



ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
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POST-GRADUATE STUDIES

INVESTIGATION INTO SOME OF THE ENGINEERING PROPERTIES OF
SOILS IN ADET TOWN

BY
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INVESTIGATION INTO SOME OF THE ENGINEERING PROPERTIES OF SOILS IN ADET TOWN

A thesis submitted to the school of graduate studies of Addis Ababa University, Addis Ababa Institute of Technology (AAiT), School of Civil and Environmental Engineering, Post-Graduate studies in partial fulfillment of the requirements for the Masters of Science in Geotechnical Engineering Stream of Civil and Environmental Engineering School.

By

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DECLARATION

I, the undersigned, declare that this thesis is my original work performed under the supervision of my research advisor Dr- Ing Samuel Tadesse and has not been presented as a thesis for a degree in any other university. All sources of materials used for this thesis have also been duly acknowledged.

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SYMBOLS AND ABBREVIATIONS

AASHTO	-	American Association of Highway and Transportation Officials
a_v	-	Coefficient of compressibility
BS	-	British standard
c_c	-	Compression index
c_r	-	Recompression index
c_v	-	Coefficient of consolidation
e	-	Void ratio
k	-	Coefficient of permeability
LL	-	Liquid limit
m_v	-	Coefficient of volume compressibility
NCL	-	Normal consolidation line
Pc	-	Preconsolidation pressure
PI	-	Plasticity index
PL	-	Plastic limit
q_u	-	Unconfined compressive strength
UC	-	Unconfined compression
URL	-	Unloading reloading line
USCS	-	Unified Soil Classification System

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ABSTRACT

The purpose of this study is to investigate soils engineering properties and prepare soil map of Adet town. Samples from ten test pits were used for this study. Both disturbed and undisturbed samples were retrieved from the open test pits dug manually.

Laboratory tests performed on disturbed soil samples included natural moisture content, specific gravity, Atterberg limits, free swell as well as grain size analysis. Oedometer consolidation tests, swelling pressure test and unconfined pressure tests were also carried out by performing tests on undisturbed samples.

Reconnaissance survey and laboratory test results revealed that the soils in the town are mainly two types. The first one which covers the northern part of the town is black clay soil which has a characteristics of specific gravity ranging from 2.62 to 2.67, liquid limit of 77-86%, plasticity index of 42-51% , clay fraction of 56-71%, free swell values of 67-100%, compression index of 0.266, recompression index of 0.047,preconsolidation pressure of 250kPa,coefficient of permeability ranging from 10^{-8} to 10^{-11} cm/sec and swelling pressure of 125kPa.

The second type that is found in most parts of the town is red soils which are classified as clay and inorganic silts according to Unified Soil Classification System. These red soils have characteristics of specific gravity ranging from 2.70 to 2.85, liquid limit of 47-72%, plasticity index of 14-39%, clay fraction of 21-90%, compression index of 0.19-0.299, recompression index of 0.023- 0.029,pre consolidation pressure ranging from 150 to300 kPa, coefficient of permeability ranging from 10^{-8} to 10^{-10} cm/sec and free swell values of 27-67.5%.

1. INTRODUCTION

1.1 General

Every civil engineering structure has to be founded on the soil and thus shall transmit the loads to the soil stratum. Soil is, therefore, the ultimate foundation material which supports the structure. The proper functioning of the structure will, therefore, depend critically on the engineering properties of the underlying soil.

Adet is one of the oldest town in the Amhara region, which was founded in 1591. The growth of the town is so slow as compared to its age. Due to its distance (which is around 45km) from Bahir Dar and the new road which is now being constructed from Bahir Dar to Adet, the town is expected to grow fast and become an alternative way for the journey to Addis Ababa.

The town obtained its master plan recently and reconstruction of infrastructures has started according to the master plan.

In the master plan, residential areas, government offices, roads, recreational areas and commercial areas are clearly indicated. These areas need extended construction of buildings and roads. Thus a research on the properties of soils is important. The objective of this research is to investigate some of the engineering properties of soils in the area which have the potential for expansion.

1.2 Objectives of the thesis

The objectives of this thesis work are the following:

- To determine the index properties of soils in Adet town
- To determine the shear strength of soils in the town
- To determine the consolidation characteristics of soils in the town.
- To prepare the soil map of the town.

1.3 Methodology

Generally, samples from ten test pits were used for this study. Both disturbed and undisturbed samples were retrieved from the open test pits. In the field GPS reading was taken to locate the coordinate of test pits.

From the samples retrieved the following laboratory tests were done

- Natural moisture content
- Specific gravity
- Grain size analysis
 - Sieve analysis
 - Hydrometer
- Atterberg limit tests
 - Liquid limit
 - Plastic limit
- Free swell tests
- Unconfined compression tests
- Swell consolidation and consolidation tests

All the above tests were done according to British standard (BS).

The sensitivity of balance used in this study is 0.1g which has its own effect on results obtained and should be considered when evaluating the results.

1.4 Organization of the thesis

This thesis is organized into the following six main chapters

Chapter one introduces the general description, objective and methodology of the study.

Chapter two presents the literature review about soil formation, soil types, clay minerals.

Chapter three deals with description of the study area.

Chapter four presents the types of laboratory tests carried out and results obtained in this research work.

Chapter five deals with discussion on the laboratory results obtained from this study and presents soil map of the study area.

Chapter six is the conclusions and recommendations drawn from this research work.

Finally, results of all laboratory tests are presented in appendix.

2. LITERATURE REVIEW

2.1 Soil Formation

The materials that constitute the earth's crust are arbitrarily divided by the civil engineer into two categories, soil and rock. Soil is a natural aggregate of mineral grains that can be separated by such gentle mechanical means as agitation in water. Rock, on the other hand, is a natural aggregate of minerals connected by strong and permanent cohesive forces [23].

Soils are formed from the physical and chemical weathering of rocks. Physical weathering involves reduction of size without any change in the original composition of the parent rock. The main agents responsible for this process are exfoliation, unloading, erosion, freezing, and thawing. Chemical weathering causes both reductions in size and chemical alteration of the original parent rock. The main agents responsible for chemical weathering are hydration, carbonation, and oxidation. Often, chemical and physical weathering takes place in concert [5].

Residual soils are formed directly from the physical and chemical weathering of the parent material, normally rock of some sort. These soils retain many of the elements that comprise the parent rock. Sedimentary soils are formed by a depositional process, normally in a marine or lake environment. The composition of these soils depends on the environment under which they were transported and is often different from the parent rock. Sedimentary soils are seen to undergo a various additional processes beyond the initial physical and chemical weathering of the parent rock in the figure below [24].

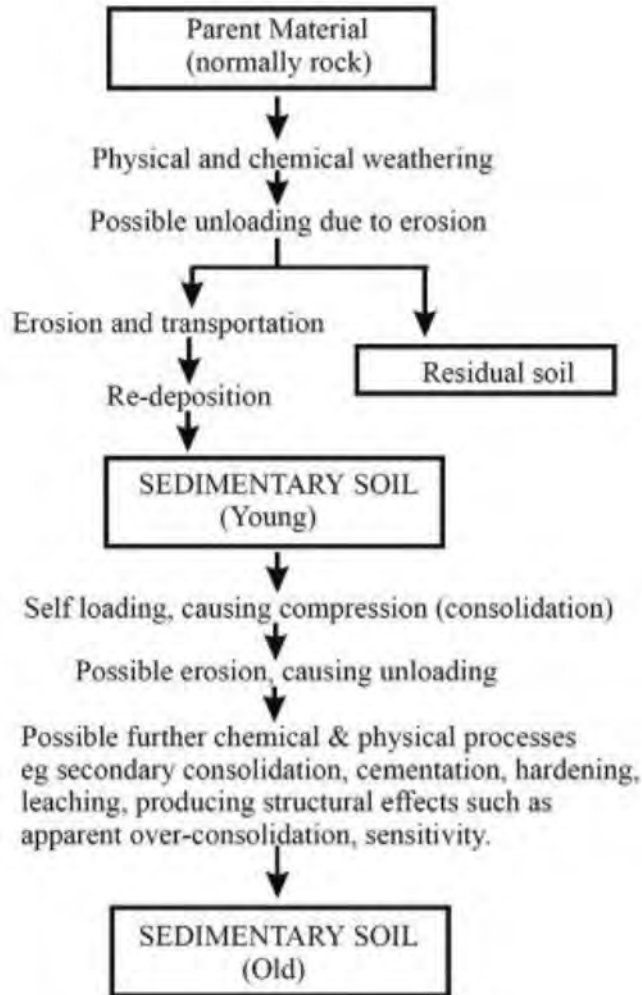


Fig 2.1 Soil formation factors influencing soil behavior [24].

2.2 Soil Types

Common descriptive terms such as gravels, sands, silts and clays are used to identify specific textures in soils. We will refer to these soil textures as soil types; that is, sand is one soil type, clay is another. Texture refers to the appearance of a soil. Sands and gravels are grouped together as coarse grained soils. Clays and silts are fine grained soils. The coarseness of soils is determined from knowing the distribution of particle sizes, which is the primary means of classifying coarse-grained soils [5]. In coarse grained soils the most important properties do not depend on the constituent minerals although locally, the minerals may control the frictional characteristics of the individual grains. In these soils, the particles are so large that the forces between the grains other than those due to externally applied forces and gravity are small. The non-clay minerals such as mica, feldspar, and quartz which constitute sand and silt do not render any plasticity and cohesion to the soil. Thus, the influence of the constituent minerals becomes appreciable with the decrease in size [19].

To characterize fine-grained soils, further information on the types of minerals present and their contents are necessary. The response of fine grained soils to loads, known as mechanical behavior, depends on the type of minerals present [5].

2.3 Clay minerals

Minerals are crystalline materials and make up the solids constitute of a soil [5]. The most important grain property of fine-grained soil materials is the mineralogical composition. If the soil particles are smaller than about 0.002 mm, the influence of the force of gravity on each particle is insignificant compared with that of the electrical forces acting at the surface of the particle. A material in which the influence of the surface charges is predominant is said to be in the colloidal state. The colloidal particles of soil consist primarily of clay minerals that were derived from rock minerals by weathering, but that have crystal structures differing from those of the parent minerals.

The basic building blocks of the clay minerals are the silica tetrahedron and the alumina octahedron. These blocks form tetrahedral and octahedral layers (Fig 2.2), different combinations of which produce a unit sheet of the various types of clays. The arrangement and the chemical

composition of these layers determine the type of clay mineral [23].The tetrahedral units combine by the sharing of oxygen ions to form a silica sheet. The octahedral units combine through shared hydroxyl ions to form a gibbsite sheet[7].

The main groups of clay crystalline materials that make up clays are the minerals kaolinite, illite and montmorillonite[2].

2.3.1 Kaolinite

Kaolinite is one of the most common clay minerals in sedimentary and residual soils. A unit sheet of kaolinite, which is approximately 0.7 nm ($\text{nm} = 10^{-9} \text{ m}$) thick, is composed of one aluminum octahedral layer and one silicon tetrahedral layer, joined together by shared oxygen's. A typical particle of kaolinite consists of a stack of sheets forming a stiff hexagonal plate with flat-faced edges. It is about 100 nm in thickness with a breadth/thickness of about 5 to 10 [23].

The structural units are held together by hydrogen bonds between the hydroxyls of the octahedral sheet and the oxygen's of the tetrahedral sheet. The bonding with hydrogen bond results in considerable strength and stability with little tendency in the interlayer's to allow water and to swell. Kaolinite is, thus, the least 'active' of the clay minerals [6].

Halloysite is one of the most common minerals in residual soils, particularly those derived from volcanic parent material. It is a member of the kaolin subgroup of clay minerals [23].Two distinct forms of this mineral exist; one a non hydrated form having the same structural composition as kaolinite and the other a hydrated form consisting of unit kaolinite layers separated from each other by a single layer of water molecules .

The intersheet water in the hydrated halloysite is removed irreversibly starting at 60° to 75°C ,and because of this a hydrated halloysite, which has also been termed halloysite ($4\text{H}_2\text{O}$), can dehydrate irreversibly to halloysite ($2\text{H}_2\text{O}$) sometimes known as metahalloysite [18].

2.3.2 Illite

Illite is the most common clay mineral in stiff clays and shales as well as marine and lacustrine soft clay and silt deposits[23] . It has a basic structure consisting of a sheet of gibbsite between and combined with two sheets of silica. In the silica sheet there is partial substitution of silicon

by aluminium. The combined sheets are linked together by relatively weak bonding due to non-exchangeable potassium ions held between them [7]. Illite, therefore, swell much more than kaolinite in the presence of water.

2.3.3 Montmorillonite

Montmorillonite has the same basic structure as illite. The interlayer bonding between the tops of silica sheets is mainly due to Vander Waals forces and is, thus, very weak compared to hydrogen or other ion bonding. Partial isomorphic substitution such as Al^{3+} for Si^{4+} in the tetrahedral sheet and Mg^{2+} , Fe^{2+} , Li^+ or Zn^+ for Al^{3+} in the octahedral sheet also take place, resulting in a relatively large net negative charge deficiency. Further, montmorillonite has the largest specific surface among major clay minerals. All these factors mean that a large amount of water and other exchangeable ions can easily enter between the layers causing the layers to be separated. Because of this affinity for water, clay soils containing montmorillonite mineral are susceptible to substantial volume changes. They swell as the water grains entry into the lattice structure and shrink if the water is removed because of some reason. Its excessive swelling capacity may seriously endanger the stability of overlying structures and road pavements [20].

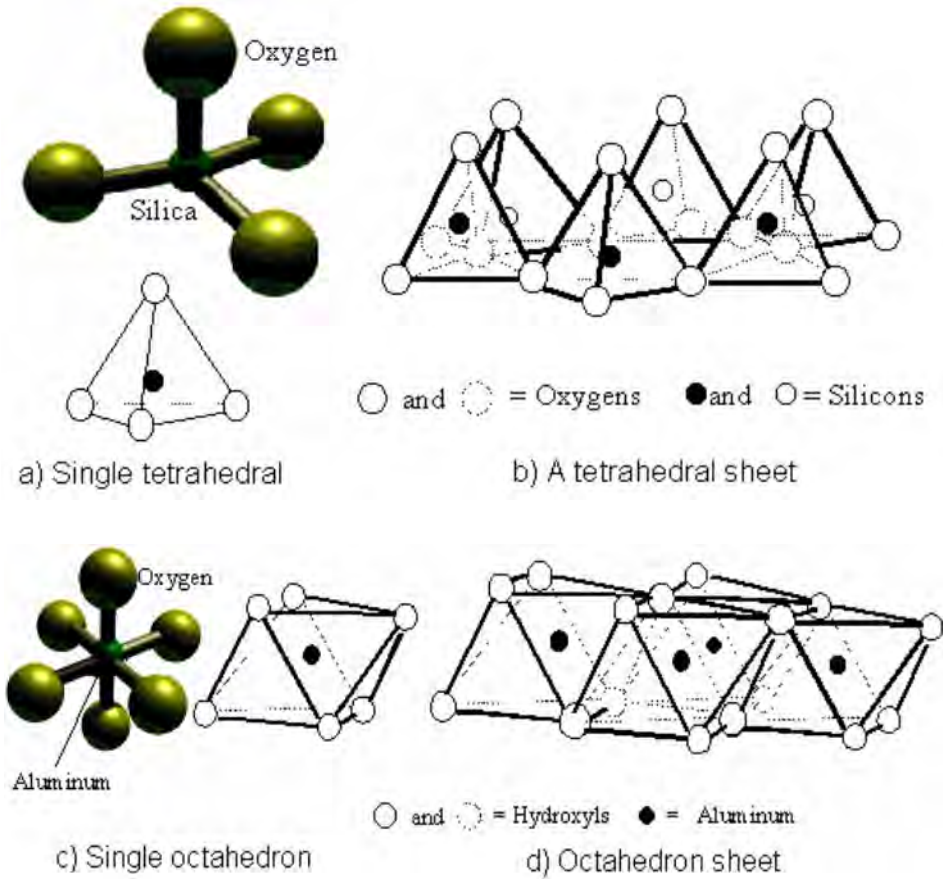


Figure 2.2: a) Silica tetrahedron b) Silica sheets c) Aluminum Octahedron d) Alumina sheet[5].

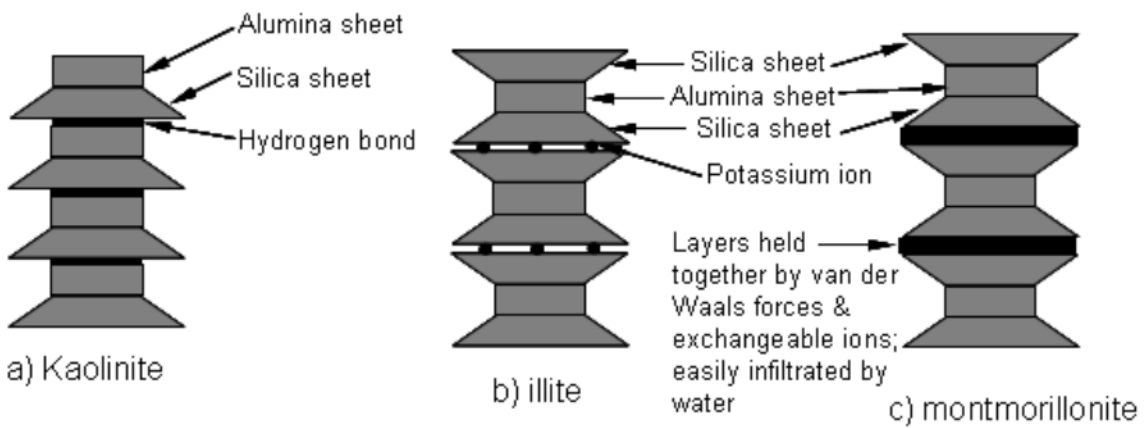


Figure 2.3: Structure of kaolinite, illite and montmorillonite [5].

3.0 DESCRIPTION OF THE STUDY AREA

3.1 Location

Adet is a town in northwestern Ethiopia (Fig 3.1). Located at about 45km south of Bahir Dar in the western Gojjam zone of Amhara Region, this town has a latitude and longitude of $11^{\circ}16'N, 37^{\circ}29'E$ with an altitude of 2216 meters above sea level. It is the largest settlement in Yilmana Densa woreda.

The study area for this thesis work covers mainly the places which have the potential for expansion and infrastructures to be built. It is bounded by latitudes $11^{\circ}15.326'N$ and $11^{\circ}16.537'N$ to the south and north; and longitudes $37^{\circ}28.863'E$ and $37^{\circ}29.829'E$ to the west and east respectively.

Generally, samples from ten test pits were used for this study. The global coordinates of test pits i.e northing, easting and elevations are shown in Table 3.1 and their location on the map of Adet is also shown in Fig 3.2 .

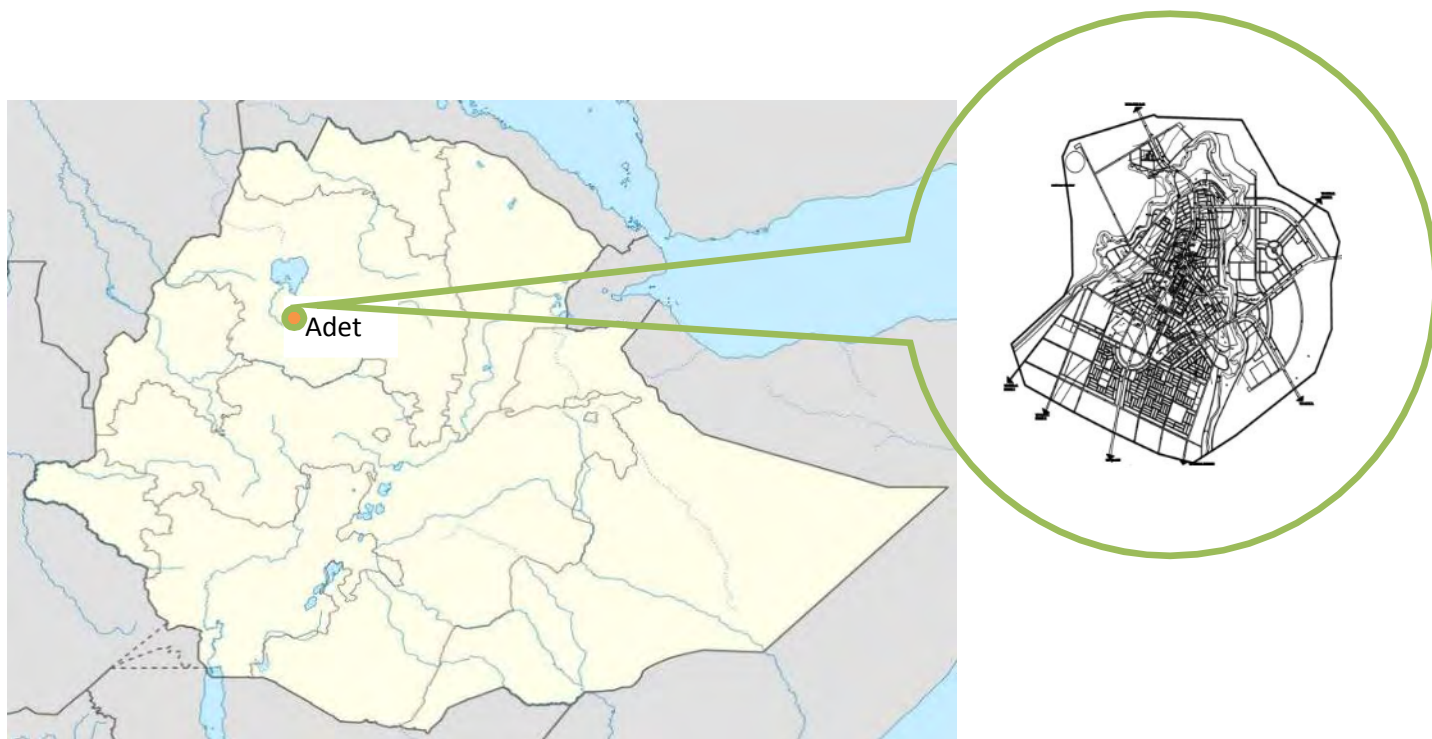


Fig 3.1 Location of the study area on the map of Ethiopia.

Table 3.1 Global coordinates of test pits location

Test Pit No	Easting	Northing	Elevation
TP 1	37 ⁰ 29.312'	11 ⁰ 16.537'	2177m
TP 2	37 ⁰ 29.829'	11 ⁰ 16.234'	2169m
TP 3	37 ⁰ 29.511'	11 ⁰ 15.360'	2221m
TP 4	37 ⁰ 28.863'	11 ⁰ 15.527'	2270m
TP 5	37 ⁰ 29.150'	11 ⁰ 15.326'	2250m
TP 6	37 ⁰ 29.491'	11 ⁰ 16.061'	2229m
TP 7	37 ⁰ 29.529'	11 ⁰ 15.711'	2208m
TP 8	37 ⁰ 29.230'	11 ⁰ 15.936'	2250m
TP 9	37 ⁰ 29.159'	11 ⁰ 15.584'	2256m
TP 10	37 ⁰ 29.197'	11 ⁰ 16.120'	2214m



Fig 3.2 Location of test pits shown on map of Adet town.

3.2 Climate

3.2.1 Rainfall

Based on 10 years of metrological data (from 1996 to 2005) for Adet station, the average annual rainfall is 1238mm with a maximum of 1695mm in 1996 and a minimum of 956mm in 2002[14]. As shown in Fig 3.3, more than 70% of the rainfall occurs in months of June, July, August and September.

3.2.2 Temperature

In a mountainous tropical country like Ethiopia, altitude is by far the most important factor in controlling climate. It affects distribution of both temperature and rainfall. Generally, regions between 1500 - 2300 meters a.m.s.l. (categorized as 'woina dega' or sub tropical climate) have temperatures that range between 15 - 20°C, areas between 500 – 1500 meters a.m.s.l. (i.e. 'kola' or tropical climate) have 20 -30°C and areas below 500 meters a.m.s.l. (i.e. 'bereha' or desert climate) have a temperature of 30°C and above[13].

The town of Adet, with an altitude of 2216 meters above sea level, has a mean minimum, mean maximum and mean average monthly temperature of 9.56, 26.06 and 17.81⁰C respectively. The maximum annual temperatures occur in either March or April whereas minimum annual temperature occurs in either November or December as shown in Fig 3.4.

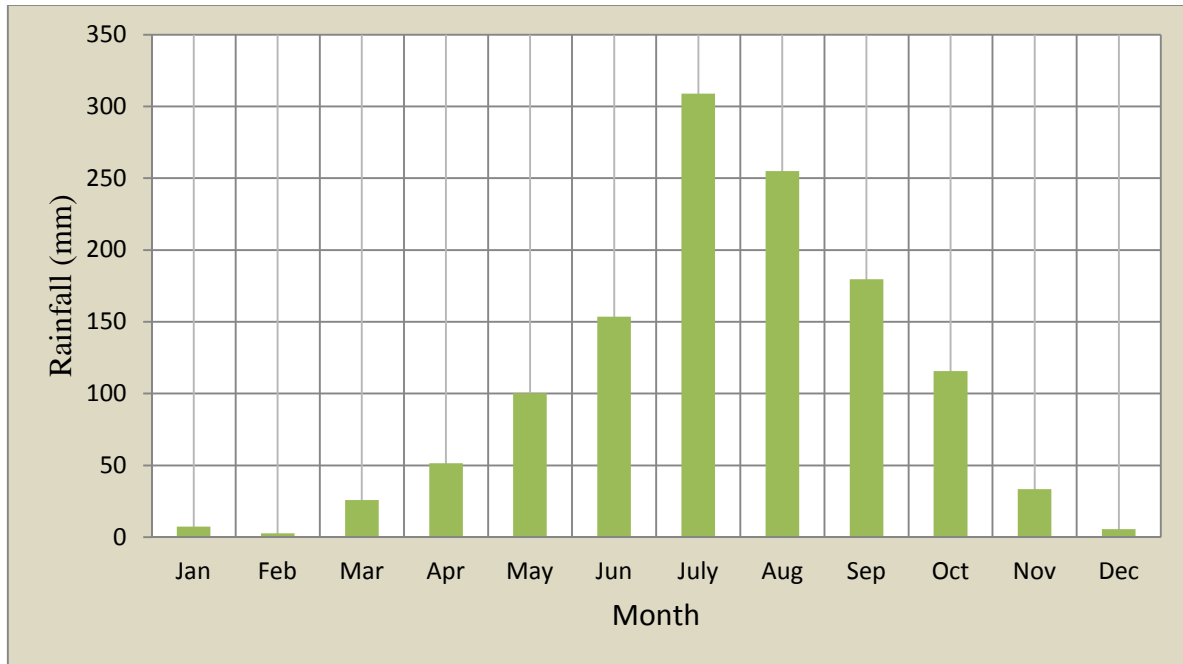


Fig 3.3 Mean monthly rainfall distribution of Adet town [14].

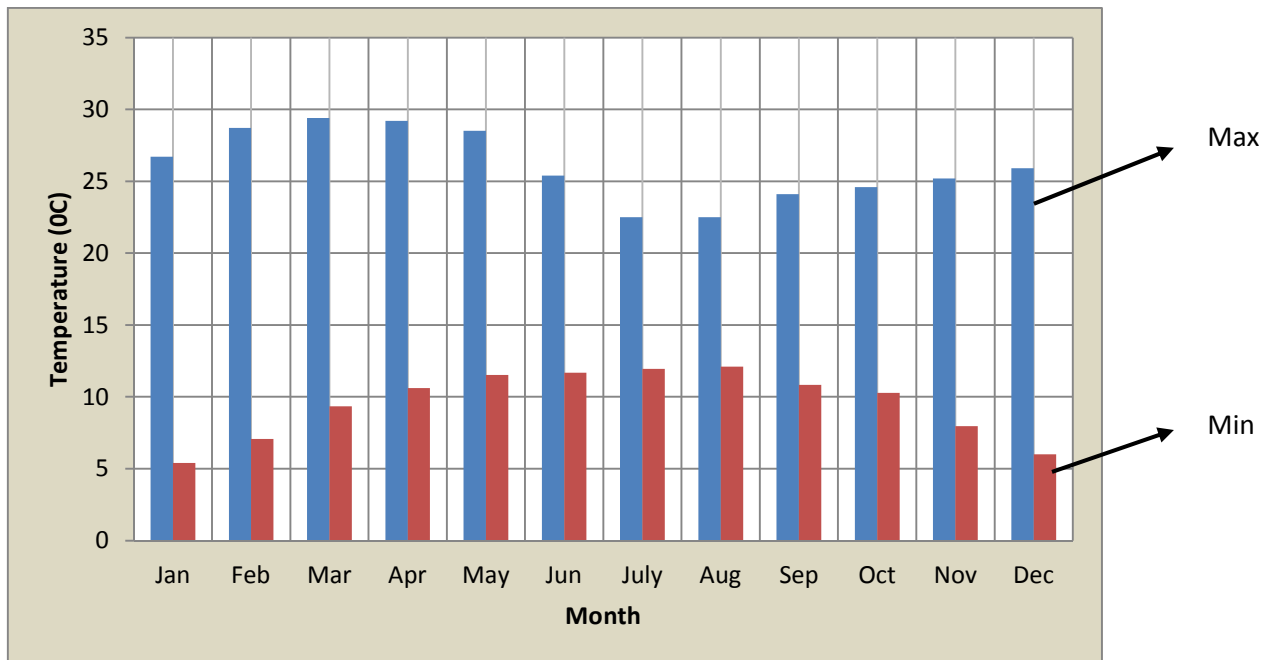


Fig 3.4. Average monthly maximum and minimum temperature distribution in Adet(1996-2005). [14]

4. LABORATORY TESTS AND RESULTS

4.1 Index properties

4.1.1 General

In geotechnical engineering success depends on practical experience. Since personal experience is necessarily somewhat limited, the engineer is compelled to rely at least to some extent on the records of the experiences of others. If these records contain adequate descriptions of the soil conditions, they constitute a storehouse of valuable information. Otherwise, they may be misleading. Consequently, one of the foremost aims in attempts to reduce the hazards in dealing with soils has been to find simple methods for discriminating among the different kinds of soil in a given category. The properties on which the distinctions are based are known as index properties, and the tests required to determine the index properties are classification tests[23].

The index Properties of soils investigated in this study include natural moisture content, particle size distribution , Atterberg limits, specific gravity and free swell.

4.1.2 Determination of index properties

4.1.2.1 Natural moisture content

Determination of natural moisture content of soils was carried out by oven-drying method and in accordance with BS 1377:Part 2:1990.

Soil samples used for natural moisture content determination had been previously collected from the field, where they were immediately well sealed in plastic bags to prevent moisture loss. The experimental results are presented in Table 4.1.

Table 4.1 Natural moisture content test result

Test pit No	Depth (m)	Natural moisture content (%)	Remark
1	1.5	36.11	Black clay soil
	3.0	39.09	Black clay soil
2	1	25.82	Black clay soil
	3.0	23.65	Gravel soil
3	1.5	35.72	Red soil
	3.0	32.87	Red soil
4	1.5	27.72	Red soil
	3.0	28.61	Red soil
5	1.5	33.04	Red soil
	3.0	29.95	Red soil
6	1.5	29.48	Red soil
	3.0	40.91	Red soil
7	1.5	28.5	Red soil
	3.0	27.96	Red soil
8	1.5	26.93	Red soil
	3.0	28.48	Red soil
9	1.5	30.87	Red soil
	3.0	32.43	Red soil
10	1.5	27.99	Red soil
	3.0	31.16	Red soil

4.1.2.2 Particle size distribution

A basic element of a soil classification system is the determination of the amount and distribution of the particle sizes in the soil. The distribution of particle sizes larger than 0.075 mm (No. 200 sieve) is determined by sieving, while a sedimentation process (hydrometer test) is used to determine the distribution of particle sizes smaller than 0.075 mm.

A sieve analysis is performed by washing the soil on the No. 200 sieve in order to remove all the fines (i.e., silt and clay size particles)[11].A hydrometer test is conducted on the soil sample passing sieve No.200.The experimental results are presented in Table 4.2 and the particle size distribution curves are shown in Fig 4.1and Fig 4.2.

Table 4.2 Particle size analysis test result

Test Pit No	Depth (m)	% Gravel	% Sand	% Silt	% Clay	Remark
1	1.5	0.25	13.91	14.83	71	Black clay soil
	3.0	0.1	6.17	15.73	78	Black clay soil
2	1.0	0.08	12.92	31	56	Black clay soil
	3.0	64.05	11.8	14.62	9.52	Gravel soil
3	1.5	0.0	14.38	17.12	68.5	Red soil
	3.0	0.0	10.47	16.53	73	Red soil
4	1.5	0.0	28.57	10.43	61	Red soil
	3.0	0.17	26.97	8.87	64	Red soil
5	1.5	0.02	1.48	14	84.5	Red soil
	3.0	0.0	0.98	14.02	85	Red soil
6	1.5	1.57	33.43	39.67	25.33	Red soil
	3.0	0.1	19.64	58.41	21.85	Red soil
7	1.5	0.0	6.62	19.38	74	Red soil
	3.0	0.13	7.77	15.1	77	Red soil
8	1.5	5.12	30.73	27.81	36.3	Red soil
	3.0	3.87	19.73	50.4	26	Red soil
9	1.5	0.0	0.58	9.42	90	Red soil
	3.0	1.43	9.58	18.98	70	Red soil
10	1.5	0.0	2.5	17.5	80	Red soil
	3.0	0.0	4.08	25.91	70	Red soil

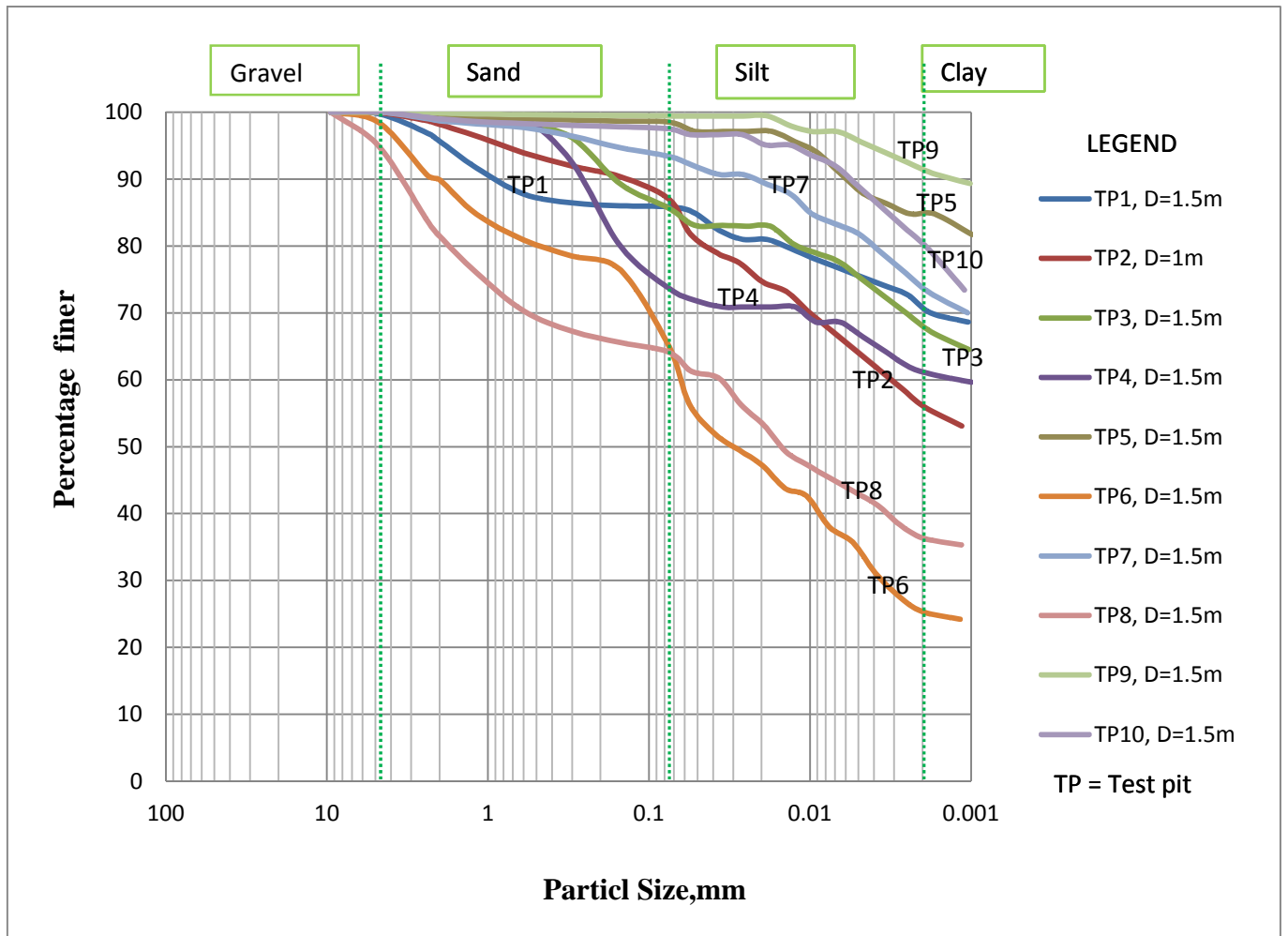


Fig 4.1 Particle size distribution curves at a depth of 1.5 and 1m.

