.1 for Extreme LC; OK" if $FS_{sliding} \geq 1.1$
"SF < 1.1 for Extreme LC; NG" otherwise

$CHECK_{sliding} =$ "SF > 1.1 for Extreme LC; OK"



STABILITY ANALYSIS OF STILLING BASIN

Uplift $\quad U_{SB} = 434.991 \cdot kip$

Uplift Resistance $\quad DL_{SB} := W_{slab\_SB} + W_{water\_SB} = 674.312 \cdot kip$

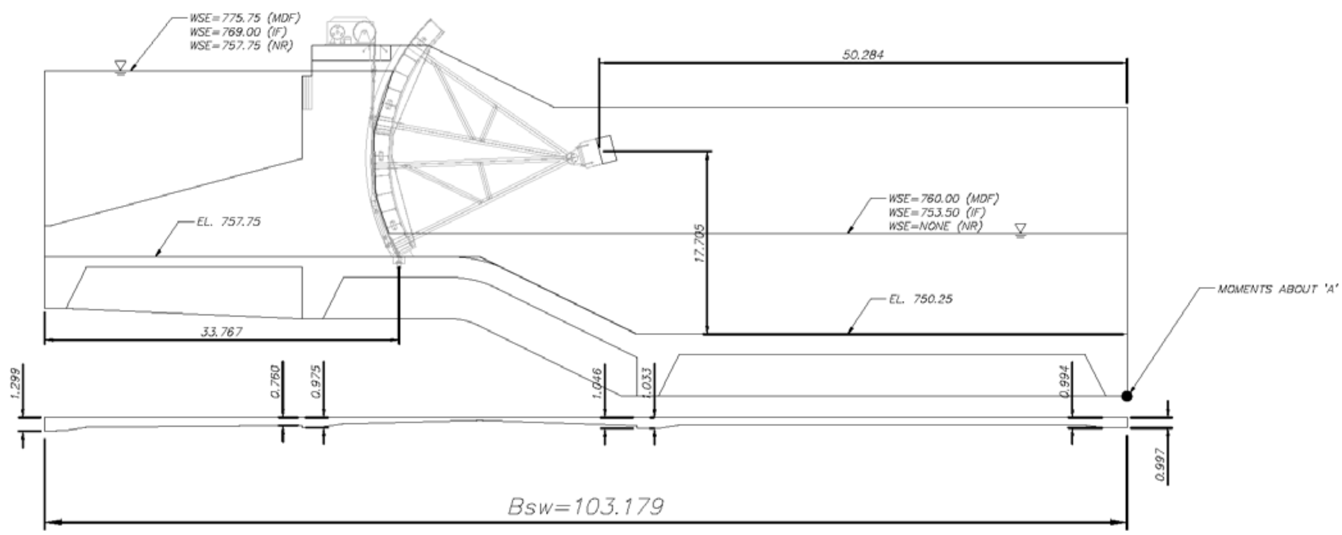
$$SF_{up\_SB} := \frac{DL_{SB}}{U_{SB}} = 1.55$$

$$CHECK_{Uplift\_SB} := \begin{cases} \text{"SF > 1.3 for Usual LC; OK"} & \text{if } SF_{up\_SB} \geq 1.3 \\ \text{"SF < 1.3 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT STILLING BASIN

$CHECK_{Uplift\_SB}$ = "SF > 1.3 for Usual LC; OK"

GEOMETRY OF HFB (SPILLWAY)



CHECK FOR STABILITY FOR OBE EARTHQUAKE

Material and Seismic Properties)

$PGA := 0.318$ $\quad k_h := \left(\frac{2}{3}\right) \cdot PGA = 0.212$ $\quad \gamma_{moist} := 130pcf$ $\quad \gamma_w := 62.4pcf$ $\quad \gamma_c := 150pcf$

$K_o := \frac{55pcf}{\gamma_{moist}} = 0.423$

HFB Geometries

$t_{wall} := 24in$ $\quad L_{SW\_SB} := 30ft$ $\quad B_{SW} := 103.18ft$ $\quad B_{total} := 166.6792ft$

$t_{apron} := 12in$ $\quad t_{slab} := 24in$ $\quad B_{SB} := 63.5ft$

$EL_{lwr\_SB} := 750.25ft$ $\quad EL_{upr\_SW} := 757.75ft$ $\quad WSE_{hw} := 757.75ft$ $\quad WSE_{tw} := 750.25ft$

Geometries (from AutoCAD Mass Properties)

$A_{slab\_SB} := 149.8472ft^2$ $\quad A_{wall\_SW} := 2790.1071ft^2$ $\quad A_{water\_SW} := 0ft^2$ $\quad Gate_{mud\_INCA} := 3kip$

$A_{water\_SB} := 0ft^2$ $\quad A_{slab\_SW} := 232.9664ft^2$ $\quad A_{up\_SW} := 13.5008klf$

$A_{up\_SB} := 14.4997klf$ $\quad A_{walk\_SW} := 11.25ft^2$ $\quad Gate_{DL\_INCA} := 19kip$

Moment Arms (From AutoCAD Mass Properties)

$CG_{uplift\_SWx} := 52.3887ft$

$CG_{walk\_SWx} := 73.9500ft$

$CG_{slab\_SWx} := 48.4651ft$

$CG_{gate\_trunion\_horz} := 50.284ft$

$CG_{wall\_SWx} := 49.2553ft$

$CG_{gate\_trunion\_vert} := 17.7ft$

$CG_{water\_SW} := 58.6249ft$

$CG_{gate\_sill} := 33.676ft$

$CG_{uplift\_SB} := 51.6426ft$

$CG_{slab\_SB} := 33.8179ft$

$CG_{water\_SB} := 30.8559ft$

$CG_{slab\_total} := 0ft$

$CG_{wall\_SWy} := 13.9221ft$

$CG_{slab\_SWy} := 7.6986ft$

$CG_{walk\_SWy} := 33.2501ft$

Restoring Loads

$W_{wall\_SW} := t_{wall} \cdot A_{wall\_SW} \cdot \gamma_c = 837.032 \cdot kip$

$W_{water\_SW} := A_{water\_SW} \cdot \gamma_w \cdot L_{SW\_SB} = 0 \cdot kip$

$W_{slab\_SW} := A_{slab\_SW} \cdot L_{SW\_SB} \cdot \gamma_c = 1.048 \times 10^3 \cdot kip$

$W_{walk\_SW} := A_{walk\_SW} \cdot L_{SW\_SB} \cdot \gamma_c = 50.625 \cdot kip$

$W_{slab\_SB} := A_{slab\_SB} \cdot L_{SW\_SB} \cdot \gamma_c = 674.312 \cdot kip$

$W_{water\_SB} := A_{water\_SB} \cdot \gamma_w \cdot L_{SW\_SB} = 0 \cdot kip$

$W_{gate} := \left(Gate_{DL\_INCA} + Gate_{mud\_INCA}\right) = 22 \cdot kip$

$W_{total\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} + W_{walk\_SW} + W_{gate} = 1.958 \times 10^3 \cdot kip$

$W_{total\_SB} := W_{slab\_SB} + W_{water\_SB} = 674.312 \cdot kip$

$W_{total} := W_{total\_SW} + W_{total\_SB} = 2.632 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SW} := W_{wall\_SW} + W_{slab\_SW} + W_{walk\_SW} + W_{gate} = 1.958 \times 10^3 \cdot kip$

$W_{EQ\_mass\_SB} := W_{slab\_SB} = 674.312 \cdot kip$

$W_{EQ\_mass} := W_{EQ\_mass\_SW} + W_{EQ\_mass\_SB} = 2.632 \times 10^3 \cdot kip$

Driving Lateral Loads

$$H_{PGA\_SW} := k_h \cdot W_{EQ\_mass\_SW} = 415.097 \cdot kip$$

$$H_{PGA\_SB} := k_h \cdot W_{EQ\_mass\_SB} = 142.954 \cdot kip$$

$$H_{hydrostatic} := \frac{\gamma_w \cdot (WSE_{hw} - WSE_{tw})^2 \cdot L_{SW\_SB}}{2} = 52.65 \cdot kip$$

Hydrodynamic loading is ignored due to shallow water in the basin and with sloped walls

Uplift

$$U_{SW} := A_{up\_SW} \cdot L_{SW\_SB} = 405.024 \cdot kip$$

$$U_{SB} := A_{up\_SB} \cdot L_{SW\_SB} = 434.991 \cdot kip$$

$$U_{total} := U_{SW} + U_{SB} = 840.015 \cdot kip$$

STABILITY ANALYSIS OF HSB (TAINTER GATE @ SPILLWAY)

Overturning Driving at Spillway

$$M_{OT\_PGA} := k_h \cdot (W_{wall\_SW} \cdot CG_{wall\_SWy} + W_{walk\_SW} \cdot CG_{walk\_SWy} + W_{slab\_SW} \cdot CG_{slab\_SWy}) = 4.538 \times 10^3 \cdot kip \cdot ft$$

$$M_{OT\_SW} := U_{SW} \cdot CG_{uplift\_SWx} + \left[H_{hydrostatic} \cdot \frac{(WSE_{hw} - WSE_{tw})}{3} \right] = 2.135 \times 10^4 \cdot kip \cdot ft$$

Table 3-5 Requirements for Location of the Resultant – All Structures

Site Information Category	*Load Condition Categories* Usual	Unusual	Extreme
All Categories	100% of Base in Compression	75% of Base in Compression	Resultant Within Base

Overturning Resisting at Spillway

$$M_{R\_SW} := W_{wall\_SW} \cdot CG_{wall\_SWx} + W_{slab\_SW} \cdot CG_{slab\_SWx} + W_{walk\_SW} \cdot CG_{walk\_SWx} + W_{water\_SW} \cdot CG_{water\_SW} = 9.578 \times 10^4 \cdot kip \cdot$$

$$SF_{OT\_SW} := \frac{M_{R\_SW}}{(M_{OT\_SW} + M_{OT\_PGA})} = 3.7$$

Table 3-4 Required Factors of Safety for Flotation – All Structures

	Load Condition Categories		
Site Information Category	**Usual**	**Unusual**	**Extreme**
All Categories	1.3	1.2	1.1

Uplift Resistance at Spillway

$$DL_{SW} := W_{wall\_SW} + W_{slab\_SW} + W_{water\_SW} = 1.885 \times 10^{3} \cdot kip$$

$$SF_{up\_SW} := \frac{DL_{SW}}{U_{SW}} = 4.655$$

$$e'\_SW := \frac{\left(M_{R\_SW} - M_{OT\_SW} - M_{OT\_PGA}\right)}{DL_{SW}} = 37.07 \cdot ft$$

$$e_{SW} := \frac{B_{SW}}{2} - e'\_SW = 14.52 \cdot ft \qquad OT_{SW} := \frac{3 \cdot e'\_SW}{B_{SW}} = 107.783 \cdot \%$$

$$CHECK_{OT} := \begin{cases} \text{"<75\% Base in Compression; OK"} & \text{if } OT_{SW} \geq 75\% \\ \text{">75\% Base in Compression; NG"} & \text{otherwise} \end{cases}$$

$$CHECK_{Uplift} := \begin{cases} \text{"SF > 1.3 for Usual LC; OK"} & \text{if } SF_{up\_SW} \geq 1.3 \\ \text{"SF < 1.3 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT SPILLWAY ONLY:

$CHECK_{OT}$ = "<75% Base in Compression; OK"

$CHECK_{Uplift}$ = "SF > 1.3 for Usual LC; OK"

SLIDING RESISTANCE ON TOTAL STRUCTURE

$\mu_{car} := .55$ $\mu_{cif} := .45$ $ht_{key} := 4ft$ $N_{key} := 6$ $c_{ohesion} := 0psf$ $L_{tot} := B_{total} \cdot L_{SW\_SB}$

$q1\_2_{water} := \left(WSE_{hw} - EL_{upr\_SW}\right) \cdot \gamma_w = 0 \cdot psf$

$q3\_6_{water} := \left(WSE_{tw} - EL_{lwr\_SB}\right) \cdot \gamma_w = 0 \cdot psf$

$q1\_2_{B.O.key} := \left(t_{apron} + ht_{key}\right) \cdot \gamma_c = 750 \cdot psf$

$q3\_6_{B.O.key} := \left(t_{slab} + ht_{key}\right) \cdot \gamma_c = 900 \cdot psf$

$q1\_2_{T.O.key} := \left(t_{apron}\right) \cdot \gamma_c = 150 \cdot psf$

$q3\_6_{T.O.key} := \left(t_{slab}\right) \cdot \gamma_c = 300 \cdot psf$

Passive Pressure of Keys

$$pw1\_2_{B.O.key} := \frac{\left[267psf + 245psf + 159psf + 135psf + 4\gamma_w \cdot \left(ht_{key} - 4ft\right)\right]}{4} = 201.5 \cdot psf$$

$$pw1\_2_{T.O.key} := \frac{(0psf + 0psf + 0psf + 0psf)}{4} = 0 \cdot psf$$

$$pw3\_5_{B.O.key} := \frac{\left[530psf + 497psf + 466psf + 470psf + 473psf + 473psf + 6\gamma_w \cdot \left(ht_{key} - 4ft\right)\right]}{6} = 484.833 \cdot psf$$

$$pw3\_5_{T.O.key} := \frac{(309psf + 188psf + 208psf + 222psf + 223psf + 224psf)}{6} = 229 \cdot psf$$

$$pw6_{B.O.key} := \frac{\left[286psf + 286psf + 2\gamma_w \cdot \left(ht_{key} - 4ft\right)\right]}{2} = 286 \cdot psf$$

$$pw6_{T.O.key} := \frac{(94psf + 94psf)}{2} = 94 \cdot psf$$

$$p1\_2 := \frac{\left[\left(q1\_2_{water} + q1\_2_{B.O.key} - pw1\_2_{B.O.key}\right) + \left(q1\_2_{water} + q1\_2_{T.O.key} - pw1\_2_{T.O.key}\right)\right]}{2} = 349.25 \cdot psf$$

$$p3\_5 := \frac{\left[\left(q3\_6_{water} + q3\_6_{B.O.key} - pw3\_5_{B.O.key}\right) + \left(q3\_6_{water} + q3\_6_{T.O.key} - pw3\_5_{T.O.key}\right)\right]}{2} = 243.083 \cdot psf$$

$$p6 := \frac{\left[\left(\frac{q3\_6_{water}}{2} + q3\_6_{B.O.key} - pw6_{B.O.key}\right) + \left(\frac{q3\_6_{water}}{2} + q3\_6_{T.O.key} - pw6_{T.O.key}\right)\right]}{2} = 410 \cdot psf$$

$$p_{avg} := \frac{2p1\_2 + 3p3\_5 + p6}{6} = 306.292 \cdot psf$$

$$P_{keys} := \left(N_{key} \cdot p_{avg} \cdot ht_{key} \cdot L_{SW\_SB}\right) = 220.53 \cdot kip$$

At Rest Pressure of Keys for Sidewall Friction

$p_{p\_slide\_\gamma sub} := 30pcf$ $\quad L_{slide\mu} := B_{SB} + B_{SW} = 166.68\,ft$ $\quad n_{\mu\_key\_slide\_face} := 2$ $\quad n_{\mu\_wall\_slide\_face} := 2$

$p_{p\_slide\_\gamma moist} := 55pcf$ $\quad ht_{wall\_slide\_face} := 10ft$

$$P_{\mu\_slide\_wall} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma moist} \cdot ht_{wall\_slide\_face} + p_{p\_slide\_\gamma sub} \cdot (ht_{key} + t_{slab}) \right] \cdot (ht_{wall\_slide\_face} + ht_{key} + t_{slab})}{2} \cdot n_{\mu\_wall\_slid}\right.$$

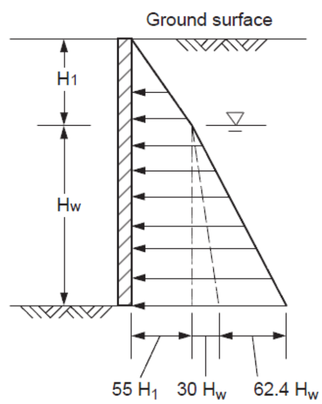
$$P_{\mu\_slide\_key} := \mu_{cif} \cdot \left[\frac{\left[p_{p\_slide\_\gamma sub} \cdot (ht_{key} + t_{slab})^2 \right]}{2} \cdot n_{\mu\_key\_slide\_face} \cdot L_{slide\mu} \right] = 81.006 \cdot kip$$

$$P_{\mu DL} := \mu_{car} \cdot (W_{total} - U_{total}) = 9.858 \times 10^5\, lbf$$

$$P_R := P_{\mu DL} + P_{keys} + P_{\mu\_slide\_key} + P_{\mu\_slide\_wall} = 2.163 \times 10^3 \cdot kip$$

$$H_D := k_h \cdot W_{EQ\_mass} = 558.051 \cdot kip$$

$$FS_{sliding} := \frac{P_R + c_{ohesion} \cdot L_{tot}}{H_D} = 3.877$$



Non-yielding (At Rest) Wall Pressure (psf)

