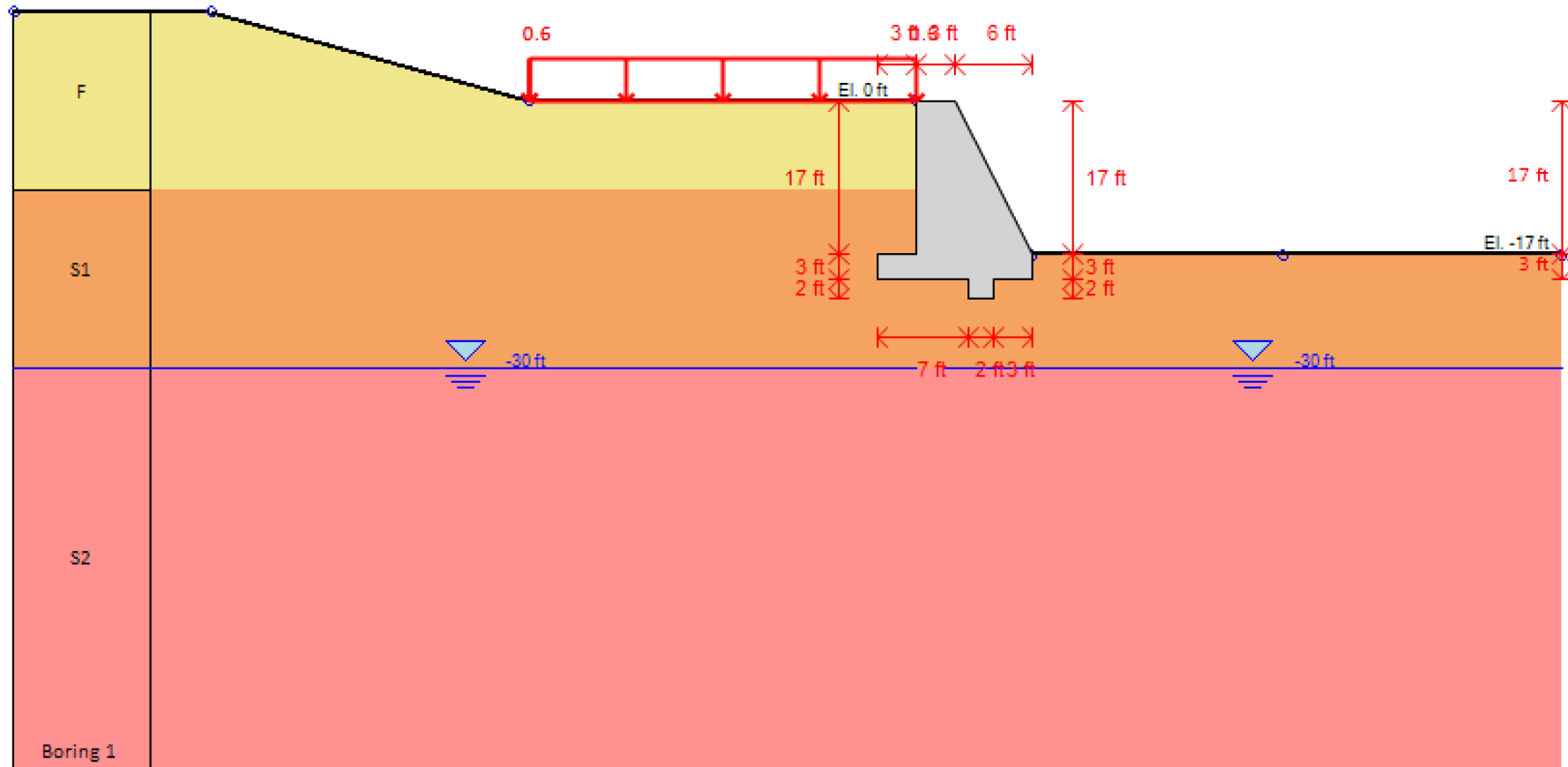
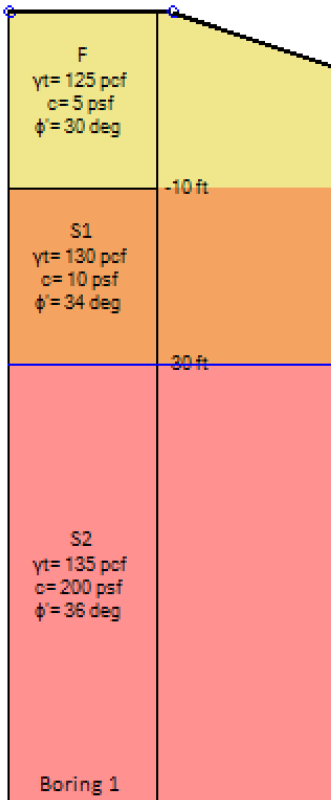


