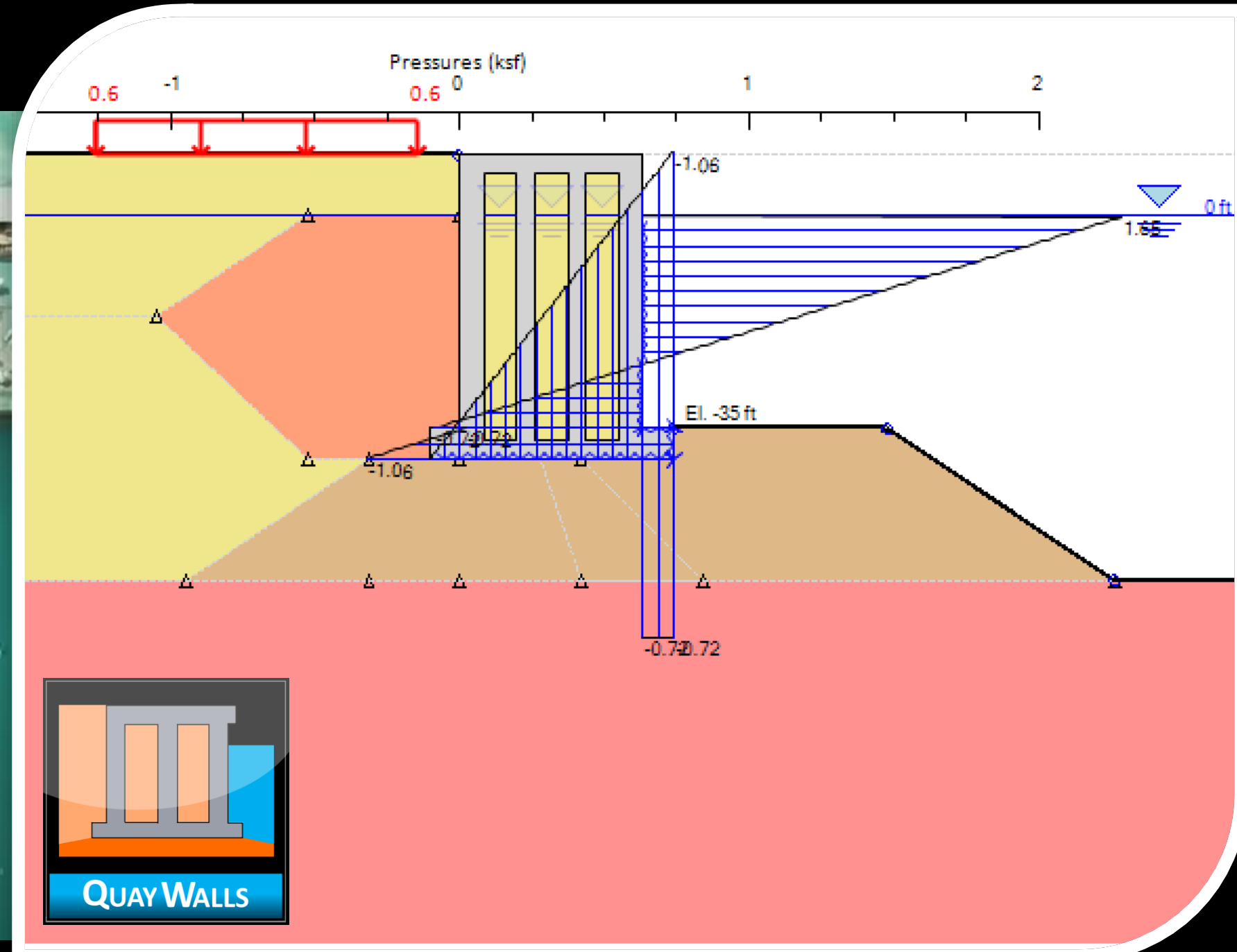


QuayWalls: The Ultimate Software for the Design of Gravity Quay Walls

Presentation: Dimitrios Mamoglou, Senior Engineer, Deep Excavation LLC
mamoglou@deepexcavation.com - T: +1-206-279-3300



Our Company

Deep Excavation LLC
240 W 35th Street, Suite 1004
New York, NY, 10001
USA

Websites:
www.deepexcavation.com
www.deepex.com

Contact Information:
sales@deepexcavation.com
training@deepexcavation.com

- Software solutions for excavation and foundation professionals
- Consulting Services - Design of deep excavations and pile foundations
- Virtual Reality applications for geotechnical engineers and contractors



DeepEX



HoloDeepEX



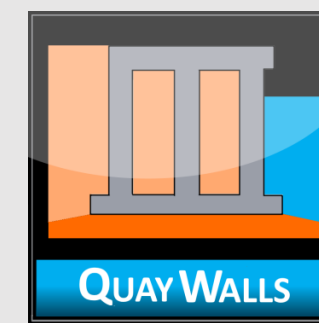
DeepFND



HelixPile



SnailPlus



QuayWalls



SiteMaster



PART 1: QuayWalls Software Features and Methods



QuayWalls - Main Software Capabilities

- ✓ Design Gravity Type Quay Walls (Any Shape)
- ✓ Calculate Wave Pressures and Overtopping Flow Rates
- ✓ Model Wizard - Automatic Model Generation
- ✓ Include External Loads (Surface Surcharges - Mooring Loads & More)
- ✓ Calculate Seismic Pressures
- ✓ Full Structural & Geotechnical Design

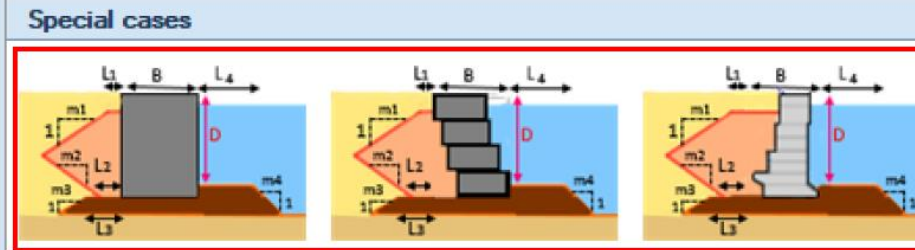
More information:

[Click here to learn more:
QuayWalls – Features and Capabilities](#)

- Automatic Model Generation for all Project Stages:**
- ✓ Select Wall Type
 - ✓ Define Soil Properties and Stratigraphy
 - ✓ Define External Surcharges
 - ✓ Define Mooring Loads
 - ✓ Define Analysis Settings
 - ✓ Define Wave Pressures
 - ✓ Select to Apply Seismic Loads


B. Dimensions

L1	25	ft	m1	1.5	
L2	15	ft	m2	1.5	
L3	15	ft	m3	1.5	
L4	30	ft	m4	1.5	
			h1	10	ft
			Base ground El.	-60	ft
			Tidal lag water difference	5	ft
			Final Excavation Depth D	45	ft
			Wall Height H	50	ft
			Excavation Width B	100	ft
			Top of Wall Elevation	10	ft
			Ground water Elevation	0	ft




Please define your basic soil types. Soil types are used in borehole records (borings).

Define soils from text description
 Note: For estimation only, you can describe your soil str language. DeepEX will estimate all properties! Not a su geotechnical investigation1

1.  **Edit soil types**

Please define an approximate soil layer stratigraphy (boring). A boring uses soil types and top of layer elevations.

