A STUDY ON SOIL CHEMICAL AND PHYSICAL PROPERTIES OF OXISOLS AS INDICATOR TO PREDICT SHALLOW SLOPE FAILURE

BY

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ABSTRACT

Landslides or slope failure has slowly become a major concern in Malaysia due to the rapid development of rural areas. Despite advances in science and technology, these events continue to result in human suffering, millions in property losses and environment degradation. The aim of this research was to find the indicator to predict shallow slope failure by studying the soil chemical and physical properties of oxisols. The comparison between the contain of the properties between stable slope and failure slope was discussed and analyzed with an observation and experiments from two different sites, which are at proposed highway KM13, Teluk Kemang, Port Dickson, Negeri Sembilan and alongside PLUS North- South highway road (from KM 420.0 to KM 445.5). The research discussed about the data interpretation and on how soil chemical and physical properties are related to the slope failure. From the outcome of the research and understanding of the relationship between soil chemical and physical properties and soil, the indicator of shallow slope failure which was based on the soil chemical properties found was used in measuring the slope hazardous level. From the data analysis, it is concluded overall that soil chemical and physical properties in stable slope contained more heavy metal, micronutrients, total nitrogen content, total organic carbon, available phosphorus and exchangeable cation concentration content for at least half of value content in failure slope. But unlikely in the stable slope, the content of cation exchange capacity (CEC) is high in failure slope. For soil pH, the values showed not much different between the stable and failure slope. In additional, it is also concluded that soil texture, clay contents, soil pH value, CEC, organic carbon contents, nitrogen contents and phosphorus content are those important elements in soil that could make the soil structure strong or weak. The elements contributed to each other as binding agents which will affect the strong soil structure. Soil pH values, CEC value and soil texture volume contents are the major factors of the shallow slope failure, as their characteristics affect the binding force of other elements. Thus, hopefully the areas which have a potential of slope failures occurring will be recognized and identified, in order to make sure the mass movement can be avoided and to help the developers and other parties involved in developing hillsides to find the better solution in order to prevent the landslides from happen again.

ملخص البحث

على الرغم من وفرة نظريات إدارة مياه الأمطار المختلفة، الا انه لا يوحد تصنيف واضح لمكوناتها. اضافة لذالك, قلة المناقشات المقدمة في مياه الامطار و جريان المياه مع الدورة المائية الهايدرولوجيه جعلت الغاية والاهداف لادارة جريان المياه اقل نجاحا في ادر المشاكل الناجمة من جريان المياه كالفيضانات, تلوث المياه و تدهور النطام البيئي. وبالتالي, يهدف هذا البحث لدراسة مكونات نظرية مياه المطار وادارة المجاري المائية. تم صياغة ثلاثة اهداف رئيسية هي (أ) تحديد مكونات نظرية مياه المطار وادارة المجاري المائية, (ب) لاستكشاف تفاصيل هذه المكونات, (ت) و لتوضيح علاقة الدورات الهيدرولوجية مع التفاصيل المستكشفة لهذه المكونات. تم استخدام المجلات المتوفره عبر النترنت, ومنتديات النقاش و المقابلات عبر البريد الاكتروني كمنهاج لجمع البيانات لهذا البحث النوعي. وقد تم استخدام خطوات التحليل المقارن الستة لتخليل البيانات. وبناء على ذالك, فان البحث حدد ن مكونات نظرية مياه المطار وادارة المجاري المائية من خلال عملية تسلسلة من ثلاثة عناصر, (أ) الدورة الهيدرولوجية و عناصرها المادية,(ب) المفاهيم, و (ت) الاستراتيجيات. اول المكونات السبعة للدورة الهيدرولوجية (الاعتراض, تسلسل, الجريان السطحي, كساد التخزين, التبخر والنتح, تدفق المياه الجوفية و حرك المياه السطحية) هي عملها من حلال الغطاء النباتي, التربة, التضاريس والاشكال المائية.اما المكون الثاني والثالث فقط احتويا على اثنا عشر مفهوما و عشرون استراتيجية تم تحديدها وادرجها حسب الاولوية في العلاقة مع الدورة الهيدرولوجية. وظافة لذلك, فقد تم تحيد الاهداف والغايات المنقحة لمكونات نظرية مياه المطار وادارة المجاري المائية. الهدف من التنقيح لاجل حفظ واعادة خزن التجمعات المائية الصحية من خلال اكثر تكرار للدورات الهدرولوجية في مفهوم واستاتيجية نظرية مكونات مياه الامطار وادارة المجاري المائية. الهداف المنقحة هي (أ) لتطوير ادارة مياه الامطار من اجل تحسين الدورات الهيدرولوجية و الحد من مقدار الجريان المائي, (ب) لتحسين ادارة المجاري المائية من خلال التقليل من عددها وتحسين من نوعية المجداري المائية, و (ت) ولتحسين الاداء الوظيفي للدورة الخيدرولوجية من خلال استراتيجية نظرية مكونات مياه الامطار وادارة المجاري المائية.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science Built Environment.