Example 8: Gravity Retaining Wall

Example 8: Gravity Retaining Wall LEM Analysis - AASHTO LRFD Load Combinations



A. Soil Properties and Stratigraphy (Soil Layers)



Elev. (ft)	Soil (-)	γ_t (pcf)	C' (psf)	ϕ' (deg)	E (ksf)	exp (-)
0	F - Sand	125	5	30	500	0.5
-10	S1 - Sand	130	10	34	800	0.4
-30	S2 - Sand	135	200	36	1200	0.4

1. General Boring Information - Coordinates

Name: Boring 1

Coordinates X: -65.617 ft Y: 0 ft

The x coordinate controls where the boring is shown in your design. Each design section uses one boring (soil strata). You can use a different boring for each design section.

SPT Data Option (Applies to Design Section)

SPT Record: Not assigned [Add edit SPT records]

Pass same SPT log to boring (3D visualizations)

CPT Record Option (Applies to Design Section)

CPT Record: Not assigned [Add edit CPT records]

2. Boring Layers - Layer Elevations

	Top Elev. (ft)	Soil Type	OCR	Ko	Edit
	10	F	1	0.5	Edit
	-10	S1	1	0.4408...	Edit
	-30	S2	1	0.412	Edit
*					

A. General C. Elasto-plastic D. Bond E. Adv. F. Piles

4. Unit Weights - Density

γ_t 130 pcf γ_{bulk} 125 pcf γ'_s 67.6

5. Strength Parameters and Poisson Ratio

Drained strength properties

c' 10 psf ϕ' 34 degrees

Peak - constant vol. (for estimation)


ϕ_{cv} Omitted degrees ϕ_{peak} Omitted degrees

ν 0.35

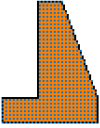
B. Wall Section Properties, Wall Position and Depth

Retaining Wall Data


Select wall type




Select from available wall type



Wall type 2



Wall type 3



Wall type 4

Dimensions Materials Results Descriptions

Wall Name:

1. Reinforcement

Use	P1	P2	Rebar	S(in)	No.	Clear(in)	Ast(in2)
<input checked="" type="checkbox"/>	A	B	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	B	C	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	C	D	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	D	E	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	E	F	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	F	G	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	G	H	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	H	I	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	I	J	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	J	K	#3	6	1	3	0.11
<input checked="" type="checkbox"/>	K	A	#3	6	1	3	0.11

