

Practice course - braced excavation modeling with

DeepXcav 2010

Deep Excavation LLC

INTRODUCTION

DeepXcav 2010 is a software program for braced excavations in soils with 2D limit-equilibrium and non-linear analysis methods, and structural verification of all elements (with AISC, ASD, Eurocodes).

It offers the ability to analyze walls with multiple braces (tiebacks) in multilayered soils.

The non-linear analysis considers elastoplastic behavior for the whole soil-wall-support system.

The program also offers the ability to perform traditional limit-equilibrium analyses.

The graphical interface is completely interactive and the input is simplified to a great extent.

The program utilizes archives of wall types, structural and soil materials, ground anchors etc.

The analysis can be performed in either an ultimate state or at a service state (allowable design or LRFD).

The program offers the ability to automatically set all critical settings according to the desired design methodology.

INTRODUCTION

It is strongly recommended to model all the necessary construction stages as the real construction sequence affects the obtained results. It is therefore advised to subdivide the construction of the model in more than one stages as required.

Stage 0

- Define basic project information (name, coordinates etc).
- Reset global elevations to match the general site elevations.
- Material selection
 - Definition of soil types and soil stratigraphy (borings).
 - Definition of structural material archives for concrete, steel, and rebar steel used in walls and supports (tiebacks, struts, slabs, etc.).

INTRODUCTION

- Define the initial surface elevations and coordinates (horizontal, inclined, berms etc)..
- Apply surface loads: strip loads (uniform or trapezoid), linear loads, 3D.
- Apply loads directly on the wall: Distributed loads, linear loads, moments, imposed displacements or rotations.
- Define basic wall type: Soldier pile walls, sheet pile, secant pile, diaphragm walls etc.

INTRODUCTION

- **STAGE 1**
 - Excavation
 - Lowering the excavation to the first level (left or right, typically up to 10ft or 3.5m)

- **STAGE 2**
 - Insert ground anchor, strut, or slab support above the excavation level. **It is recommended to create a separate stage where the support is activated and the excavation levels are kept the same as in the previous stage.**
 - Define the newly inserted support type, basic dimensions, and prestress for ground anchors.

INTRODUCTION

➤ STAGE 3

- Final retained ground level;
- Final excavation to subgrade level.

➤ STAGE 4

- Application of seismic loads if required. The seismic load can be applied at anytime during the construction of the model, not only at the end. Like for the insertion of the supports, it is better to create an appropriate phase in which only the seismic load is applied.
- Select the applicable structural design code (USA, Europe, etc).
- Automatic generation of the Design Approached (Europe).
- Calculate and verify the design.

INTRODUCTION

➤ 4 levels of results

- Summary tables showing principal results.
- On screen diagrams.
- Detailed diagrams.
- Detailed tables showing wall results for every node and every stage along the wall.

➤ Report

It is possible to construct a report with simple drag & drop of prototype report sections. The reports can include any stage and any design section of the calculation. Reports can be exported in PDF and Word formats.

Do not forget to Press "Select all" to include all the stages and design sections for the report.

Soil properties

ϕ' = friction angle used in calculations for non-clay soils and limit-equilibrium analysis.

Serves for the calculation of the lateral earth pressure coefficients K_0 , K_a and K_p .

E' elasticity of the soil (in non-linear analysis).

ϕ_{cv} = Constant volume shearing angle (used for clays in NL analysis).

ϕ_{cv} is NOT used for sand, silt and rock soil types.

The program offers a number of correlations to help the user estimate ϕ_{cv} and the calculation friction angle ϕ' .

ϕ_{cv} is required for clay soil types when a non-linear analysis is performed.

SOIL PROPERTIES

ϕ_{PEAK} = Peak angle of shearing (used for clays in NL analysis).

NOT required for sands, silts and rocks.

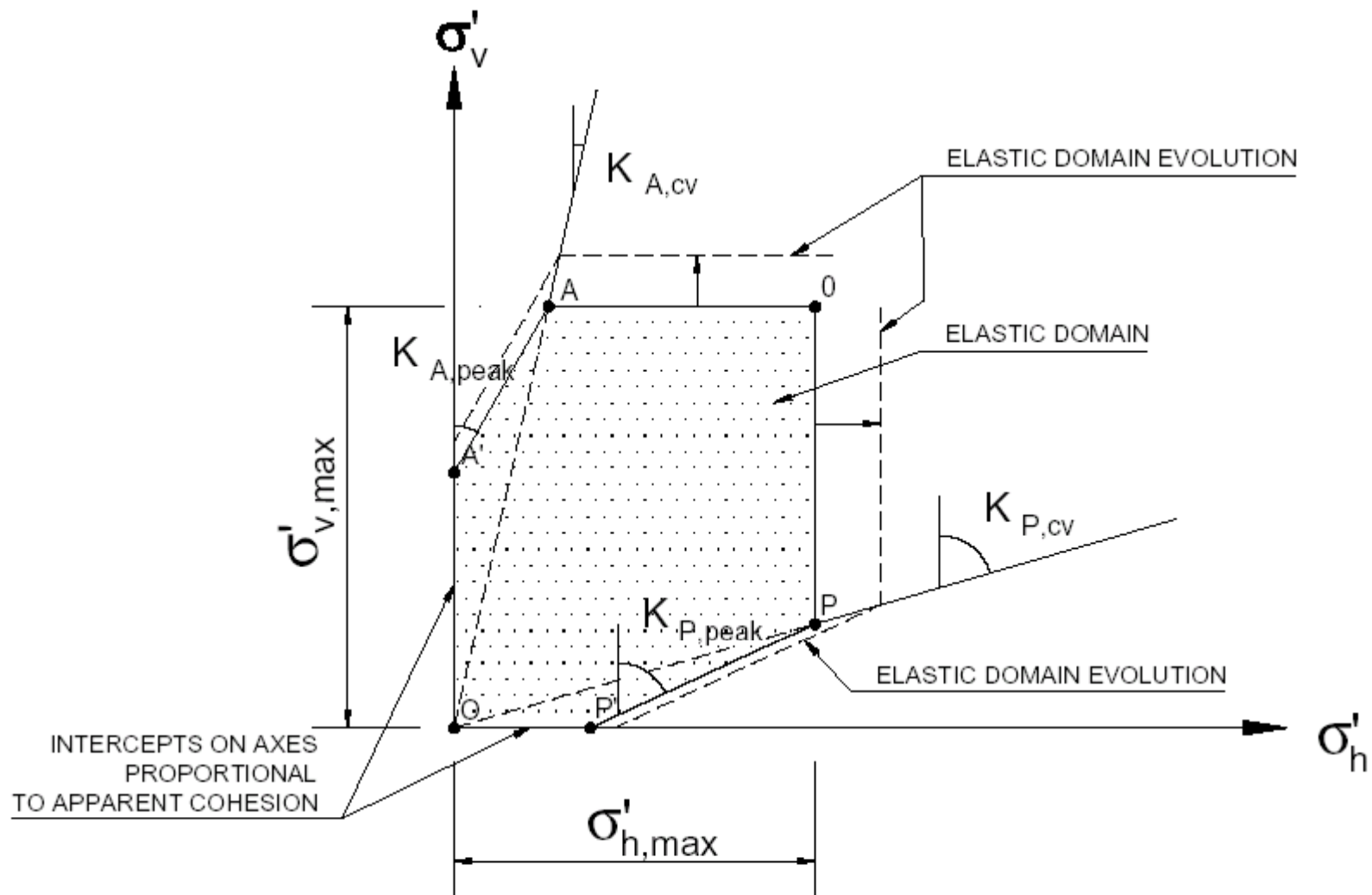
Correlations are available to relate ϕ_{cv} with ϕ_{PEAK} and ϕ' .

ϕ_{PEAK} is required for clays in non-linear analysis and is used in determining the soil elasticity domain.

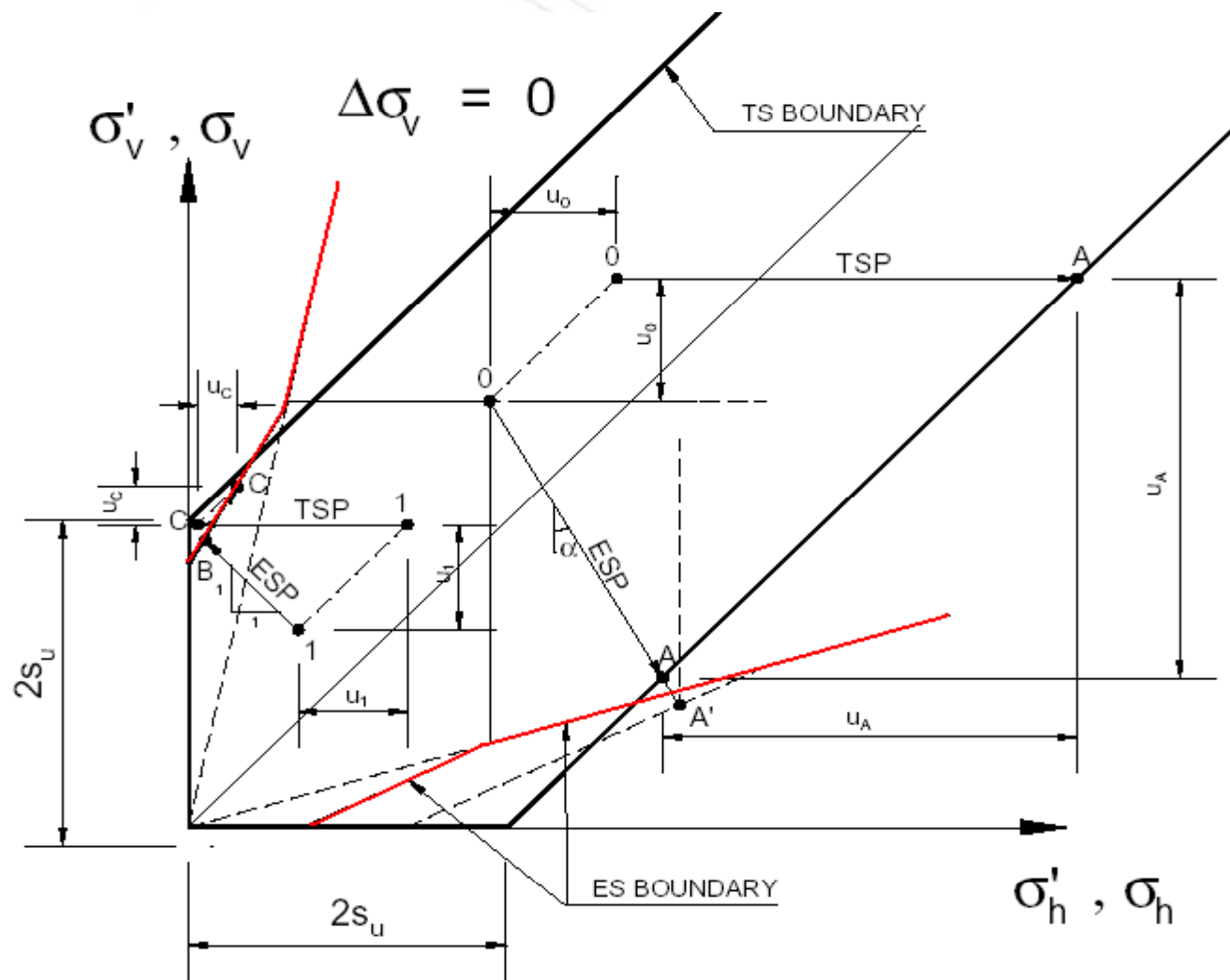
S_u (undrained shear strength) is not enabled with sands, silts and rocks. E' and S_u are required with clays as it defines the elastic domain frontier. When the simplified clay modeling is used, S_u is the only parameter used together with the undrained elastic modulus E_u .

c' (effective cohesion) is an optional parameter for sands, silts, and rocks. For clays it is only used in limit equilibrium analysis during drained conditions.

SOIL PROPERTIES -ELASTICITY SOIL DOMAIN

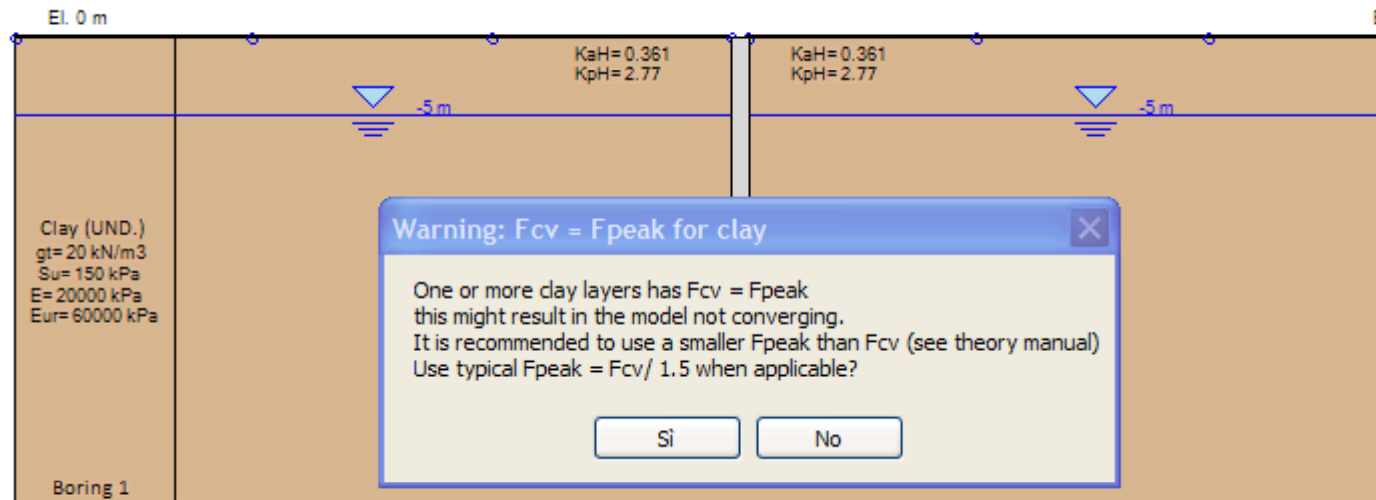


SOIL PROPERTIES



SOIL PROPERTIES

Φ cv'	28	degrees
Φ peak'	28	degrees



Analysis warning: For clays when $\Phi_{PEAK} = \Phi_{CV}$

Analysis NL: it gives a warning since the apparent cohesion c' cannot be determined

SOIL PROPERTIES

k_x = horizontal permeability coefficient.

k_z = vertical permeability coefficient.

k_x & k_z used to determine water pressures in ground water flow analysis (1D-2D) and hydrodynamic effects during earthquakes.

K_a = active earth pressure coefficient. Calculated with Rankine method (default).

K_p = passive earth pressure coefficient. Calculated with Rankine method (default).

Note: K_a and K_p within the soil type dialog are calculated with the corresponding friction angle. It is strongly recommended to only use the default rankine values within this dialog.

SOIL PROPERTIES

- Autoestimate K_a - K_p when Soil friction values are changed
- Use default engine K_a and K_p (Rankine, soil friction only)

- 8. Include soil in parameter variation
 - Include in parameter variation (i.e. Eurocode, Statistical analysis). It is strongly recommended to keep this option checked.

- It is recommended to maintain the option Autoestimate K_a and K_p for friction angle checked. This allows the automatic calculation of K_a and K_p when the friction angle is changed.
- *The option Use default engine Rankine $K_a - K_p$ is used in the NL analysis.*
- *Option include soil in parameter variation:* Includes the soil type in soil strength reduction design approaches (similar to Eurocode 7, etc)

A tool is available that allows the manual calculation of K_a and K_p based on various theories.

SOIL PROPERTIES

Friction Angle, Wall Friction, and Slope Angle B

$\phi = 30.000$ ° $\beta = 0.000$ ° $\delta = 0.000$ ° ax= 0 g
 az= 0 g

Active Coefficient Values

	Rankine	Coulomb	Richards-Shi	
$\phi = 30$ °	K_a : 0.333	0.333	0.333	$c' = 0$ kPa
$\delta/\phi = 0$	K_{ah} : 0.333	0.333	0.333	$\sigma'_v = 1$ kPa
$\beta/\phi = 0$	Accept Value of K_{ah}	Accept Value of K_{ah}	Accept Value of K_{ah}	

Ka estimation dialog and data:

- ϕ' : soil friction angle
- β = surface slope angle
- δ = wall-soil interface friction angle.

Note: For clays the angle δ must necessarily be inserted in this window and it cannot change during all the course of the analysis. For sands δ can be changed from the main menu and can have various values in any stage.

Note: When the window is closed the values of b and d are reset, however the K_a values are preserved.

SOIL PROPERTIES

Method	Active Coefficient				Passive Coefficient			
	Available	Surface angle	Wall Friction	EQ. ²	Available	Surface angle	Wall Friction	EQ.
Rankine	Yes	No ¹	No ¹	No	Yes	No ¹	No ¹	No
Coulomb	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Caquot-Kerisel Tabulated	No	-	-	-	Yes	Yes	Yes	No
Lancellota	No	-	-	-	Yes	Yes	Yes	Yes

¹ The Rankine values are converted automatically to Coulomb if the program detects soil-wall friction or an inclined surface with a single slope angle.

² Seismic effects are considered separately.

A. General | B. Resistance | C. Elasto-plastic | D. Bond

10. Soil Model and Behavior

Elastic-Plastic (Linear Load-Reload)
Exponential
Subgrade-modulus

10.1 Loading Elasticity Parameters

Evc 20000 kPa >
exp 0.5 > Pref 95.8 kPa >
 α_v 0.5 > α_h 0.5 >

10.1 Simplified clay model (Undrained analysis and TSP)

Eu 0 > Kwu 4714.5 kN/m³

Used only when Total Stress Analysis is selected (Undrained only)

10.2 Reloading Elasticity Modulus

Eur 60000 kPa >

SOIL PROPERTIES

The *Elasto - Plastic* tab is used to define the elastoplastic behavior of the soil (and therefore the soil reactions) in each calculation stage, depending on the drainage conditions and the stress history.