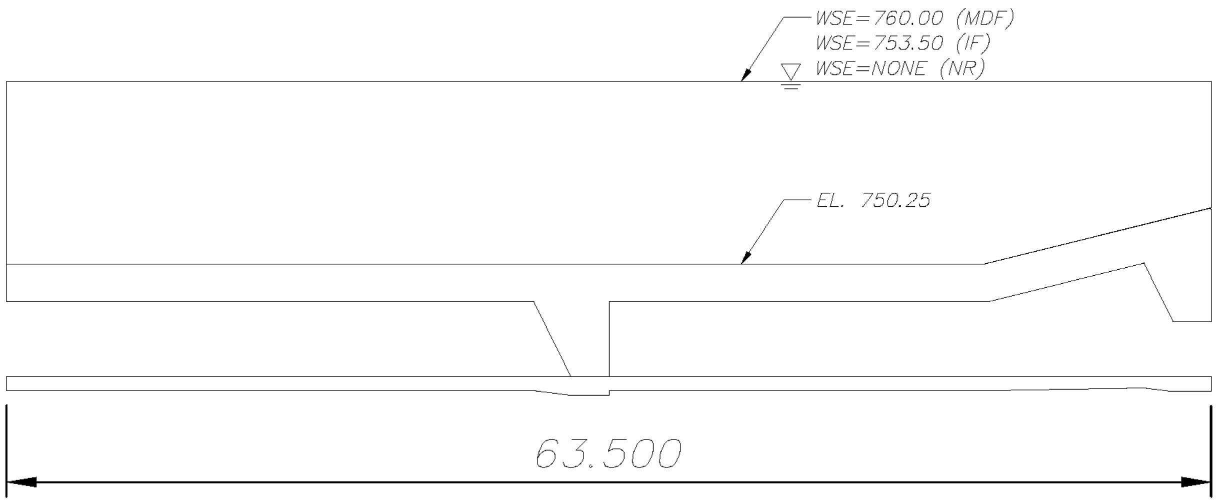
Table 3-3 Required Factors of Safety for Sliding - Normal Structures

Load Condition Categories

Site Information Category	Usual	Unusual	Extreme
Well Defined	1.4	1.2	1.1
Ordinary	1.5	1.3	1.1
Limited	3.0	2.6	2.2

$$CHECK_{sliding} := \begin{cases} \text{"SF > 1.2 for Unusual LC; OK"} & \text{if } FS_{sliding} \geq 1.2 \\ \text{"SF < 1.2 for Unusual LC; NG"} & \text{otherwise} \end{cases}$$

$CHECK_{sliding}$ = "SF > 1.2 for Unusual LC; OK"



STABILITY ANALYSIS OF STILLING BASIN

Uplift $U_{SB} = 434.991 \cdot kip$

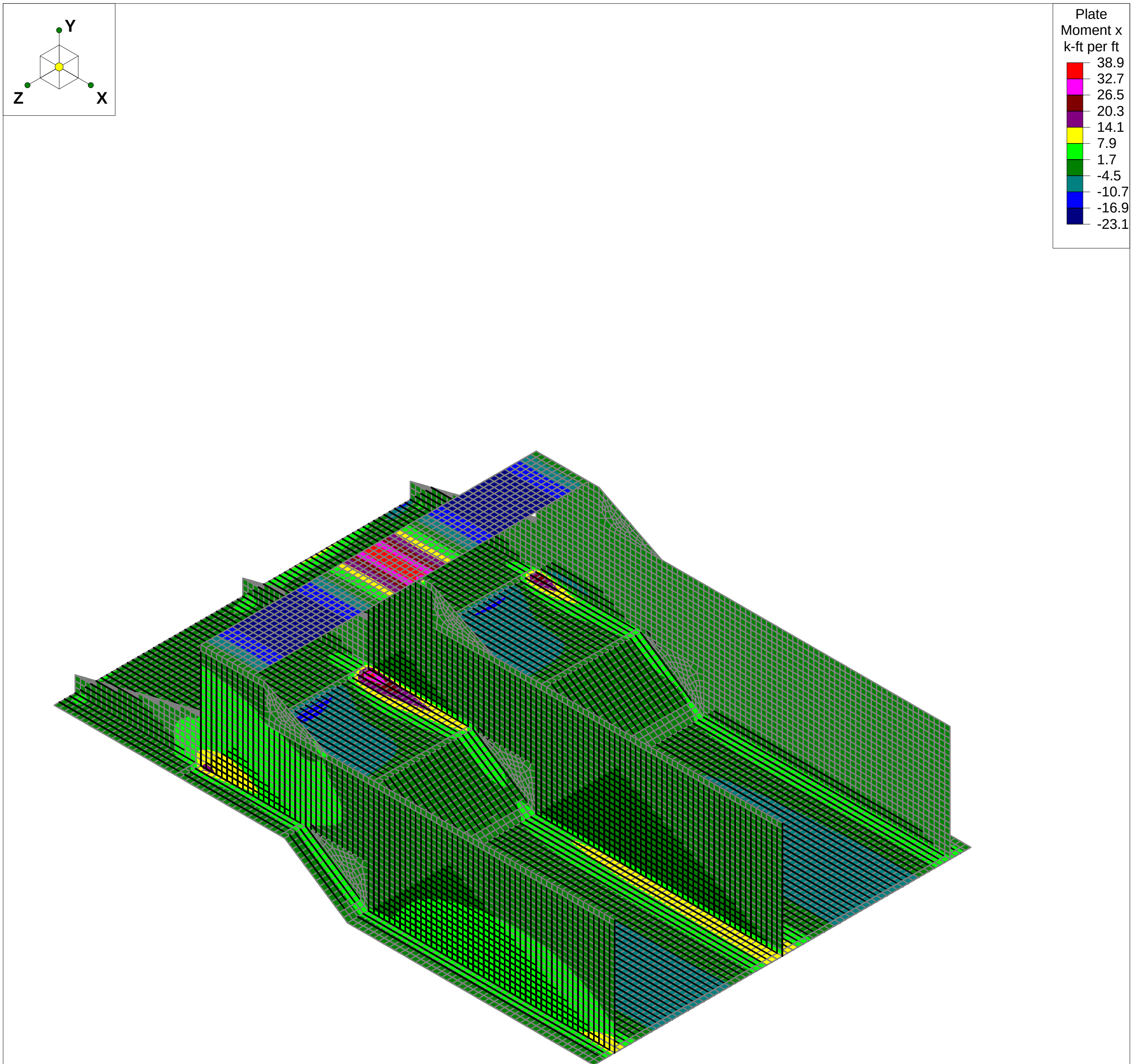
Uplift Resistance $DL_{SB} := W_{slab\_SB} + W_{water\_SB} = 674.312 \cdot kip$

$$SF_{up\_SB} := \frac{DL_{SB}}{U_{SB}} = 1.55$$

$$CHECK_{Uplift\_SB} := \begin{cases} \text{"SF > 1.3 for Usual LC; OK"} & \text{if } SF_{up\_SB} \geq 1.3 \\ \text{"SF < 1.3 for Usual LC; NG"} & \text{otherwise} \end{cases}$$

STABILITY RESULTS AT STILLING BASIN

$CHECK_{Uplift\_SB} =$ "SF > 1.3 for Usual LC; OK"



Results for LC 6, DL+LL (SERVICE)

Tt		SK - 6
msp	HSB	Jan 25, 2013 at 3:02 PM
	ISOMETRIC VIEW	HSB-R1.r3d

Concrete Properties

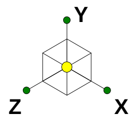
	Label	E [ksi]	G [ksi]	Nu	Therm (\...	Density[...	f'c[ksi]	Lambda	Flex Steel[ksi]	Shear Steel[ksi]
1	Conc3000NW	3156	1372	.15	.6	.145	3	1	60	60
2	Conc3500NW	3409	1482	.15	.6	.145	3.5	1	60	60
3	Conc4000NW	3644	1584	.15	.6	.145	4	1	60	60
4	Conc3000LW	2085	907	.15	.6	.11	3	1	60	60
5	Conc3500LW	2252	979	.15	.6	.11	3.5	1	60	60
6	Conc4000LW	2408	1047	.15	.6	.11	4	1	60	60

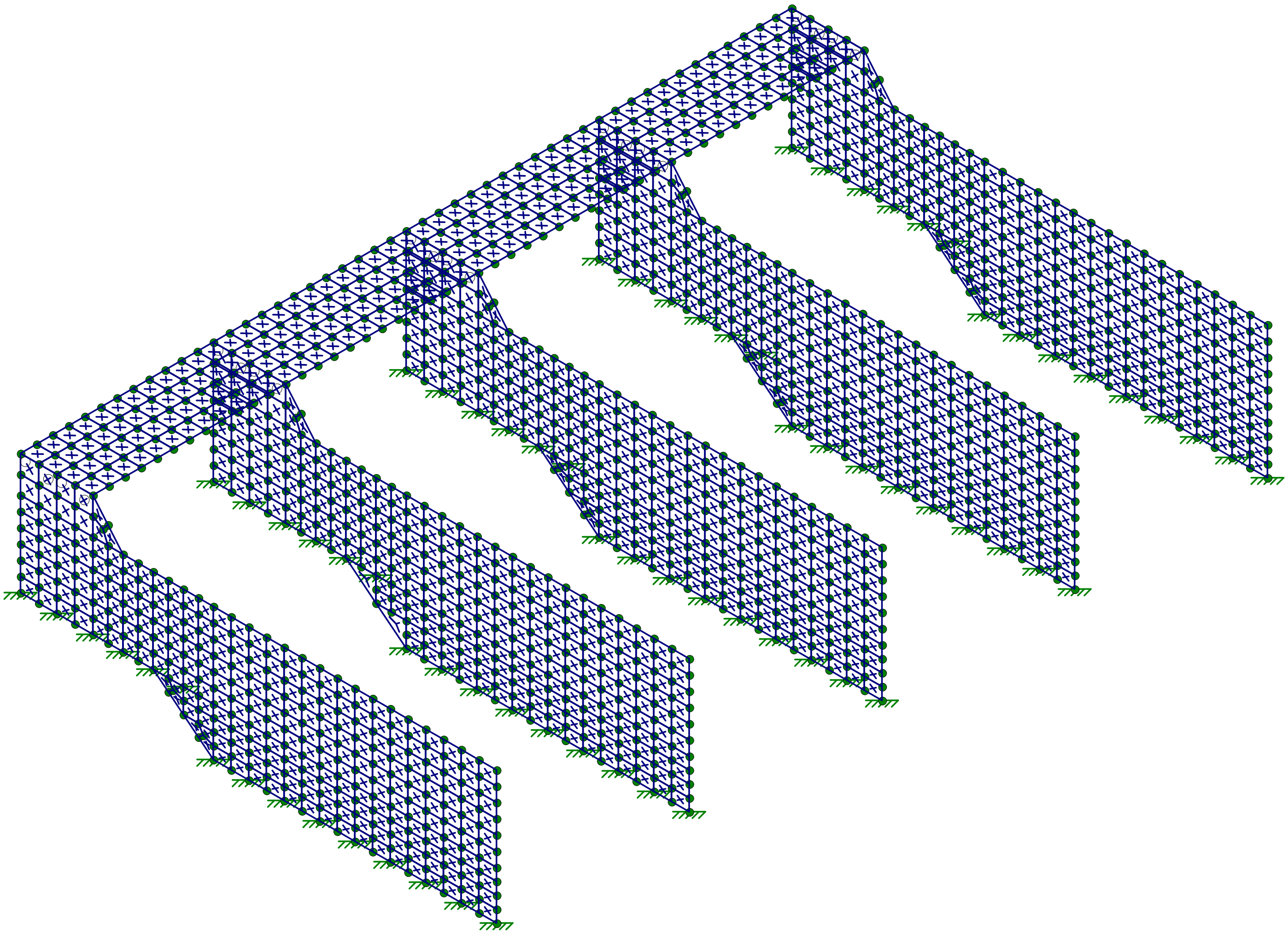
Basic Load Cases

	BLC Description	Category	X Gr...	Y Gr...	Z Gra...	Joint	Point	Distributed	Area(Memb...	Surfa...
1	DL	DL		-1				280		
2	UPLIFT - MDF: 3 DRAINS	HL				6		630		
3	IL - Gate Torque	IL				4				
4	LL - Walkway Live Load	LL								640
5	EQ Vertical (2/3 Eh) for MDE	ELY		-.281						
6	UPLIFT - MDF: 3 DRAINS, ...	OL1				6		700		
7	EQ Horiz (ELZ)	ELZ			.422			48		
8	Earth Pressue_sat soil; EPL...	OL5						48		
9	Earth Pressure_no sat; ELP...	OL6						48		

Load Combinations

	Description	Solve	PDe...	S...	BLC	Fa...	BLC	Fa...	BLC	Fa...	BLC	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...
1	DL				DL	1														
2	LL				DL	1			LL	1										
3	MDF UPLIFT (3 DRAINS): HL1						HL	1												
4	EQ (ELY)										ELY	1								
5	DL+HL (SERVICE)				DL	1	HL	1												
6	DL+LL (SERVICE)				DL	1			LL	1										
7					DL	1.4														
8	EM2100-2-2104 (Hf=1.3)				DL	1.4														
9	1.4DL (STRENGTH)				DL	1.4														
10	U1 = Hf*[1.4DL + 1.7HL1] (STRENGTH)	Yes			DL	1.82	HL	2.21												
11	U2 = Hf*[1.4DL + 1.7LL] (STRENGTH)				DL	1.82			LL	2.21										
12	U3 = [1.4DL + 1.7HL1] (STRENGTH)				DL	1.4	HL	1.7												
13	U4a = Hf*[1.4DL + 1.7EPL] (STRENGTH):Ea...				DL	1.82	OL5	2.21												
14	U4b = [1.4DL + 1.7EPL] (STRENGTH):Earth ...				DL	1.4	OL5	1.7												
15	U5 = [1.4DL + 1.7LL+1.7IL_GATE)] (STREN...				DL	1.4			LL	1.7	IL	1.7								
16	U6 = Hf*[1.4DL + 1.7LL+1.7IL_GATE)] (STR...				DL	1.82			LL	2.21	IL	2.21								
17	U7 = Hf*[1.4DL + 1.7HL2] (STRENGTH): Out...				DL	1.83	OL1	2.21												
18	VERTICAL EQ RESPONSE FOR MDE (EQ ...																			
19	U8 = 0.75[Hf(1.0(D+L)+1.25ELY)]				DL	.975					ELY	1....								
20	U9 = 0.75[(1.0(D+L)+1.25ELY)]				DL	.75					ELY	.938								
21	HORIZONTAL EQ RESPONSE FOR MDE (...																			
22	U10 = 0.75[Hf(1.0(D+L)+1.25ELZ)				DL	.975	OL6	.975			ELZ	1....								
23	U11 = 0.75[(1.0(D+L)+1.25ELZ)]				DL	.75	OL6	.75			ELZ	.938								





Loads: BLC 10, Seismic Mass

Tt		SK - 1
msp	HSB	Jan 22, 2013 at 3:09 PM
	Response Spectrum Modal Analysis	HSB_response spectra.r3d

Dynamics Input

Number of Modes	400
Load Combination Number	1 - Seismic Mass
Acceleration of Gravity	32.2 (ft/sec^2)
Convergence Tolerance	0.0001

Response Spectra Data

X Direction Spectra	ASCE 2010, Parametric Design Spectra
Modes Used	All 400 modes
Mode No. for Signs	
Modal Combination Method	SRSS
Damping Ratio	5 Percent

Y Direction Spectra	ASCE 2010, Parametric Design Spectra
Modes Used	All 400 modes
Mode No. for Signs	
Modal Combination Method	SRSS
Damping Ratio	5 Percent

Z Direction Spectra	ASCE 2010, Parametric Design Spectra
Modes Used	All 400 modes
Mode No. for Signs	
Modal Combination Method	SRSS
Damping Ratio	5 Percent

Frequencies / Participation

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
1	5.925	.169			39.01
2	6.875	.145			
3	6.876	.145			.066
4	6.876	.145			.003
5	6.876	.145			
6	6.915	.145			22.311
7	11.229	.089			.014
8	12.068	.083		.948	
9	12.667	.079		.003	
10	12.67	.079			.045
11	12.682	.079		.007	.03
12	12.692	.079		.02	.014
13	12.723	.079			3.17
14	13.601	.074			.006
15	15.228	.066	.019	8.332	
16	21.552	.046	.006	.008	.012
17	21.624	.046	.003	.002	.008
18	21.684	.046			.11
19	21.737	.046			.002
20	21.867	.046			1.651
21	28.117	.036			
22	28.299	.035	.113	.02	
23	28.4	.035	.004	.006	
24	28.975	.035			
25	29.77	.034	.946		
26	30.407	.033			.938

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
27	30.457	.033			.338
28	30.771	.032	.029	.001	.012
29	31.004	.032			
30	33.344	.03			.315
31	33.807	.03	.008	.007	
32	35.254	.028	1.831	.026	
33	35.682	.028			.092
34	36.716	.027	.025		.005
35	36.993	.027	16.304	.03	
36	37.618	.027	1.122	.002	
37	38.076	.026			.064
38	39.108	.026	.75	.001	
39	39.629	.025			10.196
40	39.634	.025			.108
41	39.676	.025	.046		
42	39.766	.025	.046		
43	39.788	.025			.06
44	41.18	.024			.002
45	42.381	.024	.147		
46	43.122	.023			.61
47	43.611	.023			.029
48	45.079	.022	.168	.001	
49	45.788	.022			.279
50	46.207	.022	.299		.003
51	46.528	.021			1.491
52	47.109	.021			.1
53	47.834	.021	.001		
54	47.984	.021			.445
55	48.083	.021	.106		.003
56	48.15	.021	.002		.377
57	48.529	.021			
58	48.974	.02	.074		
59	58.653	.017			.051
60	58.767	.017	.302	.003	
61	58.985	.017			
62	59.218	.017	.566	.006	
63	59.534	.017	.001		.003
64	60.151	.017	1.232	.008	
65	61.556	.016			.189
66	62.478	.016	.16		
67	62.682	.016			.036
68	63.219	.016			.175
69	63.265	.016	.041	.001	.003
70	63.617	.016	.001		.222
71	63.763	.016			.045
72	63.77	.016	.021		.011
73	66.228	.015	.668		
74	68.256	.015			
75	72.152	.014	.829	.423	
76	72.482	.014			
77	74.753	.013	.018		.001
78	74.87	.013	7.57	.37	
79	75.32	.013	.353	.005	
80	75.504	.013	24.693	.479	
81	75.649	.013	.577	.013	

