EFFECTS OF MOISTURE AND CLAY MINERALS ON THE STRENGTH OF SOIL ALONG KOTA BELUD – RANAU ROAD IN TAMPARULI, SABAH.

MOHAMED ALI YUSOF BIN MOHD HUSIN

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10 AUGUST 2012

Mohamed Ali Yusof Bin Mohd Husin
PS2008-8415

CERTIFICATION

NAME : **MOHAMED ALI YUSOF BIN MOHD HUSIN**

MATRIC NO. : **PS2008-8415**

TITLE : **EFFECTS OF MOISTURE AND CLAY MINERALS ON THE STRENGTH OF SOIL ALONG KOTA BELUD – RANAU ROAD IN TAMPARULI, SABAH.**

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DECLARED BY

1. SUPERVISOR

Assoc. Prof. Dr. Baba Musta Signature

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ABSTRACT

EFFECTS OF MOISTURE AND CLAY MINERALS ON THE STRENGTH OF SOIL ALONG KOTA BELUD – RANAU ROAD IN TAMPARULI, SABAH.

Landslide had long been regarded as one of the major geohazard in Sabah. Intense tropical climate of the region act as a catalyst that speed up the weathering process resulting in the decreasing resistance in rock mass and the formation of clay. Clay mineral in soil is a product of weathering process that contributes to the occurrence of landslides because of their properties. Due to constant heavy downpour that acts as the main triggering factor, it causes a decrease in strength of soil. The objective of the study is to determine the effects of moisture and clay minerals on the strength of soil. The research area is located along Kota Belud – Ranau Road in Tamparuli, Sabah. The study area is underlain prominently by Crocker Formation aged from Late Eocene to Early Miocene. Soil of the area is a weathering product from the exposed sedimentary rock formation known as Crocker, the alternating different lithology of this formation from one sampling station to another reflects the diversity in terms of engineering properties. Moisture data obtained from the Proctor Compaction Test was applied using the manipulation of Unconfined Compression Test by treating the samples with 5% of increment and decrement of moisture from the optimum moisture content. The analysis yielded the strength of soil ranges from 49.5 kPa to 114.5 kPa for optimum moisture, 12.5 kPa to 50 kPa for 5% increment and 77 kPa to 222 kPa for 5% decrement. The term Compressive Strength Difference is introduce in this research, it is defined as the percentage of compressive strength difference of the manipulated samples to its compressive strength at optimum moisture. Sample with clayey material scored 75%, the highest percentage of compressive strength difference loss when treated with 5% increase of moisture. Whilst, sample with sandy material scored 145%, the highest percentage of compressive strength difference gain when treated with 5% decrease of moisture. Clay mineral analysis was executed by X-Ray Diffraction Analysis (XRD) and yielded clay minerals such as halloysite, montmorillonite, illite-montmorillonite and illite, which are significant in all the samples. Scanning Electron Microscopy (SEM) observation shows Illite, illite-montmorillonite and montmorillonite is often observed and characterized by their unique features. It is concluded that engineering properties of soil in the study area provide variety of results and this mainly controlled by the type of soil. This research shows that effect of moisture and clay mineral to the properties of the sample has a direct impact on the compressive strength of soil.

