ANALYSIS OF SLOPE STABILITY AND PROPOSED REMEDIAL WORK FOR FAILURE SLOPE AT KUALA LUMPUR

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This project report is dedicated to my beloved father and mother

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ABSTRACT

The objective of this study is to determine the cause of failure and evaluate the slope stability in order to propose remedial measure for stabilization. The investigate slope discussed in this paper is located at Persiaran Endah and within 10 kilometers from Kuala Lumpur. This slope is around 23 to 28 meter height and approximate 55^0 to 66^0. The pertinent engineering properties were analyzed from field test borings which were drilled up to 22 meters depth, seismic refraction survey, inclinometer data, back analysis result, and engineer judgment. Back analysis was carried out to estimate the mobilized shear strength of the problematic layer. SLOPE/W program of Universiti Teknologi Malaysia was used for analysis. Based on the result of the field investigation and numerical analysis the lowest factor of safety (FOS) that evaluated from the existing slope in critical section was found to be 0.741. Therefore, soil nailing was recommended to reinforce the slope, which has an acceptable FOS of 1.525 under static condition. Hence, the installation of soil nailing, grid beam, and drainage were selected for remediation to ensure the long term stability of the failure slope.

ABSTRAK

Objektif kajian ini adalah untuk menganalisis punca kegagalan cerun serta mencadangkan langkah pemulihan penstabilan cerun. Cerun yang dikaji dalam projek ini adalah terletak di Persiaran Endah dan kira-kira jarak 10 kilometer dari Kuala Lumpur. Cerun kajian ini adalah 23 hingga 28 meter tinggi dan anggaran kecerunannya adalah 55^0 hingga 66^0. Sifat-sifat kejuruteraan yang berkaitan dianalisis daripada *borings* yang telah digerudi sehingga kedalaman 22 meter, *sismic refraction survey*, data *inclinometer*, *back analysis*, dan wajaran daripada jurutera. *Back analysis* dijalankan untuk menganggarkan kekuatan ricih kerahan bagi lapisan yang bermasalah. SLOPE/W program Universiti Teknologi Malaysia telah digunakan dalam analisis tersebut. Berdasarkan keputusan penyiasatan sekitar dan analisis berangka, faktor keselamatan terendah (FOS) yang dinilai pada kritikal cerun seksyen adalah 0.741. Oleh itu, *soil nailing* telah dipasang untuk mengukuhkan cerun denagn factor keselamatan 1.525 yang kukuh dalam keadaan statik. Kesimpulanya, pemasangan *soil nailing*, *grid beam*, dan saliran pengailiran telah dicadangkan untuk pemulihan supaya dapat memastikan kestabilan jangka panjang bagi cerun kegagalan tersebut.

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LIST OF ABBREVIATIONS

FS	=	Factor of Safety
FOS	=	Factor of Safety
F	=	Factor of Safety
Z_R	=	Right Inter-slice Force
h_R	=	Height of the Z_R
CIU	=	Isotropic Consolidation Undrained Test
JKR	=	Jabatan Kerja Raya
BH	=	Borehole
INC	=	Inclinometer
SG	=	Specific Gravity
MC	=	Moisture Content
JPS	=	Jabatan Pengaliran & Saliran
UD	=	Undisturbed Sample
SPT	=	Standard Penetration Test
LEM	=	Limit Equilibrium Method

LIST OF SYMBOL

c_u	=	Unconfined Shear Strength
c’	=	Drained Shear Strength
δ	=	Inter-slice Force Inclination Angle
c	=	Cohesion
φ	=	Angle of Internal Friction
ϕ’	=	Effective Friction Angle
ϕ	=	Friction Angle
σ_3	=	Cell Pressure
$\sigma_{3'}$	=	Effective Consolidation Pressure
u_b	=	Pore Water Pressure
u_i	=	Steady Pore Pressure
δ_{Vc}	=	Total Change in Volume
τ	=	Shear Strength
σ'_n	=	Normal Stress

