GENERAL GEOLOGY AND CUT-SLOPE STABILITY ANALYSIS OF SOIL USING SLOPE/W AT KAMPUNG JABIR, JELI, KELANTAN.

by

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DECLARATION

I declare that this thesis entitled "General Geology and Cut-Slope Stability Analysis of Soil using Slope/W at Kampung Jabir, Jeli, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

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General Geology and Cut-Slope Stability Analysis of Soil Using Slope/W at Kampung Jabir, Jeli, Kelantan.

ABSTRACT

The soil cut-slope stability analysis using Slope/W software is one of the simple methods to determine the slope stability based on the factor of safety (FOS). When the FOS value is less than one means the slope is unstable. The objective of this study was to produce a geological map of the study area with a scale of 1: 25,000 and to analyse the slope stability at study areas using the Slope/W. The lithology of the study area consists of three types of rock which is shale, granite and slate. Ages of rocks are Ordovician to Triassic, Permian to Triassic and Triassic. The alluvium is formed during Quaternary period. There are four locations that have failed slopes in the study area. The size of failed slope is in the range of small which is 28 m^3, 84 m^3, 71 m^3 to medium that 569 m^3. In order to determine the physical properties of the soil in the study area, there are three laboratory tests was conducted which is the sedimentation test, Atterberg limits tests and Vane shear test. The sedimentation test is done to determine the grain size distribution and the results shown the study area is composed of three types of soils which are fine sand, silt and clay. Atterberg limits tests have been done to determine the Liquid Limit (LL) of soil and the results shown that the soil at the cut slope is slightly plasticity, low plasticity, medium plasticity and high plasticity. Vane shear test have been done to determine the shear strength of soil. Software Slope/W has been used to analyse four cut slopes in the study area and found two cut slopes are stable and two cut slopes are unstable.

Keywords : Soil, Slope, Stability, Slope/W, Failure, Factor of Safety

Geologi am dan Analisis Kestabilan Tanah Cerun Terpotong Menggunakan Slope/W di Kampung Jabir, Jeli, Kelantan.

ABSTRAK

Analisis kestabilan tanah cerun terpotong dengan menggunakan perisian Slope/W adalah salah satu jenis kaedah yang mudah untuk menentukan kestabilan cerun terpotong berdasarkan nilai Faktor Keselamatan. Apabila nilai FOS adalah kurang daripada satu bermakna cerun tidak stabil. Objektif kajian ini adalah untuk menghasilkan peta geologi kawasan kajian dengan skala 1:25,000 dan untuk menganalisis kestabilan cerun terpotong di kawasan kajian menggunakan Slope/W. Litologi kawasan kajian terdiri daripada tiga jenis batuan iaitu syal, granit dan sabak. Umur batuan tersebut ialah Ordovisi hingga Triassik, Perm hingga Triassik dan Triassik. Aluvium yang terbentuk dalam tempoh Kuarter. Terdapat empat lokasi yang mengalami kegagalan cerun di kawasan kajian. Saiz cerun gagal adalah dalam julat yang kecil iaitu 28 m^3, 84 m^3, 71 m^3 kepada medium yang 569 m^3. Bagi menentukan sifat-sifat fizikal tanah di kawasan kajian, terdapat tiga ujian makmal dijalankan iaitu ujian pemendakan lumpur, ujian had Atterberg dan ujian kekuatan ricih. Ujian pemendakan dilakukan untuk menentukan taburan saiz butiran dan keputusan yang ditunjukkan kawasan kajian terdiri daripada tiga jenis tanah yang pasir halus, kelodak dan tanah liat. Ujian had Atterberg telah dilakukan untuk menentukan had cecair (LL) tanah dan keputusan menunjukkan bahawa tanah di cerun potong sedikit keplastikan, keplastikan rendah, keplastikan sederhana dan keplastikan yang tinggi. Ujian kekuatan ricih telah dilakukan untuk menentukan kekuatan ricih tanah. Perisian Slope/W telah digunakan untuk menganalisis empat cerun terpotong di kawasan kajian dan mendapati dua cerun terpotong stabil dan dua cerun terpotong tidak stabil.

Kata kunci : Tanah, Cerun, Kestabilan, Slope/W, Kegagalan, Faktor Keselamatan

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LIST OF ABBREVIATIONS

XPL	Cross polarized
JPS	Development of Irrigation and Drainage
D	Diameter
E	East
FOS	Factor of Safety
GIS	Geographic Information System
GPS	Global Positioning System
H	Height
HCL	Hydrocloric acid
LL	Liquid Limit
JMG	Mineral and Geosciences Department
N	North
PPL	Plane polarized
PI	Plastic Index
PL	Plastic Limit
S_s	Shear strength
S	South
T	Torque
W	West

LIST OF SYMBOLS

cm	Centimetre
g	Gram
h	Hour
kg cm	Kilogram centimeter
kg/cm^2	Kilogram per centimetre square
km	Kilometre
kN/m^3	Kilonewton per metre cube
kPa	Kilopascal
m	Metre
m^3	Meter cube
ml	Millilitre
mm	Millimetre
min	Minute
µm	Micrometre
s	Second
>	Greater than
<	Less than
°C	Degree Celsius
%	Percent

CHAPTER 1

INTRODUCTION

1.1 General background

The cut slope stability is very important nowadays to protect or safe people from the dangerous event that will occur if the cut slope is unstable. So, there are some causes such as infrastructure by human made or natural hazards that make the cut slope will be unstable.

Cut slope failures is the movement of mass of rock, debris or earth down the slope. Cut slope failures occur all over the world and cause large property damage and many fatalities every year. Cut slope stability analysis is one type of method measure to determine the stability of a cut slope based on the soil strength. In Malaysia, a terrible landslide had happened on 26 November 2016 at Taman Idaman, Serendah in Hulu Selangor that has led to the great loss in property caused by the rapid flow of underground water.

The natural hazards such as landslide are not controllable. So, people should always be aware mostly people that are living near to the potential cut slope failures and road users. So, they need to be preparing for what will happen for them in the future. We cannot predict the natural hazard that will come in the future.

1.2 Problem statements

The geological map of Kampung Jabir are not updated and the information about this area also less. Furthermore, Kampung Jabir have a several cut slope failures that occurred along the road from Jeli city to Kuala Balah. The cut slope stability are affected by intense rainfall, weathering and construction activities. Cut slope failure occurred because of the unstable cut slope. This disaster can lead to great loss of properties and life. To overcome the disaster from occur, the cut slope needs to be analysed. The Slope/W is used to analyse the cut slope stability in terms of factor of safety (FOS) which is indicates the stability of the cut slope with a low cost.

1.3 Research objectives

There are some objectives in this study which are:

i. To produce geological map of Kampung Jabir at scale 1:25,000.

ii. To analyse the cut slope stability at the study area using Slope/W software.

1.4 Study area

1.4.1 Location

Jeli is a district in Kelantan, Malaysia. The study area is at Kampung Jabir, Jeli which is the dimension of the area is 5km x 5km which covered 25 km^2. The study area has a longitude between 101°51'12''E to 101°53'56''E and latitude between 5°30'31''N to 5°33'19''N (Figure 1.1). The study area is between Jeli city and Kuala Balah.

BASE MAP OF KAMPUNG JABIR, JELI

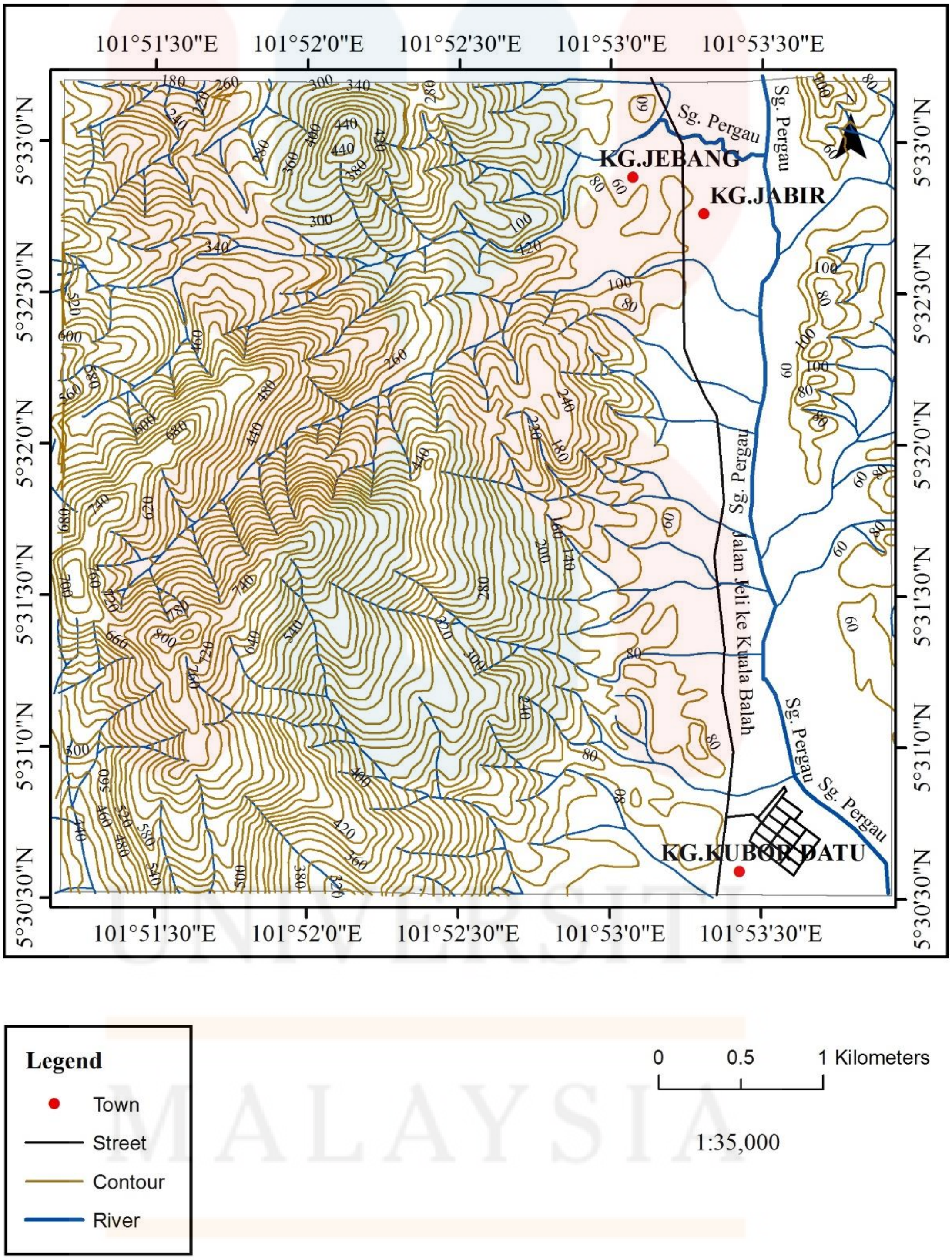

Figure 1.1 Base map of Kampung Jabir, Jeli, Kelantan.

1.4.2 Demography

Population distribution of Jeli was prepared and published by Department of Statistics, Malaysia. According to *Total population by ethnic group, Local Authority area and state, Malaysia, 2010*, the population in Jeli area is about 33,186 people with different background and races. This area is dominated by Malays which is 31,606 followed by Chinese 91, and Indians 58. This area also has non-Malaysian citizens which is 890. Population distribution of Jeli can be seen on Table 1.1 and Figure 1.2.

Table 1.1 Population distribution in Jeli

The population			Total	Total	Total
Malaysian Citizen	**Bumiputera**	Malay	31,606	32,126	33,186
		Other Bumiputera	520		
	Non-Bumiputera	Chinese	91	170	
		Indian	58		
		Others	21		
Non Malaysian Citizen		Foreign people	890	890	

(Source : *Total population by ethnic group, Local Authority area and state, Malaysia, 2010*)

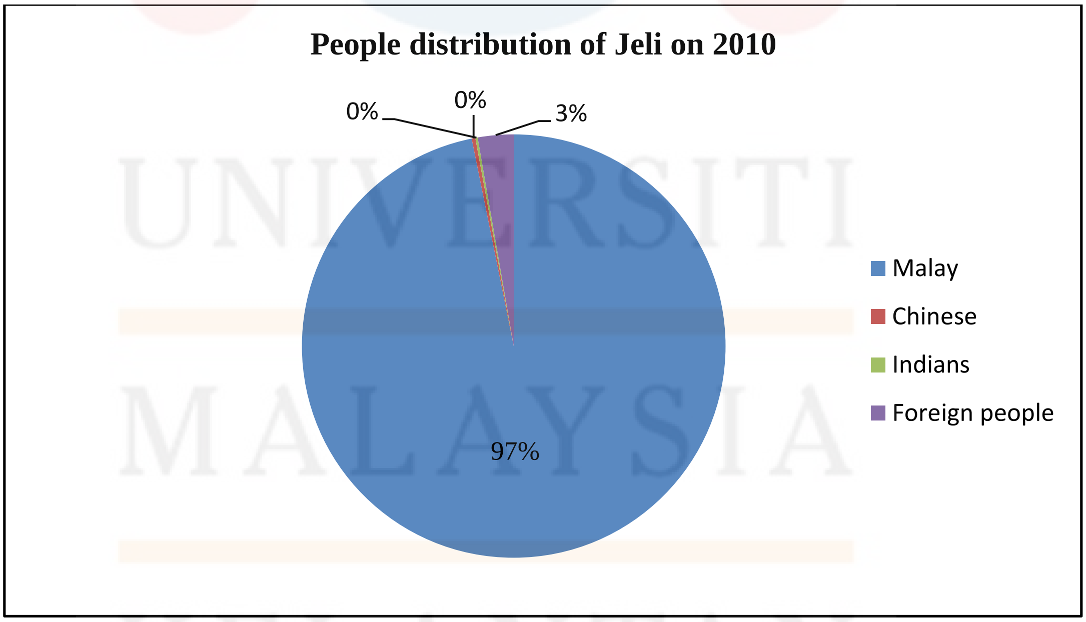

Figure 1.2 Population distribution in Jeli
(Source : *Total population by ethnic group, Local Authority area and state, Malaysia, 2010)*

1.4.3 Rainfall

The rain distribution of Jeli is presented by Development of Irrigation and Drainage (JPS) of Kelantan. The statistic of the rain distribution is measured from January to December 2014 (Figure 1.3). The total annual rainfall 2014 is 4,907.0 mm. In 2014, the highest total rainfall is 1,542.0 mm which is in December. The lowest total rainfall is 6.0 mm in February.

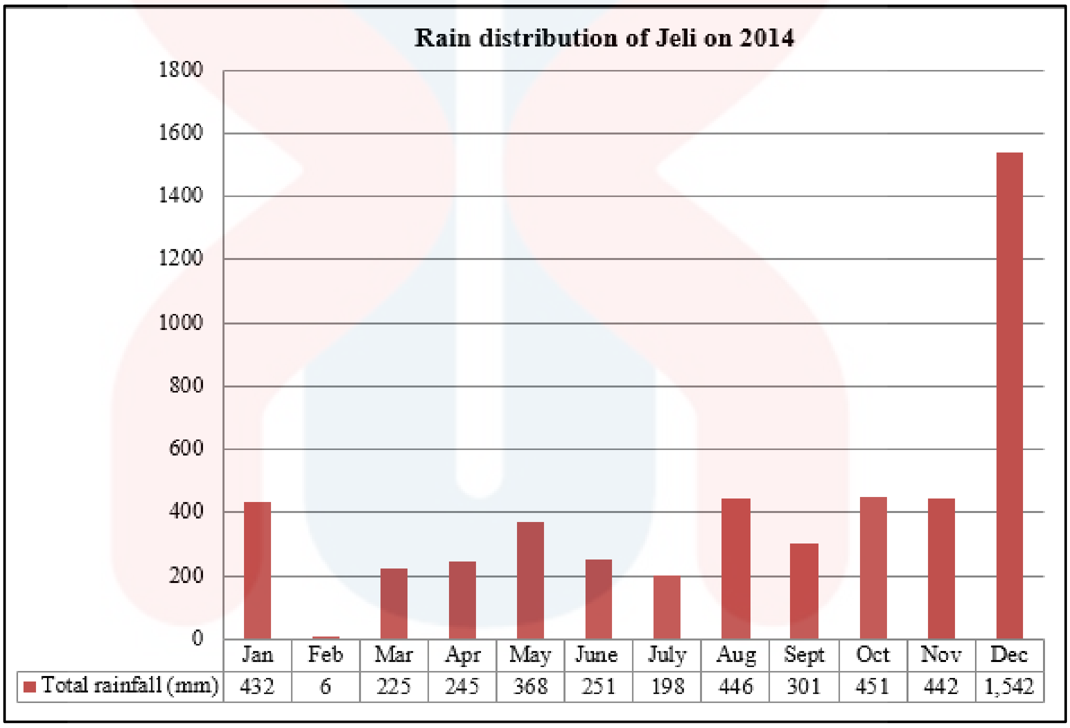

Figure 1.3 Rain distribution chart (Source : Development of Irrigation and Drainage (JPS) of Kelantan,2014)

1.4.4 Land use

The study area mostly dominated by hill and forest area. The forest covered 50% of the study area. Moreover, the rubber estate that located at the foothill covered 35%. The land of the study area also used 6% for grass and thatch. Besides, only 5% of land is used for orchard and 4% for residential area (Figure 1.4).

LAND USE MAP OF KAMPUNG JABIR, JELI

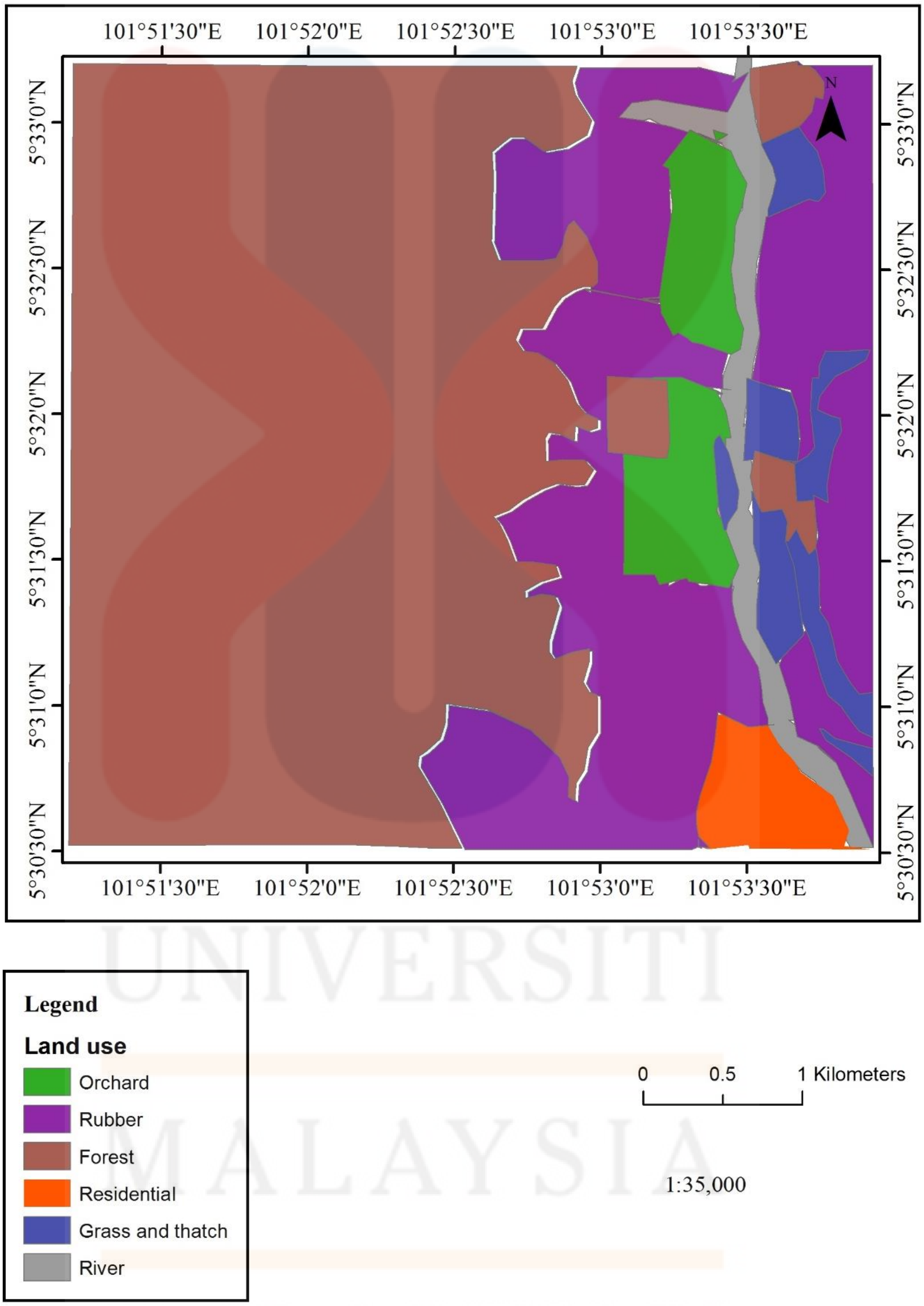

Figure 1.4 Land use of Kampung Jabir, Jeli, Kelantan.

