Design of an anchored retaining wall
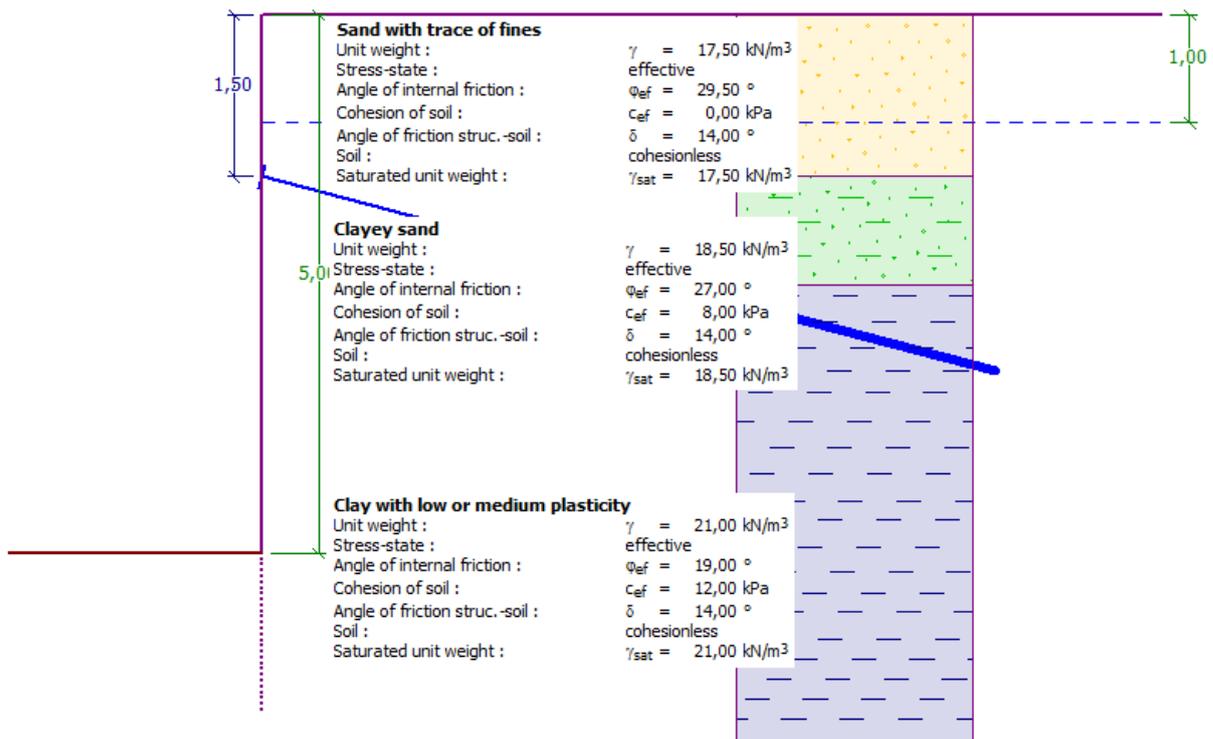
Program: Sheeting design

File: Demo_manual_05.gp1

This engineering manual describes how to design a retaining wall with one row of anchors.

Assignment

Design a retaining wall with one row of anchors made from sheet pile type *VL 602* (steel *S240 GP*) using the EN 1997-1 (EC 7-1, DA3) standard. The depth of the ditch will be 5,0 m. The anchor row is 1,5 m below the surface. The soils, geological profile, ground water table and shape of the terrain are the same as in the previous manual (no. 4). Remove construction stage 2, because we will not consider flooding in this task. Consider redistribution of earth pressures because of anchoring. Furthermore, use an increased active pressure because of the limitation of the deformation of the structure (coefficient of increased active pressure equal to 0,25)

Sand with trace of fines
Unit weight : γ = 17,50 kN/m³
Stress-state :   effective
Angle of internal friction : φ_{ef} = 29,50 °
Cohesion of soil : c_{ef} = 0,00 kPa
Angle of friction struc.-soil : δ = 14,00 °
Soil :   cohesionless
Saturated unit weight : γ_{sat} = 17,50 kN/m³

Clayey sand
Unit weight : γ = 18,50 kN/m³
Stress-state :   effective
Angle of internal friction : φ_{ef} = 27,00 °
Cohesion of soil : c_{ef} = 8,00 kPa
Angle of friction struc.-soil : δ = 14,00 °
Soil :   cohesionless
Saturated unit weight : γ_{sat} = 18,50 kN/m³

