Design of a non-anchored retaining wall

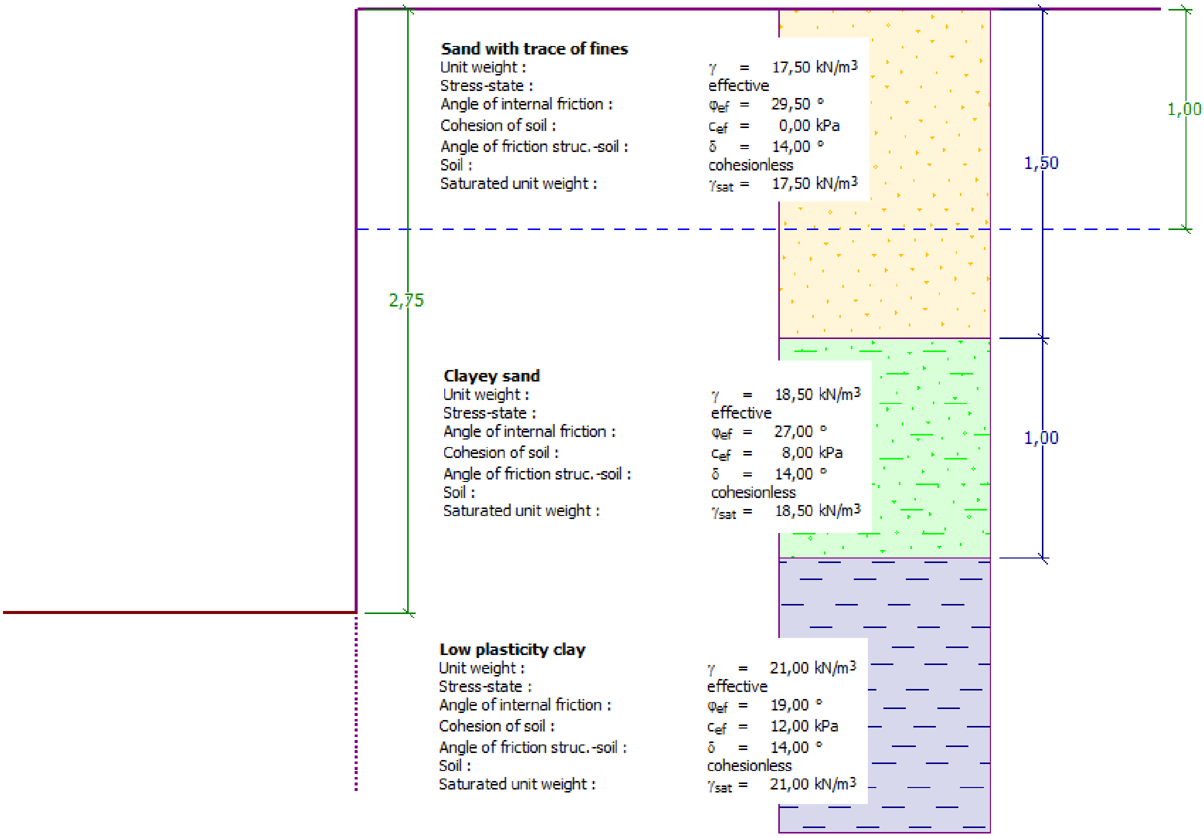
Program: Sheeting design

File: Demo_manual_04.gp1

This engineering manual describes the design of a non-anchored retaining wall for permanent and accidental loads (flooding).

Assignment

Design a non-anchored retaining wall from a pile sheeting *VL 601* using the EN 1997-1 (EC 7-1, DA3) standard in non-homogenous geologic layers. The material of the sheet pile is a steel of type *S 240 GP*. The depth of the excavation is 2,75 m. The groundwater table is in a depth of 1,0 m. Furthermore, analyze the construction for flooding, when the water is 1,0 m above the top of the wall (mobile anti-flood barriers should be installed).



Scheme of a non-anchored wall from pile sheeting – assignment

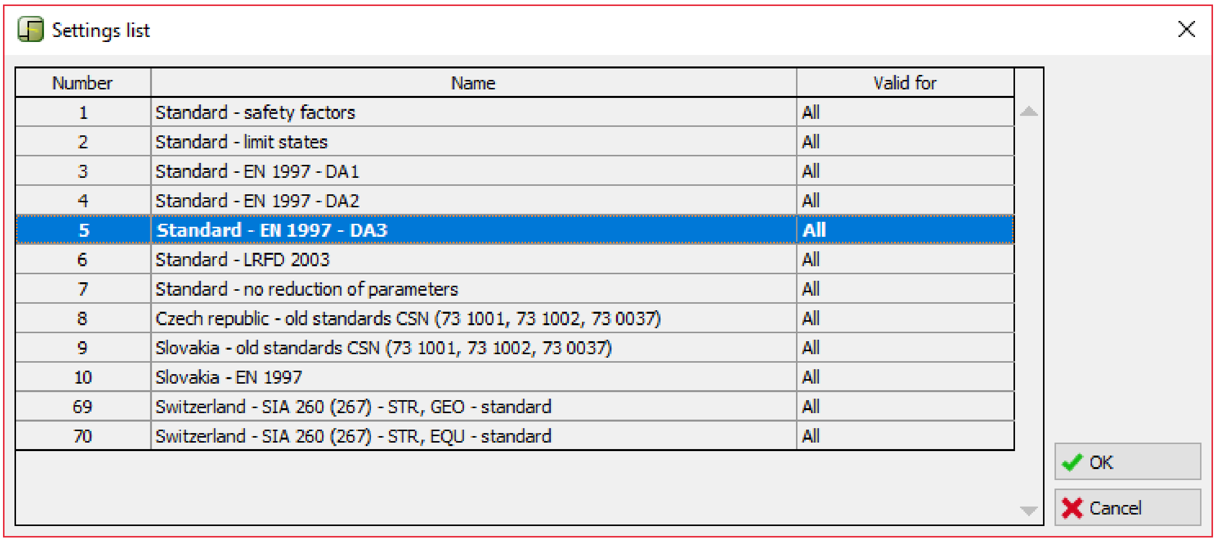
Solution:

To solve this problem, we will use the GEO5 “Sheeting design” program. In this manual , we will explain each step in solving this problem:

- 1st construction stage: permanent design situation
- 2nd construction stage: accidental design situation
- Dimensioning of a cross-section
- Stability verification
- Analysis result and conclusion

Construction stage 1

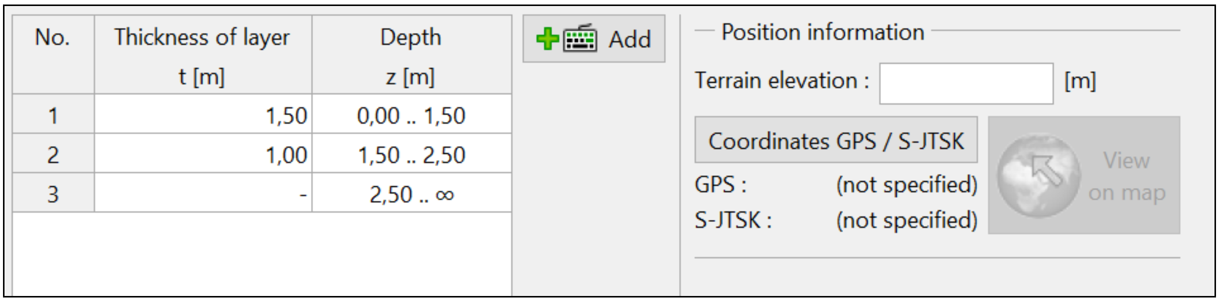
In the “Settings” frame click on “Select settings” and then choose No. 5 – “Standard – EN 1997 – DA3”.



Number	Name	Valid for
1	Standard - safety factors	All
2	Standard - limit states	All
3	Standard - EN 1997 - DA1	All
4	Standard - EN 1997 - DA2	All
5	**Standard - EN 1997 - DA3**	**All**
6	Standard - LRFD 2003	All
7	Standard - no reduction of parameters	All
8	Czech republic - old standards CSN (73 1001, 73 1002, 73 0037)	All
9	Slovakia - old standards CSN (73 1001, 73 1002, 73 0037)	All
10	Slovakia - EN 1997	All
69	Switzerland - SIA 260 (267) - STR, GEO - standard	All
70	Switzerland - SIA 260 (267) - STR, EQU - standard	All

“Settings list” Dialog window

Firstly, go to the "Profile" frame and add two new interfaces using the "Add" button. One will be in the depth of 1,5 m and the other one in the depth of 2,5 m.

