ANALISIS SIMULASI KESTABILAN CERUN: SATU KAJIAN KES KEGAGALAN CERUN DI BANGUNAN TAMBAHAN FAKULTI KEJURUTERAAN MEKANIKAL UTM

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Disertasi ini dikemukakan sebagai memenuhi
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To my be loved ones and those who love me

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ABSTRACT

The soil movement on a failed slope had caused substantial failure of sheet pile wall positioned at about 6m from the new laboratory of Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM). To facilitate investigating causes of the failure, a computer simulation of slope stability using PLAXIS 7.2 is performed to simulate slope conditions before and after construction of the study area. The results of simulation analysis establishes the fact that global soil mass movement started from the elevation of the newly filled water tank to downhill direction toward to installed sheet pile generates a combination of mobilized shear force and lateral pressure larger than the capacity or strength of the sheet pile. The associated stresses also create the occurrence of the up heaving underneath the road pavement adjacent to the new buildings. Furthermore, the simulation analysis deduces that the slope instability becomes greater as moisture or pore-water pressure in the slope increases or decreasing in soil's shear strength.

ABSTRAK

Pergerakan bumi atas cerun telah menyebabkan kegagalan tembok cerucuk keping yang terletak kira-kira 6m daripada Bangunan Tambahan Fakulti Kejuruteraan Mekanikal (FKM), Universiti Teknologi Malaysia (UTM). Model simulasi dengan penggunaan perisian PLAXIS 7.2 telah dijalankan untuk menentukan kestabilan cerun sebelum dan selepas aktiviti pembinaan di kawasan tersebut. Model simulasi ini adalah bertujuan untuk mengenalpasti punca-punca dan sebab-sebab berlakunya kegagalan. Keputusan analisis simulasi menunjukkan bahawa pergerakan bumi ini adalah berbentuk serantau bermula daripada puncak bukit di mana lokasi tangki air yang baru dibina menuju ke arah kaki bukit di mana tembok cerucuk keping dibina. Daya ricih dan tekanan sisi yang diaruh oleh pergerakan ini adalah lebih besar daripada kekuatan cerucuk keping yang dibina dan telah menyebabkan bonggokkan tanah dibawah jalan raya sebelah bangunan baru tersebut. Keputusan analisis ini juga mendapati bahawa kestabilan cerun akan terjejas dengan kenaikan tekanan air atau dengan penurunan kekuatan ricih tanah.

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SYMBOL	PARAMETER	UNITS
c'	Effective cohesion	kN/m^2 or kPa
E	Modulus Young	kN/m^3
i	Hydraulic gradient	/
k	Coefficient of permeability (or hydraulic conductivity)	m/s
k_h	Coefficient of permeability (horizontal flow)	m/s
k_v	Coefficient of permeability (vertical flow)	m/s
K_A	Coefficient of Active earth pressure	/
K_o	Coefficient of earth pressure at rest	/
K_p	Coefficient of Passive earth pressure	/
ϕ'	Effective friction angle	Degrees
ν	Poisson ratio	/
γ_{bulk}	Bulk unit weight	kN/m^3
γ_{dry}	Dry unit weight	kN/m^3
γ_{wet}	Wet unit weight	kN/m^3
τ	Shear stress	kN/m^2 or kPa

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CHAPTER I

INTRODUCTION

1.1 Background of the Study

Population growth and accompanying economic development have meant that civil engineering projects are increasingly being carried out in mountainous regions in tropical countries. Wesley (1994) found that probably highway construction is the most important among those hilly development, however hydroelectric construction, geothermal power plants, and recreational resorts also constitute major projects.

Over the last decade, we have had numerous landslides culminating in tragedies and it is no coincidence that they all happened in hilly regions. The fact is, slopes are inherently unstable. While erosion in the form of soil run-offs occurs daily, slopes can collapse and result in destructive landslides.