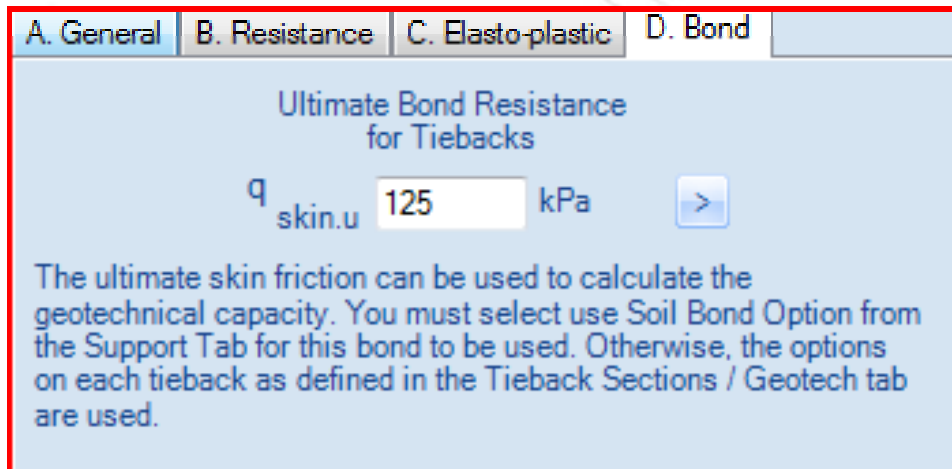
For clays an option to use a Simplified clay model is also available (Total Stress Analysis).

For all soil types:

- Evc = Elastic compression modulus during primary loading. The oedometer modulus can be used as a rough approximation.
- Eur = Elastic modulus during reloading (on excavation side)

For the clays and the Simplified Clay Model:

- Eu = Elastic modulus during undrained conditions.



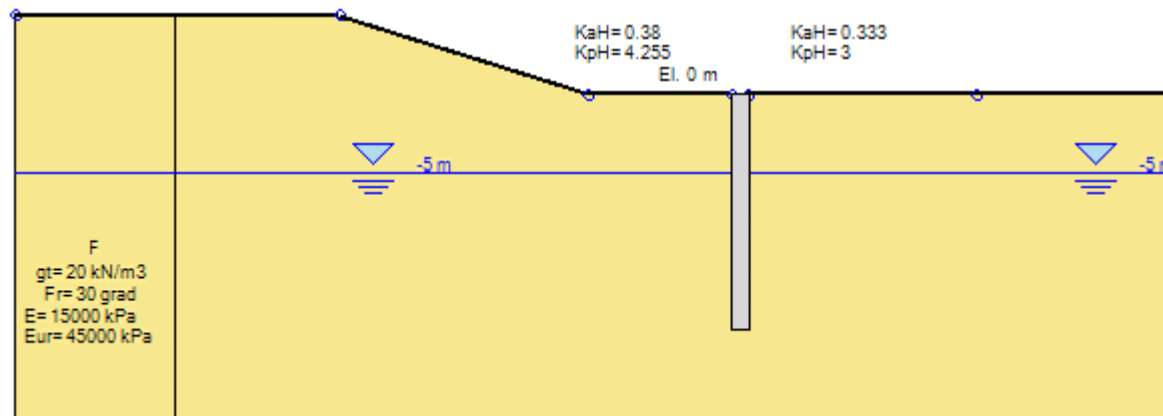
SOIL PROPERTIES

In the Tab D. Bond it is possible to select the ultimate adhesion value between the soil type and the fixed length of ground anchors.

Note: The software considers initially an arbitrary default value. This value is used for all anchors whose grouted length is within this type of soil layer. The possibility exists to define a custom value of skin friction for each tieback type irrespective of the soil type. In order to activate this option go to the Load/Support tab in the main program and uncheck the "Use soil bond values to calculate geotech capacity of tiebacks). In this way the software uses the defined value of q in the window of the pulling properties of each tieback section (archive).

A tool is available to correlate q with pressiometer test data according to correlations by Bustamante and FHWA. Note that q is dependent both on the soil type and on the drilling technique.

Surface profile definition

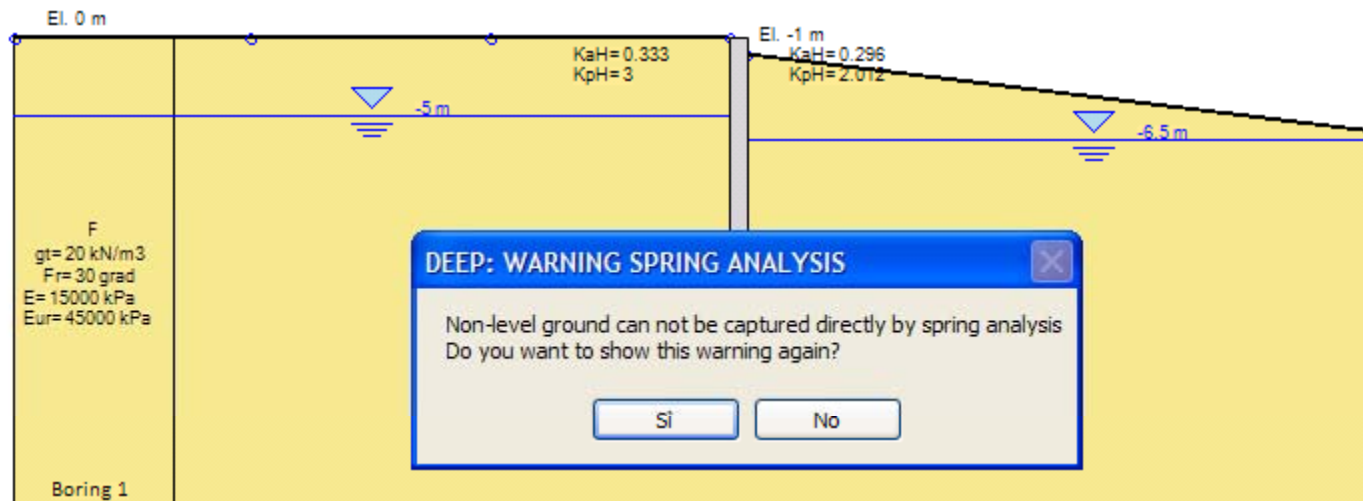


Conventional analysis: no warning.

NL Analysis: no warning.

Note: Remember to extend the model coordinates so that the surface profile fits.

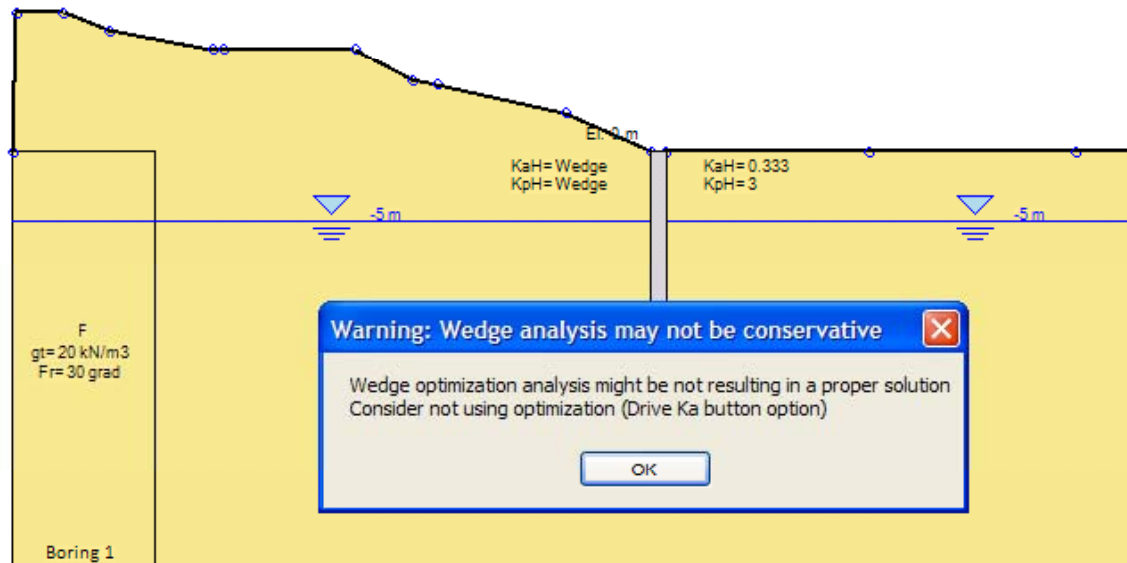
Surface profile definition (inclined surface)



Conventional analysis: no warning

NL Analysis: Warning for approximations during analysis with inclined surface.

Surface profile definition

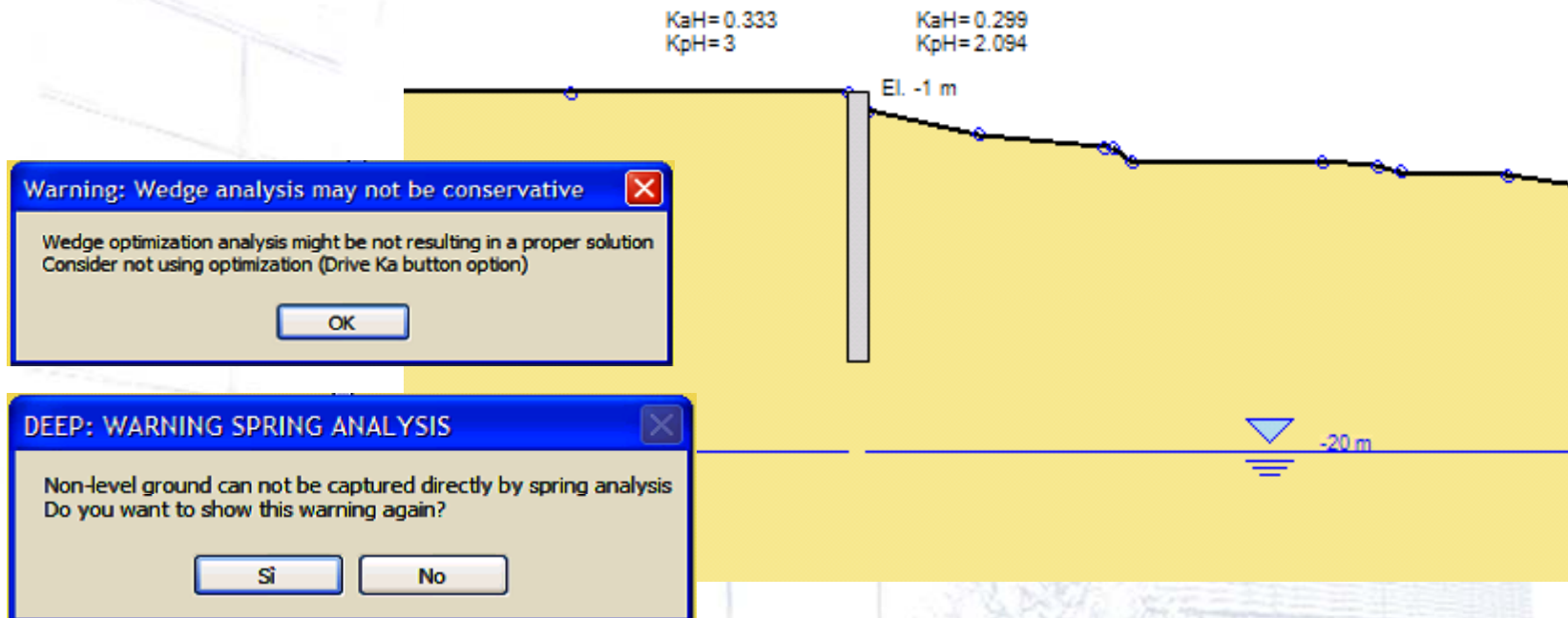


Conventional analysis: Warning that wedge analysis optimization might not be resulting in a proper solution.

Recommendation -> deactivate wedge analysis optimization from ka button.

NL Analysis: no warning (left side modelled with a series of strip loads).

Surface profile definition



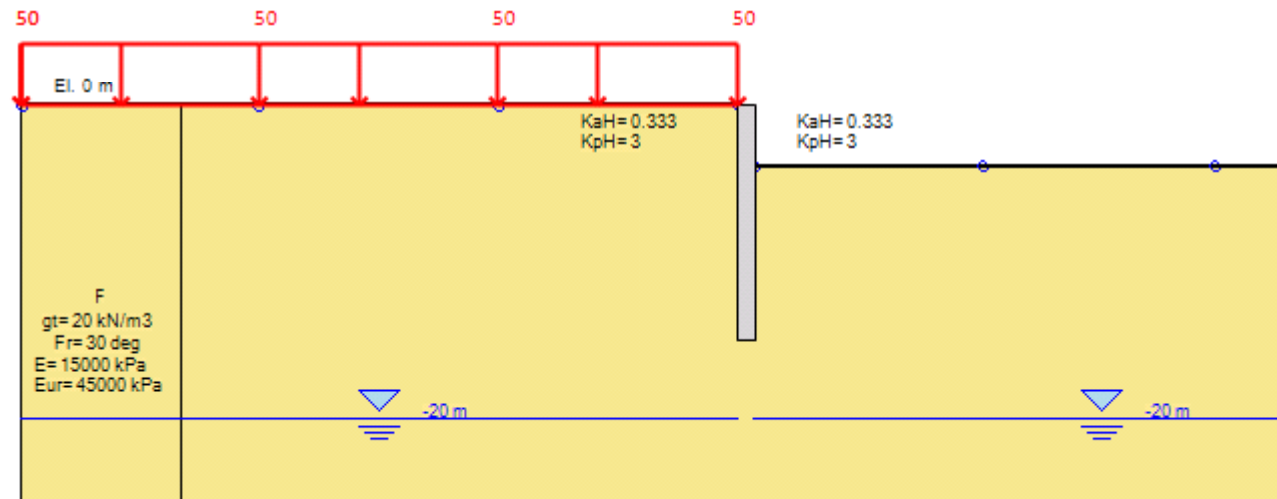
Conventional analysis: Wedge analysis optimization routine warning.

NL Analysis: Warning that certain approximations are made.

Available load types

Surcharge Type	Permanent/ Temporary (P/T)	Exists in Paratie Engine	Exists in Conventional Analysis	Conventional Analysis Comments
Surface Line load	P & T	No	Yes	Theory of elasticity. Can include both Horizontal and Vertical components.
Line load	P & T	No	Yes	Same as above
Wall Line Load	P & T	No	Yes	Same as above
Surface Strip Surcharge	P & T	Yes	Yes	Same as above
Wall strip Surcharge	P & T	Yes	Yes	Same as above
Arbitrary Strip Surcharge	P & T	No	Yes	Theory of elasticity. Vertical Direction only.
Footing (3D)	P	No	Yes	
Building (3D)	P	No	Yes	
3D Point Load	P & T	No	Yes	
Vehicle (3D)	T	No	Yes	
Area Load (3D)	P & T	No	Yes	
Moment/Rotation	-	Yes	No	-

Surface loads

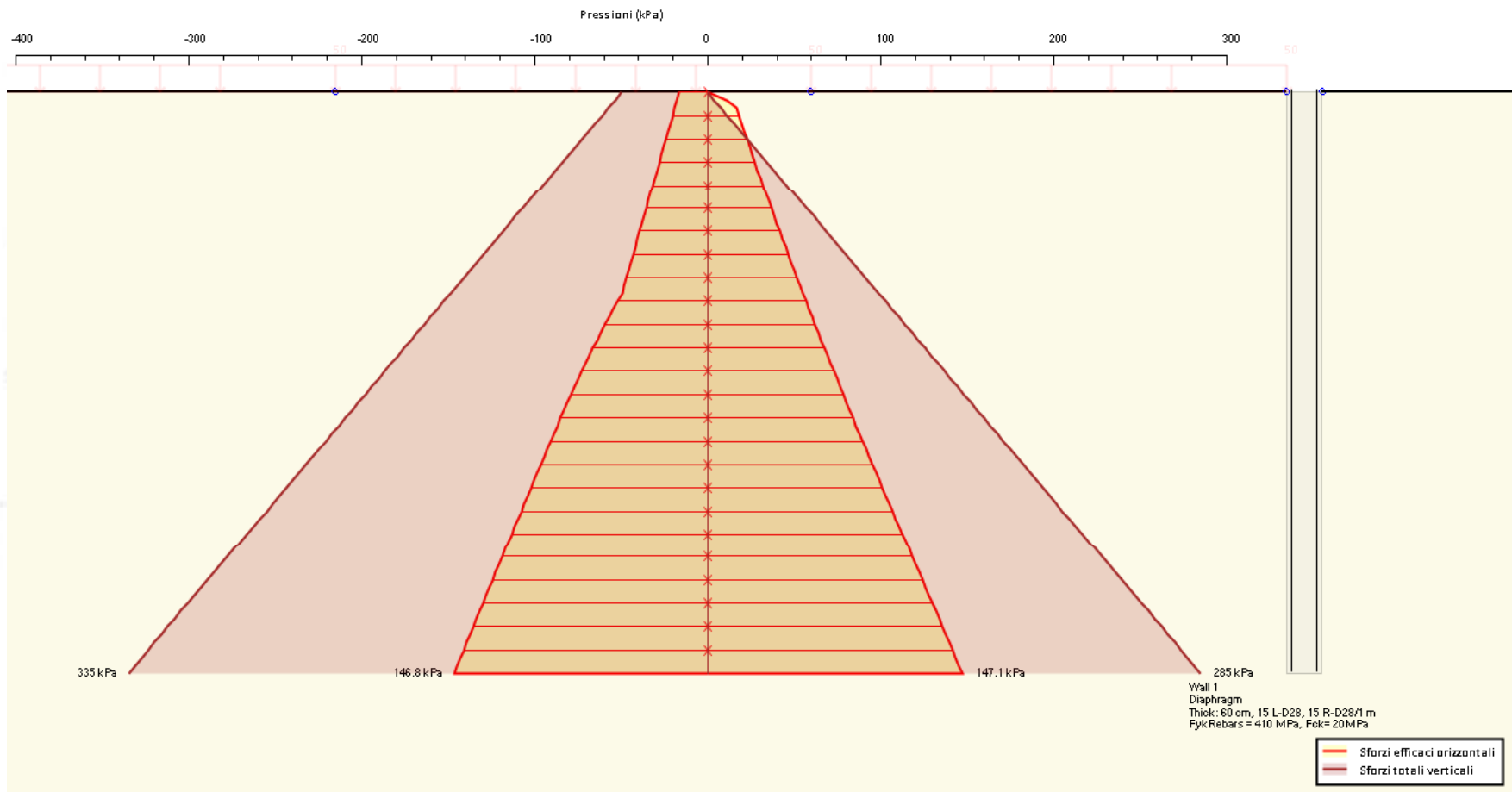


- Surface loads or strip loads (infinite length) are available with different options:
- Uniform field surcharge applied on the whole side (directly on the vertical stress)
 - Strip load with theory of elasticity or distribution angle.
 - Strip load not applied on the surface or with trapezoidal distribution.

Note: a load of equal length to the halfspace, is automatically used as a field surcharge surcharge even if the option is explicitly selected.

