

## Verification of a retaining wall with one anchor row

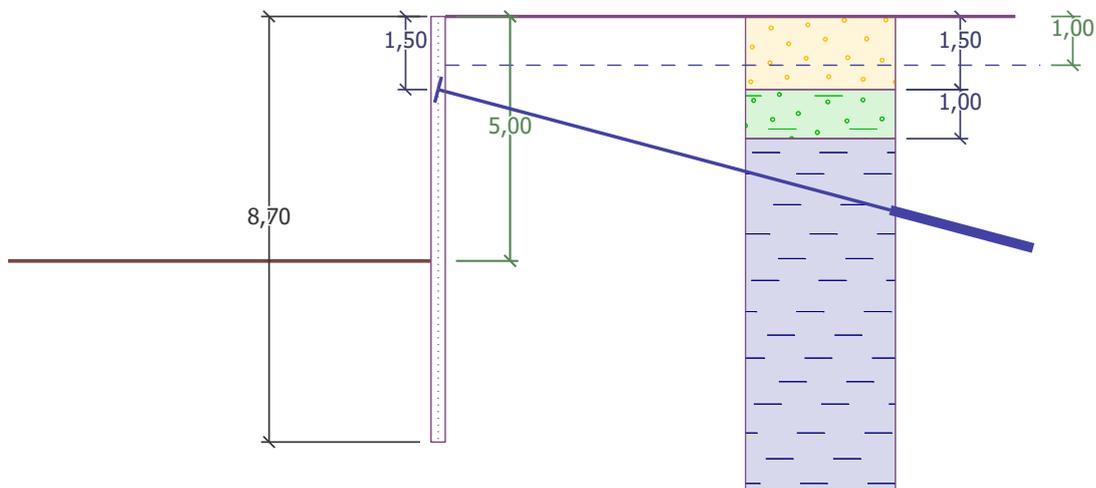
Program: Sheeting check

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*

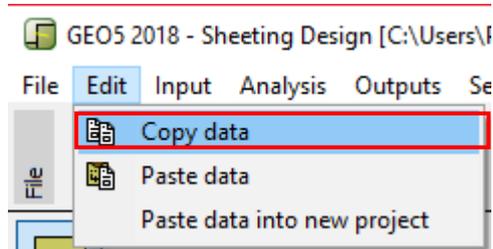
### Solution:

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).

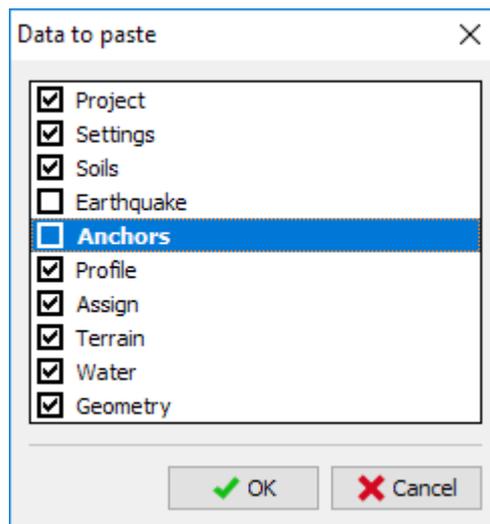
## Construction stage 1

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”.



*“Edit - Copy data” Dialog window*

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 the anchors manually in the 2<sup>nd</sup> stage. Now that we have most of the important data from the last task copied into this program, we don’t have to input anything else.



*“Data to paste” Dialog window*

In the “Settings” frame, 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 :

Pressure analysis

Consider the minimum dimensioning pressure

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

“Settings” (Analysis of pressures) Frame

*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 behavior 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).*

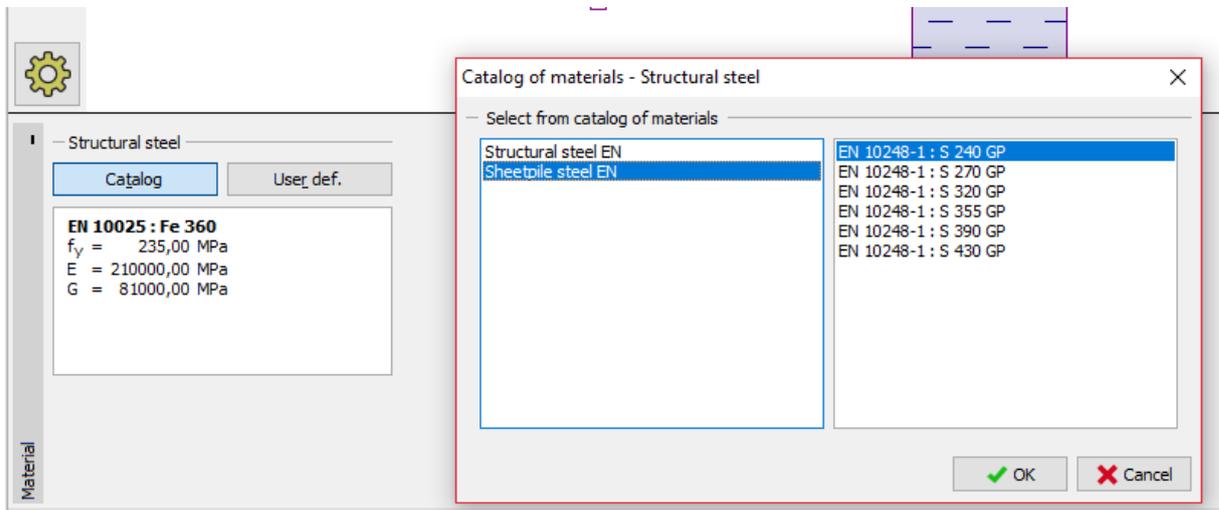
Then, open the frame “Modulus  $k_h$ ”, and choose the “analyze – Schmitt” option. This method of determining the modulus of subsoil reaction depends on the oedometric modulus and the stiffness of the structure (more info can be found in HELP – F1).