1.4.5 Social economic

Most of the resident of Kampung Jabir involved in rubber tapping, agriculture and growing fruits in their orchards such as watermelon (Figure 1.5). This is because the soils in study area is fertile then it is suitable for agriculture. There are also residents who run small retail businesses to generate their income. Moreover, some of them involve in government sector.

Coordinate : N 5° 33' 09.89" , E 101° 53' 21.9"
Figure 1.5 Watermelon farm

1.4.6 Road connection

Jeli is the main connection for user to go to the southern Kelantan using the Jeli-Dabong road. Jeli also located 98 km away from Kota Bharu through the East-West Highway. The East-West Highway is a highway that gives a short journey from Kota Bharu, Kelantan to north-western towns and cities of Malaysia such as Alor Star and Penang. The study area connecting the Jeli city with Kuala Balah (Figure 1.6).

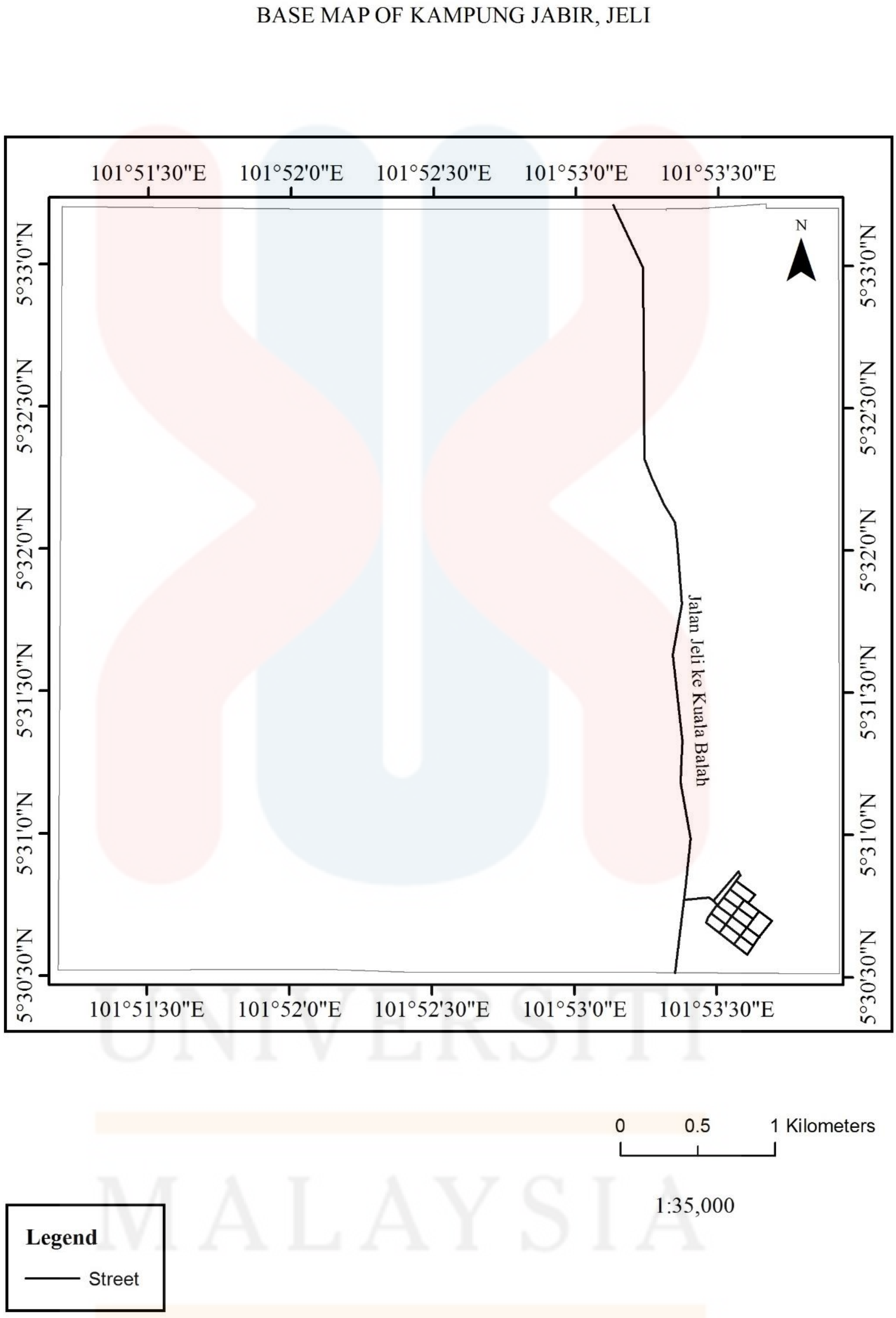

Figure 1.6 Jeli-Kuala Balah road

1.5 Scope of the study

The study area is located at Kampung Jabir, Jeli and covered 25 km^2. It is located in the mountainous region. This study focuses on the general geology and specification of cut-slope stability study. The main purposes are to produce map of study area, determine soil properties and the stability of the selected cut slopes.

The research needed field geological mapping for the general geology. For the cut slope stability study, it needed to focus on soil properties. There are several number of cut slope failures along the road. The four selected cut slope was selected and two samples are taken from each slope for analysis. Slope/W software was used to analyse the stability of each cut slope in term of the factor of safety.

1.6 Research importance

This research study is to provide the information and understanding of the general geology. Besides, to gain knowledge regarding to the cut slope stability analysis using Slope/W at Kampung Jabir, Jeli, Kelantan. Moreover, this study is to produce the latest geological map of the area. The base map produced will include the latest information about drainage pattern, geomorphology, structural geology and lithology of the rock in the area.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

In this chapter, the regional geology and the tectonic setting will be explained based on study area. Moreover, the stratigraphy, structural geology, historical geology and petrography of the study area will be clarified. The cut slope also is explained with the illustration.

2.2 Regional Geology and Tectonic Setting

Peninsular Malaysia is a part of the Eurasian Plate, the South-East Asian part which is known as Sundaland (Hutchison, C.S., 1973). Peninsular Malaysia also can be separated into Western Belt, Central Belt and Eastern Belt in terms of change in granite lithology characteristics (Metcalfe, I., 2000). The Bentong-Raub line (Bentong Sature line) was recommended as the major tectonic boundary between the western and central belt of Peninsula Malaysia (Tjia and Syed, 1996). Each granite belt has characteristic mineral deposits (Hutchison, C.S., 2009). West part of the suture is the Main Range biotite granite which is evidently megacrystic and the ilmenite series, while the granitoids of East Malaya are more equigranular, contain both biotite and hornblende, and many are of the magnetite series (Hutchison, C.S., 1989).

The regional geology of Kelantan includes of west zone that dominated by granites of Main Range, central zone of sedimentary and metasedimentary rocks and east zone dominated by Boundary Range Granite (Heng et al., 2006). According to Macdonald (1967), central and south of Kelantan involves of Triassic argillo-arenacceoussediments with intercalated volcanics and limestone. Field evidence shown that the presence of contact metamorphism indicates that the Taku Schist is older than Kemahang Granite (Khoo, 1980). Taku Schist also well-known as Kelantan Schist by Savage (1925). Taku Schist name was used by MacDonald (1967) due to its good outcrop discovery along Taku river.

The Bentong-Raub suture prolong to the north because of the Main Range Granite intrudes the suture zone rocks greatly more broadly and the metasediments have undergone a higher grade of metamorphism than in the south. Mohd. Raji (1990) mapped the Kampung Batu Melintang in more detail and described muscovite-quartz schist, garnet-muscovite schist, silimanite-muscovite schist, biotite-hornblende schist, hornblende-epidote schist, and biotite-hornblende gneiss. Other country rock such as slate, meta-tuff, meta-agglomerate, phyllite, marble and biotite hornfels at the granite contact.

2.2.1 Stratigraphy

The Peninsular Malaysia is divided into Western Belt, Central Belt and Eastern Belt characterized by dissimilar stratigraphy. Most of the stratigraphy in Kelantan lies on Central Belt. The Central Belt is enclosed by the Bentong Suture in the west and by the Lebir Fault in the east.

Kelantan state in the central belt had Upper Palaeozoic rocks at Gua Musang Formation in the west part, Aring Formation in the south part, Taku Schist in east part and Raub Group that further south. There are two areas in Kelantan where Mid-

Triassic ammonoid fossil, used as biostratigraphy zoning, were found in Gua Panjang and Aring (Rahman, O.A., 2010).

Moreover, the Upper Palaeozoic rocks are mostly of argillaceous strata and volcanic rocks with minor arenaceous and calcareous sediments deposited in the shallow marine environment, with intermittent submarine volcanism, starting from the Upper Carboniferous to Permian then to Triassic. Triassic lava unconformably overlies Permian phyllite in south Pahang and Johor, marking a transformation from submarine to subaerial volcanism in the south (Foo, 1983). Besides, the siliceous shales along the Bilut Valley access road have the orthoceraconic nautiloid ‶*Orthoceras*″, whose known age range is Ordovician to Triassic (Alexander, 1968).

The Mangga formation is well bare in the upper reaches of Sungai Machang lengthening southwards to Kampung Gunung in the Batu Melintang area. The Mangga formation (Malaysia) are found to be same stratigraphically with the Ka Lu Bi formation (Thailand). The Ka Lu Bi formation consists of thin to medium bedded shales, sandstones and conglomerates with quartz vein and dyke. The Taku schist include mainly schists which are wholly crystalline and generally completely schistosed. Mica schist is the main rock type. Local deformation and low-grade metamorphism took place in the shear and contact zones then metamorphosed the original rocks to slate, phyllite, phyllitic shale and marked slate.

2.2.2 Structural Geology

Common structure that have been spotted in the area are large and small faulting, folding, foliation, shear zone and joints. Kelantan state is characterised with faults such as the Bok Bak Fault Zone, Lebir Fault Zone and Galas Fault Zone as the major faults. The Bok Bak Fault zone is a sigmoidal NW- SE striking fault that cut completely across the Main Range Granite. It shows a 30.5 km long sinistral slip in the 330° direction successively across area in Baling in the south Kedah (Burton, 1965). Raj (1982) have applied a Landsat imageries to describe the possibility southward extension of Bok Bak fault up to southwest Kelantan thus by returning the continuity of the Main Range granite in southwest Kelantan and centre part of Perak, he decided a 20 km left-lateral displacement.

The Lebir Fault zone could be represented trending NNW-SSE with curved lineaments along the Sungai Lebir close to Manek Urai in Kelantan, with a minimal 10 km wide of strike-slip movement. Aw (1990) found the evidence for sinistral movement along the fault zone in the Sungai Aring area. Besides, the Galas Fault Zone with the NNW-SSE striking fault cut the Upper Cretaceous Stong Complex. A Sungai Renyok that within the Stong Complex that link of Kenerong leucogranite veins and metasedimentary enclaves is exposed (Singh et. al,1984). Deformation in Permo-Triassic strata in Kelantan is exposed along a road Kuala Krai to Dabong. The slate contains a bedding-parallel or sub-parallel slaty cleavage that has been folded together with bedding into tight to isoclinal folds.

2.2.3 Historical geology

The oldest rocks in Kelantan generally are metapalites with lesser volcanic fragmental and minor arenaceous and calcareous intercalation at northerly trending belt bordering the foothills of the Main Range and lengthening eastward up to Sungai Nenggiri that Lower Paleozoic age (MacDonald,1967). Next, volcanic-sedimentary rock at the eastern side of Kelantan is Permian age overlapped by the Lower Paleozoic sequence in Southern Kelantan. Hutchison (1961) suggests that Taku Schist is the oldest rock in peninsula but Khoo and Lim (1983) questioned the validity of this suggestion. The age of Taku Schist is dubious but it is believed its age in Permo-Triassic which represent the age of the central and north Kelantan. The age of rock in central and south of Kelantan is Triassic. Sedimentary and meta-sedimentary rocks have ages between Ordovician and Cretaceous.

2.3 Slope

2.3.1 Cut slope

Cut slope is cutting out the soil or rock material from a hill or mountain. The cut slope is formed in the construction of roads, railway lines, canal or building.

2.3.2 Types of Cut Slope

Cut slope can be divided into rock cut slope and soil cut slope. For rock cut slope, the soft rocks such as shale and sandstone can be excavated without blasting. The hard rocks such as igneous rock, metamorphic rocks and carbonates are required blasting to excavate. For soil cut slope, the soil can be excavated without blasting.

2.3.3 Cut Slope Stability

The instability of hard rock cut slopes is typically controlled by rock discontinuities (joint and joint sets) within the rock. The shear strength, compressive strength, tensile strength also can give impact to the rock cut slope. For soil cut slope, there are four factors that gave the greatest impact to the cut slope stability which is gradient, soil strength, slope material and groundwater.

According to Ishak, H. (2009), the first indication of instability is usually a tension crack in the ground behind the crest of the slope, sometime go along with slumping of the soil in front of the crack. In addition, the slope stability depend on driving forces and resisting forces. The driving forces cause the material go downslope movement. For resisting forces, it prevent the movement. When the driving forces surpass the resisting forces, the slope is unstable and effects in mass wasting. The main driving force is gravity and the main resisting force is the material's shear strength.

Factor of Safety (FOS) is the ratio of resisting forces to driving forces. So, the value of FOS that more than 1 is mean it safe while the value of FOS that less than 1 is mean unsafe.

2.3.4 Cut Slope Failure

In tropical areas such as Malaysia, slope failure is either induced by natural processes or by human activities (Jasmi and Azlikamil, 2000). Cut slope failures can cause damage of properties and loss of lives. The cut slope failure was triggered by rainfall, erosion, geological factors, construction activities and rises of pore water pressure.

The slope failure movement such as translational failure and rotational failure can happens when shear stress more than shear strength of the material forming the slope. The cross section of slope failure is shown in Figure 2.1. The behavior of the slide depends on the type of material whether that material is homogeneous (isotropic) material (similar properties in all directions) (Figure 2.2) or inhomogeneous (anisotropic) material with planes of weakness (Figure 2.3) (Niroumand, H. et al., 2012). According to Varnes (1978), the classification of mass movement must consist of the type of movement and materials. (Table 2.1 and Figure 2.4).

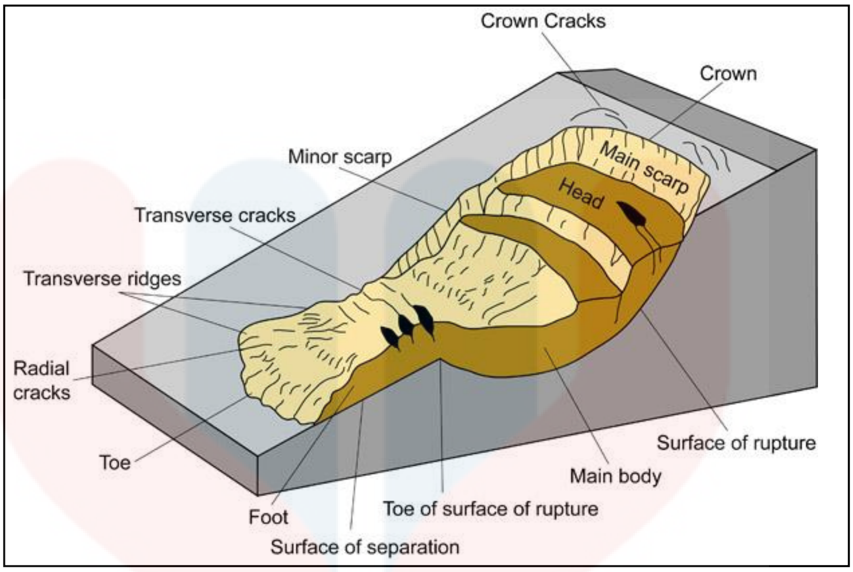

Figure 2.1 The cross section of slope failure (Varnes,1985)

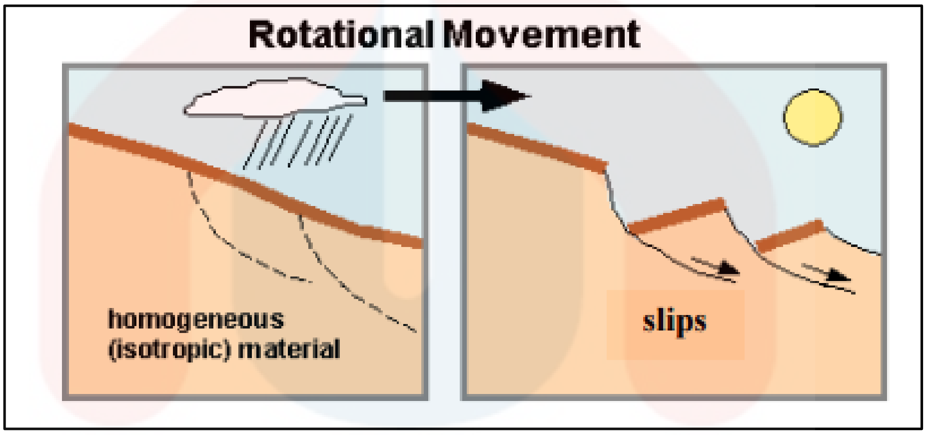

Figure 2.2 Slope failure of homogeneous (isotropic) materials (similar properties in all directions) (Niroumand, H. et al., 2012).

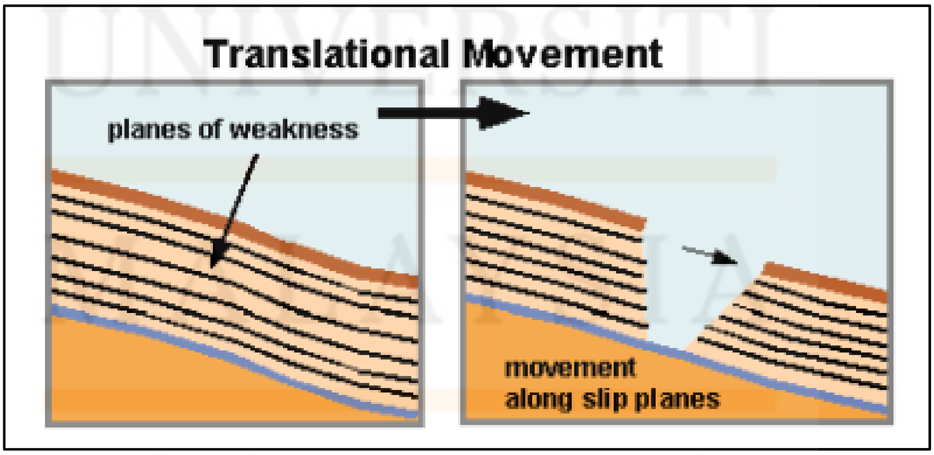

Figure 2.3 Slope failure of inhomogeneous (anisotropic) materials with planes of weakness (Niroumand, H. et al., 2012).

