

Design of a non-anchored retaining wall

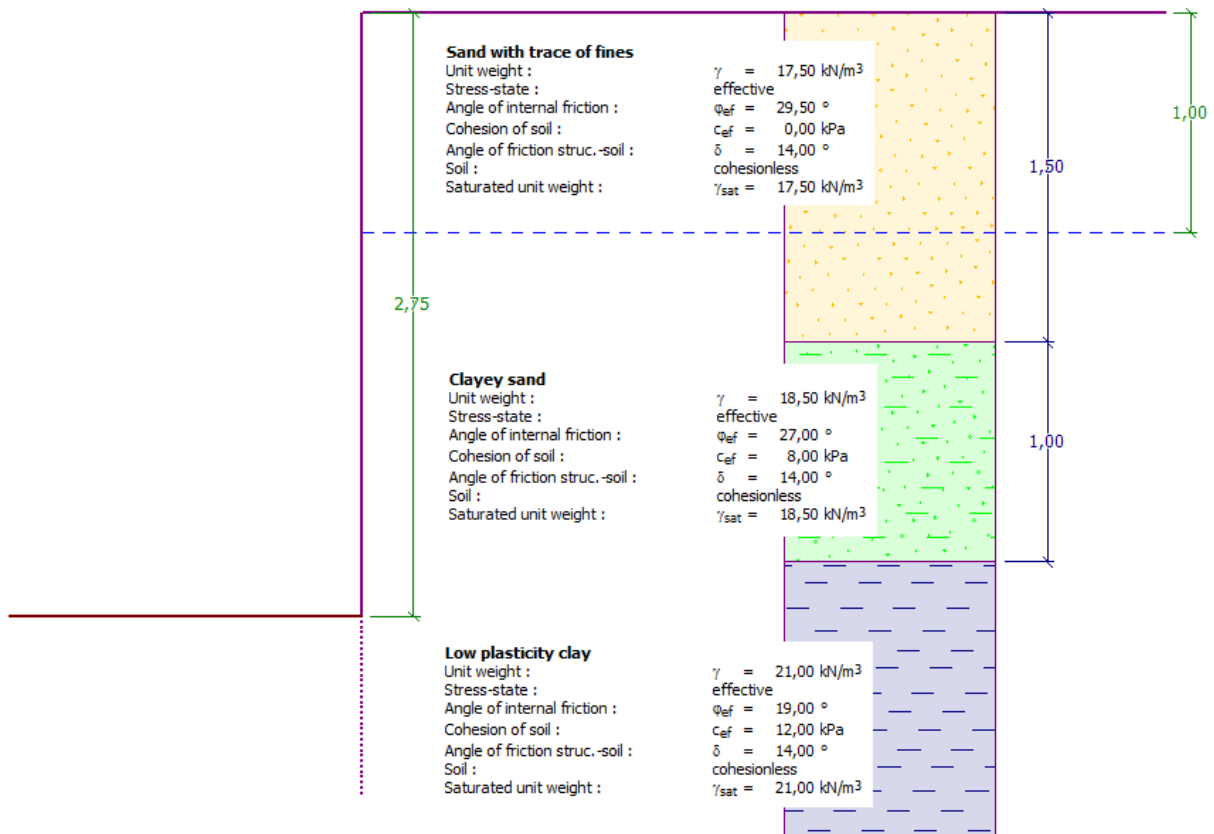
Program: Sheeting design

Soubor: Demo_manual_04.gp1

In this chapter, the design of a non-anchored retaining wall for permanent and accidental loads (flooding) is described.

Assignment

Design a non-anchored retaining wall from 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 steel S 240 GP. The depth of the excavation is 2,75 m. The ground water table is in a depth of 1,0 m. Also analyse 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

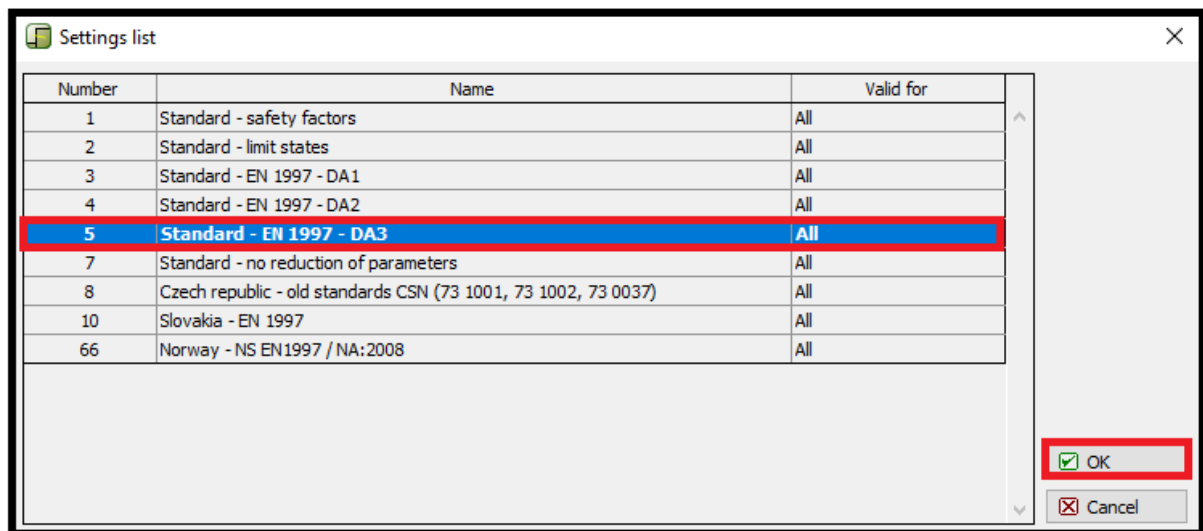
Solution:

