Field test interpretation and creation of a geological model

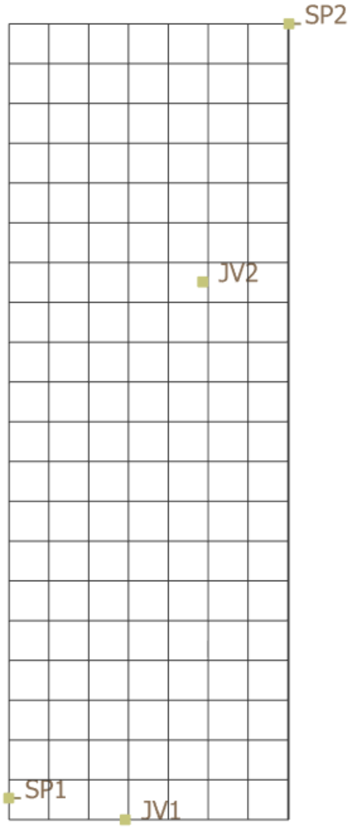
Program: Stratigraphy
File: Demo_manual_38.gsg

Introduction

The goal of this engineering manual is to show some basic work with the "Stratigraphy" program. More complex modifications are described in the following engineering manual No. 39.
The "Stratigraphy" program provides a simple way to create complex geological models. Nevertheless, the program does not make any decisions on its own and the resulting model should correspond to the decisions and ideas of the geologist. This manual is focused on a basic understanding of the modelling principle.

Assignment

The result of our work will be a geological model of the construction site, where the geological investigation was carried out. During the geological survey, two boreholes and two cone penetration tests (CPT) were carried out. The shape of the construction site and the locations of the boreholes and CPTs are shown in the following picture.



Construction site scheme

The names, types and coordinates of the tests are described in the following table:

Name	Type	Coordinates [m]		
		x	y	z
JV1	borehole	11,4	88	187,96
JV2	borehole	15	113	187,8
SP1	CPT	6	89	unknown
SP2	CPT	19	125	unknown

The soil layers in the boreholes are described as follows:

Borehole JV1			
Thickness	Depth	Soil	
[m]	[m]	Classification	Description
0,7	0 - 0,7	Y	Made-up ground
7,8	0,7 - 8,5	F8	Clay with high plasticity
8,5	8,5 - 17,0	F6	Clay with low plasticity

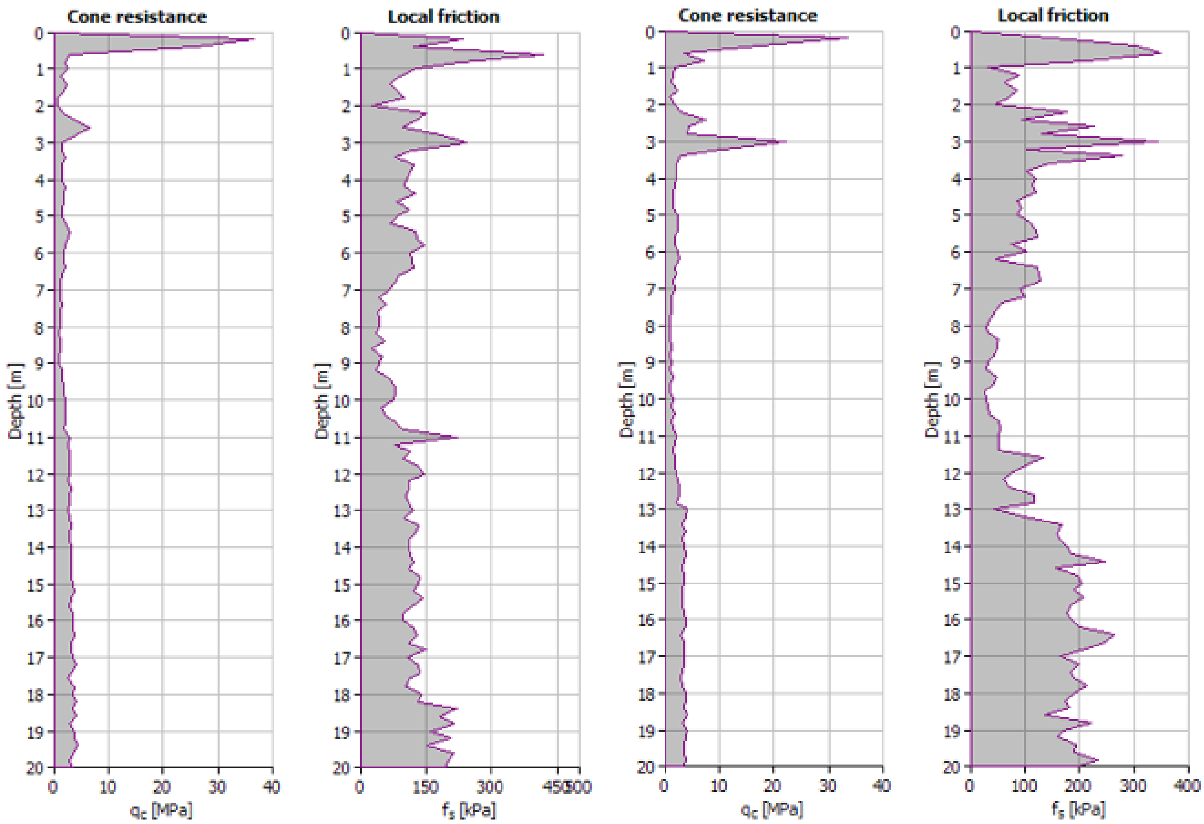
Borehole JV2			
Thickness	Depth	Soil	
[m]	[m]	Classification	Description
0,7	0 - 0,7	Y	Made-up ground
2,5	0,7 - 3,2	F8	Clay with high plasticity
0,3	3,2 - 3,5	S3	Silty sand
7,2	3,5 - 10,7	F8	Clay with high plasticity
1,8	10,7 - 12,5	F6	Clay with low plasticity
0,2	12,5 - 12,7	G3	Silty gravel
5,9	12,7 - 18,6	F6	Clay with low plasticity

The ground water table in the boreholes is described as follows:

- Borehole *JV1* – depth of GWT under the terrain: 8 m
- Borehole *JV2* – depth of GWT under the terrain: 8,5 m

CPTs will be imported directly into the program in the form of table data, just as we obtained it from the geologist. For clarity, the values of penetration resistance and shear friction are shown in the following graphs.

CPT SP1 CPT SP2



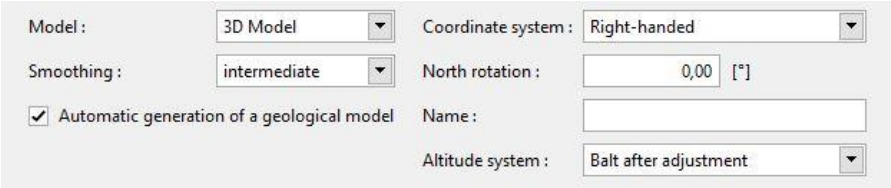
CPTs were carried out without pore pressure (u_2) measurements – the tests were not of the CPTu type.

Note: The files for import (SP1.txt, SP2.txt) are part of GEO5 installation and they are located in the folder FINE in public documents.

Note: The process of importing table data is explained in the program help (F1 or online: https://www.finesoftware.eu/help/geo5/en/table-data-import-01/) or in the engineering manual No. 27 (https://www.finesoftware.eu/download/engineering-manuals/235/en/27_import-txt_en/).

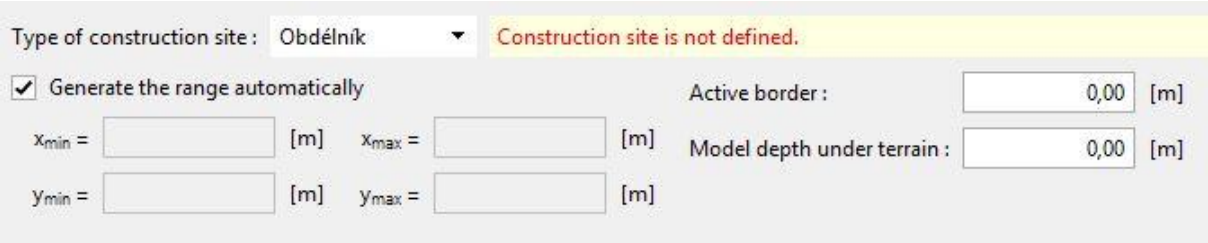
Modelling process

When the "Stratigraphy" program is launched, we firstly check the general settings in the frame "Settings". We leave the model settings on "3D model" with "intermediate" smoothing and automatic generation of the geological model. We recommend to turn on this option in case of small and easy geological models. For larger and more difficult models it is better to turn it off and use manual generation. Coordinate system will be right-handed.



Frame "Settings"

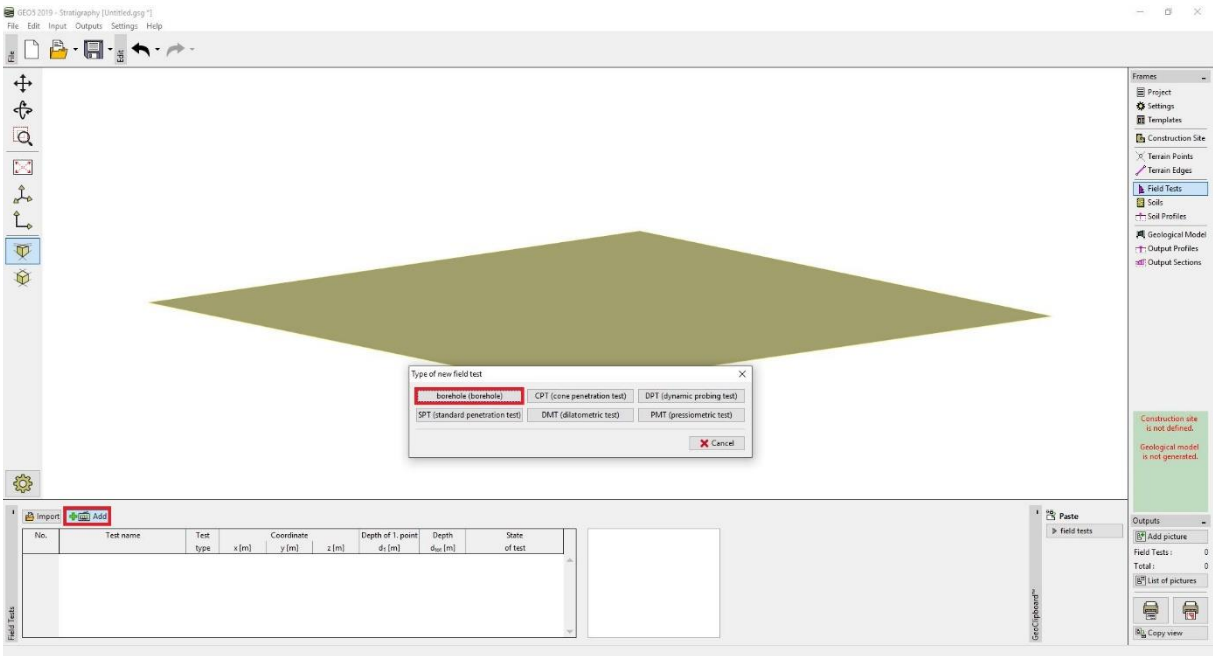
We also leave the standard settings on in the frame "Construction site".