Modulus of reaction : analyze - Schmitt ▼

“Modulus  $k_h$ ” Frame

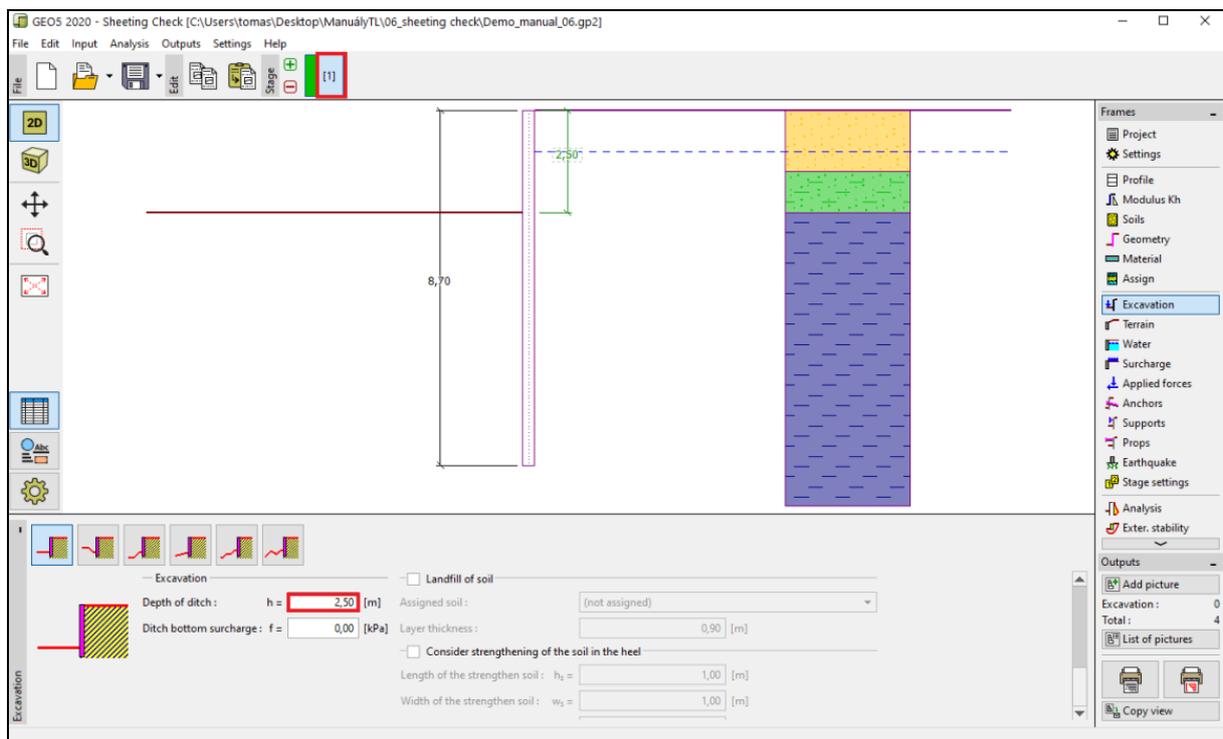
*Note: The modulus of subsoil reaction is an important input when analyzing a structure using the method of dependent pressures (elastic-plastic nonlinear model). Modulus  $k_h$  affects the deformation, which is needed to reach active or passive pressures (more info can be found in HELP – F1).*

