PSEUDO-DYNAMIC SLOPE STABILITY STOCHASTIC ANALYSIS BY RANDOM FINITE ELEMENT METHOD

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Seismic stability analysis of natural or man-made slopes is an important topic of research for the safe design in the seismic zone. Natural slopes are usually stable when they are not disturbed by any external force, such as seismic forces. For assessing the seismic responses of slopes, considering the characteristics of input ground motions and the properties of soil media are needed. There are four main methods for seismic stability analysis of slopes: pseudo-static (Seed, 1979), Newmark sliding block analysis (Newmark, 1965), numerical analysis (Jingshan et al., 2001) and testing method using shaking table and centrifuge apparatus. In these methods, the pseudo-static method is the simplest at the earliest applications (Siyahi, 1998).

The pseudo-static method is modified from the Limit Equilibrium Method (LEM) in seismic stability analysis. In fact, the seismic load is equivalent to invariably horizontal and vertical forces, and the problem of seismic stability of slopes is simplified into a static problem in the pseudo-static method. In the next step, the ratio of resistant forces to driving forces on a potential sliding surface defines as Factor of Safety (FS). The slope is considered safe only if the calculated safety factor clearly exceeds unity. However, due to the model and parameter uncertainties, even a factor of safety greater than one does not confirm the safety against failure of slope. Therefore, it is important to calibrate the deterministic method considering the effect of different sources of model and parameter uncertainties. Reliability analyses provide a rational framework for dealing with uncertainties and decision making under uncertainty.

Since three decades ago, many probabilistic methods have been devised for analysis of the stability of slopes (Johari and Gholampour, 2018). Stochastic analysis of slope seismic stability has received attention in the literature and has been used as an effective tool to evaluate uncertainty so prevalent in the variables (Burgess et al., 2019) and (Johari and Khodaparast, 2015).

In this research, the Random Finite Element Method (RFEM) is used for stochastic analysis and reliability assessment of seismic stability of slopes without seepage. For this purpose, a MATLAB coded program was developed. To demonstrate the accuracy of the program, the determined factor of safety and displacement of the slope are verified with finite element software. The program was provided for the two-dimensional, plane strain condition using eight-node quadrilateral elements together with reduced integration (four Gauss points per element) of elastic visco-plastic soil with the MC failure criterion.

The selected stochastic parameters are internal friction angle, cohesion and unit weight of soil, which are modelled using a truncated normal probability density function and the horizontal seismic coefficient which is considered to have a truncated exponential probability density function. As a result, the reliability index of pseudo-dynamic slope stability by RFEM analysis was calculated.

To verify the accuracy of the results obtained in this research, results were compared with PLAXIS and Griffiths (Griffiths and Lane, 1999). For this aim, a slope was modeled in MATLAB and PLAXIS with the same soil properties. These parameters are given in Table 1. Furthermore, the compared results are given in Table 2. It can be seen that the results of the coded program has very close to Griffiths (Griffiths and Lane, 1999).

Table 1. The selected soil properties for verification of the model.

Parameters	ϕ (Deg.)	C (kN/m²)	ψ	E (kN/m²)	υ	γ(kN/m³)
Value	20.0	15.0	0.0	1.e5	0.3	20.0

Table 2. Comparison of the results.

Methods	FS	Maximum Displacement (m)
Proposed model	1.54	0.0277
Plaxis	1.54	0.0243

The deformed mesh with magnified displacements and the maximum shear strain of soil are shown in Figures 1 and 2, respectively. According to the results, the mechanism is almost a single wedge failure which starts from the bottom of the slope.

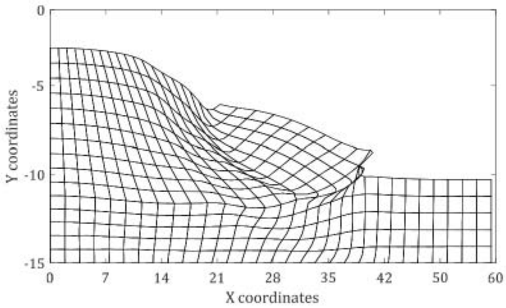

Figure 1. The deformed mesh of slope.

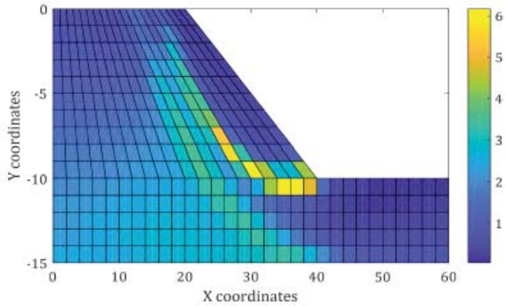

*Figure 2. Maximum shear strain*10-3.*

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