Verification of the Mobilized Passive Factor of Safety.

DeepXcav software program (Version 2011)

(ParatiePlus within Italy)

Version 1.0

Issued: 12-Dec-2010

Deep Excavation LLC

www.deepexcavation.com

Verification of the Mobilized Passive Factor of Safety for Eurocode 7 cases for Greece and German DIN standards.

The EC7 adaptations in Greece and in Germany include a special approach in determining the passive safety factor in the non-linear analysis. In this approach, the basic wall analysis is performed without any factors on the active and passive earth pressure factors (Ka and Kp) while the external loads are standardized by the permanent action partial safety factor (1.35 for DA2* in Greece). The analysis is then performed, and the sliding safety factor is calculated by summing all driving forces and applying the appropriate partial safety factors. For this calculation the support reaction is taken as a permanent favorable action while the passive resistance is divided by the favorable resistance safety factor (1.4). Then the overall check:

Driving forces x factors - Support forces x factors <= Resisting forces/Partial safety factor

Then the passive mobilized safety factor is reported as:

FS = (Resisting forces/Partial safety factor)/(Driving forces x factors - Support forces x factors)

The purpose of this example (Figure 1) is to provide verification calculations for the safety factors when such a calculation is performed

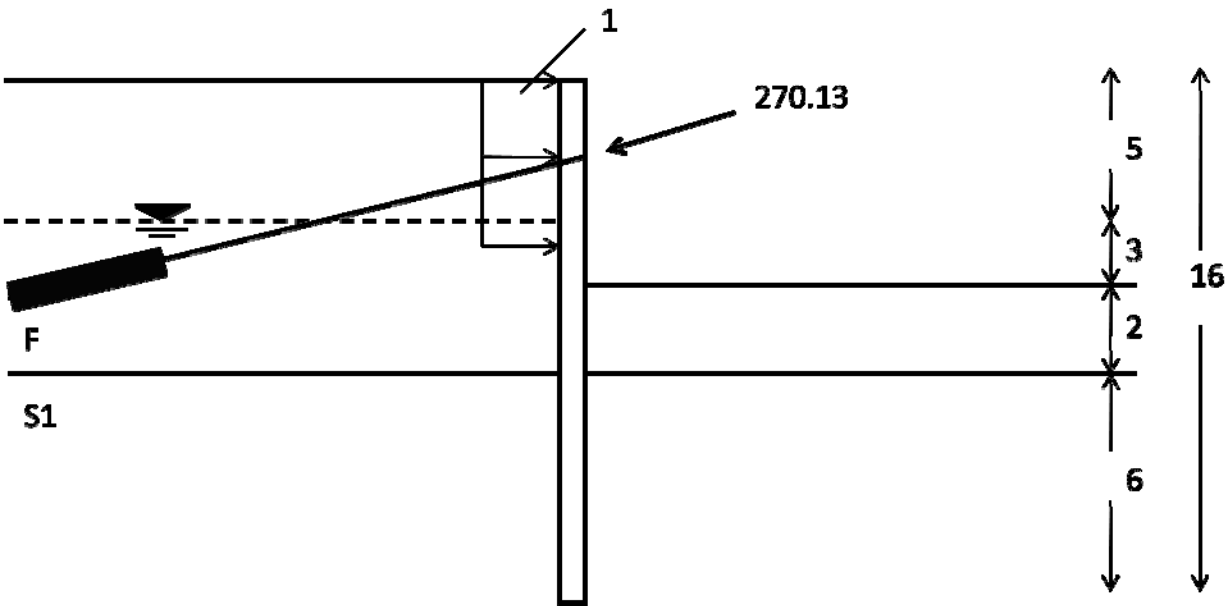


Figure 1: Model.

This model includes a diaphragm wall with one level of ground anchors (Figure 1). The example file includes an 8m excavation at the right side of the wall. The soil profile consists of two layers with properties presented in the following Table:

Table 1: Soil Properties

	c′ (kN/m²)	ϕ′ (deg.)	γ (kN/m³)
Soil F	0.0	30.0	20
Soil S1	0.0	34.0	21

For simplicity in calculations, the hydrostatic pressures are assumed. The calculated water pressure diagrams are presented in Figure 2.