…….....
Rashidi Othman
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Built Environment).

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Dean, Kuliyyah of Architecture and Environmental Design

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Muhammad Hazrin Bin Abd Ghapar

Signature…… Date ……

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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Affirmed by Muhammad Hazrin Abd Ghapar.

…….. ……

Signature Date

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Slope failures are significant natural hazards in many areas throughout the world. Generally, slope failures can be defined as a downward movement of a large amount of slope material, also known as mass movement. Slope failures can occur suddenly in one easily recognized movement, or almost imperceptibly over a period of many years. And because of the sudden collapse of slope, many people fail to escape from it if it occurs near a residential area, thus resulting in a higher rate of fatalities (Grift, 2007). This disaster can be triggered by weather events, geologic events, human modification of the landscape, or most commonly, some interaction of all of the above. Therefore, slope failures occur nearly everywhere slopes exist. Mountainous regions, hilly regions, and coastlines have the greatest risk of slope failures. Slope failures are natural disasters that often originate in steep slopes. Expanding urbanization and changing land-use practices have increased the frequency of their occurrence (Grift, 2007).

According to Kim (2000), landslides have caused large numbers of casualties and huge economic losses in hilly and mountainous areas of the world. They further elaborate that in tropical countries where annual rainfall can reach as high as 4500mm and high temperatures around the year caused intense weathering to their soil and rock profile where in certain location can reach 100 m in depth. With these set of climate and geological condition, combined with other causative factors, landslide is one of the most destructive natural disasters in tropical region including Malaysia (Kim, 2000).

Hence there is a need for a comprehensive program to reduce landslide losses that will marshal the capability of all levels of government and private sector. Successful and cost effective landslide loss reduction measures can and should be taken in the many jurisdictions facing landslide problems. Federal and state governments can prevent and reduce landslide losses through, creation of early warning and monitoring system, better policy and effective implementation, outlining design procedures, creation of local hazard mapping, land use management, building, grading controls, among others (Mariappan, 2009).

1.2 RESEARCH BACKGROUND

Landslides or slope failure has slowly become a major concern in Malaysia due to the rapid development of rural areas. Despite advances in science and technology, these events continue to result in human suffering, millions in property losses and environment degradation. The most common type of landslide in Malaysia is the shallow slide where the slide surface is usually less than 4 meter deep and occurs during or immediately after intense rainfall (Ali Jawaid, 2000). Other types of landslide are deep- seated slide, debris flow and geologically control such as wedge failures and rock fall. During the period from 1993 to 2004, a number of major landslides were reported in Malaysia, involving fill and cut of natural slopes, which also resulted in loss of lives (Harwant Singh, 2006).

The landslides that occurred in the New Klang Valley Express Highways region in the year 2003 have alerted the highway authorities and other governmental organizations toward the seriousness of landslide management and prevention. The October 2002 landslide in Kuala Lumpur which completely destroyed a few houses and killed six members of a family is still fresh in the memory of the people.