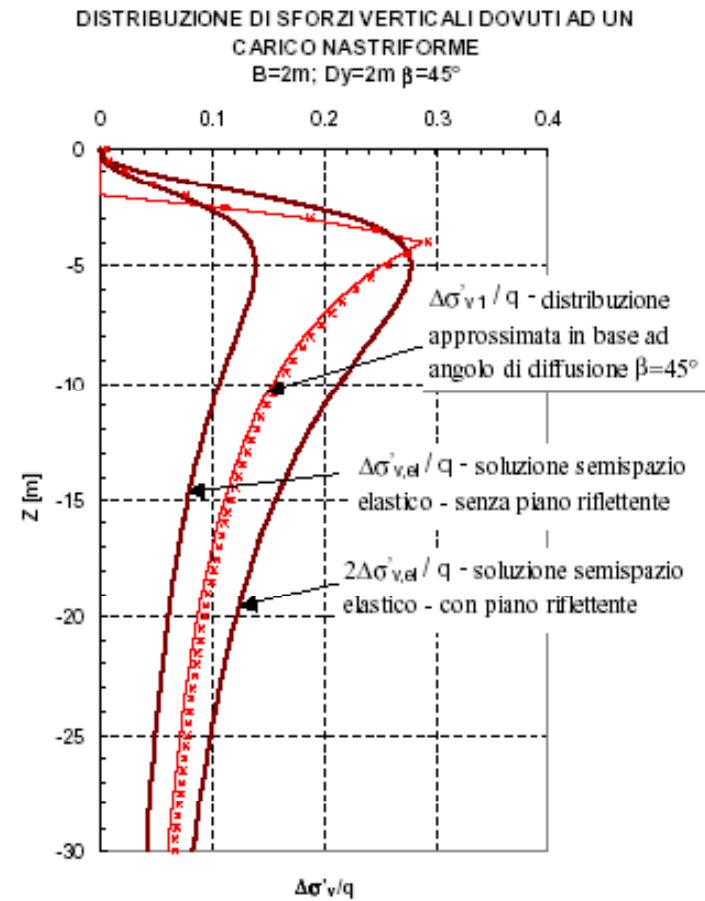
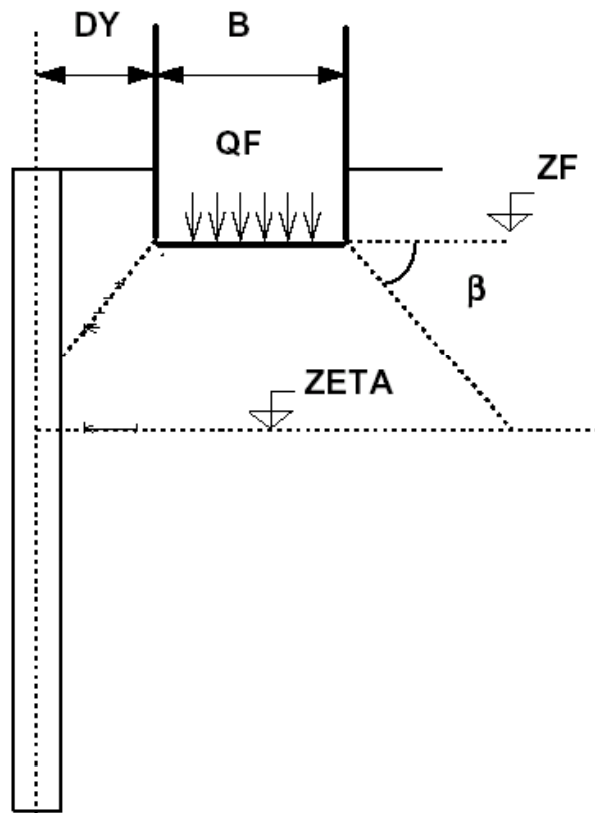
Surface loads

Field surcharge applied on model half space
(vertical stress increase on left)

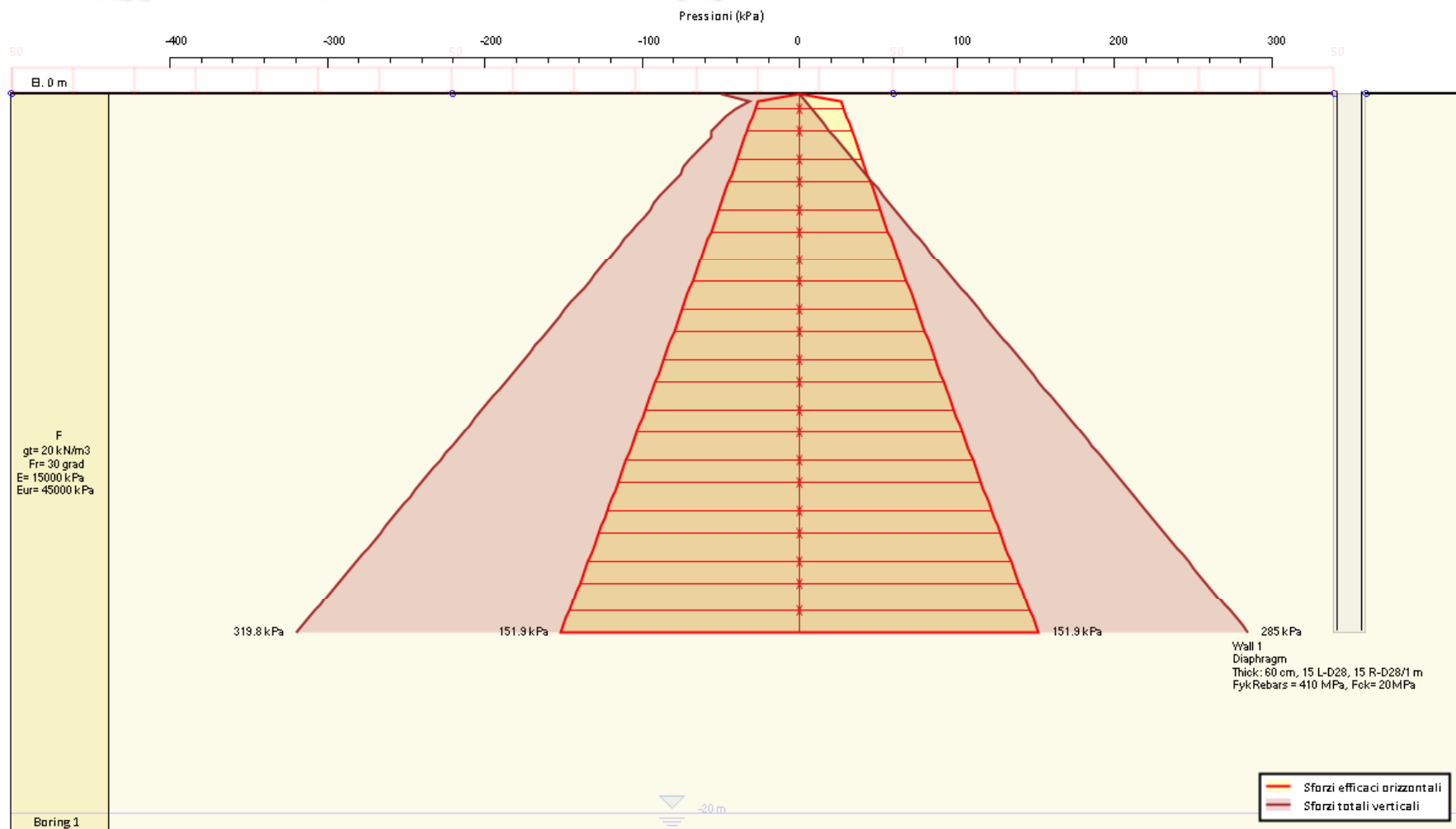


Strip load with distribution angle (NL Analysis)

Uniform load of finite length

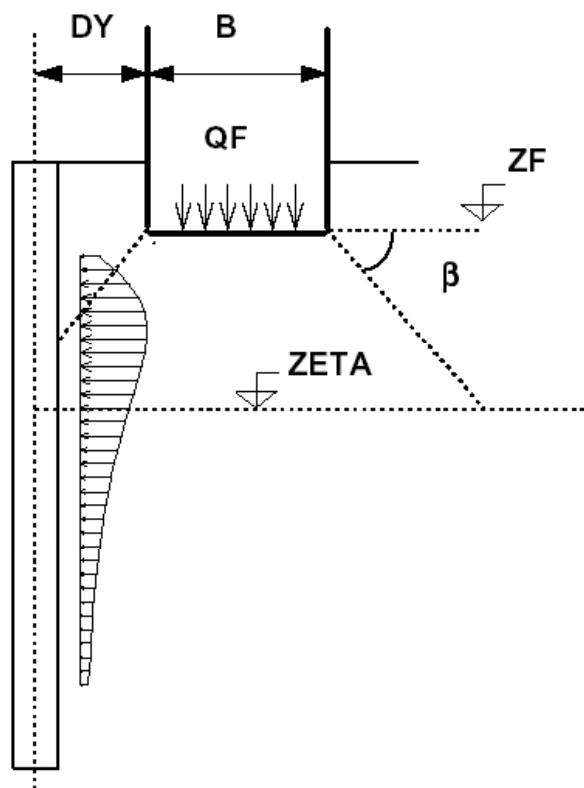


Surface loads

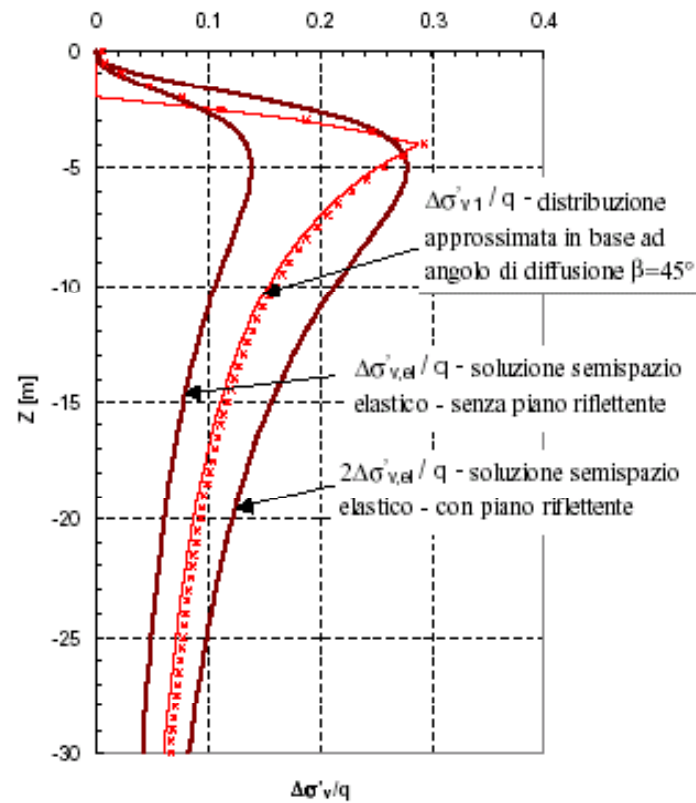


Surface loads

Strip modificato per mezzo del fattore m



DISTRIBUZIONE DI SFORZI VERTICALI DOVUTI AD UN CARICO NASTRIFORME
 $B=2m; Dy=2m \beta=45^\circ$



Surface loads from elasticity applied on the wall

Input file NL analysis.

step 0 : Stage 0

setwall Leftwall

geom 0 0

water -20 0 -15 0 0

dload step Leftwall -0.2 10.7774 0 0

dload step Leftwall -0.4 17.7593 -0.2 10.7774

dload step Leftwall -0.6 21.069 -0.4 17.7593

dload step Leftwall -0.8 22.3904 -0.6 21.069

dload step Leftwall -1 22.8495 -0.8 22.3904

dload step Leftwall -1.2 22.9459 -1 22.8495

dload step Leftwall -1.4 22.8805 -1.2 22.9459

dload step Leftwall -1.6 22.7365 -1.4 22.8805

dload step Leftwall -1.8 22.5512 -1.6 22.7365

dload step Leftwall -2 22.343 -1.8 22.5512

dload step Leftwall -2.2 22.1213 -2 22.343

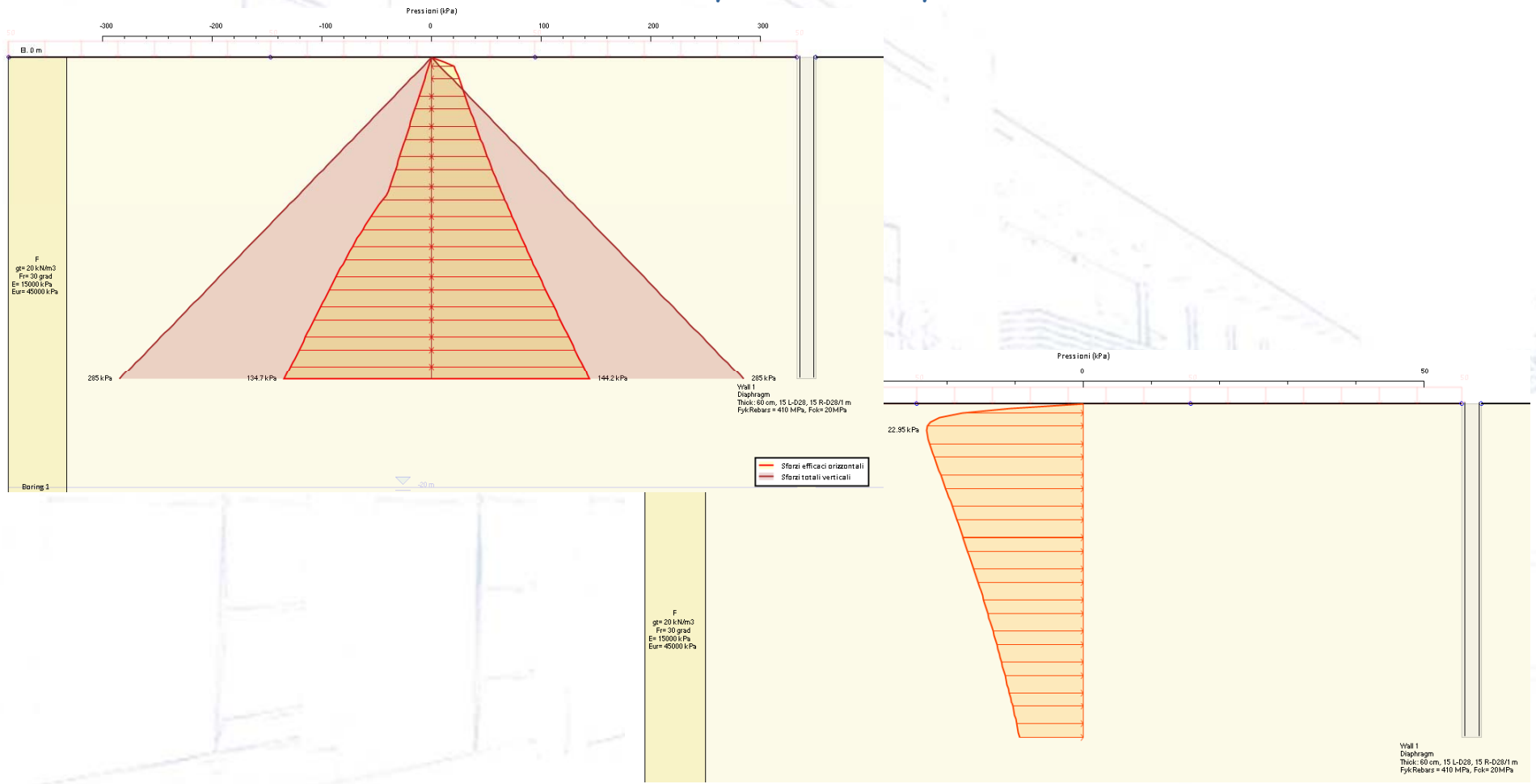
dload step Leftwall -2.4 21.8914 -2.2 22.1213

dload step Leftwall -2.6 21.6565 -2.4 21.8914

dload step Leftwall -2.8 21.4186 -2.6 21.6565

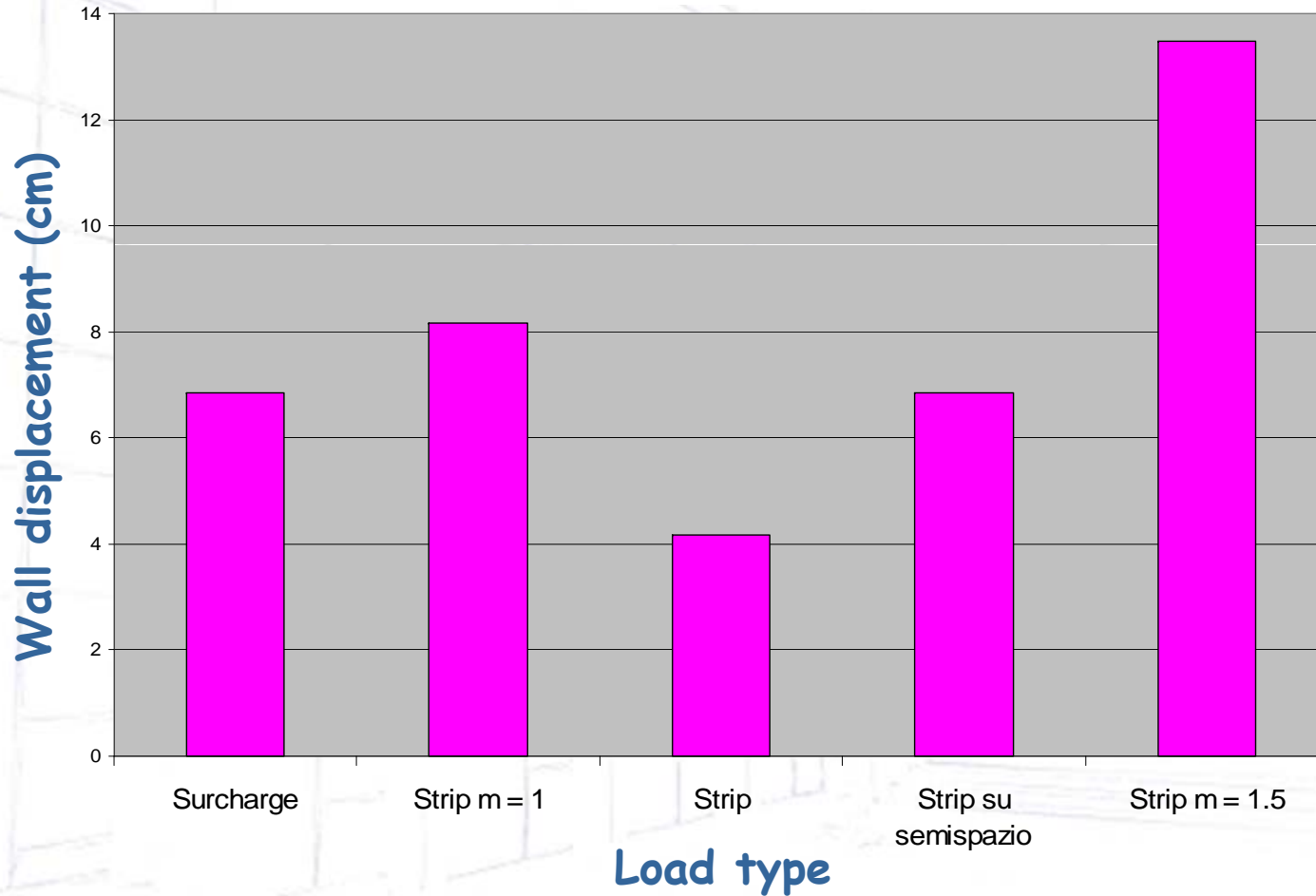
Surface loads

When the theory of elasticity is used.