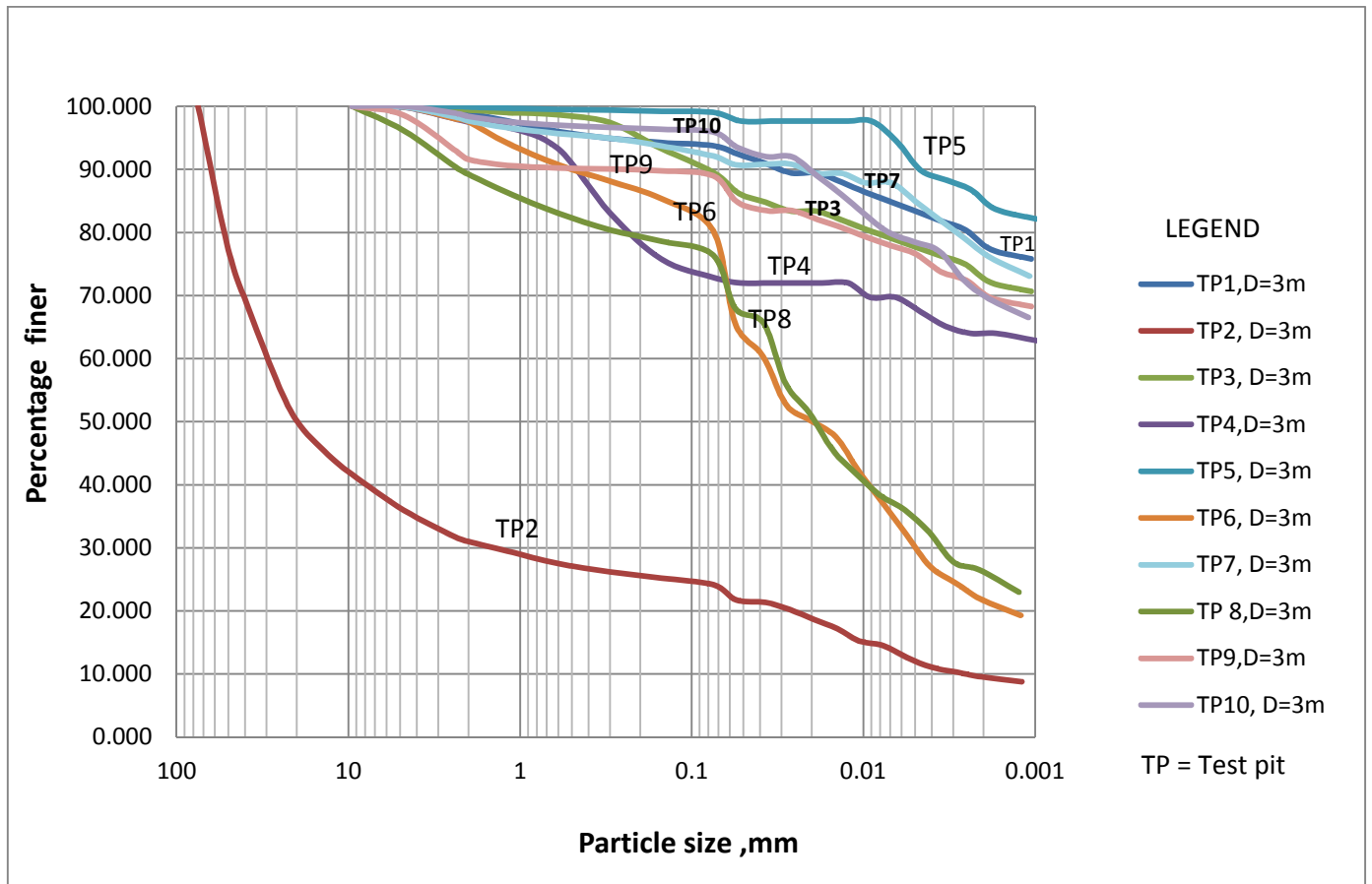


Fig 4.2 Particle size distribution curves at a depth of 3m.

4.1.2.3 Atterberg limits

The consistency of a fine grained soil is the physical state in which it exists. It is used to denote the degree of firmness of a soil. Consistency of a soil is indicated by such terms as soft, firm or hard. A fine grained soil can exist in four states, namely, liquid, plastic, semi-solid or solid state. The water contents at which the soil changes from one state to the other are known as consistency limits or Atterberg limits. The water content alone is not an adequate index property of a soil. At the same water content, one soil may be relatively soft, where as another soil may be hard. However, the soils with the same consistency limits behave somewhat in a similar manner. Thus consistency limits are very important index properties of fine grained soils [9].

Liquid limit: liquid limit determination of soil samples taken from the excavated 10 pits was carried out using the Casagrande apparatus and in accordance with BS 1377:Part2:1990. The results of liquid limit tests are presented in Table 4.3.

Plastic limit: plastic limit tests were carried out on the same sample used for liquid limit determination. The test procedures are given in BS 1377:Part 2:1990. The results of plastic limit tests are presented in Table 4.3.

Plasticity index (PI) is the range of moisture content over which a soil exhibits plasticity. It is the numerical difference between the liquid limit and the plastic limit [19].

Activity (A) of a clay is defined as

$$A = \frac{PI}{\text{clay fraction}}$$

Table 4.3 Test results of Atterberg limits

Test Pit No	Depth (m)	LL	PL	PI	Activity (A)
1	1.5	85.36	35.05	50	0.71
	3.0	79.03	35.65	43	0.53
2	1.0	77.24	34.59	43	0.76
3	1.5	63.88	31.45	32	0.47
	3.0	66.55	33.07	33	0.46
4	1.5	62.04	32.94	29	0.48
	3.0	65.82	31.23	35	0.54
5	1.5	63.35	32.1	31	0.37
	3.0	60.50	31.51	29	0.34
6	1.5	51.43	31.37	20	0.79
	3.0	50.14	35.72	14	0.66
7	1.5	67.97	31.02	37	0.50
	3.0	71.80	33.2	39	0.50
8	1.5	60.91	30.17	31	0.85
	3.0	48.86	33.74	15	0.58
9	1.5	61.92	31.75	30	0.34
	3.0	62.29	31.98	30	0.43
10	1.5	61.24	32.79	28	0.36
	3.0	64.77	31.01	34	0.48

Clays that are inactive are defined as those clays that have an activity less than 0.75, normal activity is defined as those clays having an activity between 0.75 and 1.25, and active clay is defined as those clays having an activity greater than 1.25[11].

4.1.2.4 Specific gravity

The specific gravity is a dimensionless parameter that relates the density of the soil particles to the density of water [11]. The specific gravity test was conducted by using density bottle .The results are presented in Table 4.4.

Table 4.4 Specific gravity test results

Test pit No	Depth(m)	Specific gravity
1	1.5	2.67
	3.0	2.62
2	1.0	2.63
	3.0	2.73
3	1.5	2.71
	3.0	2.73
4	1.5	2.74
	3.0	2.76
5	1.5	2.77
	3.0	2.77
6	1.5	2.85
	3.0	2.82
7	1.5	2.72
	3.0	2.73
8	1.5	2.8
	3.0	2.82
9	1.5	2.73
	3.0	2.81
10	1.5	2.7
	3.0	2.78

4.1.2.5 Free swell

Free swell tests consist of placing a known volume of dry soil (10ml) in water and noting the swelled volume after the material settles, without any surcharge, to the bottom of a graduated cylinder. The difference between the final and initial volume, expressed as a percentage of initial volume, is the free swell value. The free swell test is very crude and was used in the early days when refined testing methods were not available [6]. Free swell test results are shown in Table 4.5.

Table 4.5 Free swell test results

Test Pit No	Depth(m)	Free swell(%)
1	1.5m	99.5
	3.0m	70
2	1.0m	67.5
3	1.5m	42.5
	3.0m	40
4	1.5m	42
	3.0m	40
5	1.5m	42.5
	3.0m	35
6	1.5m	27.5
	3.0m	30
7	1.5m	60
	3.0m	67.5
8	1.5m	45
	3.0m	35
9	1.5m	42.5
	3.0m	37.5
10	1.5m	35
	3.0m	45

4.2 Unconfined compression test

The safety of any geotechnical structure is dependent on the strength of the soil. If the soil fails, a structure founded on it can collapse, endangering lives and causing economic damages. The strength of soils is therefore of paramount importance to geotechnical engineers. The word strength is used loosely to mean shear strength, which is the internal frictional resistance of a soil to shearing forces [5].

Although the triaxial test is widely used for investigating the shear strength of soils, it is relatively expensive test to perform. Consequently, several other kinds of equipment are used for subsurface investigations .

The unconfined compression (UC) test is widely used to determine the consistency of saturated clays and other cohesive soils. A cylindrical vertical specimen with a height -to-diameter ratio of about 2 and typically 38mm in diameter is set up between end plates. A vertical load is applied incrementally at such a rate as to produce a vertical strain of about 1 to 2% per minute. The unconfined compressive strength (q_u) is considered to be equal to the load at which failure occurs, or at which the axial strain reaches 20% if there is no sudden failure, divided by the cross sectional area of the sample at the time of failure [23]. The experimental results for the undisturbed soil samples in this study are presented in Table 4.6 and the curves for unconfined compression test results are shown in Fig 4.3 and Fig 4.4.

Table 4.6 Unconfined compression test results

Test pit No	Depth((m)	q_u (kPa)	Liquidity Index(I_L)	Consistency*
1	1.5m	103.04	0.021	stiff
	3.0m	101.35	0.131	stiff
3	1.5m	134.66	0.123	stiff
	3.0m	127.65	0.017	stiff
6	1.5m	166	-0.047	hard
	3.0m	84.87	0.405	Medium stiff
7	1.5m	145	-0.021	hard
	3.0m	187.16	-0.117	hard
10	1.5m	371.35	-0.176	hard
	3.0m	442.17	-0.021	hard

*The consistency of soil and liquidity index(I_L) values are related as: stiff ($I_L=0-0.25$),medium stiff($I_L=0.25-0.5$),soft($I_L=0.5-0.75$) [16]

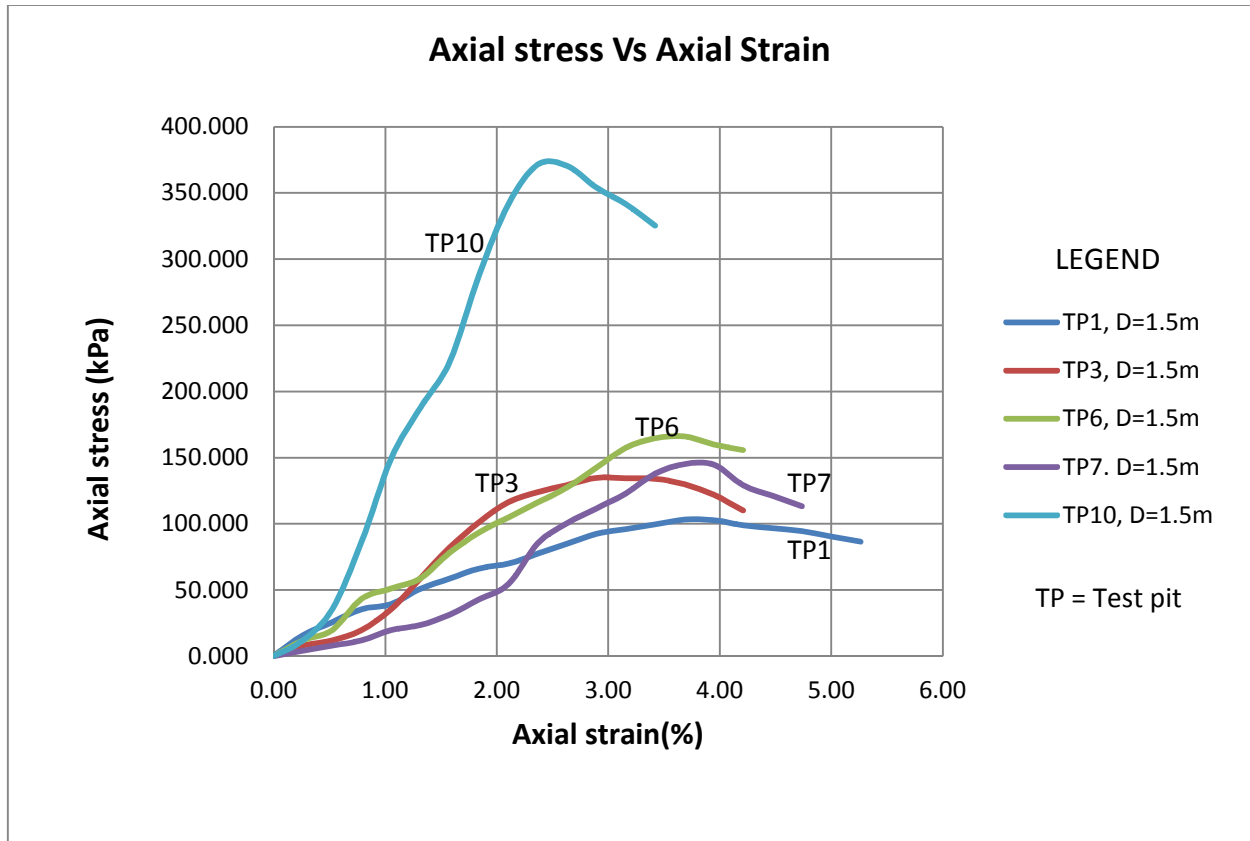


Fig 4.3 Curves for unconfined compression test results at a depth of 1.5m

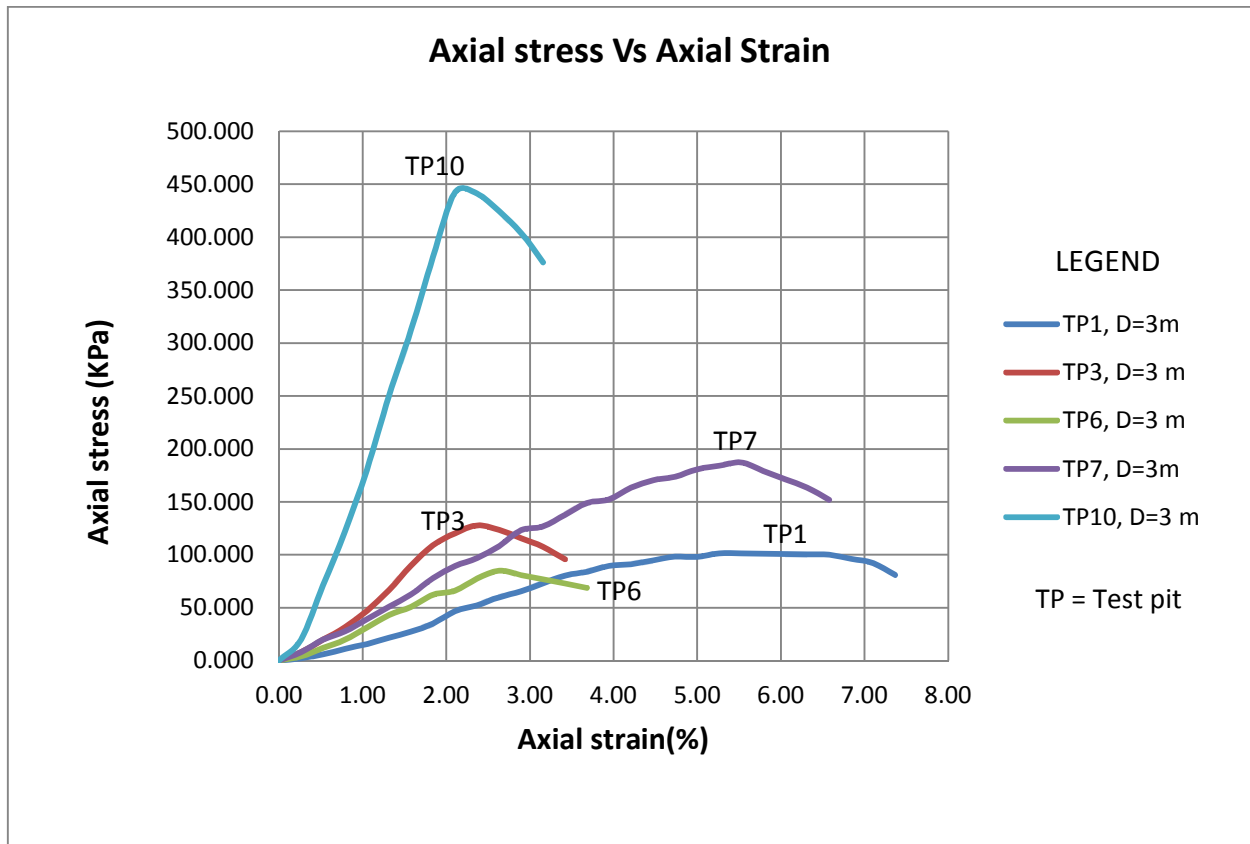


Fig 4.4 Curves for unconfined compression test results at a depth of 3.0m

4.3 Consolidation tests

4.3.1 General

It is a well established fact that when a material is stressed, it undergoes strain. Soil is no exception. When a soil is loaded because of the construction of a structure, its volume will decrease due to the rearrangement of soil particles. If it is assumed that both the soil particles and the water in the voids are incompressible and the soil is completely saturated, the change in volume of the soil can occur only if water is forced out of the voids. The vertical downward displacement brought about by this volume change shows itself as the settlement of the structure standing over the soil. Since the rate at which the water moves out of the voids is dependent on the permeability of the soil, the settlement of the structure itself is a function of the permeability of the soil and is, thus, time dependent [20].

When fine-grained soils are subjected to changes in load due to construction, they deform in a way different from that of coarse-grained materials. Their deformation takes place not only at the time of the load application, but also continues for very long time periods which may last several years. The long-term settlement of fine-grained soil layers is primarily controlled by consolidation [2]. Consolidation is the process of time-dependent settlement of saturated clayey soil when subjected to an increased loading [10].

The properties that characterize the magnitude and rate of deformation for fine-grained soils are determined in the consolidation test [2].

Oedometer consolidation tests were carried out in this study to investigate and establish consolidation-settlement characteristics of normally consolidated as well as over consolidated clay soils found, in terms of estimating the amount and rate of settlement when externally loaded. The tests were carried out on saturated clays.

Oedometer consolidation tests were carried out on undisturbed specimens of the soils previously collected from the study area. The procedures were followed as described in BS 1377:Part 5: 1990, and the results of consolidation tests are presented in Fig 4.5 and Fig 4.6.

4.3.2 Determination of consolidation coefficients and other parameters

4.3.2.1 Compression Index

Compression index, C_c , is numerically equal to the slope of the straight portion of e-log P curve. Its value is constant beyond the range of the recompression, since beyond this point the plot of e against log P is a straight line [22]. The results are shown in Table 4.7

$$c_c = -\frac{e_2 - e_1}{\log \frac{p_2}{p_1}}$$

where subscripts 1 and 2 denote two arbitrarily selected points on the NCL

4.3.2.2 Recompression index

The recompression index, C_r , is the slope of the unloading portion of the e-log P curve. The determination of the recompression index is important in the estimation of consolidation settlement of over consolidated clays[8]. The results are shown in Table 4.7.

$$c_r = -\frac{e_2 - e_1}{\log \frac{p_2}{p_1}}$$

where subscripts 1 and 2 denote two arbitrarily selected points on the URL.

4.3.2.3 Preconsolidation Pressure

The preconsolidation pressure, P_c , is the maximum past effective overburden pressure to which the soil specimen has been subjected. It can be determined by using a simple graphical procedure proposed by Casagrande [8]. The results are shown in Table 4.7.

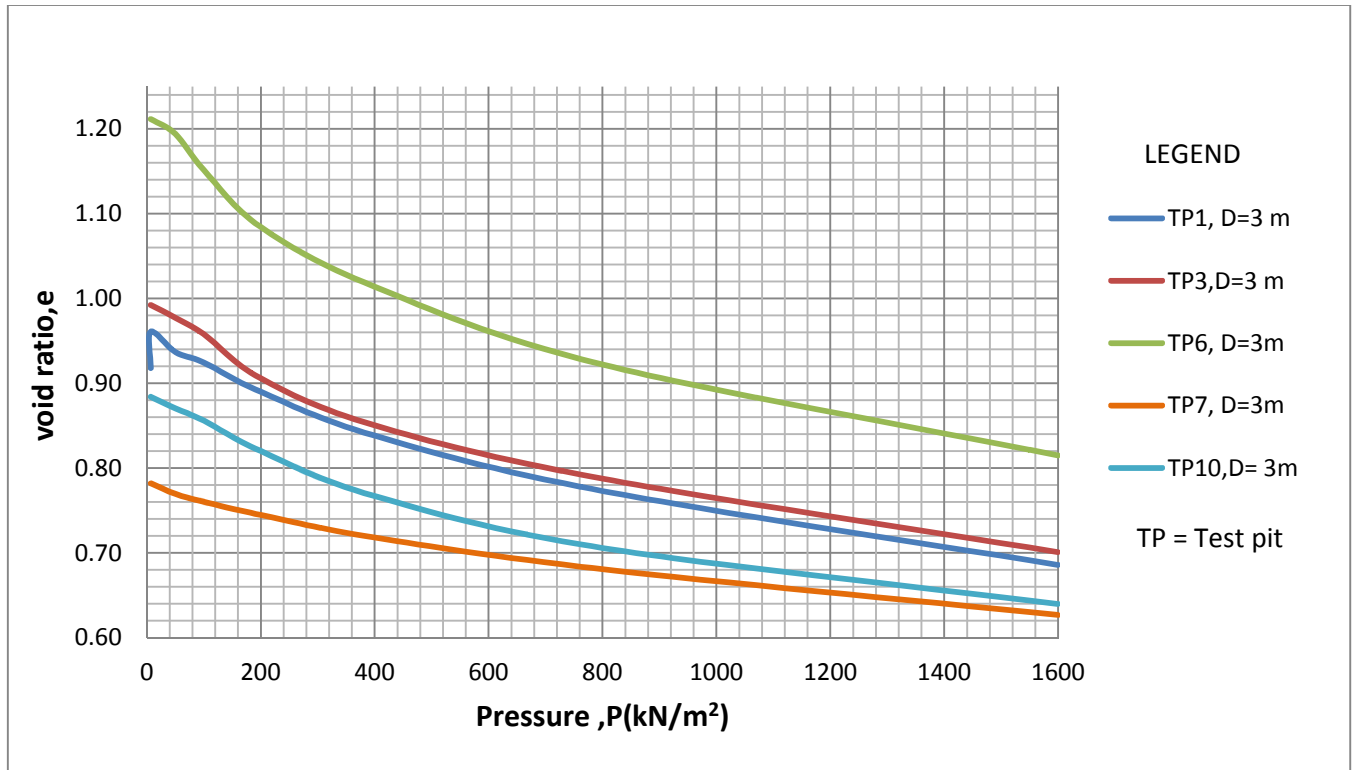


Fig 4.5 Void ratio Vs Pressure (linear scale)

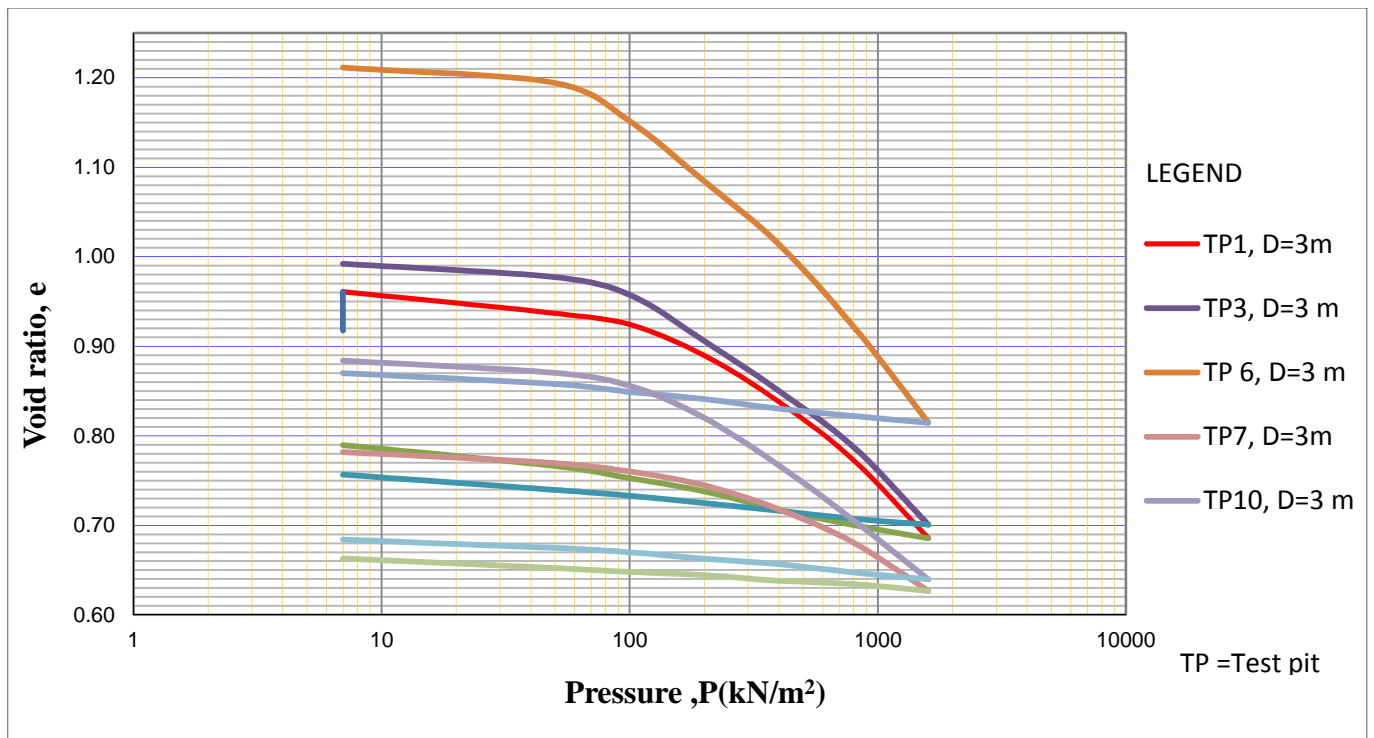


Fig 4.6 Void ratio Vs Pressure (log scale)

Table 4.7 Consolidation parameters

Test pit No	Depth (m)	Cc	Cr	Pc
1	3	0.266	0.047	250
3	3	0.198	0.025	200
6	3	0.299	0.029	175
7	3	0.166	0.027	300
10	3	0.199	0.023	150

4.3.2.4 Coefficient of consolidation

This parameter relates the change in excess pore pressure with respect to time, to the amount of water draining out of the voids of a clay layer during the same time, as a result of consolidation. The value of C_v for a particular pressure increment in the oedometer test can be determined by comparing the characteristics of the experimental and theoretical consolidation curves, the procedure being referred to as curve-fitting. The characteristics of the curves are brought out clearly if time is plotted to a square root or a logarithmic scale. It should be noted that once the value of C_v has been determined, the coefficient of permeability can be calculated, the oedometer test is thus a useful method for obtaining the permeability of a clay[7]. Taylor's square root of time fitting method has been used in this study.

Taylor's square root of time fitting method

Taylor's method uses the similarity in shape between the theoretical curve of U vs $\sqrt{T_v}$ and dial readings vs \sqrt{t} . The theoretical curve is characterized by a straight line portion at least upto $U = 60$ percent. Taylor observed that the abscissa of the curve at $U = 90$ percent was 1.15 times the abscissa of the extension of the straight line. Taylor used this characteristic feature to locate the 90 percent consolidation point on the experimental plot [20]. A typical graphical plot is shown in Fig 4.7. The determined values of coefficient of consolidation are presented in Table 4.8. Graph of coefficient of consolidation vs pressure is shown in Fig 4.8.

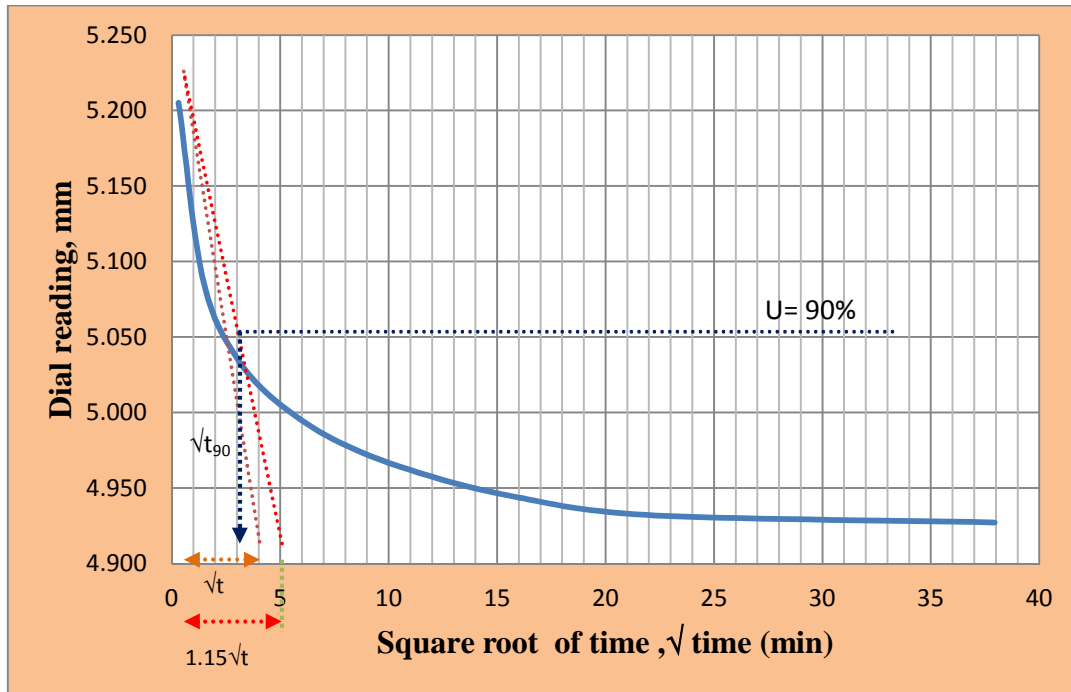


Fig 4.7 Typical curve of (square root of time method) Pit no 03, Depth 3m, loading 800kPa

Table 4.8 Coefficient of consolidation results

Test pit No	Depth, m	Pressure P, (kN/m ²)	Coefficient of consolidation, C _v (10 ⁻³ cm ² /sec)
1	3	50	8.6400
		100	0.4600
		200	0.4500
		400	0.4000
		800	0.1300
		1600	0.0800
3	3	50	6.2300
		100	3.4400
		200	2.1220
		400	2.0050
		800	1.8813
		1600	0.8825
6	3	50	4.5800
		100	3.4100
		200	3.2400
		400	1.7300
		800	1.5300
		1600	1.1200

Table 4.8 (cont'd)

Test pit No	Depth, m	Pressure P, (kN/m ²)	Coefficient of consolidation, C _v (10 ⁻³ cm ² /sec)
7	3	50	7.1900
		100	3.4900
		200	3.4400
		400	1.4900
		800	1.4400
		1600	0.7700
10	3	50	14.0500
		100	3.4600
		200	3.3700
		400	2.0500
		800	1.6500
		1600	1.4300

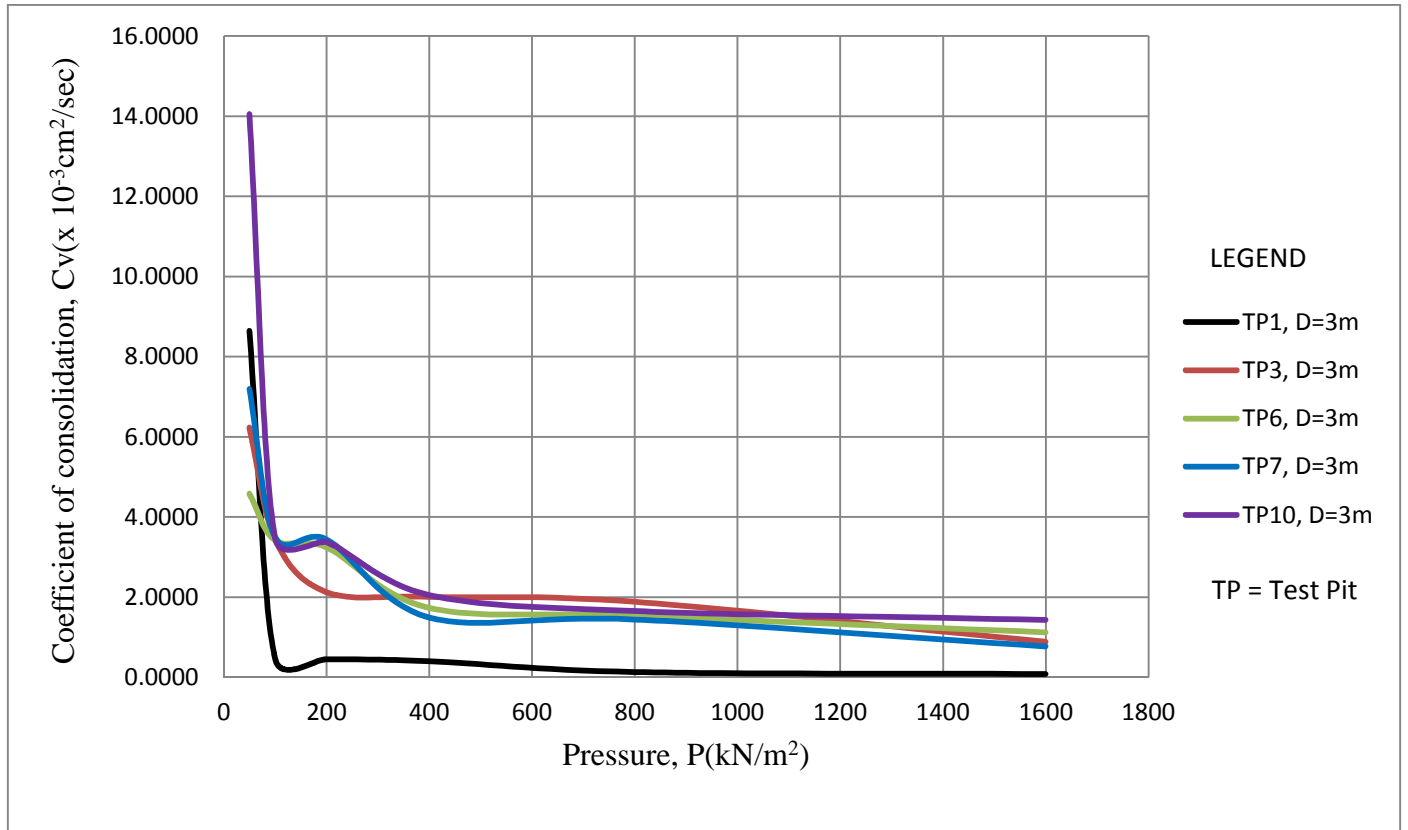


Fig 4.8 Coefficient of Consolidation Vs Pressure for the loading range of 50-1600kPa

4.3.2.5 Indirect determination of the coefficient of permeability

The coefficient of permeability of fine grained soil can be indirectly determined by the consolidation test. The coefficient of permeability, k , can be calculated using the relation

$$C_v = \frac{k(1+e_0)}{a_v \gamma_w} \text{ or } = \frac{k}{m_v \gamma_w}$$

Hence, $k = c_v m_v \gamma_w$

Where c_v = coefficient of consolidation

$$m_v = \frac{a_v}{1+e_0} = \text{coefficient of volume compressibility}$$

a_v = coefficient of compressibility

γ_w = unit weight of water

e_0 = initial void ratio

Values of k and m_v calculated for soils under this study are given in Table 4.9. The values of a_v can be computed from Fig 4.5. The relationship between coefficient of permeability and pressure is shown in Fig 4.9.

