WORK INSTRUCTIONS FOR ENGINEERS

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OP-015. PROCEDURE FOR OBTAINING SHEAR STRENGTHS PARAMETERS FROM BACK-ANALYSES OF IDENTIFIED SLIP SURFACE

15.0 PROCEDURE FOR OBTAINING SHEAR STRENGTHS PARAMETERS FROM BACK-ANALYSES OF IDENTIFIED SLIP SURFACE

15.1. INTRODUCTION

A brief guide on obtaining shear strength parameters from back-analyses of identified slip surface.

15.2. REFERENCES

1) Wesley, L. D. and Leelaratnam, V. (2001) Shear strength parameters from back-analysis of single slips. Geotechnique 51, No.4, p. 373-374.
2) Yamagami, T. & Ueta, Y. (1996) Back analysis of strength parameters for landslide control works. Proceedings of the International Conference on Landslides (ed D. H. Bell), Christchurch, New Zealand, pp. 619-624, Balkema : Rotterdam.

15.3. LIMITATIONS

The methods described above are applicable only to slopes consisting of homogeneous materials. Therefore, the methods should be used with caution.

15.4. METHODS

15.4.1. Method A

1) Model the geometry and groundwater condition of the failed slope. (Refer Fig. 1)
2) Perform slope stability analyses by fixing the actual failure surface. Obtain combination of c' and ϕ' with Factor of Safety = 1.0.
3) Perform slope stability analyses using the combination of c' and ϕ' obtained from Step 2 to indicate the most critical slip surface with the calculated Factor of Safety. (Refer Fig. 2)
4) Only one of the slip circles has a Factor of Safety near to 1.0 in which the slip surface is also very close to the identified slip surface. The values of c' and ϕ' of this slip surface will be the true shear strength for the slip surface.

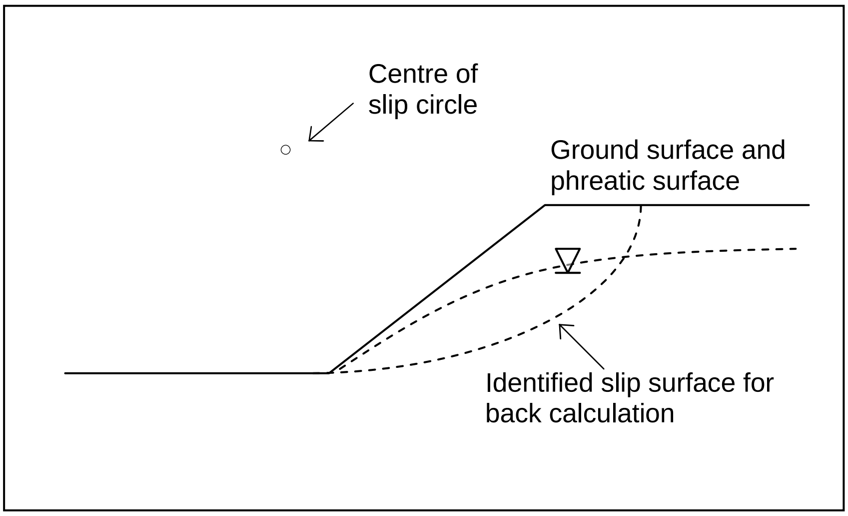

Fig. 1. Geometry showing the position of the actual slip circle

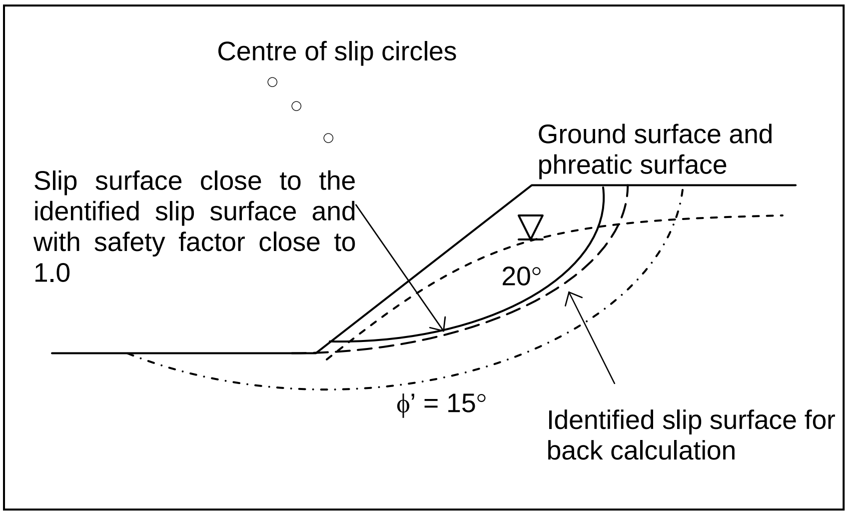

Fig. 2. Critical circles obtained using the shear strength parameters obtained from back-analysis of the actual slip circle

15.4.2. Method B

1) Model the geometry and the groundwater condition of the failed slope. (Refer Fig. 1)
2) Perform slope stability analyses by fixing the identified slip surface. Obtain a range of values for c' and φ' for Factor of Safety = 1.0. Plot the set of values in graph c' VS tan φ'. The plot will resemble a straight line. (Refer Fig. 3)
3) Perform another slope stability analyses. Treat it as an intact slope and do not fix the failure surface. By adjusting either one of the strength parameters (c' or φ') against the other strength parameter with the Factor of Safety of 1.0, another range of c' and φ' value can be established. Plot the set of values in graph c' VS tan φ'. The plot will resemble a curve. (Refer Fig. 3) The point where the two sets of values coincide defines the true strength values that must apply in the field.

