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Methods of Finding Factor of Safety of Finite Slopes and Comparing It With Field Results

Shivam Mane[#1], Akash Vasudev[*2], Prithviraj Jagtap[#3]

Omkar Vadar[#4] · Abhishek Adivarekar[#5]

[#]*Civil Engineering Department,,Sanjay Ghodawat Institute,Atigre, Kolhapur,Maharashtra,India*

***Abstract*— Analysis of slope stability and safety is a major area of concern for civil engineering. This is a reasonable point that many analytical methods have been developed to date. The classic method of slope stability analysis involves the determination of the slope safety factor to take safety measures against any instability. Various techno investigators worked to develop a new method in which to calculate the failure or reliability of the slope.**

***Keywords*— Slip Trial; The sense of security; Erosion; Elasto-plastic; Probablistic; c - Interaction, Friction angle of soil, Soil density.**

I. INTRODUCTION

This document The stiffness of natural and man-made slopes such as roads and railways, road cuts etc. poses a major problem for geotechnical engineers. These vulnerable slopes make this story worse so that's why it needs to be analyzed and designed carefully. The two-dimensional fast-paced method is the most widely used method because of its simplicity. The primary method used by the mid-level elemental firm method is the marginal fit method (LEM) when calculating FOS to predict slope stability. These methods remain popular because of their simplicity and consequently the reduced number of desired parameters, namely slope geometry, topography, geology, static and dynamic loads, geotechnical parameters and hydrogeologic conditions. generalization of sensing techniques such as finite element method (FEM), variance method (FDM), force reduction method (SRM), force increment method (SIM), margin analysis, etc. to work. If the FOS is determined to be large enough, then the inclined surface will be judged as stable (safe). However, if FOS is sufficient at 1.0 or so, it is considered to be unsafe. However, these definitions did not explain the uncertainty within the soil slope. As a result, groundbreaking techniques began to develop as they became ready to explain the uncertainties that exist within the soil slope. A review of the empirical literature conducted by various investigators in the field of 2D slope stabilization is discussed below. This paper focuses on the precision and hence the probabilistic method for slope stability analysis.

II. WAYS TO LEARN

Deterministic approach involve various techniques such as: limit equilibrium methods (LEMs), limit analysis (LA), finite element analysis (FEM) and finite difference method (FDM). In limit equilibrium methods a balanced soil mass tending to slide under the influence of gravity is investigated. Failure during this method is described because the condition when driving forces (or moments) exceeds the resisting forces (or moments). Moment equilibrium is usually used for the analysis of rotational landslides. The factor of safety with reference to moment is defined as ???Fm??? and given by: Fm = Mr Md Where, Mr = the sum of the resisting moments and Md = the sum of the driving moment. In case of circular failure surface, the instant point for convenience is taken because the center of the circle (of which slip surface may be a part) and for non-circular failure surface, an arbitrary point could also be taken within the analysis. Force equilibrium is usually applied to translational or rotational failures. In such cases failure surface is either planar or polygonal. The corresponding factor of safety ???Ff??? defined with reference to forces is given by: Ff = ??f(2) Where, the available shear strength of soil and ????????= the shear stress needed to mobilize the slip To avoid these limitations some researchers introduced the finite element (FE) method with Elasto-plastic soil models for slope stability. one among the earliest studies that used FEM for stability analysis of slopes involved assumption of ??u??? 0, Smith and Hobbs. Analysis of variety of slopes was administered and an inexpensive agreement with Taylor???s charts was obtained. Zienkiewicz et al considered a c soil slope and obtained good agreement with slip circle solutions. Griffiths used the FE method to point out reliable slope stability results for a huge range of soil types and geometric configurations as compared with the charts of Bishop and Morgenstern. Ugai and Leshchinsky yield similar results like the rigorous limit equilibrium approach for homogenous slopes. Griffiths and Lane used the finite element method in conjunction with an elastic-perfectly plastic (Mohr-Coulomb) stress-strain method. Failure was considered because the situation when no convergence occurs within the required number of iterations. For finite element analysis slope is split in small fragments called elements and a stress-strain relationship is defined for the case. Fourofrelationships are generally used i.e. linear elastic, multi-linear elastic, hyperbolic and elastoplastic. Each relationship has its own advantages and limitations. for instance linear elastic stress-strain relationships are simple but they're useful in modelling the behavior of real soils at low stress levels and little strains. Similarly elasto-plastic and elasto-visco-plastic stress-strain relationships model the behavior of soils on the brink of failure, at failure, and after failure more realistically but these are more complex .