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

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



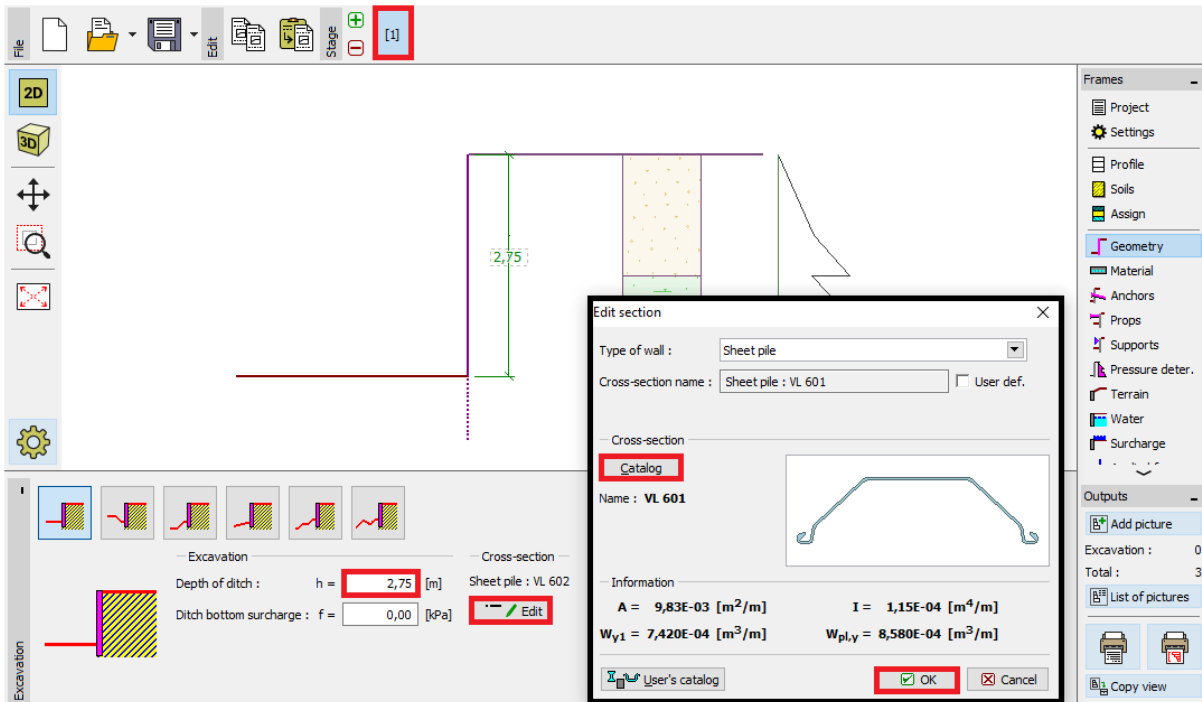
Dialog window “Settings list”

Then, input the geological profile and the parameters of the soil according to the following table and assign them to the profile. Stress state is considered as an **effective**, pressure at rest is calculated for **cohesionless** soils and calculation of uplift is selected as a **standard** one for each soil. We will not consider change of unit weight due to saturation.

Soil (Soil classification)	Profile [m]	Unit weight γ [kN/m ³]	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

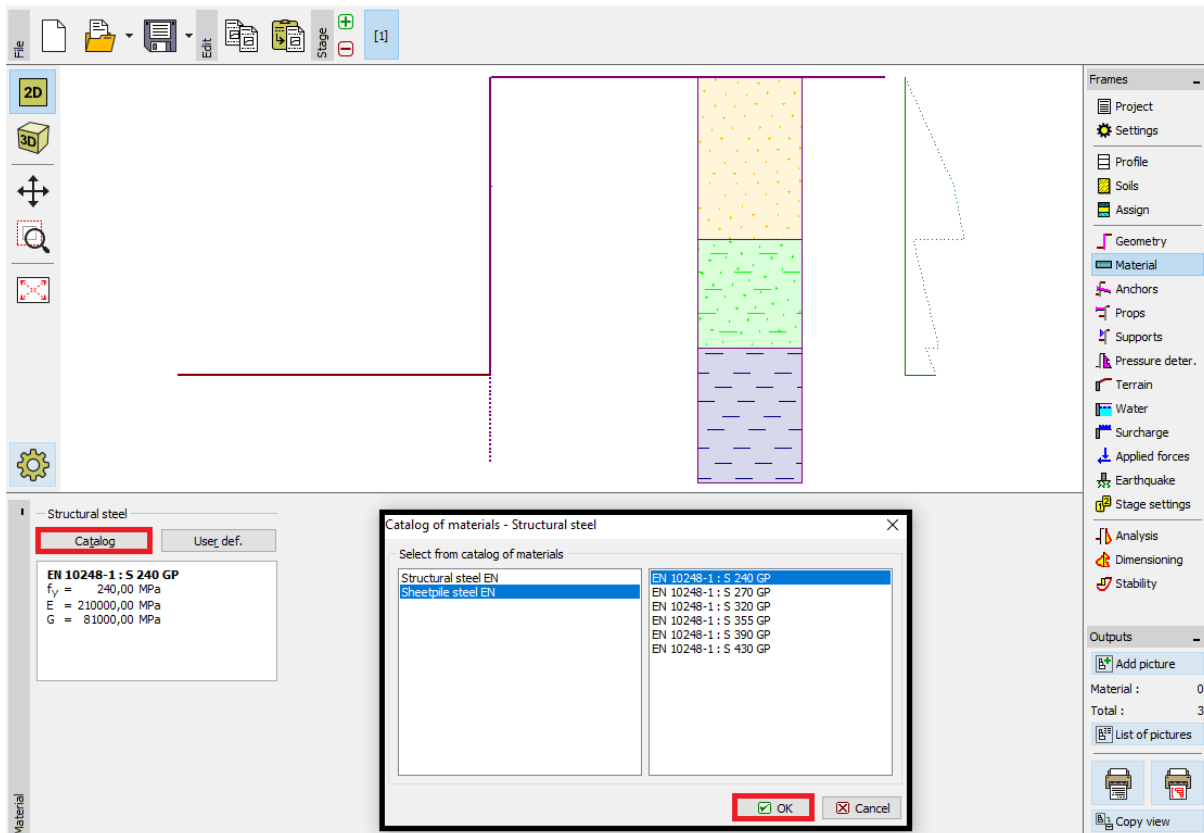
Dialog window "Add new soils"

In the frame “Geometry”, select the shape of the bottom of the excavation and input its depth. We also choose the type of the cross-section in this frame.