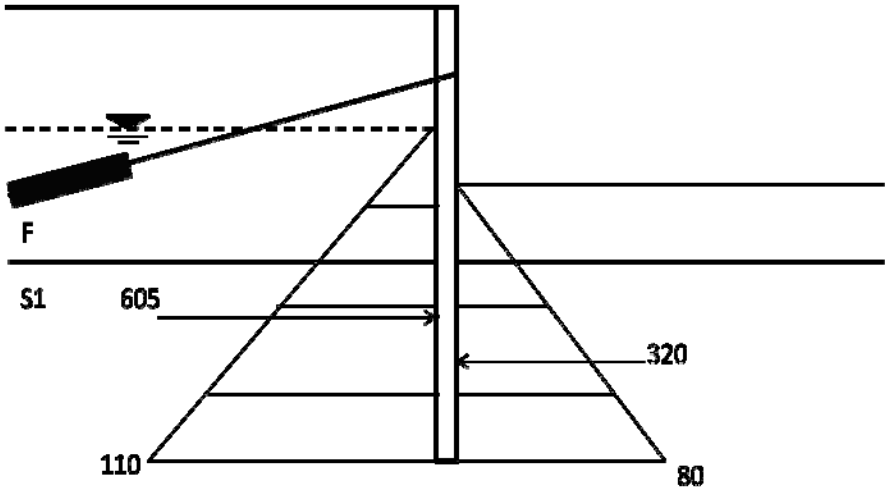


Figure 2: Hydrostatic Pressures.

The total net unfactored Hydrostatic force is 605 – 320 = 285 kN/m.

The driving pressures are 578.72 kPa.

The horizontal support reaction is 270.13 * cos(20) = 253.839 kN/m

The total surcharge on the wall is 7 kN/m.

The values above should be multiplied with the partial Eurocode Factors presented in table 2.

Table 2: Eurocode 7 partial Factors

FS DriveEarth	1.35
FS Water	1.35
FS Variable Loads	1.5

So, the total Drive force is:

FDrive = FDriveSoil * FS DriveEarth + FHyd * FS Water + F surch * FS VL – F support * FS DriveEarth =>

FDrive =578.72 * 1.35 + 285 * 1.35 + 7 * 1.5 – 253. 839 * 1.35 = 833.839 kN/m.

The theoretical maximum passive resisting pressures are presented in the following Figure:

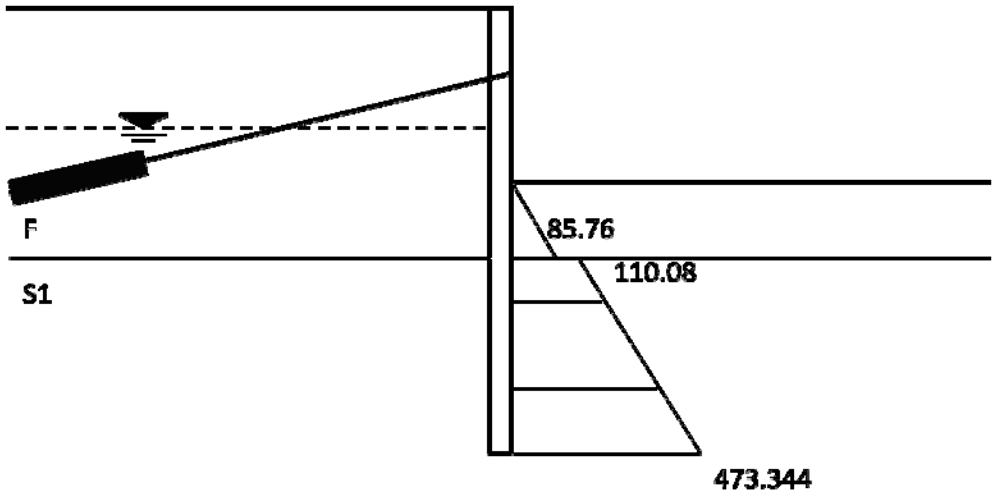


Figure 3: Resisting Pressures.

The total Resisting force is 1836.032 kPa and it should be divided by the partial Factor FS Res = 1.4.

Thus, F Resist = F res / FS Res = 1836.032 / 1.4 = 1311.451 kPa.

The mobilized Passive Factor of Safety is: FS_Mob.Passive = F Resist / F Drive = 1311.451 / 833.839 =>

FS_Mob.Passive = 1.573.

Figure 4 shows a model screen capture from DeepXcav. Figures 5 and 6 display the hydrostatic pressures and the Summary results table with the calculated factors of safety (FS).

