UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF AN EXPERT SYSTEM FOR THE EVALUATION OF POTENTIAL INSTABILITY ANALYSIS OF CUT SLOPES

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By

SAIFUL ISKANDAR KHALIT

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

May 2003

Dedicated to

My family especially

Khalit Tahir
Rokiah Haji Abdul Hamid
Kamariah Khalit
Ahmad Rizal Khalit
Ahmad Fuad Khalit

"MAY ALLAH BLESS YOU" ! !

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

DEVELOPMENT OF AN EXPERT SYSTEM FOR THE EVALUATION OF POTENTIAL INSTABILITY ANALYSIS OF CUT SLOPES

By

SAIFUL ISKANDAR BIN KHALIT

May 2003

Chairman : Associate Professor Husaini Omar, Ph.D.

Faculty : Engineering

Expert System for Potential Instability Slope Analysis codename ExPISA was developed to generate the computerized stereonet, hence to predict the mode of potential failure of cut slope. It will be used for slope monitoring and maintenance during early stage of construction of the slope. The system was developed through consultations of field expertise and field studies. The purpose of the domain expert was to determine suitable geological discontinuities parameters which are involved in the development of the Expert System. The discontinuity data were obtained and analysed using computerized stereonet. The database *.* sgp file developed in sequential file format which can be updated and referred through the ExPISA itself. The Expert System was able to predict potential slope instability as wedge failure, planar failure or wedge and planar failure. The Expert System was validated and verified using twenty case studies from two different location and assumption of 'IF-THEN-ELSE' programming technique.

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

PEMBANGUNAN SISTEM PAKAR UNTUK ANALISIS CERUN YANG BERPOTENSI TIDAK STABIL

Oleh

SAIFUL ISKANDAR BIN KHALIT

Mei 2003

Pengerusi : Profesor Madya Husaini Omar, Ph.D.

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Sistem Pakar untuk menganalisa potensi kestabilan cerun dengan kod nama ExPISA telah dibangunkan untuk menjana aplikasi 'stereonet' secara berkomputer dan seterusnya dapat menjangkakan keadaan ketidakstabilan sesuatu cerun. Sistem ini boleh digunakan untuk tujuan pemantauan dan pemuliharaan cerun pada awal pembinaan. Sistem pakar ini juga dibangunkan dengan bantuan nasihat oleh golongan pakar dan pengumpulan data di lapangan. Tujuan penglibatan pakar di dalam pembangunan sistem ini adalah untuk mengenalpasti parameter geologi yang sesuai. Berdasarkan daripada keputusan yang diambil dari tapak kajian, analisa data dibuat menggunakan kaedah 'stereographical'. Hasilnya, keputusan untuk keadaan ketidakstabilan cerun yang berpotensi untuk gagal dapat dijangkakan samada kegagalan baji, planar atau kedua-duanya sekali boleh diperolehi. Data-data boleh dikemaskini dan disimpan dalam storan dalam bentuk format fail *.* sgp. Sistem Pakar ini telah disahkan dan disahihkan dengan dua puluh kes kajian dari dua lokasi yang berbeza dan penggunaan teknik pengaturcaraan 'IF-THEN-ELSE'.

ACKNOWLEDGEMENTS

In the Name of Allah, Most Merciful & Most Compassionate

I would like to express my gratitude to my supervisor, Associate Professor Dr. Husaini Omar for his untiring supervision and encouragement. I would also like to thank to my supervisory committee consisting of Prof. Ir. Dr. Mohamed Daud and Dr. Rosely Ab. Malik for their comments and suggestions.

I also wish to place on record my gratitude indeed to my family who were and are constantly praying for my success.

The author is also grateful to the following for their support and contribution: Mr. Aziman Madun, Mr. Muhammad Naim Rouyan, Mr. Ahmad Zaidi Hampden, Ms. Azura Ahmad, Mr. Mohd Sal Salsidu, Ms. Azfariza Azizi, Mr. Adnan Arifin, Mr. Rozaini Md Yusof, Mr. Zaharudin Hisam and all MTD-RC staff.