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



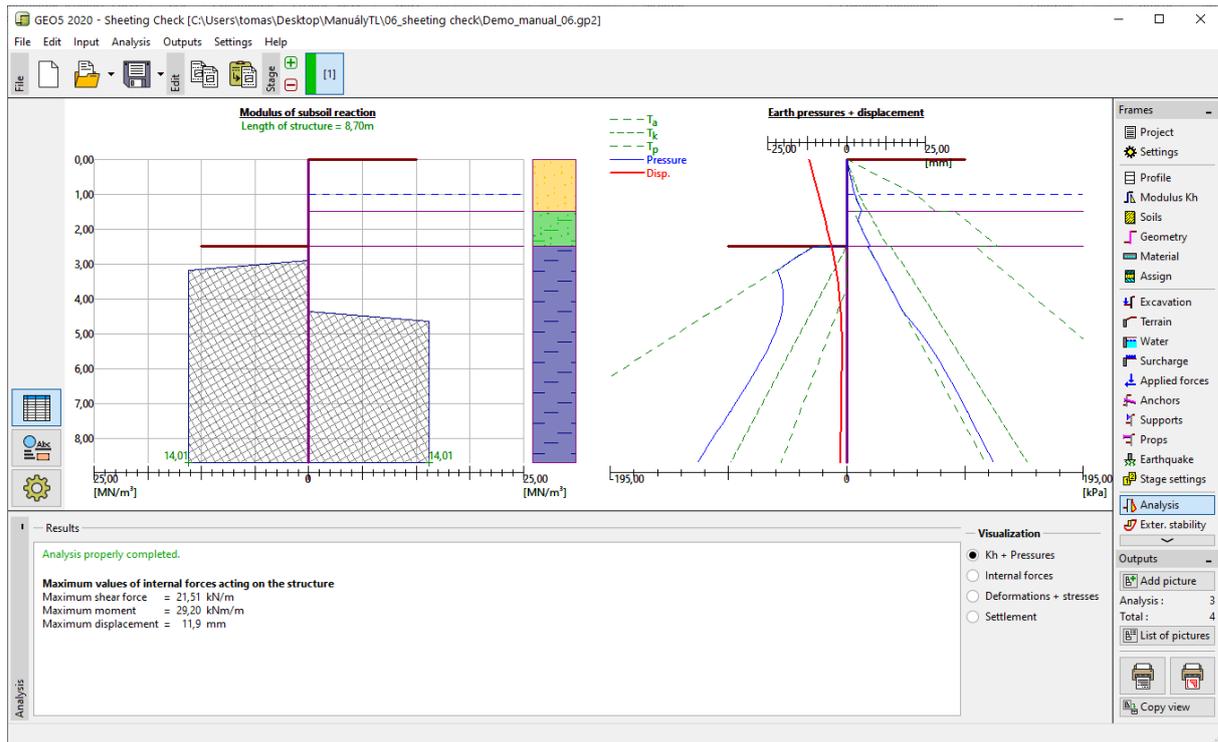
“Catalog of materials” Dialog window

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



“Excavation” Frame – Construction stage 1

Then, go to the “Analysis” frame. 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).



“Analysis” Frame – 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 “Settings”, “Profile”, “Modulus  $k_h$ ”, “Soils” and “Geometry” frames, because this data should stay the same for all construction stages.

In the “Anchors” frame 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]

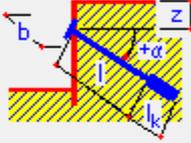
— Stiffness —

Type of input :

Diameter :  $d_s =$   [mm]

Elasticity modulus :  $E =$   [MPa]

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

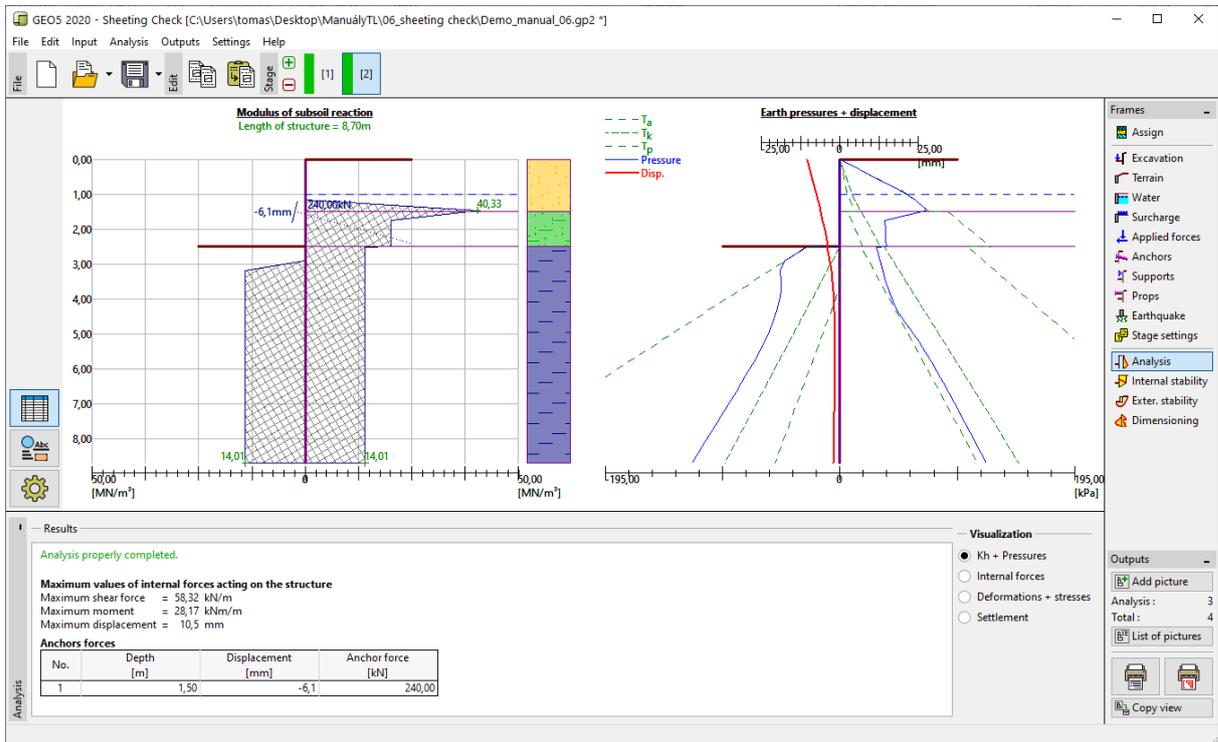


*“New anchor” Dialog window*

*Note: For anchored walls it can be an advantage to introduce the anchor in a separate construction stage and then have the excavation modeled in the following stage. The reason for that is the iteration of the modulus of subsoil reaction – when modeling 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.