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
82	75.913	.013	5.298	.381	
83	76.165	.013	.019	.014	.003
84	76.199	.013	.001	.002	.045
85	76.364	.013	.039	.184	.011
86	76.413	.013	.004	.047	.048
87	76.898	.013	.002		.007
88	77.663	.013		.003	.029
89	77.757	.013	.194	5.288	
90	81.472	.012	.001		
91	82.235	.012			.333
92	82.266	.012		.015	
93	82.279	.012			.055
94	82.328	.012			.017
95	83.004	.012	.023	.018	
96	94.225	.011			
97	96.131	.01	.002		
98	96.218	.01			.004
99	96.286	.01	.002		.034
100	96.318	.01			.117
101	96.518	.01			.006
102	97.661	.01	.014	.021	
103	98.728	.01		.001	.002
104	100.057	.01	.025	.037	.204
105	100.445	.01	.01	.018	.381
106	100.691	.01			.004
107	101.748	.01	.058	.005	.002
108	101.844	.01	.011		.003
109	103.408	.01		.006	
110	103.442	.01			
111	104.963	.01	.239	.111	
112	106.095	.009	1.918	7.338	
113	106.562	.009	.106	.829	
114	106.601	.009			
115	107.263	.009		.003	.33
116	107.313	.009		.006	.44
117	107.365	.009			.667
118	107.438	.009		.008	.295
119	107.503	.009		.003	.01
120	107.555	.009		.002	.503
121	107.949	.009		.146	.002
122	108.078	.009			.872
123	108.135	.009		.402	
124	108.331	.009		.005	.45
125	108.34	.009		.059	.197
126	108.412	.009	.067	5.635	.021
127	108.482	.009		.027	.072
128	108.533	.009	.004	.017	
129	108.617	.009	.005	.188	.003
130	108.731	.009	.044	.312	.041
131	109.338	.009	3.074	34.977	
132	111.092	.009		.002	.01
133	112.416	.009	.482	.526	.005
134	113.019	.009	.911	.471	.008
135	113.232	.009	.044	.019	.305
136	113.78	.009	.141	.046	.165

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
137	114.182	.009	.014	.005	.149
138	114.537	.009	.555	.209	.008
139	114.979	.009	.08	.053	.002
140	115.615	.009			.097
141	116.015	.009			
142	117.822	.008	.311		
143	117.841	.008			
144	118.056	.008	.004	.005	
145	118.087	.008			
146	118.128	.008			.001
147	118.486	.008	.002	.005	
148	118.837	.008	.002		.015
149	118.909	.008	1.373	.342	
150	119.179	.008			.051
151	120.174	.008	2.674	.89	
152	120.363	.008			
153	120.7	.008	5.458	4.188	
154	122.863	.008			.097
155	124.149	.008	.003	2.731	
156	124.713	.008			.025
157	125.49	.008	.002	.051	.003
158	125.667	.008		.004	.01
159	125.888	.008		.039	.003
160	127.82	.008	.064	3.464	
161	129.873	.008		.052	
162	131.996	.008			.06
163	132.227	.008			.1
164	132.283	.008		.008	
165	132.558	.008			.099
166	132.949	.008	.068	.009	
167	133.192	.008			.002
168	133.506	.007			.02
169	133.585	.007	.012		.001
170	133.655	.007			
171	133.88	.007			.001
172	134.723	.007	.006	.001	
173	135.203	.007	.003	.004	
174	135.417	.007		.001	
175	137.361	.007	.02	.037	
176	138.139	.007	2.582	5.327	
177	139.274	.007	.021	.029	.108
178	139.353	.007	.101	.13	.012
179	139.665	.007	.079	.332	.003
180	139.741	.007	.02	.096	.012
181	139.812	.007	.002	.021	.001
182	140.868	.007		.004	.004
183	142.815	.007			.057
184	142.841	.007	.002	.015	
185	143.019	.007			.042
186	143.029	.007			
187	143.083	.007	.001	.002	
188	143.519	.007	.004	.013	.005
189	143.616	.007	.002	.007	.008
190	144.117	.007	.004	.018	.001
191	144.755	.007		.001	.07

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
192	146.737	.007			.007
193	147.97	.007	.01	.007	.007
194	147.985	.007	.004	.007	.013
195	148.613	.007			.026
196	149.338	.007	.004		
197	149.622	.007			
198	150.414	.007	.002		
199	150.474	.007	.028	.004	
200	152.244	.007	.015	.041	
201	153.911	.006			
202	154.277	.006		.009	
203	155.625	.006		.012	
204	156.35	.006			.007
205	157.335	.006			.008
206	162.061	.006	.005	.015	
207	164.156	.006			.036
208	164.44	.006	.002		
209	164.796	.006	.095	.652	.007
210	164.905	.006		.003	.022
211	165.063	.006	.057	.349	.006
212	165.408	.006	.003	.014	.058
213	165.862	.006	.002	.013	.007
214	166.397	.006	.001	.036	.002
215	166.437	.006			.054
216	166.5	.006			.034
217	166.727	.006			.003
218	166.798	.006		.015	.011
219	167.07	.006		.003	
220	168.115	.006			.015
221	168.241	.006			
222	168.271	.006			
223	168.359	.006			
224	169.064	.006		.062	
225	171.898	.006	.002	.014	
226	172.279	.006			.059
227	172.677	.006			.014
228	172.744	.006			.057
229	173.349	.006	.003	.002	.029
230	173.863	.006	.003	.003	.01
231	177.515	.006	.005	.005	
232	179.22	.006	.011	.025	
233	181.373	.006	.035	.089	
234	181.39	.006			.032
235	181.763	.006	.392	.816	.006
236	181.833	.005	.003	.006	
237	181.889	.005	.2	.411	.02
238	182.553	.005	.004	.011	.014
239	183.83	.005	.003	.002	.005
240	184.63	.005	.004	.001	
241	189.908	.005			
242	190.703	.005			.023
243	191.695	.005			
244	191.854	.005			.212
245	191.976	.005			.21
246	192.161	.005			.006

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
247	193.59	.005			
248	195.263	.005	.009	.049	
249	196.04	.005			.063
250	197.79	.005			
251	197.875	.005		.003	
252	198.711	.005			
253	198.738	.005			
254	199.307	.005			
255	200.288	.005	.001	.015	
256	202.233	.005			.272
257	202.244	.005			.007
258	202.245	.005			.005
259	202.257	.005			.668
260	202.982	.005			.334
261	204.095	.005			.018
262	204.107	.005			.007
263	204.113	.005			.03
264	204.126	.005			.165
265	204.762	.005			.002
266	207.051	.005	.134	.703	
267	207.071	.005	.006	.143	
268	207.19	.005		.004	.004
269	207.639	.005			.041
270	207.782	.005			.012
271	207.79	.005		.002	.001
272	207.793	.005			.023
273	207.801	.005			.04
274	208.09	.005		.006	.001
275	208.686	.005	.008		
276	209.197	.005			.004
277	209.973	.005			
278	210.185	.005			.008
279	210.699	.005	.002		
280	211.428	.005	.069	.254	
281	211.741	.005		.001	.08
282	212.595	.005	.003	.141	
283	213.215	.005			.038
284	213.358	.005			
285	213.906	.005	.013	.04	.002
286	213.985	.005	.002	.006	.002
287	214.701	.005	.002	.002	.09
288	215.262	.005		.002	
289	216.216	.005	.007		.039
290	216.451	.005	.022	.001	
291	216.992	.005			.055
292	217.165	.005	.004		
293	217.293	.005			
294	217.53	.005	.004		.006
295	217.701	.005	.073		
296	218.141	.005	.001	.001	
297	219.583	.005	.001		
298	219.652	.005	.015	.003	
299	220.247	.005	.004	.001	.39
300	220.789	.005	.053	.014	.013
301	220.982	.005	.057	.006	

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
302	222.885	.004			
303	223.359	.004			.001
304	223.598	.004		.001	.003
305	224.025	.004			
306	224.42	.004	.001	.001	.021
307	225.237	.004			.03
308	225.864	.004	.086	.006	
309	227.923	.004			
310	228.262	.004	.002		
311	230.194	.004			
312	230.781	.004			
313	230.982	.004			
314	231.908	.004			.002
315	232.519	.004	.007		
316	232.535	.004	.002		.011
317	233	.004			.003
318	233.119	.004	.003		.007
319	233.418	.004	.005		.019
320	233.764	.004	.058	.005	
321	234.623	.004	1.074	.004	
322	235.106	.004	.973	.005	.001
323	235.352	.004	.191	.002	
324	236.261	.004	.068		.003
325	236.784	.004			
326	236.802	.004			
327	236.85	.004			
328	236.892	.004			
329	237.642	.004			
330	237.815	.004			.002
331	240.112	.004			.002
332	240.404	.004	.017		
333	240.993	.004			.004
334	241.072	.004			.013
335	241.135	.004			
336	246.383	.004	.003		.013
337	246.451	.004	.017		.027
338	246.634	.004	.025		.005
339	246.686	.004	.002		.009
340	246.729	.004			.088
341	247.097	.004	.346	.002	
342	247.452	.004	1.292	.006	
343	247.627	.004	.058		
344	248.044	.004	.007		.007
345	249.38	.004	.003		
346	252.325	.004	.086	.004	
347	254.595	.004			.013
348	254.978	.004	.091		
349	255.438	.004			.015
350	256.917	.004	.006		.002
351	257.128	.004	.06		.003
352	257.228	.004			
353	257.618	.004	.004		.067
354	258.204	.004			.059
355	258.366	.004			
356	260.092	.004			.002

Frequencies / Participation, (continued)

Mode Number	Frequency (Hz)	Period (Sec)	Percent Modal Participation X Spectra	Y Spectra	Z Spectra
357	260.612	.004	.006		
358	261.264	.004			
359	261.269	.004			
360	261.336	.004			
361	261.371	.004			
362	261.899	.004			.006
363	263.106	.004	.004		.009
364	263.451	.004	.001		.017
365	263.627	.004			.024
366	263.651	.004			
367	264.148	.004			.035
368	264.473	.004			.001
369	264.62	.004			.029
370	264.654	.004			.002
371	264.804	.004			.001
372	264.843	.004			
373	265.155	.004	.005		
374	265.862	.004	.032	.006	
375	266.17	.004	.012	.002	.003
376	266.528	.004	.001		.001
377	267.007	.004	.055	.003	
378	267.479	.004			.005
379	267.972	.004			.002
380	270.547	.004	.025		
381	270.884	.004	.14	.003	
382	271.07	.004	.01		
383	271.145	.004	.107	.001	
384	271.513	.004			
385	271.926	.004	.005		.003
386	271.978	.004			
387	272.049	.004	.002		
388	272.225	.004	.021	.001	.001
389	272.246	.004			
390	272.424	.004			.001
391	272.941	.004	.004		
392	273.365	.004			
393	273.459	.004	.002		
394	273.465	.004			.009
395	273.496	.004			.01
396	273.624	.004			.012
397	276.161	.004	.072	.007	
398	276.731	.004			.019
399	278.569	.004	.004		
400	278.863	.004	.003		
Totals :			91.701	90.098	93.52

CALCULATED BY	msp	**DATE** 15 NOV 2012		**JOB TITLE**	Robles HSB
CHECKED BY		**DATE**		**SUBJECT**	RC Design

CONCRETE BEAM OR SLAB DESIGN (MOMENT, SHEAR & TORSION)

BEAM NO: HSB Turndown Slab Edge

			As(max) =	40.45	in2	p=	0.02515
f'c =	**5**	ksi	As =	1.00	in2	p=	0.00062
fy =	**60**	ksi	As(min) =	4.84	in2	p=	0.00301
b =	**24**	"	oVc =	193.29	k		
d =	**67**	"	SHEAR :	OK			
Mu =	**300**	'k	Vs(req'd)=	0.00	k		
Vu =	**35**	k	Av/s =	0.000	in2		
Lt wt conc factor:			Av/s(min)=	0.000	in2		
NW=1, LW=.75	**1.00**		**Tcr =**	**0.00**	**'k**		
Tu =	**0.00**	'k	At/s =	0.000	in2		
h =	**72**	in	Av+2At/s =	0.000	in2		
NEGLECT TORSION			Av+2At(m)=	0.020	in2		
Dist to CL Tie =	**1.68**		Al/2 =	0.00	in2		
			As =	4.84	in2		

Note: for redistributed torsion design per ACI 11.6.2.2, set Tu equal to Tcr.

BEAM DESIGN

Longitudinal Steel	
Qty	**Bar Size**
25	#4
16	#5
11	#6
9	#7
7	#8
5	#9
4	#10
4	#11

SHEAR / TORSION DESIGN FOR BEAM

Transverse Steel Tie Spacings (inches)		
Bar Size	**Single tie**	**Double tie**
#3	0.0	0.0
#4	0.0	0.0
#5	0.0	0.0
#6	0.0	0.0

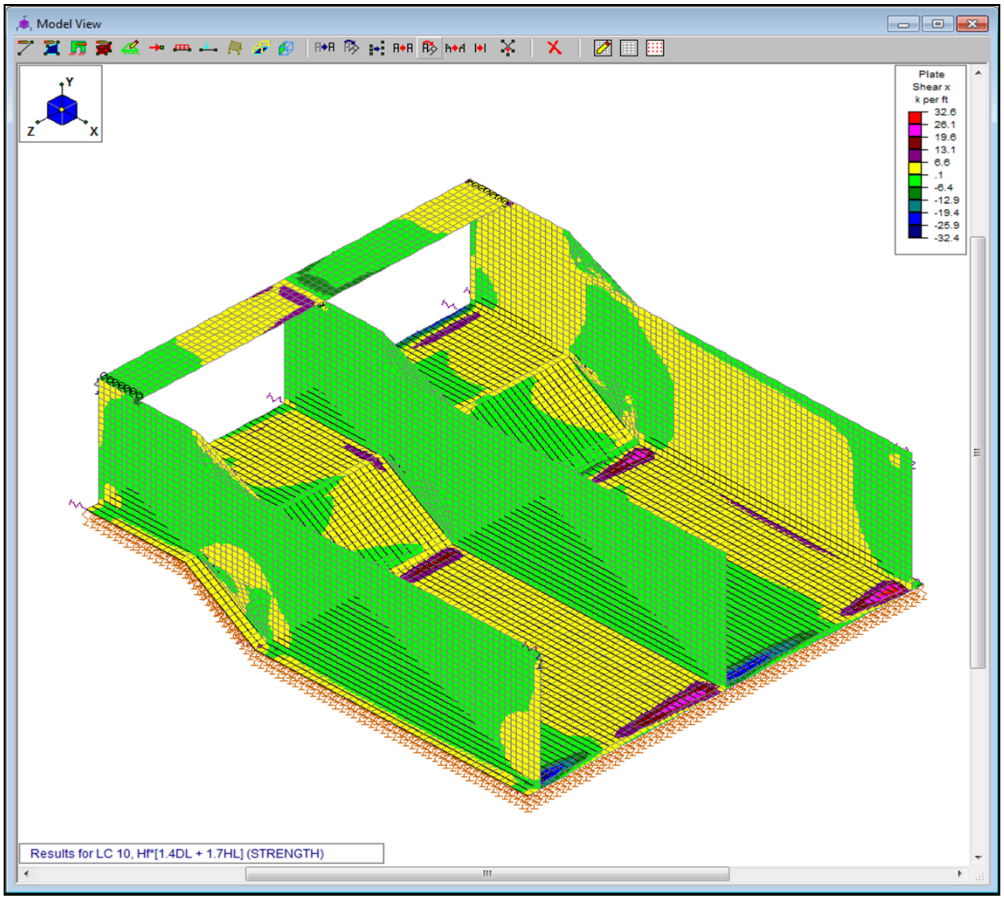
SLAB DESIGN

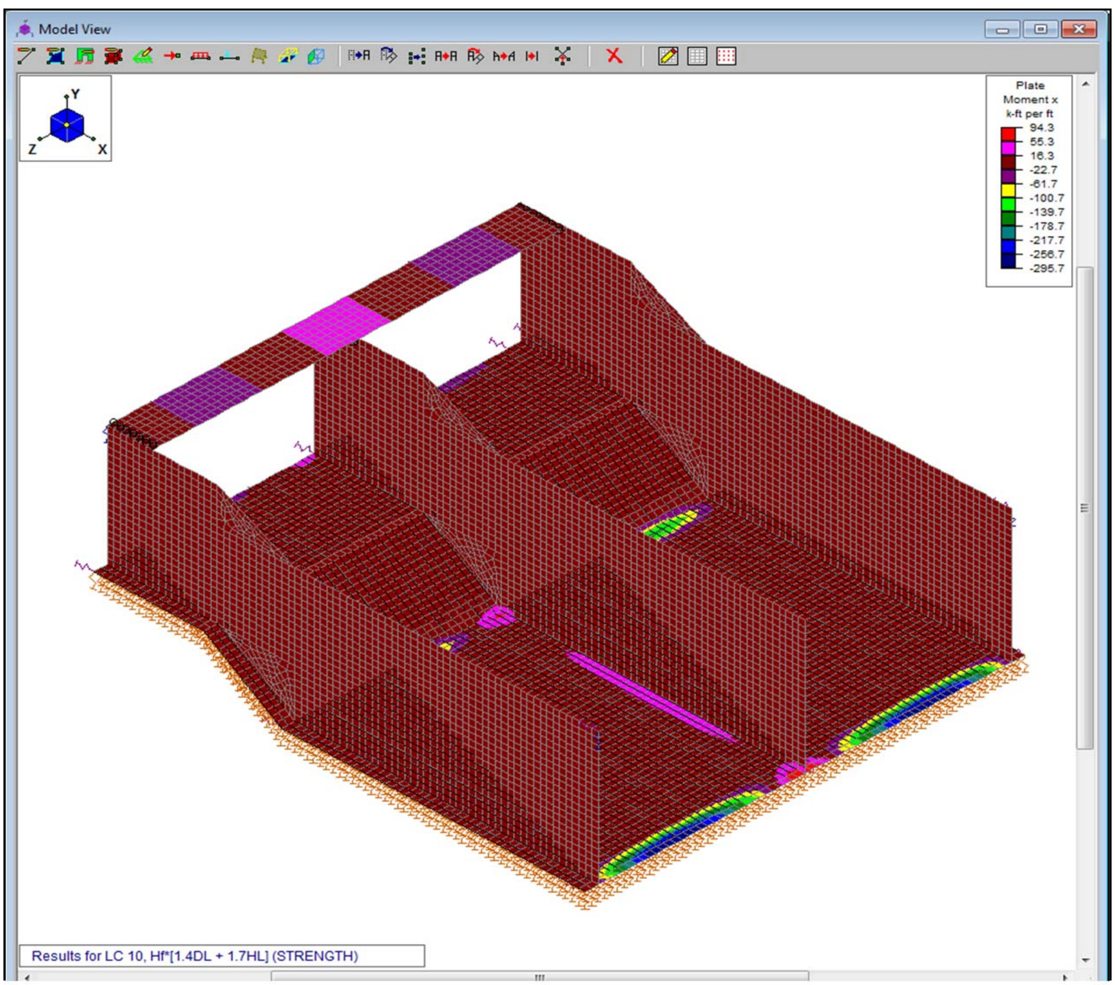
Bar Size	Spacing
#4	0.00
#5	1.00
#6	2.00
#7	2.00
#8	3.00