ABSTRAK

Gelinciran tanah telah lama dianggap sebagai salah satu geobencana utama di Sabah. Iklim tropika lampau menjadi pemangkin mempercepatkan proses luluhawa yang menyebabkan jasad batuan menjadi lemah dan menghasilkan tanah lempung. Mineral lempung dalam tanah adalah hasil proses luluhawa yang menyumbang kepada kejadian gelinciran tanah akibat dari ciri-cirinya. Hujan lebat berterusan yang bertindak sebagai faktor pencetus, menyebabkan pengurangan kekuatan tanah. Objektif kajian adalah untuk menentukan kesan kelembapan dan mineral tanah lempung ke atas kekuatan tanah. Kawasan kajian terletak di sepanjang jalan raya Kota Belud – Ranau, Tamparuli, Sabah. Kawasan kajian didominasi oleh Formasi Crocker berusia Eosen Akhir hingga Miosen Awal. Tanah di kawasan kajian adalah hasil luluhawa daripada pendedahan batuan sedimen yang dikenali sebagai Formasi Crocker, perbezaan litologi dari satu kawasan persampelan ke persampelan lain menunjukkan kepelbagaian dari segi sifat kejuruteraan tanah. Data kelembapan yang diperoleh daripada Ujian Pemadatan Proctor diaplikasikan menggunakan manipulasi Ujian Mampatan Tak Terkurung dengan mengubahsuai sampel dengan 5% peningkatan dan penurunan kelembapan daripada kandungan kelembapan optima. Keputusan analisis menunjukkan kekuatan mampatan tanah berjulat diantara 49.5 kPa hingga 114.5 kPa bagi sampel dengan kelembapan optima, 12.5 kPa hingga 50 kPa bagi sampel dengan peningkatan 5% kelembapan dan 77 kPa to 222 kPa bagi sampel dengan penurunan 5% kelembapan. Terma 'Perbezaan Kekuatan Mampatan' diperkenalkan didalam kajian ini, ia didefinisikan sebagai perbezaan peratus kekuatan mampatan sampel tanah yang dimanipulasikan kepada kekuatan mampatan tanah dengan kelembapan optima. Sampel dengan tanah lempung mencatat 75%, peratusan tertinggi untuk penurunan perbezaan kekuatan mampatan apabila diubahsuai dengan peningkatan 5% kelembapan. Manakala, sampel dengan tanah berpasir mencatat 145%, peratusan tertinggi untuk peningkatan perbezaan kekuatan mampatan apabila diubahsuai dengan penurunan 5% kelembapan. Analisis mineral lempung menggunakan Analisis Pembelauan Sinar-X (XRD) telah mengesan kehadiran mineral lempung haloisit, montmorilonit, ilit-montmorillonit dan ilit yang signifikan dalam ke semua sampel tanah. Pemerhatian Mikroskop Pengimbas Elektron (SEM) menunjukkan ilit, ilit-montmorillonit dan montmorilonit sering diperhatikan dalam kebanyakan sampel dengan pencirian unik mineral tersebut. Sifat kejuruteraan tanah di kawasan kajian disimpulkan mempunyai variasi dalam keputusan analisis kerana di kawal oleh jenis tanah. Secara kesimpulannya kajian ini menunjukkan kesan kelembapan dan mineral lempung ke atas sampel tanah mempunyai pengaruh langsung kepada kekuatan mampatan tanah.

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CHAPTER 1

INTRODUCTION

1.1 General Statement

As catastrophic events, landslides can cause human injury, loss of life, economic devastation and destroy construction works and cultural and natural heritage. The International Consortium on Landslides (Kyoji, 2004), created during the Kyoto Symposium in January 2002, is an international non-government and non-profit scientific organization. The objectives of the consortium are to promote landslide research for the benefit of society. Contemplating with the existence of this consortium, it opens up new ideas and application of related niche area research in local settings in more specific studies. The effort of recording new approached is presented in this study as a contribution into the ever expanding landslide research arena.

The immense increase of development in Kota Kinabalu district is rapidly evolving since the 90's and had expanded throughout the West Coast of Sabah. Lands and forests had been cleared for construction of residential area, industrial, high-rise building, highways and other small to heavy duty infrastructures. Besides this vast development that lead to the expansion of economy and population growth, this pursuit is the very basis of environmental catastrophe. The rising cases of geohazard have never taken seriously by the development agencies through appropriate planning and assessment (Rodeano *et al*, 2006). Based on the data by National Slope Master Plan 2009 -2023, in the course of 10 years, there were 2 major landslides that involved loss of life and properties that occurred in Sabah. Over 319 lives were lost because throughout this tragedy, the lack of policy towards developing on landslides-prone area was to blame for this unfortunate event. Slope failure dealt with various factor in order for a failure to occur, where scale and dimension were intensify by human environmental intervention. According to Rodeano *et al* (2006) slope failure has long been regarded as one of the major geohazard in Kota Kinabalu, followed by flash flood and road subsidence.

Landslides are defined as a massive mass of soil and rock debris that move downhill because of the action of gravity (National Slope Master Plan 2009 -2023). Throughout the Kota Belud – Ranau road, slope failure occurs frequently in the area, road signs alerting road user of landslides shows how dangerous and hazardous the area is. The occurrences of landslide are triggered by geological structures, morphology, climate, geotechnical properties of surface rock, weathering and water parameters (Yalcin, 2007). Landslide is one of the major processes of erosion and they are recurrent problem throughout the high relief zone and causes road damaged that will endanger road users and tenants of the area. Geohazards such as slope failure not only affect the community but the society at large where the government is burden to fund the ever increasing repair and maintenance plan. Ibrahim *et al* (1996) suggested that geohazard can be avoided and minimized by proper understanding and effort towards integration of the matter in the planning and development of town is implemented.