2.  **Edit borings** **Available wall sections**
 1: Boring 1

4. **Assign layers for quay wall fill zones**

Fill soil type	F	
Relief prism soil type	RF	Select add typical soil types for relief prism and base.
Soil type for embankment and base	GR	
Natural soil type below embankment	F	

Use a strip load 0.6 ksf 20 ft
 Behind wall 2 ft

Do not use a wall surcharge

Mooring Loads

Mooring load normal conditions	6	klf
Mooring load high wave conditions	4	klf
Mooring load high wave conditions	3	klf

2. Geotechnical Codes (Eurocode , etc)

Do not use a Code

Analyze all Code Cases in Separate Design Sections Analyze only one Code Case

Design Code **BS-6349-1-2-2016**

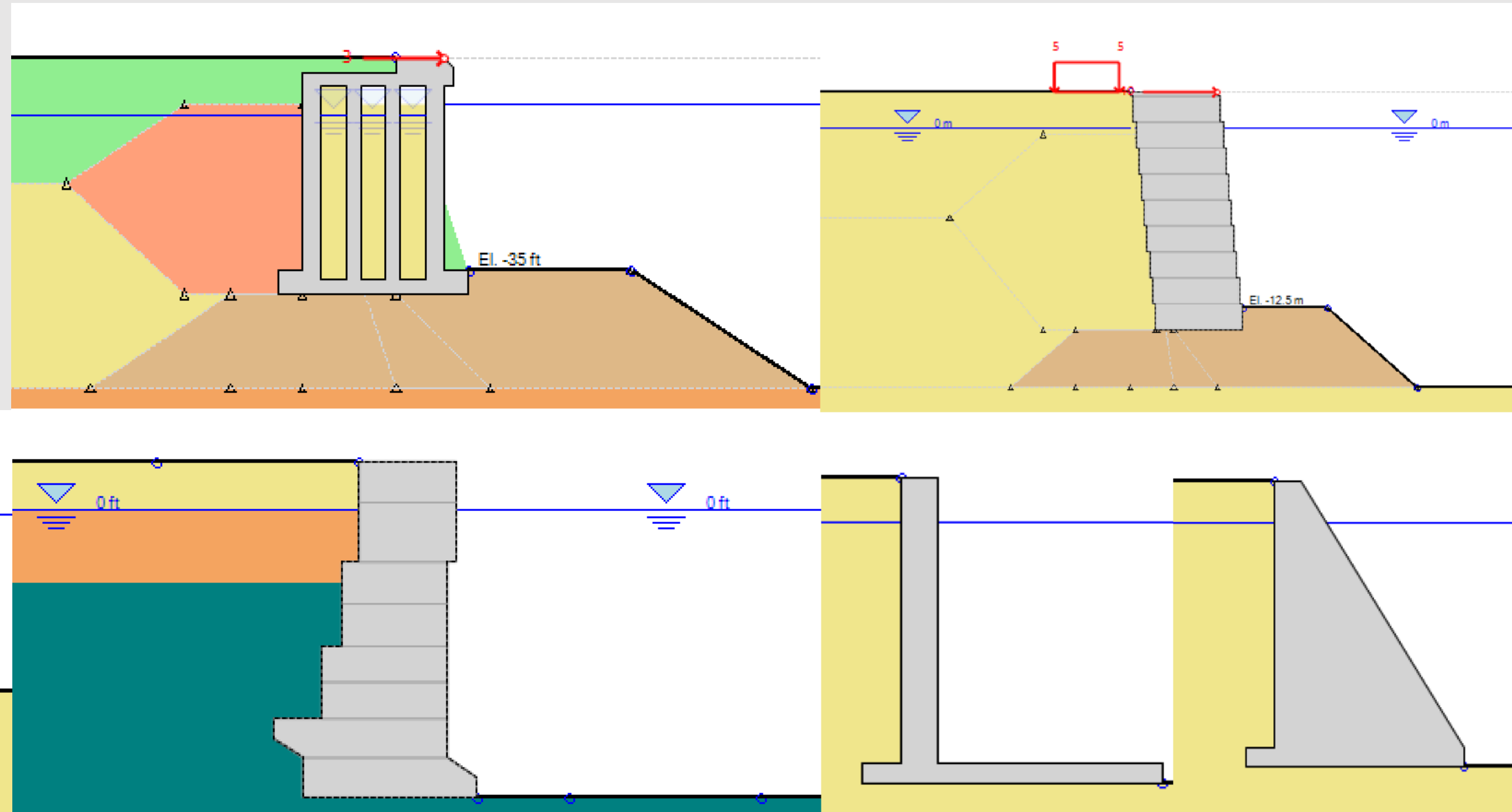
Create Base Design Section with Service Case

Link Model in Design Sections to Base Design Section

QuayWalls - Available Wall Types

Wall Types:

- Caisson Walls with Infill Zones
- Slanted Segmental Block Walls
- Segmental Block Walls with Slanted Base
- T – Shaped Walls
- Gravity Walls (Any Shape)



- ✓ Automatic Wave Options
- ✓ CEM 2011 Typical Wave Heights Implemented
- ✓ Overtopping Flow Rates
- ✓ High and Low Wave Scenarios

Wave Pressures Methods:

- Sainflou
- Goda
- Coastal Engineering Manual
- Allsop 2000
- PROVERBS 2000
- Leidraad Kustwerken
- Miche
- Cuomo 2010

Wave analysis options

Design method Goda

Design wave Hinc Sainflou 1928

Wall side to apply Coastal Engineering Manual 2002

Significant wave height Hs 5.249 m

Local wave height H 3.499 m

Average of the highest 1/3 of waves H1_3 3.499 m

Average of the highest 1/10 of waves H1_10 3.981 m

Impact waves Cuomo (Significant wave height at toe) Hmo 3.499 m

Peak period Tp 7 sec

Wave period associated with H1_3, T1_3 7 sec

Average wave period Tav 6 sec

Local wave period Tloc 7 sec

Storm duration 6 Hours

Overtopping Automatic selection with EurOtop

Influence of foreshore Automatic selection (EurOtop)

Apply settings to stages

Apply to one stage Low wave

From stage

To stage

Seaward SainFlou as modified

Goda Method Parameters

λ_1 1

λ_3 1

Options for structures protected by seaward Ignored

Use uplift for seaward base action

Use landward value for base pressure

Use adjustment factor for low wave

low wave factor 0.5

Cuomo Factor Cr 1

Wave length method From Tpeak

Pressure reductions for broken to Ignored

Wall 0

Typical Wave Heights

Condition	Min wave height Hmin (m)	Max. wave height Hmax (m)	Wave Period Tmin (sec)	Max. Period Tmax (sec)	Suggested Wave Height Hrec (m)	Suggested wave period T (sec)	Select
Individual thunderstorm	0.5	1.5	1.5	3	1.4	2.8	Select
Supercell thunderstorm	2	3	3	6	2.9	5	Select
Sea breeze	0.5	1.5	3	4	1.4	3.5	Select
Lee waves	0.5	1.5	2	5	1.4	4.5	Select
Front squall lines	1	5	4	7	4.5	6	Select
Tropical depression	1	4	4	8	3.5	7	Select
Tropical storm	5	8	5	9	7.5	8	Select
Humane Simpson Scale 1	4	8	7	11	7.5	10	Select
Humane Simpson Scale 2	6	10	9	12	9.5	11	Select
Humane Simpson Scale 3	8	12	11	13	11.5	12	Select
Humane Simpson Scale 4	10	14	12	15	13.5	14	Select
Humane Simpson Scale 5	10	14	12	15	13.5	14	Select
Weak Extratropical Cyclone	3	5	5	10	4.5	8	Select
Moderate Extratropical Cyclone	5	8	9	13	7.5	11	Select
Intense Extratropical Cyclone	8	12	12	17	11.5	15	Select
Extreme Extratropical Cyclone	13	18	15	20	17	17.5	Select
Monsoonal winds	4	7	6	11	6.5	9	Select

