Locating the critical failure surface in soil slope stability with multi layer by genetic algorithm

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ABSTRACT

Slope stability in soil is important and interesting in soil mechanic and civil engineering. Slope stability optimization methods can help us to find the lowest factor of safety. In the soil slope stability, engineers face a large search space to locate the critical failure surface in the soil layers. In this paper, various methods for determination failure surface investigated and briefly discussed and a genetic algorithm (GA) optimization is developed to solve this factor of safety minimization problem. The results show that a genetic algorithm (GA) can be successfully employed to locate the critical failure surface in a multi layer soils on the stability of soil slopes

Keywords: Slope stability, Optimization, Factor of safety, Critical failure surface, Genetic algorithm

1. INTRODUCTION

The assessment of slope stability has been one of the most important issues for geotechnical engineers for years. The determination of the factor of safety and specially the critical failure surface (A failure surface for which factor of safety is minimum) in a soil slope, helps the engineers for an economic design, it can minimize the volume of soil to be excavated. Assessment of slope stability requires special paying attention to the potential failure surface and the corresponding forces tending to cause slip and stabilizing the sliding block and computing the available margin of safety. The initial work on locating the critical failure surface in a slope stability analysis was done by Fellenius [1]. In 1962, Jumikis extended the procedure for general soils. The procedure is found to be less reliable for irregular and long slopes. Most of the existing computer programs UTEXAS3 [Edris and Wright [2]], STABL [Siegel [3]], SLOPE/W [Geo-Slope Intl [4]] however use a method of search popularly known as 'Grid' method. Baker and Garber [5] used the calculus of variations to locate the critical slip surface and to calculate associated factor of safety. Celestino and Duncan [6], and Li and White [7] used alternating variable methods to locate the critical slip surface. A genetic algorithm (GA) [Back [8], Dasgupta and Michalewicz [9], Michalewicz [10], Holland [11], Coello [12], Hedberg [13], Goldberg [14], Zoffaghari et al. [15], Yang et al. [16], Nian and Zheng [17]] is a search technique used to find approximate solutions to optimization and search problems. In this paper an investigation is made on the impact of multi layer soils on the stability of soil slopes, especially when critical failure surface is optimized. The GA (Genetic Algorithm) is used to optimize the critical failure surface; an application is used in this step.

2. Molding the slope stability problem

To employ the genetic algorithm, the factor of safety is defined as the fitness function which, must be expressed in terms of (a) the coordinates of the center of the circular failure surface (X, Y) and (b) the radius of the circular failure surface (R) (Table 1).

The Method of Slice (Bishop [18], Fellenius [1]) is the most commonly used soil slope stability method, where the soil mass above an assumed slip surface is divided into vertical slices (refer to Fig. 1).The forces (W_i, T_i and N_i) on a typical slice are shown in Fig. 1. The Factor of safety (F) in the Method of Slice is expressed as:

Table 1: *Range of control variables*

Control variable	Range
X	$\{h^*\cot(B), h^*\cot(B) - 10\}$
Y	$\{h, h + 10\}$
R	{0, 30 m}