GEOLOGY AND ASSESSMENT OF SOIL STRENGTH USING MACKINTOSH PROBE IN BANDAR JELI, KELANTAN

by

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A thesis submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honours

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DECLARATION

I declare that this thesis entitled "Geology and Assessment of Soil Strength using Mackintosh Probe in Bandar 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 :

APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in our opinion, this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honors"

Signature :
Name of Supervisor I :
Date :

Signature :
Name of Supervisor II :
Date :

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GEOLOGY AND ASSESSMENT OF SOIL STRENGTH USING MACKINTOSH PROBE IN BANDAR JELI, KELANTAN

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Abstract: This scientific research was conducted about geology and the soil strength to withstand the construction of building in study area which located at Bandar Jeli, Kelantan. The objectives of this research are to produce the geological map of study area in scale of 1:25 000 and to assess the soil strength by using Mackintosh probe. The assessment was made by recording the data of the number of the blow for every 30 cm penetration. Geological mapping was conducted in order to record geological data such as geomorphology, lithostratigraphy, structural geology and historical geology. Hand specimens of rock were collected for laboratory work which is petrography analysis in order to identify the type of the rock. Meanwhile, geological map shows the distribution of the rocks at study area which is around Bandar Jeli. The geology of the study area was identified as four types of lithology exist which are alluvium, granite, metasediment (phyllite) and gneiss. Besides that, geological map shows the estimation of the cross section of subsurface at study area. The production of geological map was by using ArcGIS version 10.2. Geomorphologically, study area have three types of landform terrain which are mountainous areas, hilly areas and plain areas. Drainage pattern was observed from base map and fieldwork, and classified as dendritic drainage pattern. Mackintosh probe test was conducted in order to assess the soil strength instead of other probes due to the only available in-situ penetration probe in University Malaysia Kelantan Jeli Campus. The raw data from this penetration test is the number of blows (M) against the depth in meter. Then, there raw data calculated by equation of $S_u = 18J^{0.3}$ to estimate undrained shear strength. These data analysed by using Microsoft Excel 2013 to construct the graph of bearing capacity against depth and undrained shear strength of the soils against depth.

Keywords: Engineering geology, soil strength, Mackintosh probe, undrained shear strength, Jeli district

GEOLOGI DAN PENILAIAN KEKUATAN TANAH MENGGUNAKAN PROBE MACKINTOSH DI BANDAR JELI, KELANTAN

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Abstrak: Penyelidikan saintifik ini dijalankan mengenai geologi dan kekuatan tanah untuk menahan pembinaan bangunan di kawasan kajian yang terletak di Bandar Jeli, Kelantan. Objektif penyelidikan ini adalah untuk menghasilkan peta geologi kawasan kajian dalam skala 1:25 000 dan untuk menilai kekuatan tanah dengan menggunakan probe Mackintosh. Penilaian dibuat dengan merekodkan data bilangan ketukan untuk penembusan setiap 30 cm. Pemetaan geologi dilakukan untuk merekod data geologi seperti geomorfologi, litostratigrafi, geologi struktur dan geologi sejarah. Spesimen batu sebesar sekepal tangan dikumpulkan untuk menjalankan kerja makmal iaitu analisis petrografi untuk mengenal pasti jenis batuan. Sementara itu, peta geologi menunjukkan jenis batuan di kawasan kajian yang terletak di sekitar Bandar Jeli. Geologi kawasan kajian telah dikenal pasti sebagai empat jenis litologi yang wujud iaitu aluvium, granit, metasediment (phyllite) dan gneiss. Di samping itu, peta geologi menunjukkan anggaran bahagian rentas bawah permukaan di kawasan kajian. Penghasila peta geologi adalah dengan menggunakan ArcGIS versi 10.2. Secara geomorfologi, kawasan kajian mempunyai tiga jenis permukaan bumi iaitu kawasan pergunungan, kawasan berbukit dan kawasan tanah mendatar. Corak saliran sungai diperhatikan dari peta asas dan kerja lapangan, dan diklasifikasikan sebagai corak saliran dendritik. Ujian probe Mackintosh dijalankan untuk menilai kekuatan tanah dan bukannya probe lain kerana hanya satu probe penembusan yang terdapat di Universiti Malaysia Kelantan Kampus Jeli. Data awal dari ujian penembusan ini adalah bilangan pukulan (M) terhadap kedalaman (meter). Kemudian, data ini dikira dengan persamaan $S_u = 18J^{0.3}$ untuk menganggarkan kekuatan ricih tanah. Data-data ini dianalisis dengan menggunakan Microsoft Excel 2013 untuk membina graf kapasiti bantalan terhadap melawan kedalaman dan kekuatan ricih tanah melawan kedalaman.

Kata kunci: Geologi kejuruteraan, kekuatan tanah, penyelidikan Mackintosh, kekuatan ricih yang tidak dapat dirasai, daerah Jeli

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LIST OF ABBREVIATIONS

km	kilometres
mm	millimetre
JKR	Jabatan Kerja Raya
JMG	Jabatan Mineral & Geosains
MP	Mackintosh probe
UCT	Unconfined Compression Test
UU	Unconsolidated Undrained Test
SPT	Standard Penetration Test
GPS	Global Position System
SI	Soil Investigation
PPL	Plane Polarized Light
XPL	Cross Polarized Light

LIST OF SYMBOLS

^{0}	Degree
%	Percentage
>	Greater than
<	Less than
N	North
E	East
W	West
S	South
N-S	North – South
E-W	East – West
б	Compression force
~	Approximately
S_u	Undrained shear strength
M	No. of blows for Mackintosh probe
N	No. of blows for Standard Penetration Test
J	No. of blows for JKR probe
Cv	The coefficient of variation

CHAPTER 1

INTRODUCTION

1.1 General Background

This research is conducted in order to fulfill the requirement of bachelor of the degree of applied science (Geoscience) of Universiti Malaysia Kelantan. The study area is at Bandar Jeli which is located in the western part of Kelantan, Malaysia. This research is focusing on the geotechnical or engineering geology interest which is to find out the assessment of soil strength using Mackintosh Probe in Bandar Jeli. Besides that, the geological aspects will be discussed in this research such as regional geology and tectonic setting, stratigraphy, structural geology and geomorphology.

1.2 Study Area

1.2.1 Location

The study area of the research is located at Bandar Jeli, Kelantan Darul Naim. Jeli is one among eleven of the district in Kelantan, Darul Naim. The constituency parliament of Jeli is located in the Western part of Kelantan. Jeli district is bordered by the state of Perak to the West, Thailand to the North, Kuala Krai district to the Southeast and Tanah Merah district to the Northeast. **Figure 2.1** shows the geological map of Kelantan.

Previously, Jeli district was originally a sub-district formed from parts of the Tanah Merah and Kuala Krai district. It was later, fully elevated to a district on 1 January 1986. Rubber tapping and other forms of plantations is the main profession for the first generation of the residents of Jeli for a living. Fortunately, due to the proper education system and dedicated teachers that had been sent to this remote area, the profession of the current generation improved much better. In the first place, the coordinate of the study area which is Bandar Jeli, Kelantan, is 5° 42’ 2.52” N in longitude and 101° 50’ 35.52” E in latitude. The study area for this research will cover the area of 25km^2 which cover 5km in longitude and 5km in latitude. **Figure 1.1** shows the base map of the study area. Based on the base map provided in **Figure 1.1**, at the Southwest of the study area is located the main town of Jeli.

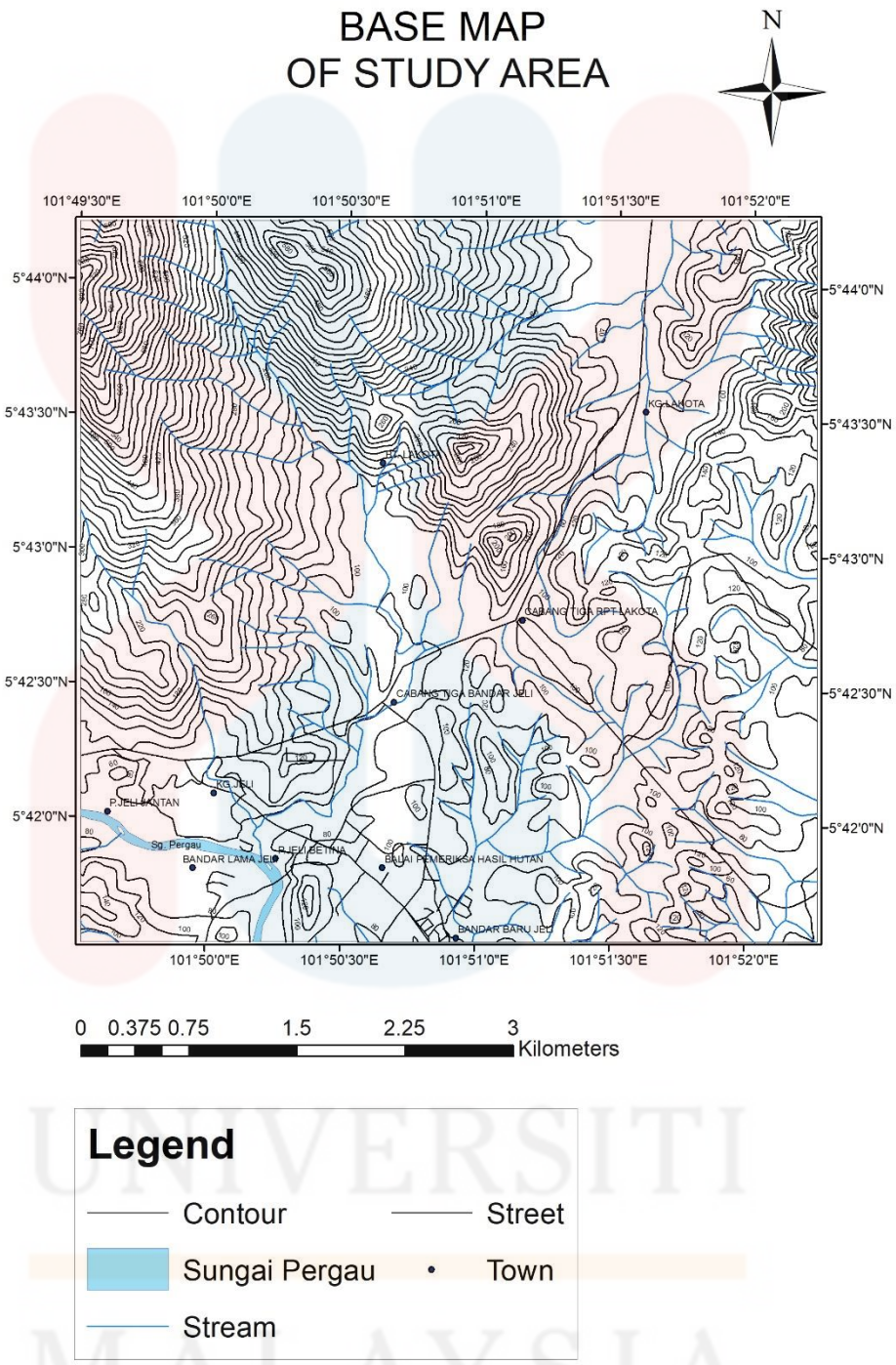


Figure 1.1: Shows the base map of the study area.

1.2.2 Accessibility

The accessibility to Bandar Jeli is mainly by the highway that connecting the district of Jeli with Gerik, Perak and all the way to Kedah or Penang, to the West; and to the East it continues to Tanah Merah and all the way to Pasir Puteh. The highway is famously known as East-West Highway. Therefore, Jeli is known as the 'western gateway into the East Coast for tourists or visitors from Perlis, Kedah and Penang.

Besides that, the junction of the Highway 66 and East-West Highway is located near Bandar Jeli. The highway which leads to Kuala Balah in the Southern part of district of Jeli is known as Highway 66. This highway leads to the shortcut to the railway town of Dabong and all the way to Kuala Krai. The entrances to the Jeli are divided into three which are; from the East through Tanah Merah or Pasir Puteh, from the West through Gerik, and Mempelam or Jelawang or Kuala Krai from the South.

1.2.3 Demography

According to the record in 2010, the population of the people in Jeli overall is about 39445 people. Instead, the report from Socio-Economic Profile of State in 2001 issued by the State Economic Planning Unit; the report shows the population of people in Jeli during 2000 is estimated at 36512 people which is 2.78% of the total population of the Kelantan state. The latest report from the State Department of Statistics showed the population of residents in Jeli rise up to 42872. This sum up of 21764 of men and 21108 of women. The breakdown of the population in Jeli by region are shown in **Table 1.1**.

Table 1.1: The breakdown of the population by region

District	Male	Female	Total (Overall)
Batu Melintang	4,826	4,864	9,690
Jeli	10,820	10,300	21,120
Kuala Balah	6,118	5,944	12,062
Total	21,764	21,108	**42,872**

(Source: The Official Website of the Jeli Land and District Office, 2014)

Then, **Table 1.2** below shows the breakdown of the population in Jeli, Kelantan is based on the races.

Table 1.2: The breakdown of the population by race

Race	Total
Malay	42,400
Orang Asli	472
Chinese	-
India	-
Other	-
Total (Overall)	**42,872**

(Source: The Official Website of the Jeli Land and District Office, 2014)

1.2.4 Landuse

In the first place, based on report by the official website of the Jeli Land and District Office, about 82 percent of the terrain in Jeli is hilly, wild or pine forests and a lot of rail of river. This terrain is located between 40 meters to 800 meters above the level of the sea. Sungai Pergau, Lata Renyok and Sungai Galas are the main rivers which flowing Jeli district.

The study by Kadir (2015), the declining of the area of the forest, and rapid increasing in the area of the agriculture as well as increasing of urban development. Due to the rapid development and improvement of facilities, infrastructures and utilities in Jeli district, a drastic declining of the virgin forest area happened in order to exploit the area. The rubber plantations is the main attraction of the people during the 1950 in order to work and living. Commonly, many families in the Jeli district own a small plantation of 6 acres or 24,000 m^2 and up to 50 acres or 200,000 m^2 in size. According to the previous record, the highest declining of the forest area was in 2004 where the percentage of the declining of forest area is by 0.76 percent from the year before. The main cause to the declining of the forest area is due to the raging exploitation of the forest for the agricultural purpose, development and urbanisation. The area of forest reserve also depleting in size. In other words, the progressive development in Jeli district promotes to the sustainable usage of the area of the virgin forest and reserve forest forming co-existence land use category between agriculture, urbanisation and forest.

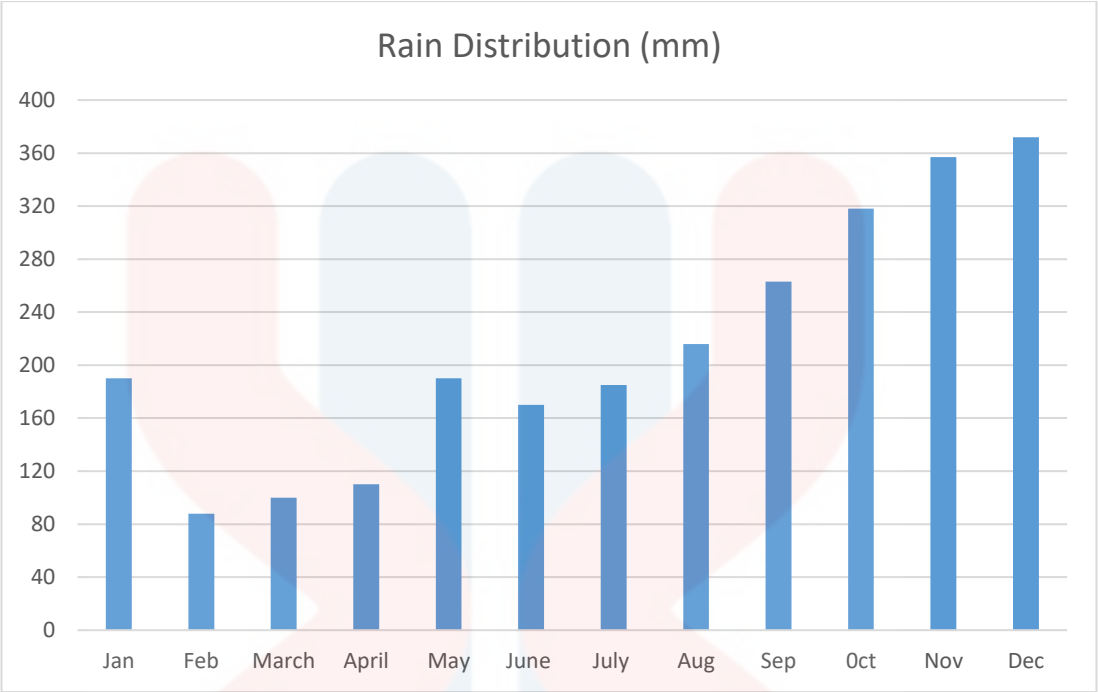
1.2.5 Climate

The condition of Malaysia is normally hot and damp throughout the years. Normally, the weather in the Malaysia is characterized by two main regimes of monsoon, which are the Northeast Monsoon stated from November to March, and the Southwest Monsoon stated from late May to September. The monsoon from the Northeast brings a heavy rainfall, to the East coast states of Peninsular Malaysia which mainly at Kelantan, Pahang, Terengganu and East Johor, particularly. However, Southwest Monsoon which is normally signifies relatively during drier weather

happens in the Western of Sarawak. There is the transition period between the monsoons which known as the inter-monsoon period.

The state of Kelantan has a climate of tropical, in which the temperatures are ranging from 21° Celsius to 32° Celsius and intermittent rain throughout the lunar year. Besides that, the East-coast monsoon from November to March is the wet season which develops in conjunction with the cold air coming from the direction of Siberia which produce a heavy rains. This phenomena often causes severe flood along the East coast states of Kelantan, Pahang, Terengganu and East Johor which located in Peninsular of Malaysia. Instead, during this season, most states experiencing monthly rainfall distribution minimum which typically 100mm to 150mm.

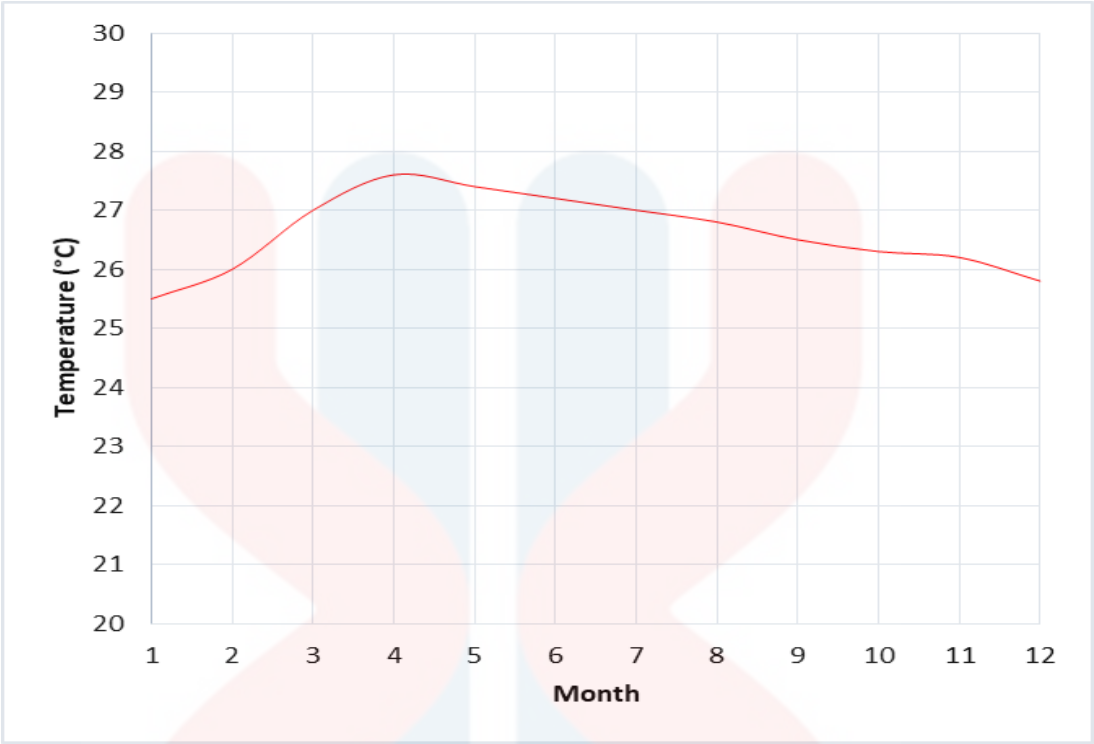
Meanwhile in the study area which is Jeli, the area has a tropical climate. Jeli has large amount of rainfall distribution throughout the lunar year due to the East-coast monsoon. Even during the dry climate, the rainfalls distribution recorded is higher compared to other areas. The average temperature in Jeli ranging from 26.7°C to 27.6°C. It is reported in about 2,562 mm of rainfalls distribution every year. Rainfall distribution of Jeli is shown in **Figure 1.2**:



(Source: Climate-Data.org, 2012)

Figure 1.2: Rainfall distribution graph in Jeli

According to the above graph, in February recorded the least amount of the rainfall distribution. The average in that month of February is 88 mm. Instead, during the December is the most amount of rainfall distribution recorded with the average of 372mm.



(Source: Climate-Data.org, 2012)

Figure 1.3: Temperature graph in Jeli

According to the Figure 1.3, the month of April experiencing the highest average temperature which is stated in about 27.6 °C. Meanwhile, the lowest average temperature was recorded throughout the lunar year is during the month of January which is in about 25.5 °C.

1.3 Problem Statement

Jeli is the developing district in Kelantan which the planning of the building is increasing due to the rising of the community. The perfect planning is necessary as to avoid any disaster happening to the construction. The initial planning like site investigation is needed for determining the suitability of the soil to construct anything such as roads, buildings, and even houses. So, this research is about to find out the strength of the soil at the study area for the foundation of construction.

1.4 Research Objectives

1. To produce the geological map of study area in scale of 1:25 000.
2. To assess the soil strength using Mackintosh Probe. The assessment is made by recording the data of the number of the blow of Mackintosh Probe test for every 30 cm penetration.

1.5 Scope of Study

This research is to study regarding the general geology of the study area which is at Jeli, Kelantan. The purposes are to produce the geological map of the study area and to assess the soil strength using Mackintosh Probe (MP). The researchers are focusing on the geological aspects which are regional geology and tectonic setting, stratigraphy, structural and geomorphology of the research area. The geological map will be made depending on this type of data collection. In addition, the research is emphasizing the uses of Mackintosh Probe (MP) to determine the strength of the variable soil properties in the study area. The data collected by the Mackintosh Probe test will be analyzed and interpreted in order to determine the soil strength assessment in Jeli.

1.6 Significance of Study

The significance of the study is to produce the geological map of study area which is an area of Jeli, Kelantan. The updated geological map can be used as a reference for other researchers and government such as Jabatan Mineral dan Geosains (JMG), FerroGeo Services and Jabatan Kerja Raya (JKR) and other companies.

In addition, this study will assess the soil strength around the study area. So, for the construction, they can refer this research to find if their building planning is suitable for that site.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of previous study or research regarding the topic or study area of the research. It introduces the framework for case study consists the main focus of the research. The geological review will emphasize the general geology at Peninsular Malaysia and more specific at Jeli district, Kelantan.

2.2 Regional Geology and Tectonic Setting

Firstly, the Peninsular of Malaysia can be divided into three belts which is according to the longitudinal belts, Western, Eastern and Central, which each of them have own distinctive characteristics and geological features. Tectonic activities occurred during the Palaeozoic era and Mesozoic era which affecting the land mass principally in the formation of the faulting and folding. Regional structures as well as the geological structures were observed from the faulting and folding in the aerial or satellite image. According to the Department of Minerals and Geoscience Malaysia in 2003, mentioned that geological local structures include folding, jointing, faulting and jointing in the granitic rocks.