Frame “Geometry”

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

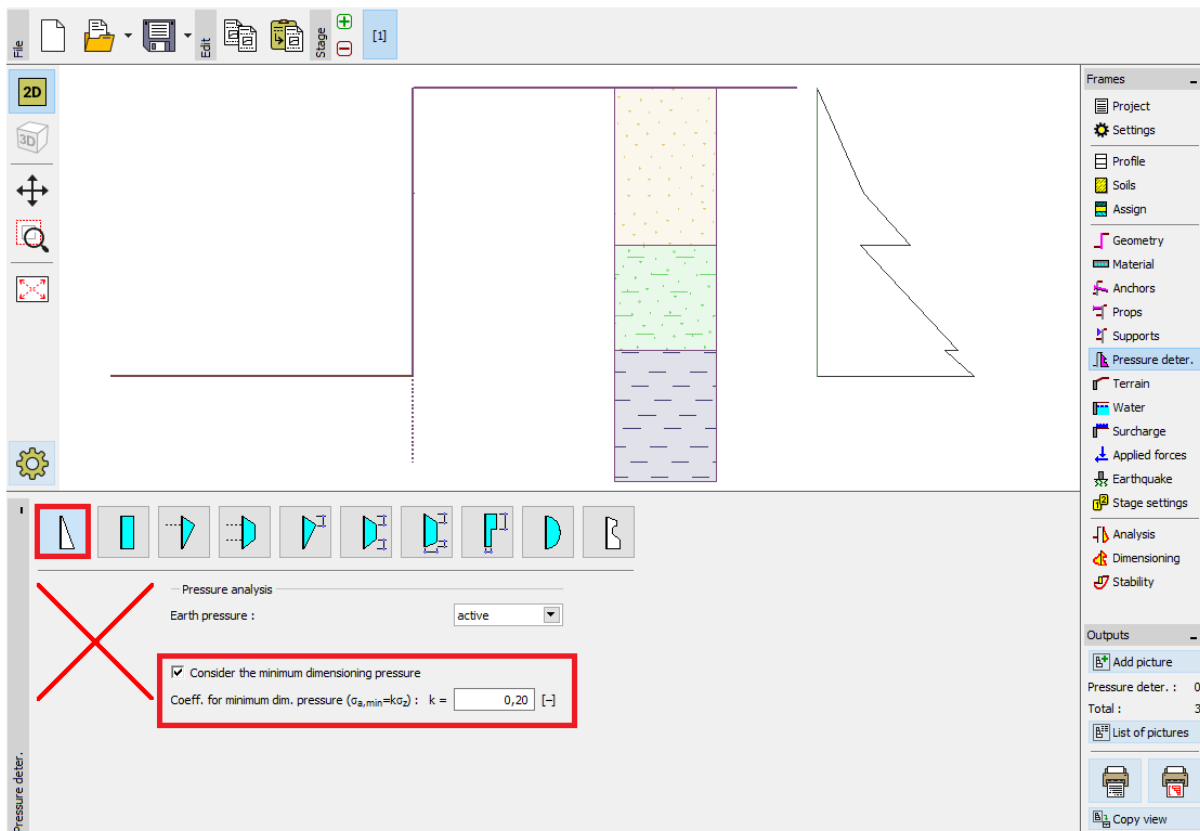


Frame “Material”

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

In the frame “Terrain”, the setting remains horizontal.

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

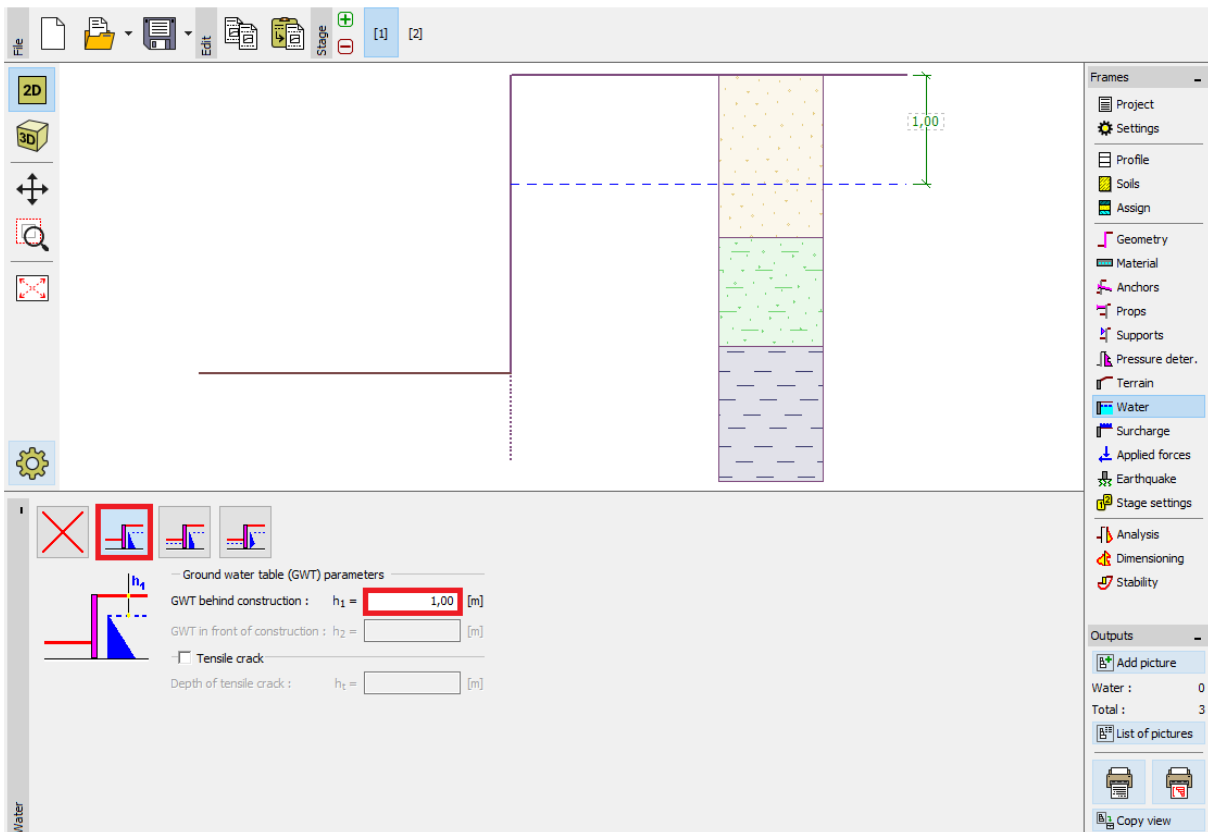


The frame “Pressure determination”

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 $K_a = 0.2$. It means that the minimum pressure on the structure is 0.2 of geostatic stress – never less.

