Determination of critical failure surface in slope stability analysis using optimization algorithms (PSO & GA)

Ali Johari[1], Masoud Sahebkar[2]

1- Assistant Professor, Department of Civil and Environmental Engineering, Shiraz University of Technology, Shiraz, Iran
2- Ms Candidate of Geotechnical Engineering, Department of Civil and Environmental Engineering, Shiraz University of Technology, Shiraz, Iran

m.sahebkar@sutech.ac.ir

Abstract

The use of limit equilibrium methods are the common approaches for determining of soil slope stability in geotechnical engineering project. In these methods many researchers tend to find a circular critical failure surface for homogeneous soils, but failure surfaces can be non-circular especially for layered slopes. Finding of critical failure surface of a general soil slope is a difficult problem as the non-convex and multiple minima exist of the safety factor objective function. In this paper simple genetic algorithm and particle swarm optimization methods are employed to find the critical non-circular failure surface. For this purpose the Morgenstern–Price method is used to find the factor of safety. A computer program was coded by MATLAB for searching the minimum factor of safety. The result of a example is compared with stress-deformation method using PLAXIS software for one example. It shows the determined safety factors are very close to each other for two methods.

Keywords: Critical failure surface, Factor of safety, Slope stability, Particle swarm optimization, Genetic algorithm.

1. INTRODUCTION

There are many different ways to compute the factor of safety of artificial or natural slopes including limit equilibrium, limit analysis, finite element and finite difference methods. In recent years the finite element method has been used for slope stability analysis, but limit equilibrium methods are still common practice. The use of both the limit equilibrium and the limit analysis methods for general problems requires the selection of trial failure surfaces. Among all trial slip surfaces, the slip surface that has the lowest factor of safety is selected as the critical failure surface. Safety factors of slip surfaces are usually computed by using limit equilibrium methods (e.g. [1-3]).

In most of the commercial programs, only systematic pattern search for critical circular failure surface is available to the engineers. The centers of rotation are defined over a grid and a contour of factor of safety will be drawn. This approach cannot be applied to non-circular failure mode. Circular failure mode is a special case of non-circular failure mode and it is usually not the most critical case. Due to the limitations 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. The location of the critical failure surface can be viewed as a form of nonlinear non-smooth global optimization problem and the objective function to be minimized is the factor of safety function.

In view of the limitations of the classical optimization methods, the current approach to locate the critical failure surface is the adoption of heuristic global optimization methods. The term heuristic is used for algorithms which find solutions among all the possible ones, but they do not guarantee that the best will be found, therefore, they may be considered as approximate and not accurate algorithms. These algorithms usually find a solution close to the best one, and they find it fast and easily.

Baker and Garber [4] have used calculus of variation to this problem. They received to an Euler's differential equation, but this method is too hard for engineers. Then Revilla and Castillo [5] have applied