Saiful Iskandar Khalit

I certify that an Examination Committee met on 06th May 2003 to conduct the final examination of Saiful Iskandar Khalit on his Master of Science thesis entitled "Development of an Expert System for Evaluation of Potential Instability Analysis of Cut Slopes" 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 Examination Committee are as follows:

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DECLARATION

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

SAIFUL ISKANDAR KHALIT

Date: 10/9/2003

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

General

Technology in the field of information technology has been developing very fast over the last decade. The expert system as a computerized advisory program attempts to imitate the reasoning processes and knowledge of experts in solving specific types of problems. It can provide expert problem solving performance in a specific competency domain by exploiting a knowledge base and reasoning mechanism as a method which could create a great interest to system developer because of their potential to enhance organization's productivity and make ease to end user where human experts are becoming increasingly difficult to find and retain. Current applications are restricted to relatively limited and narrowly defined areas of expertise (Agre and Dochev, 1993).

Human experts tend to specialize in relatively narrow problem-solving areas and tasks. Typically, human experts posses characteristics such as solving a problem quickly and fairly accurate, explaining what they do, judge the reliability of their own conclusions, knowing when they are stumped, and communicating with each other (Turban, 1992).

An interesting area in language environment developments has been the emergence of Object Oriented Programming (OOP) language. In the OOP, objects include their own procedures and data and communication via message. OOP language has contributed significantly to the expert tool set by providing greatly enhanced user interfaces. Besides conventional programming languages, such as FORTRAN and C, OOPs are designed and optimized for the procedural manipulation of data (such as numbers and arrays) (El-Bibany, 1996). Humans, however, often solve complex problems using very abstract, symbolic approaches which are not well suited for implementation in conventional languages. Although abstract information can be modeled in these languages, considerable programming effort is required to transform the information to a format usable with procedural programming paradigms (Darlington, 2000).

One of the results of research in the area of artificial intelligence has been the development of techniques which allow the modeling of information at higher levels of abstraction. These techniques are embodied in languages or tools which allow programs to be built that closely resemble human logic in their implementation and are therefore easier to develop and maintain. These programs, which emulate human expertise in well defined problem domains, are called expert systems (Ketata et. al., 2000).

Engineers seek tools to expedite the process of searching acceptable solutions. A knowledge based expert system is a tool of such kind. It is a computer presentation contains the knowledge and heuristics of one or more experts and simulates the performance of those experts in solving problems in similar domains. An expert system is also considered an effective means of collecting, organizing, preserving and propagating valuable knowledge which has been developed and accumulated by experts through years of experience (Gero and Stanton, 1988).

Problem Statements

There are approximately thirty two thousand kilometers of roads and highways throughout Malaysia. The majority of these traverses across undulating terrain. Construction and maintenance costs for roads and highways traversing mountainous terrain in Malaysia are relatively high because of some criteria such as intensive earthworks, located in difficult areas, unfavourable geology with in tropical climate (Kong, 1999). Landslide disrupts communications hence loss of trade, business opportunities and inconvenience to public and potential of loss of life and property. Lack of maintenance and improper planning on slope preventive and remedial could result in slope instability. In some cases due to slope instability, many slope failures have been detected or reported in Malaysia during raining season (Affendi, 1996). In January 1996, a cut slope collapsed at the North-South Expressway which involved slope failure where one road user was killed. Such a thing will make knotty problems for those engineers whom expert in geotechnical areas. In addition, in May 1999, the landslide at Bukit Antarabangsa was cut off 10, 000 residents from the Jalan Hulu Klang main road. Due to this problem, transportation was affected by loss of business opportunities (Anon, 2000).

Before slope failure occurs, there exists mode of potential failures which tend to be neglected by engineers (Omar and Aziz, 1996). Potential instability of slope analysis, at present, this work mainly relies on human expertise. There are not many systems especially an expert system being developed to carry out slope analysis based on

geological information. Today, a few of programs have been developed such as DIPS, Z_Soil and Quickplot. Stereographic projection analysis or Schmidt Net is done using plotting method. Human expertise is expensive and difficult to maintain, to transfer and to be documented. For this reason, an expert system of this field could be developed. It can generate a computerized stereographic projection of the slope conditions and determine a mode of potential failure based on geological data which will be developed. This system could assist a young engineer or non expert to evaluate the potential instability of slope.