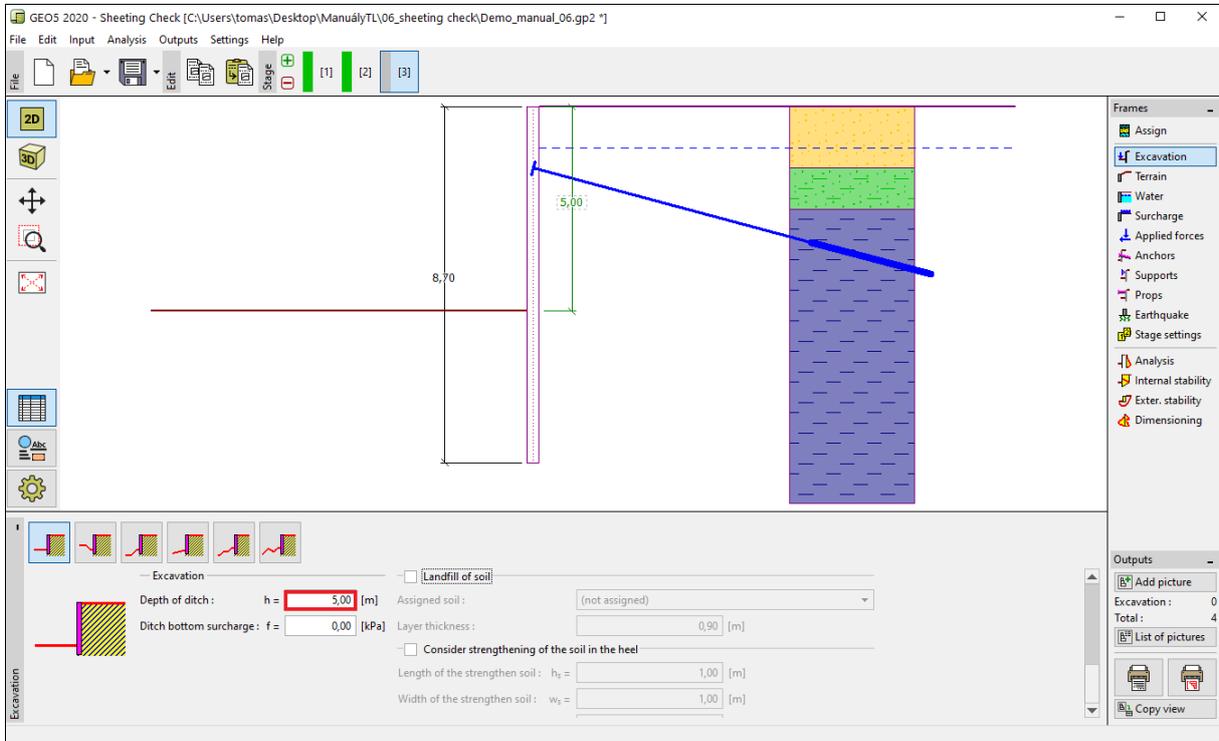


*“Analysis” Frame – Construction stage 2*

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.