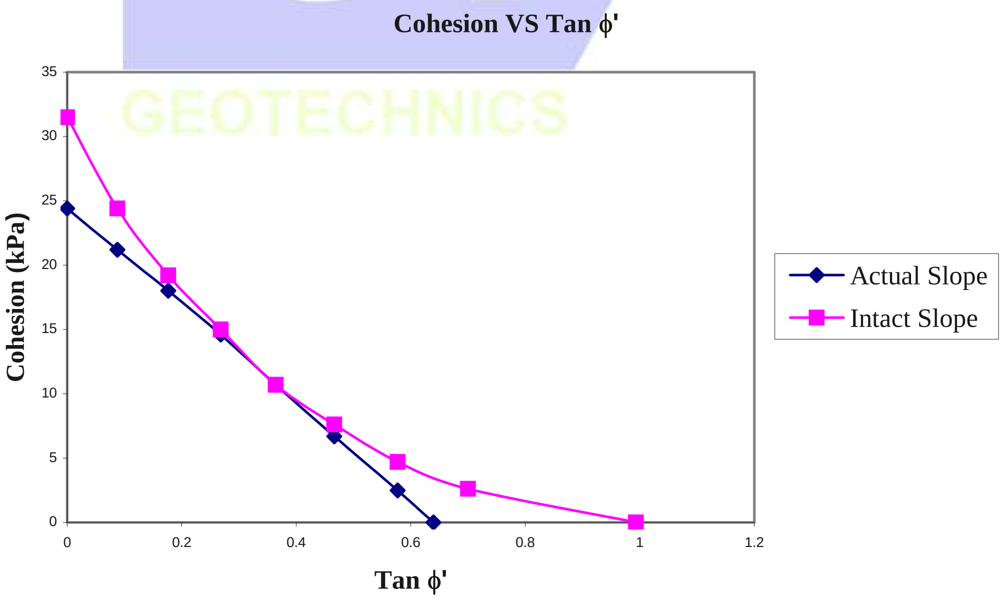

Fig. 3. Combinations of c' and tan f' giving factor of safety =1.0

15.4.3. Method C

1) Model the geometry of the failed slope. (Refer Fig. 1)
2) Perform slope stability analyses by fixing the actual failed slope. Obtain a range of c' and ϕ' values for Factor of Safety =1.0. Plot the failure envelopes for the respective combination of c' and ϕ' on the graph. (Refer Fig. 4)
3) Perform slope stability analyses for the intact slope. Obtain another range of c' and ϕ' values for Factor of Safety =1.0. Plot the failure envelopes for the respective combination of c' and ϕ' on another graph. (Refer Fig. 4)
4) Place one graph on top of another. Identify the envelope common to the intact slope and actual failed slope. The corresponding strength parameters for the common envelope will be the true strength for the actual slip surface.

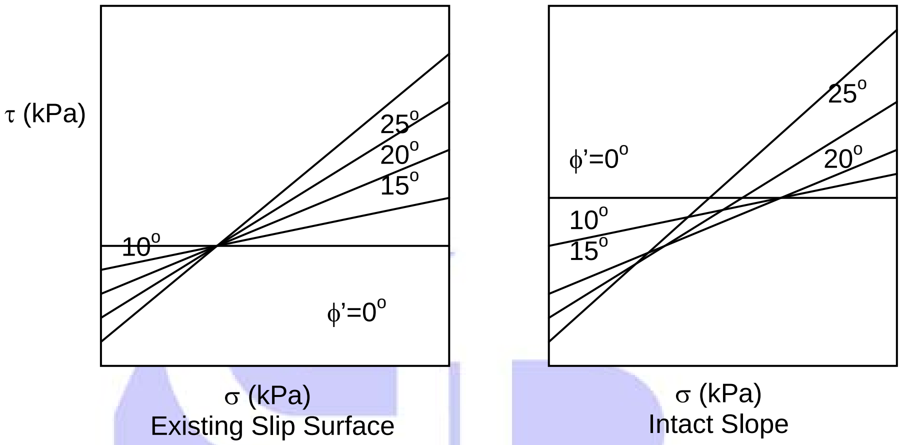

Fig. 4. Mohr-Coulomb failure envelopes from the existing slip surface and intact slope

15.4.4. Method D

15.4.4.1. First Method

1) Model the geometry of the failed slope. (Refer Fig. 1)
2) Perform slope stability analysis for the identified slip surface. Obtain a range of c' and ϕ' values for Factor of Safety= 1.0.
3) Using the combination of c' and ϕ' values obtained in Step 2, perform stability analyses for the intact slope. A range of Factors of Safety is obtained for the respective combinations of c' and ϕ'. Plot Factors of Safety VS tan ϕ' in a graph. (Refer to the lower curve in Fig.5)
4) The true value of the shear strength is obtained when the Factor of Safety= 1.0.

