Regions with no reduction

Program: FEM

File: Demo_manual_35.gmk

Introduction

Assessing the state of stability of a geotechnical construction with the help of finite element method consists of gradual reduction of shear strength parameters up to the point when the limiting state of equilibrium between the loading and bearing capacity of the structure is exceeded. This state is manifested by the loss of convergence of the nonlinear numerical analysis. The function *Regions without reduction* allows for selecting elements which are excluded from the parameter reduction during the stability analysis.

When to activate *Regions without reduction*

To suppress the reduction of shear strength parameters makes sense when:

- The search for the global factor of safety generates local plastic zones in the domain which do not resemble the global slip surface but may still lead to the loss of convergence.
- Due to influence of boundary conditions and the size of the computational model the localized plastic zones, initiated by the global slip surface, progress unrealistically deep into the domain.

Which material models are applicable with *Regions without reduction*

The function *Regions without reduction* is applicable with models permitted in the stability analysis (Analysis type: Slope stability), i.e.

- Mohr-Coulomb
- Modified Mohr-Coulomb
- Drucker-Prager

Soil properties in Regions without reduction

Elements in the *Region without reduction* keep their properties determining their stiffness and shear strength (cohesion and angle of internal friction) during the entire stability analysis. These elements may therefore experience plastic deformation.

What to be aware of when using *Regions without reduction*

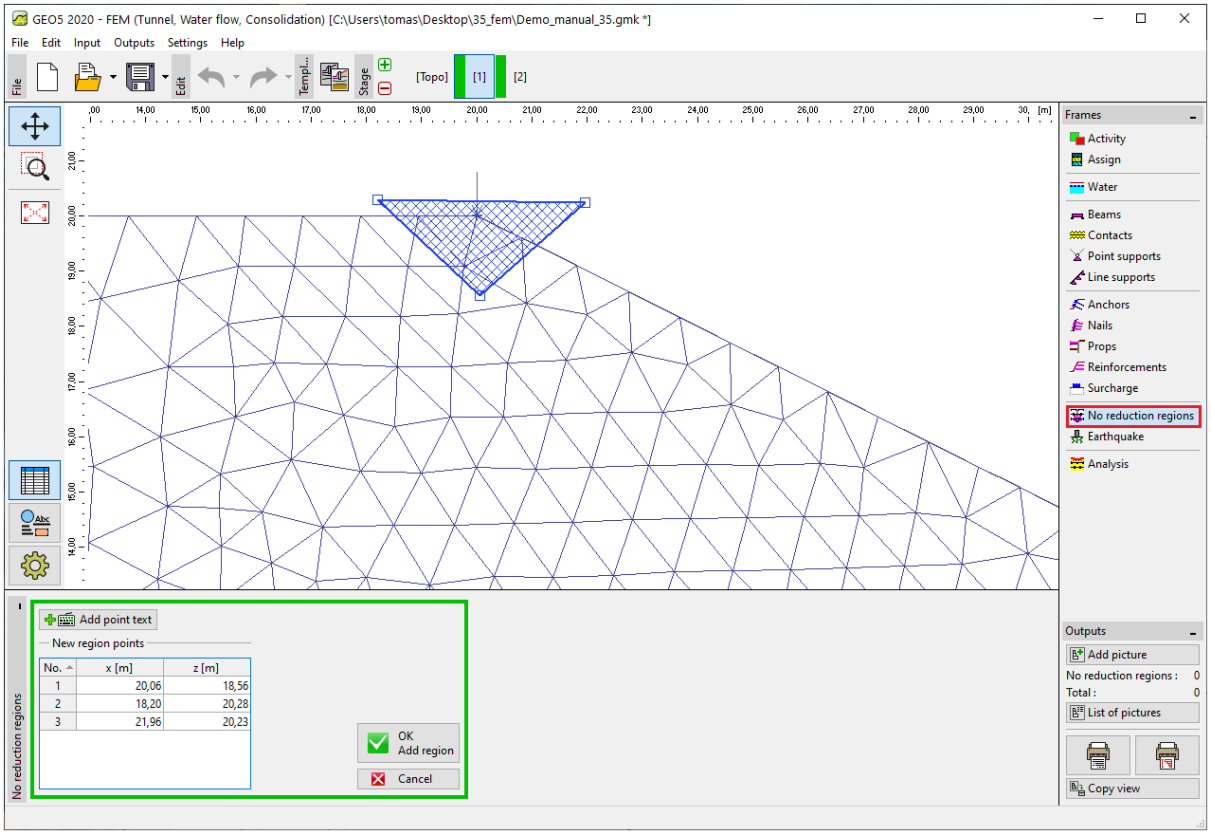
When using *Regions without reduction* we should keep in mind that there is no reduction of shear strength parameters in the selected elements. Therefore, *Regions without reduction* should not interfere with the global slip surface since in this case they would influence the resulting value of the factor of safety.