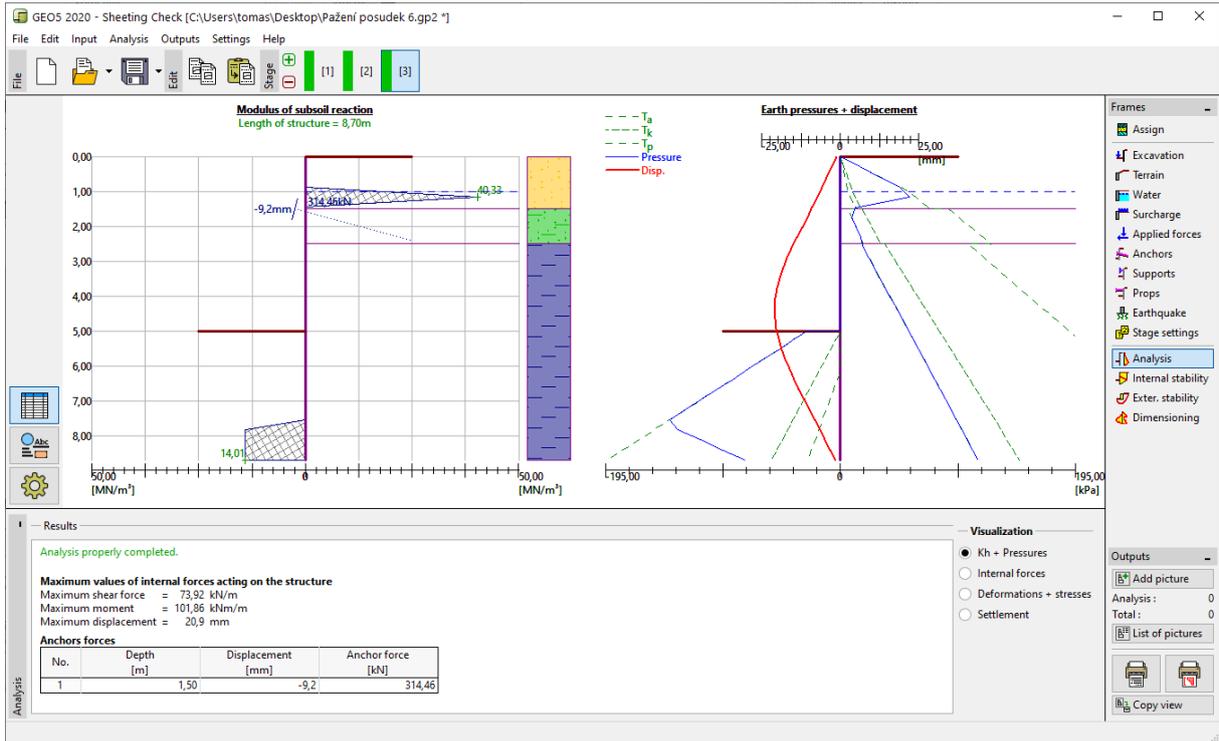
## Construction stage 3

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

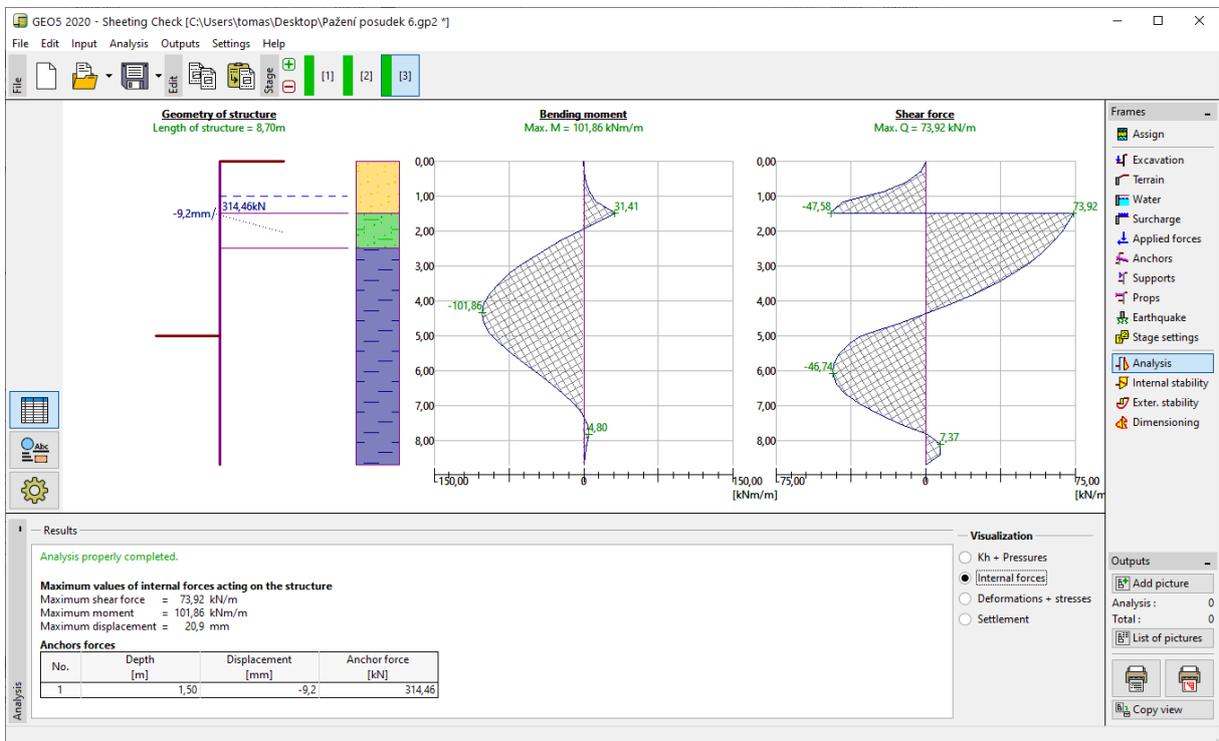


*"Excavation" Frame – Construction stage 3*

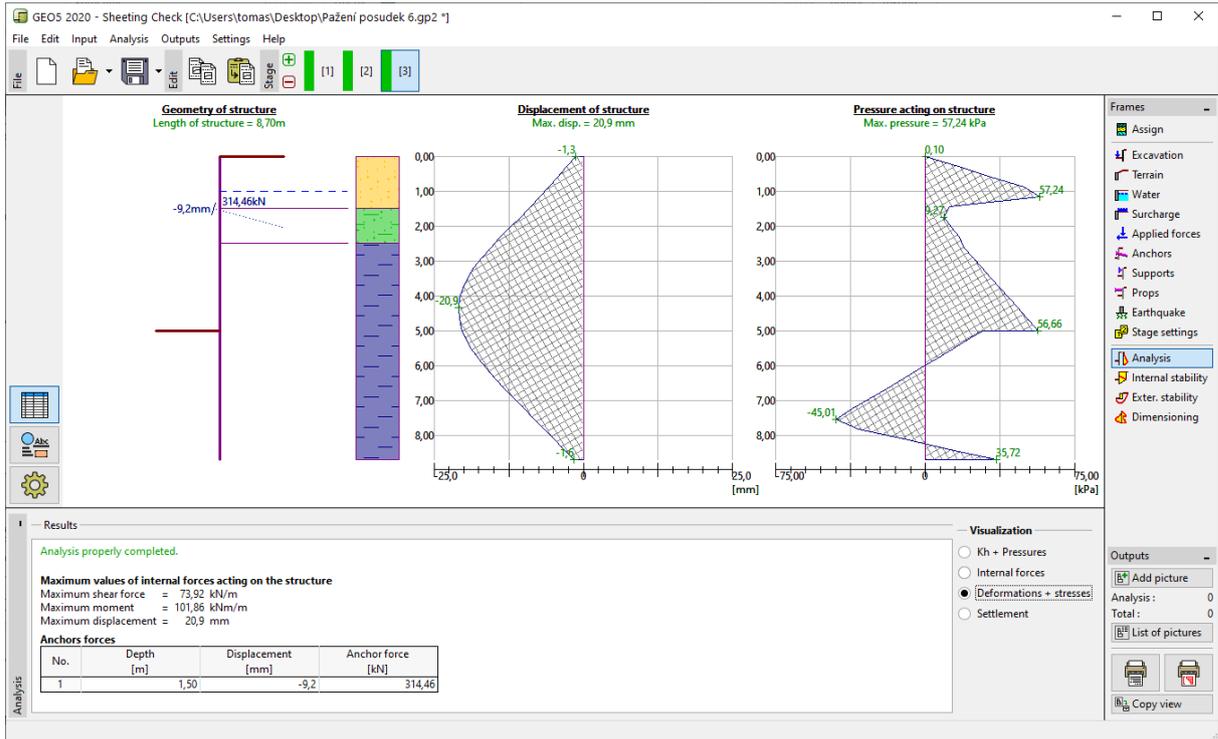
Now, perform the analysis to display the distribution of the internal forces and the displacement of the anchored structure.