Significant wave height Hs 5.249 m

Local wave height H 3.499 m

Average of the highest 1/3 of waves H1_3 3.499 m

Average of the highest 1/10 of waves H1_10 3.981 m

Peak period Tp 7 sec

Wave period associated with H1_3, T1_3 7 sec

Average wave period Tav 6 sec

Local wave period Tloc 7 sec



Pressures (kPa)

28.74

28.74

58.399

47.8

44

44

11

El. -10.668 m

Wave pressures

- ✓ Create multiply soil types and define soil properties
- ✓ Soil properties estimation tools (NSPT values - test data)
- ✓ Create multiple borings and define the horizontal stratigraphy
- ✓ Add CPT logs and SPT Records - Estimate properties from records
- ✓ Custom Layer mode: Create inclined soil layers
- ✓ Relief prism and embankment zones automatic generation

Soil Types [?] [X]

Soil Types

- F
- O1
- O2
- S1
- Clay
- S2
- Rock
- RF**
- GR

1. Name and Basic Soil Type

Soil Name: RF Color

Description: Relief prism soil

2. Soil Type - Behaviour

Gravel Show test data (SPT, CPT, Etc)

Not defined

3. Default drained-undrained behavior for clays (See Theory Manual)

Undrained behaviour Drained

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

4. Unit Weights - Density

γ_t 120 pcf γ_{bulk} 120 pcf γ_w 56

5. Strength Parameters and Poisson Ratio

Drained strength properties

c' 0 psf ϕ' 40 degrees

Peak - constant vol. (for estimation)

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

ν 0.35

6. Permeability

K_x 0.1 ft/sec K_z 0.1 ft/sec

8. At-rest coefficients

$KoNC$ 0.357212' $nOCR$ 0.5 $Ko = KoNC * (OCR)^{nOCR}$

Enable elastoplastic properties

Add New Soil

Copy Soil

Delete Selected Soil

Paste Soil

Clone

Assign layers for quay wall fill zones

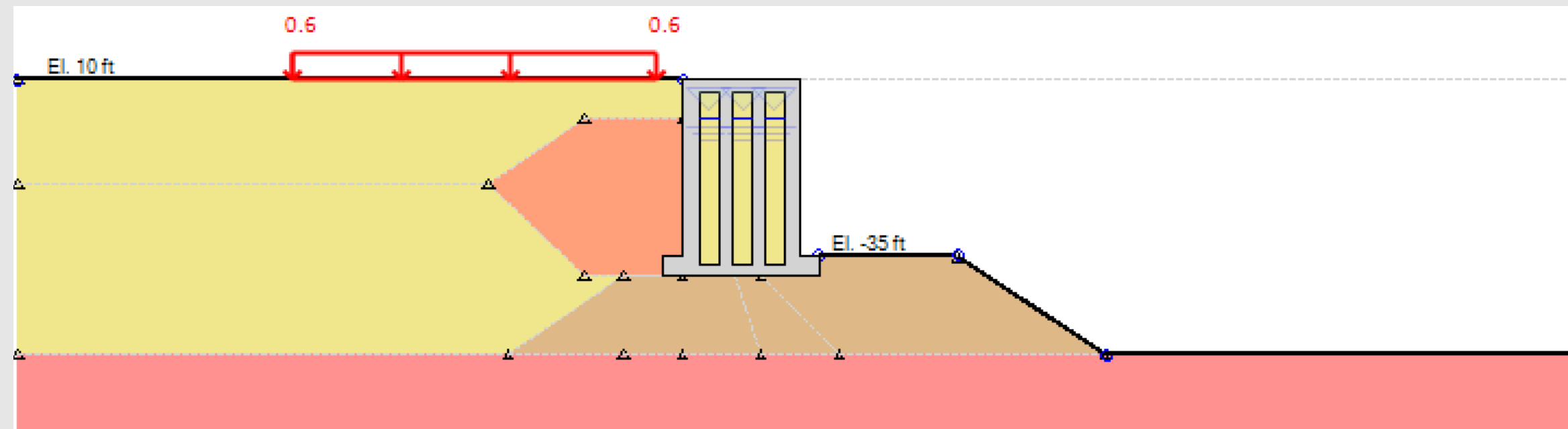
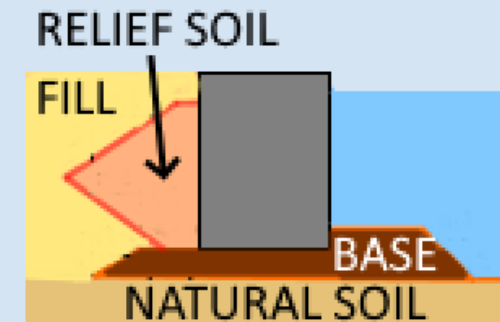
Fill soil type: F

Relief prism soil type: RF

Soil type for embankment and base: GR

Natural soil type below embankment: F

Select add typical soil types for relief prism and base.



