

Probabilistic analysis of the stability of a dam using the Monte Carlo simulation method based on the limit equilibrium method

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Abstract

Probabilistic slope stability analysis provides a tool for considering uncertainty of the soil parameters in design. In this paper, using Slide software, the Monte Carlo simulation is used as an analytical method to develop probabilistic models of slope stability based on equilibrium methods. The limit equilibrium methods are the most popular approaches in slope stability analysis. These methods are well known to be a statically indeterminate problem, and assumptions on the inter-slice shear forces are required to render the problem statically determinate. In modeling using this methodology, the selected stochastic parameters are internal friction angle, cohesion and unit weight of soil, which are modeled using a truncated normal probability density function (pdf). In this research, the abilities offered using models were presented by using field data obtained from Cannon dam in Iran. The results obtained show that the hybrid Monte Carlo simulation and equilibrium methods can be used successfully for slopes stability assessment.

Keywords: Probabilistic analysis, Monte Carlo simulation, Slide software, limit equilibrium methods.

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Extended Abstract:

1. Introduction

In conventional approach, slope stability analyses are conducted using constant soil properties in deterministic manner. However, there are uncertainties which result from both the material itself and the models used. Soil properties are inherently random in deposits that cause spatial variations in the material. Also, measurement errors, data inconsistency and handling procedure, inadequate geological explorations at the site, unconsidered soil properties that are hard to assess, and variations in pore water pressure cause uncertainties. To handle these uncertainties, many stochastic and probabilistic studies were conducted in geotechnical engineering analyses.

2. Materials and methods

In recent years probabilistic methods have been more frequently used in slope design. These methods are based on the calculation of the probability of failure of the slope. A probabilistic approach requires that a deterministic model exists. In this case the input parameters are described as probability distributions rather than point estimates of the values. By combining these distributions within the deterministic model used to calculate the safety factor, the probability of failure of the slope can be estimated. A technique commonly used to combine the distributions is the Monte Carlo simulation. In this case each input parameter value is sampled randomly from its distribution and for each set of random input values a safety factor is calculated. By repeating this process many times, a distribution of the safety factor is obtained. The probability of failure can be calculated as the ratio between the number of cases that failed (safety factor <1) and the total number of simulations.

3. Results and discussion

In this paper, using Slide software, the Monte Carlo simulation is used as an analytical method to develop probabilistic models of slope stability based on equilibrium methods. The limit equilibrium methods are the most popular approaches in slope stability analysis. These methods are well known to be a statically indeterminate problem, and assumptions on the inter-slice shear forces are required to render the problem statically determinate. In modelling using this methodology, the selected stochastic parameters are internal friction angle, cohesion and unit weight of soil, which are modelled using a truncated normal probability density function (pdf). In this research, the abilities offered using models were presented by using field data obtained from Cannon dam. The results obtained show that the hybrid Monte Carlo simulation and equilibrium methods can be used successfully for slopes stability assessment.

References:

- Li D., Chen Y., Lu W., Zhou C., 2011, "Stochastic response surface method for reliability analysis of rock slopes involving correlated non-normal variables", *Computers and Geotechnics*, 38: 58-68.
- Malkawi A.I.H., Hassan W.F., Abdulla F.A., 2000, "Uncertainty and reliability analysis applied to slope stability", *Structural Safety*, 22: 161-187.

Radhi M.M., Pauzi N.M., Omar H. "Probabilistic approach of rock slope stability analysis using Monte Carlo simulation". In: International Conference in Construction and Building Technology, Malayzya, 2008 .