Clay with low or medium plasticity
Unit weight : γ = 21,00 kN/m³
Stress-state :   effective
Angle of internal friction : φ_{ef} = 19,00 °
Cohesion of soil : c_{ef} = 12,00 kPa
Angle of friction struc.-soil : δ = 14,00 °
Soil :   cohesionless
Saturated unit weight : γ_{sat} = 21,00 kN/m³

*Scheme of the 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 task:

- Analysis 1: permanent design situation - wall fixed at heel

- Analysis 2: permanent design situation - wall hinged at heel

- Cross-section verification

- Stability verification

- Analysis result (conclusion)

Basic input

Leave the "Settings", "Profile", "Soils" and "Assign" frames from the previous problem unchanged. In the frame "Geometry", input the depth of the ditch as 5,0 m and select the type of the cross-section as sheet pile *VL 602*.
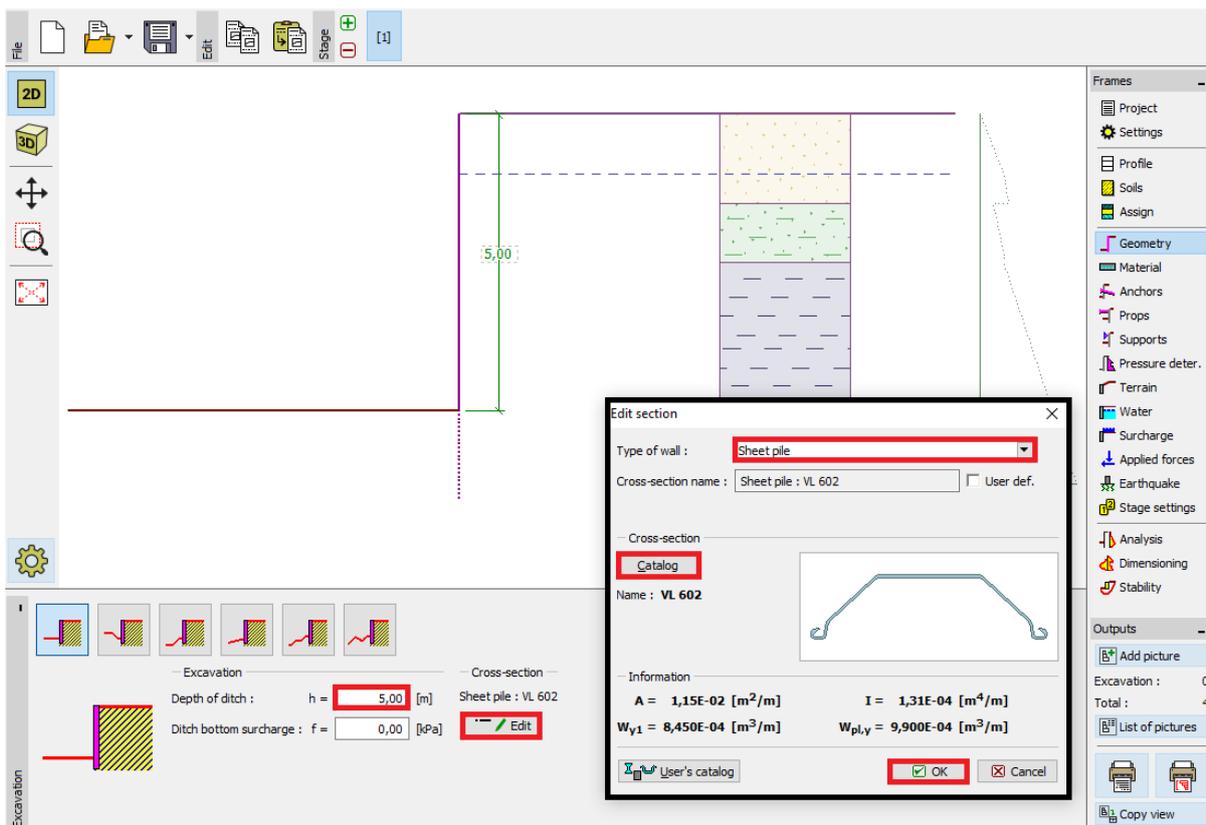
Frame "Geometry" – depth of the ditch and cross-section selection

