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STABILITY ANALYSIS OF PORPHYRITE ROCK SLOPE IN THE TAHAM ROAD USING POINT ESTIMATE METHOD (PEM)

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ABSTRACT: This study presents the probabilistic stability analysis of porphyrite rock slope in the Taham road in NW of Iran using point estimate method (PEM). In this paper numerical modeling is used to determine the strength reduction factor (SRF) of the porphyrite rock slope. Using point estimate method (PEM) we combine probabilistic input variables such as the material constant for intact rock (mi), the geological strength index (GSI), deformation modulus (E), intact uniaxial compressive strength (σ_{ci}), and evaluate the distribution of the output variable namely strength reduction factor (SRF). The obtain results show that probabilistic approach, when it is possible to have sufficient data on the quality of the rock mass, leads to a better understanding of the project risks.

Keywords: Probabilistic analysis, Porphyrite Rock slope, Taham road, Strength Reduction Factor.

INTRODUCTION

The slope stability of rocks is an important problem in geotechnical engineering. The parameters required for stability analysis of slopes often are not well known. In these cases it is favorable to perform a parametric study where model behaviour is examined for a range of possible inputs. Therefore, probabilistic methods are used in these cases and here the point estimate method (PEM) has been applied. The purpose of the method is to be able to combine probabilistic input variables and to evaluate the distribution of the output variables. The rule of PEM is to compute solutions at various estimation points and to combine them with appropriate weighting in order to get an estimation of the distribution of the output variables (Rocsceince, 2012).

Stability by strength reduction is a manner that the factor of safety is determined by weakening the soil or rock in stages in an elastic-plastic finite element analysis until the slope fails. The factor of safety is considered to be the factor by which the soil or rock strength needs to be reduced to reach failure (Dawson et al., 1999; Griffiths and Lane, 1999).

In the Strength Reduction approach, the soil or rock strength is dummy reduced, and so there is a need to redistribute the stresses. This can be done by the stress redistribution algorithm, and so this option can be indirectly used to do a strength reduction stability analysis.

The strength reduction factor (SRF) is defined as:

$$SRF = \left[\tan\varphi \big/ \tan\varphi f \right] = \left[c \big/ cf \right]$$

Where φf and cf are the effective stress strength parameters at failure, or the reduced strength. The strength reduction method usually uses the same SRF for all material and for all strength parameters, so that the stability factor reduces to one number in the end.

This paper attempts to present probabilistic analysis of the porphyrite rock slope in the Taham road in the northwest of Iran. Road cutting has caused several rock slopes in the road, but in here the porphyrite rock slope is investigated. Joints are the most basic structures that have subjected rocks and caused dense fracturing in these rocks.

THE PORPHYRITE ROCK SLOPE

This slope is composed of the porphyrite rocks with a dip of 86 degrees and a height of 26.02 meters.

Material characteristics of the porphyrite rocks

The physical and mechanical characteristics of the porphyrite rocks were determined on obtained samples of boreholes and field tests on outcrops. The specific gravity of the porphyrite rocks varies from 2.67 to 2.70. The values of minimum and maximum UCS varies from 110 to 115 MPa respectively, and the average value of 112 MPa.

The average value for the rock material constant mi is determined using Hoek and Brown (1988) failure criterion. The value of mi for the porphyrite rocks is obtained equal to 20.

Mechanical properties of the porphyrite rock masses

The rock mass properties such as the rock mass strength (σ_{cm}), the rock mass deformation modulus (Em), the rock mass constants (mb, s and a) and the shear strength parameters of the rock mass (C and φ) are calculated by the Rock-Lab program defined by Hoek et al. (2002) (Figure 1).

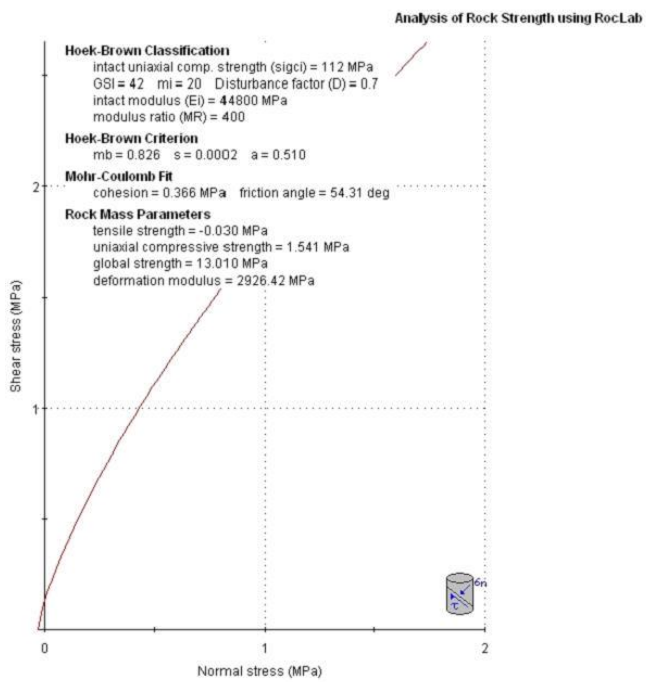
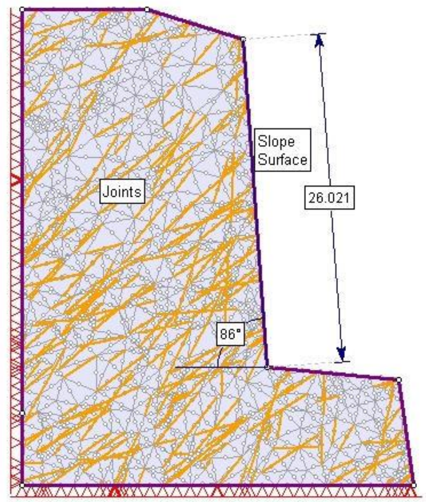


Figure 1. The geomechanical parameters of the porphyrite rock masses

Stability analysis of the porphyrite rock slope

The numerical method is employed for stability analysis of the porphyrite rock slope in the Taham road. Numerical analysis of rock slopes in the study area is accomplished using a two-dimensional hybrid element model, called Phase2 Finite Element Program (Rocscience 1999). The Veneziano joint network model is used for numerical analysis (Figure 2) and this model is based on a Poisson line process. It adapts the Poisson process to generate joints of finite length (Dershowitz, 1985).