Table 4.9 Coefficient of volume compressibility and coefficient of permeability values

Test pit No	Depth m	Pressure P (kN/m ²)	Coefficient of consolidation, C_v (10 ⁻³ cm ² /sec)	Coefficient of volume compressibility, m_v (10 ⁻⁴ m ² /kN)	Coefficient of permeability, k (10 ⁻⁹ cm/sec)
1	3	400	0.400	1.41	0.564
		800	0.130	0.92	0.120
		1600	0.080	0.64	0.051
3	3	400	2.005	1.5	3.008
		800	1.881	0.88	1.656
		1600	0.883	0.64	0.565
6	3	400	1.730	1.74	3.010
		800	1.530	1.19	1.821
		1600	1.120	0.74	0.829
7	3	400	1.490	0.78	1.158
		800	1.440	0.55	0.798
		1600	0.770	0.42	0.320
10	3	400	2.050	1.50	3.075
		800	1.650	0.89	1.469
		1600	1.430	0.50	0.715

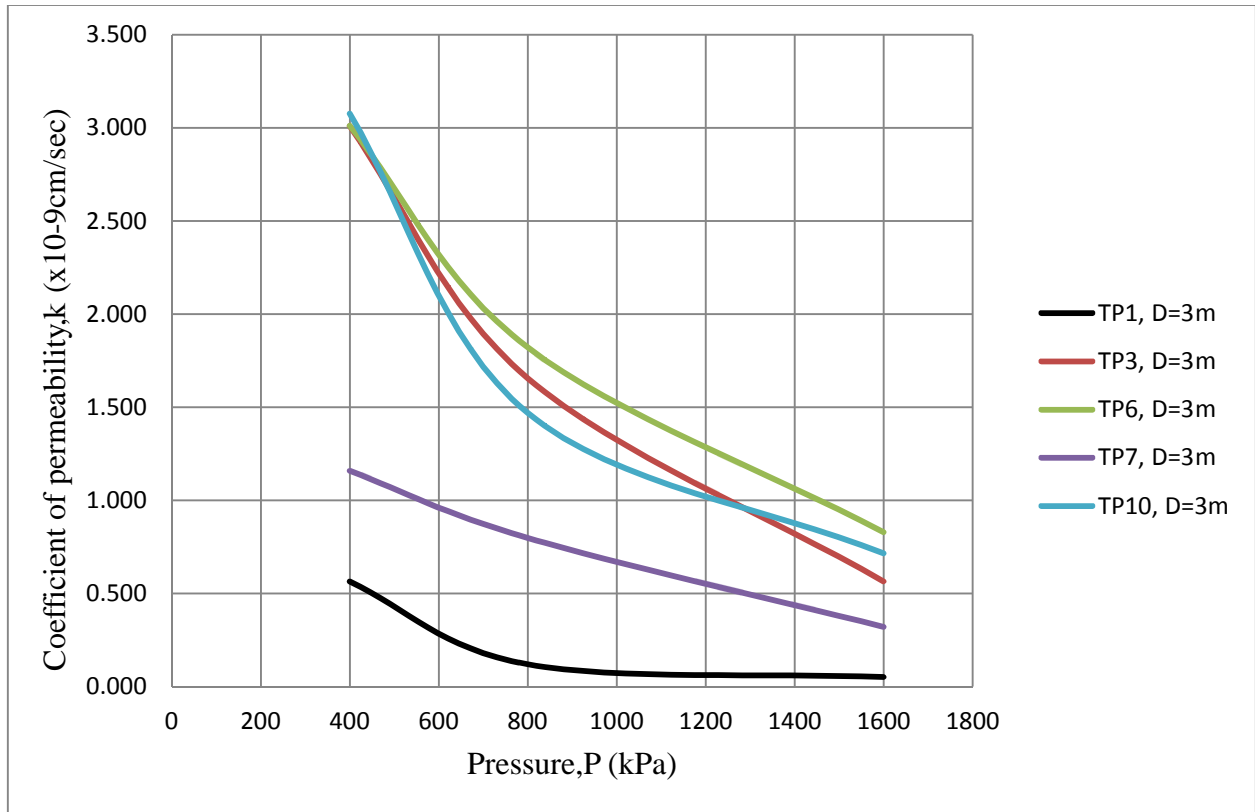


Fig 4.9 Coefficient of permeability vs Pressure

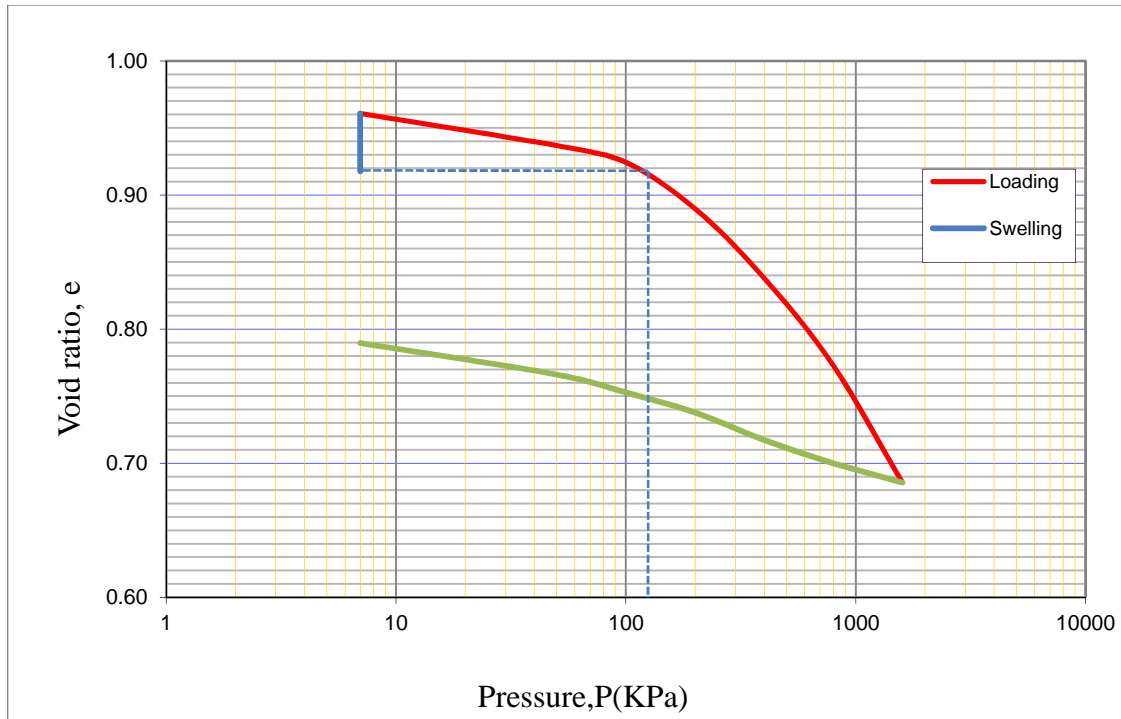
4.4 Swelling Pressure test

Clay soils containing montmorillonite mineral swell considerably upon imbibing water from outside. These soils also shrink upon removal of water. Clay soils containing other clay minerals do not exhibit the volume change characteristic to the same degree as those containing montmorillonite mineral. Expansive soils or swelling soils are those soils which have the tendency to increase in volume when water is available and to decrease in volume if water is removed. These volume changes in swelling soils are the cause of many problems in structures that come into their contact or constructed out of them. Expansive soils are common in Africa, Australia, India, South America, United States, Israel, Indonesia, Burma and some countries in Europe.

When an expansive soil imbibes water from outside, pressure builds up inside the soil. If free swelling of the soil is restrained by the placement of a structure over the soil, this pressure, called the swelling, is exerted by the soil on the overlying structure. Swelling pressure can be defined as the maximum force per unit area that needs to be placed over a swelling soil to prevent volume increase. Swelling pressure is a very useful index of the trouble potential of expansive soil [20].

Swelling pressure determination was carried out using the consolidation apparatus. The result of the swell-consolidation test for black soil under this study is shown in Fig 4.10. In the test, the specimen is placed in an oedometer under a small surcharge of about 7kN/m^2 . Water is added to the specimen, allowing it to swell and reach an equilibrium position after some time. Subsequently, loads are added in convenient steps, and the specimen is consolidated. The plot of void ratio versus $\log p$ is shown in Fig 4.11. The e versus $\log p$ plot crosses the horizontal line through the point of initial condition. The pressure corresponding to the point of intersection is the swelling pressure [8].

In this study, swelling pressure of 125kPa has been determined for the black clay soil as shown in the figure below.



. Fig 4.10 Plot of void ratio versus log-pressure for sample TP1, D=3m

5.0 DISCUSSION OF THE TEST RESULTS

5.1 Discussion

5.1.1 Index properties

The grain size analysis result indicate that the soils, except at TP2 below 1m depth, are fine grained soils (more than 50% passing through number 200 sieve) according to USCS. The soil found at TP 2 below 1m depth is coarse grained soil (having more than 50% retained on number 200 sieve) and classified as GM based on USCS.

The dominant proportions of soil particles in red soils are clay ranging from 21-90%, silt fraction 8.87-58.41%, sand fraction 0.5-33.4% and gravel content from 0-5%.The proportions of soil particles in black clay soils are clay ranging from 56-78%, silt fraction 15-31%,sand fraction 6-14% and gravel content from 0-0.25%.

The red soil soil in the study area has liquid limit ranging from 47-72%, plastic limit ranging from 30-36%, and plastic index from 14-39%. While the black clay soil has liquid limit ranging from 77-85%, plastic limit ranging from 34-36%, and plastic index from 43-50%.

Fine grained soils are classified based on the plasticity chart as shown in Fig 5.1. The results of classification according to unified soil classification are shown in Table 5.1.

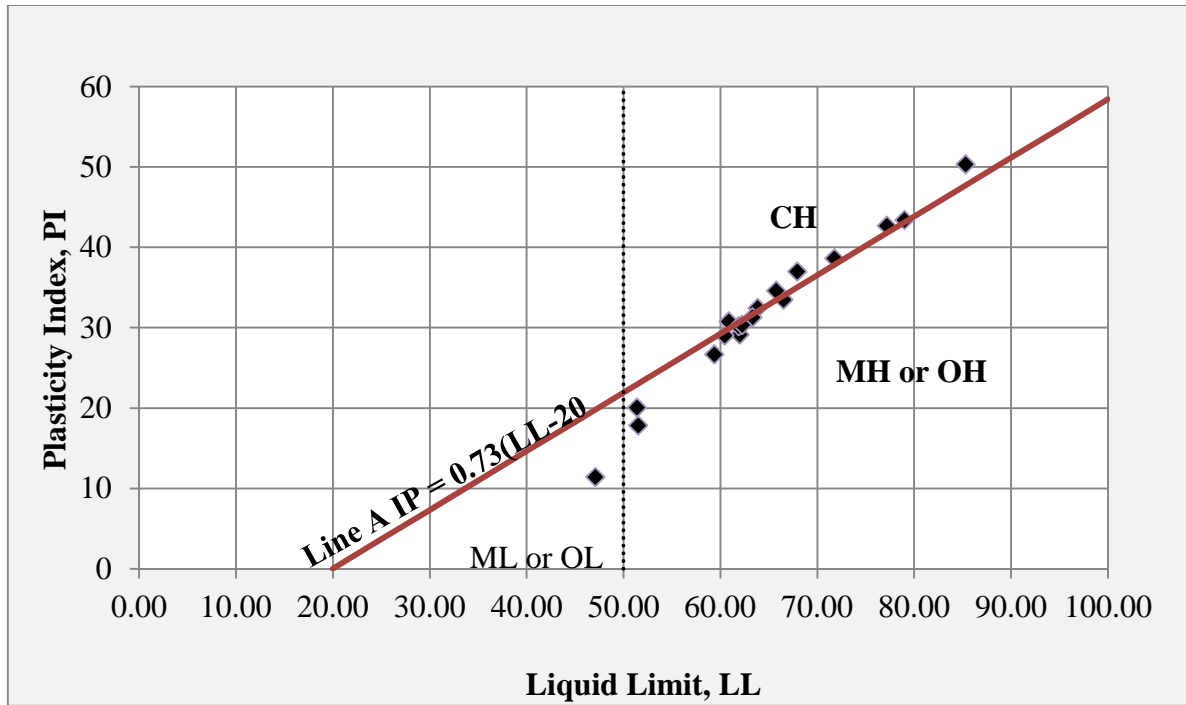


Fig 5.1 Plasticity chart according to USCS

Table 5.1 USCS classification of soils in Adet town

Test No	Pit	Depth	LL	PI	Soil Classification USCS*
1		1.5m	85.36	50.31	CH
		3.0m	79.03	43.38	CH
2		1.0m	77.24	42.65	CH
3		1.5m	63.88	32.43	CH
		3.0m	66.55	33.48	MH
4		1.5m	62.04	29.1	MH
		3.0m	65.82	34.59	CH
5		1.5m	63.35	31.25	MH
		3.0m	60.5	28.99	MH
6		1.5m	51.43	20.06	MH
		3.0m	47.14	11.42	ML
7		1.5m	67.97	36.95	CH
		3.0m	71.8	38.6	CH
8		1.5m	60.91	30.74	CH
		3.0m	51.55	17.81	MH
9		1.5m	61.92	30.17	MH
		3.0m	62.29	30.31	MH
10		1.5m	59.44	26.65	MH
		3.0m	64.77	33.76	MH

* In USCS classification CH, MH and ML are to describe: C= Inorganic clay, M= Inorganic silt, L= Low plasticity (LL<50%) and H= High plasticity (LL>50%).

In Table 5.1, the black clays involved in this study have been classified as high plasticity inorganic clays(CH) while the red soils fall in the class of low to high plasticity inorganic silts (ML,MH) and inorganic clays of high plasticity(CH).

Most of the red soils plot below the A line on the plasticity chart. Since A line is not developed

for the soil in our country, it should be used in great caution for classification. For example, the soil in TP9 at a depth of 1.5m has clay content 90% and 9% silt but it is classified as inorganic silt using plasticity chart. Based on the practical experience, Wesley proposed that soils which plot well below the A- line behave as silts while those which plot well above the A line behave as clays. The red soils which are very close but below the A line are classified as silty clay .

Classification of soils in the study area based on AASHTO classification system is shown in Table 5.2. From this table it can be observed that the soils in the study area are classified in group A-7-5 and A-1-b. Thus ,the black clays and red soils of the study area are not suitable as subgrade material.

Table 5.2 AASHTO soil classification of Adet soil samples

Test Pit No	Depth (m)	Group Classification	Group Index	General rating as subgrade material
1	1.5	A-7-5	50	Poor
	3.0	A-7-5	49	Poor
2	1.0	A-7-5	44	Poor
	3.0	A-1-b	0	Excellent
3	1.5	A-7-5	32	Poor
	3.0	A-7-5	36	Poor
4	1.5	A-7-5	22	Poor
	3.0	A-7-5	27	Poor
5	1.5	A-7-5	38	Poor
	3.0	A-7-5	35	Poor
6	1.5	A-7-5	13	Poor
	3.0	A-7-5	12	Poor
7	1.5	A-7-5	41	Poor
	3.0	A-7-5	43	Poor
8	1.5	A-7-5	19	Poor
	3.0	A-7-5	15	Poor
9	1.5	A-7-5	37	Poor
	3.0	A-7-5	32	Poor
10	1.5	A-7-5	32	Poor
	3.0	A-7-5	39	Poor

The specific gravity of soils in this study ranges between 2.62 and 2.85, which is within the range of results obtained from a previous study carried out in Bahir Dar[15] .

Free swell test results of black clay soils indicate that the soils are moderately expansive soil having free swell values from 67-100%.While, the red soils free swell values ranges from 27 to

67.5%. Of which most of the red soils exhibit free swell values less than 50% which are considered as low in degree of expansion.

5.1.2 Unconfined compression test results

The unconfined compressive strength (UCS) values for the black clay soils ranges from 101 to 103kPa at moisture content of 36-41% while that of red soils ranges from 84 to 422kPa at moisture content of 28-40%. One of the red clay sample shows a higher UCS value which can be mainly due to the natural cementation of the undisturbed sample.

5.1.3 Consolidation test results

The preconsolidation pressures determined according to Casagrande's method on log scale ranges from 100-300kPa. The compression and recompression indices of the soils are calculated from the straight line portions of loading and unloading e-log p curve. The black clay soil has a compression index, C_c , 0.266 and recompression index, C_r , 0.047 whereas the red soil has a compression index, C_c , ranging from 0.166 to 0.299 and recompression index, C_r , ranging from 0.023 to 0.029. The values of coefficient of consolidation, C_v , lie in the range from 0.46 to 0.08 $\times 10^{-3}$ cm²/sec for the black clay soil and from 3.49 to 0.77 $\times 10^{-3}$ cm²/sec for the red soils when loaded in the range of 100 to 1600kPa as shown in Fig 5.2. The high rates of consolidation by the red soils could be attributed to their relatively high permeability ($k = 3.07 \times 10^{-9}$ to 3.2×10^{-10} cm/sec) which facilitate faster drainage and rapid dissipation of pore water pressures.

On the other hand, the black clays are characterized by relatively lower permeability ($k = 5.64 \times 10^{-10}$ to 5.1×10^{-11} cm/sec) so that drainage and dissipation of pore water pressures on loading would be less rapid, causing slower consolidation settlement.

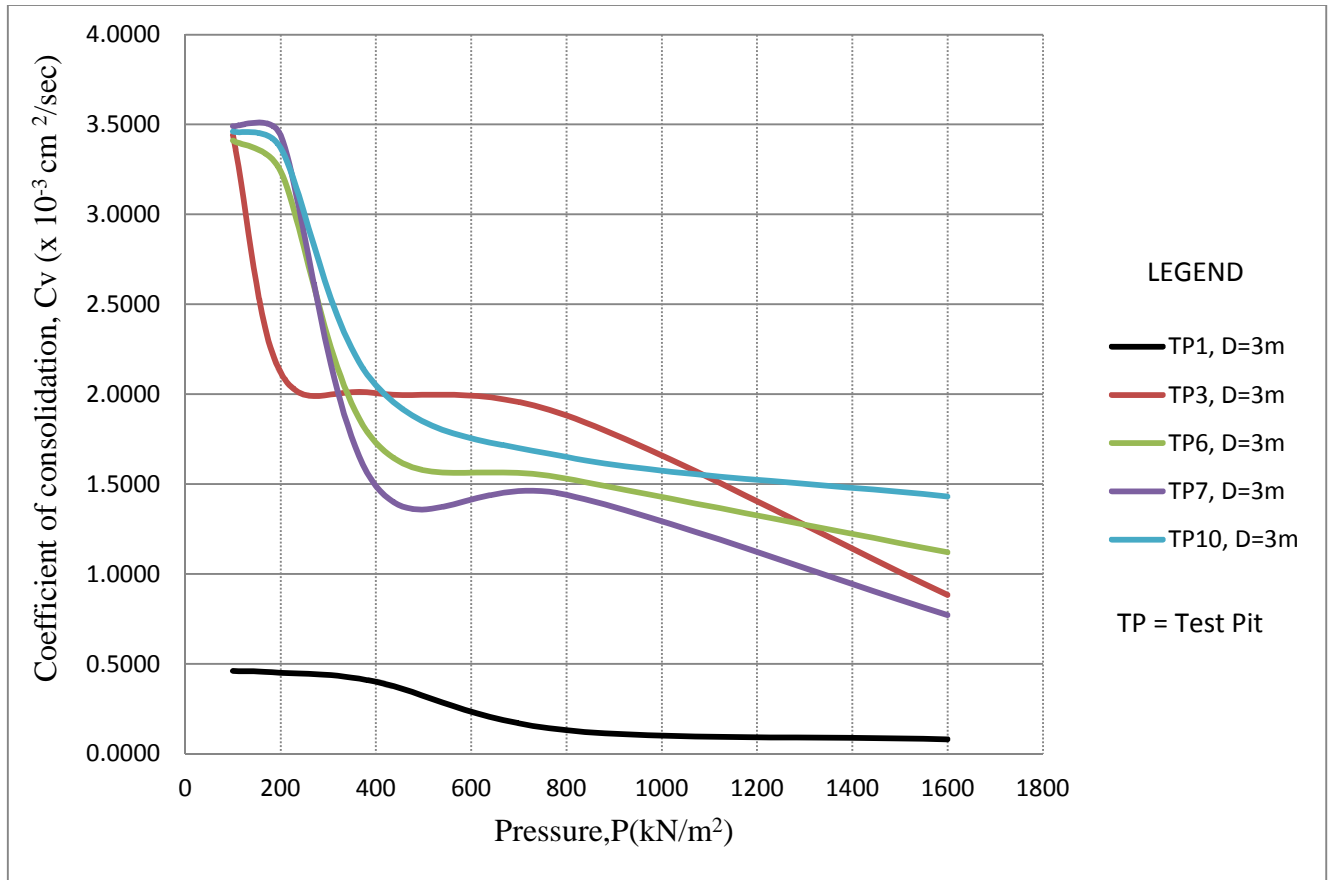


Fig 5.2 Coefficient of Consolidation Vs Pressure for the loading range of 100-1600kPa

The coefficient of permeability of soils determined from Oedometer test ranges from 10^{-8} to 10^{-11} cm/sec and this shows that the soils are impervious.

The permeability vs pressure curves of the red soils plot higher than those of black clays. This indicates that the higher permeability of red clay soils to the black clays in this study.

The swelling pressure determined from the swell consolidation test indicate that the black clay soil has a swelling pressure of 125kPa which can cause considerable damage to lightly loaded structures. .

5.2. Comparative results of Adet soils

Results of the present study can be compared with the other research data as shown in the following tables.

Table 5.3 Comparison of red clay soil data

	Previous research[17]	Previous research[15]	Present research
Soil type	Red clays	Red clay*	Red soil
Location	Merawi	Bahir Dar	Adet town
Clay content %	63.59-91.26	74-82	21-90%
Activity	<0.75	0.56	<0.75
Clay minerals		Kaolinite	-
Liquid limit %	53.04-68.25	61-68	47-72
Plastic index %	28.56-39.82	24-31	11-39
Specific gravity	2.7-2.76	2.75-2.83	2.70-2.85
UCS(kPa)	63.67-117.81	148-220	84-442

*The fine grained soils in Bahir Dar are classified as inorganic silts of high plasticity(MH)[15].

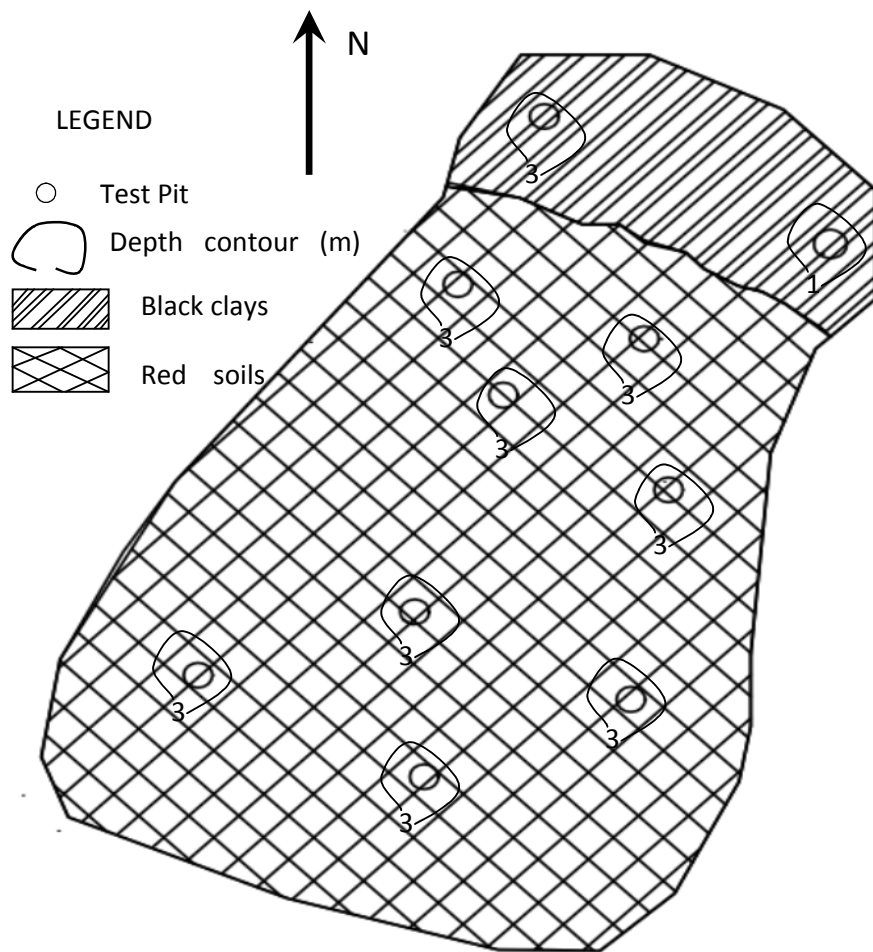
Table 5.4 Comparison of black clay soil data

	Previous research[12]	Present research
Soil type	Black clays	Black clays
Location	Bahir Dar town	Adet town
Clay content %	55.4-87	56-71
Free swell	78-215	67-100
Liquid limit %	75-112.05	77-86
Plastic index %	44.5-76.42	42-51
Specific gravity	2.55-2.81	2.62-2.67
UCS(kPa)		101-103
Swelling pressure (kPa)	75.95-547.52	125*

*The swelling pressure was determined from one soil sample..

5.3 Tentative soil map of the study area in Adet town

Soil map shows the distribution of soils in the area. The soil map of the study area in Adet town is prepared based on the result from ten test pits. The test pits are dug upto a depth of 3m. The soil in the area is mainly divided into red soil and black clay soil as shown in Fig 5.3 . The black clay soil is limited in the northern part of the town where the area is relatively flat and in lower elevation. The majority of the area is covered with red soils. The delineation between the red soil and black cotton soil is made using interpolation between neighboring test pits. The soil map prepared here is not detailed enough and should be updated in the future with further research including the geology and natural features of the area.



Red soils

Also described as low to high plasticity inorganic silts and high plasticity inorganic clays

Index properties
 Clay fraction: 21-90%
 Plastic limit : 30-36%
 Liquid limit : 47-72%
 Plastic index : 14-39%
 Specific gravity: 2.7-2.85
 Free swell : 27-67.5%

UCS : 84-442 KPa

Consolidation characteristics

$C_c = 0.19-0.299$
 $mv = 0.42-3.95 \times 10^{-4} \text{ m}^2/\text{kN}$
 $C_v = 0.77-17.4 \times 10^{-3} \text{ cm}^2/\text{sec}$

Permeability: $10^{-9} - 10^{-10} \text{ cm/sec}$

Depths: upto 3m

Black clays

Index properties	Free swell: 67-100%	Consolidation characteristics
Clay fraction: 56-78%		$C_c : 0.266$
Natural moisture: 25-39%	Swelling pressure: 125kPa	$mv : 0.64-1.41 \times 10^{-4} \text{ m}^2/\text{kN}$
Plastic limit : 34-36%		$C_v : 0.08-8.64 \times 10^{-3} \text{ cm}^2/\text{sec}$
Liquid limit : 77-85%	UCS: 101-134 kPa	Permeability: $10^{-10}-10^{-11} \text{ cm/sec}$
Plastic index : 42-51%		
Specific gravity: 2.62-2.67		Depths: up to 1m to 3m

Fig 5.3 Tentative soil map of the study area in Adet town

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. There are both black clay soils and red soils in the town of Adet. The black clay soils are found in the relatively lower elevation and flat lying areas of the town. However, most of the areas in the town is covered with red soils.
2. The red soils have specific gravity ranging from 2.70 to 2.85, liquid limit of 47-72%, plasticity index of 14-39%, clay fraction of 21-90%. While the black clay soils have specific gravity ranging from 2.62 to 2.67, liquid limit of 77-86%, plasticity index of 42-51% , clay fraction of 56-71%.
3. The activity of black clay soils ranges from 0.53 to 0.76. While the red soils have an activity ranging from 0.33 to 0.85.
4. The swelling pressure as it was determined from one soil sample has shown the black clay to exhibit swelling pressure of 125kPa, which may have destabilization effect on light weight structure.
5. The free swell values of black clay soils, ranges from 67-100%, indicate that the soils are moderately expansive soils. Most of the red soils have free swell values less than 50 percent whereas the whole red soil's free swell values ranges from 27-67.5%.
6. The consistency of red soils is found to be medium stiff to hard as UCS ranges from 84-442kPa at natural moisture content of 28-40%. While the consistency of black clay soils is found to be stiff as UCS ranges from 101 to 103kPa at natural moisture content of 36-41%.
7. The coefficient of permeability determined indirectly from one dimensional consolidation test ranges from 10^{-10} to 10^{-11} cm/sec for the black clay soil and ranges from 10^{-9} to 10^{-10} cm/sec for the red soil.

6.2 Recommendations

1. The soil map of the town should be improved by taking additional samples from the areas not covered in this study particularly around the boundary between the red soils and black cotton soils because the delineation is made using interpolation between neighboring test pits.
2. The soil map presented in this study is tentative and should be improved in the future with further research including the geology. Thus, one should be very careful in using the tentative soil map.
3. The mineralogical composition of soils in Adet town is not studied in this research. If the mineralogical composition of fine grained soil is known, its effect on the engineering properties of the soils can be clearly identified.

7.0 Reference

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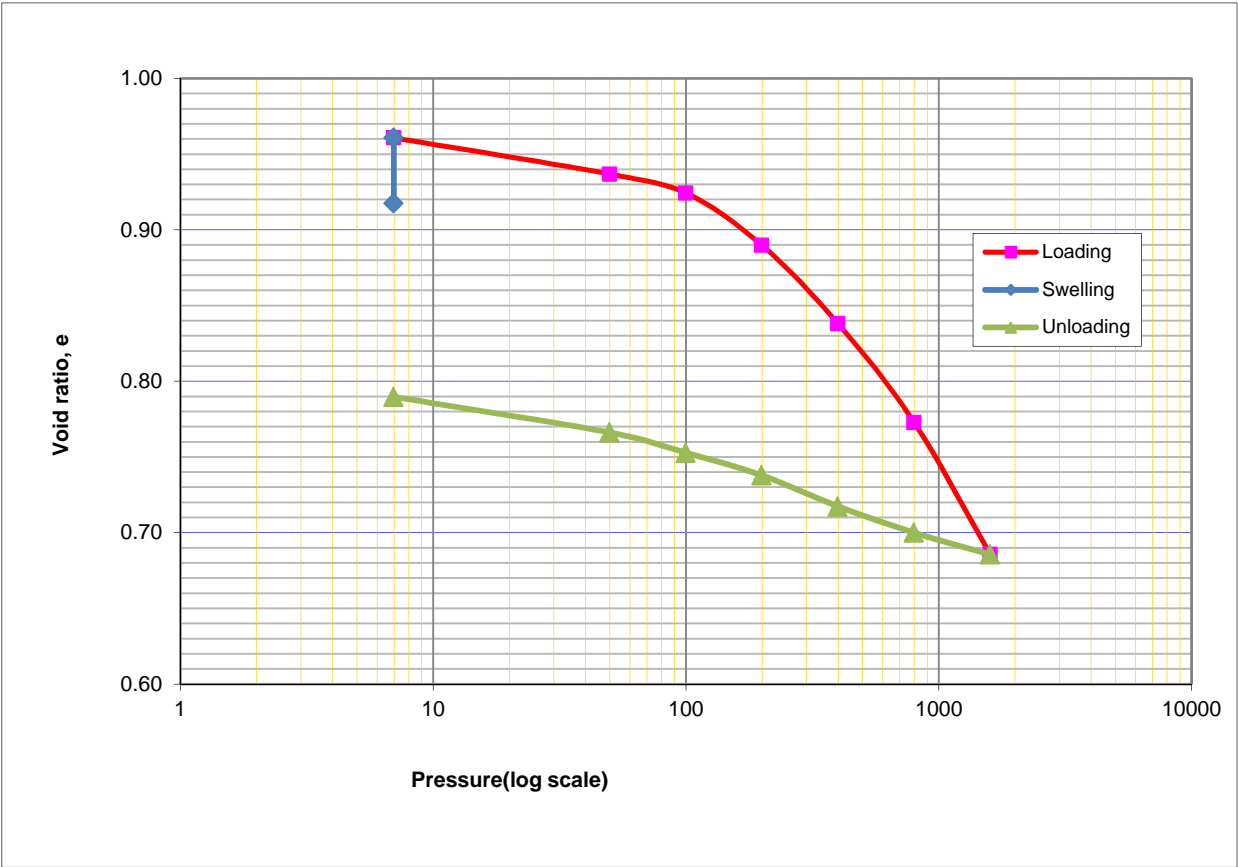
APPENDIX A Consolidation and swell consolidation test result

A1 Swell consolidation test result of TP1 at D=3m

Sample type: *Un disturbed* **Initial void ratio:** *0.92*
Sample height: *2cm* **Wet density ,g/cm³** *1.76*
Sample area *19.635cm²* **Seating Load:** *7Kpa*
Initial moisture content: *28.91%*

Applied pressure P (kPa)	Final dial reading (mm)	Change in specimen height (mm)	Final specimen height (mm)	Void height (mm)	Void ratio
Loading					
7	5.000	0.00	20.00	9.57	0.918
7	5.450	0.45	20.45	10.02	0.961
50	5.200	0.20	20.20	9.77	0.937
100	5.070	0.07	20.07	9.64	0.924
200	4.710	-0.29	19.71	9.28	0.890
400	4.170	-0.83	19.17	8.74	0.838
800	3.490	-1.51	18.49	8.06	0.773
1600	2.580	-2.42	17.58	7.15	0.686
Unloading					
1600	2.580	-2.42	17.58	7.15	0.686
800	2.730	-2.27	17.73	7.30	0.700
400	2.910	-2.09	17.91	7.48	0.717
200	3.125	-1.88	18.13	7.70	0.738
100	3.280	-1.72	18.28	7.85	0.753
50	3.420	-1.58	18.42	7.99	0.766
7	3.665	-1.34	18.67	8.24	0.790

A2 Void ratio Vs Pressure (log scale) curve for TP1 at D=3m

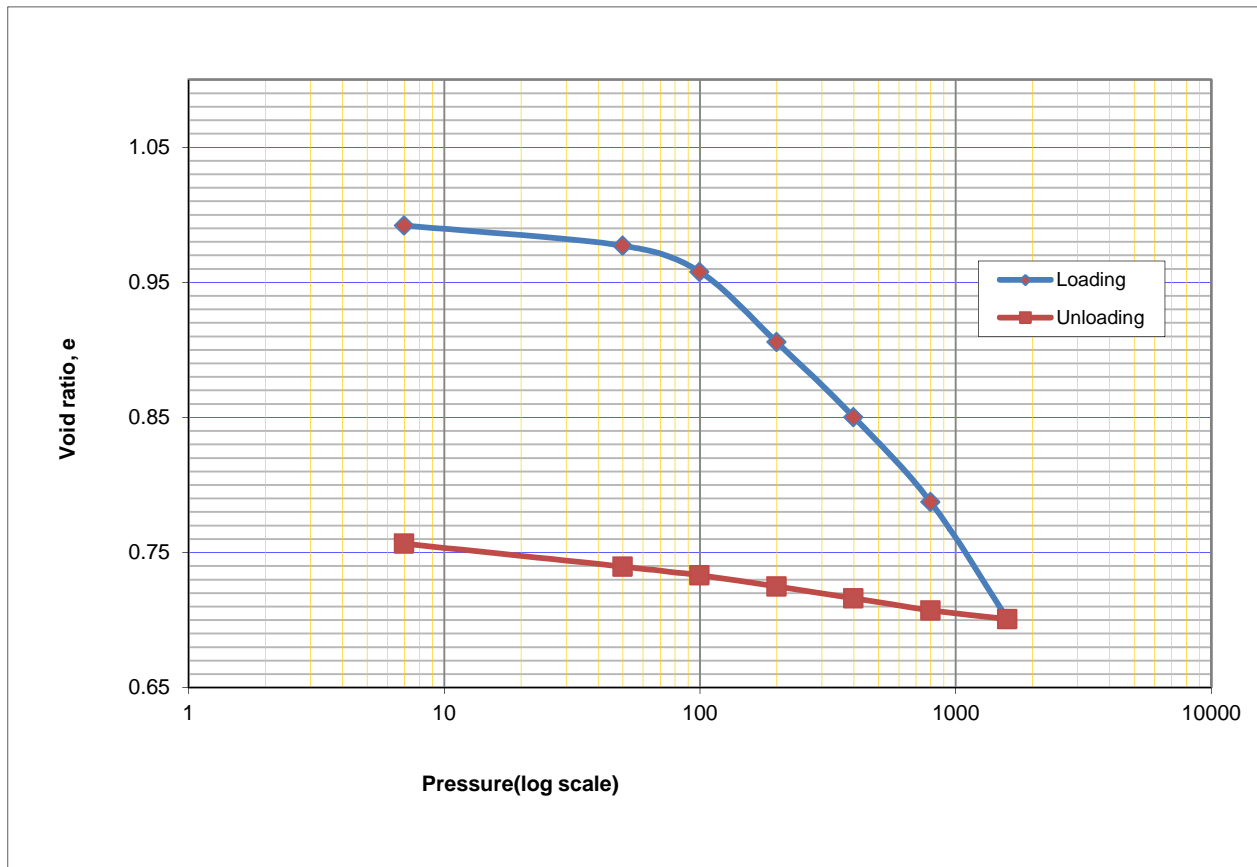


A3 Consolidation test result of TP3 at D=3m

Sample type: *Un disturbed* **Initial void ratio:** *0.994*
Sample height: *2cm* **Wet density ,g/cm³** *1.85*
Sample area *19.635cm²* **Seating Load:** *7Kpa*
Initial moisture content: *35.46%*

Applied pressure P (kPa)	Final dial reading (mm)	Change in specimen height (mm)	Final specimen height (mm)	Void height (mm)	Void ratio
Loading					
7	7.000	0.00	20.00	9.97	0.994
50	6.830	-0.17	19.83	9.80	0.977
100	6.635	-0.37	19.64	9.61	0.958
200	6.114	-0.89	19.11	9.08	0.906
400	5.557	-1.44	18.56	8.53	0.850
800	4.927	-2.07	17.93	7.90	0.787
1600	4.057	-2.94	17.06	7.03	0.701
Unloading					
1600	4.057	-2.94	17.06	7.03	0.701
800	4.122	-2.88	17.12	7.09	0.707
400	4.212	-2.79	17.21	7.18	0.716
200	4.299	-2.70	17.30	7.27	0.725
100	4.382	-2.62	17.38	7.35	0.733
50	4.447	-2.55	17.45	7.42	0.739
7	4.617	-2.38	17.62	7.59	0.756