15.4.4.2. Second Method

1) Model the geometry of the failed slope. (Refer Fig. 1)
2) Perform slope stability analysis for the intact slope. Obtain a range of c' and ϕ' values for Factor of Safety= 1.0.
3) Using the combination of c' and ϕ' values from obtained in Step 2, perform stability analyses for the identified slip surface. A range of Factors of Safety is obtained for the respective combination of c' and ϕ'. Plot Factors of Safety VS tan ϕ' in the graph. (Refer to upper curve in Fig. 5)
4) The true value of the shear strength is obtained when the Factor of Safety= 1.0.

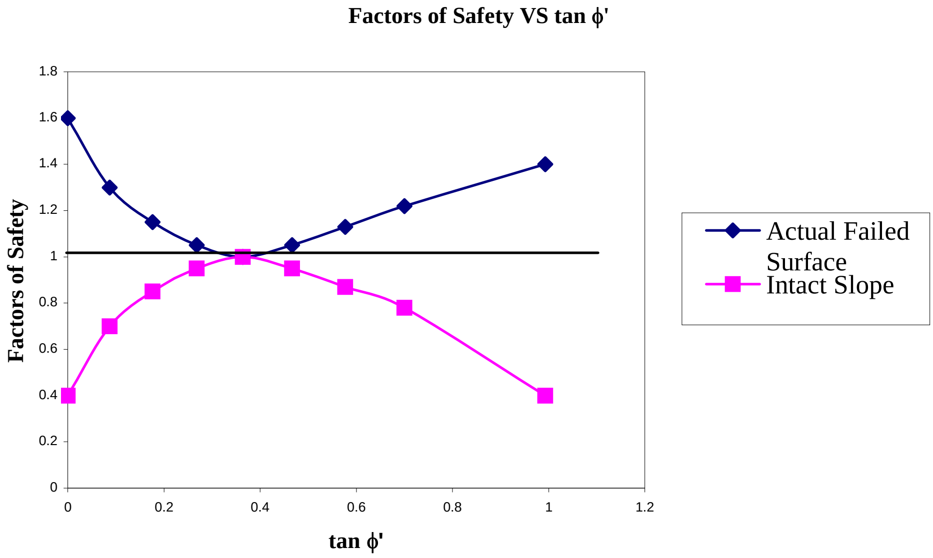

Fig. 5. Graph of Factor of Safety against tan f’ for identified slip surface and intact slope

15.5. USING STED TO OBTAIN BACK-ANALYSED SHEAR STRENGTH

STED or PCSTABL is used widely in G&P’s office for slope stability and analyses problem. Though STED can perform various types of analyses, it does not offer any option to control the radius of the slip circle (Bishop option). Thus, it is not easy to input the identified slip plane for the back-analyses purpose.

There are two options to input an identified slip circle and the options are described as below:

15.5.1. Method 1

1) Model the geometry of the failed slope and the identified slip circle in a Cad drawing. (Refer Fig. 1)
2) Obtain the diameter and the centre of the circle from the Cad drawing.
3) Calculate the coordinates of the points which the slip circle passes through. The interval of the points must be close enough that when the points are joined together, a smooth slip circle is produced.
4) Using the coordinates obtained from the Cad drawing, input the identified slip circle into STED using Type 7 Bishop, Specified Surface in the Analysis Type.
5) Specified the number of points and input the coordinates.
6) Once the slip circle is specified, the back-analyses can be carried out using any one of the four methods as described above.

15.5.2. Method 2

1) Calculate the coordinates of the points which the actual slip circle passes through.
2) By fixing the actual location of the initiation and termination points of the slip circle, perform the Type 2 Bishop Circular analyses with a tried c’ and f’ value.
3) Go to View and check the coordinates of the points which the slip circle passes against the actual coordinates of the points.
4) If the coordinates of the points obtained from the analyses do not match well with the actual coordinates, perform another analyses using a different c’ and ϕ’ value.

5) Step 4 is repeated until the coordinates of the points are close enough to the actual coordinates.

6) Once the actual slip circle is obtained, it can be used for the back-analyses by performing Type 8 Import critical surface coordinates from output file.

7) The analysis type will automatically changed to Type 7 Bishop, Specified Surface once the coordinates are imported from the output file.

8) The back-analyses can then be carried out using any one of the four methods as described above.