Reliability Assessment of Cohesive Vertical Cut Stability

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Abstract

Slope stability analysis is a complex engineering problem due to heterogeneous nature of soils and participation of a large number of factors involved. The inherent uncertainties of the parameters which affect slope stability dictate that problem is of a probabilistic nature rather than being deterministic. Probabilistic analysis of slope stability has received considerable attention in the literature, and has been used as an effective tool to evaluate uncertainty that is so prevalent in variables. In this research, the jointly distributed random variables method is used for probabilistic analysis and reliability assessment of the stability of cohesive vertical cut. The selected stochastic parameters are height, cohesion and unit weight, which are modeled using a truncated normal probability distribution function. The angle of slope relative to vertical is regarded as constant parameter. The results are compared with the Monte Carlo simulation and First Order Second Moment method. Comparison of the results indicates the superior performance of the proposed approach for assessment of reliability.

Keywords: Reliability, Jointly distributed random variables, Monte Carlo simulation, First Order Second Moment method, slope stability.

1. Introduction

The problem of slope stability is a statically indeterminate problem. There are different methods of analysis available for engineers to assess the stability of slopes. It can be carried out by the Limit Equilibrium Method (LEM), the limit analysis method, the Finite Element Method (FEM) or the finite difference method. By far, most engineers still use the limit equilibrium method, with which they are more familiar. These methods are widely documented in geotechnical literature and use principles of static equilibrium to evaluate the balance of driving and resisting forces [e.g., [1-4]]. The factor of safety is defined as the ratio of resisting forces over driving forces, or, alternatively, as the shear strength divided by the calculated shear stresses. A factor of safety greater than one indicates a stable slope and a value less than one indicates impending failure. Therefore, these methods are restricted by the use of single valued parameters to describe the slope's characteristics. However, the inherent uncertainties of the characteristics which affect slope stability dictate that the slope stability problem is of a probabilistic nature rather than being deterministic.

In general, the uncertainty in the stability of a slope is divided into three distinctive categories: soil parameter uncertainty, model uncertainty and human uncertainty[5].Parameter uncertainty is the uncertainty in input parameters for analysis [6,7], model uncertainty is due to the limitation of theories and models used in performance prediction [8], while human uncertainty is due to human error[9]. In this research, parameter uncertainty is assessed.

2. Slope With Plane Sliding

In cohesive soils one often disregards the local stability of the soil, as it is deemed secondary to the stability of the entire face. A problem could occur, however, in cases where a pressure gradient towards the face is present. This is easily conceivable in an earth-pressure balance shield with support pressures below the local hydrostatic pressure [10].

3. Upper Bound Solution

The simple upper bound solution for the critical height of a vertical cut in a cohesive material is presented in many textbooks on soil mechanics, e.g. Verruijt [11]. For a vertical cut with height *h* assume a straight failure plane as sketched in figure 1. In this case the weight of the failure wedge is given by: