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Slope Stability Analysis Using A Spreadsheet

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Abstract

The analysis of stability of slopes is one of the utmost significance as its failure may lead to loss of lives and great economic losses. Slope stability analysis is to determine the endangered area and safe design of human-made or natural slope. Nowadays, spreadsheet has been used in design and analysis of geotechnical structures. Spreadsheet has the capability of solving problems in short time which make design calculation easier especially when involving trial and error method. Today, there is a lot of software on the market that can be used for slope stability analysis. Some are quite rigorous, while some are expensive. A simulation of slope stability analysis will be developed using Microsoft Excel and find Factor of Safety of the slope. The methods used for the analysis of stability of slopes are Ordinary and Bishop's Method. This spreadsheet assists and provides facilities to the students and designers to compute the slope analysis fast and easily in the future. This study is expected to save cost and time in the analysis and design of the slope compared to manual calculations. To ensure that the spreadsheet is developed to be reliable, the comparison will be made using the analysis through SLOPE/W. Besides that, the purpose of this study is to analyse the slope stability for one case study. The result obtained using simulation in excel program can be used in found factor of safety in slope stability analysis.

Key-word: - Slope Stability Analysis, Factor of Safety

1. Introduction

The boundary surface of a soil mass inclined to horizontal and exposed to atmosphere or in contact with free water is called a slope (Alam Singh, 2008). When a slope fails, it is often called a landslide or a slope failure. Several classification methods and systems have been proposed for landslides. Landslides are the downward and outward movement of slope material because of exhaustion of shear strength (Raj, 2008). Slope failure is one of the oldest geotechnical problems. Even though it is less catastrophic as compared with other geotechnical hazards such as earthquake, the occurrence of landslide and slope failure is more frequent.

Hill slope in Malaysia are vulnerable to soil erosion and shallow slope failure due to intense and frequent rainfall events. Malaysia's annual rainfall is about 1500mm to 3000 mm per annum with an average 2400mm (Latif and Chan ,1995; Muhammad Barzani et al, 2010; Suhaila & Abdul Aziz, 2007). According to Bujang et al. (2008), annual rainfall and high temperatures will encourage weathering process so as to break through 100m into the ground, and hence capable produced of large-scale landslide. Analysing the stability of earth structures is the oldest type of numerical analysis in geotechnical engineering. The idea of discretizing a potential sliding mass into slices was introduced early in 20th century.

There are various methods or equipment used in the making of the geotechnical design work involving the calculation of solving the problems of the design, such as calculators and computers to assist the design engineers. The present use of computers in solving geotechnical designs is very useful and helped engineers to compute the slope analysis. Having knowledge in geotechnical design and with the help of some of the computer programs, it is an advantage to solve geotechnical problems easily. On the today's market, there are many programming tools are introduced and each of them has advantages and disadvantages in terms of cost, speed and flexibility (Wolff, 1995).

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The use of spreadsheets is always the first choice even though there are various computer programs using programming languages such as FORTRAN and BASIC programming. Spreadsheets with a high-quality interface have the ability to calculate the use of complex formulas and also to solve problems in a short time. Meanwhile, manual calculations are sometimes time-consuming and challenging, especially when using trial and error methods. Using spreadsheets, setting and modification of the design calculations can be done easily and in a short time. This method is the best solution to the problem of soil mechanics and a requirement that cannot be ignored.

1.1 Aims and Objectives

This study emphasizes on the slope stability analysis using the Microsoft Excel. This study will provide facilities to students and designers to compute the slope analysis quickly and easily in the future. Therefore, this study is expected to save cost and time in the analysis of the slope compared to manual calculations. To achieve this aim, several objectives are outlined as below:

- 1) To develop a spreadsheet for slope stability analysis.
- 2) To validate the result from spreadsheet with SLOPE/W
- 3) To establish slope stability analysis for a case study in Kg Chennah and Kg Esok in Jelebu Negeri Sembilan.

1.2 Scope of Works

The scope of this study is to build sheet in Microsoft excel for slope stability analysis and determines the factor of safety of the slope. The used data is to generate the spreadsheet that was taken from reference books. The data analysis is made from Ordinary and Bishop Method from books and case study.

3. Methodology

Microsoft excels sheets were used in the building of slope stability analysis. This process involved the inclusion of the relevant formula in the analysis. In this study, two methods of analysis of the calculation sheet were developed, that are Ordinary Method and Bishop Method. Once it is completed, the obtained data from reference books is used to analyze slope stability. From the same example, using Slope / w analysis to ensure that the sheet is made correctly and can be used for the analysis of case studies. From the case study, the value of factor of safety from excel simulation will be distinguished to slope/w and JKR result.