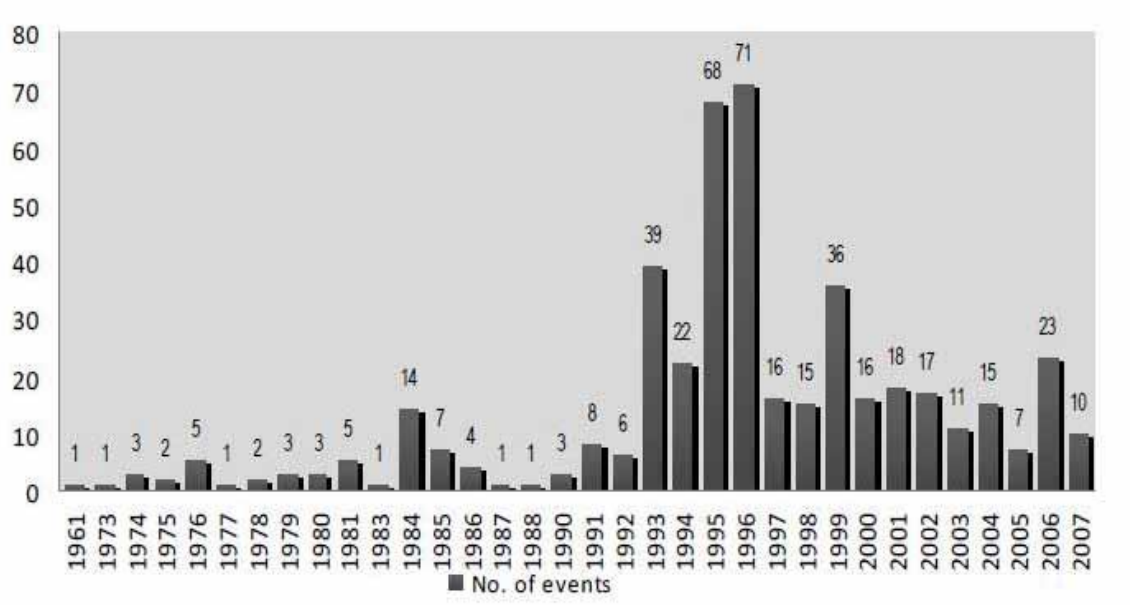

Figure 1.1: Numbers of landslide events in Malaysia, 1961 – 2007 (Malaysian National Slope Master Plan – Challenges to producing an effective plan, 2008)

There are four types of landslides which are most common in Malaysia: topple, rock falls and debris flows also known as mud flows. Factors can trigger landslides are intense and prolonged rainfall, as well as shocks or vibration such as seismic activity. Public should look out for signs such as water or earth bulging appearing at the base of a slope or retaining wall as well as tension crack at the ground surface (Public Works Department Malaysia, 2010).

Many slope failures cases are not predictable, as there are unexpected to happen because the methods used to identify the potential slope failure areas are not standardized and specified, besides there are various types of them.

Landslide is a common hazard in the hilly regions which causes heavy losses to life and properties every year. Since 1980 various research and analyses have been carried out in the GIS environment to identify factors responsible for causing landslides (Sharma, 2009). The important conditioning factors identified by the researchers are slope, geological, geomorphologic structures and land use coupled with triggering factors like rainfall and a few of the anthropogenic activities. Soil forms the upper most part of the earth crust and it is expected that the various soil characteristics like depth, surface texture, depth texture, soil erosion, hydraulic conductivity, stoniness etc. play significant role in causing landslide in an area (Sharma, 2009). There are many research conducted on landslide but most of them were focused on how the land falls cause by physical reactions of soil affects by the nature (Rickson and Morgan, 1995).