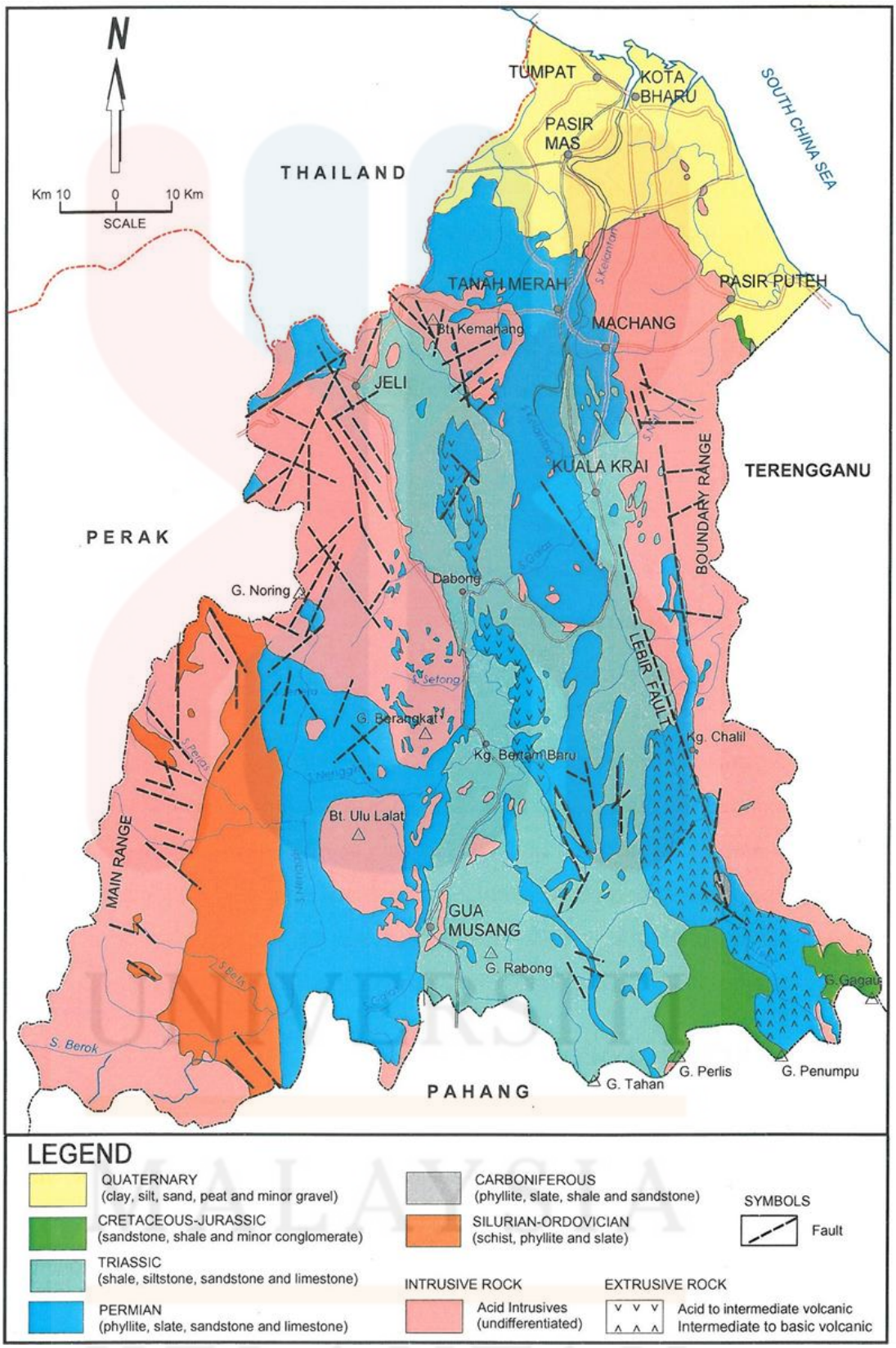


Figure 2.1: The geological map of the state of Kelantan, Darul Naim

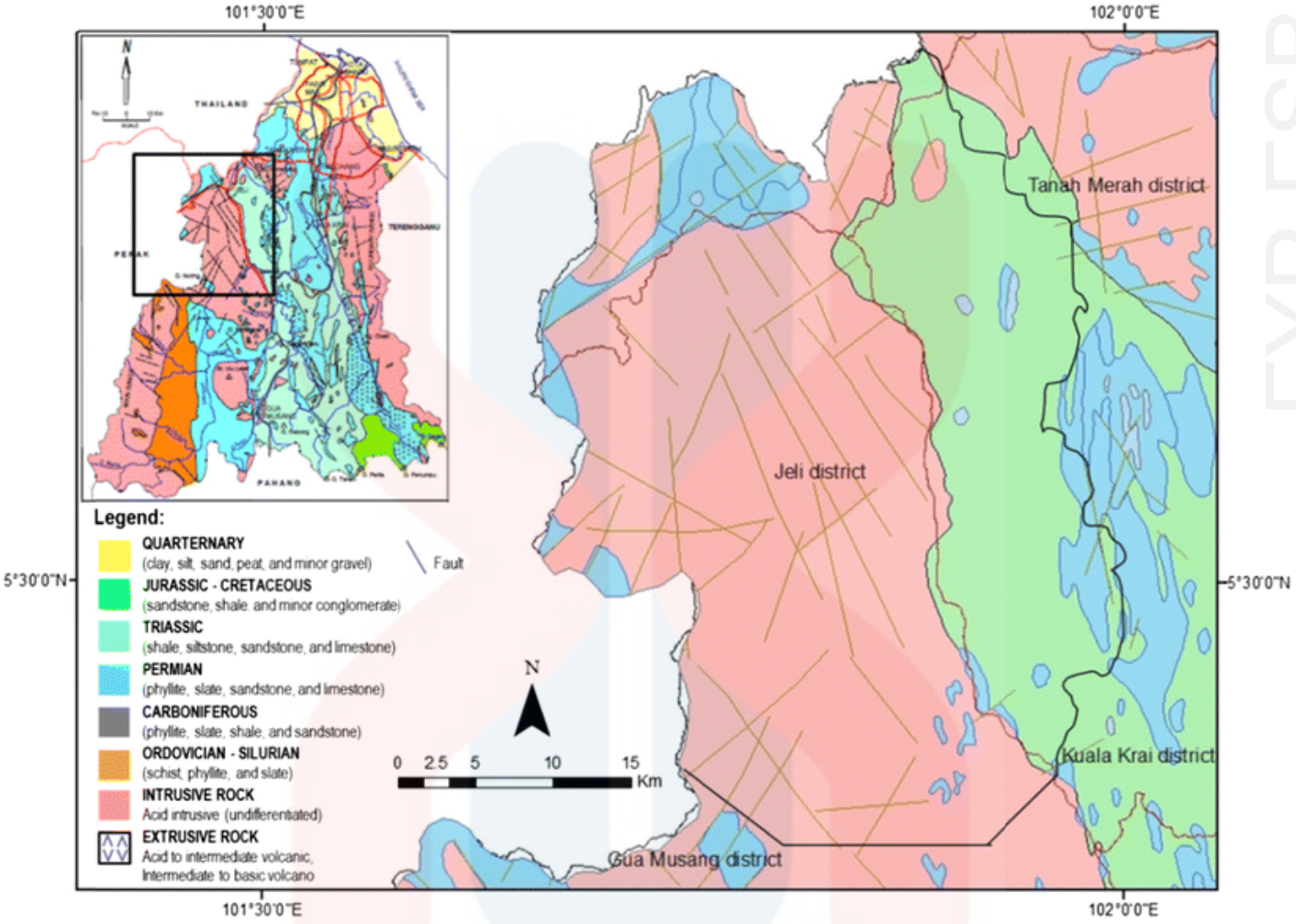


Figure 2.2: Map of General geology of Jeli district (Department of Minerals and Geoscience Malaysia 2003).

(Insert: General geology of Kelantan)

2.3 Stratigraphy

In the first place, the system of the Mesozoic is exposed in two separate belts in the Peninsular of Malaysia, which is one from the North to the South along the axial region and the other one is at the North-Western extremity region. Based on the chronostratigraphic, it is sub-divided into sequences of two, which namely an Upper Mesozoic molasses sequence and a largely Triassic flysch sequence.

Then, there are differences in nomenclature along the axial belt even for connected extensions of the similar unit as a result of isolated work that eventually merging together. The Jerai Formation, Kerdau Formation, Gunung Rabong Formation, Telong Formation and Gua Musang Formation which is located at the Northern potion are overlapping and reduced essentially to the Telong Formation and Aring Formation. There are currently formations which are known as Semantan Formation and Kaling Formation, which consist of the central part that are referred to as the Lipis Group, Kerdau Formation, Kaling Formation, Semantan Formation, Gua Musang Formation and Jerai Formation.

Then, the rock types which are metamorphic such as politic, schists, phyllite and amphibole schist also included at the Central Belt which bordering the Main Range Granite. However, the Taku-Schists which located at the North of Kelantan is the largest tract of regional metamorphic rocks in the Central Belt. Moreover, the terrain is even larger if the low grade phyllite which bordering the formation of Taku-Schists also included. According to the MacDonald (1967), the Taku-Schists border is actually of the biotite grade or even higher.

Besides that, the enveloping rocks show a succession from chlorite to biotite also included in the Taku-Schists and this can be geologically mapped in the area of

Manek Urai in Kuala Krai, Kelantan. Sillimanite rocks and kyanite rocks which is in higher grade also occur in this formation. The metamorphism type that happened is known as the Barrovian type. Based on the research by MacDonald in 1967, rising of the andalusite is due to the late intrusive contact rocks metamorphosed.

However, there is also theory that interpreted that the rocks of the Triassic age which are intrusive igneous rock were metamorphosed in the enlarged Taku-Schists. Since the assemblage of the rock is predominantly subordinate amphibolite with the politic schists, which is not similar to the adjacent of the rocks at Central Belts of clastic, acid volcanic and especially limestone, then the interpretation stated that the Taku-Schists that are exposed are older compared than Permian. The metamorphism of the Taku-Schists is indicated ended by the late Triassic based on the ages of rocks.

The district of Jeli is located by the foot of the Main Range which is famously known as the backbone of the Peninsular of Malaysia. There rocks in this area are mostly intrusive granitic rocks with several enclaves of metamorphic and meta-sedimentary or sedimentary rocks. The granite of the Main Range Granite which is up to the state boundary of Perak and Pahang, and included the West of Kelantan have the lithology of granite from that range. There are several rock types composed at Jeli which are; Firstly, the Triassic sedimentary rocks from Gunung Rabong Formation, which consisting of limestone, sandstone, siltstone and shale (Department of Minerals and Geoscience Malaysia, 2003); Secondly, the Permian sedimentary rocks which is Gua Musang Formation, which consisting of sandstone, limestone, slate, and phyllite and; lastly, the granitic rocks of acid intrusive rocks which are a lot can be found in Jeli area. The general geology of Jeli district is shown in **Figure 2.2**.

2.4 Structural Geology

An important structural feature is the North-Northwest trending Lepar fault zone near the margins of the belts. In addition, in the direction of North is the Lebir fault zone which follow the valley of Sungai Lebir. Although the evidence to establish the Lebir fault is not enough satisfactory, nevertheless that zone could well be structure that is older that probably developed during pre-late Triassic with later rejuvenating movements.

Undoubtedly, the folding happened in the geological events of the deformation history to the pre-continental rocks in the Central Belt. Based on the research by Gobbett (1973), there was a suggestion stated that the rocks have been folded isoclinally based solely on the geological mapping or field observation of a thick and possibly repeated sequence of rocks dipping in particular direction. Generally, the strike of the regional of the rocks is by the direction of North-South with moderate to steep dips either towards West of East. Ranjut syenite in the West of Pahang which are late high level plutons may had distorted around the regional strike of strata.

Then, in the Taku-Schists formation, it appear to have experiencing a phase of recumbent folding coeval with metamorphism and another phase of open folding after the complex has metamorphosed. As the result from the late folding is the complex forming of an antiformal plunge structure with the fold axis of North-South. The Tekai Group may be coeval with this phase of late folding. The folding into broad folds with limbs dipping gently occurred at the Tekai Group. The axis of the fold are similar to the Taku-Schists anti-form which is North-South.

Equally important, based on the lineament analysis from the geological map of state of Kelantan, the major local geological structures in Jeli district are along

Northeast-Southwest directions and Northwest-Southeast directions. Based on the research by Mumtaz Jihan (2015), there is a strike slip fault that can be observed along the Sungai Pergau. That fault affect the rock by causing the rock moving to the left which is left lateral, that can be observed by the aerial or satellite image. Moreover, at the location of the lineament also have another faults.

2.5 Geomorphology

According to the research by Unjah et al. (2001), there are four types of landforms or landscapes terrain at the Kelantan state, which are the; (1) Mountainous areas, (2) hilly areas, (3) coastal areas, and (4) plain landscape. The study area which is Jeli have all the landforms/landscapes mentioned except for the coastal areas which only exist at the Northern part of the Kelantan state. Firstly, the mountainous landforms stated is in the North and West of the district of Jeli. The landform consists of the Main Range Granite, the Stong Migmatite Complex, and the schists. This landform is featured by some mountain valleys and mountain ridges. Meanwhile, the hilly areas are distributed along the foot of the mountain range. The landforms causes the two types of hills to form which are isolated hills and elongated hills. Lastly, the plain landscape was formed in the Central and East of the district of Jeli.

2.6 Mackintosh Probe Test

This section will focus on the method used in this research which is testing of the soil strength using Mackintosh Probe (MP). The Mackintosh Probe test is a geotechnical method to survey and test the strength of the soil in the subsurface of the

Earth. The research is also about determining the resistance or the shear strength of the soil which is at the Bandar Jeli in the districts of Jeli, Kelantan.

2.6.1 Shear Strength of Soils

The individual particles that consisted in the soils is defined to easily roll and slide relative to each other. Hence, the equal to the maximum value of shear stress that can be mobilized within a soil mass without any failure is the definition of shear strength of a soil.

Then, shear strength of a soil is a function of the applied stresses as well as the manner in which these stresses are applied. As to determine the bearing capacity of foundations, the understanding of the shear strength is necessary, as the pressure applied laterally is exerted on retaining walls, and the slopes stability.

The term of shear strength is used in the soil mechanic field to describe the magnitude of the shear stress that the soil or any site can sustain. Then, the result of friction and interlocking of particles is the shear resistance, and possibly bonding or cementation at contacts of the particles. Resulting from the interlocking of particles, particulate materials may be contract or expand in volume as it is subject to shear strains. When the volume of the soil expands, the density in the particles will declining and also the strength will decline; which related to this case, the reduction of shear stress would be followed by the peak strength. When the materials stops contracting or expanding, relationship of the stress-strain will level off, and when bond between inter-particles are broken. The theoretical state in which the shear strain increases while the shear stress remain constant is called the steady state, critical state, or residual strength.

The density of the particles affect the volume change behaviour and inter-particles friction, the intergranular forces contact, and to a lesser extent, other factors such as the direction of the shear stress and the rate of shearing. The effective stress is defined as the average normal intergranular contact forces per unit area.

When the water cannot flow into or out from the soil, the stress path is known as the undrained stress path. In undrained shear, when the incompressible fluid such as water surround the particles, then without drainage, the density of water cannot change, instead the pressure of water and effective stress will change. On the other hand, when the fluids can flow freely out through the pores, then the pressures of the pore will remain constant and test path is known as a drained stress path. If the soil is drained, then the soil is free to contract or dilate during shear. In reality, the soil is actually partially drained, somewhere between drained idealized conditions and perfectly undrained conditions.

The drainage conditions, the effective stress, the density of the particles, the direction of the strain, and the rate of strain affect the shear strength of the soil.

Constant volume shearing, which is undrained shear strength, the theory of Tresca may be used to estimate the shear strength, instead for the drained conditions, the theory of Mohr-Coulomb may be used.

These are the factors controlling shear strength of soils:

i. Soil Composition (Basic material in soil): Mineralogy, shape of the particles, grain size and the distribution of grain size, pore fluid type and content, ions in pore fluid and in grain.

ii. State (Initial): Defined by the void ratio initially, shear stress and effective normal stress. These are the terms to describe the state which are: Dense, loose, normally consolidated, over consolidated, soft, stiff, dilative contractive, etc.

iii. Structure: The arrangement of particles within the soil mass; the manner the particles are distributed or packed. Features such as slickensides, layers, cementation, fissures, joints, voids, pockets, etc., are part of the structure. The terms for the structure of the soil are: remolded, undisturbed, disturbed, flocculent, stratified, layered, laminated; honey combed, compacted, and deflocculated; cemented; single-grained; flocculated, isotropic and anisotropic.

iv. Loading conditions: Effective stress path, i.e., undrained, and drained; and type of loading, as example the magnitude, rate (dynamic, static), and time history (cyclic, monotonic).

Undrained Shear Strength (S_u):

The design and analysis of foundations, embankments, and retaining structures, used the undrained shear strength, and also measured using variety of in-situ and laboratory tests. The laboratory tests, in examples such as the triaxial or unconfined compression tests, appropriate form of drilling and sampling must be done to recover the relatively undisturbed samples. The process of the sampling and the laboratory testing may be a long time-consuming and also expensive. Moreover, the process to obtain a highly quality sample for an accurate laboratory test results is really difficult. The traditional technique of such as drilling, sampling, and test in laboratory are more expensive and time-consuming method compared to the in-situ testing which offers much cheaper in cost method and less time-consuming to perform. While the process of in-situ is much easier and convenient compared to the laboratory strength

testing, appropriate correlations must be developed for each in-situ test to apply for the results to design of the foundation of the soil.

The Mackintosh probe test is to estimate the undrained shear strength for the design of the foundation only for a shallow foundations. Currently, there has been demand to update the existing correlation for the test of the Mackintosh probe to better estimate the undrained shear strength of soft soils for the design of the Earth retaining structures and embankments. According to the Garfield (2008), the correlations that are already existed between Mackintosh probe resistance and undrained shear strength are often encountered at shallow depth. Due to the limitation of data for the weaker soils, there exist the considerable uncertainty when estimating the undrained shear strength of medium to soft soils from Mackintosh probe resistance. The below table which is the **Table 2.1** shows the previous correlation between S_u and M.

Table 2.1: Previous correlations between S_u – M (Mackintosh probe)

Researcher	Soil Types	Location	Equations	Remarks
Hossain & Ali	Soft Clay	Saudi Arabia	S_u (kPa) =K.M	K = 1.59-2.04
	Alluvium	Khozestan province, South of Iran	$S_u = 2.5M$	From vane shear, UU and UCT
Fakher et al.	Alluvium and soft clay	Saudi Arabia and Iran	$S_u = 0.90M^{0.96}$	From N and M correlation and Equation 1
	Very soft soil		$S_u =$ 0.64M+10.88	

Fatnanta et al.	Soft soil	Indonesia	S_u = 0.94M+10.88	Vane shear & Mackintosh probe
	Medium stiff soil		S_u = 0.63M+19.75	

(Source: Fairus Yusof, 2017)

The number of the blows of the Mackintosh Probe for every 300mm is represent by the symbol of M. Hossain & Ali in 1990 had proposed the first correlation after doing the research for soft clay in Sabkha which is in Saudi Arabia. The research done using Mackintosh probe test and field vane shear. Then, there are two equations had been proposed by the researcher named Fakher et al., the first equation was derived by using the results of a vane shear test, unconfined compression test (UCT) and unconsolidated undrained test (UU) correlating with the Mackintosh probe test. The second equation by Fakher et al. is according to the correlation of the standard penetration test, N, with the blows of the Mackintosh probe, M, by combining data from Sabtan & Shehata. Then, new correlation is proposed which is:

$$N = 0.15M^{0.96}$$

After that, the equation of the Terzaghi et al. which is $S_u = 6N$, a correlation of S_u and (M) had been proposed by them:

$$S_u = 0.90\ M^{0.96}$$

Later, during 2013, a Mackintosh probe test was performed at Pekan Baru, Indonesia to propose a new correlation. The research by Fatnanta et al. is done by relating the Mackintosh Probe test with the field vane shear test. The correlation is categorized for medium stiff soil, soft soil, and very soft soil. However, the equation proposed are not valid when the value of M is zero.

Lastly, the latest research which performed at Universiti Tun Hussein Onn Malaysia (UTHM) had proposed a new correlation which by using the correlation of the field vane test and the JKR probes. The JKR probe and Mackintosh probe test is the similar in the application.

$$S_u = 18J^{0.3}$$

2.6.2 Mackintosh Probe (MP)

There is a wide range of dynamic and static penetrometers can be used, with different types being used in different conditions of substrate materials. However, even there are many penetrometers are available, but the objective of all probing is the same which is to provide a profile of penetration resistance with depth in order to give an assessment of the variability of in-situ materials on site.

The common and simple probe used in the geotechnical method is Mackintosh Probe test. The components of the Mackintosh Probe consist of rods which can be threaded together with connectors/barrel connectors and normally fitted with a driving point at their base. At the top of the probe is equipped with a light hand-operated driving hammer. The tool is an economical method to determine the resistance of the soil deposits. The results are simple which is in terms of blows per unit depth of penetration, and are plotted as blow-count/ depth graphs.

The driving point of the tool is streamlined in longitudinal section with a maximum diameter of 27mm. The hammer at the top has a total weight of ±4.5kg. The diameter of the rods are 12mm and the length is 1.2m. The probe is operated by driving the point and rods into the ground with equal blows of the full drop height from the hammer at the top; the record is taken for every 150mm of penetration of the probe.

Due to the light hammer weight, the penetration of the Mackintosh Probe is limited in the depths and materials (Clayton C.R.I., Matthews M.C. and Simons N.E., 1995).

These are the main advantages of the usage of Mackintosh probe:

(1) Faster in speed of operation;

(2) When access is poor and terrain difficult to reach, the usage of Mackintosh probe is a benefit;

(3) require minimum personnel and equipment;

(4) Very low cost for the equipment;

(5) Simple in operation and data recording and analysis;

(6) Use in the interpolation of soil strata and properties between boreholes and trial pits;

(7) Can minimize the number of boreholes needed.

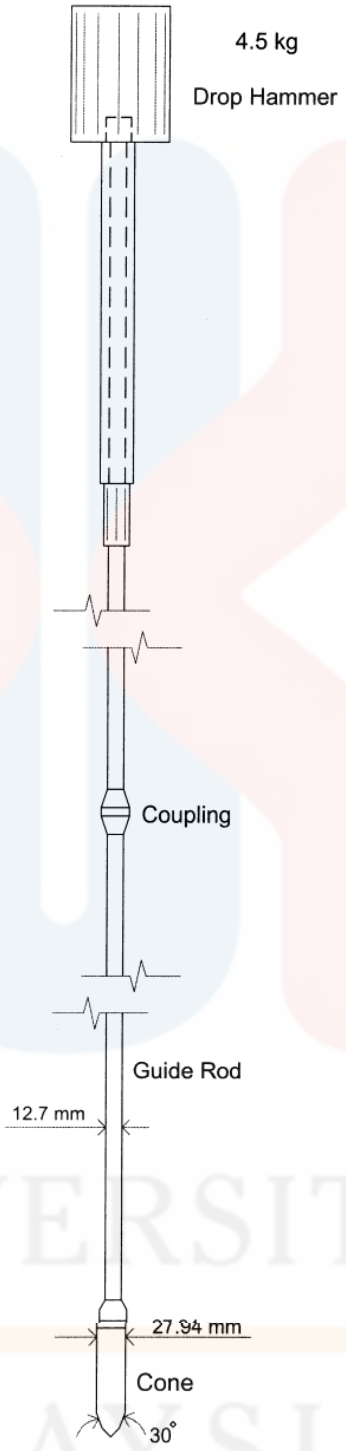


Figure 2.3: The set-up and dimensions of Mackintosh Probe

The following is the procedure to run the Mackintosh Probe:

1. The equipment assembled together and screwed. Next, the diameter of the cone is measured in SI unit.

2. A distance of 300mm is measured an marked by the marker at the rod of the Mackintosh probe before starting the test.
3. Then, the equipment for the test is set up on the ground.
4. Pulled the hammer at the top until it reached the maximum level. Then, let the hammer dropped freely driven by the gravity forces for the cone to penetrate into the soils.
5. The sum of the number of a blow for penetration of 300mm is recorded.
6. The hammer is taken off on the last 300mm of each rod and joined an existing rod with another rod and lastly the hammer. The blow proceed and stopped when:
    i. The blows of the test is more than 400 for 300mm penetration.
    ii. The depth reached the maximum which is 15m.

2.6.3 Repeatability of Mackintosh Probe results

The repeatability of Mackintosh Probe results is an important consideration. To determine this a series of tests were carried out at each site. In each series, two, three, or four Mackintosh tests were repeated at very close proximity (in plan less than 0.5 m). A linear increase of *M* (blows/100 mm) versus depth can be seen for the top 1.0 m of soil.

In order to study the repeatability of results it is important to choose a suitable parameter that represents the repeatability. The use of the standard deviation value *(s)* is not appropriate for this purpose because *(s)* is large for large values of *M*. However the coefficient of variation *(Cv)* can be considered as an indicative parameter because it represents a normalized standard deviation. *Cv* is calculated using the following formula:

$$Cv = s\sqrt{\bar{x}}$$

Where:

$\bar{x}$ is the average of *M* at each depth

s is the standard deviation of *M* at each depth

Table 2.2 shows some soil properties, determined by various standard tests, together with their coefficient of variation reported by various researchers. The sources of variability in soil properties differ, and accordingly the coefficients of variation differ for different properties.