Open the frame "Anchors" and click on the "Add" button. In this case, add one anchor row in the depth of 1,5 m below the top of the wall with anchor spacing of 2,5 m. Also define the slope of the anchors (15 degrees).
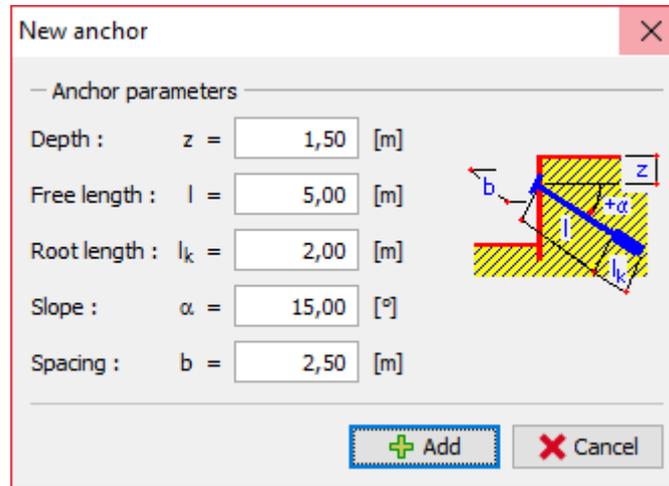
Frame "Anchors" – dialog window "New anchor"

Note: The length of the anchors has no effect on the analysis of internal forces in the "Sheeting Design" program, it is only shown for visualization purposes. It only has an influence on the overall stability in the program "Slope Stability".

Now we'll move to the frame "Pressure determination".

In this frame, we have to define the type of the redistribution of the pressure acting on the structure. Furthermore, it is necessary to determine, if the redistributed pressure only acts to the depth of foundation pit or all the way to the null point.

Note: In the null point, the magnitude of the passive pressure in front of the structure is the same as the magnitude of the earth pressure behind the wall - the total sum of the pressure at this point is zero.
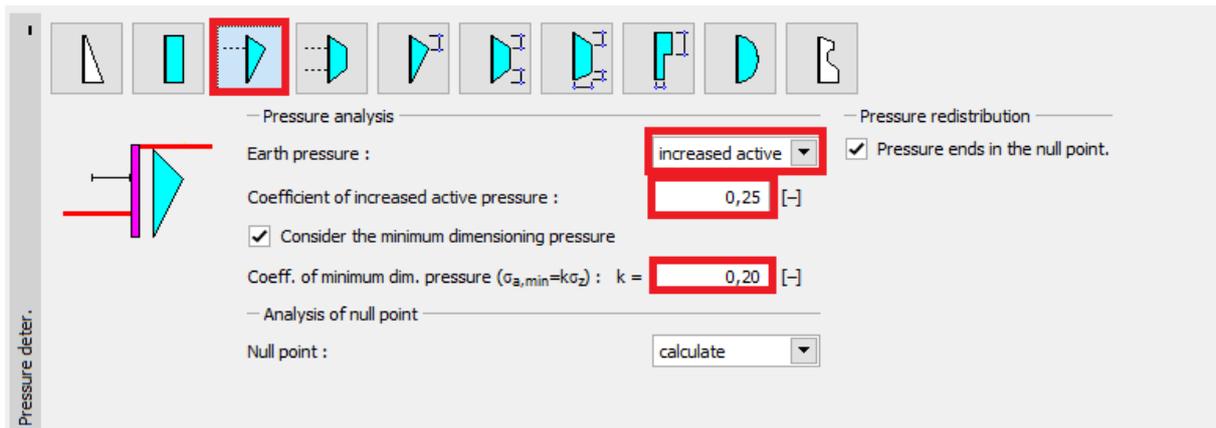
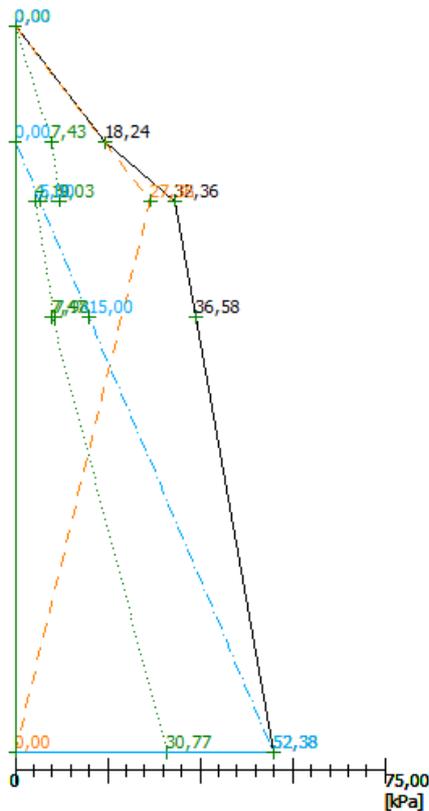*Frame "Pressure determination"*

For the purpose of our example (anchored wall with one row of anchors) it is recommended to use a triangular redistribution with a peak in the location of the anchoring (it's the same for a strutted structure).