A4 Void ratio Vs Pressure (log scale) curve for TP3 at D=3m



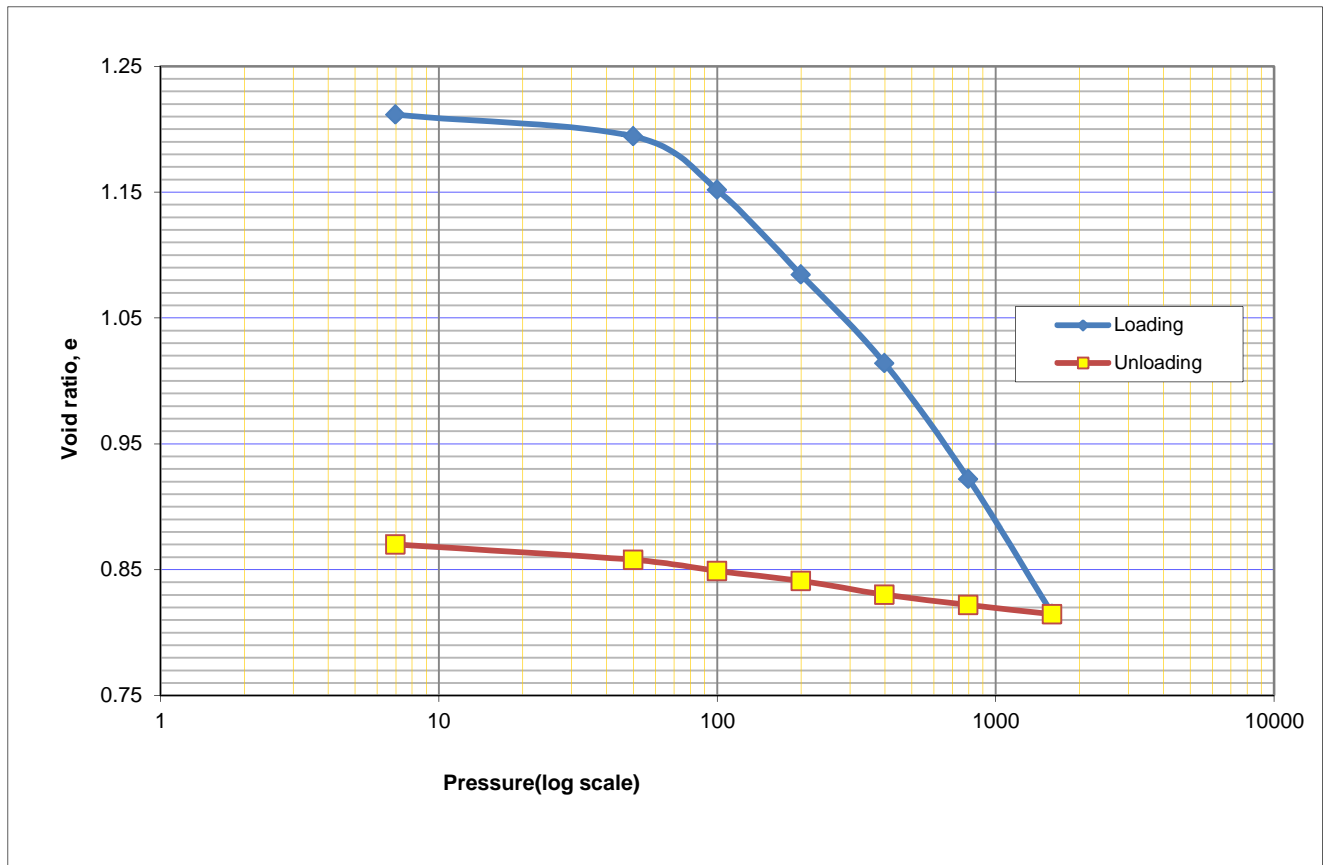
A5 Consolidation test result of TP6 at D=3m

Sample

type:	Un disturbed	Initial void ratio:	1.212
Sample height:	2cm	Wet density ,g/cm3	1.81
Sample area	19.635cm²	Seating Load:	7Kpa
Initial moisture content:	42.28%		

Applied pressure P (kPa)	Final dial reading (mm)	Change in specimen height (mm)	Final specimen height (mm)	Void height (mm)	Void ratio
Loading					
7	6.000	0.00	20.00	10.96	1.212
50	5.835	-0.17	19.84	10.80	1.194
100	5.450	-0.55	19.45	10.41	1.152
200	4.841	-1.16	18.84	9.80	1.084
400	4.204	-1.80	18.20	9.16	1.014
800	3.374	-2.63	17.37	8.33	0.922
1600	2.404	-3.60	16.40	7.36	0.815
Unloading					
1600	2.404	-3.60	16.40	7.36	0.815
800	2.469	-3.53	16.47	7.43	0.822
400	2.544	-3.46	16.54	7.50	0.830
200	2.642	-3.36	16.64	7.60	0.841
100	2.714	-3.29	16.71	7.67	0.849
50	2.794	-3.21	16.79	7.75	0.858
7	2.904	-3.10	16.90	7.86	0.870

A6 Void ratio Vs Pressure (log scale) curve for TP6 at D=3m

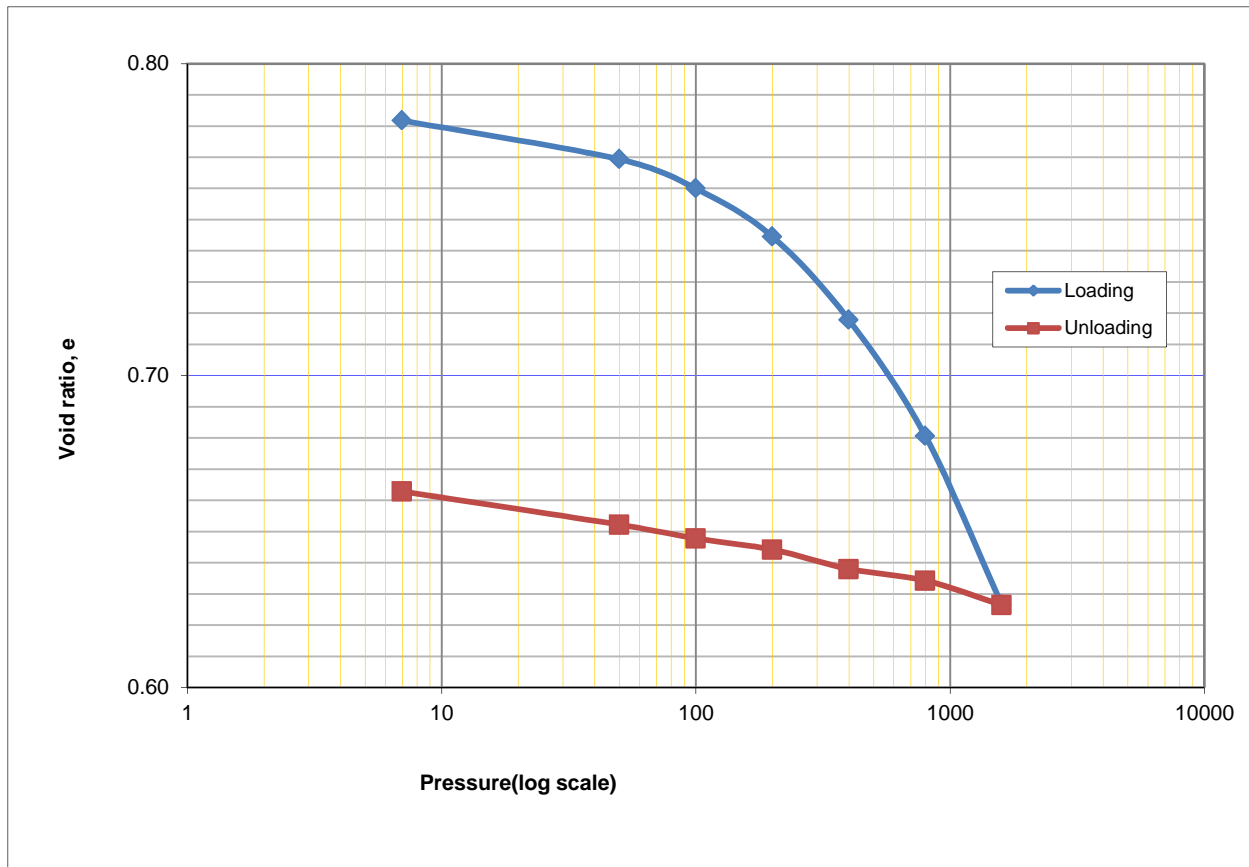


A7 Consolidation test result of TP7 at D=3m

Sample type: *Un disturbed* **Initial void ratio:** *0.775*
Sample height: *2cm* **Wet density ,g/cm3** *1.98*
Sample area *19.635cm²* **Seating Load:** *7Kpa*
Initial moisture content: *28.66%*

Applied pressure P (kPa)	Final dial reading (mm)	Change in specimen height (mm)	Final specimen height (mm)	Void height (mm)	Void ratio
Loading					
7	8.000	0.00	20.00	8.73	0.775
50	7.940	-0.06	19.94	8.67	0.769
100	7.835	-0.17	19.84	8.57	0.760
200	7.661	-0.34	19.66	8.39	0.745
400	7.360	-0.64	19.36	8.09	0.718
800	6.940	-1.06	18.94	7.67	0.681
1600	6.330	-1.67	18.33	7.06	0.626
Unloading					
1600	6.330	-1.67	18.33	7.06	0.626
800	6.418	-1.58	18.42	7.15	0.634
400	6.460	-1.54	18.46	7.19	0.638
200	6.530	-1.47	18.53	7.26	0.644
100	6.570	-1.43	18.57	7.30	0.648
50	6.620	-1.38	18.62	7.35	0.652
7	6.740	-1.26	18.74	7.47	0.663

A8 Void ratio Vs Pressure (log scale) curve for TP7 at D=3m

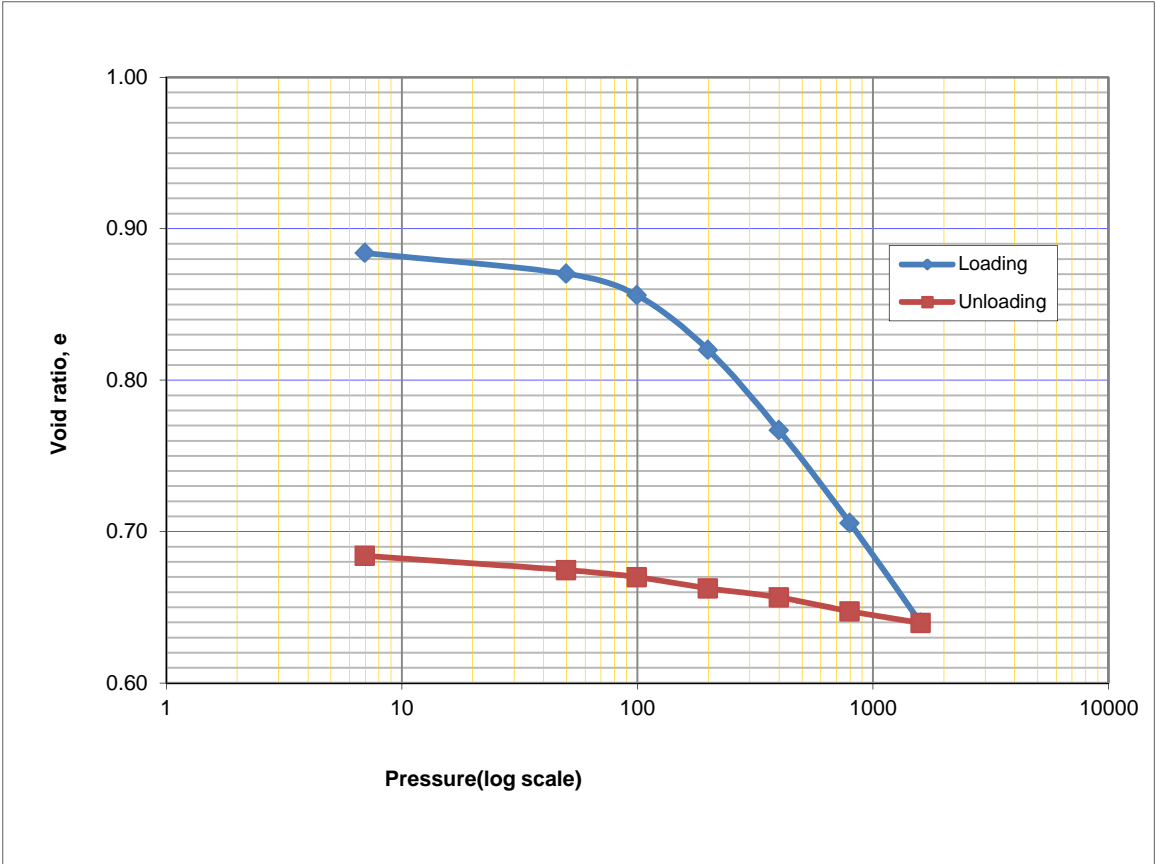


A9 Consolidation test result of TP10 at D=3m

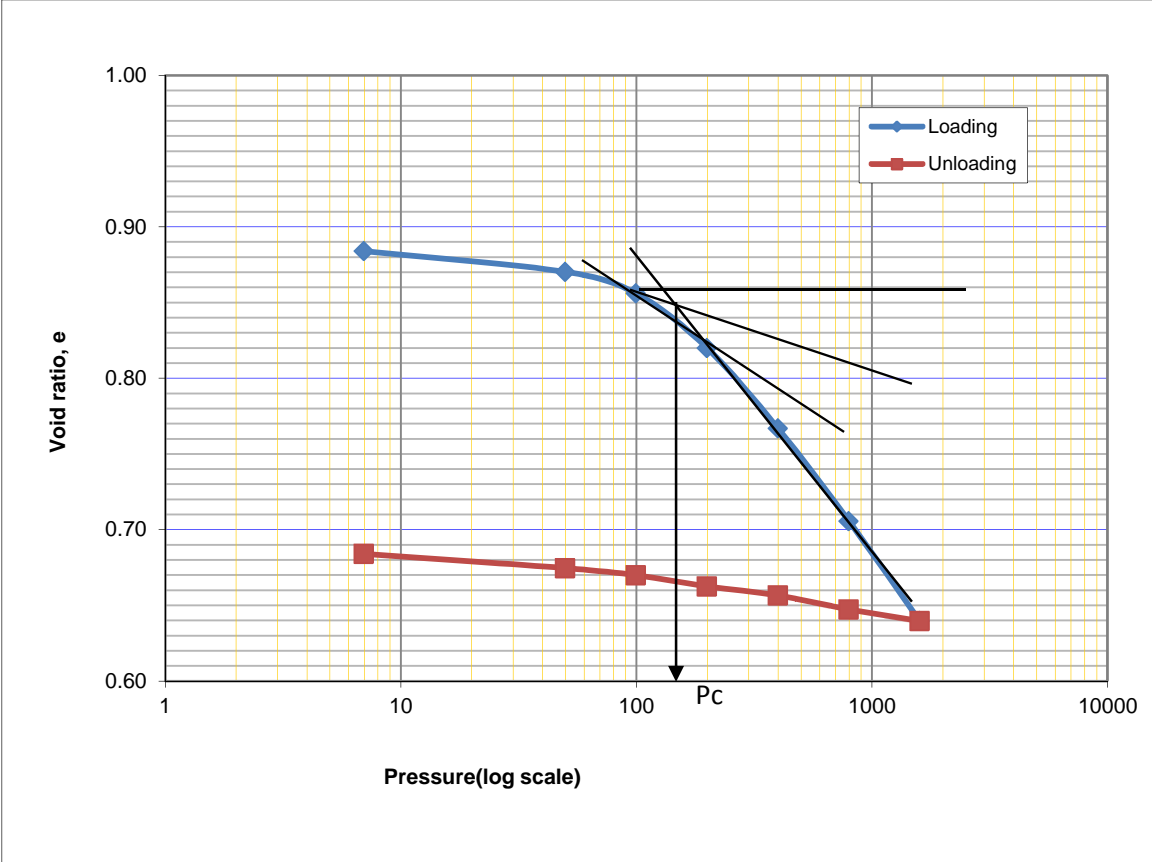
Sample type: *Un disturbed* **Initial void ratio:** *0.881*
Sample height: *2cm* **Wet density ,g/cm³** *1.90*
Sample area *19.635cm²* **Seating Load:** *7Kpa*
Initial moisture content: *28.64%*

Applied pressure P (kPa)	Final dial reading (mm)	Change in specimen height (mm)	Final specimen height (mm)	Void height (mm)	Void ratio
Loading					
7	7.000	0.00	20.00	9.37	0.881
50	6.880	-0.12	19.88	9.25	0.870
100	6.728	-0.27	19.73	9.10	0.856
200	6.345	-0.66	19.35	8.72	0.820
400	5.780	-1.22	18.78	8.15	0.767
800	5.130	-1.87	18.13	7.50	0.706
1600	4.428	-2.57	17.43	6.80	0.640
Unloading					
1600	4.428	-2.57	17.43	6.80	0.640
800	4.510	-2.49	17.51	6.88	0.647
400	4.608	-2.39	17.61	6.98	0.656
200	4.672	-2.33	17.67	7.04	0.662
100	4.750	-2.25	17.75	7.12	0.670
50	4.800	-2.20	17.80	7.17	0.675
7	4.900	-2.10	17.90	7.27	0.684

A10 Void ratio Vs Pressure (log scale) curve for TP10 at D=3m



A11 Determination of preconsolidation pressure of TP10 at D=3m



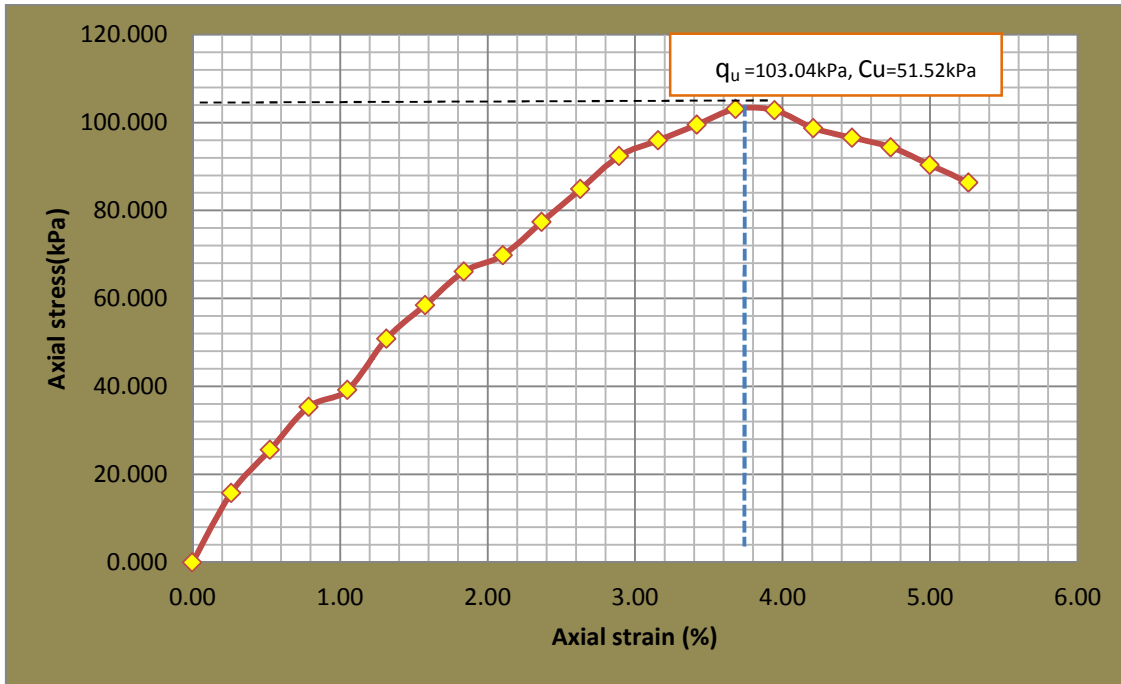
APPENDIX B Unconfined compression test results

B1 Unconfined compression test result of TP1 at D=1.5m

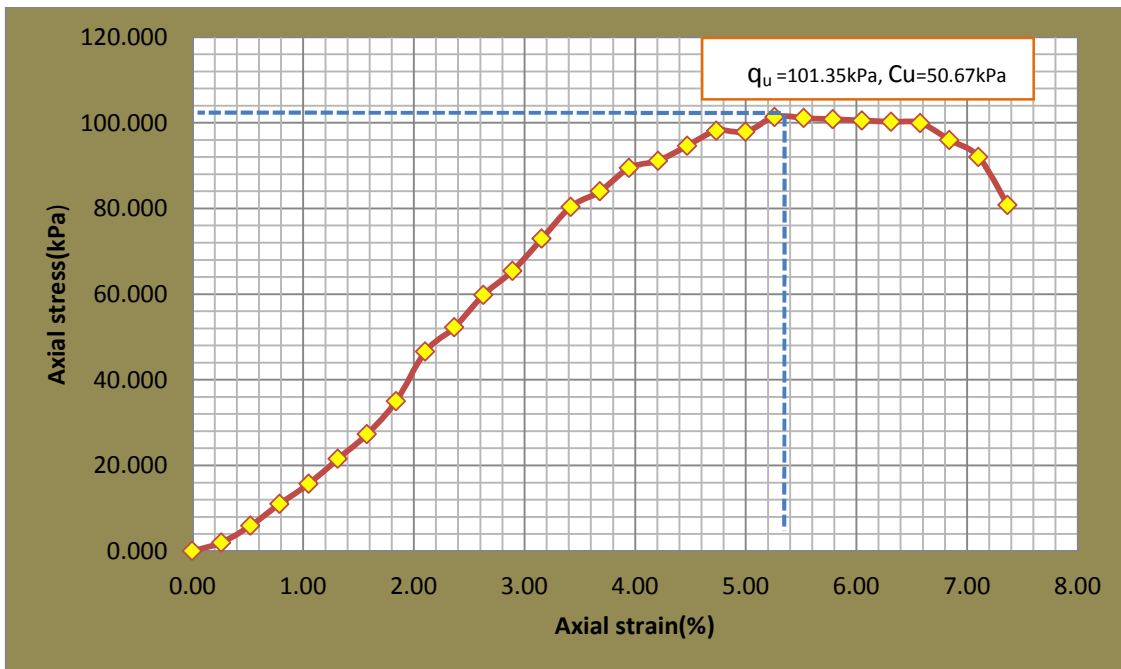
Test Pit No	1		
Test Pit Depth , m	1.5m	Ring Calibration Factor, kN/div	0.04493
Diameter of sample , mm	38	Moisture content, %	36.11
Length of sample , mm	76	Wet unit weight, g/cc	1.83

Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.4	0.0180	0.00114	15.807
0.4	0.53	0.65	0.0292	0.00114	25.618
0.6	0.79	0.9	0.0404	0.00114	35.377
0.8	1.05	1	0.0449	0.00115	39.204
1	1.32	1.3	0.0584	0.00115	50.829
1.2	1.58	1.5	0.0674	0.00115	58.493
1.4	1.84	1.7	0.0764	0.00116	66.115
1.6	2.11	1.8	0.0809	0.00116	69.816
1.8	2.37	2	0.0899	0.00116	77.365
2	2.63	2.2	0.0988	0.00116	84.872
2.2	2.89	2.4	0.1078	0.00117	92.337
2.4	3.16	2.5	0.1123	0.00117	95.924
2.6	3.42	2.6	0.1168	0.00117	99.490
2.8	3.68	2.7	0.1213	0.00118	103.035
3	3.95	2.7	0.1213	0.00118	102.753
3.2	4.21	2.6	0.1168	0.00118	98.677
3.4	4.47	2.55	0.1146	0.00119	96.513
3.6	4.74	2.5	0.1123	0.00119	94.360
3.8	5.00	2.4	0.1078	0.00119	90.335
4	5.26	2.3	0.1033	0.00120	86.332

B3 Unconfined compression test result curve of TP1 at D=1.5m



B4 Unconfined compression test result curve of TP1 at D=3m



B5Unconfined compression test result of TP3 at D=1.5m

Test Pit Depth , m **1.5** **Ring Calibration Factor, kN/div** **0.04493**
Diameter of sample , mm **38** **Moisture content, %** **35.43**
Length of sample , mm **76** **Wet unit weight, g/cc** **1.73**

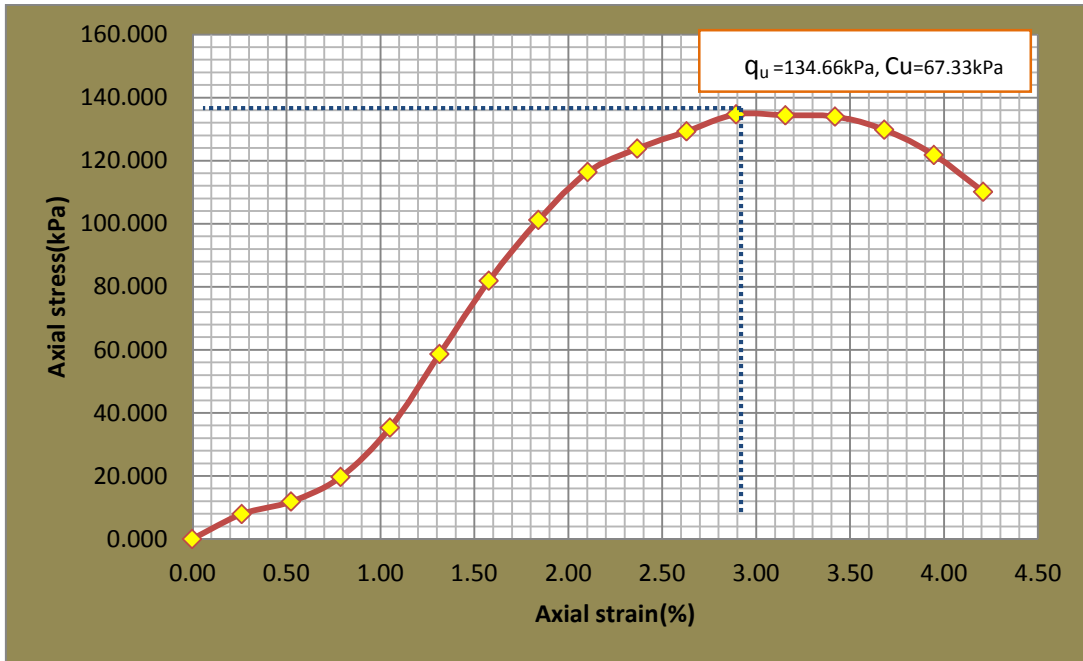
Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.2	0.0090	0.00114	7.903
0.4	0.53	0.3	0.0135	0.00114	11.824
0.6	0.79	0.5	0.0225	0.00114	19.654
0.8	1.05	0.9	0.0404	0.00115	35.283
1	1.32	1.5	0.0674	0.00115	58.649
1.2	1.58	2.1	0.0944	0.00115	81.890
1.4	1.84	2.6	0.1168	0.00116	101.116
1.6	2.11	3	0.1348	0.00116	116.360
1.8	2.37	3.2	0.1438	0.00116	123.784
2	2.63	3.35	0.1505	0.00116	129.237
2.2	2.89	3.5	0.1573	0.00117	134.659
2.4	3.16	3.5	0.1573	0.00117	134.294
2.6	3.42	3.5	0.1573	0.00117	133.929
2.8	3.68	3.4	0.1528	0.00118	129.748
3	3.95	3.2	0.1438	0.00118	121.782
3.2	4.21	2.9	0.1303	0.00118	110.062

B6 Unconfined compression test result of TP3 at D=3m

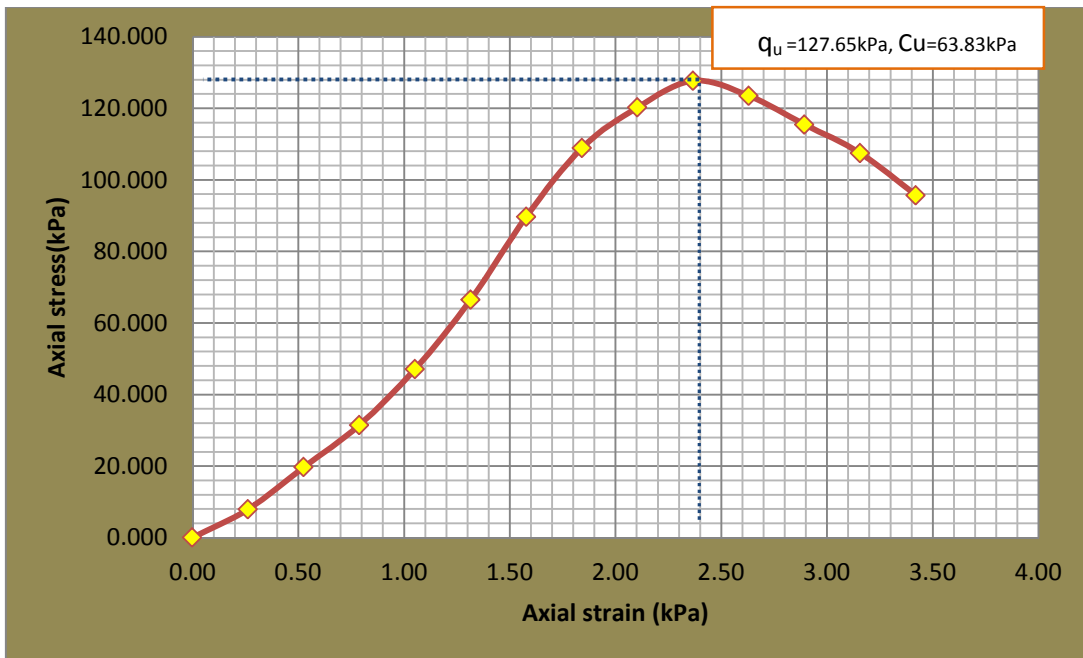
Test Pit Depth , m **3.00** **Ring Calibration Factor, kN/div** **0.04493**
Diameter of sample , mm **38** **Moisture content, %** **33.63**
Length of sample , mm **76** **Wet unit weight, g/cc** **1.88**

Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.2	0.0090	0.00114	7.903
0.4	0.53	0.5	0.0225	0.00114	19.706
0.6	0.79	0.8	0.0359	0.00114	31.446
0.8	1.05	1.2	0.0539	0.00115	47.045
1	1.32	1.7	0.0764	0.00115	66.469
1.2	1.58	2.3	0.1033	0.00115	89.689
1.4	1.84	2.8	0.1258	0.00116	108.895
1.6	2.11	3.1	0.1393	0.00116	120.239
1.8	2.37	3.3	0.1483	0.00116	127.652
2	2.63	3.2	0.1438	0.00116	123.450
2.2	2.89	3	0.1348	0.00117	115.422
2.4	3.16	2.8	0.1258	0.00117	107.435
2.6	3.42	2.5	0.1123	0.00117	95.663

B7 Unconfined compression test result curve of TP3 at D=1.5m



B8 Unconfined compression test result curve of TP3 at D=3m



B9 Unconfined compression test result of TP6 at D=1.5m

Test Pit Depth , m **1.5m** **Ring Calibration Factor, kN/div** **0.04493**
Diameter of sample , mm **38** **Moisture content, %** **30.42**
Length of sample , mm **76** **Wet unit weight, g/cc** **1.96**

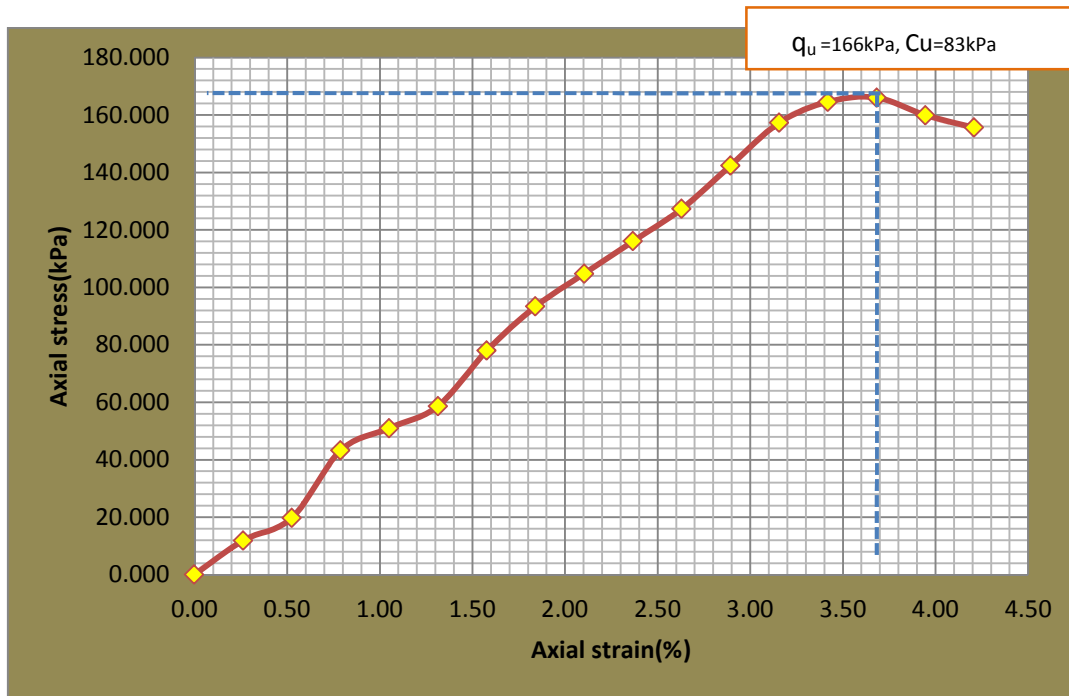
Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.3	0.0135	0.00114	11.855
0.4	0.53	0.5	0.0225	0.00114	19.706
0.6	0.79	1.1	0.0494	0.00114	43.239
0.8	1.05	1.3	0.0584	0.00115	50.965
1	1.32	1.5	0.0674	0.00115	58.649
1.2	1.58	2	0.0899	0.00115	77.990
1.4	1.84	2.4	0.1078	0.00116	93.338
1.6	2.11	2.7	0.1213	0.00116	104.724
1.8	2.37	3	0.1348	0.00116	116.047
2	2.63	3.3	0.1483	0.00116	127.308
2.2	2.89	3.7	0.1662	0.00117	142.353
2.4	3.16	4.1	0.1842	0.00117	157.315
2.6	3.42	4.3	0.1932	0.00117	164.541
2.8	3.68	4.35	0.1954	0.00118	166.001
3	3.95	4.2	0.1887	0.00118	159.839
3.2	4.21	4.1	0.1842	0.00118	155.606

B10 Unconfined compression test result of TP6 at D=3.0m

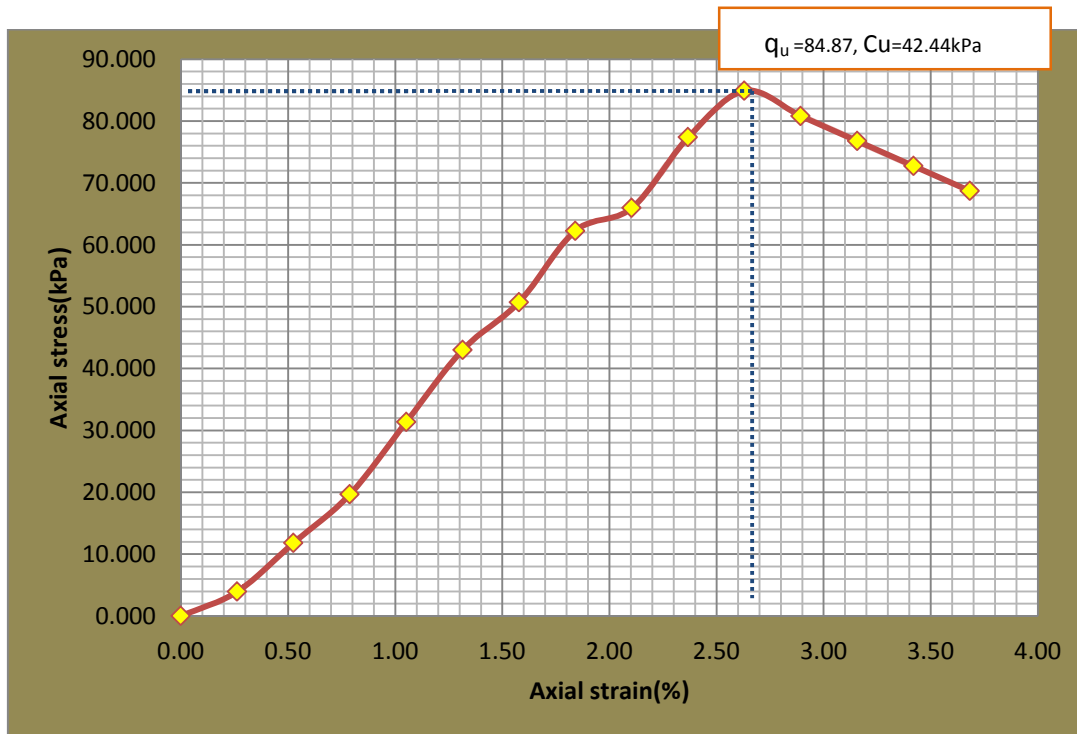
Test Pit Depth , m **3.0m** *Ring Calibration Factor, kN/div* **0.04493**
Diameter of sample , mm **38** *Moisture content, %* **40.34**
Length of sample , mm **76** *Wet unit weight, g/cc* **1.74**

Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.1	0.0045	0.00114	3.952
0.4	0.53	0.3	0.0135	0.00114	11.824
0.6	0.79	0.5	0.0225	0.00114	19.654
0.8	1.05	0.8	0.0359	0.00115	31.363
1	1.32	1.1	0.0494	0.00115	43.009
1.2	1.58	1.3	0.0584	0.00115	50.694
1.4	1.84	1.6	0.0719	0.00116	62.226
1.6	2.11	1.7	0.0764	0.00116	65.937
1.8	2.37	2	0.0899	0.00116	77.365
2	2.63	2.2	0.0988	0.00116	84.872
2.2	2.89	2.1	0.0944	0.00117	80.795
2.4	3.16	2	0.0899	0.00117	76.739
2.6	3.42	1.9	0.0854	0.00117	72.704
2.8	3.68	1.8	0.0809	0.00118	68.690