Seismic Pressures - Procedure in QuayWalls

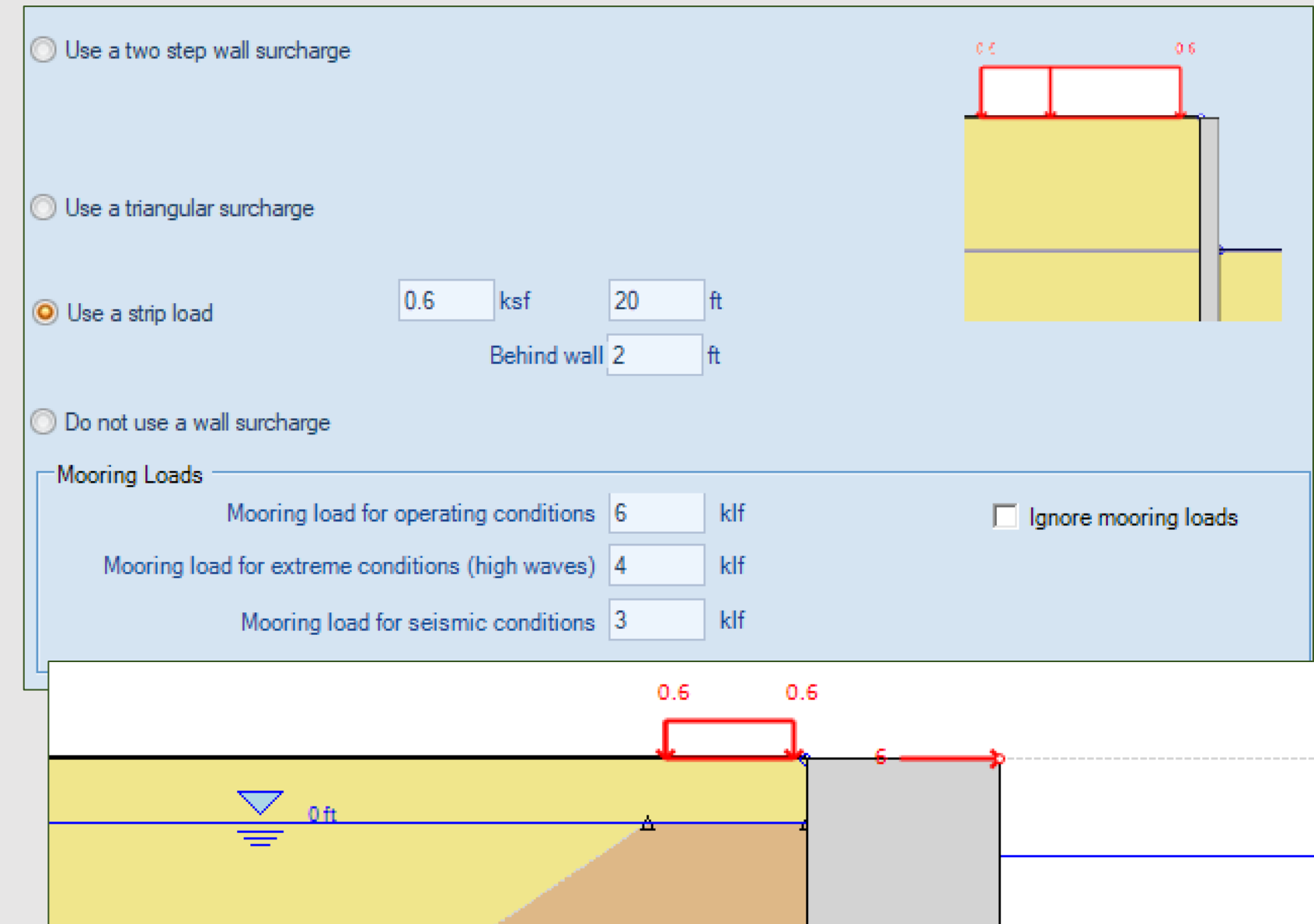
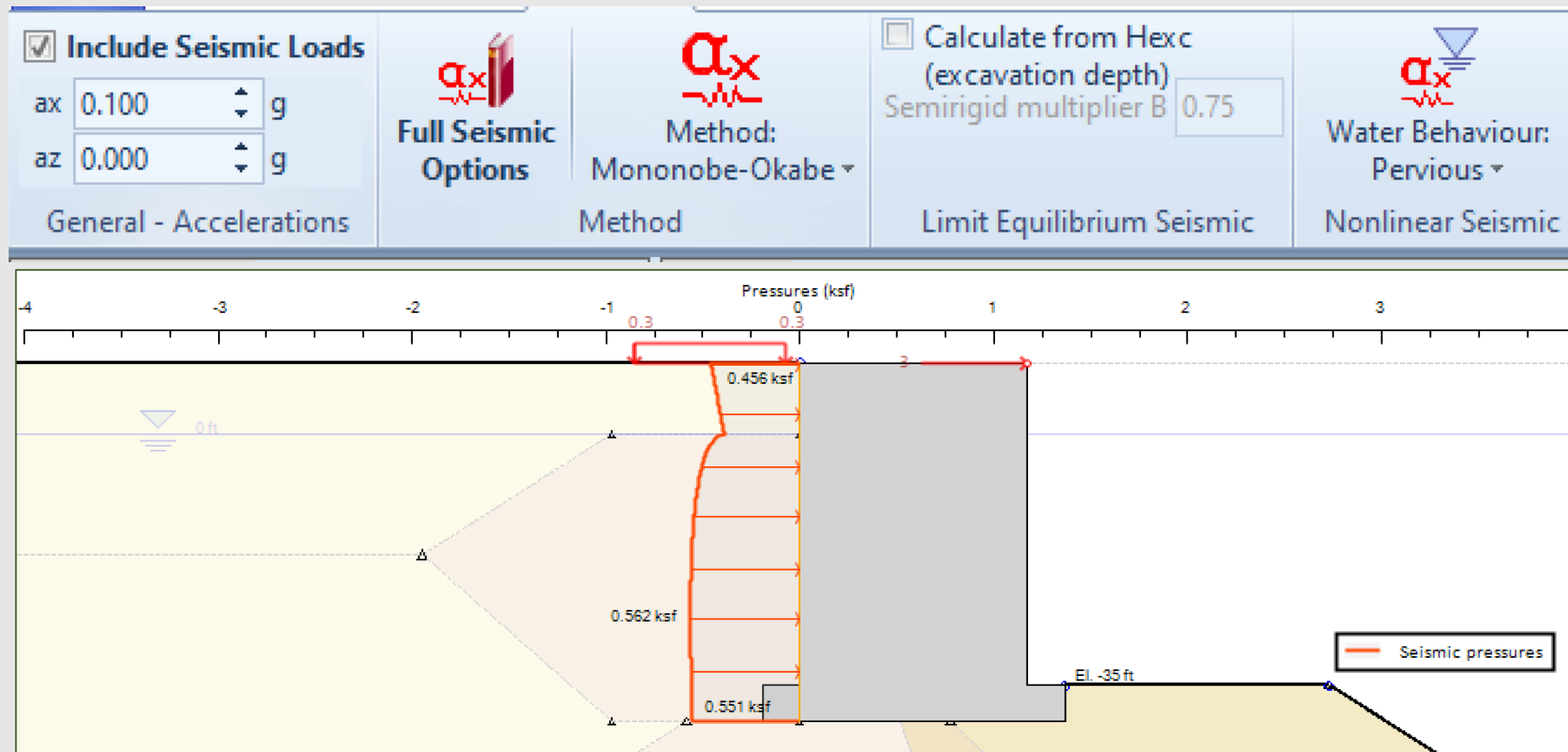
- Define Seismic Accelerations Ax and Az
- Select Seismic Pressures Calculation Method

Seismic Pressure Methods

- ✓ Semirigid
- ✓ Mononobe-Okabe (frictional soils)
- ✓ Wood Automatic
- ✓ Wood Manual

External Loads:

- ✓ Define external surface loads
- ✓ Define loads on the walls
- ✓ Include mooring loads (automatic model wizard options)



- ✓ Design Standards – Load Combinations: AASHTO LRFD, Eurocode 7, BS-6349 + more
- ✓ Structural Design Codes: ACI, AISC, LRFD, Eurocodes 2, 3 & 8, AS3600, AS 4100, CN + more
- ✓ Calculate moment capacity
- ✓ Perform all checks according to the selected design standard
- ✓ Export detailed report with all structural design calculations

Calculation Options for Both Walls

Kp Passive Method

Do Not Use A Code

Analyze only one Code Case

Design Code

BS-6349-1-2-2016

- Default
- EC7, 1997
- EC7, 2007
- DM08_ITA
- EC7-Greece
- XP P 94
- DIN 1054 (2005)
- AASHTO LRFD 8 (2018)
- BSEN 1997-1
- PEN DOT AASHTO (2010)
- CALTRANS LRFD (2012)
- CALTRANS LRFD (2012) x Approach
- CN-Level 1
- CN-Level 2
- CN-Level 3
- AASHTO-17, GSBTW-2
- AASHTO GFRP-2 (2017)
- BS-6349-1-2-2016**
- AASHTO LRFD 9th (2020)

Structural code options

Concrete Code Options

- 1:ACI 318-11
- 1:ACI 318-11**
- 2:EC2-2004
- 3:EC2-German Annex
- 4:EC2-Cyprus Annex
- 5:EC2-French Annex
- 6:EC2-Austrian Annex
- 7:EC2-Italian Annex
- 8:EC2-Netherlands Annex
- 9:EC2-Czech Annex
- 10:EC2-Belgium Annex
- 11:EC2-Slovakian Annex
- 12:EC2-Danish Annex
- 13:EC2-Finish Annex
- 14:EC2-Swedish Annex
- 15:EC8-Greek Annex
- 16:EC8-Italian Annex
- 17:EC8-Austrian Annex
- 18:EC8-Bulgarian Annex
- 19:EC8-Cyprus Annex
- 20:EC8-Slovenian Annex
- 21:EC8-French Annex
- 22:EC2-Greek Annex
- 23:EC2-2004
- 24:AS 3600-2009
- 25:CN (China)