Note: Redistribution of earth pressures (due to anchoring) can better describe a real load on a structure. The redistribution is recommended for active and increased active pressure. For pressure at rest, redistribution is inappropriate. Only the basic earth pressure (calculated based on the geological profile not considering the influence of water and surcharge) is redistributed. It is possible to find more information about this in the program help (F1).

Next, we have to select the type of the pressure acting on the structure. We will consider an increased active pressure with coefficient 0,25.

Note: The coefficient of increased active pressure determines the ratio of the pressure at rest and the active pressure. In our task 25% of the increased active pressure consists of pressure at rest and 75% is formed by the active pressure. More information can be found in the program help (F1).

Note: On the right side of the screen we can see the acting pressure. The original pressure is shown in green, the redistributed pressure is orange and the influence of the surcharge and the water is blue. The total pressure is shown in black.

Basic pressure		....
Redistributed pressure		– – – – – –
Other pressure		– · – · – · – · – · –
Total pressure		————————

Frame "Pressure determination" – acting pressures

We skip the frames "Material", "Props", "Supports", "Terrain", "Water", "Surcharge", "Applied forces", "Earthquake" and "Stage settings" and move to the frame "Analysis".

In this frame we will perform analyses for a wall hinged at heel and for a wall fixed at heel.

Analysis No. 1 – wall hinged at heel

In the frame "Analysis" select support at heel. Firstly, select "**Wall hinged at heel**" and perform the analysis.
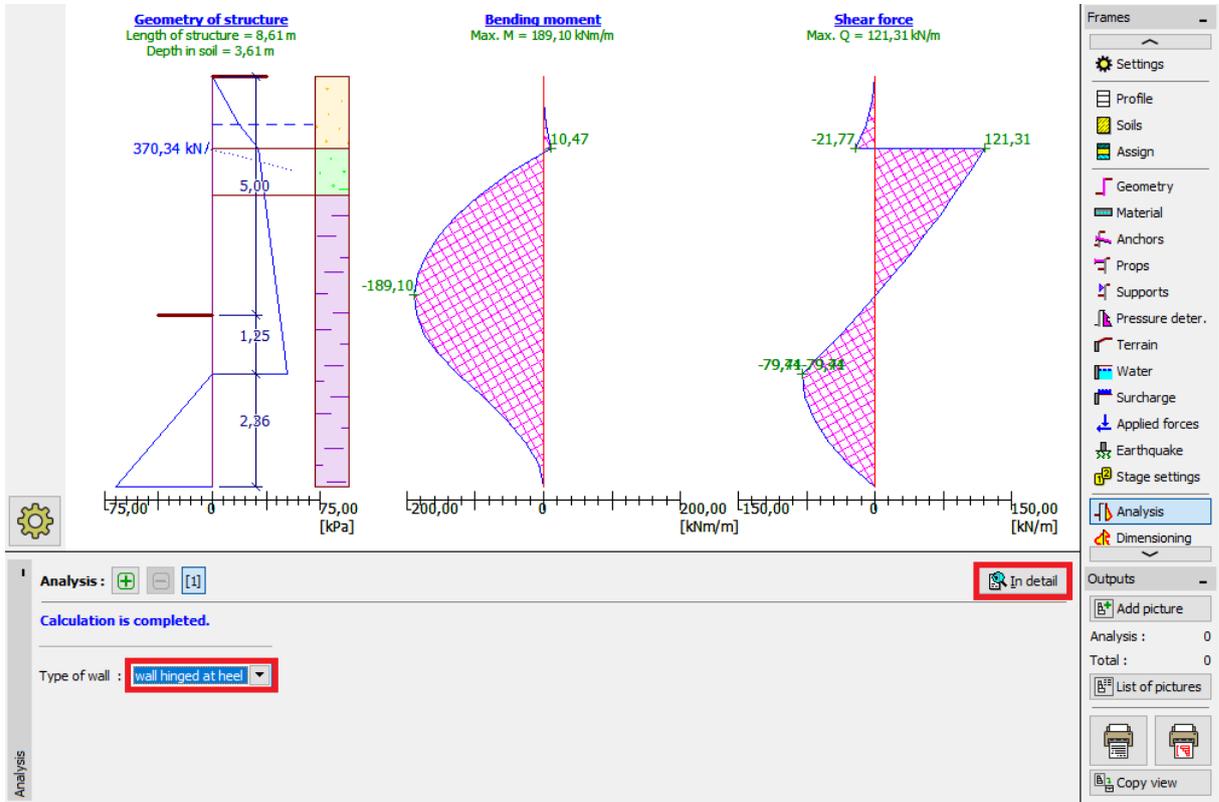
Frame "Analysis" – Construction stage 1 (Wall hinged at heel)