How to define *Regions without reduction*

Note: To assess stability in a given stage of standard stress analysis it is possible to open the stability analysis window. In this window, however, the function Regions without reduction is not accessible. Should we like to exploit this feature we first save this file using the option „File-Save as“. Upon

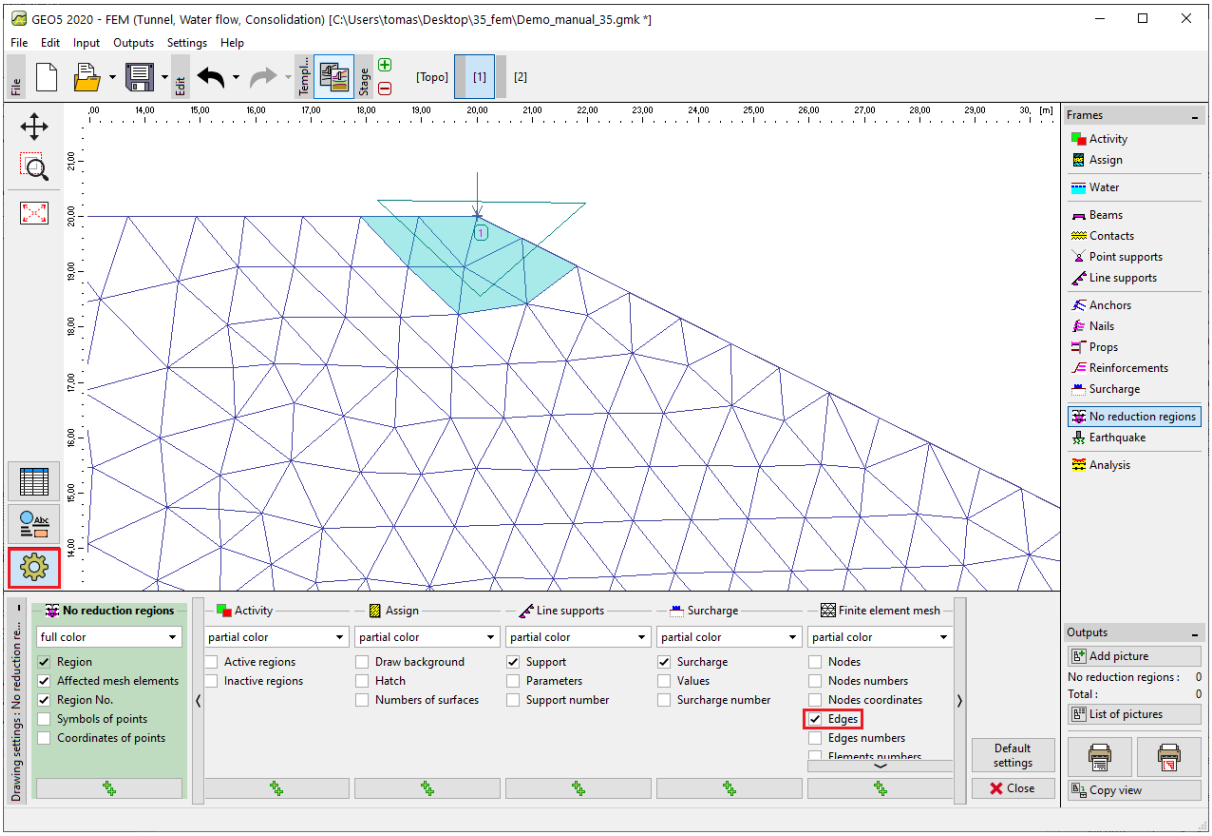
opening the new file in GEO5 FEM the program automatically selects the „Analysis type: Slope stability“, where the function Regions without reduction can already be adopted.

Region without reduction is specified in the selected calculation stage when using the stability analysis computational mode. A polygonal region is defined by inputting its vertexes directly on the screen. All elements, which at least partially fall within this region, are highlighted.



Screen for defining Regions without reduction

Note: When defining a Region without reduction it appears useful to display the finite element mesh by checking Drawing settings -> Finite element mesh -> Edges, see Figure.



