

Verification of a retaining wall with one anchor row

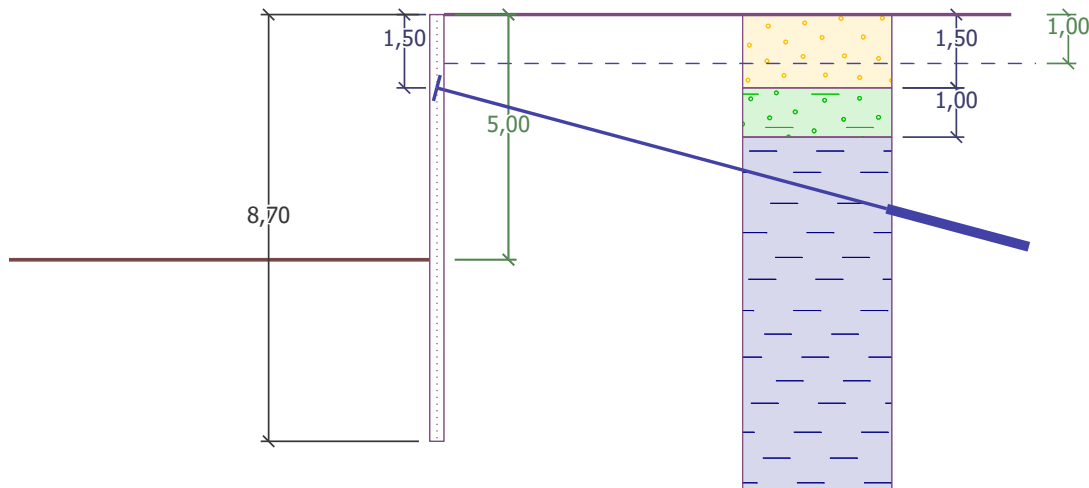
Program: Sheeting check

File: Demo_manual_06.gp2

In this chapter, we will show you how to verify a retaining wall. We will perform a verification of its dimensioning, the inner stability of its anchors and the overall stability of the structure.

Assignment

Verify the retaining wall that you designed in engineering manual no. 5.



Scheme of the anchored wall from pile sheeting – assignment

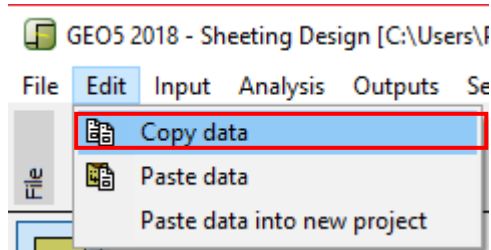
Solution:

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

- Construction stage 1: excavation of a ditch to a depth of 2,5 m, geometry of the wall,
- Construction stage 2: anchoring of the wall,
- Construction stage 3: excavation of a ditch to a depth of 5,0 m,
- Verification of the inner stability of the anchors, the overall stability of the structure and dimensioning of the steel section (sheet pile).

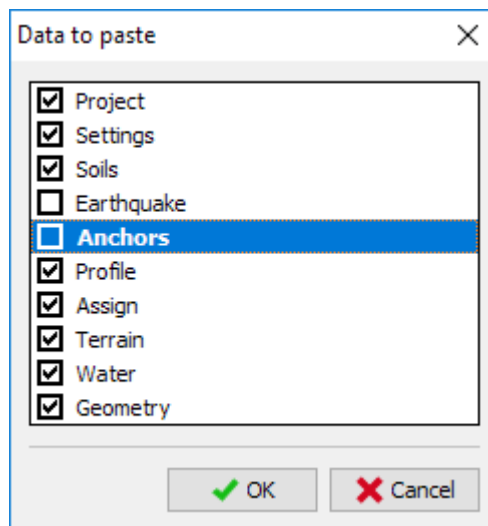
Construction stage 1

To make our work easier, we can copy the data from the previous task, when we designed the retaining wall in the “Sheeting design” program. First, in the “Sheeting design” program click on “Edit” in the upper toolbar and select “Copy data”.



Dialog window “Edit - Copy data”

Now go to the “Sheeting check” program, click on “Edit” in the upper toolbar and select “Paste data”. We will not paste all data, because we will define anchors manually in the 2nd stage. Now that we have most of the important data from the last task copied into this program, we don’t have to input much else.



Dialog window “Data to paste”

In the frame “Settings”, click on “Select settings” and check that the selected setting is no.5 “Standard – EN 1997, DA3”. Then, set the analysis of depending pressures to “Reduce according to analysis settings”. Leave the coefficient for minimum dimensioning pressure at $k = 0,2$ and change the number of FEs to 30.

Analysis of depending pressures : reduce according to analysis ▼

Number of FEs to discretize wall : 30

Pressure analysis

Consider the minimum dimensioning pressure

Coeff. for minimum dim. pressure ($\sigma_{a,min}=k\sigma_2$) : k = 0,20 [-]

Frame “Settings” (Analysis of pressures)

Note: The selection “Analysis of depending pressures – do not reduce” enables the analysis of limit pressures (active and passive) without the reduction of input parameters by partial factors. This results in a better estimate of the real behaviour of the structure. On the other hand, it does not follow the EN 1997-1 Standard (more info can be found in the program HELP – F1).