4. Results and Discussion

4.1 Development Of Simulation In Excel Program

Basic slope stability as written by Roy Whitlow (2001) is selected for developing the spreadsheet. In this study, the writer used Ordinary and Bishop Simplified method to build the excel program for slope stability analysis. The slope has gradient 1V:1.85H and 10m height. The geometry, properties of soil and critical slip surface (ordinary method) are shown in figure 1.

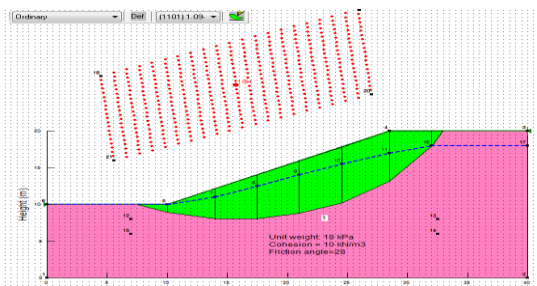


Figure 1 : Critical Slip surface for Ordinary Method

Table 1: Comparison value of factor of safety

Example data	Factor of Safety		Percentage of different
	Excel	Slope/W	
Ordinary Method	1.080	1.094	1.4%
Bishop Method	1.316	1.315	0.1%

The value of FOS is 1.080 for simulation in excel program (ordinary method) and 1.316 for Bishop Method as shows in and the difference value FOS for excel program and slope/w for both method shown in table 1. Referring to that table, the percentage of different using excels and slope/w for Ordinary Method is 1.4% and 0.1% for Bishop Method.

4.1 Case Study

After the simulation is verified with the slope/w, the author used the simulation by excel program to analyze one of the case studies of the construction of proposed upgrading of existing road linking from Kg Chennah to Kg Esok in the district of Jelebu, Negeri Sembilan. The journey of 2km road is expected to transverse and wind on deep cuts and fills along the valley of hilly mountainous terrains of Kenabo Forest Reserved. Summary result from JKR for 12m fill slope in firm silt is value of FOS is 1.94 for Bishop method. Figure 2 shows the geometry, soil properties and critical slip surface for the slope in this case study. Table 2 shows the different value using excel program, slope/w and JKR. It shows that the value is almost similar.

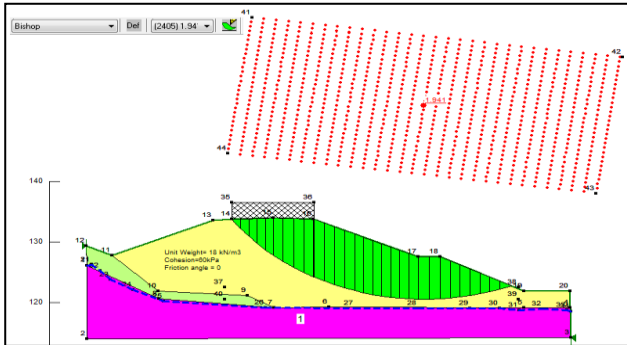


Figure 2: Critical Slip Surface for case study (Bishop Method)

Table 2: Comparison value of factor of safety (case study)

Case Study	Factor of Safety		
	Excel	Slope/W	JKR
Ordinary Method	1.941	1.941	-
Bishop Method	1.941	1.941	1.94

5. CONCLUSION

On the whole, objectives of this study are achieved. An excel program for analysis soil slope stability has been successfully developed. The conclusions that can be drawn from this study are as follows:

- 1) The Excel program can be used as a tool to analyze slope stability analysis as limited to the ordinary and Bishop Method.
- 2) The factor of safety is obtained based on the method chosen and compared to slope/w for the validity.

6. LIMITATION AND RECOMMENDATION

The use of spread sheets in analysing the data can be more time saving than manual calculations. Spreadsheet is able to make automatic computation to solve trial and error methods. However, spreadsheet is limited in drawing form of slope failure. By using scale drawing on a graph paper, it can ensure the sharpness of every angle, width and height of each slice on the slip surface. For the next study, the author suggests to use other software in the market such as Microsoft Visual Basic 6.0, Slide and so on to analysed slope stability. Besides that, Monte Carlo simulation can also be used to integrate reliability concept into slope stability analysis by developing a probabilistic model and determine the probability distribution of factor of safety and reliability index of a slope.

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