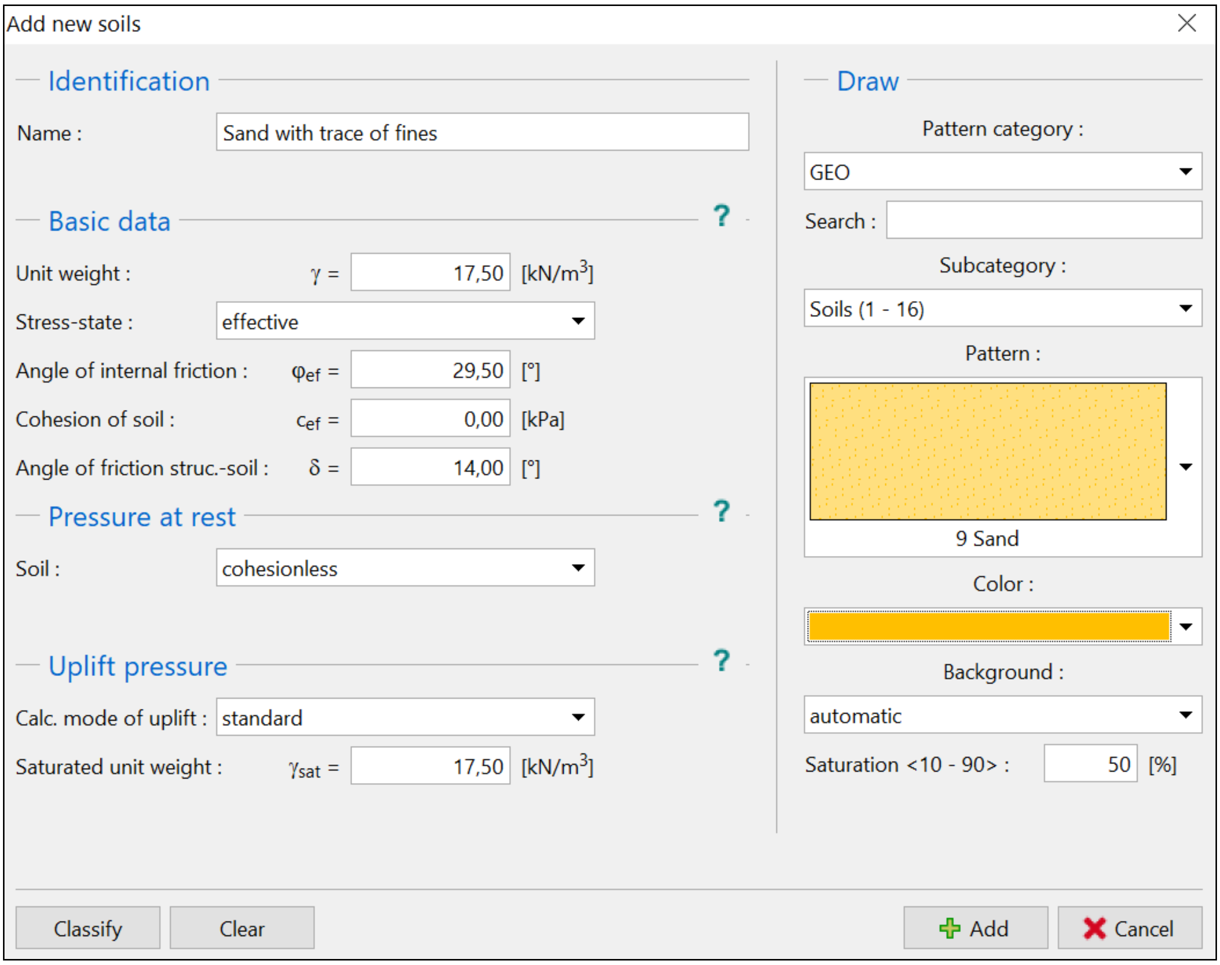


"Profile" frame – Add new interface

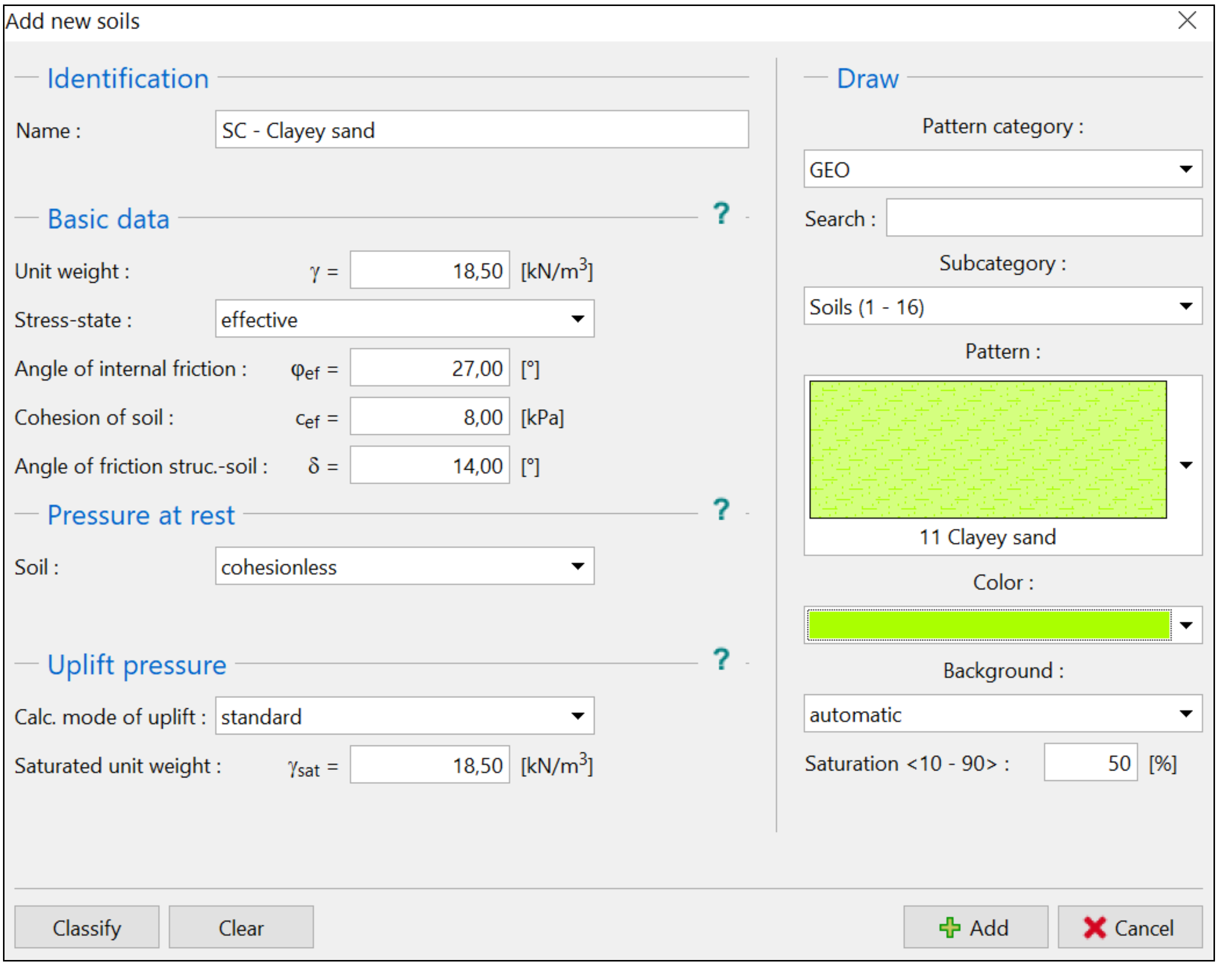
Then, go to the "Soils" frame and add new soils by clicking the "Add" button, input the parameters of the soils according to the following table or pictures and assign them to the profile. The stress state is considered as **effective**, the pressure at rest is calculated for **cohesionless** soils and the calculation of uplift is selected as **standard** for each soil. We will not consider a change of unit weight due to saturation.

Soil (Soil classification)	Profile $[m]$	Unit weight $\gamma \left[kN/m^3\right]$	Angle of internal friction φ_{ef} $[°]$	Cohesion of soil c_{ef} $[kPa]$	Angle of friction structure – soil $\delta = [°]$
S-F – Sand with trace of fines, medium dense soil	0,0 – 1,5	17,5	29,5	0,0	14,0
SC – Clayey sand, medium dense soil	1,5 – 2,5	18,5	27,0	8,0	14,0
CL, CI – Clay with low or medium plasticity, firm consistency	from 2,5	21,0	19,0	12,0	14,0