Structural code options

Concrete Code Options

- 1:ACI 318-11

Steel Code Options

- 17:AISC 360-10 ALL.**
- 1:ASD 1989
- 2:EC3 2005-CEN
- 3:LRFD 13th Edition 2005
- 4:NTC 2008
- 5:EC3 2005-Bulgaria
- 6:EC3 2005-Slovenia
- 7:EC3 2005-UK
- 8:EC3 2005-Norway
- 9:EC3 2005-Sweden
- 10:EC3 2005-Finland
- 11:EC3 2005-Denmark
- 12:EC3 2005-Portugal
- 13:EC3 2005-Germany DIN
- 14:EC3 2005-Singapore
- 15:EC3 2005-Greece
- 16:ANSI/AISC 360-10
- 17:AISC 360-10 ALL.**
- 18:BS 5950-1:2000
- 19:AS/NZS 4100
- 20:CN (China)
- 21:ANSI/AISC 360-16
- 22:AISC 360-16 ALL.

calculations

Left side design moment capacity $M_{cap.des.L} = \frac{M_{cap.ult.L}}{FS} = \frac{26374.2}{1.5} = 17582.8 \text{ kN}$

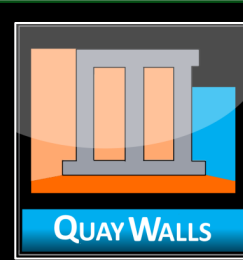
Right side design moment capacity $M_{cap.des.R} = \frac{M_{cap.ult.R}}{FS} = \frac{26374.2}{1.5} = 17582.8 \text{ kN}$

Design shear capacity $V_{cap.des} = \frac{V_{cap.ult}}{FS} = \frac{5139.9}{1.5} = 3426.6 \text{ kN}$

Left side moment stress check $RAT_{ML} = \frac{4161.418\text{kN-m}}{17582.813\text{kN-m}} = 0.237$

Combined stress check $RAT_{MN} = 0$ is smaller than moment check alone.

Set $RAT_{MN} = 0.237$



PART 2: Additional Modules - Expand QuayWalls Software Capabilities

Slope Stability
Analysis

Finite Element
Analysis

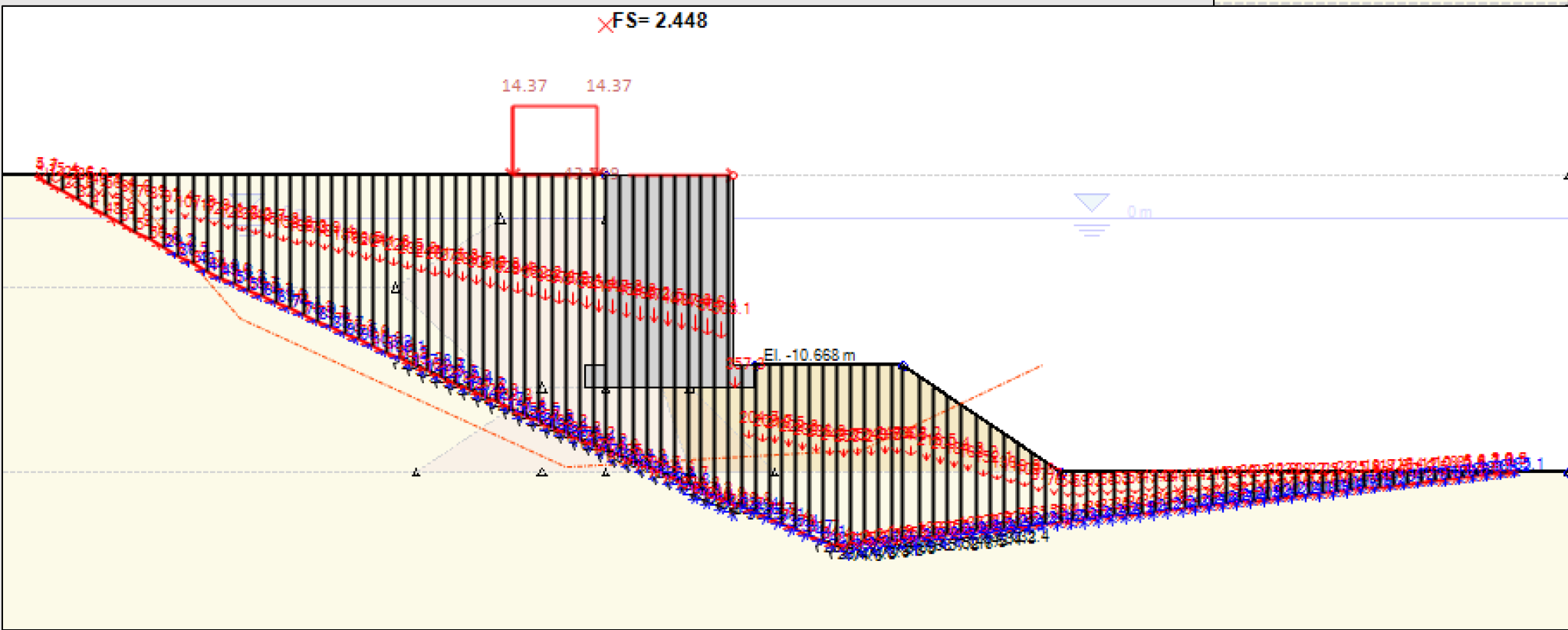
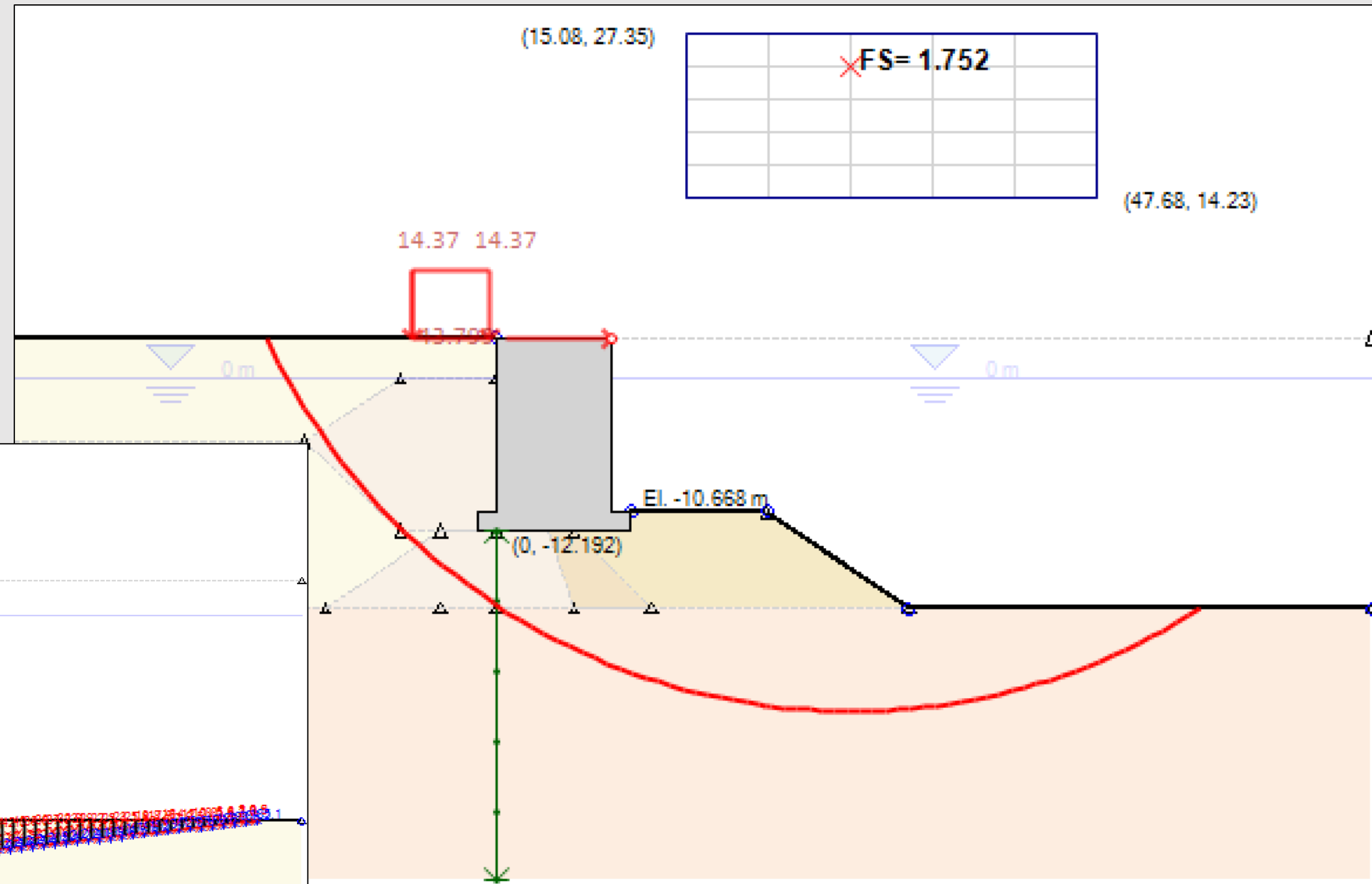
Soil Estimation -
Statistical Analysis