No Shear Reinf in wall or ftg per ACI 11.5.5

Provide 16#5 bars at turndown slab edge; temp controls; typical for all turndown edges at HSB; max loading is checked

HSB Turndown Slab Edge





CALCULATED BY	msp	**DATE**	15 NOV 2012	**JOB TITLE**	Robles HSB
CHECKED BY		**DATE**		**SUBJECT**	RC Design

CONCRETE BEAM OR SLAB DESIGN (MOMENT, SHEAR & TORSION)

BEAM NO: HSB 24" base slab

			As(max) =	6.34	in2	p=	0.02515
f'c =	5	ksi	As =	0.19	in2	p=	0.00075
fy =	60	ksi	As(min) =	0.81	in2	p=	0.00320
b =	12	"	oVc =	30.29	k		
d =	21	"	SHEAR :	OK			
Mu =	17.8	'k	Vs(req'd)=	0.00	k		
Vu =	6	k	Av/s =	0.000	in2		
Lt wt conc factor:			Av/s(min)=	0.000	in2		
NW=1, LW=.75	1.00		**Tcr =**	**0.00**	**'k**		
Tu =	0.00	'k	At/s =	0.000	in2		
h =	24	in	Av+2At/s =	0.000	in2		
NEGLECT TORSION			Av+2At(m)=	0.010	in2		
Dist to CL Tie =	1.68		Al/2 =	0.00	in2		
			As =	0.81	in2		

Note: for redistributed torsion design per ACI 11.6.2.2, set Tu equal to Tcr.

BEAM DESIGN

Longitudinal Steel	
Qty	**Bar Size**
5	#4
3	#5
2	#6
2	#7
2	#8
1	#9
1	#10
1	#11

SHEAR / TORSION DESIGN FOR BEAM

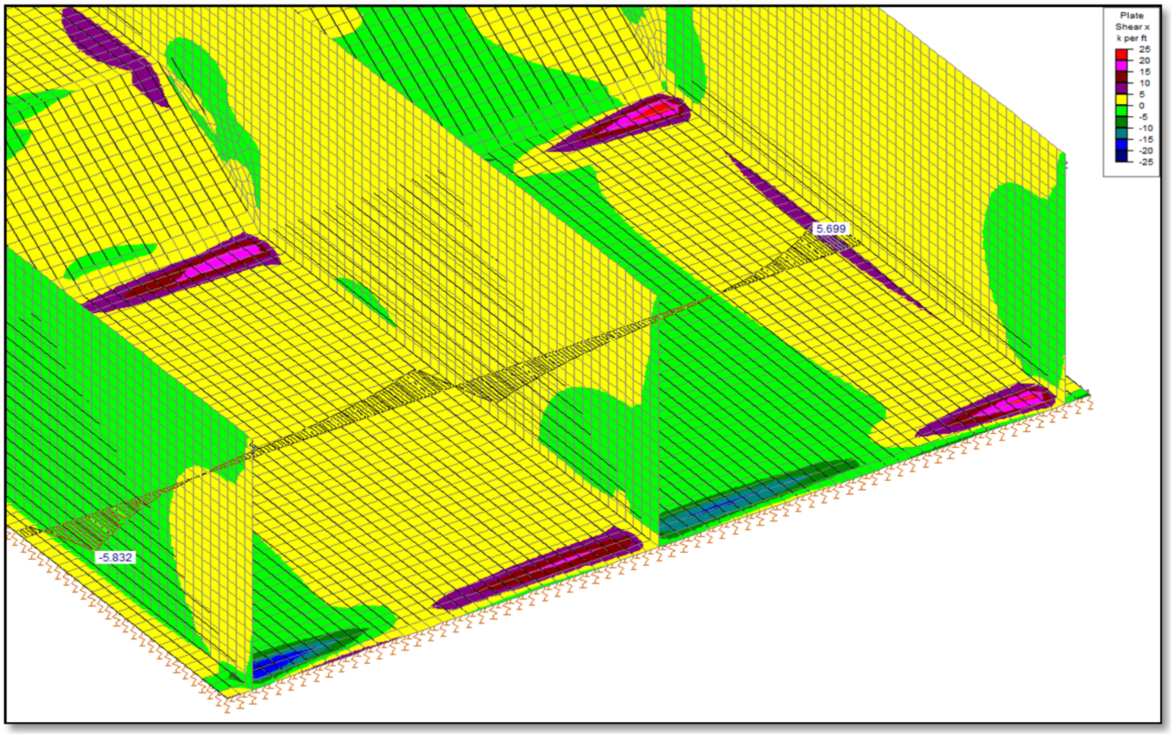
Transverse Steel Tie Spacings (inches)		
Bar Size	**Single tie**	**Double tie**
#3	0.0	0.0
#4	0.0	0.0
#5	0.0	0.0
#6	0.0	0.0

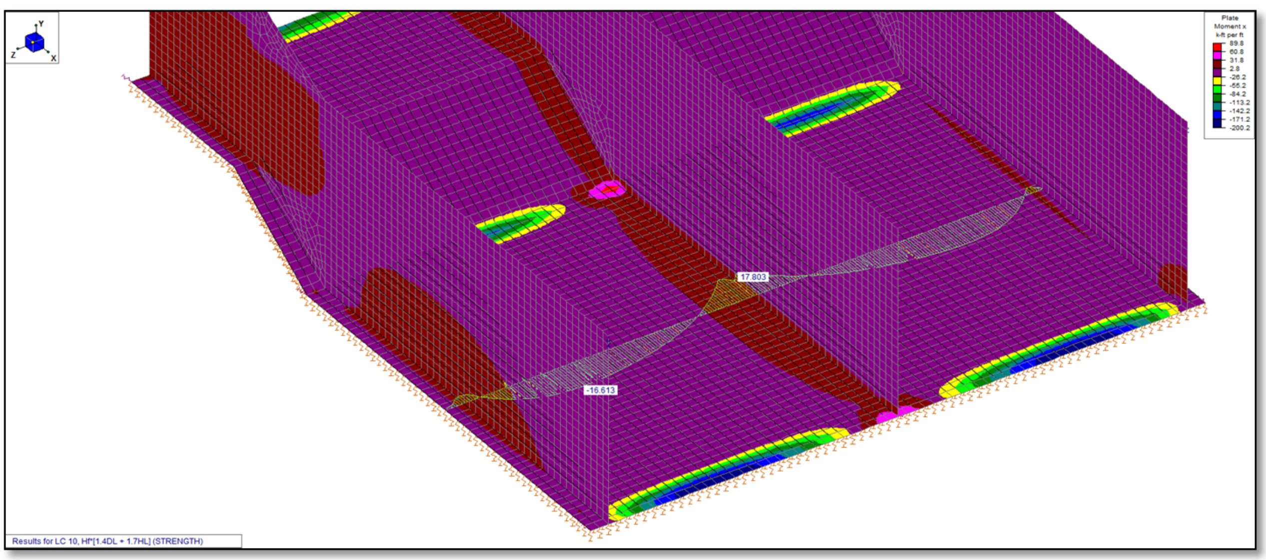
SLAB DESIGN

Bar Size	Spacing
#4	2.00
#5	4.00
#6	6.00
#7	8.00
#8	11.00

No Shear Reinf in wall or ftg per ACI 11.5.5

HSB 24" base slab





CALCULATED BY	msp	DATE	15 NOV 2012	JOB TITLE	Robles HSB
CHECKED BY		DATE		SUBJECT	RC Design

CONCRETE BEAM OR SLAB DESIGN (MOMENT, SHEAR & TORSION)

BEAM NO: HSB 18" Walkway Slab

			As(max) =	4.53	in2	p= 0.02515
f'c =	5	ksi	As =	1.25	in2	p= 0.00692
fy =	60	ksi	As(min) =	0.64	in2	p= 0.00354
b =	12	"	oVc =	21.64	k	
d =	15	"	SHEAR :	OK		
Mu =	79.937	'k	Vs(req'd)=	0.00	k	
Vu =	13.485	k	Av/s =	0.000	in2	
Lt wt conc factor:			Av/s(min)=	0.010	in2	
NW=1, LW=.75	1.00		**Tcr =**	**0.00**	**'k**	
Tu =	0.00	'k	At/s =	0.000	in2	
h =	18	in	Av+2At/s =	0.000	in2	
NEGLECT TORSION			Av+2At(m)=	0.010	in2	
Dist to CL Tie =	1.68		Al/2 =	0.00	in2	
			As =	1.25	in2	

Note: for redistributed torsion design per ACI 11.6.2.2, set Tu equal to Tcr.

BEAM DESIGN

Longitudinal Steel	
Qty	**Bar Size**
7	#4
5	#5
3	#6
3	#7
2	#8
2	#9
1	#10
1	#11

SHEAR / TORSION DESIGN FOR BEAM

Transverse Steel Tie Spacings (inches)

Bar Size	Single tie	Double tie
#3	7.0	7.0
#4	7.0	7.0
#5	7.0	7.0
#6	7.0	7.0

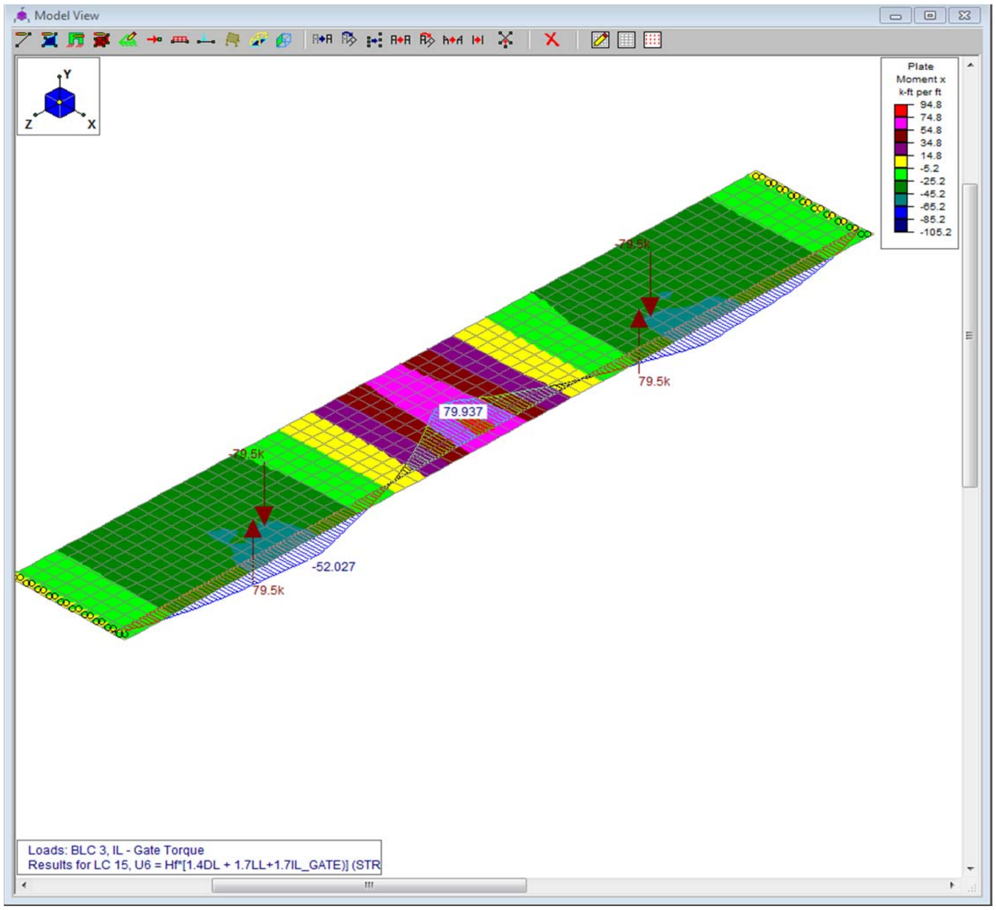
SLAB DESIGN

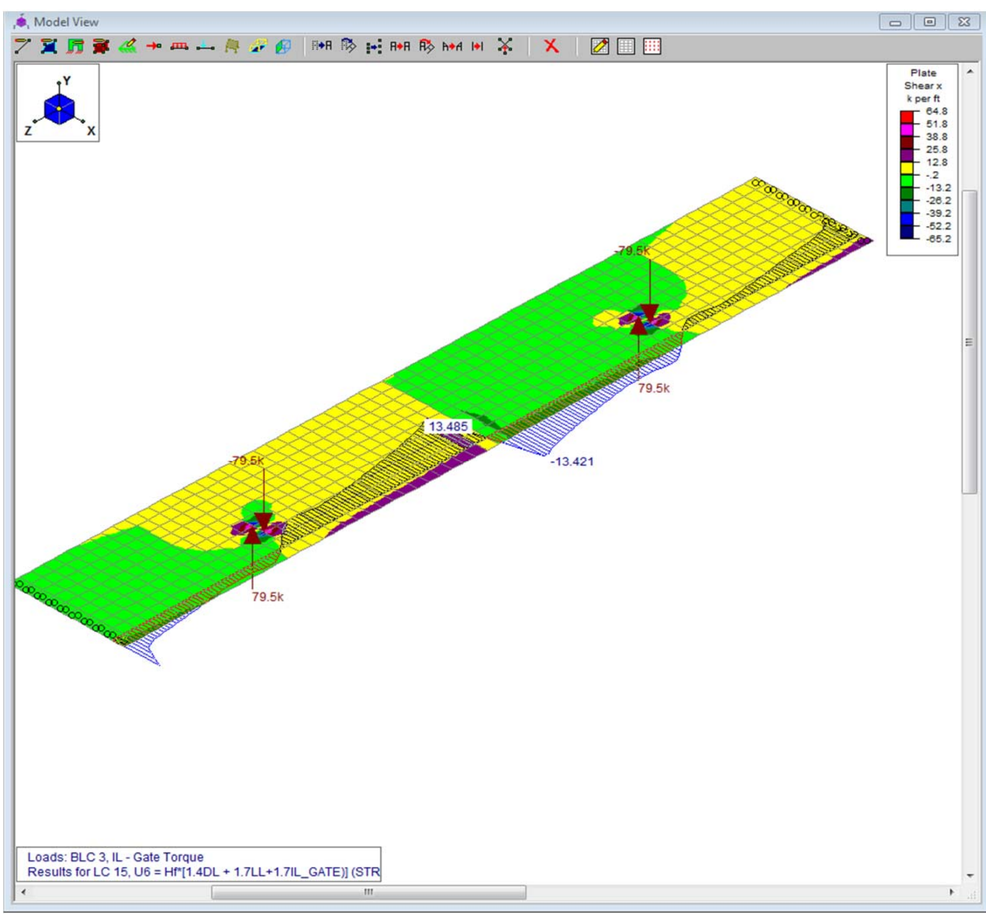
Bar Size	Spacing
#4	1.00
#5	2.00
#6	4.00
#7	5.00
#8	7.00

No Shear Reinf in wall or ftg per ACI 11.5.5

Provide 12#8 TOP & BOT
& #4 T1 TIES @ 6" O/C/

HSB 18" Walkway Slab





CALCULATED BY	msp	**DATE** 15 NOV 2012		**JOB TITLE**	Robles HSB
CHECKED BY		**DATE**		**SUBJECT**	RC Design

CONCRETE BEAM OR SLAB DESIGN (MOMENT, SHEAR & TORSION)

BEAM NO: HSB West Exterior Wall (Non-yielding backfill w/ EQ)

			As(max) =	6.34	in2	p=	0.02515
f'c =	**5**	ksi	As =	0.28	in2	p=	0.00110
fy =	**60**	ksi	As(min) =	0.81	in2	p=	0.00320
b =	**12**	"	oVc =	30.29	k		
d =	**21**	"	SHEAR :	OK			
Mu =	**25.991**	'k	Vs(req'd)=	0.00	k		
Vu =	**14.57**	k	Av/s =	0.000	in2		
Lt wt conc factor:			Av/s(min)=	0.000	in2		
NW=1, LW=.75	**1.00**		**Tcr =**	**0.00**	**'k**		
Tu =	**0.00**	'k	At/s =	0.000	in2		
h =	**24**	in	Av+2At/s =	0.000	in2		
NEGLECT TORSION			Av+2At(m)=	0.010	in2		
Dist to CL Tie =	**1.68**		Al/2 =	0.00	in2		
			As =	0.81	in2		

Note: for redistributed torsion design per ACI 11.6.2.2, set Tu equal to Tcr.