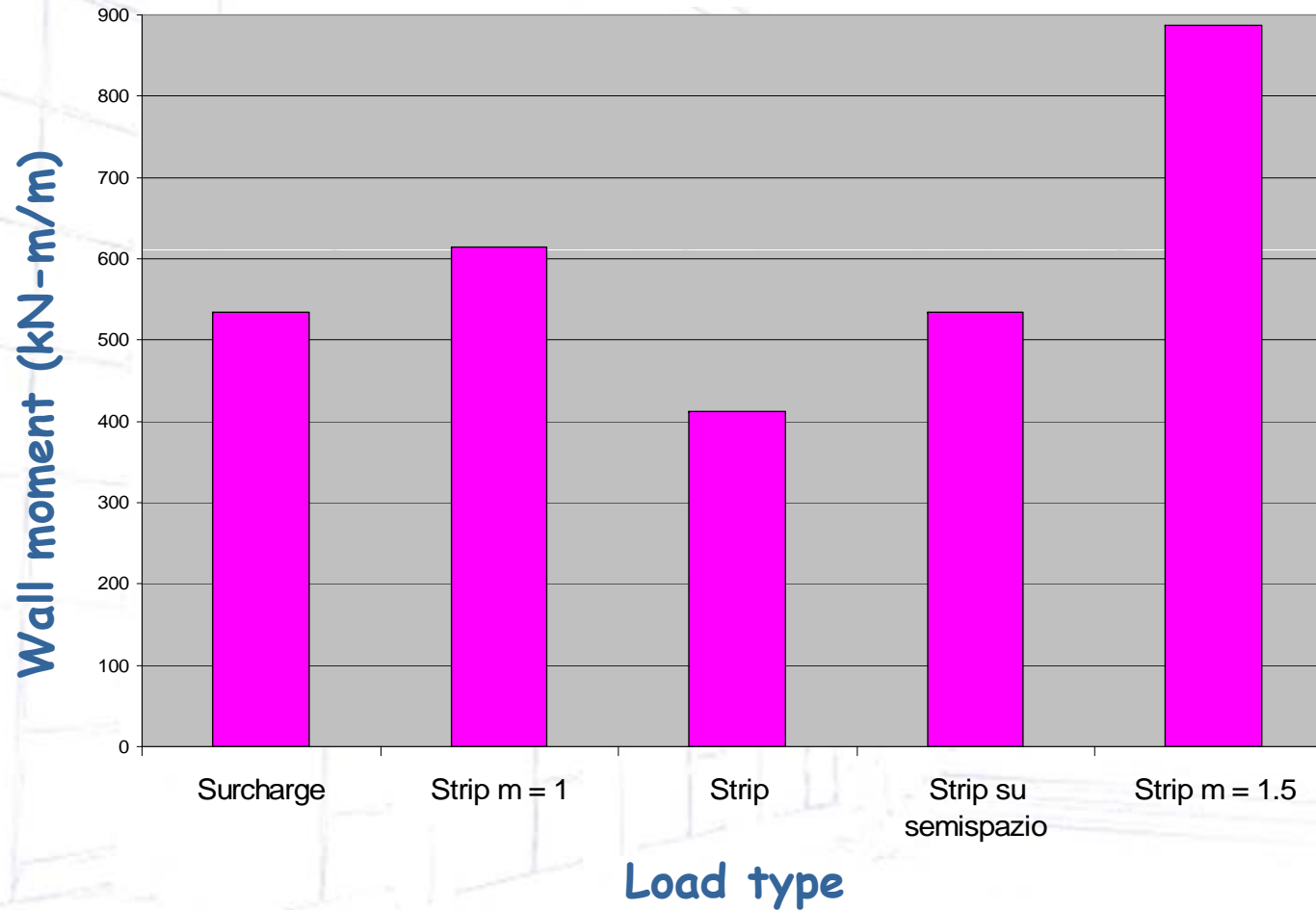
Surface loads

$c' = 0$ kPa



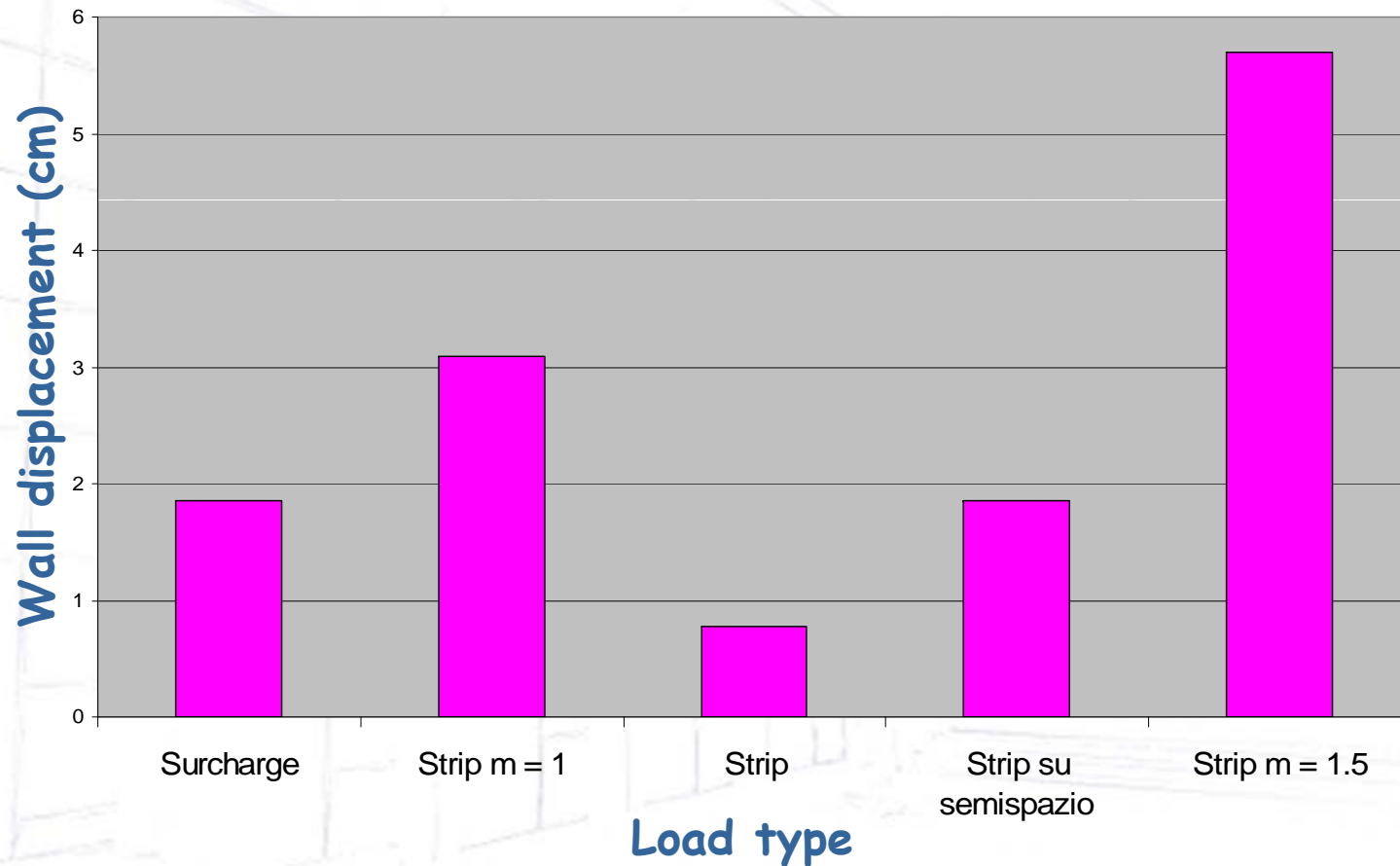
Surface loads

$c' = 0$ kPa



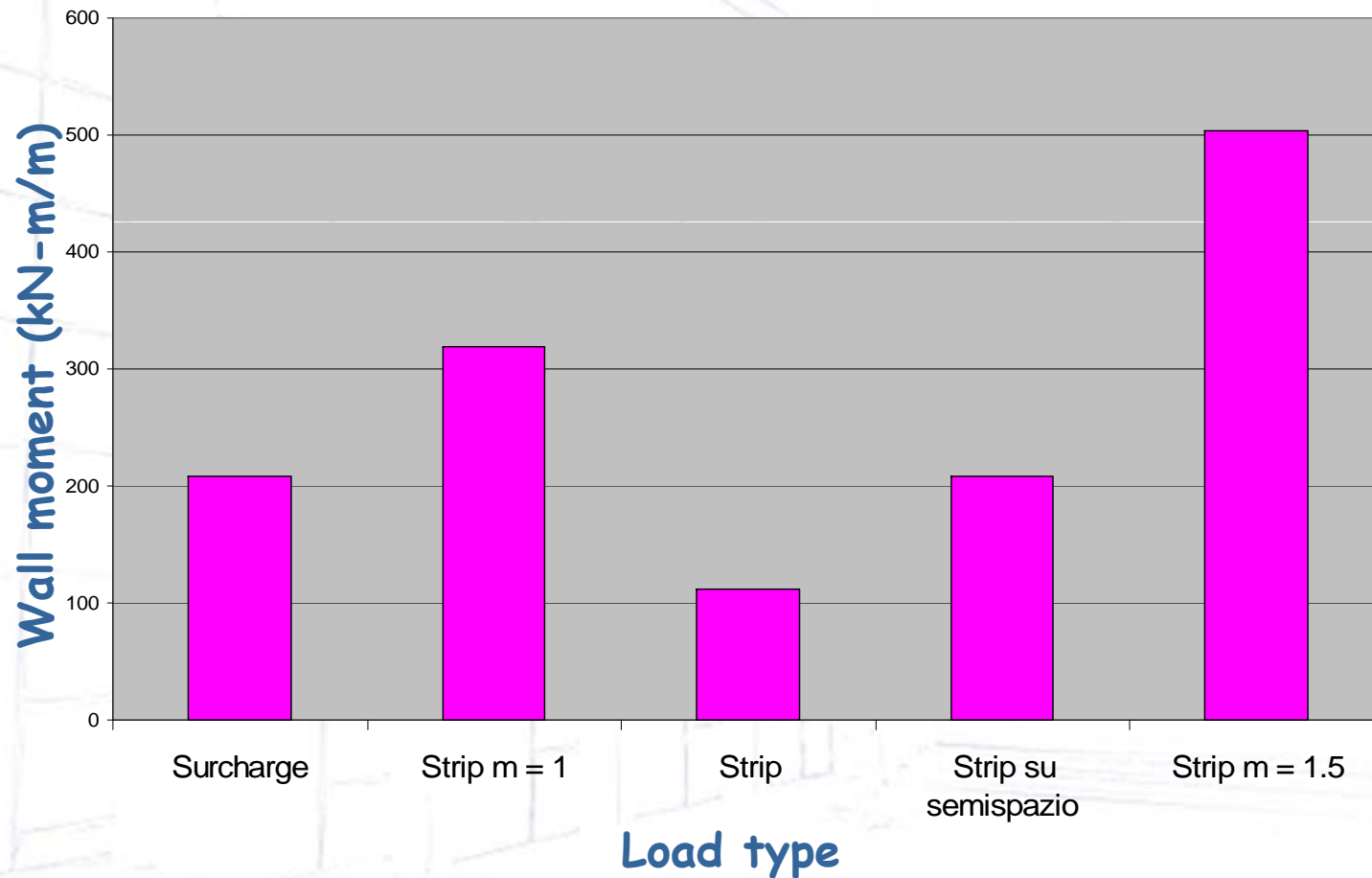
Surface loads

$c' = 10 \text{ kPa}$



Surface loads

$c' = 10 \text{ kPa}$



WALL PARAMETERS

Diaphragm wall reinforcement options (left side and right side)

Edit Wall Properties

Wall Sections

A. Wall Type D. Concrete-Rebar F. Draw

1. Concrete Section Type

Rectangular

Use more than one reinforcement sections

2. Section Dimensions

D 24 in A 288 in² lxx 13824 in⁴

B 12 in Bw 39.3700 in tf 24.0157 in

3. Longitudinal Reinforcement (Tension - Compression)

Top Rebars (left side)

N 6 Bars # #8 = AsTop 4.74 in² Ctop 3 in

Bottom Rebars (Right Side)

N 6 Bars # #9 = AsBot 6 in² Cbot 3 in

4. Shear Reinforcement

Bar# = As 0 in² sV 0 in sH 0 in

Shear reinforcement is spiral Metric Rebars D10 for 10mm Diam

Treat wall as slab for shear capacity calculations (diaphragm walls only)

Redimension wall automatically

OK Cancel

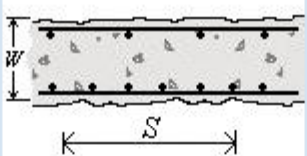
WALL PARAMETERS

Diaphragm walls shear reinforcement.

A. Wall Type D. Concrete-Rebar F. Draw

1. Concrete Section Type

Rectangular



Use more than one reinforcement sections

2. Section Dimensions

D 24 in A 288 in² lxx 13824 in⁴

B 12 in Bw 39.3700 in tf 24.0157 in

3. Longitudinal Reinforcement (Tension - Compression)

Top Rebars (left side)

N 6 Bars # #8 = AsTop 4.74 in² Ctop 3 in

Bottom Rebars (Right Side)

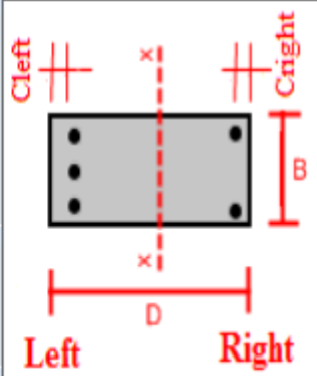
N 6 Bars # #9 = AsBot 6 in² Cbot 3 in

4. Shear Reinforcement

Bar# = As 0 in² sV 0 in sH 0 in

Shear reinforcement is spiral Metric Rebars D10 for 10mm Diam

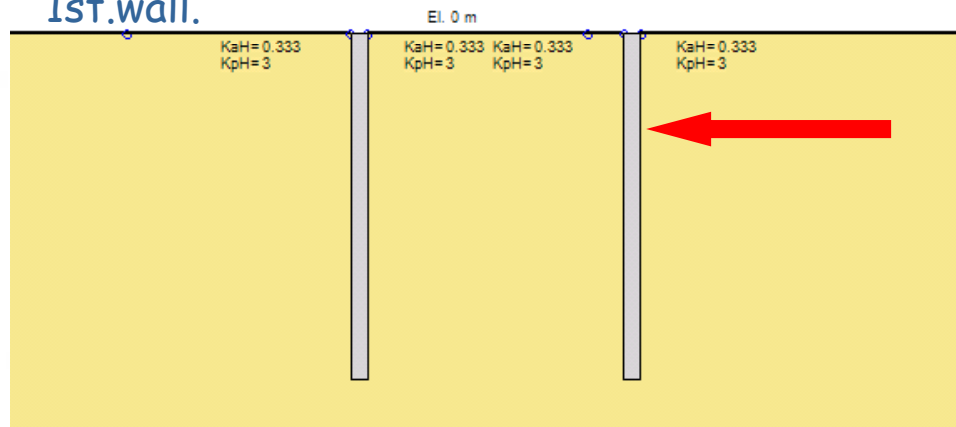
Treat wall as slab for shear capacity calculations (diaphragm walls only)



Note: In the default option there is no shear reinforcement.
sV = Vertical spacing.
sH = Horizontal spacing.

WALL PARAMETERS

Warning: The reinforcement on the 2nd wall has the same layout (left & right) as the 1st wall.



Concrete-Rebar F. Draw

Reinforcement Type: Circular

One reinforcement sections

Dimensions: A 288 in², lxx 13824 in⁴, B 12 in, Bw 39.3700 in, tf 24.0157 in

3. Longitudinal Reinforcement (Tension - Compression)

Top Rebars (left side): N 6, Bars # #8, = AsTop 4.74 in², Ctop 3 in

Bottom Rebars (Right Side): N 6, Bars # #9, = AsBot 6 in², Cbot 3 in

4. Shear Reinforcement: Bar# [], = As 0 in², sV 0 in, sH 0 in

Shear reinforcement is spiral Metric Rebars D10 for 10mm Diam

Treat wall as slab for shear capacity calculations (diaphragm walls only)

WALL PARAMETERS

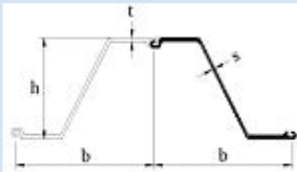
For pile walls and sheet pile walls:

The parameter unsupported length factor below the excavation is important.