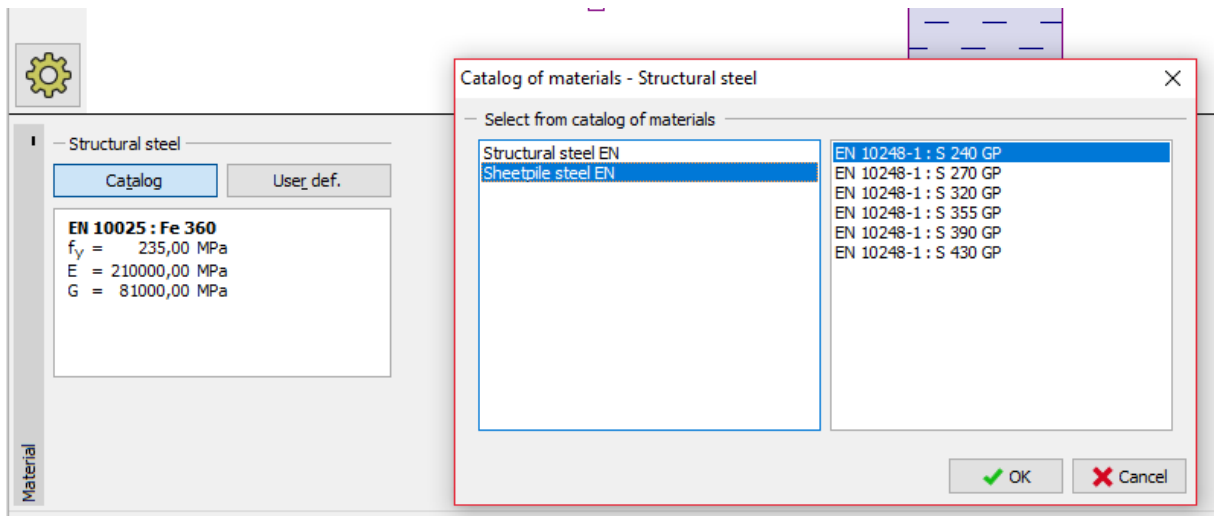
Then, open the frame “Modulus k_h ”, and choose the “analyze – Schmitt” option. This method of determining the modulus of subsoil reaction depends on the oedometric modulus and the stiffness of the structure (more info can be found in HELP – F1).

Modulus of reaction : analyze - Schmitt ▼

Frame “Modulus k_h ”

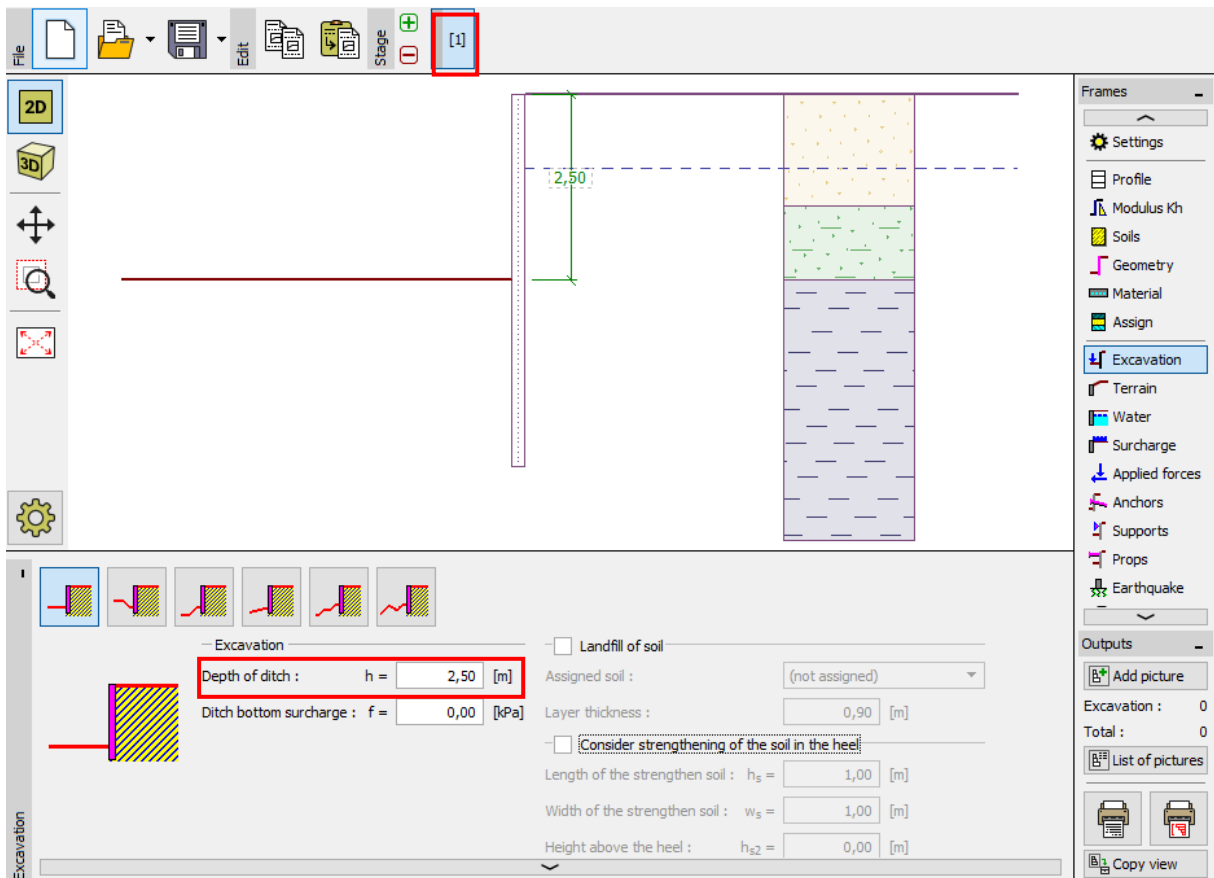
Note: The modulus of subsoil reaction is an important input when analyzing a structure using the method of dependent pressures (elastic-plastic nonlinear model). Modulus k_h affects the deformation, which is needed to reach active or passive pressures (more info can be found in HELP – F1).

In the frame “Material”, select the appropriate class of steel for the structure from the catalog. In this case, select the **EN 10248-1: S 240 GP** type.



