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A REVIEW PAPER ON STABILITY OF SLOPES ANALYSIS AND METHODS

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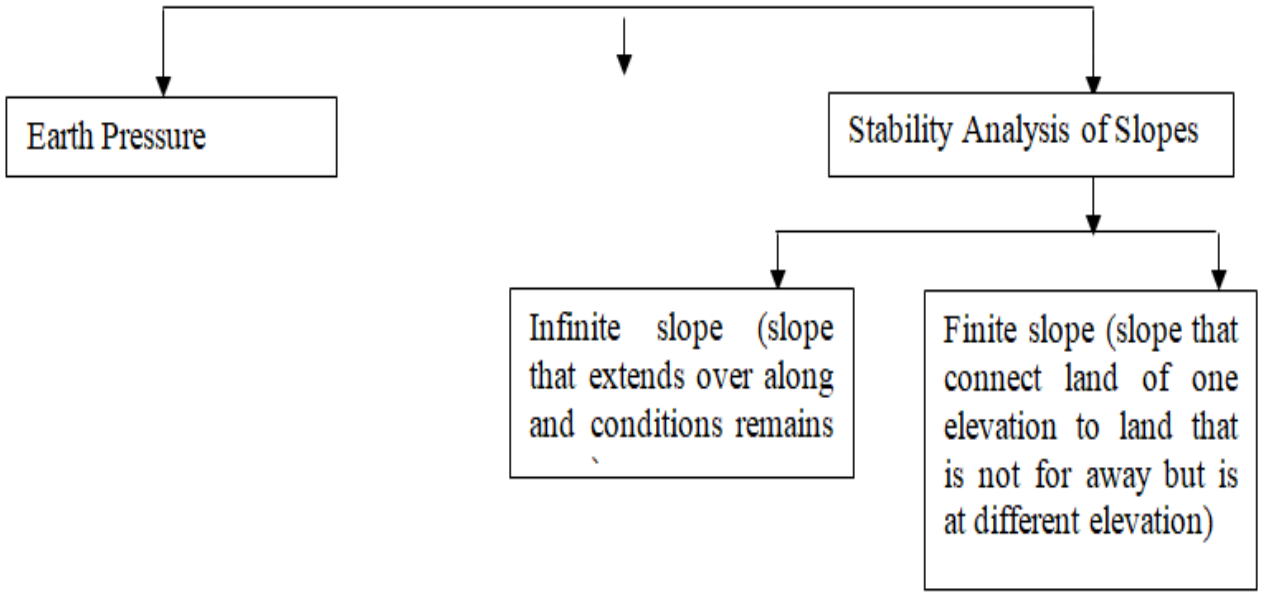
ABSTRACT- Due to the problems of slope stability many alternative methods are introduced to ensure the safety of slopes. It can be done by determining the factor of safety against failure by sliding for a given slope. All these methods are different from each other in terms of their simplification and accuracy. In this paper the current methods for slope stability analysis are discussed in detail by the author. Following methods for slope stability discussed below: limit equilibrium methods, numerical analysis method, limit analysis method.

Keywords: Slope Stability, Limit Equilibrium, Numerical Methods, Limit Analysis, factor of safety.

I. INTRODUCTION

Slope stability is one of the most frequent problem in civil engineering which can be seen in many projects like tunnels, highways and dams. Many techniques are used to ensure the stability of a given slope. Slopes can be defined as artificial and natural. Artificial slopes or man-made slopes are such as in cuttings and embankments for highways and railroads, temporary excavation, landscaping operations for development of site etc. Natural slopes such as in hillside and valleys, coastal and river cliffs and so on. The basic purpose for the analysis of stability of slope is to determine the factor of safety against slope failure. If the value of factor of safety is greater than one then the slope is considered as safe, but if it is one or less than one it will be unsafe. To determine the factor of safety for slopes some methods are discussed below in this paper.

APPLICATONS OF SHEAR STRENGTH THEORY



II. LIMIT EQUILIBRIUM METHOD

To determining applied stresses and mobilized strength over a trial slide soil silp surface, then a factor of safety is determined by considering these two quantities. So many trial failure surfaces are taken to find the most critical, or the minimum value. For the calculating the values of shear stress and compare the available resistance, its calculated by mohr coulomb's failure criteria.

By this compression derives the factor of safety for shear strength.

$F=\tau_f/\tau$

The main difference between different limit equilibrium methods is in the assumptions made about shape of slide surface (Circular, plane, logarithmic, etc.) and equilibrium equation that can be satisfied (force or moment equilibrium or both).