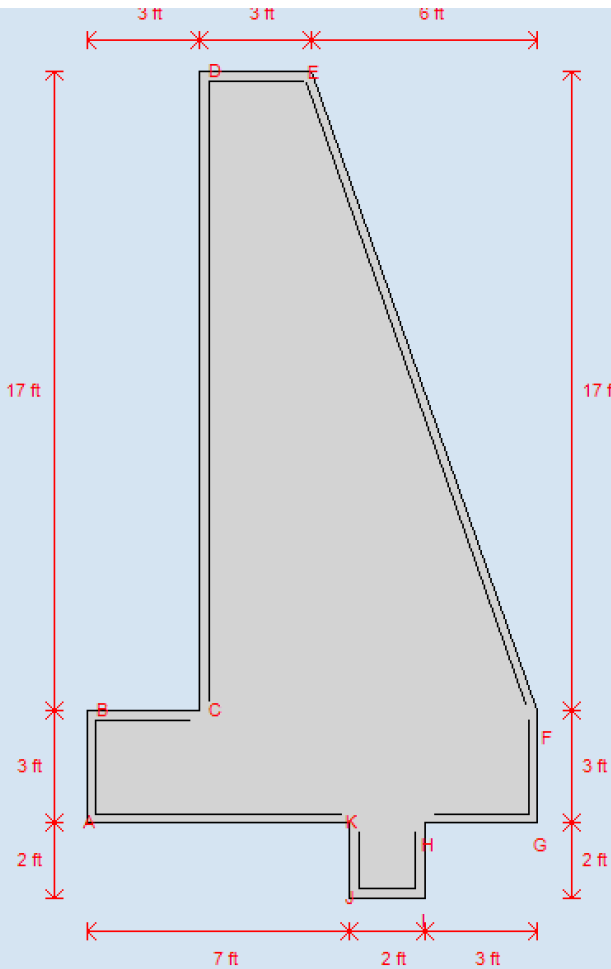


Diagram showing wall section properties and dimensions:

- Height: 17 ft
- Base width: 12 ft (3 ft + 3 ft + 6 ft)
- Top width: 3 ft
- Distance to left top corner: 3 ft
- Heel thickness: 3 ft
- Toe thickness: 3 ft
- Use key:
- Key height: 2 ft
- Key distance to left corner: 7 ft
- Key thickness: 2 ft
- Drain back face:
- Use a rectangular cap at the top:

C. Analysis Settings & Design Codes

- Wall Friction: 50% of the soil friction
- Water Pressures: Simplified Flow
- Cantilever Method (LEM): Free Earth Method + CALTRANS Approximations for displacements
- Soil Pressures: Active & Passive (All Stages)

The screenshot shows a software interface for analysis settings. It includes several sections: 'Water behaviour' with options for Clays (Default), Analysis (Simple), and Wave Forces; 'Include Wall Friction' with a 'K_aK_p AUTO' button and a '1st wall' dropdown set to '50'; 'Drive Pressures: Active' and 'Resist Pressures: Passive' buttons; 'Supports: Beam' and 'Cantilever: Free-earth' dropdowns; and 'Limit Equilibrium Methods (Current Stage)' with a dropdown set to 'Beam: California Trenching and Shoring Manual 2011'.

- Steel Code: AISC 360-16 Allowable
- Concrete Code: ACI 318-19
- Analysis Code: None (Service Conditions)
- Seismic Pressures: $a_{design} = 0.1g$ (Extreme I Case)
- Seismic Pressures Method: Mononobe-Okabe

The screenshot shows two overlapping panels. The top panel is 'Concrete Code Options' with a dropdown menu set to '26:ACI 318-19'. The bottom panel is 'Steel Code Options' with a dropdown menu set to '22:AISC 360-16 ALL.'. To the right of these panels is a 'Full Seismic Options' section with a checked 'Include Seismic Loads' box, and two input fields: 'ax' with a value of 0.100 and 'az' with a value of 0.000, both with units of 'g'. Below these is a 'Method' dropdown set to 'Mononobe-Okabe'.