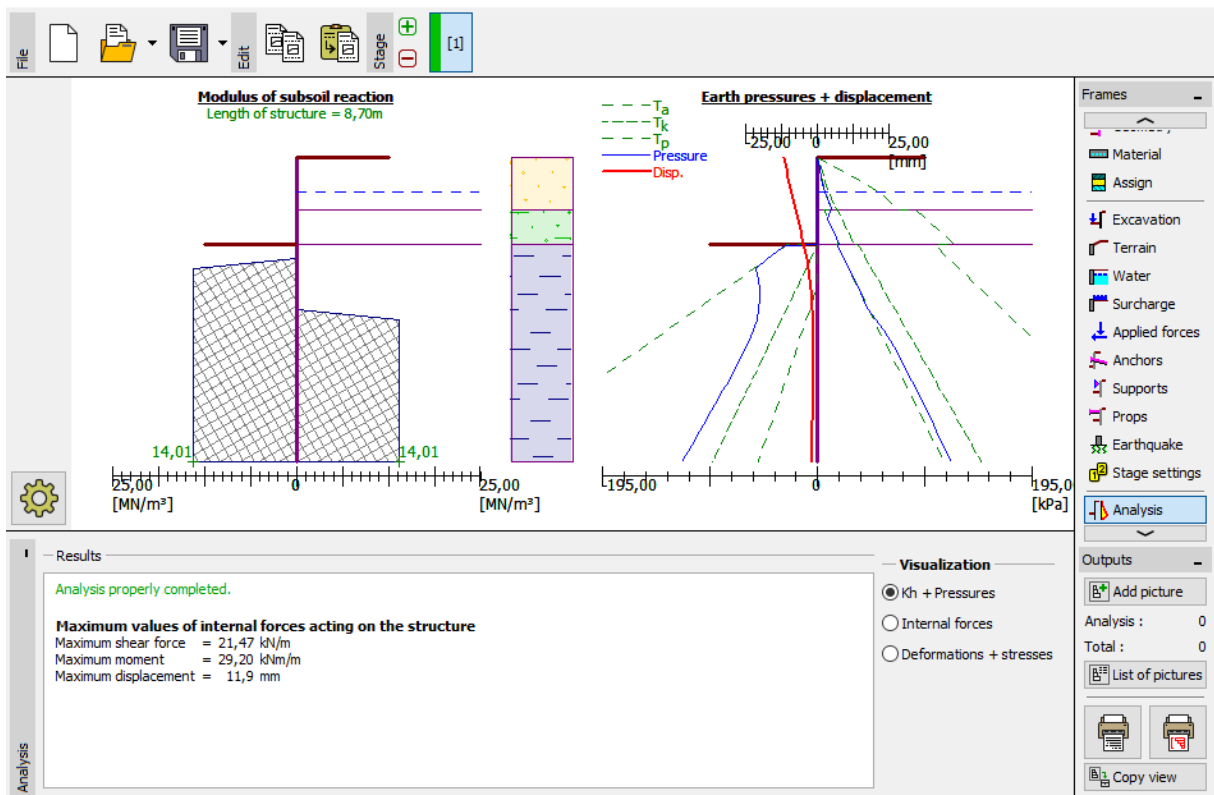
Dialog window “Catalog of materials”

Now, go to the frame “Excavation” and input the depth of the first ditch as 2,50 m in the first construction stage.



Frame “Excavation” – Construction stage 1

Then, go to the frame “Analysis”. In the left part of the frame, you can see the modulus of subsoil reaction; in the right section the shape of the deformed structure, the real and limit earth pressures and the displacement (for more information, see HELP – F1).



Frame “Analysis” – Construction stage 1

Construction stage 2

Add another construction stage with the following attributes. Here we’ll define the anchoring of the wall. We cannot change anything in the frames “Settings”, “Profile”, “Modulus k_h ”, “Soils” and “Geometry”, because this data should stay the same for all construction stages.

In the frame “Anchors” click on the “Add” button. For the sheet pile wall, design one row of anchors in a depth of 1,5 m under the ground level. We will not specify the type of the anchors, because anchor verification is not the aim of our task. Define the parameters of the anchors as follows:

- total length of the anchors: $l_c = 10$ m (free length of an anchor $l = 7$ m, length of the root $l_k = 3$ m)
- slope of the anchors: $\alpha = 15^\circ$
- spacing between the anchors: $b = 2,5$ m

Then input the necessary parameters to calculate the anchor stiffness (diameter $d = 32$ mm and modulus of elasticity $E = 210$ GPa) and the prestress force $F = 240$ kN .

New anchor
✕

Anchor type :

Name :

— Anchor parameters —

Depth : $z =$ [m]

Free length : $l =$ [m]

Root length : $l_k =$ [m]

Slope : $\alpha =$ [°]

Spacing : $b =$ [m]

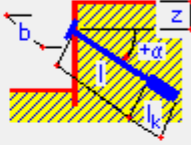
— Stiffness —

Type of input :

Diameter : $d_s =$ [mm]

Elasticity modulus : $E =$ [MPa]

Pre-stressing force : $F =$ [kN]