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CHAPTER 1

INTRODUCTION

1.1 Background

The developments in soil and rock mechanics play an important role in the evolution of slope stability analyses in geotechnical engineering. The increasing demand for the engineered cut and fill slopes in construction projects has enhanced the needs for deepened understanding on the analytical methods, investigation tools and stabilization methods in order to solve slope stability problems. (Abramson et al., 2002)

In Malaysia, landslide records from the year 1966 to 2003 showed that 42% of landslides occurred in hilly terrain areas and more than 90% occurred in developed area such as in the infrastructural area, residential area and commercial area. In order to carried out more investigation works for landslides in 2004, Public Works Department Malaysia has establish a new branch called Slope Engineering Branch that involved in mitigation, research and development, risk management, safety and planning on slope and etc. (Slope Engineering Branch, 2010)

Slope Engineering Branch Malaysia state that the investigations carried out thus far revealed that causes of landslides are due to physical, geological and human elements. Based on landslide forensic statistical data for large scale failure from year 2004 to 2007, it was found that about 57% of landslides were due to human factor, whereas 29% were attributed to physical factor and 14% was caused by various geo-

logical factors. It has also discovered that most of the landslides occurred at manmade slopes.

With the incresed developments that have encroached into the hilly areas over the pass two decades, Malaysia experience frequent landslides with a number of major slope failure which cause damage and incovenience to the pulic. Among the most notorious landslides was the colloapse of a slope with rubble wall, bringing down Tower 1 Apartment of Highland Towers and killing 48 people on 11th December 1993. The towers were built in 1978 at Taman Hillview, Hulu Klang Selangor. (Gue & Cheah , 2007)

This landslide tragedy should be a good lessons for the relevant parties in Malaysia so that improvement and more effective precaution measures can be taken by them to avoid the destruction of lives and properties. Landslides not only bring detrimental effects to the environment, but to the people and the economy as well. Therefore, a reliable slope stability analysis should be carried out so that similar incidents can be avoided in future.

To deal with these slope stability issues various approaches have been adopted and developed over the years. The approaches now have been more of computational rather than the manual. Various software are available to analyze the slopes that are liable to failure by the calculating the factor of safety. Among the famous approach are finite elements and limit equilibrium methods.

However, when using limiting equilibrium methods to analyze slopes, several numerical inconsistencies and computational difficulties may occur in locating the critical slip surface (depending on the geology) and hence establishing a factor of safety. Despite these inherent limitations, due to its simplicity limiting equilibrium continues to be the most commonly used approach (N. A. Hammouri et al. 2008). Program SLOPE/W is formulated in terms of moment and force equilibrium factor of safety equations. Limit equilibrium methods that used in this program include Morgenstern-Price, General limit equilibrium, Spencer, Bishop, Ordinary, Janbu etc.

Hence, SLOPE/W is a main program that being chose to conduct the slope stability analysis in various cases.

1.2 Problem Statement

Slope stability analysis is a vital analysis especially in a construction project nearby the slope area. This analysis is performed to assess the safe design of human-made or natural slopes and the equilibrium conditions. Improper slope analysis design might cause slope failure which has been acknowledge as one of the most frequent disaster that can lead to great loss of properties and life. Thus, the initial soil investigation has to be done properly in order to achieve the actual soil condition for the certain place where we want to start construction.

However, the stability of sloped land areas, landslide, is a main concern where movements of existing or planned slopes would have an effect on the safety of people and property or the usability and value of the area. Although, a lot of slope analysis had carried out, but the possible of slope failure is still high. The quoted phenomena take place due to either an incorrect approach to the assessment of their stability, or mistakes made at the stage of geotechnical investigations, erroneous assumptions made in the phase of carrying out calculation, or an improper location of machines on the slope surcharge. One of the causes of the incorrect assessment of slope stability may be inaccurate determination of the geological structure of the slope in question. (Das, 2011)

Based on the *Jabatan Pengairan dan Saliran Malaysia* (JPS), Kuala Lumpur was experienced a high intensity rainfall on March 2012. Consequently, three slope failures were reported to occur along Jalan Persiaran Endah. These slope failures are categorized as critical level because it is located beside the main road to a tourist spot and just occur beside the residence areas. When slope failure occurs, the debris encroaches on the road and may also cause damage to lives and properties from time to time. Hence, the public safety is threatened directly and the immediately

remediation should be commenced. Therefore, this study is intended to carry out a slope stability analysis on failure slope and in the same time, propose some remedial measures based on the field investigation and stability analysis of the slope .