In our case, we need to know the embedment depth of the sheet pile and also the anchor force. For a **wall hinged at heel**, the values are:
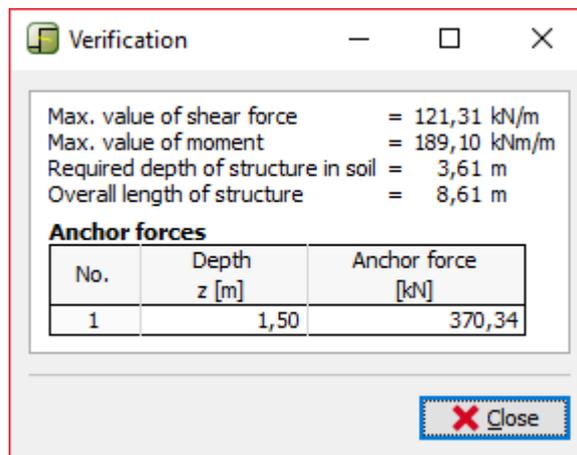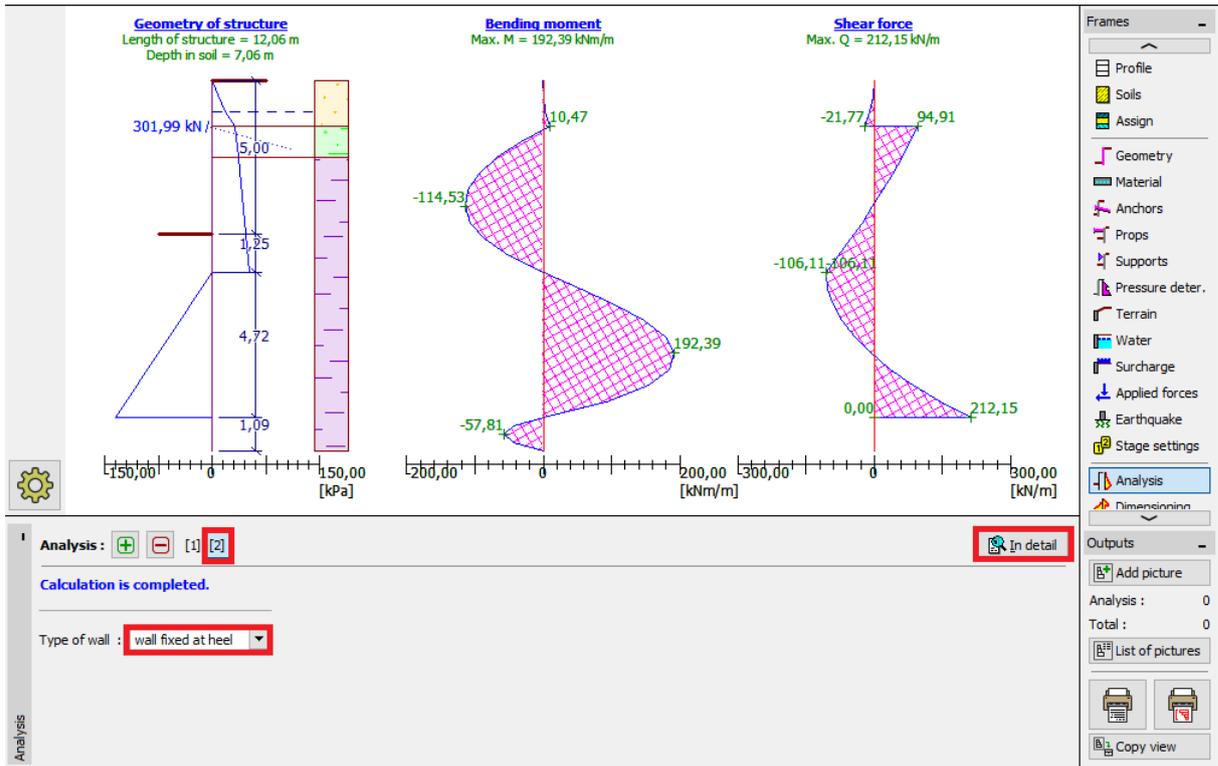