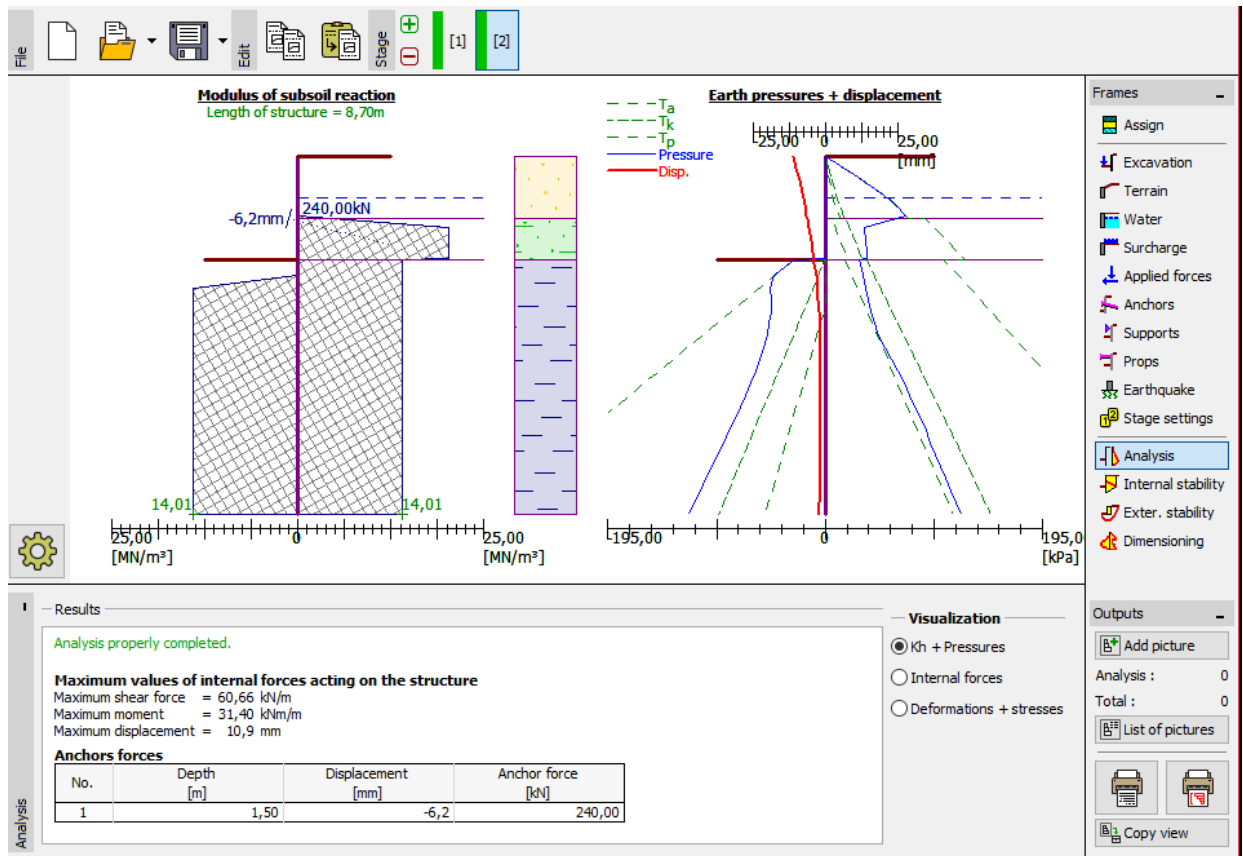


Dialog window "New anchor"

Note: For anchored walls it can be an advantage to introduce the anchor in a separate construction stage and then have the excavation modelled in the following stage. The reason for that is the iteration of the modulus of subsoil reaction – when modelling both the anchors and the excavation in one stage, the calculation may become unstable and not find any solutions.

Note: The stiffness of the anchors is considered in the next stages of construction. The forces in the anchors are changing due to the deformation of the structure (more info can be found in HELP – F1).

The other input parameters don't change. Now, perform the analysis.



Frame "Analysis" – Construction stage 2

In the previous figure it is shown that the added anchor caused the structure to be pushed into the soil more. The soil pressure near the anchor has risen up to the size of the passive pressure or the redistribution increased the earth pressures acting on the structure.

Construction stage 3

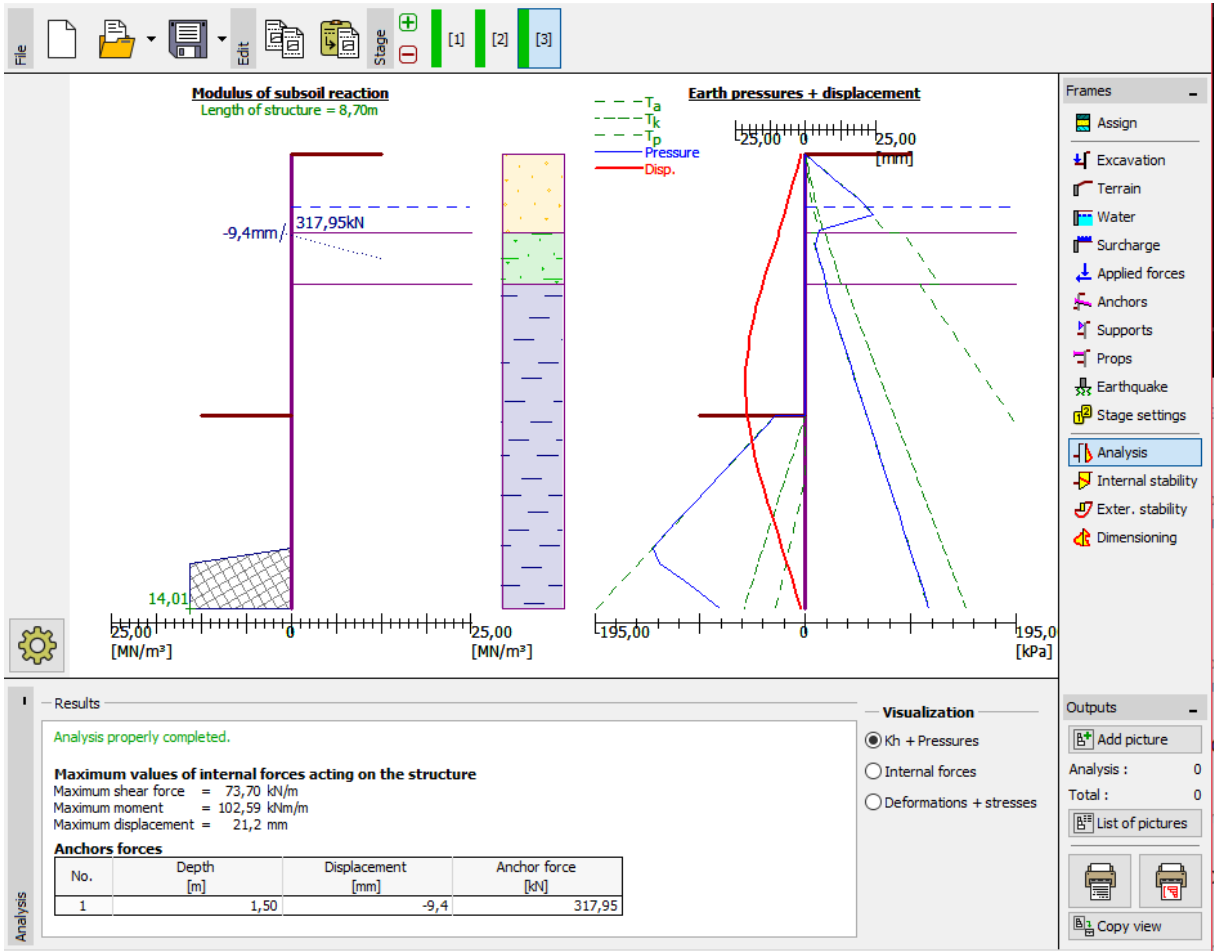
Now we'll add another construction stage, where we'll define the overall excavation of the ditch. In the frame "Excavation", change the depth of the ditch to the last depth (5,0 m).