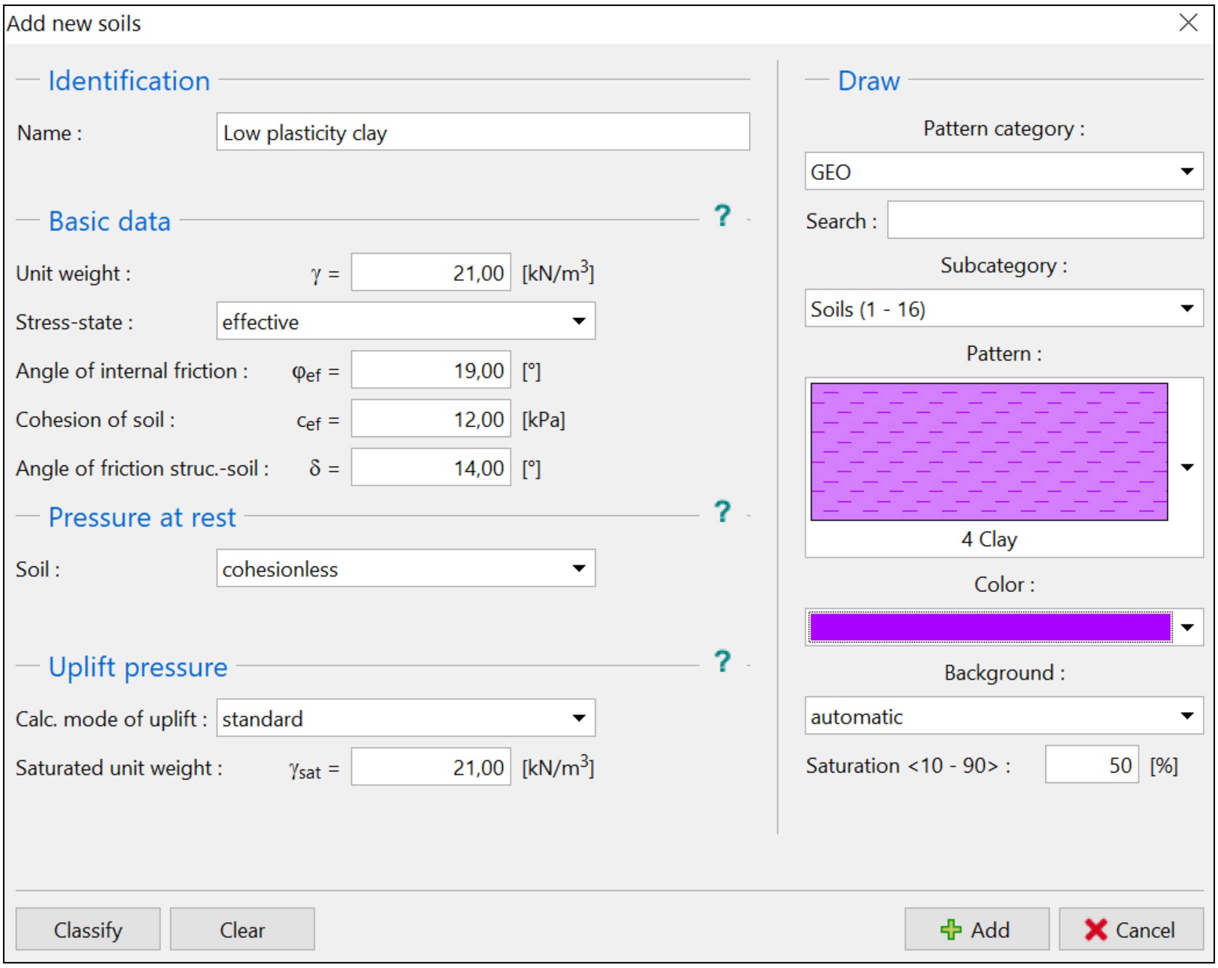
Table – soil parameters



"Add new soils" Dialog window – Sand with traces of fines

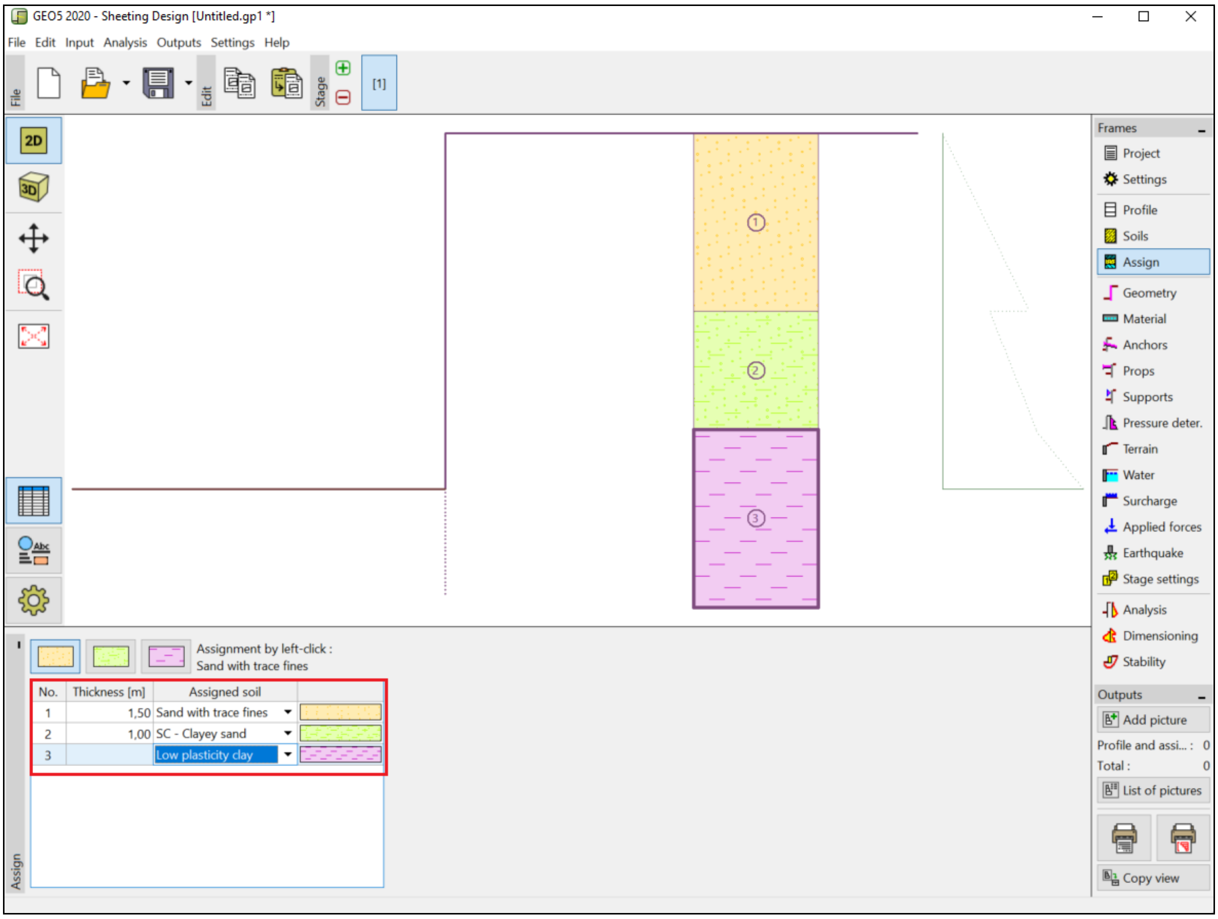


"Add new soils" Dialog window – Clayey sand



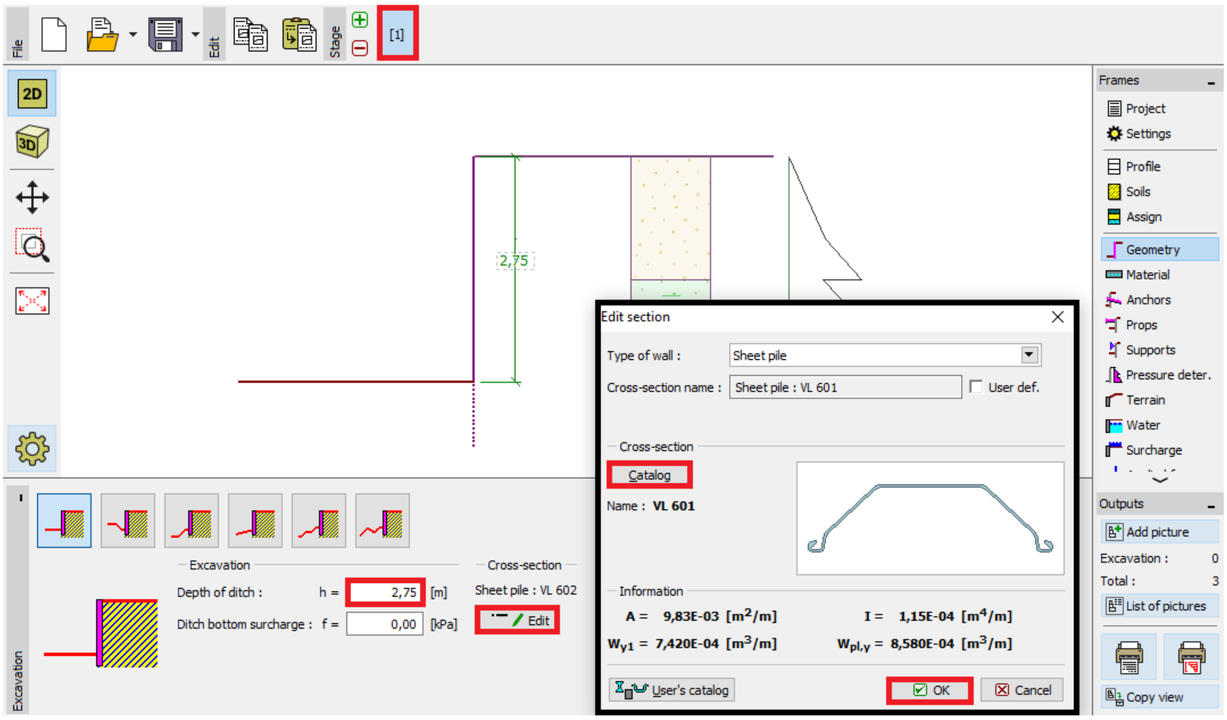
"Add new soils" Dialog window – Low plasticity clay

Then, in the "Assign" frame, assign the soils to the layers as shown in the picture below.



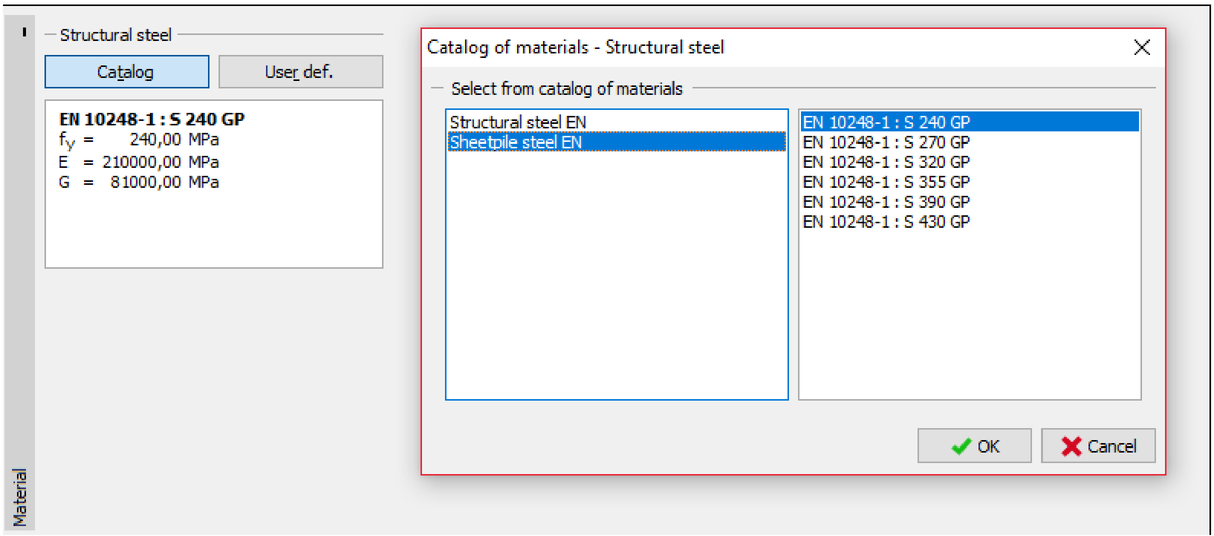
"Assign" frame – soil assignment

In the "Geometry" *frame*, select the shape of the bottom of the excavation and input its depth (2.75 m). Then, click on *"edit"* to select the type of the cross-sections. For our example, we will consider a sheet pile VL 601.



