DETERMINATION OF SOIL STRENGTH, SETTLEMENT AND CHEMICAL CONTENT OF BUKIT AMPANG LANDFILL

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DETERMINATION OF SOIL STRENGTH, SETTLEMENT AND CHEMICAL
CONTENT OF BUKIT AMPANG LANDFILL

NURUL AIN BINTI ABD RASHID

Report submitted in partial fulfillment of requirements

for the award of the degree of

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JUNE 2015

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DEDICATION

I am grateful to the Allah SWT for the good health and wellbeing that were necessary to complete this thesis.

I place on record, my sincere thank you to my parent Mr. Abd Rashid bin Dawi and Mrs. Misnah bt Abu Salim and my siblings for their love, dream, endless encouragement and sacrifice throughout my life.

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ABSTRACT

A landfill is a site for disposal of waste materials by burial and is the oldest form of waste treatment. Dumping of municipal solid waste can effect and change the geotechnical properties of soil. Limited availability of land for dumping encourages the uncontrolled dumping of waste, on the outskirts of city that take a large space of land. . Some chemical content on dump site soil may affect the future structure to develop such as concrete on foundation and steel pile. Different locations of dump site have different soil characteristics and chemical content. The aim of this study generally to determine the geotechnical properties, chemical content, strength parameter and settlement magnitude of the soil. The structure may damage from long term effect such as corrosion, eroded and also reduce in workability. There are possibilities present of Iron (Fe), Manganese (Mn), Copper (Cu), Cadmium (Cd), Chlorine (Cl), Chromium (Cr), Lead (Pb), and Nitrogen (N) in the soil. From the study, it's shown that specific gravity of soil is much lower from normal soil since it does contain organic matter. Besides that, the soil also has high plasticity due to polluted by variety of dump and leachate that may affect its characteristic. The chemical content that present in the soil are more than 20 but only 8 elements and oxides have more than 1% present percentage in the soil. Undrained triaxial test with increase confining pressure $\sigma^3 = 60$ kPa, $\sigma^3 = 120$ kPa and $\sigma^3 = 240$ kPa reported that highest cohesion and angle of friction are 16 kN/m^2 and 43.2° respectively for waste soil in Bukit Ampang Landfill. The compressibility coefficients = 0.393 cm^2/MN, compression index = 0.333, and consolidation settlement at 240 minutes show that the soil are settled between 1.0 mm to 1.11 mm.

ABSTRAK

Tapak pelupusan sampah adalah kawasan pembuangan bagi sisa dengan cara perkambusan dan ia adalah salah satu cara tertua dalam merawat sisa. Lambakan sisa pepejal boleh mengakibatkan serta merubah ciri-ciri geoteknik tanah. Ruang yang sempit untuk pembuangan sampah menyebabkan pelambakan sampah tidak terkawal di pinggir-pinggir bandar serta mengambil ruang yang besar. Kewujudan elemen kimia didalam tanah pelupusan sampah boleh mempengaruhi struktur pembangunan pada masa hadapan seperti konkrit dan cerucuk besi. Tapak pelupusan sampah yang berbeza mempunyai ciri-ciri tanah dan kandungan kimia yang berbeza. Tujuan kajian ini dijalankan adalah untuk menentukan ciri-ciri geoteknik tanah, kandungan kimia, parameter kekuatan dan magnitud mendapan tanah. Struktur bangunan berkemungkinan rosak dalam jangka masa panjang dengan kerosakan seperti berkarat, terhakis dan berkurang dalam ciri kebolehkerjaan. Antara elemen kimia yang berkemungkinan wujud di dalam tanah ini adalah Iron (Fe), Manganese (Mn), Copper (Cu), Cadmium (Cd), Chlorine (Cl), Chromium (Cr), Lead (Pb), dan Nitrogen (N). Berdasarkan kajian, gravity tentu tanah adalah lebih rendah daripada tanah normal disebabkan ada kehadiran bahan organic di dalamnya. Selain itu, tanah ini juga mempunyai kadar keplastikan yang tinggi oleh kerana pencemaran daripada sampah sarap dan berkemungkinan juga terpengaruhi dengan air larutan resapan. Kandungan kimia yang terkandung adalah lebih dari 20 elemen tetapi hanya 8 elemen dan oksida yang mempunyai lebih dari 1% kehadirannya didalam tanah. Ujian 'Undrained triaxial' dengan tekanan pegurungan $\sigma^3 = 60$ kN/m^2, $\sigma^3 = 120$ kN/m^2 and $\sigma^3 = 240$ kN/m^2 melaporkan kepaduan tanah tertinggi adalah dengan nilai 16 kN/m^2 dan nilai sudut geseran adalah 43.2° pada tanah di tapak pelupusan sampah Bukit Ampang. Mangnitud mendapan seperti pekali mampatan = 0.393 cm^2/MN, indeks pekali = 0.333 dan kadar mendapan menunjukkan pada minit ke 240 tanah mendap diantara 1.0 mm hingga 1.11 mm.

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LIST OF SYMBOLS

σ^3	Confining Pressure
°	Degree
C	Celcius
σ_v	Total Vertical Stress
σ_h	Total Horizontal Stress
%	Percentage
G_s	Specific Gravity
Kt	Permeability
P_c	Strength Parameter
C_c	Compression Stress
C_r	Compression Index
C_v	Coefficient of Consolidation
S_c	Consolidation Settlement

LIST OF ABBREVISTIONS

CS	Control Soil
HDPE	High Density Polyethelene
MPAJ	Majlis Perbandaran Ampang Jaya
SDY	Soil Dumping Yard
SRDY	Soil Reclaimed Dumping Yard
XRF	X-ray Fluorescence

CHAPTER 1

INTRODUCTION

1.1   Introduction

A landfill is a site for disposal of waste materials by burial and is the oldest form of waste treatment. Municipal solid waste is disposed by dumping on land on most Malaysia region. Dumping of municipal solid waste can effect and change the geotechnical properties of soil. Limited availability of land for dumping encourages the uncontrolled dumping of waste, on the outskirts of city that take a large space of land. The area of this study is at Ampang dump site located within Bukit Seputeh Forest Area, under jurisdiction of Majlis Perbandaran Ampang Jaya (MPAJ). It is approximately 2 km from Hulu Langat town. Solid waste from Ampang and Hulu Langat areas had been disposed at this landfill since 1980s. The average amount of solid waste dumped in this area was 287 tons/day (Agamuthu, 2013).

The geotechnical properties of waste soil of open dumping area are important since there are so many abandoned dumping areas which are to be used for future development. The open dumping area which has no post closure maintenance such as landfill would pose serious hazards to the resident due to differential settlement of the waste soil.

Estimation of settlement for municipal solid waste is critical to the successful site operation and the future development as well as to the maintenance of the sites (Park et al., 2007). Thus, geotechnical properties experimental work conducted would help in the settlement estimation and

design of foundation for future development in order to understand the behavior of waste soil after closure of dumping area.

1.2   Problem Statement

Waste soil consists of waste material such as concrete debris, decayed wood, plastics and others. The heterogeneous content of waste soil makes the geotechnical properties difficult to categorize and analyzed. Other than that, there are two issues related to the dumping of municipal solid waste. It is to check the long term effect of municipal waste disposal chemical on soil properties to the strength and settlement of soil for future urban development. Limited availability of land encourages the uncontrolled dumping of waste, on the outskirts of the city causing a serious environmental and public health hazard. The quantity of solid waste generated, the scarce availability of land and the pollution caused to the soil and groundwater makes the management of municipal solid waste a major challenge in a dense urban environment. Knowing the strength of soil will easier the process in deciding type of foundation to construct in the soil. Weak soil strength need to use deep foundations like pile foundation and well foundation.

Some chemical content on dump site soil may affect the future structure to develop such as concrete on foundation and steel pile.This study is importance to analyze the suitability of material use for structure before development. Past research of 'Geotechnical Properties of Waste Soil from Open Dumping Area in Malaysia' (Irfah, Husaini & Zainuddin, 2011) state that the geotechnical properties of experimental work conducted would help in the settlement estimation and design of foundation for future development in order to understand the behavior of waste soil after closure of dumping site.

1.3   Objective

The aim of this study generally:

1)   To determine the geotechnical properties of soil at Bukit Ampang Landfill.

2)   To determine the strength parameters and settlement magnitude of the soil.

3)   To check the present of chemical content in the soil.

1.4   Scope of Study

The aim of study is to investigate the characteristic soil that dump by municipal solid waste. Different locations of dump site have different soil characteristics. This is depends on the age of dump collect at the site, quantity of the waste and type of waste that dump at the site. Chemical content in the soil also will be different at the different landfill. The territory that involves in this study is only at Bukit Ampang dump site, Ampang. The area Ampang dump site located within Bukit Seputeh Forest Area, under jurisdiction of Majlis Perbandaran Ampang Jaya (MPAJ). It is approximately 2 km from Hulu Langat town. The samples that will be test are from three different locations around the dump site area.

Figure 1.1: Location of Landfill Site, Bukit Ampang.

The three main properties that will be investigated in this study are strength, settlement magnitude and chemical content of the soil. The importance of find the strength of soil is to determine the suitability of structure with the soil such as foundation. Before deciding type of foundation to be used in development, first the strength of soil must be investigate. The weak type of soil should use deep foundation as to support the load from super structure from above such as pile foundation and well foundation. Settlement in soil is a process by which soils decrease in volume. Most footing design for high strength soil is supported on shallow foundation that controlled by allowable rocking and settlement. Induce soil cyclic deformation is from displacement produced by static and dynamic load. Chemical present in the soil may affect the structure. The structure may damage from long term effect such as corrosion, eroded and also reduce the workability of the structure. There are possibilities present of Iron (Fe), Manganese (Mn), Copper (Cu), Cadmium (Cd), Chlorine (Cl), Chromium (Cr), Lead (Pb), and Nitrogen (N) in the soil.

1.5   Significant of Studies

The analysis of soil is important in order to prevent any problem arise in the future. A detail studies and investigation of dump soil at land fill need to be carried out and deep understanding about it to civil engineer is very important. Urbanization is progressing at an alarming rate resulting in the generation of very large quantities of municipal solid waste. Expanding city lines put enormous pressure on availability of land. In line with this, land utilized for dumping the municipal solid waste is a major concern. The excessive input of unsorted municipal household wastes may likely lead to changes in soil physical and chemical characteristics. This can distort interrelationships among biophysical and chemical soil functions. It may also lead to loading of nitrates and heavy metals in soil and ground water.

These studies also are useful as reference for future studies and as a reference for the party that involve in construction development at the landfill site. Besides that, the analysis from this study also can give the first impression

about soil characteristic at time the research is conducted. The soil characteristic can be compared with the present research at current time.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is the study of information that related with the research. This study is important to ensure all information concerning the topic can be collected and analyze. The information for this chapter are collected from past thesis, journal, magazine and reference book.

In this chapter, the topic that will elaborate divided to four parts. The first part is the properties of soil at open dumping site. Secondly is the site investigation ant test that will take part during the investigation. Thirdly is about soil sampling method that will take part during the study. Last but not least, the fourth part will discuss in detail about soil properties and behavior of the soil.

2.2 Landfill Soil Properties Definition

To understand the behavior of waste soil after closure of dumping area, study on geotechnical properties experimental work conducted would help in the settlement estimation and design of foundation for future. The urbanization is progressing at an alarming rate resulting in the generation of very large quantities of municipal solid waste. Expanding city lines put enormous pressure on availability of land (Evangelin, 2013). There is limited research on geotechnical properties for characteristics of differential settlement and high moisture content on landfill soil. There are differences between landfill and open dumping area. Landfill are able to manage proper gas collection and leachate

recirculation, top cover, daily cover, proper post closure maintenance care and proper drainage system. While open dumping area is not practice good management aspect as landfill.

The open dumping area is usually not easy to be treated due to its complexity of geotechnical properties of soil. In Malaysia, the landfills could be classified into 4 levels namely Level 1, Level 2, Level 3, and Level 4. Level 1 is controlled tipping and Level 2 is sanitary landfill with bunk embankment and daily soil covering. Level 3 is sanitary landfill with leachate recirculation system and lastly, Level 4 is sanitary landfill with a leachate treatment system by Ministry of Housing and Local Government, 1990 (Bun.K, 2011). Bukit Ampang landfill can be classified as Level 3 because it is a sanitary landfill with leachate reticulation system.

According to (Bun.K, 2011), the study of geotechnical properties of waste soil of open dumping area are important since there are so many abandoned dumping areas which are to be used for future development. The open dumping area with rarely maintenance and care could pose serious hazards to the resident due to differential settlement of the waste soil. Maintenance of the sites and municipal solid waste estimation of settlement is critical to the successful site operation and for the future development (Park et al., 2007).

Based on study that has been carried out by Irfah (2011), Waste soil consists of waste material such as concrete debris, decayed wood, plastics and others. The heterogeneous content of waste soil makes the geotechnical properties difficult to categorize and analyzed. Laboratory works such as compaction test, consolidation test, triaxial and direct shear test are conducted on waste soil to know its geotechnical properties. Based on standard proctor test, the waste soil has a maximum dry density of 1567 kg/m^3 with optimum moisture content of 29%. The odometer test shows the maximum displacement of 4 mm within 100 minutes. Based on direct shear test, the undrained cohesion is in the range of 2- 4 kPa and angle of friction of 14^0-27^0. The triaxial test on

unconsolidated undrained condition showed that the cohesion is 3 kPa and angle of friction on the range of 0 to 10.5^0.

2.3   Landfill Soil Profile

Based on typical anatomy of landfill soil profile that provided by Waste Management Inc, North America (2003), it is state that landfill soil profile consist of five layer which are on the top is protective cover, follow by composite cap system, working landfill, leachate collection system and composite liner system.

Top soil layer of landfill have protective layer where it is cover by vegetation. Native grasses and shrubs are planted to prevent erosion on underlying landfill soil and to give a pleasant view on the landfill area. The top soils function as a supporter of vegetation growth and help to maintaining the nutrient and moisture of the soil. Protective cover soil is a landfill cap system that provides additional moisture retention to help support the cover vegetation.

For the second and third layer of landfill soil profile which is composite cap system and working landfill, both of this layer act as drainage layer and daily cover for the soil. Composite cap system consists of three sub layer which are drainage layer, geomembrane and compacted clay. Drainage layer is a layer of sand and gravel that drain excess precipitation from protective soil cover. This is to help ensure the stability and avoid infiltration of water through the landfill cap system. A geotextile fabric is located on top of drainage layer to provide separation of solid particle from liquid. The working landfill layer have daily cover layer and waste layer is functional as cover to reduce odors, keep litter from scattering and help deter scavengers.

Leachate is a liquid that has filtered through the landfill. The fourth main layer leachate collection system needs to collects leachate so it can be removed from the landfill and disposed of or treated properly. The leachate collection

system consist of three elements which is leachate collection layer, filter geotextile and Leachete collection pipe system.

The last main layer is composite liner system that layered with geomembrane that typically constructed of a special type of plastic called High Density Polyethylene or HDPE. HDPE is tough, impermeable and extremely resistant to attack by compounds that might be in the leachate. Below the geomembrane layer, there is located the compacted clay that act as additional barrier to prevent leachate from leaving the landfill. This layer also helps to prevent landfill gas escape. The native soil beneath the landfill which is prepared subgrade is prepared as needed prior to beginning landfill construction. The typical soil profile of landfill is as shown in Figure 2.1.

Legend:

1-Cover Vegetation

2-Top Soil

3-Protective Cover Soil

4-Drainage Layer

5-Geomembrane

6-Compacted Clay

7-Daily Cover

8-Waste

9-Leachate Collection
  Layer

10-Filter Geotextile

11-Leachate Collection
  Pipe System

12-Geomembrane

13-Compacted Clay

14-Prepared Subgrade

Figure 2.1: Typical Anatomy of Landfill Soil Profile.

2.4   Chemical Existence in Soil

Chemical present in the soil may affect the structure. The structure may damage from long term effect such as corrosion, eroded and also reduce the workability of the structure. There are possibilities present of Iron (Fe), Manganese (Mn), Copper (Cu), Cadmium (Cd), Chlorine (Cl), Chromium (Cr), Lead (Pb), and Nitrogen (N) in the soil.

The soil elements that were analyzed can all move back and forth between several chemical forms within the soil. They may also be dissolved in soil solution as ions or molecules with a positive or negative charge. They may be bound in insoluble forms, often through association with parent minerals. The parent materials slowly release the elements over time as part of the natural weathering process. The follows is a description of these elements roles in plants and slightly more detail on their general behavior in soils. Except where noted, this information is from Brady and Weil, 1996.

Potassium is crucial to most ionic functions of a plant in the soil, including stomatal control, the maintenance of turgor pressure, and charge balance during selective ion uptake across root membranes. It is also a coenzyme in many biochemical reactions. The primary source of potassium in soil solution is the weathering of parent rocks. Within an acidic soil, potassium may be tightly bound in insoluble minerals (micas and feldspars), slowly available when associated with 2:1 type minerals, moderately available when associated with clay and humus colloids, and easily available when in soil solution. The small amount of potassium dissolved in soil solution as an ion is highly leachable, although losses of potassium from runoff and erosion is not a significant problem in forests, compared to some elements.

Plants use calcium to build cell walls. It also helps keep P available in the root zone by binding with other competitor ions. It commonly comprises 0.5 % of a plant. Because it is bound within cell walls, it does not leach from the leaves nor circulate within the plant. However, it can easily leach through soil

layers. Its primary source is from weathering, and then it is stored as a cation which is a positively charged ion on soil exchange sites also known asnegatively charged.

Magnesium is the central atom of the chlorophyll molecule. It also is an important co-enzyme. It is very mobile in plants as a cation. It generally makes up 0.2 % of plants. The primary source of potassium in soil solution is the weathering of parent rocks. Within most soils are large amounts of potassium bound in unavailable forms. In acidic soils, the largest proportion of potassium is bound in iron- and aluminum- bound insoluble minerals. They may also bind with manganese. In its ionic or available form, phosphate strongly adsorbs to soil particles and does not quickly flush out of the system. Still, losses in runoff are important.

Iron primarily originates from chemical weathering of the parent material. The amount found in plants is several orders of magnitude lower than the amount in mineral soil. Its movement in soil horizons is due mainly to chemical processes within the soil, rather than association with organic matter or uptake by biomass. Therefore, its distribution patterns exemplify the chemical redistribution occurring as the soil rest ratifies into horizons. In fact, the distinctive color of the soil horizons is caused by iron.

Manganese is generally plentiful in acid soil and may reach toxic levels below a pH of 6.5 as in the pitch pine site. It generally leaches out of acidic soils and deposits in alkaline soil layers. In soils, zinc is tightly adsorbed to magnesium. On average, plants contain around 20 ppm of zinc. Zinc is a key component of growth control hormones and aids in protein synthesis. Copper is especially plentiful in acidic, sandy soils. Though it only comprises 0.1 ppm of the plant, it is an important enzyme activator found mostly in the chloroplasts of leaves.