Objectives

The main aim of this research is to develop an expert system for potential instability analysis of cut slopes. Specific objectives are as follows:

- to determine geological discontinuities parameters which can be used in the Expert System;
- to determine acquired domain expert on mode of potential slope failure to be incorporated into Expert System; and
- to develop and verify an Expert System that can advise on potential slope instability based on findings mentioned above.

Scope and Limitation

The studies were carried out at two different locations of cut slopes. For the purpose of field data collection, the field study was carried out along cut slopes at Package 2 of the Pos Selim Highway and at Package 1D and 1E (Temerloh to Maran) of the East Coast Expressway. The Pos Selim Highway is part of the Malaysia's East-West Highway projects which is currently under construction. The construction of the highway started early 1997 and was scheduled to be completed in the year 2000. However, the complexity of the geology setting of the areas has caused a delay in construction. The East Coast Expressway is an extension of the Kuala Lumpur – Karak Highway which was developed by MTD Capital in 1988. The construction of the highway began at Karak Interchange and end at Kuantan Interchange. The geological parameter structure chosen are Dip, Dip Direction, Angle of Internal Friction, Slope Angle and Slope Face/Direction after which the system is developed based on geological parameter data using Microsoft Visual Basic version 6.0.

Expected Outcome of the Research

The expected output of the research is the development of potential instability of expert system for cut slope based on the selected geological structures known as dip, dip direction, angle of internal friction, slope angle and slope face/direction. There are four modes of potential failure that can be categorized as wedge, planar, wedge and planar and also no failure.

CHAPTER 2

LITERATURE REVIEW

Introduction

In recent years, competition on land use for industrial, residential and roadwork area require land to be formed by cutting back slopes in hilly terrain of Malaysia. Increasing hill slope development and expansion of road and highway network, has not just created more cut and fill slopes, but also brought us closer to the natural slopes (Affendi, 1996). For example, at the Arthur's Pass National Park of New Zealand, debris flows, rockfall, and a large rock avalanche on State Highway 73 were responsible for major highway reconstruction required at the Zig Zag and Otira Gorge. The high rate of erosion is due to combined effects of high altitude, frequent heavy rain, ongoing uplift of the Southern Alps, and highly fractured bedrock. Major active faults occur within 20 km of Arthur's Pass, and earthquakes of magnitude M7 have occurred nearby in historical times, initiating landslides which damaged the highway (Paterson, 1996). When this construction was being carried out in cut slope area, problems related to potential instability were well known (Donald and Chen, 1997). The phenomenon of potential instability can be explained by the following causes such as decreasing resisting force due to may be fracturing, saturation with water, shaking, planes of weakness oriented parallel to slope and removal of vegetation.

Discontinuities

The knowledge on the geology of the field study will assist an engineer to predict the type of potential slope failure. In other words, the geological conditions must also be reviewed during construction to verify the formation of slope instability and to ensure unpredictable problem to be taken into reassessment, when necessary (Omar and Aziz, 1996).

Discontinuities or weakness of planes are those structural features, which separate intact rock blocks within a rock mass. The mechanical properties of joints features will vary according to the process of their formation. Faults will exhibit distinctive characteristics and will respond in different ways to applied loads. In this study, the term discontinuity will be used to define the structural weakness plane upon which movement can take place. The presence or absence of discontinuities has very important influence upon the stability of slopes and the detection of the geological features is one of the most critical parts of stability investigations (Ojankangas, 1991). Figure 2.1 shows that a formation of discontinuities at the research area at CH 76000 of East Coast Expressway (Package 1E1).

Figure 2.1: The discontinuities at CH 76000 of East Coast Expressway (2002)

Joints

Parting-planes known as joints are formed in rocks and are the most common structure to affect the behavior of soil and rock engineering works. Fractures on which there has been no movement, or no discernible movement, or on one side or wall relative to the other. They often reflect in their patterns a systematic geometry and symmetry (West, 1995), as shown below in Figure 2.2.