B11 Unconfined compression test result curve of TP6 at D=1.5m



B12 Unconfined compression test result curve of TP6 at D=3.0m



B13 Unconfined compression test result of TP7 at D=1.5m

Test Pit Depth , m **1.5m** *Ring Calibration Factor, kN/div* **0.04493**
Diameter of sample , mm **38** *Moisture content, %* **30.25**
Length of sample , mm **76** *Wet unit weight, g/cc* **1.83**

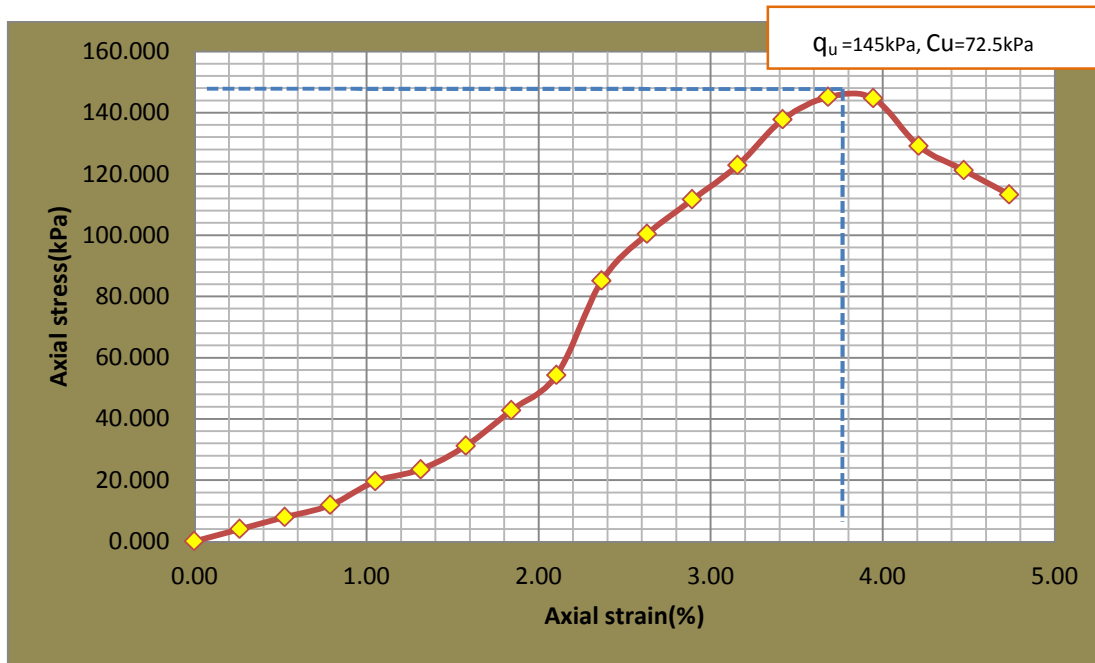
Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.1	0.0045	0.00114	3.952
0.4	0.53	0.2	0.0090	0.00114	7.882
0.6	0.79	0.3	0.0135	0.00114	11.792
0.8	1.05	0.5	0.0225	0.00115	19.602
1	1.32	0.6	0.0270	0.00115	23.460
1.2	1.58	0.8	0.0359	0.00115	31.196
1.4	1.84	1.1	0.0494	0.00116	42.780
1.6	2.11	1.4	0.0629	0.00116	54.301
1.8	2.37	2.2	0.0988	0.00116	85.101
2	2.63	2.6	0.1168	0.00116	100.303
2.2	2.89	2.9	0.1303	0.00117	111.574
2.4	3.16	3.2	0.1438	0.00117	122.783
2.6	3.42	3.6	0.1617	0.00117	137.755
2.8	3.68	3.8	0.1707	0.00118	145.012
3	3.95	3.8	0.1707	0.00118	144.616
3.2	4.21	3.4	0.1528	0.00118	129.039
3.4	4.47	3.2	0.1438	0.00119	121.115
3.6	4.74	3	0.1348	0.00119	113.232

B14 Unconfined compression test result of TP7 at D=3.0m

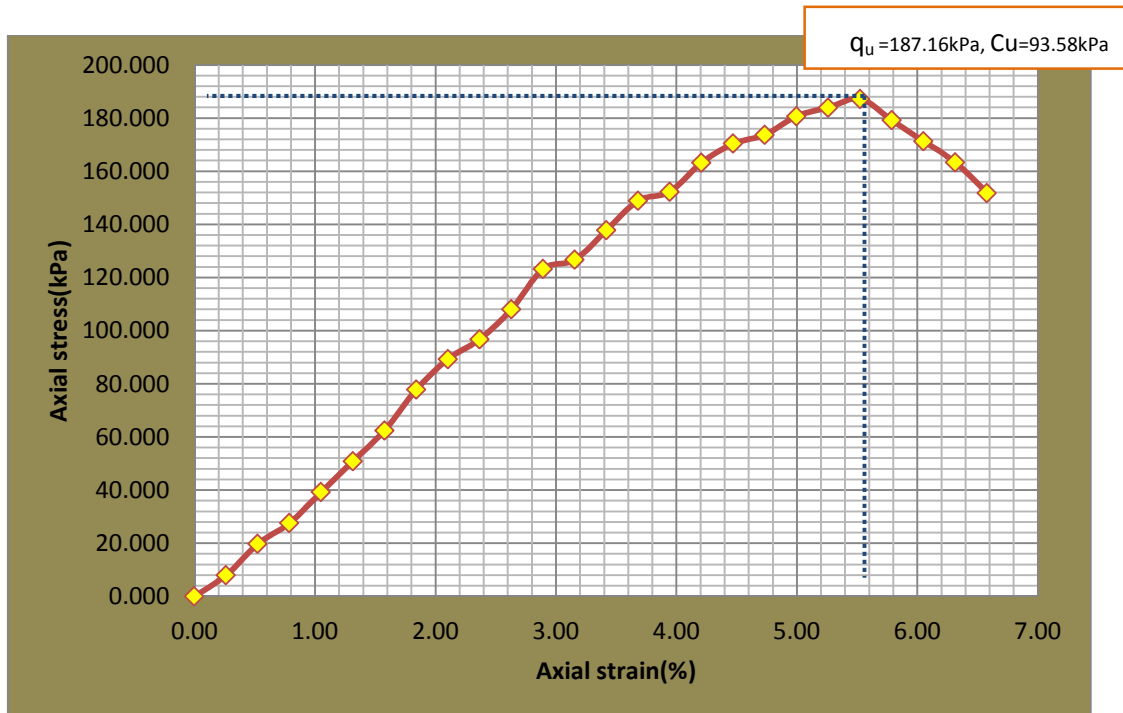
Test Pit Depth , m **3.0** **Ring Calibration Factor, kN/div** **0.04493**
Diameter of sample , mm **38** **Moisture content, %** **28.69**
Length of sample , mm **76** **Wet unit weight, g/cc** **2.01**

Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.2	0.0090	0.00114	7.903
0.4	0.53	0.5	0.0225	0.00114	19.706
0.6	0.79	0.7	0.0315	0.00114	27.516
0.8	1.05	1	0.0449	0.00115	39.204
1	1.32	1.3	0.0584	0.00115	50.829
1.2	1.58	1.6	0.0719	0.00115	62.392
1.4	1.84	2	0.0899	0.00116	77.782
1.6	2.11	2.3	0.1033	0.00116	89.209
1.8	2.37	2.5	0.1123	0.00116	96.706
2	2.63	2.8	0.1258	0.00116	108.019
2.2	2.89	3.2	0.1438	0.00117	123.116
2.4	3.16	3.3	0.1483	0.00117	126.620
2.6	3.42	3.6	0.1617	0.00117	137.755
2.8	3.68	3.9	0.1752	0.00118	148.828
3	3.95	4	0.1797	0.00118	152.227
3.2	4.21	4.3	0.1932	0.00118	163.196
3.4	4.47	4.5	0.2022	0.00119	170.317
3.6	4.74	4.6	0.2067	0.00119	173.623
3.8	5.00	4.8	0.2157	0.00119	180.671
4	5.26	4.9	0.2202	0.00120	183.924
4.2	5.53	5	0.2247	0.00120	187.156
4.4	5.79	4.8	0.2157	0.00120	179.169
4.6	6.05	4.6	0.2067	0.00121	171.224
4.8	6.32	4.4	0.1977	0.00121	163.321
5	6.58	4.1	0.1842	0.00121	151.758

B15 Unconfined compression test result curve of TP7 at D=1.5m



B16 Unconfined compression test result curve of TP7 at D=3.0m



B17 Unconfined compression test result of TP10 at D=1.5m

Test Pit Depth , m **1.5m** **Ring Calibration Factor, kN/div** **0.04493**
Diameter of sample , mm **38** **Moisture content, %** **28.09**
Length of sample , mm **76** **Wet unit weight, g/cc** **1.92**

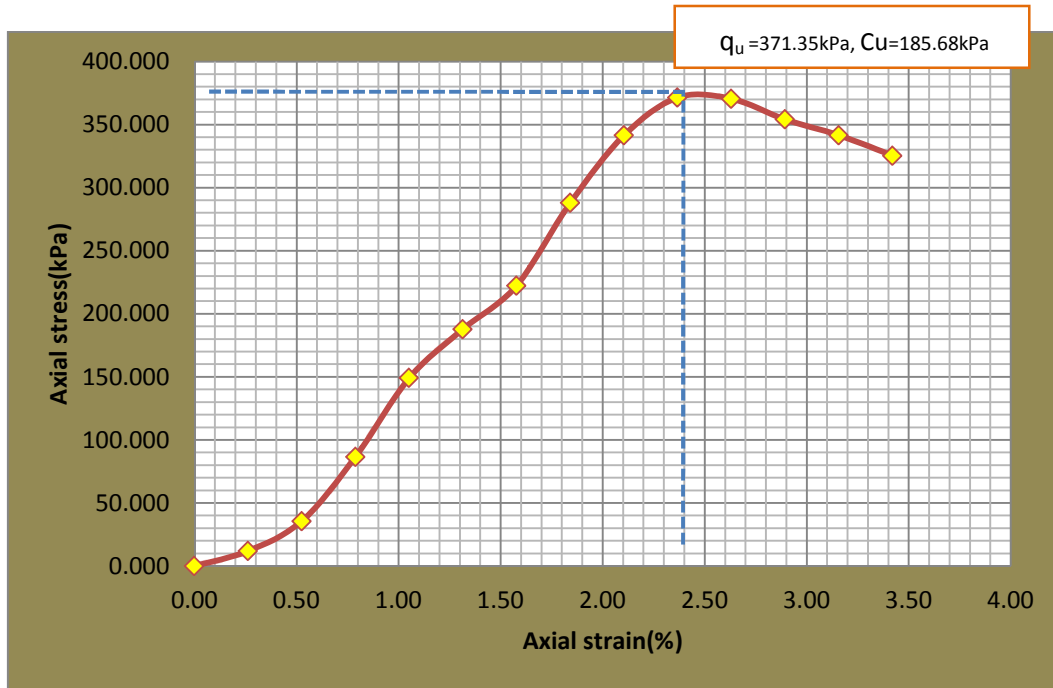
Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.3	0.0135	0.00114	11.855
0.4	0.53	0.9	0.0404	0.00114	35.471
0.6	0.79	2.2	0.0988	0.00114	86.478
0.8	1.05	3.8	0.1707	0.00115	148.974
1	1.32	4.8	0.2157	0.00115	187.678
1.2	1.58	5.7	0.2561	0.00115	222.273
1.4	1.84	7.4	0.3325	0.00116	287.793
1.6	2.11	8.8	0.3954	0.00116	341.323
1.8	2.37	9.6	0.4313	0.00116	371.351
2	2.63	9.6	0.4313	0.00116	370.350
2.2	2.89	9.2	0.4134	0.00117	353.960
2.4	3.16	8.9	0.3999	0.00117	341.490
2.6	3.42	8.5	0.3819	0.00117	325.256

B18 Unconfined compression test result of TP10 at D=3.0m

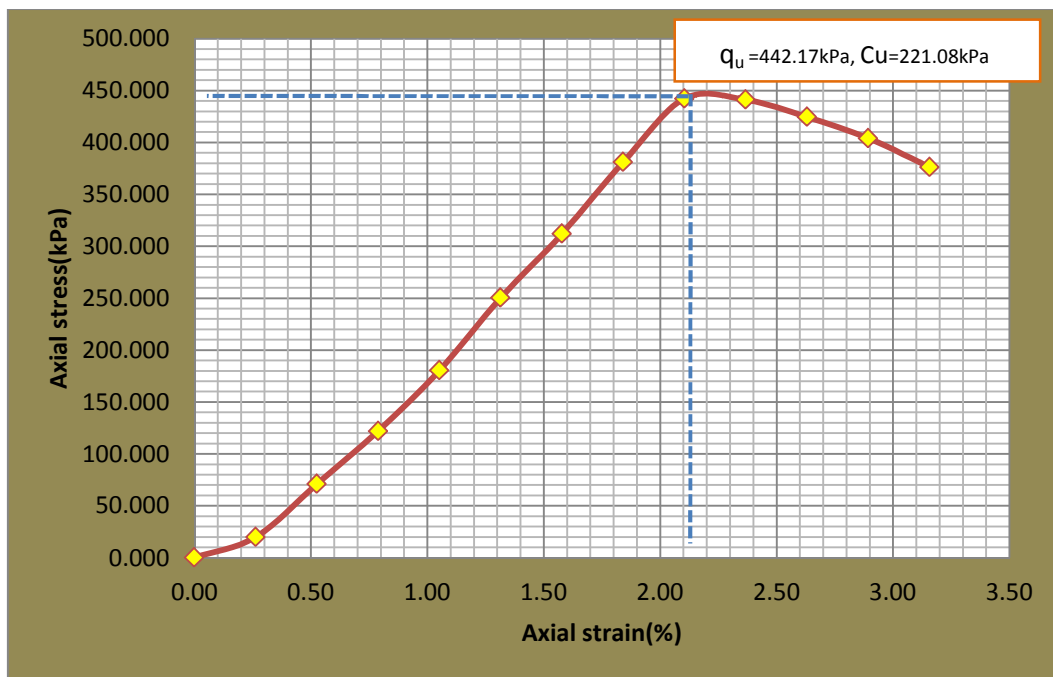
Test Pit Depth , m **3.00** *Ring Calibration Factor, kN/div* **0.04493**
Diameter of sample , mm **38** *Moisture content, %* **30.30**
Length of sample , mm **76** *Wet unit weight, g/cc* **1.99**

Axial deformation in mm	Axial strain (%)	Proving Ring reading (div)	Axial Load(kN)	Corrected Area(m ²)	Axial stress(kPa)
0	0.00	0	0.0000	0.00113	0.000
0.2	0.26	0.5	0.0225	0.00114	19.758
0.4	0.53	1.8	0.0809	0.00114	70.942
0.6	0.79	3.1	0.1393	0.00114	121.855
0.8	1.05	4.6	0.2067	0.00115	180.337
1	1.32	6.4	0.2876	0.00115	250.237
1.2	1.58	8	0.3594	0.00115	311.962
1.4	1.84	9.8	0.4403	0.00116	381.131
1.6	2.11	11.4	0.5122	0.00116	442.168
1.8	2.37	11.4	0.5122	0.00116	440.980
2	2.63	11	0.4942	0.00116	424.360
2.2	2.89	10.5	0.4718	0.00117	403.976
2.4	3.16	9.8	0.4403	0.00117	376.022

B19 Unconfined compression test result curve of TP10 at D=1.5m



B20 Unconfined compression test result curve of TP10 at D=3.0m



Appendix C Grain size analysis results

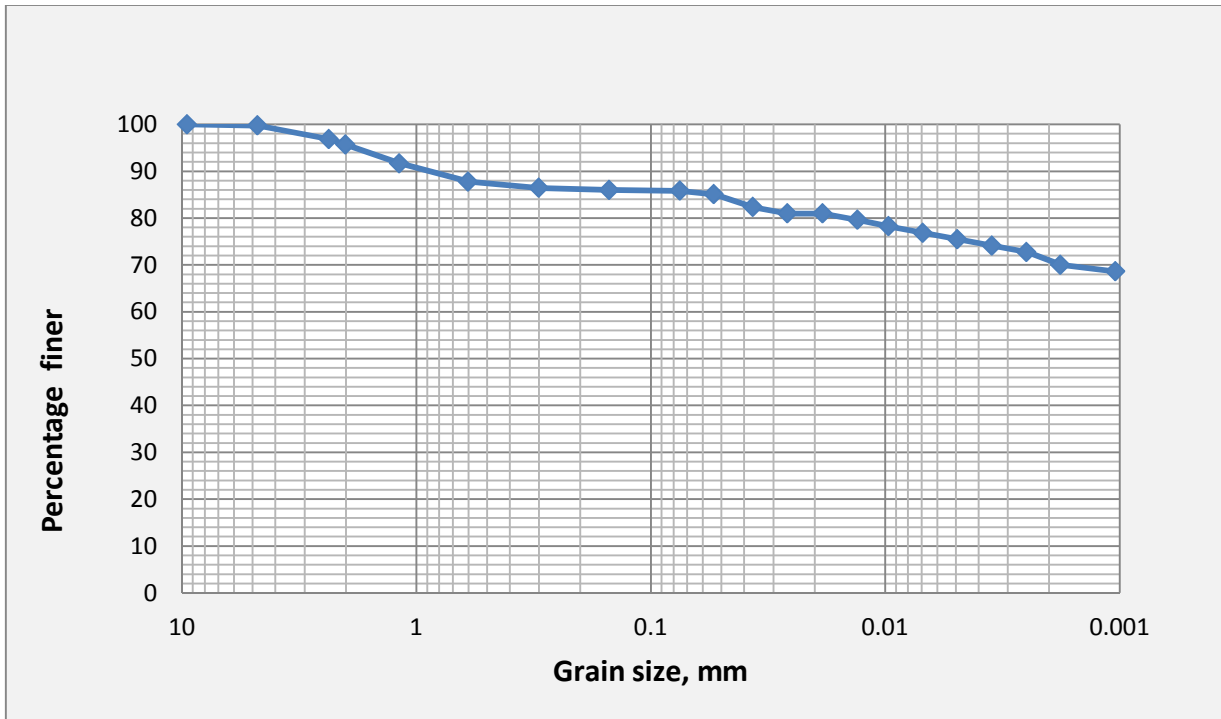
C1 Grain size analysis result of TP1 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	307.5	309	1.5	0.250	0.250	99.750
No 8	2.36	334	351.5	17.5	2.917	3.167	96.833
No 10	2	376	383	7	1.167	4.333	95.667
No 16	1.18	353	377	24	4.000	8.333	91.667
No 30	0.6	348.5	372	23.5	3.917	12.250	87.750
No 50	0.3	316.5	324.5	8	1.333	13.583	86.417
No 100	0.15	295.5	298	2.5	0.417	14.000	86.000
No 200	0.075	263	264	1	0.167	14.167	85.833
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.0325	0.0015	1.031	8.10	0.0536	99.1256	85.083
1	1.0315	0.0015	1.03	8.40	0.0366	95.9280	82.338
2	1.031	0.0015	1.0295	8.50	0.0261	94.3292	80.966
4	1.031	0.0015	1.0295	8.50	0.0184	94.3292	80.966
8	1.0305	0.0015	1.029	8.60	0.0131	92.7304	79.594
15	1.03	0.0015	1.0285	8.75	0.0097	91.1316	78.221
30	1.0295	0.0015	1.028	8.90	0.0069	89.5328	76.849
60	1.029	0.0015	1.0275	9.05	0.0049	87.9340	75.477
120	1.0285	0.0015	1.027	9.20	0.0035	86.3352	74.104
240	1.028	0.0015	1.0265	9.30	0.0025	84.7364	72.732
480	1.027	0.0015	1.0255	9.55	0.0018	81.5388	69.987
1440	1.0265	0.0015	1.025	9.70	0.0010	79.9400	68.615

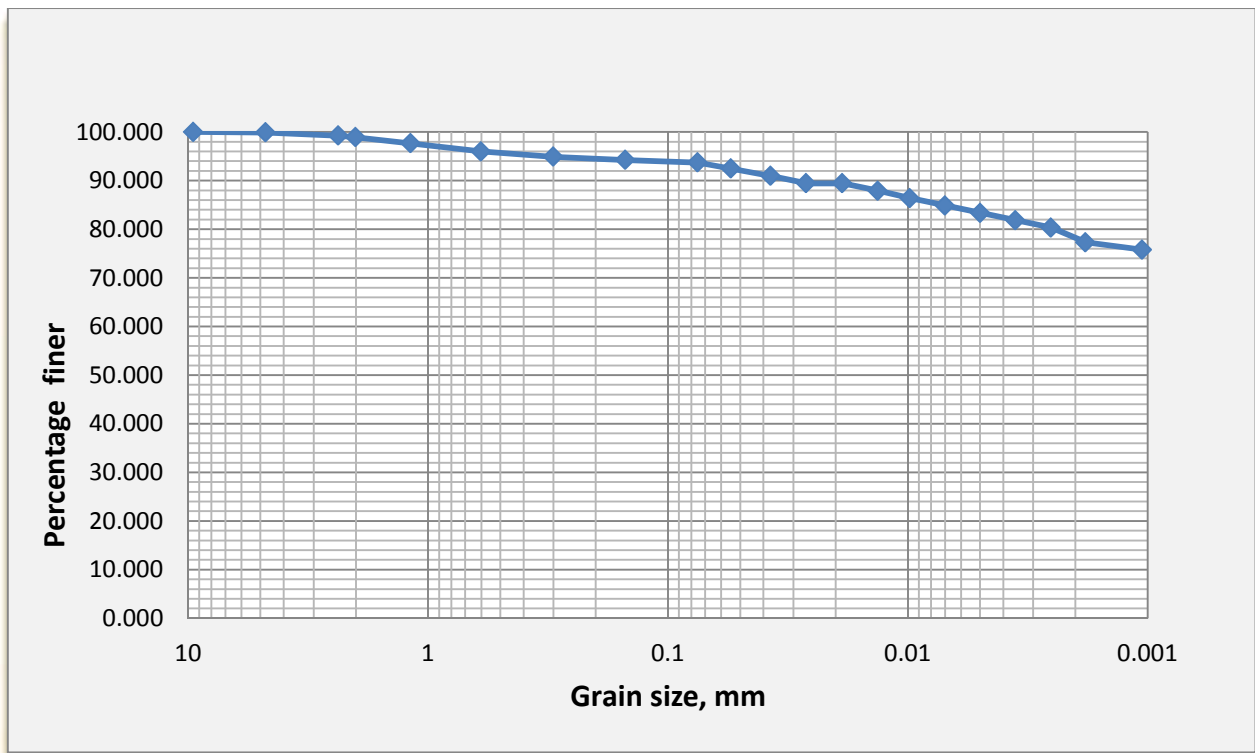
C2 Grain size analysis result of TP1 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	Cummulative percentage Retained	Percentage finer
No 4	4.75	307.6	308.2	0.6	0.100	0.100	99.900
No 8	2.36	334.4	338.4	4	0.667	0.767	99.233
No 10	2	376	378	2	0.333	1.100	98.900
No 16	1.18	353	360.4	7.4	1.233	2.333	97.667
No 30	0.6	348.8	358.8	10	1.667	4.000	96.000
No 50	0.3	317	323.6	6.6	1.100	5.100	94.900
No 100	0.15	295.8	299.8	4	0.667	5.767	94.233
No 200	0.075	263	266	3	0.500	6.267	93.733
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.032	0.0015	1.0305	8.1	0.054	98.637	92.456
1	1.0315	0.0015	1.03	8.4	0.037	97.020	90.940
2	1.031	0.0015	1.0295	8.5	0.026	95.403	89.424
4	1.031	0.0015	1.0295	8.5	0.019	95.403	89.424
8	1.0305	0.0015	1.029	8.6	0.013	93.786	87.909
15	1.03	0.0015	1.0285	8.75	0.010	92.169	86.393
30	1.0295	0.0015	1.028	8.9	0.007	90.552	84.877
60	1.029	0.0015	1.0275	9.05	0.005	88.935	83.362
120	1.0285	0.0015	1.027	9.2	0.004	87.318	81.846
240	1.028	0.0015	1.0265	9.3	0.003	85.701	80.330
480	1.027	0.0015	1.0255	9.55	0.002	82.467	77.299
1440	1.0265	0.0015	1.025	9.7	0.001	80.850	75.783

C3 Grain size distribution curve for TP1 at D=1.5m



C4 Grain size distribution curve for TP1 at D=3.0m



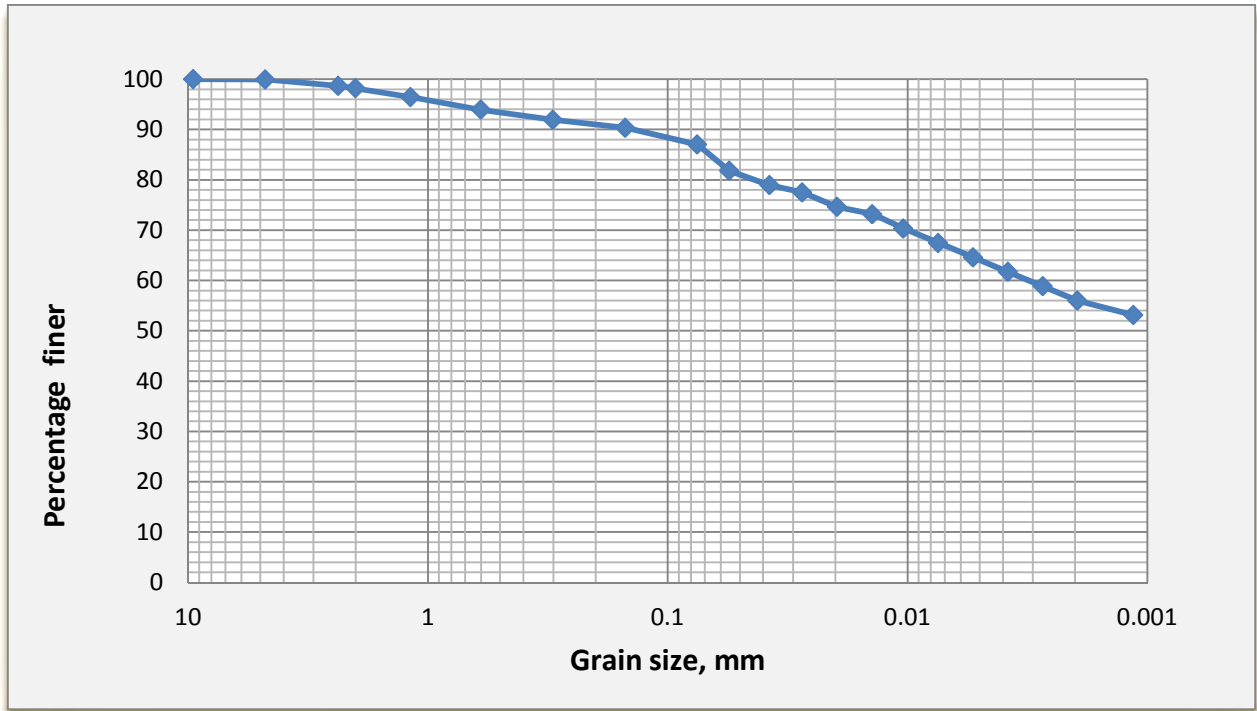
C5 Grain size analysis result of TP2 at D=1.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	307.5	308	0.5	0.083	0.083	99.917
No 8	2.36	334	341.5	7.5	1.250	1.333	98.667
No 10	2	376	379	3	0.500	1.833	98.167
No 16	1.18	353	363.5	10.5	1.750	3.583	96.417
No 30	0.6	348.5	363.5	15	2.500	6.083	93.917
No 50	0.3	316.5	328.5	12	2.000	8.083	91.917
No 100	0.15	295.5	305	9.5	1.583	9.667	90.333
No 200	0.075	263	271.5	8.5	1.417	11.083	88.917
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	percentage finer for combined analysis
0.45	1.0295	0.0015	1.028	8.4	0.055	90.353	80.339
1	1.029	0.0015	1.0275	8.6	0.038	88.740	78.904
2	1.0285	0.0015	1.027	9.2	0.027	87.126	77.470
4	1.0275	0.0015	1.026	9.4	0.020	83.899	74.601
8	1.027	0.0015	1.0255	9.55	0.014	82.286	73.166
15	1.026	0.0015	1.0245	9.85	0.010	79.059	70.297
30	1.025	0.0015	1.0235	10.1	0.007	75.832	67.427
60	1.024	0.0015	1.0225	10.35	0.005	72.605	64.558
120	1.023	0.0015	1.0215	10.6	0.004	69.378	61.689
240	1.022	0.0015	1.0205	10.85	0.003	66.151	58.820
480	1.021	0.0015	1.0195	11.15	0.002	62.925	55.950
1440	1.02	0.0015	1.0185	11.4	0.001	59.698	53.081

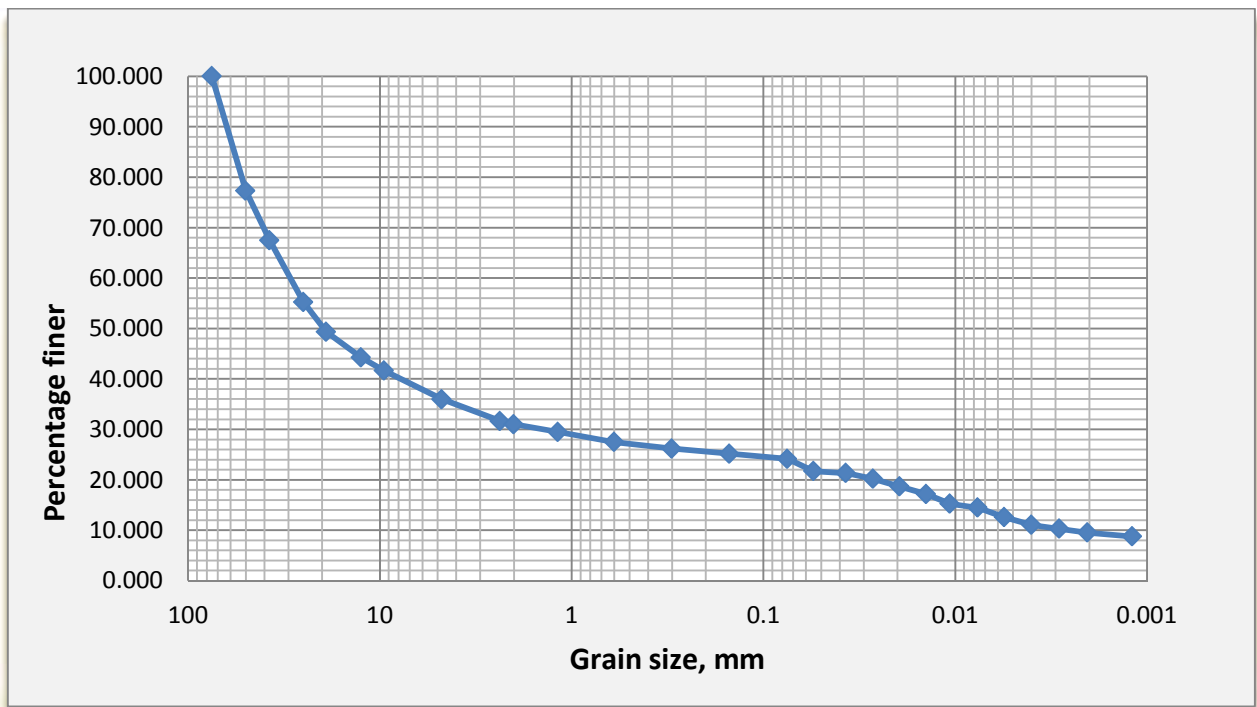
C6 Grain size analysis result of TP2 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
3"	75	725.6	725.6	0	0	0	100
2"	50	721.2	2196	1474.8	22.689	22.689	77.311
1.5"	37.5	715	1355.4	640.4	9.852	32.542	67.458
1"	25	726.4	1520.6	794.2	12.218	44.760	55.240
3/4"	19	731.4	1116.8	385.4	5.929	50.689	49.311
1/2"	12.5	679	1008.6	329.6	5.071	55.760	44.240
3.8"	9.5	712.4	882	169.6	2.609	58.369	41.631
No 4	4.75	737	1106.4	369.4	5.683	64.052	35.948
No 8	2.36	735	1014.6	279.6	4.302	68.354	31.646
No 10	2	713.4	756.2	42.8	0.658	69.012	30.988
No 16	1.18	611.4	710	98.6	1.517	70.529	29.471
No 30	0.6	601.8	730.4	128.6	1.978	72.508	27.492
No 50	0.3	581.2	666.8	85.6	1.317	73.825	26.175
No 100	0.15	557.8	622.6	64.8	0.997	74.822	25.178
No 200	0.075	543	610.6	67.6	1.040	75.862	24.138
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	percentage finer for combined analysis
0.45	1.03	0.0015	1.0285	8.75	0.055	89.946	21.712
1	1.0295	0.0015	1.028	8.90	0.037	88.368	21.331
2	1.028	0.0015	1.0265	9.30	0.027	83.634	20.188
4	1.026	0.0015	1.0245	9.85	0.019	77.322	18.664
8	1.024	0.0015	1.0225	10.35	0.014	71.010	17.141
15	1.0215	0.0015	1.02	11.00	0.011	63.120	15.236
30	1.0205	0.0015	1.019	11.30	0.008	59.964	14.474
60	1.018	0.0015	1.0165	11.95	0.006	52.074	12.570
120	1.016	0.0015	1.0145	12.45	0.004	45.762	11.046
240	1.015	0.0015	1.0135	12.75	0.003	42.606	10.284
480	1.014	0.0015	1.0125	13.00	0.002	39.450	9.523
1440	1.013	0.0015	1.0115	13.25	0.001	36.294	8.761

C7 Grain size distribution curve for TP2 at D=1.0m



C8 Grain size distribution curve for TP2 at D=3.0m



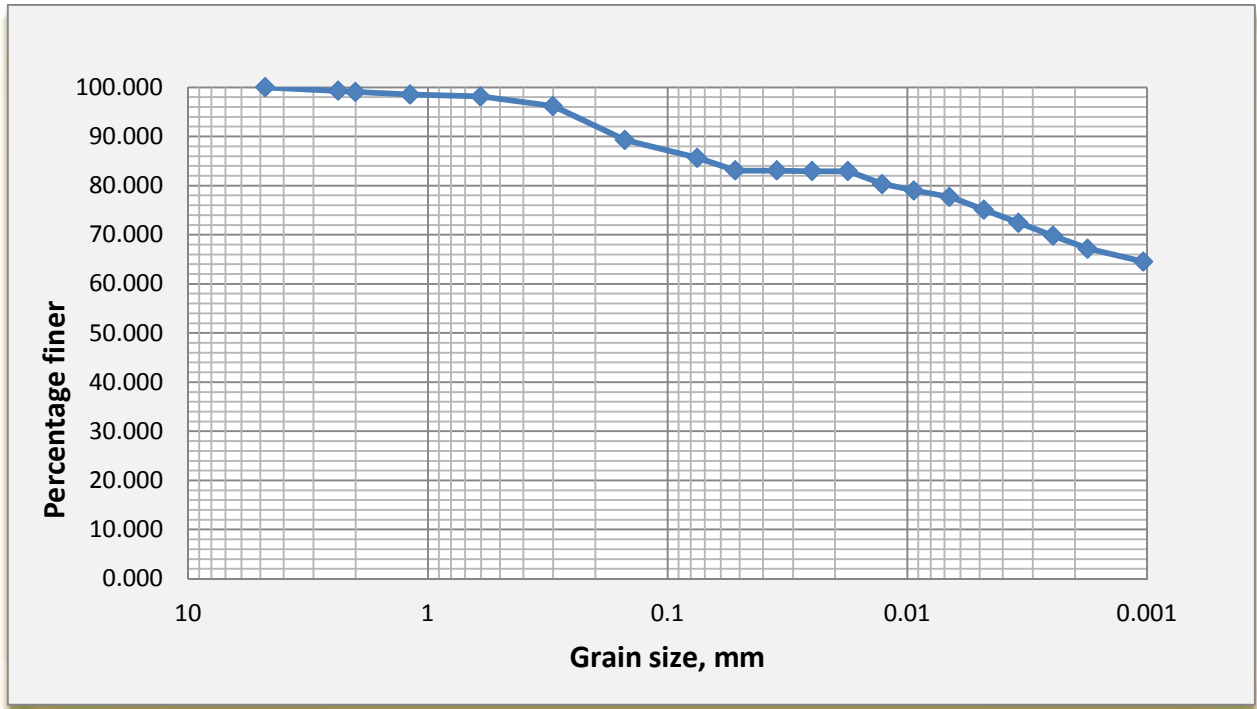
C9 Grain size analysis result of TP3 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	307.6	307.6	0	0.000	0.000	100.000
No 8	2.36	334	338.4	4.4	0.733	0.733	99.267
No 10	2	376	377.4	1.4	0.233	0.967	99.033
No 16	1.18	353.2	356.2	3	0.500	1.467	98.533
No 30	0.6	348.8	351.2	2.4	0.400	1.867	98.133
No 50	0.3	317	328.8	11.8	1.967	3.833	96.167
No 100	0.15	295.8	337.4	41.6	6.933	10.767	89.233
No 200	0.075	262.8	299.8	37	6.167	16.933	85.622
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	percentage finer for combined analysis
0.45	1.0335	0.0015	1.032	7.80	0.052	100.000	83.067
1	1.0335	0.0015	1.032	7.80	0.035	100.000	83.067
2	1.033	0.0015	1.0315	7.95	0.025	99.842	82.936
4	1.033	0.0015	1.0315	7.95	0.018	99.842	82.936
8	1.032	0.0015	1.0305	8.25	0.013	96.673	80.303
15	1.0315	0.0015	1.03	8.40	0.009	95.088	78.986
30	1.031	0.0015	1.0295	8.50	0.007	93.503	77.670
60	1.03	0.0015	1.0285	8.75	0.005	90.334	75.037
120	1.029	0.0015	1.0275	9.05	0.003	87.164	72.404
240	1.028	0.0015	1.0265	9.30	0.002	83.994	69.771
480	1.027	0.0015	1.0255	9.55	0.002	80.825	67.138
1440	1.026	0.0015	1.0245	9.85	0.001	77.655	64.506

