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PARAMETRIC STUDY OF SLOPE STABILITY USING PLAXIS SOFTWARE

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PARAMETRIC STUDY OF SLOPE STABILITY USING PLAXIS SOFTWARE

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This thesis is submitted to Engineering Faculty, Universiti Malaysia Sarawak as a partial fulfillment of Bachelor Degree of Engineering With Honours (Civil Engineering) Award

For Ayah,
who believes that his daughter can achieve anything in this world and be the best among the best

For Ibu,
who giving all her love and trust to her daughter and always pray for my happiness and successful life

For Azfaruddin,
who always be my everything

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ABSTRAK

Slope stability defined as the resistance of an inclined surface to failure by sliding or collapsing. The stability of the slope cannot be determined perfectly because of many factors that can effects the stability from time to time. Therefore, the stability of the slopes can be analyzed with many ways such as infinite slope analysis, finite element analysis, block analysis, planar surface analysis and circular surface analysis. Nowadays, Finite element method has been increasingly used in slope stability analysis. When the slope geometry and subsoil conditions have been determined, the stability of a slope maybe assessed using computer analysis. Most of the computer programs used for slope stability analysis are based on the limiting equilibrium approach for a two dimensional model. This Analysis was conducted using two-dimensional finite element program, PLAXIS. The safety factor is evaluated using gravity loading and phi-c reduction procedure. Mohr-Coulomb soil parameters and different levels of global coarseness were examined to know its effect to the computed factor of safety. Result from this parametric study, factor of safety changed with a given levels of global coarseness. But, factor of safety remain unchanged with increasing Young's modulus and Poisson's ratio. Other than that, factor of safety is directly proportional with angle of internal friction and cohesion.

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CHAPTER I

INTRODUCTION

1.1 General

Nowadays, slope stability has become the major issue in Malaysia due to the rapid infrastructure development. The topography of Malaysia influences the construction industry and the slope stability is the main problem occurs recently. Today, the request of residential area such as houses, commercial and industrial buildings increase from time to time. So, the safety of the buildings that surrounds by the hills be the main attentions for people. Furthermore, people today more educated and more concern about their safety.

There are some evidence regarding problems that created by the slope failure such as Landslide in Kilometer 302 North and South Highway on 11 October 2004, Landslide at Bukit Antarabangsa on December 2008 and the most popular tragedy in Malaysia was the collapse of the Block 1 Highlands Tower in 1993. Based on these evidences, it is proven that the slope plays the main role of the building. Without serious attention on the slope safety, more problems will occur and more people will become the victims of the slope failure.

Based on the geology term, slope stability defined as the resistance of an inclined surface to failure by sliding or collapsing. Gravitational forces are always acting on a mass of soil or rock beneath a slope. But, the movement does not occur when the strength of the mass is equal or greater than the gravitational forces. Types of failure depend on types of slope movements. There are various detail explanations on this but following simplified types from Craig (1994) and das (2007), slope failures can be categorized as rotational slips and translational and compound slips.

There are many issues that civil engineers or the geologist can investigate and explore in the slope stability field. Few decades ago, study on analysis of slope stability have been performed by earlier researcher such as Wu and Kraft (1970), Cornel (1971), Alonzo (1976), Tang and others (1976), and Vanmarcke (1977). Based on their study, it is proven that the slope stability defect by the different types of soil, property of soils, and modelling error in implementing analytical methods (Oka and Wu, 1990).

The stability of the slope cannot be determined perfectly because of many factors that can effects the stability from time to time. Therefore, the stability of the slopes can be analyzed with many ways such as infinite slope analysis, finite element analysis, block analysis, planar surface analysis and circular surface analysis. On construction site, the civil engineers and geologist are responsible for slope and the foundation stability. The main reason is to make sure the safety of the public from any slope failure surrounds them.

1.2 Problem Statement

Most of geotechnical engineers are responsible to check the safety of slopes based on the type of slope which are natural slopes, slopes of excavations and compacted embankments. The check includes finding out the value of shear stress acting on the most critical sliding surface and compares it with the shear strength of the soils. Usually, the most critical sliding surface or the failure surface is with the minimum factor of safety. Limiting equilibrium methods are used in the analysis of slope stability. The stability analysis of the slope is difficult to perform. Evaluation of variables such as the soil stratification and it's in-situ shear strength parameters may prove to be formidable task.

Slope stability analysis is an important area in geotechnical engineering. Most textbooks on soil mechanics include several methods of slope stability analysis. A detailed review of equilibrium methods of slope stability analysis is presented by Duncan (Duncan, 1996). These methods include the ordinary method of slices, Bishop's modified method, force equilibrium methods, Janbu's generalized procedure of slices, Morgenstern and Price's method and Spencer method. These methods, in general, require the soil mass to be divided into slices. The directions of the forces acting on each slice in the slope are assumed. This assumption is a key role in distinguishing one limit equilibrium method from another.

