Reliability Analysis of Rock Wedge Stability: Knowledge-Based Clustered Partitioning Approach

Ya-Fen Lee1; Yun-Yao Chi2; C. Hsein Juang, F.ASCE3; and Der-Her Lee4

Abstract: In this paper a knowledge-based clustered partitioning technique is developed for determining reliability index and failure probability of rock wedge. Here, the a reliability index is analyzed and the optimization is carried out using a knowledge-based clustered partitioning (KCP) technique. The reliability index computed with this KCP technique is compared with those using other approaches such as the Excel Solver-based method. The new technique for determining the reliability index involves a global search method and is found effective and efficient. Reliability analysis with this KCP technique is then used to examine the influence of parameter uncertainties and correlations among the parameters on the failure probability of rock wedges. Significant findings are derived from the sensitivity and parametric analysis. DOI: 10.1061/(ASCE)GT.1943-5606.0000618. © 2012 American Society of Civil Engineers.

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Introduction

Variability in the parameters of earthen materials has long been recognized (e.g., Harr 1987; Baecher and Christian 2003). Sources of variability include the inherent variability of earthen materials, measurement errors, and transformation (model) uncertainties. The inherent variability of earthen materials is associated with the randomness of natural processes. The measurement errors may be attributed to different test equipment, operators, and testing procedures. The transformation uncertainties can be induced when empirical or correlation-based models are employed to transform field or laboratory measurements to the design inputs (Phoon and Kulhawy 1999). The variability in the geotechnical parameters can lead to various degrees of uncertainty in the results of an engineering analysis. To deal with this uncertainty, the concept of an allowable factor of safety (FS) is generally employed in the design. This design concept, involving an allowable FS that has been calibrated with experience and/or field observations, is quite rational and has been used satisfactorily for decades. However, the physical meaning of FS is often hard to explain well. For instance, how much safer is FS = 1.2 over FS = 1.1 in a given geotechnical problem? Many investigators (e.g., Oka and Wu 1990; Christian et al. 1994) have argued that the concept of probability of failure or reliability can provide a more consistent measure of the safety level in many geotechnical problems.


Although many approaches are available for determining the probability of failure, the focus in this paper is on the reliability analysis technique. In particular, the reliability index proposed by Hasofer and Lind (1974), denoted as \( \beta_{HL} \), is computed with a knowledge-based clustered partitioning (KCP) technique. As an example to demonstrate this KCP technique, the problem of rock wedge stability is analyzed. The paper is structured into three main parts: (1) the reliability index and KCP technique, (2) rock wedge stability analysis and validation of the KCP-based reliability method, (3) sensitivity analysis of rock wedge stability.