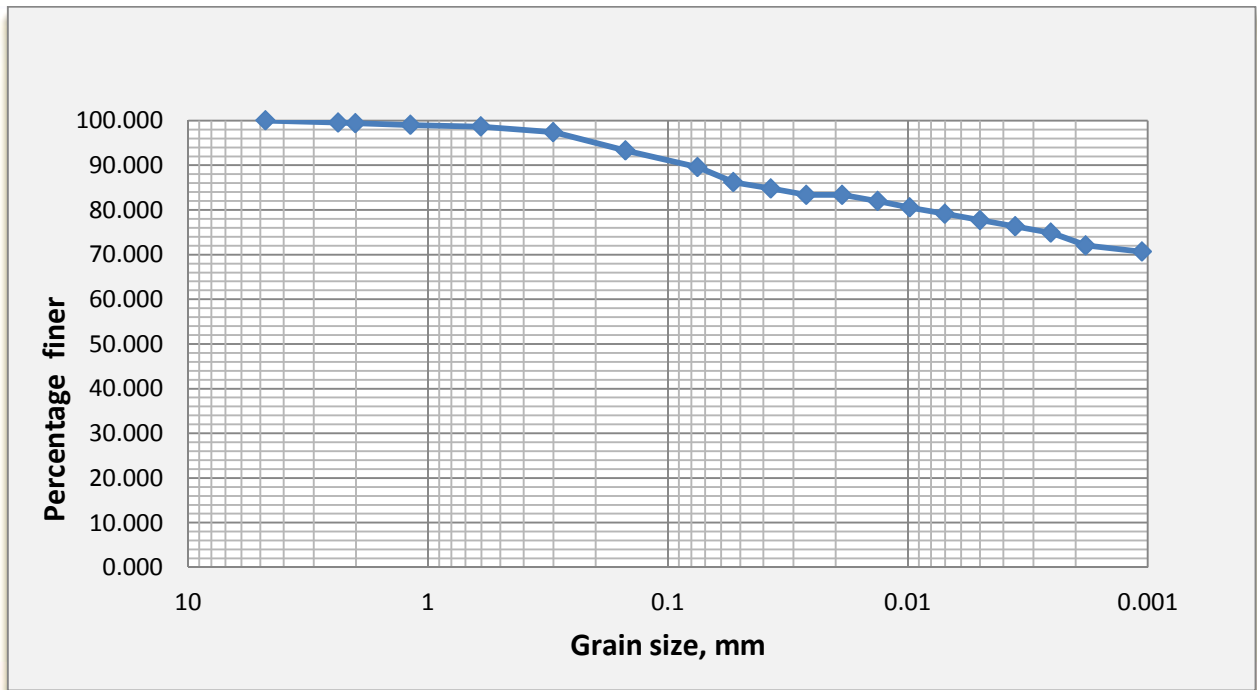
C10 Grain size analysis result of TP3 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	307.6	307.6	0	0.000	0.000	100.000
No 8	2.36	334	336.8	2.8	0.467	0.467	99.533
No 10	2	376	376.8	0.8	0.133	0.600	99.400
No 16	1.18	353.2	355.6	2.4	0.400	1.000	99.000
No 30	0.6	348.8	351	2.2	0.367	1.367	98.633
No 50	0.3	317	324.4	7.4	1.233	2.600	97.400
No 100	0.15	295.8	320.6	24.8	4.133	6.733	93.267
No 200	0.075	262.8	285.2	22.4	3.733	10.467	89.533
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	percentage finer for combined analysis
0.45	1.032	0.0015	1.0305	8.25	0.053	96.258	86.183
1	1.0315	0.0015	1.03	8.4	0.037	94.680	84.770
2	1.031	0.0015	1.0295	8.5	0.026	93.102	83.357
4	1.031	0.0015	1.0295	8.5	0.019	93.102	83.357
8	1.0305	0.0015	1.029	8.6	0.013	91.524	81.944
15	1.03	0.0015	1.0285	8.75	0.010	89.946	80.532
30	1.0295	0.0015	1.028	8.9	0.007	88.368	79.119
60	1.029	0.0015	1.0275	9.05	0.005	86.790	77.706
120	1.0285	0.0015	1.027	9.2	0.004	85.212	76.293
240	1.028	0.0015	1.0265	9.3	0.003	83.634	74.880
480	1.027	0.0015	1.0255	9.55	0.002	80.478	72.055
1440	1.0265	0.0015	1.025	9.7	0.001	78.900	70.642

C11 Grain size distribution curve for TP3 at D=1.5m



C12 Grain size distribution curve for TP3 at D=3.0



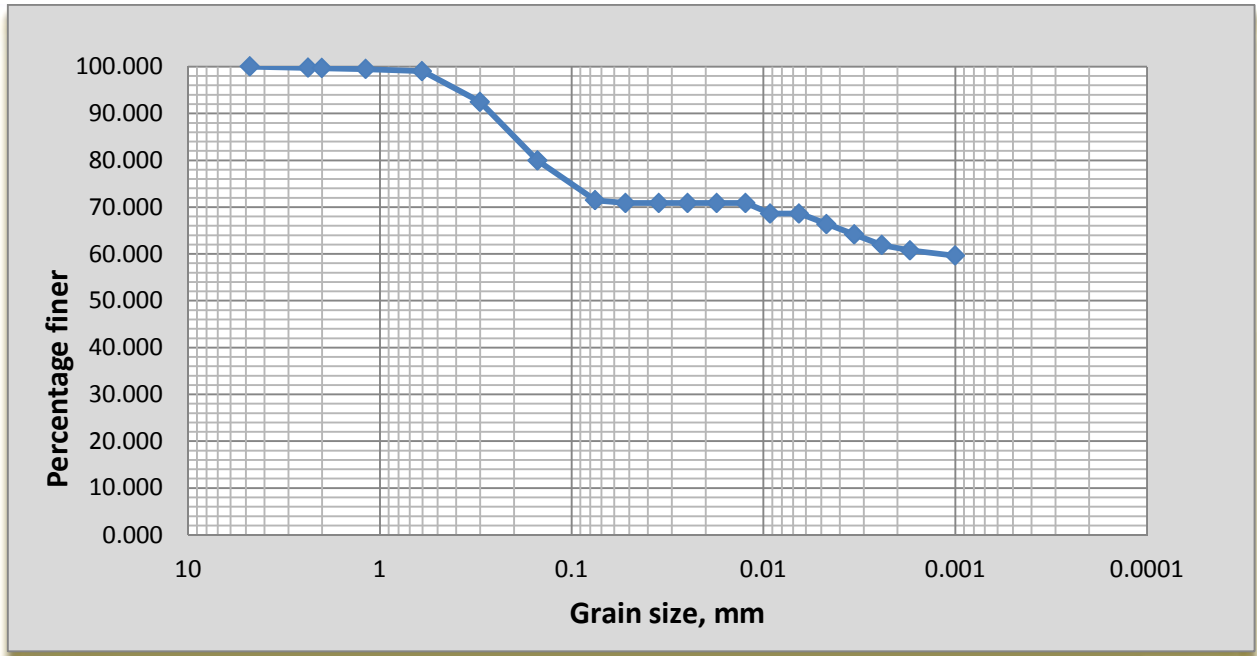
C13 Grain size analysis result of TP4 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	307.6	307.6	0	0.000	0.000	100.000
No 8	2.36	334	335.6	1.6	0.267	0.267	99.733
No 10	2	376	376.4	0.4	0.067	0.333	99.667
No 16	1.18	353.2	354.4	1.2	0.200	0.533	99.467
No 30	0.6	348.8	351.4	2.6	0.433	0.967	99.033
No 50	0.3	317	356.4	39.4	6.567	7.533	92.467
No 100	0.15	295.8	371	75.2	12.533	20.067	79.933
No 200	0.075	262.8	313.8	51	8.500	28.567	71.433
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.033	0.0015	1.0315	7.95	0.052	99.206	70.866
1	1.033	0.0015	1.0315	7.95	0.035	99.206	70.866
2	1.033	0.0015	1.0315	7.95	0.025	99.206	70.866
4	1.033	0.0015	1.0315	7.95	0.017	99.206	70.866
8	1.033	0.0015	1.0315	7.95	0.012	99.206	70.866
15	1.032	0.0015	1.0305	8.25	0.009	96.057	68.617
30	1.032	0.0015	1.0305	8.25	0.006	96.057	68.617
60	1.031	0.0015	1.0295	8.50	0.005	92.907	66.367
120	1.03	0.0015	1.0285	8.75	0.003	89.758	64.117
240	1.029	0.0015	1.0275	9.05	0.002	86.608	61.867
480	1.0285	0.0015	1.027	9.20	0.002	85.034	60.742
1440	1.028	0.0015	1.0265	9.30	0.001	83.459	59.618

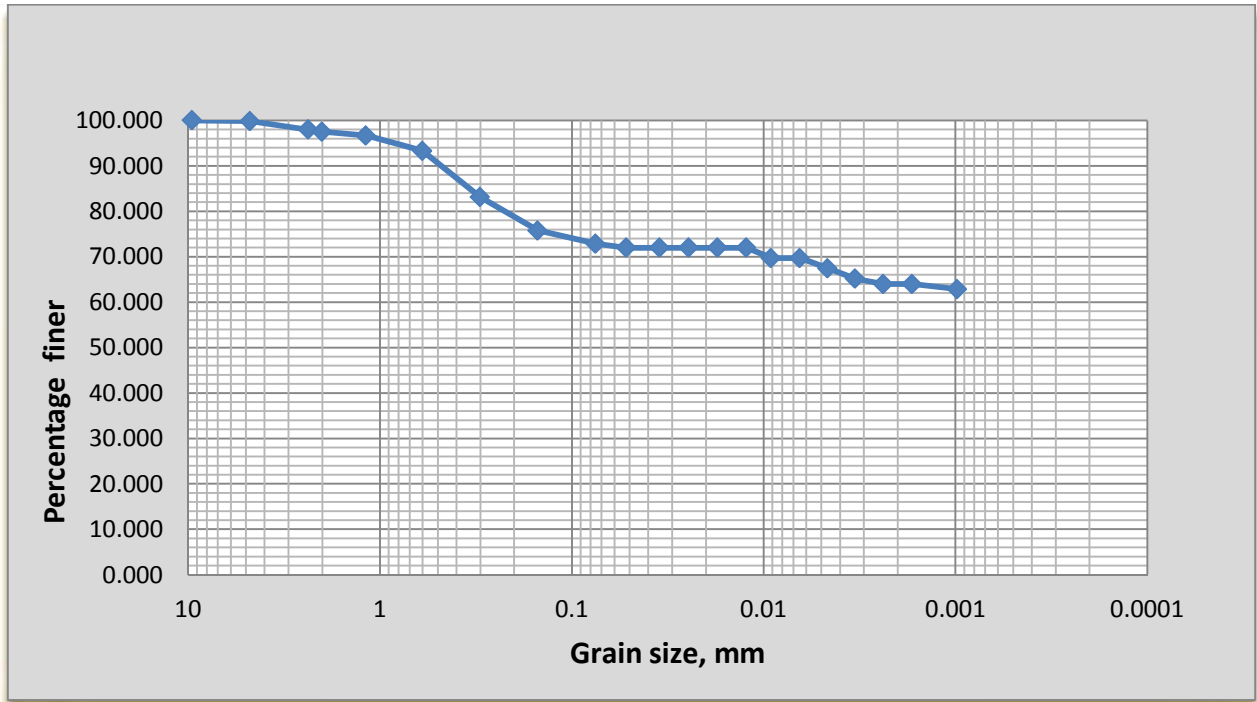
C14 Grain size analysis result of TP4 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	307.6	308.6	1	0.167	0.167	99.833
No 8	2.36	334	345.2	11.2	1.867	2.033	97.967
No 10	2	376	378.8	2.8	0.467	2.500	97.500
No 16	1.18	353.2	358.2	5	0.833	3.333	96.667
No 30	0.6	348.8	357.2	8.4	1.400	4.733	95.267
No 50	0.3	317	390	73	12.167	16.900	83.100
No 100	0.15	295.8	340	44.2	7.367	24.267	75.733
No 200	0.075	262.8	280	17.2	2.867	27.133	72.867
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.033	0.0015	1.0315	7.95	0.052	98.784	71.981
1	1.033	0.0015	1.0315	7.95	0.035	98.784	71.981
2	1.033	0.0015	1.0315	7.95	0.025	98.784	71.981
4	1.033	0.0015	1.0315	7.95	0.017	98.784	71.981
8	1.033	0.0015	1.0315	7.95	0.012	98.784	71.981
15	1.032	0.0015	1.0305	8.25	0.009	95.648	69.696
30	1.032	0.0015	1.0305	8.25	0.006	95.648	69.696
60	1.031	0.0015	1.0295	8.5	0.005	92.512	67.410
120	1.03	0.0015	1.0285	8.75	0.003	89.376	65.125
240	1.0295	0.0015	1.028	8.9	0.002	87.808	63.983
480	1.0295	0.0015	1.028	8.9	0.002	87.808	63.983
1440	1.029	0.0015	1.0275	9.05	0.001	86.240	62.840

C15 Grain size distribution curve for TP4 at D=1.5m



C16 Grain size distribution curve for TP4 at D=3.0m



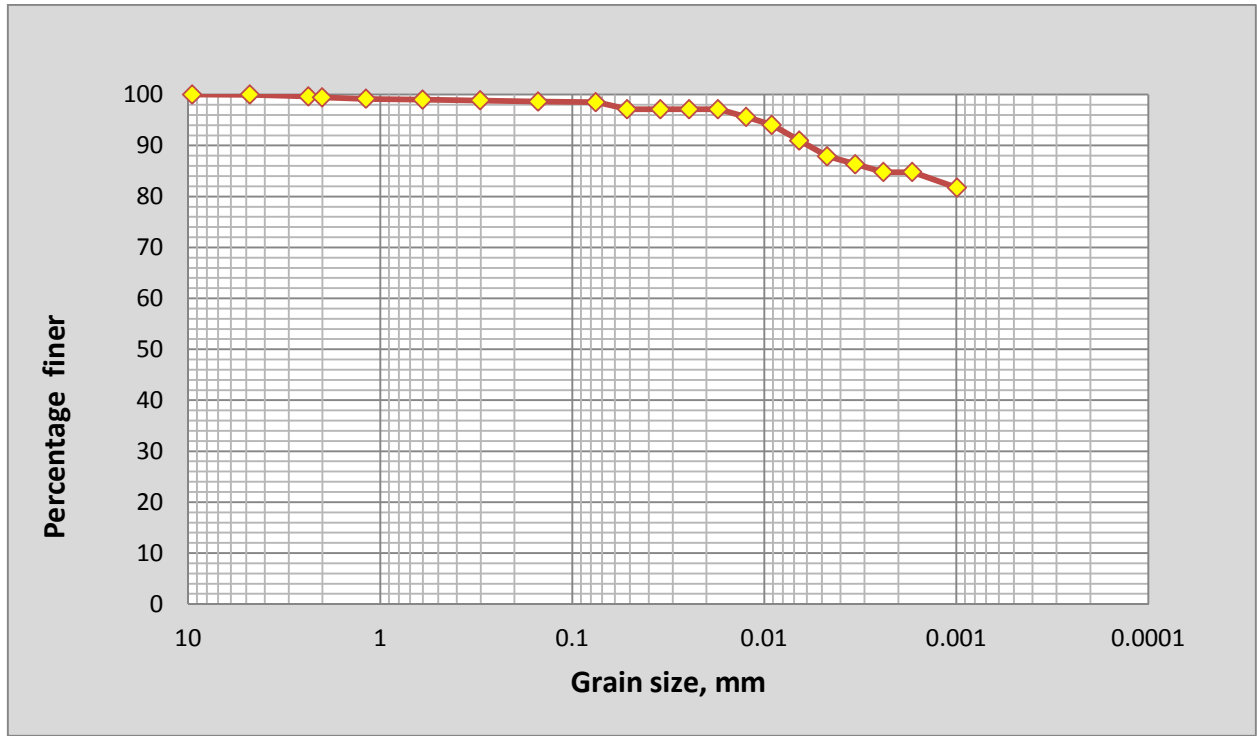
C17 Grain size analysis result of TP5 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	732	732.1	0.1	0.017	0.017	99.983
No 8	2.36	745.6	747.7	2.1	0.350	0.367	99.633
No 10	2	395.5	396.6	1.1	0.183	0.550	99.450
No 16	1.18	354.2	355.9	1.7	0.283	0.833	99.167
No 30	0.6	349.8	350.8	1	0.167	1.000	99.000
No 50	0.3	294.6	295.6	1	0.167	1.167	98.833
No 100	0.15	296.6	297.8	1.2	0.200	1.367	98.633
No 200	0.075	245.7	246.5	0.8	0.133	1.500	98.500
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.033	0.0015	1.0315	7.95	0.052	98.592	97.113
1	1.033	0.0015	1.0315	7.95	0.035	98.592	97.113
2	1.033	0.0015	1.0315	7.95	0.024	98.592	97.113
4	1.033	0.0015	1.0315	7.95	0.017	98.592	97.113
8	1.0325	0.0015	1.031	8.1	0.012	97.027	95.571
15	1.032	0.0015	1.0305	8.25	0.009	95.462	94.030
30	1.031	0.0015	1.0295	8.5	0.007	92.332	90.947
60	1.03	0.0015	1.0285	8.75	0.005	89.202	87.864
120	1.0295	0.0015	1.028	8.9	0.003	87.637	86.323
240	1.029	0.0015	1.0275	9.05	0.002	86.072	84.781
480	1.029	0.0015	1.0275	9.05	0.002	86.072	84.781
1440	1.028	0.0015	1.0265	9.3	0.001	82.942	81.698

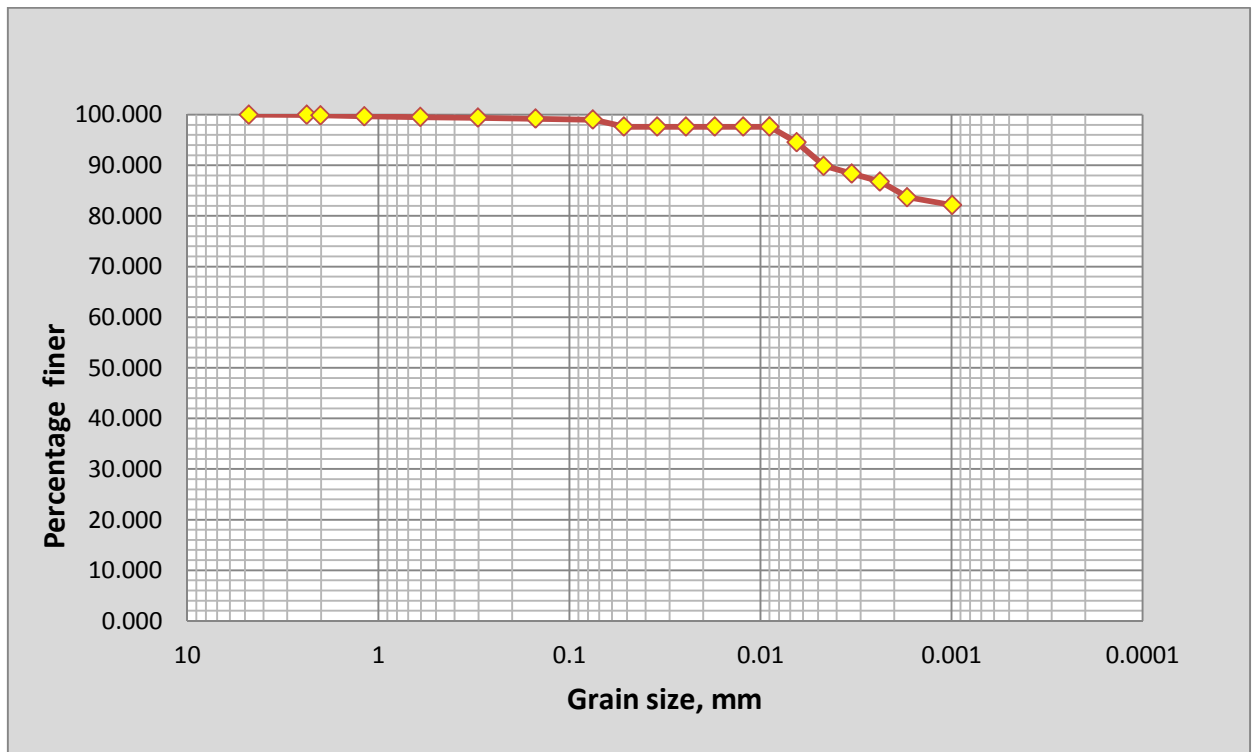
C18 Grain size analysis result of TP5 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	732	732	0	0.000	0.000	100.000
No 8	2.36	745.6	745.9	0.3	0.050	0.050	99.950
No 10	2	395.5	396	0.5	0.083	0.133	99.867
No 16	1.18	354.2	355.4	1.2	0.200	0.333	99.667
No 30	0.6	349.8	350.8	1	0.167	0.500	99.500
No 50	0.3	294.6	295.3	0.7	0.117	0.617	99.383
No 100	0.15	296.6	297.8	1.2	0.200	0.817	99.183
No 200	0.075	245.7	246.7	1	0.167	0.983	99.017
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.033	0.0015	1.0315	7.95	0.052	98.592	97.622
1	1.033	0.0015	1.0315	7.95	0.035	98.592	97.622
2	1.033	0.0015	1.0315	7.95	0.024	98.592	97.622
4	1.033	0.0015	1.0315	7.95	0.017	98.592	97.622
8	1.033	0.0015	1.0315	7.95	0.012	98.592	97.622
15	1.033	0.0015	1.0315	7.95	0.009	98.592	97.622
30	1.032	0.0015	1.0305	8.25	0.006	95.462	94.523
60	1.0305	0.0015	1.029	8.6	0.005	90.767	89.875
120	1.03	0.0015	1.0285	8.75	0.003	89.202	88.325
240	1.0295	0.0015	1.028	8.9	0.002	87.637	86.775
480	1.0285	0.0015	1.027	9.2	0.002	84.507	83.676
1440	1.028	0.0015	1.0265	9.3	0.001	82.942	82.127

C19 Grain size distribution curve for TP5 at D=1.5m



C20 Grain size distribution curve for TP5 at D=3.0m



C21 Grain size analysis result of TP6 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	732	741.4	9.4	1.567	1.567	98.433
No 8	2.36	745.6	793.2	47.6	7.933	9.500	90.500
No 10	2	395.5	399.1	3.6	0.600	10.100	89.900
No 16	1.18	354.2	385	30.8	5.133	15.233	84.767
No 30	0.6	349.8	373.1	23.3	3.883	19.117	80.883
No 50	0.3	294.6	309	14.4	2.400	21.517	78.483
No 100	0.15	296.6	309.2	12.6	2.100	23.617	76.383
No 200	0.075	245.7	255.5	9.8	1.633	25.250	74.750
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.026	0.0015	1.0245	9.85	0.056	75.484	56.425
1	1.024	0.0015	1.0225	10.35	0.039	69.322	51.819
2	1.023	0.0015	1.0215	10.6	0.028	66.241	49.516
4	1.022	0.0015	1.0205	10.85	0.020	63.160	47.212
8	1.0205	0.0015	1.019	11.3	0.014	58.539	43.758
15	1.02	0.0015	1.0185	11.4	0.010	56.998	42.606
30	1.018	0.0015	1.0165	11.95	0.008	50.836	38.000
60	1.017	0.0015	1.0155	12.2	0.005	47.755	35.697
120	1.015	0.0015	1.0135	12.75	0.004	41.593	31.091
240	1.0135	0.0015	1.012	13.1	0.003	36.972	27.637
480	1.0125	0.0015	1.011	13.4	0.002	33.891	25.334
1440	1.012	0.0015	1.0105	13.55	0.001	32.350	24.182

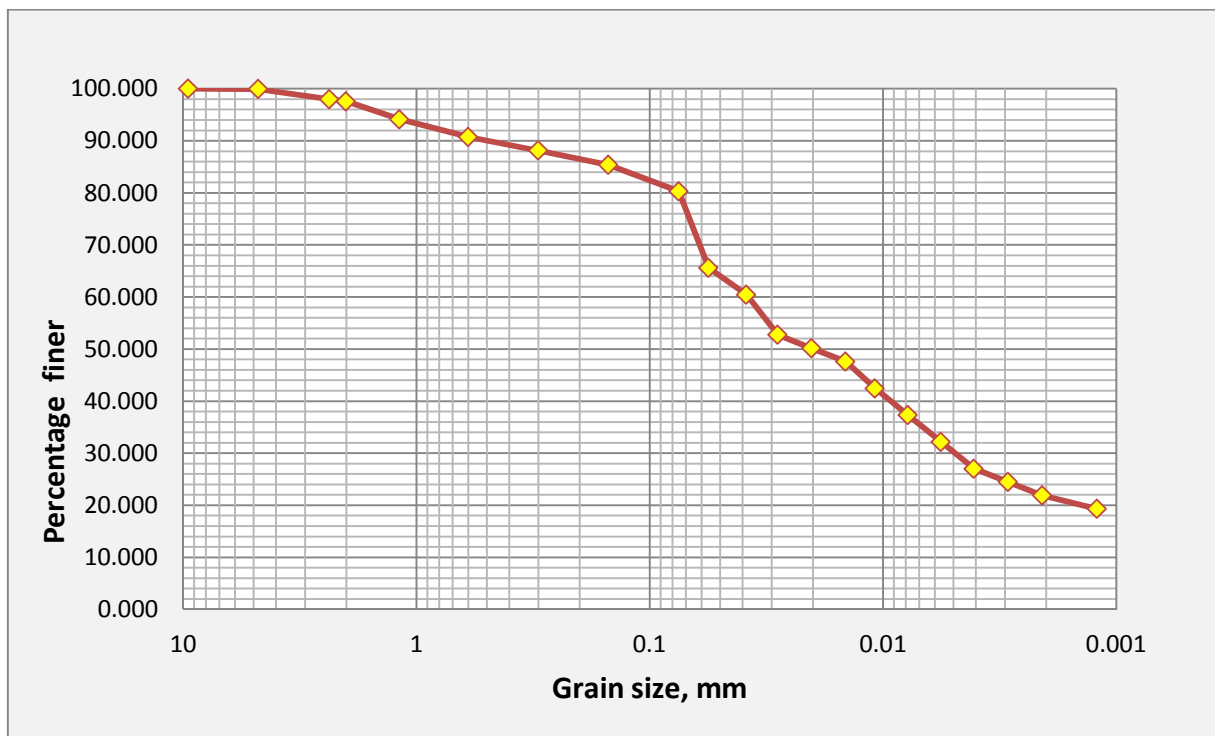
C22 Grain size analysis result of TP6 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	732	732.6	0.6	0.100	0.100	99.900
No 8	2.36	745.6	757.1	11.5	1.917	2.017	97.983
No 10	2	395.5	398.1	2.6	0.433	2.450	97.550
No 16	1.18	354.2	374.8	20.6	3.433	5.883	94.117
No 30	0.6	349.8	370.1	20.3	3.383	9.267	90.733
No 50	0.3	294.6	310.3	15.7	2.617	11.883	88.117
No 100	0.15	296.6	313.3	16.7	2.783	14.667	85.333
No 200	0.075	245.7	259.9	14.2	2.367	17.033	82.967
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.027	0.0015	1.0255	9.55	0.056	79.024	65.564
1	1.025	0.0015	1.0235	10.1	0.038	72.826	60.422
2	1.022	0.0015	1.0205	10.85	0.028	63.529	52.708
4	1.021	0.0015	1.0195	11.15	0.020	60.430	50.137
8	1.02	0.0015	1.0185	11.4	0.014	57.331	47.566
15	1.018	0.0015	1.0165	11.95	0.011	51.133	42.424
30	1.016	0.0015	1.0145	12.45	0.008	44.935	37.281
60	1.014	0.0015	1.0125	13	0.006	38.737	32.139
120	1.012	0.0015	1.0105	13.55	0.004	32.539	26.997
240	1.011	0.0015	1.0095	13.8	0.003	29.440	24.426
480	1.01	0.0015	1.0085	14.05	0.002	26.341	21.855
1440	1.009	0.0015	1.0075	14.3	0.001	23.242	19.284

C23 Grain size distribution curve for TP6 at D=1.5m



C24 Grain size distribution curve for TP6 at D=3.0m



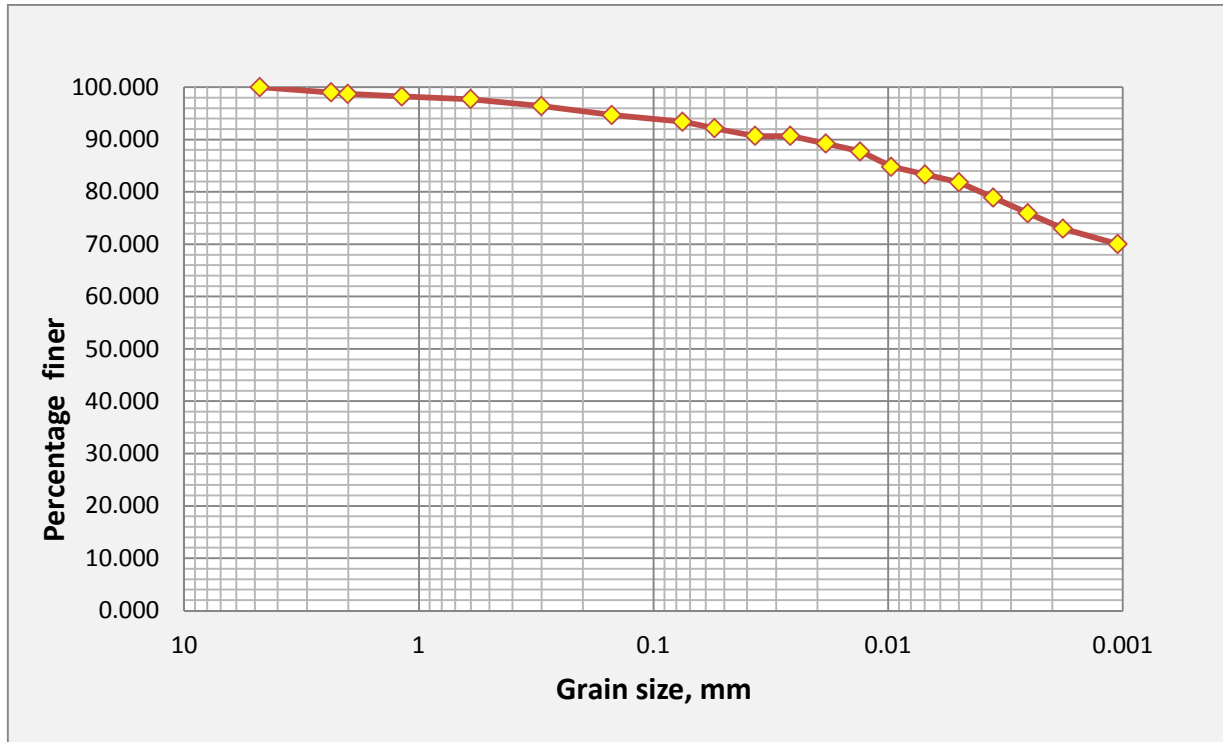
C25 Grain size analysis result of TP7 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	309.3	309.3	0	0.000	0.000	100.000
No 8	2.36	335.8	341.9	6.1	1.017	1.017	98.983
No 10	2	318.5	320.2	1.7	0.283	1.300	98.700
No 16	1.18	281.3	284.1	2.8	0.467	1.767	98.233
No 30	0.6	277.2	280.4	3.2	0.533	2.300	97.700
No 50	0.3	262.4	270.2	7.8	1.300	3.600	96.400
No 100	0.15	264.9	275.3	10.4	1.733	5.333	94.667
No 200	0.075	245.9	253.6	7.7	1.283	6.617	93.383
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.0335	0.0023	1.0312	8.04	0.055	98.679	92.150
1	1.033	0.0023	1.0307	8.19	0.037	97.098	90.673
2	1.033	0.0023	1.0307	8.19	0.026	97.098	90.673
4	1.0325	0.0023	1.0302	8.34	0.019	95.517	89.197
8	1.032	0.0023	1.0297	8.46	0.013	93.935	87.720
15	1.031	0.0023	1.0287	8.69	0.010	90.772	84.766
30	1.0305	0.0023	1.0282	8.84	0.007	89.191	83.289
60	1.03	0.0023	1.0277	8.99	0.005	87.610	81.813
120	1.029	0.0023	1.0267	9.26	0.004	84.447	78.859
240	1.028	0.0023	1.0257	9.49	0.003	81.284	75.906
480	1.027	0.0023	1.0247	9.79	0.002	78.121	72.952
1440	1.026	0.0023	1.0237	10.06	0.001	74.958	69.999

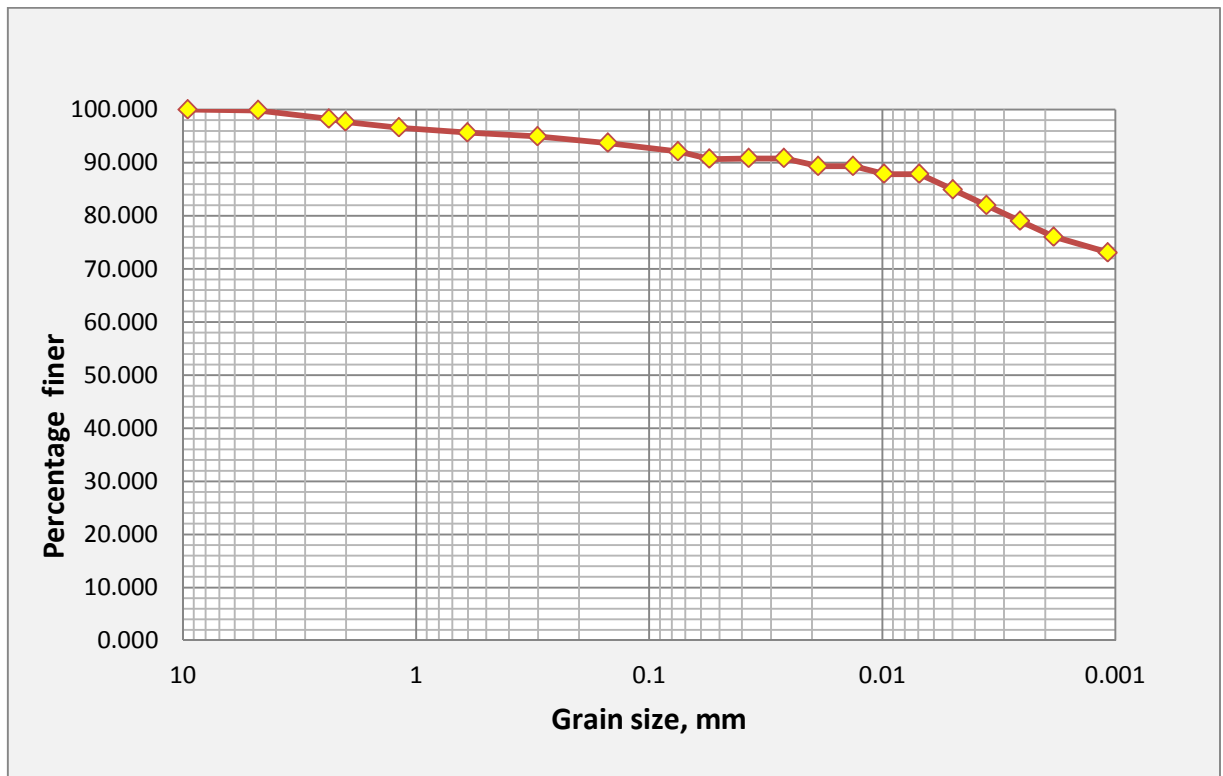
C26 Grain size analysis result of TP7 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	309.3	310.1	0.8	0.133	0.133	99.867
No 8	2.36	335.8	345.4	9.6	1.600	1.733	98.267
No 10	2	318.5	322	3.5	0.583	2.317	97.683
No 16	1.18	281.3	287.9	6.6	1.100	3.417	96.583
No 30	0.6	277.2	282.7	5.5	0.917	4.333	95.667
No 50	0.3	262.4	266.8	4.4	0.733	5.067	94.933
No 100	0.15	264.9	272.3	7.4	1.233	6.300	93.700
No 200	0.075	245.9	255.5	9.6	1.600	7.900	92.100
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.0335	0.0023	1.0312	8.04	0.055	98.469	90.690
1	1.033	0.0023	1.0307	8.19	0.037	96.891	90.819
2	1.033	0.0023	1.0307	8.19	0.026	96.891	90.819
4	1.0325	0.0023	1.0302	8.34	0.019	95.313	89.340
8	1.0325	0.0023	1.0302	8.34	0.013	95.313	89.340
15	1.032	0.0023	1.0297	8.46	0.010	93.735	87.861
30	1.032	0.0023	1.0297	8.46	0.007	93.735	87.861
60	1.031	0.0023	1.0287	8.69	0.005	90.579	84.903
120	1.03	0.0023	1.0277	8.99	0.004	87.423	81.945
240	1.029	0.0023	1.0267	9.26	0.003	84.267	78.986
480	1.028	0.0023	1.0257	9.49	0.002	81.111	76.028
1440	1.027	0.0023	1.0247	9.79	0.001	77.955	73.070