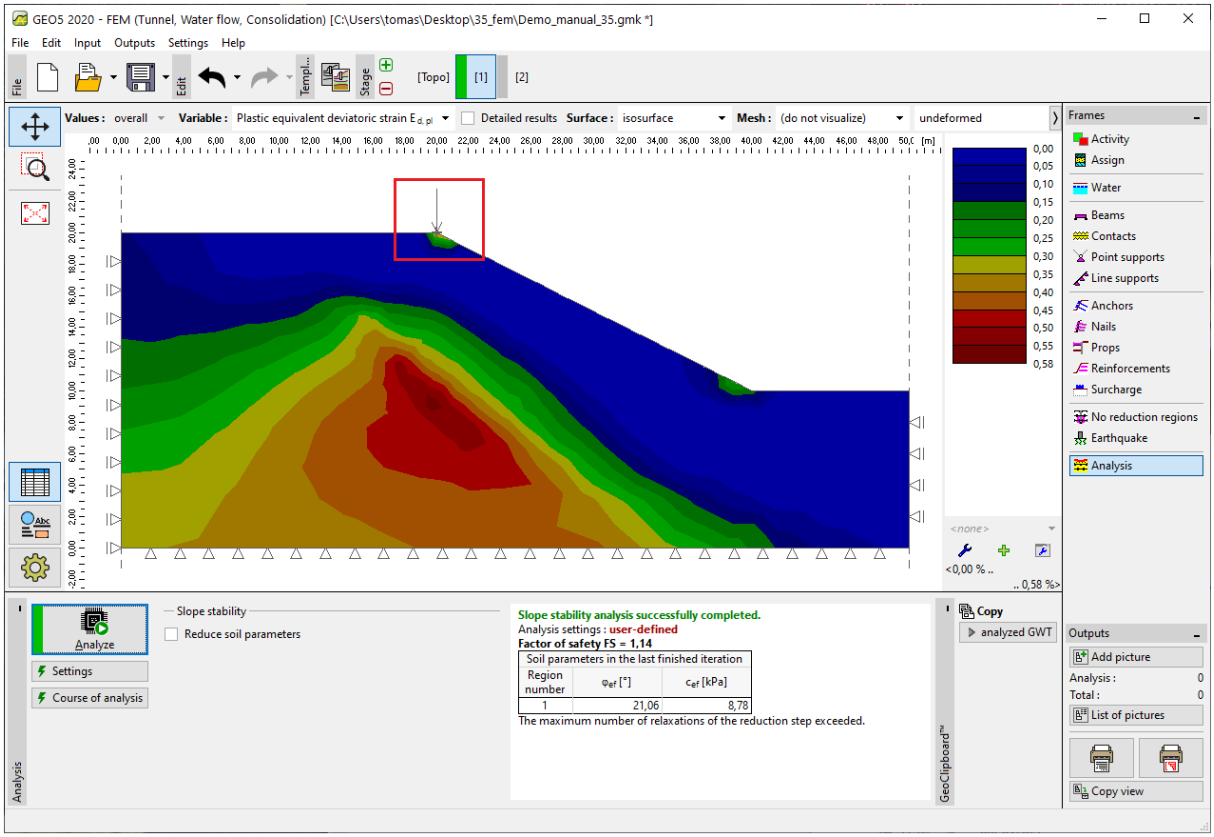
Setting finite element mesh visualization

The Region without reduction remains active also in subsequent stages, but it can be deactivated. Removing this region in the subsequent calculation stage allows again for the reduction of strength parameters in respective elements.

Example of application of *Region without reduction*

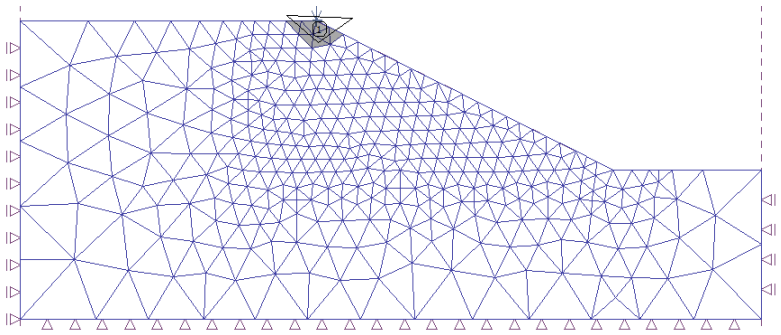
Application of regions without reduction of shear strength parameters will be illustrated through the stability analysis of a slope loaded by a line loading located on the top edge. Geometry and material parameters of soil in the homogeneous profile are inputted in the Demo_manual_35.gmk file.