“Geometry” frame

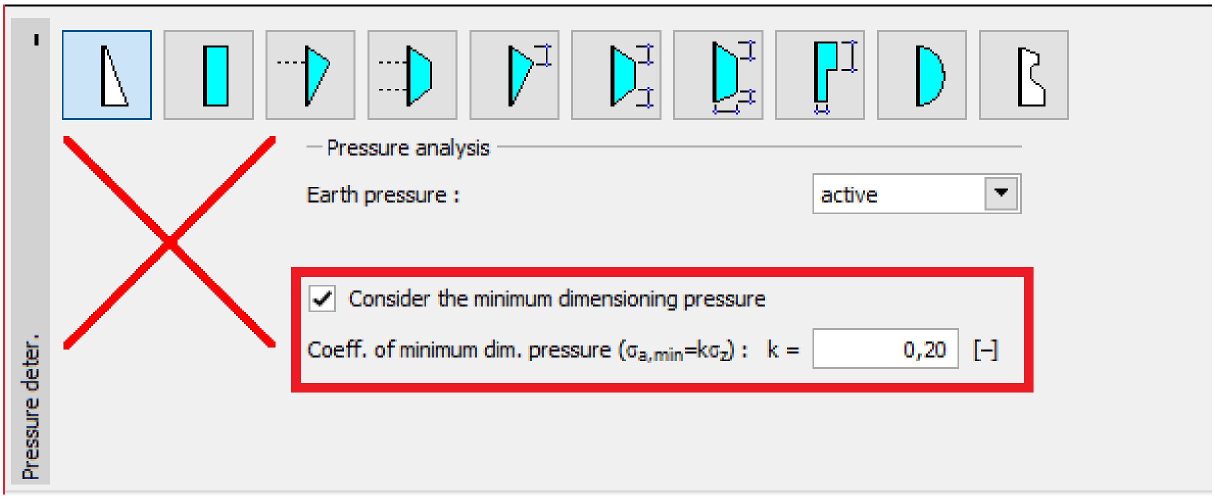
In the “Material” frame we set the required type of steel to S 240 GP (sheet pile steel).



“Material” frame

In this case, we do not use the “Anchors”, “Props”, “Supports”, “Surcharge” or “Applied forces” frames. The frame “Earthquake” is also not important in this analysis, because the structure is not located in a seismically active area. In the “Terrain” frame, the setting remains horizontal.

Then we move to the "Pressure determination" frame. In this frame we will choose the possibility "Consider the minimum dimensioning pressure".

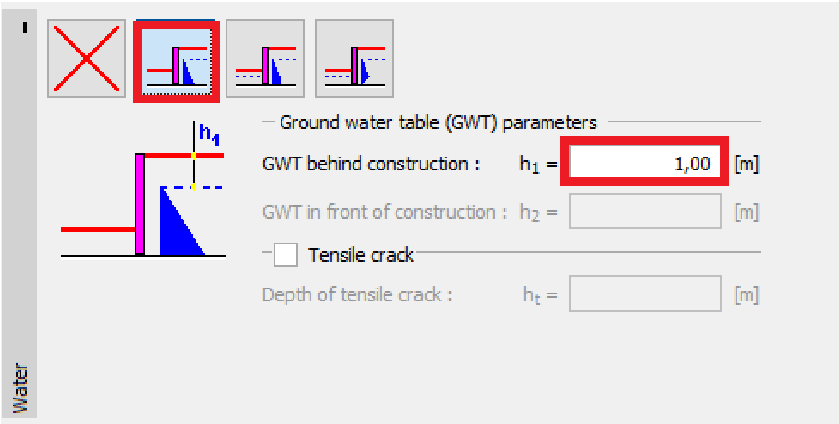


"Pressure determination" frame

Note: For cohesive soils it is recommended by some standards to use the minimal dimensioning pressure acting on the retaining wall. The standard value for the coefficient of minimal dimensioning pressure is Ka = 0.2. It means that the minimum pressure on the structure is at least 20% of the geostatic stress – never less.

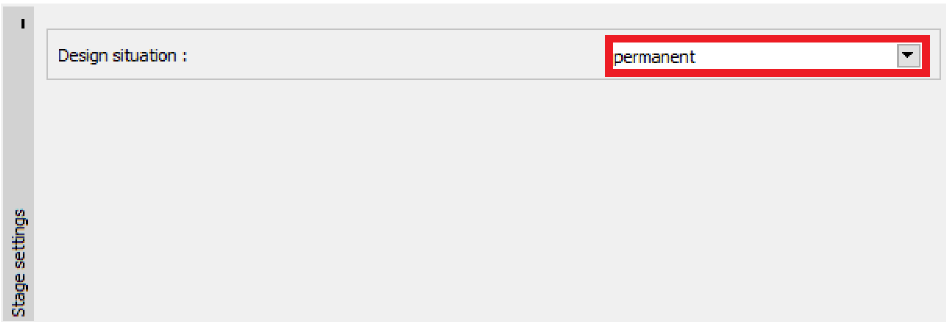
Note: In the case of anchored retaining walls, it is recommended to use the redistribution of acting pressure because of anchoring. If we want to reduce the deformation of the sheet pile, it is also possible to increase the pressure acting on the structure (increased active, at rest) in the same frame. Both of these possibilities are described in the program help (F1) or the next engineering manual [No. 5 - Design of an anchored retaining wall](#).

In the “Water” frame input the GWT value as 1,0 m.



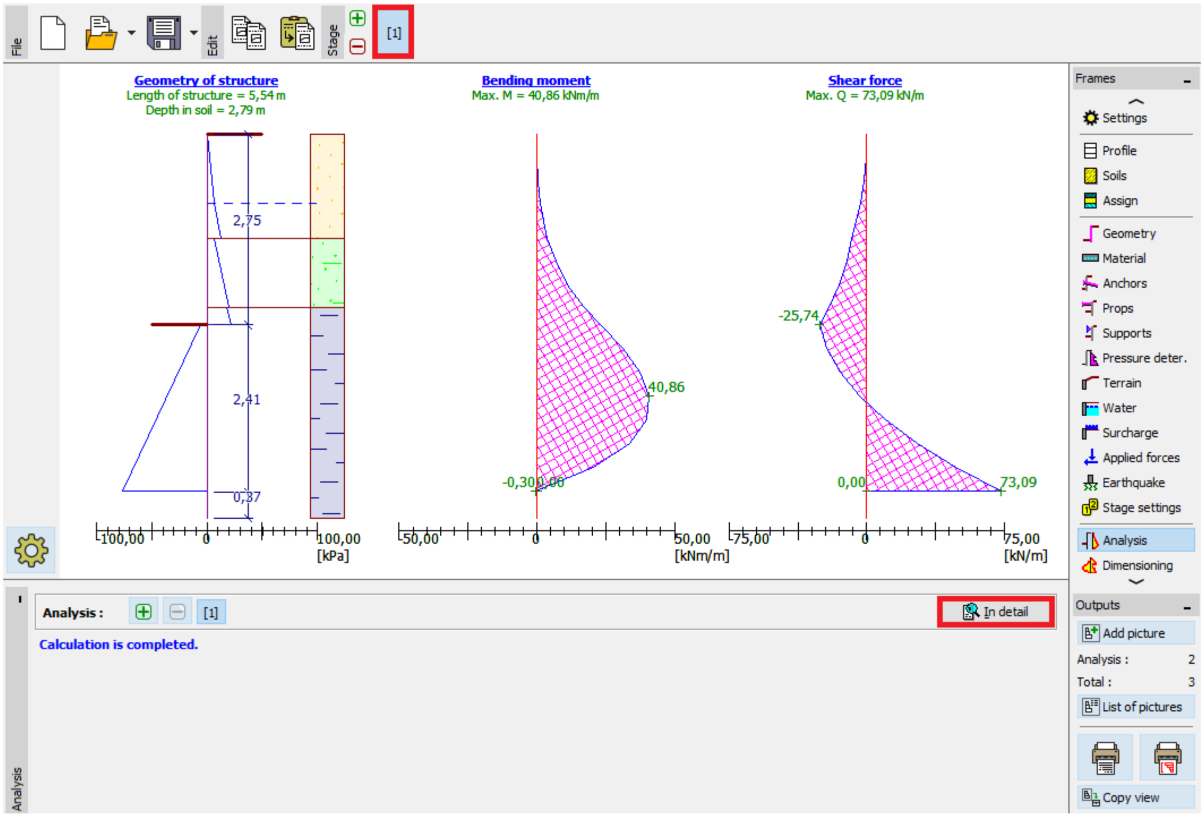
“Water” frame – 1st construction stage

Then, in the “Stage settings”, select the permanent design situation.