Pile Supported
Abutments

More information:

Click here to learn more:
[QuayWalls – Features and Capabilities](#)

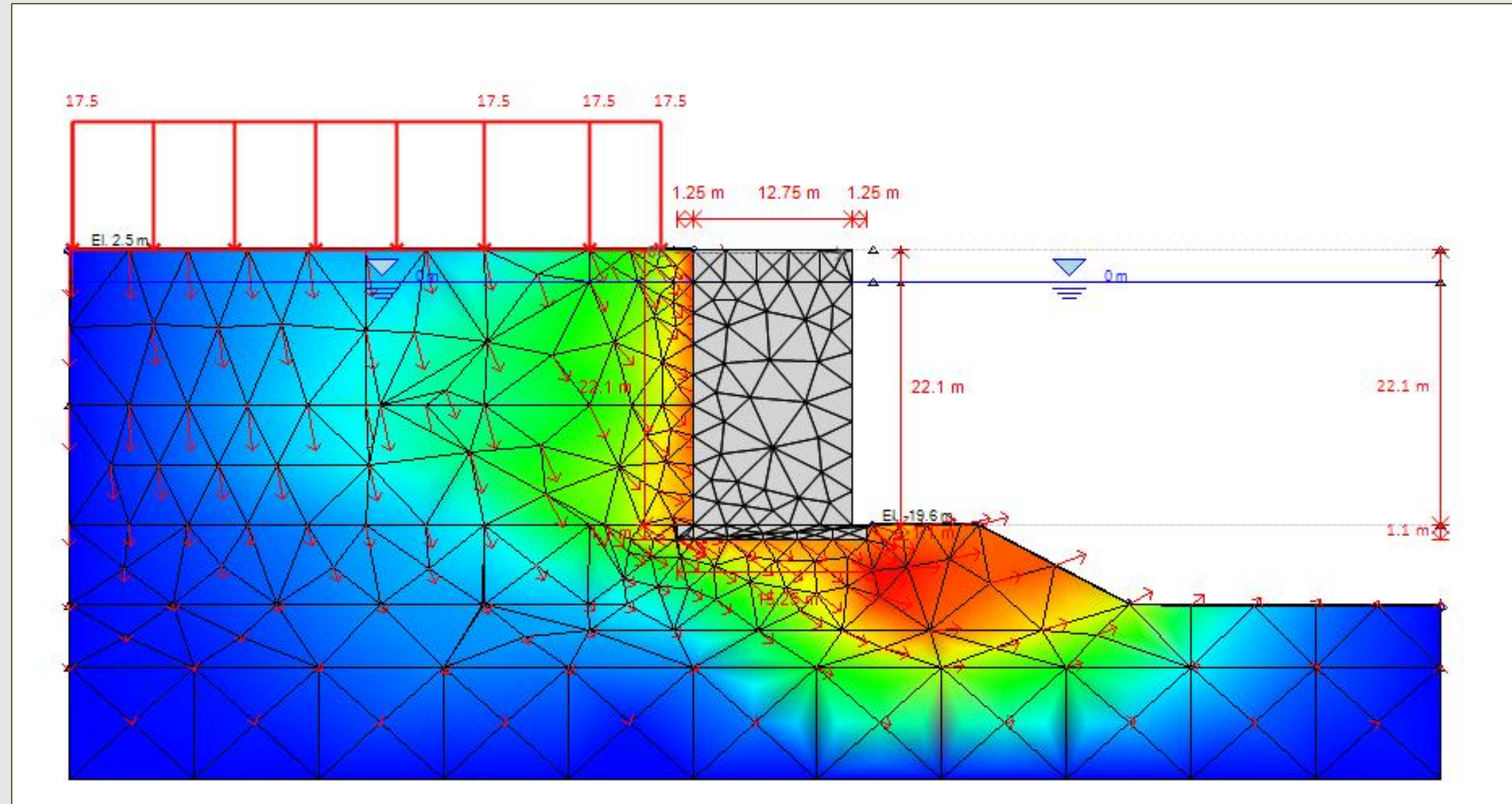
- ✓ Bishop Method
- ✓ Morgenstern Price Method (G.L.E.)
- ✓ Spencer Method
- ✓ Ordinary (Swedish) Method
- ✓ Automatic Slope Search Method
- ✓ Single Point Slope Center
- ✓ Rectangular Slope Center
- ✓ Define Radius Search Limits
- ✓ Clouterre Standards for Soil Nails



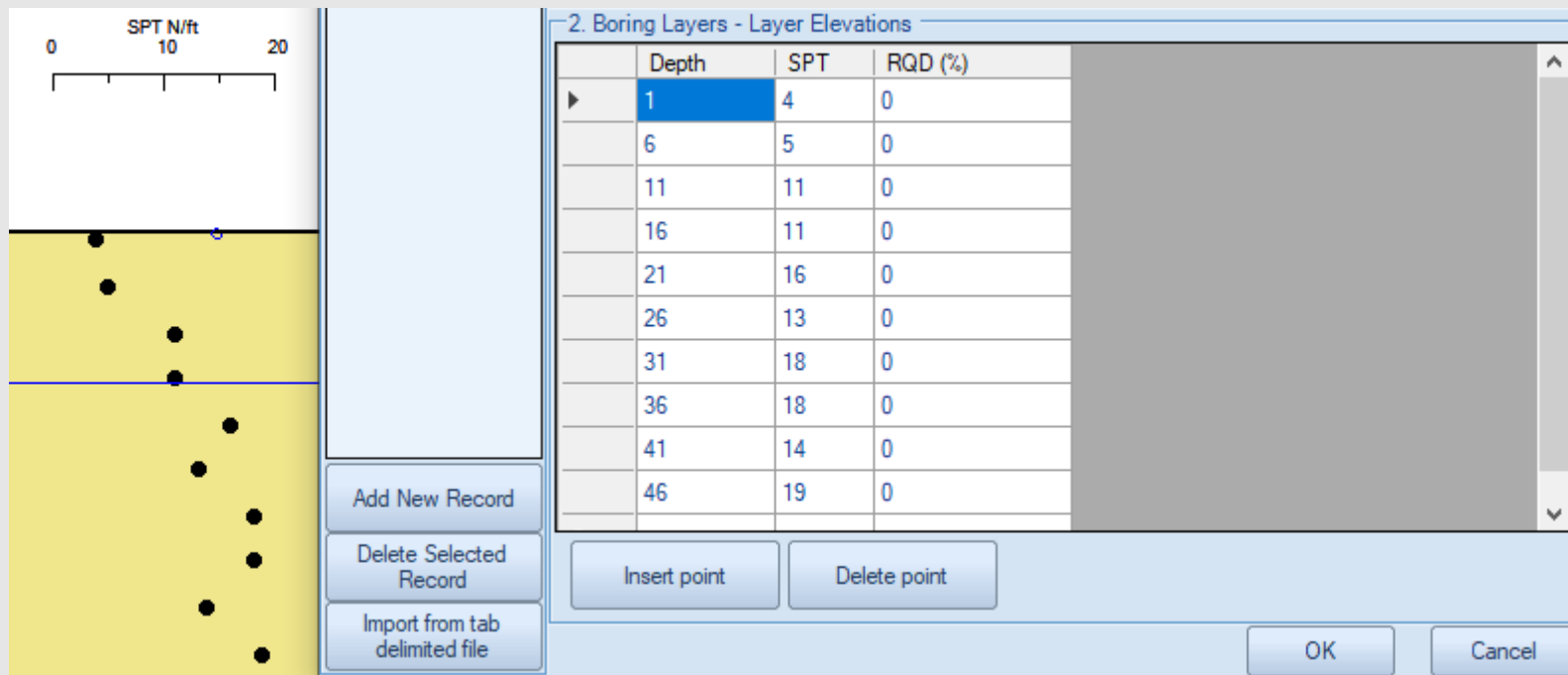
- ✓ Moments and reactions calculated with Finite Elements
- ✓ Automatic FEM mesh generation
- ✓ Consider full soil-structure interaction
- ✓ Calculate surface settlements
- ✓ Display soil mass displacements, settlements & stresses shadings