S.no.	Method name	Description of methods
1.	Ordinary method of slices(fellenius)	This method neglects all interslice forces and fails to satisfy force equilibrium for the slide mass as well as for the individual slices. However this is the simplest procedures based in the methods of slices.
2.	Bishop's simplified methods	Bishop assumes that all interslice shear forces are zero, reducing the number of unknowns by (n-1). This leaves (4n-1) unknowns, leaving the solution overdetermined as horizontal force equilibrium will not be satisfied for one slice.
3.	Janbu's method	Janbu assumes zero interslice shear forces, reducing the number of unknowns to (4n-1). This leads to an overdetermined solution that will not completely satisfy moment equilibrium conditions. However, janbu presented a correction factor $f_{c,}$ to account for this inadequacy.
4.	Bishop's rigorous method	Bishop assumes (n-1) interslice shear force to calculate of f_s. Since this assumption leaves (4n-1) unknowns, moment equilibrium cannot be directly satisfied for all silices. However, bishop introduces an additional unknowns by suggesting that there exists a unique distribution of the interslice resultant force, out of possible infinite number, that there will rigorously satisfy the equilibrium equations.
5.	Janbu's generalized method	Janbu assumes a location of the thrust line, thereby reducing the number unknowns to (4n-1). Sama (1979) points out that the position of the normal stress on the last (uppermost) since is not used and hence moment equilibrium is not satisfied for the last slice. However similar to the rigorous bishop method. Janbu's generalized method also suggests that the actual location of the trust line is an additional unknown, and thus equilibrium can be satisfied rigorously if the assumption selects the correct thrust line.
6.	Cumann's wedge theory	Culmann's method is used for the approximate stability of homogeneous slopes. A plane failure surface passing through the toe is assumed. A plane failure surface is not a correct assumption of homogeneous soil. However its simple failure mechanism and is described for purpose of illustration and for the determination of the approximate value of the factor of safety.
7.	Swedish circle method	The actual shape of slip surface in the case of finite slope is curvilinear. It is approximated as circular. The assumption circular slip surface and its application of stability analysis of slopes was developed in sweden. This method is known as swedish circle method.

III. NUMERICAL ANALYSIS METHODS

This methods give reasonable approximations to the "correct" or "exact" mathematical solution of the governing equations of the mechanics of slope stability. They are, however, much more typical and complicated than limit equilibrium methods: they take into account deformations (strains) and not just forces (stresses) like the more conventional limit equilibrium methods do.

Numerical methods have been broadly used in the past several years due to advances in computing power. In a broad sense, numerical methods can be classified into two parts one is continuum and another is discontinum methods.

There is so many number of numerical methods that have been presented in above literature to carried out the behavior of systems made of geomaterials. The most important and the most widely used methods are:

(a) For continuum, Finite Difference Method (FDM), Finite Element Method (FEM) and Boundary Element Method (BEM). (b) For discontinum, Distinct Element Method (DEM); Discontinuous Deformation Analysis (DDA), and Bonded Particle Model (BPM).

IV. FINITE DIFFERENCE METHOD

The Finite Difference Method (FDM) is based on the basis that governing differential equations of elasticity theory can be easily represented by finite differences. The method is the oldest among all of the numerical methods in geotechnical engineering and it was used even before the arrival of computers with the finite difference method, the set of differential equations is briefed to a system of linear equations, which can be solved by using any classical methods given above.

V. FINITE ELEMENT METHOD

The finite element method is a technique extremely used to perform for analysis of finite element analysis for engineering purpose. This method is also used for analysis geotechnical problems, The FEM gives it power by ability simulating physical behavior materials by use of a calculating tools without simplify problem.

In the strength reduction method, decrease strength parameters of the slope until slope become unstable. So, the safety of factor determine ratio between actual strength parameters and critical strength parameters. The gravity increase method is well suited for analyzing the stability of embankment is constructing because the rate of construction can be simulated with the rate at which gravity loading on the embankment is increased.

VI. BOUNDARY ELEMENT METHOD

With the help of Boundary Element Method (BEM), only the boundaries of the medium need to be shorted. This is in contrast to the other two continuum methods, the finite Difference and the Finite Element methods, where the entire medium has to be discretized.
In the BEM, the solution is approximated at the boundaries while equilibrium and compatibility are exactly satisfied in the interior of the medium. The advantage of limiting the discretization to the boundaries is that the problem is reduced by one order: From 3D to a 2D surface problem at the boundary, and from 2D to a line problem.
Requirements for slope stability analysis with numerical methods are: High-end computer; have relevant software; understanding of advanced soil mechanics, including material models and numerical methods.

VII. LIMIT ANALYSIS METHOD

In the limit analysis method the soil's models are a perfectly plastic material obeying a related flow rule. With this idealization of the soil behavior, two plastic bounding theorems (lower and upper bounds) can be proved.

The bound theorems of limit analysis are particularly useful if both upper and lower bound solutions can be calculated, because the true collapse load can then be bracketed from above and below. This feature is not much valuable in cases for which an exact solution cannot be carried out (such as slope stability problems) because it provides a built-in error check on the accuracy of the approximate collapse load.
In the upper bound theorem:- The displacement field compound from ones with constant velocity, then have to compute two rates:
1. Rate of work done by external loads (such as weight)
2. The rate of lose energy inside slide surface

According to the upper bound theorem, for each compatible Plastic displacement collapse will be occurred if the rate of lose energy inside slide slip surface. By standing different mechanisms, the best (least) upper bound value may be found.
In the lower bound theorem, should be assumption an allowable stress field, firstly, this stress filed is a dis-continuum field and compound from several separate zone which covering the whole soil mass.
According to the lower bound theorem, if this filed can satisfying equilibrium equations and stress boundary conditions, and stress lower then yielding stress, so failure not will be occurred.
In this note that in the lower bound theorem, the strain and displacements are not considered and that the state of stress is not necessarily the actual state of stress at collapse.

VIII. CONCLUSION

This paper discussed and analysis different-different type of stability of slope analysis. Limit equilibrium method is less accurate than another methods. Limit equilibrium methods are based of three factor of safeties i.e. friction, cohesion and shear strength Limit analysis method and numerical methods are more accurate and quick but these methods are lengthy and require enough knowledge. For the use of these methods for analysis is based on two parameters one is location of slopes and another is shape of probable slip surface.

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