Frame "Analysis (1)" – dialog window "In detail"

Then, we will perform the analysis for a wall fixed at heel (analysis no. 2). We will design the embedment depth based on the comparison of the two results.
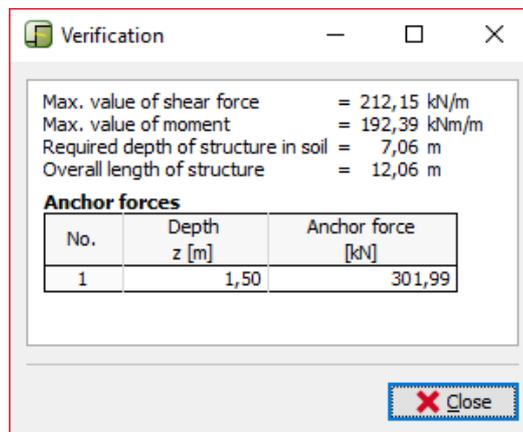
Analysis No. 2 – wall fixed at heel

Now, add a new analysis using the plus symbol in the bottom left corner of the frame.

Select the "**Wall fixed at heel**" option and perform the analysis.

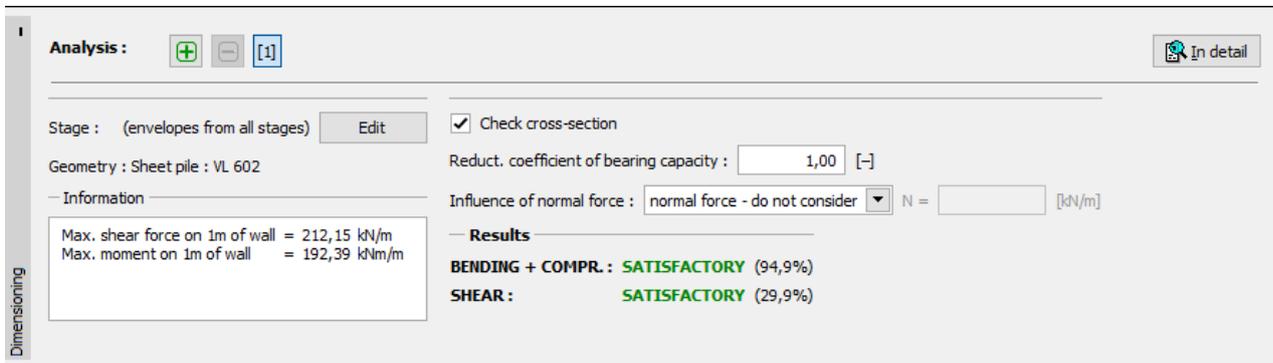*Frame "Analysis" – Construction stage 2 (Wall hinged at heel)*

For a **wall fixed at heel**, the values are:

Frame "Analysis" – dialog window "In detail"

Cross-section verification

The cross-section verification is performed automatically for the maximum values of internal forces from all construction stages and analyses.


Frame „Dimensioning"

We see, that the designed type of sheet pile (VL 602) is satisfactory for all verifications.

If the verification does not produce satisfactory results, it is necessary to change the type of the cross-section in the frame "Geometry".

Stability verification

In the frame "Stability" the program shows the recommended range of lengths of the structure in soil. The overall length of the structure should be in the interval "$H_{fixed} - H_{hinged}$". For a wall fixed at heel, the length of the structure is larger, but the anchor force is smaller. For a wall hinged at heel, it is the opposite, so the anchor force is larger and the length of the construction is smaller.