Table 2.2: Coefficient of variation for soil engineering test *(Lee et al. 1983)*

Test	**Reported *Cv* (%)**	**Recommended Standard**
Angle of friction (sands	5-15	10
CBR	17-58	25
Undrained cohesion (clays)	20-50	30
Standard penetration test (SPT)	27-85	30
Unconfined compressive strength (clays)	6-100	40

It can be seen that the variation of *Cv* for the results of the Standard Penetration Test (N), which is basically a super heavy dynamic probe test, is reported to be between 27 and 85% with a recommended standard of 30% (Lee et al. 1983).

The repeatability of SPT test results could be used as a measure of the repeatability of Mackintosh Probe results by comparing the *Cv* values of the two methods. In the present research, the values of *Cv* have been determined for each depth in each series of tests performed at very close proximity.

2.6.4 Bearing Capacity

The bearing capacity is very useful in the field of geotechnical engineering, which the bearing capacity is defined as the capacity of the soil to support the loads applied to the soil or ground. The average contact pressure between the foundations and the soil which not produce shear failure to the soil is the bearing capacity of the soil. Then, there is ultimate bearing capacity which is the maximum pressure or load can be supported without soil failure; meanwhile, allowable bearing capacity is defined by the ultimate bearing capacity divided by a factor of safety. Sometimes, settlement with large quantity may occur under loaded foundations without actual shear failure

occurring on soft soil sites; which in such cases, the maximum allowable settlement affecting the allowable bearing capacity.

Three modes of failure that limit the bearing capacity of the soils are local shear failure, general shear failure, and punching shear failure.

This is the relationship between Safe Pressure and the Mackintosh Probe: -

$P = (2\ 860 + 550\ (R - 40)^{1/2} \times 0.04788\ kN/m^2$ **for blows > 40**

P = Refer Table xx **for blows < 40**

Where,

P = Safe Pressure (kN/m2)

R = Mackintosh Probe Penetration resistance in blows/0.3m

IS1904-1978 recommended that the safe bearing capacity should be calculated on the basis of the soil test data. Instead, in absence of such data, the values of safe bearing capacity can be taken equal to the presumptive bearing capacity values given in **Table 2.3**, for different types of soils and rocks. It is further recommended that for non-cohesive soils, the values should be reduced by 50% if the water table is above or near base of footing.

Table 2.3: Relationship of type of soil/rock with safe/allowable bearing capacity

Type of Soil / Rock	**Safe / Allowable Bearing Capacity (kN/m^2)**
Rock	3 240
Soft rock	440
Coarse sand	440
Medium sand	245
Fine sand	440
Soft shell / Stiff clay	100
Soft clay	100
Very soft clay	50

(Source: Geotechdata.info, 2015)

For preliminary design purposes, study gives presumed bearing values which are the pressures which would normally result in an adequate factor of safety against shear failure for particular soil types, but without consideration of settlement. These values are as follows:

Table 2.4 Presumed bearing value for different types of rocks and soils

Category	**Types of rocks and soils**	**Presumed bearing value**
Non-cohesive soils	Dense gravel or dense sand and gravel	>600 kN/m²
	Medium dense gravel, or medium dense sand and gravel	<200 to 600 kN/ m²
	Loose gravel, or loose sand and gravel	<200 kN/ m²
	Compact sand	>300 kN/ m²
	Medium dense sand	100 to 300 kN/ m²
	Loose sand	<100 kN/ m² *depends on degree of looseness*
Cohesive soils	Very stiff bolder clays & hard clays	300 to 600 kN/ m²
	Stiff clays	150 to 300 kN/ m²
	Firm clay	75 to 150 kN/ m²
	Soft clays and silts	<75 kN/ m²
	Very soft clay	Not applicable
Peat		Not applicable
Made ground		Not applicable

(Source: Geotechdata.info, 2015)

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

There are specific materials and procedure for doing the research regarding this topic. The uses of all the materials and procedure are necessary in order to achieve the objectives of the research. The flow chart for the research also included in this chapter, which is very important to conduct the research systematically. For further reference, the flowchart of the research is shown in **Figure 3.1**.

3.2 Materials

During the research, fieldwork will be conducted which will need materials for geological mapping, field observation and collecting data. The materials needed will be discussed in this section.

3.2.1 Mackintosh Probe (MP)

The Mackintosh Probe is a portable and lightweight penetrometer. It is among the probe that is faster and cheaper compared to other penetrometers especially when the depth of the soil deposits is moderate, soft or loose soils. Mackintosh Probe has 30° cone penetrometer. The total number of blows for every 150mm depth of

penetration into the soil deposit will be recorded and used as a measure of the consistency of cohesive soil.

3.2.2 Global Positioning System (GPS)

Global Positioning System (GPS) is a navigation system that among the most accurate in giving data. The tool operates based on the satellite in space, monitoring stations on Earth and GPS receivers. There are various functions of GPS which are really necessary for geological mapping such as for traverse, knowing the coordinate of the exact location, measuring elevation, showing the pattern of the contour and storage for sampling data.

3.2.3 Compass

Compass is the navigational instrument for showing the relative direction of magnetic poles for the Earth. The instrument consists of a magnetized pointer (which marked the North or N end) free to align itself with the Earth's magnetic field. There are two types of the compass which are usually used which are Suunto and Brunton. In geological mapping, this compass can measure the strike and dip of the outcrop at the field.

3.2.4 Measuring tape

Measuring tape is an equipment which is needed for geological mapping. The basic function of the measuring tape is to measure the dimension of outcrop in the

field. Besides, this equipment can be used to take the measurement of the bed thickness and the lithology area of the outcrop.

3.2.5 Hand lens

A hand lens is a tool that is necessary for geological mapping. The function of hand lens is to magnify the image of the rock to identify the type, shape, color, composition, and dimension of the minerals in the rocks. Besides that, a small structure in the field can be seen using this tool.

3.2.6 Geological hammer

Geological hammer is necessary for breaking the rock apart or to split apart layers in soft rock. There are two types of the geological hammer that are usually used which are tip pointed rock hammer and chisel tip rock hammer. The purpose of breaking the rock apart is to identify the fresh surface of the rock which describes the minerals of the rock clearly.

3.2.7 Base Map

Geologists often use a base map or topographic map for construction of the surface geologic map. Base map prepared by creating and editing spatial data using ArcGIS. Base map shows the landform of the study area. **Figure 1.1** shows the base map of study area.

3.2.8 Sample bags

Geologists used sample bags as the storage for the rock sample, fossil sample, sediment sample or other samples in the field. After storing the sample, the sample bags must include the tags so that the sample will not be confused with each other. One sample bags are only for one sample.

3.2.9 Field notebook

Observing and recording are the important things at the field. As for recording, the field notebook is a must for the geologists. Instead of only relying on the GPS to store the data, manually recording of data also is a must to avoid from losing of data.

3.3 Methods

To accomplish the objectives of the research, the section of the methods is really important. The research must be completed by a certain duration which this section is a big help.

3.3.1 Preliminary Research

A preliminary research of desk study is important for the research. Preliminary study is the first stage of exploration of issues/topics/interests to a proposed quality evaluation or review. The study can be done by using various sources such as articles, journals, journal articles, books, news, bulletin, and from the internet.

In addition, the preliminary study can be obtained by getting data from the related government office according to our topic. As for the engineering geologist, some of the data had been obtained by the related government office as the data needed for the construction of the areas.

3.3.2 Official Statistics

Official statistics are statistics or data published by the agencies of the government or other public bodies as a public good. Regarding the research of this final year project, the data collected by government agencies are really important. The previous site investigation (SI) made from government agencies such Jabatan Kerja Raya (JKR) and Majlis Daerah Jeli is really helpful. JKR used SI data to develop the road or street. Meanwhile, Majlis Daerah Jeli may have some SI data since they are doing development in Jeli.

3.3.3 Geological mapping

One of the objectives is to update the latest geological map for the study area. As to accomplish this objective, the geological mapping is necessary. Geological mapping is aiming for identifying the geological aspects of the study area such as stratigraphy, lithology, geomorphology and structural geology.

3.3.4 Mackintosh Probe (MP) test

Mackintosh Probe test is to determine and provide the profile of penetration resistance with the depth, in order to give an assessment of the variability of the soil.

Besides that, this test can determine sub-surface straits graphed and identify materials present. It also can help to evaluate soil density and in-situ stress condition. The propose area for the Mackintosh Probe test is at any construction sites or any location that has the results of Mackintosh Probe test to compared the result with previous test.

3.4 Report

The final step for the final year project research is writing the report. Various chapters are included in the report writing which are an introduction, literature review, materials and methodologies, general geology, specification, and conclusion. The specification referred to the selected topic or interest by the researcher. The format of the report is as guidelines given by the Faculty of Earth Science, Universiti Malaysia Kelantan.

RESEARCH FLOW CHART

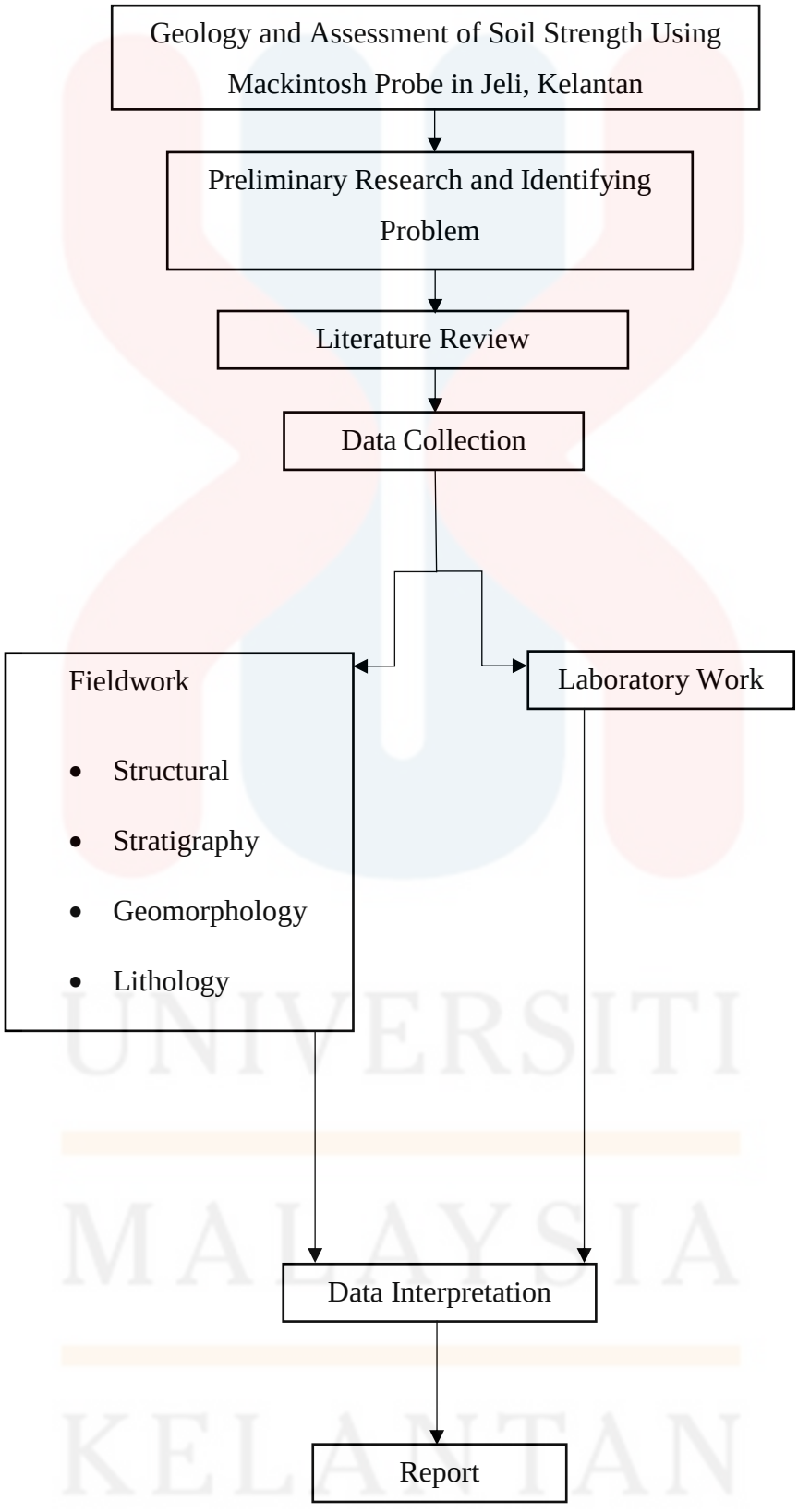


Figure 3.1: The flow chart of the research

CHAPTER 4

GENERAL GEOLOGY

4.1 INTRODUCTION

This chapter will cover the findings from the geological mapping of this study. The findings include the observation and study of geomorphology, stratigraphy, petrography, structural geology and regional geology in Bandar Jeli

4.1.1 Accessibility

The road around Bandar Jeli is mostly paved road due to the development and educational institutional. Instead of that, there are some roads that have bad condition such as unpaved road and plantation road which is at rural area around Jeli. Besides that, there are several main roads that are connected to the Bandar Jeli which another places. In Northeast-Southwest of the study area, there is East-West Highway that connects Gerik, Perak with Jeli, Kelantan which pass through and connects the Southwest at Kalai and Batu Melintang area of Jeli and the Northeast which is Ayer Lanas. In addition, the main roads which connecting from Bandar Jeli also can lead to Gua Musang, Kelantan which passes through Dabong, Kelantan.

4.1.2 Land use

The overall usage of the study area is described as the soil use. Based on the report from Department of Mineral and Geoscience Kelantan (2003), there are about 60 % of the Kelantan state is covered by forest, mainly within reserved land and state land, which is located at the districts of Jeli, Kuala Krai and Gua Musang in Southern of Kelantan state. Some 60% of the State of Kelantan is under forest cover, mainly within state land and reserved land, located in the districts of Jeli, Kuala Krai and Gua Musang in southern Kelantan. Approximately 22% of Kelantan state is for agriculture purpose and only about 1% used for mining and urban.

Focussing in Bandar Jeli, land use here are classified into two categories which is built up and non-built up land use. Based on the Jeli Local Planning Report (2012), there are approximately 1.63% of Bandar Jeli are in category of built up land use which comprises of housing area, business and services area, industrial area, educational institution and public facilities. This also include the scattered settlements that exists in Bandar Jeli. According to the research, built up land use are focusing along the main road and main town. The influence to this trend is basically due to the factor of various basic necessaries, basic facilities and infrastructure facilities.

The development in Bandar Jeli also influenced by the built up new facilities and services such as educational institution, health institution, and security services. All these facilities and services are the factors that attract more population to live in Jeli because the human development depends on these facilities.

Then, the non-built up land use are the main category of land use in Bandar Jeli which comprises about 98.37% of Bandar Jeli. This category include the land use for agriculture, wasteland or empty land, forest, forest reserve, state forest reserve and

water body. The land use for agriculture include usage for the crop like rubber, palm, paddy, fruits and activity of husbandry which include cow, goat and buffalo and fish.

Equally important, for the forest reserve, the forest reserves that are located at Jeli are the Jeli Forest Reserve and Sator Forest Reserve. Furthermore, for the water body, the study area has one main river which is Sungai Pergau that can be seen in the Southwest of the study area. This main river is connected with another streams that causing the drainage pattern formed in Bandar Jeli. This river are a very important for agriculture and domestic use in Bandar Jeli.

4.1.3 Traverses and Observation

Geological mapping, traversing, and field observation are the important processes for the data collection. The data obtained was combined and processed to produce a complete information about the geology of study area. The information of geological of the study area would later be a guidance for another researchers for their research. The information of rock distribution in the study area, paleo-environment, the processes happened and the geological or structural information that occurred in the study area previously. Based on the information, the lithology of the study area could lead to the discovery of valuable minerals and ore that could be industrial mined.

In the first place, traversing is the method use for data collection from geological mapping and field observation. During geological mapping, the raw data such as specimen of rock samples, coordinate of the outcrops, strike and dip reading, morphology and geological structure are being recorded, observed and collected. Petrographic analysis also done in the laboratory for determining the type of the rocks

accurately. **Table 4.1** below shows the coordinates where the observation and sampling station are done.

Table 4.1: The coordinate of every station for observation and sampling

Station	Coordinate
1	N 05° 43’ 13.1” E 101° 50’ 47.4”
2	N 05° 43’ 39.6” E 101° 52’ 5.80”
3	N 05° 42’ 28.7” E 101° 49’ 57.8”
4	N 05° 43’ 53.8” E 101° 51’ 12.1”
5	N 05° 42’ 31.1” E 101° 51’ 0.10”
6	N 05° 43’ 2.30” E 101° 51’ 36.6”
7	N 05° 41’ 44.0” E 101° 50’ 12.1”

In order for a better understanding of the study area, geological mapping and field observations are done in purpose to collect all the data and information. The traverse map are shown in the **Figure 4.1**. The figure show where the traversing and geological mapping are done. In addition, **Figure 4.2** is the outcrops map in study area. This map show the location of samples collected. The map shows three main elements in the map which is the drainage, topography and culture. The contour lines are to represent the relief and shows both natural and man-made features of the study area. The map give idea for planning ideal route and shows higher possibility of structures presence in a particular area. Traversing along the streets and streams are done in order to justify the assumptions made by observing on the topography map. This is due to the by following the streets, the accessibilty to the outcrops is much easier. Therefore, the reading and observation on the outcrop can be made. Rivers or streams are more likely to have outcrops because the water channels is the main medium for transporting the rocks that had weathered from the original outcrops location.

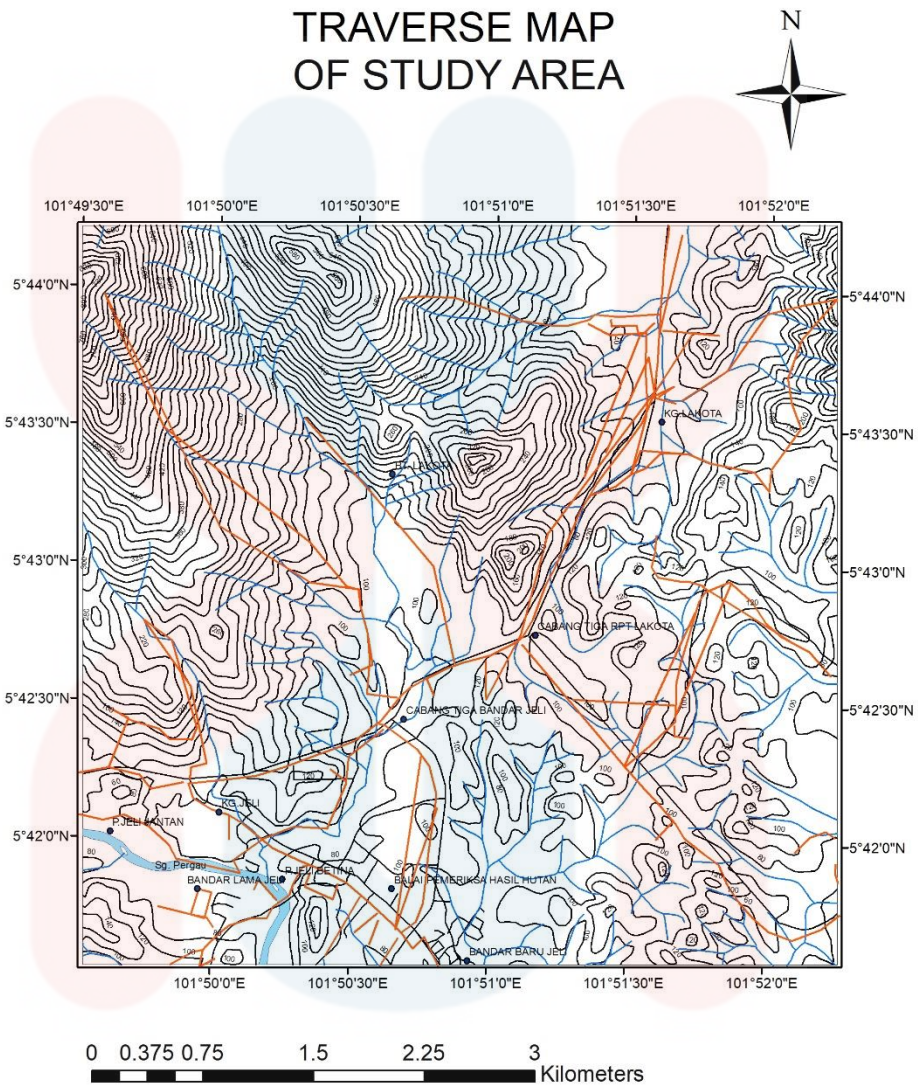


Figure 4.1: Traverse map of study area

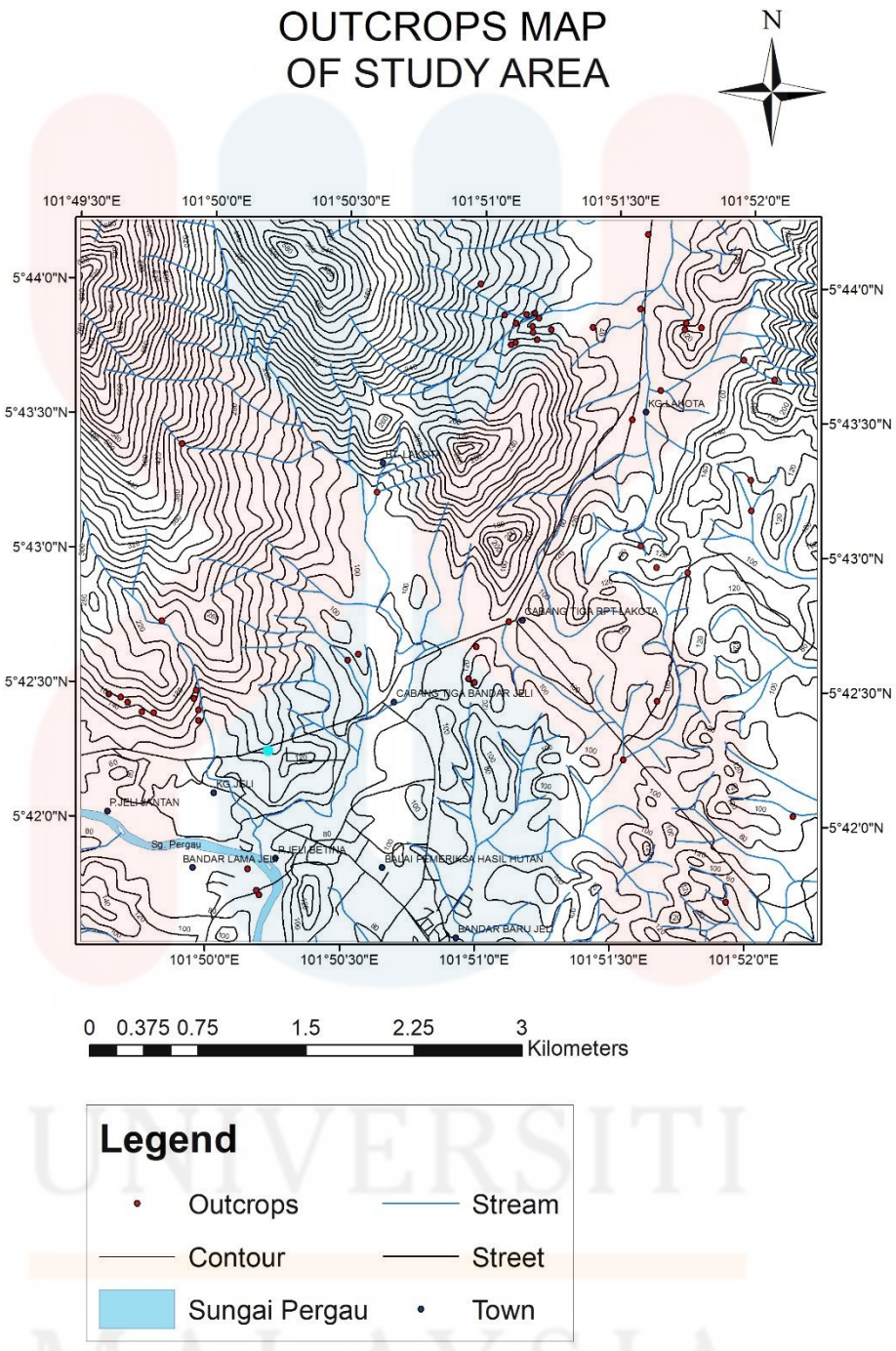


Figure 4.2: Outcrop map in study area

4.2 GEOMORPHOLOGY

The physical geologic which can be observed at certain area which influenced by the structure, lithology and topography of the study area is known as geomorphology. There are three classification of the geomorphologic study which are based on morphology, morphodynamic and morphogenesis.