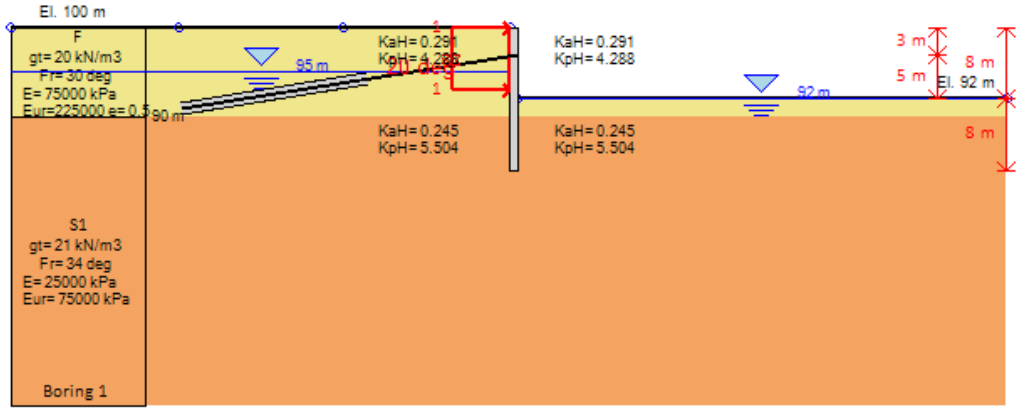


Figure 4: Model in DeepXcav.

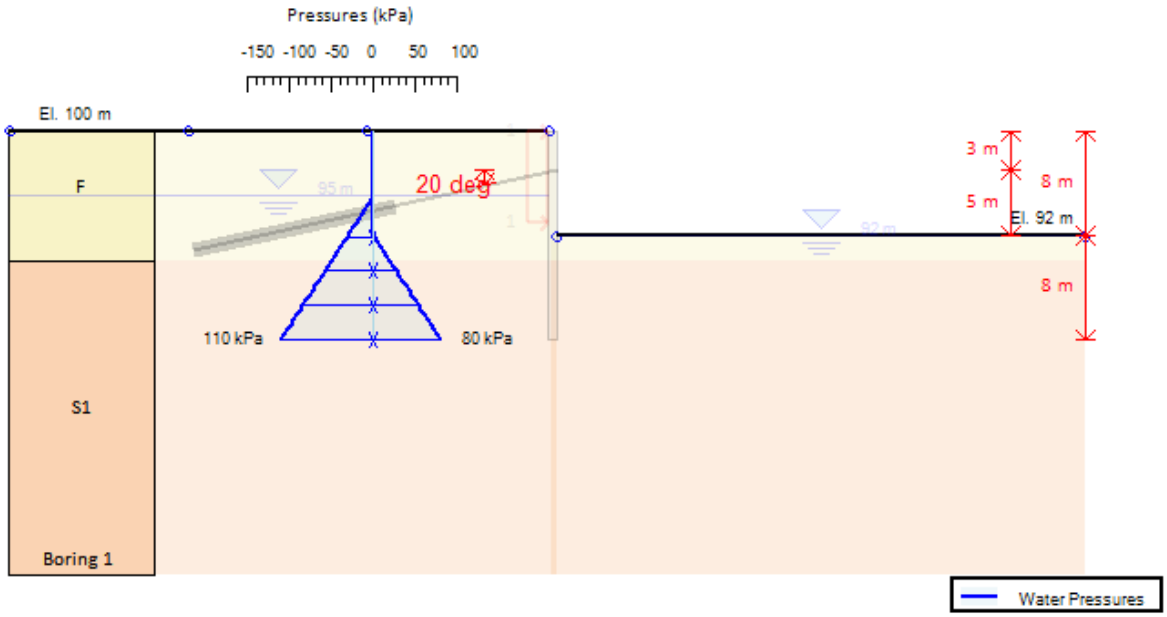
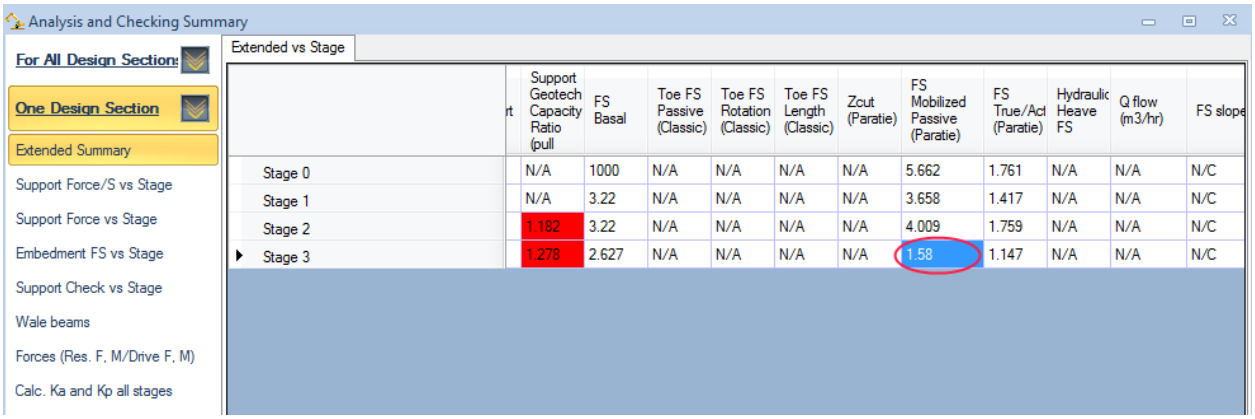