1.3 SOIL PROBLEMS IN MALAYSIA

1.3.1 Landslide in Malaysia

Landslides have caused large numbers of casualties and huge economic losses in hilly and mountainous areas of the world. In tropical countries the annual rainfall, which can reach as high as 4500 mm, and high temperatures around the year cause intense weathering and formation of thick soil and weathered rock profile (Abdullah, 1996). A series of landslide (inclusive of debris flow) events since 1993 has resulted in a number of deaths and property extensive destruction.

In Malaysia, most of the high consequence slope failures involved man-made slopes. However, there were a few devastating debris flows that may not have been caused by human activities. The first major landslide event, which has since become the landmark landslide was the landslide that brought down an apartment block in an area known as Highland Towers, near the capital, Kuala Lumpur in 1993. In this incident, 48 people perished when the foundation of the apartment block was undermined by the landslide.

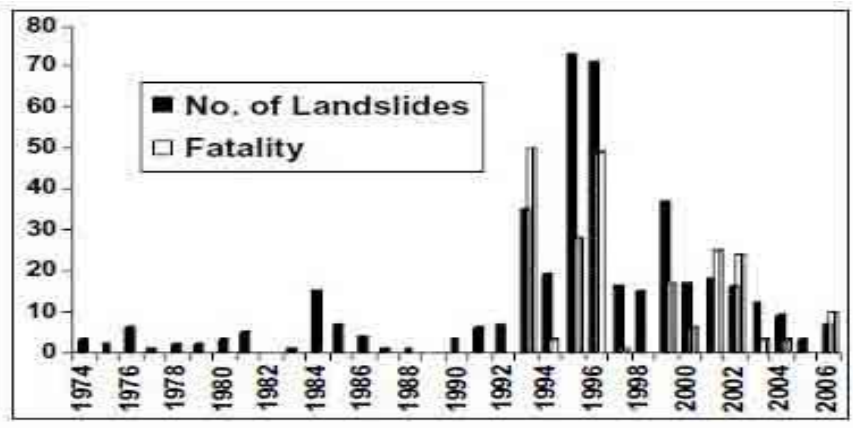

Figure 1.2: Landslides and fatalities due to landslides between 1974 to 2006 (Malaysian National Slope Master Plan – Challenges to producing an effective plan, 2008)

According to the Malaysian National Slope Master Plan (2009), the main contributing factors to trigger the landslides are found to be geological causes or ground conditions, hydrological causes, morphological causes, physical causes and human causes. These main contributing factors are based on the review of selected worldwide literatures. A total of 30 case studies excluding Malaysia were carried out with reference from countries such as China, Italy, Thailand, Russia, Taiwan, Germany, Korea, Japan, and Australia**.**

Figure 1.3 presents the contributing factors of landslides based on selective worldwide literatures. The statistics indicate that ground conditions and human causes are the major contributing factors of landslide failures on a worldwide basis. In addition, the occurrence of landslides also due to mismanagement of land use due to the increasing number of population and the needs of land for producing agricultural products that, that force people to stay in landslide hazard areas.

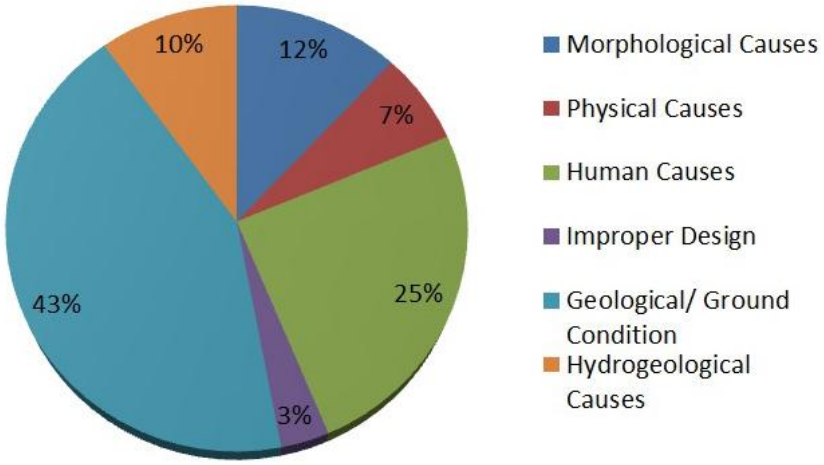

Figure 1.3: Contributing factors of landslides based on selective worldwide literature (Malaysian National Slope Master Plan, 2009)