BEAM DESIGN

Longitudinal Steel	
Qty	**Bar Size**
5	#4
3	#5
2	#6
2	#7
2	#8
1	#9
1	#10
1	#11

SHEAR / TORSION DESIGN FOR BEAM

Transverse Steel Tie Spacings (inches)		
Bar Size	**Single tie**	**Double tie**
#3	0.0	0.0
#4	0.0	0.0
#5	0.0	0.0
#6	0.0	0.0

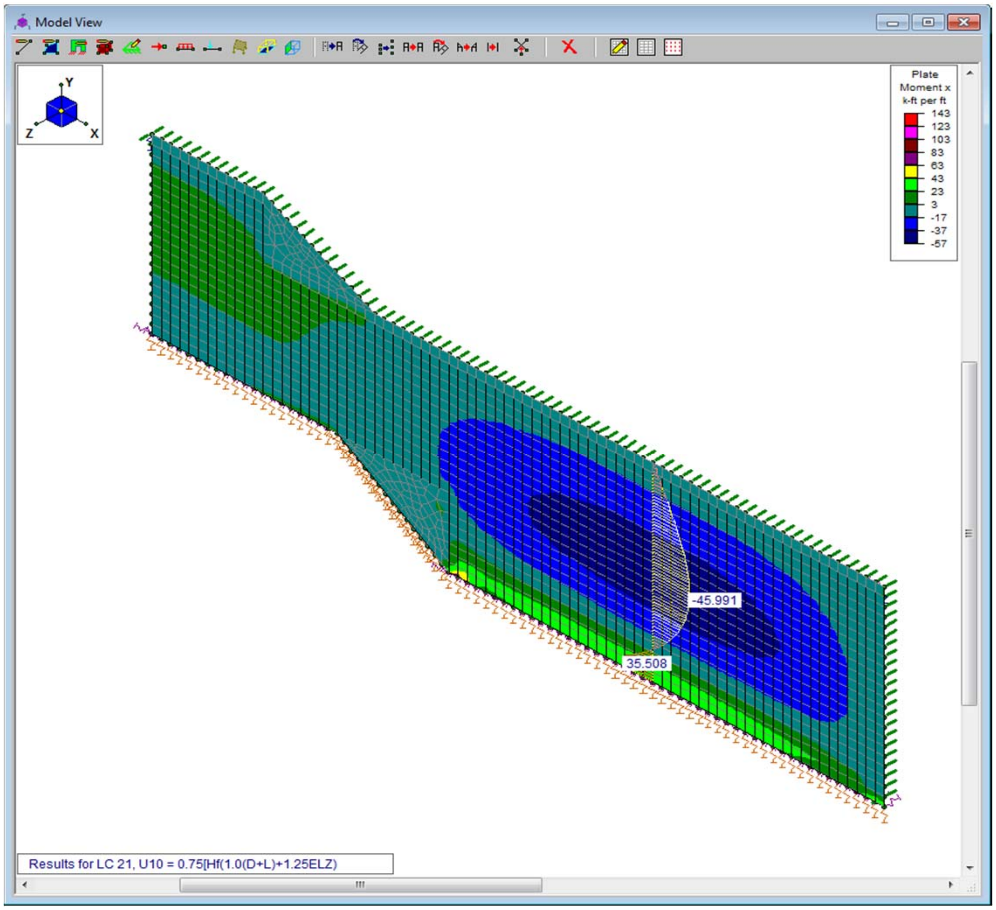
SLAB DESIGN

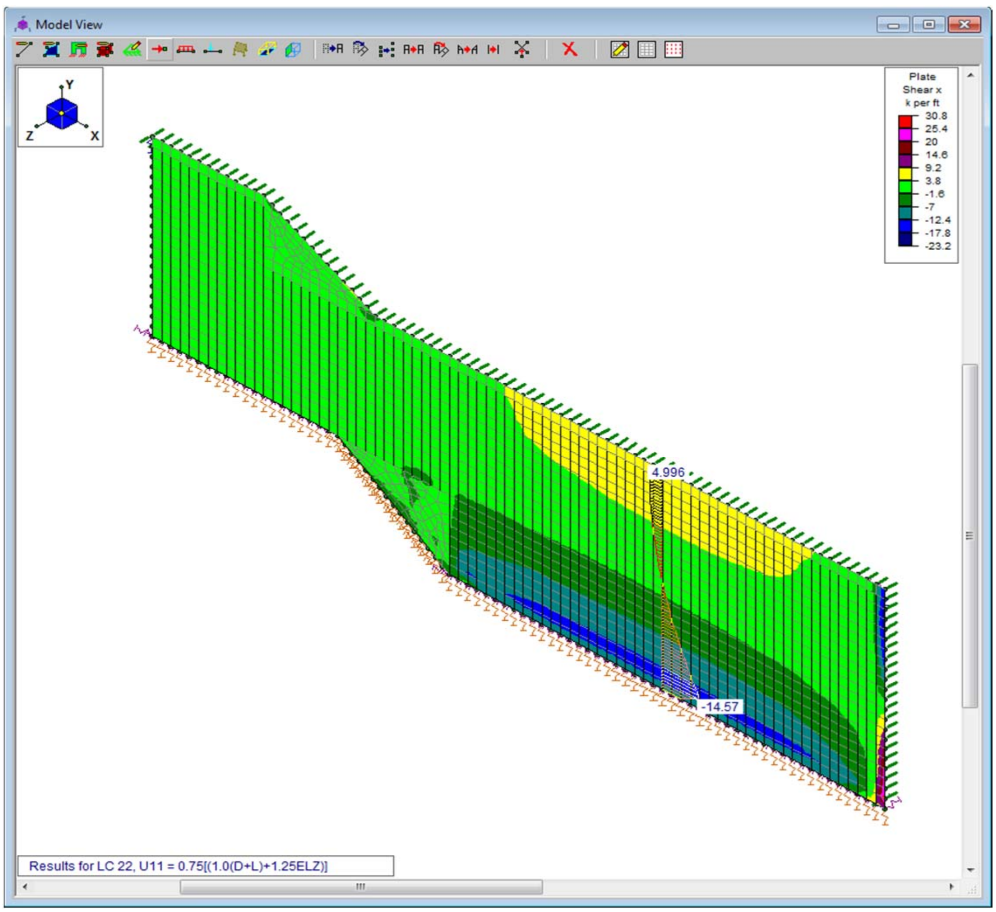
Bar Size	Spacing
#4	2.00
#5	4.00
#6	6.00
#7	8.00
#8	11.00

No Shear Reinf in wall or ftg per ACI 11.5.5

Provide #8@9" TOP & BOT per LC4a

HSB West Exterior Wall (Non-yielding backfill w/ EQ)





CALCULATED BY	msp	**DATE**	15 NOV 2012	**JOB TITLE**	Robles HSB
CHECKED BY		**DATE**		**SUBJECT**	RC Design

CONCRETE BEAM OR SLAB DESIGN (MOMENT, SHEAR & TORSION)

BEAM NO: HSB West Exterior Wall (Non-yielding backfill no EQ)

			As(max) =	6.34	in2	p=	0.02515
f'c =	**5**	ksi	As =	0.95	in2	p=	0.00377
fy =	**60**	ksi	As(min) =	0.89	in2	p=	0.00354
b =	**12**	"	oVc =	30.29	k		
d =	**21**	"	SHEAR :	OK			
Mu =	**87.25**	'k	Vs(req'd)=	0.00	k		
Vu =	**26.941**	k	Av/s =	0.000	in2		
Lt wt conc factor:			Av/s(min)=	0.010	in2		
NW=1, LW=.75	**1.00**		**Tcr =**	**0.00**	**'k**		
Tu =	**0.00**	'k	At/s =	0.000	in2		
h =	**24**	in	Av+2At/s =	0.000	in2		
NEGLECT TORSION			Av+2At(m):	0.010	in2		
Dist to CL Tie =	**1.68**		Al/2 =	0.00	in2		
			As =	0.95	in2		

Note: for redistributed torsion design per ACI 11.6.2.2, set Tu equal to Tcr.

BEAM DESIGN

Longitudinal Steel	
Qty	**Bar Size**
5	#4
4	#5
3	#6
2	#7
2	#8
1	#9
1	#10
1	#11

SHEAR / TORSION DESIGN FOR BEAM

Transverse Steel Tie Spacings (inches)		
Bar Size	**Single tie**	**Double tie**
#3	10.0	10.0
#4	10.0	10.0
#5	10.0	10.0
#6	10.0	10.0

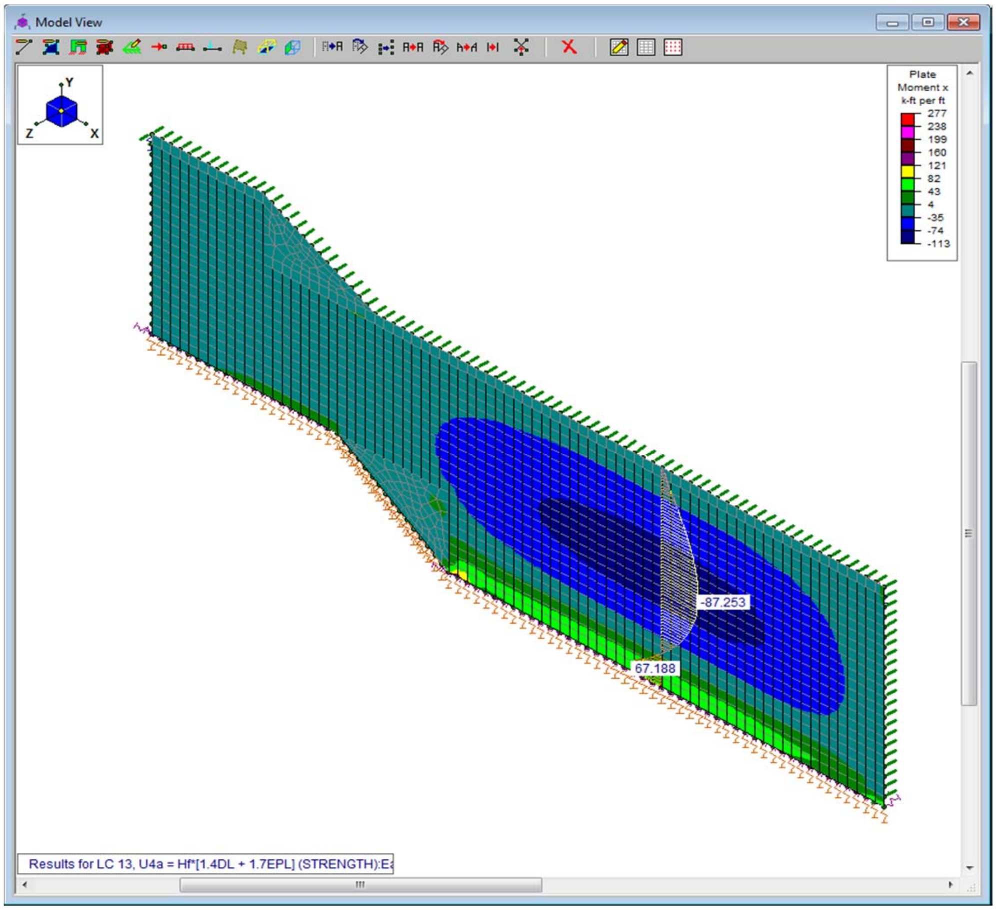
SLAB DESIGN

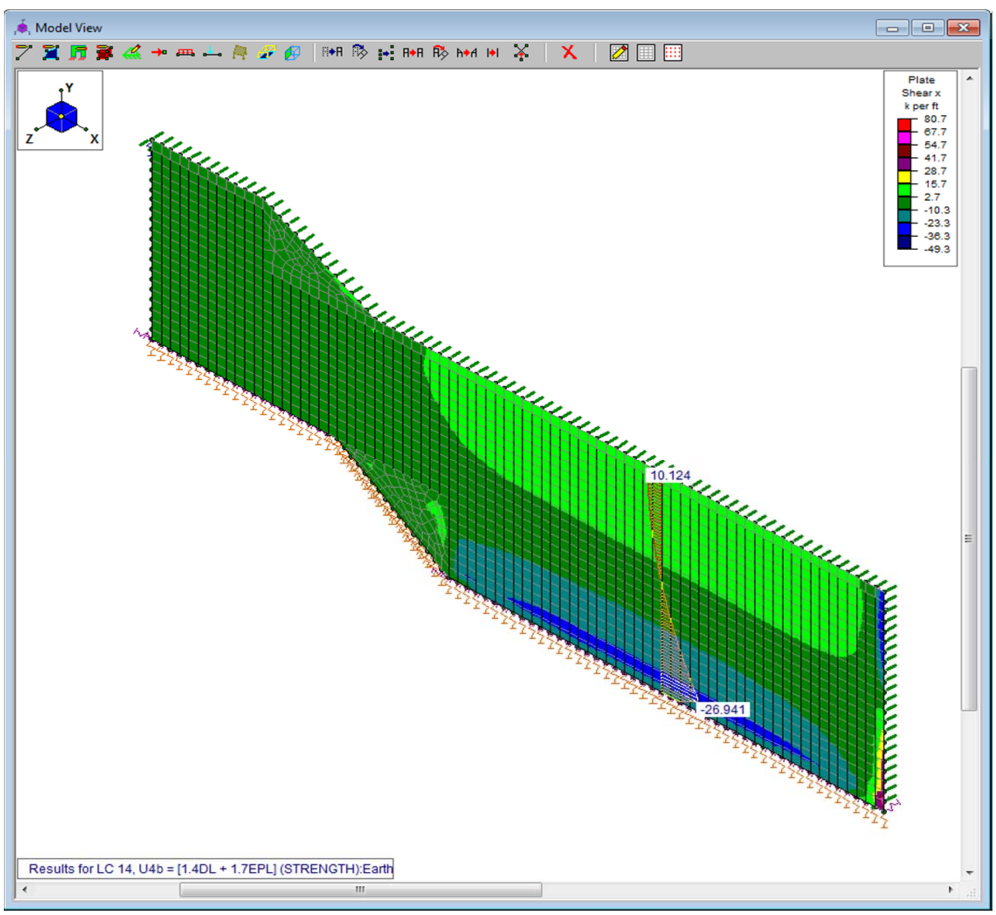
Bar Size	Spacing
#4	2.00
#5	3.00
#6	5.00
#7	7.00
#8	9.00

No Shear Reinf in wall or ftg per ACI 11.5.5

Provide #8@9" TOP & BOT per LC4a

HSB West Exterior Wall (Non-yielding backfill no EQ)





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Cantilevered Retaining Wall Design

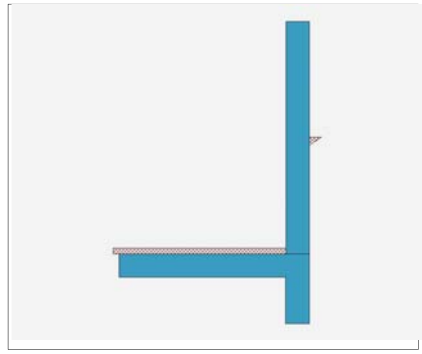
Code: IBC 2009,ACI 318-08,ACI 530-08

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	10.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	92.4 psf/ft
	=	
Passive Pressure	=	450.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	0.00 pcf
Footing||Soil Friction	=	0.550
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

Surcharge Over Heel	=	100.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Axial Load Applied to Stem

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

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
The above lateral load has been increased by a factor of		1.00
Wind on Exposed Stem	=	20.0 psf

Wind acts left-to-right toward retention side.

Adjacent Footing Load

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

Design Summary

Wall Stability Ratios

Overturning	=	4.17	OK

Slab Resists All Sliding !

Total Bearing Load	=	12,000 lbs	
...resultant ecc.	=	15.27 in	
Soil Pressure @ Toe	=	392 psf	OK
Soil Pressure @ Heel	=	1,108 psf	OK
Allowable	=	4,000 psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	470 psf	
ACI Factored @ Heel	=	1,330 psf	
Footing Shear @ Toe	=	16.8 psi	OK
Footing Shear @ Heel	=	0.0 psi	OK
Allowable	=	75.0 psi	

Sliding Calcs Slab Resists All Sliding !