The screenshot shows the GEO5 software interface for configuring a construction stage. The main window displays a 2D cross-section of a ditch with a depth of 5.00 m. The software interface includes a top toolbar with file and stage management icons, a left sidebar with 2D/3D view toggles and navigation tools, and a right sidebar with a 'Frames' list and an 'Outputs' section. The bottom panel is the 'Excavation' configuration window, which includes a small diagram of the ditch and various input fields for soil properties and dimensions.

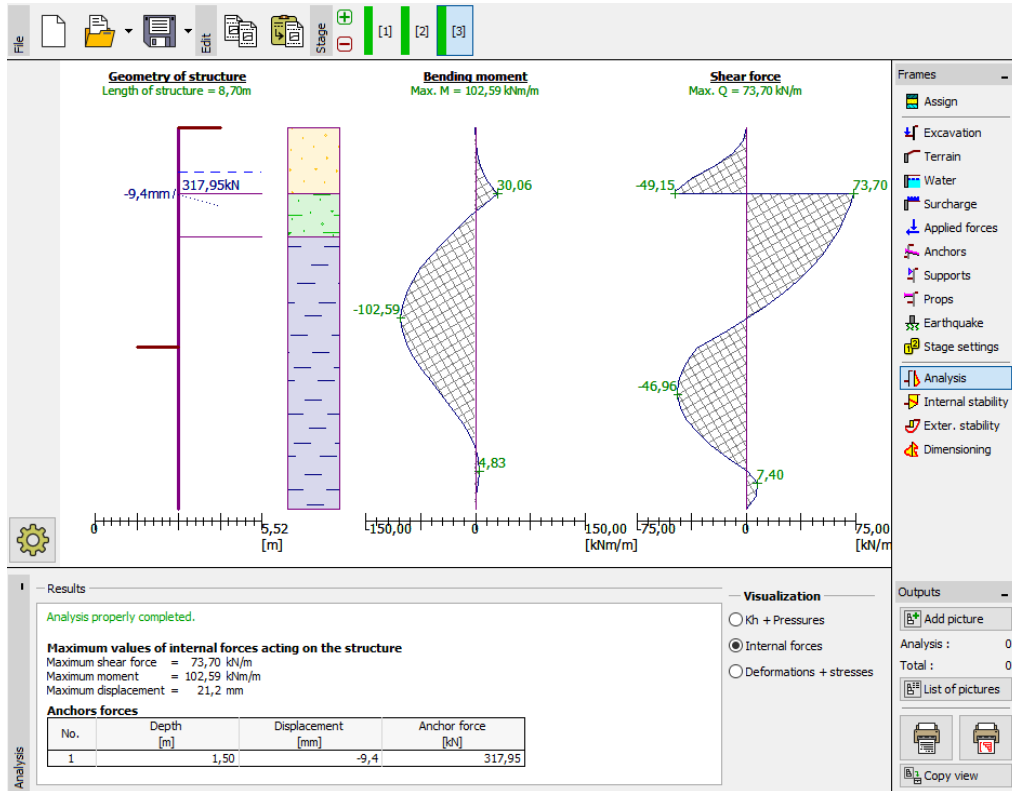
Parameter	Value	Unit
Depth of ditch	5,00	[m]
Ditch bottom surcharge	0,00	[kPa]
Assigned soil	(not assigned)	
Layer thickness	0,90	[m]
Length of the strengthen soil	1,00	[m]
Width of the strengthen soil	1,00	[m]
Height above the heel	0,00	[m]
Angle of internal friction	30,00	[°]
Cohesion of soil	0,00	[kPa]

Frame "Excavation" – Construction stage 3

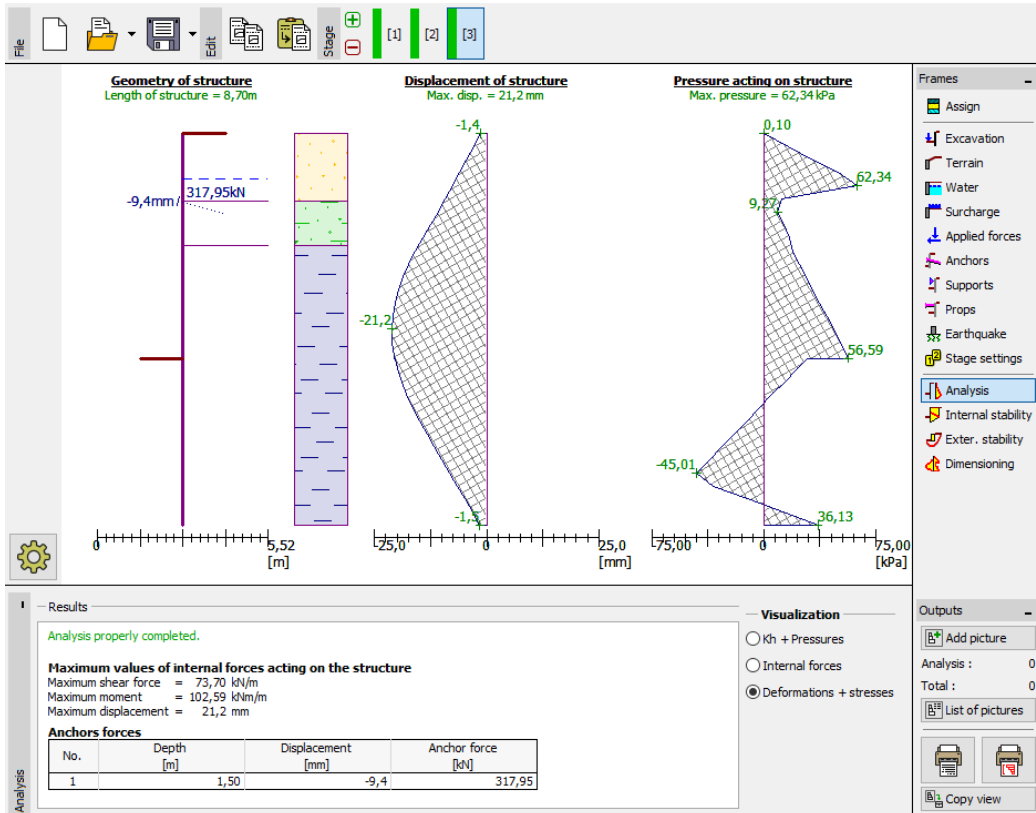
Now, perform the analysis to display the distribution of the internal forces and the displacement of the anchored structure.