A study found that the most common landslides triggering factors are intense rainfall, rapid snowmelt, water level change, volcanic eruption, earthquake shaking and change of slope geometry. The landslides triggering factors based on selective worldwide literatures is presented in Figure 1.4. The statistic indicated that rainfall and water level change are the major triggering factors of a landslide.

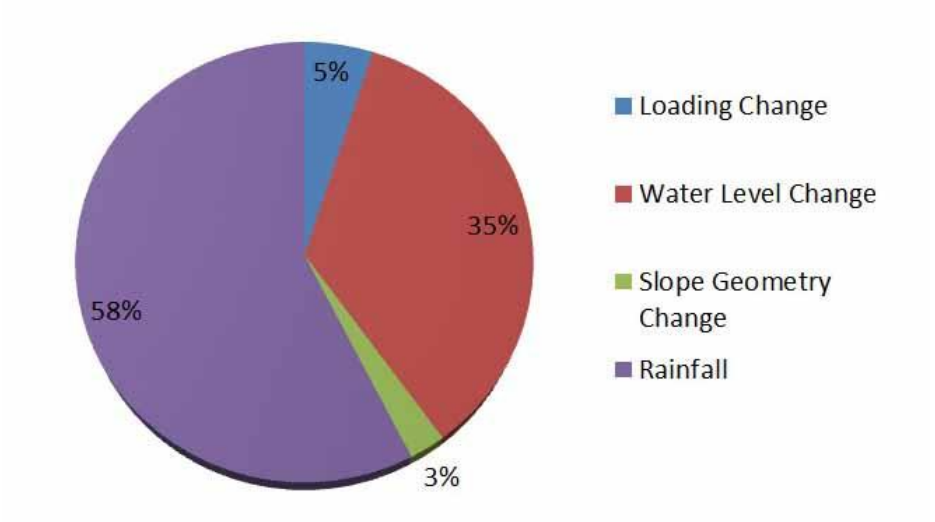

Figure 1.4: Landslides triggering factors based on selective worldwide literature (Malaysian National Slope Master Plan, 2009)

Based on the worldwide literature review, a summary of landslide contributory and triggering factors is presented. However, not all the factors are applicable to Malaysia condition. Gue and Tan (2006) found that most of the slope failures in Malaysia are due to design errors, construction errors, design and construction errors, geological features and maintenance.

Malaysian National Slope Master Plan (2009) also has similar study after Gue and Cheah (2008). Figure 1.5 shows the statistic of contributing factors of landslides based on Malaysia case history. The causes of landslides can be due to the abuse prescriptive methods, inadequate study of past failures, design errors including insufficient site specific ground investigation. However, lack of appreciation of water such as underestimating existing groundwater table and inadequate capacity of surface drainage is also one of the factors causing the landslides.

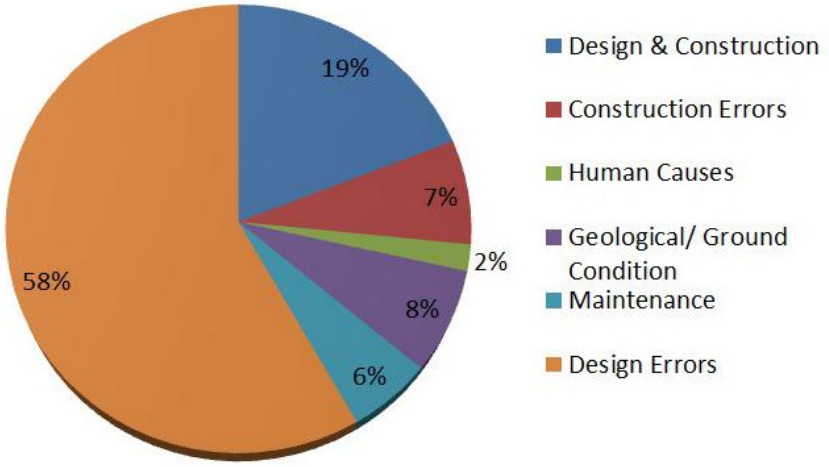

Figure 1.5: Contributing factors of landslides based on selective Malaysia case history (Malaysian National Slope Master Plan, 2009)

Landslides in the Malaysia are often triggered by intense rainfall, change in water level and change of slope geometry. The main factor that caused slope failure at numbers site in hillside development in Malaysia is rainfall and storm water activity (Farisham, 2007). Figure 1.6 shows the landslides triggering factors based on selective Malaysia case history. The statistics indicated that rainfall is the major triggering factor to cause a slope failure. It is well known fact that in a tropica climate with a continuous heavy and prolonged rainfall during the two monsoons in a year, slope failures in Malaysia are not uncommon.

As such, the effect of expected intense rainfall on the slope stability should have been taken into account in the slope design (Malaysian National Slope Master Plan, 2009). Geometry change is also a significant factor that causes a slope failure. Liew (2004) suggested that cut slope has a high frequency of failure. This is probably due to the many uncertainties in identifying and establishing the weak structure, subsoil variation and the adverse ground water level.

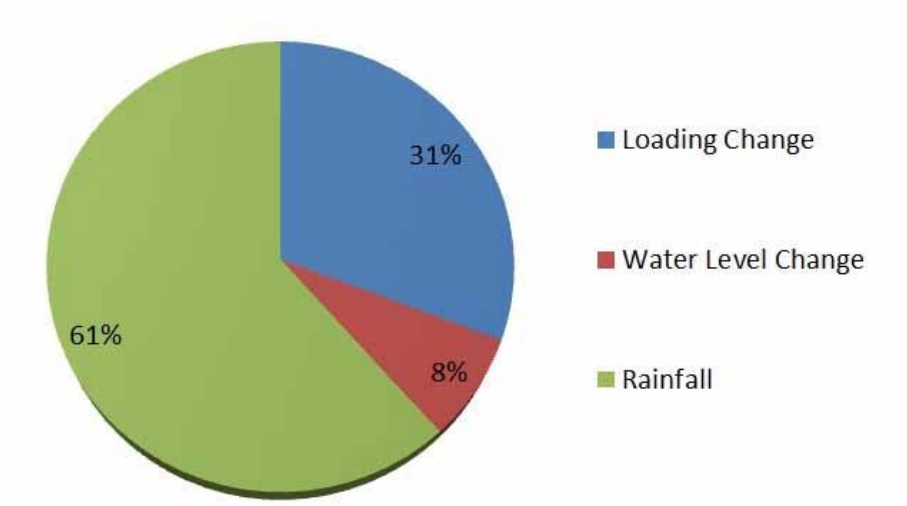

Figure 1.6: Landslide triggering factors based on selective Malaysia case history (Malaysian National Slope Master Plan, 2009)

1.3.2 Soil Erosion in Malaysia

Accelerated soil erosion is endemic throughout the humid tropics where less developed countries can ill afford to lose such valuable soil nutrient. Yet, relatively little is known of its dynamics and rates of occurrence under different land use and management conditions in Malaysia. However, authors such as while Peh (1978) and Leigh (1982) are well known for their work on erosion under undisturbed rain forest cover.

Aiken (1982), Maene (1975), and Soong (1980) have worked on rates of erosion in agricultural areas, while Leigh (1982), Gupta (1985), and Mykura (1989) have studied soil loss in urban areas.

In Malaysia, accelerated soil erosion occurs when land clearing and earth moving activities expose the ground surface (Sharifah, 2006). With many incidences of landslides, mudslides and erosion occurrences lately, especially in the highlands in Malaysia, properties were damaged and lives were lost.