



UNIVERSITI PUTRA MALAYSIA

***SLOPE MONITORING AND SLOPE FAILURE THRESHOLD
DETERMINATION AT KM 46 JALAN SIMPANG PULAI-CAMERON
HIGHLANDS, MALAYSIA***

NUR ANATI BT AZMI

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DETERMINATION AT KM 46 JALAN SIMPANG PULAI-CAMERON
HIGHLANDS, MALAYSIA**

By

NUR ANATI BT AZMI

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

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Chair: Zainuddin Md. Yusoff, PhD

Faculty: Engineering

In Malaysia, landslide is one of the common natural disasters and a growing public concern, especially for the people who frequent the hilly road or mountainous terrain. There are many factors that cause landslides such as groundwater level, geological properties such as type of rocks, soil, joint, and fault, slope condition, and geometry of slopes. The objectives of this research can be divided into four objectives. First objective is to develop a geological-geotechnical-geomorphologic map of the study area. The second objective which is to identify the mode of failure within the study area and within the Pos Selim area can be achieved using all the parameters involved from first objective. The third objective is to analyze the slope monitoring data from geotechnical equipments that can be retrieved wirelessly. Lastly, threshold values for the slope failure risk potential can be determined. The slope chosen is the KM 46 Jalan Simpang Pulai-Cameron Highlands in Perak. The slope was monitored using the Wireless Sensor Network (WSN). Geology of the area mainly consists of granite and schist which are moderately to highly weathered and the schist area had complex structures which are highly fractured. Slope monitoring instruments were installed at the site of selected locations. Surface extensometers (SEM) were installed to measure the ground displacement. Inclinometers (IPI) used to monitor the subsurface or underground movement. Vibrating wire piezometers (VWP) and rain gauge, (RG) were installed to measure the ground water level and rainfall intensity. Some of the instruments were installed at different depth in boreholes while the SEM was located on the slope. All these instruments were connected to wireless devices and data from the instruments were directly sent wirelessly to the users through a web. A reliable and justified combination of the parameters obtained was developed into an equation that can be used to obtain the threshold value. A Risk Level Guide, which is categorized into "LOW", with threshold value less than 0.8, while "MEDIUM" between 0.8 to 1.6 and "HIGH" was more than 1.6. This guide is based on the threshold values obtained and special considerations are also placed on the qualitative aspects such as discontinuity analysis. This guide can be used as another source to trigger the alarm system by the local authorities at the site apart from other methods such as visual inspection of the soil movements.

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

**PEMANTAUAN CERUN DAN PENENTUAN NILAI AMBANG BAGI
KEGAGALAN CERUN DI KM 46 JALAN SIMPANG PULAI-CAMERON
HIGHLANDS, MALAYSIA**

Oleh

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Disember 2015

Pengerusi: Zainuddin Md. Yusoff, PhD

Fakulti: Engineering

Di Malaysia, tanah runtuh merupakan salah satu bencana alam yang telah menyebabkan kebimbangan orang ramai semakin meningkat, terutamanya bagi mereka yang sering menggunakan jalan berbukit atau tinggal di kawasan pergunungan. Terdapat banyak faktor yang menyebabkan tanah runtuh seperti tahap air bawah tanah, ciri geologi seperti jenis batuan, tanah, kekar, dan sesar, keadaan cerun, dan geometri cerun. Objektif kajian ini boleh dibahagikan kepada empat. Objektif pertama adalah menghasilkan peta geologi-geoteknik dan geomorfologi untuk kawasan kajian. Objektif kedua adalah mengenalpasti jenis kegagalan berdasarkan parameter terlibat daripada objektif pertama. Objektif ketiga adalah menganalisis data pemantauan cerun daripada alatan geoteknikal yang boleh dicapai secara wayarles. Akhir sekali adalah untuk menentukan nilai ambang yang boleh menyebabkan potensi kegagalan cerun. Cerun yang dipilih ialah cerun di KM 46 Jalan Simpang Pulai-Cameron Highlands di Perak. Cerun tersebut dipantau menggunakan Sensor Rangkaian wayarles (WSN). Geologi kawasan tersebut kebanyakan terdiri daripada granit dan syis dengan gred luluhawa tinggi dan syis kawasan terbabit mempunyai struktur kompleks dengan bahan sangat rapuh. Instrumen pemantauan cerun telah dipasang di lokasi cerun dipilih. Salah satu alat yang dipasang adalah extensometer permukaan. Extensometer permukaan digunakan untuk mengukur anjakan tanah atau pergerakan. Inklinometer juga telah dipasang dan digunakan untuk memantau pergerakan bawah permukaan atau bawah tanah. Getaran piezometer wayar dan hujan tolok telah dipasang untuk mengukur paras air bawah tanah dan intensiti hujan. Kesemua instrumen telah dipasang pada kedalaman yang berbeza dalam lubang-lubang digerudi di lokasi terpilih dan dipasang di permukaan. Semua peralatan ini disambungkan kepada peranti tanpa wayar dan data daripada instrumen telah terus dihantar secara wayarles kepada pengguna melalui web. Gabungan parameter yang diperolehi telah menghasilkan satu persamaan yang boleh digunakan untuk mendapatkan nilai kritikal. Panduan tahap risiko yang dihasilkan telah dibahagikan kepada tiga kategori iaitu tahap "RENDAH" dengan nilai kritikal tidak lebih dari 0.8, bagi nilai "SEDERHANA" pula nilai kritikalnya adalah antara 0.8 hingga 1.6 dan bagi nilai kritikal untuk tahap "TINGGI" adalah lebih daripada 1.6. Tahap risiko ini dihasilkan berdasarkan nilai kritikal yang mengambil kira aspek khas kualitatif iaitu analisis ketakselajaran. Tahap risiko ini boleh digunakan sebagai sumber untuk