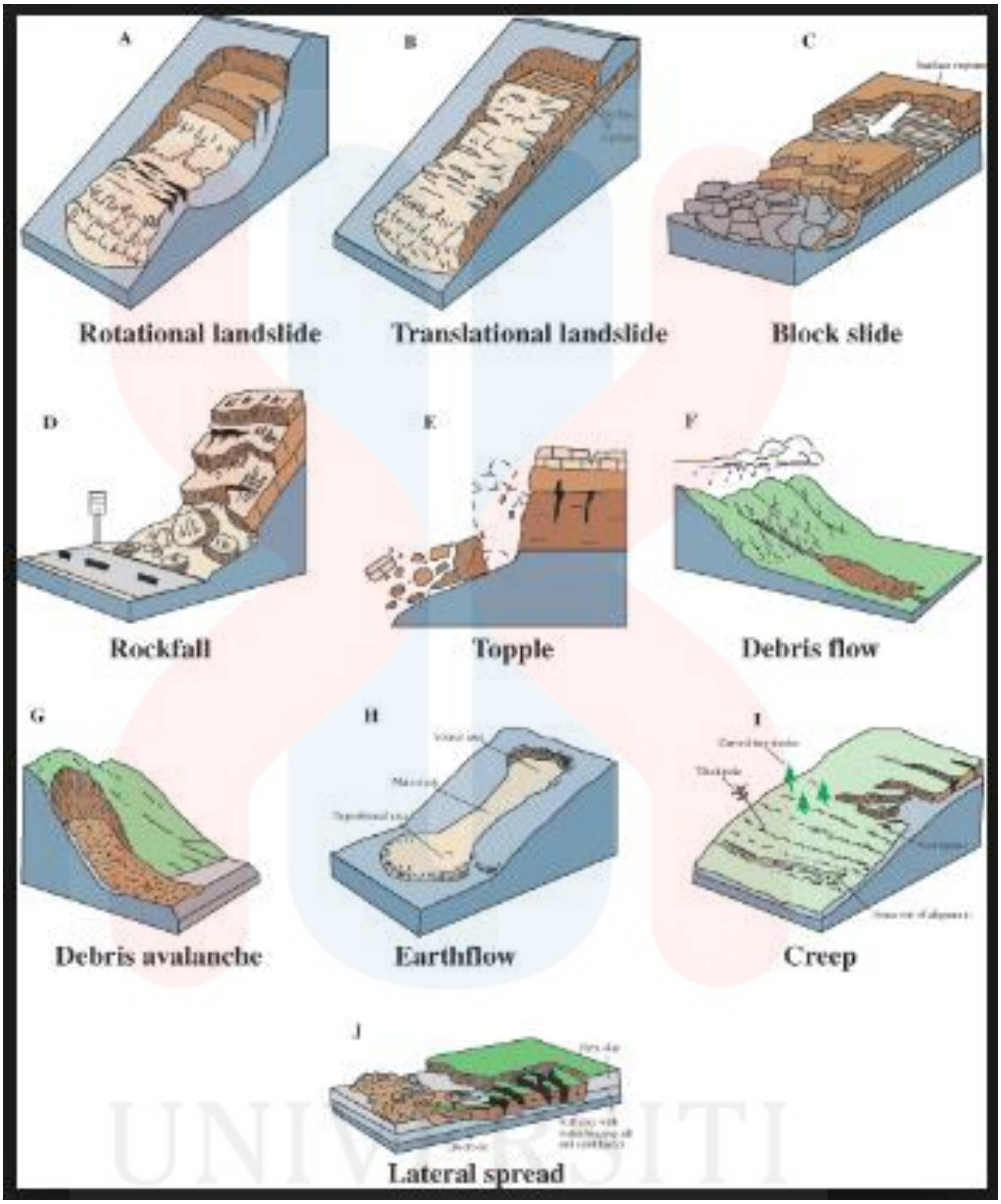

Figure 2.4 Type of landslides (Varnes, 1978)

Table 2.1 Type of landslides (Varnes, 1978)

Type of Movement		Type of Material		
		Bedrock	Engineering soils	
			Predominantly coarse	Predominantly Fine
Falls		Rock fall	Debris fall	Earth fall
Topples		Rock topple	Debris topple	Earth topple
Slides	Rotational	Rock slides	Debris slides	Earth slides
	Translational			
Lateral spreads		Rock spread	Debris spread	Earth spread
Flows		Rock flow (deep creep)	Debris flow (soil creep)	Earth flow (soil creep)
Complex		Combination of two or more principal types of movement		

2.4 Slope/W Software

The limit equilibrium theory has generally used in slope stability analysis for years. Equilibrium method of slope stability analysis all involved assumptions because the numbers of equilibrium equations presented is smaller than the number of unknown involved (Felix, 2003).

GeoStudio 2016 Slope/W Software is geotechnical software that can be used to determine the factor of safety (FOS) of slopes. (Figure 2.5). Slope/W software will analyse data in order to get slope stability by input the data from the slope at field and laboratory to the software. To create model in this software, the unit weight of material and shear strength of the material is needed. FOS value that resulted from the software that more than 1 is considered as stable.

In 1973, the engineer calculate manually to analyse the slope stability. They need extra time and energy to design a slope using the conventional method of slope stability analysis. Then, the advanced method is created to make things easier in the calculation, save time and give the accurate result.

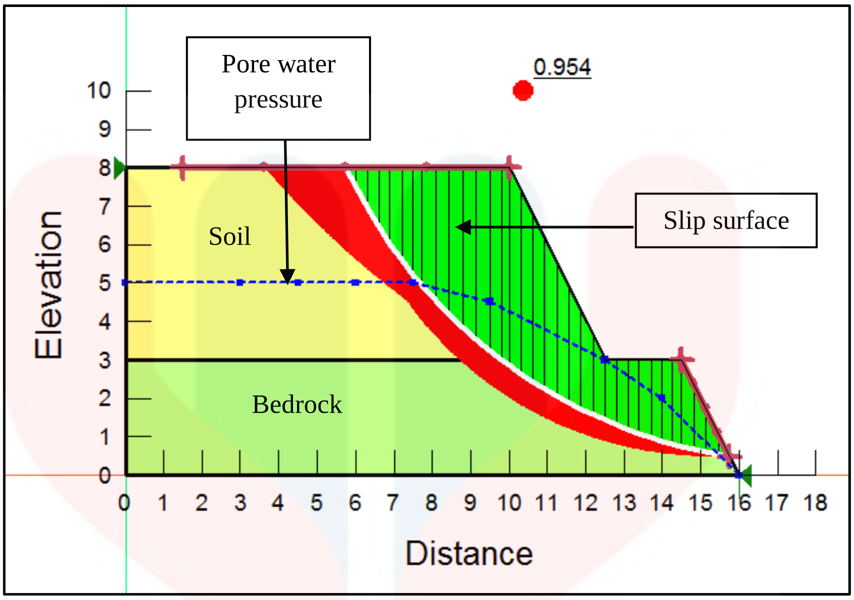

Figure 2.5 The slope stability analysis in term of factor of safety (FOS).

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

The idea about the research was developed through literature review. To continue this research project, the materials and the suitable methodologies was listed. The methodologies were organized to make sure the progression is smooth and follow the objective required. The research flow chart that should be taken in this study has been shown (Figure 3.1).

3.2 Materials

This research study used some equipment for geological mapping, collect data at study area and laboratory test (Table 3.1 and Table 3.2).

Table 3.1 Materials and their uses.

NO	MATERIALS / TOOLS	USES
1	Geological hammer	For splitting and breaking rocks to obtain a fresh surface of rock.
2	Global Positioning System (GPS)	To determine coordinates and elevation., tracking structures
3	Compass (Suunto/Brunton)	For find the direction and measure strike and dip of geological structure.
4	Hand lens	To identify minerals in rock at the field before further analysis in the laboratory.
5	Sample bags	For store the sample of rock or soil.
6	Measuring tape	To take actual measurements of slope and structures at the field.
7	Dilute Hydrochloric Acid (HCL)	To test if a rock contains carbonate minerals.
8	Camera	To take photographs of all important features at field
9	Base map/topological map of study area	As a reference in conducting the research at study area.
10	Sieve	For grain size analysis
11	Pipette	To distribute a precise amount of liquid
12	Casagrande apparatus	To determine the liquid limit of soil
13	Vane shear test apparatus	To determine shear strength of clay soil

Table 3.2 Software and their uses

No	Software	USES
1	Slope/W software	To analyse cut slope stability
2	ArcGIS Version 10 software	A geological information system (GIS) used for producing the base map of the study area.
3	GeoRose 0.4.1.0	To plot structural geology rose diagram, equal area and equal angle stereonet diagram
4	DNRGPS 6.0.0.15	To transfer data between Garmin handheld GPS receivers and GIS software
5	Google Earth Pro	To view and explore areas by oblique angle

3.3 Methodology

For this research, the study area has been traversed using compass and GPS for geological mapping. The cut slope survey also has been done during geological mapping. The sample also collected from study area to be analysed in the laboratory.

3.3.1 Preliminary studies

This research was starting with reading the journals and literature research from previous study. The published journals that have been referred get from websites. Besides, knowledge also gains from unpublished thesis from University Malaysia Kelantan and reading materials get from library of University Malaysia Kelantan. The topography map is acquires from the Laboratory of Geosciences and Soil Sciences then use as a base map. The topographical information is related with images from Google Earth Pro software and Geographical Information System (GIS) software to find the exact location of the study area.

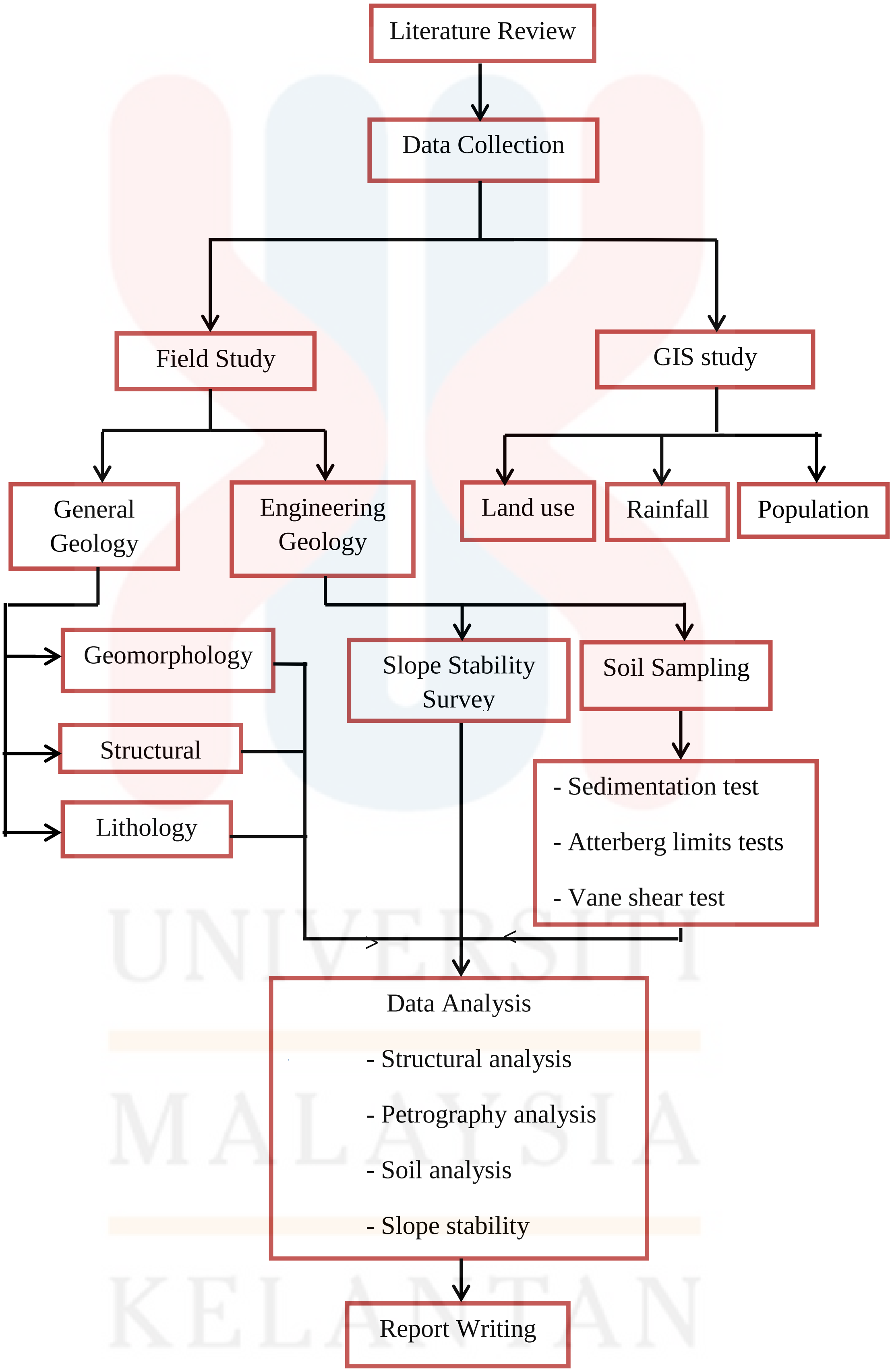

Figure 3.1 Research flow chart

3.3.2 Field studies

a) General Geological Mapping

The study area has been traversed using compass and GPS. So, the exact location for localities can be determined on the map. The study area has been observed from higher state to lower state according to the techniques of geological mapping to understanding more about the geomorphology of the study area. Some pictures of the geomorphology and the geological structure such as joint and bedding have been taken for information. For structural analysis, the orientation (strike and dip) of joint and bedding have been taken from the outcrop. Other than that, the lithology also have been determined during mapping.

b) Cut slope stability survey

The cut slope survey has been done during geological mapping to identify whether the study area have a potential for cut slope failure happened. The sample at stable slope and failure slope have been collected from each cut slope for analysis. The height and unit weight of soil of the cut slope have been determined at to input in Slope/W software for cut slope stability analysis. The unit weight of soil was determined by using the cylinder pipe and pushed it into the soil. The soil in the cylinder pipe must be compacted. The slope geometry, type of slope failure, size of slope failure, failure geometry, type of material, weathering grade and protection also have been identified at every cut slope of study area. During survey the study area, the other features have been discovered such as river, farm, main road and town.

3.3.3 Laboratory Work

a) Sedimentation Test

Sieve is an apparatus that used for grain size analysis. For particles larger than 0.075 mm the sieving method is used and the sedimentation method is used for particles of 0.075 mm or less (Muni, 2007). Then, the sedimentation procedure is chosen for the soil that very much smaller silt and clay size (fine) particles by pipette method. For this research study, the 2 mm and 63µm siever size was used for pre-treatment and wet sieving. The result will be recorded and presented in a graph of percentage passing against particle size. The Table 3.3 show the grain size of soil. Clay is stronger than sandy.

Table 3.3 Grain Size of Soil (USGS,1985)

Very coarse soils	Boulders		>200 mm
	Cobbles		60 – 200 mm
Coarse soils	Gravel	Coarse	20 – 60 mm
		Medium	6 – 20 mm
		Fine	2 – 6 mm
	Sand	Coarse	0.6 – 2.0 mm
		Medium	0.2 – 0.6 mm
		Fine	0.06 – 0.2 mm
Fine soils	Silt	Coarse	0.02 – 0.06 mm
		Medium	0.006 – 0.02 mm
		Fine	0.002 – 0.006 mm
	Clay		< 0.002

The test began with the prepared the dried samples that had been passed a 2 mm sieve. By using pipette method, the 12 g soil samples are needed. The soil has been placed in a 650 ml conical beaker and 50 ml of distilled water was added into it. The suspension has been boiled gently until the volume is reduced to about 40 ml. A similar beaker that contained 40 ml of water was used as a comparison in order to judge the right amount. The samples were allowed to cool and 75 ml of hydrogen peroxide was added into it. Then, the samples have been covered with the cover-glass and allowed to stand overnight.

The next day, a filter funnel has been set up with a filter paper for filtration process. The samples in the conical beaker were transferred to filter funnel and the beaker was rinsed with a little distilled water to ensure that no soil was lost. The samples that have been transferred into a conical flask should be added 100 ml of distilled water. The samples also were added 25 ml hydrogen peroxide. The conical flasks have been placed on the mechanical shaker for 4 hour or overnight to shake them vigorously until all the soil was in suspension.

After that, the samples of soil with suspension were transferred to 63 µm sieve for wet sieving, nested on a receiver without loss of soil. The soil was washed with a jet of distilled water from a wash bottle, until all fine material was washed through the sieve. The amount of water should not exceed 500 ml for the pipette test. The material that retained on the 63 µm sieve was transferred to an evaporating dish. Then, the material was dried and weighted. Besides, the materials that passing the 63 µm sieve have been used for pipette test.

For pipette test, the suspension of pre-treatment soil passing the 63 µm sieve was transferred with glass funnel from receiver into a 500 ml sedimentation cylinder. No soil must be lost in this operation. The water level in the cylinder has been made up to the 500 ml calibration mark with added distilled water. The sedimentation cylinder placed in the constant temperature bath (25ºC). The sedimentation cylinder then was shaken thoroughly by inverting end-over-end for several times. Next, the suspension of soil was placed in the bath and the stopwatch was started (Figure 3.2).

The samples were pipetted at three specific time intervals from zero time for each sample (Figure 3.3). These times depend on the specific gravity of the particles in the suspension. The sampling pipette was moved on its supporting frame over the sedimentation cylinder. The pipette was lowered into the suspension until the tip was

10 cm below the surface of the water in the cylinder. The 25 ml suspension was pipetted every three specific time interval.

Figure 3.2 The pipette test

SG of silt and clay fraction	*Times after shaking of starting sampling operation*					
	1st sample		*2nd sample*		*3rd sample*	
	min	*s*	*min*	*s*	*h*	*min*
2.50	4	30	50	30	7	35
2.55	4	20	49	0	7	21
2.60	4	10	47	30	7	7
2.65	4	5	46	0	6	54
2.70	4	0	44	30	6	42
2.75	3	50	43	30	6	30
2.80	3	40	42	0	6	20
2.85	3	35	41	0	6	10
2.90	3	30	40	0	6	0
2.95	3	25	39	0	5	50
3.00	3	20	38	0	5	41
3.05	3	15	37	0	5	33
3.10	3	10	36	0	5	25
3.15	3	5	35	0	5	18
3.20	3	0	34	30	5	10

Figure 3.3 Pipette sampling time (Head, 1980)

The suspensions that have been pipetted were transferred to the evaporating dishes. Three evaporating dishes have been weighted and labelled with M_1, M_2 and M_3 before put the suspensions into it. The suspension that have been transferred into the evaporating dish must be weighted before putted it on oven at 105ºC for dryness. After the suspension dry, the evaporating dishes have been weighted again.

b) Atterberg Limit Test

This test is used to determine the consistency of fine-grained soils. A fine grained of soil usually exists in its particles surrounded by water. The amount of water in the soil is describes as consistency. The state are used to describe the soil consistency is solid, semi-solid, plastic and liquid.

The plasticity index can be determined by obtained the liquid limit and plastic limit values. The Plastic Index range can describe about their plasticity. (Table 3.4). The plasticity chart also shown (Figure 3.4).

