UNIVERSITI PUTRA MALAYSIA

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STABILITY ANALYSIS OF WEATHERED ROCK CUT SLOPE USING GEOLOGICAL MAPPING AND LABORATORY TESTS

By

AZIMAN BIN MADUN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

August 2002

Specially Dedicated to My Family

Kamsiah Ahmad

Abdul Muiz Aziman

Muhammad Fauzan Aziman

Abstract of thesis presented to Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

STABILITY ANALYSIS OF WEATHERED ROCK CUT SLOPE USING GEOLOGICAL MAPPING AND LABORATORY TESTS

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AZIMAN BIN MADUN

August 2002

Chairman : Associate Professor Husaini bin Omar, Ph.D.

Faculty : Engineering

A study on determining the stability of weathered rock cut slope using geological mapping and laboratory tests. The study is divided into two parts: field work and laboratory testing. The field study focused on the measurement and analysis of the orientation and characteristics of discontinuity. Identification of rock types, weathering grades and observation of cut slope conditions were also included in the field study. Laboratory testing involved determination of natural moisture content, particle size distribution and shear strength. Discontinuity data were analyzed using stereographical method for identification of potential instabilities. A factor of safety (FOS) analysis was conducted on unstable cut slopes using SWEDGE software and manual calculation It is found that the geological mapping and laboratory tests are feasible for assessing slope stability. The FOS analysis has distinguished 10 slope to be considered as fail whilst the other 6 are consider stable same as field observation.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

ANALISA KESTABILAN CERUN BATUAN TERLULUHAWA MENGGUNAKAN PEMETAAN GEOLOGI DAN UJIAN MAKMAL

Oleh

AZIMAN BIN MADUN

Ogos 2002

Pengerusi : Profesor Madya Husaini Omar, Ph.D.

Fakulti : Kejuruteraan

Kajian telah dijalankan untuk mengenal pasti kestabilan cerun potongan dengan menggunakan pemetaan geologi dan ujian makmal. Kajian terbahagi kepada dua bahagian iaitu kajian di lapangan dan di makmal. Di lapangan, kajian terhadap ketakselanjaran iaitu menentukan orentasi dan sifat ketakselanjaran. Pengecaman litologi batuan, keadaan pengluluhawaan dan pencerapan keadaan cerun potongan juga termasuk di dalam kajian di lapangan. Di makmal, analisa kelembapan tanah semulajadi, pengredan saiz tanah dan kekuatan ricih. Data ketakselanjaran dianalisa menggunakan kaedah plot stereografikal bagi menentukan potensi ketidakstabilan. Cerun potongan yang tidak stabil akan dianalisa faktor keselamatan (FK) dengan menggunakan perisian SWEDGE dan secara pengiraan. Kajian mendapati pemetaan geologi dan ujian makmal dapat menilai kestabilan cerun. Analisa FK mendapati 10 cerun gagal dan 6 lagi stabil sama seperti cerapan di lapangan.

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Lastly, my deep appreciation goes to the entire members of my family; beloved wife and children for their invaluable love and patience. Also to my dearly beloved mother, Rasimah Ahmad, for her constant prayers and blessing for my success.

I certify that an Examination Committee met on 29th August 2002 to conduct the final examination of Aziman Madun on his Master of Science thesis entitled "Stability Analysis of Weathered Rock Cut Slope Using Geological Mapping and Laboratory Tests " in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledge. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

AZIMAN MADUN

Date: 12/11/02

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LIST OF ABBREVIATIONS

FOS	Factor of safety
deg	Degree
CH	Chainage
RHS	Right hand side
LHS	Left hand side
QU	Quick undrained
UU	Unconsolidated undrained
CD	Consolidated drained
CU	Consolidated undrained
$\sigma 1$	Lateral pressure + principal stress-pore pressure
$\sigma 3$	Lateral pressure
σ	Normal stress
τ	Shear stress
Φ	Friction angle
A_p	Area of failure plane
C	Cohesion
U	Uplift water pressure
V	Horizontal water pressure
W	Weight of failure block
ψ_p	Angle of failure plane
ψ_f	Angle of slope
Z	Depth of tension crack
Z_w	Depth of water in tension crack.
γ	Rock density
γ_w	Water density

CHAPTER I

INTRODUCTION

Background

The search for human needs such as food, shelter and communication has lead to civilization. Thus civilization was the basis for development in the world for centuries. It has led to improve standards of living for mankind. Building technology is part of civilization. As a result, a modern network of roads is one of its products that has enabled connectivity and communication between one colony of people to another. Roadways are vital infrastructure to promote development in any area. It triggers economic development and prospers a nation from the biggest to the most remote.

