GeoStudio Example File
Basic Probabilistic Stability Analysis

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Introduction

A probabilistic analysis can be done in SLOPE/W to characterize the risk of failure due to variability in material properties, pore-water pressure conditions, surcharge and point loads, and reinforcement parameters. This example illustrates how to conduct a probabilistic analysis in SLOPE/W.

Numerical Simulation

Figure 1 shows the model configuration, which comprises an embankment over a foundation soil. There are a total of four analyses in the GeoStudio Project. Analyses 1 and 3 are set as the Parent for Analyses 2 and 4, respectively. Both Parent analyses are deterministic, which implies that the inputs are constant. The children analyses are exactly the same as the Parent except that both use the probabilistic option. The probabilistic analysis is only performed on the five (5) critical slip surfaces saved in the Parent analysis (Figure 2).

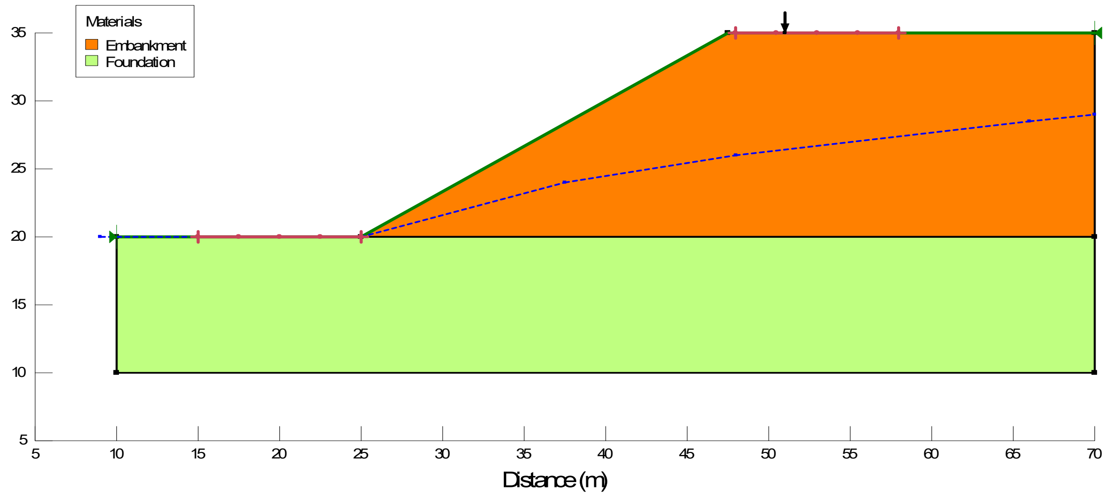

Figure 1. Problem domain for stability analysis.

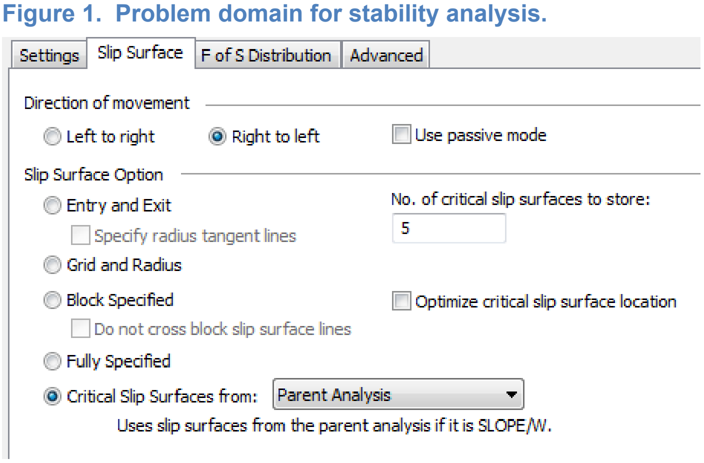

Figure 2. Example of setting the critical slip surface to the Parent.

The probabilistic inputs for Analysis 1 are shown in Figure 3. In SLOPE/W, the dispersion in the input data is described using a probability offset function. For example, the friction angle (ϕ') of the embankment material is shown in Figure 4. The offset of the mean is zero; that is, the normal distribution of ϕ' will be centered at the deterministic value specified as 30°. The dispersion is specified as one standard deviation. This means ϕ' will vary between 25 and 35°

or ϕ' will be 30±5°. The probability density function and the sampling function are shown in Figure 5 and Figure 6, respectively. Although not used in this example, a c-Phi correlation can be specified and the sampling distance can be specified (see SLOPE/W engineering book).