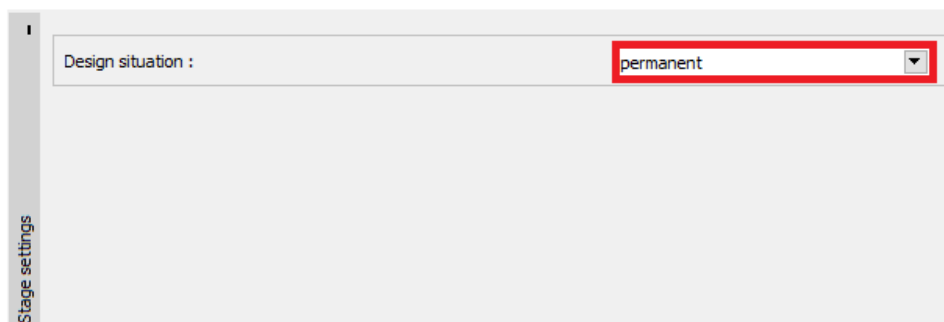
Note: In the case of anchored retaining walls it is recommended to use the redistribution of acting pressure because of anchoring. If we want to reduce the deformation of the sheet pile, it is also possible to increase the pressure acting on the structure (increased active, at rest) in the same frame.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

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



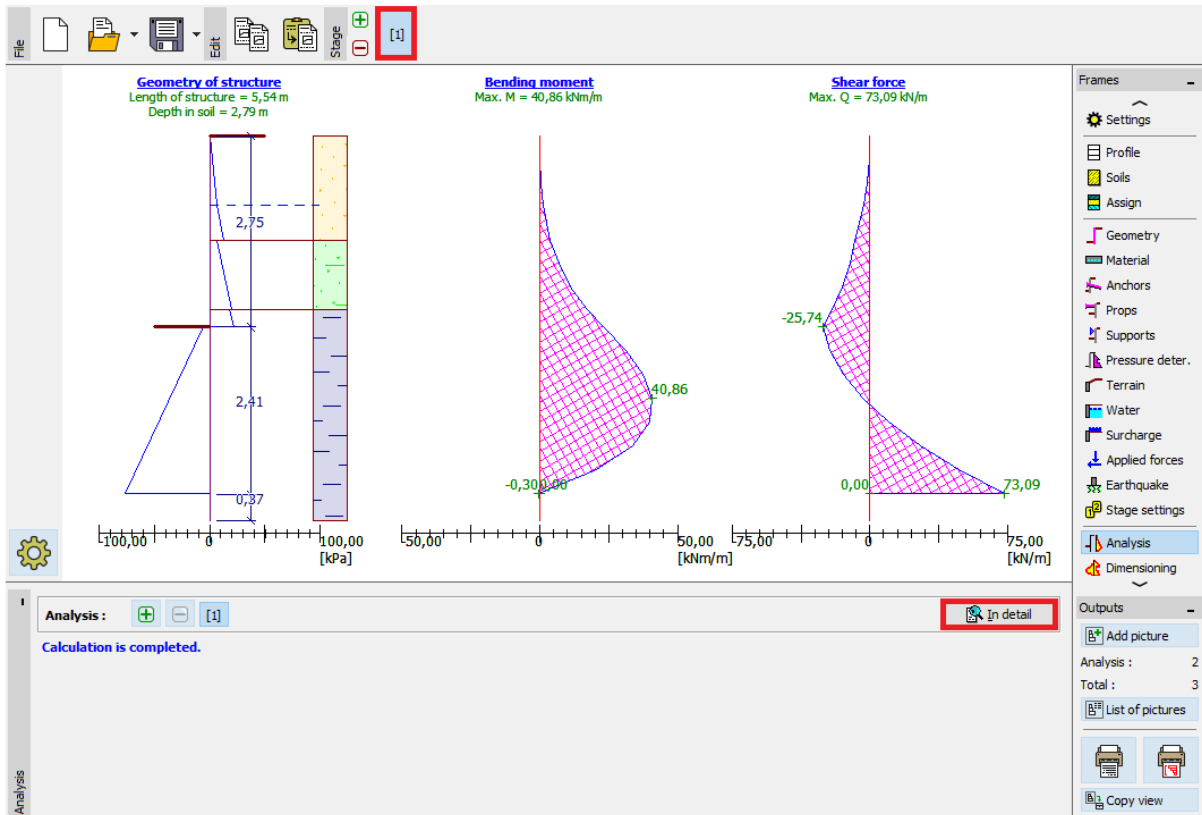
Frame “Water” – 1st construction stage

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



Frame “Stage settings (1)”

Now, open up the frame “Analysis”. In this frame the program automatically calculates the internal forces and the necessary depth of the structure in soil.



Frame “Analysis”

All results can be displayed using the button “In detail”.

Max. value of shear force	= 73,09 kN/m
Max. value of moment	= 40,86 kNm/m
Required depth of structure in soil	= 2,79 m
Overall length of structure	= 5,54 m

Frame “Analysis” – construction stage 1 – dialog window “In detail”

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

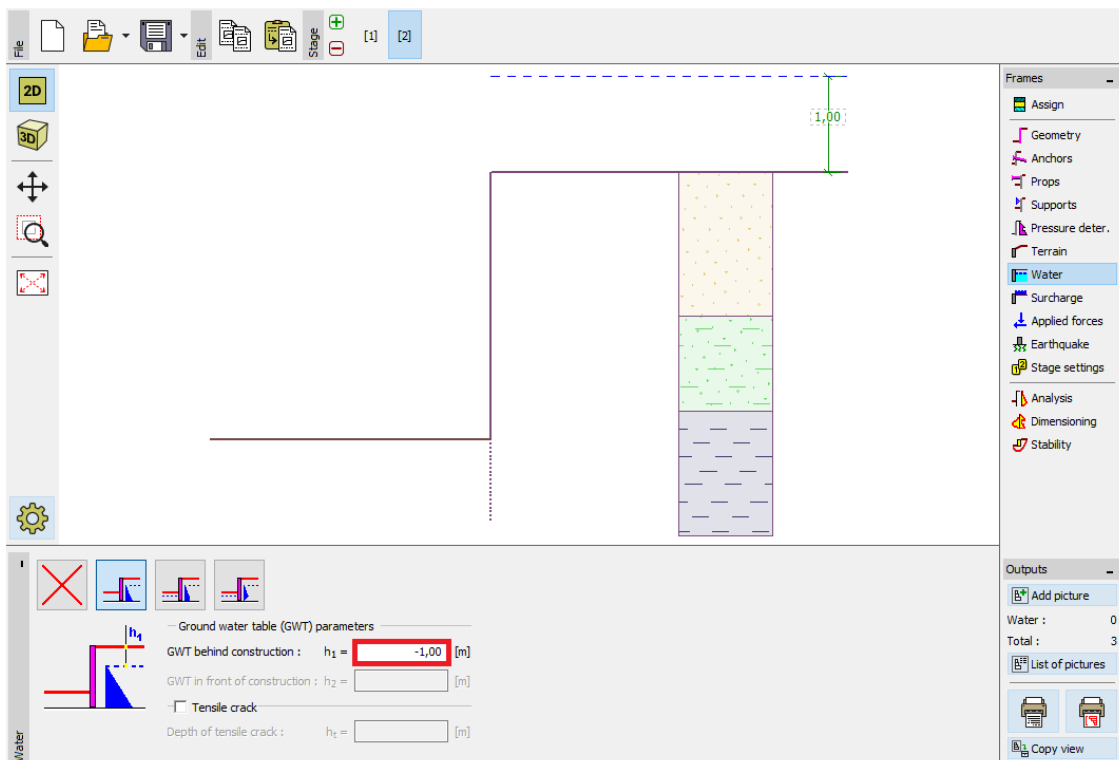
Basic input – Construction stage 2

Now, select stage 2 on the “Construction stage” toolbar in the upper left corner of your screen. (If needed, add a new one)