Frame "Analysis" – Construction stage 3



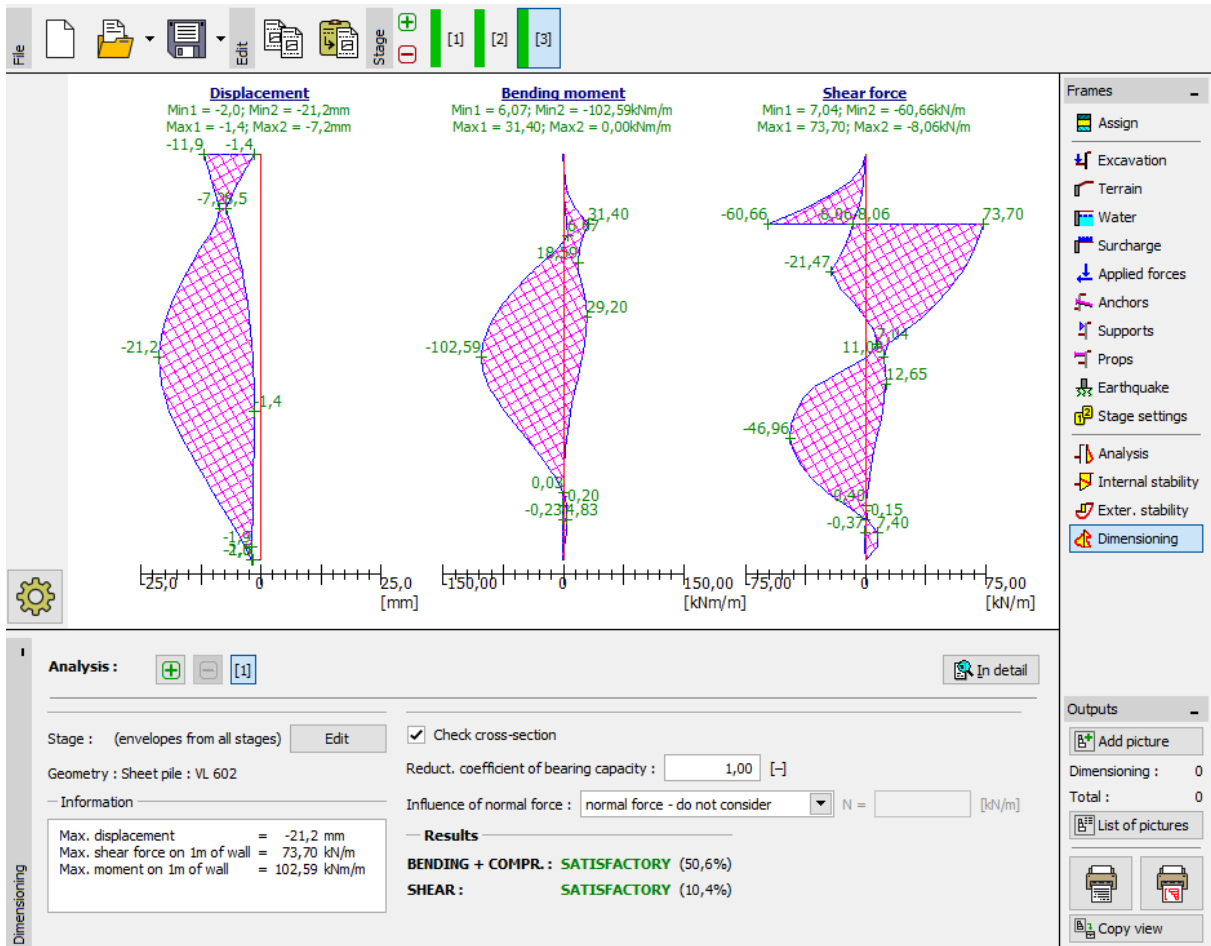
Frame "Analysis" – Construction stage 3 (Internal forces)



Frame "Analysis" – Construction stage 3 (Displacement and earth pressure on the structure)

Verification of the material and the cross section of the sheet pile:

Then, open up the frame “Dimensioning”. The maximum observed moment on the structure is 102,59 kNm/m. The overall utilization of the sheet pile of type **VL 602** from EN 10248-1: S 240 GP steel is **50,6 %**. The maximum displacement of the structure (21,2 mm) is also satisfactory.



Frame “Analysis” – Construction stage 3 (Total utilization of sheet pile of type VL 602)

Verification of the anchor stability

To verify the stability of the anchors, go to the frame “Internal stability”. You can see, that the internal stability of the anchors is not satisfactory (the total utilization is **190,3 %**). This means, that the anchor could tear away from the soil.