D. AASHTO LRFD LOAD COMBINATIONS

We will examine all AASHTO LRFD 9th Load Combinations:

- Service
- Strength IA
- Strength IB
- Strength II
- Extreme I

Design Sections	Mmax (k-ft...)	Rmax (k/ft)
? 0: Model - LEM	-	-
? 1: 0: AASHTO LRFD 9th (2020): Service I	-	-
? 2: 0: AASHTO LRFD 9th (2020): Strength Ia	-	-
? 3: 0: AASHTO LRFD 9th (2020): Strength Ib	-	-
? 4: 0: AASHTO LRFD 9th (2020): Strength II	-	-
? 5: 0: AASHTO LRFD 9th (2020): Extreme I	-	-

Code	AASHTO LRFD 9th (2020)
Case	Strength Ia
Parameter	Safety Factor
Seismic multiplier EQ	0
Variable loads γ_{LL}	1.75
Permanent loads $\gamma_{p,DL}$	1
Temporary anchors	1
Permanent anchors	1.11
$\tan(\text{friction angle})$	1
Eff. cohesion c'	1
Shear strength S_u	1
Earth unfavorable $\gamma_{p,EH}$	1.35, $F_{kA} = 1.5$
Earth favorable $\phi_{p,EH}$	0.75
Water unfavorable γ_{WA}	1
Water favorable ϕ_{WA}	1
HYDraulic unfavorable γ_{HYD}	1
HYDraulic favorable ϕ_{HYD}	1
UPLift unfavorable γ_{UP}	1
UPLift favorable ϕ_{UP}	1
Bearing ϕ_{bear}	0.55
Used FS wall STR	Service

Code	AASHTO LRFD 9th (2020)
Case	Strength Ib
Parameter	Safety Factor
Seismic multiplier EQ	0
Variable loads γ_{LL}	1.75
Permanent loads $\gamma_{p,DL}$	1.35
Temporary anchors	1
Permanent anchors	1.11
$\tan(\text{friction angle})$	1
Eff. cohesion c'	1
Shear strength S_u	1
Earth unfavorable $\gamma_{p,EH}$	1.35, $F_{kA} = 1.5$
Earth favorable $\phi_{p,EH}$	0.75
Water unfavorable γ_{WA}	1
Water favorable ϕ_{WA}	1
HYDraulic unfavorable γ_{HYD}	1
HYDraulic favorable ϕ_{HYD}	1
UPLift unfavorable γ_{UP}	1
UPLift favorable ϕ_{UP}	1
Bearing ϕ_{bear}	0.55
Used FS wall STR	Service

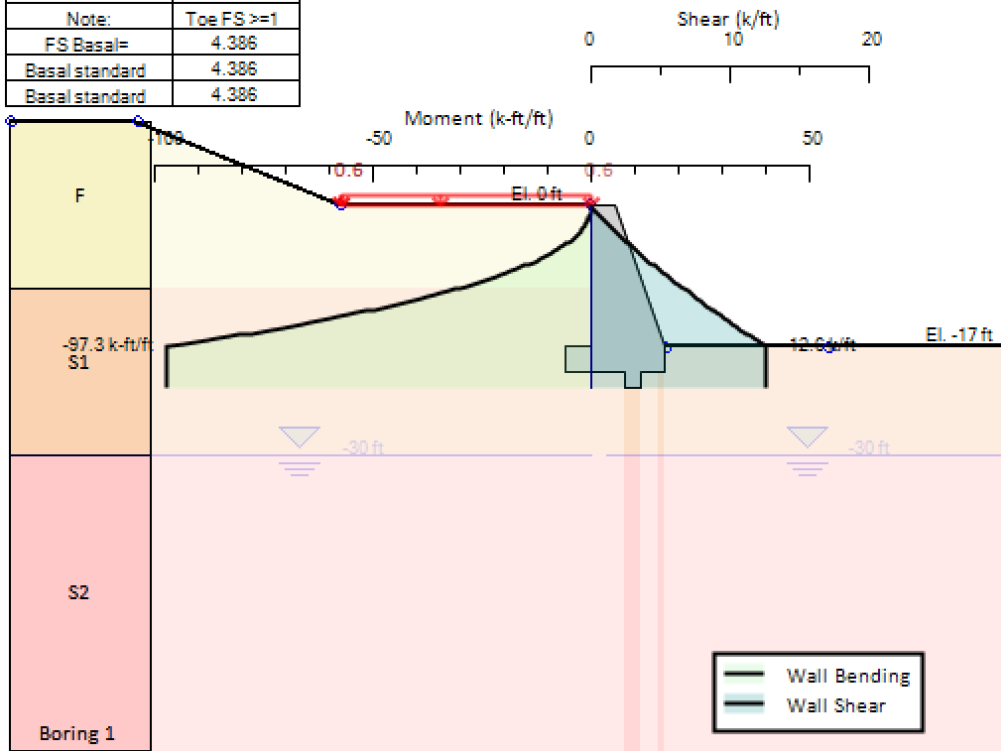
Code	AASHTO LRFD 9th (2020)
Case	Strength II
Parameter	Safety Factor
Seismic multiplier EQ	0
Variable loads γ_{LL}	1.35
Permanent loads $\gamma_{p,DL}$	1.35
Temporary anchors	1
Permanent anchors	1.11
$\tan(\text{friction angle})$	1
Eff. cohesion c'	1
Shear strength S_u	1
Earth unfavorable $\gamma_{p,EH}$	1.35, $F_{kA} = 1.5$
Earth favorable $\phi_{p,EH}$	0.75
Water unfavorable γ_{WA}	1
Water favorable ϕ_{WA}	1
HYDraulic unfavorable γ_{HYD}	1
HYDraulic favorable ϕ_{HYD}	1
UPLift unfavorable γ_{UP}	1
UPLift favorable ϕ_{UP}	1
Bearing ϕ_{bear}	0.55
Used FS wall STR	Service