C27 Grain size distribution curve for TP7 at D=1.5m



C28 Grain size distribution curve for TP7 at D=3.0m



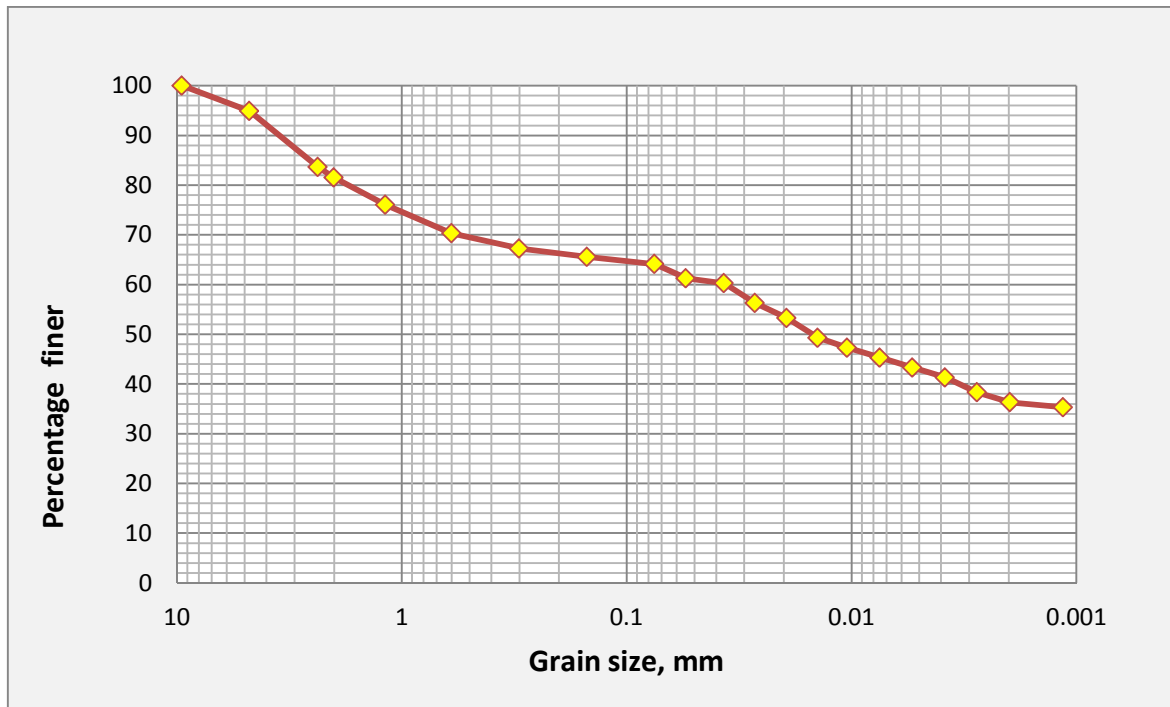
C29 Grain size analysis result of TP8 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
3.8"	9.5	312	312	0	0.000	0.000	100.000
No 4	4.75	309.1	339.8	30.7	5.117	5.117	94.883
No 8	2.36	335.4	402.8	67.4	11.233	16.350	83.650
No 10	2	318.4	331.4	13	2.167	18.517	81.483
No 16	1.18	281.2	314	32.8	5.467	23.983	76.017
No 30	0.6	277.1	311.5	34.4	5.733	29.717	70.283
No 50	0.3	262.5	280.7	18.2	3.033	32.750	67.250
No 100	0.15	264.8	275	10.2	1.700	34.450	65.550
No 200	0.075	245.7	254.3	8.6	1.433	35.883	64.117
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.033	0.0023	1.0307	8.19	0.054	95.511	61.238
1	1.0325	0.0023	1.0302	8.34	0.037	93.955	60.241
2	1.0305	0.0023	1.0282	8.84	0.027	87.733	56.251
4	1.029	0.0023	1.0267	9.26	0.019	83.066	53.259
8	1.027	0.0023	1.0247	9.79	0.014	76.844	49.270
15	1.026	0.0023	1.0237	10.06	0.010	73.733	47.275
30	1.025	0.0023	1.0227	10.29	0.007	70.622	45.280
60	1.024	0.0023	1.0217	10.56	0.005	67.511	43.286
120	1.023	0.0023	1.0207	10.79	0.004	64.400	41.291
240	1.0215	0.0023	1.0192	11.24	0.003	59.733	38.299
480	1.0205	0.0023	1.0182	11.46	0.002	56.622	36.304
1440	1.02	0.0023	1.0177	11.59	0.001	55.066	35.307

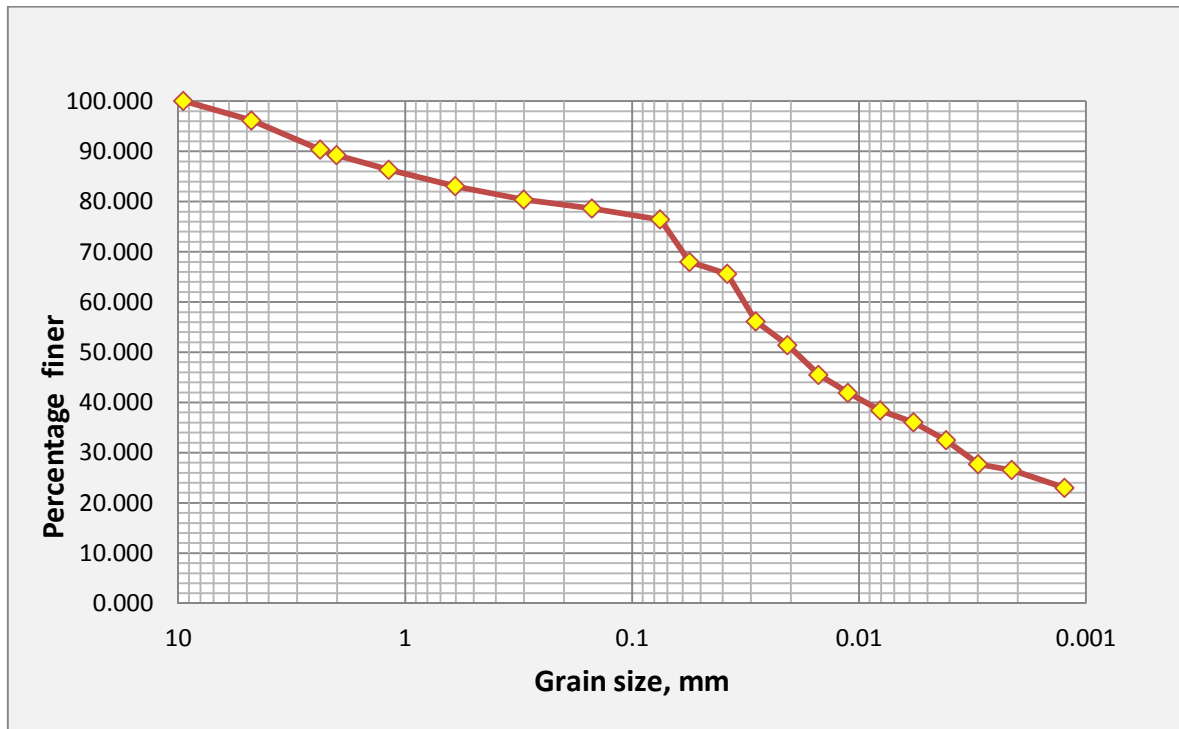
C30 Grain size analysis result of TP8 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	309.1	332.3	23.2	3.867	3.867	96.133
No 8	2.36	335.4	370.4	35	5.833	9.700	90.300
No 10	2	318.4	324.9	6.5	1.083	10.783	89.217
No 16	1.18	281.2	298.7	17.5	2.917	13.700	86.300
No 30	0.6	277.1	296.7	19.6	3.267	16.967	83.033
No 50	0.3	262.5	278.3	15.8	2.633	19.600	80.400
No 100	0.15	264.8	275.6	10.8	1.800	21.400	78.600
No 200	0.075	245.7	258.9	13.2	2.200	23.600	76.400
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.031	0.0023	1.0287	8.69	0.056	88.938	67.949
1	1.03	0.0023	1.0277	8.99	0.038	85.840	65.581
2	1.026	0.0023	1.0237	10.06	0.028	73.444	56.111
4	1.024	0.0023	1.0217	10.56	0.021	67.246	51.376
8	1.0215	0.0023	1.0192	11.24	0.015	59.499	45.457
15	1.02	0.0023	1.0177	11.59	0.011	54.851	41.906
30	1.0185	0.0023	1.0162	12.04	0.008	50.202	38.354
60	1.0175	0.0023	1.0152	12.26	0.006	47.103	35.987
120	1.016	0.0023	1.0137	12.69	0.004	42.455	32.436
240	1.014	0.0023	1.0117	13.19	0.003	36.257	27.700
480	1.0135	0.0023	1.0112	13.34	0.002	34.708	26.517
1440	1.012	0.0023	1.0097	13.76	0.001	30.059	22.965

C31 Grain size distribution curve for TP8 at D=1.5m



C32 Grain size distribution curve for TP8 at D=3.0m



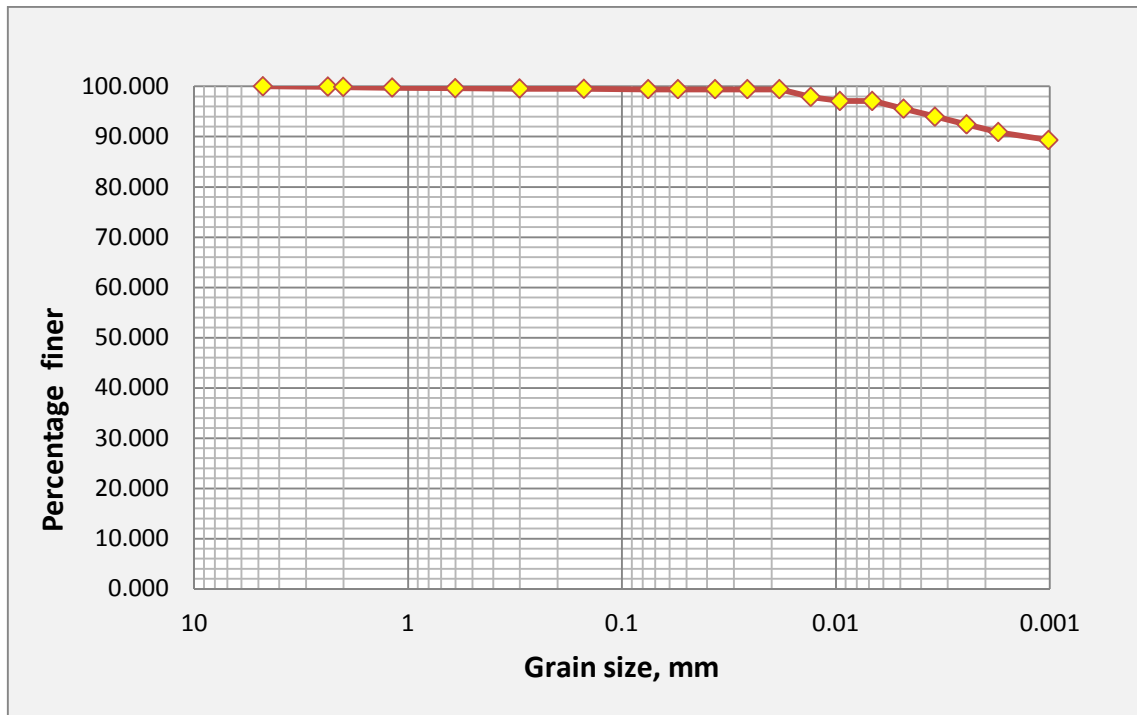
C33 Grain size analysis result of TP9 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	308.9	308.9	0	0.000	0.000	100.000
No 8	2.36	335.5	336	0.5	0.083	0.083	99.917
No 10	2	318.4	318.7	0.3	0.050	0.133	99.867
No 16	1.18	281.4	282.3	0.9	0.150	0.283	99.717
No 30	0.6	277.1	277.7	0.6	0.100	0.383	99.617
No 50	0.3	262.4	262.9	0.5	0.083	0.467	99.533
No 100	0.15	264.9	265.1	0.2	0.033	0.500	99.500
No 200	0.075	245.9	246.4	0.5	0.083	0.583	99.417
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.034	0.0023	1.0317	7.89	0.054	100.000	99.417
1	1.034	0.0023	1.0317	7.89	0.037	100.000	99.417
2	1.034	0.0023	1.0317	7.89	0.026	100.000	99.417
4	1.034	0.0023	1.0317	7.89	0.018	100.000	99.417
8	1.0335	0.0023	1.0312	8.04	0.013	98.469	97.895
15	1.0335	0.0023	1.0312	8.04	0.010	97.653	97.083
30	1.0335	0.0023	1.0312	8.04	0.007	97.653	97.083
60	1.033	0.0023	1.0307	8.19	0.005	96.088	95.527
120	1.0325	0.0023	1.0302	8.34	0.003	94.523	93.972
240	1.032	0.0023	1.0297	8.46	0.002	92.958	92.416
480	1.0315	0.0023	1.0292	8.56	0.002	91.393	90.860
1440	1.031	0.0023	1.0287	8.69	0.001	89.828	89.304

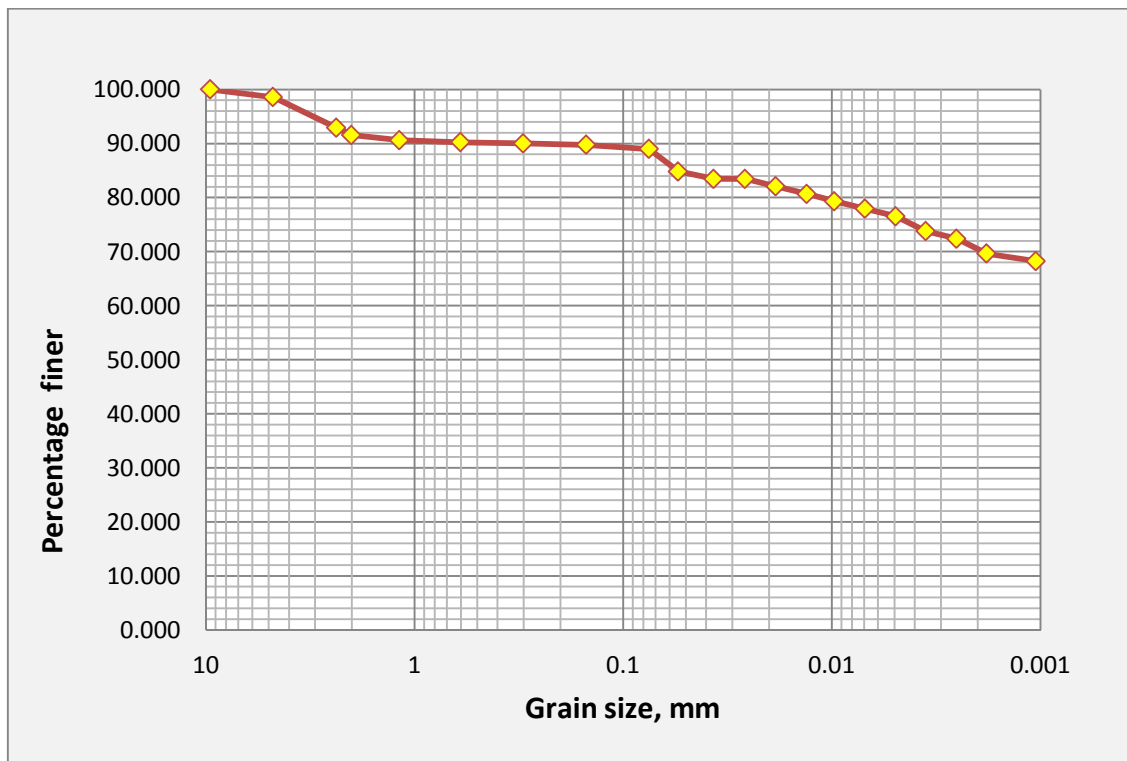
C34 Grain size analysis result of TP9 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	308.8	317.4	8.6	1.433	1.433	98.567
No 8	2.36	335.4	369.4	34	5.667	7.100	92.900
No 10	2	318.1	326.1	8	1.333	8.433	91.567
No 16	1.18	281.2	286.9	5.7	0.950	9.383	90.617
No 30	0.6	277	279.4	2.4	0.400	9.783	90.217
No 50	0.3	262.4	263.5	1.1	0.183	9.967	90.033
No 100	0.15	264.8	266.4	1.6	0.267	10.233	89.767
No 200	0.075	245.6	250.3	4.7	0.783	11.017	88.983
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.033	0.0023	1.0307	8.19	0.054	95.320	84.819
1	1.0325	0.0023	1.0302	8.34	0.037	93.768	83.438
2	1.0325	0.0023	1.0302	8.34	0.026	93.768	83.438
4	1.032	0.0023	1.0297	8.46	0.019	92.216	82.056
8	1.0315	0.0023	1.0292	8.56	0.013	90.663	80.675
15	1.031	0.0023	1.0287	8.69	0.010	89.111	79.294
30	1.0305	0.0023	1.0282	8.84	0.007	87.558	77.912
60	1.03	0.0023	1.0277	8.99	0.005	86.006	76.531
120	1.029	0.0023	1.0267	9.26	0.004	82.901	73.768
240	1.0285	0.0023	1.0262	9.36	0.003	81.348	72.387
480	1.0275	0.0023	1.0252	9.64	0.002	78.243	69.624
1440	1.027	0.0023	1.0247	9.79	0.001	76.691	68.242

C35 Grain size distribution curve for TP9 at D=1.5m



C36 Grain size distribution curve for TP9 at D=3.0m



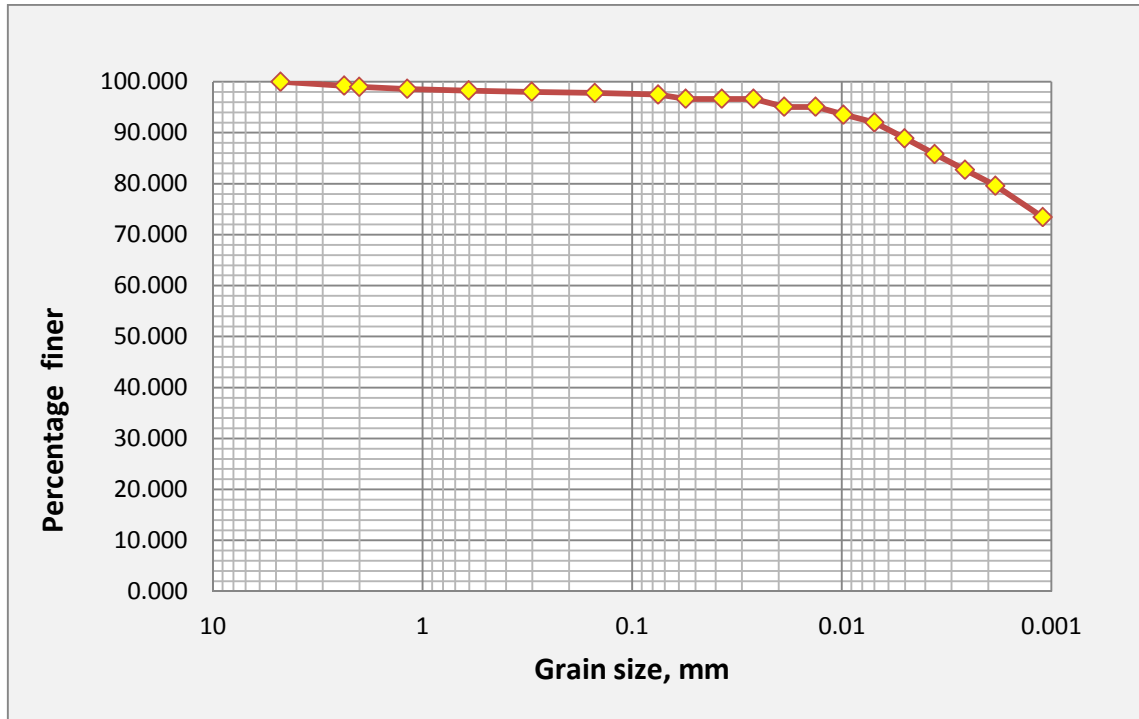
C37 Grain size analysis result of TP10 at D=1.5m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	308.8	308.8	0	0.000	0.000	100.000
No 8	2.36	335.4	340.2	4.8	0.800	0.800	99.200
No 10	2	318.1	319.4	1.3	0.217	1.017	98.983
No 16	1.18	281.2	283.5	2.3	0.383	1.400	98.600
No 30	0.6	277	279	2	0.333	1.733	98.267
No 50	0.3	262.4	263.9	1.5	0.250	1.983	98.017
No 100	0.15	264.8	266.1	1.3	0.217	2.200	97.800
No 200	0.075	245.6	247.4	1.8	0.300	2.500	97.500
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.0335	0.0023	1.0312	8.04	0.055	99.106	96.628
1	1.0335	0.0023	1.0312	8.04	0.037	99.106	96.628
2	1.0335	0.0023	1.0312	8.04	0.026	99.106	96.628
4	1.033	0.0023	1.0307	8.19	0.019	97.518	95.080
8	1.033	0.0023	1.0307	8.19	0.013	97.518	95.080
15	1.0325	0.0023	1.0302	8.34	0.010	95.929	93.531
30	1.032	0.0023	1.0297	8.46	0.007	94.341	91.983
60	1.031	0.0023	1.0287	8.69	0.005	91.165	88.886
120	1.03	0.0023	1.0277	8.99	0.004	87.988	85.789
240	1.029	0.0023	1.0267	9.26	0.003	84.812	82.691
480	1.028	0.0023	1.0257	9.49	0.002	81.635	79.594
1440	1.026	0.0023	1.0237	10.06	0.001	75.282	73.400

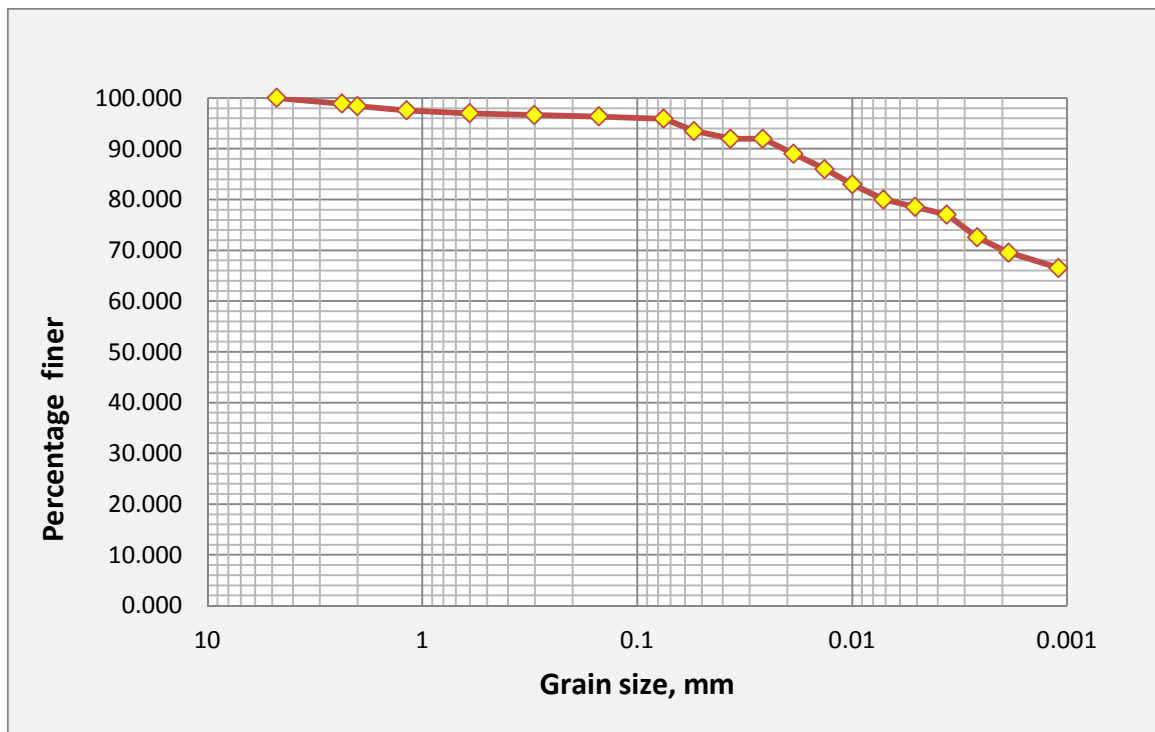
C38 Grain size analysis result of TP10 at D=3.0m

Sieve No	Sieve opening in mm	Mass of sieve (g)	Mass of sieve + Retained soil	Mass of Retained soil	Percentage Retained	cummulative percentage Retained	Percentage finer
No 4	4.75	308.9	308.9	0	0.000	0.000	100.000
No 8	2.36	335.5	342.3	6.8	1.133	1.133	98.867
No 10	2	318.4	321.3	2.9	0.483	1.617	98.383
No 16	1.18	281.4	286.4	5	0.833	2.450	97.550
No 30	0.6	277.1	280.6	3.5	0.583	3.033	96.967
No 50	0.3	262.4	264.4	2	0.333	3.367	96.633
No 100	0.15	264.9	266.7	1.8	0.300	3.667	96.333
No 200	0.075	245.9	248.4	2.5	0.417	4.083	95.917
Time	Actual reading	Composite correction	Corrected reading	Effective depth(cm)	Grain size(mm)	Percentage finer	Percentage finer for combined analysis
0.45	1.0335	0.0023	1.0312	8.04	0.054	97.456	93.477
1	1.033	0.0023	1.0307	8.19	0.037	95.894	91.979
2	1.033	0.0023	1.0307	8.19	0.026	95.894	91.979
4	1.032	0.0023	1.0297	8.46	0.019	92.771	88.982
8	1.031	0.0023	1.0287	8.69	0.013	89.647	85.986
15	1.03	0.0023	1.0277	8.99	0.010	86.523	82.990
30	1.029	0.0023	1.0267	9.26	0.007	83.400	79.994
60	1.0285	0.0023	1.0262	9.36	0.005	81.838	78.496
120	1.028	0.0023	1.0257	9.49	0.004	80.276	76.998
240	1.0265	0.0023	1.0242	9.94	0.003	75.591	72.504
480	1.0255	0.0023	1.0232	10.16	0.002	72.467	69.508
1440	1.0245	0.0023	1.0222	10.44	0.001	69.344	66.512

C39 Grain size distribution curve for TP10 at D=1.5m



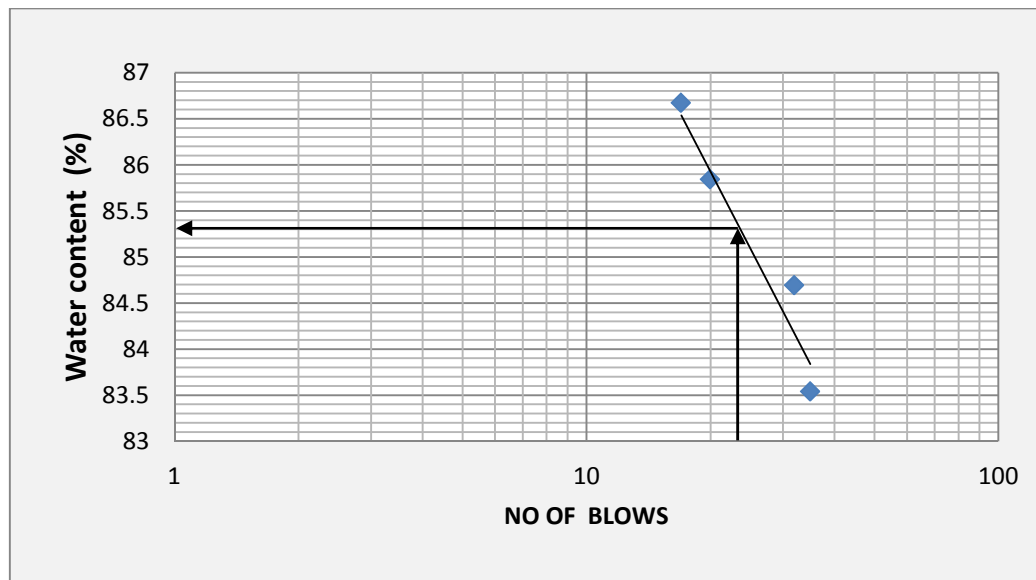
C40 Grain size distribution curve for TP10 at D=3.0m



Appendix D Liquid limit test results

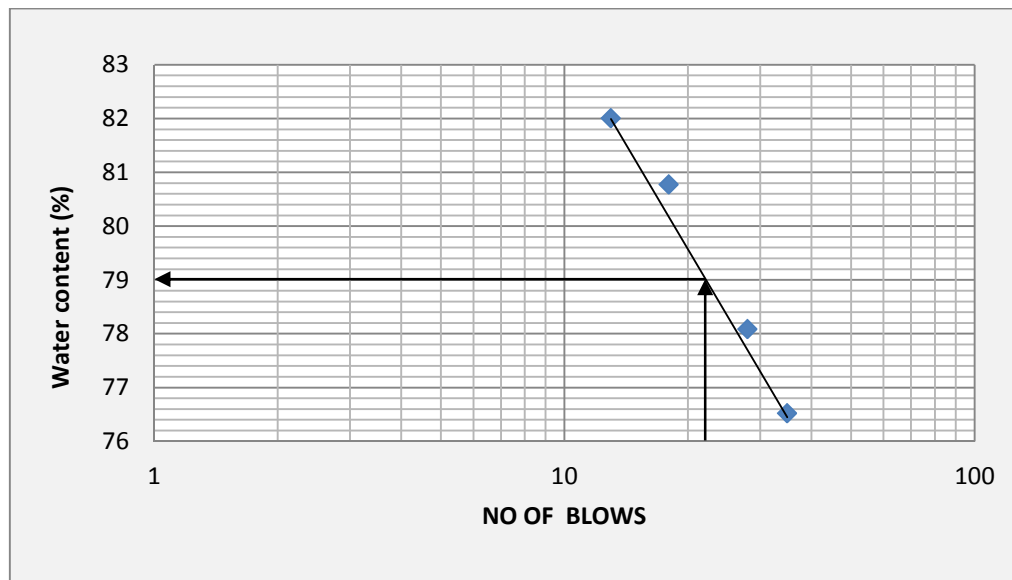
D1 Liquid limit test result of TP1 at D=1.5m

Trial No	1	2	3	4
Container No	16	M2	12	T1
Mass of container, gm	37.5	37.6	37.5	37.5
Mass of container + wet soil, g	52	55.7	58.5	59.9
Mass of container + dry soil, g	45.4	47.4	48.8	49.5
Mass of water, g	6.6	8.3	9.7	10.4
Mass of dry soil, g	7.9	9.8	11.3	12
Water content, %	83.54	84.69	85.84	86.67
No of blow	35	32	20	17



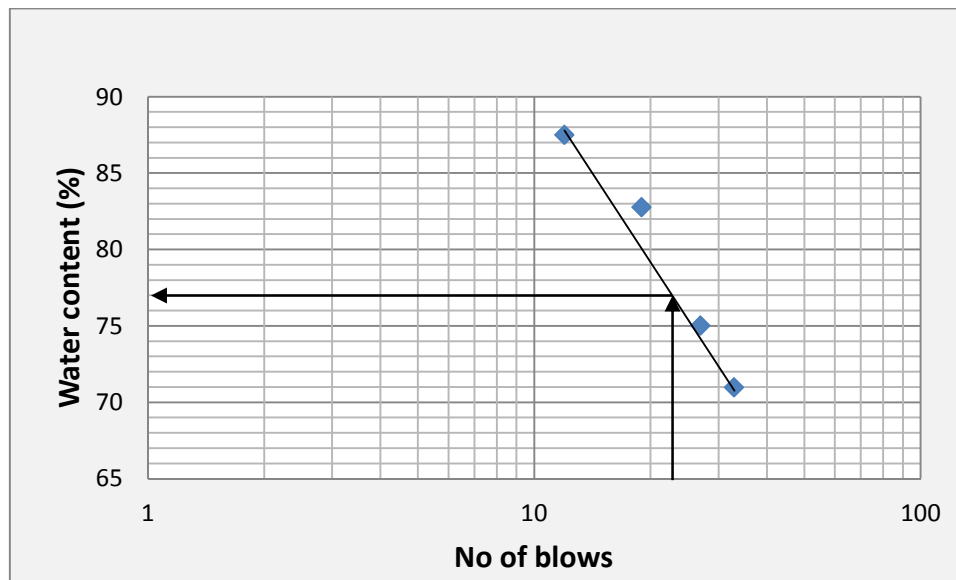
D2 Liquid limit test result of TP1 at D=3.0m

Trial No	1	2	3	4
Can No	61	62	A14	Z2
Mass of container, g	36.9	37.7	37	37.5
Mass of container + wet soil, g	57.2	56.5	50	55.7
Mass of container + dry soil, g	48.4	48.1	44.3	47.5
Mass of water, g	8.8	8.4	5.7	8.2
Mass of dry soil, g	11.5	10.4	7.3	10
Water content,%	76.52	80.77	78.08	82.00
No of blow	33	18	28	13



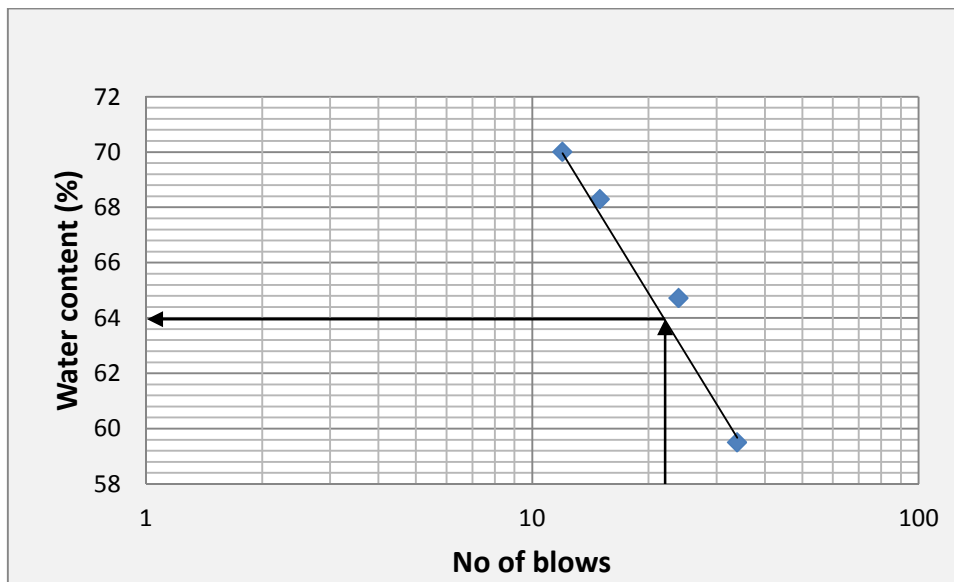
D3 Liquid limit test result of TP2 at D=1.0m

Trial No	1	2	3	4
Container No	64	N2	A14	61
Mass of container, g	37.2	37.1	36.9	36.8
Mass of container + wet soil, g	42.5	41.3	41.4	42.1
Mass of container + dry soil, g	40.3	39.5	39.3	39.7
Mass of water, g	2.2	1.8	2.1	2.4
Mass of dry soil, g	3.1	2.4	2.4	2.9
Water content,%	70.97	75.00	87.50	82.76
No of blow	33	27	12	19



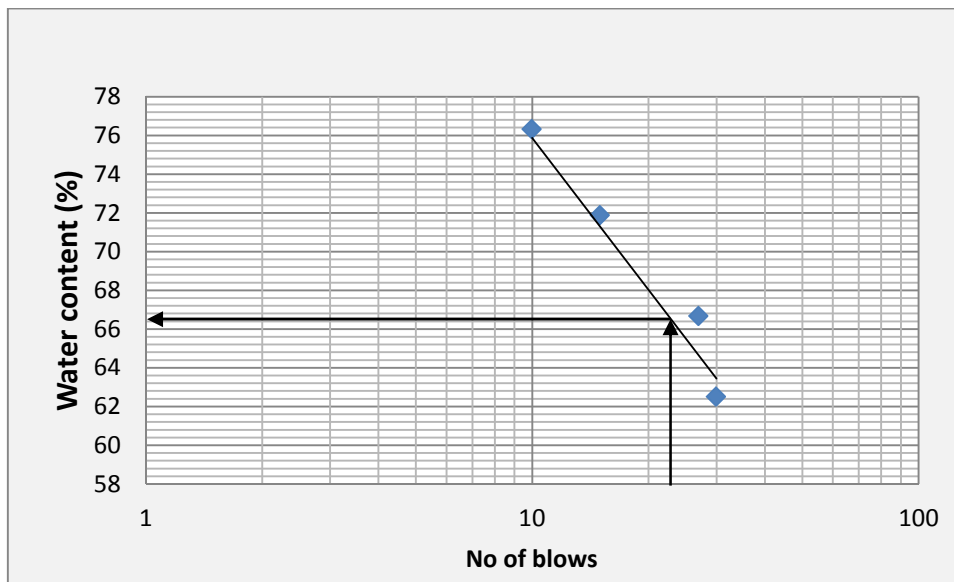
D4 Liquid limit test result of TP3 at D=1.5m

