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Stability analysis of a slope in the allotment garden complex „Am Poisenbach e.V." in Freital

Standsicherheitsuntersuchung einer Böschung in der Kleingartensparte „Am Poisenbach e.V." in Freital

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Introduction

Slope stability is a major topic in the field of geotechnical engineering, due to its great importance in preventing landslides and monitoring slopes for risk factors that may indicate signs of collapse. In this analysis, a slope was selected in Freital, Saxony to be studied. Figure 1 show a cross section along the slope.

The Limit Equilibrium method was used for the analysis, a technique that has been developed and refined upon by many authors over the years. After comparing five chosen models, the Janbu Model [1] was selected for analysis.

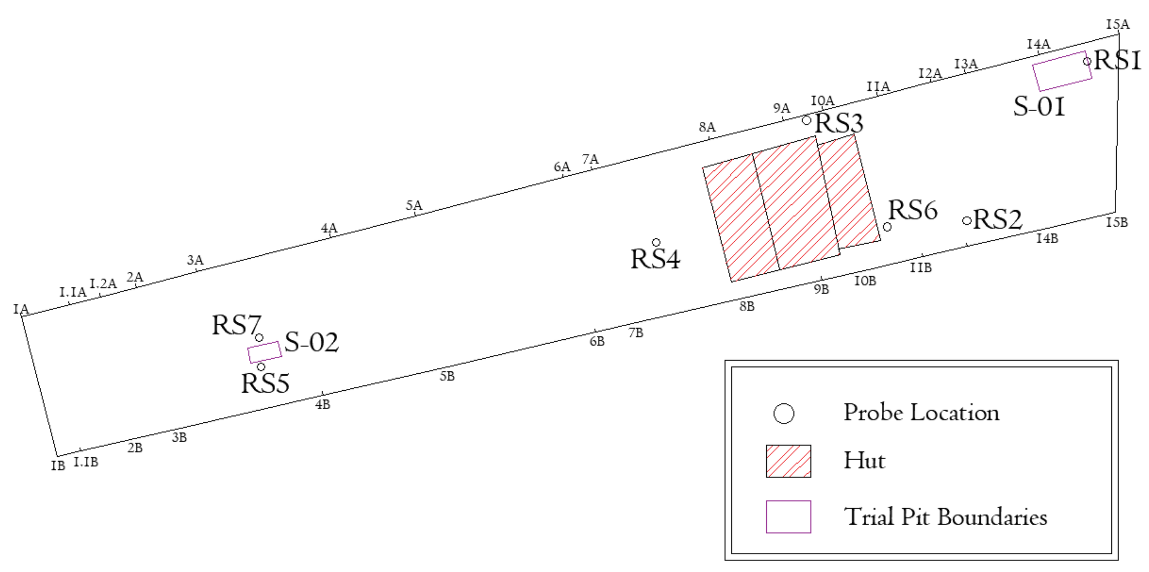

Fig. 1: Map of the site showing the locations of the tests.

Field Tests & Surveying

In order to acquire information about the topography of the slope and about the soil layers comprising the slope, multiple site visits were undertaken in order to measure the site using surveying methods. These measurements were later compared against publically available LiDAR data. The two methods were found to be in agreement, as Figure 1 shows.

Field tests were comprised of two parts; dynamic probing and trial pits. Seven probes were hammered into the slope, the locations of which can be seen marked on Figure 1. In dynamic probing, a series of steel rods in driven into the earth and the number of blows needed for each 10 cm of penetration is recorded.

The number of blows needed is a good proxy for the relative density of the soil layers. By comparing the results from the probes, a rough layer boundary could be approximated (shown in Figure 2), which was used later on in creating the model.