In soils, aluminum immobilizes phosphorous and generally increases the acidity and concentration of cations including the other elements analyzed in this

study.   Like most elements, aluminum becomes toxic above certain concentrations. It is poisonous to some plants above 1 ppm and to most plants above 15 ppm.

Lead complexes with organic matter in the soil and accumulates in certain organic tissues of plants. In high enough concentrations, it can cause brain damage in humans. Biomass is not a significant sink for lead and most is found in the forest floor and underlying mineral soil (Siccama and Smith 1978; Siccama et. al., 1980; Smith and Siccama, 1981; Heinrichs and Mayer 1980).

2.5   Previous Study

2.5.1 Soil   Properties   governed   by   Municipal   Solid   Waste   at Visakhapatnam, Andhra Pradesh, India.

Based on studies that carried out by (V.Saritha, 2014) at Visakhapatnam, India there are several comparison have been made. Visakhapatnam is a major port and the second largest city in the state of Andhra Pradesh with a population of approximately 1.3 million. It is located 625 kilometres east of state capital, Hyderabad. The study has been designed and executed in two stages, in the first stage the soil samples from the dumping yard were collected and analyzed. The study progressed with comparing the results with two other land use patterns in order to get a depth of understanding on the effects of solid waste on soil. Three sites on three land forms varying in conditions were selected for the present study, Site A -Soil from Dumping Yard at Kapula Uppada (SDY), Site B-Soil from reclaimed Dumping yard (SRDY) and Site C- Control Soil at GITAM Campus Garden Soil (CS).

The comparison between the physico-chemical parameters of Surface soils of the three sampling sites. As shown from graph in Figure 2.2 that presents the comparative account of physic chemical parameters of the surface samples from the three study areas. Site A was recorded with highest pH value which is 8, the lowest pH was also recorded at Site C with 6.50 of the same

location. The mean of the pH was recorded highest for the same site with 7.20. Electrical conductivity was recorded highest at site C of reclaimed dump yard with 1.92mmhos and lowest at site A of dumping yard with 1.07mmhos. The mean of electrical conductivity was highest for reclaimed dump yard soils with 1.78%. 9.70% and 1.60% were the maximum and minimum moisture content reported at Site C and Site A of garden and dumping yard soils respectively. 7.64% was the mean at maximum for garden soils.

The bulk density of soil 1.92% and 0.30% of utmost and smallest percent are identified at Site B of garden soil and Site C of dumping yard soils respectively. The peak of mean obtained was 1.41% for garden soil samples. 8.08% and 1.32% of water holding capacity were noted at Site B and Site C. Specific gravity was observed to be utmost for garden soil at Site C for garden soil with 1.99% and least also for the sample soil at Site B with 1.14%. Whereas peak mean was observed for dumping yard soils with 1.74%.

The present of chemical content such as Calcium was observed to be almost same for all the samples but the highest was observed for Site B of reclaimed dump yard soils with 30mg/l and a mean of 17.50mg/l was also recorded for the same location. Magnesium was also stable for almost all samples varying at 10 and 20 mg/l. But the highest mean was observed for dumping yard soils with 15mg/l. Organic carbon has shown crest at Site C of garden soil with 8.55% and dip at Site B of dumping yard soils with 0.38%. It has recorded a mean of 6.94% for garden soils.
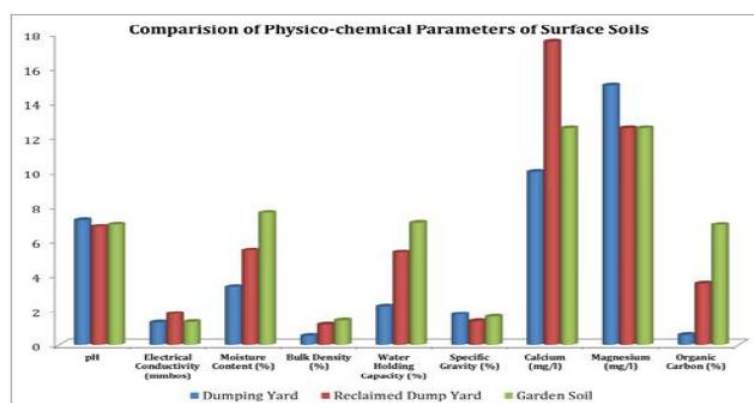
Figure 2.2: Comparative account of physic chemical parameters

2.5.2 Geotechnical Properties of Waste Soil from Open Dumping Area in Malaysia.

Irfah (2011) has carried out studies on geotechnical properties of samples of waste soils that collected from open dumping area in Sri Hartamas. The samples are labeled as SHL 1, SHL 2 and SHL 3. The result is compared with normal soil that collected from Bukit Chuping area which has high moisture content and settlement characteristics.. These samples are labeled as BK 1, BK 2 and BK 3. Based on analysis of sample SHL 1, the sample consists of a bulk of waste which the sizes are more than 2 mm. Thus, the waste soils combined with gravel are 57.5%. The soil consists of 40% sand, 1.5% silt and 1% clay, 30% of concrete debris waste and 27.5% gravel. For sample SHL 2, the soil consists of 35% sand, 0% silt, 0% clay, debris concrete waste 35%, and gravel 30%. In sample SHL 3, the sample consists of 40% sand, 0% silt, 0% clay, 30% concrete debris waste, and 30% gravel. Some of the waste material that combined with clay and silt could also be found in the sample. But this result does not being captured using sieve analysis equipment.

Table 2.1 shows the soil composition of normal soil and waste soil. The soil BK 1 consists of 42.5% sand, 0% silt and 0% clay, 57.5% gravel. The soil BK 2 consists of 66.67% sand, 0% silt and 0% clay, 33.33% gravel. The soil BK 3 consists of 67.67% sand, 2.33% silt and 0% clay, 30% gravel. This sample is normal soil used as control parameters in order to compare the differences between the two samples.

Table 2.1 : Soil Composition of Waste Soil and Normal Soil

Sample No. Sieve Size (mm)	SHL 1	SHL 2	SHL 3	BK 1	BK 2	BK 3
	Total Percent Passed (%)			**Total Percent Passed (%)**		
2.00	42.5	35	42.5	42.5	66.67	70.00
1.18	22.5	20	22.5	22.5	41.67	42.33
0.600	12.5	12.5	12.5	7.5	20.00	21.67
0.425	10	7.5	7.5	3.75	5.00	7.33
0.300	5	2.5	2.5	1.75	1.67	4.00
0.150	2.5	0	2.5	0.25	0.00	2.33
0.0063	1	0	2.5	0	0.00	2.33
Pan	0	0	2.5	0	0.00	0.00

Figure 2.3 show the particle size distribution of waste soil. Between these two samples, SHL 1, SHL 2 and SHL 3 have a soil grain size in between 0.15 mm to 2 mm and more than 2 mm. While BK 1, BK 2 and BK 3 has more than 40% of the normal soil less than 2 mm sieve size. It could be concluded that the waste soil has size more than 2 mm compared to normal soil.
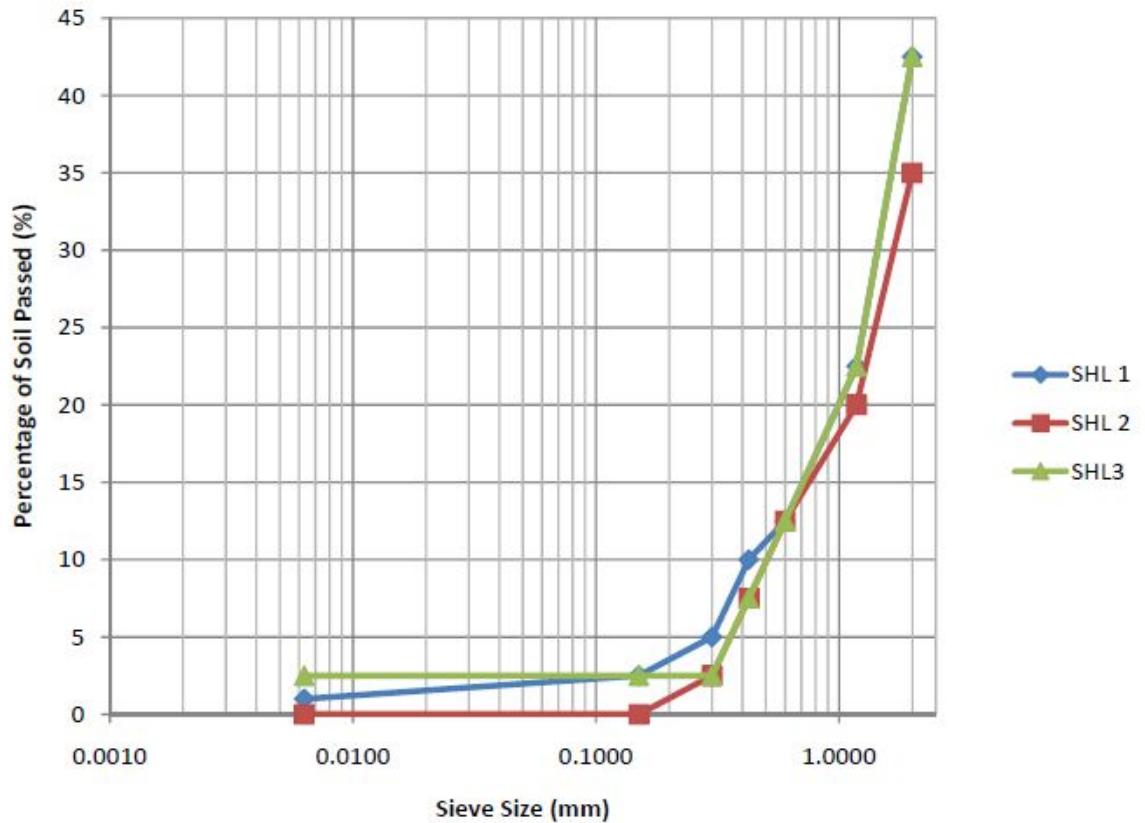
Figure 2.3 : Particle size distribution of waste soil.

The compaction test result gives the maximum dry density of 1540 kg/m3 at 29% optimum moisture content. The compaction curve is shown in Figure 3. There were approximately 66% differences between the result of maximum dry density from open dumping area and fresh landfill. The difference is approximately 40% in the optimum moisture content. The samples from open dumping area are less moisturized due to the exposed of the samples to the air without any daily cover. In Figure 2.4, the compaction curves show the highest

maximum dry density of 1540 kg/m3 at optimum moisture content of 29% for waste soil.
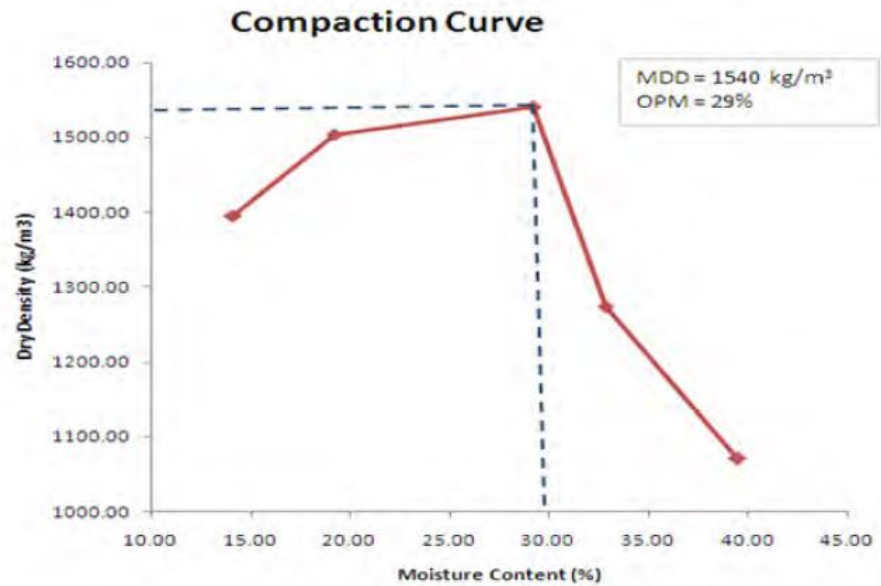
Figure 2.4 : Compaction Curve of Waste Soil

To find the strength of the soil, triaxial tests were done under different confining pressure. The Mohr's circles are plotted to determine the angle of friction and cohesion of waste soil. Figure 2.5, Figure 2.6 and Figure 2.7 show the Mohr's circles for 3 samples of waste soil namely SHL 1, SHL 2 and SHL 3. The major principles stress does increase with the gradual increase of confining pressure. The highest cohesion value is 3 kPa and highest angle of friction is 10.5^{0}.

Mohr's circle of waste soil (SHL 1) with $\sigma_3 = 60$ kPa, $\sigma_3 = 80$ kPa and $\sigma_3 = 100$ kPa
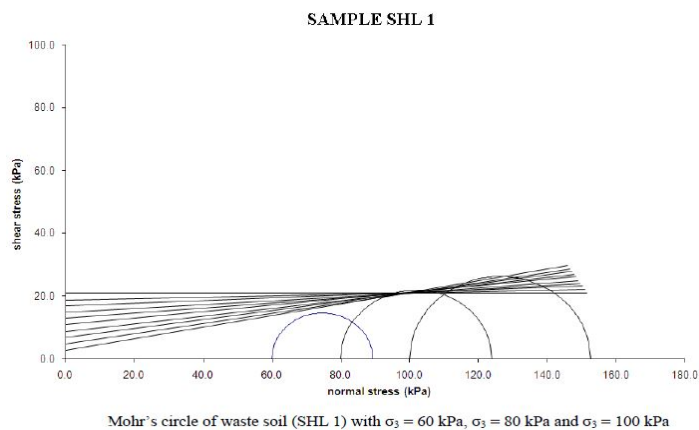
Figure 2.5 : Mohr's Circle of SHL 1

Mohr's circle of waste soil (SHL 2) with $\sigma_3 = 60$ kPa, $\sigma_3 = 80$ kPa and $\sigma_3 = 100$ kPa
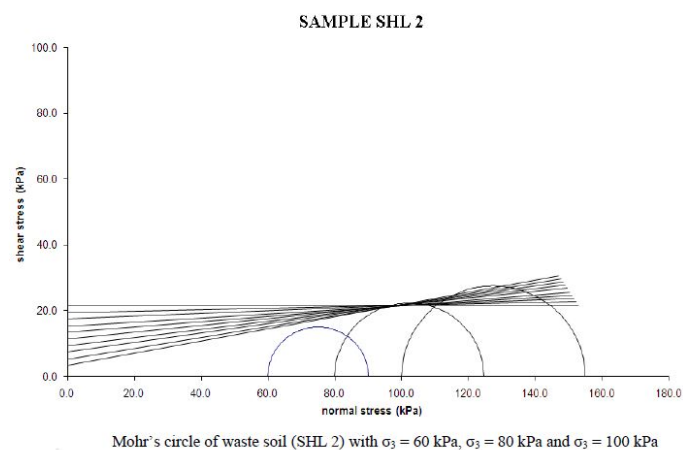
Figure 2.6 : Mohr's Circle of SHL 2

Mohr's circle of waste soil (SHL 3) with $\sigma_3 = 60$ kPa, $\sigma_3 = 80$ kPa and $\sigma_3 = 100$ kPa
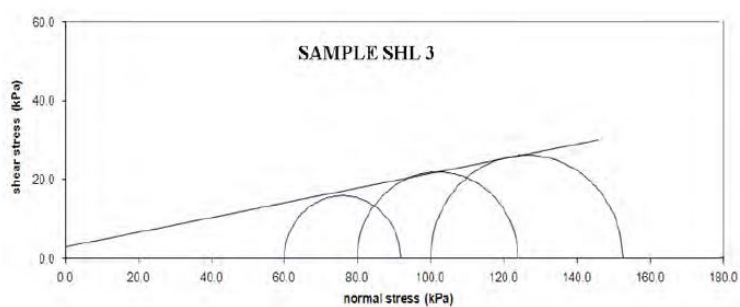
Figure 2.7 : Mohr's Circle of SHL 3

2.6   Site Investigation

According to (Das, 2007), site investigation consist 3 phase which is planning, making test boreholes, and collecting soil samples. Das also state that exploration of soil can be divided into four phase. First are collecting all data and information needed of structure such as type of structure and its future use. Secondly is gathering the information of subsoil condition where it is can obtain from soil manual publish, geologic survey, existing soil exploration report and existed county soil survey maps. Next is, inspect the site and surrounding area. Lastly, conduct several test at site and collect disturb and undisturbed from various depths for visual observation.

2.7   Soil Sampling

2.7.1   Field Sampling

Field soil samplings are include subsurface sampling and laboratory testing of the soil samples retrieved. The test that involve in this sampling method are Atterberg limits tests, water content measurements, and grain size analysis,. These tests may be performed on disturbed samples obtained from thick walled soil samplers. Properties such as shear strength, stiffness hydraulic conductivity, and coefficient of consolidation may be significantly altered by sample disturbance. To measure these properties in the laboratory, high quality sampling is required.

In study of soil analysis (J.Benton, 1999) has stated that sampling technique require careful consideration because naturally soil are variable horizontally as well vertically. For determining sampling boundaries the common factor are topography and the soil type. The common strategies used to collect sampling are simple random sampling, stratified random sampling and systematic or grid sampling. Stratified random sampling are method where selecting individual core in random.

2.7.2   Laboratory Sample Preparation

Laboratory sample preparation can be divided into two processes according to Soil Analysis Handbook of Reference Methods (J.Benton, 1999) which are drying and crushing or grinding. According to (J.Benton), drying process should be done as promptly and rapidly as possible to minimize microbial activity or mineralization. Moisture, texture and organic matter content will help to determine time required to bring soil sample to an air dried condition. Temperature during drying process should not exceed 38° C or 100° F to avoid changes in the physio-chemical properties of the soil. The moisture content of an air dried soil will be determined by the physiochemical properties of the soil and the relative humidity of air surrounding the sample.

In a study on crushing and grinding (J.Benton) said that grinding can have an effect on some elemental determination such as copper (Cu), iron (Fe), and zinc (Zn). Sample size reduction is needed and detail care must be practice to ensure that the sample mixed thoroughly before dividing during crushing and mixing process. Contaminate of soil sample such as composition of contacting surface or deposition of dust and/or previous sample residue can attain from this process.

2.7.3   Transportation of sample to laboratory

According to soil analysis (J.Benton, 1999) , if the period of time between field sample collection and arrival at the laboratory will be more than several days, field-moist soil, when placed in an air-tight container, can undergo significant biological changes at room and elevated temperatures. Organic matter decomposition can release elements or ion such as phosphorus (P), sulfate (SO_4), boron (B) and nitrate (NO_3) into the soil solution, while anaerobic conditions can result in organic matter decomposition and loss of nitrogen (N) from the soil. For long term transport, the collected soil should be kept in cool environment [5-10°C or 40-50°F] and excess water should be removed by partial drying, keeping the soil just moist.