A. Wall Type C. Sheet Piles F. Draw

1. Section Designation (from database)
Section AZ 19

2. Sheet pile properties

h 15 in	A 7.74 in ² /ft	
b 24.8 in	tf 0.413 in	
lxx 270.8 in ⁴ /ft	s 0.413 in	
Sxx 36.08	alpha 55.4 degrees	
Unsupported Length Lx factor below excavation 5 x wall Width		

Recalculate Properties

A. Wall Type E. Lagging B. Steel Beams F. Draw

1. General - Steel Beam Section

Section HE 300A

Unsupported Length Lb (Excavation Increment) 3 ft

Unsupported Length Lx factor below excavation 5 x pile W

Section is channel [

Double channels s 5 in

Is Pipe

Fill concrete

Effectiveness of Concrete for Stiffness Calculations (see theory manual) 25 %

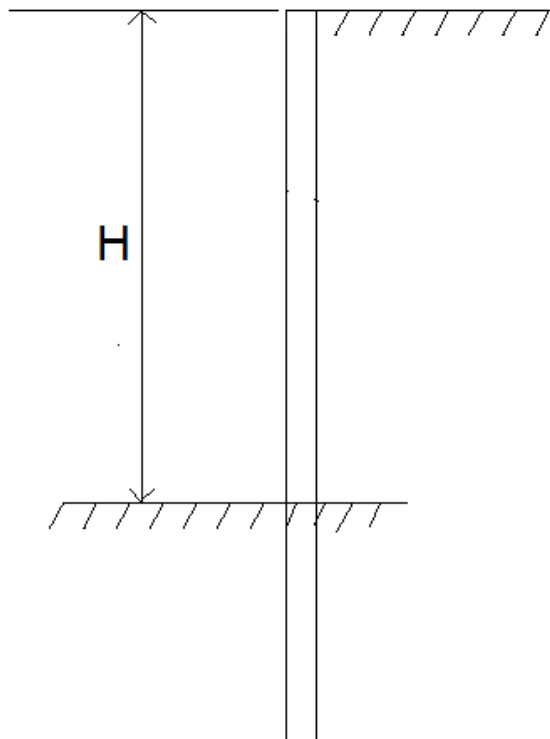
Edit strut properties manually

Threaded steel pipe reduction

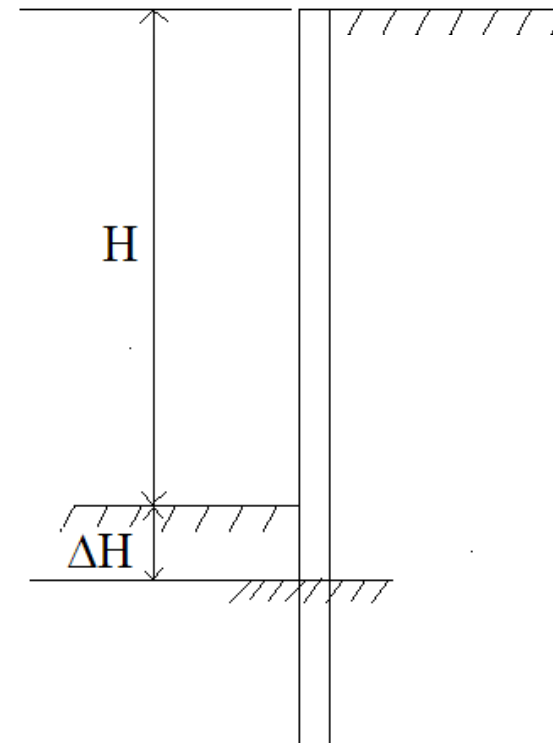
Reduce steel pipe capacity due to threads Available Thread Strengt 50 %

WALL PARAMETERS

Unbraced length for structural design of soldier piles and sheet piles



With factor = 0



With unbraced length increased by ΔH
 $\Delta H = x/100$ spessore paratia or
 $\Delta H = LF \times \text{Wall width}$

WALL PARAMETERS

Soldier piles and sheet piles: equivalent thickness calculation

Sheet piles: $T_{eq} = \sqrt[3]{\frac{12J_{xx}}{S}}$

$S = 1$ for sheet pile walls

Piles:

$$J_{eq} = \frac{(E_s J_{tubo} + E_{cls} J_{cls})}{E_{om} N}$$

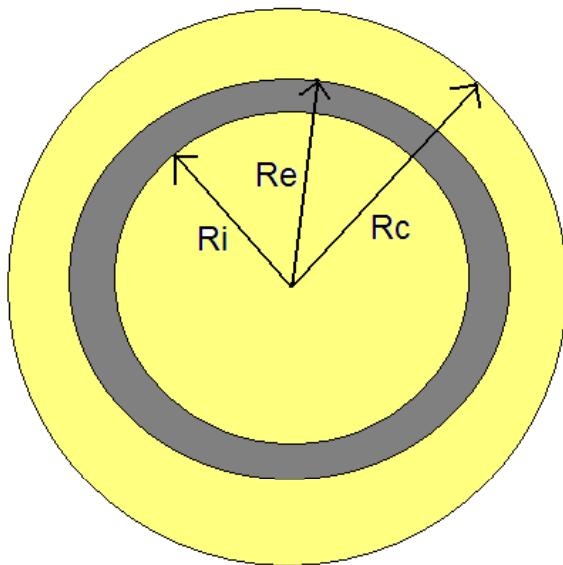
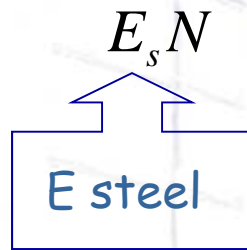
$N = 1/S, S = \text{pile spacing}$

$E_{om} = E \text{ mat. Selected normalization material.}$

WALL PARAMETERS

Soldier piles: equivalent thickness in DeepXcav

$$J_{eq} = \frac{(E_s J_{tubo} + E_{cls} J_{riempimento+crosta})}{E_s N}$$



$$J_{tubo} = \frac{\pi(R_e - R_i)^4}{4}$$

$$J_{riempimento+crosta} = \frac{\pi R_i^4}{4} \frac{x}{100} + \frac{\pi(R_c - R_e)^4}{4}$$

$$T_{eq} = \sqrt[3]{\frac{12J_{xx}}{S}}$$

WALL PARAMETERS

TABELLA DI CONFRONTO SPESSORI EQUIVALENTI

	PARATIE 7.0	PARATIE PLUS (senza camicia)	PARATIE PLUS (camicia esterna)
t_{tubo} (cm)	1,2	1,2	1,2
$r_{\text{est,tubo}}$ (cm)	9	9	9
I_{tubo} (cm ⁴)	2246	2246	2246
r_{est} (cm)	11	11	11
r_{int} (cm)	7,8	7,8	7,8
$I_{\text{cls - interno}}$ (cm ⁴)		2907	2907
$I_{\text{cls - cover}}$ (cm ⁴)		0	6346
% area cls	/	100	100
$I_{\text{cls - tot}}$ (cm ⁴)	11499	2907	9253
E_{cls} (Mpa)	31000	31000	31000
E_{steel} (Mpa)	210000	210000	210000
s (passo in cm)	40	40	40
N (=1/s)	0,025	0,025	0,025
J_{eq} (cm ⁴)	98,58	66,87	90,29
t (cm)	10,6	9,3	10,27

WALL PARAMETERS

Soldier piles with offset

6. Pile offset options (double row of piles for soldier piles and tangent pile walls only)

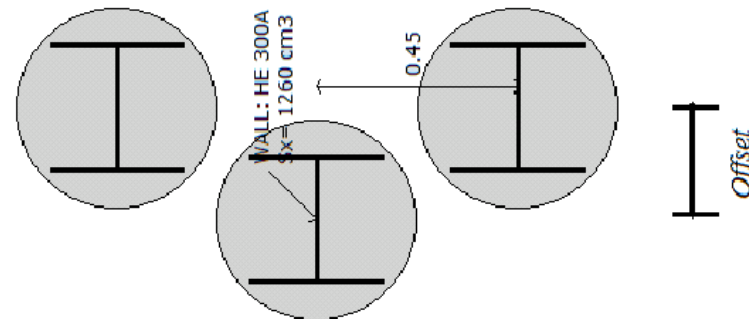
Use pile offset

Pile offset ft

Use stiffness increase

Stiffness factor for $A \times (0.5 \text{ offset})^2$ %

$$\frac{\Delta J}{palo} = \frac{x}{100} A \left(\frac{\text{offset}}{2} \right)^2$$



A = Steel or concrete element area.

x = Factor for increase in stiffness by user.

Note: the increased moment of inertia ΔJ is only used in the equivalent thickness of the wall during analysis and not for the structural capacity calculations.

WALL PARAMETERS

Custom wall

User mat.

Release bottom and top.

3. Dati generali

Top (m)	Mat.	I _{xx} (cm ⁴)	Svincolo base paratia	Svincolo sommità paratia	t (m)
10	0: Use...	3750000	All	None	1
5	0: Use...	3750000	None	All	1

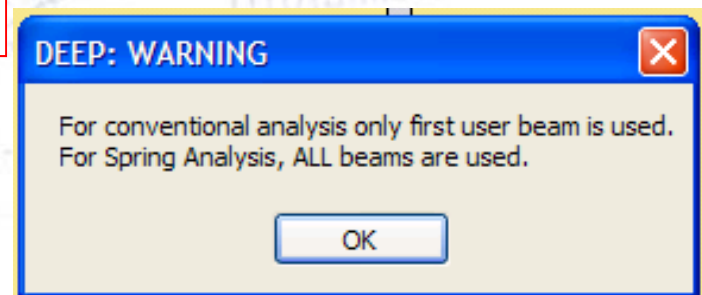
Top elevation

Inertia

Equiv. thickness

$$T_{eq} = \sqrt[3]{\frac{12J_{eq}}{S}}$$

Warning:



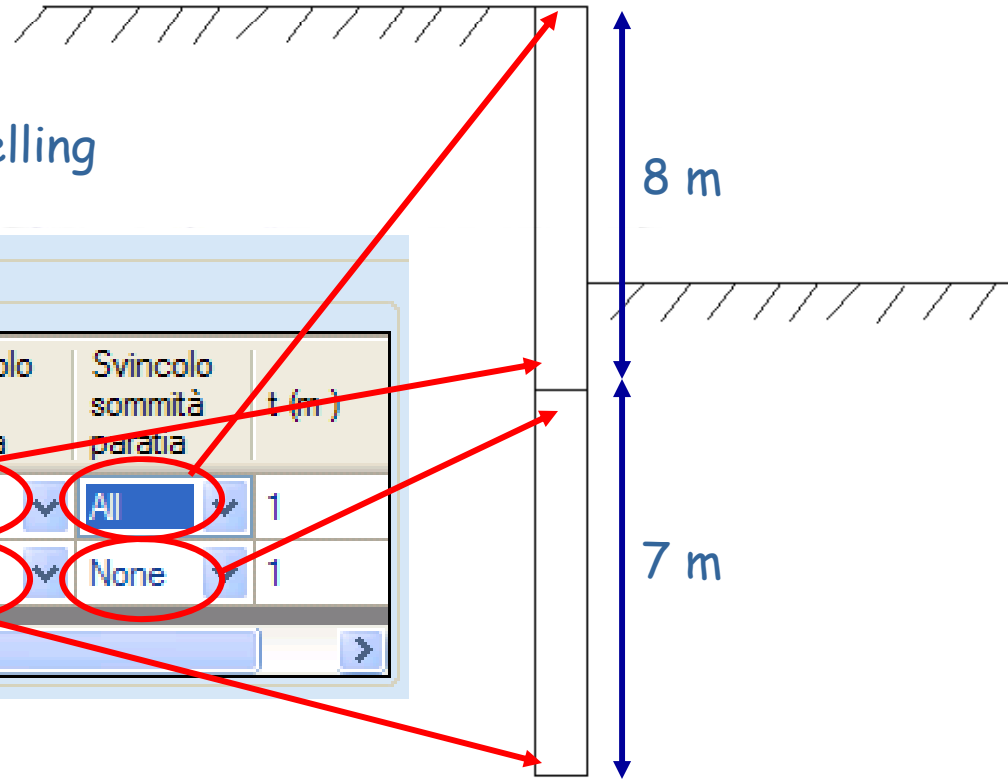
WALL PARAMETERS

Custom wall

Correct modelling

3. Dati generali sezione

	Top (m)	Mat.	box (cm4)	Svincolo base paratia	Svincolo sommità paratia	t (m)
	8	0: Use... ▾	83333...	None ▾	All ▾	1
	7	0: Use... ▾	83333...	All ▾	None ▾	1



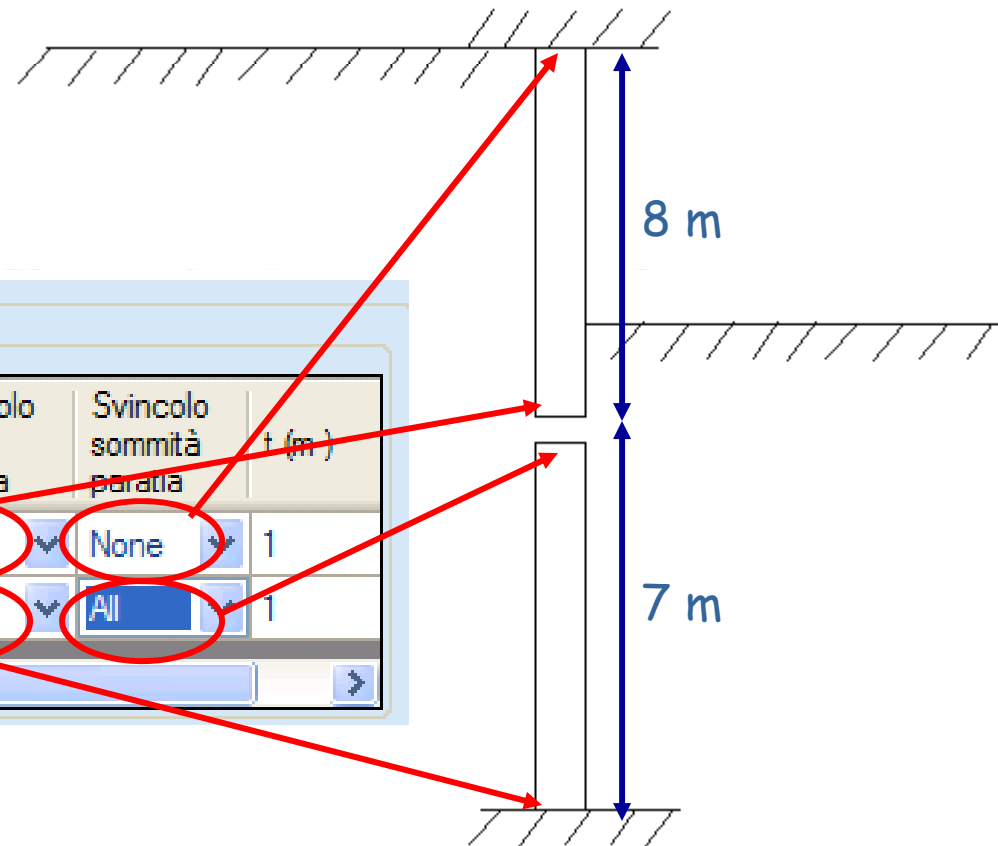
WALL PARAMETERS

Sezioni personalizzate

Assurdo!

3. Dati generali sezione

	Top (m)	Mat.	box (cm4)	Svincolo base paratia	Svincolo sommità paratia	t (m)
	8	0: Use...	83333...	All	None	1
	7	0: Use...	83333...	None	All	1



WALL PARAMETERS

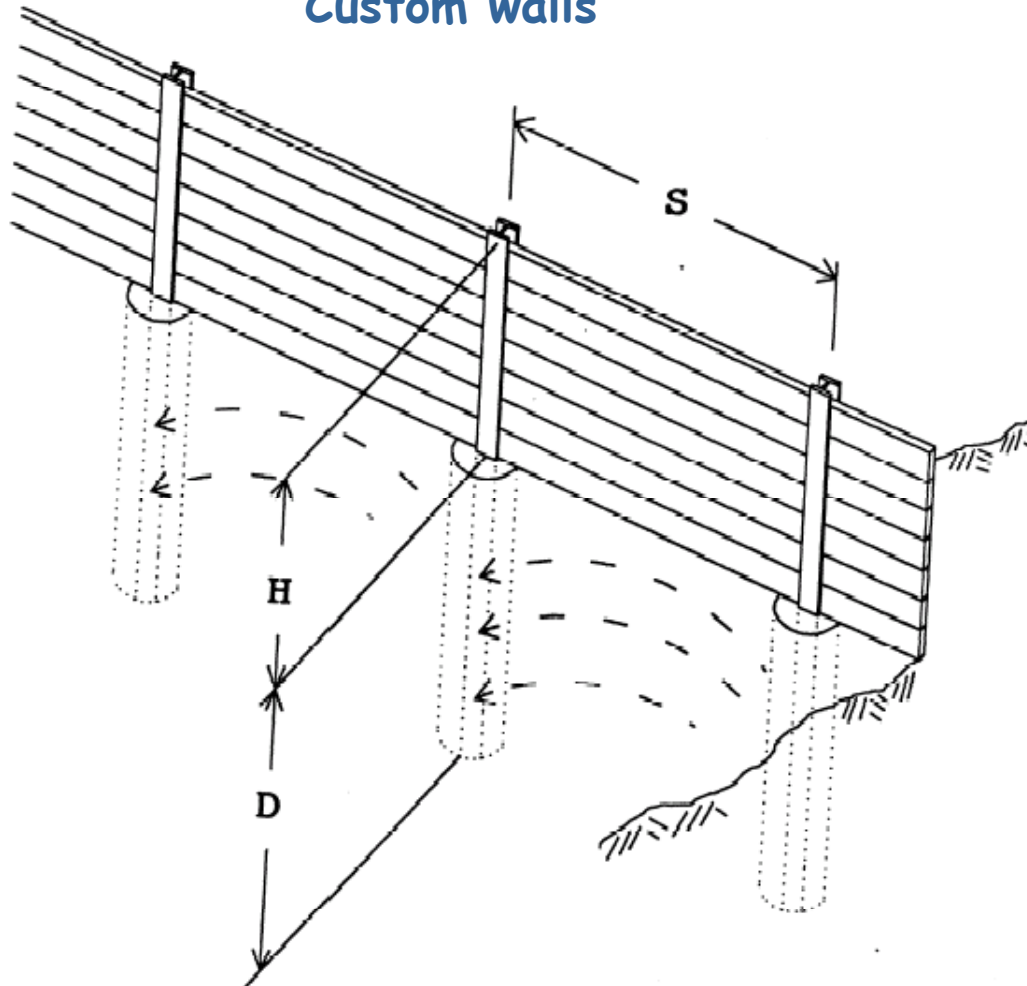
Release options

3. Dati generali sezione

	Top (m)	Mat.	box (cm4)	Svincolo base paratia	Svincolo sommità paratia	t (m)
	8	0: Use...	83333	None	Shear	1
	7	0: Use...	83333	Mom...	None	1

WALL PARAMETERS

Custom walls



Currently a wall of this type can be modeled with the custom wall or with multiple wall elements.

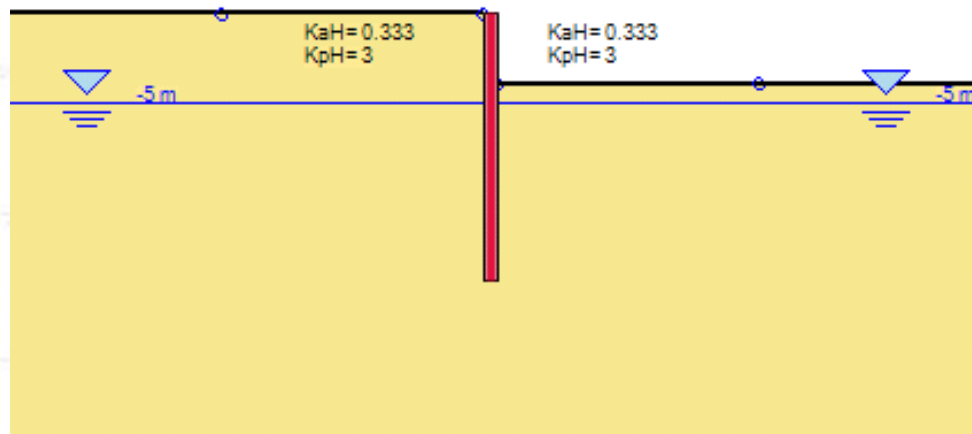
With custom walls it is not possible to perform a structural analysis.