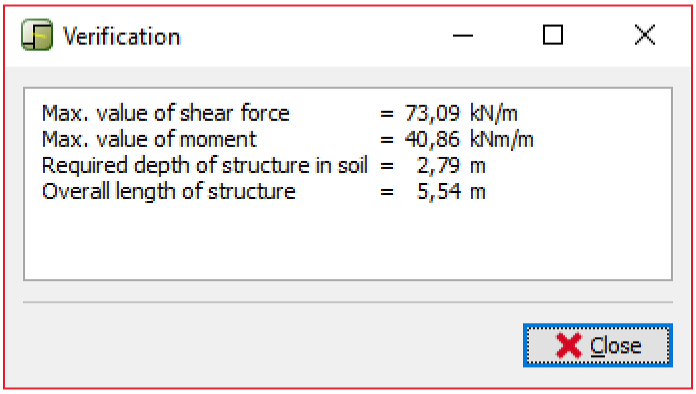
“Stage settings (1)” frame

Now, open up the "Analysis" frame. In this frame the program will automatically calculate the internal forces and the necessary depth of the structure in the soil.



"Analysis" frame

All results can be displayed using the "In detail" button.

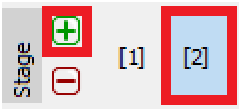


"Analysis" frame – construction stage 1 – "In detail" dialog window

In the next stage, we are going to show you, how to analyze the minimum in-soil depth and the internal forces in case of an accidental design situation – floods.

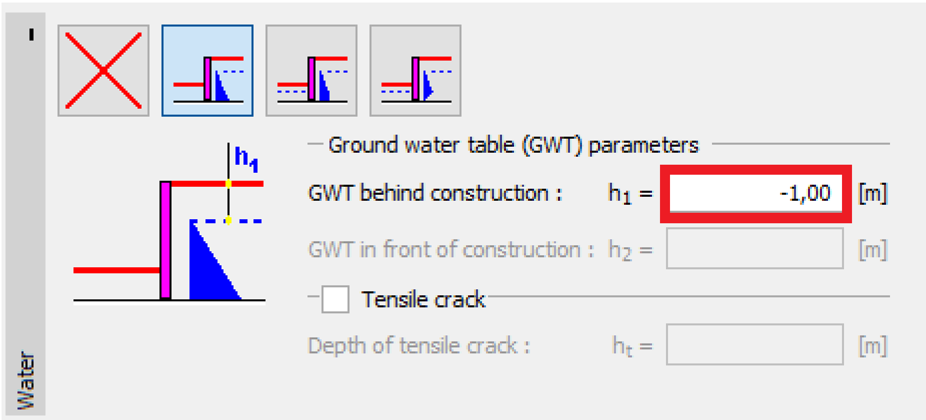
Basic input – Construction stage 2

Now, add a new construction stage on the "Construction stage" toolbar in the upper left corner of your screen.



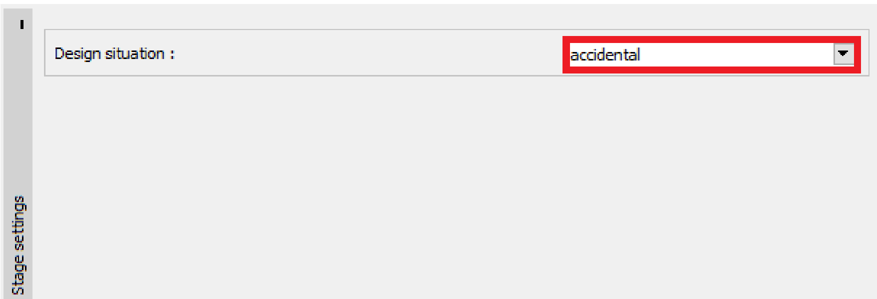
"Construction stage" toolbar

In the "Water" frame, change the GWT behind the structure to -1,0 m. We will not consider water in front of the structure.



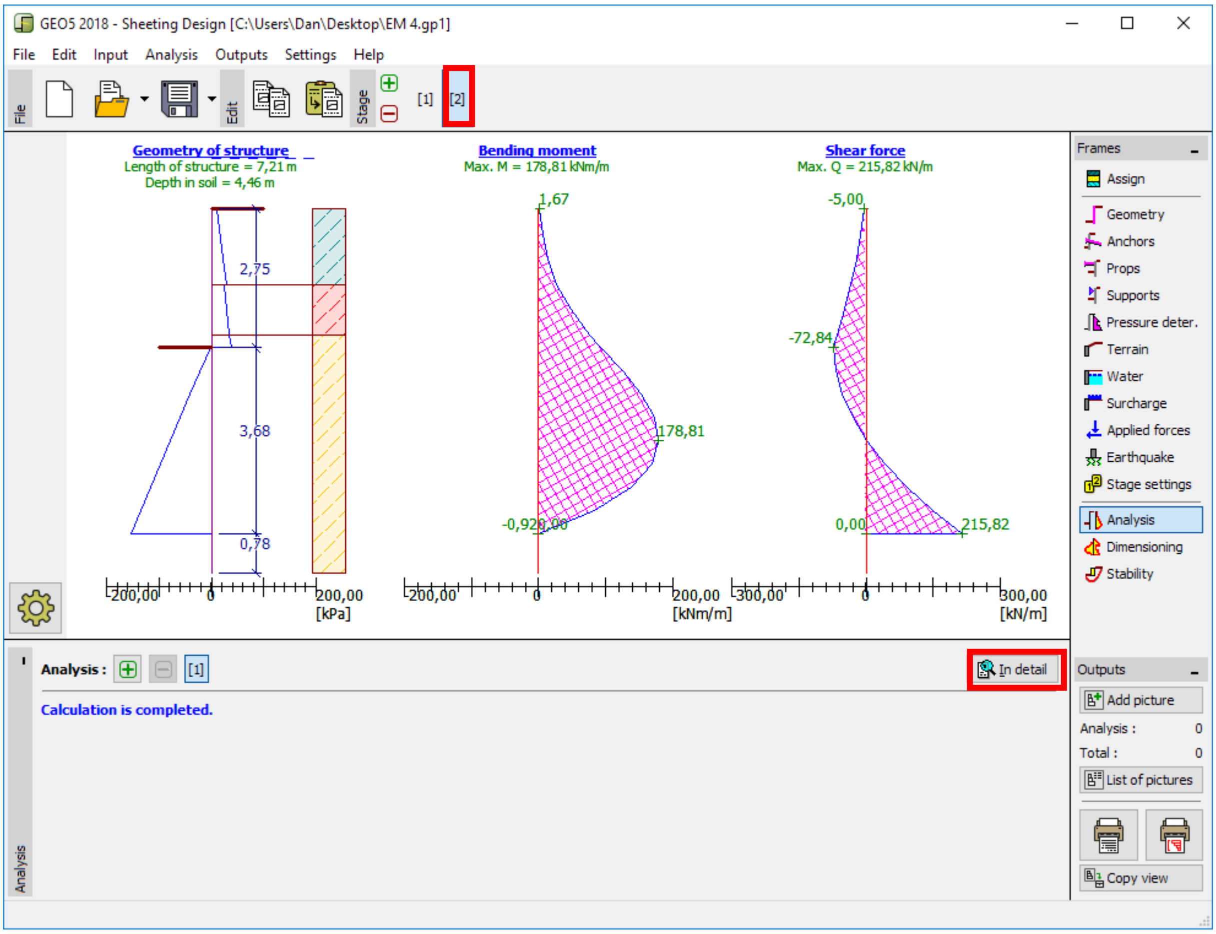
"Water" frame

Then, in the "Stage settings" frame, select the "Accidental" design situation.

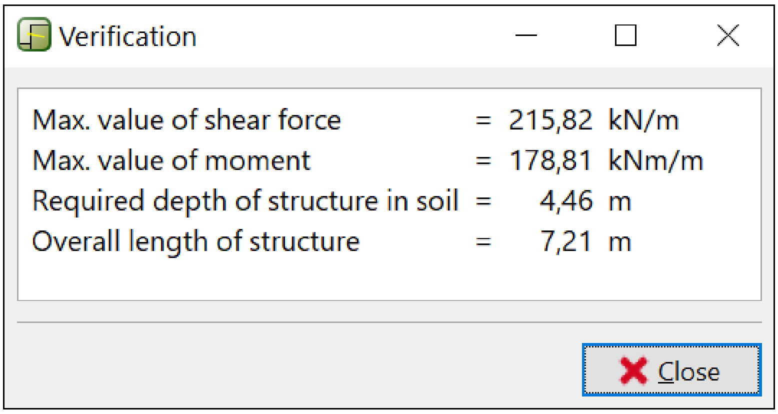


"Stage settings (2)" frame

All of the other values are the same as in the 1st construction stage, so we do not have to change anything else. Therefore we can go straight to the "Analysis" frame and see the detailed results.