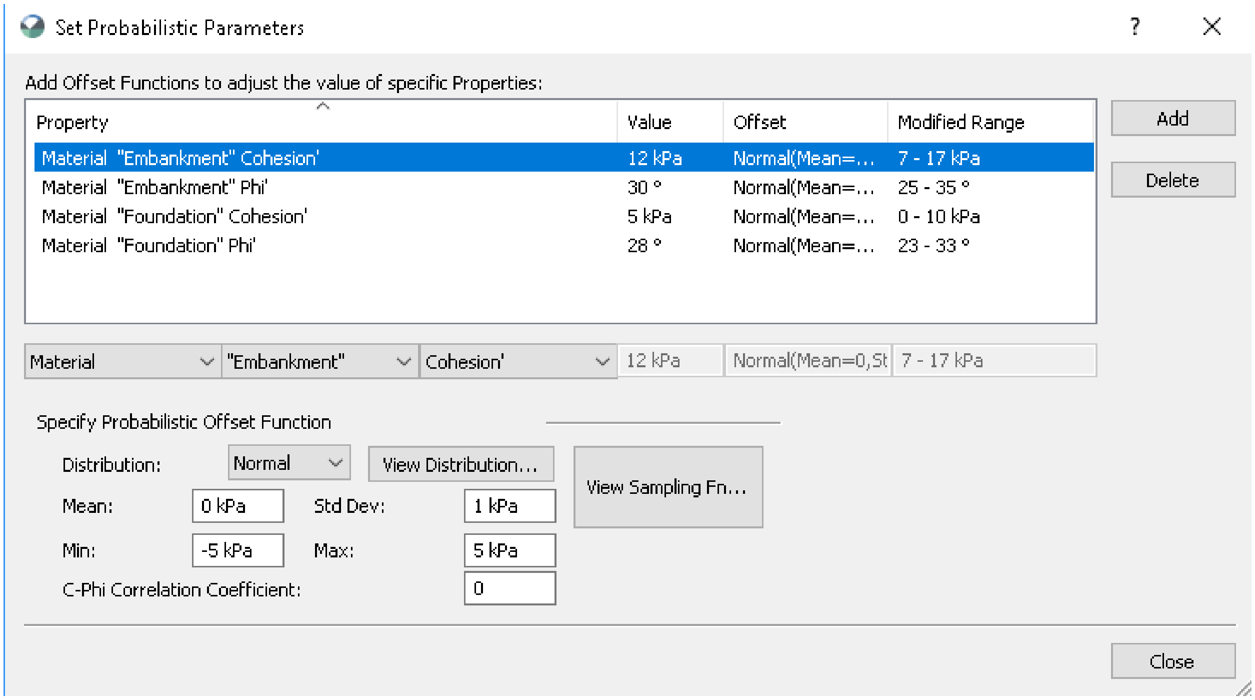

Figure 3. Probabilistic parameters for Analysis 1.

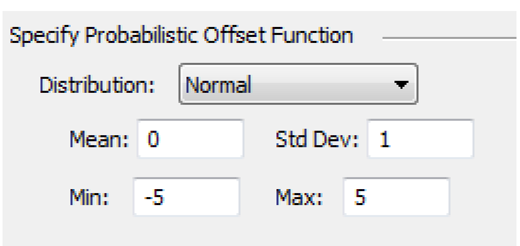

Figure 4. Friction angle offset function properties.

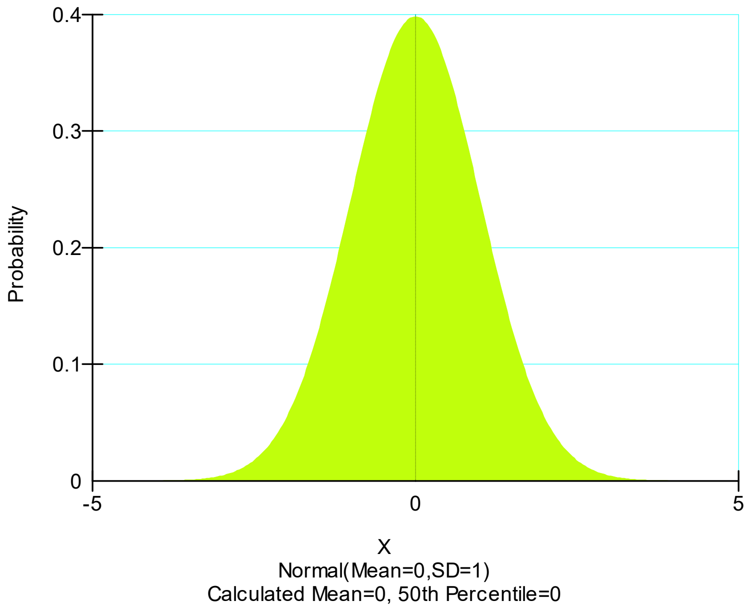

Figure 5. A typical probability density function.