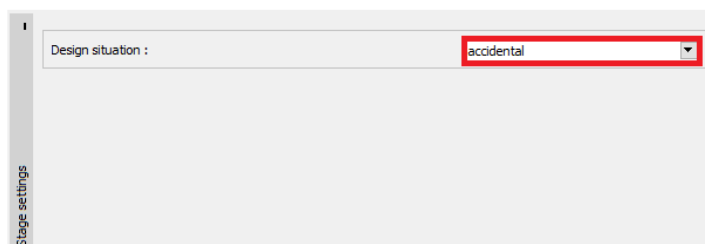
“Construction stage” toolbar

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



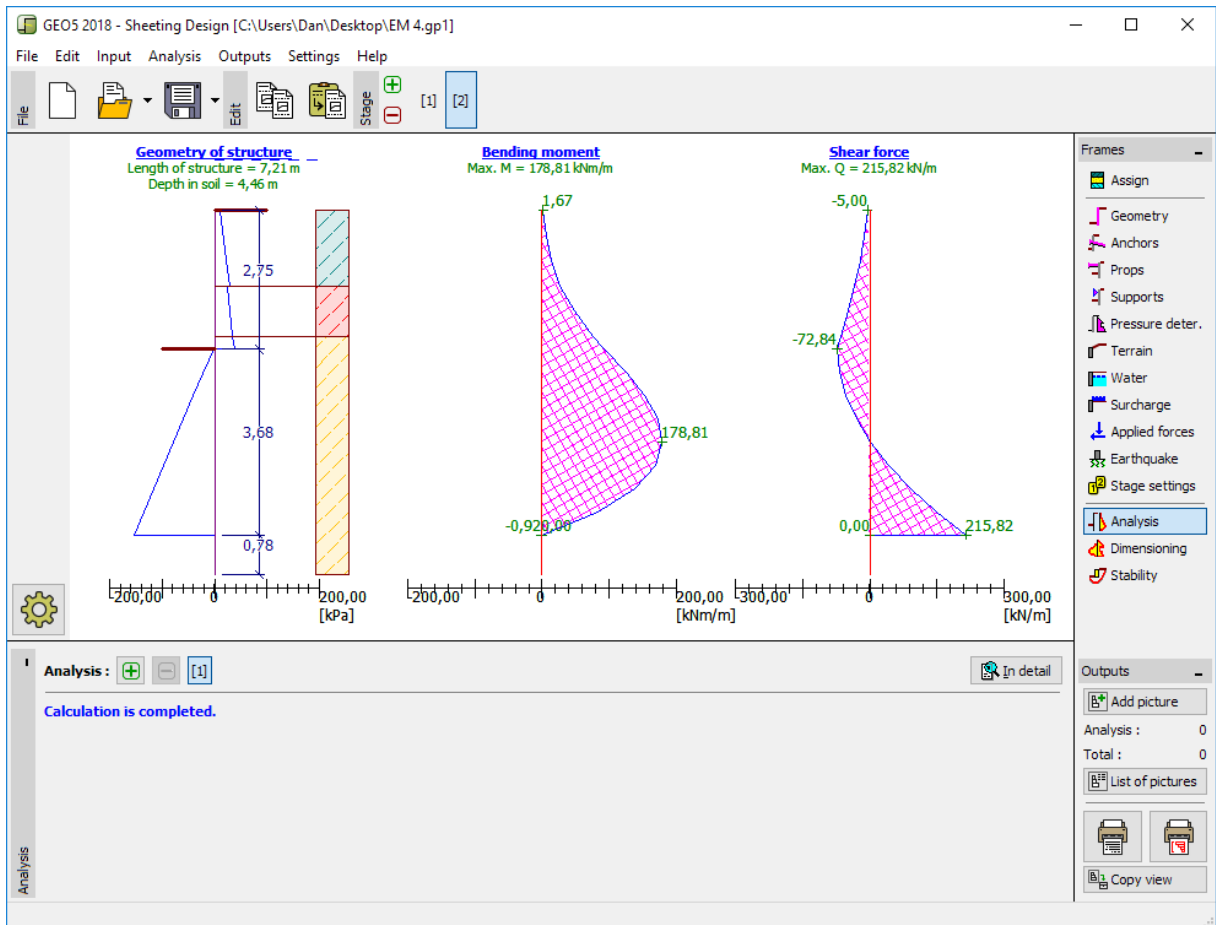
Frame “Water”

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



Frame “Stage settings (2)”

All of the other values are the same as in the 1st construction stage, so we don't have to change the data in any other frames. We, therefore, go straight to the frame "Analysis" and see the detailed results.



Frame "Analysis"