According to Bujang *et al* (2008) and Rodeano *et al* (2006) landslides in the region is triggered by two major factors, steep slopes and heavy precipitation. Geomorphology, geology and climate play the most important role in preparatory process of landslide in any region (Dahal *et al*, 2008). The First World Landslide Forum (2008), illustrate a compilation of landslide research from all over the world. From the forum one key aspect is highlighted as the major landslide triggering mechanism; rainfall. Braja (2010) has demonstrated a relationship between shear strength of soil with increasing moisture in terms of consistency.

The 1st International Conference on Clays and Clay Minerals (Ekosse *et al*, 2011) has listed the prospect of clay minerals in geohazardous environment. Clay minerals produce very important soil types, which are known to have high plasticity, cohesion, and swelling potential but low hydraulic conductivity and friction angle; they also known for their dominating influence of the entire soil mass even if they only exists on a small fractions (Al-Shayea, 2001). It is believed that intense rainfall increases the water content in clays that leads to a reduction in the stability of natural slopes (Yalcin 2007). In this study the clay occurring as a result of weathering of the Miocene aged sedimentary rock in Kota Belud – Ranau Road is

investigated on its influenced to moisture, based on geotechnical properties and in connection with landslide propensity.

1.2 Statement of Problem

Landslides have been regard as one of the major catastrophe having impact on human and development. The sheer mass of material involved and the speed at which they occur make them potentially disastrous as a consequence because of the extensive damage they can cause to property and lives (National Slope Master Plan 2009 -2023). Various review of studies published in the literature on landslide and its factors, mechanism and modelling but few on the materials of landslide itself. No known person had conducted a research on landslides material in the study area. Review of studies that had been published in the literature shows that no clear conclusions can be drawn as to in what manner moisture and altering minerals affects the soil strength. The material of landslide in the area occasionally comprises of a mixture of rocks and soil. This material will be the foundation of the research where moisture and clay minerals aspects are determined.

In order to conduct a research, scopes need to be determined first to focus the study to necessary parts. The scopes of this study are:

1. Covering the major landslides that have a direct impact on Kota Belud-Ranau Road.
2. Involving landslides having at least 5 meters and above of failure distance.
3. Focusing on the material of landslides, concentrating on the moisture and clay minerals through laboratory analysis.
4. Comparing the main difference of each landslide, to conclude the cause through moisture and clay minerals aspects.

1.3 Research Objectives

The main objectives of this study are:

1. To determine engineering properties of soil in the study area.
2. To compare the strength of soil from landslides slopes by applying it through Uniaxial Compression Test.
3. To determine effects of moisture on the strength of soil in the study area.
4. To determine the effect clay minerals in soils having impact on strength of soil in the study area.

1.4 Importance of Study

Malaysia at large; had faced slope failure occurrences that claimed lives and loss of property. The recorded death toll caused by slope failure goes way back since the 1900's. In the future hopefully this study can be referred by the public as a guidance on the better understanding of slope failure and it's direct impact on human lives. The importance's of the study are:

1. Comparing theoretical and practical data to illustrate viable relation that is functional and relevant to this study.
2. Establishing crucial information on factors that contribute to landslides
3. Act as a reliable source of information on slope stability evaluation to ensure public safety.
4. Illustrating the nature and range of slope stability control factors that need to be taken into consideration to prevent or reduce the risk of slope failure.
5. Creating awareness among people on the impact of human environmental intervention on slope failure specifically.

1.5 Location of Study Area

The research area is located in the West Coast of Sabah, in a subdistrict of Kota Kinabalu known as Tamparuli (Figure 1.1). It covers the Kota Belud-Ranau Road intersection from Kampung Bongol to Kampung Botung. This road is the an alternative access road for the Kota Belud , Kudat, Kota Marudu other North territory community to Ranau, Telupid and the other parts in East Coast of Sabah. The area is bounded by the latitude 6° 05′ N to 6° 11′ N and the longitude 116° 24′ E to 116° 29′ E. The area is accessible through major roads and some unsealed roads as shown in Figure 1.2.