Table 3.4 Plasticity Index, PI value (AASHTO T90 – Standard Method of test for determining the Plastic Limit and Plasticity Index of Soil, 1988)

PI Range	Description
0	Non plastic
1-5	Slightly plastic
5-10	Low plasticity
10-2	Medium plasticity
20-40	High plasticity
>40	Very high plasticity

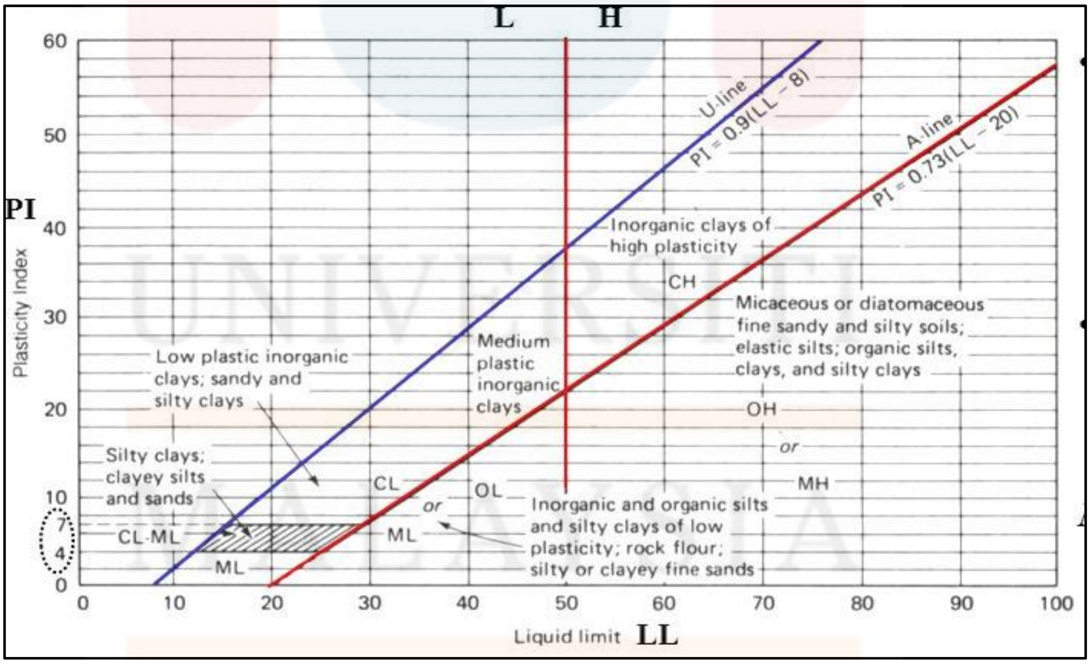

Figure 3.4 The plasticity chart (Holtz, R.D. and Kovacs, 1981)

For plasticity chart, an A-line divides the inorganic clays and the inorganic silts. Inorganic clay values lie above the A-line and values for inorganic silts lie below the A-line. Organic silts plot in the same region (below the A-line and with LL ranging from 30 to 50) as the inorganic silts of medium compressibility. Organic clays is plot in the same area as inorganic silts of high compressibility (below the A-line and LL greater than 50).

The information provided in the plasticity chart is great value and it is the base for the classification of fine-grained soils in the Unified Soil Classification System. The U-line is almost the upper limit of the relationship of the plasticity index to the liquid limit for any soil.

Plastic index (PI) is the range of the water content in the soil that describe its plastic properties. Non-plastic material cannot be determined their plastic limit. Plasticity index for sands is zero. Determination of plasticity index can used an equation 3.1.

$$\mathbf{PI = LL - PL} \text{ (British Standard 1377:1995)} \qquad \mathbf{(3.1)}$$

PI = Plasticity Index

LL = Liquid Limit

PL = Plastic Limit

To determine the liquid limit by using the Casagrande apparatus, 200 g of dry soil that passing 425 μm sieve is required. The natural soil have been cut up into small pieces or shredded by using a cheese grater. Then, the soil was placed on the glass plate and mixed thoroughly with a little distilled water using two palette knives or spatulas. The small portion was saved for plastic limit test. The paste was placed on the airtight container and sealed. The paste was leaved for overnight at the cool placed.

The Casagrande apparatus must be clean and dry. The Casagrande apparatus dropped at a height of 10 mm at a two drops per second. Before that, mixed soil was placed into the Casagrande cup. Soil pat on the Casagrande apparatus should form approximately horizontal surface (Figure 3.5). Grooving tool is used to cut a straight groove down the centre of the cup.

The crank apparatus turn at a rate of two drops per second and the drop count is recorded. It takes to make the two halves of the soil pat came into contact at the bottom of the groove along a distance of half inch. The weight of the moisture can with the soil sample is taken and leaved in oven for dryness.

Remaining material is added and mixed. Small amount of the distilled water added to increase the water content so that the number of drops required closing the groove decrease. Trial number drop value should include 1 to 10 drops, one closure between 10 to 20 drops and one closure trial closure between 20 to 30 drops. The water content from each trial will be determined.

To determine the plastic limit of soil, quarter of the original soil sample was added with distilled water until the soils consistency where it can be rolled without sticking to the hand. When the soil thread crashes at approximately 3.0 mm, the plastic limit is reached. The soil was crumbled and put into moisture and weighted.

The soil sample placed in the oven for at least 16 hours. Water content then determined. Plasticity index can be determined from the plastic limit subtracted with liquid limit.

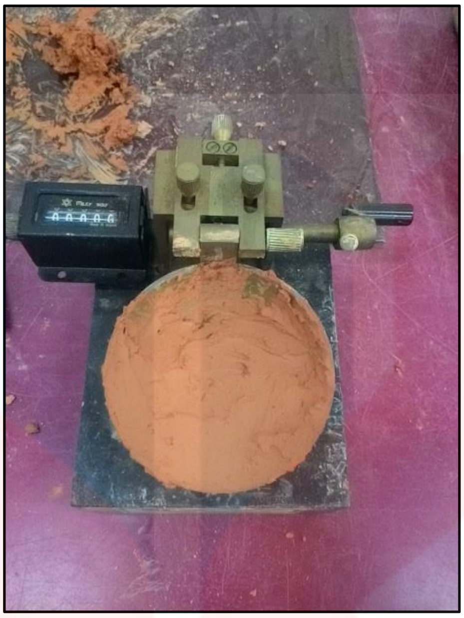

Figure 3.5 Casagrande cup

c) The Vane Shear Test

Figure 3.6 The Vane Shear Test equipment

The Vane Shear Test was used to determine the shear strength of clay soil (Figure 3.6). It is a cheaper and quicker method that has been done in laboratory. This test is done for soils that had a low shear strength (less than 0.3 kg/cm^2) which is triaxial or unconfined tests cannot be performed. The shear strength of soil can be calculate by equation 3.2.

$$\mathbf{S_s} = \frac{T}{\pi\left(\frac{HD^2}{2}+\frac{D^3}{6}\right)} \qquad \textbf{(3.2)}$$

Where, S_s is shear strength of soil in kg/cm^2, T is torque in kg cm (corrected for the vane rod and torque rod resistance, if any), D is overall diameter of vane in cm and H is height of vane in cm.

The test has been done by prepared the soil sample of dimensions 3 cm diameter and 6 cm height (the height of vane is usually twice its diameter). The sample has been compacted into the sample container and placed the sample container into the hole that has been provided at the base of the vane shear apparatus. The initial readings of the angle of vanes were recorded. The shear vanes were gently lowered into the sample to their full length without disturbing the soil sample. The top of the vanes must be 1 cm below the top of the sample.

The vanes were rotated at a uniform rate by suitable operating the torque application handle until the sample was failed. The final reading of the angle of twist was recorded.

d) Thin Section Preparation

The thin section method is use as an evidence for a lithology that shows the different type of rock at different location at the study area. The rock sample that has been taken from the study area has to be prepared for microscopic details. About 0.03 mm thick slice of rock samples attached to a glass made.

Thin section prepared with cut out the rock samples into smaller piece by using cut-off saw. Then, the smaller piece was reduced by cutting into chip using trim saw. After that, the grinding process was applied to eliminate any saw mark from the cutting. Next, the chip attached to the slide with glue. For this step, the chip was heated up by placing it on the hot plates with the polished side up and then spread the glue on chip. Later, the slide was grinded to get the exact thickness and the cover slip was added.

3.3.4 Data processing

Data from the GPS have been transferred to the computer. Then, the GPS data has been input into DNR software. Software ArcGIS 10.0 involves plotting the traverse route using DNR software, editing the data, production of map and rerouting the lithologies. In structural geology, the rose diagrams produced by GeoRose needed the dip and strike values to know the orientation of joints.

The soil particle distribution test had a calculation and graph to be done. The liquid limit and plastic limit also had a calculation. Moreover, the Vane Shear tests have to find the torque from the graph and input the value to the formula to find the shear strength. Microsoft Excel were used for tabulates the data, graph sketching and calculation.

3.3.5 Data analyses and Interpretations

Software ArcGIS 10.0 is used in geological mapping data analysis to present the data that obtained at the field. The traverse route, map and the lithologies produced by ArcGIS 10.0 needed to be analyses and interpret. Software GeoRose also used in mapping data analysis and structural geology analysis.

For engineering geology data analysis and interpretation, software Slope/W was used to analyse the stability of cut slope. The height, unit weight and strength of soil for each slope have been determined at field and laboratory then had to be key in into the Slope/W software. The result showed the cut slope are stable or unstable in terms of Factor of Safety (FOS). The FOS value that more than 1 is considered as stable using Morgenstern-Price Method.

3.3.5 Report writing

Report writing is the last method for the research's works. All the records and discovery must be shows in this report. Data analysis and interpretation will be develops continue with discussion. Later, report writing will be encounter by conclusion and suggestion or recommendation. The report writing must follow the guidelines provided by Geosciences Department of University Malaysia Kelantan.

FYP FSB

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter, the general geology of the study area including geomorphology, stratigraphy, structural geology and historical geology were described. All the data were done from field observation and laboratory data analysis.

The traverse map shows the location of station for observation, sampling and measurement on structural during the field mapping (Figure 4.1). All the data collected for each station was pointed in the traverse map as shown in Table 4.1.

Table 4.1 Activities at each stations

Station (S)	Coordinates	Elevation (m)	Activities/ Observation
1	N 05º33’ 8.1” E 101º 52’ 46.3”	124	Geomorphologic observation
2	N 05º32’ 46.2” E 101º 53’ 00.2”	83	Collecting rock sample (Granite), geomorphologic observation
3	N 05º32’ 27.3” E 101º 52’ 38.2”	126	Geomorphologic observation
4	N 05º32’ 38.9” E 101º 53’ 33.8”	81	Collecting rock sample (Slate), geomorphologic observation
5	N 05º31’ 57.2” E 101º 53’ 13.6”	54	Geomorphologic observation
6	N 05º31’ 18” E 101º 53’ 21.3”	70	Collecting rock sample (Shale), geomorphologic observation, measurement on structural
7	N 05º31’ 24.6” E 101º 53’ 35.4”	40	Geomorphologic observation
8	N 05º30’ 39.5” E 101º 53’ 35.4”	46	Collecting rock sample (Shale), geomorphologic observation
9	N 05º30’ 51.8” E 101º 53’ 6.8”	66	Geomorphologic observation
10	N 05º30’ 42.7” E 101º 52’ 46.6”	128	Collecting rock sample (Granite), geomorphologic observation, measurement on structural

TRAVERSE MAP OF KAMPUNG JABIR, JELI

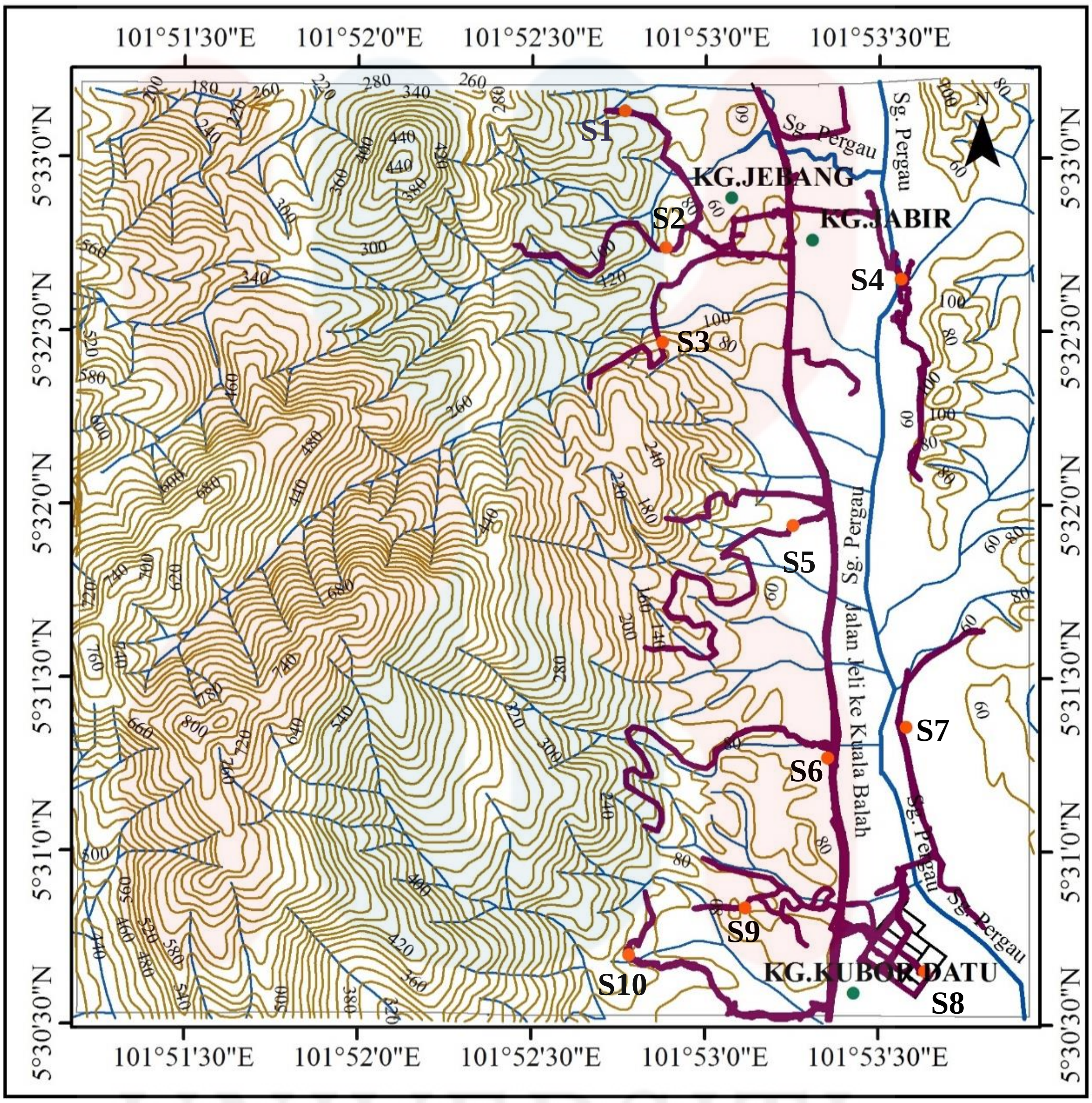

Figure 4.1 The traverse map shows the stations of observation, sampling and measurement on structural

4.2 Geomorphology

In geomorphologic study, the topographic map and aerial photographs have been referred. Not only that, the geomorphologic study also based on field observation. The geomorphology area consist of the topography and drainage pattern that give a view about the type of rocks at study area.

4.2.1 Topographic Unit Classification

The topography of study area can be separated into three main features, which are mountain area, hill area and undulating area based on Table 4.2. The study area is mountain on the west part and hill at center part and flatter toward the east part of study area (Figure 4.2).

The elevation of study area ranges from the lowest elevation of 60 m to the highest elevation of 800 m. The pattern of topography that shows the lines of the contour is very close means the topography is high and steep. However, the line of the contour that far away means the topography is low area.

The mountain landform, which has mean elevation more than 301 m, covered 35% of study area. The hill landform has mean elevation range from 76 m to 300 m, covered 25% of study area. The undulating area has mean range elevation 31 m to 75 m, covered 40% and located at the east part of study area.

Geomorphology analysis is done at the study area. The type of rocks that found in the area are known based on contour pattern. For the study area, the mountainous area has the characteristic of igneous rock. Furthermore, the hilly area belongs to igneous rocks and metamorphic rocks (Figure 4.3). Yet, the undulating area have a sedimentary rock.

Igneous rock is identified as the major rock constituent in the study area. This is because the mainstream part of the study area have mountainous landform and hilly landform. There is also metamorphic rock that can be found at foothill area in the east part of study area. The sedimentary rock can be found at flatter area in the center of south part.

Table 4.2 Topographic unit based on mean elevation above the sea level (Raj,2009)

No	Mean elevation above the sea level (m)	Topographic unit
1	<15	Low lying
2	16-30	Rolling
3	31-75	Undulating
4	76-300	Hilly
5	>301	Mountainous

Figure 4.3 Hilly landform at Kampung Jabir

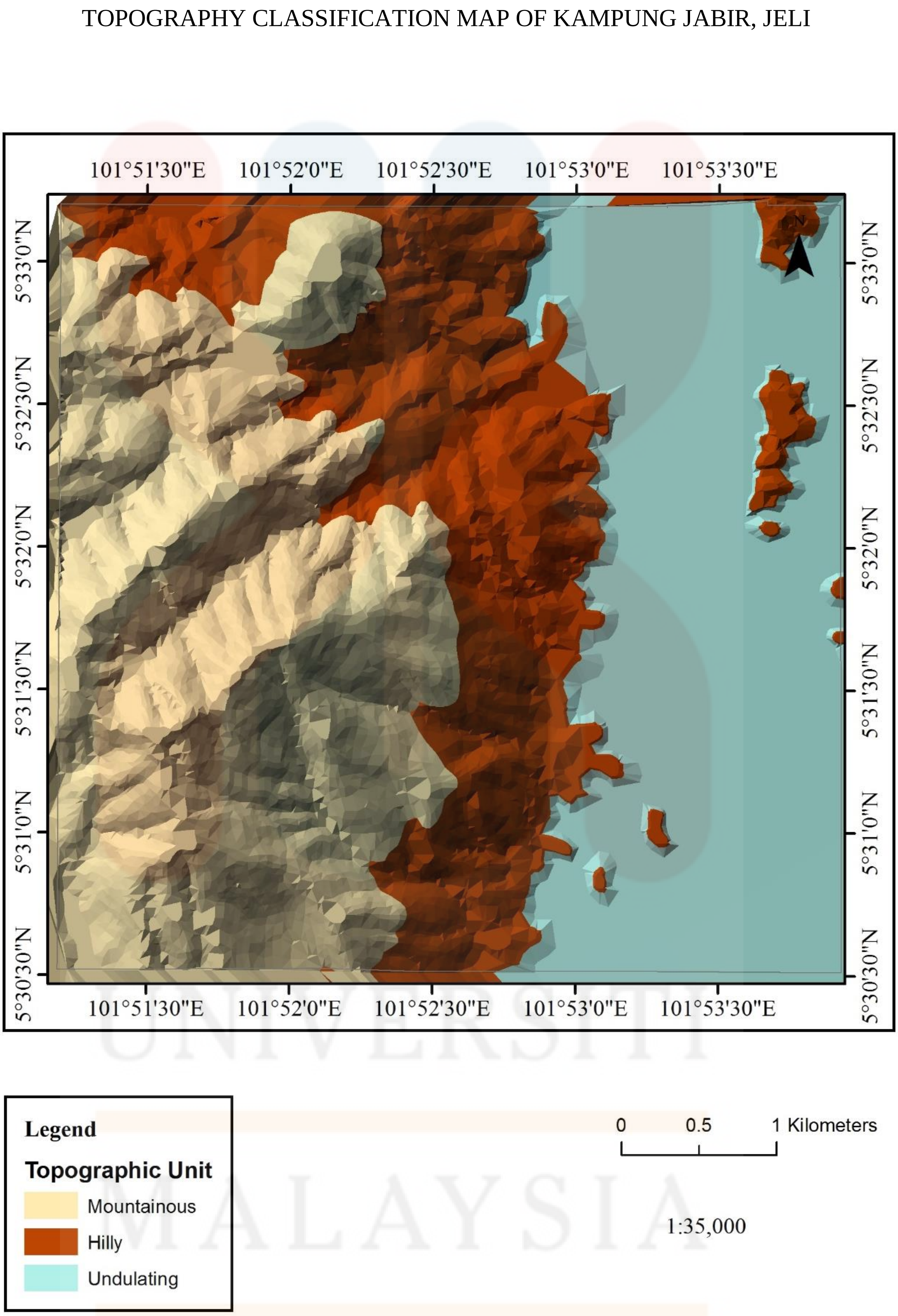

Figure 4.2 The Topography Classification Map of study area

4.2.2 Drainage Pattern

A drainage pattern can be identified based on the main characteristics of their form and texture. Drainage patterns depend on the topography and the presence of bedrock structure.

In study area, there are two type of drainage pattern that can be found which are dendritic pattern and parallel pattern (Figure 4.4). The most found pattern is dendritic pattern which is covered over half of the study area. The parallel pattern is found at the west part of study area.