Frame "Construction site"

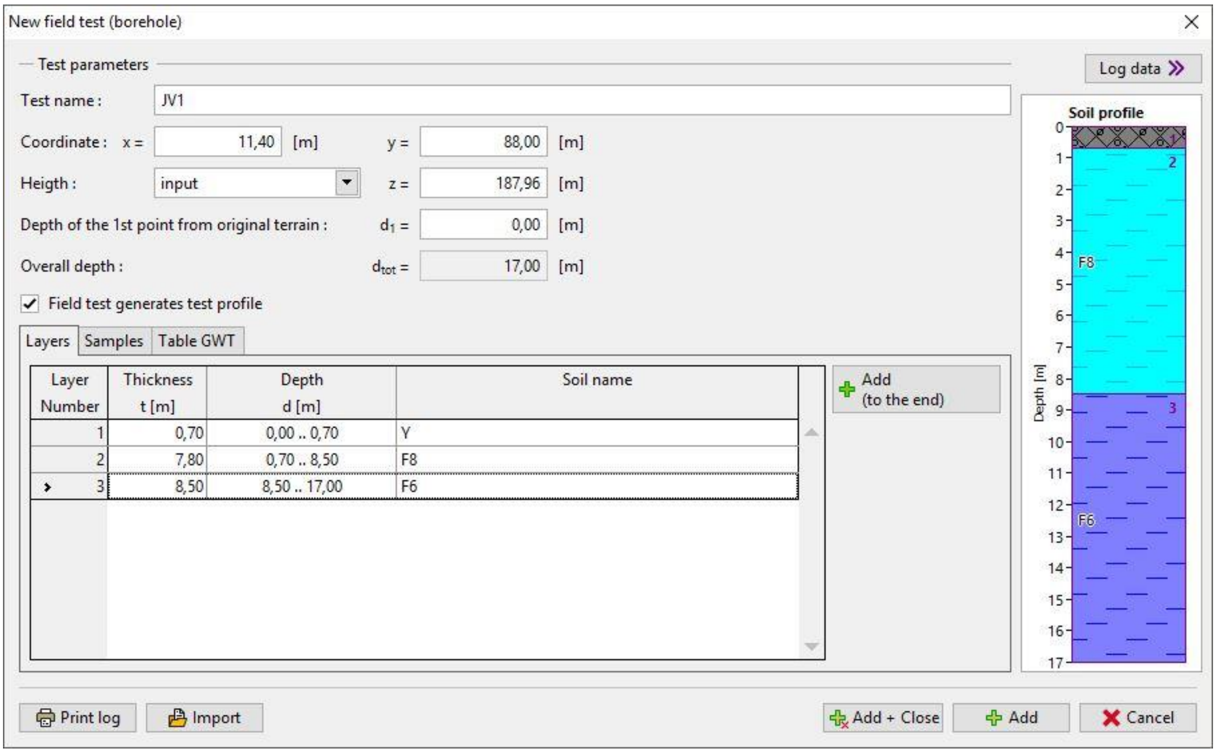
We skip the frame "Terrain Points" – the dimensions of our model will be determined according to the coordinates of boreholes and CPTs.

In the frame "Field Tests", we will input boreholes *JV1* and *JV2*. These boreholes are added using the "Add" button and selecting the required type of field test (borehole).

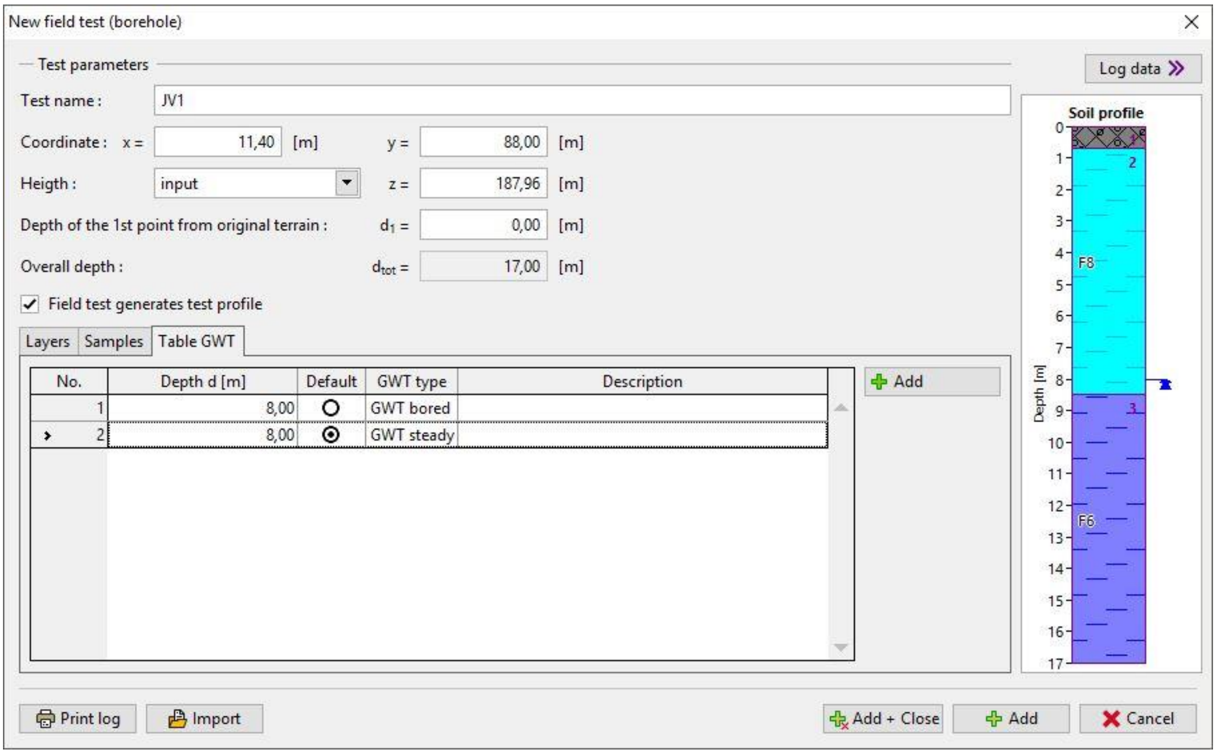


Frame "Field Tests" – inputting boreholes

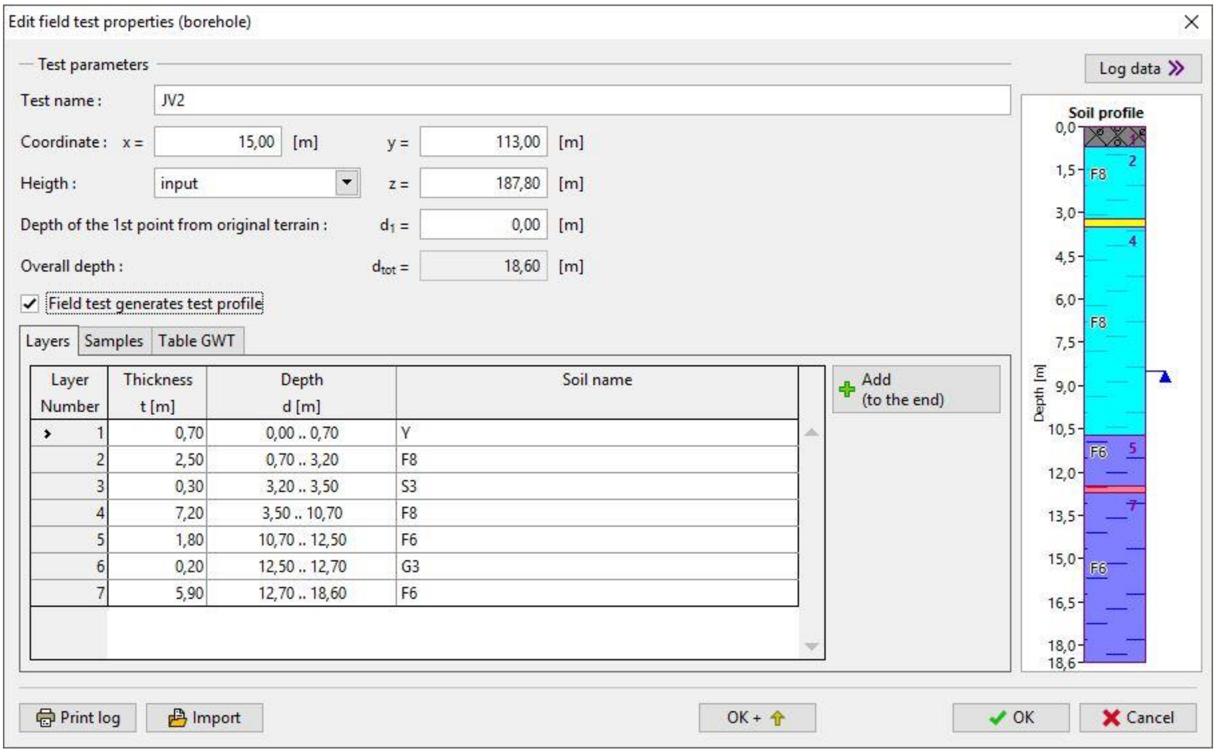
Coordinates of boreholes, soil layers (thickness, name, pattern and colour) and GWT are entered according to the information above as follows:



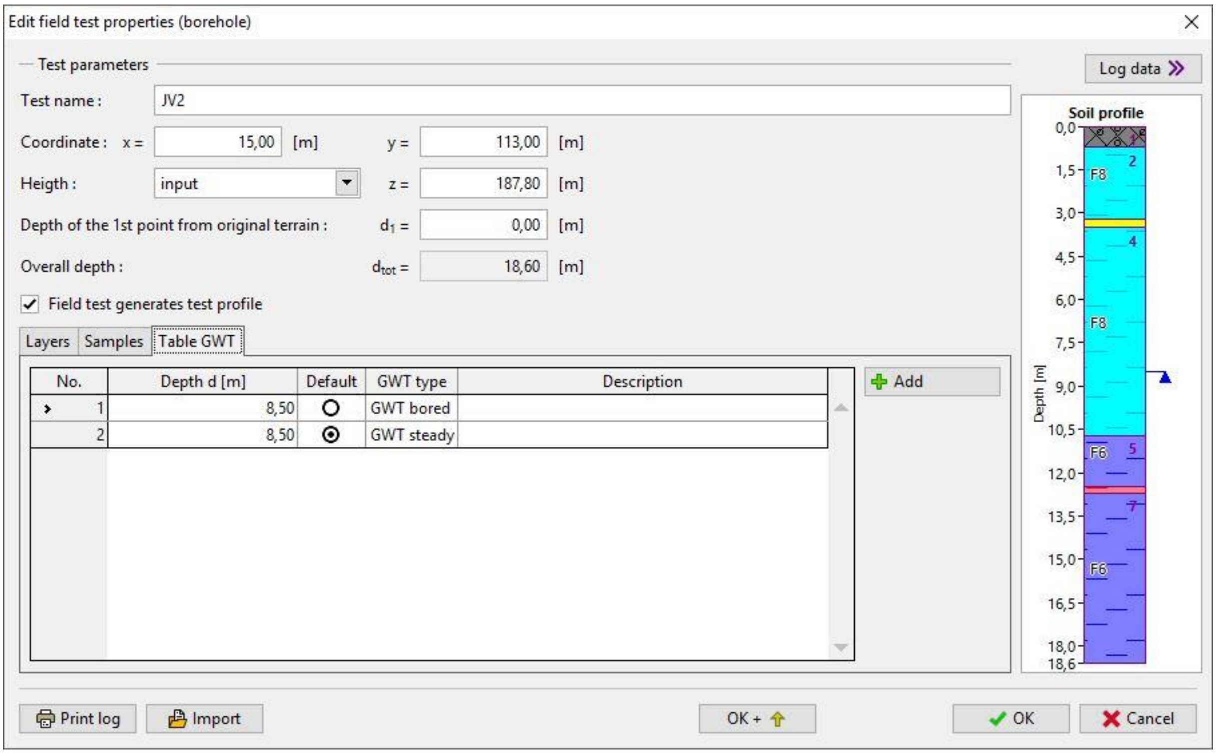
Inputting borehole JV1 – layers



Inputting borehole JV1 - GWT

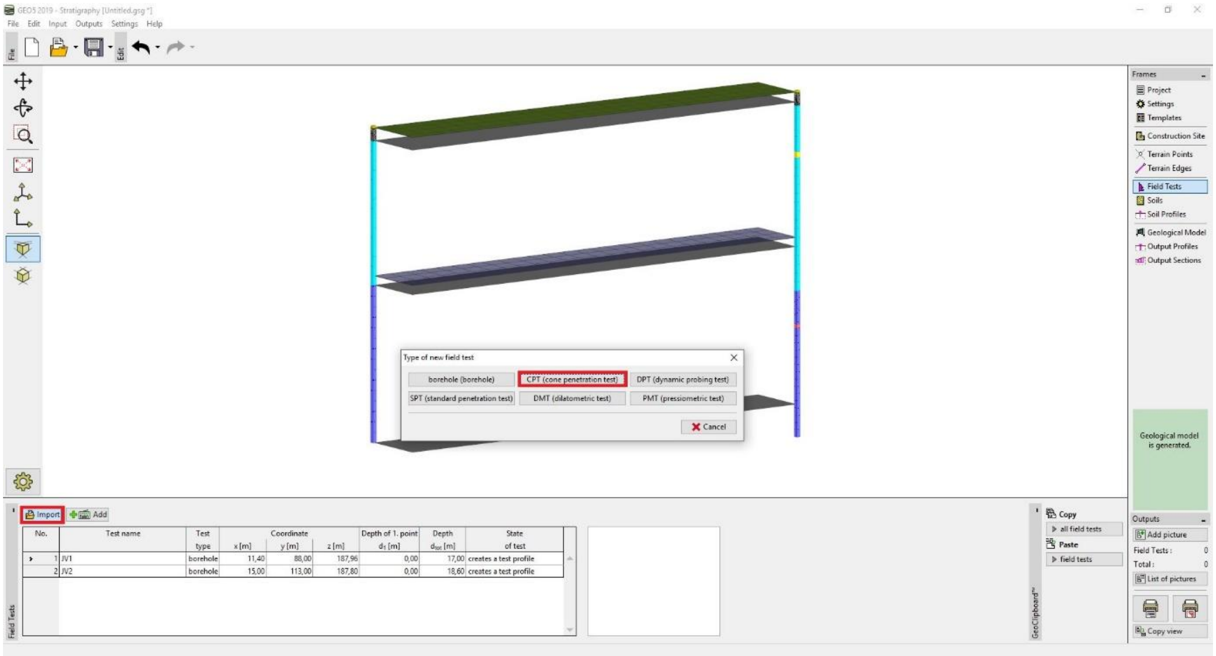


Inputting borehole JV2 – layers



Inputting borehole JV2 - GWT

Next we have to enter CPT tests – the measured values are not entered manually, but we import them as a table. The import is performed using the “Import” button and selecting the required type of field test (CPT).

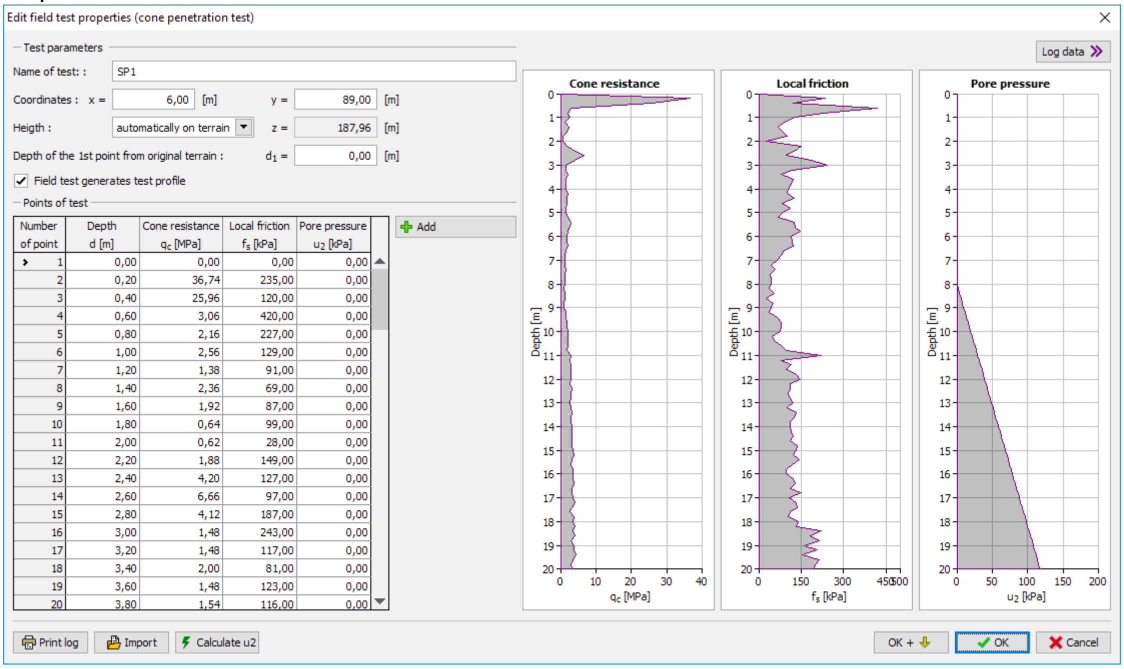


Frame “Field tests” – CPTs import

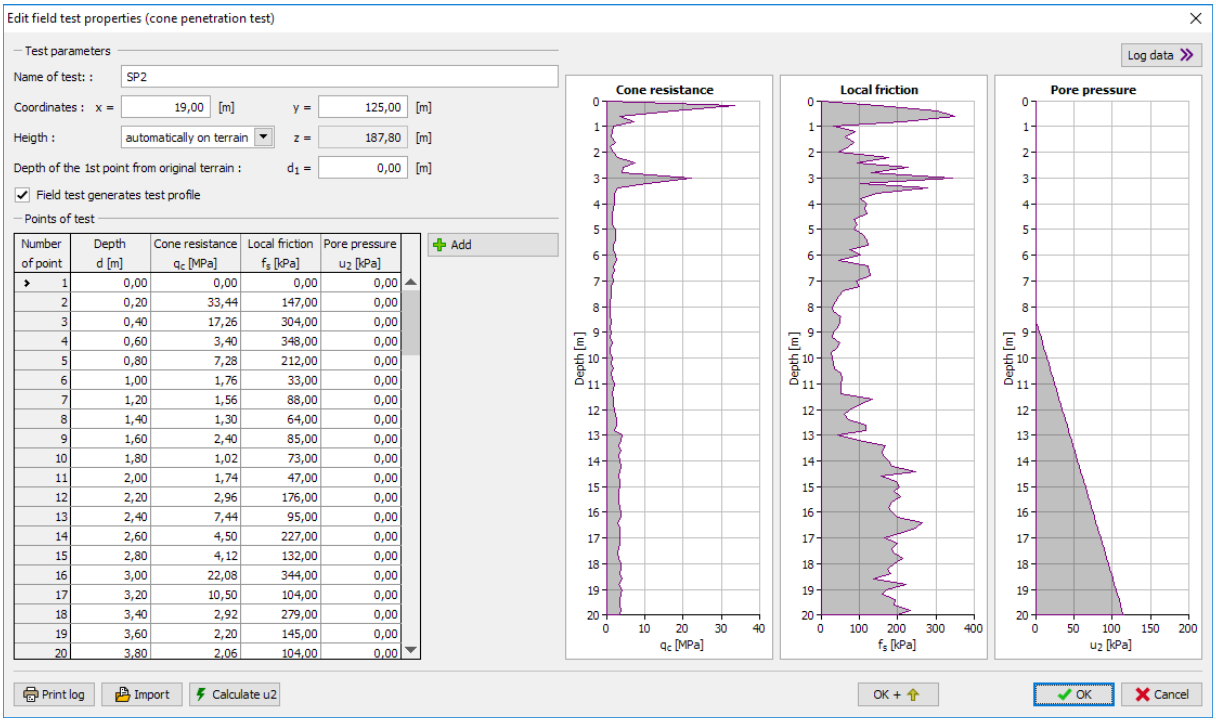
We don’t have any information about the *z*-coordinates of the CPT tests. Therefore, we will locate them on the generated terrain automatically according to the *z*-coordinates of boreholes *JV1* and *JV2*. Pore pressure (u_2) wasn’t measured during the CPT. We will let the program calculate the pore pressure automatically using the ground water table in boreholes *JV1* and *JV2*.