“Analysis” Frame – Construction stage 3



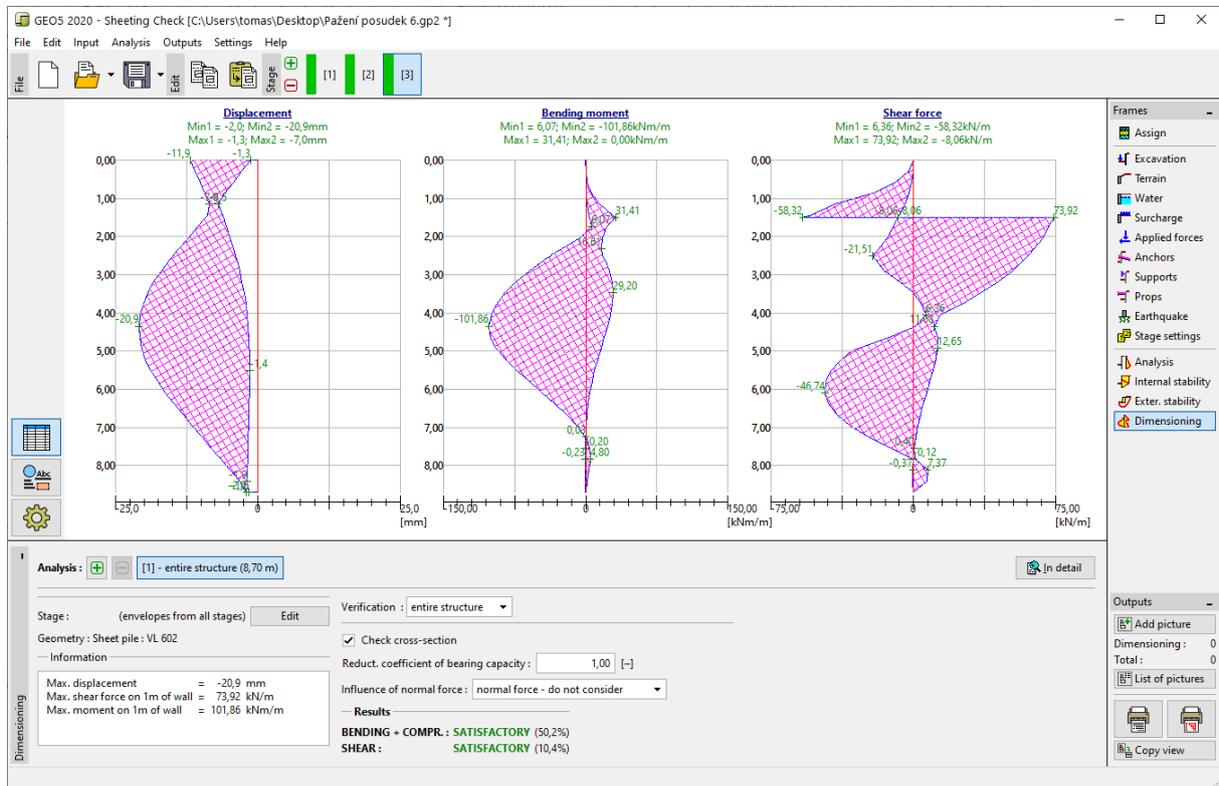
“Analysis” Frame – Construction stage 3 (Internal forces)



*"Analysis" Frame – 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 “Dimensioning” frame. The maximum observed moment on the structure is 101,86 kNm/m. The overall utilization of the sheet pile of type **VL 602** from EN 10248-1: S 240 GP steel is **50,2 %**. The maximum displacement of the structure ( 20,9 mm) is also satisfactory.



“Analysis” Frame – 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 “Internal stability” frame. You can see, that the internal stability of the anchors is not satisfactory (the total utilization is **141,16 %**). This means, that the anchor could tear away from the soil.

The screenshot shows the GEO5 2020 software interface. The main window displays a 2D grid representing a soil mass with a purple line indicating an anchor. The bottom panel shows a table of anchor verification results for anchor No. 1, indicating a utilization of 141.16% and a 'NOT OK' status.