The most common type is dendritic drainage pattern which is spreading and tree-like pattern with an uneven branching of tributaries in many way. This shape changes on gently sloping basins with same rock type. Dendritic patterns create when the underlying rock structure does not powerfully enough to control the position of stream channels. Then, dendritic patterns tend to change in areas where the rocks have a roughly equal, resistance to weathering and erosion and not strongly jointed like shale.

In addition, a parallel drainage is representative of the basaltic pattern. This is because of the effect of stepped topography with some relief. The streams are rapid and straight with very few tributaries and all flow in the same direction.

Next, the stage of the river is essential to be known. There is a main river in study area which is Pergau River at the East part. The river indicate to be at the old stage river (Figure 4.5). This is due to the features of the river which has very low steepness in the river gradient. Besides, the river has very broad floodplain and have a lot of meanders arc. These features are abundant and prominent for older river.

Other than that, the Pergau river also has a lot of sand deposits at the center of the rivers. That means the rivers are able to transport fine sediments such as silts and clays. The channels of the rivers are broad due to the widespread side erosion and the water flow is fairly slow.

Figure 4.5 Old stage river (Pergau river)

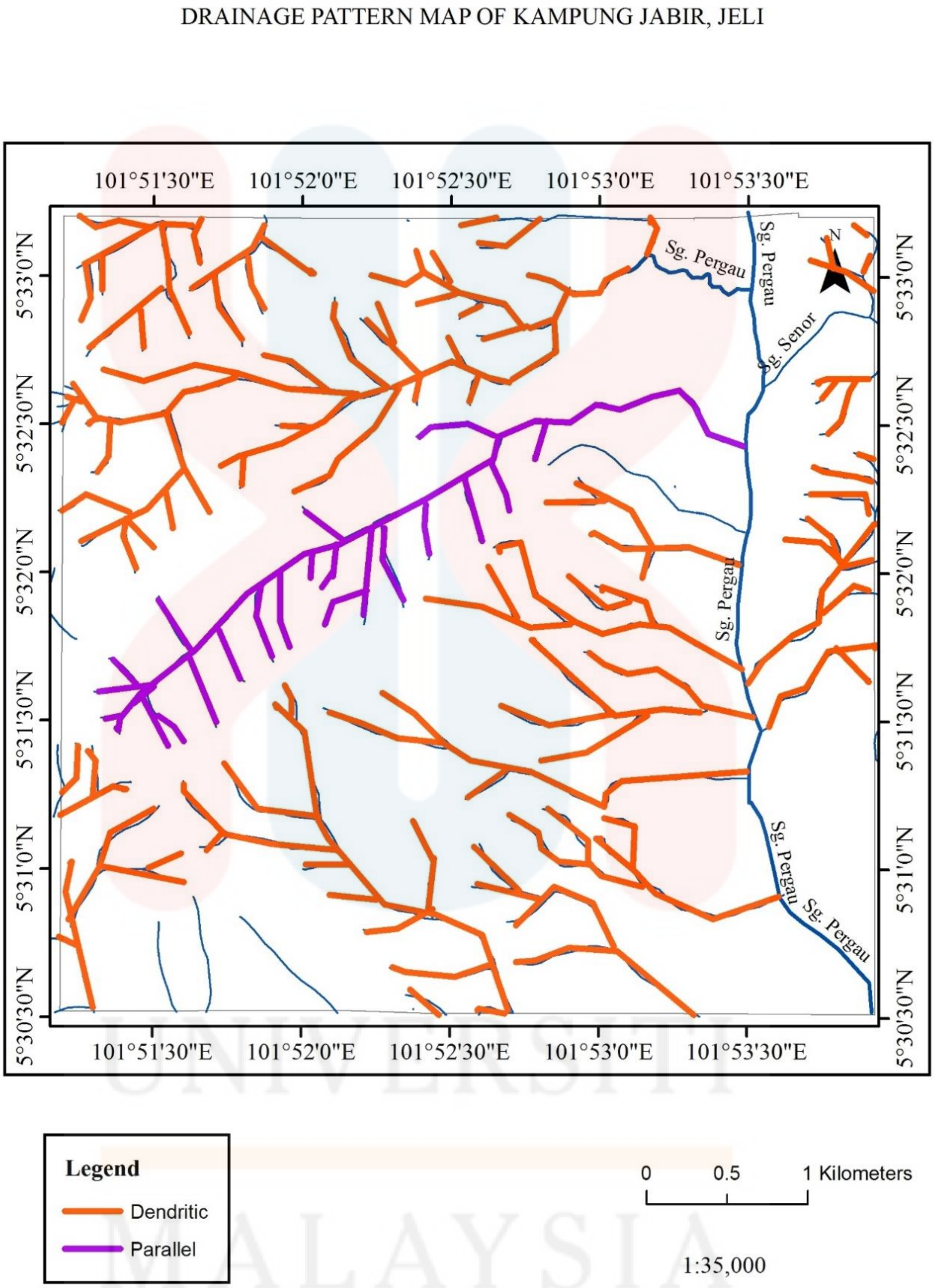

Figure 4.4 Drainage pattern map of Kampung Jabir

4.2.3 Weathering process

Weathering is the breaking down of rocks, soil and minerals through contact with the Earth's atmosphere, biology and waters. From the field observation, there are two type of weathering process that occurred in the study area which is physical weathering and biological weathering.

i) Physical weathering

Physical weathering or mechanical weathering is the breakdown of bare rock without any changes to the chemical composition of the rock. Rainfall, wind and temperature become an agent to fastening the breakdown of earth material. The physical weathering at N 05º31' 18", E 101º 53' 21.3" can be seen on the shale that breaks into small pieces (Figure 4.6). The rainfall and hot and dry climate make the shale break and weathered.

ii) Biological weathering

For biological weathering, the rock is disintegrates because of the biological activity of plants, animal and microbes. The biological weathering at N 05º31' 18", E 101º 53' 21.3" can be seen on the shale that covered by vegetation and become lose. The biological weathering might take place as growing plant roots that give the stress or pressure on the rock (Figure 4.7).

Figure 4.6 Physical weathering in the study area

Figure 4.7 Biological weathering in the study area

4.3 Stratigraphy

Stratigraphic study is the sub-division of a sequence of rock strata into map able units. In this study also can determining the time relationship that are involved and correlating units of the entire sequence with rock strata in other place.

4.3.1 Lithology unit

In the study area, there are three main lithology units which are igneous rock unit, metamorphic rock unit and sedimentary rock unit. Igneous rock unit involves of granite, while metamorphic rock consists of slate. Then, sedimentary rock unit composed of shale. The features of the rocks exposed are explained in detail below from the oldest to the youngest of the rock.

a) Shale

The outcrop is marked at N 05º30’ 39.5”, E 101º 53’ 35.4” which at the south of the study area. The outcrop have the dimension 4 m in height and 6 m width. The outcrop is beside the houses. The outcrop is fresh and the upper part of the outcrop is weathered become a soil (Figure 4.8).

For hand specimen, the colour of rock is grey colour. This rock is very fine-grained. The texture of shale is smooth. This rock also fissile and laminated. No fossil present. Shale does not react with HCL (Figure 4.9).

Figure 4.8 Outcrop of shale at Station 8

Figure 4.9 Hand specimen of Shale

b) **Granite**

The outcrop is situated at N 05º32' 46.2", E 101º 53' 00.2" which is at the west of study area. The height of outcrop is 0.5 m and the width of the outcrop is 3 m (Figure 4.10). The outcrop is found in the rubber estate and foothill. Some part of the outcrop is weathered.

Figure 4.10 Outcrop of granite at Station 2

Based on hand specimen shown in Figure 4.11, the color of rock is white because it is intrusive igneous rock. The rock is a coarse-grained that can be seen by the naked eyes. This rock also very hard and crystalline. The texture of the rock is rough (Figure 4.11).

Figure 4.11 Hand specimen of granite

From the microscopic observation, the grain size of the minerals is larger (Figure 4.12). The rock contains 20% quartz, 70% Alkali feldspar, 3% plagioclase and 7% biotite. From that outcome, the name of the rock is Biotite Granite Porphyry.

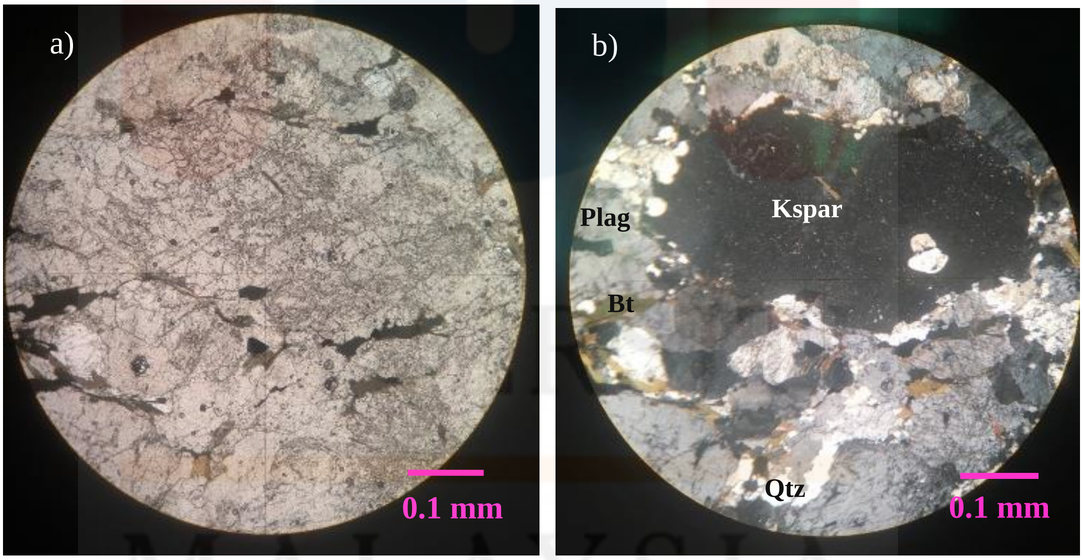

Figure 4.12 Thin section analysis of granite under 4x10 magnification **a)** Plain polarize **b)** Cross polarize

c) **Slate**

The outcrop is located at N 05º32' 38.9", E 101º 53' 33.8" which is at east of the study area. The height of outcrop is 1.5 m and the width of the outcrop is 3 m. The outcrop is on the Pergau river (Figure 4.13). The outcrop is fresh and some part of the outcrop is weathered. The outcrop also covered by moss.

Figure 4.13 Outcrop of granite at Station 4

For hand specimen, the color of rock is grey. The rock is a fine-grained that cannot be seen by the naked eyes. This rock also hard and dull. The texture of the rock is smooth (Figure 4.14). This rock have a foliation.

Figure 4.14 Hand specimen of Slate

Slate had been observed under microscope 4x10 of plane polarised (PPL) and cross polarised (XPL). The grain size of the minerals is smaller (Figure 4.15). The rock contains 55% biotite (mica) and 45% quartz. A tiny new flakes of mica grow can be seen in Figure 4.15. They tend to line themselves up to left because of the compression. The rock breaks along a cleavage plane.

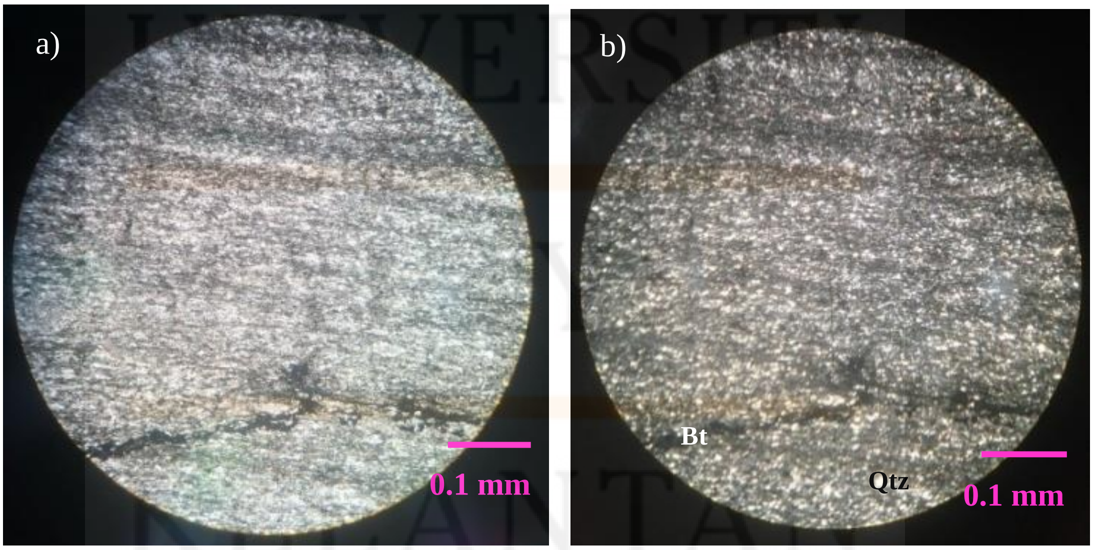

Figure 4.15 Thin section analysis of slate under 4x10 magnification **a)** Plain polarize **b)** Cross polarize

4.3.2 Lithostratigraphy

Lithostratigraphy is a part of stratigraphy that related with the study of strata or rock layers. Lithostratigraphic unit represent the bodies of rocks, structure that are specified and described on the basic of their lithologic properties and their stratigraphic relations. Lithostratigraphy of the study area was done through outcrop study, hand specimen analysis, petrography and literature reviews.

The lithostratigraphy column of the study area is presented in Table 4.3 Rock that was found in the study area includes of igneous rock, metamorphic rock and sedimentary rock. These rock aged from Upper Ordovician to Upper Triassic. The oldest rock is shale following by granite from Lower Permian to Upper Triassic. Shale and granite are involved in Mangga Formation.

During Triassic period, slate is believed from Taku Schist Formation. The regional deformation and low-grade metamorphism took place in the shear and contact zones then metamorphosed shale to slate. The alluvium is formed during Quarternary period. The geological map can be seen on Figure 4.16.

Table 4.3 The lithostratigraphy of study area

ERA	PERIOD	UNIT	LITHOLOGY	DESCRIPTION
CENOZOIC	Quarternary	Alluvial		Alluvial consists mainly of sand, silt and clay.
MESOZOIC	Triassic	Taku Schist Formation		Slate : Dark grey colour
PALEOZOIC	Permian	Mangga Formation		Granite : White colour
	Ordovician			Shale : Light grey

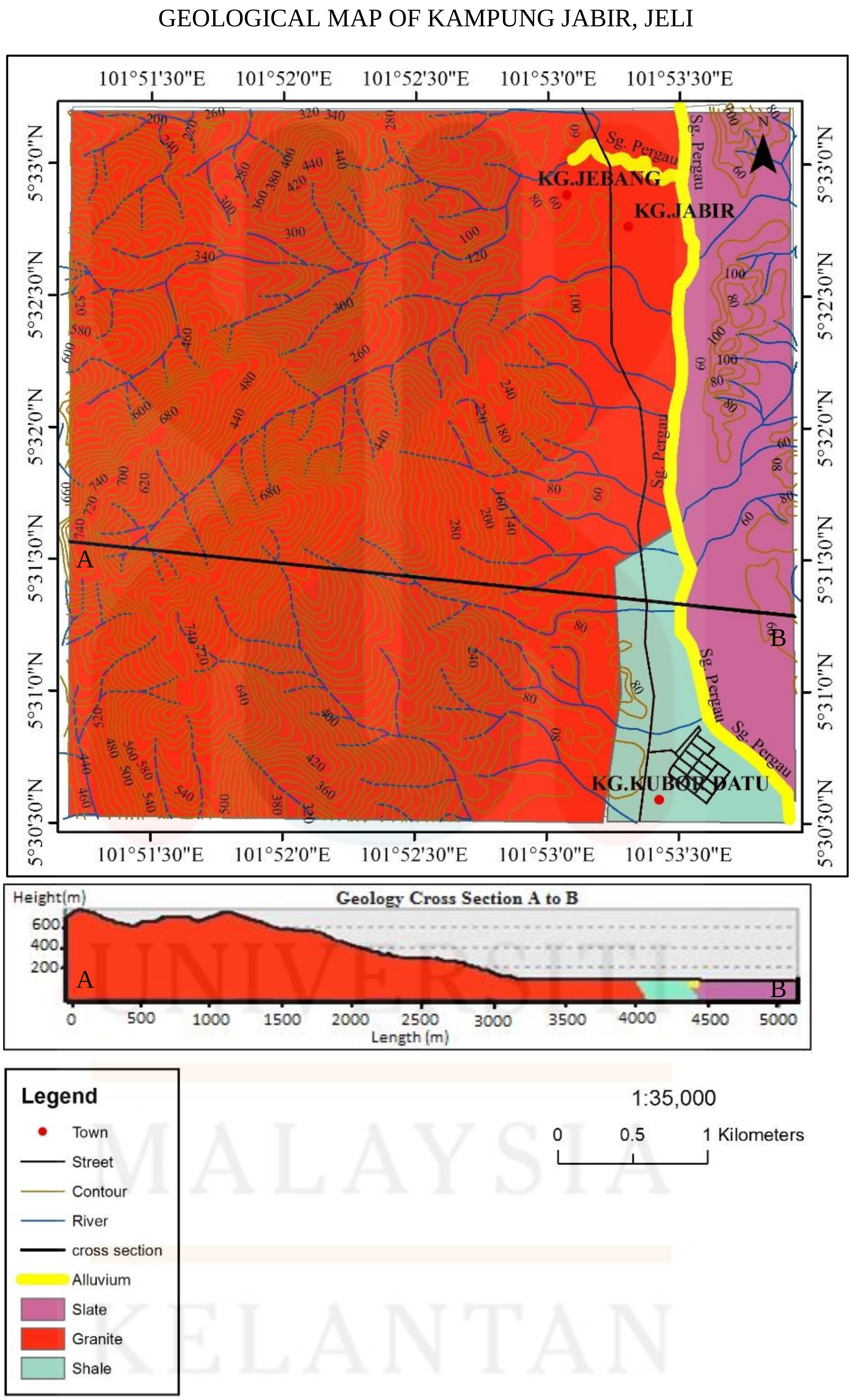

Figure 4.16 The geological map of study area

4.4 Structural Geology

Structural geology is learn about the processes and effects of rock deformation. The structural analysis can be done by the field observation. There are many types of structural analysis can be done including lineament analysis, joint analysis and fold analysis.

i) Lineament analysis

A lineament is any straight or curve characteristics of Earth's surface that expressed a fault line or fracture line. The Google Maps Terrain have been used to analyze and interpret these linear features based on regional scale. Figure 4.17 show the lineament near the study area in regional scale. The orientation of each lineament is determined and plotted into rose diagram to determine the force direction.