The CPT *SP1* is close to borehole *JV1*, therefore the GWT will be 8 m below the terrain. The CPT *SP2* is close to borehole *JV2* and therefore the GWT is 8,5 m deep below the terrain.

The imported CPTs look like this:

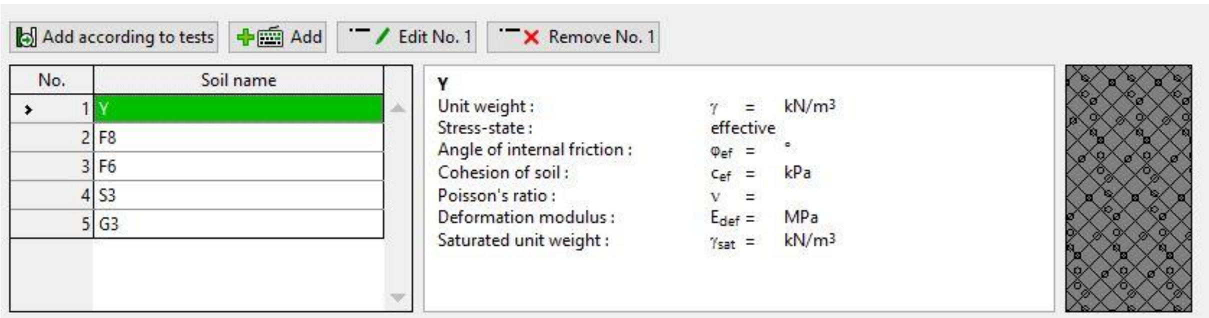


Import of CPT SP1



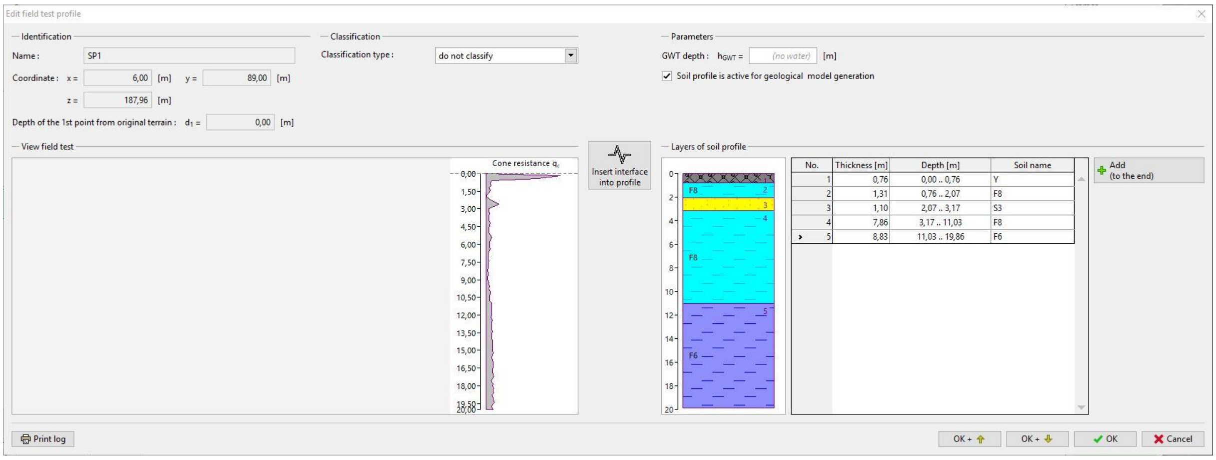
Import of CPT SP2

We enter all soils from boreholes *JV1* and *JV2* (*Y, F6, F8, S3, G3*) by the "Add according to tests" button. It is also possible to assign the geotechnical parameters to each soil. These parameters have no influence on the model – they are used to generate geological documentation or to export the data to other GEO5 programs. In this simple case, we will assign no parameters to the soils.



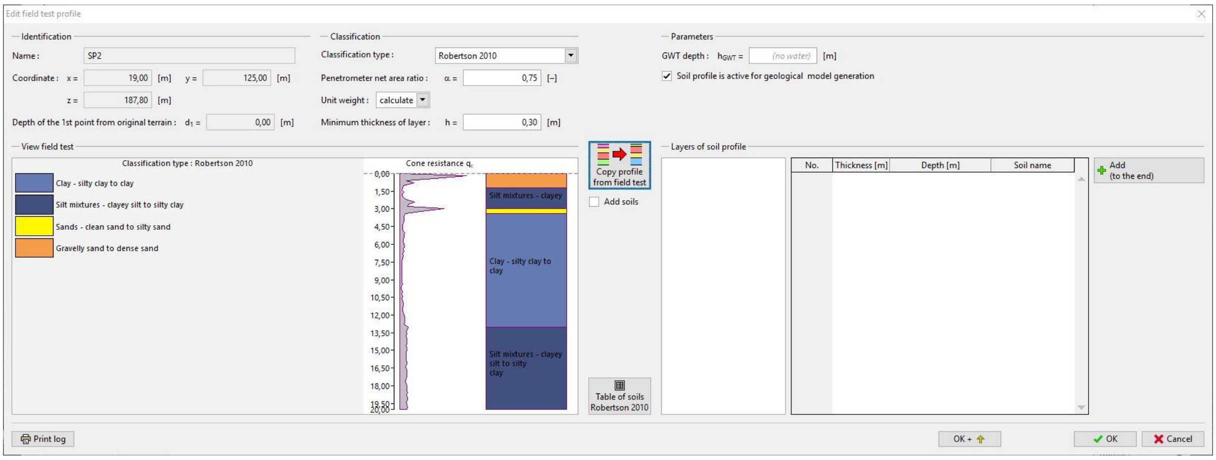
Add soils according to tests

Now we will move on to the "Soil Profiles" frame. In this frame, we can see that the test profiles were created automatically from boreholes *JV1* and *JV2*. Whenever the test profiles from CPTs are created automatically, it is necessary to interpret the measured values with regards to the geological profile. It can be done manually or automatically according to Robertson´s soil classification (1986 or 2010). For clarity purposes, we will show both approaches in this manual.
Firstly, we will create a geological profile manually from CPT *SP1*. We select the "do not classify" option in the central part of the dialog window.
In the left part of the dialog window, we can see a graph of penetration resistance q_c. Using the left mouse button click on this graph, the assumed geological interferences are created in the right part of the dialog window. We will assign the soils to the layers according to the soils in borehole *JV2*. The ground water table wasn't measured, so we don't enter it. It will be generated automatically according to the GWT input in boreholes *JV1* and *JV2*.



Manual creation of the geological profile according to the CPT

We will now move on to the *SP2* test. Now we will use the automatic creation of a geological profile according to the soil classification (Robertson, 2010). After the CPT is interpreted, we usually obtain a large number of thin layers. It is not easy work with such a big number of layers, therefore we will filter them for minimum thickness of layer (0,3 m).

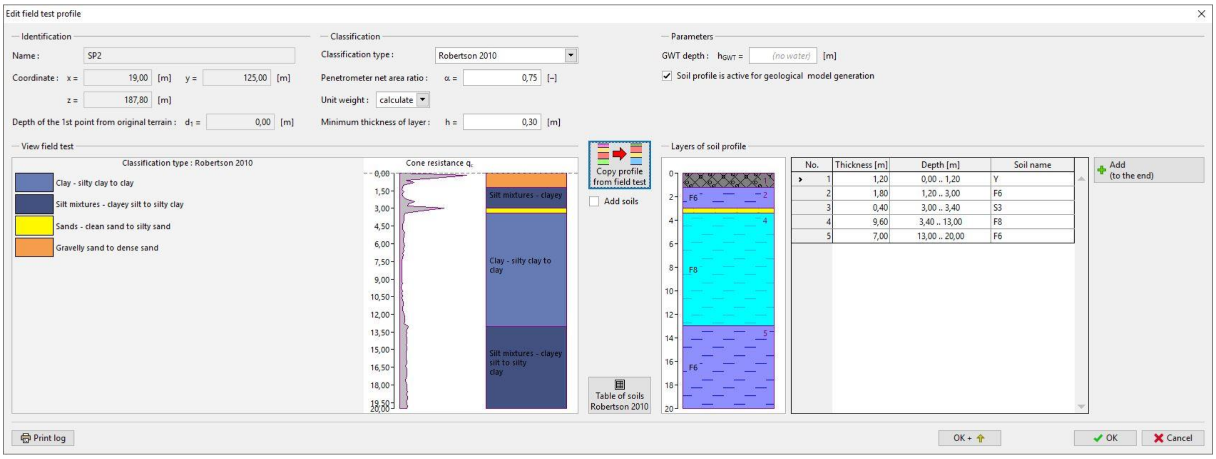


The result of soil classification according to CPT

Using the “Table of soils – Robertson 2010” button, we assign the entered soils (from boreholes *JV1* and *JV2*) to the soils from the CPT classification.