1.3 Aim and Objectives of Study

The aim of this study is to investigate the stability of the slopes by determining the factor of safety and to proposed safe slopes at Jalan Pesiaran Endah, Seputeh, Kuala Lumpur. Therefore, the objectives of this project are:

i. To identify the main cause of slope failure along Persiaran Endah, Kuala Lumpur.
ii. To ascertain the design parameters and stability of the failure slopes based on the SLOPE/W 2007 programme.
iii. To determine the appropriate remedial method on slope failure in term of factor of safety.

1.4 Scope of Research

The investigation is limited to the colapsed section (hereafter will be referred to as the investigated slope). SLOPE/W programme (by GEO-SLOPE) is use to analyze the probability of failure of a slope. The minimum factor of safety will be computed by using the critical parameters from the soil investigation reports data and back analysis results. The data consists of soil investigation report which is gathered from one related consultant company's project. The case study is located at Persiaran Endah Seputeh 50460, Wilayah Persekutuan Kuala Lumpur. This site can be accessed via Jalan Robson and it is within 10 km from Kuala Lumpur City Centre. The study area consists of three slopes failure namely Site 1, 2 and 3 and all are different in geometry. However, in this study, the detail study on slope stability analysis is only performed on failure slope at site 2 (section GG' and HH'). This is

because site 2 is more critical in term of geometry if compare to another two sites. The location of case study is shown in Figure 1.1.

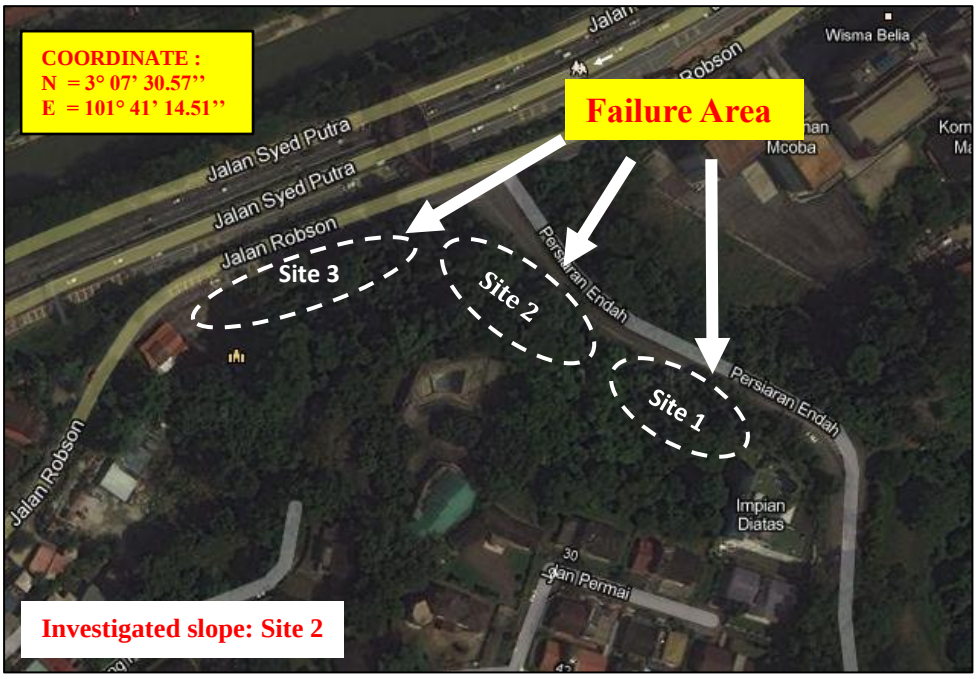

Figure 1.1: Site Location (Google Map)

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