Slope failures increase when a naturally occurring weak zone or what is called a "fault plane" in geological terminology is present. Landslides on November 20, 2002 at Taman Hillview, Ampang, occurred in such a high-risk zone. Actually, this kind of tragedy is not a new story in our country for instance the infamous Highland Tower Tragedy that happened in 1993 which is just at the side of the tragedy that happened.

Landslides and other gravity-stimulated mass movements are important and costly problem, and they are a continual source of concern for geotechnical engineers and engineering geologists throughout the world, particularly in geologically 'active' regions. They occur worldwide and are described as sudden, short-lived geomorphic events that involve the rapid-to-slow descent of soil or rock in sloping terrains. They can occur on any terrain given the right conditions of soil, moisture and the angle of slope.

Risks of landslides are enhanced in the tropics, where thick, loose residual soil, the result of deep weathering, can be easily eroded. Until and unless a holistic stance in tackling landslides is taken, lives and properties will be at stake and taxpayers' money will be wasted on rescue missions.

Although many mitigation works had been planned and designed prior to the construction of the project, there still exist many uncertainties associated with the material, spanning from its complex origin. Hence, its come the importance to analyze the stability of the existing slope. However, most of the times it is too costly or impossible to monitor the slope for the whole of its service life.

1.2 Problem Statement

There are many circumstances in slopes, where the civil engineer must investigate the stability of slope by performing slope stability analysis. Over the years, much research work had been carried out by researchers namely, Wu and Kraft (1970), Cornell (1971), Alonzo (1976), Tang et al. (1976), and Vanamrcke (1977), regarding the reliability analyses of slopes. They found that the uncertainties occur due to the variability of soil properties, systematic errors or model errors in measurement of properties, and model errors in analytical methods (Oka & Wu, 1990). It should be noted that all calculations for their work were made for the critical slip surface. The search for the critical failure surface, carried out over a number of admissible slip surfaces, is by and large still performed by repeated trials or by the grid search method (Nguyen, 1985).

Existing methods of slope stability analysis using slices (Bishop 1955, Janbu 1957) are based on the limit equilibrium theorem. An implicit assumption in equilibrium analyses of slope stability is that the stress-strain behaviour of the soil is ductile, i.e., that the soil does not have a brittle stress-strain curve (where the shearing resistance drops off after reaching a peak). This limitation results from the fact that the methods provide neither information regarding the magnitudes of the strains within the slope, nor any indication about how they may vary along the slip surface (Duncan, 1996). Besides it, the analysis only considered force and moment acting on the slices with total disregard to the deformation developed in the slices. Thus, it is not possible to obtain reliable results from the analyses if solely based on the method of slices (Terado et al., 1999).

Thus, in order to obtain a unique solution it is necessary to introduce extra conditions. Better analysis should therefore take into account the displacement and deformation of the slices, and also the stresses in the soil mass in determining the stability of slope. However, the problem arises in incorporating these extra conditions in the conventional slope stability analysis.

In the other hand, the stability analyses are performed not only to provide a factor of safety once the soil properties are known, but also to establish field shear strengths from the study of failures. It is rational to carry out the study determining what actually happened after an unexpected instability has occurred. It is therefore necessary to do some analyses in reverse, which is usually termed as "back analysis". The investigation is not mean to blame who or whom should be responsive to the failure but it collects valuable information that could be used in designing the remedial works as well as guidelines for further projects. The awareness of importance of back analysis has resulted in development of various methods in back analysis. However, the problem always arises in determining the suitable method of analysis and the way back analysis can be carried out.

1.3 Objective and Scope of the Study

The objective of this study is to determine the stability of the slope before and after the construction of *Bangunan Tambahan Fakulti Kejuruteraan Mekanikal, UTM.*

Stability analysis of slope is carried out based on the computer modelling using PLAXIS V7.2 (professional edition), a finite element package. A real case study of slope failure was chosen in fulfilling the objective of the study. Shear strength reduction technique is chosen for the determination of safety factor for its formulation based on finite element. The critical failure surface is found automatically. The values of shear strength parameters (c, ϕ) at failure along the failure plane are back calculated with the factor of safety is assumed to be unity.