"Analysis" frame

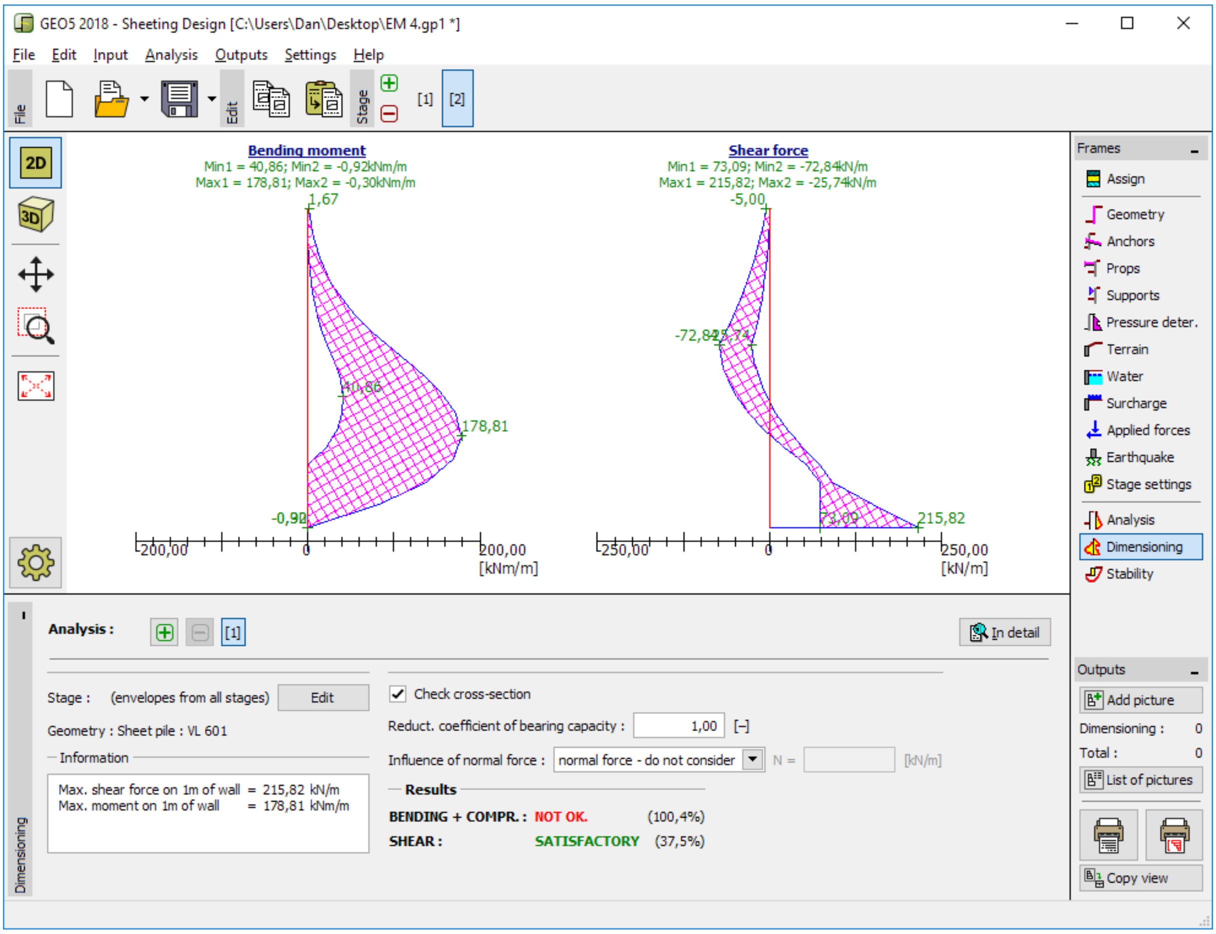


"Analysis" frame – construction stage 1 – "In detail" dialog window

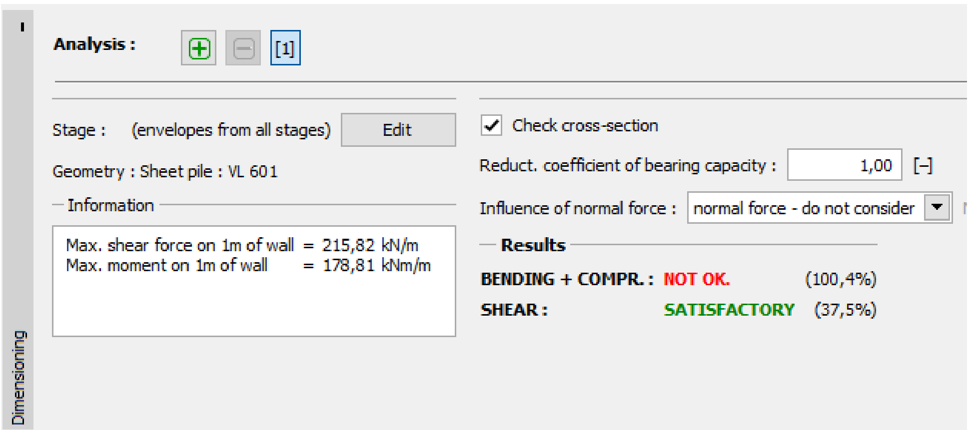
Now it is necessary to verify the cross-section of the sheet pile for bending + compression and shear.

Verification of the cross-section

Move to the “Dimensioning” frame.



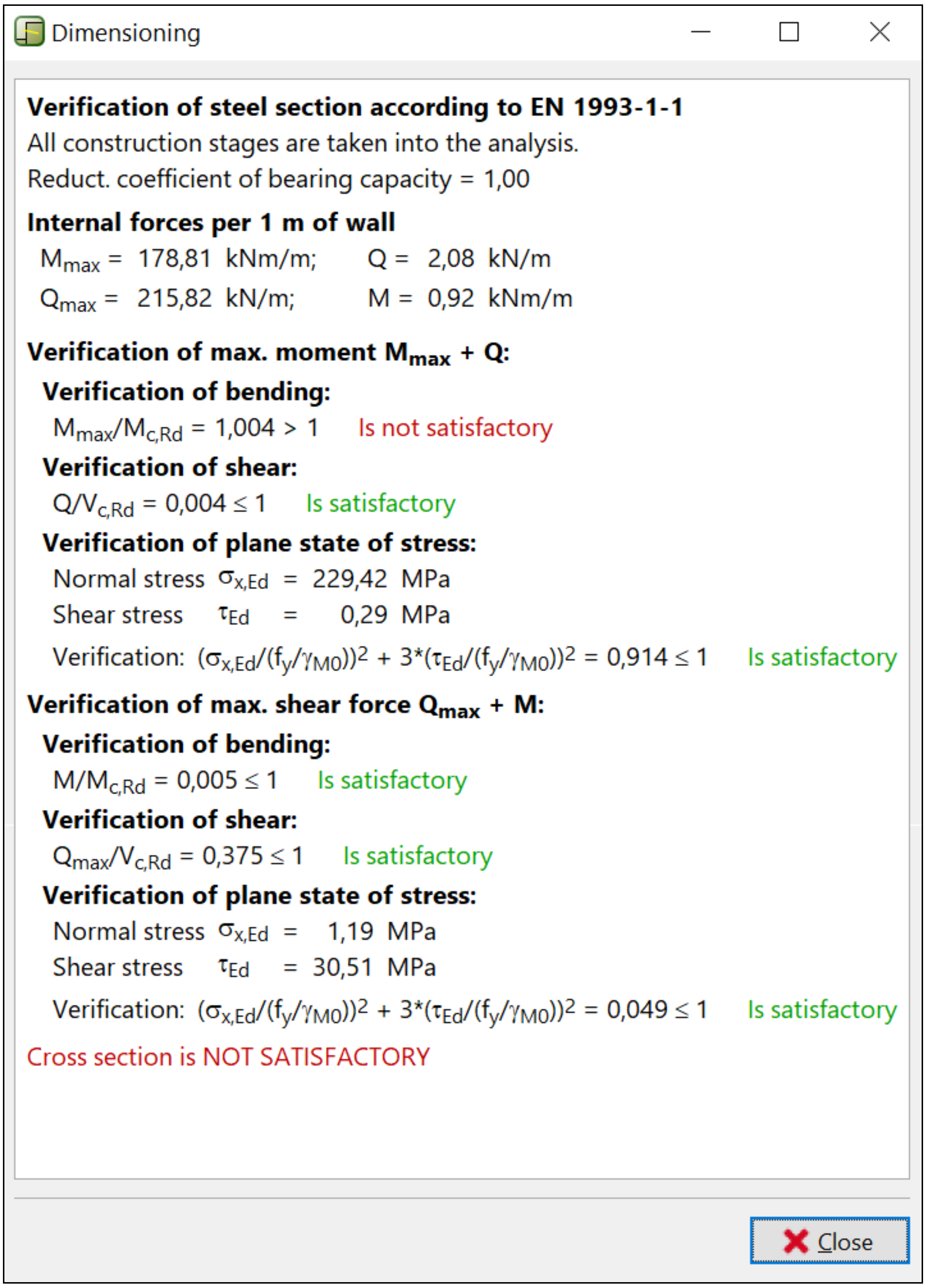
“Dimensioning” frame



“Dimensioning” frame – verification results

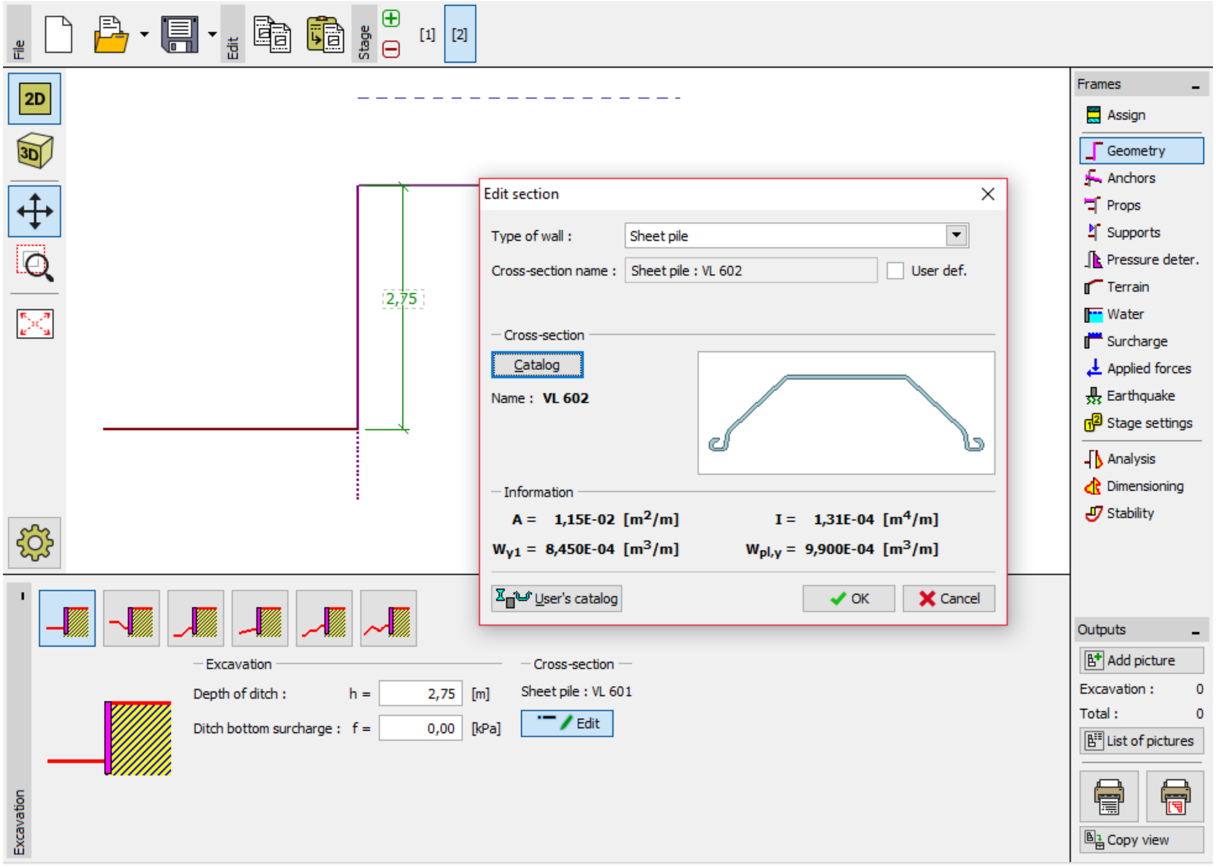
Note: The maximum values of internal forces from all stages are displayed in the "Dimensioning" frame. If we want to use the results from specific construction stages, we have to select them using the "Edit" button.