1.6 Climatological Condition

Based on the Köppen-Geiger climate classification, the study area is bounded in the Tropical rainforest climate region (Peel *et al*, 2007). It is characterized by annual average temperature of 18°C and may extend to as much as 25°C away from the equator and annual average precipitation at least 60mm. Monsoon season influenced the rain distribution in the study area; there are two major annual Monsoons the southwest from May to September, and the northeast from November to March. Rain distribution in of the study area in the last 10 years is shown in Figure 1.3.

1.7 Topography

The topography of the study area is high relief mountainous terrain ranging from 100m to 1600m in height underlain by the Crocker Formation. Quaternary deposits are limited to river valleys throughout the area. Highest point is in the southeast of the map with 1650m height, while the lowest point is located at the northwest of the study area with less than 100m height. The topography increases from northwest to southeast of the study area. Figure 1.4 show the topography map of the study area.

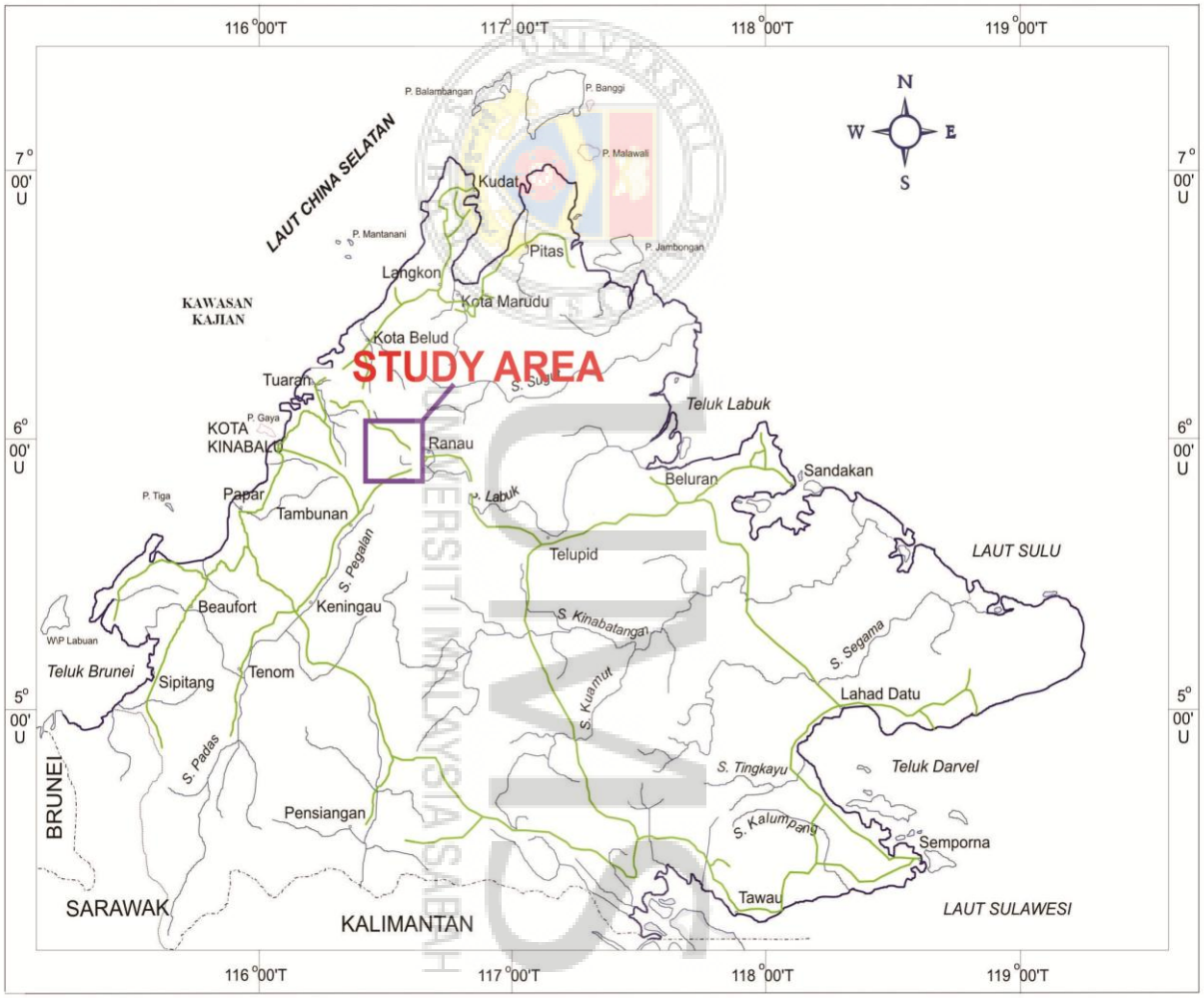

Figure 1.1: The study area in Sabah Map.