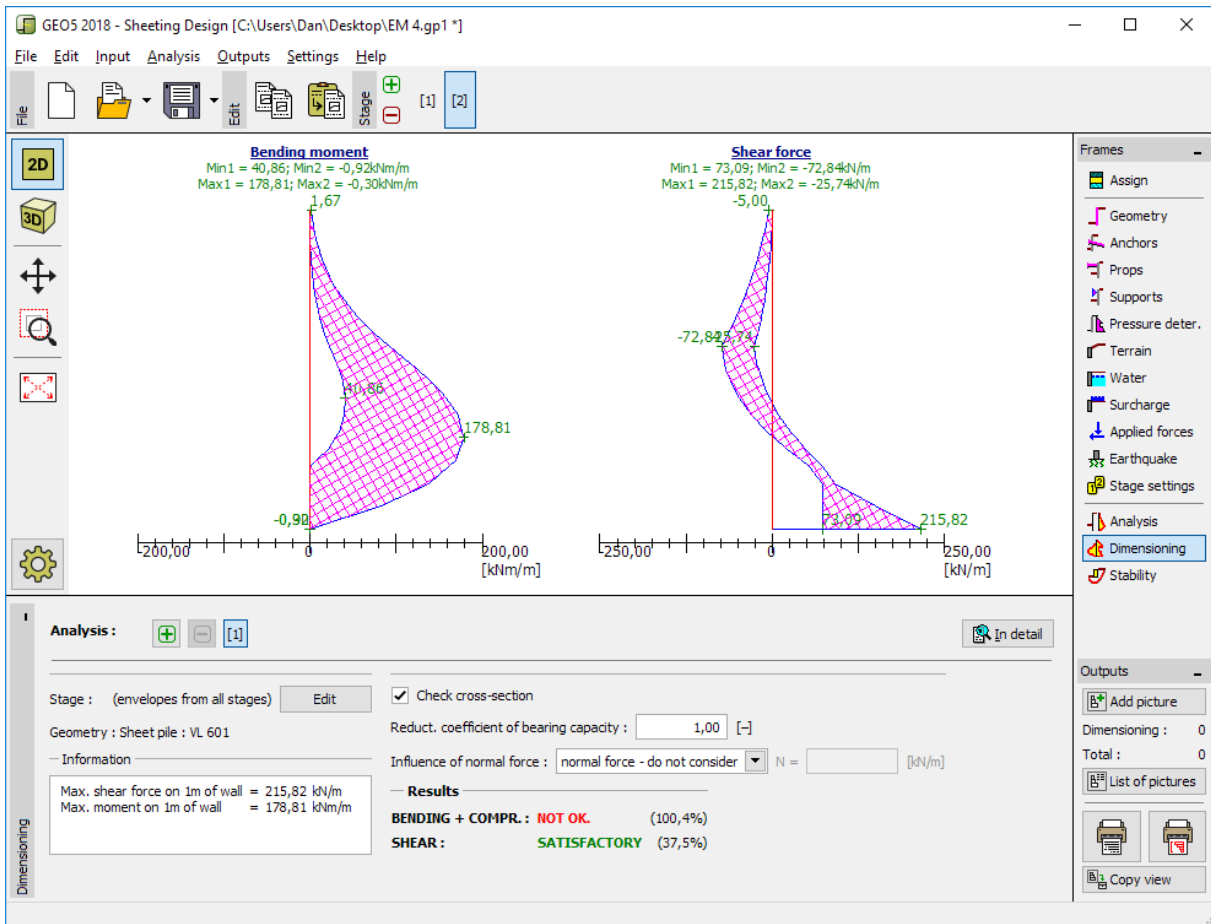
Max. value of shear force	= 215,82 kN/m
Max. value of moment	= 178,81 kNm/m
Required depth of structure in soil	= 4,46 m
Overall length of structure	= 7,21 m

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

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

Verification of the cross-section

Now we move to the frame “Dimensioning”.

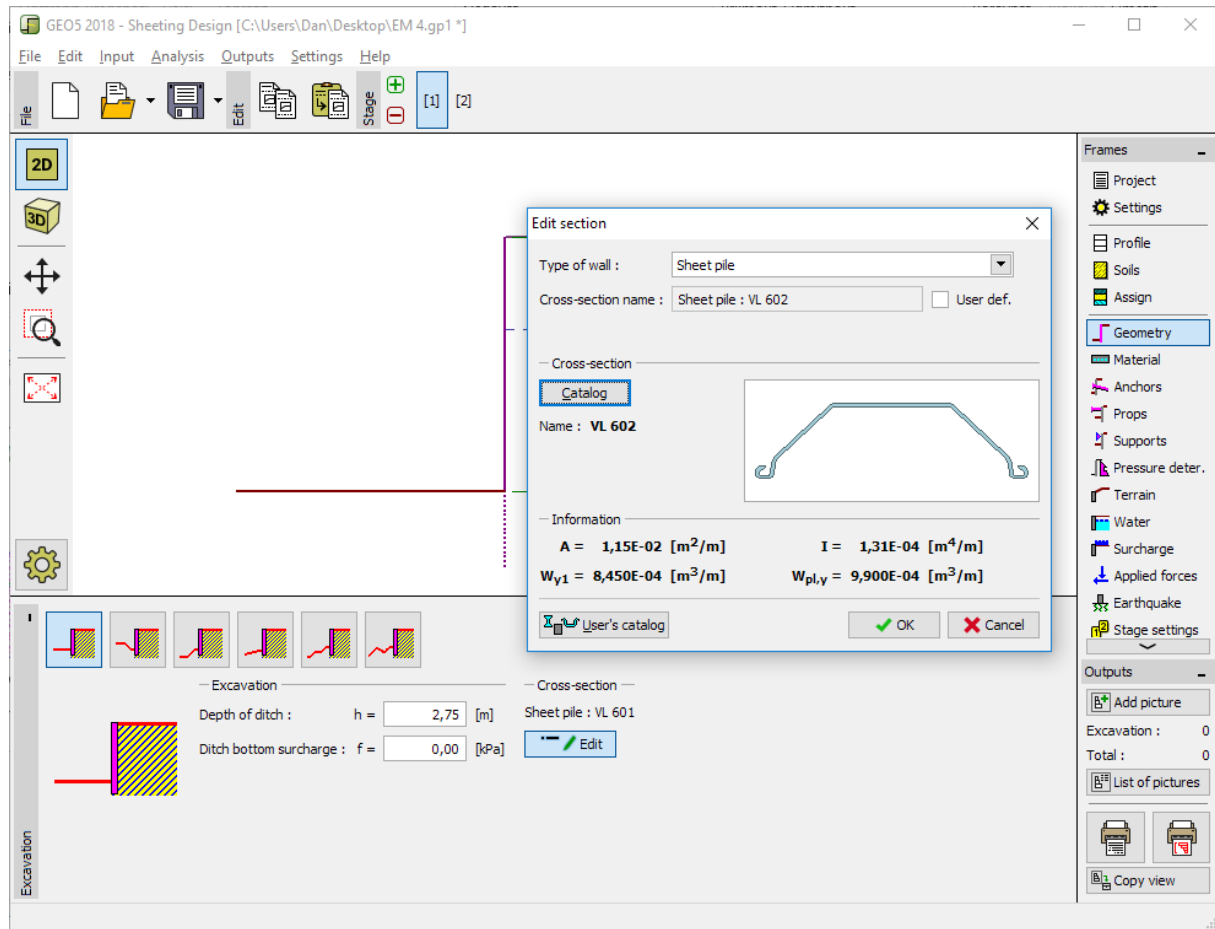


Frame “Dimensioning”

