THE PSEUDO-DYNAMIC ANALYSIS OF CRITICAL NON-CIRCULAR SLIP SURFACE IN EARTH SLOPES

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This paper presents a new approach to determine the minimum factor of safety and the associated critical line segment pseudo-dynamic slip surface. The new technique is called Alternating Variable Local Gradient (AVLG) that it is based on Univariat method. The slip surface shape is line segment (or non-circular). The safety factor is calculated using Janbu function. This procedure can truly convert the initial slip surface to critical slip surface with the different conditions of slope and soil properties. The critical slip surface obtained in this method provides both minimum factor of safety and more accordance with reality in nature. Resultant critical slip surface is reasonable also comparative study of numerical examples indicate the efficiency and accuracy of proposed method.

Evaluating the stability of slopes in soil is an important, interesting and challenging aspect of civil engineering. Over the past decades, the calculation of the factor of safety and the search for a slip surface with the critical or minimum factor of safety, has led to development of new and more effective methods. In most of the commercial softwares, the search for critical circular slip surface is available. Due to the limitation of the commonly used slope stability analysis programs which cannot locate the critical non-circular failure surface of a slope under general conditions with general constraints, most of the engineers are forced to perform the search on a trial and error basis (Cheng, 2003). In first works on optimization of slope stability various simple methods have been used by different researchers. Celestino and Duncan (1981) described a simple search method, referred to as the alternating variable technique to determine critical noncircular slip surfaces. This simple numerical method, applicable to practical problems involving layered soils and other complexities, is used to search for the critical slip surface. To search for the non-circular surface with the lowest factor of safety, a number of repeated trials are performed. Each trial begins by shifting each of the points defining the slip surface to two new positions, and calculating the factor of safety. As this is done, all the other points are kept at their original estimated positions. Furthermore Nguyen (1985) presented on optimization technique to determine both the minimal factor of safety and the associated critical failure surface. The technique treats the factor of safety as an optimal function of the N geometrical coordinated defining potential admissible failure surfaces, and searches for the optimum by a simplex reflection algorithm (in conjunction with the Omit equilibrium) through an N-dimensional space defined by these geometrical coordinates. On the other, the optimization techniques for the slope stability have also been used using variational limiting equilibrium by different researchers. Leshchinsky in 1990 presented a generalized slope stability method, which is based on the variational limiting equilibrium analysis introduced by Baker and Garber (1977). Optimization is the act of obtaining the best result under given circumstances (Rao, 1991). In design, construction and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decisions is to either minimize the effort required or maximize the desired benefit. Time consuming and falling into the trap of local minimum are problems of this approach.

Example: This example considers a slope of a homogeneous soil with pore water pressure (Figure 1) and seismic coefficient equal to 0.2.

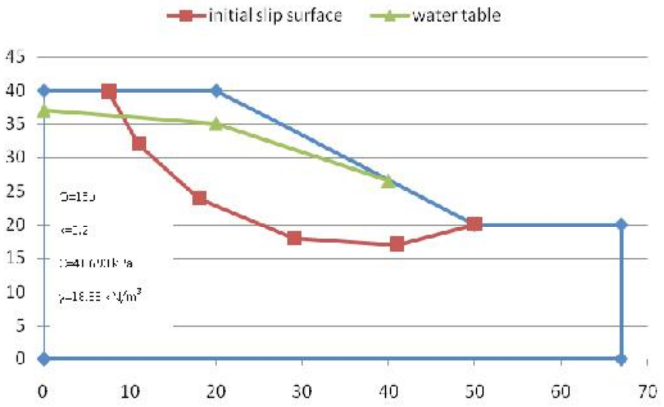

Figure 1. Properties and initial slip surface and water table

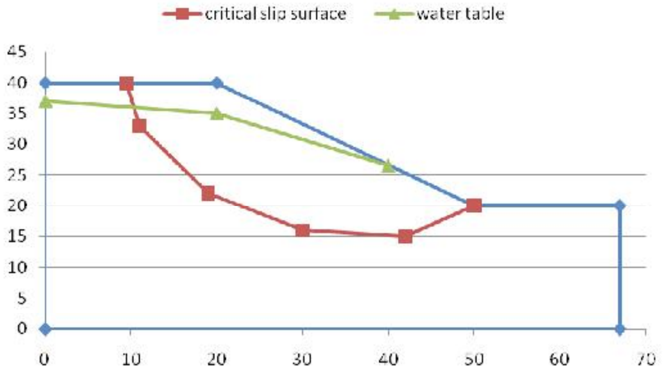

Figure 2. Critical slip surface

At first, is founded critical circular slip surface using search method (FS=1.088). Then 15 nodes are selected on the critical circular slip surface. It is an initial line segment slip surface to optimize using AVLG method. Then the initial slip surface is optimized after 6 trials (FS=0.98). Figure 2 shows the final circular and line segment critical slip surface, which gives the global minimum factor of safety. Table 1 demonstrates the results that are obtained by the present procedure. The minimum factor of safety for circular slip surface is 1.088 and minimum factor of safety, which is obtained by the present procedure, is 0.98 indicating that factor of safety is improved about 10 percent.

Table 1. Comparison of initial safety factor and critical line segment safety factor

	initial slip surface	critical line segment slip surface	Percent of improvement
Present method	1.088	0.98	10

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