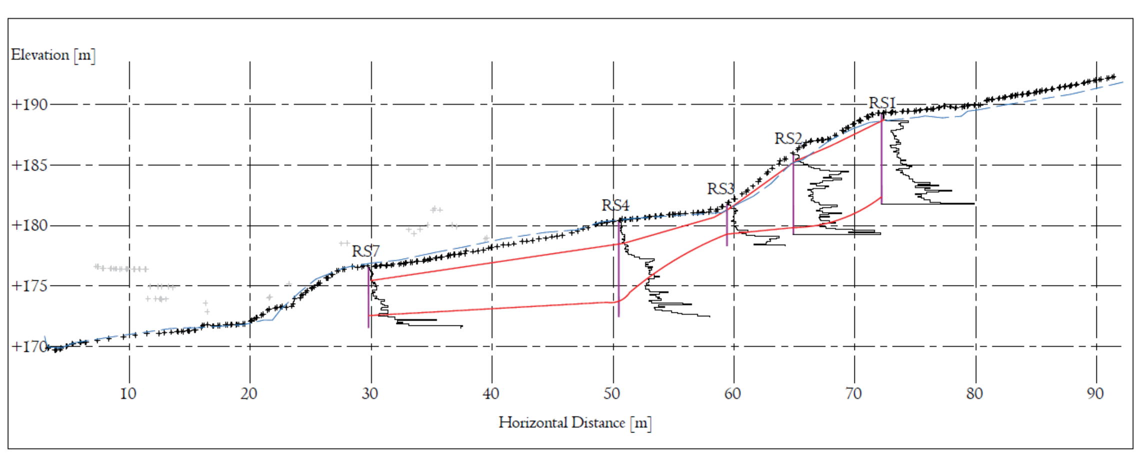

Fig. 2: Longitudinal cross-section along the slope with probing results, showing the assumed layer boundaries in red

In order to acquire soil samples for lab testing, two trial pits were excavated and the uncovered layers were noted. The pit S-01 contained two layers beneath the surface layer, which were named S-01/1 & S-01/2. Similarly, pit S-02 contained 3 layers, the samples thereof were named S-02/1, /2, & /3; in order of increasing depth. Sampling cylinders (three per pit) were also used to acquire undisturbed samples from both pits.

Laboratory Experiments

Experiments were carried out on the five samples in order to determine their physical & mechanical properties. Figure 3 shows the results of the sieving and hydrometer analysis, which, together with the Atterberg limits determination, allowed the soils to be classified. The main test used for determining the material parameters of the soils was the direct shear test, which allowed the friction angle and effective cohesion of the soil to be measured (see Figure 4). These parameters were used as input for the modeling. Fall cone tests and a triaxial test were also done in order to determine the undrained shear strength of the undisturbed samples.

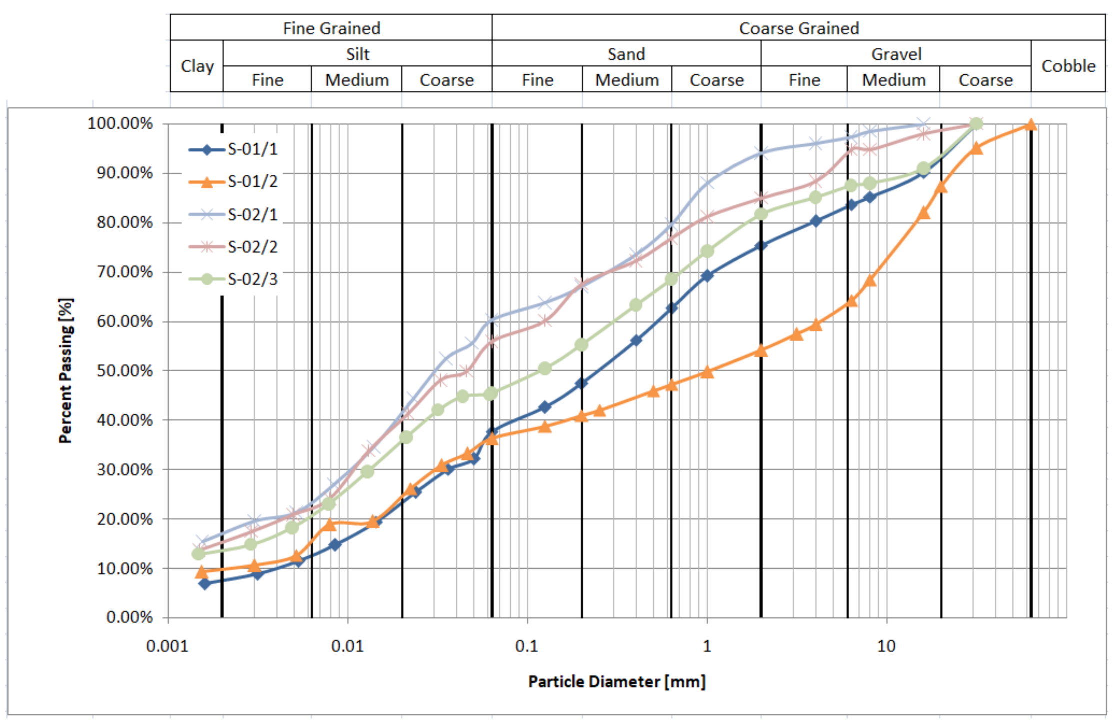

Fig. 3: Grain size distribution curves for all five soil samples.