Lateral Sliding Force	=	7,705.7 lbs

Stem Construction

Top Stem

		Stem OK
Design Height Above Ftg	ft =	0.00
Wall Material Above "Ht"	=	Concrete
Thickness	=	24.00
Rebar Size	=	# 8
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge
Design Data		
fb/FB + fa/Fa	=	**0.470**
Total Force @ Section	lbs =	8,849.2
Moment....Actual	ft-# =	35,126.2
Moment.....Allowable	=	74,775.5
Shear.....Actual	psi =	34.3
Shear.....Allowable	psi =	106.1
Wall Weight	=	300.0
Rebar Depth 'd'	in =	21.50
LAP SPLICE IF ABOVE	in =	33.26
LAP SPLICE IF BELOW	in =	
HOOK EMBED INTO FTG	in =	16.80

Masonry Data

f'm	psi =	
Fs	psi =	
Solid Grouting	=	
Use Half Stresses	=	
Modular Ratio 'n'	=	
Short Term Factor	=	
Equiv. Solid Thick.	=	
Masonry Block Type	=	Medium Weight
Masonry Design Method	=	ASD

Concrete Data

f'c	psi =	5,000.0
Fy	psi =	60,000.0

Load Factors

Building Code	IBC 2009,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Cantilevered Retaining Wall Design

Code: IBC 2009,ACI 318-08,ACI 530-08

Footing Dimensions & Strengths

Toe Width	=	14.00 ft
Heel Width	=	2.00
Total Footing Width	=	16.00
Footing Thickness	=	24.00 in
Key Width	=	24.00 in
Key Depth	=	48.00 in
Key Distance from Toe	=	14.00 ft

f'c = 2,500 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0028
Cover @ Top 3.00 @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel
Factored Pressure	=	470	1,330 psf
Mu' : Upward	=	70,662	0 ft-#
Mu' : Downward	=	42,924	0 ft-#
Mu: Design	=	27,738	0 ft-#
Actual 1-Way Shear	=	16.81	0.00 psi
Allow 1-Way Shear	=	75.00	0.00 psi

Toe Reinforcing = # 8 @ 12.00 in
Heel Reinforcing = # 8 @ 12.00 in
Key Reinforcing = None Spec'd

Other Acceptable Sizes & Spacings

Toe: #4@ 3.00 in, #5@ 4.75 in, #6@ 6.75 in, #7@ 9.00 in, #8@ 12.00 in, #9@ 15.00
Heel: Not req'd, Mu < S * Fr
Key: Slab Resists Sliding - No Force on Key

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	6,652.8	4.00	26,611.2
Surcharge over Heel	=	852.9	6.00	5,117.5
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=	200.0	17.00	3,400.0
	=			
Total		7,705.7	**O.T.M.**	35,128.7

Resisting/Overturning Ratio = **4.17**
Vertical Loads used for Soil Pressure = 12,000.0 lbs

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=		16.00	
Sloped Soil Over Heel	=			
Surcharge Over Heel	=		16.00	
Adjacent Footing Load	=			
Axial Dead Load on Stem	=			
* Axial Live Load on Stem	=			
Soil Over Toe	=		7.00	
Surcharge Over Toe	=			
Stem Weight(s)	=	6,000.0	15.00	90,000.0
Earth @ Stem Transitions	=			
Footing Weight	=	4,800.0	8.00	38,400.0
Key Weight	=	1,200.0	15.00	18,000.0
Vert. Component	=			
Total =		12,000.0 lbs	**R.M.=**	146,400.0

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

DESIGNER NOTES:

Title : **HSB West no Eh; saturated soil** Page: ______
Job # : **200-01297** Dsgnr: **msp** Date: 25 JAN 2013
Description....
West HSB Wall no EQ

This Wall in File: C:\Users\matt.petaja\Documents\2 - TEMP\Ro

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Restrained Retaining Wall Design

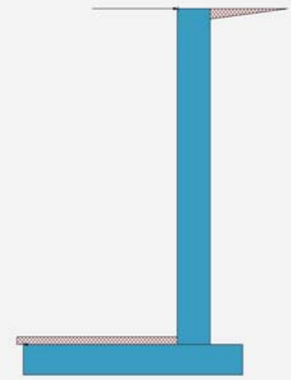
Code: AASHTO LRFD

Criteria

Retained Height	=	22.00 ft
Wall height above soil	=	0.00 ft
Total Wall Height	=	22.00 ft
Top Support Height	=	22.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	92.4 psf/ft
	=	
Passive Pressure	=	312.4 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Frictior	=	0.400
Soil height to ignore for passive pressure	=	12.00 in



Thumbnail

Surcharge Loads

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

Axial Load Applied to Stem

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

Uniform Lateral Load Applied to Stem

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

Adjacent Footing Load

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

Earth Pressure Seismic Load

K_h Soil Density Multiplier = 0.422 g Added seismic per unit area = 0.0 psf

Stem Weight Seismic Load

F_p / W_p Weight Multiplier = 0.422 g Added seismic per unit area = 0.0 psf

Seismic Self-Weight acts left-to-right toward retention side.

Design Summary

Total Bearing Load	=	21,280 lbs	
...resultant ecc.	=	13.24 in	
Soil Pressure @ Toe	=	764 psf	OK
Soil Pressure @ Heel	=	1,739 psf	OK
Allowable	=	4,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	955 psf	
ACI Factored @ Heel	=	2,174 psf	
Footing Shear @ Toe	=	47.7 psi	OK
Footing Shear @ Heel	=	19.0 psi	OK
Allowable	=	106.1 psi	
Reaction at Top	=	4,472.1 lbs	
Reaction at Bottom	=	22,139.1 lbs	

Sliding Calcs Slab Resists All Sliding !
Lateral Sliding Force = 22,139.1 lbs

Concrete Stem Construction

Thickness	=	30.00 in	Fy	=	60,000 psi
Wall Weight	=	375.0 psf	f'c	=	5,000 psi

Stem is FIXED to top of footing

		@ Top Support	Mmax Between Top & Base	@ Base of Wall
		Stem OK	Stem OK	Stem OK
Design Height Above Ftg	=	22.00 ft	12.19 ft	0.00 ft
Rebar Size	=	# 9	# 9	# 9
Rebar Spacing	=	10.00 in	10.00 in	10.00 in
Rebar Placed at	=	Edge	Edge	Edge
Rebar Depth 'd'	=	26.50 in	26.50 in	26.50 in
Design Data				
fb/FB + fa/Fa	=	0.000	0.369	0.824
Mu....Actual	=	0.0 ft-#	51,333.1 ft-#	114787.8 ft-#
Mn * Phi.....Allowable	=	139276.8 ft-#	139276.8 ft-#	139276.8 ft-#
Shear Force @ this height	=	7,826.2 lbs		31,305.2 lbs
Shear.....Actual	=	24.61 psi		98.44 psi
Shear.....Allowable	=	141.42 psi		106.07 psi
Rebar Lap Required	=	37.23 in	37.23 in	
Hooked embedment into footing			=	13.36 in

Other Acceptable Sizes & Spacings:

Toe: # 8 @ 12.00 in	-or-	#4@ 3.00 in, #5@ 4.75 in, #6@ 6.75 in, #7@ 9.00 in
Heel: # 8 @ 12.00 in	-or-	Not req'd, Mu < S * Fr
Key: No key defined	-or-	No key defined

Load Factors

Building Code	AASHTO LRFD
Dead Load	1.250
Live Load	1.500
Earth, H	1.750
Wind, W	1.400
Seismic, E	1.000

Restrained Retaining Wall Design

Code: AASHTO LRFD

Footing Strengths & Dimensions

Toe Width	=	12.00 ft
Heel Width	=	5.00
Total Footing Width	=	17.00
Footing Thickness	=	24.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	2.00 ft

f'c = 5,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0028
Cover @ Top = 3.00 in @ Btm.= 4.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	955	2,174	psf
Mu' : Upward	=	0	12,468	ft-#
Mu' : Downward	=	0	19,287	ft-#
Mu: Design	=	52,689	6,819	ft-#
Actual 1-Way Shear	=	47.65	18.96	psi
Allow 1-Way Shear	=	106.07	106.07	psi

Summary of Forces on Footing : Slab RESISTS sliding, stem is FIXED at footing

Forces acting on footing for soil pressure

>>> Sliding Forces are restrained by the adjacent slab

Load & Moment Summary For Footing : For Soil Pressure Calcs

Moment @ Top of Footing Applied from Stem			=	-65,593.0 ft-#
Surcharge Over Heel	=	lbs	ft	ft-#
Adjacent Footing Load	=	lbs	ft	ft-#
Axial Dead Load on Stem	=	lbs	ft	ft-#
Soil Over Toe	=	780.0 lbs	6.00 ft	4,680.0 ft-#
Surcharge Over Toe	=	lbs	ft	ft-#
Stem Weight	=	8,250.0 lbs	13.25 ft	109,312.5 ft-#
Soil Over Heel	=	7,150.0 lbs	15.75 ft	112,612.5 ft-#
Footing Weight	=	5,100.0 lbs	8.50 ft	43,350.0 ft-#
Total Vertical Force	=	21,280.0 lbs	Base Moment =	204,362.0 ft-#

Soil Pressure Resulting Moment = -23,482.0 ft-#

DESIGNER NOTES:

Cantilevered Retaining Wall Design

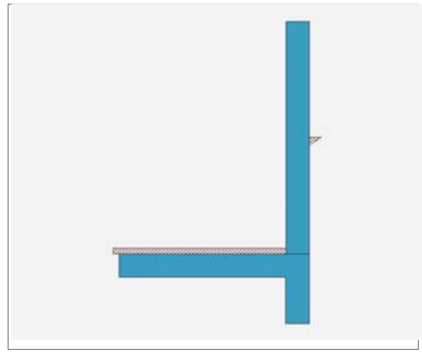
Code: IBC 2009,ACI 318-08,ACI 530-08

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	10.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Coulomb Soil Pressure calculation		
Soil Friction Angle	=	30.0 deg
Active Pressure:Ka*Gamma	=	37.8 psf/ft
Passive Pressure:Kp*Gar	=	390.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	0.00 pcf
Footing||Soil Friction	=	0.550
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

Surcharge Over Heel	=	100.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Axial Load Applied to Stem

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

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
The above lateral load has been increased by a factor of		1.00
Wind on Exposed Stem	=	20.0 psf

Wind acts left-to-right toward retention side.

Adjacent Footing Load

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

Earth Pressure Seismic Load

Design Kh	=	0.212 g
Kae for seismic earth pressure	=	0.448
Ka for static earth pressure	=	0.291
Difference: Kae - Ka	=	0.157

Using Mononobe-Okabe / Seed-Whitman procedure

Added seismic base force 1,026.8 lbs

Stem Weight Seismic Load

F_p / W_p Weight Multiplier = 0.212 g

Added seismic base force 908.6 lbs

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Cantilevered Retaining Wall Design

Code: IBC 2009,ACI 318-08,ACI 530-08

Design Summary

Wall Stability Ratios

Overturning	=	5.25	OK

Slab Resists All Sliding !

Total Bearing Load	=	12,000 lbs	
...resultant ecc.	=	22.51 in	
Soil Pressure @ Toe	=	222 psf	OK
Soil Pressure @ Heel	=	1,278 psf	OK
Allowable	=	4,000 psf	

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	267 psf	
ACI Factored @ Heel	=	1,533 psf	
Footing Shear @ Toe	=	14.5 psi	OK
Footing Shear @ Heel	=	0.0 psi	OK
Allowable	=	75.0 psi	

Sliding Calcs Slab Resists All Sliding !

Lateral Sliding Force	=	4,809.9 lbs

Load Factors

Building Code	IBC 2009,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

Top Stem

			Stem OK
Design Height Above Ftg	ft	=	0.00
Wall Material Above "Ht"		=	Concrete
Thickness		=	24.00
Rebar Size		=	# 8
Rebar Spacing		=	12.00
Rebar Placed at		=	Edge

Design Data

fb/FB + fa/Fa		=	**0.354**
Total Force @ Section	lbs	=	5,464.4
Moment....Actual	ft-#	=	26,454.4
Moment.....Allowable		=	74,775.5
Shear.....Actual	psi	=	17.2
Shear.....Allowable	psi	=	106.1
Wall Weight		=	300.0
Rebar Depth 'd'	in	=	21.50
LAP SPLICE IF ABOVE	in	=	33.26
LAP SPLICE IF BELOW	in	=	
HOOK EMBED INTO FTG	in	=	16.80

Masonry Data

f'm	psi	=	
Fs	psi	=	
Solid Grouting		=	
Use Half Stresses		=	
Modular Ratio 'n'		=	
Short Term Factor		=	
Equiv. Solid Thick.		=	
Masonry Block Type		=	Medium Weight
Masonry Design Method		=	ASD

Concrete Data

f'c	psi	=	5,000.0
Fy	psi	=	60,000.0

Footing Dimensions & Strengths

Toe Width	=	14.00 ft
Heel Width	=	2.00
Total Footing Width	=	16.00
Footing Thickness	=	24.00 in
Key Width	=	24.00 in
Key Depth	=	48.00 in
Key Distance from Toe	=	14.00 ft

f'c = 2,500 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0028
Cover @ Top 3.00 @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel
Factored Pressure	=	267	1,533 psf
Mu' : Upward	=	62,352	0 ft-#
Mu' : Downward	=	42,924	0 ft-#
Mu: Design	=	19,428	0 ft-#
Actual 1-Way Shear	=	14.45	0.00 psi
Allow 1-Way Shear	=	75.00	0.00 psi
Toe Reinforcing	=	# 8 @ 12.00 in	
Heel Reinforcing	=	# 8 @ 12.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: #4@ 3.00 in, #5@ 4.75 in, #6@ 6.75 in, #7@ 9.00 in, #8@ 12.00 in, #9@ 15.00
Heel: Not req'd, Mu < S * Fr
Key: Slab Resists Sliding - No Force on Key

Cantilevered Retaining Wall Design

Code: IBC 2009,ACI 318-08,ACI 530-08

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	2,725.1	4.00	10,900.5
Surcharge over Heel	=	349.4	6.00	2,096.3
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=	-200.0	17.00	-3,400.0
Seismic Earth Load	=	1,026.8	7.20	7,393.3
Seismic Stem Self Wt	=	908.6	12.00	15,264.0
Total		4,809.9	**O.T.M.**	27,892.9
	=		=	

Resisting/Overturning Ratio = **5.25**
Vertical Loads used for Soil Pressure = 12,000.0 lbs

If seismic included the min. OTM and sliding ratios may be 1.1 per IBC '09, 1807.2.3.

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=		16.00	
Sloped Soil Over Heel	=			
Surcharge Over Heel	=		16.00	
Adjacent Footing Load	=			
Axial Dead Load on Stem	=			
* Axial Live Load on Stem	=			
Soil Over Toe	=		7.00	
Surcharge Over Toe	=			
Stem Weight(s)	=	6,000.0	15.00	90,000.0
Earth @ Stem Transitions	=			
Footing Weight	=	4,800.0	8.00	38,400.0
Key Weight	=	1,200.0	15.00	18,000.0
Vert. Component	=			
Total =		12,000.0 lbs	**R.M.=**	146,400.0

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

DESIGNER NOTES:

Restrained Retaining Wall Design

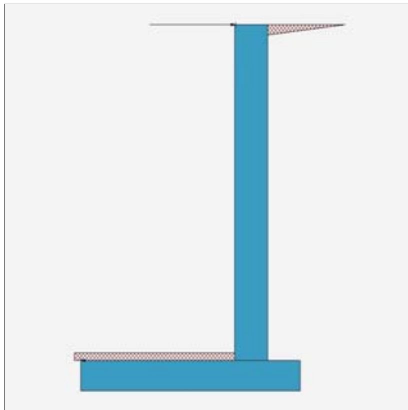
Code: IBC 2006,ACI 318-05,ACI 530-05

Criteria

Retained Height	=	22.00 ft
Wall height above soil	=	0.00 ft
Total Wall Height	=	22.00 ft
Top Support Height	=	22.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	55.0 psf/ft
	=	
Passive Pressure	=	450.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Frictior	=	0.400
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

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

Axial Load Applied to Stem

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

Uniform Lateral Load Applied to Stem

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

Adjacent Footing Load

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

Earth Pressure Seismic Load

K_h Soil Density Multiplier = 0.212 g Added seismic per unit area = 424.4 psf

Stem Weight Seismic Load

F_p / W_p Weight Multiplier = 0.212 g Added seismic per unit area = 79.5 psf

Seismic Self-Weight acts left-to-right toward retention side.