With additional wall elements it is now possible to use different wall sections (Version 8.1)

WALL PARAMETERS

Wall width (conventional analysis)

4m excavation 4 m in sand



4. Dimensions

Width d	<input type="text" value="0.29"/>	m
Hor. Space S	<input type="text" value="1.5"/>	m
Passive width (below exc.)	<input type="text" value="0.9"/>	m
Active width (below exc.)	<input type="text" value="0.3"/>	m

The "passive width and active width below exc." are used to multiply soil pressures on the wall element below the excavation grade (see manual).

WALL PARAMETERS

Safety factors for conventional analysis

$$FS_{\text{passive}} = \frac{F_H \text{ resisting side}}{F_H \text{ driving side}}$$

$$FS_{\text{rotational}} = \frac{M \text{ resisting}}{M \text{ driving}}$$

$$FS_{\text{embedment length}} = \frac{\text{Provided wall embedment length (below excavation)}}{\text{Embedment length required for } FS = 1 \text{ from preceding safety factors}}$$

WALL PARAMETERS

Active and passive widths (conventional analysis)

4. Dimensions

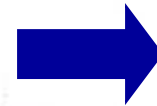
Width d m

Hor. Space S m

Passive width (below exc.) m

Active width (below exc.) m

The "passive width and active width below exc." are used to multiply soil pressures on the wall element below the excavation grade (see manual).



$$\left\{ \begin{array}{l} FS_H = 1.597 \\ FS_{rot} = 1.053 \\ FS_{inf} = 2.001 \end{array} \right.$$

4. Dimensions

Width d m

Hor. Space S m

Passive width (below exc.) m

Active width (below exc.) m

The "passive width and active width below exc." are used to multiply soil pressures on the wall element below the excavation grade (see manual).



$$\left\{ \begin{array}{l} FS_H = 0.356 \\ FS_{rot} = 0.234 \\ FS_{inf} = 0.234 \end{array} \right.$$

4. Dimensions

Width d m

Hor. Space S m

Passive width (below exc.) m

Active width (below exc.) m

The "passive width and active width below exc." are used to multiply soil pressures on the wall element below the excavation grade (see manual).



$$\left\{ \begin{array}{l} FS_H = 1.459 \\ FS_{rot} = 1.284 \\ FS_{inf} = 1.333 \end{array} \right.$$

Ground anchors (Tiebacks)

1.3 Lengths

Lfree 8 m

Lfix 5 m

Effective Lfix 50 % Lfix

Auto Length

Horizontal Spacing 3 m

Percentage of the fixed length included in the stiffness calculation.

1.3 Lengths

Lfree 0 m

Lfix 5 m

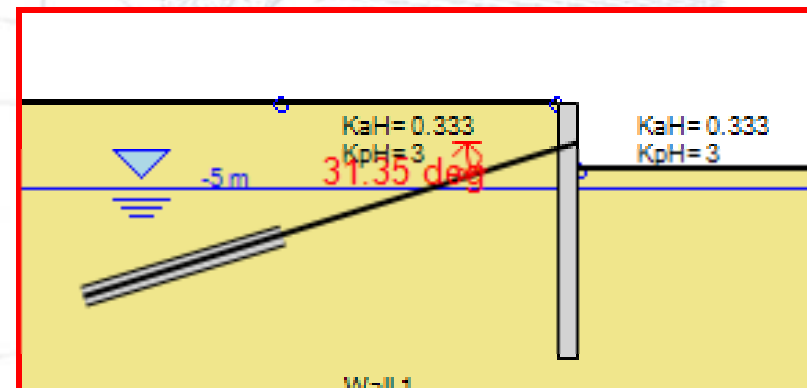
Effective Lfix 50 % Lfix

DEEPEXCAVATION CONTRACTOR

NOTE: Typical Tieback free lengths >= 5 m
Do you want to use 5 m?

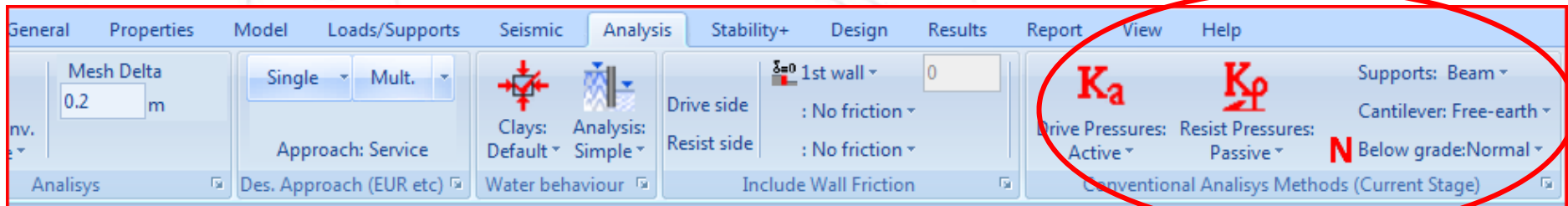
Yes No

Modellazione micropali di ancoraggio

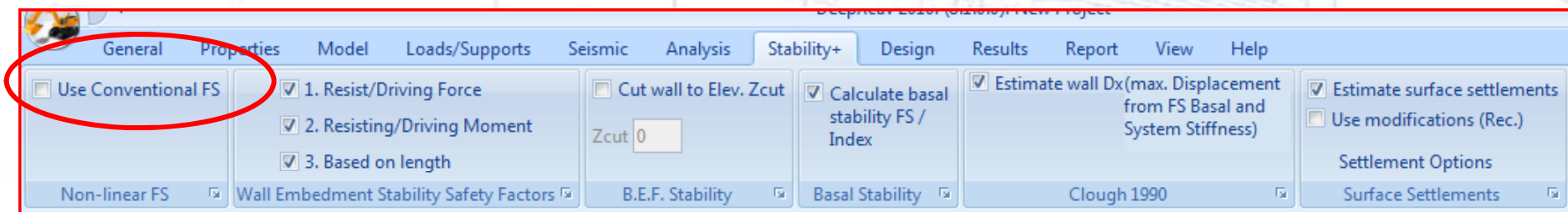


Conventional analysis options

Analysis menu:



Stability + Menu:



↑
Classical

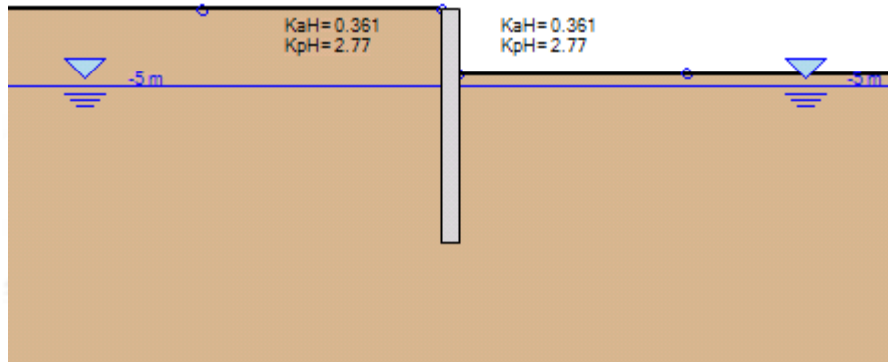
↑
NL

↑
Classical

↑
Classical /NL

Example 1: $\phi_{cv} = \phi_{peak}$ with clay model

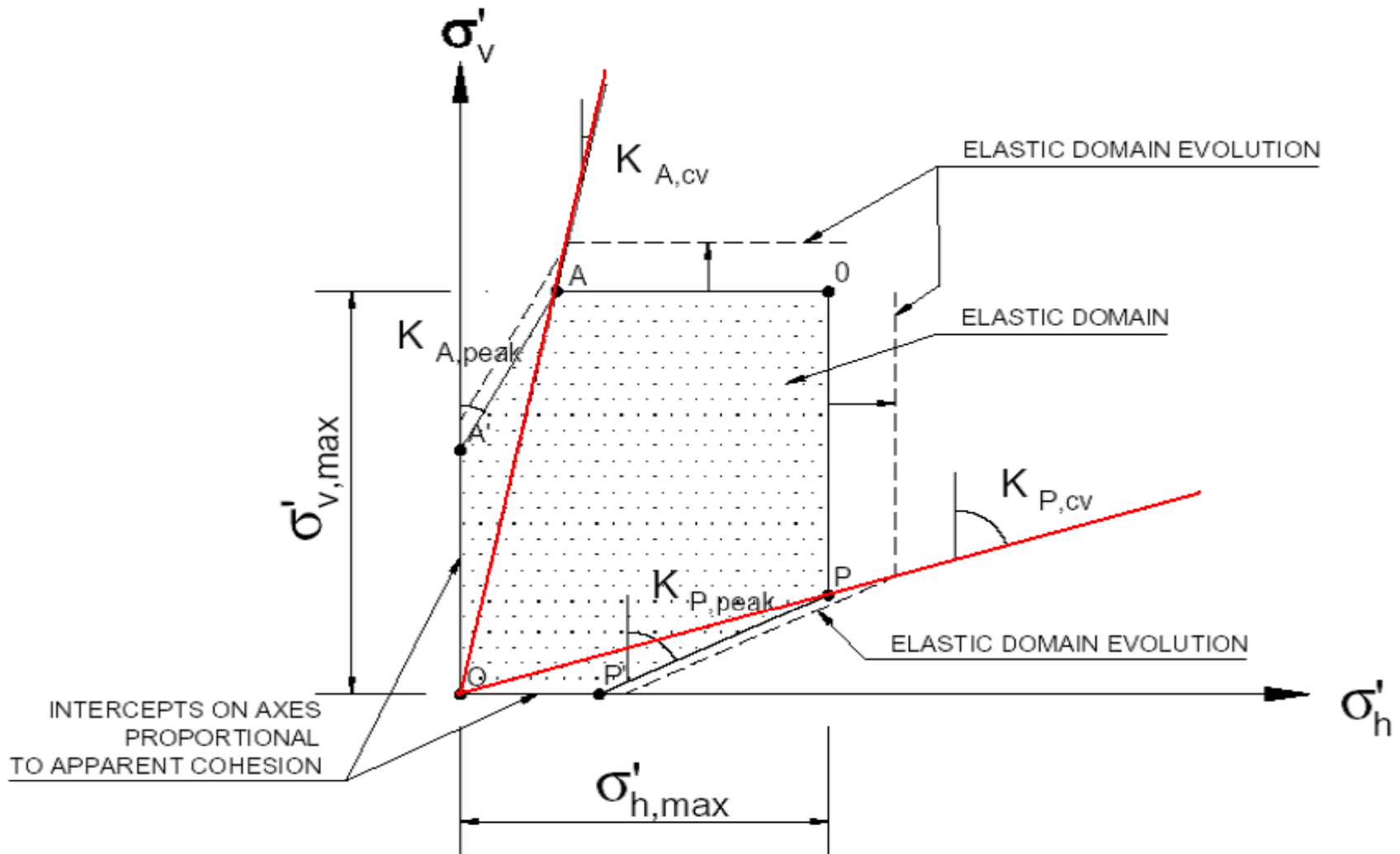
Excavation 4.5 m in clay. Wall = default diaphragm wall



$\phi_{cv} = 21^\circ, \phi_{peak} = 15.1^\circ \rightarrow$ Max displacement = 2.09 cm

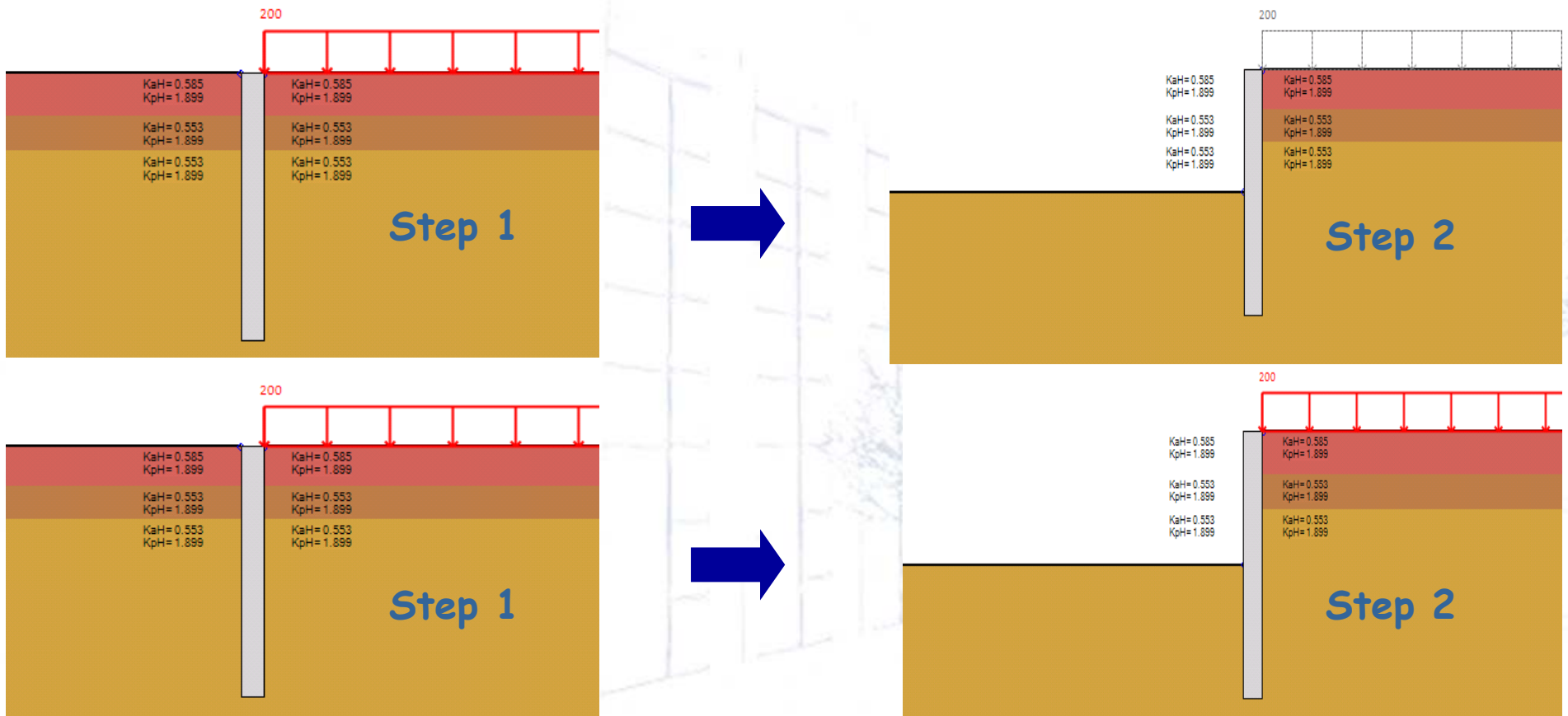
$\phi_{cv} = 21^\circ, \phi_{peak} = 21^\circ \rightarrow$ Max displacement = 2.32 cm

Example 1: $\phi_{cv} = \phi_{peak}$ with clay model

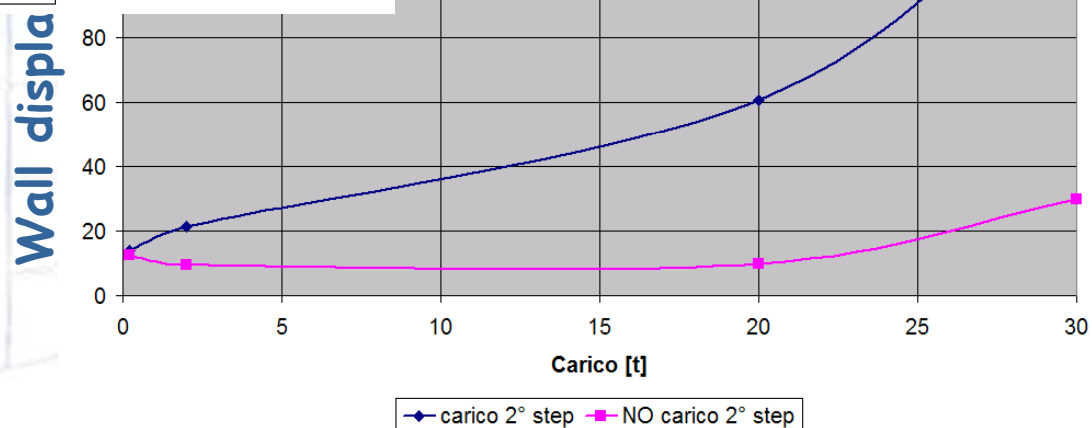
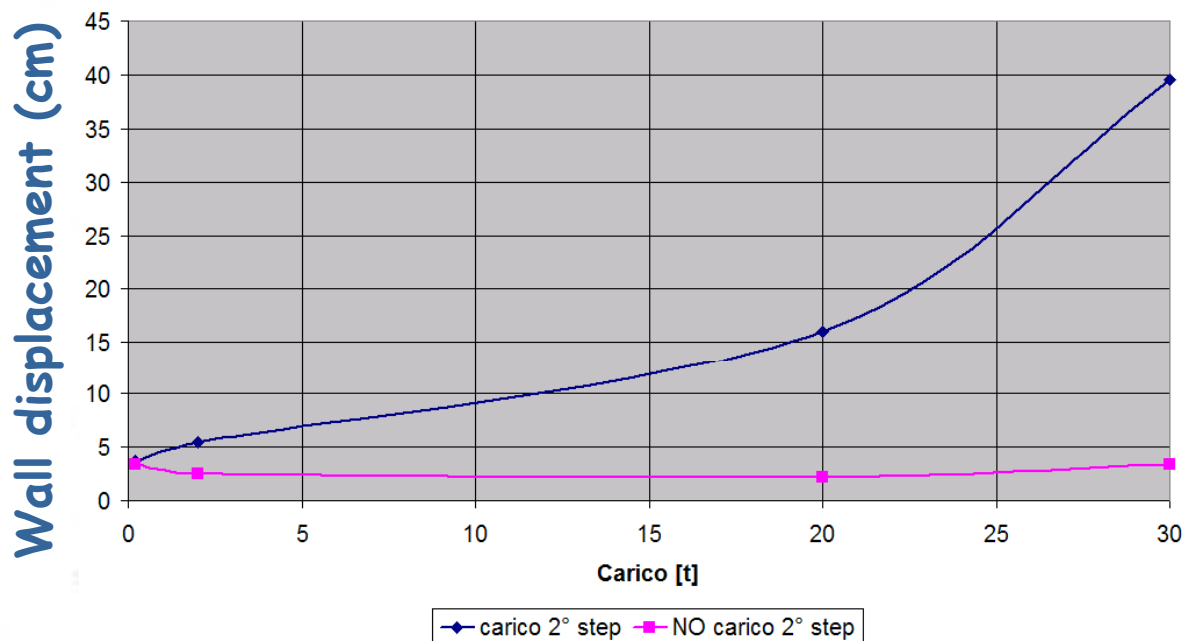