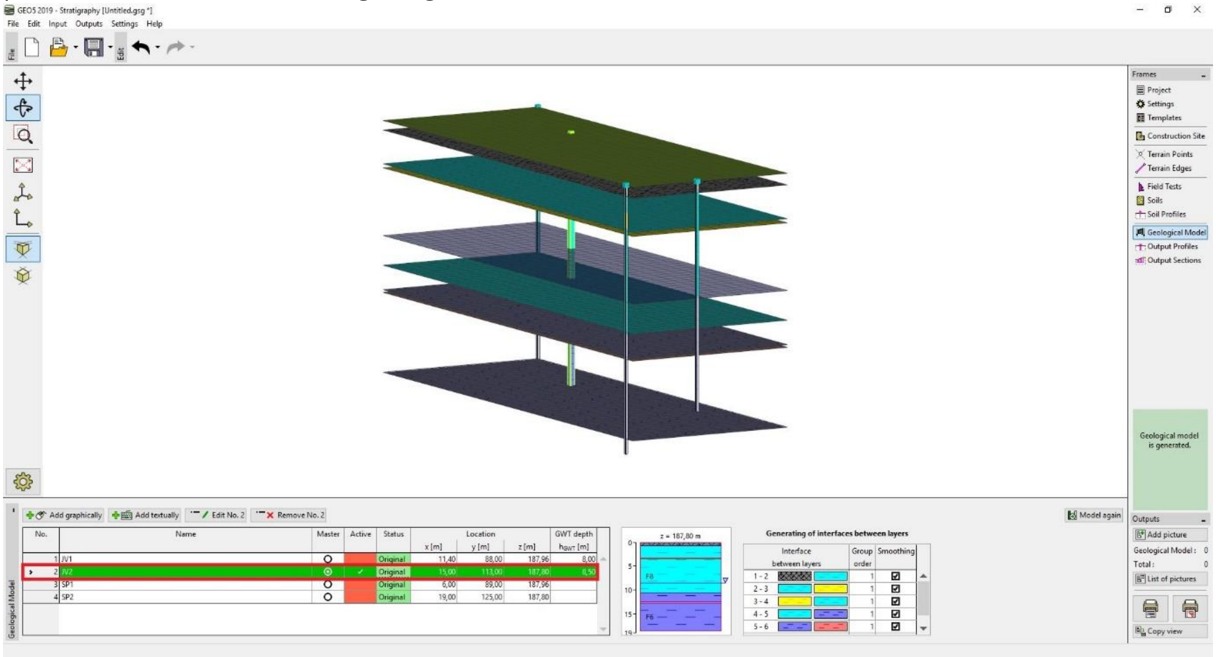
Table of soils assignment

Using the “Copy profile from field test” button, the geological profile is generated from the entered soils in the layers corresponding to the CPT classification results.



Automatic creation of a geological profile according to CPT soil classification

Now we move on to the "Geological Model" frame. Here we can see the "boreholes" (geological profiles) created according to the boreholes (*JV1*, *JV2*) and CPTs (*SP1*, *SP2*). We select borehole *JV2* as the master borehole – this borehole is the deepest and contains all types of soils – for this reason, it provides the best view of the geological conditions in the construction site.

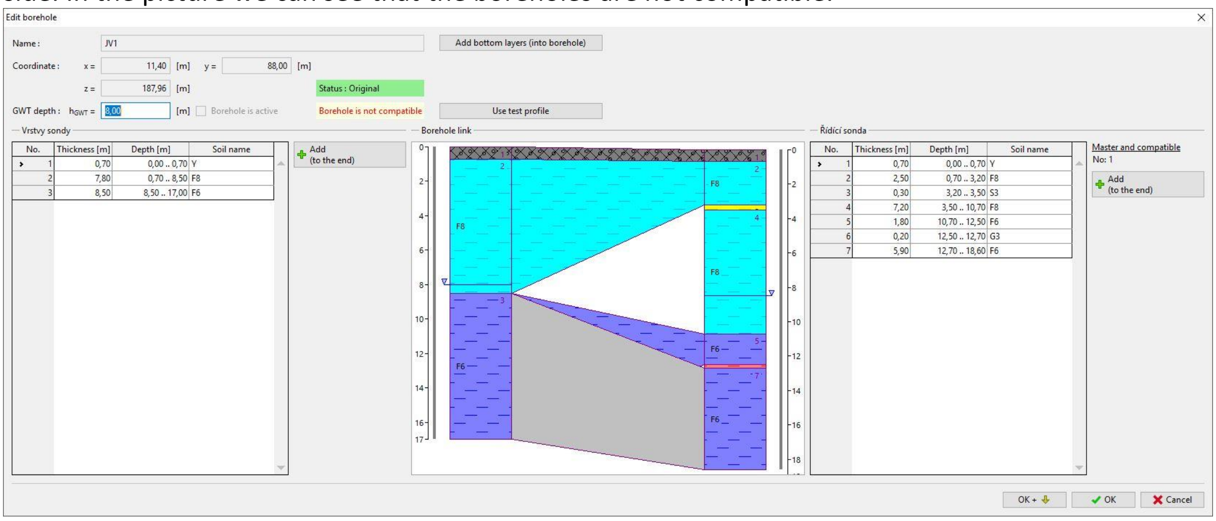


Frame "Geological Model" – selecting the master borehole

The other boreholes are shown in red – it means that they are not compatible with the master borehole. The geological model is generated from the master borehole and from the compatible boreholes. Thus, it is appropriate to modify all boreholes to be compatible. After that, the geological model is created according to all data from the geological survey. Therefore, we will modify all boreholes to be compatible with the master borehole.

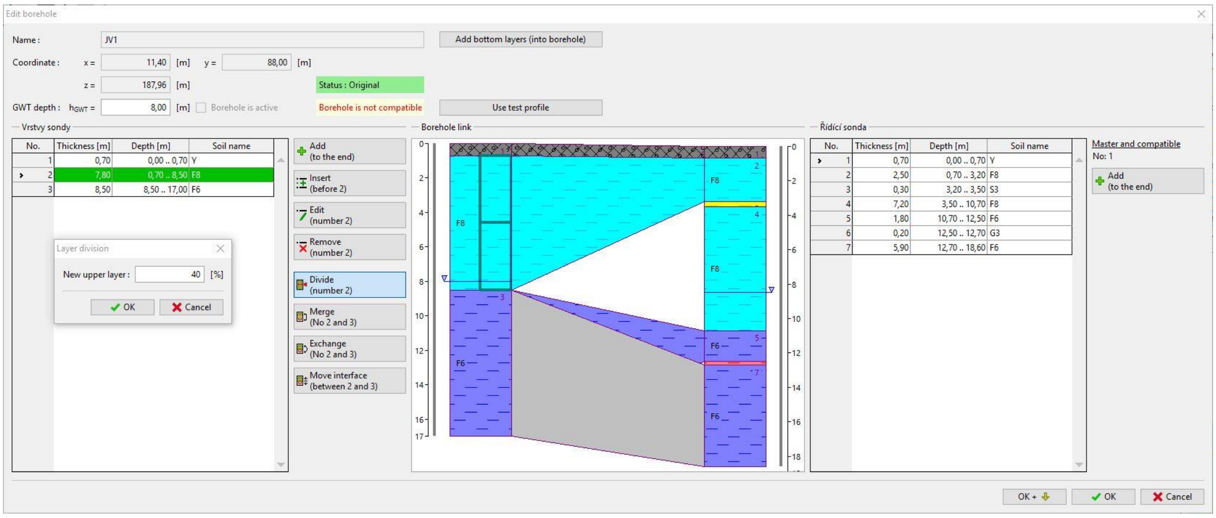
Modification of borehole JV1

We will start with the modification of borehole JV1. After selecting this borehole, we can see the actual borehole (JV1) in the left part of the dialog window. The master borehole (JV2) is displayed on the right side. In the picture we can see that the boreholes are not compatible.



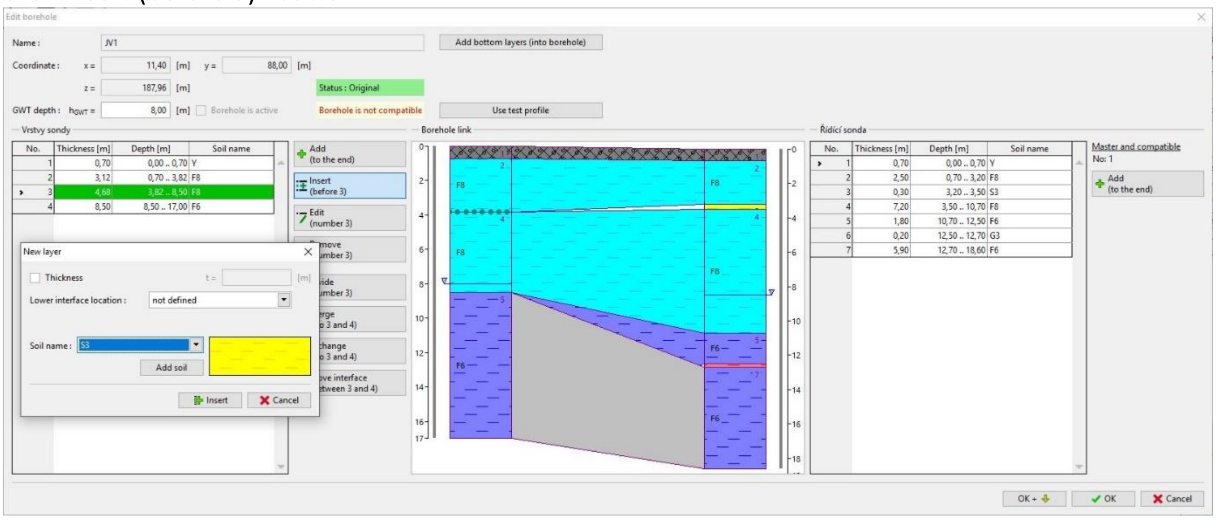
Original state of borehole JV1

There are no sandy and gravel layers (S3, G3) in borehole *JV1*. We assume approximate horizontal geological layers (based on the general geological knowledge of this location). For this reason, we divide layers F6 and F8 and insert layers S3 and G3 with **not defined interface location** between the newly created layers. The geological profile of borehole JV1 is not changed, but now it is compatible with the master borehole.
Firstly, we divide layer 2 in the ratio 4:6 (upper layer has a thickness of 40 % of the original layer).