4.2.1 Topography

Topography is the arrangement of the natural and artificial physical features of an area. Contours are imaginary lines that connect location of the same elevation in an area. The value of contour line which is elevation reflects the height of a place. High value of the elevation shows that it was in a higher area. Relationships with height difference morphography elements are stated in the **Table 4.2** below:

Table 4.2: The relationship absolute altitude and morphography element

ABSOLUTE ALTITUDE	MORPHOGRAPHY ELEMENT
<50 meters	Lowland
50 meters – 100 meters	Lowland inland
100 meters – 200 meters	Low hills
200 meters – 500 meters	Hills
500 meters – 1500 meters	High hills
1500 meters – 3000 meters	Highlands
>3000 meters	High mountains

(Source: Van Zuidam, 1985)

A difference in the altitude or the elevation is usually measured from the surface of the sea. This is due to the sea level is considered as a field that has the number to-altitude or elevation equal to zero. The importance of the introduction of the difference in height is to declare a state of morphography and morphogenetic of a landform, such as hills, mountains. The study area which is Bandar Jeli have low hills and high hills.

Figure 4.3 shows the 3-dimensional map of study area. Based on this 3-dimensional map, the highest elevation or altitude is ~840m which is at the international border of Kelantan-Siam and the lowest elevation or altitude is ~40m.

Based on the observation and literature review, the landform of Bandar Jeli is considered to be due to the volcanic activity and faulting in the previous time of geological events. The outcrops that are found in the study area are mostly granite, meta-sedimentary and metamorphic rock that originally from igneous rocks. This might happen due to the volcanic activity that happen in the previous time. Based on the observation of the lineament from the lineament map in **Figure 4.31**, the previous faulting occurred in Jeli. The lineament lines can be seen from the straight lineament that are shown on the river drainage pattern or continuous contours.

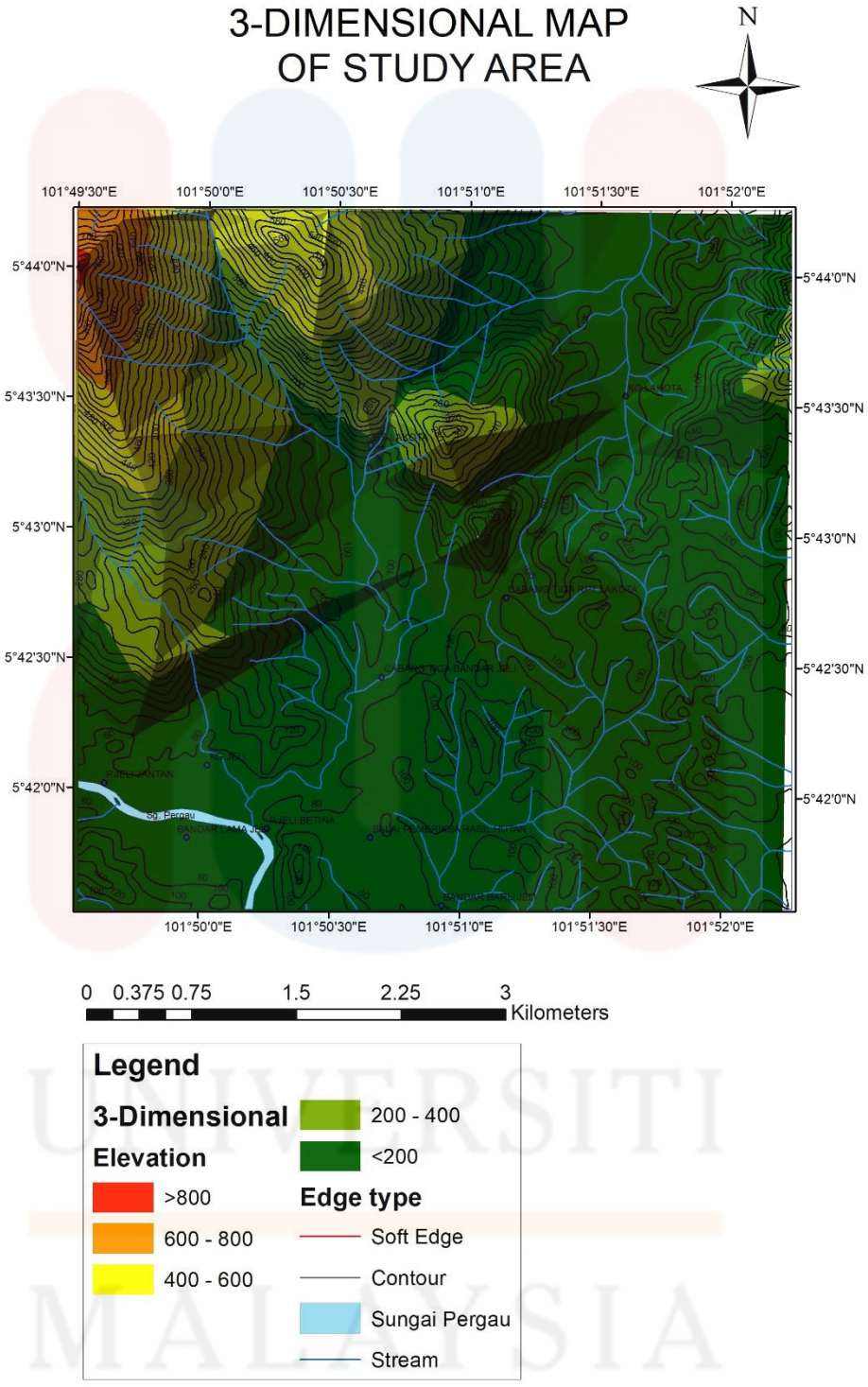


Figure 4.3: 3-Dimensional map of study area

4.2.2 Geomorphologic Classification

Based on the topographic map in Figure 4.4, the study area is divided into three sections for classification of geomorphological study. Based on the Raj (2009), previously, an ancient landslide had happen causing this area to form geomorphologically. The theory is proven by the discovery of various size of rocks that accumulated and scattered in this area. According to the pattern of the contour at section A, the lineament lines observed by the contour of hills that indicate the faulting had occurred before.

Next, according to the section B, this area is categorised as denudation area. This is due to the elevation in this area is lower compared to section A, and most of the ground at this part is flat. Denudation is the process of reduction of elevation of an area due to the weathering process and erosion process. The lowest elevation that can be observed in the map is ~40m and the highest is ~200m. The hills area at Eastern of the area are formed are formed from the intrusion of magma. Then, in section C, which located at the Southwest part of the map of study area, the area is hilly which located besides Sungai Pergau. The highest elevation of section C is ~220m and the lowest is ~80m which is at the side of Sungai Pergau. Based on lineament map in **Figure 4.29**, the lineament line that indicate the ancient faulting occurred along Sungai Pergau.

After that, for the geomorphology of the river, the direction of the flow of river is by Southwest in the map. In order of sedimentation process that had occurred, the formation of meandering by the side of the river happened. The estimation of the deep of the river is about ~2m. The width of the river are measured to be about ~30m. By the side of the river presence a lot of outcrops which are mostly meta-sedimentary rocks.

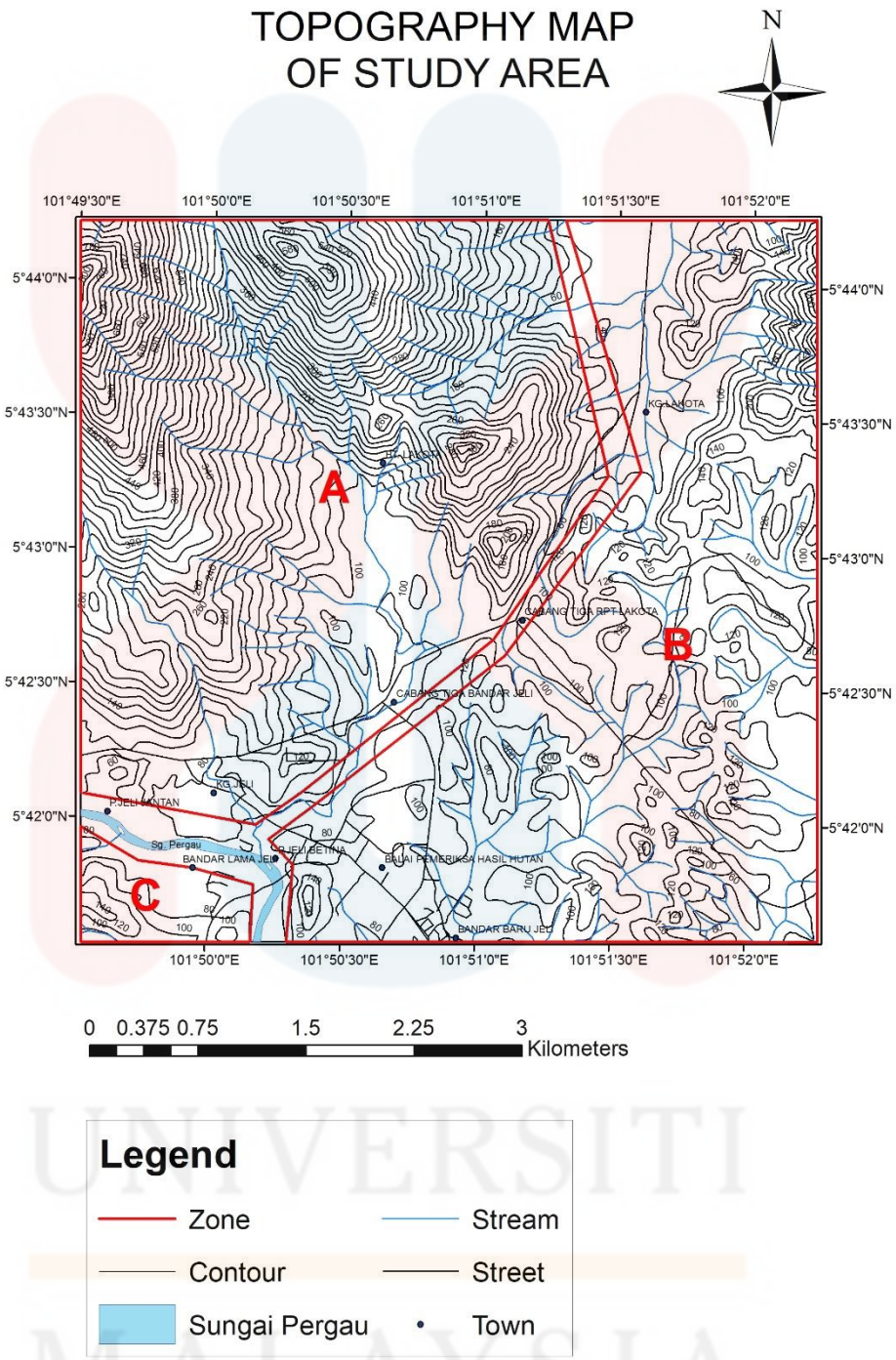


Figure 4.4: Topographic map in the study area

4.2.3 Drainage Pattern

Sungai Pergau is the main river flowing in Bandar Jeli. In field observation, the side of the river are observed to be covered with meanders that are formed due to the sedimentation process. The depth of the river is about to 1 metre during dry season and the water level can rise up to 3 metre from the river bed during the raining season. After the measurement, the width of the Sungai Pergau at Jeli is about 30 metre. As a result from the massive flood that occurred in Kelantan in December 2014, the side of the Sungai Pergau in Jeli happens to have landslide and this event has exposed many outcrops.

There are a lot of rivers, streams and lakes that causing the forming of the drainage pattern. There is only one type of drainage pattern that can be observed in the map of drainage pattern which is shown in the **Figure 4.5**. When the streams flow across a ground landscape, the streams will generally increase in size and the streams will combine and merge with other nearest streams. The drainage pattern is the network of stream. There are four general pattern in drainage pattern system which is dendritic, rectangular, trellis and radial.

According to the drainage pattern map, the drainage pattern in the study area is mostly and only dendritic. Dendritic pattern are the most common type of drainage pattern. This type of drainage pattern occurs due to the soft underlying sedimentary rocks thus not influence the flow of the water at the streams. This pattern follow the influence of the gravity which causes the water to follow the slope of the terrain when the underlying strata is stable. Many small streams joined together and formed the shape of likely branches of tree and flow into the main river.

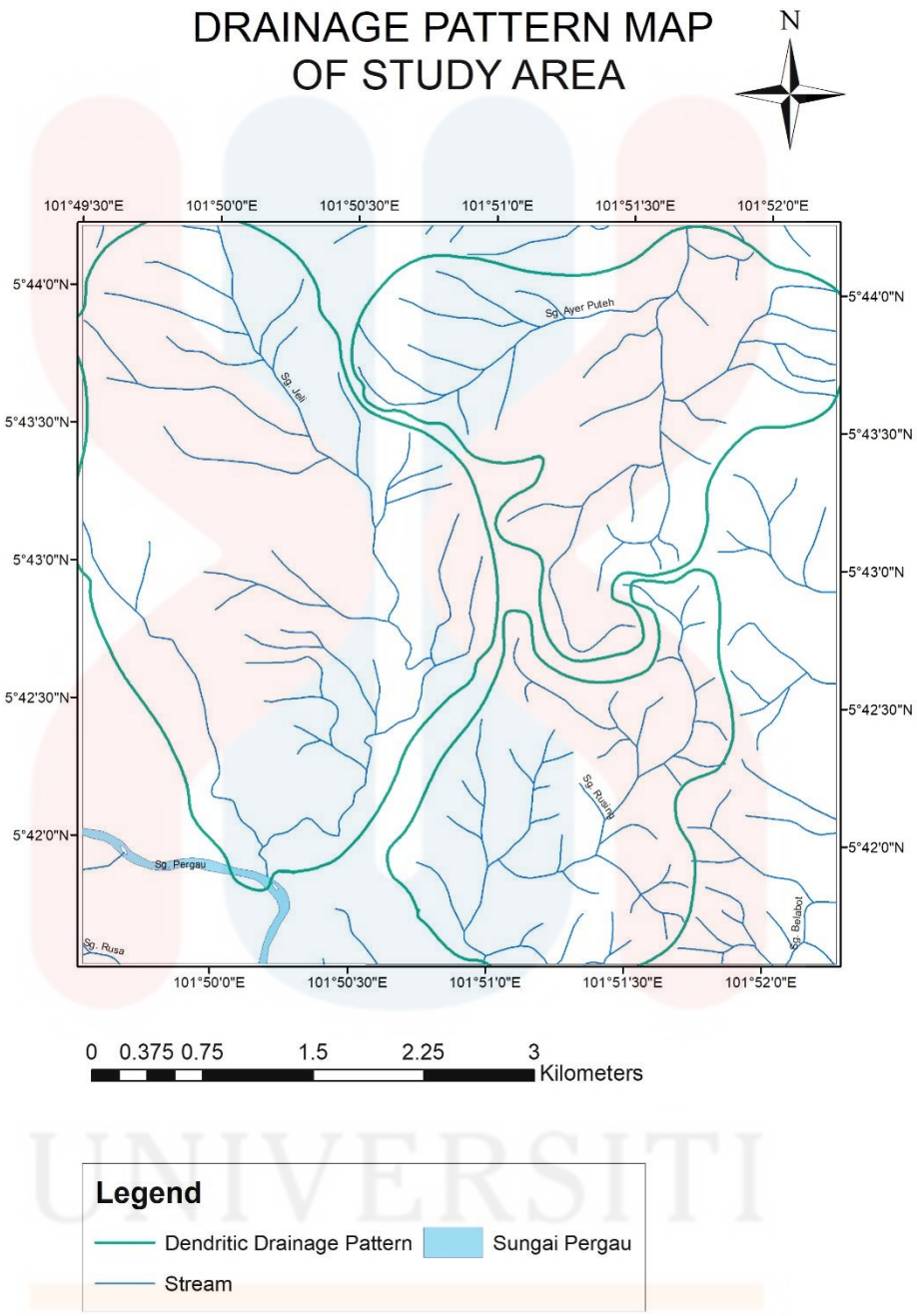


Figure 4.5: Drainage pattern map in study area

4.3 LITHOSTRATIGRAPHY

The lithology of a rock unit is a description of the physical characteristics of the rock by observing the features that visible at the original outcrop, by hand specimen or core of sample or with microscopic analysis in the laboratory such as the colour, texture, grain size, grain shape, or composition of minerals.

The classification of the rock bodies based on the observable lithological properties of the strata and their relative stratigraphic positions is known as lithostratigraphy. Meanwhile, stratigraphy includes the information about the processes, distributions of geography, and the paleo- environment of the previous glaciers and glaciation. This involves an attempt to determine the sequence chronologically of geological events over a wide area. The method to recognized and defined on the basis of observable characteristics of the rock. Facies is the description of the strata based on the physical appearance. Instead of the age, the lithostratigraphic units are only defined by lithic characteristics.

The formation is the fundamental for the lithostratigraphic unit. A formation in the field is a lithologically distinctive stratigraphic unit that is large enough to be traceable and mappable. The formations can be subdivided into members and beds and aggregated with other formations to form into groups and supergroups.

4.3.1 Station

In the first place, for lithological observation and classification in the study area, several stations were established at the place where outcrop is found. The coordinate list for the station is shown in **Table 4.1**. From the observation and mapping activity,

the types of lithology that are recognized from the study area are alluvium, granite, phyllite and gneiss.

a) Station 1:

The coordinate of station 1 is N 05° 43’ 13.1” E 101° 50’ 47.4”. The place is known as Bukit Lakota or Bukit Jeli which located at the side of the East-West Highway. The outcrop can be found deep into the forest following the water flow. After the observation, the lithology there is igneous rock which is granite.

Figure 4.6: The outcrop of granite at station 1

The outcrop that has been found at station 1 in Bukit Lakota is already covered by biologically, which is mosses, and chemically weathered. The grade of the weathering to this area is considered to be at grade of III which is moderately weathered. There are a lot of geological structures that can be found at this place like veins and joints.

Figure 4.7: The vein found at station 1

Based on **Figure 4.7** above, this is an example of vein that had been found at station 1. The vein is the igneous rock that intrude into the outcrop of granite. Then, according to the **Figure 4.8**, the example of the joints and fractures that had been discovered at station 1 with the compass as the scale.

Figure 4.8: The joints at station 1

b) Station 2:

Station 2 is located at Kampung Lakota which the coordinate of the location is N 05° 43’ 39.6” E 101° 52’ 5.8”. The outcrop can be found deep into the forest which has to go through the rubber plantation of the village into the wild forest. The outcrop can be found at the flow of the river at the middle of the hill. After the observation been made, the type of the rock there is identified as the igneous rock which is granite.

c) Station 3:

The coordinate of the station 3 is N 05° 42’ 28.7” E 101° 49’ 57.8”. In the first place, the location of station 3 is not near by the main town of Jeli, more specifically this station is located at the side of the East-West Highway and situated at the streams between Simpang Tiga Jeli and Shell Gas Station. In order to construct the highway

connecting Jeli to Gerik in Perak and Tanah Merah, Kelantan, the hill has been cut causing the outcrop to be exposed. In field observation, the main type of rock here is the intrusive igneous rock with some veins intrude into the outcrop.

Figure 4.9: Outcrop at station 3

The dimension of the outcrop exposed estimated to be about 10 meters in height and about 30 meters in width approximately as shown in the **Figure 4.9**. Several parts of the outcrop is already undergo physical, biological and chemical weathering. The physical weathering occur due to the human activity in constructing the highway. Then, the biological weathering occurs due to the growth of the plants, mosses and leach on the outcrop. The rate of weathering of the outcrop is slightly weathered or at grade II. This is because the outcrop there is mostly still fresh because the minerals and structures can be clearly seen. Although, many parts of the outcrop is already covered by soils and plants, but overall, the outcrop is still in good condition.

Figure 4.10: Shows the contact between granite and gneiss at station 3

After the geological mapping, there are two types of rock that are presence at this station which is granite and gneiss. Based on the **Figure 4.10**, the contact of granite and gneiss is the granite intrude into the gneiss rock bodies. Meanwhile, in **Figure 4.11** below, contact is obvious which the granite is situated at the bottom of the outcrop and at the top of the outcrop is gneiss. This proved that the granite are coming later as the intrusion produced by the magma intrusion into the rock bodies of gneiss.

Figure 4.11: The contact of granite and gneiss at station 3

In addition, the composition of the minerals in the granite through the hand lens is dominantly composed of quartz, biotite and feldspar. This granite is assumed to be formed together with the Kemahang Formation.

d) Station 4:

The location of the station 4 is located at Lakota or more specifically known as Kampung Air Tawar, Lakota. This location is located at the side of the East-West Highway and the coordinate is N 05° 43’ 53.8” E 101° 51’ 12.1”. The outcrop is at the river of the hill in the middle of the durian plantation. The grade of weathering is III which the outcrop there are moderately weathered since the outcrop already covered by plants which is biological weathering and also chemical weathering. The outcrops there have been identified as the intrusive igneous rock which is granite.

e) Station 5:

The coordinate of the station 5 is at the point of N 05° 42’ 31.1” E 101° 51’ 0.10”. The outcrop is obvious at the football field inside the Politeknik Jeli beside the Petronas Gas Station. The dimension of the outcrop is very large which the height is 16 meters and the width is 60 meters. Before this, the hill there was exploded by using the dynamite for the purpose of the construction of Politeknik Jeli which is one of the higher educational institution in Jeli. Due to that, the outcrop at the field exposed.

After the field observation, the outcrop have a few type of rocks which are the gneiss, granite and migmatite. Then, the previous volcanic activity causes many quartz veins in the outcrop. Fortunately, the outcrop at this station is very fresh and the structure can be observed clearly. The outcrop is shown in Figure **4.12**.

Figure 4.12: Outcrop at station 5

The observation to the sample of gneiss in this area is the foliation colour of grey and white alternating each other. There are some parts of this place which the granite intrude into the gneiss bodies due to the magmatic activity. The theory is the granite intrude when the gneiss from Taku-Schist formation was intruded with granite

from Kemahang Granite formation. Besides that, there is also migmatite which is the mixture of the metamorphic rock and igneous rock due to the high temperature and high pressure. The fold like shape of foliation found as the example in Figure **4.13**.

Figure 4.13: Fold-like shape of the foliation at outcrop at station 5

f) Station 6:

The coordinate of station 6 is located at the point of N 05° 43’ 2.30” E 101° 51’ 36.6”. Station 6 is located at the Lakota which is at the side of the East-West highway just beside the house of the citizen. The observation there indicate that the grade of weathering there is slightly weathered which is grade II. The outcrop is exposed there due to the cut of the slope for the construction purpose. After the field observation, the type of rock there is meta-sedimentary which phyllite. The outcrop in Figure **4.14**.

Figure 4.14: The exposed outcrop found at station 6

g) Station 7:

The coordinate for the station 7 is at the point of N 05° 41’ 44.0” E 101° 50’ 12.1”. The location of the station is at Sungai Pergau which located under the bridge that connects Kampung Seberang Jeli and Jeli Lama. There are a lot of outcrops exposed by the side of the river which shown in the **Figure 4.15**. The sample of the rock is quite fresh with the grade of weathering is at grade of II which is slightly weathered. This happened due to the laminar flow of the Sungai Pergau. The level of the river keep rising and decreasing frequently due to the nearer dam which is Pergau dam releases water twice a day.

Figure 4.15: Shows the outcrop at station 8

In field observation, the rock is meta-sedimentary which is phyllite rock and igneous rock which is granite. There are also some rock with metamorphic characteristics.

4.3.2 Hand Specimen and Field Identification

The specimen of the rock sample within the size of a hand collected from every station for further studies in the laboratory using microscopic analysis under light microscope. **Table 4.3** show the type of rock for every station.

Table 4.3: Type of rock for every station

Station	Type of Rock
1	Igneous rock
2	Igneous rock
3	Igneous rock
4	Igneous rock
5	Metamorphic rock and Igneous rock
6	Meta-sediment
7	Meta-sediment

Figure 4.16 shows the hand specimen of sample from station 1 which located at Bukit Lakota. The sample is really weathered which can be classified into class II which is moderately weathered. The grain size is coarse grain which can be seen through naked eyes. The specimen is light coloured or white with dark coloured biotite minerals. The rock is intrusive igneous rock.

Figure 4.16: Sample from station 1

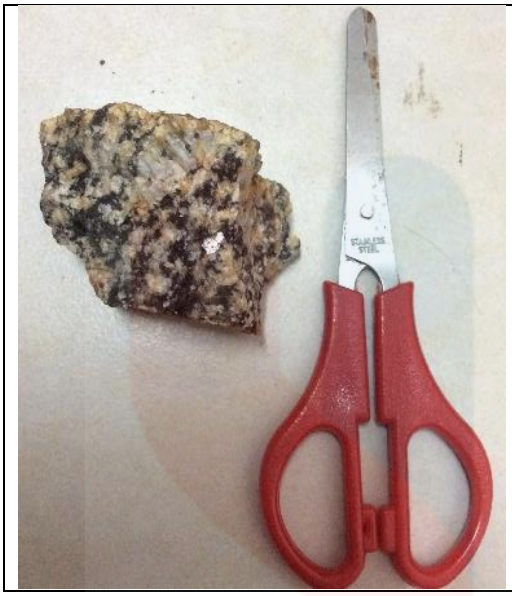


Figure 4.17 shows the hand specimen of sample from station 2 which is at rubber orchard in Lakota. The specimen of igneous rock is slightly weathered. The size of the grain is very coarse which the quartz and biotite minerals can be observed by naked eyes.