Shear strength reduction analyses is carried out using Phase2 in the basis of Hock–Brown criterion and the strength reduction factor (SRF) for this slope is determined. According to results of numerical analysis, strength reduction factor (SRF) of this slope is 1.44 and any rotational failure will not occur (Figure 3).



Material Name	Color	Initial Element Loading	Unit Weight (MN/m3)	Elastic Type	Young's Modulus (MPa)	Poisson's Ratio
Porphyrite		Field Stress and Body Force	0.0267	Isotropic	2926.42	0.3

Figure 2. The model of slope with Veneziano joint network

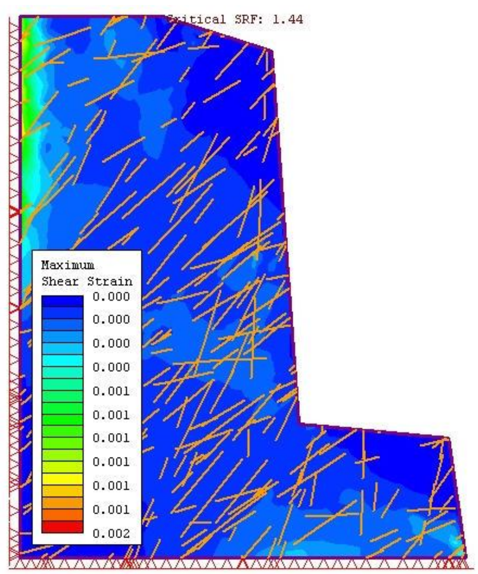


Figure 3. Shear strength reduction analysis of the porphyrite rock slope in deterministic analysis (Critical SRF= 1.44)

PROBABILISTIC STABILITY ANALYSIS OF THE PORPHYRITE ROCK SLOPE

Probabilistic stability analysis of the porphyrite rock slope includes analysis of shear strength reduction factor. The best guess for the Hoek and Brown parameters enter and run the analysis. However, the properties of these parameters are not well known, so we will run a statistical analysis by varying the parameters in a systematic way to see the range of possible behaviours.

Probabilistic stability analysis is done by selecting the standard deviation to 1, 2 and 3 for the material constant for intact rock (mi), the geological strength index (GSI), deformation modulus (E), and intact uniaxial compressive strength (σ_{ci}). For each the above, the strength reduction factors (SRF) of the porphyrite rock slope is obtained and its changes in percent is shown in Figure 4.

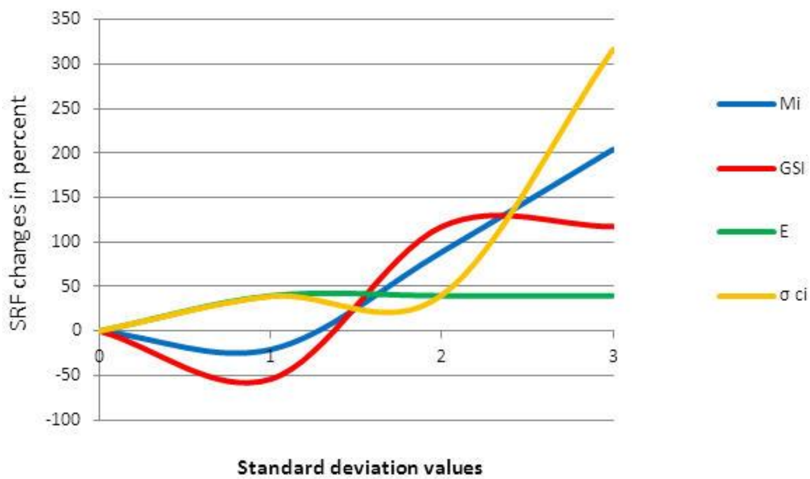


Figure 4. Diagram of changes the SRF for geomechanical parameters with different values of standard deviation

The diagram in Figure 4 shows that by applying the uncertainty in geomechanical parameters of porphyrite rocks, the amount of strength reduction factor (SRF) of the slope is mainly increased. As can be seen, the greatest change in the amount of strength reduction factor (SRF) is related to the uncertainty in the parameters of σ_{ci} and mi with a standard deviation to 3. Furthermore, the parameters of E and GSI have the least impact on the strength reduction factor of the porphyrite rock slope. This suggests that the stability of the porphyrite rock slope is more sensitive to the intact uniaxial compressive strength and lithology of slope.

CONCULSION

This study presents probabilistic analysis of the porphyrite rock slope in the Taham road in northwest of Iran. Based on the information collected in the field and laboratory, the slope stability is investigated. Shear strength reduction analyses is evaluated using Phase2 and the strength reduction factor (SRF) for the rock slopes is determined. Due to uncertainty in rock masses properties specially mi, GSI, E and σ_{ci}, a probabilistic analysis using PEM method is accomplished for determination of the strength reduction factor (SRF).

The obtained results present that in this slope any rotational failure will not occur and the greatest change in the amount of strength reduction factor (SRF) is related to the uncertainty in the parameters of σ_{ci} and mi. The results of this study also indicated that the deterministic approach of the stability analysis should be used associated with probabilistic method to analyze the slope stability condition.

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