Soil Models:

- ✓ Elastoplastic Model
- ✓ Exponential (Hyperbolic) Model (approximate solution)
- ✓ Exponential (Hyperbolic) Model (complete solution): Soil hardening model



- ✓ Estimate Soil Properties with different methods
- ✓ Review a statistical analysis of the estimated properties
- ✓ Select the project values with a high level of certainty



1. Name and material: Set 1, Determine confidence values at Lower bound 25%

2. Density and Strength 3. Elasticity 4. Bond Resistances 5. Lateral Pile 6. OCR

Select Equations to use for estimating soil parameters

2.A: Soil Density

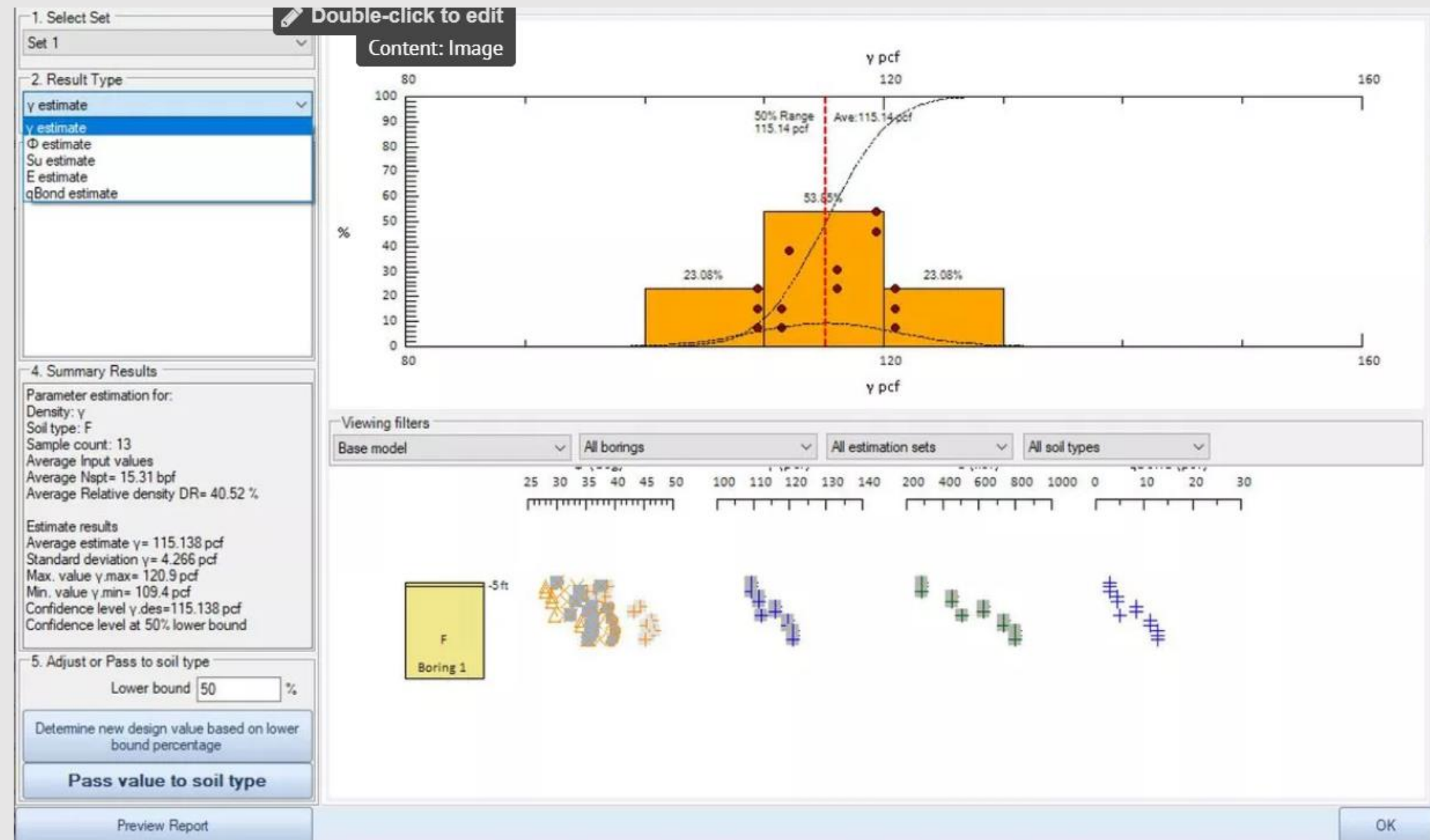
- γ Kullhawy, Mayne, 1990, Table 2-9, pg. 1-54
- DR, Bowles et. al., DeepEX approach
- DR, Manual of Estimating Soil Parameters, Table 2-9, pg. 2-19