The resulting distribution of the equivalent plastic strain corresponding to the loss of stability in case of standard analysis is plotted in the Figure below. It is clear that apart from a local plastic zone developed at the point of application of the line loading, the analysis predicts an unrealistic evolution of plastic strains in the central region of the analyzed domain associated with the size of the domain and boundary conditions. The present distribution of the equivalent plastic strain does not certainly indicate evolution of the global slip surface. From this point of view, the predicted value of the factor of safety equal to 1.14 is not reliable.



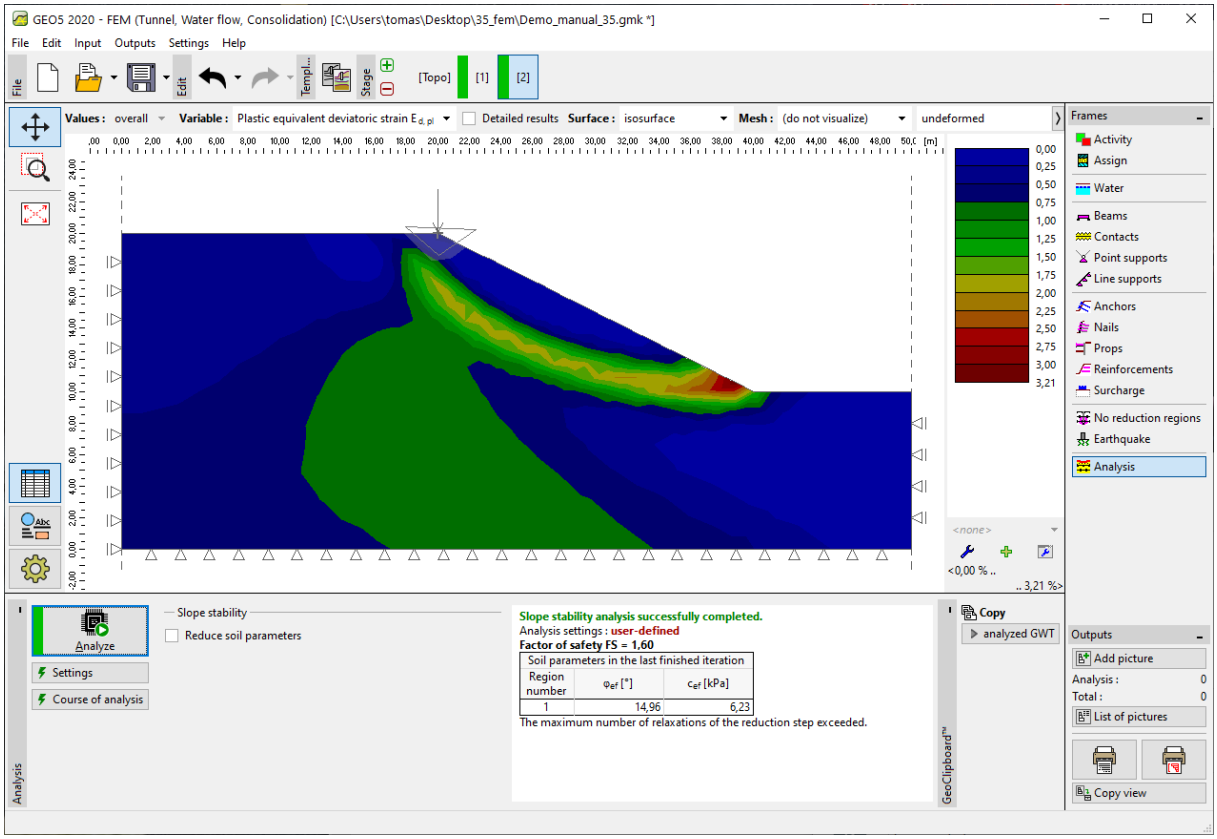
Unrealistic distribution of equivalent plastic strain

In the subsequent calculation stage we introduced a small region without reduction around the point of load application.



Extension and location of Region without reduction

The results of slope stability analysis exploiting the *Region without reduction* are plotted in the following figure. In this the analysis predicts the shape and location of the global slip surface relatively well. Parasite plastic strains in the central region caused by boundary conditions are still present, but in this case they are much smaller in comparison to those present within the slip surface and do not significantly contribute to the loss of stability. The resulting factor of safety equal to 1.6 is reasonable.



Distribution of equivalent plastic strain indicating evolution of the global slip surface

Conclusion

The function *Regions without reduction* available within the *Stability* computational mode allows in certain regions for suppressing the reduction of shear strength parameters of soils. This ad-hoc approach provides solution in cases when the analysis does not converge from other reason than is the global loss of structural stability.