Design Summary

Total Bearing Load	=	21,280 lbs	
...resultant ecc.	=	11.02 in	
Soil Pressure @ Toe	=	846 psf	OK
Soil Pressure @ Heel	=	1,658 psf	OK
Allowable	=	4,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,015 psf	
ACI Factored @ Heel	=	1,989 psf	
Footing Shear @ Toe	=	47.2 psi	OK
Footing Shear @ Heel	=	19.1 psi	OK
Allowable	=	106.1 psi	
Reaction at Top	=	6,819.3 lbs	
Reaction at Bottom	=	20,107.0 lbs	

Sliding Calcs Slab Resists All Sliding !
Lateral Sliding Force = 20,107.0 lbs

Concrete Stem Construction

Thickness	=	30.00 in	Fy	=	60,000 psi
Wall Weight	=	375.0 psf	f'c	=	5,000 psi

Stem is FIXED to top of footing

		@ Top Support	Mmax Between Top & Base	@ Base of Wall
		Stem OK	Stem OK	Stem OK
Design Height Above Ftg	=	22.00 ft	12.90 ft	0.00 ft
Rebar Size	=	# 9	# 9	# 9
Rebar Spacing	=	10.00 in	10.00 in	10.00 in
Rebar Placed at	=	Edge	Edge	Edge
Rebar Depth 'd'	=	26.50 in	26.50 in	26.50 in
Design Data				
fb/FB + fa/Fa	=	0.000	0.365	0.746
Mu....Actual	=	0.0 ft-#	50,798.0 ft-#	103961.9 ft-#
Mn * Phi.....Allowable	=	139276.8 ft-#	139276.8 ft-#	139276.8 ft-#
Shear Force @ this height	=	9,917.1 lbs		26,466.9 lbs
Shear.....Actual	=	31.19 psi		83.23 psi
Shear.....Allowable	=	141.42 psi		106.07 psi
Rebar Lap Required	=	37.23 in	37.23 in	
Hooked embedment into footing			=	13.36 in

Other Acceptable Sizes & Spacings:

Toe: # 8 @ 12.00 in	-or-	#4@ 3.00 in, #5@ 4.75 in, #6@ 6.75 in, #7@ 9.00 in
Heel: # 8 @ 12.00 in	-or-	Not req'd, Mu < S * Fr
Key: No key defined	-or-	No key defined

Load Factors

Building Code	IBC 2006,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Restrained Retaining Wall Design

Code: IBC 2006,ACI 318-05,ACI 530-05

Footing Strengths & Dimensions

Toe Width	=	12.00 ft
Heel Width	=	5.00
Total Footing Width	=	17.00
Footing Thickness	=	24.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	2.00 ft

f'c = 5,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0028
Cover @ Top = 3.00 in @ Btm.= 4.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	1,015	1,989	psf
Mu' : Upward	=	0	11,192	ft-#
Mu' : Downward	=	0	18,516	ft-#
Mu: Design	=	21,975	7,323	ft-#
Actual 1-Way Shear	=	47.23	19.05	psi
Allow 1-Way Shear	=	106.07	106.07	psi

Summary of Forces on Footing : Slab RESISTS sliding, stem is FIXED at footing

Forces acting on footing for soil pressure

>>> Sliding Forces are restrained by the adjacent slab

Load & Moment Summary For Footing : For Soil Pressure Calcs

Moment @ Top of Footing Applied from Stem		=		-69,531.1 ft-#
Surcharge Over Heel	=	lbs	ft	ft-#
Adjacent Footing Load	=	lbs	ft	ft-#
Axial Dead Load on Stem	=	lbs	ft	ft-#
Soil Over Toe	=	780.0 lbs	6.00 ft	4,680.0 ft-#
Surcharge Over Toe	=	lbs	ft	ft-#
Stem Weight	=	8,250.0 lbs	13.25 ft	109,312.5 ft-#
Soil Over Heel	=	7,150.0 lbs	15.75 ft	112,612.5 ft-#
Footing Weight	=	5,100.0 lbs	8.50 ft	43,350.0 ft-#
Total Vertical Force	=	21,280.0 lbs	Base Moment =	200,423.9 ft-#

Soil Pressure Resulting Moment = -19,543.9 ft-#

DESIGNER NOTES:

Cantilevered Retaining Wall Design

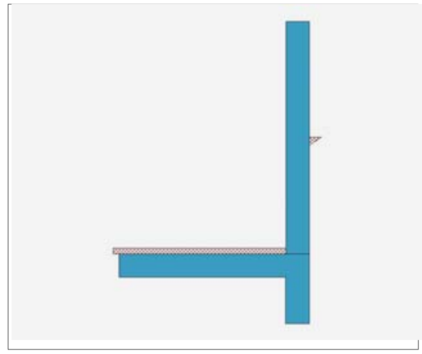
Code: IBC 2009,ACI 318-08,ACI 530-08

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	10.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Coulomb Soil Pressure calculation		
Soil Friction Angle	=	30.0 deg
Active Pressure:Ka*Gamma	=	37.8 psf/ft
Passive Pressure:Kp*Gar	=	390.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	0.00 pcf
Footing||Soil Friction	=	0.550
Soil height to ignore for passive pressure	=	12.00 in



Surcharge Loads

Surcharge Over Heel	=	100.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Axial Load Applied to Stem

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

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft
The above lateral load has been increased by a factor of		1.00
Wind on Exposed Stem	=	20.0 psf

Wind acts left-to-right toward retention side.

Adjacent Footing Load

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

Earth Pressure Seismic Load

Design Kh	=	0.422 g

Using Mononobe-Okabe / Seed-Whitman procedure

Kae for seismic earth pressure	=	0.736
Ka for static earth pressure	=	0.291
Difference: Kae - Ka	=	0.445

Added seismic base force 2,913.3 lbs

Stem Weight Seismic Load

F_p / W_p Weight Multiplier = 0.422 g

Added seismic base force -1,808.6 lbs

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Cantilevered Retaining Wall Design

Code: IBC 2009,ACI 318-08,ACI 530-08

Design Summary

Wall Stability Ratios

Overturning	=	9.34	OK
		Slab Resists All Sliding !	
Total Bearing Load	=	12,000 lbs	
...resultant ecc.	=	34.73 in	
Soil Pressure @ Toe	=	0 psf	OK
Soil Pressure @ Heel	=	1,567 psf	OK
Allowable	=	4,000 psf	
		Soil Pressure Less Than Allowable	
ACI Factored @ Toe	=	0 psf	
ACI Factored @ Heel	=	1,880 psf	
Footing Shear @ Toe	=	10.4 psi	OK
Footing Shear @ Heel	=	0.0 psi	OK
Allowable	=	75.0 psi	

Sliding Calcs Slab Resists All Sliding !

Lateral Sliding Force	=	4,379.2 lbs

Load Factors

Building Code	IBC 2009,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

Top Stem

Stem OK

Design Height Above Ftg	ft	=	0.00
Wall Material Above "Ht"		=	Concrete
Thickness		=	24.00
Rebar Size		=	# 8
Rebar Spacing		=	12.00
Rebar Placed at		=	Edge

Design Data

fb/FB + fa/Fa		=	**0.124**
Total Force @ Section	lbs	=	4,171.9
Moment....Actual	ft-#	=	9,243.3
Moment.....Allowable		=	74,775.5
Shear.....Actual	psi	=	5.0
Shear.....Allowable	psi	=	106.1
Wall Weight		=	300.0
Rebar Depth 'd'	in	=	21.50
LAP SPLICE IF ABOVE	in	=	33.26
LAP SPLICE IF BELOW	in	=	
HOOK EMBED INTO FTG	in	=	16.80

Masonry Data

f'm	psi	=	
Fs	psi	=	
Solid Grouting		=	
Use Half Stresses		=	
Modular Ratio 'n'		=	
Short Term Factor		=	
Equiv. Solid Thick.		=	
Masonry Block Type		=	Medium Weight
Masonry Design Method		=	ASD

Concrete Data

f'c	psi	=	5,000.0
Fy	psi	=	60,000.0

Footing Dimensions & Strengths

Toe Width	=	14.00 ft
Heel Width	=	2.00
Total Footing Width	=	16.00
Footing Thickness	=	24.00 in
Key Width	=	24.00 in
Key Depth	=	48.00 in
Key Distance from Toe	=	14.00 ft

f'c = 2,500 psi   Fy = 60,000 psi

Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0028

Cover @ Top 3.00   @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel
Factored Pressure	=	0	1,880 psf
Mu' : Upward	=	48,320	0 ft-#
Mu' : Downward	=	42,924	0 ft-#
Mu: Design	=	5,396	0 ft-#
Actual 1-Way Shear	=	10.44	0.00 psi
Allow 1-Way Shear	=	75.00	0.00 psi
Toe Reinforcing	=	# 8 @ 12.00 in	
Heel Reinforcing	=	# 8 @ 12.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: Slab Resists Sliding - No Force on Key

Cantilevered Retaining Wall Design Code: IBC 2009,ACI 318-08,ACI 530-08

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	2,725.1	4.00	10,900.5
Surcharge over Heel	=	349.4	6.00	2,096.3
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=	200.0	17.00	3,400.0
Seismic Earth Load	=	2,913.3	7.20	20,975.7
Seismic Stem Self Wt	=	-1,808.6	12.00	-30,384.0
Total		4,379.2	**O.T.M.**	15,669.6
	=		=	

Resisting/Overturning Ratio = **9.34**
Vertical Loads used for Soil Pressure = 12,000.0 lbs

If seismic included the min. OTM and sliding ratios may be 1.1 per IBC '09, 1807.2.3.

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=		16.00	
Sloped Soil Over Heel	=			
Surcharge Over Heel	=		16.00	
Adjacent Footing Load	=			
Axial Dead Load on Stem	=			
* Axial Live Load on Stem	=			
Soil Over Toe	=		7.00	
Surcharge Over Toe	=			
Stem Weight(s)	=	6,000.0	15.00	90,000.0
Earth @ Stem Transitions	=			
Footing Weight	=	4,800.0	8.00	38,400.0
Key Weight	=	1,200.0	15.00	18,000.0
Vert. Component	=			
Total =		12,000.0 lbs	**R.M.=**	146,400.0

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

DESIGNER NOTES:

Title : **HSB West w/ MDE, no saturated soil** Page: ______
Job # : **200-01297** Dsgnr: **msp** Date: 25 JAN 2013
Description....
West HSB Wall with MDE Loads

This Wall in File: C:\Users\matt.petaja\Documents\2 - TEMP\Ro

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Restrained Retaining Wall Design

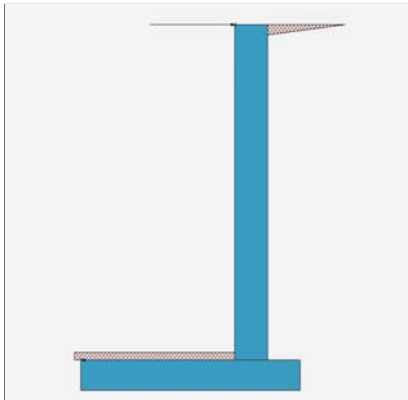
Code: IBC 2006,ACI 318-05,ACI 530-05

Criteria

Retained Height	=	22.00 ft
Wall height above soil	=	0.00 ft
Total Wall Height	=	22.00 ft
Top Support Height	=	22.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	55.0 psf/ft
	=	
Passive Pressure	=	450.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Frictior	=	0.400
Soil height to ignore for passive pressure	=	12.00 in



Thumbnail

Surcharge Loads

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

Axial Load Applied to Stem

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

Uniform Lateral Load Applied to Stem

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

Adjacent Footing Load

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

Earth Pressure Seismic Load

K_h Soil Density Multiplier = 0.422 g Added seismic per unit area = 844.8 psf

Stem Weight Seismic Load

F_p / W_p Weight Multiplier = 0.422 g Added seismic per unit area = -158.3 psf

Seismic Self-Weight acts left-to-right toward retention side.

Design Summary

Total Bearing Load	=	21,280 lbs
...resultant ecc.	=	4.79 in
Soil Pressure @ Toe	=	1,075 psf OK
Soil Pressure @ Heel	=	1,428 psf OK
Allowable	=	4,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	1,291 psf
ACI Factored @ Heel	=	1,714 psf
Footing Shear @ Toe	=	51.4 psi OK
Footing Shear @ Heel	=	21.4 psi OK
Allowable	=	106.1 psi
Reaction at Top	=	8,326.3 lbs
Reaction at Bottom	=	22,618.7 lbs

Sliding Calcs Slab Resists All Sliding !
Lateral Sliding Force = 22,618.7 lbs

Concrete Stem Construction

Thickness	=	30.00 in	Fy	=	60,000 psi
Wall Weight	=	375.0 psf	f'c	=	5,000 psi

Stem is FIXED to top of footing

		@ Top Support	Mmax Between Top & Base	@ Base of Wall
		Stem OK	**Stem OK**	**Stem OK**
Design Height Above Ftg	=	22.00 ft	13.08 ft	0.00 ft
Rebar Size	=	# 9	# 9	# 9
Rebar Spacing	=	10.00 in	10.00 in	10.00 in
Rebar Placed at	=	Edge	Edge	Edge
Rebar Depth 'd'	=	26.50 in	26.50 in	26.50 in
Design Data				
fb/FB + fa/Fa	=	0.000	0.453	0.904
Mu....Actual	=	0.0 ft-#	63,035.0 ft-#	125914.6 ft-#
Mn * Phi.....Allowable	=	139276.8 ft-#	139276.8 ft-#	139276.8 ft-#
Shear Force @ this height	=	12,910.6 lbs		31,456.1 lbs
Shear.....Actual	=	40.60 psi		98.92 psi
Shear.....Allowable	=	141.42 psi		106.07 psi
Rebar Lap Required	=	37.23 in	37.23 in	
Hooked embedment into footing			=	13.36 in

Other Acceptable Sizes & Spacings:

Toe: # 8 @ 12.00 in	-or-	#4@ 3.00 in, #5@ 4.75 in, #6@ 6.75 in, #7@ 9.00 ir
Heel: # 8 @ 12.00 in	-or-	Not req'd, Mu < S * Fr
Key: No key defined	-or-	No key defined

Load Factors

Building Code	IBC 2006,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

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Restrained Retaining Wall Design

Code: IBC 2006,ACI 318-05,ACI 530-05

Footing Strengths & Dimensions

Toe Width	=	12.00 ft
Heel Width	=	5.00
Total Footing Width	=	17.00
Footing Thickness	=	24.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	2.00 ft

f'c = 5,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0028
Cover @ Top = 3.00 in @ Btm.= 4.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	1,291	1,714	psf
Mu' : Upward	=	0	9,011	ft-#
Mu' : Downward	=	0	18,516	ft-#
Mu: Design	=	55,301	9,505	ft-#
Actual 1-Way Shear	=	51.38	21.44	psi
Allow 1-Way Shear	=	106.07	106.07	psi

Summary of Forces on Footing : Slab RESISTS sliding, stem is FIXED at footing

Forces acting on footing for soil pressure

>>> Sliding Forces are restrained by the adjacent slab

Load & Moment Summary For Footing : For Soil Pressure Calcs

Moment @ Top of Footing Applied from Stem			=	-80,582.8 ft-#
Surcharge Over Heel	=	lbs	ft	ft-#
Adjacent Footing Load	=	lbs	ft	ft-#
Axial Dead Load on Stem	=	lbs	ft	ft-#
Soil Over Toe	=	780.0 lbs	6.00 ft	4,680.0 ft-#
Surcharge Over Toe	=	lbs	ft	ft-#
Stem Weight	=	8,250.0 lbs	13.25 ft	109,312.5 ft-#
Soil Over Heel	=	7,150.0 lbs	15.75 ft	112,612.5 ft-#
Footing Weight	=	5,100.0 lbs	8.50 ft	43,350.0 ft-#
Total Vertical Force	=	21,280.0 lbs	Base Moment =	189,372.2 ft-#

Soil Pressure Resulting Moment = -8,492.2 ft-#

DESIGNER NOTES:

Concrete Beam

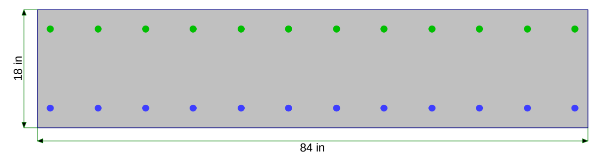
Description : Typical Walkway Supporting Hoists; Check Calc for RISA-3D

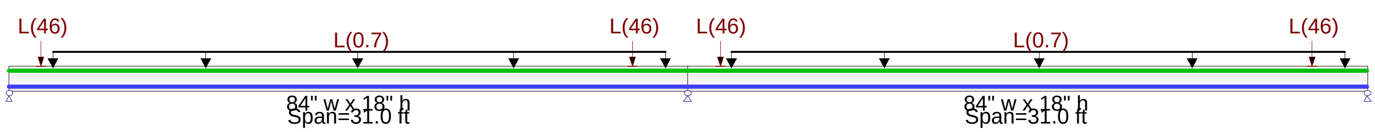
Material Properties

Calculations per ACI 318-08, IBC 2009, CBC 2010, ASCE 7-05

f'c	=	5.0 ksi	ϕ Phi Values	Flexure :	0.90	
fr = $f'c^{1/2}$ * 7.50	=	530.33 psi		Shear :	0.750	
ψ Density	=	145.0 pcf	β_1	=	0.80	
λ LtWt Factor	=	1.0				
Elastic Modulus	=	3,122.0 ksi	Fy - Stirrups		40.0 ksi	
fy - Main Rebar	=	60.0 ksi	E - Stirrups	=	29,000.0 ksi	
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size # =	#	3	
			Number of Resisting Legs Per Stirrup =		2	

Load Combination 2006 IBC & ASCE 7-05





Cross Section & Reinforcing Details

Rectangular Section, Width = 84.0 in, Height = 18.0 in
Span #1 Reinforcing....
12-#8 at 3.0 in from Bottom, from 0.0 to 32.0 ft in this span 12-#8 at 3.0 in from Top, from 0.0 to 32.0 ft in this span
Span #2 Reinforcing....
12-#8 at 3.0 in from Bottom, from 0.0 to 31.0 ft in this span 12-#8 at 3.0 in from Top, from 0.0 to 31.0 ft in this span