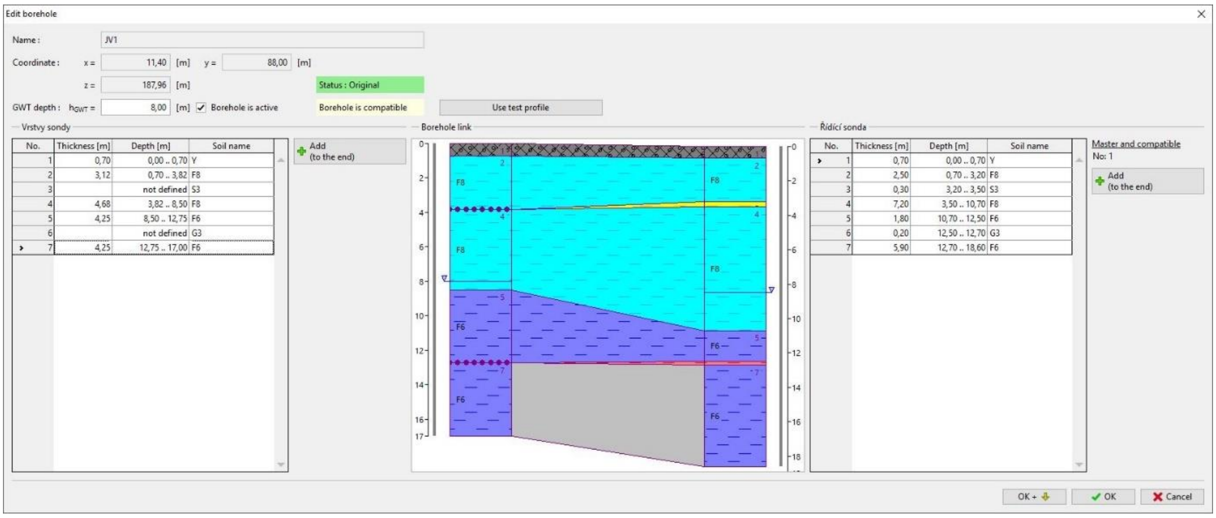
Dividing layer 2 (F8)

Now, we will enter a new layer of soil S3 with zero thickness between the newly divided layers using the “Insert (before 3)” button.



Inserting a new layer S3

We will modify the bottom part of the borehole in the same way. Firstly, we divide layer 5 (F6) using the “Divide (number 5)” button in the ratio 1:1 (upper layer – 50 %). Then we enter a new layer of soil G3 (zero thickness) using the “Insert (before 6)” button. The boreholes *JV1* and *JV2* are now compatible.

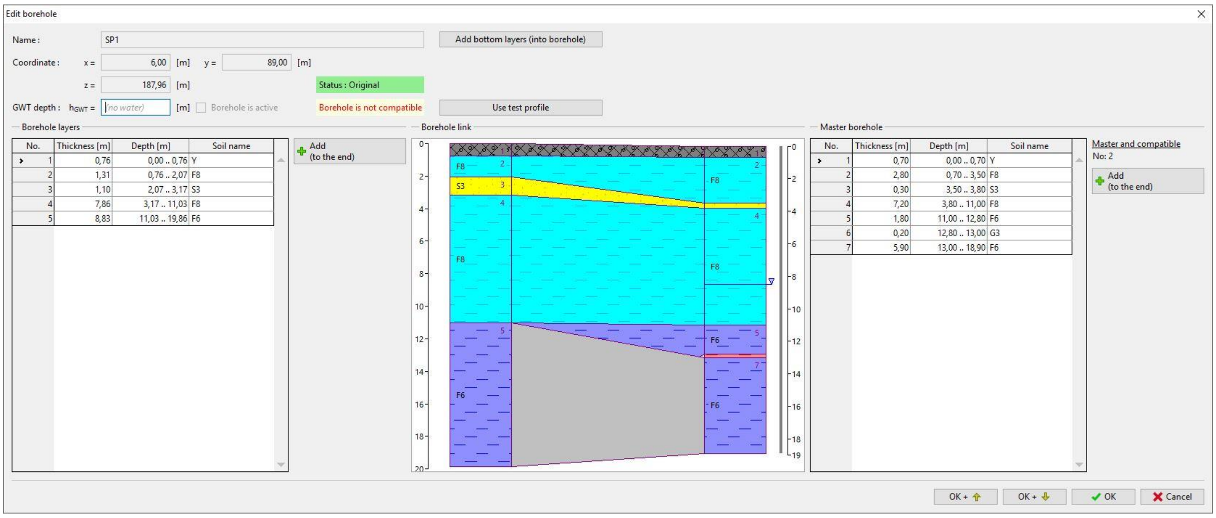


New state of borehole JV1

Modification of borehole SP1

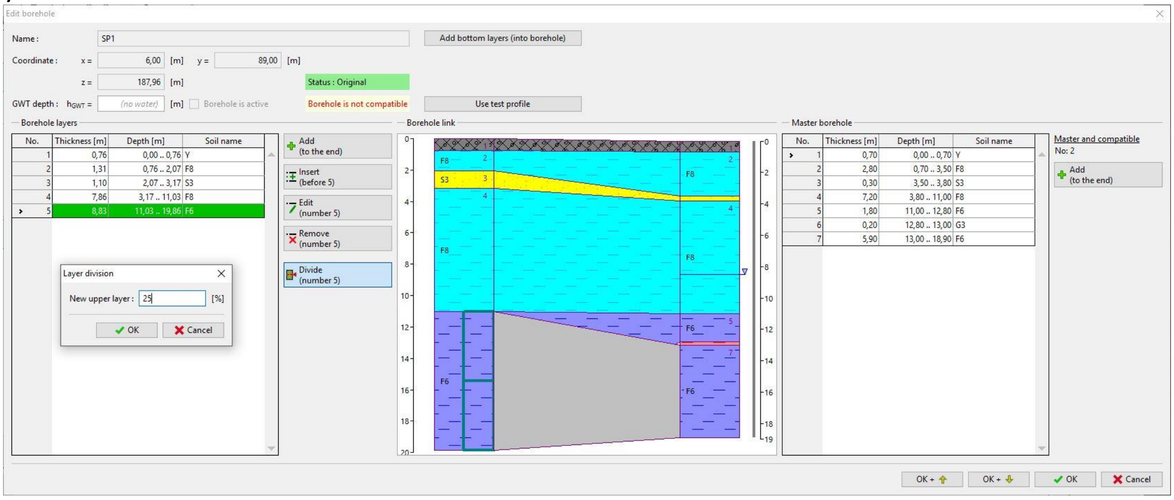
Now we can start modifying borehole *SP1* – geological profile in this borehole was created manually according to the measured penetration resistance q_c in the CPT *SP1*.

In the dialog window, we can see that borehole SP1 is not compatible with the master borehole. In this case, just the bottom part is not compatible. The upper part of the borehole is correct – both boreholes contain a sandy layer S3.



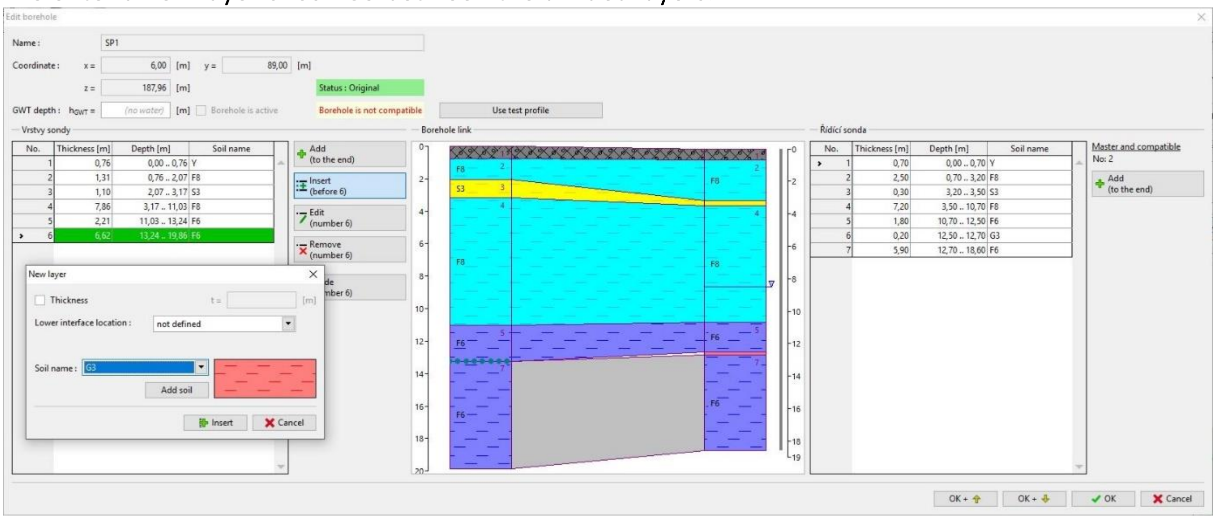
Original state of borehole SP1

There is no gravel layer (G3) in borehole *SP1*. We will perform a similar modification as we did for borehole *JV1*. Firstly, we divide layer 5 (F6) – the new upper layer will consist of only 25 % of the original layer.



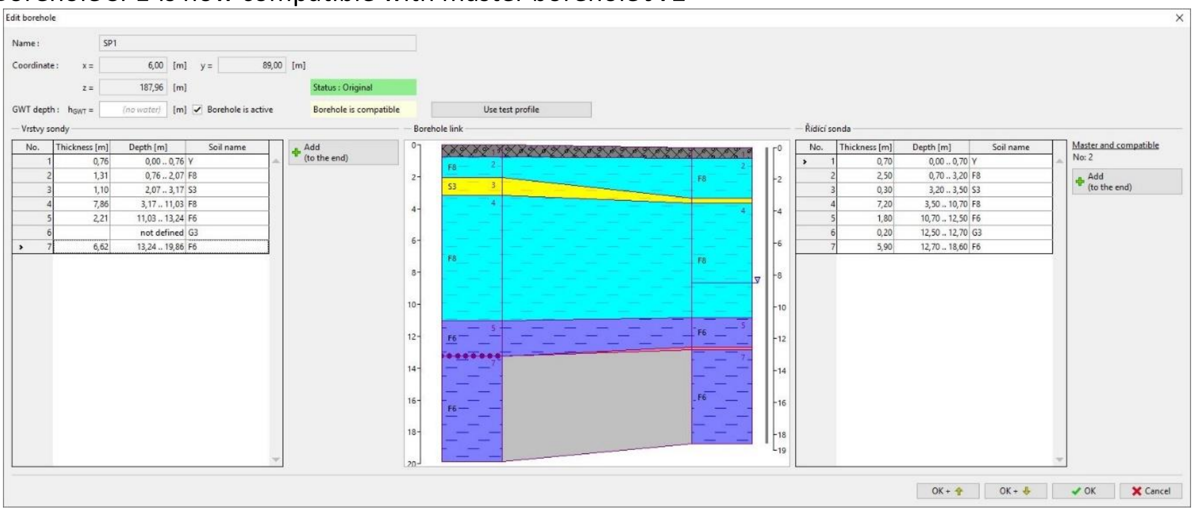
Dividing layer 5 (F6)

We enter a new layer of soil G3 between the divided layers.