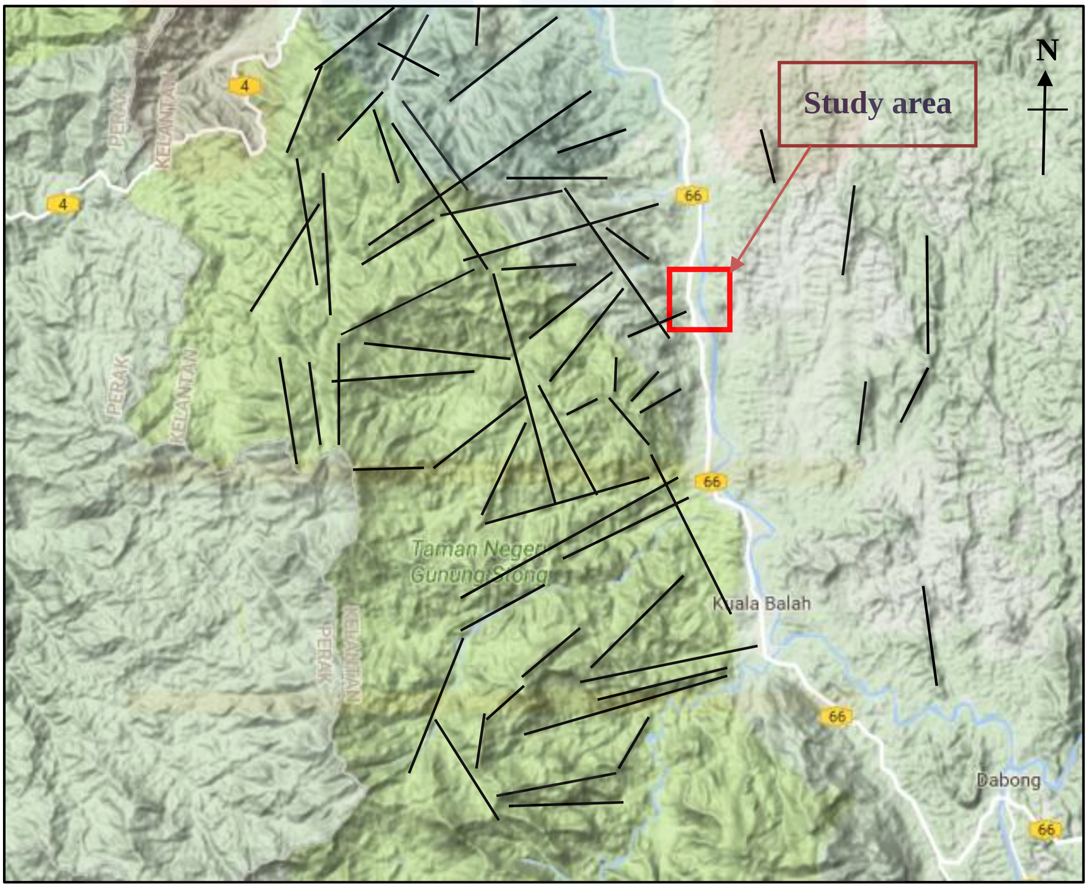

Figure 4.17 The lineament (Source : Google Maps Terrain) Scale 1:400,000

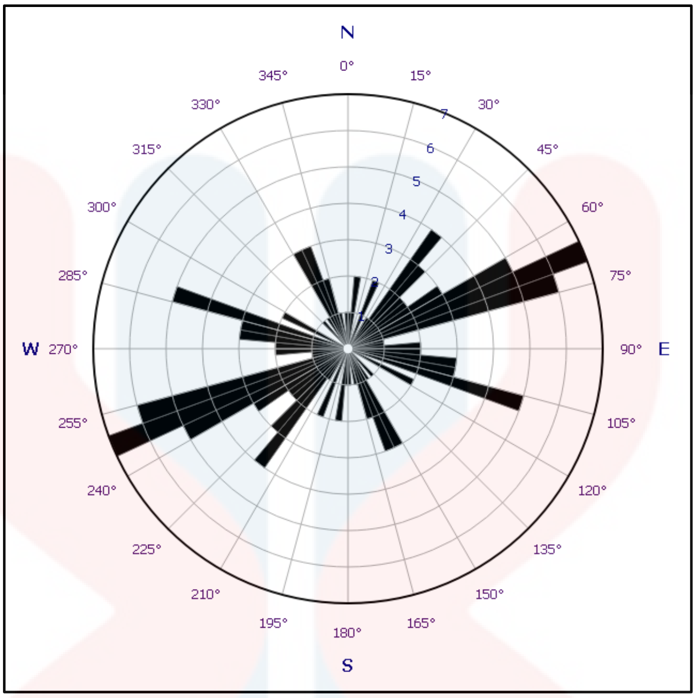

Figure 4.18 Rose diagram for lineament

Based on the Figure 4.18, the major orientation of the lineament was in NNE-SSW direction. Minor orientation of the lineament was in SSE-NNW.

ii) Joint analysis

Joint analysis was done to identify the direction of forces acting based on fracture on rocks. Joint analysis also was prepared by taking 100 readings of strike on the surface of granite found at N 05º30' 42.7", E 101º 52' 46.6". This rock is situated in the stream which is SSW part of the study area. Figure 4.19 shows the joint set. The joints that are found are extension joint with the length ranges from 2.0 m to 3.0 m. Figure 4.20 shows the rose diagram of joint analysis which has major direction of force was NNE-SSW. Minor direction of force was SSE-NNW.

Figure 4.19 The joint set at Station 10

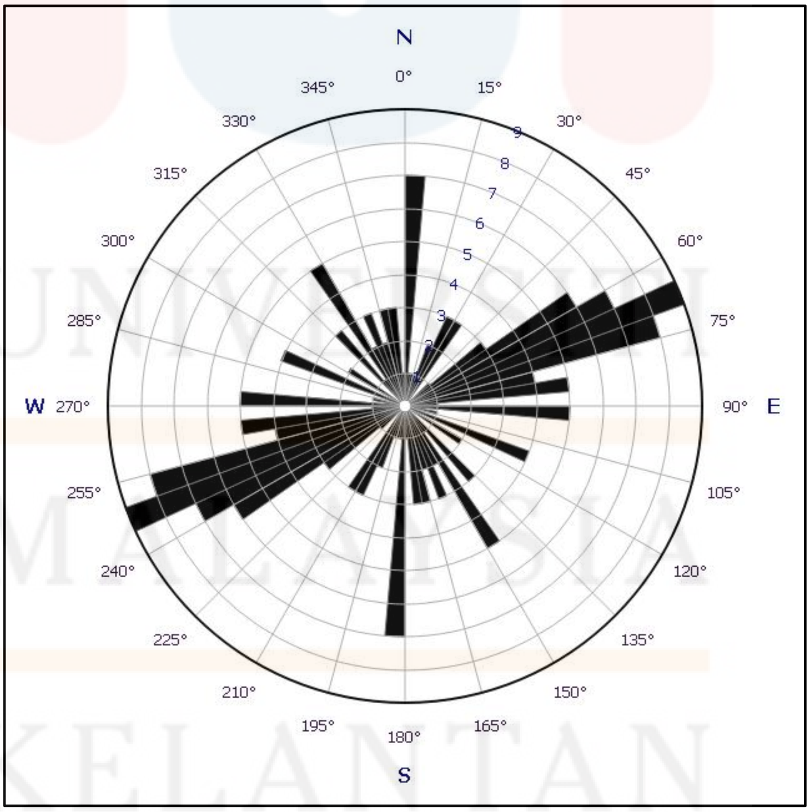

Figure 4.20 The rose diagram of joint analysis at Station 10

The major orientation of the joints that are found at granite was NNE-SSW direction. The lineament interpretation data was used as a correlation with the joints. The rose diagram of lineament analysis also shown the major direction of force was NNE-SSW. The orientation of joints that found at the study area was in similar direction as the orientation of lineament. Then, the direction of the force that acted upon during the joint formation can be concluded that was similar to the lineament which is NNE-SSW direction.

iii) Folding analysis

Bedding was found at N 05º31’ 18”, E 101º 53’ 21.3”. Bedding is layering at shale outcrop close to the road. The bedding directions is shown in Figure 4.21.

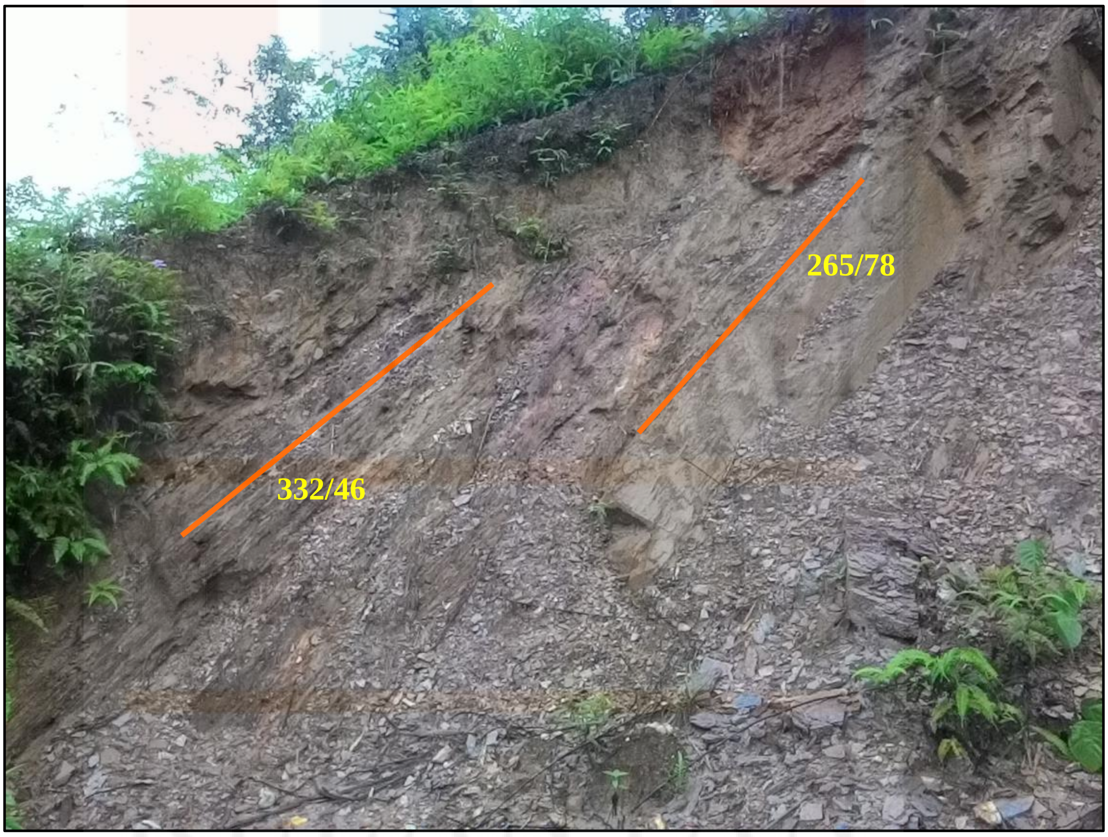

Figure 4.21 Bedding found at the Station 6

4.5 Historical Geology

The oldest rocks at study area are shale that formed during Ordovician to Triassic period. Then, granite formed during Permian to Triassic period. Shale and granite are related with Mangga Formation. When come to Triassic period, slate was formed. The regional deformation and low-grade metamorphism took place in the shear and contact zones then metamorphosed shale to slate. Slate are involve with Taku Schist Formation. The alluvium is formed during Quarternary period.

CHAPTER 5

CUT-SLOPE STABILITY ANALYSIS OF KAMPUNG JABIR

5.1 Introduction

The cut slope failure occurs when the downward movements of material due to the gravity and the shear stresses exceed the shear strength. From the field observation, sampling and laboratory test, the data and information are collected. Further analysis is carried out and recorded for cut slope stability analysis. For the soil properties, there are some laboratory test that had been used such as sedimentation test, Atterberg Limit test and Vane Shear test. The Slope/W software was used to analyse the cut slope stability.

5.2 Cut slope failure inventory

To conduct cut slope failure inventory or analysis, there are few parameters that should be noticed such as size of cut slope failure, mode of cut slope, factor that influence cut slope failure and type of material. There are two types of factor that make the cut slope failure which is static and dynamic.

For static factor that are categorized as earth material features such as porosity or density, slope geometry, mechanical characteristic such as material strength and others. Meanwhile, for dynamic factor can be classified as groundwater, surface water, natural characteristic of earth material, discontinuity, weathering grade, disturb from other sides and others.

Size of cut slope failure can be identified by calculate the height, width and depth of the cut slope failure. Size of cut slope failure is written in the unit m^3. Size of cut slope failure can be grouped into four scales which is small, medium, large and very large (Table 5.1). The classification scale of slope failure are based on the estimated value of the volume that failed. Common cut slope failure are planar, wedges, circular and toppling. There are two types of material either soil or rock can be found at the slope failure.

Table 5.1 Classification scale of slope failure based on the estimated value of the volume that failed (Tajul Anuar Jamaluddin,1990)

Slope failure scale	Volume of material that fail (m^3)
Small	<100
Medium	100-1000
Large	1000-5000
Very large	>5000

According to Figure 5.1, there are four locations of slope failure that occurred and had been observed at the study area. For location 1, the coordinate of slope failure is N 05° 31" 05.7', E 101° 53" 23'. The type of material is soil and the size of the slope failure is medium size. The mode of the slope failure is slump. The causes of slope failure at this location are heavy rainfall, groundwater condition and weathering. The sample of soil was collected at stable slope (1) and failure slope (2) that can be seen on Figure 5.2.

The location 2, the coordinate of slope failure is N 05° 31" 07.9', E 101° 53" 22.4'. The type of material is soil and the size of slope failure is small size. The mode of the slope failure is slump. The causes of slope failure are weathering grade, groundwater condition and rainfall. The sample of soil was collected at stable slope (3) and failure slope (4) that can be seen on Figure 5.3.

Location 3 have a coordinate N 05° 31" 18', E 101° 53" 21.3'. The type of material is soil and weathered shale. The size of slope failure is small size. The mode of the slope failure is slump. The causes of slope are weathering grade, groundwater condition and heavy rain. The sample of soil was collected at stable slope (5) and failure slope (6) that can be seen on Figure 5.4.

Location 4 have a coordinate N 05° 31" 15.0', E 101° 53" 22.3'. The type of material is soil. The size of slope failure is small. The mode of the slope failure is slump. The causes of slope failure are groundwater condition, rainfall and weathering grade. The sample of soil was collected at stable slope (7) and failure slope (8) that can be seen on Figure 5.5. The summary of the cut-slope failure analysis are shown in Table 5.2. The Gabion wall is shown in Figure 5.6 and the stone pitching is shown in Figure 5.7.

Table 5.2 The summary of the cut-slope failure analysis

Location	**1**	**2**	**3**	**4**
Coordinate	N 05° 31" 05.7' E 101° 53" 23'	N 05° 31" 07.9' E 101° 53" 22.4'	N 05° 31" 18' E 101° 53" 21.3'	N 05° 31" 15.0' E 101° 53" 22.3'
Geometry slope	Width : 52m Height : 7.5 m Angle of slope : 42°	Width : 12.8m Height : 3.12 m Angle of slope : 34°	Width : 15.5m Height : 5 m Angle of slope : 44°	Width : 7.2 m Height : 6.2 m Angle of slope : 32°
Type of slope failure	Slump	Slump	Slump	Slump
Size of slope failure	Medium	Small	Small	Small
Failure geometry	Width : 49.5 m Height : 5 m Depth : 2.3 m	Width : 10 m Height : 2.8 m Depth : 1 m	Width :14 m Height : 3 m Depth : 2 m	Width : 5.9 m Height : 5.2 m Depth : 2.3 m
Type of material	Soil	Soil	Soil and weathered shale	Soil
Slope protection	Stone pitching and Gabion wall	none	Gabion wall	none

SLOPE STABILITY SURVEY MAP OF KAMPUNG JABIR, JELI

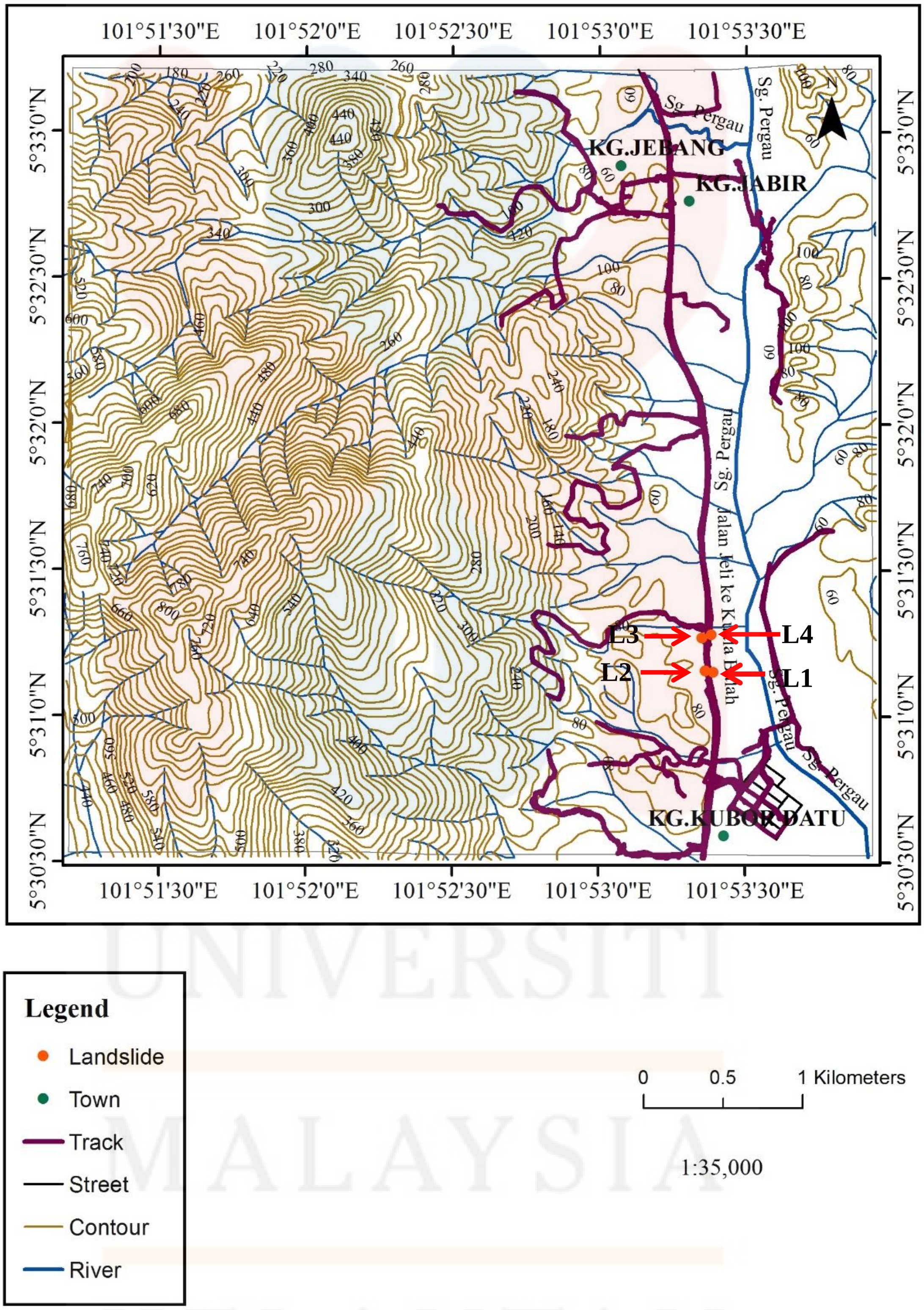

Figure 5.1 Locations of slope failure

Figure 5.2 Slope failure at location 1

Figure 5.3 Slope failure at location 2

Figure 5.4 Slope failure at location 3

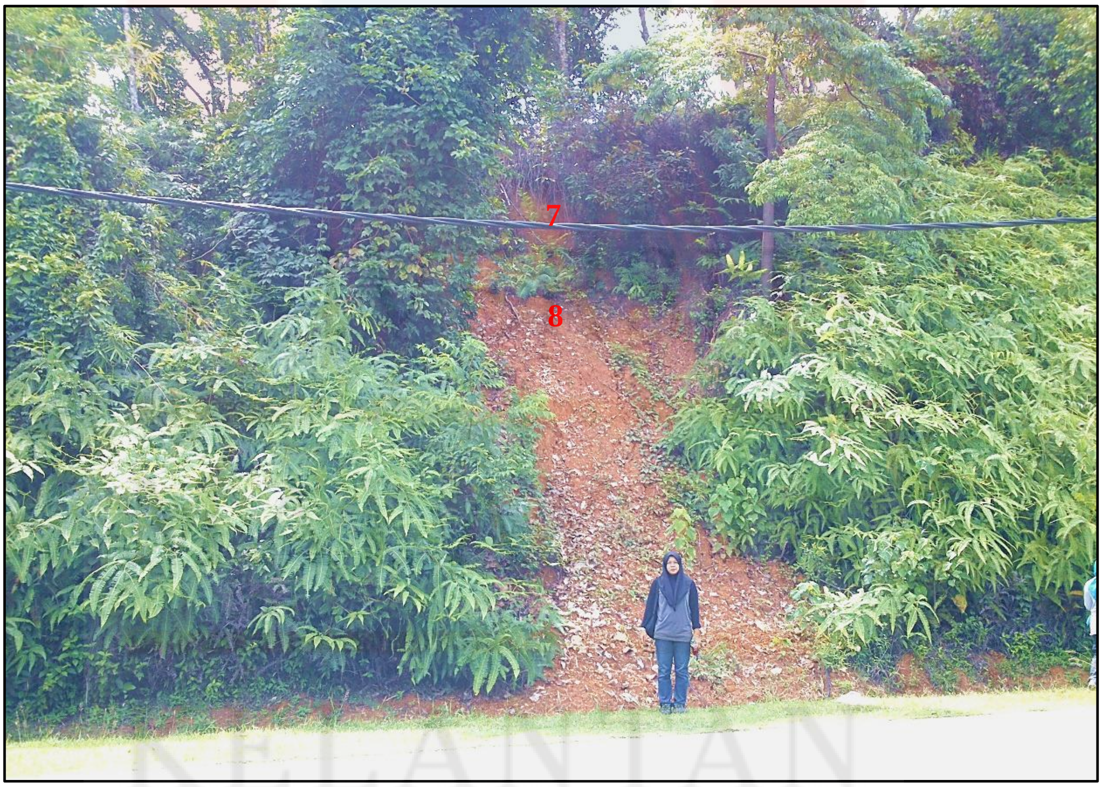

Figure 5.5 Slope failure at location 4

Figure 5.6 Gabion wall at location 3

Figure 5.7 Stone pitching at location 1

5.3 Slope/W Analysis

The Slope/W analysis has been done on four cut slope at study area. The Slope/W analysis has been done to determine the stability of the cut slopes based on the Factor of Safety (FOS) value.