Figure 4.17: Sample from station 2

Figure 4.18 shows the hand specimen of rock sample at station 3 which located at a stream in front of Shell oil gas station. The sample is light in colour consisting of quartz, biotite, feldspar and etc. The size of the grain is medium and well sorted. The sample is intrusive igneous rock.

Figure 4.18: Sample from station 3

Figure 4.19 shows the hand specimen of rock sample at station 4 which is located at Kampung Air Tawar, Lakota. The sample is milky white in colour consisting of quartz, feldspar, granite and etc. The size of grain is medium and well sorted. The rock is moderately weathered. The sample is intrusive igneous rock.

Figure 4.19: Sample from station 4

Figure 4.20 shows the hand specimen of rock sample at station 5 which located at Politeknik Jeli. The colour of the rock is formed of alternating dark and light bands which is called foliation. The foliation indicate the process of metamorphism. The rock is metamorphic rock.

Figure 4.20: Sample from station 5

Figure 4.21 shows the hand specimen of rock sample at station 5 which is at Politeknik Jeli. The colour of the rock is dark colour. The sample contains the mixture of metamorphic and igneous texture. Somehow, the rock has slightly foliation band of dark and light minerals.

Figure 4.21: Sample from station 5

Figure 4.22 shows the hand specimen of rock sample at station 6 which located at the side of East-West highway in Lakota. The colour of the rock is dark brown of grey in colour. There are signs of previous bedding can be observed. The sample is fine grained in size. The rock is meta-sedimentary rock.

Figure 4.22: Sample from station 6

Figure 4.23 shows the hand specimen of rock sample at station 7 which located at Sungai Pergau, Seberang Jeli. The sample is light brown and grey in colour. The previous bedding of the rock can be observed. The rock is meta-sedimentary rock.

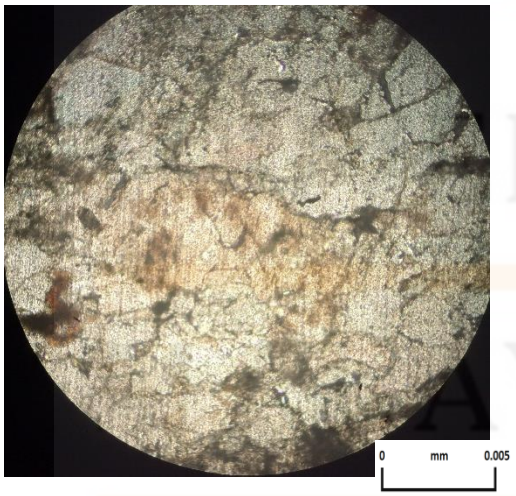
Figure 4.23: Sample from station 7

4.3.3 Petrography Analysis

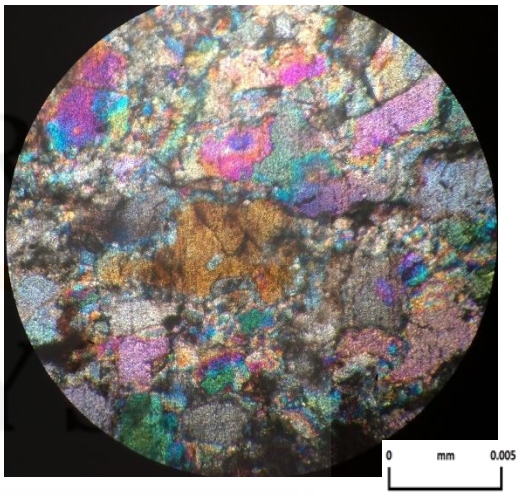
Location: N 05° 42’ 28.7” E 101° 49’ 57.8”

Name of rock: Microgranite (Plutonic rock)

In microscopic analysis, this rock sample consists of quartz, biotite and muscovite mineral. The left photograph is observed under light microscope under plane polarized light (PPL) and the right photograph is cross polarized light (XPL) (magnification 10X). The photograph under XPL is not clear due to the rock sample that is moderately weathered in condition. But, the mineral in this sample can be easily distinguished under XPL. The quartz are white to grey in colour under PPL and featureless under XPL. Muscovite is white to grain colour in PPL, but in XPL the mineral observed is pinkish, light green and light blue colour. Biotite mineral is observed to be light brown under PPL and in XPL the mineral seems to be in brown colour.



Plane Polarized Light (PPL)



Cross Polarized Light (XPL)

Figure 4.24: Plane Polarized Light (PPL) and Cross Polarized Light (XPL) of microgranite

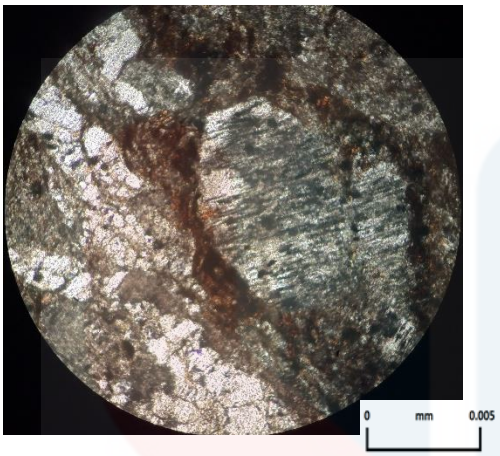
Table 4.4: Mineral description of microgranite

Name of rock: Microgranite		
Type of rock: Intrusive igneous rock		
Mineralogy Description		
Mineral composition	Total (%)	Description of mineral
Quartz	30	Quartz is typically the most transparent mineral in rocks. There is no cleavage and the mineral is high relief.
Muscovite	20	Muscovite is milky white to grey in PPL, but light pink, blue and green colour in XPL. There are some cleavage can been observed that distinguished muscovite with other minerals.
Biotite	10	Under microscope, this biotite mineral seems to be light brown in colour in PPL but appears to be brown colour in XPL.

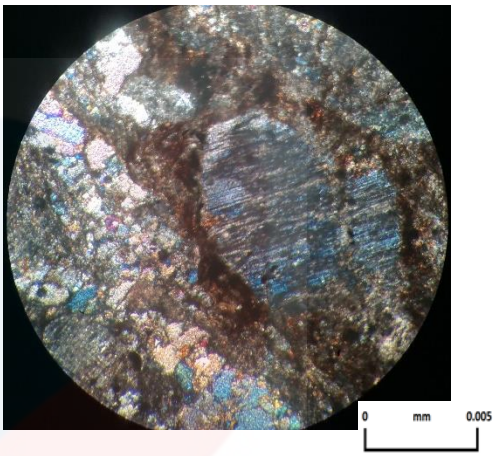
Location: N 05° 42’ 31.1” E 101° 51’ 0.1”

Name of rock: Migmatite

Under microscopic analysis (magnification 10X), the left photograph is the sample being observed in PPL, meanwhile in the right photograph is the sample being observed in XPL. The minerals that can be observed is quartz and muscovite. Quartz mineral is high in relief can be observed and distinguished in PPL. Muscovite mineral are colourless in PPL, but in XPL in light pink and light blue colour.



Plane Polarized Light (PPL)



Cross Polarized Light (XPL)

Figure 4.25: Plane Polarized Light (PPL) and Cross Polarized Light (XPL) of migmatite

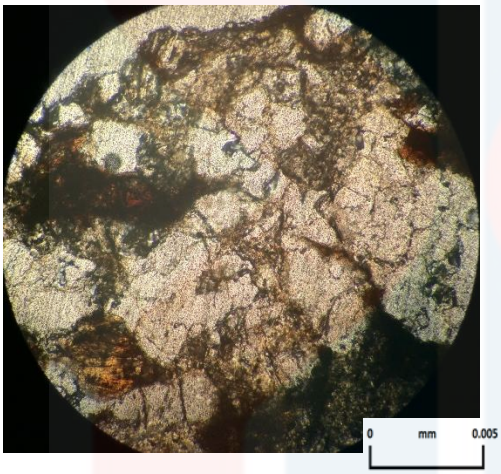
Table 4.5: Mineral description of migmatite

Name of rock: Migmatite		
Type of rock: Mixture of metamorphic and igneous rock		
Mineralogy Description		
Mineral composition	Total (%)	Description of mineral
Quartz	10	In this observation, quartz is white in PPL and shiny in XPL which can be distinguished with plagioclase which is milky white in PPL.
Muscovite	30	Muscovite mineral shape is euhedral with perfect zoning. The mineral is light pink and blue in colour under XPL.

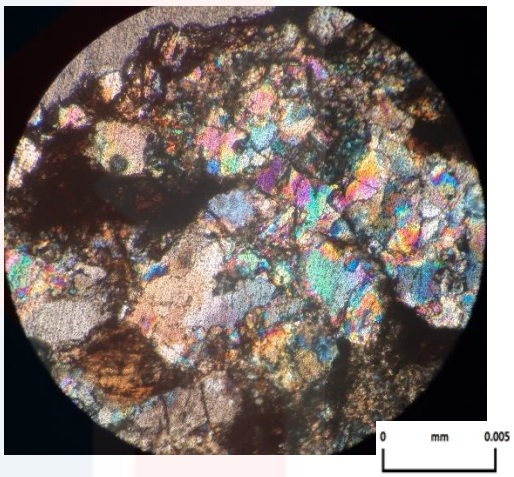
Location: N 05° 43’ 13.1” E 101° 50’ 47.4”

Name of rock: Granite (Plutonic rock)

In microscopic analysis (magnification 10X), the minerals consist in the specimen is the quartz, tourmaline and muscovite. The crystal faces in this observation is subhedral which is partially formed. The dark area in this thin section is due to the weathering that occurred at the sample of rock. Tourmaline mineral is yellow in colour in both in PPL and XPL observation.



Plane Polarized Light (PPL)



Cross Polarized Light (XPL)

Figure 4.26: Plane Polarized Light (PPL) and Cross Polarized Light (XPL) of granite

Table 4.6: Mineral description of granite

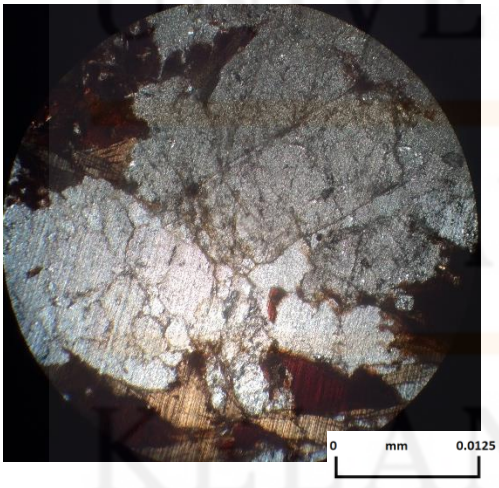
Name of rock: Granite		
Type of rock: Intrusive igneous rock		
Mineralogy Description		
Mineral composition	Total (%)	Description of mineral
Quartz	10	The mineral with high relief which happen to let the light to pass through in PPL.

Muscovite	20	Muscovite that is light pink and light blue colour observed in XPL. There are cleavages that can be observed in this minerals.
Tourmaline	5	Tourmaline is an aluminium rich ferromagnesian mineral that can be observed in the thin section with yellow colour.

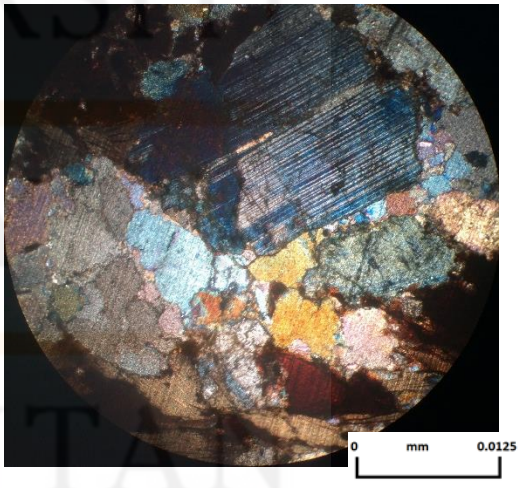
Location: N 05° 43’ 39.6” E 101° 52’ 5.8”

Name of rock: Coarse-grain granite (Plutonic rock)

These are photographs of a thin section of coarse grain granite (magnification 10X). By comparing the plane polarized light (Left) and crossed polarizer (Right) images, the minerals consist in there can be distinguished which are quartz, muscovite, biotite and plagioclase. The plagioclase mineral has twinning in dark blue colour. Meanwhile, the dark coloured minerals is biotite.



Plane Polarized Light (PPL)



Cross Polarized Light (XPL)

Figure 4.27: Plane Polarized Light (PPL) and Cross Polarized Light (XPL) of coarse-grain granite

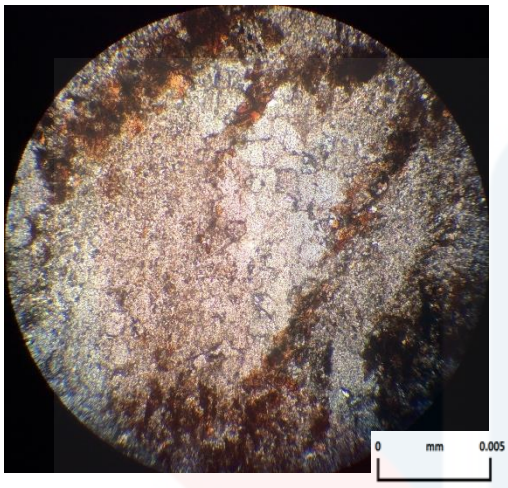
Table 4.7: Mineral description of coarse-grain granite

Name of rock: Coarse grain granite		
Type of rock: Intrusive igneous rock		
Mineralogy Description		
Mineral composition	Total (%)	Description of mineral
Quartz	10	Quartz mineral coloured white to grey in PPL but light brown in the XPL.
Biotite	15	Biotite mineral can be distinguished with the other mineral which is this mineral is dark in colour.
Muscovite	10	Muscovite is white to grey in PPL but in light pink and light blue in XPL.
Plagioclase	10	Plagioclase mineral is very common in igneous rock. This mineral is colourless in PPL but dark blue in XPL. There is twinning in this mineral.

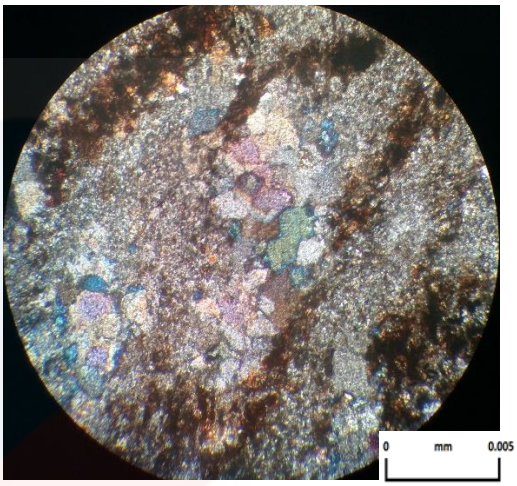
Location: N 05° 42’ 31.1” E 101° 51’ 0.1”

Name of rock: Gneiss

This specimen of rock sample is taken at Politeknik Jeli which is by the side of the East-West highway. Under microscopic analysis which the magnification is 10X, the sample of rock is observe under PPL and XPL to distinguish the minerals contents. This sample consists of minerals quartz, feldspar, muscovite and biotite. The dark minerals in the rock sample is biotite.



Plane Polarized Light (PPL)



Cross Polarized Light (XPL)

Figure 4.28: Plane Polarized Light (PPL) and Cross Polarized Light (XPL) of gneiss

Table 4.8: Mineral description of gneiss

Name of rock: Gneiss		
Type of rock: Metamorphic rock		
Mineralogy Description		
Mineral composition	Total (%)	Description of mineral
Quartz	20	High relief mineral that can be observed in white or grey colour in PPL.
Feldspar	10	Colourless in PPL but grey/black/white in XPL.
Muscovite	10	Colourless in PPL but light blue/pink in XPL.
Biotite	10	Dark mineral in the sample of rock.

4.3.4 Stratigraphy

Based on the **Table 4.9**, the age of the rock is shown in the lithostratigraphic column. The granite that are vastly found in the study area are referred to be a part of the Kemahang Granite Formation. Meanwhile, the gneiss found in this study area are related with the Taku-Schist formation and this formation had been intrude by the Kemahang Granite formation and resulting large scale of Cretaceous biotite with age of 124 Ma.

Table 4.9: The lithostratigraphic column in study area

AGE		ROCK UNIT IN STUDY AREA	DESCRIPTION
ERA	PERIOD		
CENOZOIC	QUATERNARY	ALLUVIUM	Alluvium Unit: Unconsolidated soil/sediment that has been eroded, reshaped by water which located at Pergau River.
MESOZOIC	TRIASSIC	GRANITE	Granite Unit: Consists of foliated granite, coarse-grained granite, and microgranite (including some schist).
		PHYLLITE	Phyllite: Consists of argillite, low grade metasedimentary and meta-volcanic rocks.
		GNEISS	Gneiss: Consists of metamorphic rocks such as gneiss and migmatite.

4.4 Structural Geology

During geological mapping, there are several places where the fresh outcrops exposed to the surface where the structural geology can be observed. In the study area, there are several set of joint found and recorded. A joint is a crack of natural origin in the continuity of either a layer or rock body that do not have any measureable parallel to the surface or plane of the fracture. Usually, the joints occur as joint sets and systems. **Figure 4.29** shows the joints that is found at the study area.

Figure 4.29: Joints at the study area

4.4.1 Joint Analysis

To determine the direction of force which acted on a rock mass, the joint analysis is required. In geological point of view, the fracturing and discontinuities for a joint analysis is among the important properties of rock that need to be observed.

Most of the outcrop that are exposed at the ground surface have fractures and discontinuities. Then, by using rose diagram analysis, the strike of joint or fracture of a rock can be interpreted. Based on the **Figure 4.30**, the maximum stress on the rock comes from the Northeast and Southwest of the study area.

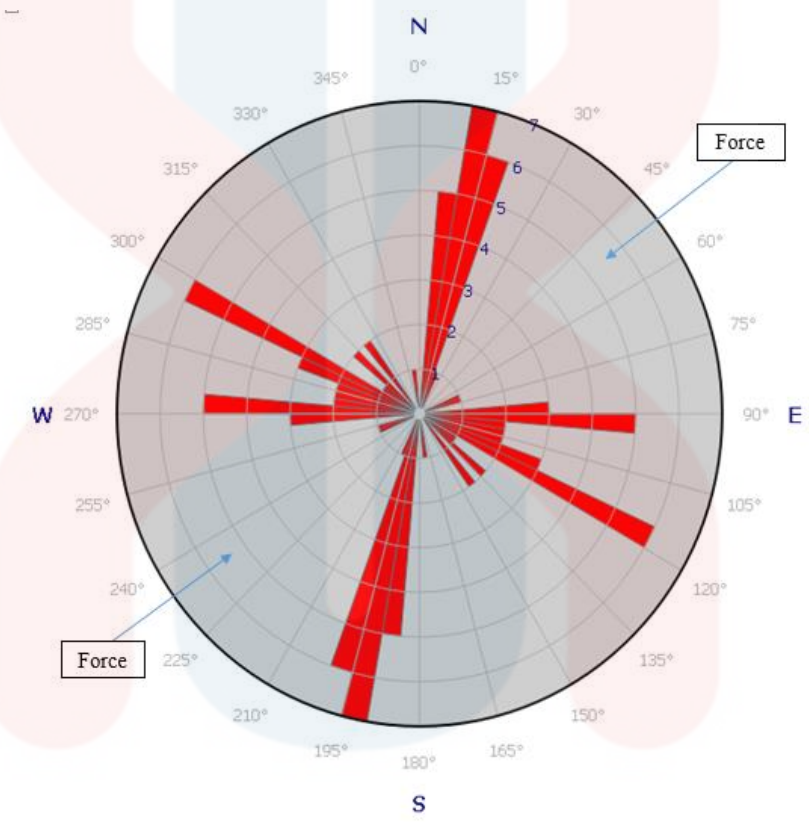


Figure 4.30: Rose diagram at the study area

4.4.2 Lineament Analysis

Lineament are defined as linear surface features that is mappable, which differ clearly from the patterns of adjacent features and probably reflect unseen underground phenomena. The subsurface effect is controlled by the structures of geological like fault and fold. Lineament also affect the morphology of an area such as the existence of streams, channels and construction of roads.

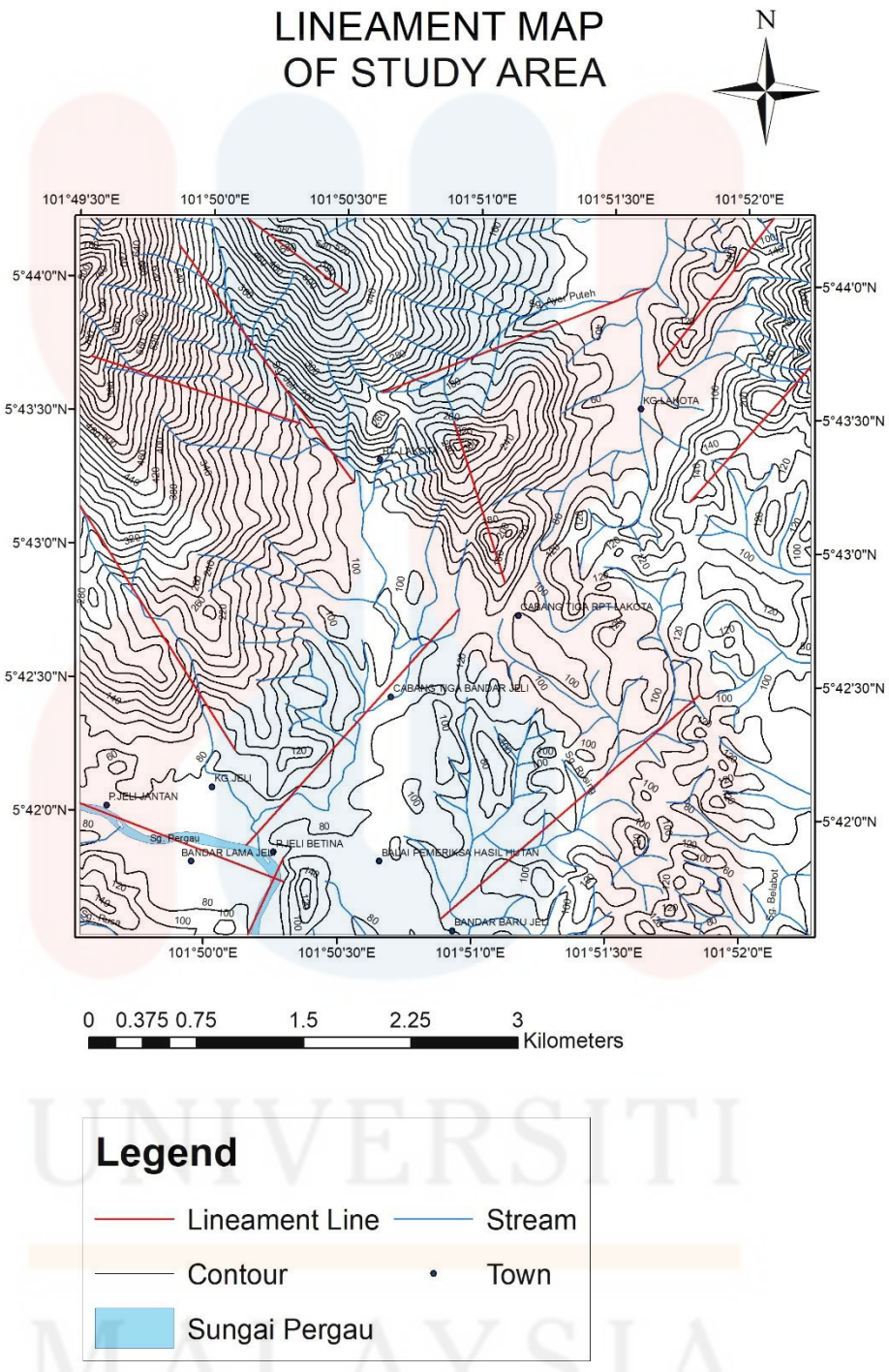


Figure 4.31: Lineament line drawn in the lineament map of study area

4.4.3 Fault Analysis

Fault is defined as the fracture or break along the crust of the Earth that occur when the forces that holding the rock had been overcomes by the shear stress on a rock. In addition, fault is an important role in changing the pattern of lineament and morphology of an area. Normally, fault can be found by observing the lineament line in the satellite or aerial image during desk study. This geological feature also can be found during geological mapping and field observation activity.

In the study area, the fault can be identified during desk study, which the lineament line lies along Sungai Pergau. The type of fault there is strike slip fault that moves horizontally. The direction of the movement indicate the right lateral fault of left lateral fault. The fault is recognized due to the 90° of angle that formed on the river observed by the aerial image indicates the fault had happened in ancient time.