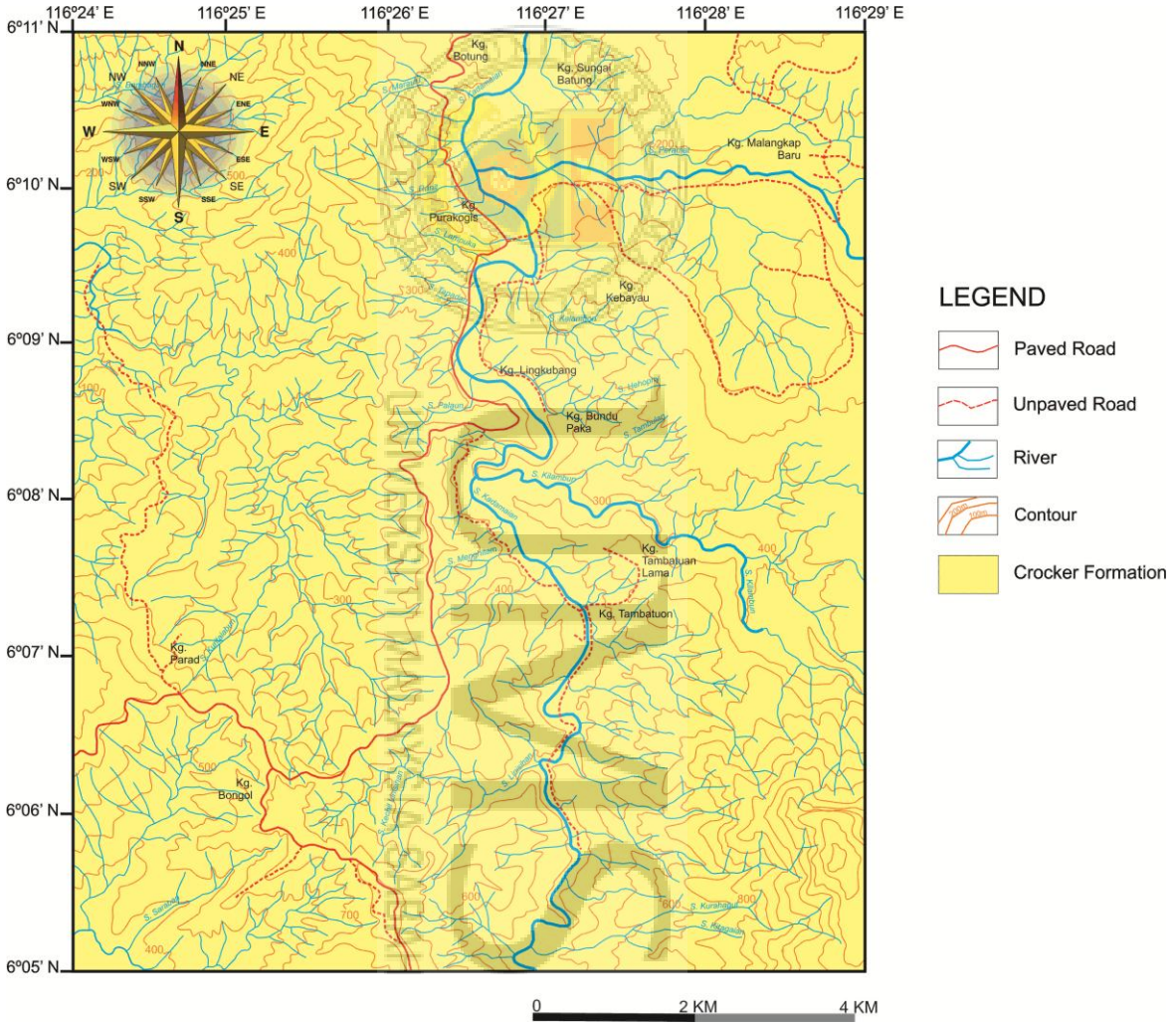

Figure 1.2: Geological map of the study area in Tamparuli, Sabah.