Figure 5: Hydrostatic pressures.



	Support Geotech Capacity Ratio (pull	FS Basal	Toe FS Passive (Classic)	Toe FS Rotation (Classic)	Toe FS Length (Classic)	Zcut (Paratie)	FS Mobilized Passive (Paratie)	FS True/Act (Paratie)	Hydraulic Heave FS	Q flow (m3/hr)	FS slope
Stage 0	N/A	1000	N/A	N/A	N/A	N/A	5.662	1.761	N/A	N/A	N/C
Stage 1	N/A	3.22	N/A	N/A	N/A	N/A	3.658	1.417	N/A	N/A	N/C
Stage 2	1.182	3.22	N/A	N/A	N/A	N/A	4.009	1.759	N/A	N/A	N/C
Stage 3	1.278	2.627	N/A	N/A	N/A	N/A	1.58	1.147	N/A	N/A	N/C

Figure 6: Calculated FS in DeepXcav.

In addition, in Figure 7 is presented the table with the Code factors used in this model.

Code	EC7-Greece
Case	DA-2*: A1 + M1 + R2
Parameter	Safety Factor
Seismic multiplier	0
Variable loads	1.5
Permanent loads	1.35
Temporary anchors	1.1
Permanent anchors	1.1
tan(friction angle)	1
Eff. cohesion c'	1
Shear strength Su	1
Earth unfavorable	1.35
Earth favorable	1.4
Water unfavorable	1.35
Water favorable	1
HYDraulic unfavorable	1.35
HYDraulic favorable	0.9
UPLift unfavorable	1.1
UPLift favorable	0.9
Used FS wall STR	1

Figure 7: Eurocode & - Greece factors.

The following section includes the calculation of the FS_Mob.Passive as presented in the Calculation Progress file of DeepXcav.

Calculate the horizontal support actions (unfactored).

* Total actions due to supports FXsupports = 253.98kN/m

* Linear loads on wall factored results Drive FX.line= 0, resisting force FXres.line = 0 kN/m

* Factored Loads on wall due to strip loads and other elastic loads FXstripNET = 10.5kN/m

* Unfactored water force calculations.

* Water force on left side FXwatL = 604.462kN/m

* Water force on right side FXwatR = 320.041kN/m

* Net unfactored water force FXwatNet= 284.421kN/m

* Safety calculations with partial factors follow:

* Factored Resisting soil force FXresist = FXsoil.Unfactored / FS_RES = 1840.6kN/m/1.4 = 1314.714kN/m

* Factored driving forces FXdrive = FXdriveSoil x FS_DriveEarth + FXwat x FS_Water + FXline - FX.res.line + FX.seismic + FXstripNET - FXsupportsNET x FS_DriveEarth =>

* FXdrive = 578.34 x 1.35 + 284.421 x 1.35 + 0 - 0 + 0 + 10.5 - 253.98 x 1.35=>

* FXdrive = 832.354kN/m

* FS.overall.PassiveMobilized = FXresist / FSdrive = 1.58

Table 3: Result comparison

Solution	FS_Mobilized.Passive
Manually calculated	1.573
DeepXcav	1.58

Therefore, the program calculations are verified.