4.5 Historical Geology

There are two formations that are presence in the study area which are the Kemahang Granite formation and Taku-Schist Formation. Based on the research by Macdonald (1967), Kemahang Granite was formed during Triassic. During Triassic period, the Sukhirin Granite can be correlated with Tan Yong Granite pluton that resulted from the intrusion of Sukhirin Granite. Meanwhile, the Taku-Schist formation had been intruded by Kemahang Granite and resulted large scale of Cretaceous biotite with age of 124 Ma which existed since the era of Pre-Cambrian.

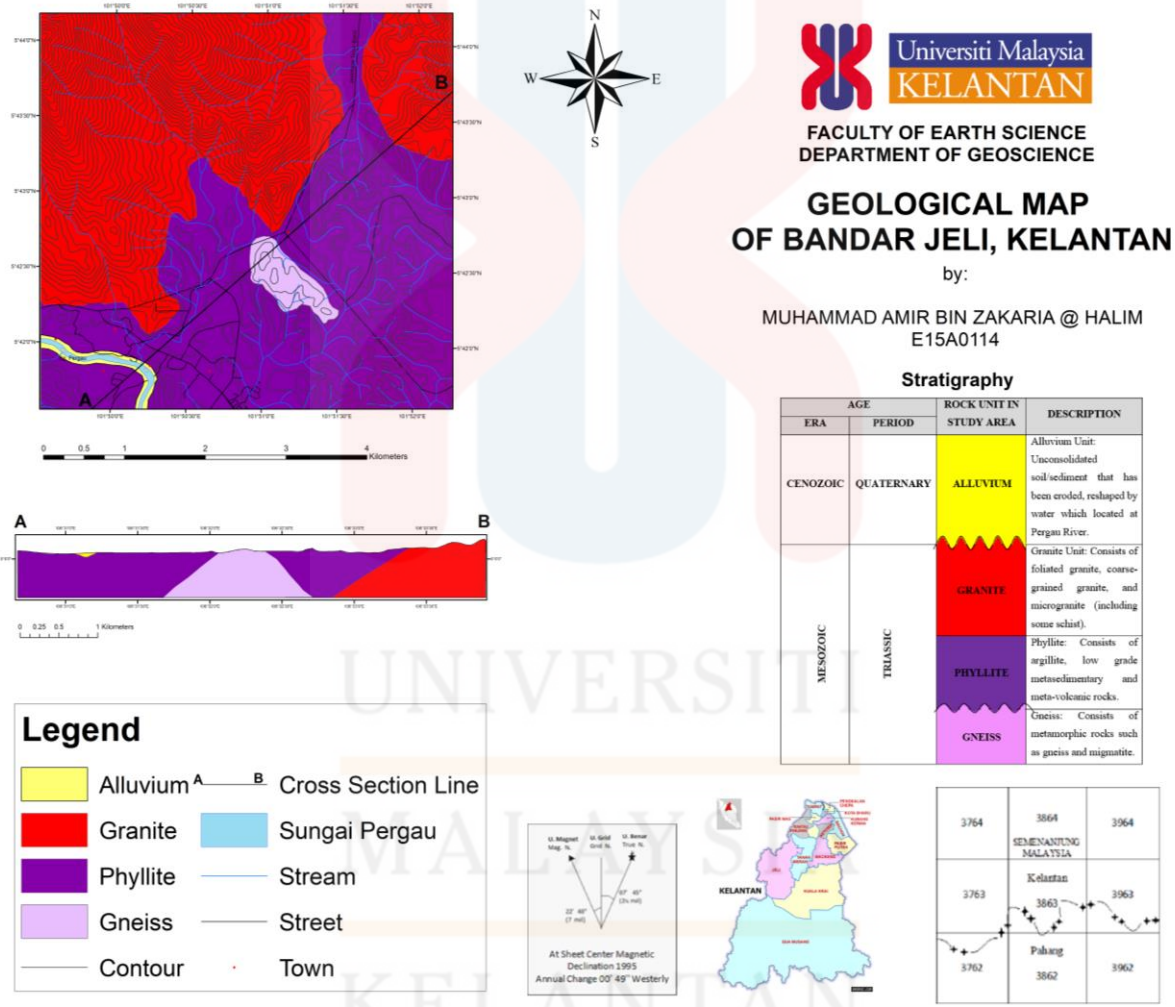


Figure 4.32: Geological Map of Bandar Jeli, Kelantan

CHAPTER 5

ASSESSMENT OF SOIL STRENGTH

5.1 Specification

Before start construction of any building, site investigation is first conducted. This is because the condition of the soil at that particular site for construction need to be evaluated to determine suitable foundation use for the building of any construction. The soil play a very vital role since the soil is the support for the load constructed on the surface of Earth and the load on the surface will be transferred directly to the ground. Therefore, the site investigation of the soil is very vital to ensure the soil is capable to withstand the load transfer to the soil.

In this research, the Mackintosh probe is used as a method to evaluate the soil strength. The Mackintosh probe is relatively inexpensive and a simple procedure needed to run the site investigation. This probe is commonly used in Malaysia, especially for preliminary site investigation, which in purpose to assess the subsoil layer and the bearing capacity of the soils. To identify soft or weak materials or slip plane can be evaluate by the method of Mackintosh probe test. As a result, the consumption of this probe may reduce the number of bore holes required and directly decrease the overall cost for the project.

5.2 Discussion

In this section, results acquired from the Mackintosh Probe test are discussed. The results are presented in form of tables and graphs. In addition, the location of the tests were carried out will be presented by a map. **Figure 5.1** shows the map that has the location tests were carried out. **Table 5.1** shows the coordinate for every position of Mackintosh probe test was carried out.

Table 5.1: The coordinate for every position of test carried out

Position No.	Coordinate
Jeli 1	N 05° 43’ 51.6” E 101° 51’ 46.0”
Jeli 2	N 05° 41’ 45.8” E 101° 50’ 14.5”
Jeli 3	N 05° 42’ 18.3” E 101° 51’ 36.2”
Jeli 4	N 05° 42’ 21.6” E 101° 50’ 52.2”
Jeli 5	N 05° 42’ 17.6” E 101° 49’ 59.7”

According to the data in the **Figure 5.2**, **Figure 5.3**, **Figure 5.4**, **Figure 5.5**, and **Figure 5.6**, the layer of the soil is weaker at the upper 5 meters which is consider to be the layer of the soft clay. This is because when the Mackintosh probe being pulled out after reached the impermeable layer, the mud covered the rod of Mackintosh probe. The point of depth with less than 40 blows is considered to be contain a groundwater mix with the soil.

However, the depth below of 5 meters are considered to be stronger soil which this depth can be considered contain a bedrock or stronger soil. The penetrating test that has been done in Bandar Jeli is mostly not over than 10 meters depth due to the lithological of the area which is the intrusive igneous rock and metamorphic.

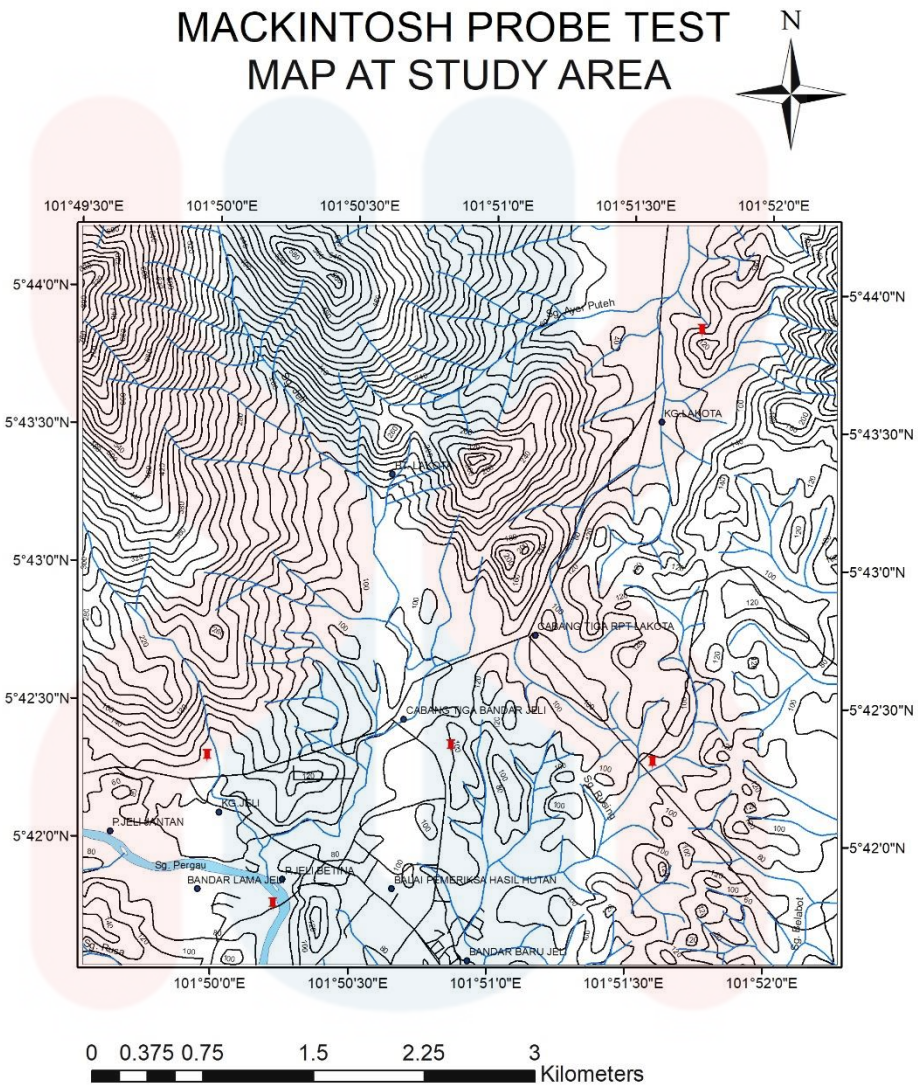
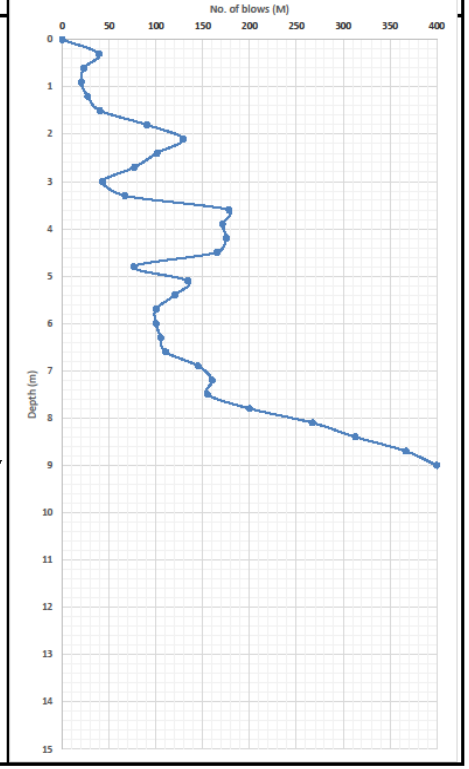


Figure 5.1: Location of Mackintosh Probe test

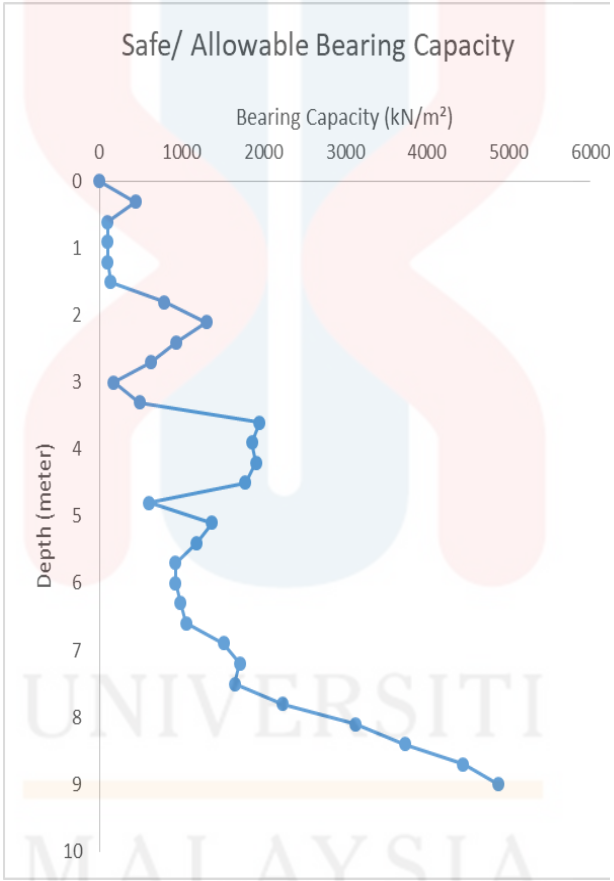
MACKINTOSH PROBE TEST

Project :	MACKINTOSH PROBES TEST FOR FINAL YEAR PROJECT BANDAR JELI, JAJAHAN JELI KELANTAN DARUL NAIM.
Position No.	JELI 1
Coordinate	N 05° 44' 51.6", E 101° 51' 46"
Reduced Level	Existing G.L.
Date	31/10/2018

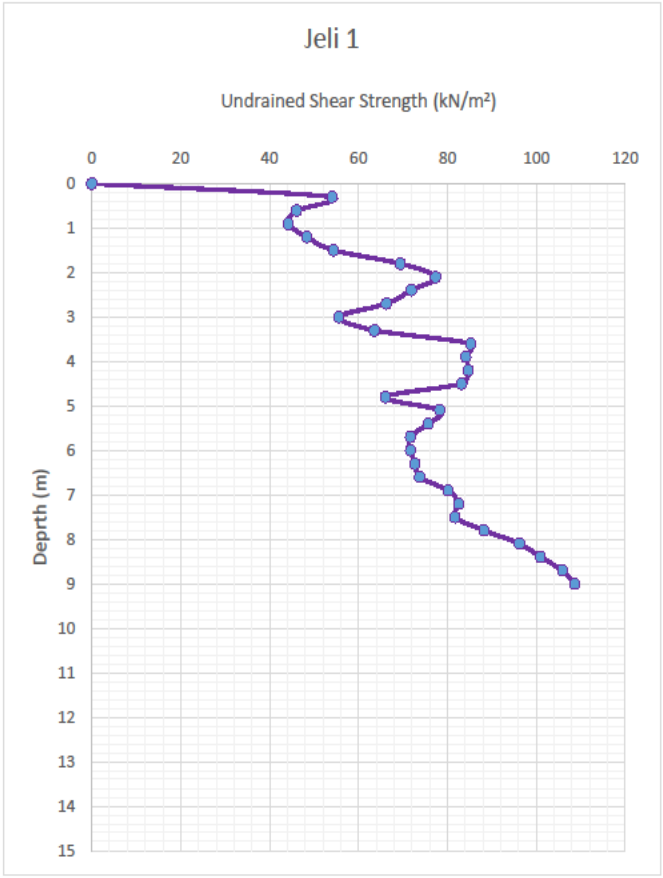
Depth (m)	No of Blows
0.0 - 0.3	0
0.3 - 0.6	39
0.6 - 0.9	23
0.9 - 1.2	20
1.2 - 1.5	27
1.5 - 1.8	40
1.8 - 2.1	90
2.1 - 2.4	129
2.4 - 2.7	101
2.7 - 3.0	77
3.0 - 3.3	43
3.3 - 3.6	67
3.6 - 3.9	178
3.9 - 4.2	171
4.2 - 4.5	175
4.5 - 4.8	165
4.8 - 5.1	76
5.1 - 5.4	134
5.4 - 5.7	120
5.7 - 6.0	100
6.0 - 6.3	100
6.3 - 6.6	105
6.6 - 6.9	110
6.9 - 7.2	145
7.2 - 7.5	160
7.5 - 7.8	155
7.8 - 8.1	200
8.1 - 8.4	267
8.4 - 8.7	313
8.7 - 9.0	367
9.0 - 9.3	400
9.3 - 9.6	
9.6 - 9.9	(14cm)
9.9 - 10.2	
10.2 - 10.5	
10.5 - 10.8	
10.8 - 11.1	
11.1 - 11.4	
11.4 - 11.7	
11.7 - 12.0	
12.0 - 12.3	
12.3 - 12.6	
12.6 - 12.9	
12.9 - 13.2	
13.2 - 13.5	
13.5 - 13.8	
13.8 -14.1	
14.1 - 14.4	
14.4 - 14.7	
14.7 - 15.0	
G.W.L(m)	



Graph of Mackintosh probe test



Graph of safe/allowable bearing capacity



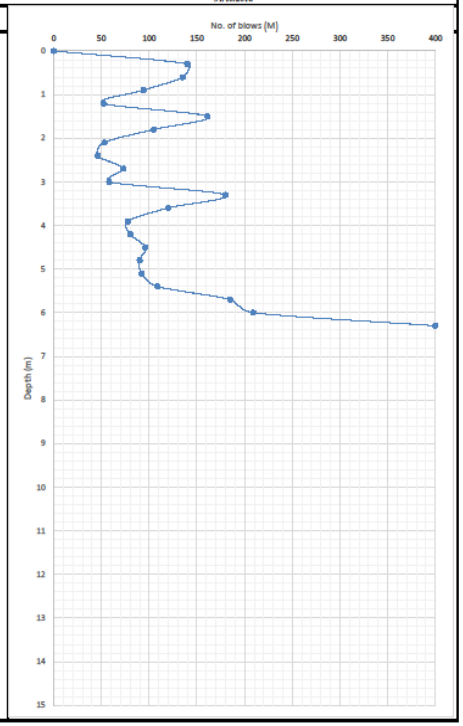
Graph of undrained shear strength

Figure 5.2: Graphs for the results for location Jeli 1

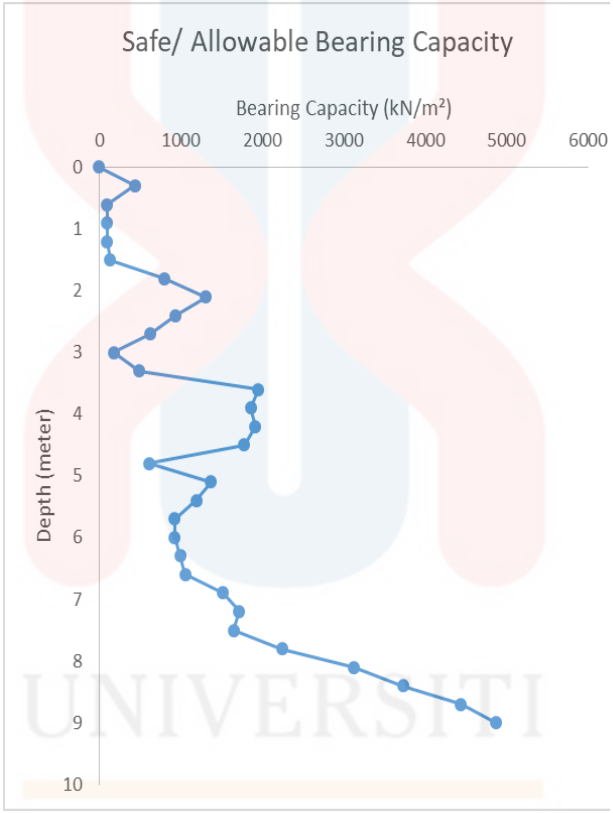
MACKINTOSH PROBE TEST

Project :	MACKINTOSH PROBES TEST FOR FINAL YEAR PROJECT BANDAR JELI, JAJAHAN JELI, KELANTAN DARUL NAIM
Position No.	JELI 2
Coordinate	N 05° 41' 45.8", E 101° 50' 14.5"
Reduced Level	Basing G.L.
Date	31/10/2018

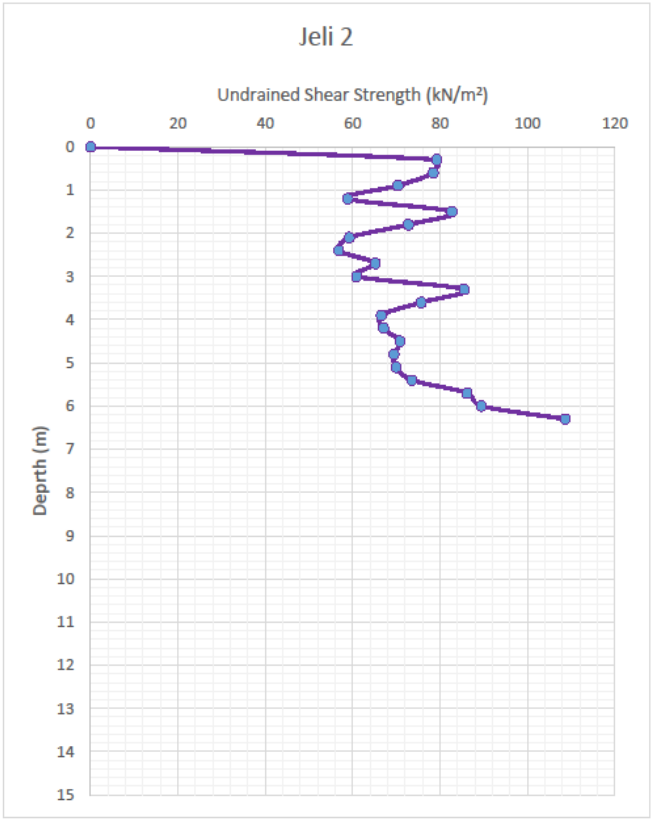
Depth (m)	No of Blows
0.0 - 0.3	0
0.3 - 0.6	140
0.6 - 0.9	135
0.9 - 1.2	94
1.2 - 1.5	52
1.5 - 1.8	161
1.8 - 2.1	105
2.1 - 2.4	53
2.4 - 2.7	46
2.7 - 3.0	73
3.0 - 3.3	58
3.3 - 3.6	180
3.6 - 3.9	120
3.9 - 4.2	78
4.2 - 4.5	80
4.5 - 4.8	96
4.8 - 5.1	90
5.1 - 5.4	92
5.4 - 5.7	109
5.7 - 6.0	185
6.0 - 6.3	209
6.3 - 6.6	480
6.6 - 6.9	
6.9 - 7.2	(2 cm)
7.2 - 7.5	
7.5 - 7.8	
7.8 - 8.1	
8.1 - 8.4	
8.4 - 8.7	
8.7 - 9.0	
9.0 - 9.3	
9.3 - 9.6	
9.6 - 9.9	
9.9 - 10.2	
10.2 - 10.5	
10.5 - 10.8	
10.8 - 11.1	
11.1 - 11.4	
11.4 - 11.7	
11.7 - 12.0	
12.0 - 12.3	
12.3 - 12.6	
12.6 - 12.9	
12.9 - 13.2	
13.2 - 13.5	
13.5 - 13.8	
13.8 -14.1	
14.1 - 14.4	
14.4 - 14.7	
14.7 - 15.0	
G.W.L.(m)	



Graph of Mackintosh probe test



Graph of safe/allowable bearing capacity



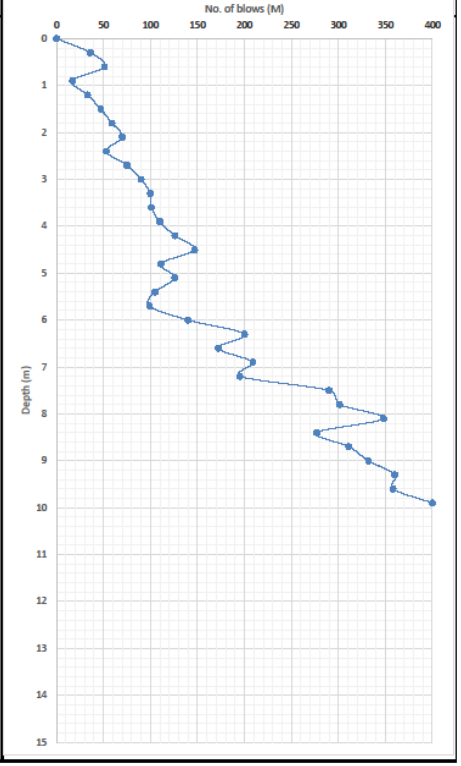
Graph of undrained shear strength

Figure 5.3: Graphs for the results for location Jeli 2

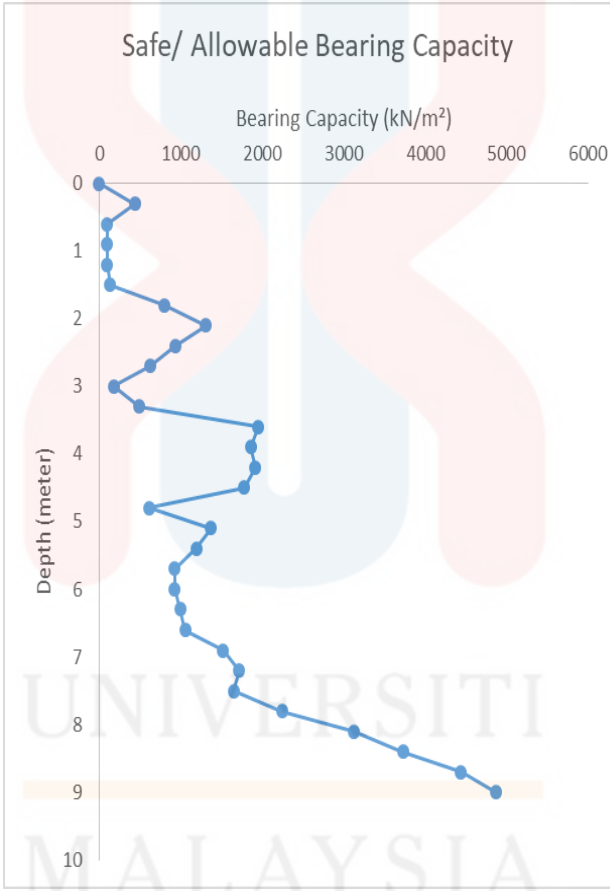
MACKINTOSH PROBE TEST

Project :	MACKINTOSH PROBES TEST FOR FINAL YEAR PROJECT BANDAR JELI, JAJAHAN JELI, KELANTAN DARUL NAIM.
Position No.	JELI 3
Coordinate	N 05° 42' 18.2", E 101° 51' 36.2"
Reduced Level	Existing G.L.
Date	31/10/2018