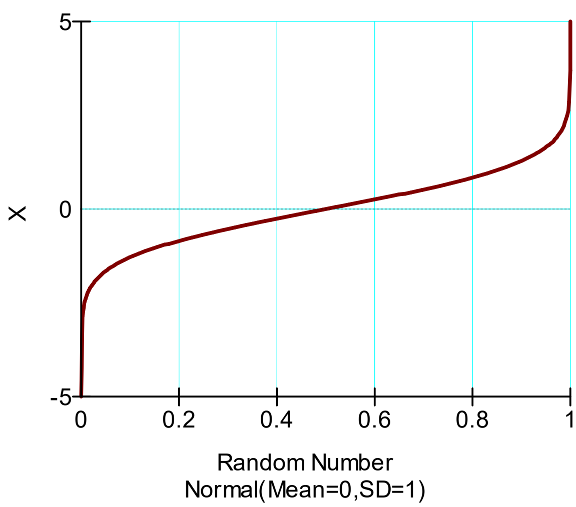

Figure 6. A typical sampling function.

Results and Discussion

Figure 7 presents the location of the critical slip surface and deterministic FOS for Analysis 1. A summary of the probabilistic results for Analysis 2 are given in Table 2. It shows the minimum and maximum safety factors. In this example, the slip surface with the lowest factor of safety also has the lowest probabilistic factor of safety (Slip # 1). This trend may not always occur. Notice that the lowest minimum factor of safety for slip surface #3 is lower than for #2.

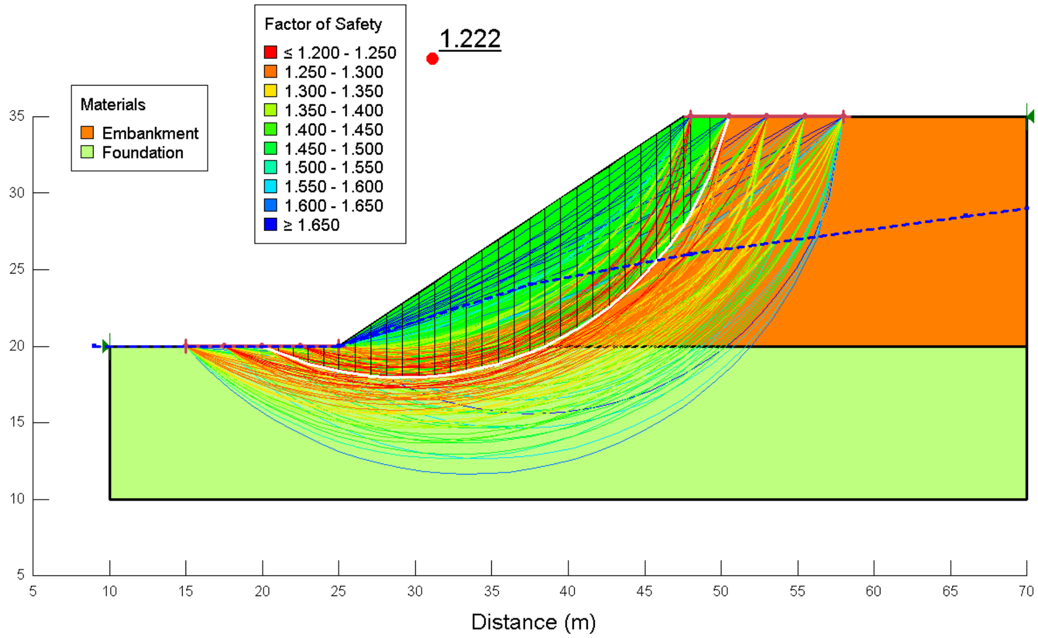

Figure 7. Deterministic FOS and location of critical slip surface for the Analysis 1.

Table 2. Probabilistic results for Analysis 2.