Code	AASHTO LRFD 9th (2020)
Case	Extreme I
Parameter	Safety Factor
Seismic multiplier EQ	1
Variable loads γ_{LL}	0.5
Permanent loads $\gamma_{p,DL}$	1.35
Temporary anchors	1
Permanent anchors	1.11
$\tan(\text{friction angle})$	1
Eff. cohesion c'	1
Shear strength S_u	1
Earth unfavorable $\gamma_{p,EH}$	1.35, $F_{kA} = 1.5$
Earth favorable $\phi_{p,EH}$	1
Water unfavorable γ_{WA}	1
Water favorable ϕ_{WA}	1
HYDraulic unfavorable γ_{HYD}	1
HYDraulic favorable ϕ_{HYD}	1
UPLift unfavorable γ_{UP}	1
UPLift favorable ϕ_{UP}	1
Bearing ϕ_{bear}	0.55
Used FS wall STR	Service

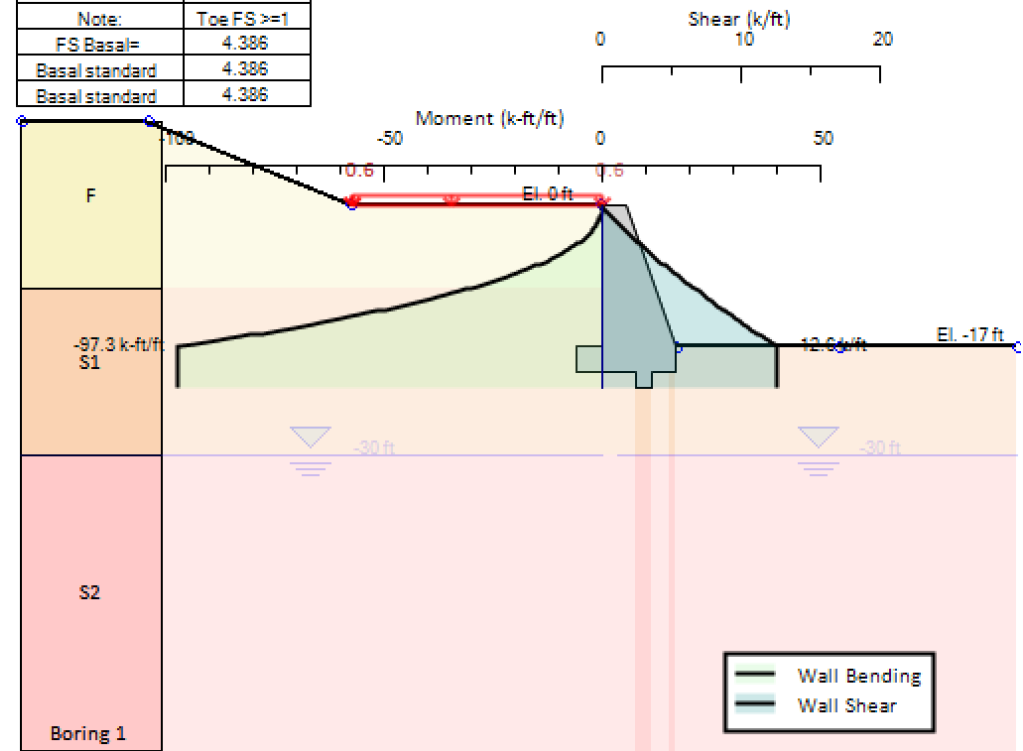
E1. LEM Analysis Results

Wall Toe Safety:	Wall 1
Min FS=	0.563
FS Bearing=	0.563
FS pas. =	2.12
FS Rot. =	1.223
Note:	Toe FS >= 1
FS Basal=	4.386
Basal standard	4.386
Basal standard	4.386

Wall Toe Safety:	Wall 1
Min FS=	0.563
FS Bearing=	0.563
FS pas. =	2.12
FS Rot. =	1.223
Note:	Toe FS >= 1
FS Basal=	4.386
Basal standard	4.386
Basal standard	4.386



