Probabilistic Methods in Rock Slope Engineering: Basic concepts, Current Drawbacks and Possible Improvements

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Abstract

Rock slope engineering, especially, rock slope stability analysis, is a geotechnical engineering problem, characterized by many sources of uncertainties. Probabilistic methods in rock slope engineering have been brought engineers opportunities of taking such uncertainties into account. However, these methods also involve some drawbacks. One of the most important problems encountered in the probabilistic rock slope stability analysis is the correlation that exists among the random variables. Most of the existing probabilistic methods assume independency between the variables which involves calculations with remarkable inaccuracy. In this paper, basic concepts of current probabilistic methods are briefly reviewed. Next, some of their major drawbacks are mentioned. Finally, a Modified Monte Carlo Technique (MMCT) is introduced to improve the performance of the present analysis methods.

Keywords: Rock Slope Engineering, Reliability Index, Monte Carlo Simulation, Independency

1. INTRODUCTION

Uncertainty in rock slope engineering issues is unavoidable. In natural rock slopes, most variables controlling their stability are random rather deterministic. Properties of rocks are inherently heterogeneous, and natural earth formations are characterized by irregular layers of rocks with various degrees of weathering, different mechanical parameters, and geometrical patterns. A common engineering practice is to ignore the variability and uncertainty in rock parameters of interest and treat them as if they were deterministic and of single value. The worst case is usually considered and a factor of safety is obtained to account for the uncertainty and unknown range of the parameters. In many cases such approaches lead to conservative designs and can remarkably add to the project cost. On the other hand, a more moderate design may not ensure the required level of safety and stability. Hence, it is crucial to make decisions utilizing a trade-off between cost and safety.

Deterministic techniques have been extensively used in rock slope engineering. They evaluate the situation of rock slopes through a safety factor defined as the ratio of strength available along a potential slip surface to that required for failure to occur. Having ignored the uncertainty which is inherent in the nature of the slopes and in obtained results from measurement, they fail to provide an accurate assessment of slope safety and stability.

To prevail over these deficiencies of the single valued deterministic approaches, researchers have used probability theory for taking the present uncertainties in to account. Some investigators have used conventional Monte Carlo technique (MCT) to evaluate design uncertainty, [1,2] and references therein. Others have proposed the use of First Order Reliability Method (FORM) with or without Monte Carlo simulation, [3,4,5]. Moreover, some of the researchers have tried other methods including Fuzzy Reliability Analysis (FRA) and Random Set based Reliability Analysis (RSRA), [6,7]. Almost all of the present probabilistic methods assume independency between the different rock slope parameters. Such assumption is one of the main drawbacks of the probabilistic methods. Another major difficulty in probabilistic approaches is the way, through which uncertainties should be modeled and addressed and this has been resulted in the diversity of the present probabilistic methods.

In the following sections, first, some of the basic concepts are explained. Next, Central Limit Theorem (CLT) is explained based on which major drawbacks of the current probabilistic methods are discussed. Finally, a Modified Monte Carlo Technique (MMCT) is introduced which can take independency of the random variables into account.