For location 1, the height of cut slope is 8 m. The type of material is soil with the unit weight 15 kN/m^3. The cohesion of soil is 12 kPa and phi is 0°. The Slope/W gave the result in terms of Factor of Safety (FOS) value which is 0.709 (Figure 5.8). The value represent the slope is unstable. The slope will be sliding downward again.

For location 2, the height of cut slope is 4 m. The type of material is soil with the unit weight 18 kN/m^3. The cohesion of soil is 15 kPa and phi is 0°. The Slope/W gave the result in terms of Factor of Safety (FOS) value which is 1.723 (Figure 5.9). The value represent the slope is stable.

For location 3, the height of cut slope is 4 m. The type of material is soil with the unit weight 14 kN/m^3. The cohesion of soil is 10 kPa and phi is 0°. The Slope/W gave the result in terms of Factor of Safety (FOS) value which is 1.931 (Figure 5.10). The value represent the slope is stable.

For location 4, the height of cut slope is 6 m. The type of material is soil with the unit weight 14 kN/m^3. The cohesion of soil is 10 kPa and phi is 0°. The Slope/W gave the result in terms of Factor of Safety (FOS) value which is 0.946 (Figure 5.11). The value represent the slope is unstable. The slope will be sliding downward again. The summary of Slope/W can be seen on Table 5.3.

Table 5.3 The summary of Slope/W

Location	**1**	**2**	**3**	**4**
Height (m)	8	4	4	6
Type of material	Soil	Soil	Soil	Soil
Unit weight (kN/m^3)	15	18	14	14
Cohesion (kPa)	12	15	10	10
Phi (°)	0	0	0	0
FOS	0.709	1.723	1.931	0.946
Condition of slope	Unstable	Stable	Stable	Unstable

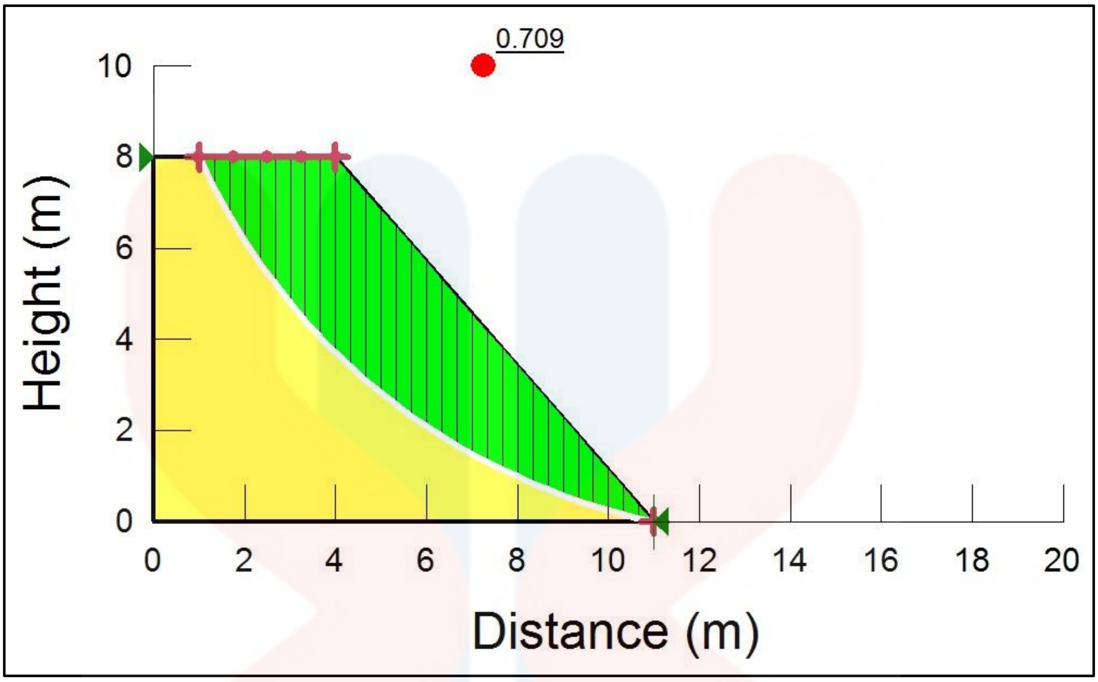

Figure 5.8 Slope/W analysis at location 1

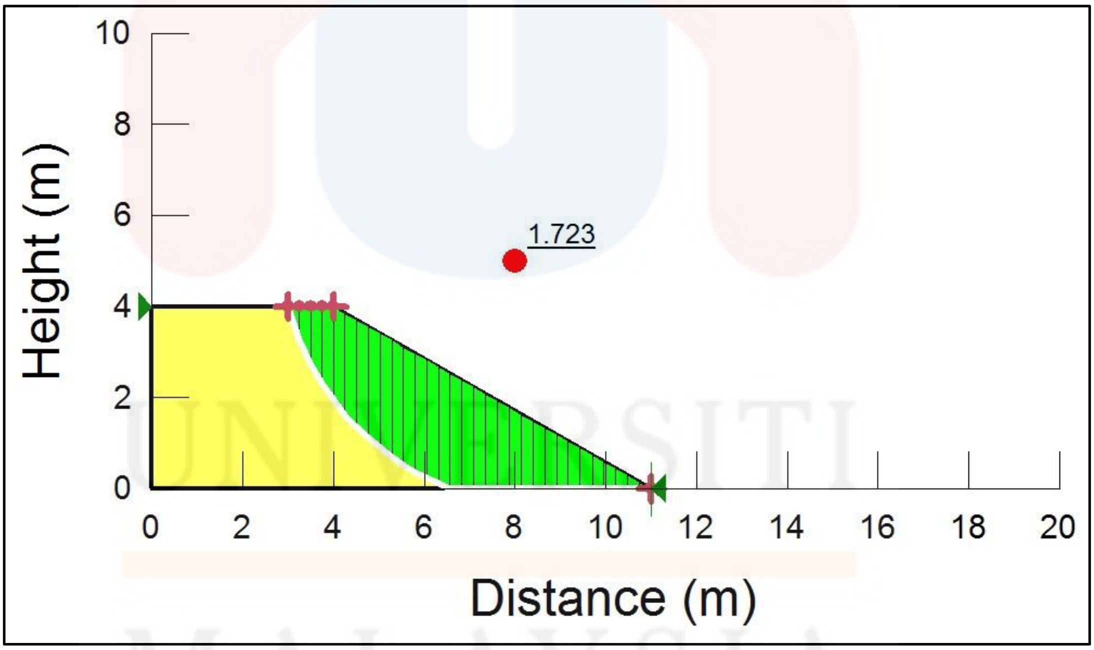

Figure 5.9 Slope/W analysis at location 2

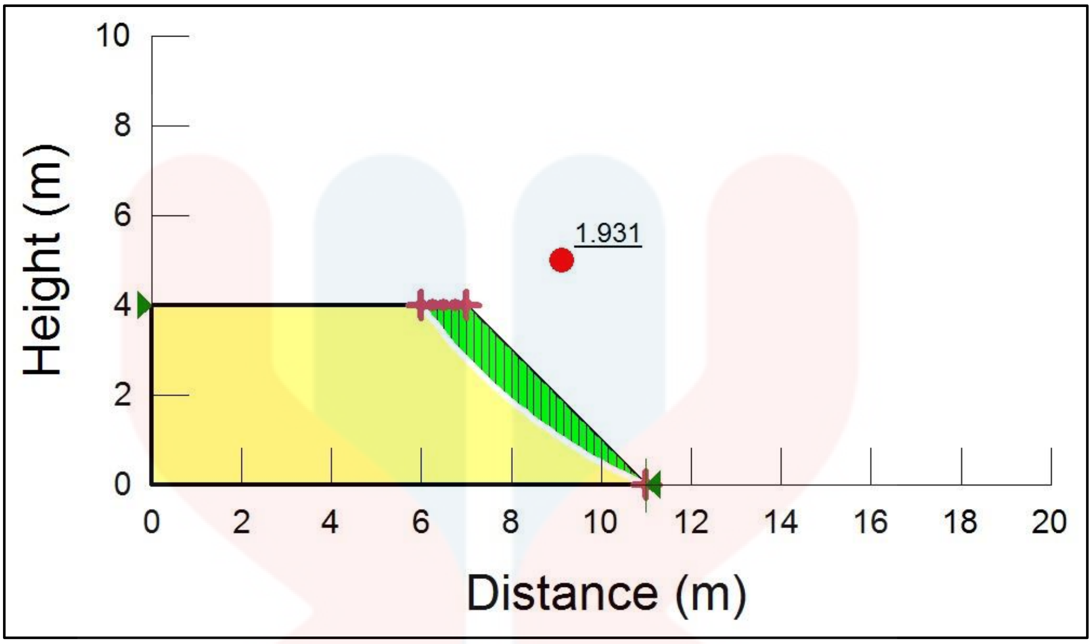

Figure 5.10 Slope/W analysis at location 3

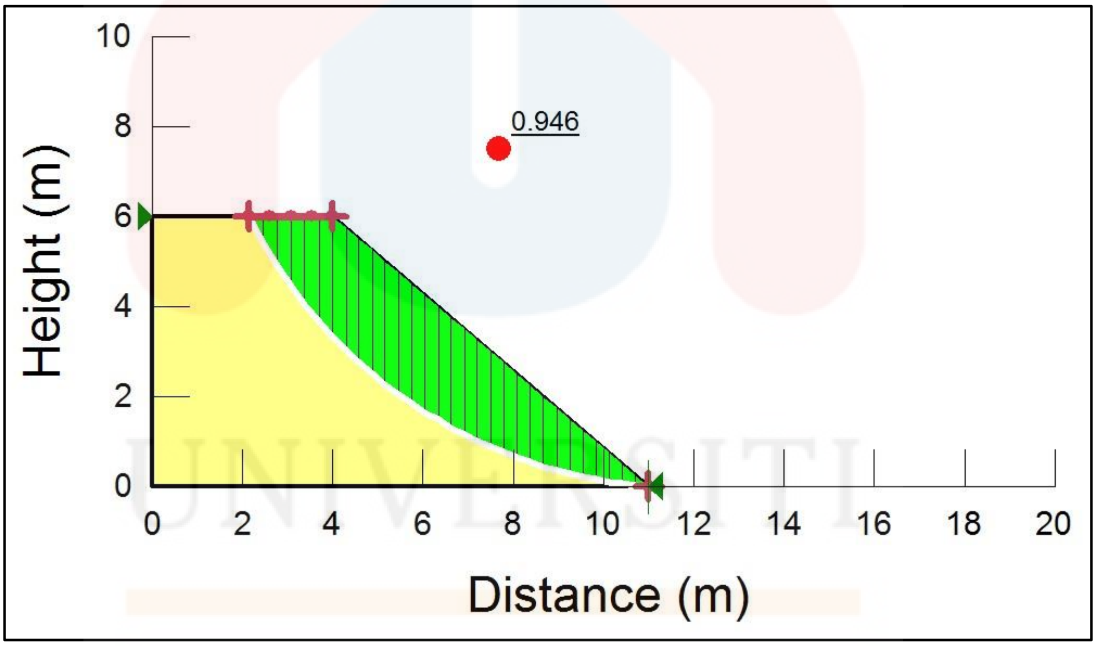

Figure 5.11 Slope/W analysis at location 4

5.4 Laboratory Testing

The eight samples of soil was undergone three types of test which are sedimentation test, Atterberg limit test that consist of plastic limit and liquid limit test and Vane Shear test. The significant of grain size analysis by sedimentation test is to determine the percentage of different grain size within the soil. Next, the Atterberg limit test are done to identify the limit of water content used and the behavior of soil can be determined. Then, the Vane Shear test is used to determine the shear strength of soil.

5.4.1 Sedimentation test

Sedimentation test is done for grain size analysis using the pipette method. The particle size of eight soil samples from four location is classified and shown in Table 5.4. Sedimentation test only can be used for fine-grained such as fine sand, silt, and clay. The graph the percentage passing against particle size of all samples have been shown in Figure 5.12. The result show that, the sample 1, 2, 4, 5, 6, 7 and 8 have more silt. The sample 3 have more clay.

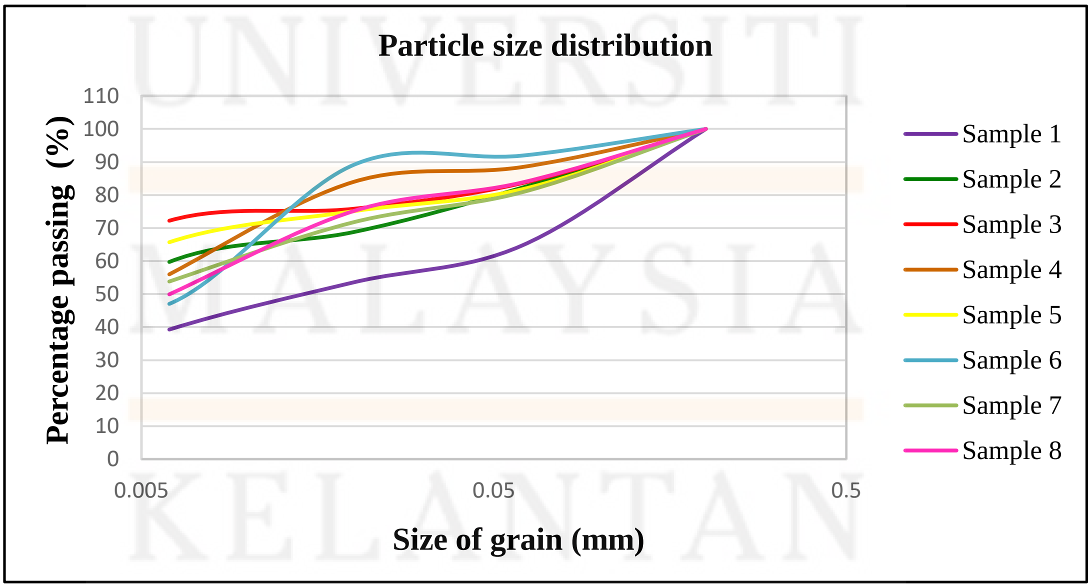

Figure 5.12 The graph of the percentage passing against particle size of all samples

Table 5.4 Grain size of soil sample using pipette test

Sample no.	Size of grain (mm)	Percentage (%)	Cumulative (%)
1	0.002 (clay)	20.37	20.37
	0.006 (fine silt)	18.89	39.26
	0.02 (medium silt)	14.29	53.55
	0.06 (coarse silt)	11.11	64.66
	0.2 (sand)	35.34	100.0
2	0.002 (clay)	26.67	26.67
	0.006 (fine silt)	33.06	59.73
	0.02 (medium silt)	9.05	68.78
	0.06 (coarse silt)	13.41	82.19
	0.2 (sand)	17.81	100.0
3	0.002 (clay)	45.13	45.13
	0.006 (fine silt)	27.08	72.21
	0.02 (medium silt)	3.61	75.82
	0.06 (coarse silt)	7.75	83.57
	0.2 (sand)	16.43	100.0
4	0.002 (clay)	27.99	27.99
	0.006 (fine silt)	27.99	55.98
	0.02 (medium silt)	27.99	83.97
	0.06 (coarse silt)	4.48	88.45
	0.2 (sand)	11.55	100.0
5	0.002 (clay)	40.1	40.10
	0.006 (fine silt)	25.6	65.70
	0.02 (medium silt)	9.4	75.10
	0.06 (coarse silt)	6.6	81.70
	0.2 (sand)	18.3	100.0
6	0.002 (clay)	44.88	44.88
	0.006 (fine silt)	2.15	47.03
	0.02 (medium silt)	42.09	89.12
	0.06 (coarse silt)	2.80	91.92
	0.2 (sand)	8.08	100.0
7	0.002 (clay)	35.87	35.87
	0.006 (fine silt)	17.94	53.81
	0.02 (medium silt)	17.94	71.75
	0.06 (coarse silt)	9.06	80.81
	0.2 (sand)	19.19	100.0
8	0.002 (clay)	26.62	26.62
	0.006 (fine silt)	23.30	49.92
	0.02 (medium silt)	25.22	75.14
	0.06 (coarse silt)	8.62	83.76
	0.2 (sand)	16.24	100.0

5.4.2 Atterberg Limit Test

Through Atterberg limit test, the plasticity index can be identified. Plasticity index is a way to determine the plasticity of soil. The plasticity index is a range of moisture content in soil that stay in a plastic state while passing from a semisolid state to liquid state. Plasticity index can be calculated by subtract the Liquid Limit and Plastic Limit of a soil.

The Table 5.5 shows the result of samples that had been classified to slightly plasticity, low plasticity, medium plasticity and high plasticity. There are two samples which are sample 1 and sample 3 that can be categorized with slightly plasticity classification with the PI range values is 1 to 5. Besides, there are three samples which are sample 2, 4 and 7 under low plasticity classification which has 5 to 10 of PI range. Next, two samples which are sample 5 and 8 are categorized as the medium plasticity in the range of 10 to 20 of PI range. Then, for high plasticity, there is only sample 6 is categorized. The graph of moisture content against the number of bumps is shown in Appandixes.

Hence, the higher the plastic index means the higher moisture content in the soil. The soil will act as plastic state as the moisture content is higher. When the water content is higher in soil, the soil become weaker and causes the slope to fail. Yet, the sample 6 with the high plasticity index tend to have high water content. That means the slope is not stable.

Table 5.5 Result of Atterberg Limit Test

Sample no.	Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI) %	Plasticity classification
1	34.79	32.98	1.81	Slightly plastic
2	29.94	24.60	5.34	Low plasticity
3	28.52	26.91	1.61	Slightly plastic
4	40.73	32.60	8.13	Low plasticity
5	40.89	22.66	18.23	Medium plasticity
6	42.10	21.77	20.33	High plasticity
7	41.23	34.69	6.54	Low plasticity
8	40.20	25.80	14.40	Medium plasticity

5.4.3 Vane Shear Test

The Vane Shear Test was done to determine the shear strength of soil. Using the spring calibration on Table 5.6, the graph Torque against the degree was plotted in Figure 5.13. The Torque value was determined by using gradient formula from the graph. The spring had a diameter 2.5 cm and the height is 5 cm. Therefore, the shear strength of soil was calculated in Table 5.7. For stable slopes show the higher shear strength of soil value than failure slopes.