In our task, the length of the structure in soil should be a value between 3,61m and 7,06m. Because the forces in the anchors do not differ too much (370 kN vs. 300 kN), it is more efficient to design a shorter structure and save more sheet pile material. Therefore, we chose the length of the structure to be 3,7 m. It is always the user's task to design the dimensions of the structure.
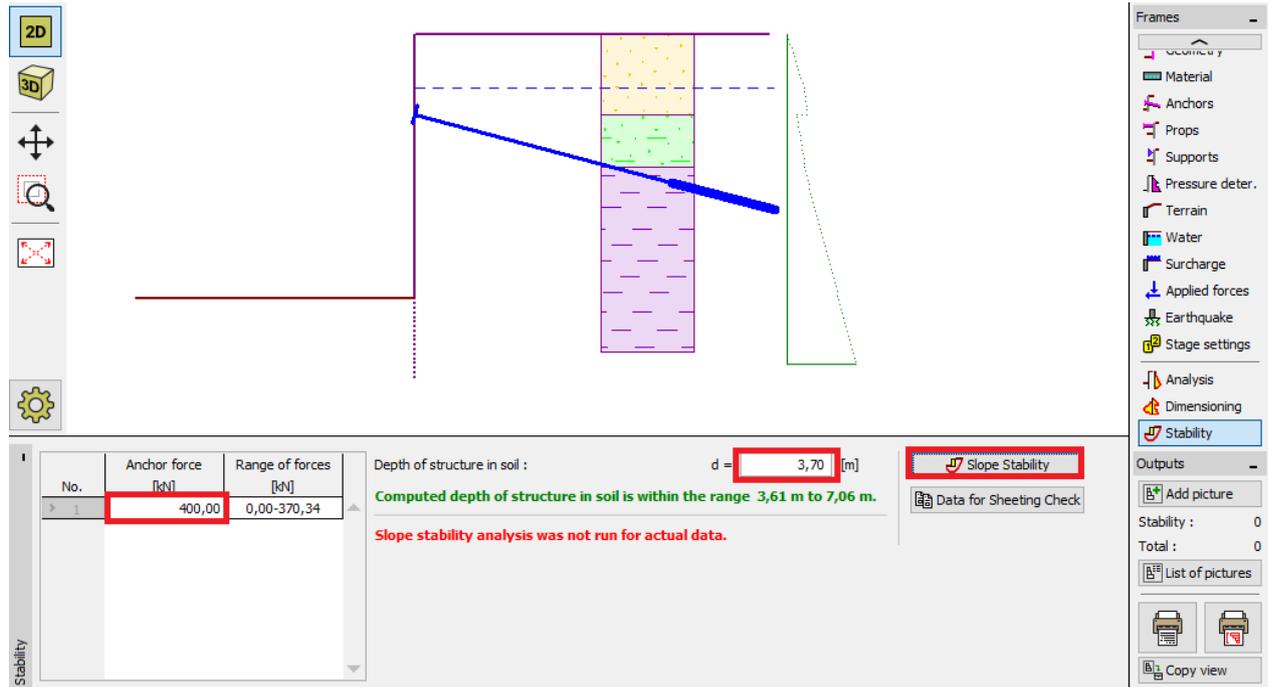
Frame "Stability"

Next, we have to enter the magnitude of the force that we predict in the anchors on the left hand side of the screen. We calculated these forces to be approximately 370 kN, so we presume the anchor force will be at least 400 kN. This force can be transferred along with other data to the program "Slope Stability" by clicking the "Slope stability" button. When the "Slope stability" program launches, go to frame "Analysis", where we perform the stability verification.
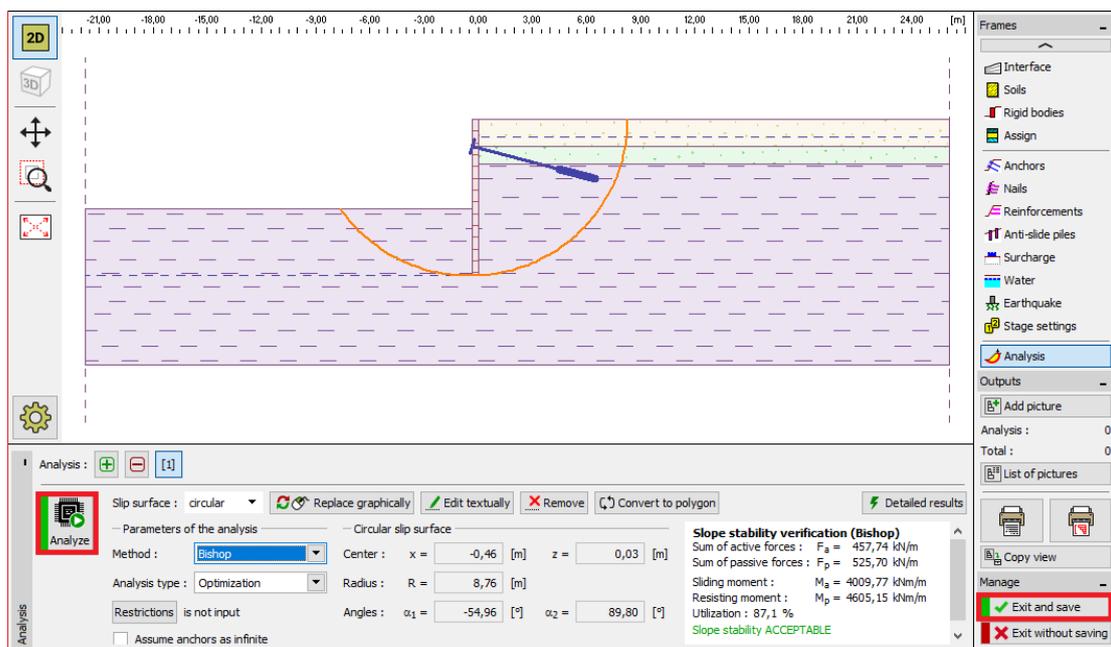