2.8   Basic Properties of soil

2.8.1   Soil Particle Size

According to (Das and Sobhan, 2010), to describe soil by their particle size is depends on the pre dominant size of particle within the soil. Massachusetts Institute of technology have developed particle size distribution table as show in Table 2.2 and size limit for grain size from gravel, sand, silt and clay in graphic form in Figure 2.8.

Table 2.2 Particle Size Classification (Braja,2010)

Name of organization	Grain size (mm)			
	Gravel	Sand	Silt	Clay
Massachusetts Institute of Technology (MIT)	>2	2 to 0.06	0.06 to 0.002	<0.002
U.S Department of Agriculture (USDA)	>2	2 to 0.05	0.05 to 0.002	<0.002
American Association of State Highway and Transportation Officials (AASHTO)	76.2 to 2	2 to 0.075	0.075 to 0.002	<0.002
Unified Soil Classification System (U.S Army Corps of Engineers, U.S Bureau of reclamation and American Society for Testing and Materials)	76.2 to 4.75	4.75 to 0.075	Fines (i.e silts and clays) <0.075	
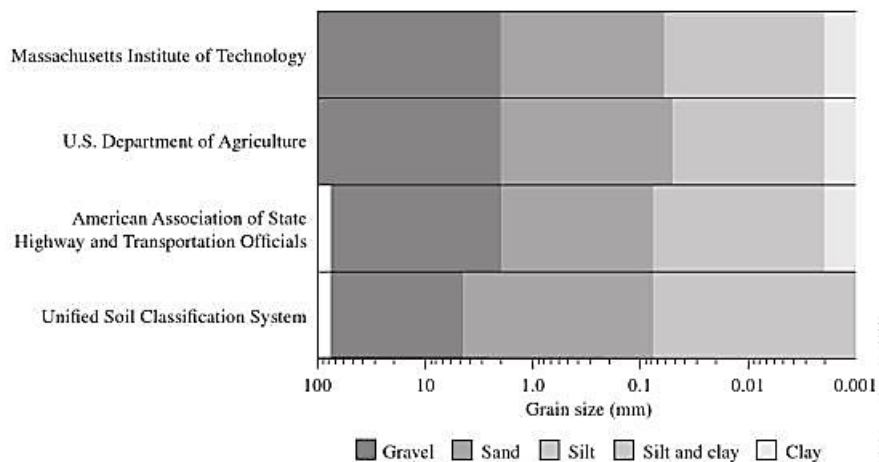
Figure 2.8: Soil separate size limit by various systems (Braja,2010)

2.8.1.1 Sieve Analysis

Sieve analysis consist of shaking the soil sample through a set of sieve that have progressively smaller opening as has been carried out by Das and Sobhan (2010). Das (2010) state that the sieve used for soil analysis is generally 203 mm in diameter. To conduct a sieve analysis, one must first oven-dry the soil then breaks all lumps into small particles. The soil is shaken trough a stack of sieves with openings of decreasing size from top to bottom with a pan is placed below the stack as Figure 2.9.

Figure 2.9: A set of sieves for a test in Laboratory (Braja,2010)

Table 2.3 U.S Standard Sieve Sizes (Braja,2010)

Sieve no.	Opening (mm)	Sieve no.	Opening(mm)
4	4.75	35	0.500
5	4.00	40	0.425
6	3.35	50	0.355
7	2.80	60	0.250
8	2.36	70	0.212
10	2.00	80	0.180
12	1.70	100	0.150
14	1.40	120	0.125
16	1.18	140	0.106
18	1.00	170	0.090
20	0.85	200	0.075
25	0.71	270	0.053
30	0.60		

2.8.1.2 Hydrometer Analysis

Hydrometer analysis is based on the principal of sedimentation of soil grain in water. When a soil specimen is dispersed in water, the particle settles at different velocities, depending on their shape, size, weight and the viscosity of water. For simplicity, it is assumed that all the soil particles are spheres and the velocity can be express by Stokes' Law (Das and Sobhan , 2010):
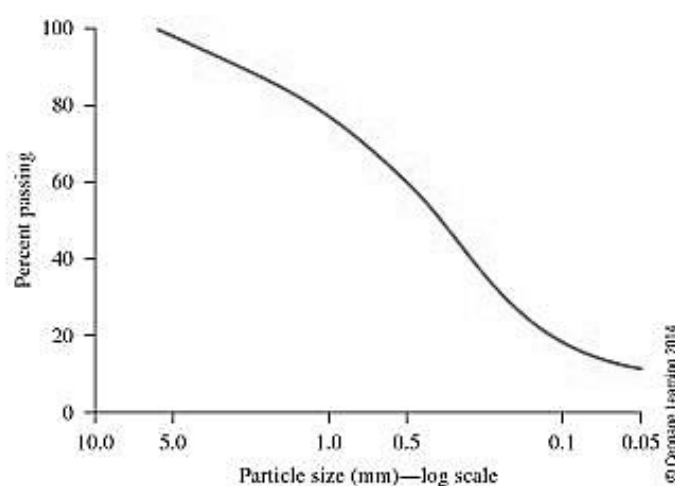
Figure 2.10: Particle-Size Distribution Curve (Braja,2010)

2.8.2   Specific Gravity

Specific gravity is defined as the ratio of the unit weight of a given material to the unit weight of water. The specific gravity of soil solids is often needed for various calculations in soil mechanic. Table 2.4 shows the specific gravity of some common mineral in soil (Das and Sobhan , 2010).

Table 2.4: Specific Gravity of Common Minerals (Braja,2010)

Mineral	Specific Gravity, G_s
Quartz	2.65
Kaolinite	2.6
Illite	2.8
Montmorillonite	2.65 – 2.80
Halloysite	2.0 – 2.55
Potassium feldspar	2.57
Sodium and calcium feldspar	2.62 – 2.76
Chlorite	2.6 -2.9
Biotite	2.8 – 3.2
Muscovite	2.76 – 3.1
Hornblende	3.0 – 3.47
Limonite	3.6 – 4.0
Olivine	3.27 – 3.7

2.8.3   Atterberg Limit

Atterberg limit is the transition of moisture content from semisolid to plastic state called plastic limit, and from plastic to liquid known as Liquid limit. Shown in Figure 2.11 are the relations of Atterberg limit with moisture content. From the figure the behavior of soil can be divided into four basic states which are solid, semisolid, plastic, and liquid.
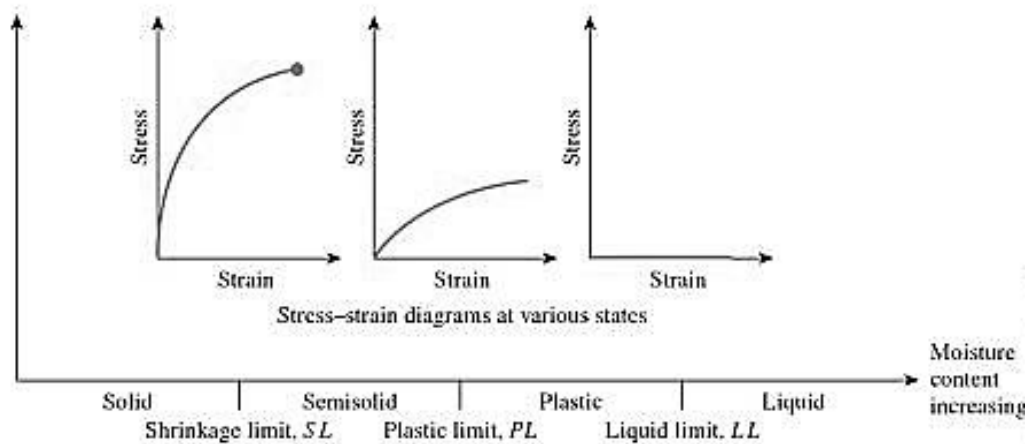
Figure 2.11: Atterberg limit

2.8.4   Consolidation

When a saturated soil layer is subjected to a stress increase, the pore water pressure is increased suddenly. In sandy soils that highly permeable, the drainage caused by the increase in the pore water pressure is completed immediately. Pore water drainage is accompanied by a reduction in the volume of the soil mass, which results in settlement. Because of rapid drainage of the pore water in sandy soils, elastic settlement and consolidation occur simultaneously (Das and Sobhan , 2010). As shown in Figure 2.12, variation of total stress, pore water pressure, and effective stress of clay layer drained at top and bottom as the result of an added stress. The total vertical stress (σ_v) acting at a point below the ground surface is due to the weight of everything lying above such as soil, water, and surface loading. Total vertical stresses are calculated from the unit weight of the soil. Any change in total vertical stress (σ_v) may also result in a change in the horizontal total stress (σ_h) at the same point.
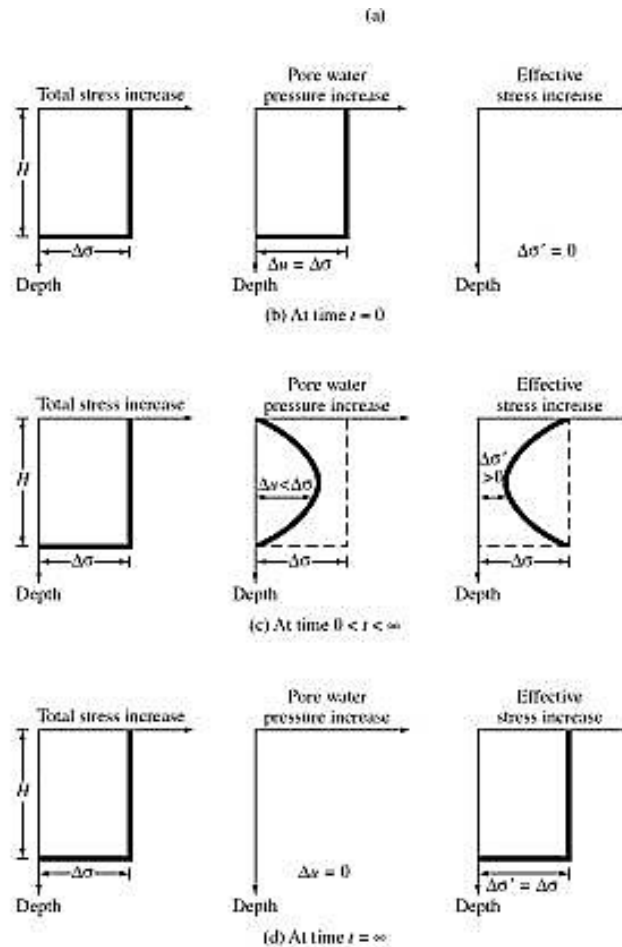
(a)

(b) At time $t = 0$

(c) At time $0 < t < \infty$

(d) At time $t = \infty$

Figure 2.12: Variation of total stress, pore water pressure, and effective stress of clay layer drained at top and bottom as the result of an added stress.

2.8.5 Shear Strength

The shear strength of soil mass is the internal resistance per unit area that the soil mass can offer to resist failure and sliding along any plane inside it. Understanding the nature of shearing resistance is important in order to analyze soil stability problem such as bearing capacity, slope stability, and lateral earth pressure on earth retaining structure. Shear strength test can determine the effect of remolding and variation on shear strength of cohesive soil depending on the direction of load application. The shear strength parameters of soil are determined in the laboratory primarily with two types of test which is direct shear test and triaxial test.

The direct shear test is the oldest and simples form of shear test arrangement. The size of specimen generally in this test is 51mm x 51mm and about 25 mm high (Das and Sobhan , 2010).

Other than that, there are three triaxial test that generally use which are consolidated drained test, consolidated undrained test and unconsolidated undrained test. From this method, shear strength parameter can be determined. In this test, a soil specimen is about 38 mm in diameter and 76 mm long generally used. The sample will carefully put inside the rubber membrane. Porous disk will place at both top and bottom of sample and sealed with O-ring. Then proceed to place specimen inside the triaxial chamber and put it on the platform of the compression machine. Run the test and the result generated. As shown in Figure 2.13, the apparatus are equipped with strain controlled triaxial load frame, triaxial cell assembly cell pressure supply panel, scale and balance sensitive to 0.1 g.
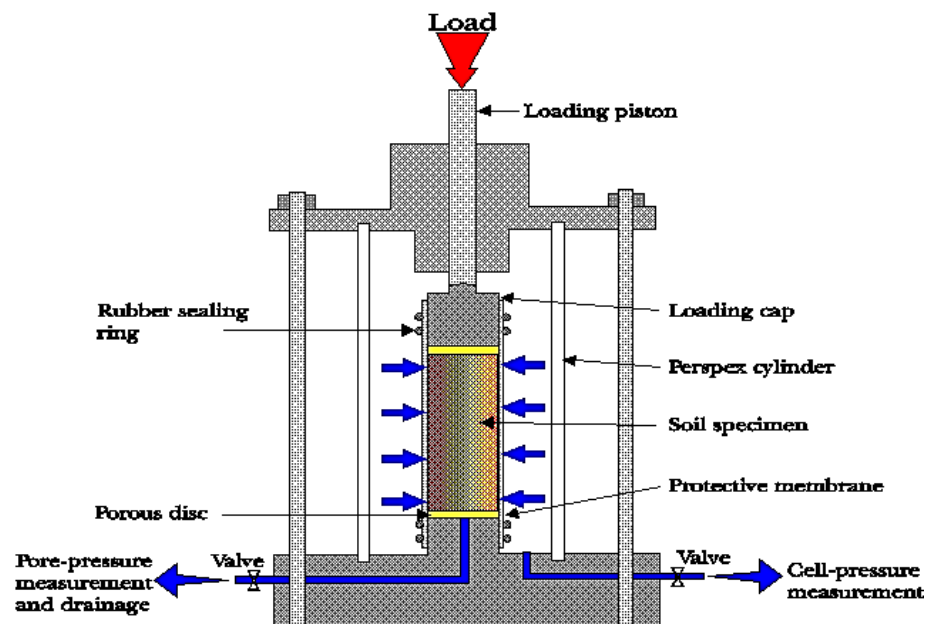
Figure 2.13: Triaxial Apparatus

CHAPTER 3

METHODOLOGY

3.1   Introduction

Methodology of this study consists of three stage which are will explain in detail the method used to carry out the result for strength, settlement and the chemical content in the soil. Besides that, methodology used also will be the guideline to achieve the proposed objective. The three stages include the process of proposed and planning, laboratory conduct and analyze the result.

First stage is proposed the research. These processes include the background studies for location of site, type of soil and past research that related to the site. Based on problem statement outcome, the objective and scope of work is carried out. When the proposal of research is accepted, the studies continue with the literature review where all related component and information will be collected from books, journal and thesis. Proceed to the second stage where the investigation process will take place. The investigations that will conduct are start from site investigation, soil sampling and continue with laboratory test. Finally the third stage of this study is analyzing the result and makes a relevant conclusion. Figure 3.1 will show the methodology flow chart of this study:

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           ┌─────────────────────┐
           │   Verify the Title  │
           └─────────────────────┘
                     │
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Carry out:

1) Problem Statement, Objective & Scope of Study.

2) Literature Riview

Investigation Process

Site Investigation

1) Choose suitable soil for sampling.

2) 2 point of sample at site

Laboratory Testing

1) Consolidation Properties

2) Permeability

3) Chemical Content

4) Strength

5) Classification of soil

Collect Data and Result

Analysis & Conclusion

Present Data in Tables & Graph

FINAL REPORT & PRESENTATION

FIGURE 3.1: Flow Chart of Methodology

3.2   Background Studies & Investigation

First stage of this study is verification of title and proposed the objective and scope of work based on problem statement that arises. After that proceed with literature review, where all information related to the study are collected such as site investigation, soil sampling, permeability, strength and consolidation properties are gather around from past journal, thesis and book.

Second stage of methodology is investigation process where the site investigations were conducted at Ampang dump site located within Bukit Seputeh Forest Area, under jurisdiction of Majlis Perbandaran Ampang Jaya (MPAJ). Site investigation are carried out to get the important information about the site and to decide sampling method that suitable for take the sample at the site.

3.3   Sampling

Sampling is carried out in order that soil and laboratory testing can be conducted. The structure of the soil is disturbed to the considerable excavation equipment. In these studies, the soil sample is taken manually by hand and not using any excavation equipment. The disturbances can be classified in following basic types such as change in the stress condition, change in the water content and the void ratio, disturbance of the soil structure, chemical changes, mixing and segregation of soil constituents. Disturbance of soil can cause by mechanism used to advance the sampler, dimension and type of sampler. For undisturbed sample the stress changes cannot be avoided. Several requirements are looked at this kind of sample such as no change due to disturbance of the soil structure, no change in void ratio and water content, no change in constituents and chemical properties.

There suitable point around the Bukit Ampang Landfill is chosen and the samples of soil were taken out. The samples of soil were taken start from depth 0.3 till 0.8 meter from the ground surface. The disturb sample will collected in

container and for undisturbed sample the soil will take out   in specific dimension and place at suitable container in order to do the sampling at the laboratory. All samples taken will transport to laboratory and stored at suitable place with constant room temperature to avoid any change in soil moisture content.

3.4   Laboratory Test

The laboratory tests that will be carried out consist of four main testing. The test involve are permeability, strength, consolidation properties and chemical content test. Other than that, some basic soil properties testing also conducted such soil particle size, specific gravity and Atterberg Limit test. These tests are carried out to obtain the geotechnical properties and behavior of Bukit Ampang. All of these testing are carried out based on British Standard (BS 1377). The testing and its method are done as the Table 3.1 below:

Table 3.1: Testing and Method for Laboratory Testing

TEST	METHOD
Soil Particle Size	• Sieve Analysis • Hydrometer Test
Specific Gravity	• Density Test
Plastic Limit, Liquid Limit & Plastic Index	• Atterberg Limit Test
Permeability Test	• Falling Head Test
Consolidation Properties	• Odometer Test
Strength	• Unconsolidated Undrained Test
Chemical Content	• X-ray Fluorescent

3.4.1 Strength

Determination of soil strength in this study is using unconsolidated undrained test (UU Test). This method can be used for determining the shear strength of cohesive type soil. The specimen is sheared at constant rate of axial deformation until failure occurs. The objectives of this test are to determine the shear strength of a cohesive soil and to observe the mode of failure of the soil specimen.

In this test undisturbed soil sample will be used where the bulk sample size of 38mm in diameter x 76mm in height. For certain case, the height to diameter ratio should be 1:2. The sample will carefully put inside the rubber membrane. Porous disk will place at both top and bottom of sample and sealed with O-ring. Then proceed to place specimen inside the triaxial chamber and put it on the platform of the compression machine. Run the test and the result generated.