Inserting a new layer G3

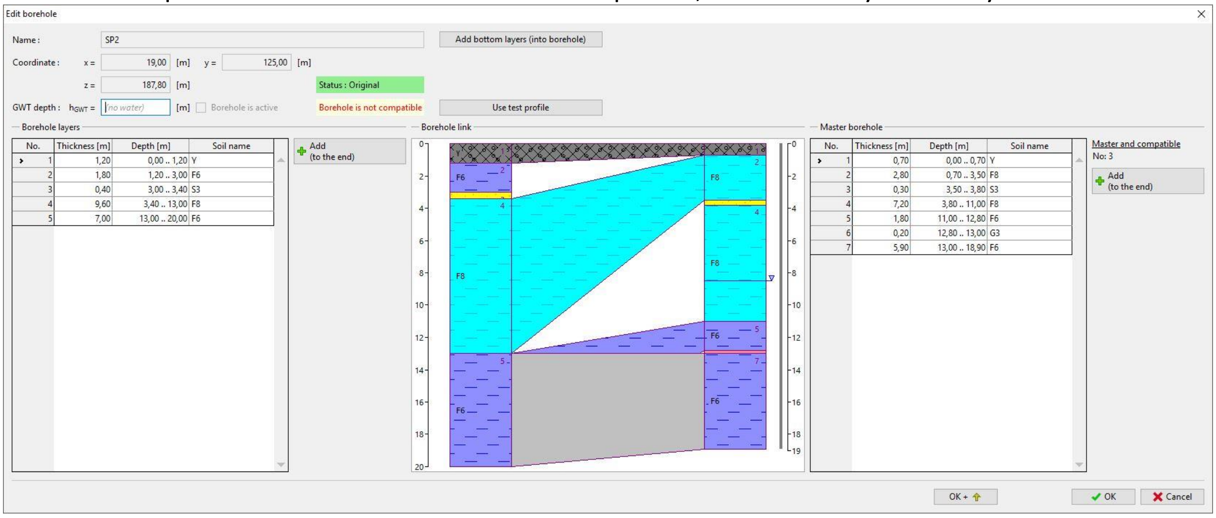
Borehole *SP1* is now compatible with master borehole *JV2*



New state of borehole SP1 – the borehole is compatible with the master borehole

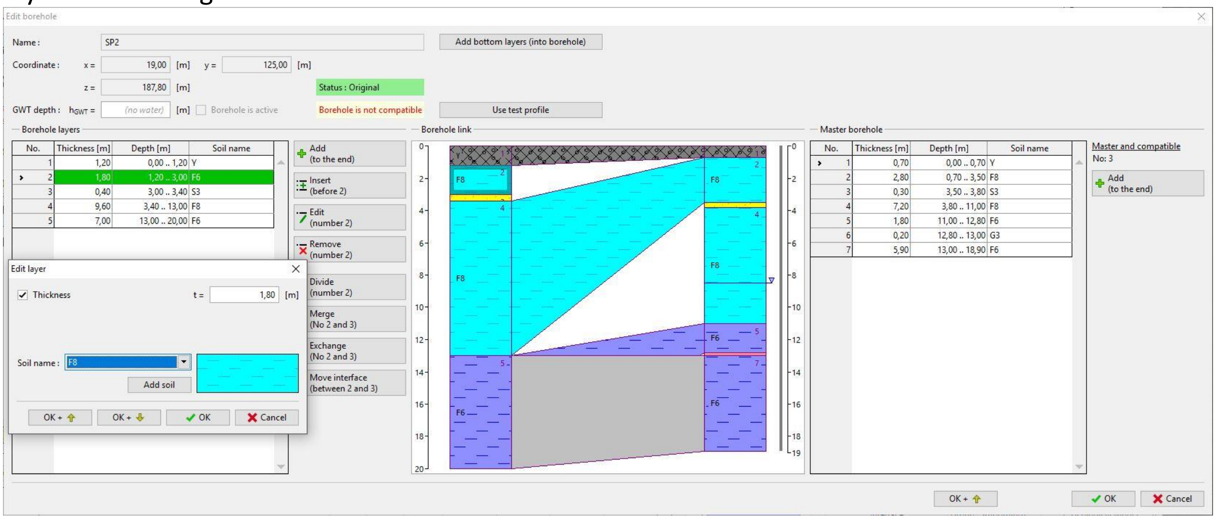
Modification of borehole SP2

Now it is time to modify the last borehole *SP2* – geological profile in this borehole was generated according to the automatic soil classification (Robertson, 2010). The original state of the borehole is shown in the picture below. Boreholes are not compatible, it is necessary to modify it.



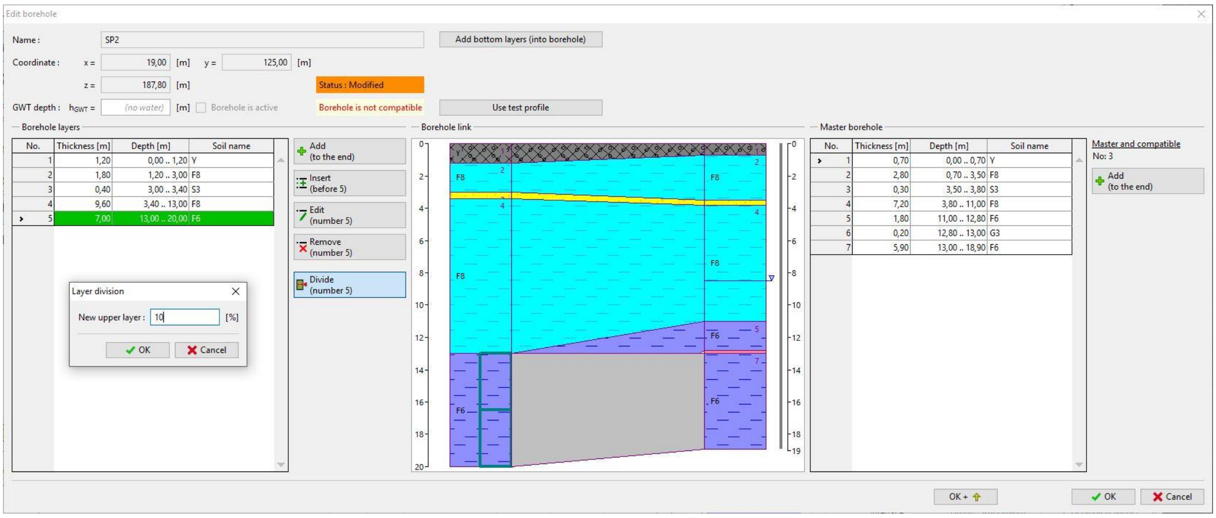
Original state of borehole SP2

The situation is more complicated in the upper part of the borehole. In borehole *SP2*, the layer of soil F6 is above the sandy layer, but in the master borehole, there is soil F8 in this layer. If we want to make the boreholes compatible, we could perform the same modifications as we did for the previous boreholes (dividing the layers and inserting new layers). Because there is no such order of layers in other boreholes and since the geological profile in this borehole was created by automatic soil classification, which doesn't always have to be absolutely exact (especially for similar soil types – F6, F8), we will assume, that layer F8 is above the sandy layer in this borehole, too. Therefore, we select layer 2 and change the soil from F6 to F8.

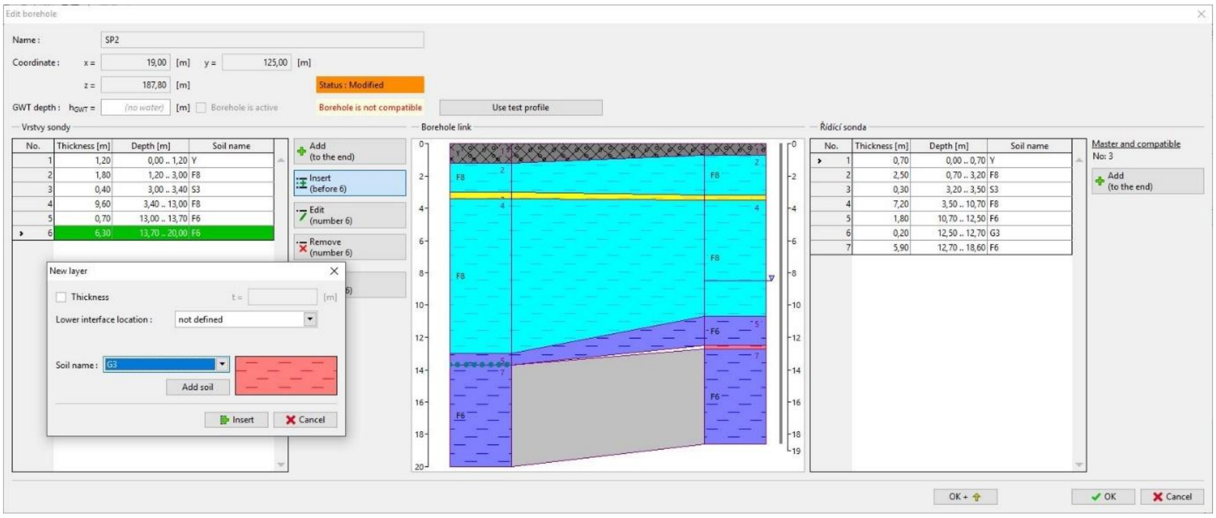


Changing the soil in layer 2 (F6 -> F8)

This way, we made the boreholes compatible in the upper part. In the bottom part, we do the same modifications as we did for boreholes *JV1* and *SP1*. We divide layer 5 (upper layer – 10 %) and insert a gravel layer G3.