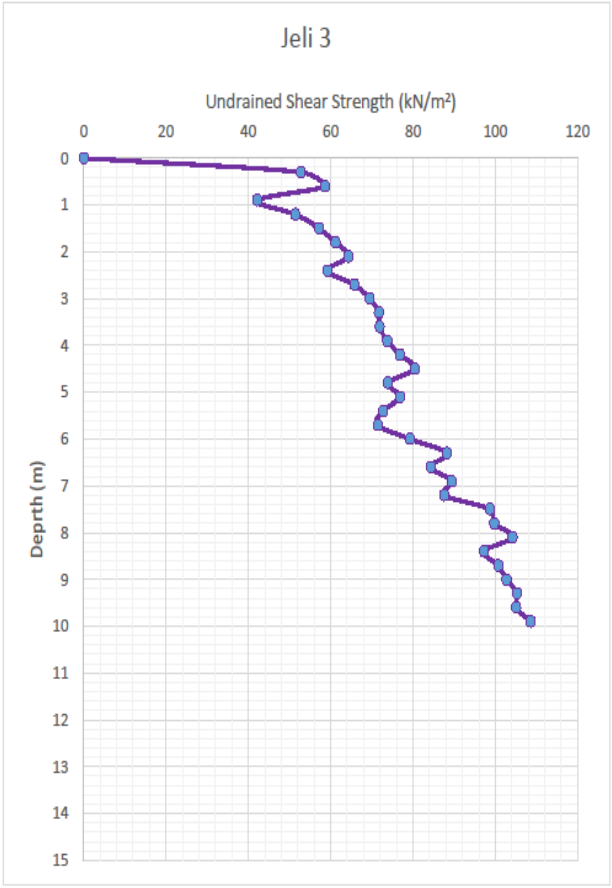
Depth (m)	No of Blows
0.0 - 0.3	0
0.3 - 0.6	36
0.6 - 0.9	51
0.9 - 1.2	17
1.2 - 1.5	33
1.5 - 1.8	47
1.8 - 2.1	59
2.1 - 2.4	70
2.4 - 2.7	53
2.7 - 3.0	75
3.0 - 3.3	90
3.3 - 3.6	100
3.6 - 3.9	101
3.9 - 4.2	110
4.2 - 4.5	126
4.5 - 4.8	147
4.8 - 5.1	111
5.1 - 5.4	126
5.4 - 5.7	105
5.7 - 6.0	99
6.0 - 6.3	140
6.3 - 6.6	200
6.6 - 6.9	172
6.9 - 7.2	209
7.2 - 7.5	195
7.5 - 7.8	290
7.8 - 8.1	301
8.1 - 8.4	348
8.4 - 8.7	277
8.7 - 9.0	311
9.0 - 9.3	332↓
9.3 - 9.6	360
9.6 - 9.9	358
9.9 - 10.2	400↓
10.2 - 10.5	
10.5 - 10.8	(15CM)
10.8 - 11.1	
11.1 - 11.4	
11.4 - 11.7	
11.7 - 12.0	
12.0 - 12.3	
12.3 - 12.6	
12.6 - 12.9	
12.9 - 13.2	
13.2 - 13.5	
13.5 - 13.8	
13.8 -14.1	
14.1 - 14.4	
14.4 - 14.7	
14.7 - 15.0	
G.W.L.(m)	



Graph of Mackintosh probe test



Graph of safe/allowable bearing capacity

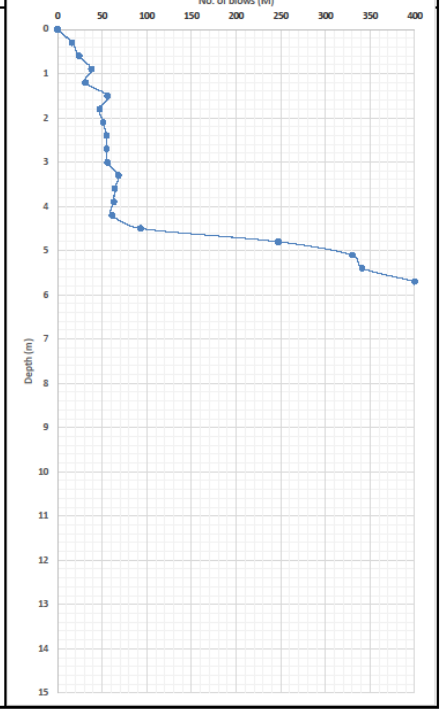


Graph of undrained shear strength

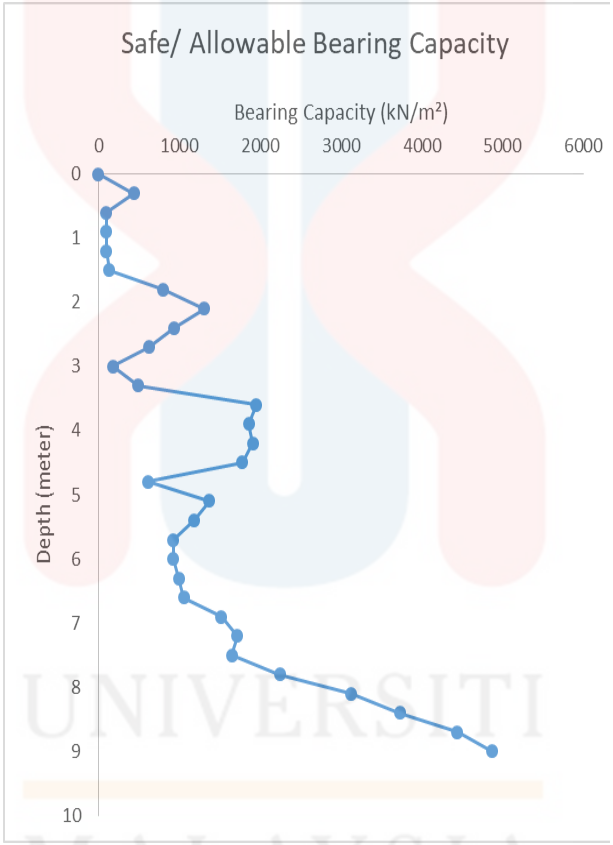
Figure 5.4: Graphs for the results for location Jeli 3

MACKINTOSH PROBE TEST

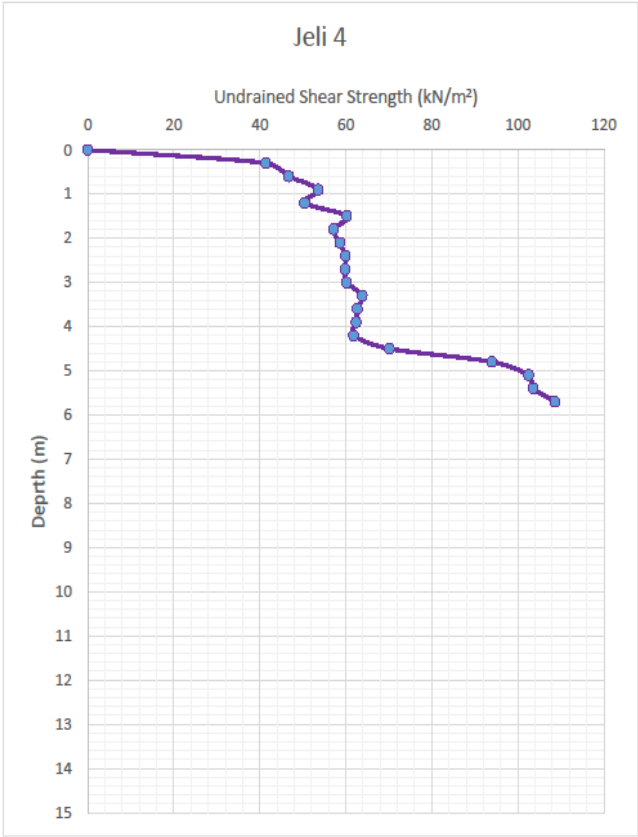
Project :	MACKINTOSH PROBES TEST FOR FINAL YEAR PROJECT BANDAR JELI, JAJAHAN JELI, KELANTAN DARUL NAIM.	
Position No.	JELI 4	
Coordinate	N 05° 42' 21.6", E 101° 50' 52.3"	
Reduced Level	Existing G.L.	
Date	31/10/2018	
Depth (m)	No of Blows	
0.0 - 0.3	0	
0.3 - 0.6	16	
0.6 - 0.9	24	
0.9 - 1.2	38	
1.2 - 1.5	31	
1.5 - 1.8	56	
1.8 - 2.1	47	
2.1 - 2.4	51	
2.4 - 2.7	55	
2.7 - 3.0	55	
3.0 - 3.3	56	
3.3 - 3.6	68	
3.6 - 3.9	64	
3.9 - 4.2	6361	
4.2 - 4.5	93	
4.5 - 4.8	247	
4.8 - 5.1	330	
5.1 - 5.4	341	
5.4 - 5.7	400+	
5.7 - 6.0		
6.0 - 6.3	(9cm)	
6.3 - 6.6		
6.6 - 6.9		
6.9 - 7.2		
7.2 - 7.5		
7.5 - 7.8		
7.8 - 8.1		
8.1 - 8.4		
8.4 - 8.7		
8.7 - 9.0		
9.0 - 9.3		
9.3 - 9.6		
9.6 - 9.9		
9.9 - 10.2		
10.2 - 10.5		
10.5 - 10.8		
10.8 - 11.1		
11.1 - 11.4		
11.4 - 11.7		
11.7 - 12.0		
12.0 - 12.3		
12.3 - 12.6		
12.6 - 12.9		
12.9 - 13.2		
13.2 - 13.5		
13.5 - 13.8		
13.8 -14.1		
14.1 - 14.4		
14.4 - 14.7		
14.7 - 15.0		
G.W.L.(m)		



Graph of Mackintosh probe test



Graph of safe/allowable bearing capacity



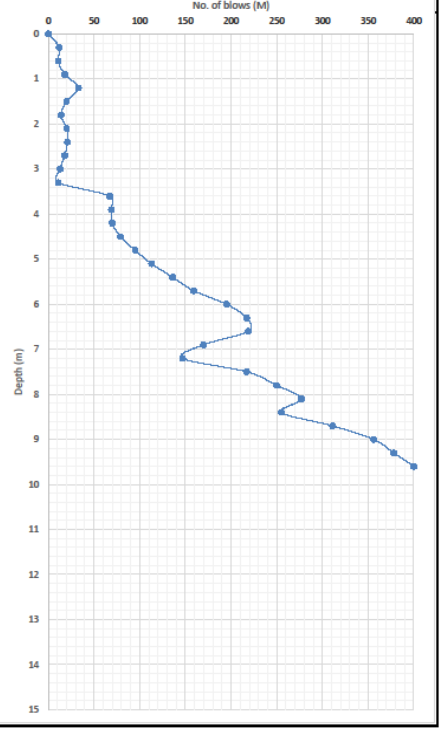
Graph of undrained shear strength

Figure 5.5: Graphs for the results for location Jeli 4

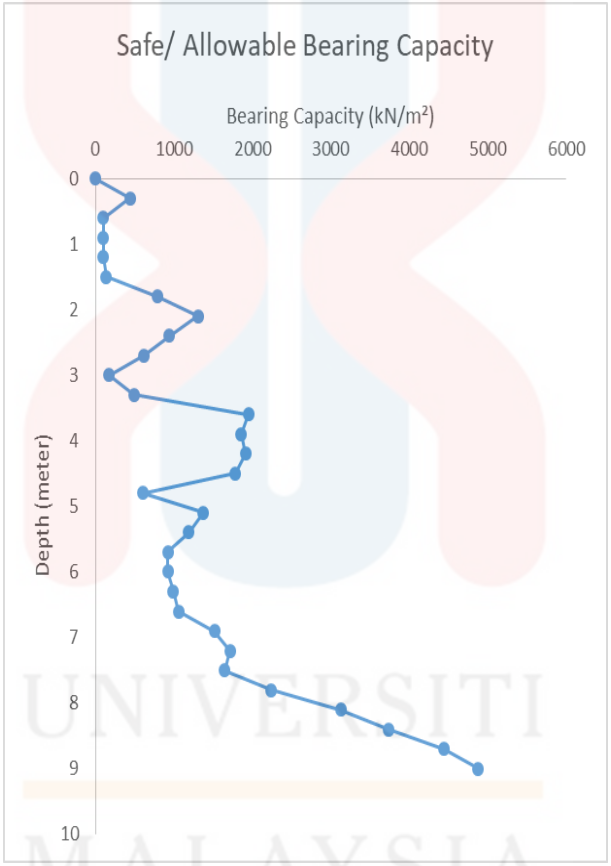
MACKINTOSH PROBE TEST

Project :	MACKINTOSH PROBES TEST FOR FINAL YEAR PROJECT BANDAR JELI, JAJAHAN JELI, KELANTAN DARUL NAIM.
Position No.	JELI 5
Coordinate	N 05° 42' 17.6", E 101° 49' 59.7"
Reduced Level	Existing G.L.
Date	31/10/2018

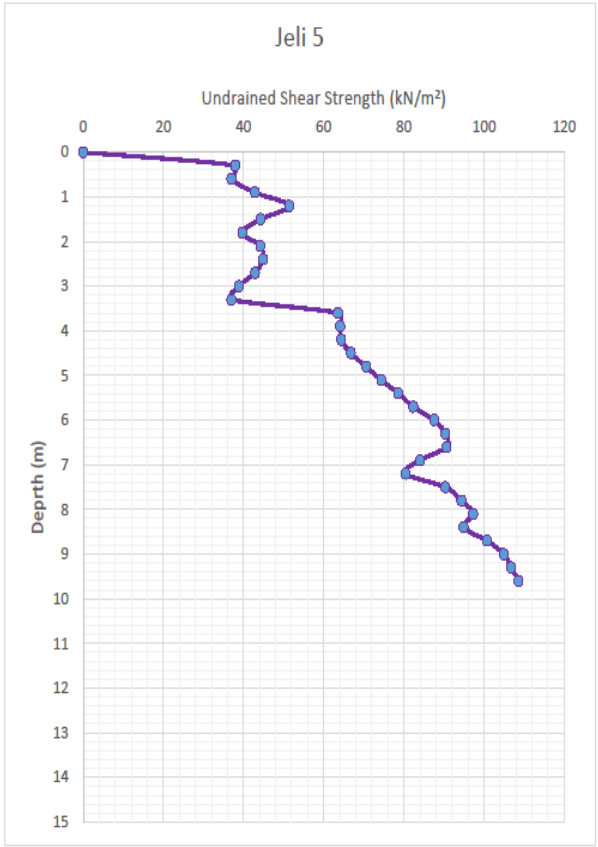
Depth (m)	No of Blows
0.0 - 0.3	0
0.3 - 0.6	12
0.6 - 0.9	11
0.9 - 1.2	18
1.2 - 1.5	33
1.5 - 1.8	20
1.8 - 2.1	14
2.1 - 2.4	20
2.4 - 2.7	21
2.7 - 3.0	18
3.0 - 3.3	13
3.3 - 3.6	11
3.6 - 3.9	67
3.9 - 4.2	69
4.2 - 4.5	70
4.5 - 4.8	79
4.8 - 5.1	95
5.1 - 5.4	113
5.4 - 5.7	136
5.7 - 6.0	159
6.0 - 6.3	195
6.3 - 6.6	217
6.6 - 6.9	219
6.9 - 7.2	170
7.2 - 7.5	147
7.5 - 7.8	217
7.8 - 8.1	250
8.1 - 8.4	277
8.4 - 8.7	255
8.7 - 9.0	311
9.0 - 9.3	356
9.3 - 9.6	378
9.6 - 9.9	400 +
9.9 - 10.2	
10.2 - 10.5	
10.5 - 10.8	
10.8 - 11.1	
11.1 - 11.4	
11.4 - 11.7	
11.7 - 12.0	
12.0 - 12.3	
12.3 - 12.6	
12.6 - 12.9	
12.9 - 13.2	
13.2 - 13.5	
13.5 - 13.8	
13.8 -14.1	
14.1 - 14.4	
14.4 - 14.7	
14.7 - 15.0	
G.W.L.(m)	



Graph of Mackintosh probe test



Graph of safe/allowable bearing capacity



Graph of undrained shear strength

Figure 5.6: Graphs for the results for location Jeli 5

Parametric studied of previous proposed correlation

A parametric study was conducted in order to verify the previous proposed equation and make comparisons with the researchers that made the correlation. **Figure 5.7** shows the graph of the comparison between the correlations made by relating the relationship between the undrained shear strength and the blows of the Mackintosh probe or JKR probe which these two probes assume to be similar in application and results.

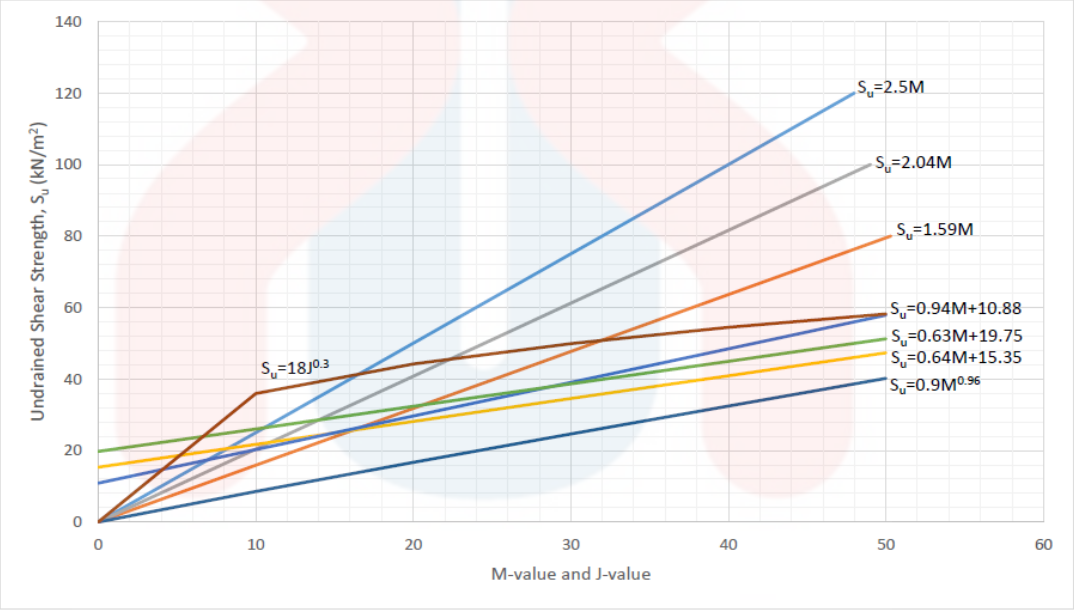


Figure 5.7: The comparison of the previous correlation for Mackintosh probe

Unfortunately, this research cannot produce the latest correlation for the Mackintosh probe due to the no other penetrating probe that can be used to correlate with the blows of the Mackintosh probe. However, the results of the undrained shear strength versus the depth is produced by referring from the equation that produced by Universiti Tun Hussein Onn Malaysia which is as follows:

$$S_u = 18J^{0.3}$$

Undrained Shear Strength (S_u) profiles:

As the number of blows for every location had been recorded, then the results of the undrained shear strength for every locations calculated by the equation of:

$$S_u = 18J^{0.3}$$

The data have been presented by the graph of undrained shear strength versus depth to represent the undrained shear strength profiles. Undrained shear strength profiles, including upper and lower bounds, were developed for each site based on the results of the laboratory and field tests. Representative undrained shear strength profiles were selected based on judgment and the evaluation and interpretation of results of field and laboratory tests. These profiles are referred to as the average undrained shear strength profiles. The results are show in the form of graph as follows:

According to the analysed data, overall the data show that the first 5 meters of the soil is classified as soft rock. This due to the denudation that happen previously. Instead, the depth over than 5 meters are higher in undrained shear strength which indicated that the bottom layer the soil may be a hard soil or even a bedrock. Overall, Jeli area is a suitable soil foundation for urbanisation and development.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The following conclusions can ca inferred as:

The main purpose of this research is to produce an updated geological map of the study area which is located at Bandar Jeli, Jeli, in Kelantan. The study area is dominated with intrusive igneous rocks which is granite at the hilly areas around Jeli. Meanwhile, the presence of the metamorphic rock at the centre of the map of the study area which is the metamorphic rocks there are gneiss and migmatite. For the geomorphology part, the study area is categorizes as hilly area where elevation in the study area is higher elevation compared to other places. The intrusion of the granite causing the area to have many meta-sedimentary rocks like phyllite. The historical geology for the study area can be said due to the volcanic activity and intrusion of magma.

The second part of the task in this research is to assess the soil strength in the study area by using Mackintosh probe test. The analysis of the site investigation is very vital thing to do in geotechnical purpose for construction of building. This analysis is to have the assessment on the soil strength. After the calculation had been made by using the correlation constructed by the researchers from Universiti Tun Hussein Onn Malaysia which is $S_u = 18J^{0.3}$,the results showed that the upper 5 meters

of the soil layer is the weaker layer that may be soft clay or soft soil. Then, in the next depth the undrained shear strength is quite high that indicated that the soil below the depth of 5 meters is stronger that may be the layer is igneous rock or another hard rock. Overall, the soil strength in Bandar Jeli is suitable for the development and urbanisation to take place due to the good foundation of soil.

6.2 Recommendations

For future study regarding this field, the number of penetrating test by Mackintosh probe test or other soil penetrating test must be increased in quantity for a better results. This is because the Mackintosh probe only limited to only shallow depth which is the maximum is 15m. Meanwhile, the reliable data is only below 5m in depth.

Besides that, the uses of another penetrating probes should be good enough to create a latest equation which will suitable which the location. The equation should be created by constructing the correlation between the Mackintosh probe and another probes. Unfortunately, due to the no other penetrating probe, the equation cannot be constructed in this research.

REFERENCES

A. Fakher, M. Khodaparast & C.J.F.P. Jones. (2006). The use of the Mackintosh Probe for site investigation in. *Geological Society of London*, 1-8.

Aziz, S. N. (2016). General geology and structural analysis of Jeli Hot Spring, Jeli, Kelantan. *Undergraduate project report, Faculty of Earth Science. (Submitted).*

BAHRIM, S. M. (2015). ASSESSMENT VARIABILITY OF ANNUAL DAILY MAXIMUM RAINFALL. *[Undergraduate Report Project][Submitted]*.

C.R.I Clayton, M.C. Matthews, N.E.Simons. (1995). *Site Investigation - 2nd ed.* England: Oxford [England] Blackwell Science.

C.S. Hutchison and D.N.K. Tan. (2007). *Geology of Peninsular Malaysia.* 50603 Kuala Lumpur, Malaysia: The University of Malaya and The Geological Society of Malaysia.

Capacity and Composition of Population. (2014). Retrieved from The Official Website Of The Jeli Land And District Office - Area and Population: http://www.ptjj.kelantan.gov.my/v4/index.php?option=com_content&view=article&id=45&Itemid=281&lang=en

Climate-Data.org. (2015, August 09). Retrieved from Graf iklim, Graf suhu, Rajah iklim - Climate-Data.org: https://ms.climate-data.org/location/184331/

D. Hossain & K. M. Ali. (1988). Shear strength and consolidation characteristics of 0bhor Sabkha. *Quarterly Journal of Engineering Geology, 21*, 347-359.