3.4.2 Permeability

The falling head permeability test is used for measuring the permeability of soil of intermediate and low permeability (less than 0.0001 m/s). This test is conduct by connected the sample to standpipe, which provides both the head of water and the means of measuring quantity of water, flowing through the sample. Several standpipes of different diameter are available and the most suitable diameter is selected.

The aim of this test is to identify the permeability of the soils at intermediate and low permeability which is less than 0.0001 m/s. Other than that is to determine the coefficient of permeability of silt or clay soil. To conduct this test the apparatus that needs to be prepared. This test is importance the falling head test is to study the behavior of soil in its natural condition with respect to water flow. This method can be applied for undisturbed sample.

On the basis of the test results, the permeability of the sample can be calculated as :

$$permeability, K\mathrm{t} = \frac{2.303 \times A \times L \times Log\left(\frac{h_1}{h_2}\right) \times 0.00001}{A \times t} \ (m/s)$$

(eqn 3.1)

Where,

K_t	=	permeability (m/s)
A	=	cross section area of used manometer tube (mm^2)
A	=	cross section of sample in permeameter cell (mm^2)
T	=	measured time interval (s)
L	=	length of sample (m)
h_1	=	start level of manometer tube = $y_1 - h_o$ (m)
h_2	=	end level of manometer tube = $y_1 - h_o$ (m)

3.4.3 Consolidation Properties

To measure the consolidation properties of soil, Odometer test are the most suitable test to obtain the amount of settlement. Furthermore, it also will provide the time needed for the sample to consolidate. Consolidation settlement is the vertical displacement of the soil surface corresponding to the volume change at any stage of the consolidation.

The test is carried out by applying a sequence of seven vertical loading and three unloading laterally confined specimen having a height of 20mm and 50mm diameter. The vertical compression under each load is observed over a period of time. Since no lateral deformation is allowed, it is a one dimensional test, from which the one dimensional consolidation parameter is derived. Besides that, there are also other parameter that determine from the test such as compression stress (P_c), compression index (C_c), and coefficient of consolidation (C_v)

During the soil sampling, the existing effective overburden pressure is also releases, which result in some expansion. When this specimen is subjected to a consolidation test, a small amount of compression that is a small change in void ratio will occur when the effective pressure applied is less than the maximum effective overburden pressure in the field to which the soil had been subjected in the past. When the effective pressure on the specimen becomes greater than the maximum effective past pressure, the change in the void ratio is much larger, and the e-log õ relationship is practically linear with a steeper slope.

3.4.4   Chemical Content

In these studies, to check the chemical content in the landfill soil is by using X-ray fluorescence test (XRF). This test is the emission of characteristic "secondary" or fluorescent X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. It is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science and archaeology.

To conduct this test, based on (IAEA,1997) some basic practical rules that must be follow which are avoid contamination of the sample and any volatilization of chemical compounds and other losses of the elements during transportation and storage. Besides that, during sampling prepare reasonably large samples for this test and take account of seasonal fluctuations in the composition of the original material and of other parameters influencing its composition of temperature and humidity.

Figure 3.2: X-ray Fluorecent Machine

CHAPTER 4

RESULT AND DISCUSSION

4.1   Analyze and Testing Data

The data that have been analyzed in this study is about the geotechnical properties of the landfill soil, chemical content, soil strength and settlement of the soil.

All of data are analyze based on the sieve analysis test, hydrometer test, specific gravity test, atterberg limit test, permeability test, unconsolidated undrained test, odometer test and chemical test.

4.2   Analysis of Basic Soil Properties

4.2.1 Soil Characteristic

The colour of sample was dark brown with a pungent odour. The specific gravity is 2.5 and 2.45 for sample A and B. there are presence of leachate infiltration and organic content in soil. The optimum moisture content of Sample A is 12.3% with dry density 1.906 kN/m^2 and Sample B 13.6% with dry density 1.760 kN/m^2.

4.2.2 Grain Size Distribution and Classification

Based on Figure 4.1 analysis, sample A consists of a bulk of waste which the sizes are more than 2 mm. Thus, the waste soils combined with gravel are 0.3%. The soil consists of 47.2% sand, 17.8% silt and 34.64% clay. For sample B, the soil consists of 40.4% of sand, 28% silt, 26.3% clay and 5.2% gravel. This classification is conduct after isolate the waste and other dump from the soil. Figure 4.1 show the graph of percentage passing of Sample A and Sample B.
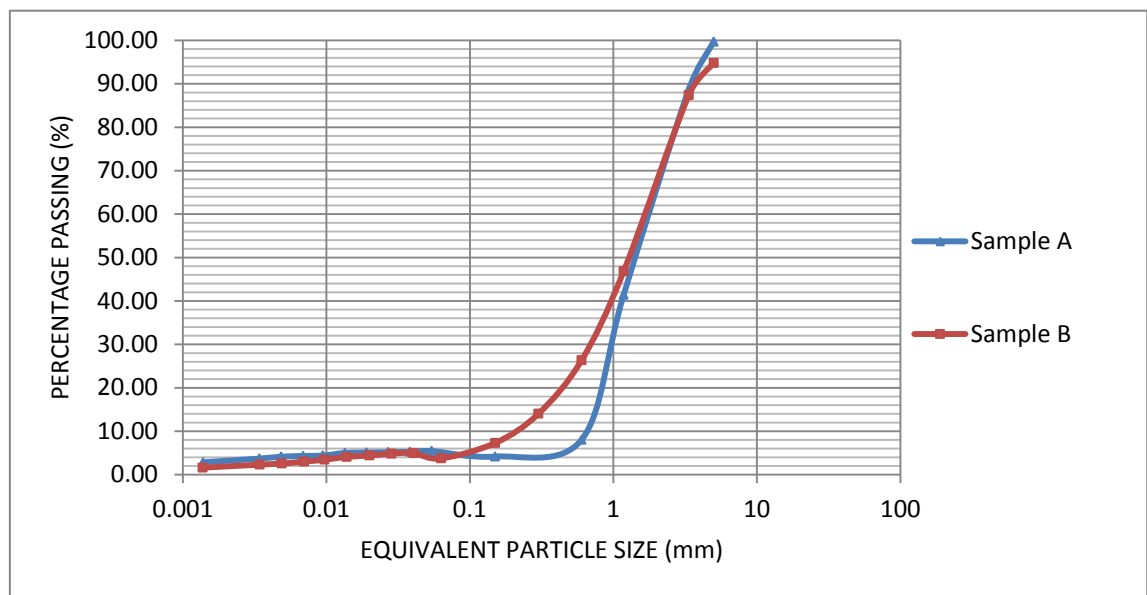
Figure 4.1: Percentage Passing of Soil Samples

4.2.3 Permeability

Permeability test was conduct at the sample optimum moisture content. The soil can be classifies as fine sand. The results are present in Table 4.1.

Table 4.1 Coefficient of Permeability

Description	Sample A	Sample B
Coefficient of Permeability (cm/s)	1.31×10^{-2}	1.28×10^{-2}

4.2.4 Consistency Limit

The atterberg limit test for sample A and Sample B shows that the soil at Bukit Ampang Landfill can be classify as high plasticity based on Burmister(1948). Plastic index of Sample A is 33.5% and Sample B 30.14%. Based on 20mm cone penetration test, the liquid limit for Sample A is 47.1% and 54.8% for Sample B. Thus, the plastic limit foer the sample are 13.06% and 24.66 for Sample A and B.

4.2.5 Consolidation Characteristics

The compressibility coefficients of compressibility, compression index, and consolidation settlement at 240 minutes, show in Table 4.2. Sample A have same consolidation settlement with Sample B.

Table 4.2 Consolidation Characteristic

Description	Sample A	Sample B
Coefficient of compressibility, m$_v$	0.393 cm²/MN	0.393 cm²/MN
Compression Index , C$_c$	0.333	0.040
Coefficient of consolidation, C$_v$	3.695 cm²/min	3.965 cm²/min
Consolidation Settlement, S$_c$	1.11mm	1.11mm

4.2.6 Strength Parameter

Undrained triaxial test are conduct with increase confining pressure $\sigma^3 =$ 60 kPa, $\sigma^3 = 120$ kPa and $\sigma^3 = 240$ kPa . Based on Table 4.3, from disturb sample from Sample A the highest cohesion recorded is 8 kPa with the lowest friction angle 34.25°. Sample B shows that the cohesion remains the same with 16 kPa with highest friction angle 34.24°.

Table 4.3 Strength Parameter

Sample	Test	Cohesion (kPa)	Angle of Friction (°)
A	1	3	43.2
	2	6	40.28
	3	8	34.25
B	1	16	34.24
	2	16	32
	3	16	34

4.2.7 Chemical Content

The present of chemical elements and oxide in soil may affect the structure. The elements that present more than 1% in Bukit Ampang landfill soil are Silicon (Si), Aluminium (Al), Iron (Fe), Potassium (K), Nickel (Ni), Copper (Cu), Gallium (Ga) and Arsenic (As). Based on Figure 3, the highest chemical elements that content in this soil is Nickel, 63% followed by Copper, 60% and Gallium, 52%.

FIGURE 4.2 Percentage of Chemical Element in soil

From Figure 4, the percentage of oxides that present in the soil are Silicon Dioxide (SiO_2) 27.19%, Aluminium Oxide (Al_2O_3) 11.21%, Iron Oxide (Fe_2O_3) 3.69%, Potassium Oxide (K_2O) 1.95%. The oxide that present more than 45 ppm in the soil are Zinc Oxide (ZnO) with the highest value 80 ppm, Gallium (III) Oxide (Ga_2O_3) 57 ppm, Copper Oxide (CuO) and Nickel Oxide (NiO) with 48 ppm.
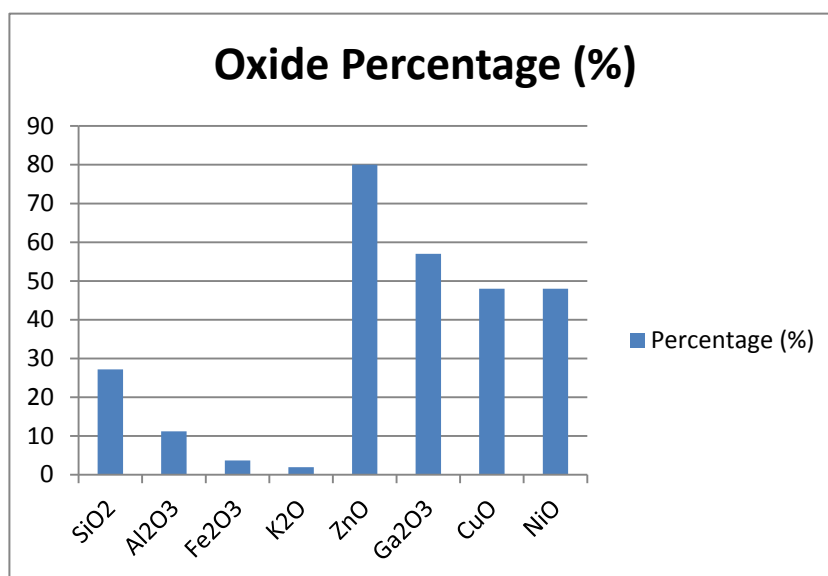
FIGURE 4.3 Percentage of Oxide in soil

The larger part of all nickel compounds that are released to the environment will adsorb to sediment or soil particles and become immobile as a result. In acidic ground however, nickel is bound to become more mobile and it will often rinse out to the groundwater.

Gallium does not exist in pure form in nature, and gallium compounds are not a primary source of extraction. Gallium is more abundant than lead but much less accessible because it has not been selectively concentrated into minerals by any geological process, so it tends to be widely dispersed. Several ores, such as the aluminum ore bauxite, contain small amount of gallium, and coal may have a relatively high gallium content. Liquid gallium wets porcelain and glass surfaces; it forms a bright, highly reflective surface when coated on glass. It can be used to create brilliant mirrors.

When copper ends up in soil it strongly attaches to organic matter and minerals. As a result it does not travel very far after release and it hardly ever enters groundwater. Copper can interrupt the activity in soils, as it negatively influences the activity of microorganisms and earthworms. The decomposition of organic matter may seriously slow down because of this.

4.3 Comparison with Past Research

As shown in Table 4.4 below, the comparison between Bukit Ampang Landfill with India landfill by (Evangelin, 2013) has been made. The comparison of index properties of soil shown that Bukit Ampang landfill has slightly higher value in specific gravity, liquid limit, plastic limit and plasticity index. Bukit Ampang landfill soil can be classified as poorly graded sand with clay and India landfill is classified as silty sand.

Table 4.4 Index Properties of soil

Location	Bukit Ampang Landfill	India Landfill (Evangelin,2013)
Specific Gravity	2.45	2.38
Gravel (%)	5.20	1.00
Sand (%)	40.52	39.80
Clay (%)	27.99	50.80
Silt (%)	26.26	8.40
D_{10}	0.41	0.08
Uniformity Coefficient, C_u	4.51	7.41
Coefficient of Curvature, C_c	1.07	0.88
Liquid Limit	54.80	20.00
Plastic Limit	24.66	18.30
Plasticity Index (I_p)	30.14	1.66
Classification	SP-SC (Poorly graded sand with clay)	SM (Silty Sand)

In Table 4.5, soil characteristics between Bukit Ampang and India landfill show slightly different in dry density where Bukit Ampang landfill has lower value compared to India Landfill. The optimum moisture content is a bit lower for Bukit Ampang landfill compare to Andhra Pradesh landfill, India (India Landfill).

Table 4.5 Soil Characteristics

Location	Bukit Ampang Landfill	India Landfill (Evangelin,2013)
Optimum Moisture Content (%)	13.6	14
Dry Density (kN/m^3)	1.76	19.8
Coefficient of Permeability (cm/s)	1.31×10^{-2}	2.28×10^{-5}

The samples from open dumping area are less moisturized due to the exposed of the samples to the air without any daily cover. The difference in the maximum particles sizes (Reddy et al. 2009) is believed to be one of the reasons responsible.

4.4 Proposed Type of Foundation for development

Pile foundation is basically a long cylinder of a strong material such as concrete that is pushed into the ground so that structures can be supported on top of it. Pile foundations can be used for weak soil such as Bukit Ampang Landfill. Since the soil layer cannot support the weight of the building, so the loads of the building have to bypass this layer and be transferred to the layer of stronger soil or rock that is below the weak layer. If the structure or buildings has very heavy, concentrated loads, such as in a high rise structure the pile foundations are capable of taking higher loads than spread footings.

The proposed foundations are end bearing piles and friction piles. In end bearing piles, the bottom end of the pile rests on a layer of especially strong soil or rock. The load of the building is transferred through the pile onto the strong layer. This pile also acts like a column. The key principle is that the bottom end rests on the surface which is the intersection of a weak and strong layer. The load therefore bypasses the weak layer and is safely transferred to the strong layer.

Friction piles work on a different principle. The pile transfers the load of the building to the soil across the full height of the pile, by friction. In other words, the entire surface of the pile, which is cylindrical in shape, works to transfer the forces to the soil.

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

As a conclusion, Bukit Ampang Landfill is not so suitable for future development since the soil characteristics are not safe for the future population or structure. But, the problem can be solved with deep research and future studies. Based on the laboratory tests have been done, it can be conclude that Bukit Ampang Landfill have soil that can be classified as poorly graded sand with clay. Since the landfill is site collection of dump and variety of waste, the soil has contained trash and rock. That can affect the soil classification. The optimum moisture content of soil is in range 12.3% to13.6%. The values are lower because it is sandy and contain more trash than water. Landfill soil must have a proper drainage for leachate. So, sandy soil is the most suitable for that purpose, thus it holds less water. The weather at site during taking the soil sample also can affect the moisture content of the soil. The atterberg limit test of soil shows that the soil at Bukit Ampang Landfill can be classify as high plasticity based on Burmister(1948). Plastic index of soil are between 30.14% to 33.5%. Based on 20mm cone penetration test, the liquid limit of the soil are between 47.1% to 54.8% .Thus, the plastic limit of soil are range from 13.06% to 24.66% .

Undrained triaxial test with increase confining pressure $\sigma^3 = 60$ kPa, $\sigma^3 = 120$ kPa and $\sigma^3 = 240$ kPa reported that highest cohesion value is 16 kPa and highest angle of friction is 43.2° for waste soil in Bukit Ampang Landfill. Generally, it can be conclude that soil at Bukit Ampang Landfill has the shear strength that increase with increasing of loading. The compressibility coefficients = 0.393 cm^2/MN, compression index = 0.33, and consolidation settlement at 240 minutes show that the soil are settled

between 1.0 mm to 1.11 mm. This consolidation process are quiet danger for development since the soil are rapidly consolidate.

The present of chemical elements and oxide in soil may affect the structure. The highest chemical elements that content in this soil is Nickel, 63% followed by Copper, 60% and Gallium, 52%. The percentage of oxides that pre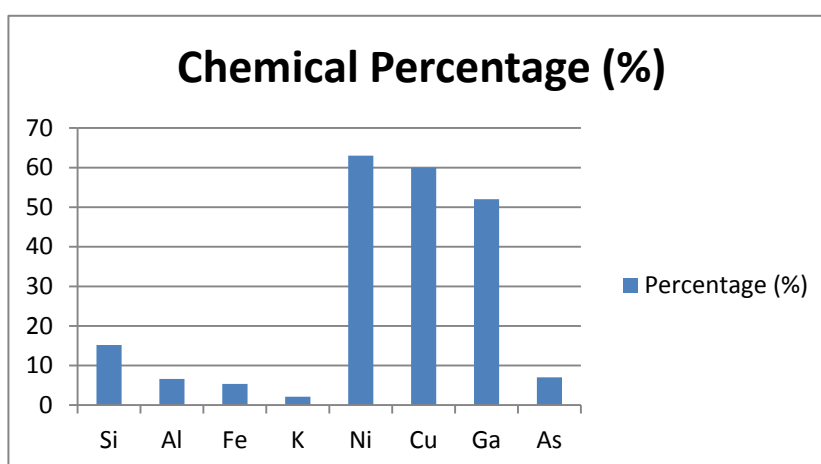sent in the soil more than 45 ppm in the soil are Zinc Oxide (ZnO) with the highest value 80 ppm, Gallium (III) Oxide (Ga2O3) 57 ppm, Copper Oxide (CuO) and Nickel Oxide (NiO) with 48 ppm.