We see, that our cross-section is not OK for "Bending + compression" verification, the utilization is more than 100 %. Detailed results can be displayed using the "In detail" button.



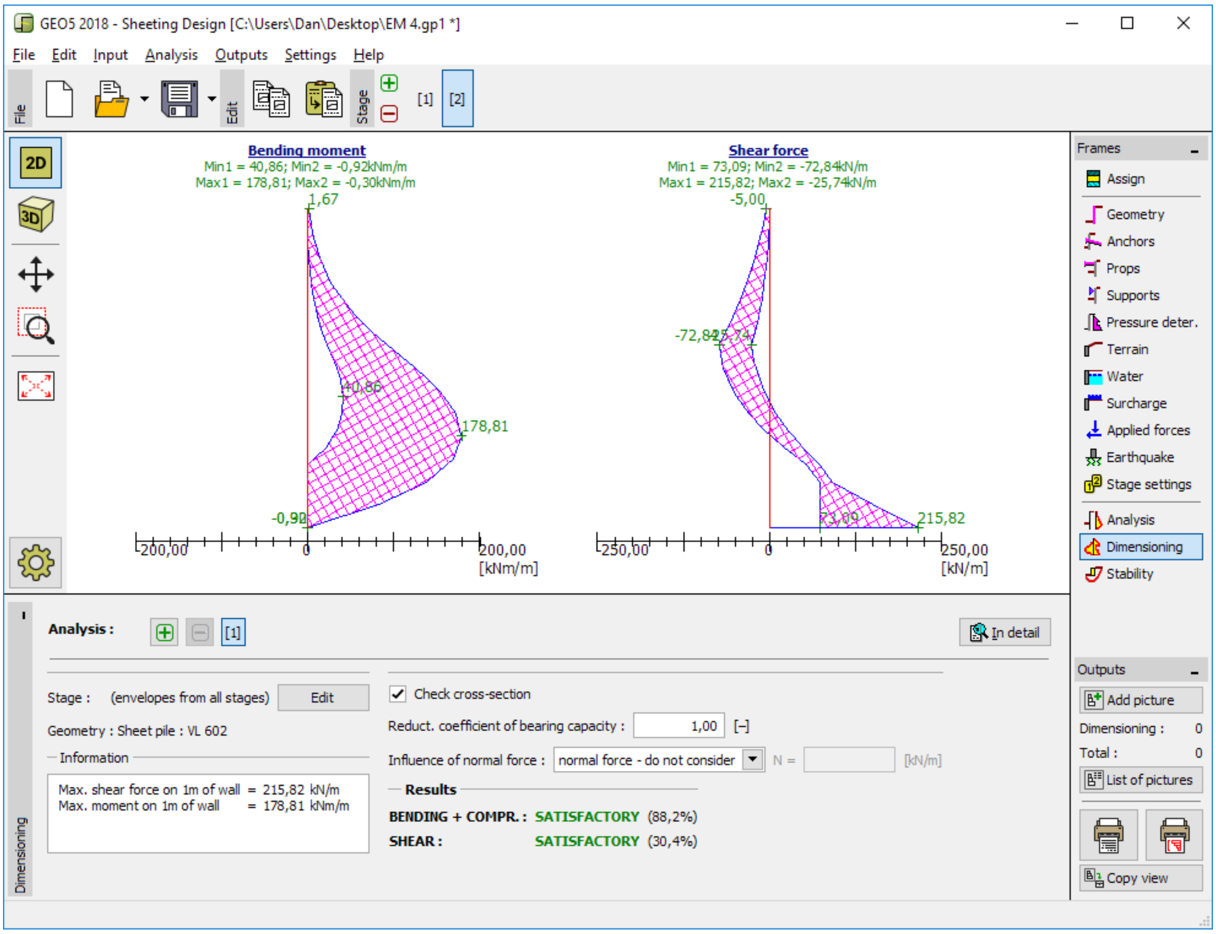
Detailed results

Because the verification of the cross-section is not satisfactory, we have to go back to the "Geometry" frame and select a bigger sheet pile – *VL 602*.

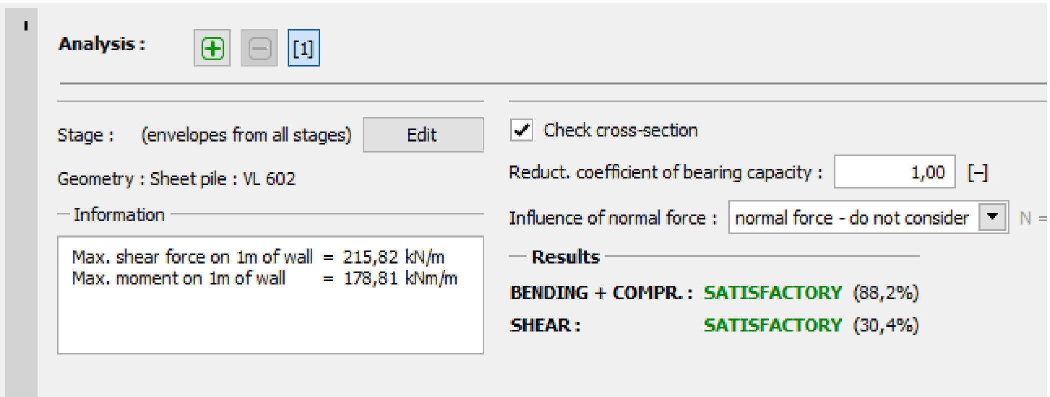


"Geometry" frame – changing the cross-section

After editing the cross-section, we will return to the "Dimensioning" frame. The verification of the new bigger cross-section pile is now satisfactory.



Frame "Dimensioning" – verification of a new cross-section



"Dimensioning" frame – new verification results

Note: Changing the cross-section has no influence on the analysis of the internal forces. The stiffness of the structure will only influence the analysis in the "Sheeting check" program, which can be used when analyzing more difficult anchored structures.

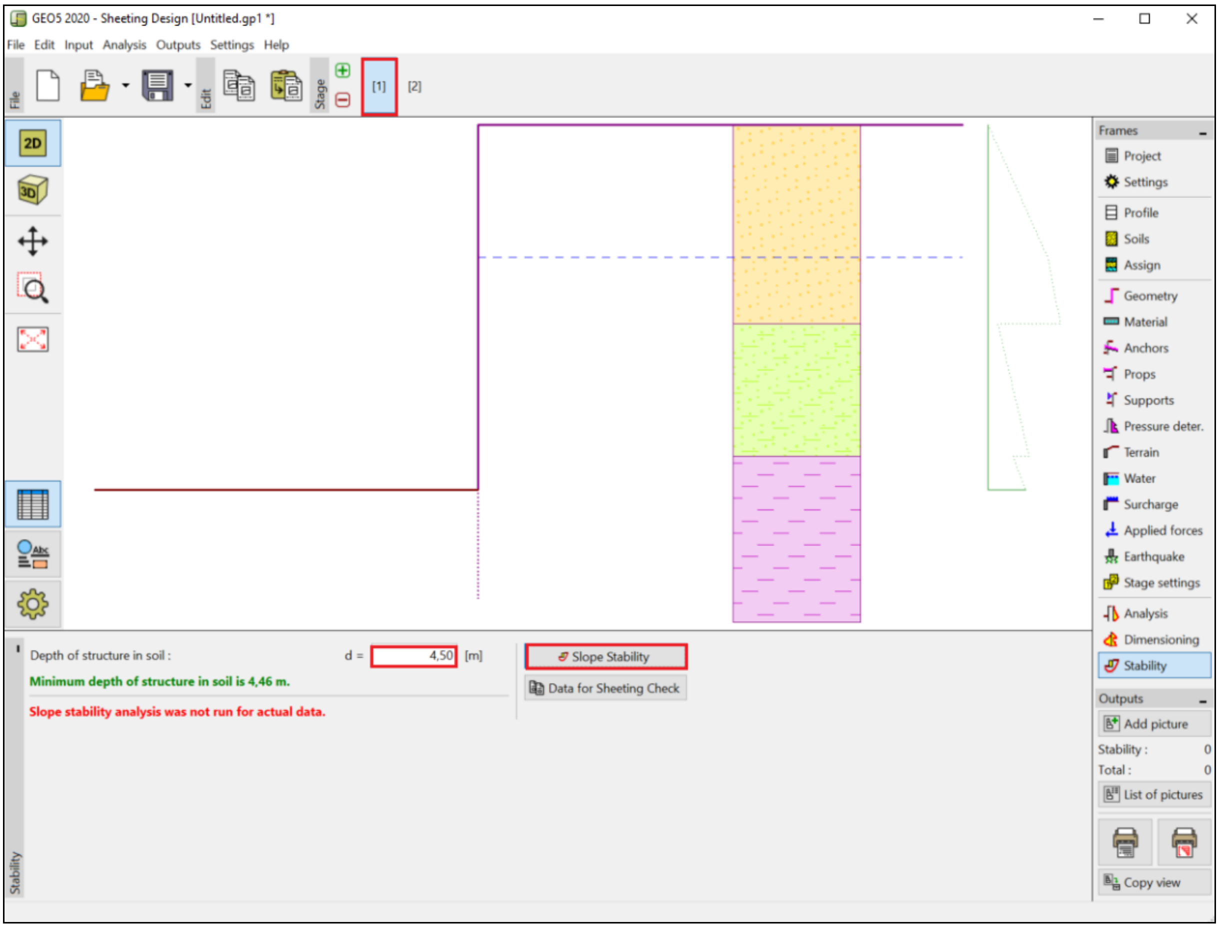
Verification of stability

Now it is necessary to verify that the structure is satisfactory in terms of overall stability. This verification is performed in the "Stability" frame.