Example 2: Clays with overconsolidation

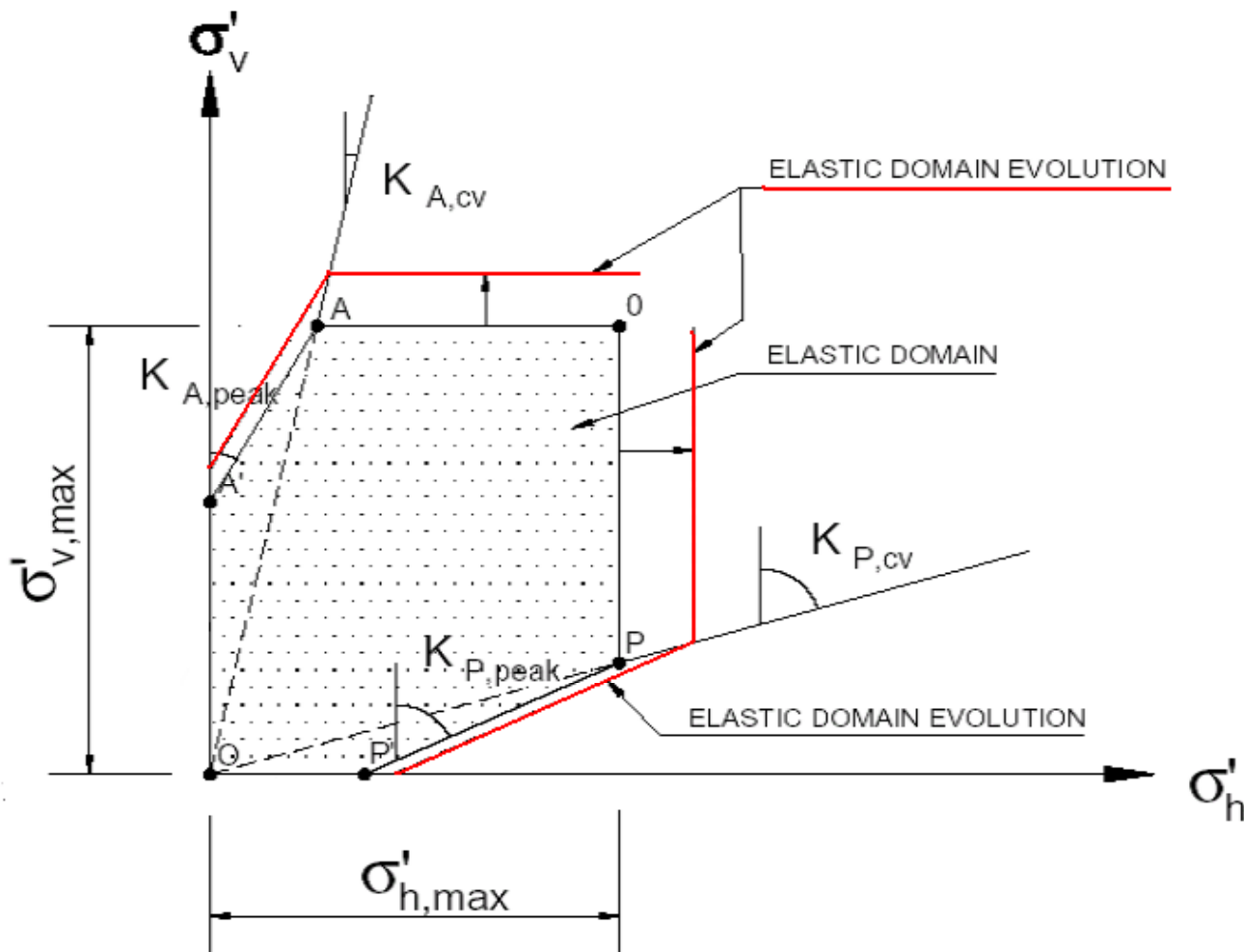
Excavation 6.5 m in clay. Wall = diaphragm, 40 cm, 6 ϕ 16mm reinforcement



Example 2: Overconsolidation and clays

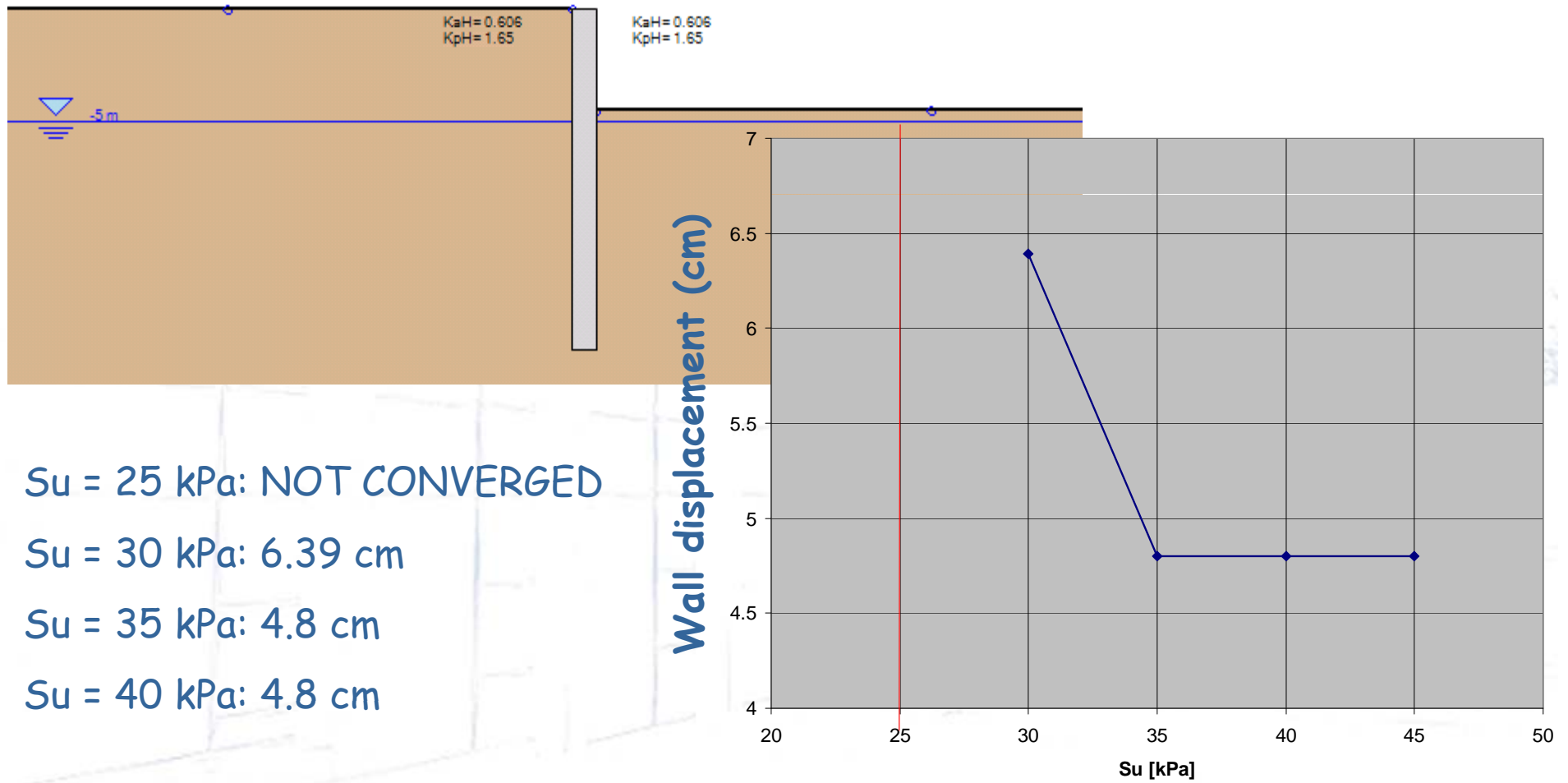


Example 2: Sovraconsolidazione nelle argille



Example 3: Effect of undrained shear strength S_u

Excavation di 4.5 m in clay. Wall = diaphragm (default)



$S_u = 25$ kPa: NOT CONVERGED

$S_u = 30$ kPa: 6.39 cm

$S_u = 35$ kPa: 4.8 cm

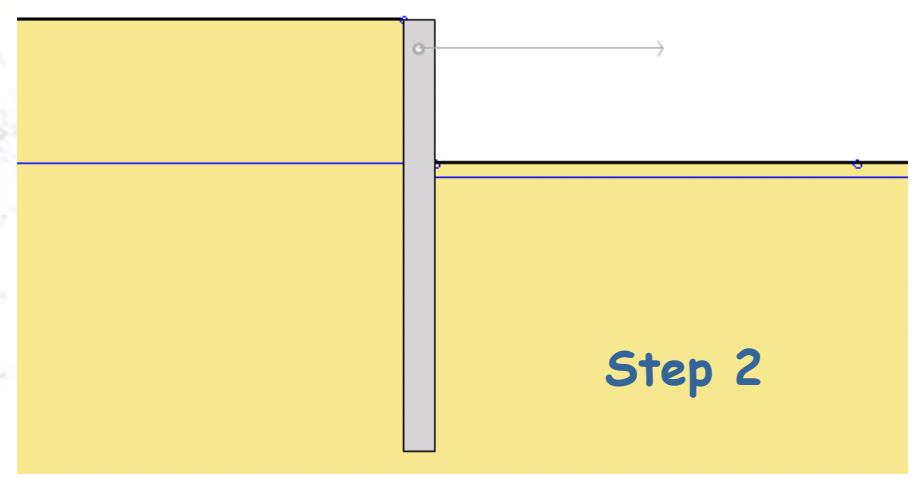
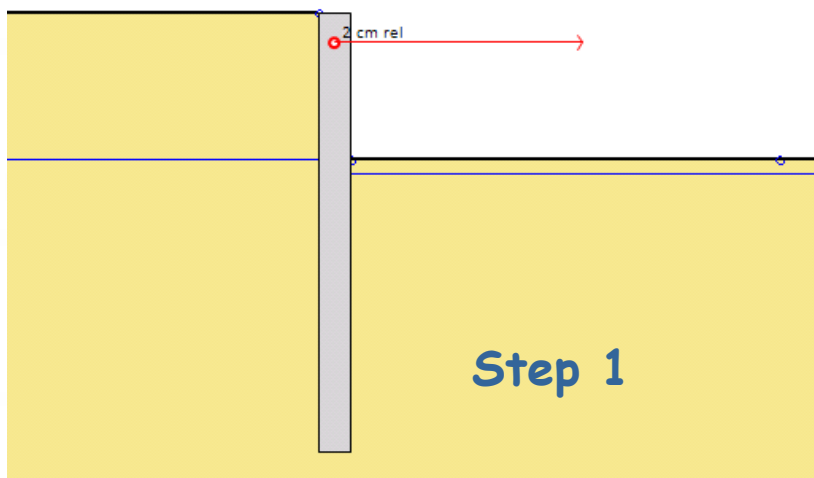
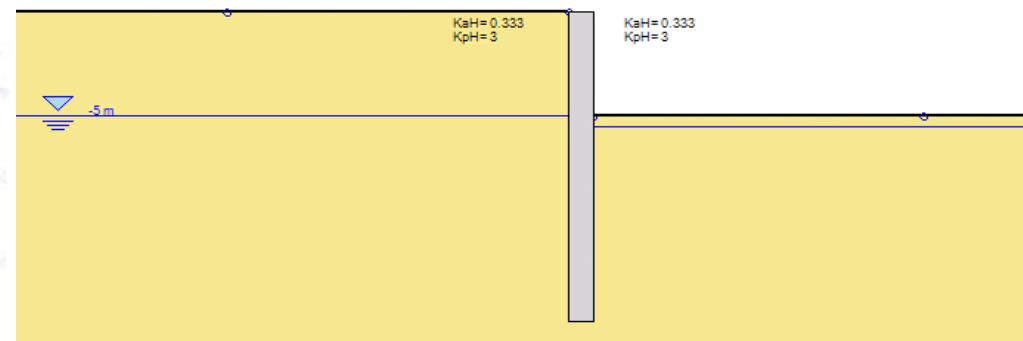
$S_u = 40$ kPa: 4.8 cm

Example 4: Imposed displacement

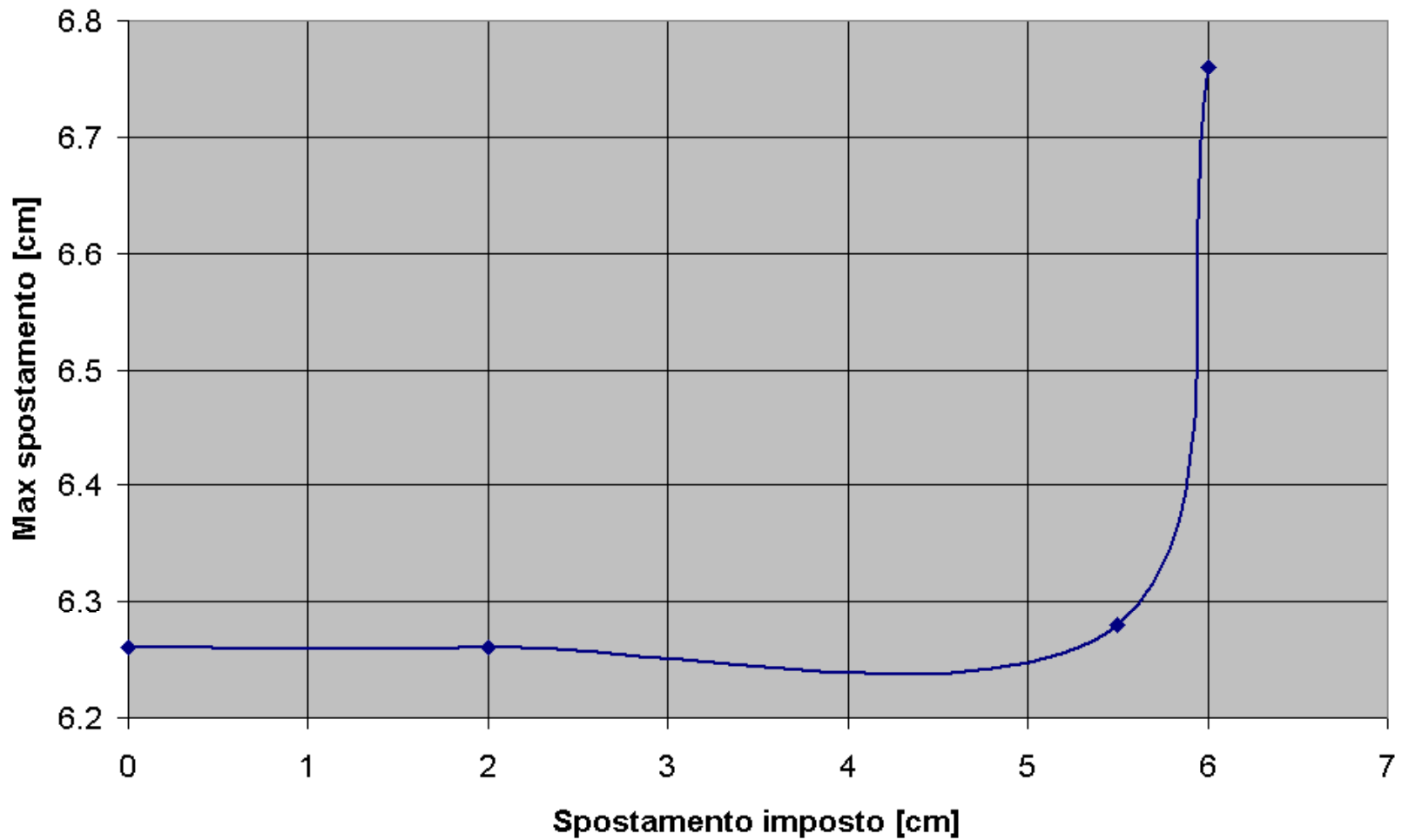
Excavation 5.0 m in sand. Wall = diaphragm (default)

Basic analysis (no imposed displacement)