Table 5.6 Torque and Degree values

Torque (kg cm)	Degree (°)
0.25	14
0.50	28
1.00	56
1.50	84
2.00	112
2.50	140
3.00	168

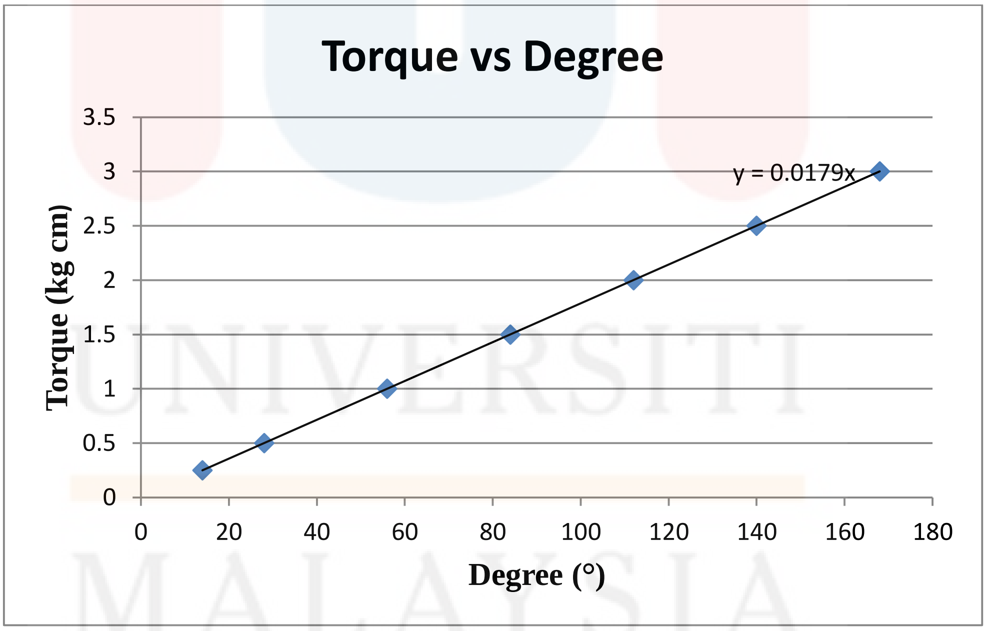

Figure 5.13 The graph of Torque against the Degree

Table 5.7 The shear strength of the samples

Sample no.	Initial angle (°)	Final angle (°)	Angle of vanes (°)	Torque (kg cm)	Shear strength (kg/cm^2)
1	162	179	17	0.30	$5.24x10^{-3}$
2	165	179	14	0.25	$4.36x10^{-3}$
3	165	181	16	0.29	$5.06x10^{-3}$
4	165	180	15	0.24	$4.19x10^{-3}$
5	160	187	27	0.48	$8.38x10^{-3}$
6	175	188	13	0.23	$4.02x10^{-3}$
7	160	180	20	0.36	$6.28x10^{-3}$
8	165	184	19	0.34	$5.94x10^{-3}$

5.5 Discussion

For cut slope at Location 1, the size of the slope failure is medium size. The type of material is soil that consist of silt with the unit weight 15 kN/m^3. The cohesion of soil is 12 kPa and phi is 0°. The Slope/W gave the result in terms of FOS value which is 0.709. The value represent the slope is unstable. The slope will be sliding downward. However, the sample 1 has a slightly plasticity and the sample 2 has a low plasticity. The low plasticity make the slope unstable. The shear strength of soil of sample 1 is $5.24x10^{-3}$ kg/cm^2 and the sample 2 is $4.36x10^{-3}$ kg/cm^2.

For location 2, the size of the slope failure is small size. The type of material is soil that consist of clay at stable slope and silt at failure slope. The unit weight of soil is 18 kN/m^3. The cohesion of soil is 15 kPa and phi is 0°. The Slope/W gave the result in terms of FOS value which is 1.723. The value represent the slope is stable. Yet, the sample 3 has a slightly plasticity and the sample 4 has a low plasticity. The low plasticity make the slope unstable. The shear strength of soil of sample 3 is $5.06x10^{-3}$ kg/cm^2 and the sample 4 is $4.19x10^{-3}$ kg/cm^2.

Location 3 have a small size of the slope failure. The type of material is weathered shale and soil that consist of silt. The unit weight of soil is 14 kN/m^3. The cohesion of soil is 10 kPa and phi is 0°. The Slope/W gave the result in terms of FOS value which is 1.931. The value represent the slope is stable. Nevertheless, the sample 5 has a medium plasticity and the sample 6 has a high plasticity. The high plasticity make the slope unstable. The shear strength of soil of sample 5 is $8.38x10^{-3}$ kg/cm^2 and the sample 6 is $4.02x10^{-3}$ kg/cm^2.

For location 4, the size of the slope failure is small size. The type of material is soil that consist of silt and the unit weight is 14 kN/m^3. The cohesion of soil is 10 kPa and phi is 0°. The Slope/W gave the result in terms of FOS value which is 0.946. The value represent the slope is unstable. The slope will be sliding downward. Then, the sample 7 has a low plasticity and the sample 8 has a medium plasticity. The medium plasticity make the slope unstable. The shear strength of soil of sample 7 is $6.28x10^{-3}$ kg/cm^2 and the sample 8 is $5.94x10^{-3}$ kg/cm^2.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

As a conclusion, the study area can be classified as undulating to mountainous topographic unit that dominated with granite which had been found in the study area. The discontinuities of rock that found in study area was joint and the sedimentary structure such as bedding also was found.

The determination of cut slope stability in study area had been achieved by Slope/W software. From the software, the FOS values that below the value of 1 was unstable. The location 2 and location 3 have a stable slope. The location 1 and location 4 have an unstable slope. It can be conclude that three slope failures have small in size where the size in range is below 100 m^3 and one slope failure is medium size in the range above 100 m^3. Three factors that contribute to this failure are groundwater condition, heavy rain and weathering activities.

The determining of physical soil properties also had been achieved by lab testing that composed of sedimentation test, Atterberg limit test and Vane Shear test. The results shown that most of the slope failures happened because of the high content of silt and clay in the earth material. In pipette analysis test, the evidence of high content of silt and clay in soil can be seen by the long time needed by soil particle to settle down at the bottom of the measuring cylinder. Thus, Atterberg limits tests results shown that soils at cut slope failure were slightly plasticity, low plasticity, medium plasticity and high plasticity. Vane shear test shown their own shear strength value of soil.

6.2 Suggestion

After the slope stability analysis using Slope/W of Kampung Jabir, Jeli, Kelantan had been done, it can be suggested the slope stabilization need to be done immediately for cut slope failures. So the safety for the people who used the road and live there will increase. The slope mitigation can be done by increasing the resisting forces and decreasing the driving force.

There are some laboratory testing can be done for this study such as triaxial shear test. A triaxial shear test is a common method to measure the strength properties of many deformable solids, especially soil (sand and clay) and other granular materials or powders. The triaxial shear test give the result more accurate than the Vane Shear test.

The slope stability analysis using Slope/W is suggested because it is simple software that give the Factor of Safety value that indicate the stability of slope. Besides, this software is free and can download it from Google. This software save the time and money.

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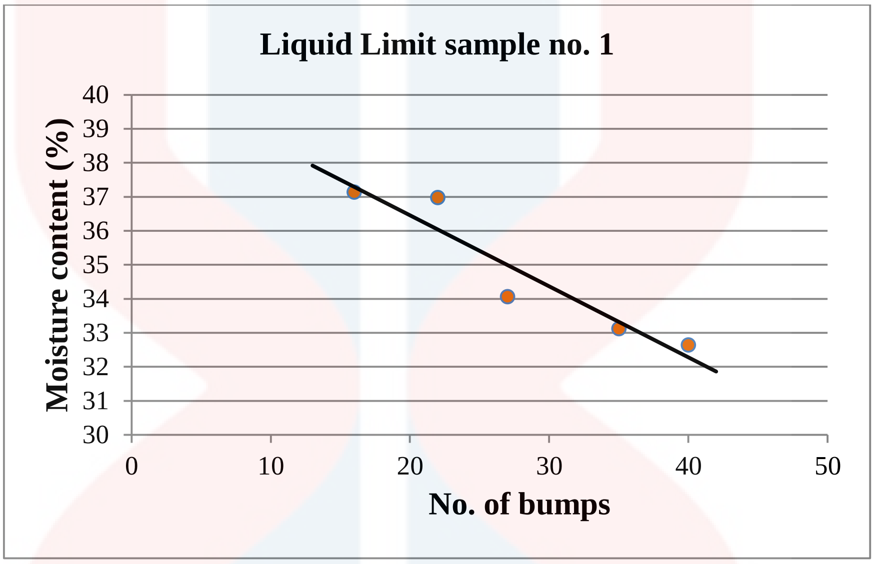
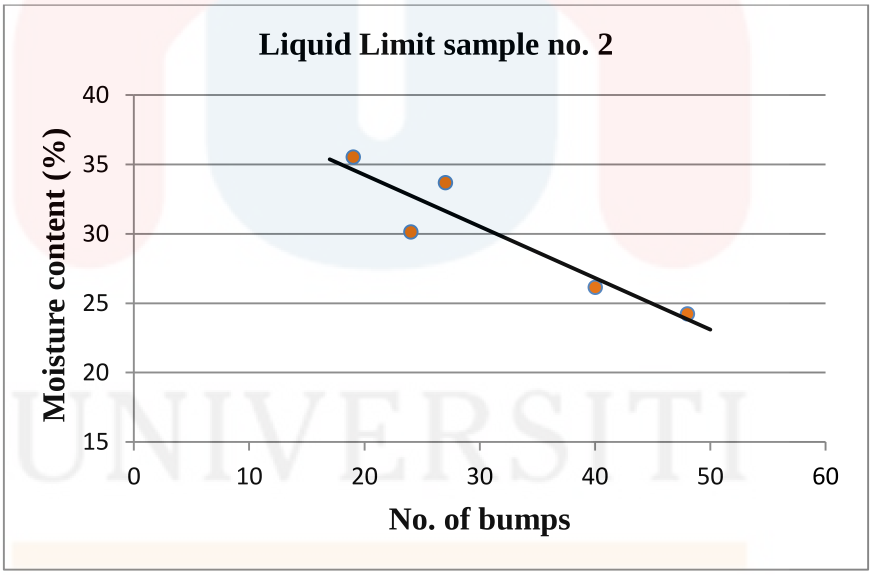
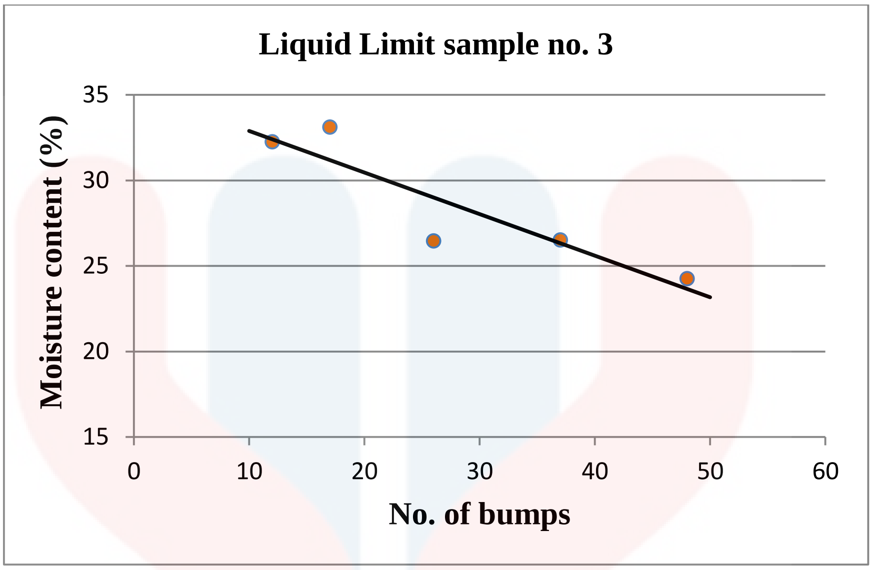
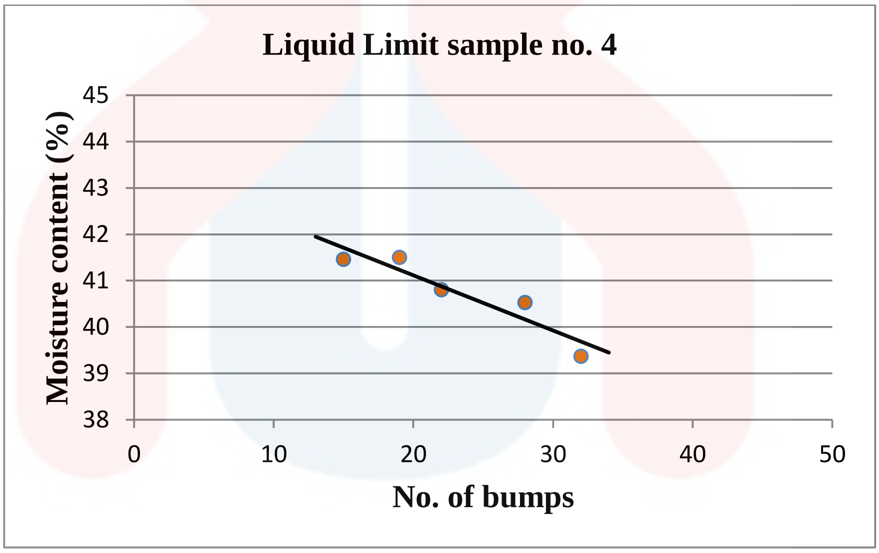
APPANDIX A

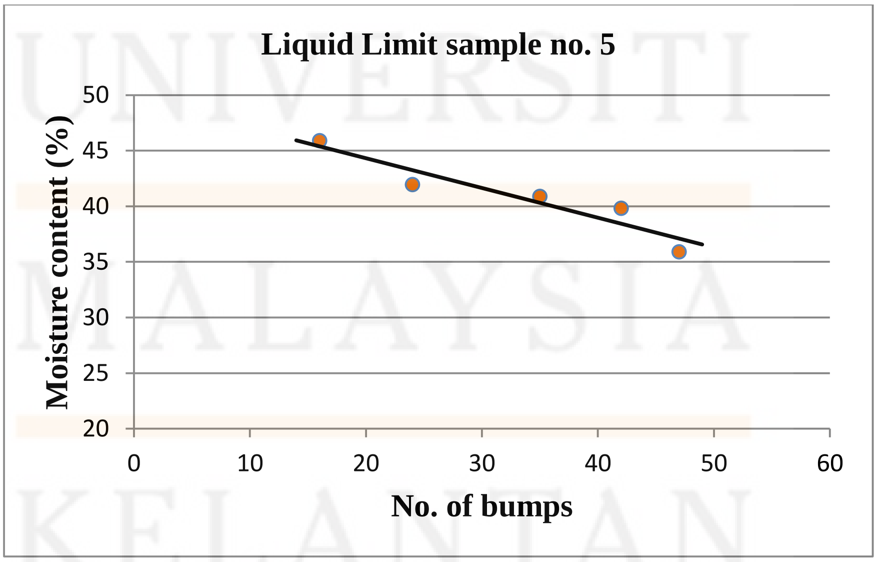
Liquid Limit






Liquid Limit sample no. 3
35
30
25
20
15
0
10
20
30
40
50
60
Moisture content (%)
No. of bumps


Liquid Limit sample no. 4
45
44
43
42
41
40
39
38
0
10
20
30
40
50
Moisture content (%)
No. of bumps


Liquid Limit sample no. 5
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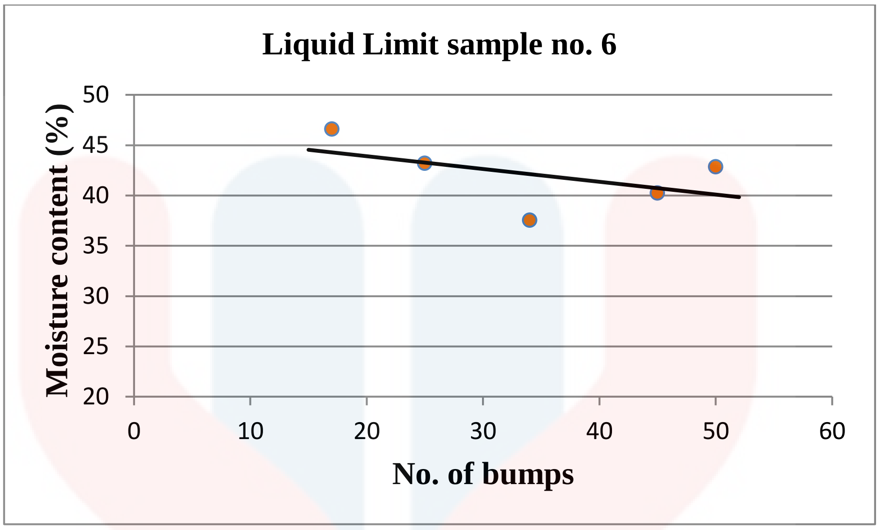
45
40
35
30
25
20
0
10
20
30
40
50
60
Moisture content (%)
No. of bumps


Liquid Limit sample no. 6
Moisture content (%)
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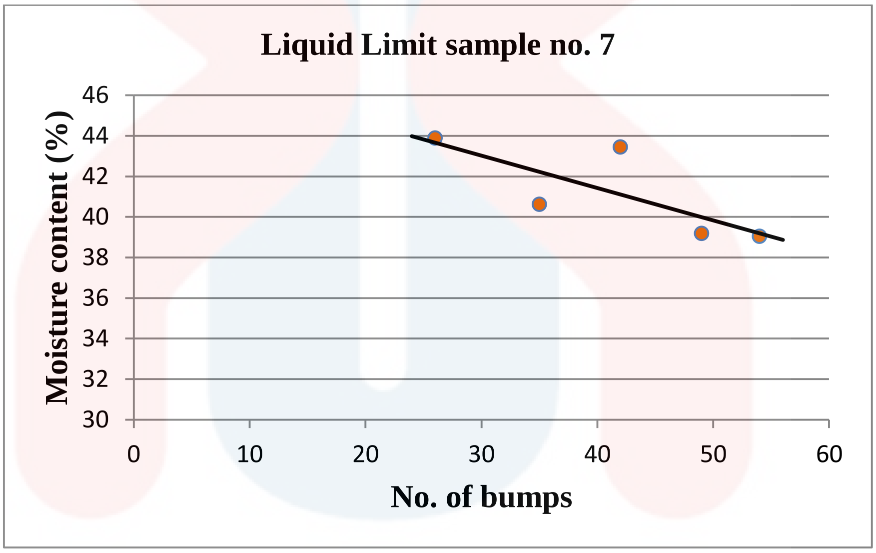
45
40
35
30
25
20
0
10
20
30
40
50
60
No. of bumps


Liquid Limit sample no. 7
Moisture content (%)
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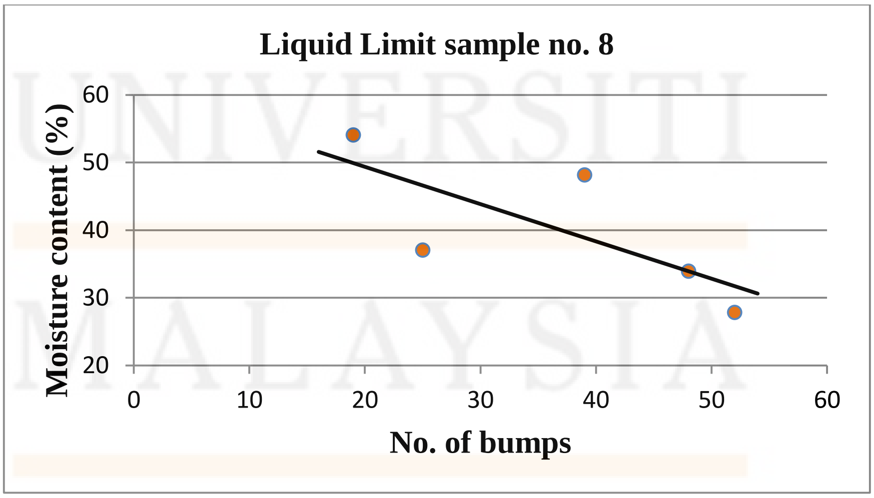
44
42
40
38
36
34
32
30
0
10
20
30
40
50
60
No. of bumps


Liquid Limit sample no. 8
Moisture content (%)
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40
30
20
0
10
20
30
40
50
60
No. of bumps