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

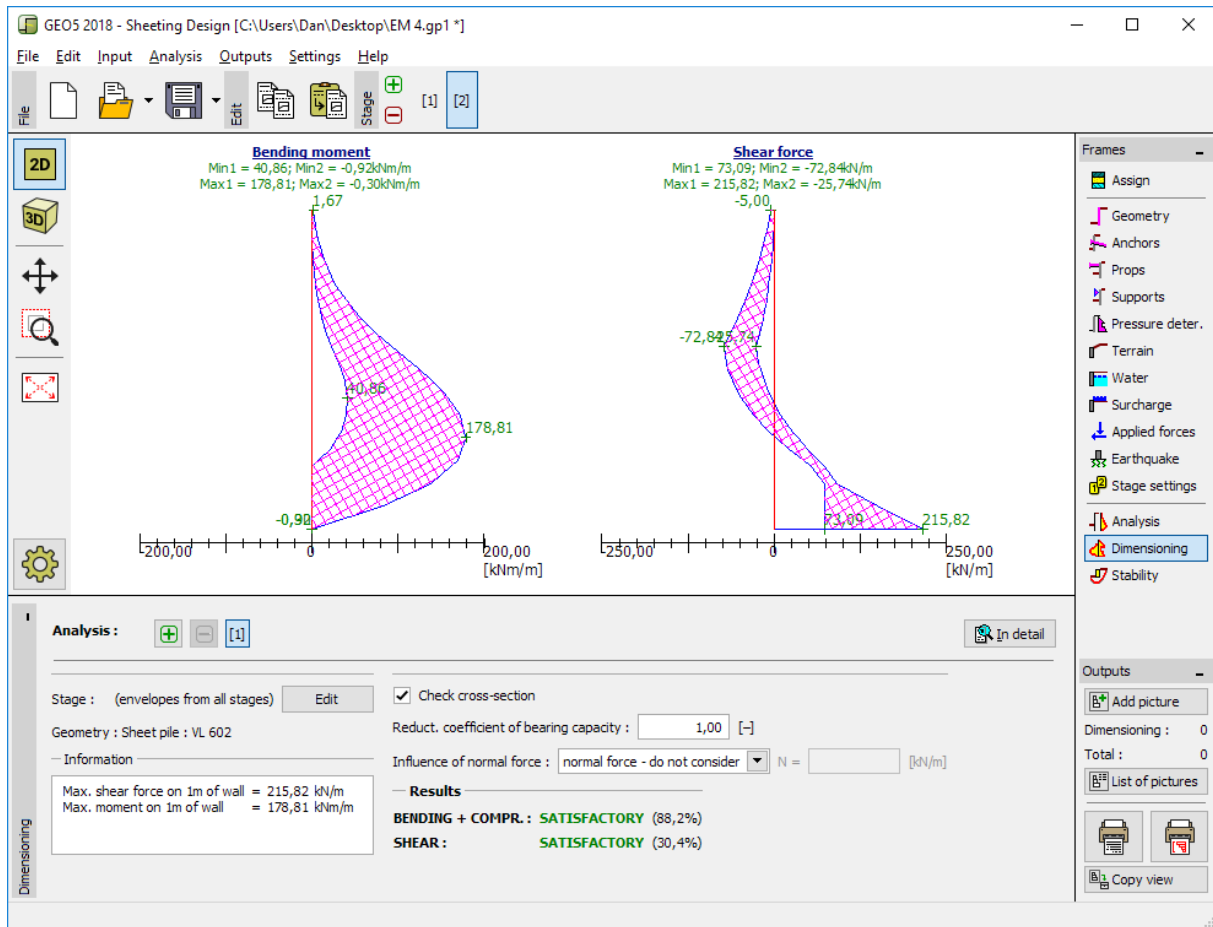
We see, that our cross-section is not OK for “Bending + compression” verification, the utilization is more than 100 %. The detailed results can be displayed using the button “In detail”.

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



Frame “Geometry” – changing the cross-section

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



Frame “Dimensioning” – verification of a new cross-section

Note: Changing the cross-section has no influence on the analysis of internal forces. The stiffness of the structure will only influence the analysis in the “[Sheeting check](#)” program, which can be used when analysing more difficult anchored structures.

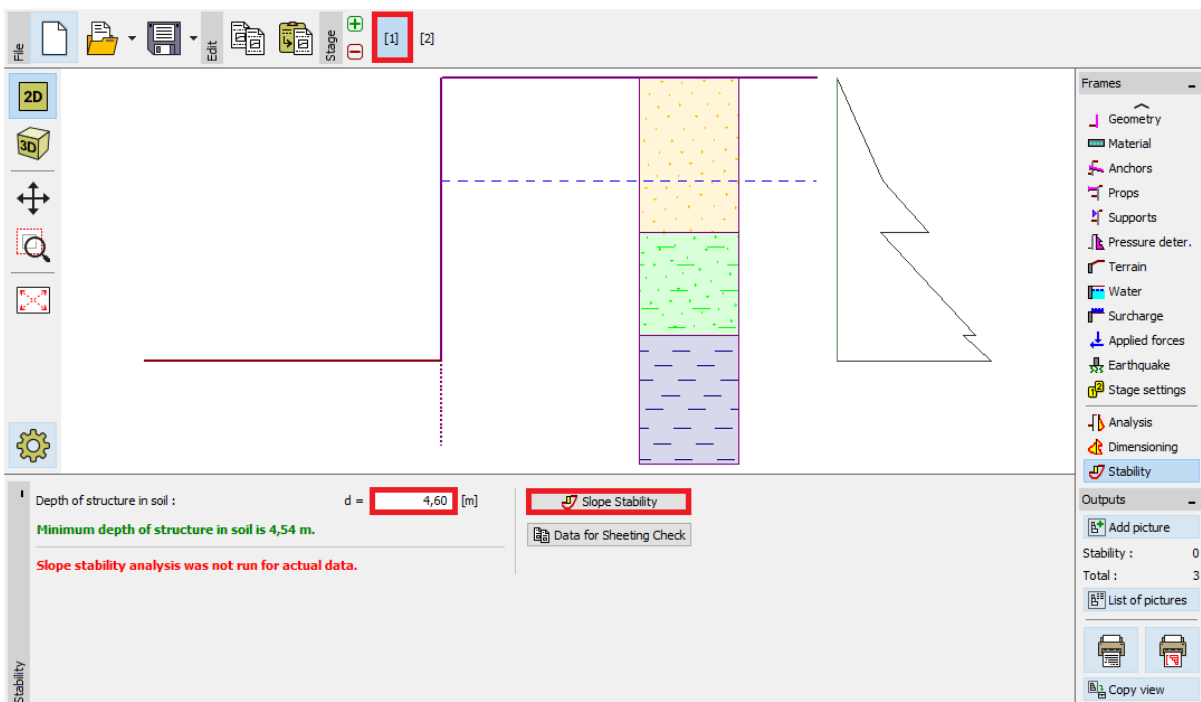
Verification of stability

Now it is necessary to verify that the structure is satisfactory for overall stability. This verification is performed in the frame “Stability”.