No.	Anchor force [kN]	Max. allow. force [kN]	Utiliz. [%]	Verification
1	317,95	167,06	190,3	Is not satisf

Results

Verification of decisive row of anchors : [In detail](#)

Anchor No. : 1

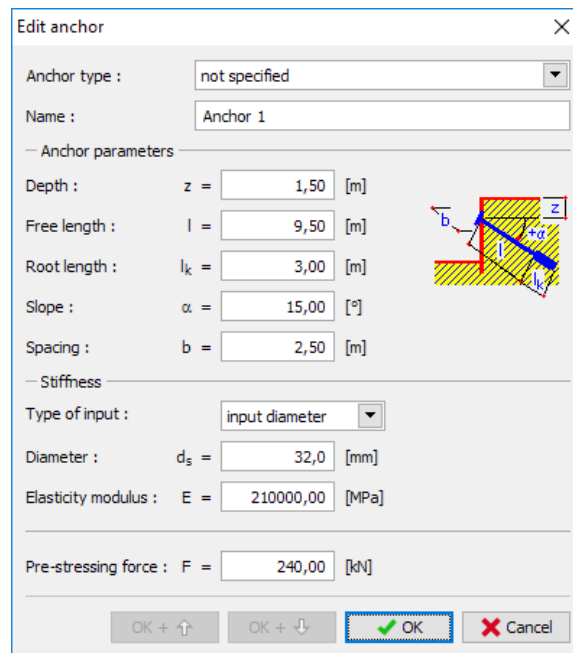
Specified anchor force = 317,95 kN

Computed max. allowable anchor force = 167,06 kN

NOT OK.

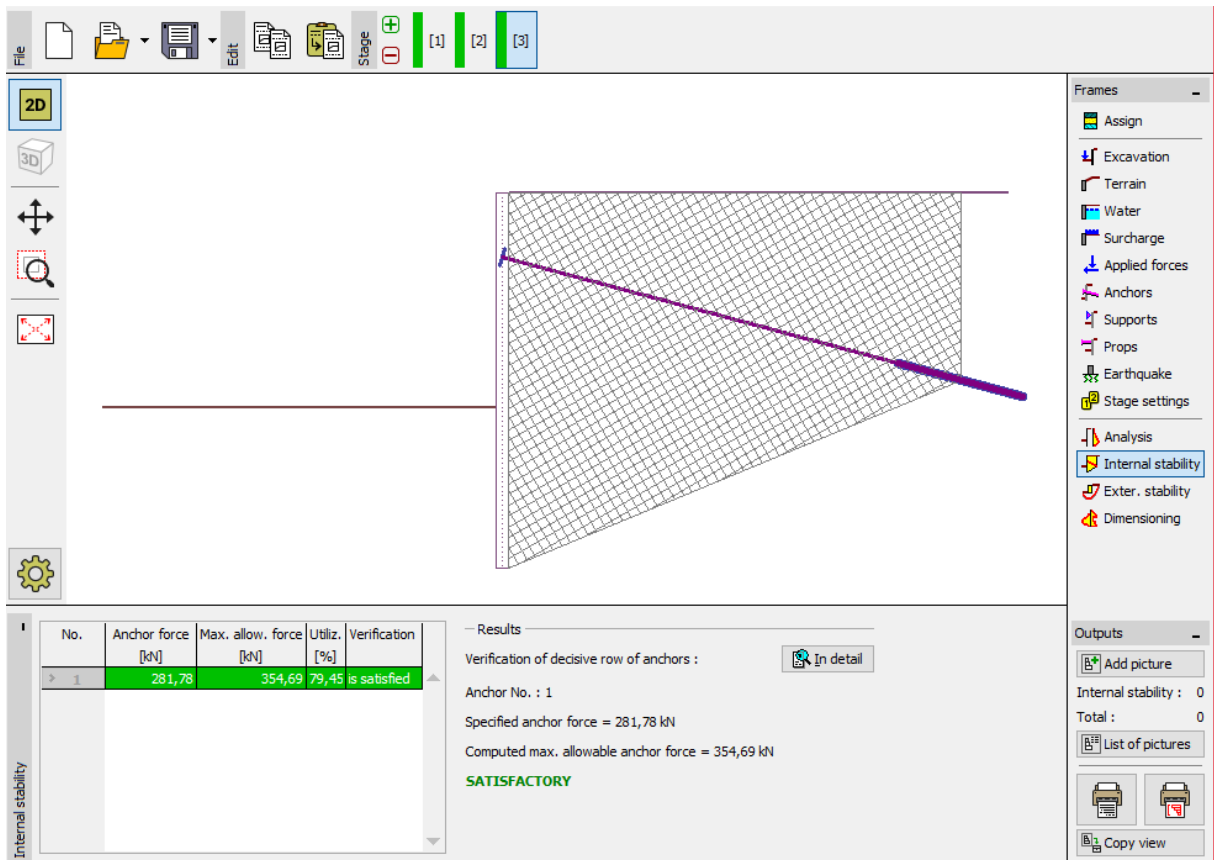
Frame “Internal stability” – Construction stage 3 (non-satisfactory result)

The reason for this is that the anchor is too short, so in the frame “Anchors” (in Construction stage 2), click on “Edit no.1” and change its free length to 9,5 meters. The total length of the anchor is now 12,5 m.



