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Slope Sensitivity Analysis using Spencer's Method in Comparison with General Limit Equilibrium Method

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Abstract

This paper analyses the sensitivity analysis of a natural-unreinforced slope in Kepong, Kuala Lumpur. In order to conduct a sensitivity analysis, several ranges of data, based on borehole information and figures and also typical range of earth materials geotechnical values are used to set the minimum and maximum value of parameters in Slide 6.0 software. Under Mohr-Coulomb failure criterion, Spencer's and General Limit Equilibrium methods of slices were used in the analysis to determine the influence of varying parameters values towards the change in safety factor. In addition, the percentage differences in safety factors obtained by both methods based on General Limit Equilibrium method are also determined in the analysis. In the analysis, water table location has the highest influence to the change in safety factors of the slope. Besides, the percentage differences in safety factors obtained by both methods are very nominal and showed a good agreement to each other.

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Keywords: Slope sensitivity analysis; Spencer's method; General limit equilibrium method

1. Introduction

The case study area is located on the west side of Taman Ehsan residential area in Kepong, Kuala Lumpur and is about 2.5 km to the southwest of Forest Research Institute Malaysia (FRIM). The studied slope is characterised by a

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hilly terrain, 125 m above sea level with an overall slope angle 34° from toe to crest. There were three boreholes dug at three points of different elevations along the slope[1]. Borehole 1 was located at the toe, borehole 3 at the top crest and borehole 2 at the middle bench between crest and toe of the slope. Based on the data of boreholes, the slope consists of two earth material layers, at which the top layer comprises of residual soil that covers a slightly fractured and weathered sandstone bedrock. Most of the soil layer depths were recorded between 11 m to 22 m and increase from crest to toe. From the soil testing data, majority of the soil is SM group and a few categorised as SC group. This classification is according to Unified Soil Classification System[2]. Overall, the overburden consists of coarse-grained soil with non-plastic silty fines.

Nomenclature

FRIM	Forest Research Institute Malaysia
F	safety factor
LEM	Limit Equilibrium Method
GLE	General Limit Equilibrium
S, S_m	total strength available and total shear strength mobilised, respectively
Q	resultant of pair of interslice forces
b, h	width and mean height of slice, respectively
α	slope of base of slice
X, E	vertical interslice shear forces and horizontal interslice normal forces, respectively
λ	a constant representing the percentage of portion of the interslice function
θ	slope of resultant Q of pair of interslice forces
F_f	value of safety factor obtained using force equilibrium equation
F_m	value of safety factor obtained using moment equilibrium equation
F_{mo}	value of safety factor which satisfies moment equation when $\theta = 0$
F_i	value of factor of safety which satisfies both force and moment equations
θ_i	value of θ which satisfies both force and moment equations
β	slope of embankment
r_u	pore-pressure coefficient
γ	bulk density
H	height of embankment
$ø'$	angle of shearing resistance with respect to effective stress
c'	cohesion with respect to effective stress
$ø'_m$	mobilised angle of shearing resistance
$f(x)$	a function that describes the manner in which X/E varies across the slope
θ_R, θ_L	angle of right and left interslice forces, respectively
Z_R,Z_L	right and left interslice forces, respectively
ICU	Isotropically Consolidated Undrained Triaxial Compression
SPT	Standard Penetration Test
CSS	critical slip surface
WTL	water table location

2. Literature Review

2.1. Limit Equilibrium Methods

Slope stability analysis can be carried out by using various methods. There are four main methods that can be used to determine the safety factor F of a slope; the Limit Equilibrium Method (LEM), Limit Analysis Method, Finite