2. B: Effective Friction Angle

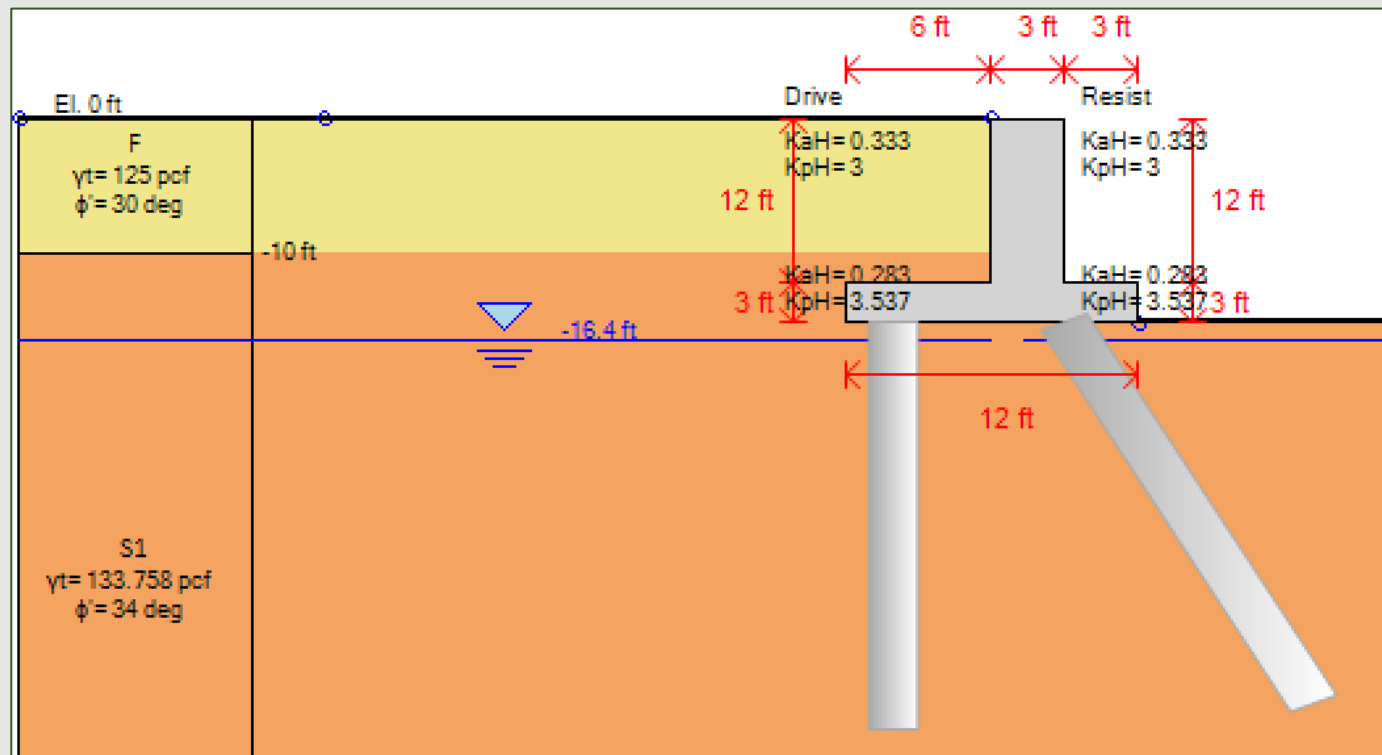
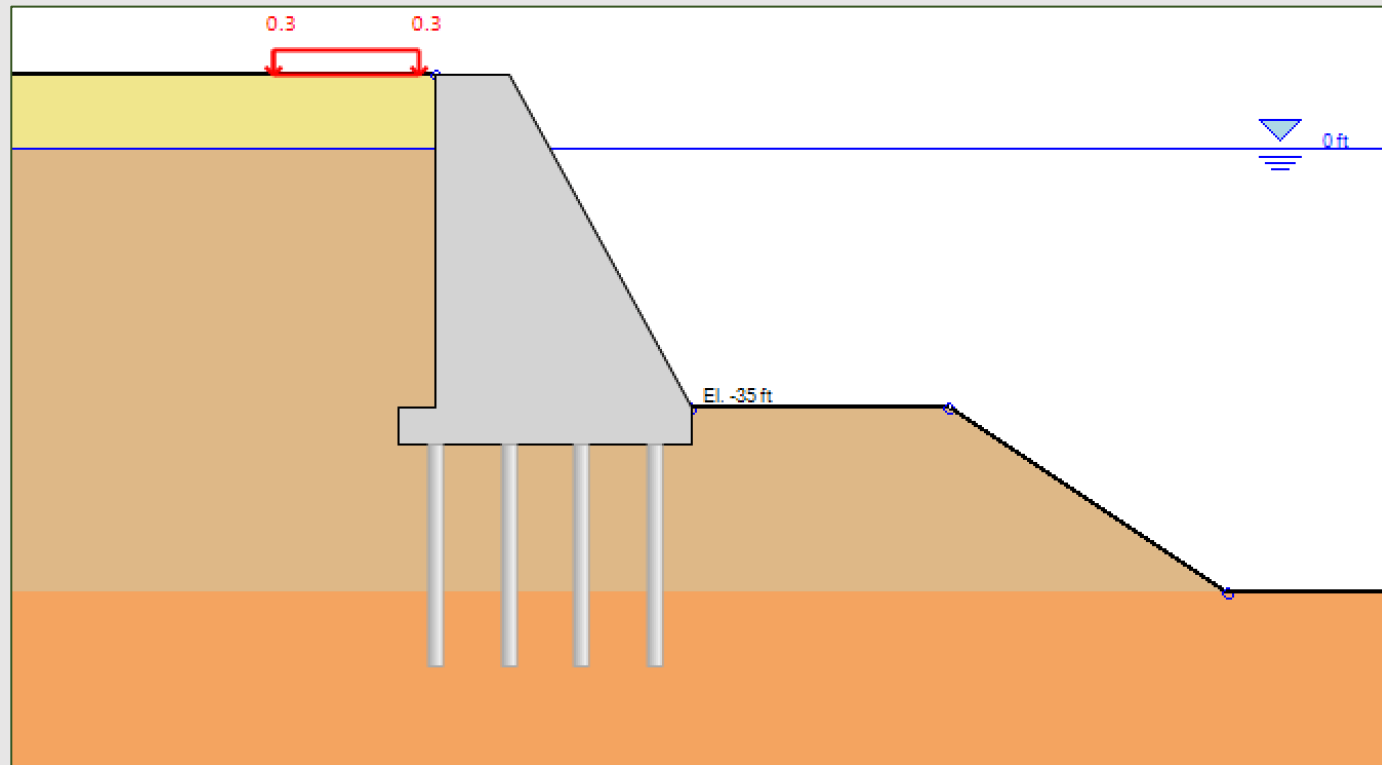
- Φ Parry, 1977 (Perko, Helical Pile Design Manual)
- Φ triaxial compression calibration, FHWA NHI 132031
- Φ Kullhawy, Chen, 2007
- Φ Terzaghi & Peck, 1967
- Φ FHWA pilot database calibrations
- Φ_{cv} , Parry 1977 for clays
- Φ Kullhawy, Mayne, 1990
- Φ Sabatini et. al, 2002, FHWA NHI-10-106
- Φ_{cv} , Holtz-Kovac 1991, 1985 for clays vs. PI, lower bound
- Φ_{cv} , Holtz-Kovac 1991, 1985 for clays vs. PI, average
- Φ_{cv} , Holtz-Kovac 1991, 1985 for clays vs. PI, upper bound

2. C: Undrained Shear Strength

- $S_u = 0.06 N Pa = 0.125 N (ksf)$, Kullhawy, Mayne, 1990, Eq 4-59, p
- $S_u (ksf) = 0.13 N$, Terzaghi-Peck 1967
- S_u vs OCR, Ladd 1977, Jamiolkowski 1985
- S_u clays, Koutsoftas & Ladd, 1985, vs. OCR and PI



- ✓ Design pile supported abutments
- ✓ Use footings (3D loads) and design the foundation piles



Edit pile sections

Section name and type
Section name: Concrete pile

Structural materials
Concrete mat.: Fc 3ksi
Rebar steel mat.: Grade 60

Section Properties
Steel sections - Hollow

Dimensions
D 24 in
C 2 in
A 55.8 in²

Section Drawing Envelope
D=24 in

Options
x: -16 mm y: 18 mm Use user defined reinforcement

OK Cancel

THANK YOU!

DESIGN AND OPTIMIZE ANY QUAY WALL SYSTEM IN MINUTES AND GAIN A COMPETITIVE EDGE!

Learn tips and tricks of deep excavation design

BOOK HERE A FREE ONLINE PRESENTATION
E: training@deepexcavation.com

or Call Us at: +1 - 206-279-3300

Review all software capabilities

CLICK HERE FOR MORE INFORMATION

Prices and Licensing Questions: sales@deepexcavation.com
Technical Support: support@deepexcavation.com

TRUSTED BY