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

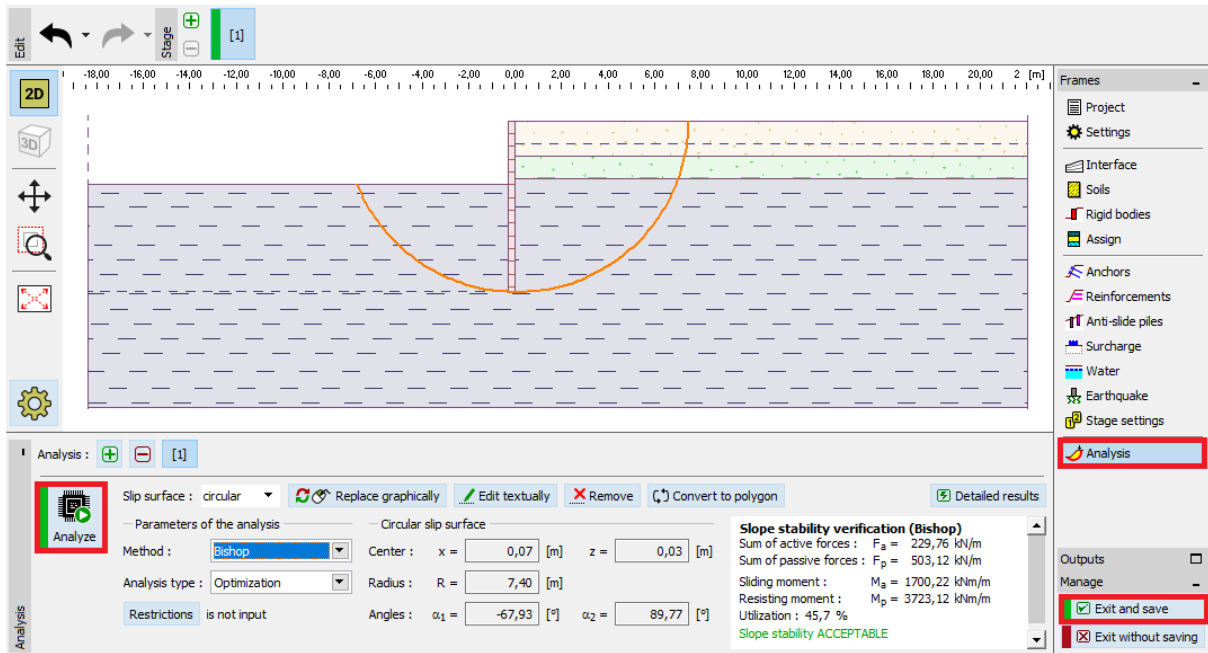
The minimum depth of the structure (based on an analysis in the 2nd construction stage) is 4,46 m. We will therefore design a sheet pile wall 4,6 m deep in the soil.

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



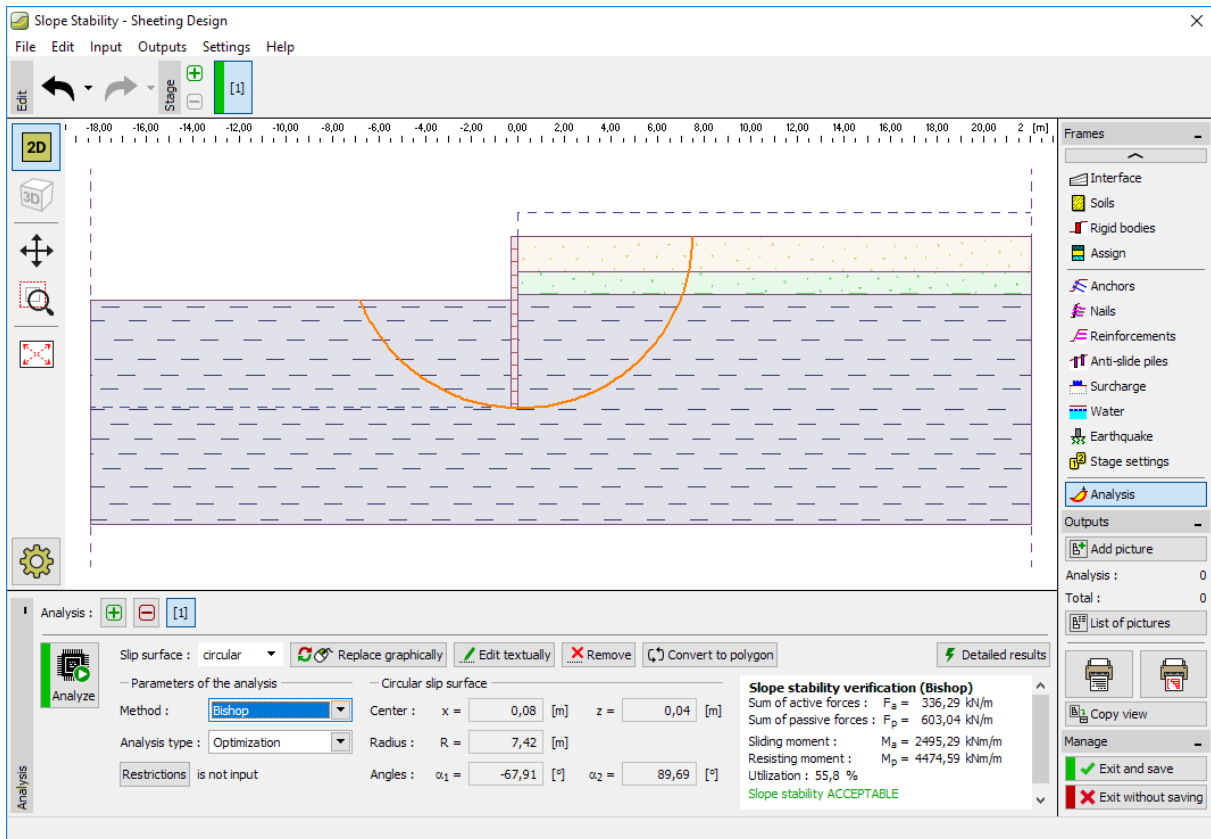
Frame “Stability” – construction stage 1

The program “Slope Stability” is launched by clicking the “Slope Stability” button. All input parameters are transferred to this program automatically.



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

We perform the same analysis for the 2nd construction stage.



Program "Slope Stability" – frame "Analysis" (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 values of the minimum depth of the structure in 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 4.6m deep in the soil with an overall length of 7.35m (4.6m + 2.75m).

This designed 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 overall length 7,35m is satisfactory for all verifications.