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APPENDIX A1

HYDROMETER SEDIMENTATION TEST REPORT SAMPLE A

Particle Size Distribution (% Passing)		
5	mm	99.71
3.35	mm	88.67
1.18	mm	41.43
0.6	mm	8.02
0.15	mm	4.17
0.054	mm	5.429
0.038	mm	5.257
0.027	mm	5.171
0.019	mm	5.084
0.013	mm	4.998
0.009	mm	4.395
0.007	mm	4.309
0.005	mm	4.137
0.003	mm	3.706
0.001	mm	2.844
CLAY	%	34.643
SLIT	%	17.828
SAND	%	47.235
GRAVEL	%	0.294
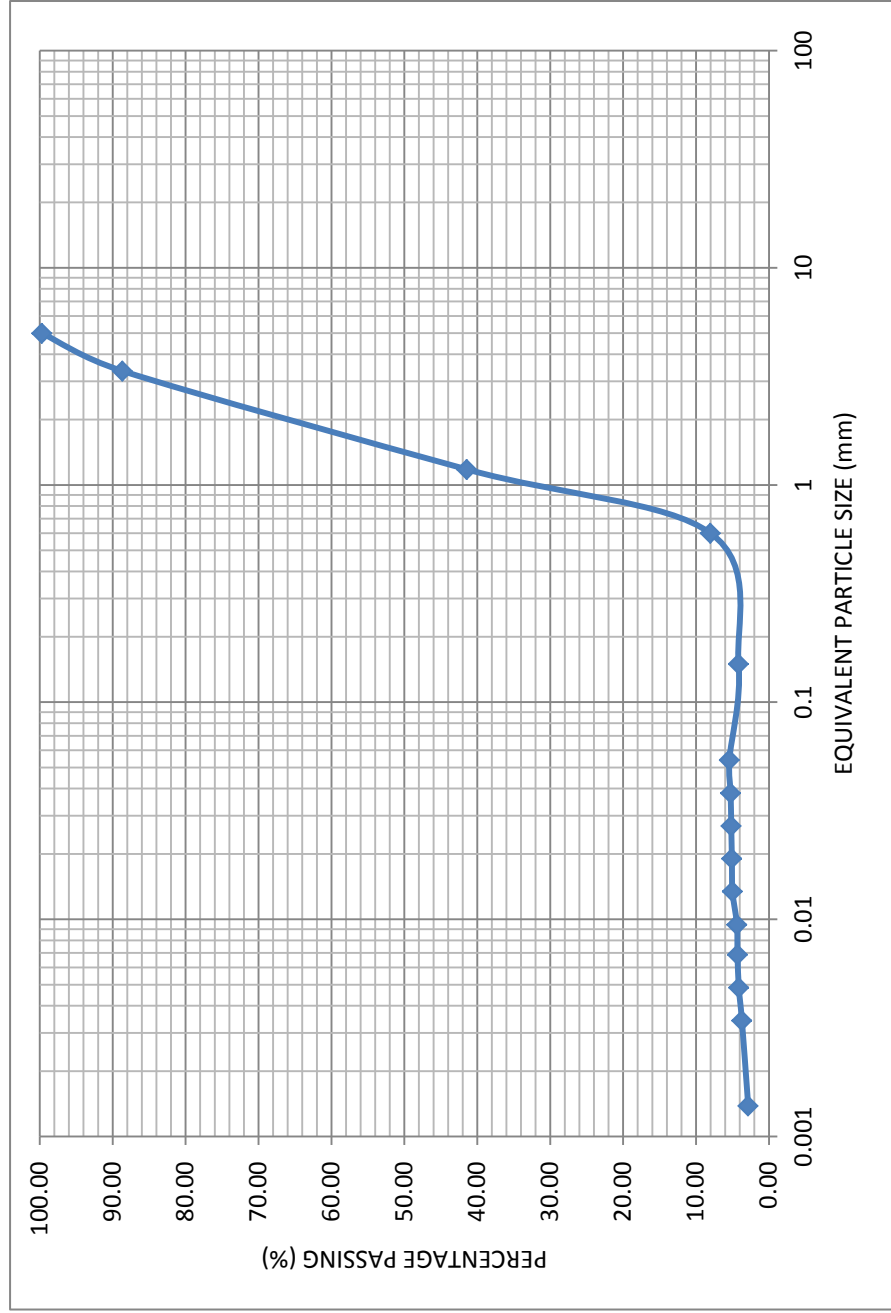
APPENDIX A2

HYDROMETER SEDIMENTATION TEST REPORT SAMPLE B

Particle Size Distribution (% Passing)		
5	mm	94.79
3.35	mm	87.37
1.18	mm	46.84
0.6	mm	26.33
0.3	mm	14.01
0.15	mm	7.29
0.063	mm	3.75
0.040	mm	4.965
0.028	mm	4.835
0.020	mm	4.399
0.014	mm	4.094
0.010	mm	3.441
0.007	mm	3.005
0.005	mm	2.570
0.003	mm	2.308
0.001	mm	1.612
CLAY	%	26.264
SLIT	%	27.996
SAND	%	40.528
GRAVEL	%	5.212
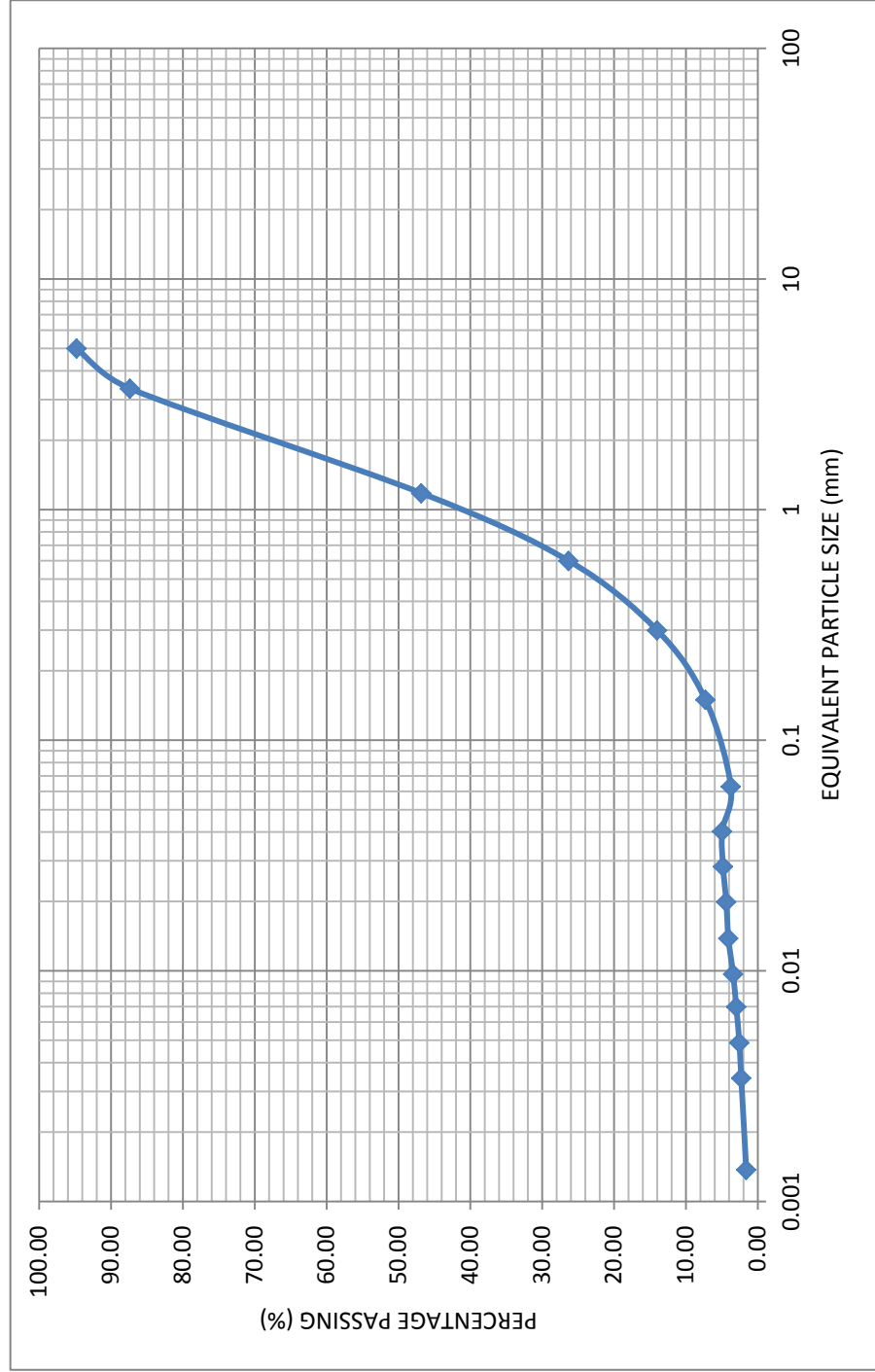
APPENDIX B1

ATTERBERG LIMITS TEST RESULT
SAMPLE A

LIQUID LIMIT

TEST NO.		1		2		3	
Cone penetration	mm	15.2	16	18	18.7	23.5	24.7
Average penetration	mm	15.6		18.35		24.1	
Container No.		4C	4A	D	5C	1D	9C
Container weight	g	10.15	10.52	10.51	10.25	10.81	10.78
Wet soil + container	g	17.8	15.64	19.57	17.07	17.12	18.95
Wet soil, W_w	g	7.65	5.12	9.06	6.82	6.31	8.17
Dry soil + container	g	15.43	14.05	16.73	14.94	15	16.29
Dry soil, W_d	g	5.28	3.53	6.22	4.69	4.19	5.51
Moisture loss W_w-W_d	g	2.37	1.59	2.84	2.13	2.12	2.66
Mosture content	%	44.89	45.04	45.66	45.42	50.60	48.28
AVERAGE MOISTURE CONTENT	%	44.96		45.54		49.44	

PLASTIC LIMIT

Container No.		63 C	72 C
Container weight	g	10.44	10.82
Wet + container	g	11.83	11.34
Wet soil, W_w	g	1.39	0.52
Dry soil + container	g	11.62	11.3
Dry soil, W_d	g	1.18	0.48
Moisture loss, W_w-W_d	g	0.21	0.04
Moisture content	%	17.80	8.33
AVERAGE MOISTURE CONTENT	%	13.06	

APPENDIX B1

Cone Penetration (mm) against Water Content (%)

mm	%
15.2	44.89
16	45.04
18	45.66
18.7	45.42
23.5	50.6
24.7	48.28

24.7	48.28
23.5	50.6
18.7	45.42
18	45.66
16	45.04
15.2	44.89
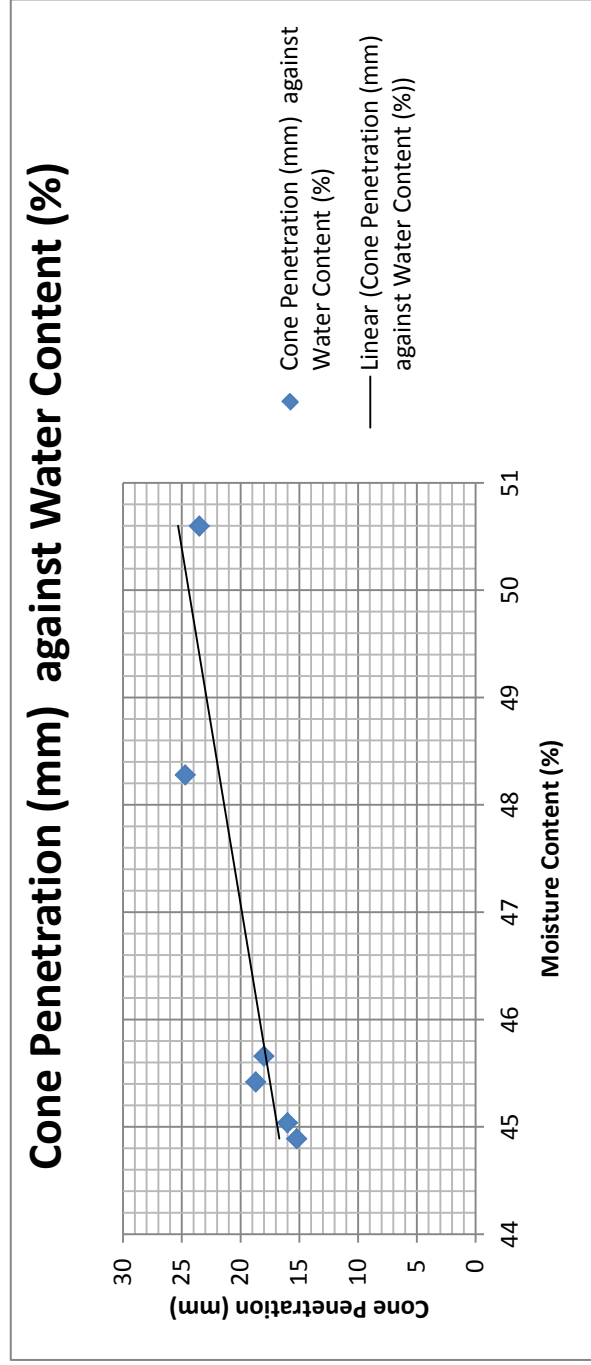
Based on the graph above, at the 20mm penetration the percentage of moisture content is 47.1 % therefore the value of the liquid limits is 47.1%.

From the table, the value of the plastic limit is 13.06 %. Thus, to find the Plastic Index is Liquid limit minus Plastic limit so the value of the Plastic index is 33.5 %, which is can be classify as high plasticity based on Burmister (1949).

APPENDIX B2

ATTERBERG LIMITS TEST RESULT
SAMPLE B

LIQUID LIMIT

TEST NO.		1		2		3	
Cone penetration	mm	13	15.1	21.4	20	24.2	25.5
Average penetration	mm	14.05		20.7		24.85	
Container No.	g	45 C	84 C	11 D	53 C	10 D	94 C
Container weight	g	24.84	24.51	24.36	24.71	9.98	9.91
Wet soil + container	g	25.96	26.03	25.52	26.12	12.28	12.58
Wet soil, W_w	g	1.12	1.52	1.16	1.41	2.3	2.67
Dry soil + container	g	25.58	25.52	25.11	25.61	11.45	11.59
Dry soil, W_d	g	0.74	1.01	0.75	0.9	1.47	1.68
Moisture loss W_w–W_d	g	0.38	0.51	0.41	0.51	0.83	0.99
Mosture content	%	51.35	50.50	54.67	56.67	56.46	58.93
AVERAGE MOISTURE CONTENT	%	50.92		55.67		57.70	

PLASTIC LIMIT

Container No.		93 C	51 C
Container weight	g	10.18	9.92
Wet + container	g	13.9	15.36
Wet soil, W_w	g	3.72	5.44
Dry soil + container	g	13.16	14.29
Dry soil, W_d	g	2.98	4.37
Moisture loss, W_w–W_d	g	0.74	1.07
Moisture content	%	24.83	24.49
AVERAGE MOISTURE CONTENT	%	24.66	

APPENDIX B2

Cone Penetration (mm) against Water Content (%)

mm	%
13	51.35
15.1	50.5
20	56.67
21.4	54.67
24.2	56.46
25.5	58.93

25.5	58.93
24.2	56.46
21.4	54.67
20	56.67
15.1	50.5
13	51.35
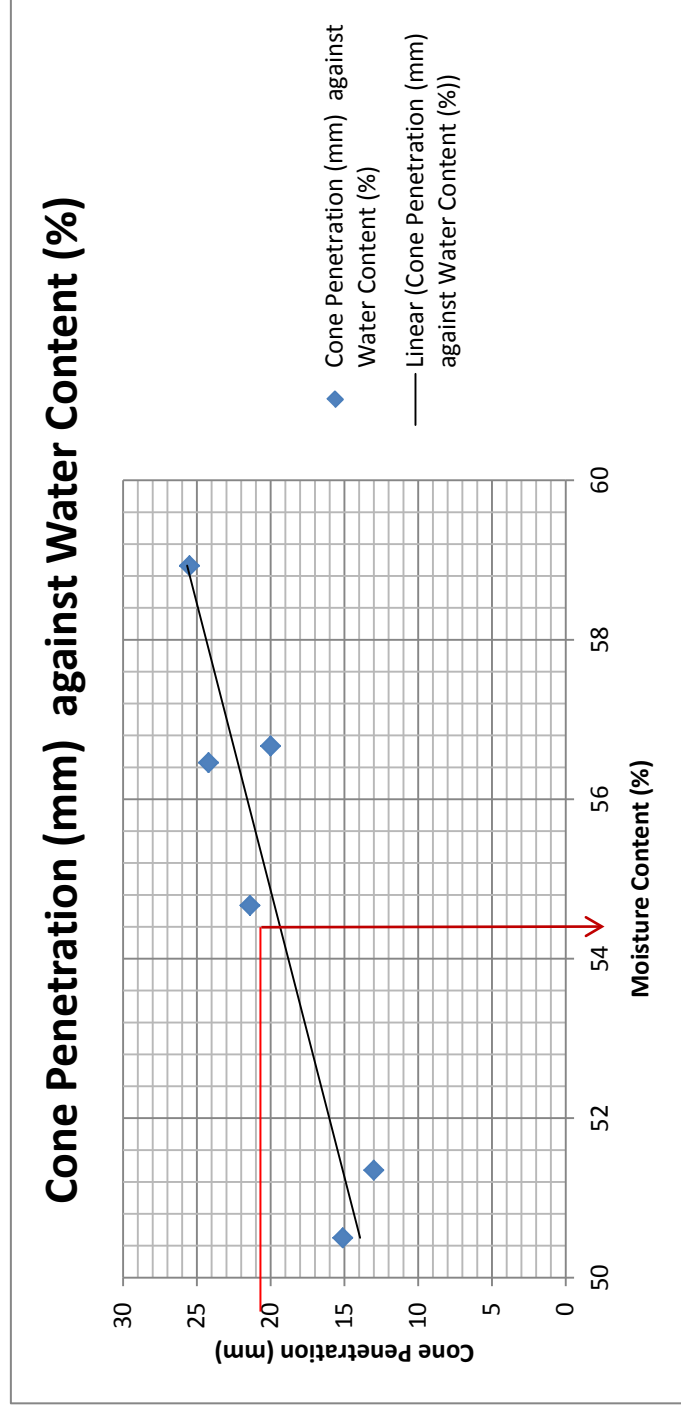
Based on the graph above, at the 20mm penetration the percentage of moisture content is 54.8 %. Therefore the value of the liquid limits is 54.8%.

From the table, the value of the plastic limit is 24.66 %. Thus, to find the Plastic Index is Liquid limit minus Plastic limit so the value of the Plastic index is 30.14 %, which is can be classify as high plasticity based on Burmister (1948).