Delwar Hossain & Kamai Mohammad Ali. (1990). Mackintosh-vs-vane estimation of undrained shear strength correlation. *Quarterly Journal of Engineering Geology, 23*, 269-272.

Kadir, M. J. (2015). Geology and Structure Geology at Kg Lawar, Jeli. *Undergraduate project report, Faculty of Earth Science. (Submitted).*

Karim, M. F. (2013). Land Use Changes in Jeli, Kelantan. *[Undergraduate Final Project Report] (Submitted).*

Malaysia, D. o. (2003). Quarry resource planning for the state of Kelantan. *Osborne & Chappel Sdn Bhd*.

Mohd Fairus Yusof, Md Nor Faliq Abd Khalid, Saiful Azhar Ahmad Tajudin. (2017). Correlation of JKR Probe with Undrained Shear. *MATEC Web of Conferences*, 103. doi:10.1051/matecconf/201710307009

Nazaruddin, Dony & Busu, Ibrahim & Eva, Hafzan & Muqtada, M. (2015). Geoheritage as the basis for geotourism development: A case study in Jeli district, Kelantan, Malaysia. . *Geojournal of Tourism and Geosites.*, 25-43.

Nazaruddin, Dony. (2015). Systematic Studies of Geoheritage in Jeli District, Kelantan, Malaysia. *Geoheritage.*, 9. 10.1007/s12371-015-0173-9. .

Shear strength (soil). (2018, May 28). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Shear_strength_(soil)

Shear Strength of Soils. (2009, December 31). Retrieved from NPTEL: http://nptel.ac.in/courses/105103097/43

T.T. Khoo, B.K. Tan. (1983). Geological Evolution of Peninsular Malaysia. *Workhop on Stratigraphic Correlation of Thailand and Malaysia*.

Tarawneh, B. (2017). Predicting standard penetration test N-value from cone penetration test data using artificial neural networks. *Geoscience Frontiers*, *8*(1), Pages 199-204. doi:https://doi.org/10.1016/j.gsf.2016.02.003.

Unjah T, Komoo I, Mohamed H (2002). Landskap Geologi Kompleks - Migmatit Stong Kelantan. *Annual Geological Conference*, Geological Society of Malaysia:p 201–p 205.

APPENDIX

Data recorded for in-situ test of Mackintosh probe tests:

Appendix 1

Location: JELI 1	
Coordinate: N 05° 44' 51.6", E 101° 51' 46"	
Depth (meter)	**No. of Blows**
0.0 – 0.3	0
0.3 – 0.6	39
0.6 – 0.9	23
0.9 – 1.2	20
1.2 – 1.5	27
1.5 – 1.8	40
1.8 – 2.1	90
2.1 – 2.4	129
2.4 – 2.7	101
2.7 – 3.0	77
3.0 – 3.3	43
3.3 – 3.6	67
3.6 – 3.9	178
3.9 – 4.2	171
4.2 – 4.5	175
4.5 – 4.8	165
4.8 – 5.1	76
5.1 – 5.4	134
5.4 – 5.7	120
5.7 – 6.0	100
6.0 – 6.3	100
6.3 – 6.6	105
6.6 – 6.9	110
6.9 – 7.2	145
7.2 – 7.5	160
7.5 – 7.8	155
7.8 – 8.1	200
8.1 – 8.4	267
8.4 – 8.7	313
8.7 – 9.0	367
9.0 – 9.3	400↓
9.3 – 9.6	
9.6 – 9.9	(14 cm)

Appendix 2

Location: JELI 2	
Coordinate: N 05° 41' 45.8", E 101° 50' 14.5"	
Depth (meter)	**No. of Blows**
0.0 – 0.3	0
0.3 – 0.6	140
0.6 – 0.9	135
0.9 – 1.2	94
1.2 – 1.5	52
1.5 – 1.8	161
1.8 – 2.1	105
2.1 – 2.4	53
2.4 – 2.7	46
2.7 – 3.0	73
3.0 – 3.3	58
3.3 – 3.6	180
3.6 – 3.9	120
3.9 – 4.2	78
4.2 – 4.5	80
4.5 – 4.8	96
4.8 – 5.1	90
5.1 – 5.4	92
5.4 – 5.7	109
5.7 – 6.0	185
6.0 – 6.3	209
6.3 – 6.6	400 ↓
6.6 – 6.9	
6.9 – 7.2	(2 cm)

Appendix 3

Location: JELI 3	
Coordinate: N 05° 42' 18.2", E 101° 51' 36.2"	
Depth (meter)	**No. of Blows**
0.0 – 0.3	0
0.3 – 0.6	36
0.6 – 0.9	51
0.9 – 1.2	17
1.2 – 1.5	33
1.5 – 1.8	47
1.8 – 2.1	59
2.1 – 2.4	70
2.4 – 2.7	53
2.7 – 3.0	75
3.0 – 3.3	90
3.3 – 3.6	100
3.6 – 3.9	101
3.9 – 4.2	110
4.2 – 4.5	126
4.5 – 4.8	147
4.8 – 5.1	111
5.1 – 5.4	126
5.4 – 5.7	105
5.7 – 6.0	99
6.0 – 6.3	140
6.3 – 6.6	200
6.6 – 6.9	172
6.9 – 7.2	209
7.2 – 7.5	195
7.5 – 7.8	290
7.8 – 8.1	301
8.1 – 8.4	348
8.4 – 8.7	277
8.7 – 9.0	311
9.0 – 9.3	332
9.3 – 9.6	360
9.6 – 9.9	358
9.9 – 10.2	400↓
10.2 – 10.5	
10.5 – 10.8	(15 cm)

Appendix 4

Location: JELI 4	
Coordinate: N 05° 42' 21.6", E 101° 50' 52.3"	
Depth (meter)	**No. of Blows**
0.0 – 0.3	0
0.3 – 0.6	16
0.6 – 0.9	24
0.9 – 1.2	38
1.2 – 1.5	31
1.5 – 1.8	56
1.8 – 2.1	47
2.1 – 2.4	51
2.4 – 2.7	55
2.7 – 3.0	55
3.0 – 3.3	56
3.3 – 3.6	68
3.6 – 3.9	64
3.9 – 4.2	63
4.2 – 4.5	93
4.5 – 4.8	247
4.8 – 5.1	330
5.1 – 5.4	341
5.4 – 5.7	400↓
5.7 – 6.0	
6.0 – 6.3	(9 cm)

Appendix 5

Location: JELI 5	
Coordinate: N 05° 42' 17.6", E 101° 49' 59.7"	
Depth (meter)	**No. of Blows**
0.0 – 0.3	0
0.3 – 0.6	12
0.6 – 0.9	11
0.9 – 1.2	18
1.2 – 1.5	33
1.5 – 1.8	20
1.8 – 2.1	14
2.1 – 2.4	20
2.4 – 2.7	21
2.7 – 3.0	18
3.0 – 3.3	13
3.3 – 3.6	11
3.6 – 3.9	67
3.9 – 4.2	69
4.2 – 4.5	70
4.5 – 4.8	79
4.8 – 5.1	95
5.1 – 5.4	113
5.4 – 5.7	136
5.7 – 6.0	159
6.0 – 6.3	195
6.3 – 6.6	217
6.6 – 6.9	219
6.9 – 7.2	170
7.2 – 7.5	147
7.5 – 7.8	217
7.8 – 8.1	250
8.1 – 8.4	277
8.4 – 8.7	255
8.7 – 9.0	311
9.0 – 9.3	356
9.3 – 9.6	378
9.6 – 9.9	400 ↓
9.9 – 10.2	
10.2 – 10.5	(9 cm)

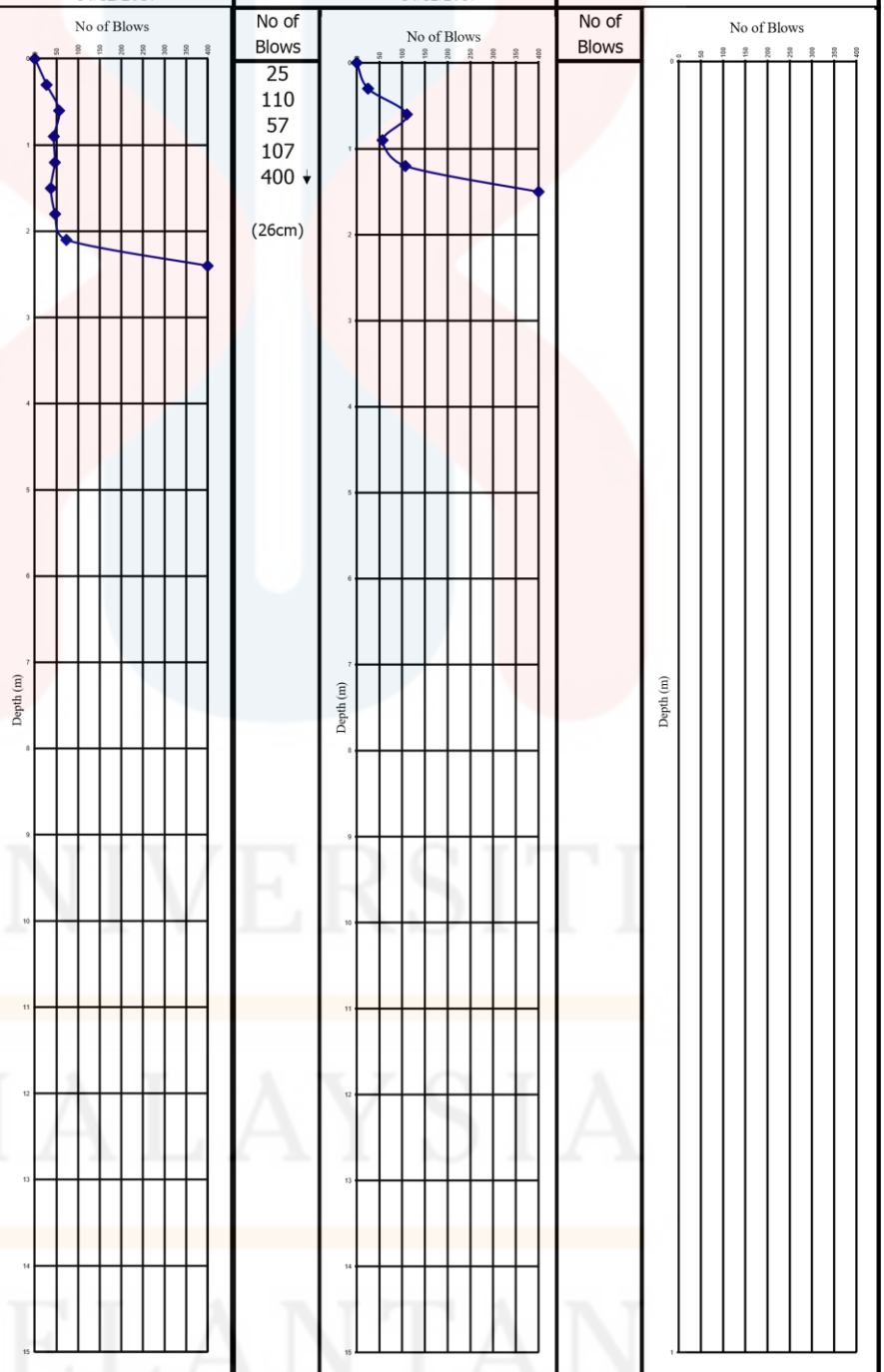
Mackintosh probe data from official statistic (Source: FerroGeo Services):

Appendix 6

MACKINTOSH PROBE TEST

Project : MACKINTOSH PROBES TEST FOR PROPOSED TELECOMMUNICATION TOWER AT LOT 746, KG. CHEDOK, MUKIM NIBONG, JAJAHAN TANAH MERAH, KELANTAN DARUL NAIM.

Position No.	MP 1	MP 2	
Reduced Level	Existing G.L.	Existing G.L.	
Date	14/12/2017	14/12/2017	
Depth (m)	No of Blows	No of Blows	No of Blows
0.0 - 0.3	27	25	
0.3 - 0.6	56	110	
0.6 - 0.9	44	57	
0.9 - 1.2	46	107	
1.2 - 1.5	37	400 ↓	
1.5 - 1.8	47		
1.8 - 2.1	73	(26cm)	
2.1 - 2.4	400 ↓		
2.4 - 2.7			
2.7 - 3.0	(13cm)		
3.0 - 3.3			
3.3 - 3.6			
3.6 - 3.9			
3.9 - 4.2			
4.2 - 4.5			
4.5 - 4.8			
4.8 - 5.1			
5.1 - 5.4			
5.4 - 5.7			
5.7 - 6.0			
6.0 - 6.3			
6.3 - 6.6			
6.6 - 6.9			
6.9 - 7.2			
7.2 - 7.5			
7.5 - 7.8			
7.8 - 8.1			
8.1 - 8.4			
8.4 - 8.7			
8.7 - 9.0			
9.0 - 9.3			
9.3 - 9.6			
9.6 - 9.9			
9.9 - 10.2			
10.2 - 10.5			
10.5 - 10.8			
10.8 - 11.1			
11.1 - 11.4			
11.4 - 11.7			
11.7 - 12.0			
12.0 - 12.3			
12.3 - 12.6			
12.6 - 12.9			
12.9 - 13.2			
13.2 - 13.5			
13.5 - 13.8			
13.8 -14.1			
14.1 - 14.4			
14.4 - 14.7			
14.7 - 15.0			
G.W.L.(m)			



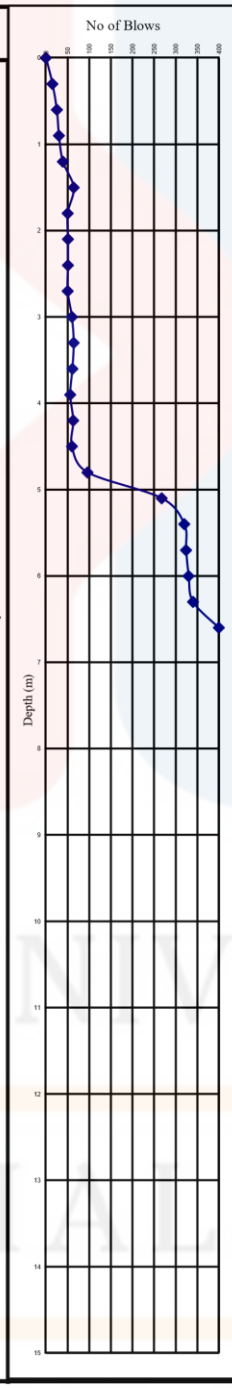
FERROGEO SERVICES	Test by : FAIZ	Checked : FATIHI	Approved : FIKRI

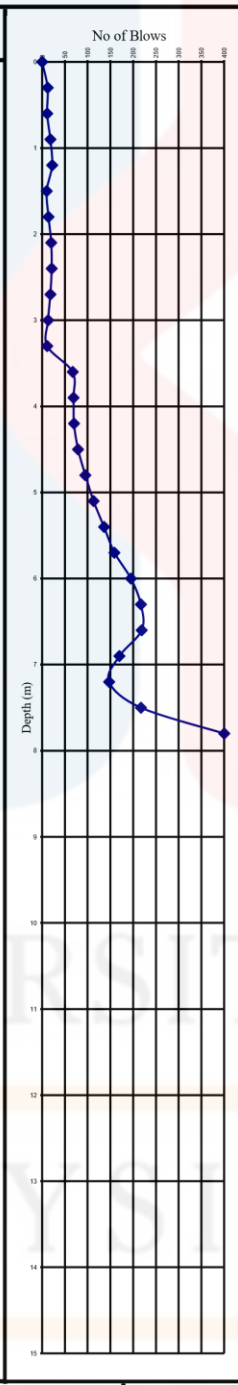
Appendix 7

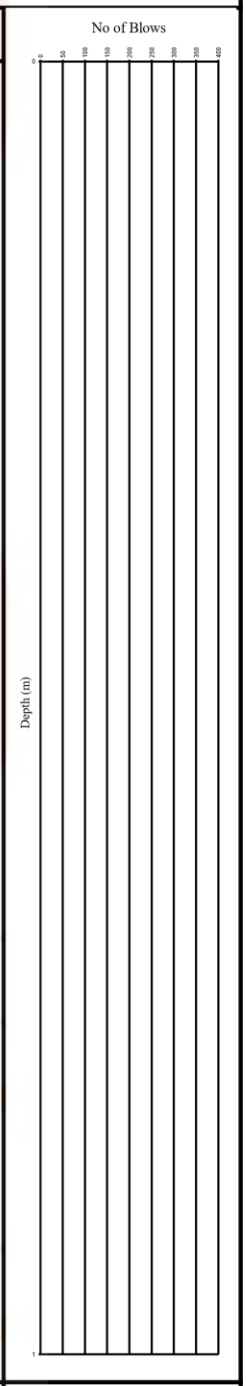
MACKINTOSH PROBE TEST

Project : MACKINTOSH PROBES TEST FOR PROPOSED TELECOMMUNICATION TOWER AT PT 1299, KG. GUNONG, MUKIM BELIMBING, JAJAHAN JELI, KELANTAN DARUL NAIM.

Position No.	MP 1	MP 2	
Reduced Level	Existing G.L.	Existing G.L.	
Date	14/12/2017	14/12/2017	
Depth (m)	No of Blows	No of Blows	No of Blows
0.0 - 0.3	15	12	
0.3 - 0.6	25	11	
0.6 - 0.9	30	18	
0.9 - 1.2	39	22	
1.2 - 1.5	64	10	
1.5 - 1.8	50	14	
1.8 - 2.1	51	20	
2.1 - 2.4	51	21	
2.4 - 2.7	50	18	
2.7 - 3.0	60	13	
3.0 - 3.3	64	11	
3.3 - 3.6	61	67	
3.6 - 3.9	56	69	
3.9 - 4.2	63	70	
4.2 - 4.5	60	79	
4.5 - 4.8	96	95	
4.8 - 5.1	268	113	
5.1 - 5.4	320	136	
5.4 - 5.7	324	159	
5.7 - 6.0	330	195	
6.0 - 6.3	340	217	
6.3 - 6.6	400 ↓	219	
6.6 - 6.9		170	
6.9 - 7.2	(9cm)	147	
7.2 - 7.5		217	
7.5 - 7.8		400 ↓	
7.8 - 8.1			
8.1 - 8.4		(7cm)	
8.4 - 8.7			
8.7 - 9.0			
9.0 - 9.3			
9.3 - 9.6			
9.6 - 9.9			
9.9 - 10.2			
10.2 - 10.5			
10.5 - 10.8			
10.8 - 11.1			
11.1 - 11.4			
11.4 - 11.7			
11.7 - 12.0			
12.0 - 12.3			
12.3 - 12.6			
12.6 - 12.9			
12.9 - 13.2			
13.2 - 13.5			
13.5 - 13.8			
13.8 -14.1			
14.1 - 14.4			
14.4 - 14.7			
14.7 - 15.0			
G.W.L.(m)		6m	







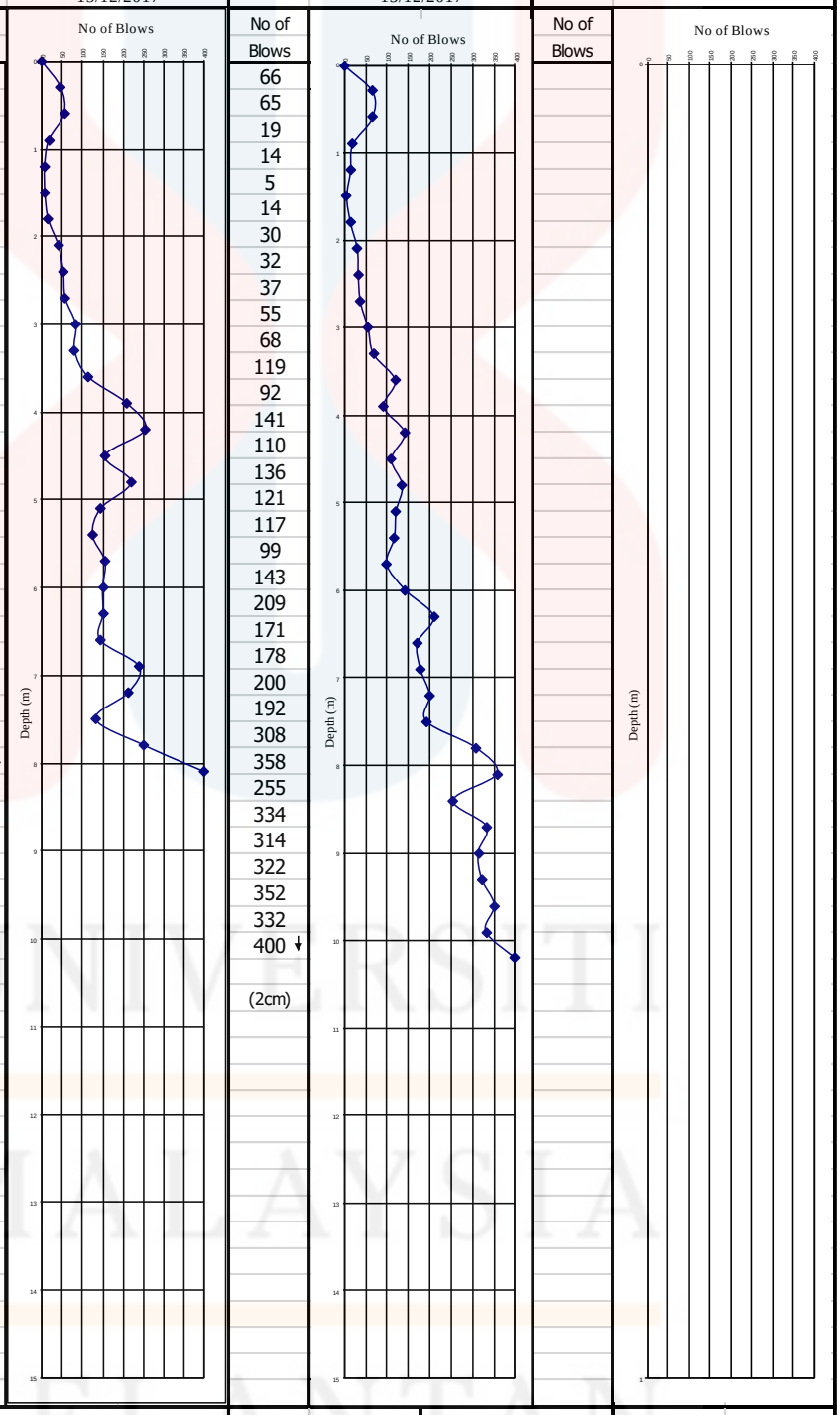
FERROGEO SERVICES	Test by : FAIZ	Checked : FATIHI	Approved : FIKRI

Appendix 8

MACKINTOSH PROBE TEST

Project :	MACKINTOSH PROBES TEST FOR PROPOSED TELECOMMUNICATION TOWER AT LOT 2152, KG. JUBAKAR TUMPAT, MUKIM TUMPAT, JAJAHAN TUMPAT, KELANTAN DARUL NAIM.		
Position No.	**MP 1**	**MP 2**	
Reduced Level	Existing G.L.	Existing G.L.	
Date	15/12/2017	15/12/2017	

Depth (m)	No of Blows	No of Blows
0.0 - 0.3	47	66
0.3 - 0.6	55	65
0.6 - 0.9	17	19
0.9 - 1.2	7	14
1.2 - 1.5	8	5
1.5 - 1.8	16	14
1.8 - 2.1	41	30
2.1 - 2.4	53	32
2.4 - 2.7	58	37
2.7 - 3.0	84	55
3.0 - 3.3	81	68
3.3 - 3.6	115	119
3.6 - 3.9	210	92
3.9 - 4.2	255	141
4.2 - 4.5	156	110
4.5 - 4.8	220	136
4.8 - 5.1	145	121
5.1 - 5.4	125	117
5.4 - 5.7	156	99
5.7 - 6.0	150	143
6.0 - 6.3	151	209
6.3 - 6.6	144	171
6.6 - 6.9	240	178
6.9 - 7.2	213	200
7.2 - 7.5	133	192
7.5 - 7.8	252	308
7.8 - 8.1	400 ↓	358
8.1 - 8.4		255
8.4 - 8.7	(2cm)	334
8.7 - 9.0		314
9.0 - 9.3		322
9.3 - 9.6		352
9.6 - 9.9		332
9.9 - 10.2		400 ↓
10.2 - 10.5		
10.5 - 10.8		(2cm)
10.8 - 11.1		
11.1 - 11.4		
11.4 - 11.7		
11.7 - 12.0		
12.0 - 12.3		
12.3 - 12.6		
12.6 - 12.9		
12.9 - 13.2		
13.2 - 13.5		
13.5 - 13.8		
13.8 -14.1		
14.1 - 14.4		
14.4 - 14.7		
14.7 - 15.0		
G.W.L.(m)		



FERROGEO SERVICES	Test by :	Checked :	Approved :
	SYAUKI	FATIHI	FIKRI