The unit weight of the soil was determined by measuring the bulk density of the undisturbed samples extracted from the sampling cylinders.

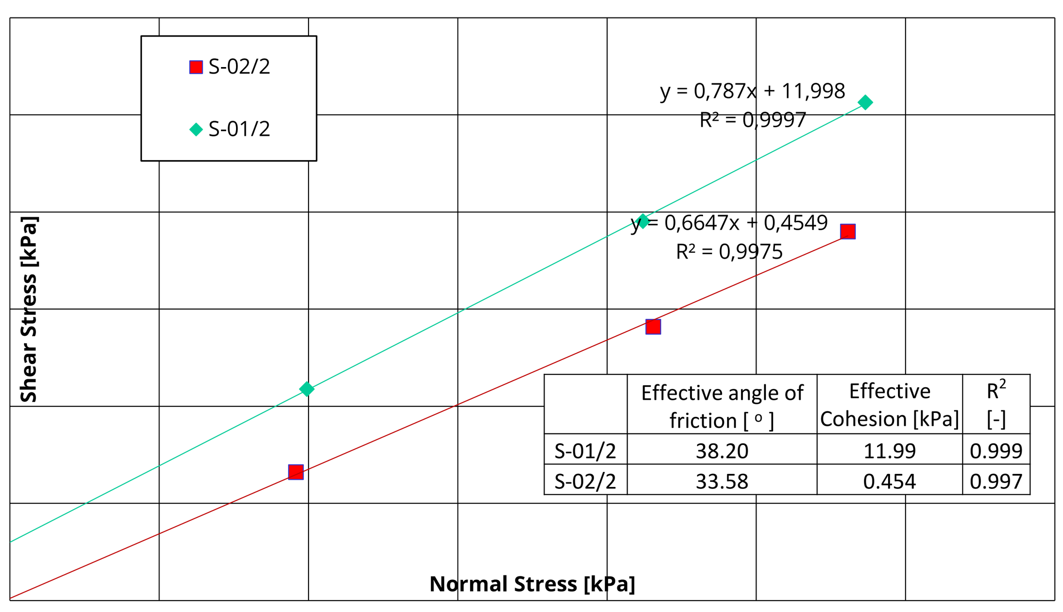

Fig. 4: The results of the direct shear tests and the derived parameters

Modeling Output

A software model was created using SLOPE/W. Since the slope is comprised of two steep slopes with a flatter part in between, the analysis was run three times, one for each of the slope and once for the entire slope system. Since ground water conditions were unknown, the models were run twice, in both dry & saturated conditions. The water table was simulated using a piezometric line drawn in the model.

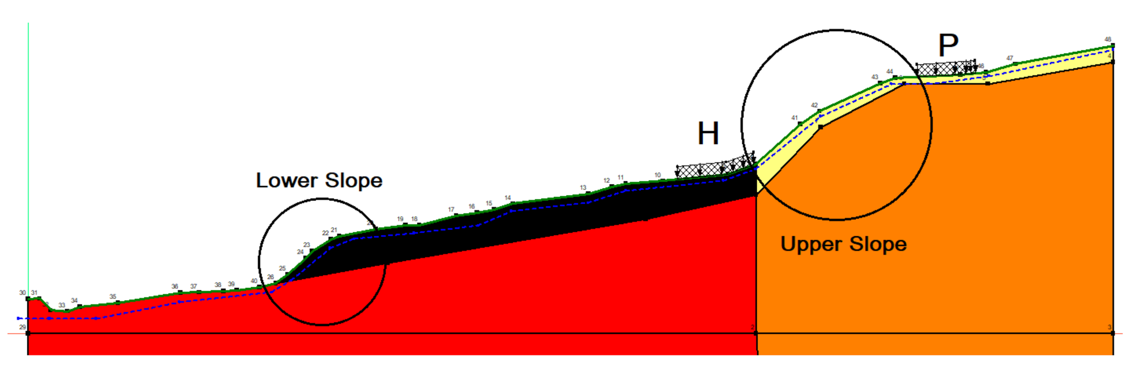

Fig. 5: Overview of the slope model. The loads H and P refer to the weight of the hut and the surcharge load respectively.