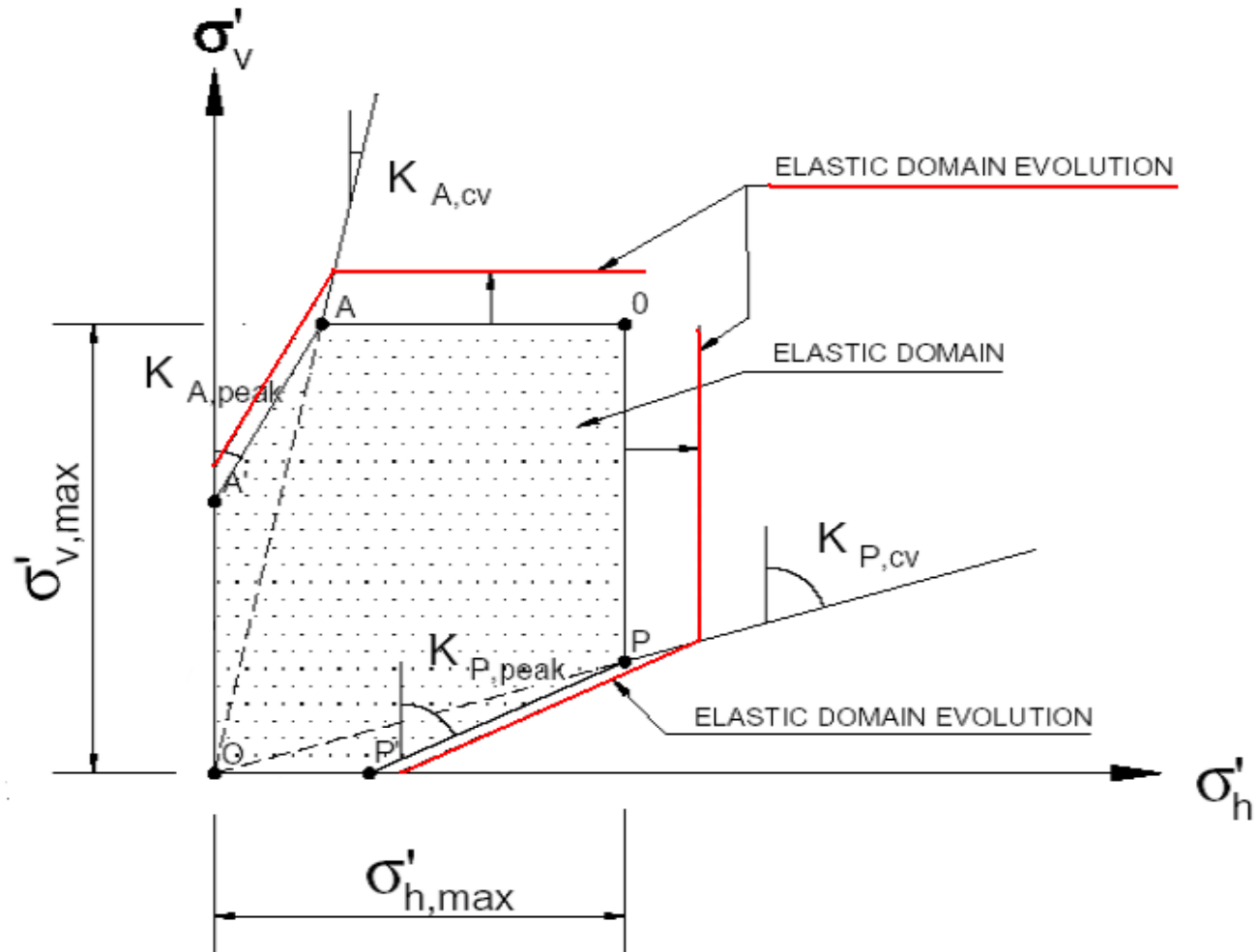
Max displacement: 6.26 cm



Example 4: Imposed displacement

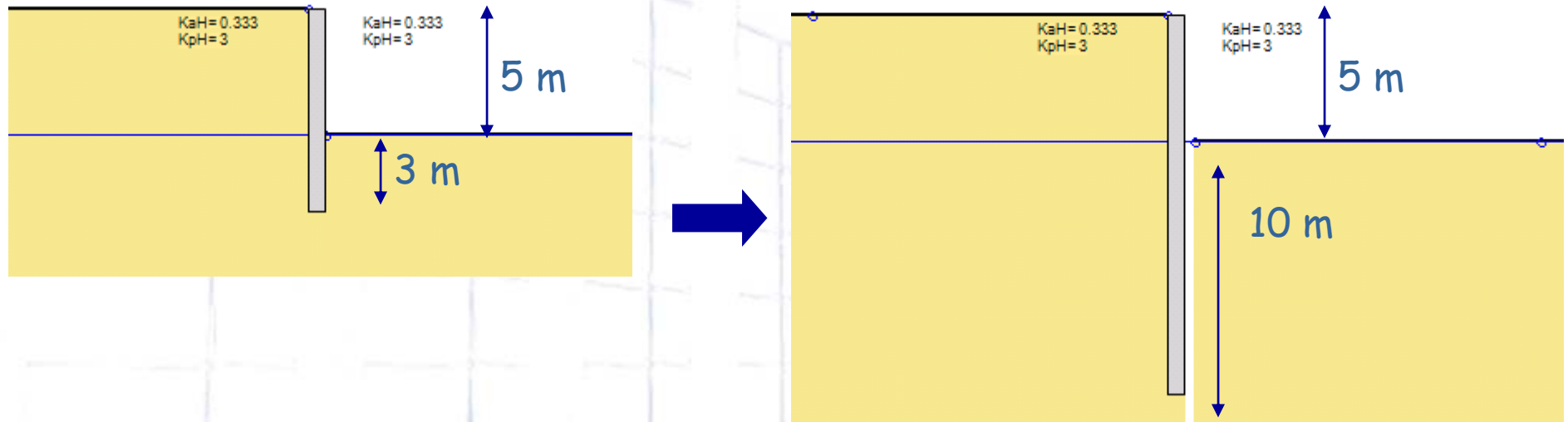


Example 4: Imposed displacement



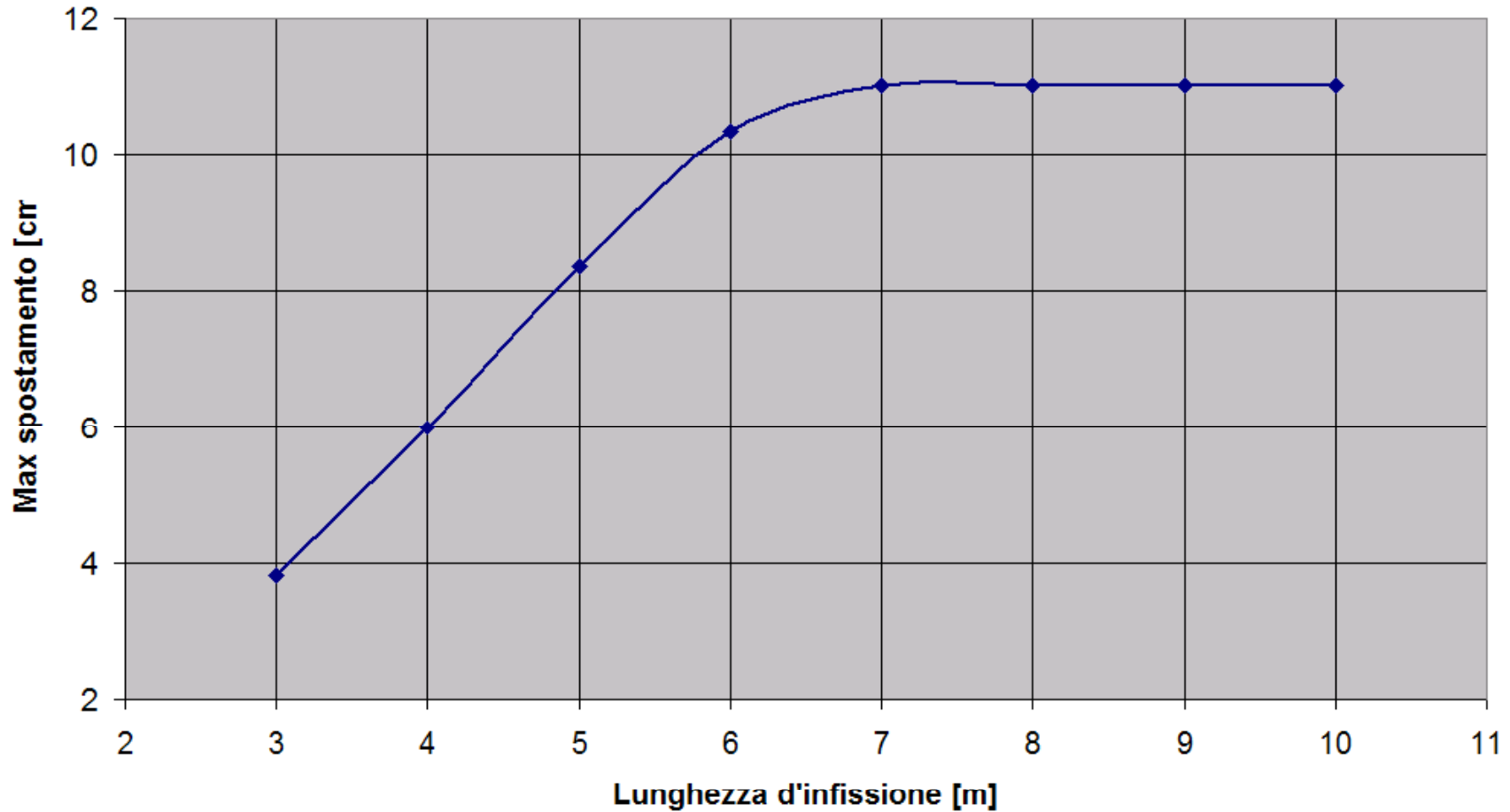
Example 5: Conventional analysis

Excavation di 5.0 m in sand con parametri di default. Wall = diaphragm (default)

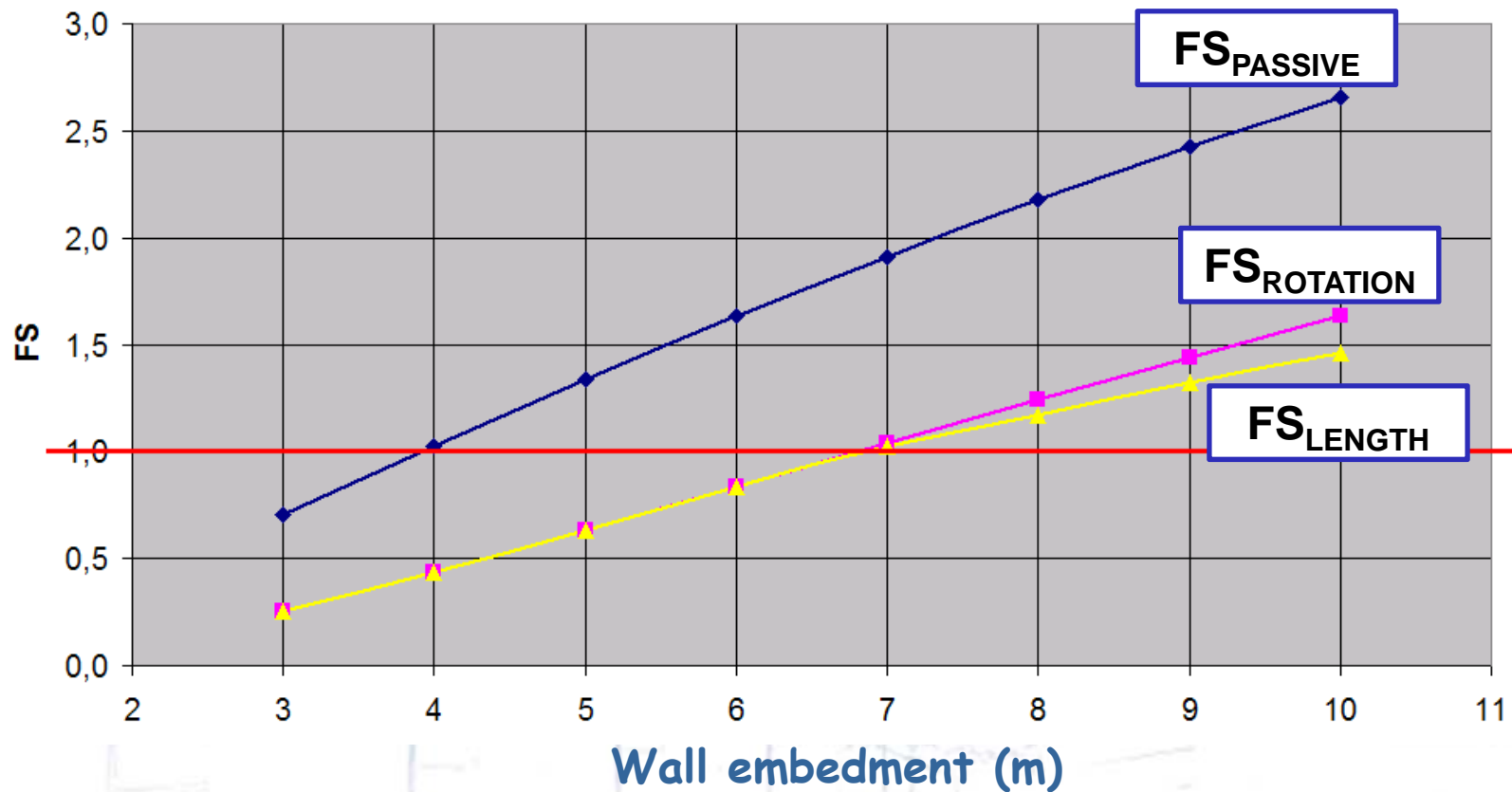


Eseguite 8 analisi convenzionali con diverse lunghezze d'infissione:
da 3 m a 10 m a passo 1 m

Example 5: Conventional analysis



Example 5: Conventional analysis



Note: Conventional analysis always converges!!!

ANALISI CONVENZIONALE + NL

Sommaro esteso							
	Risultati analisi	Spostamer paratia (cm)	Cedimen (cm)	Momento paratia (kN-m/m)	Momento paratia (kN-m)	Taglio paratia (kN/m)	Taglio paratia (kN/m)
► Infissione = 3 m	Model collapses, ...	3.81	3.5	391.85	391.85	97.93	97.93

Model collapses +
results do not include all stages in NL



Review of the classic safety factors:

FS passiva (an. classica)	FS rotazione (an. classica)	FS infissione (an. classica)
0.689	0.256	0.256

Soil propertie dialog

Soil type properties:

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

A. General B. Resistance C. Elasto-plastic D. Bond

4. Unit Weights - Density
 γ_t 20 kN/m³ γ_{dry} 19 kN/m³ γ_w 10

5. Strength Parameters and Poisson Ratio
 c' 0 kPa ϕ' 28 degrees
 S_u 150 kPa ϕ_{cv} Omitted degrees
 ν 0.45 ϕ_{peak} Omitted degrees

6. Permeability
 K_x 1E-10 m/sec K_z 1E-10 m/sec

7. Minimum Pressures for clays (Conventional Calcs)
 Min sh' 0 kPa Min Ka 0

8. Include soil in parameter variation
 Include in parameter variation (i.e. Eurocode, Statistical analysis). It is strongly recommended to keep this option checked.

A. General B. Resistance C. Elasto-plastic D. Bond

Clay-model Spring Parameters
 K_aCV 0.361 K_aP 0.361
 K_pCV 2.77 K_pP 2.77

Autoestimate K_a - K_p when Soil friction values are changed
 Use default engine K_a and K_p (Rankine, soil friction only)

IMPORTANT: K_aCV , K_aP , K_pCV and K_pP are defined in the HORIZONTAL DIRECTION.
 RECOMMEND: Define K_a and K_p values without wall friction or slope effects (best to Use Rankine K_a , K_p). Define Slope from the Model Tab. Define Wall friction from Analysis Tab. Automatic Procedures here use only Soil Friction and Wall Friction=0 and Slope Angle =0 deg

9.2 At-rest coefficients
 K_oNC 0.531 $nOCR$ 0.5
 $K_o = K_oNC * (OCR)^{nOCR}$

Elastic parameters disabled when only conventional analysis is used.

Soil properties:

A. General | B. Resistance | C. Elasto-plastic | D. Bond

10. Soil Model and Behavior

10.1 Loading Elasticity Parameters

Eload 20000 kPa

exp 0.5 Pref 95.8 kPa

α_v 0.5 α_h 0.5

10.1 Simplified clay model (Undrained analysis and TSP)

Eu 0 Kwu 4714.5 kN/m3

Used only when Total Stress Analysis is selected (Undrained only)

10.2 Reloading Elasticity Modulus

Eur 60000 kPa

10.3 Subgrade Reaction Modulus Approach

kvc 4714.57 kN/m3 kur 14143.7 kN/m3

A. General | B. Resistance | C. Elasto-plastic | D. Bond

Ultimate Bond Resistance for Tiebacks

$q_{skin.u}$ 125 kPa

The ultimate skin friction can be used to calculate the geotechnical capacity. You must select use Soil Bond Option from the Support Tab for this bond to be used. Otherwise, the options on each tieback as defined in the Tieback Sections / Geotech tab are used.

CONVENTIONAL ANALYSIS OPTIONS

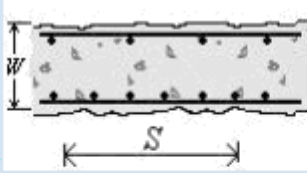
+ Edit Wall Data
✕

1. Wall Name
Wall 1

2. Wall Section Properties
Section: Wall 1 Edit section data

Equivalent wall Thickness: 0.6 m

3. Dimensions
 Top EL: 0 m
 Depth L: 15 m
 Bottom: -15 m
 Use custom passive Elev. 0 m

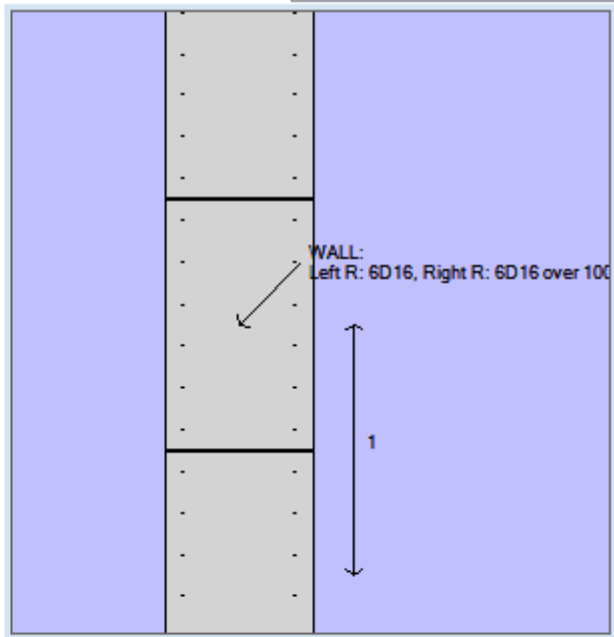


4. 3D Wall Coordinates
 xWall 0 m Out-of-plane y 0 m

5. Wall Friction - Base Adhesion Options
 Ignore Wall Friction Wall friction options apply only for soils that have frictional properties
 Use wall friction as a percentage of friction angle 0 %
 Use set wall friction at 0

Vertical undrained adhesion percentage (classical analysis)
 % of S_u for clays undrained analysis

Wall Section Drawing (Plan)



6. Beam continuity - Release codes (BEF Analysis Only)
 Top translation Top rotation
 Bottom translation Bottom rotation

7. Wall Nodes (Analysis Settings)
 Number of Nodes nD (0-200)

Conventional analyses use nD to divide wall into smaller elements. BEF uses Mesh DELTA as defined in the "Analysis Tab" in then main form and recalculates nD.

OK Cancel

PILE SPACING EFFECTS

A. Wall Type | D. Concrete-Rebar | F. Draw

1. Wall Type
 Soldier pile and lagging
 Sheet pile wall
 Secant pile wall
 Tangent Pile Wall
 Diaphragm wall
 Soldier pile and tremied concrete
 Custom

2. Wall Name
 Wall 1

3. General Section Data
 Soldier Piles: HE 300A
 Sheet Piles: AZ 26
 Use ONLY reinforcement Use plain concrete

4. Dimensions
 Width d: 0.6 m
 Hor. Space S: 1 m
 Passive width (below exc.): 1 m
 Active width (below exc.): 1 m

5. Structural Materials
 Concrete - Rebar Materials
 Concrete mat: C20/25
 Rebar steel mat: S410
 Steel Beam Materials
 Fe360

6. Pile offset options (double row of piles for soldier piles and tangent pile walls only)
 Use pile offset Pile offset: 0 m
 Use stiffness increase Stiffness factor for A x (0.5 offset)^2: 0 %

The "passive width and active width below exc." are used to multiply soil pressures on the wall element below the excavation grade (see manual).

Spacing can account for 3D effects.

In NL analysis the active width is used solely for the water pressures, and the same active and passive widths are used.

For continuous walls it is better to use the same spacing (1m or 1ft).

Important Command

HELLO