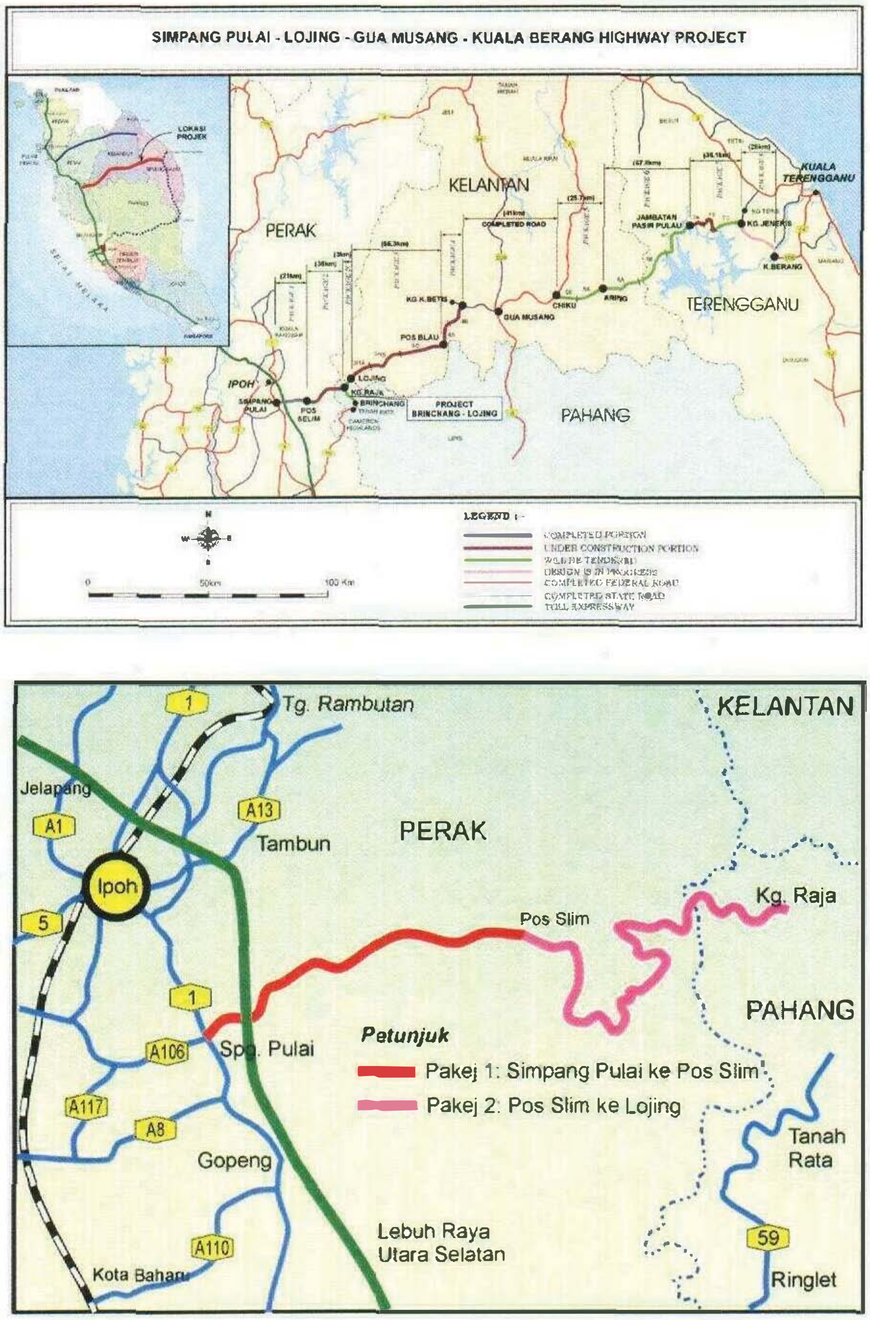
Unfortunately, construction development often fails to synchronize with the requirements of nature. Intrusion into nature usually results in catastrophes, especially when construction occurs on hilly and mountainous terrain.

