Communication Skill 1

Critical Seminar Review

Numerical Analysis of Factors of Safety and Probabilities of Failure in Geotechnical Engineering by Prof. D.V. Griffiths

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The seminar is held on the 19th October 2016, on Campus Nord UPC, by prof. D.V. Griffiths in Colorado School of Mines, USA. Among three topics shown in the slides, professor mainly present the first and the last topic, which is slope stability analysis by finite elements and risk assessment in geotechnical engineering.

In the first part, to begin with, the professor presented us the stability analysis of 2D slop section using finite element method. The soil is considered to be perfect plastic, with cohesion and friction angle. For each element in the mesh, the elastic stress is calculated and checked against Mohr-Coulomb failure envelope. However, the failure of one element does not necessarily means the failure of the slope. The stress of the failed element can be distributed to the elements around while maintaining global equilibrium. When too many elements exceeded its stress limits, the algorithm will not be able to converge and the displacement will be unrealistic big which indicates the final failure of the slope. Using the finite element analysis, the actual behavior of the slope and the development of the failure zone can be perfectly captures, presenting exactly how the slope failed. Also, as it mentioned in the slides, the elastic-plastic finite element analysis is seeking an upper and a lower bound solution simultaneously (within tolerances).

In reality, the slope is 3D, there are variable strength and geometry on the longitude direction. The solution present above will only be valid if the weakest 2D plane is selected for analysis. In the slides, professor presented us an 3D example, analyzed both in 3D analysis and 2D analysis of different sections. The graph of the results is shown in Figure 1. From the graph, it is conclusive that the application of 2D analysis should be carried with caution, as it is only to be more conservative than 3D when the most critical 2D mechanism is found.

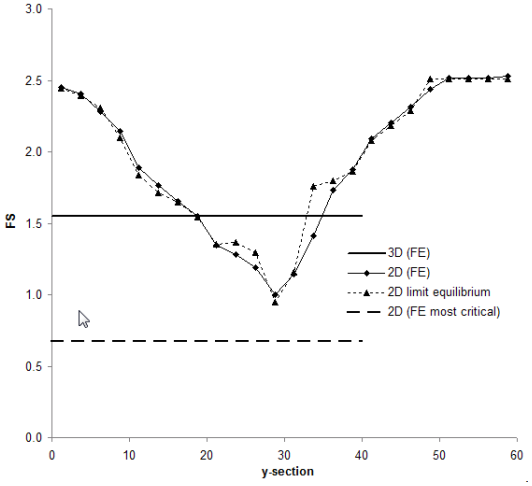

Figure 1 Factors of safety from 3D analysis and various 2D sections

In the second part, professor discussed risk assessment in the geotechnical engineering. In the old Eurocode, the factor of safety is used to describe the load carrying capacity of a system beyond the expected or actual loads. However, now it has been gradually replaced by probability of failure, as the example presented in the seminar, if the safety factor is following a normal distribution pattern, higher mean value (which in our case indicated the value of safety factor) does not necessarily means the lower probability of failure since the variance will affect the result.

There are three levels of probabilistic analysis: Expert panel, First order methods and Monte-Carlo method. The expert panel is basically an event tree; with all the possible events the possibilities is listed in with

percentages. All the percentages in the end should add up to one, which is manageable for small event but it's not applicable for large construction since there are too many variables to consider.

The second method, named FORM (First Order Reliability Method) is construct a function with normal distributed variables, by calculating the function with different variables and plot the function in 3D graph, we can obtain a line crossing the hill separating the failure and safe region. In this case, the probability of the failure will be the volume of the failure side of the performance function. FORM is an improved method compare to the previous one, but too many variables will affect the function behavior the results will be hard to read. As a matter of fact, in Figure 2 the 3D plot is obtained considering only 2 variables, more variables will be hard to control.

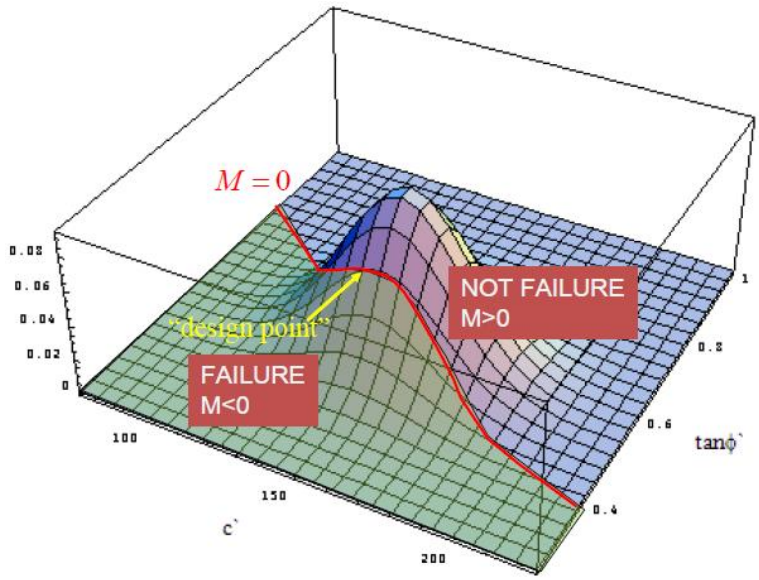

Figure 2 Joint Probability density function

The last method is called Monte-Carlo method. It is better the previous methods because it is more "random", so the results will be close to the reality. In short, the methods required numerous (usually around 10^5 times, the more the better) tests with different values of variables, the values are totally random, and the frequency of the values are according to the normal distribution of the variables. For each calculation, the failure tests are accounted and when against the number of tests, obtained the failure possibility. In such way, more tests will explore more combinations of the problem, and obtained a more accurate result. Although the number of the tests might sound enormous, but with computer it is effortless. Such calculations can be carried even in Excel, by using VBA (Visual Basic for Applications).

Above is the main contents of the seminar. The topic is mostly related to my previous study in my undergraduate course. Prof. Griffiths is very humorous, he has the old English humor in him and the seminar is more than interesting. The slides are presented on-point, with graphs to illustrate the idea and as less sentences as possible. There are a lot of examples, the show the ideas of topic. This seminar is one of the most entertaining and educational seminar I have attended in the semester. And in the end, I shall thank you Professor D.V. Griffiths offering me his slides for the seminar, it gives a great help for this review!