APPENDIX C1

FALLING HEAD PERMEABILITY
SAMPLE A

Premeameter Cell
Dimension
Diameter, $\emptyset$ =   8.917   cm
Length , L   =   12.997 cm
Area, A   =   7.000   cm²

Manometer Tube	Diameter, $\emptyset$ (cm)	Start level , h_1 (cm)	End level , h_2 (cm)	Time, t (sec)
T_1	1.622	10000	6500	90
T_2	0.732	10000	6500	33
T_3	0.814	10000	7000	30

Manometer Tube	h_1/h_2	log h_1/h_2	Radius Manometer Tube, r (m)	Area Manometer Tube, a (m²)	Area, A (m²)	Axt
T_1	1.538	0.187	0.811	1.273	7.000	629.986
T_2	1.538	0.187	0.366	0.575	7.000	230.995
T_3	1.429	0.155	0.407	0.639	7.000	209.995

Permeability of the soil :

$$K_t = \frac{a \times L}{A \times t} \, \log(h_1/h_2)$$

$K_{t_1} =$ $2.303 \times$ $\dfrac{1.273 \times 12.997}{629.98605} \, \log(1.538)$

$K_{t_1} =$ 0.0113 cm/s

$K_{t_2} =$ $2.303 \times$ $\dfrac{0.575 \times 12.997}{230.994885} \, \log(1.538)$

$K_{t_2} =$ 0.0139 cm/s

$K_{t_3} =$ $2.303 \times$ $\dfrac{0.638 \times 12.997}{209.99535} \, \log(429)$

$K_{t_3} =$ 0.0141 cm/s

$\mathbf{Kt_{average}} =$ $\mathbf{0.01312}$ **cm/s** $\approx$ $\mathbf{1.31 \times 10^{-2}}$ **cm/s**

APPENDIX C2

FALLING HEAD PERMEABILITY
SAMPLE B

Premeameter Cell
Dimension
Diameter, $\emptyset$ = 8.917 cm
Length , L   = 12.997 cm
Area, A   = 7.000 cm²

Manometer Tube	Diameter, $\emptyset$ (cm)	Start level , h_1 (cm)	End level , h_2 (cm)	Time, t (sec)
T_1	1.622	10000	6500	98
T_2	0.732	10000	6500	35
T_3	0.814	10000	7000	28

Manometer Tube	h_1/h_2	log h_1/h_2	Radius Manometer Tube, r (m)	Area Manometer Tube, a (m²)	Area,A (m²)	Axt
T_1	1.538	0.187	0.811	1.273	7.000	685.985
T_2	1.538	0.187	0.366	0.575	7.000	244.995
T_3	1.429	0.155	0.407	0.639	7.000	195.996

Permeability of the soil :

$$K_t = \frac{a \times L}{A \times t} \log(h_1/h_2)$$

$$K_{t1} = 2.303 \times \frac{1.273 \times 12.997}{685.98} \log(1.538)$$

$$K_{t1} = 0.0104 \quad \text{cm/s}$$

$$K_{t2} = 2.303 \times \frac{0.575 \times 12.997}{244.99} \log(1.923076923)$$

$$K_{t2} = 0.0131 \quad \text{cm/s}$$

$$K_{t3} = 2.303 \times \frac{0.638 \times 12.997}{196.00} \log(1.587301587)$$

$$K_{t3} = 0.0151 \quad \text{cm/s}$$

$$\mathbf{K_{t\,average}} = \mathbf{0.01288} \quad \mathbf{cm/s} \approx \mathbf{1.28 \times 10^{-2}} \quad \mathbf{cm/s}$$

APPENDIX D1

SPECIFIC GRAVITY
SAMPLE A

Density Test (Small Pyknometer Method)

Soil Type :   BUKIT AMPANG LANDFILL   Sample No: BH1

Depth Excavated :   0.5m   Date Test :   18-02-15

TEST NO.		1	2	3	4
Density Bottle No.		2g	5	5a	3g
Weight of density bottle	g	24.5	25.35	24.83	23.3
Weight of bottle + Stopper (W_1)	g	28.75	29.82	29.56	27.72
Weight of bottle + Stopper + Dry soil (W_2)	g	33.67	34.6	34.37	32.72
Weight of bottle + Stopper + soil + water (W_3)	g	81.33	82.19	82.75	80.8
Weight of bottle + Stopper + water (W_4)	g	78.38	79.33	79.86	77.8
Weight of dry soil (W_2-W_1)	g	4.92	4.78	4.81	5
Weight of water (W_4-W_1)	g	49.63	49.51	50.3	50.08
Weight of soil + water (W_3-W_2)	g	47.66	47.59	48.38	48.08
Specific Gravity		2.497	2.490	2.505	2.500
Average specific gravity		2.50			

The result of the specific gravity

Soil Type	Range of Gs
Sand	2.63 – 2.67
Silty Sand	2.67 – 2.70
Silts	2.65 – 2.70
Silty Clay	2.67 – 2.80
Clay	2.70 – 2.80
Organic Soil	1+ to 2.60

The type of soil based on Gs

Based on the result the specific gravity is 2.5. So, the type of soil is Organic Soil.

APPENDIX D2

SPECIFIC GRAVITY
SAMPLE B

Density Test (Small Pyknometer Method)
Soil Type :   BUKIT AMPANG LANDFILL   Sample No: BH2
Depth Excavated :   0.5m   Date Test :   18-02-15

TEST NO.		1	2	3	4
Density Bottle No.		18	z	10	17
Weight of density bottle	g	24.6	24.65	23.68	25.86
Weight of bottle + Stopper (W_1)	g	28.55	29.3	27.7	30.45
Weight of bottle + Stopper + Dry soil (W_2)	g	33.44	34.2	33	35.46
Weight of bottle + Stopper + soil + water (W_3)	g	80.75	82.42	81.15	83.54
Weight of bottle + Stopper + water (W_4)	g	77.85	79.53	78.05	80.54
Weight of dry soil (W_2-W_1)	g	4.89	4.9	5.3	5.01
Weight of water (W_4-W_1)	g	49.3	50.23	50.35	50.09
Weight of soil + water (W_3-W_2)	g	47.31	48.22	48.15	48.08
Specific Gravity		2.457	2.438	2.409	2.493
Average specific gravity		2.45			

The result of the specific gravity

Soil Type	Range of Gs
Sand	2.63 – 2.67
Silty Sand	2.67 – 2.70
Silts	2.65 – 2.70
Silty Clay	2.67 – 2.80
Clay	2.70 – 2.80
Organic Soil	1+ to 2.60

The type of soil based on Gs

Based on the result the specific gravity is 2.45. So, the type of soil is Organic Soil.

APPENDIX E1

STANDARD PROCTOR TEST
SAMPLE A

Rammer Weight 2.5 kg
Mould:
Height: 0.1175 m   Diameter: 0.105 m   Volume: 0.0097 m³

WATERCONTENT		5%		10%		15%		20%		25%	
Mass of Mould + Base (m_1)	kg	4.08		4.08		4.08		4.08		4.08	
Mass of Mould + Base + Compacted Specimen (m_2)	kg	5.78		5.84		6.18		6.14		6.04	
Bulk Density , $p = (m_2-m_1)/V$	Mg/m³	0.1755		0.1817		0.2168		0.2127		0.2024	
CONTAINER NO.		65C	G8	48D	32D	33C	46C	60C	4D	107C	22C
Container Weight	kg	0.0097	0.0104	0.01	0.0102	0.0104	0.0102	0.0094	0.01	0.0108	0.0104
Wet Soil + Container	kg	0.0505	0.0456	0.0256	0.0194	0.0223	0.0304	0.0216	0.0283	0.0411	0.0363
Wet Soil , Ww	kg	0.0408	0.0353	0.0156	0.0092	0.0119	0.0203	0.0122	0.0183	0.0303	0.0259
Dry Soil + Container	kg	0.0488	0.0441	0.0247	0.0191	0.0211	0.0283	0.0198	0.0256	0.0354	0.0314
Dry Soil , Wd	kg	0.0391	0.0338	0.0147	0.0089	0.0107	0.0181	0.0104	0.0156	0.0246	0.0211
Moisture Loss , Ww-Wd	kg	0.0017	0.0015	0.0009	0.0003	0.0012	0.0022	0.0018	0.0027	0.0057	0.0048
Moisture Content , w	%	4.373	4.444	6.190	3.725	11.423	12.113	17.291	17.545	23.208	23.019
Average Moisture Content	%	4.409		4.958		11.768		17.418		23.113	
Dry Density , pd = p/(1+w)	Mg/m³	0.168		0.173		0.194		0.181		0.164	
Dry Unit Weight , yd	kN/m³	1.649		1.699		1.903		1.777		1.613	

The result of Proctor Test

APPENDIX E1

Dry Density Against Moisture Content
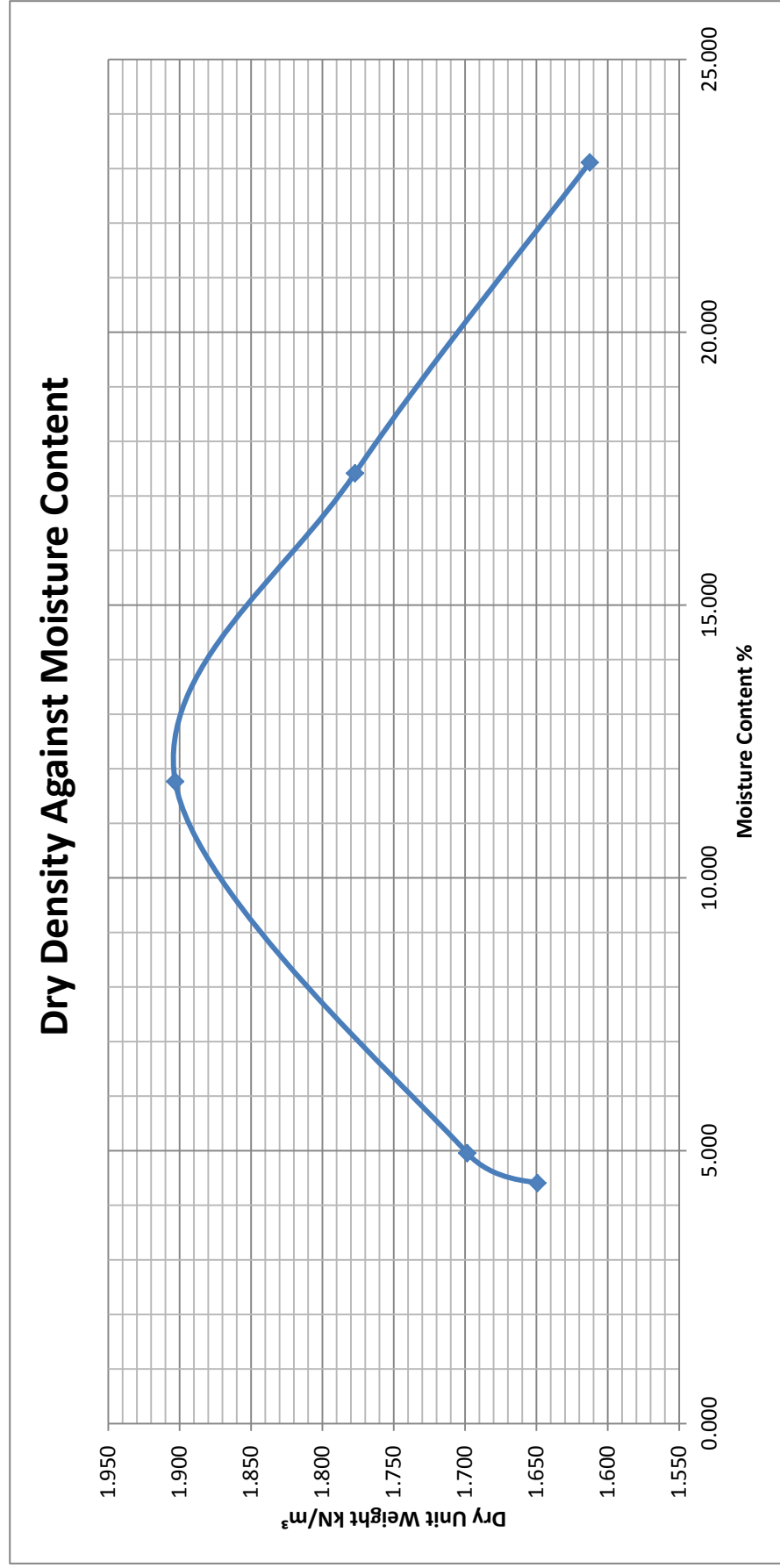
APPENDIX E2

STANDARD PROCTOR TEST
SAMPLE B

Rammer Weight 2.5 kg
Mould:
Height: 0.1175 m   Diamete   0.105 m   Volume: 0.0097 m³

WATERCONTENT		5%		10%		15%		20%		25%	
Mass of Mould + Base (m₁)	kg	4.08		4.08		4.08		4.08		4.08	
Mass of Mould + Base + Compacted Specimen (m₂)	kg	5.64		5.7		6.02		6.08		6	
Bulk Density , $p = (m_2-m_1)/V$	Mg/m³	0.1611		0.1673		0.2003		0.2065		0.1982	
CONTAINER NO.		1C	51C	G8	64C	7C	100C	76C	44C	17C	72C
Container Weight	kg	0.0102	0.0102	0.0105	0.0102	0.0103	0.0107	0.0098	0.0101	0.0099	0.0105
Wet Soil + Container	kg	0.0193	0.0214	0.0157	0.0188	0.027	0.0269	0.0353	0.0402	0.0387	0.023
Wet Soil , Ww	kg	0.009	0.0111	0.0053	0.0086	0.0166	0.0162	0.0254	0.0301	0.0288	0.0125
Dry Soil + Container	kg	0.0191	0.021	0.0155	0.0183	0.0252	0.0251	0.0314	0.0355	0.0329	0.0204
Dry Soil , Wd	kg	0.0088	0.0107	0.005	0.0081	0.0149	0.0144	0.0215	0.0254	0.023	0.01
Moisture Loss , Ww-Wd	kg	0.0002	0.0004	0.0003	0.0005	0.0018	0.0018	0.0039	0.0047	0.0059	0.0025
Moisture Content , w	%	2.262	3.825	5.169	6.196	11.836	12.500	18.114	18.396	25.566	25.528
Average Moisture Content	%	3.044		5.682		12.168		18.255		25.547	
Dry Density , pd = p/(1+w)	Mg/m³	0.156		0.158		0.179		0.175		0.158	
Dry Unit Weight , ɣd	kN/m³	1.533		1.553		1.752		1.713		1.549	