Slip #	F of S	P(Failure)	Reliability Index	Mean F of S	Std. Dev. F of S	Min. F of S	Max. F of S
1	1.222	0	5.8551	1.2219	0.037903	1.02	1.3328
2	1.224	0	5.9703	1.2241	0.037537	1.0232	1.3376
3	1.227	0	5.7972	1.227	0.039158	1.0202	1.346
4	1.229	0	5.9441	1.2288	0.038494	1.0204	1.3423
5	1.231	0	5.924	1.2303	0.038871	1.0249	1.3517

For each trial slip surface, it is possible to view the resulting Probability Density Function and Probability Distribution Function (Figure 8 and Figure 9). The probability of failure is zero because the minimum factor of safety is always greater than 1.0. Stated another way, the results indicate that there is 100% certainty that the factor of safety will not fall below 1.0 given the variability of the inputs. The minimum factor of safety, however, is close to unity.

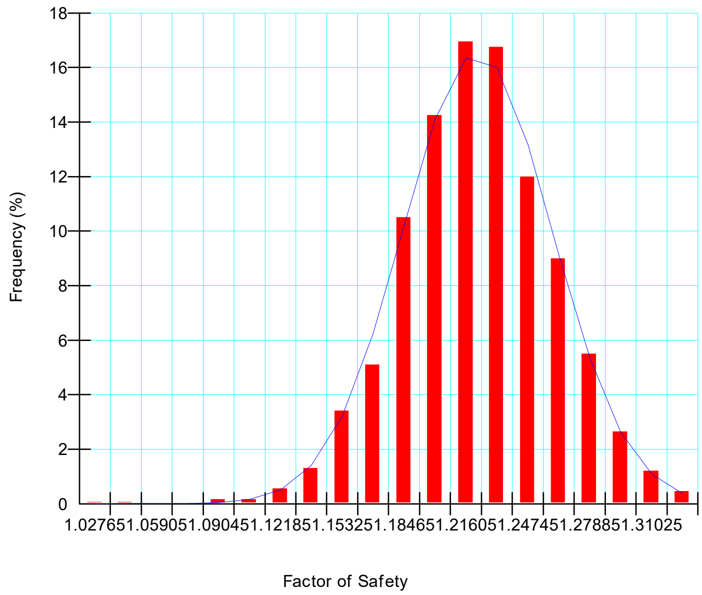

Figure 8. Probability density function for Slip #1.

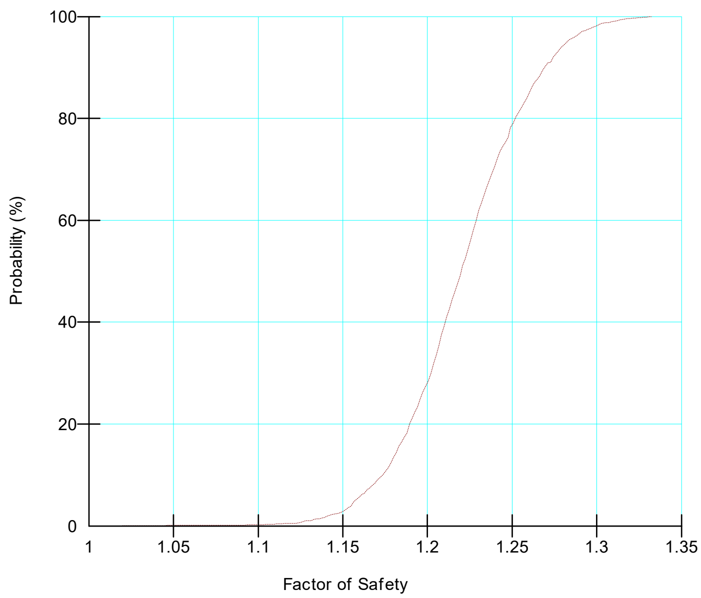

Figure 9. Probability distribution function for Slip# 1.

The addition of the point load reduces the deterministic FOS from 1.22 to 1.208. The probability of failure changed very little compared to Analysis 2, especially given that the load only varied between 75 and 125 kN.

Summary and Conclusions

This simple example demonstrates how to establish a probabilistic analysis in SLOPE/W. A probabilistic analysis can be performed on a variety of inputs including material properties, pore-water pressure conditions, external loads, and reinforcement inputs such a pull-out resistance and spacing. SLOPE/W accommodates a variety of distributions including normal, log-normal, triangular, uniform, or a user-specified spline function. Both the inputs and results can be interpreted in the context of a probability distribution function or probability density function. The results include such outputs as the probability of failure, the minimum and maximum FOS, reliability index, and other key information.