Under drained conditions, the results showed that the full slope system is stable, and that the upper slope is stable and capable of resisting a high superimposed surcharge load on the upper plateau. The lower slope was not stable and appears to be in a critical condition.

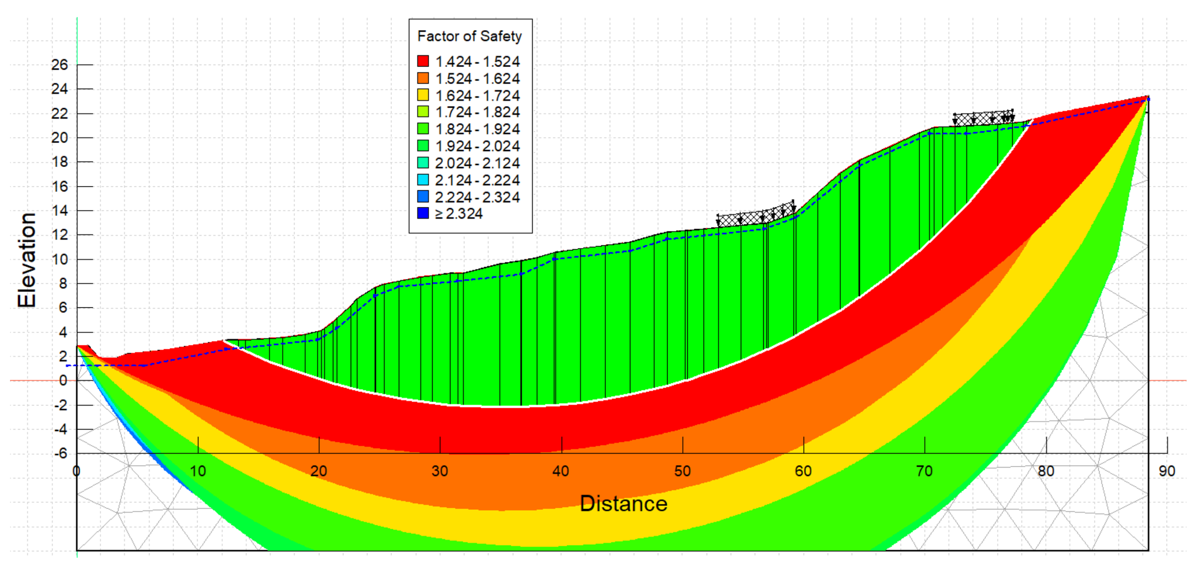

Fig. 5: Drained Model output for the full slope system under saturated conditions– All distances are in meters

To account for current stability of the lower slope, it was assumed that the vegetation growing on it was providing a form of stabilizing or anchoring. This assumption was tested in the model by raising the friction angle of the surface layer and varying its thickness. The results showed that the roots of the plants would have to extend deeply (> 2 m) to stabilize the lower slope sufficiently.

Load conditions on the upper slope were varied, alternately adding and removing the weights of the hut and of the upper load. It was discovered that the weight of the hut plays an important role in the stabilization of the upper slope, significantly increasing the factor of safety.

Summary

In conclusion, the thesis was able to analyze the stability of the slope system thoroughly. The Janbu model was found to be the most conservative of the tested models. The resulting factors of safety are presented in Table 1. Further research is needed in order to determine what other additional factors may be influencing the stability of the slope.

Slope System	Factor of Safety
Full Slope	2.794
Lower Slope	0.951
Upper Slope	2.360
Full Slope - Saturated Conditions	1.426
Lower Slope - Saturated Conditions	0.743
Upper Slope - Saturated Conditions	1.260

Table 1: Results of the Janbu model for the three slope systems under dry & saturated conditions.

3D analysis of the slope would be illuminating regarding the effect of the additional topographic information on the lower slope stability in particular.

Literature

[1 Janbu, N., London, U.K.,1957. Proceedings of the Fourth International Conference on Soil Mechanics, pp. 207-212.

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