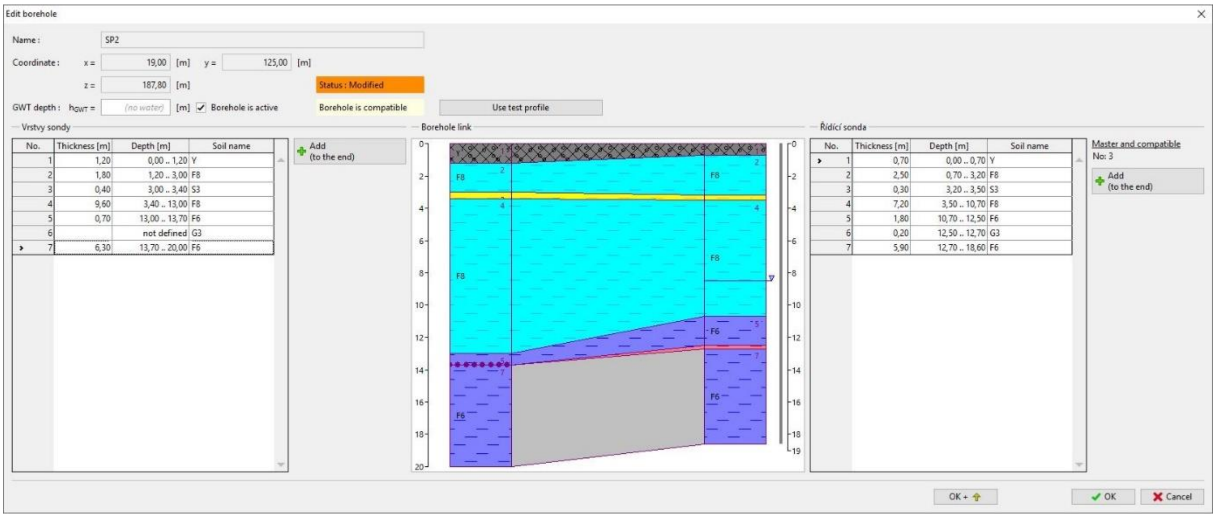


Dividing layer 5 (F6)



Inserting a new layer G3

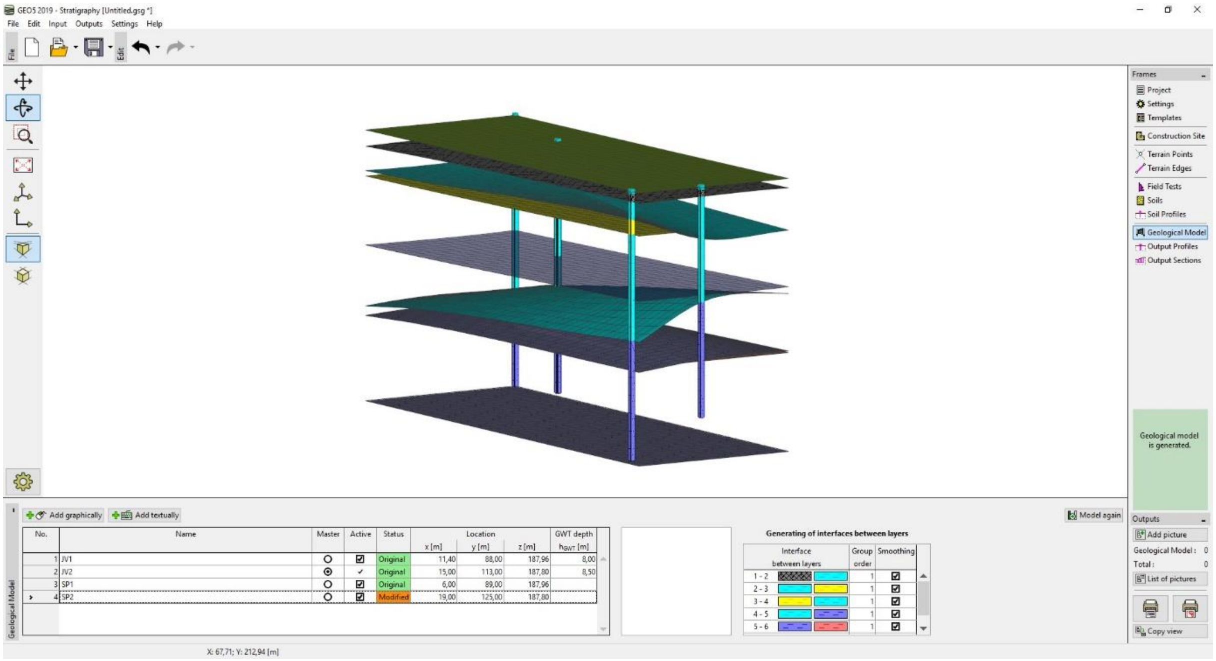
Borehole *SP2* is now compatible with master borehole *JV2*.



New state of borehole SP2 – the borehole is compatible with the master borehole

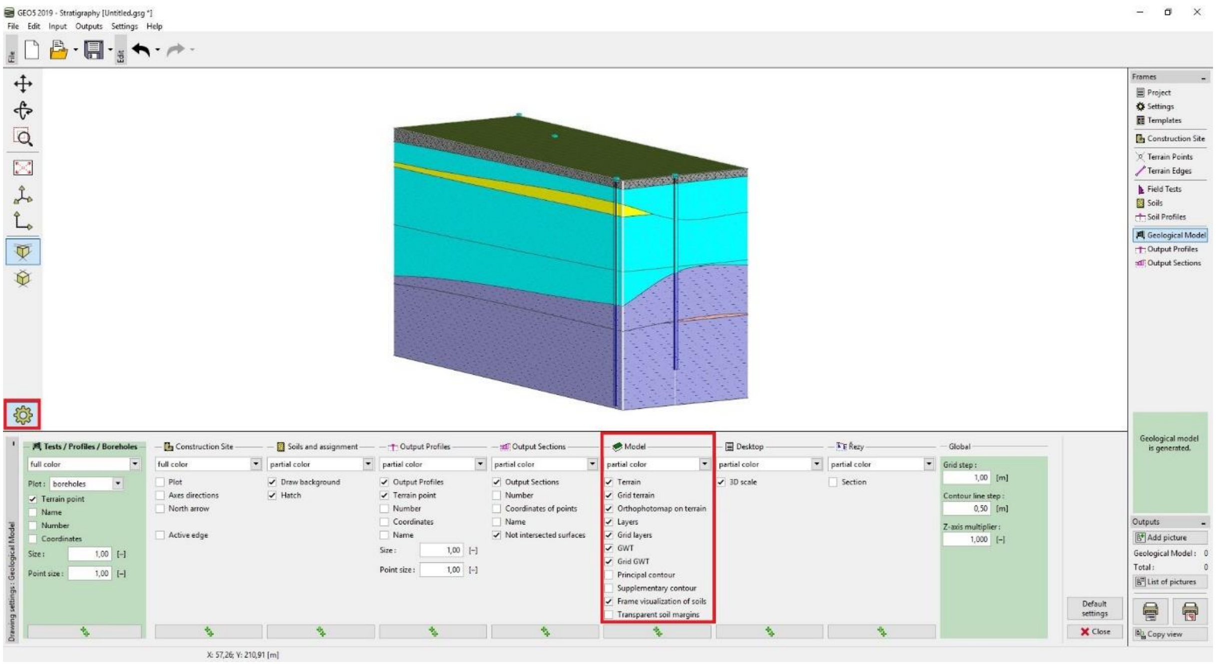
Final modifications

In the frame "Geological Model", we can see that all boreholes are now compatible. The geological model is generated according to all the tests (boreholes and CPTs).



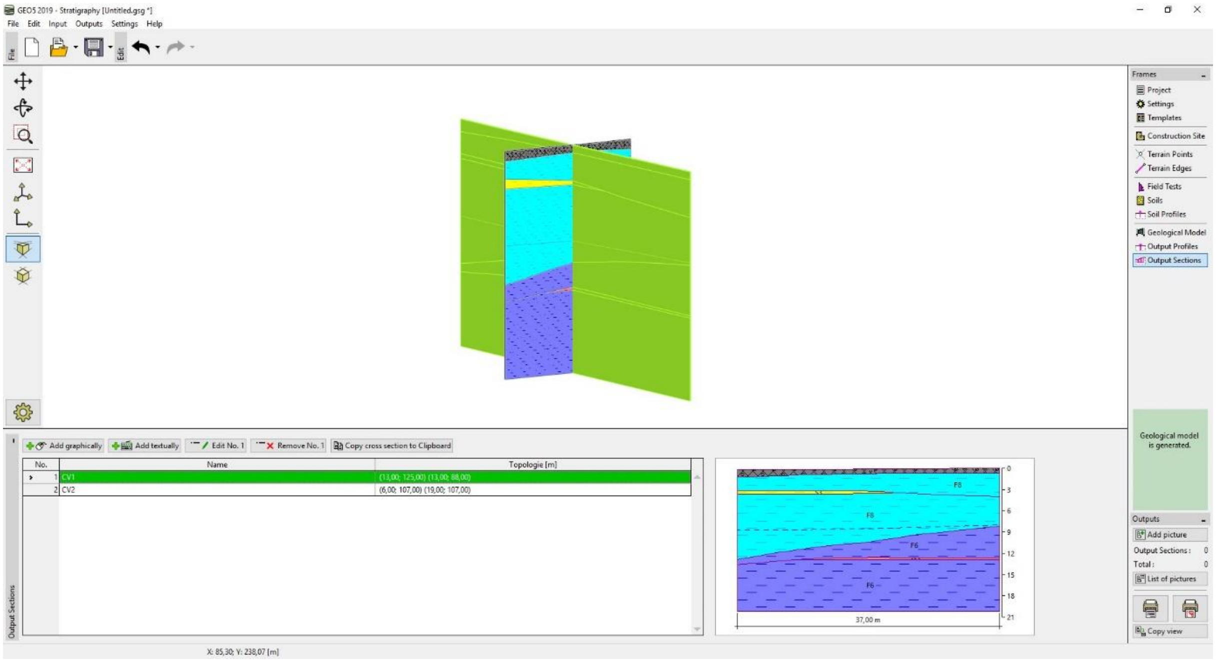
Frame "Geological Model" – generated model

For better clarity, we open the drawing settings (button with a cogwheel symbol on the left side of the screen) and select the option "Frame visualization of soils".



Frame "Geological Model" – visualization of frame soils

In the last step, we will go to the “Output sections” frame and add two perpendicular cross sections. Cross-sections are defined as follows: CV1 [13,0; 125,0]; [13,0; 88,0] and CV2 [6,0; 107,0]; [19,0; 107,0].



Frame “Output Sections”

Conclusion

We focused on some basic work with the “Stratigraphy” program in this manual, specifically on the creation of geological profiles according to the performed boreholes and cone penetration tests (CPT). We also carried out modifications of boreholes to make them compatible. It is important to note that this model was only created for the purpose of showing the different program features and modelling possibilities. In the engineering praxis, this model would be probably created in a different way – e. g. sandy and gravel layers with small thickness would be probably neglected. The “Stratigraphy” program also allows the user to create complex geological models in an easy way. The following engineering manual (No. 39) will be focused on those practises. The next manual will feature some easy modifications of the geological layers but also more difficult topics such as creating soil lenses or geological faults.