Program "Slope Stability" - analysis

Results of the analysis and conclusion

In our design, we will use sheet pile type *VL 602* from *S 240 GP* steel with an overall length of 8,7m and anchors with a 400 kN force and anchor spacing of 2,5 m. It is further possible to verify this design in the "Sheeting check" program.

If we do not want to model the task again in the program "Sheeting check", it is possible to copy all data from the "Sheeting design" program to the "Sheeting check" program by clicking the "Data for sheeting Check" button.
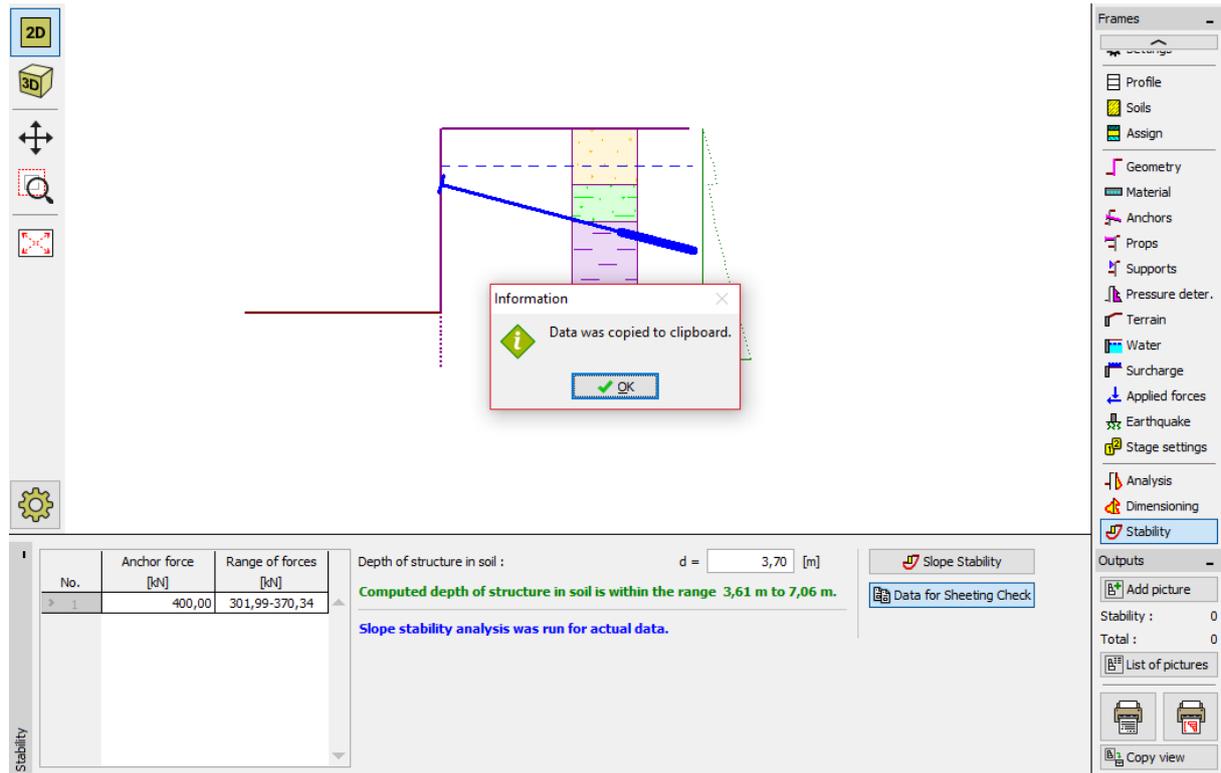
Note: It is good to verify the anchored structure in the "Sheeting Check" program, which provides information about the deformation of the structure, verifies the internal stability and the anchor bearing capacities.