The result of Proctor Test

APPENDIX E2

Dry Density Against Moisture Content

Dry Unit Weight kN/m³

Moisture Content %
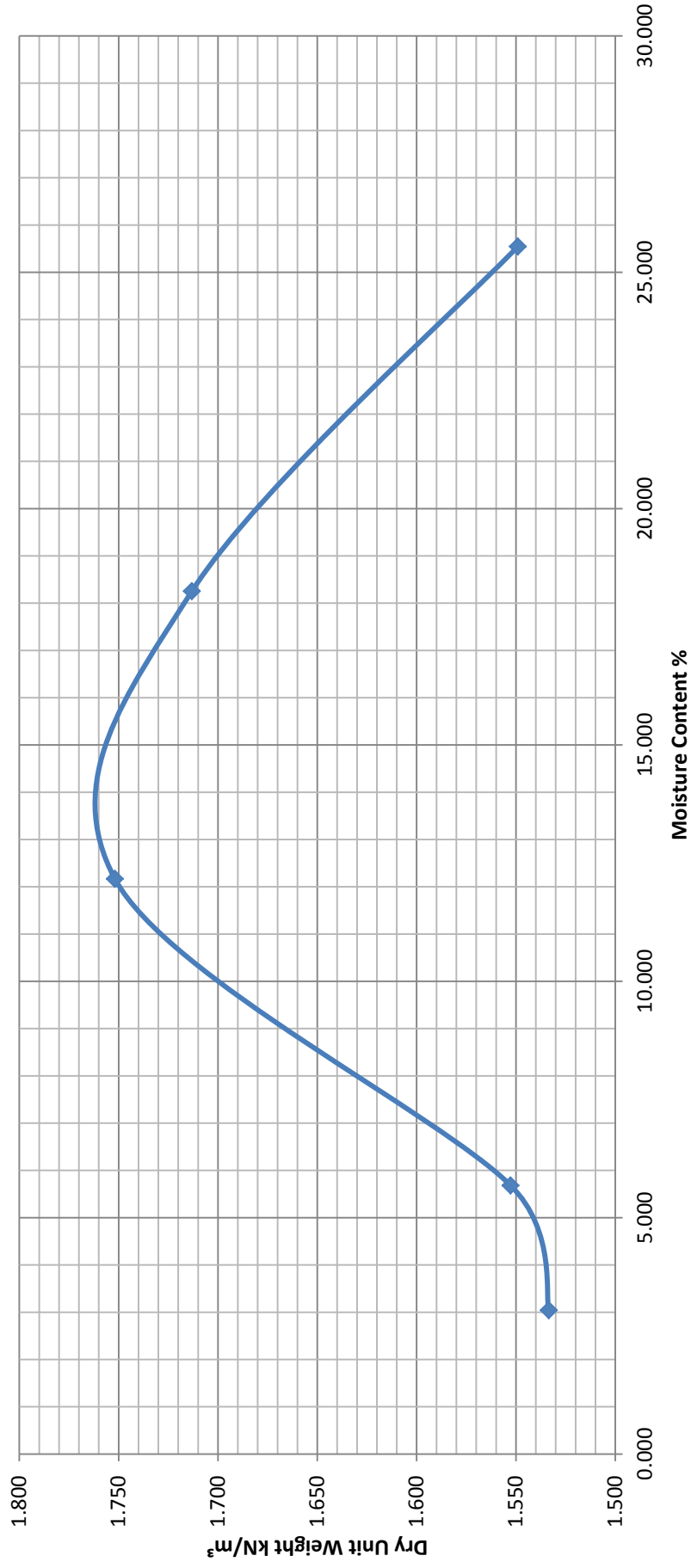
APPENDIX F1

TRIAXIAL TEST
SAMPLE A

Mohr Circle Diagram
SAMPLE A 1

Shear Stress Traction

$\emptyset =43.2°$

c = 3

Normal Stress Traction

Mohr Circle Diagram
SAMPLE A 2

Shear Stress Traction

$\emptyset =40.28°$

c = 6

Normal Stress Traction

Mohr Circle Diagram
SAMPLE A 3
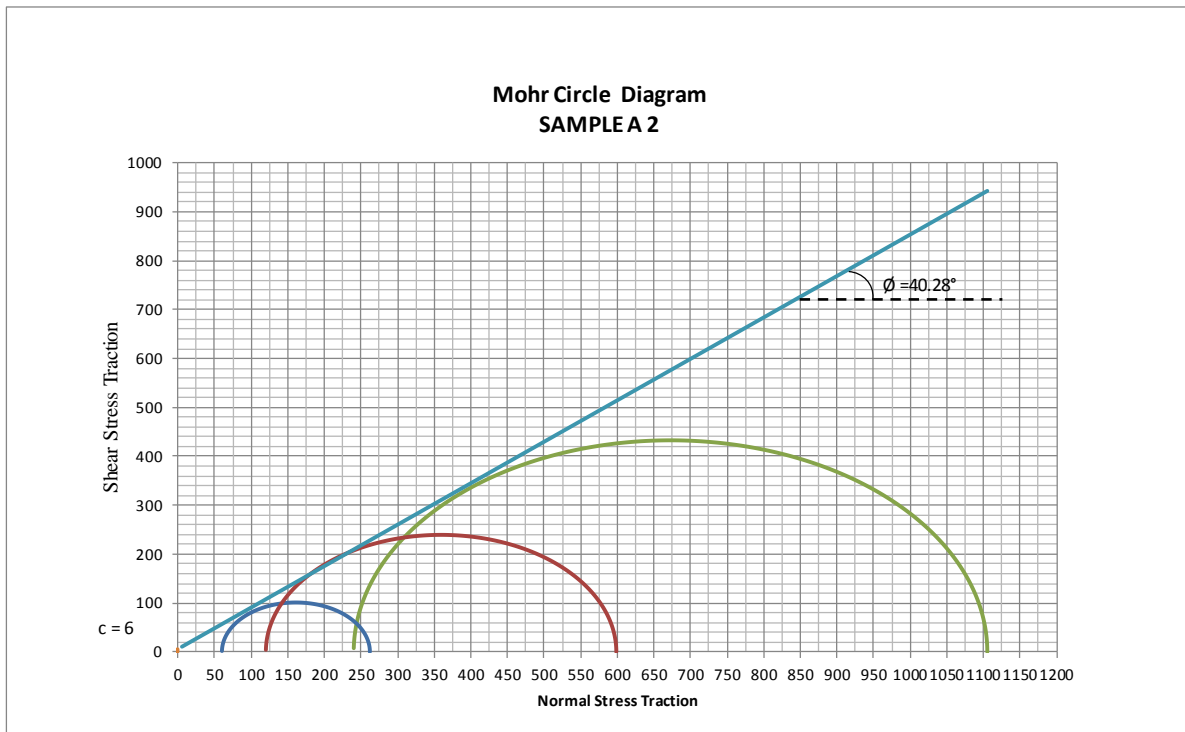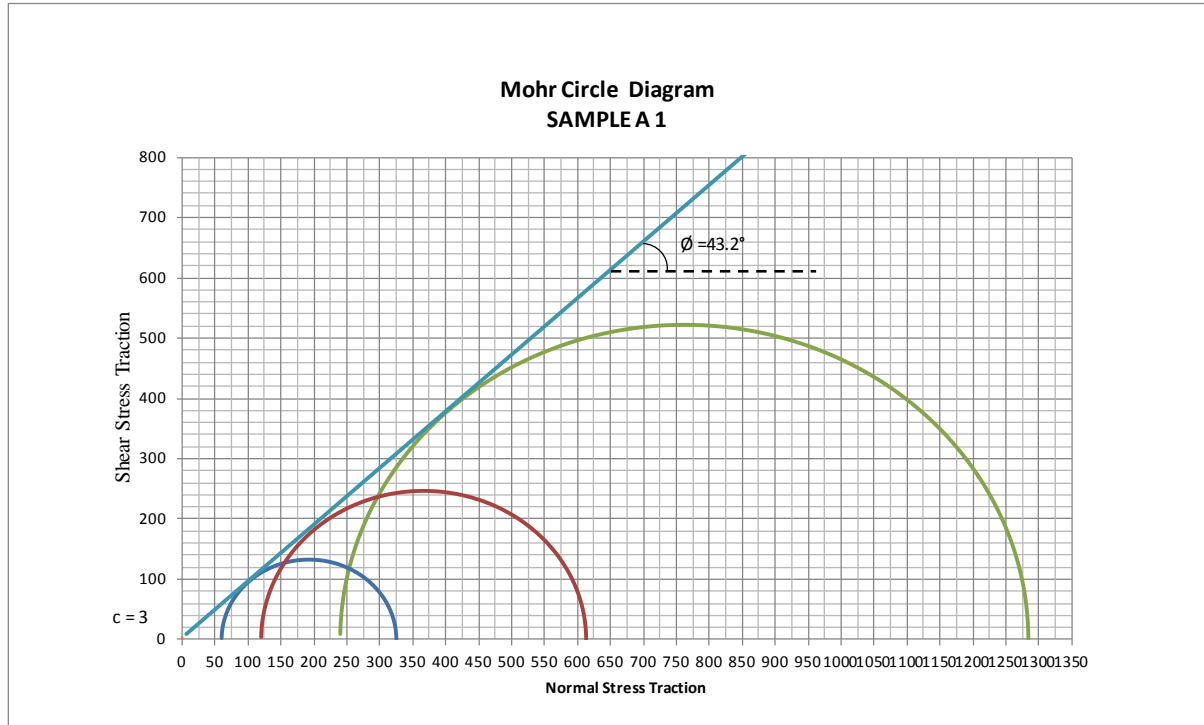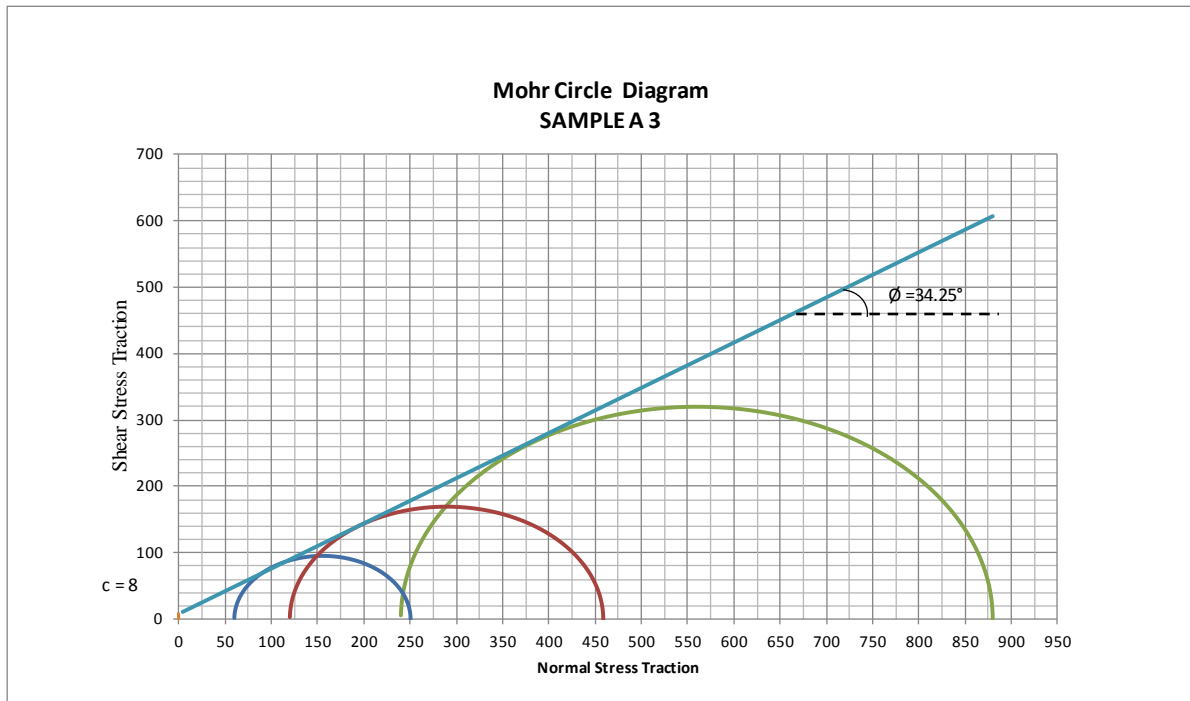
APPENDIX F2

TRIAXIAL TEST
SAMPLE B

Mohr Circle Diagram
SAMPLE B 1

Mohr Circle Diagram
SAMPLE B 2

Mohr Circle Diagram
SAMPLE B 3

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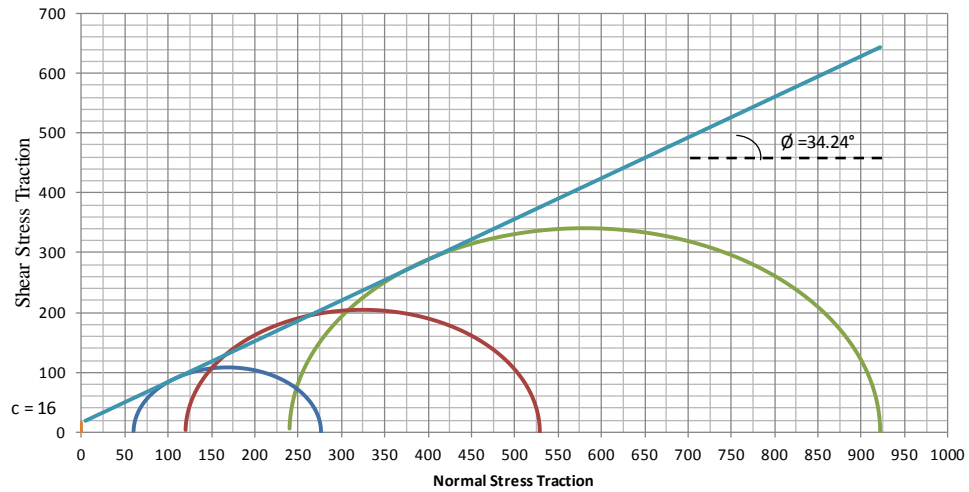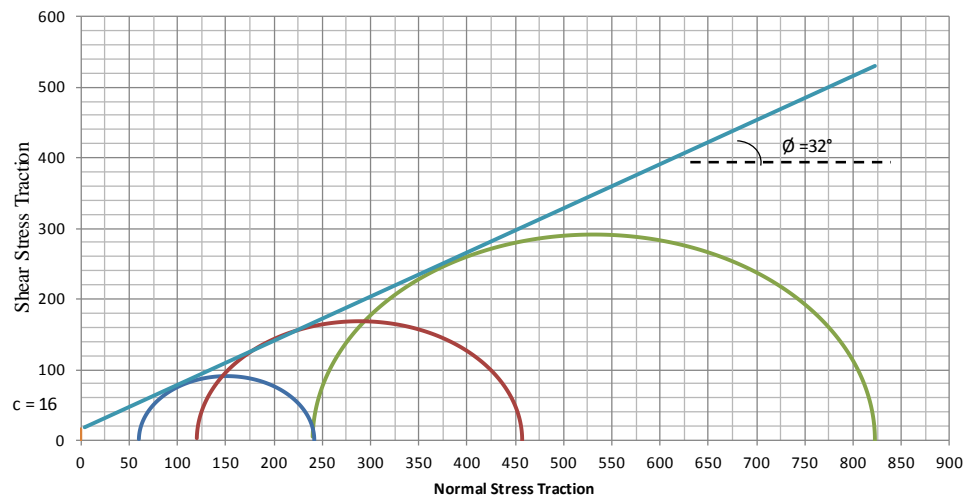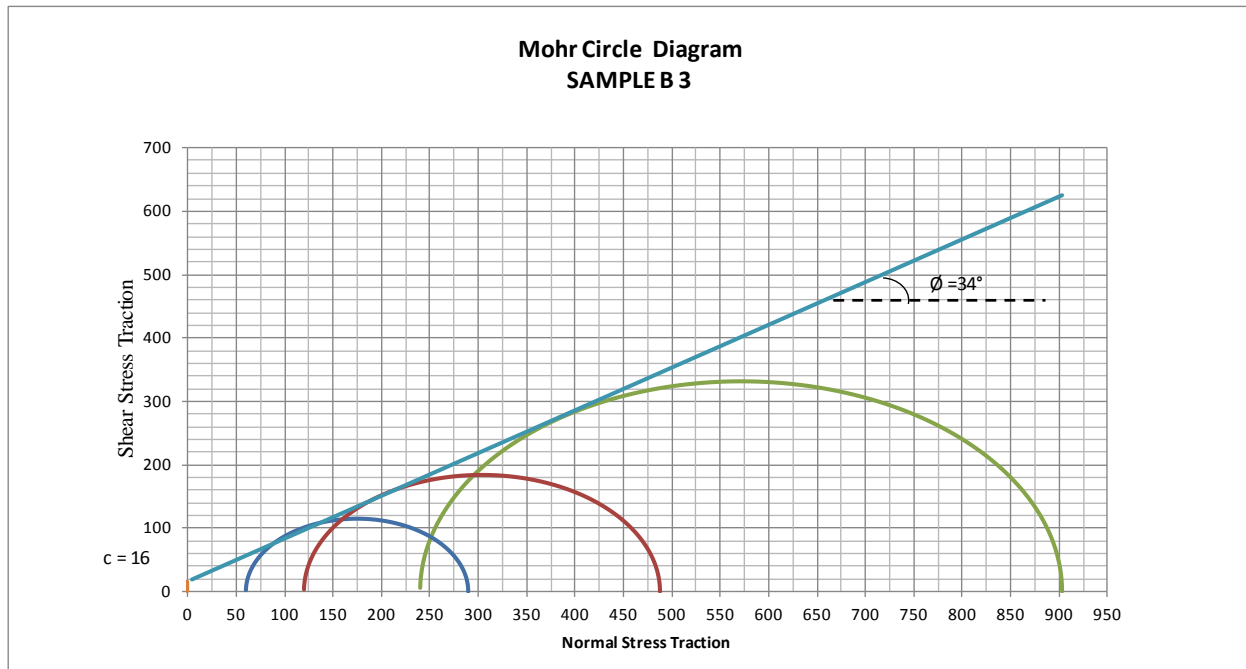
CENTRAL LABORATORY
Universiti Malaysia Pahang, Lebuhraya Tun Razak,
26300 Kuantan, Pahang Darul Makmur.
Tel : 09-5493351 Fax : 09-5493353
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CERTIFICATE OF ANALYSIS (COA)

To :	Nurul Ain Bt Abd Rashid		Attn :	
Address :	FKASA, UMP			
C.C. :			Page :	3 pages
Fax No :		Tel No : 012-3134158	Sample Lab No: 2015/160	

Sample description   : One sample in powdered form

Sample marking   : Soil

Sample preparation   : Mylar cup (Standard)

Date of sample received : 23/03/2015

Date reported   : 24/03/2015

RESULTS:

i)   **Elements**

No	Parameter	Results	Unit	Test Method
1.	Silicon (Si)	15.19	%	Quantexpress (Best Detection)
2.	Aluminium (Al)	6.62	%	Quantexpress (Best Detection)
3.	Iron (Fe)	5.34	%	Quantexpress (Best Detection)
4.	Potassium (K)	2.11	%	Quantexpress (Best Detection)
5.	Titanium (Ti)	0.42	%	Quantexpress (Best Detection)
6.	Calcium (Ca)	0.25	%	Quantexpress (Best Detection)
7.	Phosphorus (P)	0.15	%	Quantexpress (Best Detection)
8.	Sodium (Na)	0.11	%	Quantexpress (Best Detection)
9.	Rubidium (Rb)	0.11	%	Quantexpress (Best Detection)

10.	Magnesium (Mg)	0.08	%	Quantexpress (Best Detection)
11.	Barium (Ba)	0.06	%	Quantexpress (Best Detection)
12.	Zirconium (Zr)	0.05	%	Quantexpress (Best Detection)
13.	Sulphur (S)	0.02	%	Quantexpress (Best Detection)
14.	Manganese (Mn)	0.02	%	Quantexpress (Best Detection)
15.	Lead (Pb)	0.01	%	Quantexpress (Best Detection)
16.	Niobium (Nb)	0.01	%	Quantexpress (Best Detection)
17.	Chlorine (Cl)	0.01	%	Quantexpress (Best Detection)
18.	Strontium (Sr)	0.01	%	Quantexpress (Best Detection)
19.	Chromium (Cr)	0.01	%	Quantexpress (Best Detection)
20.	Zinc (Zn)	0.01	%	Quantexpress (Best Detection)
21.	Nickel (Ni)	63	ppm	Quantexpress (Best Detection)
22.	Copper (Cu)	60	ppm	Quantexpress (Best Detection)
23.	Gallium (Ga)	52	ppm	Quantexpress (Best Detection)
24.	Arsenic (As)	7	ppm	Quantexpress (Best Detection)

ii)   Oxide

No	Parameter	Results	Unit	Test Method
1.	Silicon Dioxide (SiO2)	27.19	%	Quantexpress (Best Detection)
2.	Aluminium Oxide (Al2O3)	11.21	%	Quantexpress (Best Detection)
3.	Iron Oxide (Fe2O3)	3.69	%	Quantexpress (Best Detection)
4.	Potassium Oxide (K2O)	1.95	%	Quantexpress (Best Detection)
5.	Titanium Dioxide (TiO2)	0.54	%	Quantexpress (Best Detection)
6.	Phosphorus Pentoxide (P2O5)	0.30	%	Quantexpress (Best Detection)
7.	Calcium Oxide (CaO)	0.25	%	Quantexpress (Best Detection)

8.	Sodium Oxide (Na2O)	0.21	%	Quantexpress (Best Detection)
9.	Magnesium Oxide (MgO)	0.14	%	Quantexpress (Best Detection)
10.	Rubidium Oxide (Rb2O)	0.09	%	Quantexpress (Best Detection)
11.	Zirconium Dioxide (ZrO2)	0.06	%	Quantexpress (Best Detection)
12.	Barium Oxide (BaO)	0.05	%	Quantexpress (Best Detection)
13.	Sulphur Trioxide (SO3)	0.04	%	Quantexpress (Best Detection)
14.	Arsenic Trioxide (As2O3)	0.02	%	Quantexpress (Best Detection)
15.	Manganese(II) Oxide (MnO)	0.02	%	Quantexpress (Best Detection)
16.	Niobium Pentoxide (Nb2O5)	0.02	%	Quantexpress (Best Detection)
17.	Chromium (III) Oxide (Cr2O3)	0.01	%	Quantexpress (Best Detection)
18.	Strontium Oxide (SrO2)	0.01	%	Quantexpress (Best Detection)
19.	Zinc Oxide (ZnO)	80	ppm	Quantexpress (Best Detection)
20.	Gallium (III) Oxide (Ga2O3)	57	ppm	Quantexpress (Best Detection)
21.	Copper Oxide (CuO)	48	ppm	Quantexpress (Best Detection)
22.	Nickel Oxide (NiO)	48	ppm	Quantexpress (Best Detection)

The certificate shall not be reproduced except in full without the written approval of the laboratory.

The above analysis is based on the sample submitted by the customer.

....