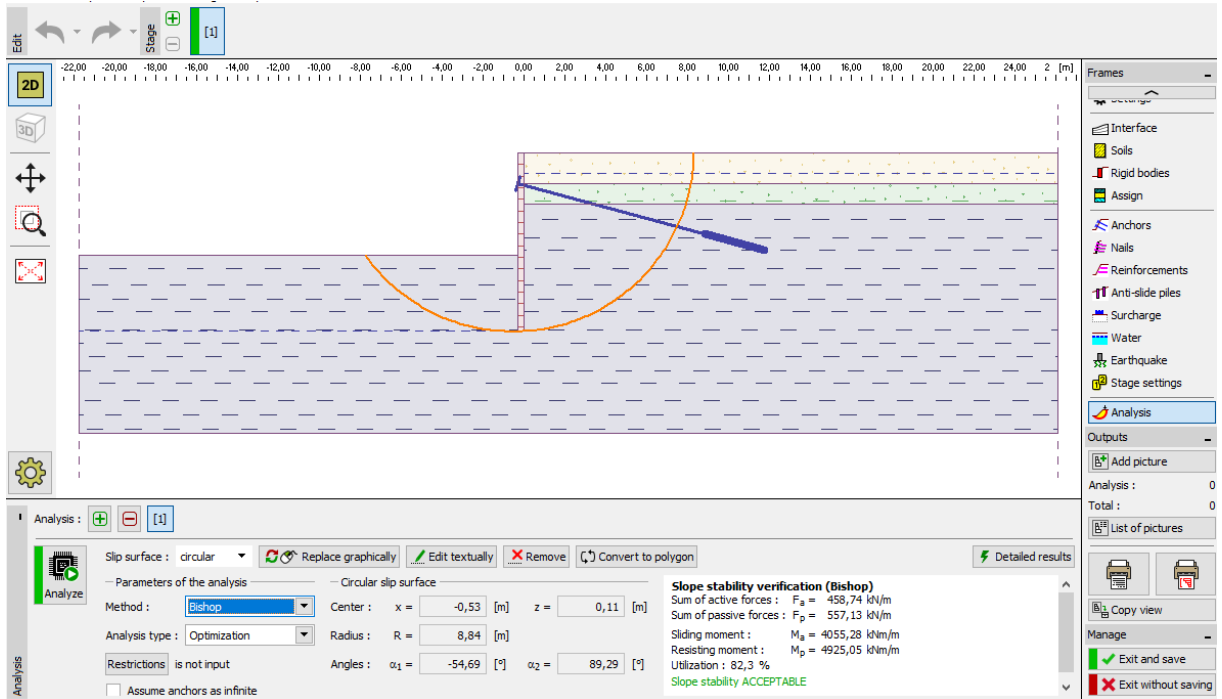
Dialog window “Edit anchor” – Construction stage 2

Then switch back to the 3rd stage of the construction, perform the analysis and then return to the frame “Internal stability”. The following figure shows that the newly designed anchor satisfies the internal stability requirements (the total utilization is **79,45 %**).



Frame “Internal stability” – Construction stage 3 (satisfactory result)

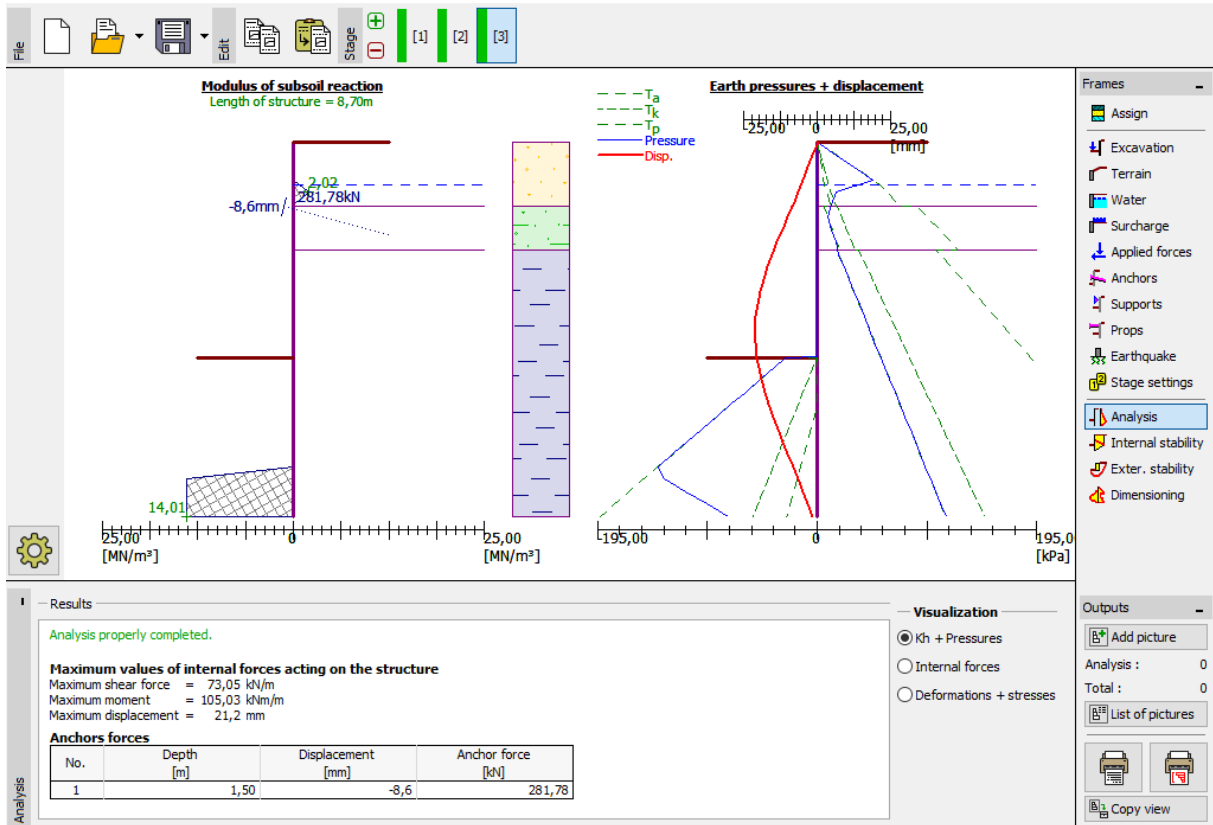
The last thing we need to check is the overall stability of the structure. Click on the “External stability” button. This will open the “Slope stability” program. In the frame “Analysis” click on the button “Analyze”. We can see, that the overall stability is acceptable. Exit the “Slope stability” program by clicking on “Exit and save”.



Frame "External stability"

Analysis results

When adjusting the length of the anchor to $l_c = 12,5$ m there is a small change in the calculation of the internal forces, deformations and earth pressures. Based on the resulting values, the results in the construction stage are as follows:



Frame "Analysis" – Construction stage 3 (after change of anchor length)

The designed sheet pile wall structure is satisfactory for all parameters:

- Utilization of the steel section: **51,8 %** OK
- Internal stability: **79,45 %** OK
- Overall stability: **82,3 %** Method – Bishop (optimization) OK