No.	Anchor force [kN]	Max. allow. force [kN]	Utiliz. [%]	Verification
1	314,46	222,77	141,16	is not satisfactory

Results  
Verification of decisive row of anchors: [In detail](#)  
Anchor No.: 1  
Specified anchor force = 314,46 kN  
Computed max. allowable anchor force = 222,77 kN  
**NOT OK.**

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

The reason for this is that the anchor is too short, so in the “Anchors” frame (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.

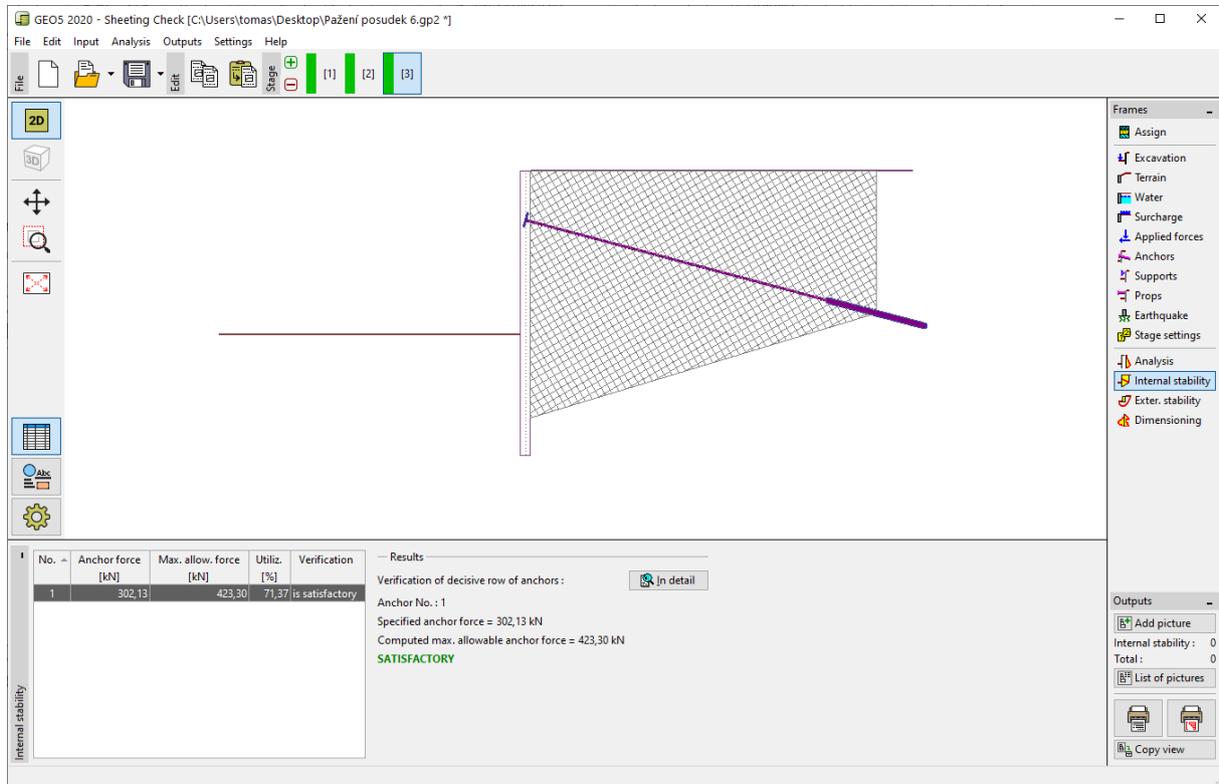
The "Edit anchor" dialog window contains the following fields and values:

- Anchor type: not specified
- Name: Anchor 1
- Anchor parameters:
  - Depth:  $z = 1,50$  [m]
  - Free length:  $l = 9,50$  [m]
  - Root length:  $l_k = 3,00$  [m]
  - Slope:  $\alpha = 15,00$  [°]
  - Spacing:  $b = 2,50$  [m]
- Stiffness:
  - Type of input: input diameter
  - Diameter:  $d_s = 32,0$  [mm]
  - Elasticity modulus:  $E = 210000,00$  [MPa]
- Pre-stressing force:  $F = 240,00$  [kN]

The diagram on the right shows a cross-section of an anchor embedded in a concrete wall. The wall thickness is labeled  $b$ . The anchor is inclined at an angle  $\alpha$  from the horizontal. The depth of the anchor in the wall is  $z$ . The free length of the anchor is  $l$ , and the root length is  $l_k$ .