In this frame the program shows the minimum depth of the structure in the soil. Stability analysis should be performed for each construction stage.

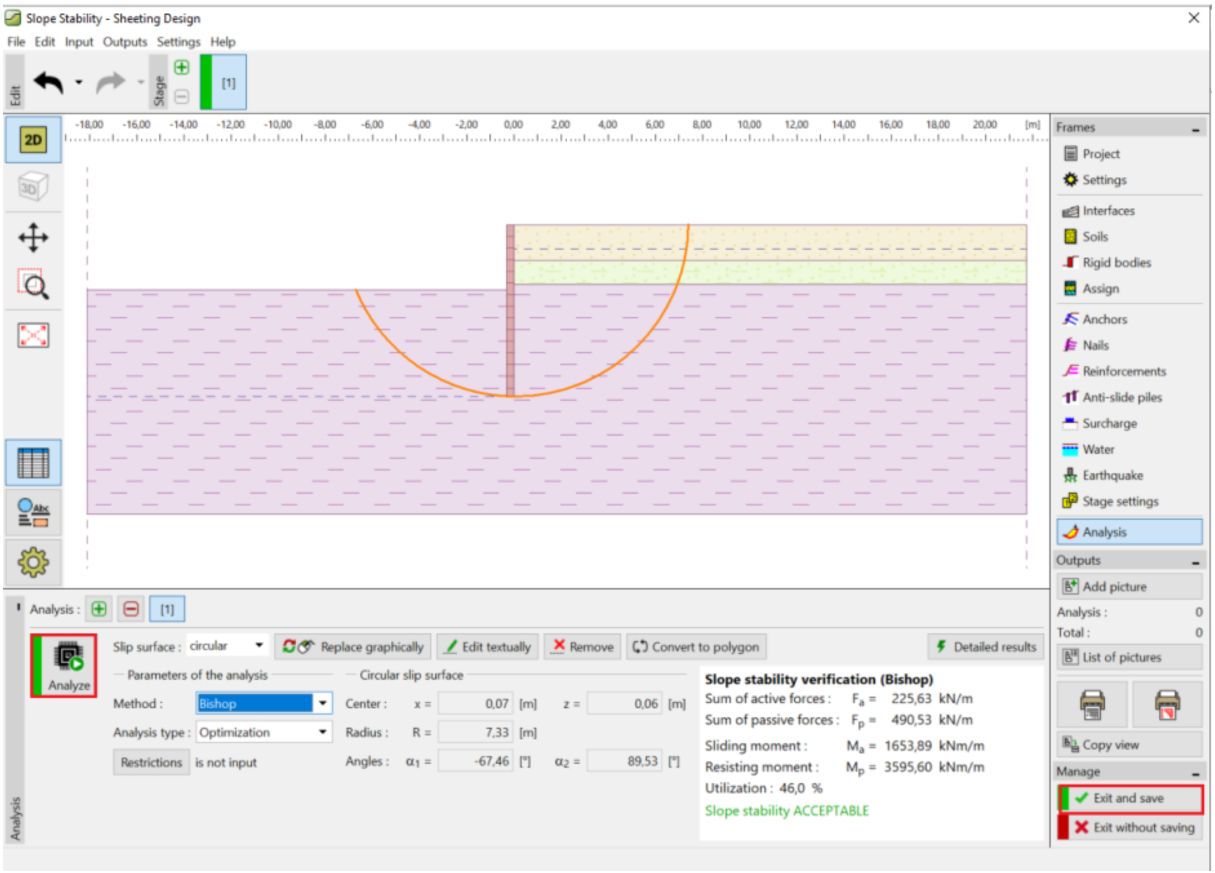
The minimum depth of the structure (based on an analysis in the 2nd construction stage) is 4,46 m. We will therefore design a sheet pile wall 4,5 m deep in the soil.

Firstly, we perform an analysis of the 1st construction stage.



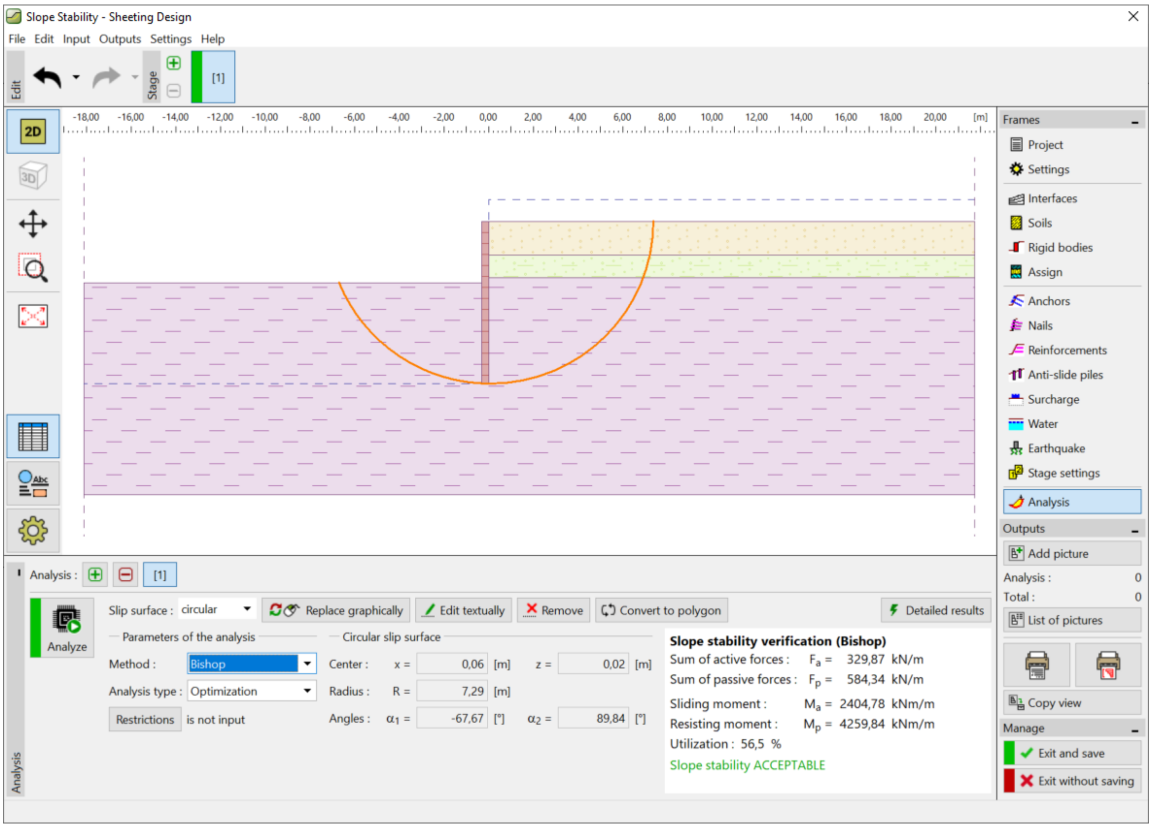
"Stability" frame – construction stage 1

Clicking the "Slope Stability" button launches the "Slope Stability" program. All input parameters are transferred to this program automatically. In the program, go to the "Analysis" frame. Select the "Bishop" method with circular slip surface optimization as shown in the picture below and click the "Analyze" button.



"Slope Stability" program – "Analysis" frame (construction stage 1)

When the analysis for the 1st stage is finished, click on "Exit and save" on the right side of the screen. Then, we will perform the same analysis for the 2nd construction stage.



"Slope Stability" program – "Analysis" frame (construction stage 2)

Analysis result and conclusion

The aim of this task was to design a sheet pile wall for a foundation pit with a depth of 2,75m.

When designing a non-anchored retaining wall, we obtain the value of the minimum depth of the structure in the soil. This depth is determined as the maximum value from all construction stages:

- Minimum depth of the structure in the first stage: 2,79m
- Minimum depth of the structure in the second stage: 4,46m

So, we will design the sheet pile wall 4,5m deep in the soil with an overall length of 7,25m (4,46 m + 2,79m).

This structure is satisfactory for overall stability. The maximum utilization of the structure does not exceed 60 %.

The originally designed cross-section of sheet pile type *VL 601* was not satisfactory for bending verification. Because of this, the cross-section was replaced with a larger type VL 602, which was satisfactory.

The sheet pile wall (cross-section type *VL 602*, steel *S 240 GP*) with an overall length of 7,25m is satisfactory for all verifications.