SYAHIDAH ALWI
LAB ANALYST
MATERIAL DEPARTMENT
CENTRAL LABORATORY

APPENDIX H

One Dimensional Consolidation Properties
(Oedometer)

ELE International

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S1

Test Details

Standard	BS 1377: Part 5 : 1990 : Clause 3	Particle Density	2.50 Mg/m3
Sample Type	Core sample	Lab Temperature	0.0 deg.C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details

Specimen Reference	C	Description	
Depth within Sample	0.00mm	Orientation within Sample	
Specimen Mass	82.55 g	Condition	Natural Moisture
Specimen Height	20.17 mm	Preparation	
Comments			

Test Apparatus

Ring Number	1	Ring Diameter	49.79 mm
Ring Height	20.17 mm	Ring Weight	69.86 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure
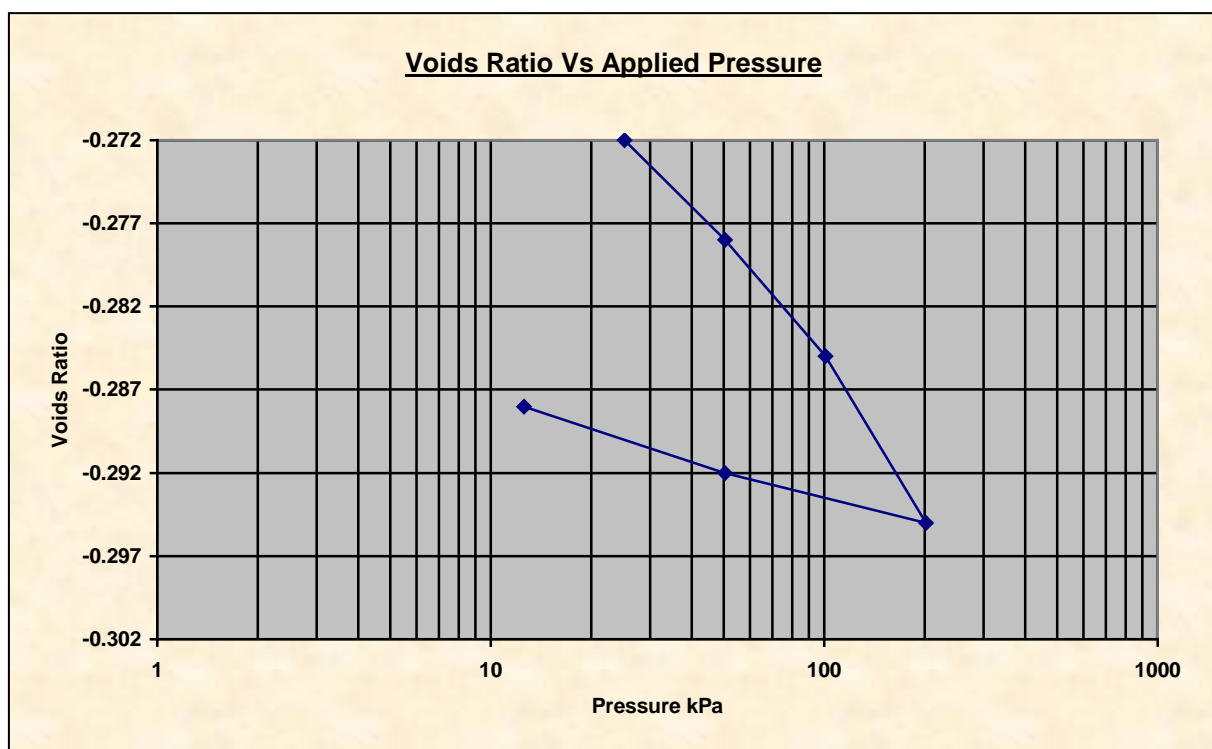
Height of Solid Particles	28.89 mm	Swelling Pressure	0.0 kPa

One Dimensional Consolidation Properties
(Oedometer)

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S1

Initial Moisture Content*	-41.3 %	Final Moisture Content	9.3 %
Initial Bulk Density	2.10 Mg/m3	Final Bulk Density	3.84 Mg/m3
Initial Dry Density	3.58 Mg/m3	Final Dry Density	3.51 Mg/m3
Initial Void Ratio	-0.3019	Final Void Ratio	-0.2878
Initial Degree of Saturation	342.02%	Final Degree of Saturation	-80.86 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	Coefficient of Volume Compressibility (m_v)	Coefficient of Consolidation (c_v)
0.00		
25.2 kPa	-1.71 m2/MN	734.96 m2/yr
50.4 kPa	0.31 m2/MN	649.85 m2/yr
100.8 kPa	0.21 m2/MN	649.73 m2/yr
201.5 kPa	0.14 m2/MN	274.01 m2/yr
50.4 kPa	0.03 m2/MN	---------
12.6 kPa	0.17 m2/MN	---------

Method of Time Fitting Used	Square Root Time

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

One Dimensional Consolidation Properties
(Oedometer)

ELE International 73

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S1

Test Details

Standard	BS 1377: Part 5 : 1990 : Clause 3	Particle Density	2.50 Mg/m3
Sample Type	Core sample	Lab Temperature	0.0 deg.C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details

Specimen Reference	B	Description	
Depth within Sample	0.00mm	Orientation within Sample	
Specimen Mass	83.10 g	Condition	Natural Moisture
Specimen Height	20.24 mm	Preparation	
Comments			

Test Apparatus

Ring Number	1	Ring Diameter	49.93 mm
Ring Height	20.24 mm	Ring Weight	68.29 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure
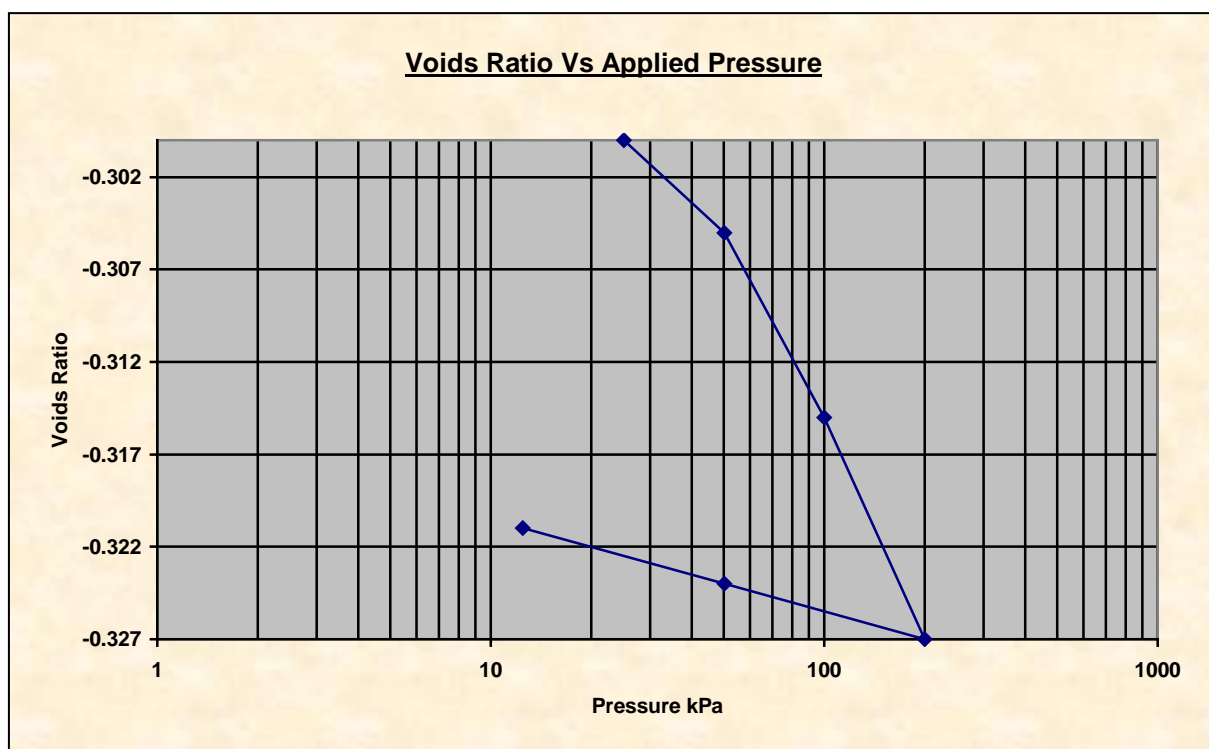
Height of Solid Particles	29.03 mm	Swelling Pressure	0.0 kPa

ELE International

Page 1 of 2

One Dimensional Consolidation Properties
(Oedometer)

ELE International

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S1

Initial Moisture Content*	-41.5 %	Final Moisture Content	9.3 %
Initial Bulk Density	2.10 Mg/m3	Final Bulk Density	4.02 Mg/m3
Initial Dry Density	3.59 Mg/m3	Final Dry Density	3.68 Mg/m3
Initial Void Ratio	-0.3027	Final Void Ratio	-0.3208
Initial Degree of Saturation	342.84%	Final Degree of Saturation	-72.46 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	Coefficient of Volume Compressibility (m_v)	Coefficient of Consolidation (c_v)
0.00		
25.1 kPa	-0.17 m2/MN	695.16 m2/yr
50.1 kPa	0.31 m2/MN	560.15 m2/yr
100.2 kPa	0.27 m2/MN	636.80 m2/yr
200.4 kPa	0.18 m2/MN	501.91 m2/yr
50.1 kPa	0.03 m2/MN	---------
12.5 kPa	0.15 m2/MN	---------

Method of Time Fitting Used	Square Root Time

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

One Dimensional Consolidation Properties
(Oedometer)

ELE International

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S2

Test Details

Standard	BS 1377: Part 5 : 1990 : Clause 3	Particle Density	2.45 Mg/m3
Sample Type	Core sample	Lab Temperature	0.0 deg.C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details

Specimen Reference	A	Description	
Depth within Sample	0.00mm	Orientation within Sample	
Specimen Mass	73.99 g	Condition	Natural Moisture
Specimen Height	20.24 mm	Preparation	
Comments			

Test Apparatus

Ring Number	1	Ring Diameter	49.93 mm
Ring Height	20.24 mm	Ring Weight	68.29 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure
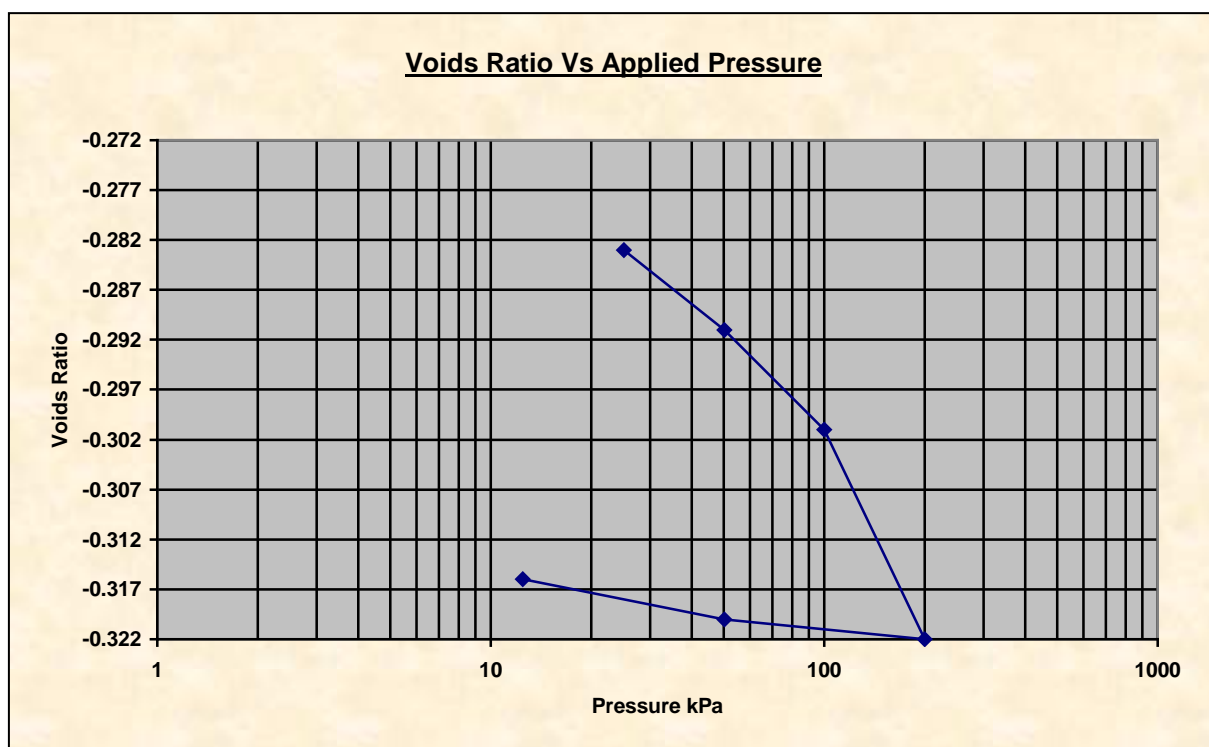
Height of Solid Particles	27.81 mm	Swelling Pressure	0.0 kPa

One Dimensional Consolidation Properties
(Oedometer)

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S2

Initial Moisture Content*	-44.5 %	**Final Moisture Content**	11.4 %
Initial Bulk Density	1.87 Mg/m3	**Final Bulk Density**	3.99 Mg/m3
Initial Dry Density	3.37 Mg/m3	**Final Dry Density**	3.58 Mg/m3
Initial Void Ratio	-0.2722	**Final Void Ratio**	-0.3157
Initial Degree of Saturation	400.90%	**Final Degree of Saturation**	-88.72 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	Coefficient of Volume Compressibility (m_v)	Coefficient of Consolidation (c_v)
0.00		
25.1 kPa	0.58 m2/MN	573.22 m2/yr
50.1 kPa	0.46 m2/MN	615.52 m2/yr
100.2 kPa	0.29 m2/MN	623.69 m2/yr
200.4 kPa	0.29 m2/MN	562.36 m2/yr
50.1 kPa	0.02 m2/MN	---------
12.5 kPa	0.15 m2/MN	---------

Method of Time Fitting Used	Square Root Time

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

One Dimensional Consolidation Properties
(Oedometer)

ELE International

Client	PSM AIN AE11034	Lab Ref	
Project		**Job**	PSM AIN AE11034
Borehole		**Sample**	S2

Test Details

Standard	BS 1377: Part 5 : 1990 : Clause 3	**Particle Density**	2.45 Mg/m3
Sample Type	Core sample	**Lab Temperature**	0.0 deg.C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details

Specimen Reference	C	Description	
Depth within Sample	0.00mm	**Orientation within Sample**	
Specimen Mass	77.03 g	**Condition**	Natural Moisture
Specimen Height	20.12 mm	**Preparation**	
Comments			

Test Apparatus

Ring Number	1	Ring Diameter	49.82 mm
Ring Height	20.12 mm	**Ring Weight**	68.40 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure
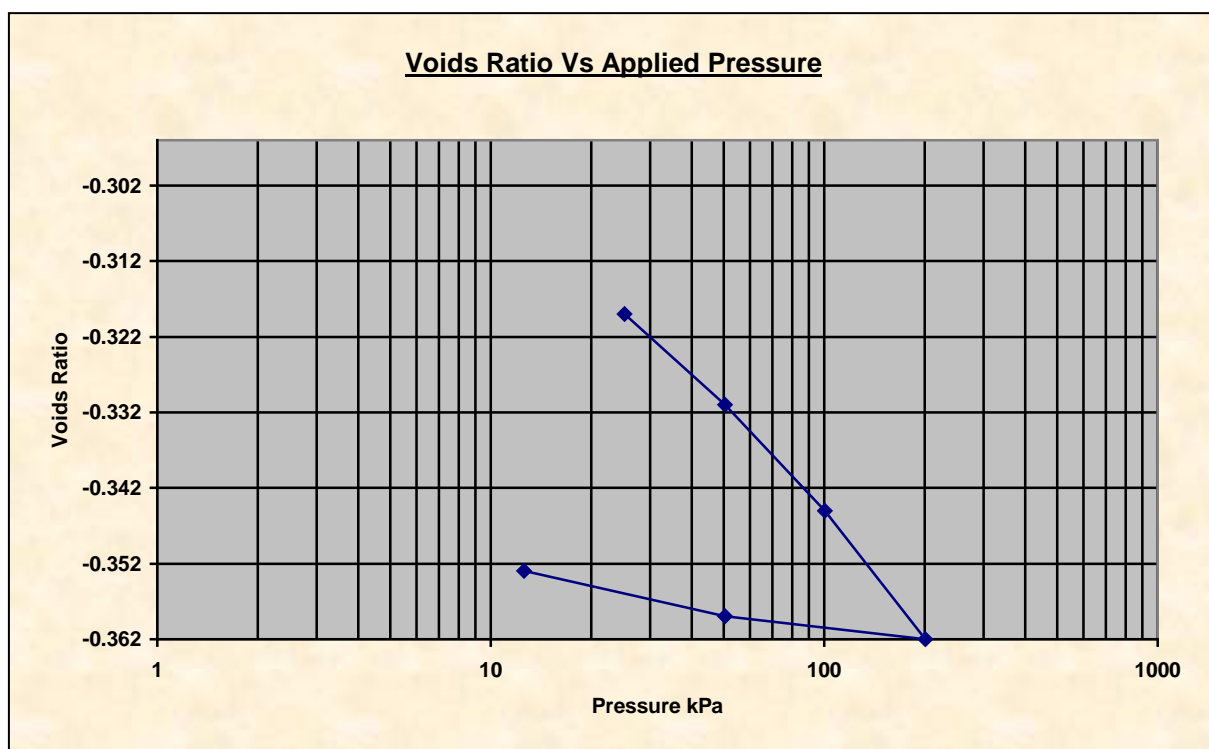
Height of Solid Particles	28.57 mm	Swelling Pressure	0.0 kPa

One Dimensional Consolidation Properties
(Oedometer)

ELE International

Client	PSM AIN AE11034	Lab Ref	
Project		Job	PSM AIN AE11034
Borehole		Sample	S2

Initial Moisture Content*	-43.6 %	**Final Moisture Content**	10.5 %
Initial Bulk Density	1.96 Mg/m3	**Final Bulk Density**	4.18 Mg/m3
Initial Dry Density	3.48 Mg/m3	**Final Dry Density**	3.79 Mg/m3
Initial Void Ratio	-0.2958	**Final Void Ratio**	-0.3529
Initial Degree of Saturation	360.70%	**Final Degree of Saturation**	-72.95 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	Coefficient of Volume Compressibility (m_v)	Coefficient of Consolidation (c_v)
0.00		
25.2 kPa	1.30 m2/MN	480.41 m2/yr
50.3 kPa	0.70 m2/MN	378.06 m2/yr
100.6 kPa	0.43 m2/MN	508.00 m2/yr
201.3 kPa	0.26 m2/MN	450.00 m2/yr
50.3 kPa	0.04 m2/MN	---------
12.6 kPa	0.23 m2/MN	---------

Method of Time Fitting Used	Square Root Time

Tested By and Date:	
Checked By and Date:	
Approved By and Date:	

APPENDIX I

BUKIT AMPANG LANDFILL SITE