Applied Loads

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

Beam self weight calculated and added to loads
Load for Span Number 1
Point Load : L = 46.0 k @ 1.50 ft
Uniform Load : L = 0.10 ksf, Extent = 2.0 -->> 30.0 ft, Tributary Width = 7.0 ft
Point Load : L = 46.0 k @ 28.50 ft
Load for Span Number 2
Point Load : L = 46.0 k @ 1.50 ft
Uniform Load : L = 0.10 ksf, Extent = 2.0 -->> 30.0 ft, Tributary Width = 7.0 ft
Point Load : L = 46.0 k @ 28.50 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.900** : 1	
Section used for this span	**Typical Section**	
Mu : Applied	-557.65 k-ft	
Mn * Phi : Allowable	619.64 k-ft	
Load Combination	+1.20D+0.50Lr+1.60L+1.60H	
Location of maximum on span	0.000 ft	
Span # where maximum occurs	Span # 2	

Maximum Deflection			
Max Downward L+Lr+S Deflection	0.144 in	Ratio =	2584
Max Upward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.247 in	Ratio =	1506
Max Upward Total Deflection	0.000 in	Ratio =	999 <180

Vertical Reactions - Unfactored

Support notation : Far left is #1

Load Combination	Support 1	Support 2	Support 3
Overall MAXimum	69.822	180.287	67.486
D Only	17.699	58.997	17.699
L Only	50.149	125.237	47.814
D+L	69.822	180.287	67.486

Shear Stirrup Requirements

Entire Beam Span Length : PhiVc/2 < Vu <= PhiVc, Req'd Vs = Not Reqd 11.5.6.1, use stirrups spaced at 0.000 in

Maximum Forces & Stresses for Load Combinations

Concrete Beam

Description : Typical Walkway Supporting Hoists; Check Calc for RISA-3D

Load Combination Segment Length	Span #	Location (ft) in Span	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	30.852	-537.93	619.64	0.87
Span # 2	2	31.000	-557.65	619.64	0.90
+1.40D					
Span # 1	1	30.852	-249.97	619.64	0.40
Span # 2	2	31.000	-256.05	619.64	0.41
+1.20D+0.50Lr+1.60L+1.60H					
Span # 1	1	30.852	-537.93	619.64	0.87
Span # 2	2	31.000	-557.65	619.64	0.90
+1.20D+1.60L+0.50S+1.60H					
Span # 1	1	30.852	-537.93	619.64	0.87
Span # 2	2	31.000	-557.65	619.64	0.90
+1.20D+1.60Lr+0.50L					
Span # 1	1	30.852	-315.41	619.64	0.51
Span # 2	2	31.000	-325.15	619.64	0.52
+1.20D+0.50L+1.60S					
Span # 1	1	30.852	-315.41	619.64	0.51
Span # 2	2	31.000	-325.15	619.64	0.52
+1.20D+0.50Lr+0.50L+1.60W					
Span # 1	1	30.852	-315.41	619.64	0.51
Span # 2	2	31.000	-325.15	619.64	0.52
+1.20D+0.50L+0.50S+1.60W					
Span # 1	1	30.852	-315.41	619.64	0.51
Span # 2	2	31.000	-325.15	619.64	0.52
+1.20D+0.50L+0.20S+E					
Span # 1	1	30.852	-315.41	619.64	0.51
Span # 2	2	31.000	-325.15	619.64	0.52

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D+L	1	0.2399	13.950		0.0000	0.000
D+L	2	0.2470	18.083		0.0000	0.000

Concrete Beam

Lic. # : KW-06002149 **Licensee : TETRA TECH INC**

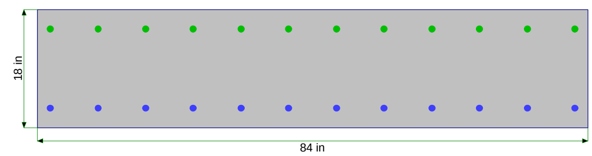
Description : Typical Walkway Supporting Hoists w/ skip LL

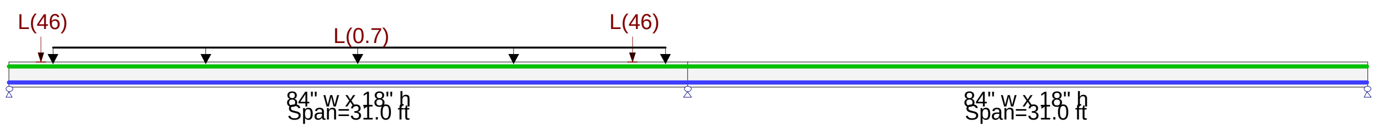
Material Properties

Calculations per ACI 318-08, IBC 2009, CBC 2010, ASCE 7-05

f'c	= 5.0 ksi	ϕ Phi Values Flexure :	0.90
fr = $f'c^{1/2}$ * 7.50	= 530.33 psi	Shear :	0.750
ψ Density	= 145.0 pcf	β_1 =	0.80
λ LtWt Factor	= 1.0		
Elastic Modulus	= 3,122.0 ksi	Fy - Stirrups	40.0 ksi
fy - Main Rebar	= 60.0 ksi	E - Stirrups =	29,000.0 ksi
E - Main Rebar	= 29,000.0 ksi	Stirrup Bar Size # = #	3
		Number of Resisting Legs Per Stirrup =	2

Load Combination 2006 IBC & ASCE 7-05





Cross Section & Reinforcing Details

Rectangular Section, Width = 84.0 in, Height = 18.0 in

Span #1 Reinforcing....

12-#8 at 3.0 in from Bottom, from 0.0 to 32.0 ft in this span 12-#8 at 3.0 in from Top, from 0.0 to 32.0 ft in this span

Span #2 Reinforcing....

12-#8 at 3.0 in from Bottom, from 0.0 to 31.0 ft in this span 12-#8 at 3.0 in from Top, from 0.0 to 31.0 ft in this span

Applied Loads

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

Beam self weight calculated and added to loads

Load for Span Number 1

Point Load : L = 46.0 k @ 1.50 ft

Uniform Load : L = 0.10 ksf, Extent = 2.0 -->> 30.0 ft, Tributary Width = 7.0 ft

Point Load : L = 46.0 k @ 28.50 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.637** : 1	Maximum Deflection		
Section used for this span	**Typical Section**	Max Downward L+Lr+S Deflection	0.230 in	Ratio = 1614
Mu : Applied	-394.614 k-ft	Max Upward L+Lr+S Deflection	-0.178 in	Ratio = 2085
Mn * Phi : Allowable	619.64 k-ft	Max Downward Total Deflection	0.333 in	Ratio = 1117
Load Combination	+1.20D+0.50Lr+1.60L+1.60H	Max Upward Total Deflection	-0.031 in	Ratio = 12028
Location of maximum on span	0.000 ft			
Span # where maximum occurs	Span # 2			

Vertical Reactions - Unfactored

Support notation : Far left is #1

Load Combination	Support 1	Support 2	Support 3
Overall MAXimum	71.728	119.507	17.699
D Only	17.699	58.997	17.699
L Only	53.437	61.695	-3.531
D+L	71.728	119.507	14.760

Shear Stirrup Requirements

Entire Beam Span Length : PhiVc/2 < Vu <= PhiVc, Req'd Vs = Not Reqd 11.5.6.1, use stirrups spaced at 0.000 in

Maximum Forces & Stresses for Load Combinations

Load Combination			Bending Stress Results (k-ft)		
Segment Length	Span #	Location (ft) in Span	Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	30.852	-375.67	619.64	0.61
Span # 2	2	31.000	-394.61	619.64	0.64
+1.40D					

Concrete Beam

Description : Typical Walkway Supporting Hoists w/ skip LL

Load Combination / Segment Length	Span #	Location (ft) in Span	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
Span # 1	1	30.852	-249.97	619.64	0.40
Span # 2	2	31.000	-256.05	619.64	0.41
+1.20D+0.50Lr+1.60L+1.60H					
Span # 1	1	30.852	-375.67	619.64	0.61
Span # 2	2	31.000	-394.61	619.64	0.64
+1.20D+1.60L+0.50S+1.60H					
Span # 1	1	30.852	-375.67	619.64	0.61
Span # 2	2	31.000	-394.61	619.64	0.64
+1.20D+1.60Lr+0.50L					
Span # 1	1	30.852	-264.70	619.64	0.43
Span # 2	2	31.000	-274.20	619.64	0.44
+1.20D+0.50L+1.60S					
Span # 1	1	30.852	-264.70	619.64	0.43
Span # 2	2	31.000	-274.20	619.64	0.44
+1.20D+0.50Lr+0.50L+1.60W					
Span # 1	1	30.852	-264.70	619.64	0.43
Span # 2	2	31.000	-274.20	619.64	0.44
+1.20D+0.50L+0.50S+1.60W					
Span # 1	1	30.852	-264.70	619.64	0.43
Span # 2	2	31.000	-274.20	619.64	0.44
+1.20D+0.50L+0.20S+E					
Span # 1	1	30.852	-264.70	619.64	0.43
Span # 2	2	31.000	-274.20	619.64	0.44

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D+L	1	0.3330	13.950	D+L	-0.0077	31.517
D Only	2	0.1030	18.083	D+L	-0.0309	4.650

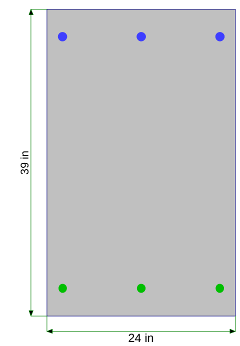
Description : Fish Ladder Support Beam at Lift Gate; 8'-9" T.O.BM to B.O.Gate (Vertical Load)

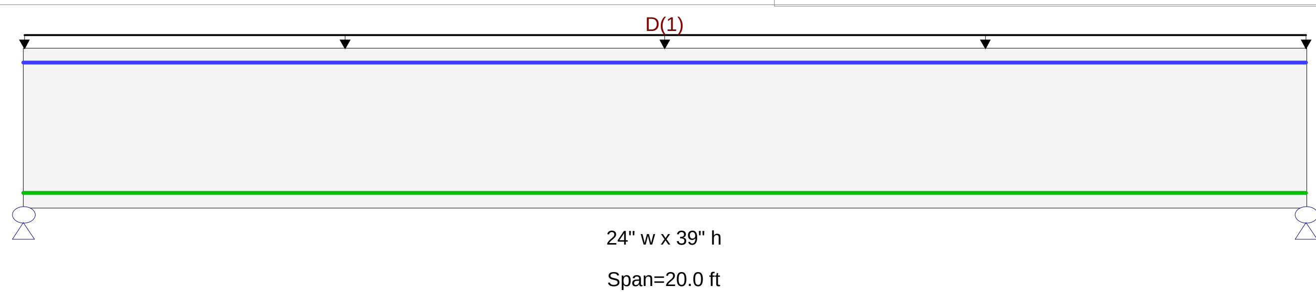
Material Properties

Calculations per ACI 318-08, IBC 2009, CBC 2010, ASCE 7-05

f'c	=	5.0 ksi	φ Phi Values	Flexure :		0.90
fr = $f'c^{1/2}$ * 7.50	=	530.33 psi		Shear :		0.750
ψ Density	=	145.0 pcf	β_1	=		0.80
λ LtWt Factor	=	1.0				
Elastic Modulus	=	3,122.0 ksi	Fy - Stirrups			40.0 ksi
fy - Main Rebar	=	60.0 ksi	E - Stirrups	=		29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size # =		#	3
			Number of Resisting Legs Per Stirrup =			2

Load Combination 2006 IBC & ASCE 7-05





Cross Section & Reinforcing Details

Rectangular Section, Width = 24.0 in, Height = 39.0 in
Span #1 Reinforcing....
3-#9 at 3.50 in from Top, from 0.0 to 20.0 ft in this span
3-#8 at 3.50 in from Bottom, from 0.0 to 20.0 ft in this span

Applied Loads

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

Beam self weight calculated and added to loads
Load for Span Number 1
Uniform Load : D = 1.0 k/ft, Tributary Width = 1.0 ft, (Lift Gate)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.357** : 1	
Section used for this span	**Typical Section**	
Mu : Applied	135.975	k-ft
Mn * Phi : Allowable	381.237	k-ft
Load Combination	+1.40D	
Location of maximum on span	10.000	ft
Span # where maximum occurs	Span # 1	

Maximum Deflection			
Max Downward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Upward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.019 in	Ratio =	12723
Max Upward Total Deflection	0.000 in	Ratio =	999 <180

Vertical Reactions - Unfactored

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	19.425	19.425
D Only	19.425	19.425

Shear Stirrup Requirements

Entire Beam Span Length : Vu < PhiVc/2, Req'd Vs = Not Reqd, use stirrups spaced at 0.000 in

Maximum Forces & Stresses for Load Combinations

Load Combination			Bending Stress Results (k-ft)		
Segment Length	Span #	Location (ft) in Span	Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	10.000	135.98	381.24	0.36
+1.40D					
Span # 1	1	10.000	135.98	381.24	0.36

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D Only	1	0.0189	9.800		0.0000	0.000

Concrete Beam

Lic. # : KW-06002149 **Licensee : TETRA TECH INC**

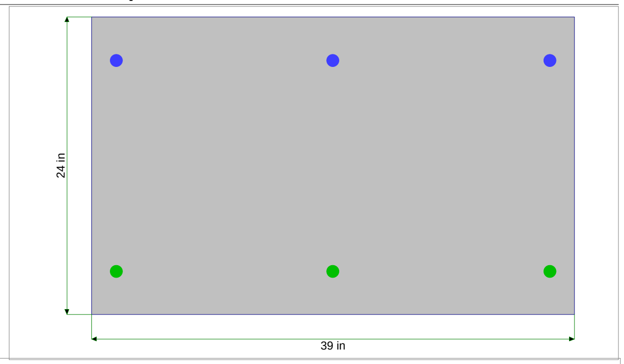
Description : Fish Ladder Support Beam at Lift Gate; 8'-9" T.O.BM to B.O.Gate (Lateral Flow)

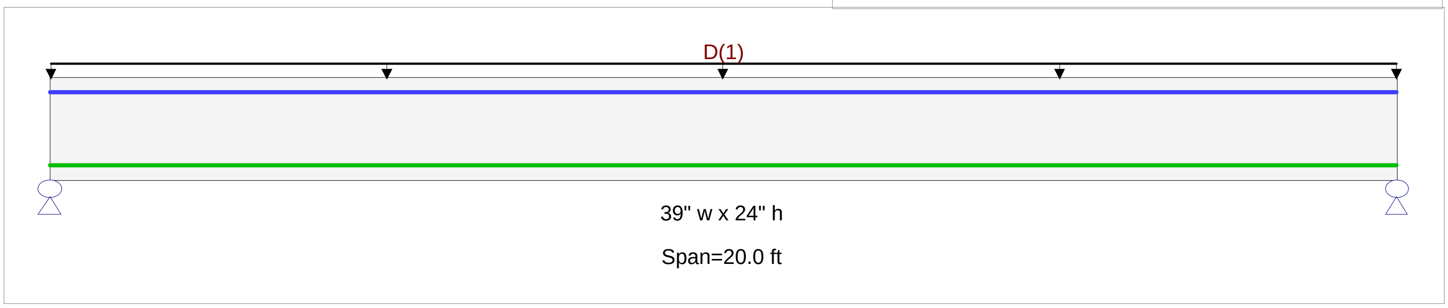
Material Properties

Calculations per ACI 318-08, IBC 2009, CBC 2010, ASCE 7-05

f'c	=	5.0 ksi	φ Phi Values Flexure :	0.90
fr = f'c$^{1/2}$ * 7.50	=	530.33 psi	Shear :	0.750
ψ Density	=	145.0 pcf	β_1 =	0.80
λ LtWt Factor	=	1.0		
Elastic Modulus	=	3,122.0 ksi	Fy - Stirrups	40.0 ksi
fy - Main Rebar	=	60.0 ksi	E - Stirrups =	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size # = #	3
			Number of Resisting Legs Per Stirrup =	2

Load Combination 2006 IBC & ASCE 7-05





Cross Section & Reinforcing Details

Rectangular Section, Width = 39.0 in, Height = 24.0 in
Span #1 Reinforcing....
3-#8 at 3.50 in from Top, from 0.0 to 20.0 ft in this span
3-#8 at 3.50 in from Bottom, from 0.0 to 20.0 ft in this span

Applied Loads

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

Beam self weight calculated and added to loads
Load for Span Number 1
Uniform Load : D = 1.0 k/ft, Tributary Width = 1.0 ft, (Lift Gate)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.574** : 1
Section used for this span	**Typical Section**
Mu : Applied	135.975 k-ft
Mn * Phi : Allowable	236.931 k-ft
Load Combination	+1.40D
Location of maximum on span	10.000 ft
Span # where maximum occurs	Span # 1

Maximum Deflection			
Max Downward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Upward L+Lr+S Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.050 in	Ratio =	4818
Max Upward Total Deflection	0.000 in	Ratio =	999 <180

Vertical Reactions - Unfactored

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	19.425	19.425
D Only	19.425	19.425

Shear Stirrup Requirements

Entire Beam Span Length : Vu < PhiVc/2, Req'd Vs = Not Reqd, use stirrups spaced at 0.000 in

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment Length	Span #	Location (ft) in Span	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	10.000	135.98	236.93	0.57
+1.40D					
Span # 1	1	10.000	135.98	236.93	0.57

Overall Maximum Deflections - Unfactored Loads

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
D Only	1	0.0498	9.800		0.0000	0.000