The analysis is based on long-term condition. Drained analysis is used in this simulation modelling. For the simplicity of the analysis, unsaturated soil condition is out of the scope of study. Stresses of the soil mass along the critical slip surfaces as well as the displacement and deformation are determined using the theory of finite element.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The stability of a slope depends on its ability to sustain load increases or changes in environmental conditions, which may affect the geomaterials mechanically or chemically (e.g. weathering) (Eberhardt, 2002).

The first outward sign of slope instability is usually a tension crack in the ground behind the crest of the slope, sometimes accompanied by slumping of the soil in front of the crack (Sarsby, 2000). The rate of failure is generally relatively slow, developing over a period of hours to days. First part of this chapter reviews investigation of slope instability including classification system that available and factors that encourage instability.

The understanding of slope instability has not come about in an ordered manner. Ideas have been advanced from time to time; some in being accepted have passed into the body of knowledge, others, because they represent concepts too advanced for the times, have been rejected, only to be resurrected at a later date, or because of their patent absurdity have been consigned to the rubbish bin. The second part reviews some of the published landmarks in early slope stability analysis, many of which are valid today, and without which none of the concepts described here would have been possible.

Over the year, limit equilibrium theory has been widely used in slope stability analysis. Equilibrium methods of slope stability analysis all involve assumptions because the number of equilibrium equations available is smaller than the number of unknowns involved (Duncan & Wright, 1980). Third part of literature review gives an overview of limit equilibrium theory that commonly used, showing how these methods may be selected which avoid significant errors arising from the mechanics of the analysis.

Increased computational power has enabled engineers to concentrate more on obtaining the right input for a slope stability analysis and on selecting the appropriate model. In the past 25 years, the finite element method has been used to analyze a large number of dams, as well as other embankments and slopes. The principal requirement for achieving reasonably accurate and useful results from these analyses in suitable presentation of the stress-strain behaviour of the soils involved (Duncan, 1996). The fourth part of this chapter reviews the theory of FE in slope stability analysis as well as information required to formulate the problem and the use of software package.

Owing to the complexities of the laboratory testing, which require costly laboratory equipment, expert test techniques and long test times, it is unpractical to rely solely on laboratory testing. In addition, the difficulties in undisturbed soil sampling also greatly limit applications of laboratory testing. Back analysis has been widely accepted for determination of the parameters for landslide control works because it avoids many of the problems associated with laboratory tests. The final part of literature review presents a detailed description of back analysis currently in use, with emphasis on the advantages and limitations of each procedure.

2.2 Investigation of Slope Failure

In the sense used herein, the term "failure" connotes an unacceptable difference between expected and observed performance (Leonards, 1982). Included are rupture or erosion of the ground, unexpected cracking that is unsightly, or reduces load-carrying capacity, or both, movements that impair the function of a structure, and monitoring systems that do not convey intended warnings in time. When a sudden rupture occurs, herein called "instability," the result is usually spectacular and often incurs heavy property damage and possibly loss of life.

It is commonly believed that investigation of instabilities offers the ultimate opportunity to gain new insights, to evaluate analytical tools, and to improve the design process. This, however, is not always the case, for the following reasons (Leonards, 1982):

i. The geometry of the structure, the loading conditions, the soil stratigraphy, and the ground-water regime prior to failure must be inferred from the original site investigation and extrapolation from adjacent ground conditions, from the plans and specifications, and from examination of the post-failure conditions. In many cases, this information is incomplete, and the very fact that adjacent material did not fail implies that conditions in the failure zone may have been different,

ii. It is always difficult and frequently impossible to reconstruct the sequence of events that led to failure; thus the factors which initiated the instability seldom can be positively identified,

iii. As the original conditions are irreparably altered (and cannot be fully reconstructed), it is not possible to test different hypotheses of failure on the prototype,

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