III.. RELIABILITY APPROACH

Soil stability also can be defined in terms of risk/probability of failure of slope or reliability of a slope. To account for various uncertainties involved within the analysis of slopes, concept of probability is extremely reliable to use. the tactic of study is predicated on the calculation of probability of failure, ???Pf??? or reliability index, ????????, which are the functions of factor of safety again. Reliability analysis of slopes and embankments is gaining popularity now-a-days. In past four decades some remarkable add this field using first-order, second-moment (FOSM) methods include Wu and Kraft[, Cornell, Alonso, Tang et a, Vanmarcke, Li and Lumb, Luckman et al, Halim and Tang. aside from FOSM method the Monte Carlo method is employed by Tobutt as a sensitivity-testing tool for slope stability analysis and also as a way for calculating the probability of failure of a given earth slope. Further Christian et al de used mean first order method to explore the use of reliability approach for slope stability analysis and application of possible concepts to account for uncertainties in slope stability parameters. Where E(F) and ??(F) are the statistical parameters of factor of safety i.e. mean and variance , respectively. Probability of failure is typically calculated on critical deterministic surface by initial researchers. Then Hassan and Wolff[found that this critical surface having the minimum factor of safety may or might not be the surface of the utmost probability of failure. Chowdhury and Xu, Liang et al and Bhattacharya et all consider the surface with minimum reliability index, ?? to be the critical slip surface. To locate the critical probabilistic surface optimization of reliability index ??, related to a group of geotechnical parameters including the statistical properties are often done. Malkawi et compared first order moment method (FOSM) and Monte Carlo simulation method (MCSM) for calculating reliability index supported various approaches like ordinary method of slices, Bishop method , janbu method. Results showed that FOSM method requires lesser calculations and computing time but MCSM is more powerful and effective scheme for more detailed reliability analysis of slope stability. Ramly et al also used Monte Carlo simulations for probabilistic analysis of a slope by taking spatial variability of soil parameters into consideration and compared the results with FOSM method and a simplified approach during which spatial variability of soil parameters is ignored. Results showed that method used gives reliability value but FOSM but more that simplified approach for the case studied whereas simplified approach significantly overestimate the probability of unsatisfactory performance for the slopes that are dominated by uncertainties because of spatial variability of soil properties.Below are the methods used for stability analysis :-

Method Of Analysis	Characteristic
Swedish Slip Circle Method	Applicable just for cohesive soil.
Method Of Slices	Each slice is analysed and least FOS of slice is said as critical.
Friction Circle Method	Failure surface assumed to be an arc of circle.
Taylor Stability number Method	Not applicable for pure cohesionless soil.

IV. CONCLUSION

Various available slope stability methods are discussed during this paper. It are often concluded from the above discussions that LEMs are simple and fewer accurate compared to other deterministic methods like FEM, FDM, limit analysis etc. These deterministic methods cannot take into account the uncertainties involved during the slope stability analysis. On the other hand, these uncertainties are taken care of by the probabilistic methods. The probability of failure or reliability index gives much more information than the FOS utilized within the deterministic approach. Further, it has been seen that newly established optimization techniques are useful in reducing the FOS or reliability index or in locating the critical slip surface either deterministic or probabilistic

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