1.3 Objectives of study

Nowadays, slope stability is one of the major problems for construction. This is because the slope failure affects the safety of the buildings or occupied area and peoples surround them. The objectives of this study are:

1. To understand the type of failure and the factors affecting the stability of the slope.
2. To study the application of the finite element method in analyzing slope stability problems.
3. To apply the PLAXIS software to simulate and analyze the slope stability problems.

1.4 Scope of Study

1. To conduct literature review on the previous research done using finite element in analyzing slope stability problems.
2. To use finite element geotechnical software PLAXIS to analyze slope stability problem.
3. Parametric study will be conducted to study the affect of certain soil properties on the behaviour of slope stability.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Slope stability analysis is an important area in geotechnical engineering. Most textbooks on soil mechanics include several methods of slope stability analysis. A detailed review of equilibrium methods of slope stability analysis is presented by Duncan (Duncan, 1996). These methods include the ordinary method of slices, Bishop's modified method, force equilibrium methods, Janbu's generalized procedure of Slices, Morgenstern and Price's method and Spencer's method.

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Limit equilibrium methods require a continuous surface passes the soil mass. This surface is essential in calculating the minimum factor of safety (FOS) against sliding or shear failure. Before the calculation of slope stability in these methods, some assumptions, for example, the side forces and their directions, have to be given out artificially in order to build the equations of equilibrium.

With the development of cheaper personal computer, finite element method has been increasingly used in slope stability analysis. The advantage of a finite element approach in the analysis of slope stability problems over traditional limit equilibrium methods is that no assumption needs to be made in advance about the shape or location of the failure surface, slice side forces and their directions. The method can be applied with complex slope configurations and soil deposits in two or three dimensions to model virtually all types of mechanisms. General soil material models that include Mohr-Coulomb and numerous others can be employed. The equilibrium stresses, strains, and the associated shear strengths in the soil mass can be computed very accurately. The critical failure mechanism developed can be extremely general and need not be simple circular or logarithmic spiral arcs. The method can be extended to account for seepage induced failures, brittle soil behaviours, random field soil properties, and engineering interventions such as geo-textiles, soil nailing, drains and retaining walls (Swan et al, 1999). This method can give information about the deformations at working stress levels and is able to monitor progressive failure including overall shear failure (Griffiths, 1999).

Generally, there are two approaches to analyze slope stability using finite element method. One approach is to increase the gravity load and the second approach is to reduce the strength characteristics of the soil mass.

2.2 Type of Slopes

There are two types of slope which are natural slopes and engineered slopes. The analysis of slopes taking into consideration a variety factors such as topography, geology and material properties.

2.2.1 Natural Slope

In many instances, significant uncertainty exists about the stability of a natural slope. Many projects intersect ridges and valleys and these landscape features can be prone to slope stability problems. Natural slopes that have been stable for many years may suddenly fail because of changes in topography, seismicity, groundwater flows, loss of strength, stress changes and weathering. Generally, these failures are not understood well because little study is made until the failure makes it necessary.

The role of progressive failure in problems associated with natural slopes has been recognized every day. The materials most likely to exhibit progressive failure are clays and shales possessing chemical bonds that have been gradually disintegrated by weathering. Weathering releases much of the energy stored in these bonds (Bjerrum, 1966). Information about landslides involving clay and shale slopes and seams has increased largely due to the original work by Bishop (1966), Bjerrum (1966), and Skempton (1964)

2.2.2 Engineered Slopes

In engineered slopes, it consist three main categories which are embankments, cut slopes and retaining wall.

2.2.2.1 Embankments

Generally, embankments slopes are designed using shear strength parameters obtained from test on samples of the proposed material compacted to the design density. The stability analyses of embankments do not usually involve the same difficulties and uncertainties as natural slopes and cuts because borrow materials are preselected and processes.

2.2.2.2 Cut Slopes

Shallow and deep cuts are important features in any civil engineering project. The aim in a slope design is to determine a height and inclination that is economical and that will remain stable for a reasonable life span.

The design is influenced by the purposes of the cut, geological conditions, in-situ material properties, seepage pressure, construction methods, and the potential occurrence of natural phenomena such as heavy precipitation, flooding, erosion, freezing and earthquakes.

Steep cuts often are necessary because of right of way and property line constraints. The design must consider measures that will prevent immediate and sudden failure as well as protect the slope over the long term., unless the slope is cut