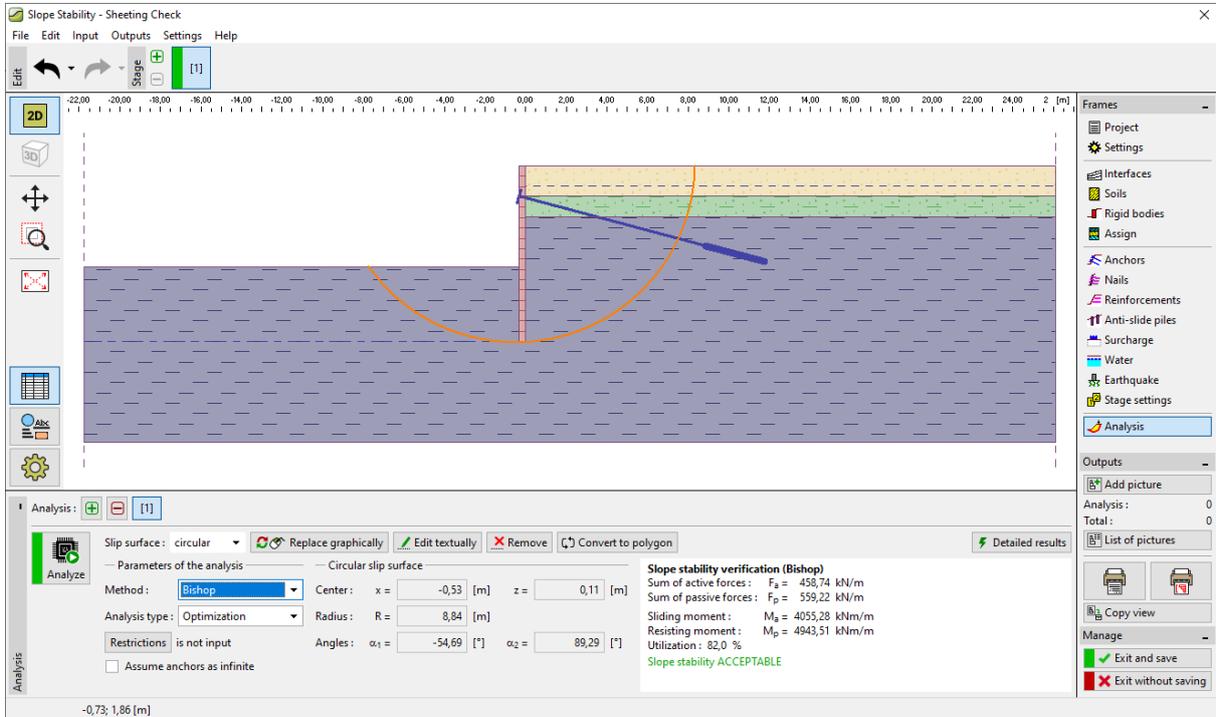
“Edit anchor” Dialog window – Construction stage 2

Then switch back to the 3<sup>rd</sup> 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 71.37%).



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

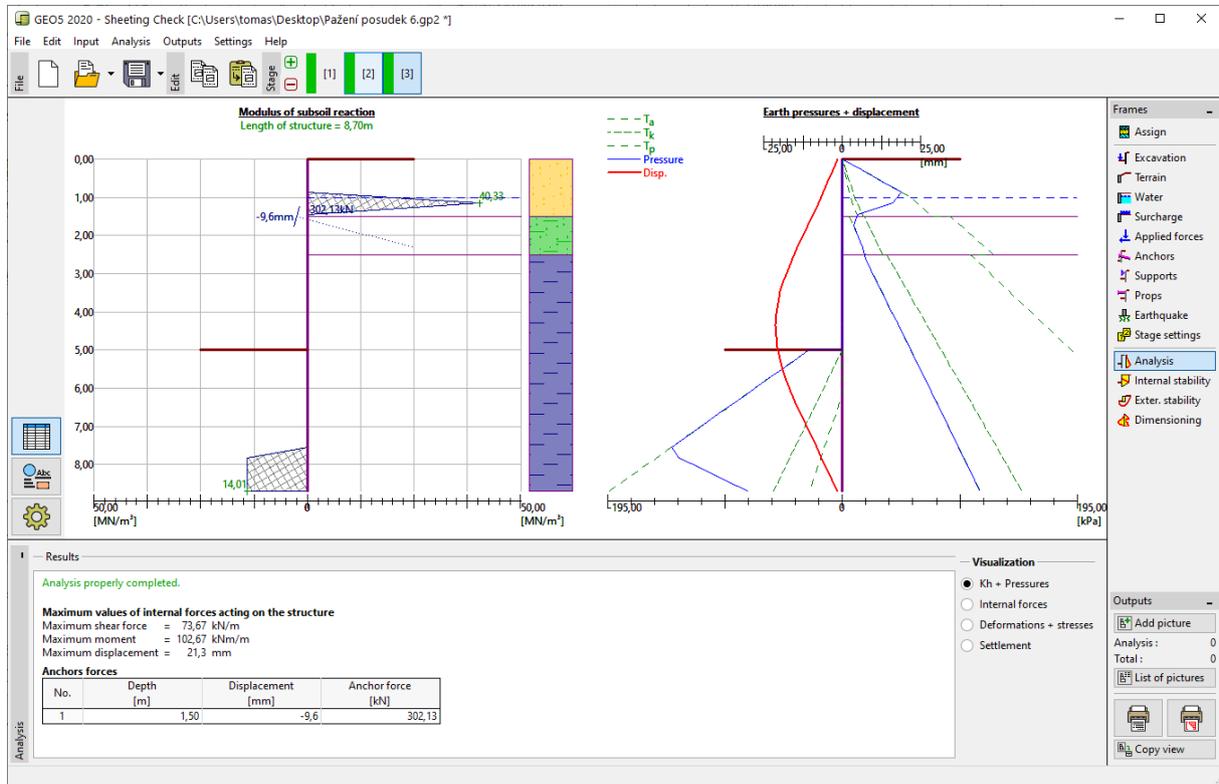
The last thing we need to check is the overall stability of the structure. Click on the “External stability” button. This will open the “Slope stability” program. In the “Analysis” frame click on the “Analyze” button. We can see, that the overall stability is acceptable. Exit the “Slope stability” program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



“External stability” Frame

## 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 the 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: **71,37 %** OK
- Overall stability: **82 %** Method – Bishop (optimization) OK