mencetuskan sistem amaran oleh pihak berkuasa tempatan selain daripada kaedah lain seperti pemeriksaan secara visual bagi pergerakan tanah.



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CHAPTER 1

INTRODUCTION

1.1 Background

Landslide is a down slope movement of rock or soil, or both, occurring on the surface of material rupture either as rotational slide or translational slide in which much of the material often moves as a coherent or a semi-coherent mass with little internal deformation. In some cases, landslides may also involve other types of movement either at the inception of the failure or later, provided that the properties change as the displaced material moves down slope. It can occur at any rock type with commonly occurred geological structures, planar weakness or local contrasts.

The term "landslide" describes a wide variety of processes that result in the downward and outward movement of slope-forming materials, including rock, soil, artificial fills, or a combination of these. The materials move by falling, toppling, sliding, spreading, or flowing.

Usually, after a slope is made, slope monitoring is essential to help detect any movement of the slope and to decide if safety measures need to be taken immediately. Several measurement techniques have been introduced to detect the slope movements and landslide risks. The most common technique is map based and aerial photograph based. The slope movements or changes are interpreted based on the geological information and terrain movements. However, these methods are costly labour-intensive and highly subjective thus the results depend on the experience and decision of the expertise (Georgevia, 2012).

Another method to detect slope movements and landslides risks is geotechnical instrumentations such as extensometers, inclinometers, piezometers and rain gauges. The data from these instruments can be taken manually or automatically in a real time monitoring. However, some used cable-based landslide monitoring system which is costly and has limited communication. An advanced technology in wireless communication has created Wireless System Network (WSN) to overcome the limited communication and to respond immediately for any change. The data can be sent to the end user immediately through e-mail, short message services (SMS) and web for further analysis. This system can help the end user to get a reliable early warning and threshold value.

1.2 Problem Statement

The Simpang Pulai – Lojing road was constructed in 1997 connecting Ipoh, Perak to Cameron Highlands, Pahang. The stretch at KM46 has faced several phases of slope failures and landslide problems. The disaster has caused major consequences to road users. Several government agencies, including Public Works Department (JKR), Ministry of Communication and Multimedia, Malaysia (KPKK) and National Centre of Excellence for Sensor Technology UPM (NEST) monitor the stability and movement of the slope using conventional and Wireless Sensor Networks (WSN) methods. The advanced-method used to monitor the movement of the slope is as an early warning system for road users.

Several systems are in place, but the current major problem is to what extent of the soil movement can be considered as the critical point before it is a complete or disastrous failure. The aim of this research is to get the critical value or threshold value that can be considered as the critical value of which an early warning system should be based on. Several researchers have attempted different approaches to overcome this problem at difficult location with varieties of soil and rock properties together with the experimental parameter namely rainfall for this research. The literature review will discuss the different methods used and conclusions made by previous researchers in order to determine threshold values of slopes for different materials and in different conditions.

1.3 Research Aims and Objectives

The main aim of this study is to monitor the data send through the WSN systems and analyze them to get the threshold value of the slope for the early warning systems.

The objectives are:

- i) To develop a geological-geotechnical-geomorphologic map of study area
- ii) To identify the mode of failure within the study area and within the Pos Selim area
- iii) To analyze the slope monitoring data from geotechnical equipments that can be retrieved wirelessly
- iv) To determine the threshold values for the slope failure risk potential

1.4 Scope of Study

This study focuses on the monitoring of slope movement and obtaining the threshold value from the monitoring data. The scope of work is as follows:

- i) The study was focused at an active landslide at Simpang Pulai highway to Cameron Highlands KM46
- ii) Geological setting for the area was determined from literature review of past studies such as lithology information, borehole data and geological mapping
- iii) This study also focused on monitoring instrumentation data from inclinometers, surface extensometers, rain gauges and piezometers sent wirelessly by WSN system
- iv) Data was analyzed from the monitoring instruments to find the relationship of the slope movement, rainfall and underground water level pattern and soil and rock properties in order to obtain definite threshold value.

1.5 Significance of Study

This study will show the relationship of the slope movement with rainfall intensity, underground water level and geological setting of the area; hence, providing a reference for local authorities in alarming the civilian if potential landslide disaster has been triggered.

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