The reasons for failure are many and range from natural slope development process often referred to as 'Acts of God' or the inappropriate design of engineered slopes. The reasons for the failure of engineered slopes can be the result of non-recognition of certain factors controlling stability in the design process or the application of inappropriate methods in the assessment of actual stability conditions (Othman et al., 1997).

In the past, studies by many researchers like Komoo, (1985), Komoo and Abdullah (1983), Komoo et al. (1985) and Tajul (1991) were directed towards developing engineering geological mapping in Malaysia. They studied the geological structure that cause slope instability in various places in Malaysia.

For this study, the author will focus on geological mapping and engineering properties. These geological mapping and engineering properties will then be used in rock slope stability analysis. The field study was conducted on cut slopes at Pos Selim Highway in Perak, the western part of Peninsular Malaysia (Figure 1.1).

The highway which is part of the East West Second Link project has been divided into a total of eight packages. Package 1 has been completed while packages 2, 3, 4 and 7 are currently in progress. This study covers package 2, which cover the area from Pos Selim in the state of Perak to Ladang Blue Valley at Cameron Highlands, Pahang. The highway will link Perak on the West Coast and Terengganu in the East Coast. The completed product will hopefully enhance economic development in the central state of Perak, North Pahang, South Kelantan and Hulu Terengganu areas.



Top: Overview of the package from Simpang Pulai to Kuala Berang.
Bottom: Close up of the Pos Selim Highway in package 2.

Figure 1.1 : The location map

The construction work for package 2 was awarded to MTD Construction Sdn. Bhd. under a Fixed Turnkey Lump Sum contract for a total of RM 282 million. The length of the proposed road is approximately 35 kilometers and was designed as a two-lane single carriageway with a design speed of 50 km/h. The road crosses over the Titiwangsa Main Range bordering Pahang and Perak.

The road begins at Pos Selim at an elevation of 496 meters in Perak and transverses over the mountainous terrain for 27 km to the Pahang border at an elevation of 1440 meters. The route continues through rolling terrain over several plantations before it ends at Ladang Blue Valley at km 35.5 at an elevation of 1402 meters.

The idea to carry out this study cause from the occurrence of a number of cut slope failures during construction along Pos Selim to Ladang Blue Valley Highway project. This study will investigate the geological structures and engineering properties that affect cut slope instability.

Objectives

The objective of the research is to study the contribution of geological structures and engineering properties in slope stability of weathered rock. The approach of this study is by means:

1. To study the geological structures by geological mapping.
2. To determine the engineering properties.
3. To carry out factor of safety analysis of cut slope.

Scope and Limitation

The study focuses on two aspects, which are geological mapping and laboratory study for engineering properties. First, geological mapping was undertaken in the field of 16 cut slope along Pos Selim to Ladang Blue Valley Highway to determine potential instability of slopes. Secondly, laboratory testing were conducted on 16 cut slope materials to determine the engineering properties. Subsequently, all data related to slope stability was used for the factor of safety analysis.

Summary

A literature review of research work conducted in various areas related to this research is presented in Chapter 2. The literature review begins with introduction of slopes and slope failures problem. The survey will look at slope stability and rock slope stability analysis. Next, a review of literature will be undertaken on geological contribution to slope instability such as weathering, engineering properties and geological structures. Next will be a review of literature related to geological mapping. The methodology of this study is discussed in

Chapter 3. Chapter 4 presents a complete account of results and discussions of findings and data obtained from both field and laboratory tests. The conclusions and recommendations of this study are presented in Chapter 5.

Expected outcome of the research

The expected outcome of the research is to obtain information and better understanding of the geological structures and engineering properties that affect cut slope instability.