Strength Ia

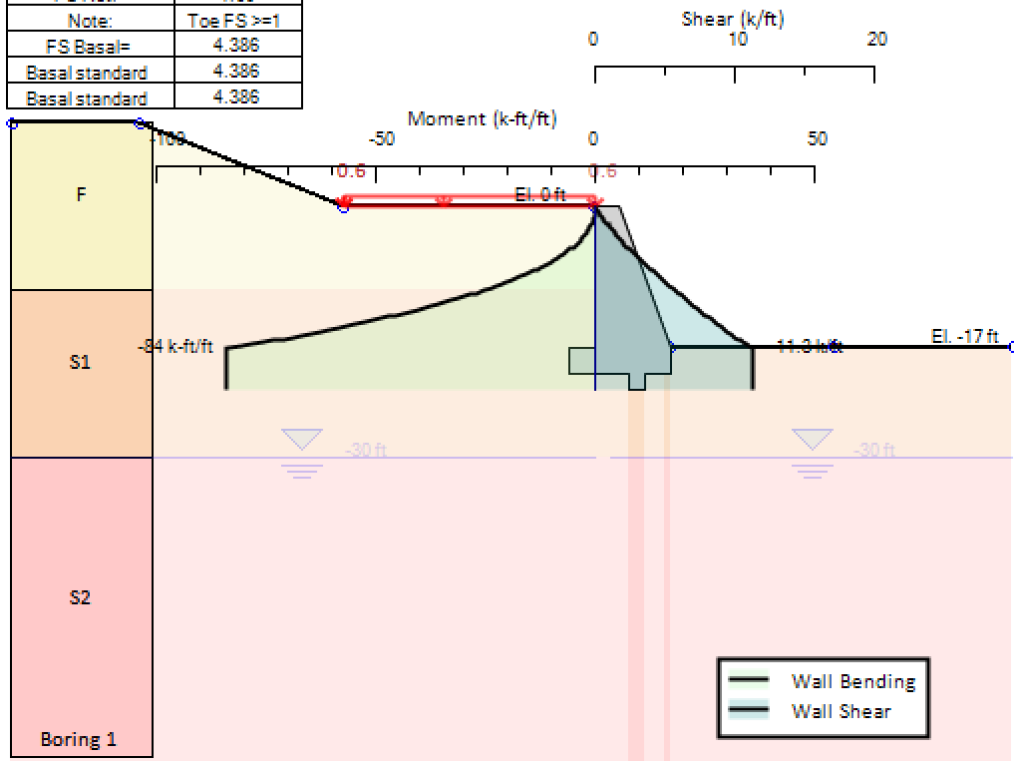


Strength Ib

Wall Moment & Shear Diagrams, Sliding - Bearing - Overturning Safety Factors

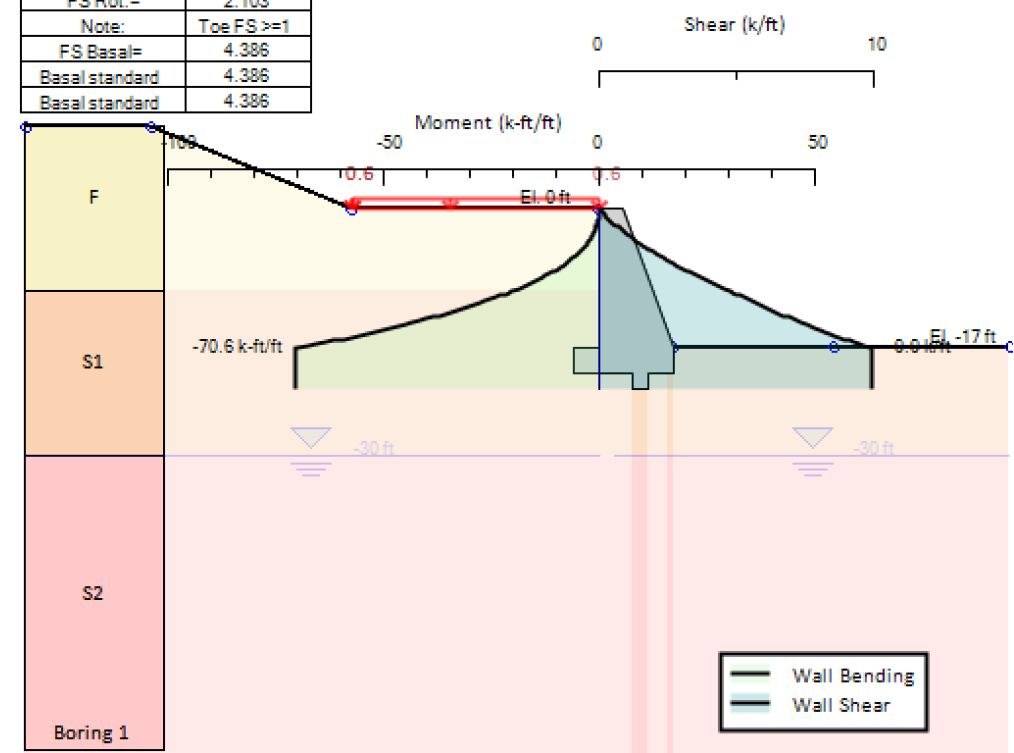
E2. LEM Analysis Results

Wall Toe Safety:	Wall 1
Min FS=	1.69
FS Bearing=	1.859
FS pas.=	2.12
FS Rot.=	1.69
Note:	Toe FS >=1
FS Basal=	4.386
Basal standard	4.386
Basal standard	4.386



Strength II

Wall Toe Safety:	Wall 1
Min FS=	1.503
FS Bearing=	2.302
FS pas.=	1.503
FS Rot.=	2.103
Note:	Toe FS >=1
FS Basal=	4.386
Basal standard	4.386
Basal standard	4.386



Extreme I

Wall Moment & Shear Diagrams, Sliding - Bearing - Overturning Safety Factors

Thank You!

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