Trial No	1	2	3	4
Container No	64	A2	K4	62
Mass of container, g	37.2	37.5	37.2	37.5
Mass of container + wet soil, g	43.9	43.1	44.1	44.3
Mass of container + dry soil, g	41.4	40.9	41.3	41.5
Mass of water, g	2.5	2.2	2.8	2.8
Mass of dry soil, g	4.2	3.4	4.1	4
Water content, %	59.52	64.71	68.29	70.00
No of blow	34	24	15	12



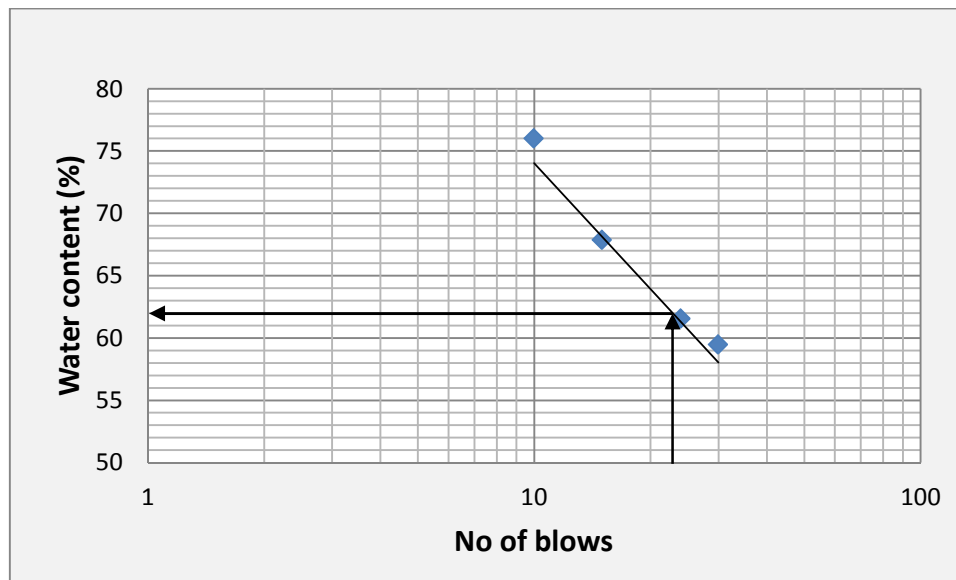
D5 Liquid limit test result of TP3 at D=3.0m

Trial No	1	2	3	4
Container No	G3	R1	17	K2
Mass of container, g	37.4	37.5	37.3	37.5
Mass of container + wet soil, g	43.9	42.5	44	43
Mass of container + dry soil, g	41.4	40.5	41.1	40.7
Mass of water, g	2.5	2	2.9	2.3
Mass of dry soil, g	4	3	3.8	3.2
Water content,%	62.50	66.67	76.32	71.87
No of blow	30	27	10	15



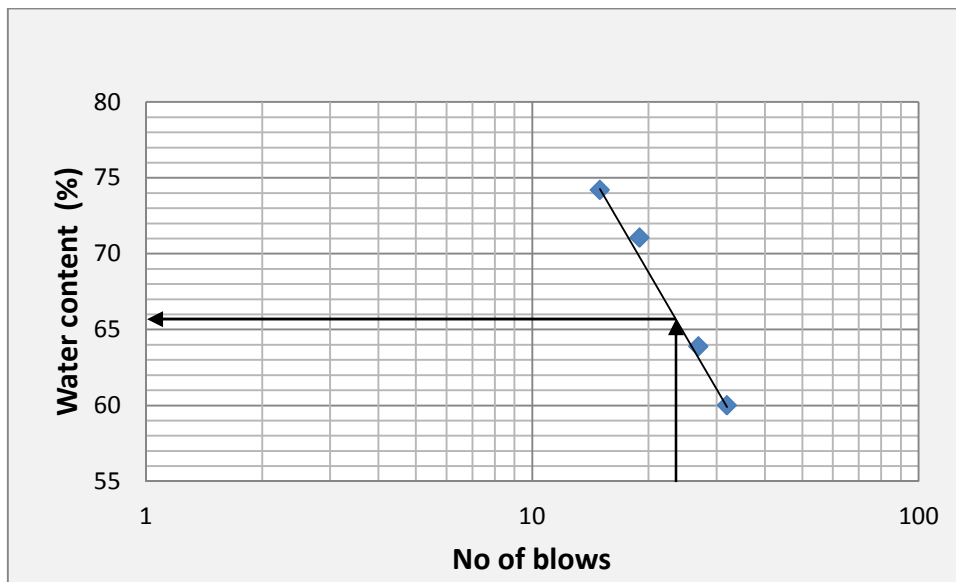
D6Liquid limit test result of TP4 at D=1.5m

Trial No	1	2	3	4
Container No	17.2	A14	61	N2
Mass of container, g	37.7	36.9	36.8	37.2
Mass of container + wet soil, g	43.6	41.1	41.5	41.6
Mass of container + dry soil, g	41.4	39.5	39.6	39.7
Mass of water, g	2.2	1.6	1.9	1.9
Mass of dry soil, g	3.7	2.6	2.8	2.5
Water content,%	59.46	61.54	67.86	76.00
No of blow	30	24	15	10



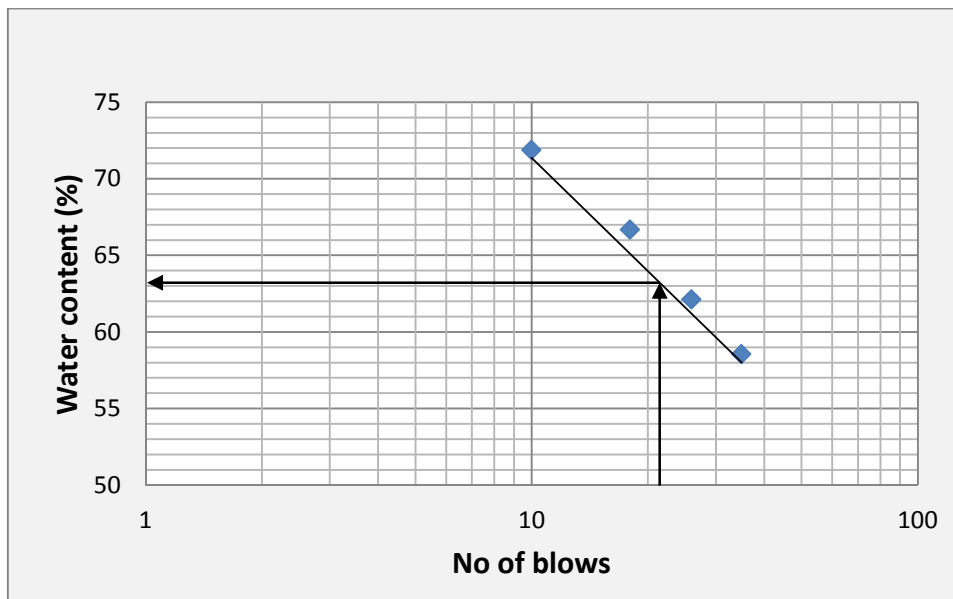
D7 Liquid limit test result of TP4 at D=3.0m

Trial No	1	2	3	4
Container No	T1	B-9	13	16
Mass of container, g	37.4	37.4	37	37.4
Mass of container + wet soil, g	44.6	43.3	42.4	43.9
Mass of container + dry soil, g	41.9	41	40.1	41.2
Mass of water, g	2.7	2.3	2.3	2.7
Mass of dry soil, g	4.5	3.6	3.1	3.8
Water content,%	60.00	63.89	74.19	71.05
No of blow	32	27	15	19



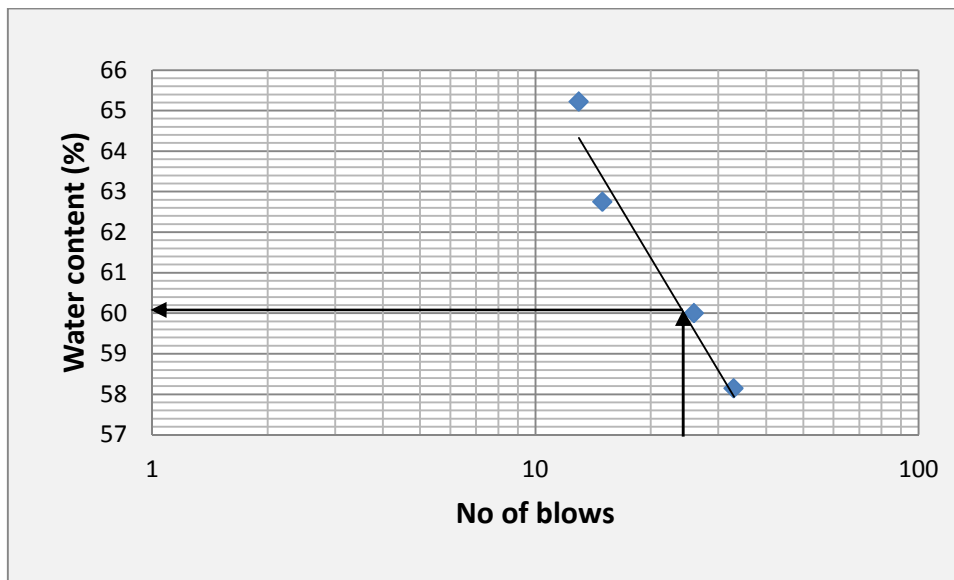
D8 Liquid limit test result of TP5 at D=1.5m

Trial No	1	2	3	4
Container No	17,2	18	A2	62
Mass of container, g	37.7	37.6	37.5	37.5
Mass of container + wet soil, g	44.2	42.95	43	43
Mass of container + dry soil, g	41.8	40.9	40.7	40.8
Mass of water, g	2.4	2.05	2.3	2.2
Mass of dry soil, g	4.1	3.3	3.2	3.3
Water content,%	58.54	62.12	71.87	66.67
No of blow	35	26	10	18



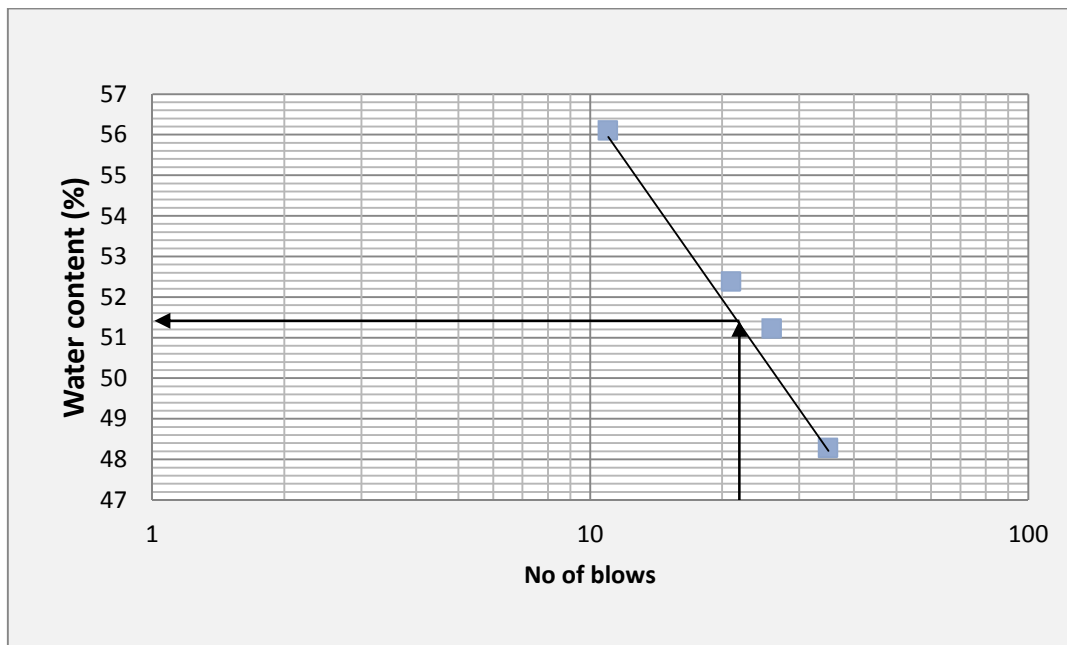
D9 Liquid limit test result of TP5 at D=3.0m

Trial No	1	2	3	4
Container No	13	T1	F1	K6
Mass of container, g	37	37.4	37	37.5
Mass of container + wet soil, g	43.8	45.7	44.2	45.1
Mass of container + dry soil, g	41.3	42.5	41.5	42.1
Mass of water, g	2.5	3.2	2.7	3
Mass of dry soil, g	4.3	5.1	4.5	4.6
Water content,%	58.14	62.75	60.00	65.22
No of blow	33	15	26	13



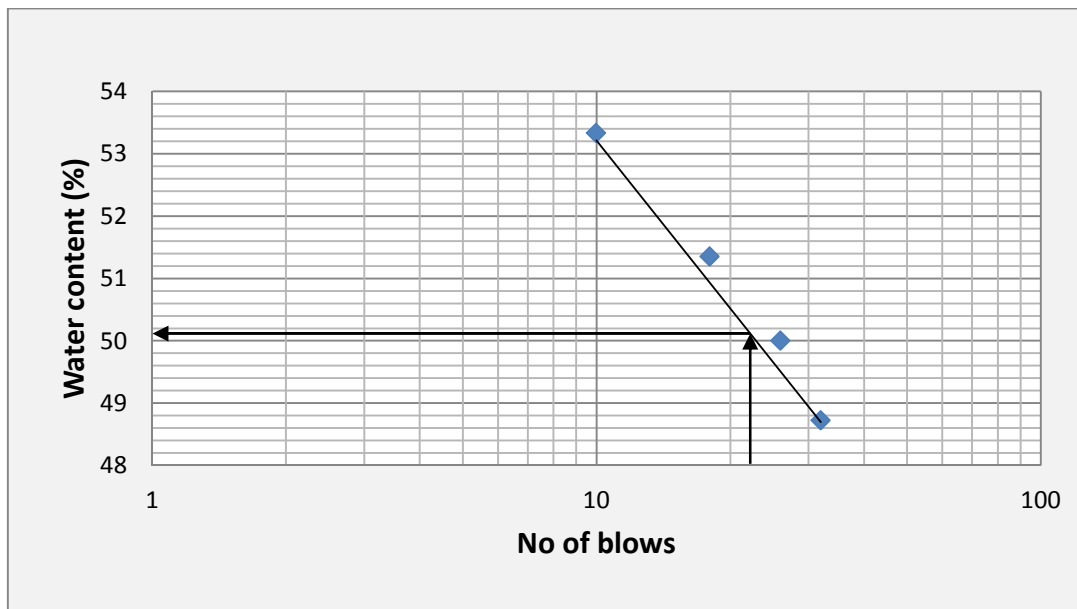
D10 Liquid limit test result of TP6 at D=1.5m

Trial No	1	2	3	4
Container No	M2	J4	T6	16
Mass of container, g	37.3	37.2	37.4	37.4
Mass of container + wet soil, g	41.6	40.4	43.6	43.8
Mass of container + dry soil, g	40.2	39.3	41.5	41.5
Mass of water, g	1.4	1.1	2.1	2.3
Mass of dry soil, g	2.9	2.1	4.1	4.1
Water content,%	48.28	52.38	51.22	56.10
No of blow	35	21	26	11



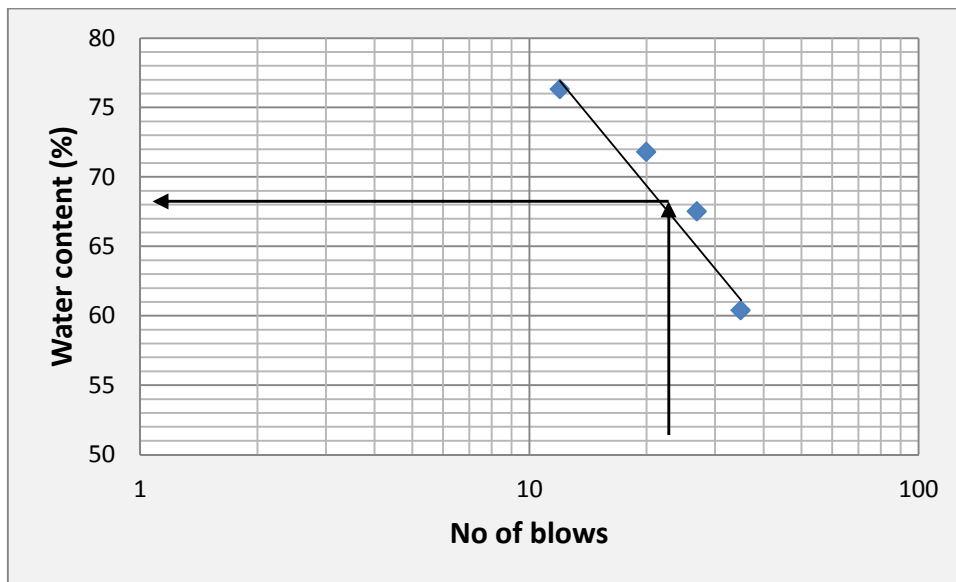
D11 Liquid limit test result of TP6 at D=3.0m

Trial No	1	2	3	4
Container No	G 3	K2	R1	B9
Mass of container, g	37.5	37.5	37.5	37.4
Mass of container + wet soil, g	43.3	42.3	43.1	44.3
Mass of container + dry soil, g	41.4	40.7	41.2	41.9
Mass of water, g	1.9	1.6	1.9	2.4
Mass of dry soil, g	3.9	3.2	3.7	4.5
Water content,%	48.72	50.00	51.35	53.33
No of blow	32	26	18	10



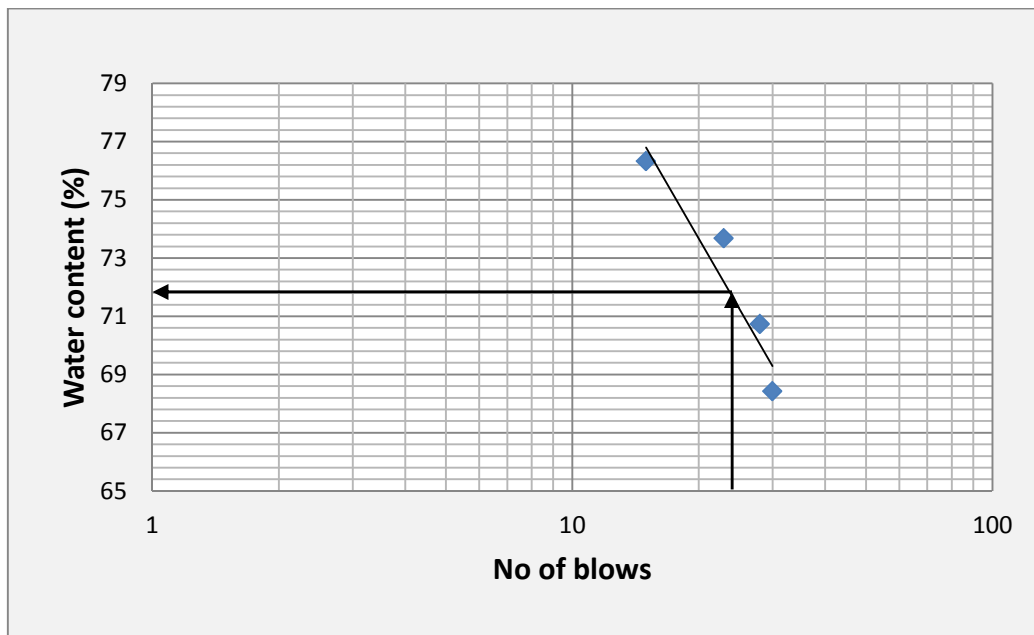
D12 Liquid limit test result of TP7 at D=1.5m

Trial No	1	2	3	4
Container No	T4	K9	L4	N2
Mass of container, g	37.6	37.5	38.2	37.5
Mass of container + wet soil, g	46.1	44.2	44.9	44.2
Mass of container + dry soil, g	42.9	41.5	42.1	41.3
Mass of water, g	3.2	2.7	2.8	2.9
Mass of dry soil, g	5.3	4	3.9	3.8
Water content,%	60.38	67.50	71.79	76.32
No of blow	35	27	20	12



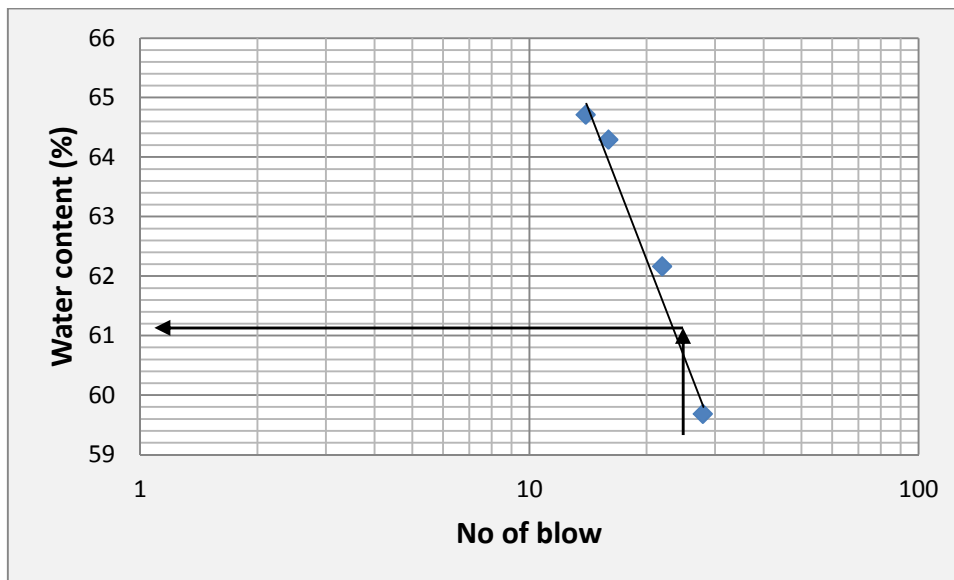
D13 Liquid limit test result of TP7 at D=3.0 m

Trial No	1	2	3	4
Container No	2	Y	T1	A2
Mass of container, g	38.3	37.7	36.6	37.5
Mass of container + wet soil, g	44.7	44.7	43.2	44.2
Mass of container + dry soil, g	42.1	41.8	40.4	41.3
Mass of water, g	2.6	2.9	2.8	2.9
Mass of dry soil, g	3.8	4.1	3.8	3.8
Water content,%	68.42	70.73	73.68	76.32
No of blow	30	28	23	15



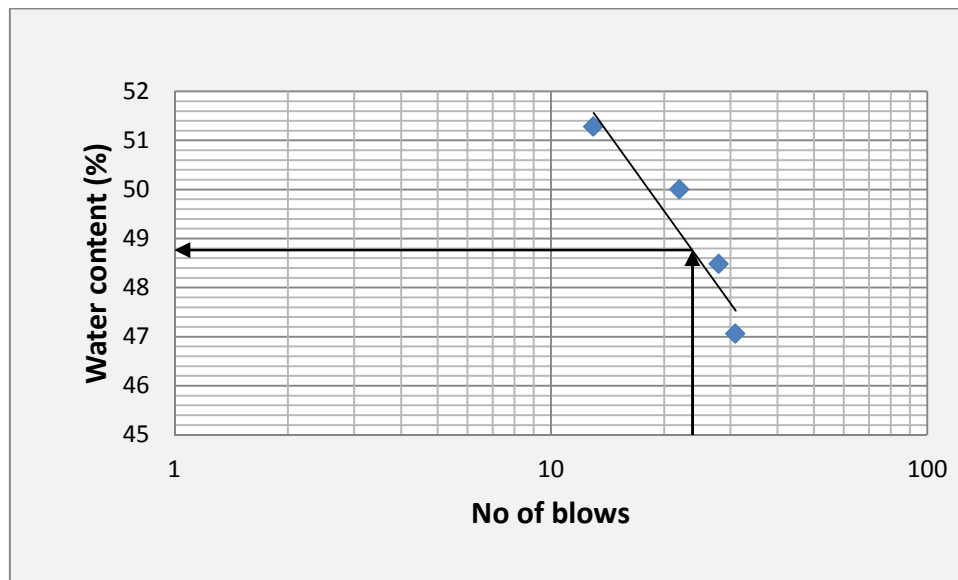
D14 Liquid limit test result of TP8 at D=1.5 m

Trial No	1	2	3	4
Container No	K6	64	B9	G3
Mass of container, g	37.8	37.8	37.7	37.8
Mass of container + wet soil, g	47.7	43.8	44.6	43.4
Mass of container + dry soil, g	44	41.5	41.9	41.2
Mass of water, g	3.7	2.3	2.7	2.2
Mass of dry soil, g	6.2	3.7	4.2	3.4
Water content,%	59.68	62.16	64.29	64.71
No of blow	28	22	16	14



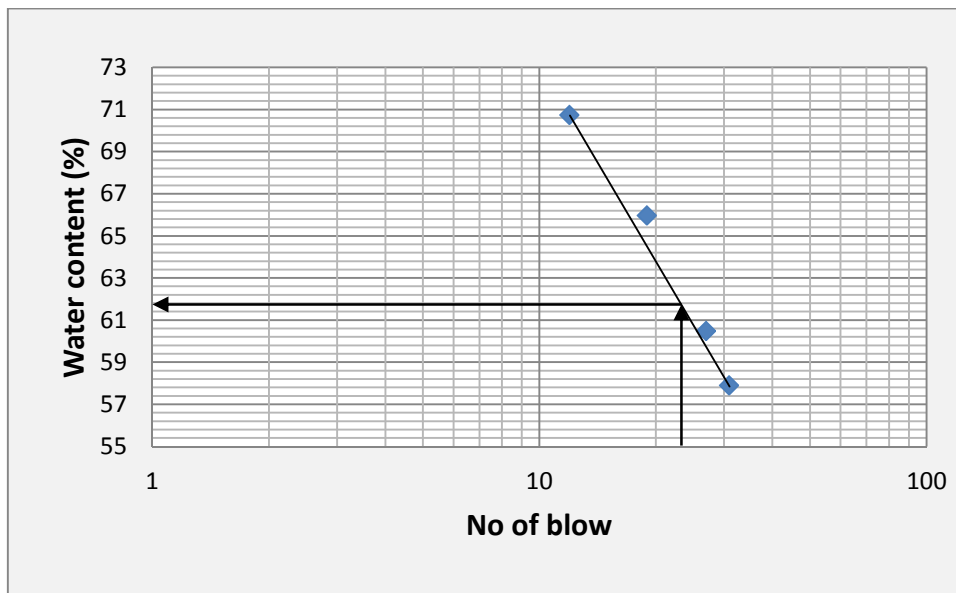
D15 Liquid limit test result of TP8 at D=3.0 m

Trial No	1	2	3	4
Container No	X1	2K5	5	Z1
Mass of container, g	37.4	38.5	37	37
Mass of container + wet soil, g	42.4	43.4	41.5	42.9
Mass of container + dry soil, g	40.8	41.8	40	40.9
Mass of water, g	1.6	1.6	1.5	2
Mass of dry soil, g	3.4	3.3	3	3.9
Water content,%	47.06	48.48	50.00	51.28
No of blow	31	28	22	13



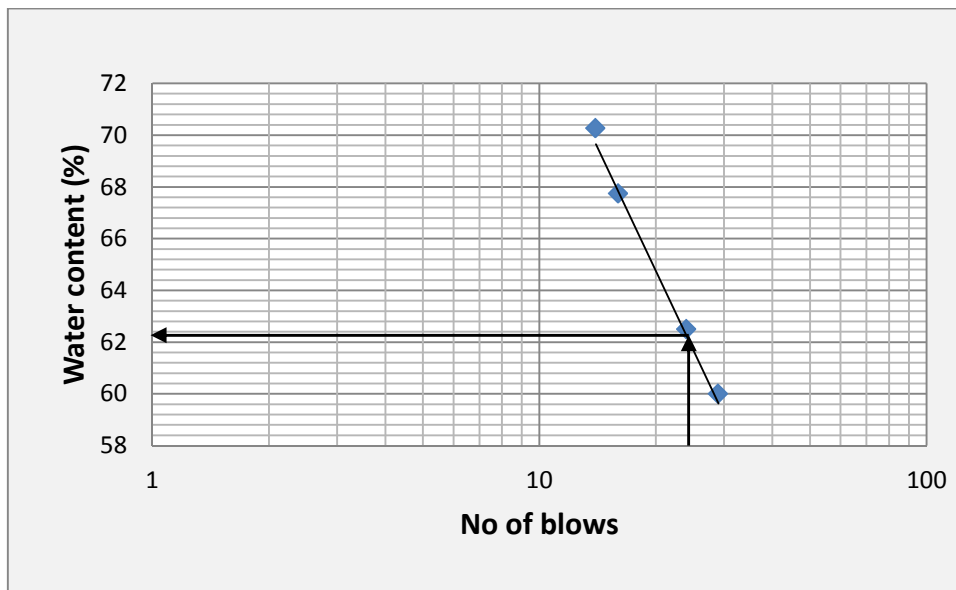
D16 Liquid limit test result of TP9 at D=1.5 m

Trial No	1	2	3	4
Container No	2	T6	B7	16
Mass of container, g	38.3	38	37.4	37.4
Mass of container + wet soil, g	44.3	44.9	44.4	45.2
Mass of container + dry soil, g	42.1	42.3	41.5	42.1
Mass of water, g	2.2	2.6	2.9	3.1
Mass of dry soil, g	3.8	4.3	4.1	4.7
Water content, %	57.89	60.47	70.73	65.96
No of blow	31	27	12	19



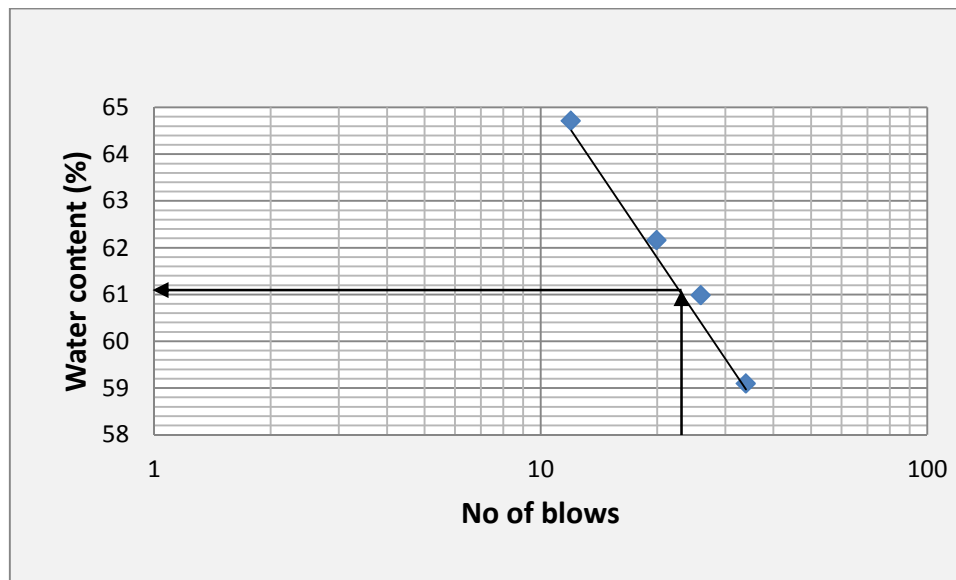
D17 Liquid limit test result of TP9 at D=3.0 m

Trial No	1	2	3	4
Container No	G3	64	K6	M2
Mass of container, g	37.8	37.9	37.8	37.7
Mass of container + wet soil, g	44.2	43.1	43	44
Mass of container + dry soil, g	41.8	41.1	40.9	41.4
Mass of water, g	2.4	2	2.1	2.6
Mass of dry soil, g	4	3.2	3.1	3.7
Water content,%	60.00	62.50	67.74	70.27
No of blow	29	24	16	14



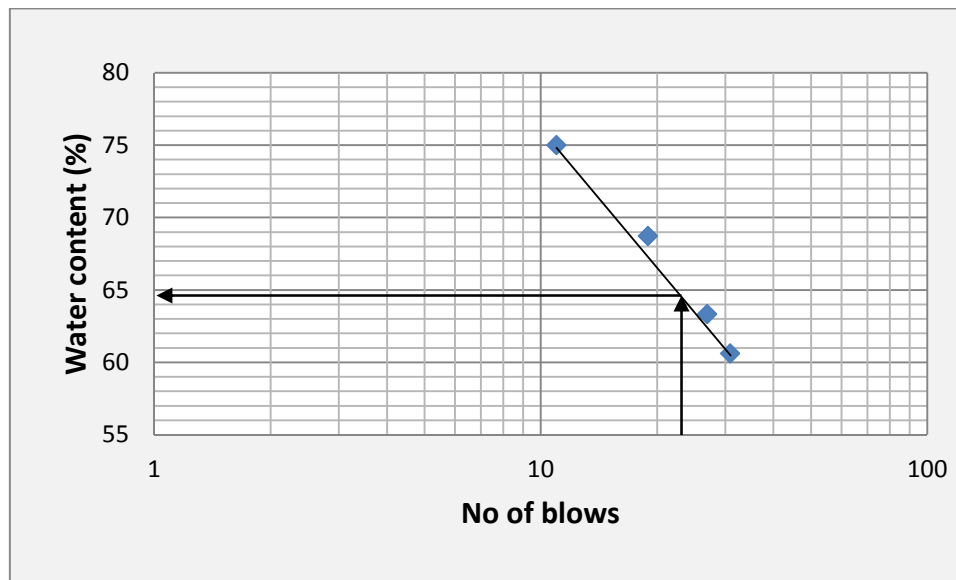
D18 Liquid limit test result of TP10 at D=1.5 m

Trial No	1	2	3	4
Container No	B7	L4	K9	T4
Mass of container, g	37.6	38.2	37.4	37.6
Mass of container + wet soil, g	44.6	44.8	43.4	43.2
Mass of container + dry soil, g	42	42.3	41.1	41
Mass of water, g	2.6	2.5	2.3	2.2
Mass of dry soil, g	4.4	4.1	3.7	3.4
Water content, %	59.09	60.98	62.16	64.71
No of blow	34	26	20	12



D19 Liquid limit test result of TP10 at D=3.0 m

Trial No	1	2	3	4
Container No	2	N2	63	T6
Mass of container, g	38.2	37.6	37.7	37.9
Mass of container + wet soil, g	43.5	42.5	45.4	43.3
Mass of container + dry soil, g	41.5	40.6	42.1	41.1
Mass of water, g	2	1.9	3.3	2.2
Mass of dry soil, g	3.3	3	4.4	3.2
Water content, %	60.61	63.33	75.00	68.75
No of blow	31	27	11	19



Appendix E Plastic limit test results

E1 Plastic limit test result of TP1 at D= 1.5m

Trial No	1	2
Container No	A1	A2
Mass of container, g	37.4	37.6
Mass of container + wet soil, g	42.5	42.9
Mass of container + dry soil, g	41.2	41.5
Mass of water, g	1.3	1.4
Mass of dry soil, g	3.8	3.9
Water content,%	34.21	35.90
Average water content,%	35.05	

E2 Plastic limit test result of TP1 at D= 3.0m

Trial No	1	2
Container No	16	13
Mass of container, g	37.4	36.9
Mass of container + wet soil, g	43.3	42.8
Mass of container + dry soil, g	41.8	41.2
Mass of water, g	1.5	1.6
Mass of dry soil, g	4.4	4.3
Water content,%	34.09	37.21
Average water content,%	35.65	

E3 Plastic limit test result of TP2 at D= 1.0m

Trial No	1	2
Container No	B9	G1
Mass of container, g	37.4	36.9
Mass of container + wet soil, g	44	44.7
Mass of container + dry soil, g	42.3	42.7
Mass of water, g	1.7	2
Mass of dry soil, g	4.9	5.8
Water content,%	34.69	34.48
Average water content,%	34.59	

E4 Plastic limit test result of TP3 at D= 1.5m

Trial No	1	2	3
Container No	A1	A2	G3
Mass of container, g	37.60	37.60	37.60
Mass of container + wet soil, g	41.40	41.60	42.20
Mass of container + dry soil, g	40.40	40.67	41.18
Mass of water, g	1.00	0.93	1.02
Mass of dry soil, g	2.80	3.07	3.58
Water content, %	35.71	30.17	28.46
Average water content, %	31.45		

E5 Plastic limit test result of TP3 at D= 3.0m

Trial No	1	2	3
Container No	R1	X1	X2
Mass of container, g	37.60	37.40	37.60
Mass of container + wet soil, g	41.00	41.60	41.00
Mass of container + dry soil, g	40.19	40.53	40.14
Mass of water, g	0.81	1.07	0.86
Mass of dry soil, g	2.59	3.13	2.54
Water content, %	31.12	34.27	33.81
Average water content, %	33.07		

E6 Plastic limit test result of TP4 at D= 1.5m

Trial No	1	2	3
Container No	R1	X1	X2
Mass of container, g	37.60	37.40	37.60
Mass of container + wet soil, g	42.00	43.60	42.80
Mass of container + dry soil, g	40.89	42.09	41.51
Mass of water, g	1.11	1.51	1.29
Mass of dry soil, g	3.29	4.69	3.91
Water content, %	33.60	32.11	33.11
Average water content, %	32.94		

E7 Plastic limit test result of TP4 at D= 3.0m

Trial No	1	2
Container No	R1	X1
Mass of container, g	37.6	37.4
Mass of container + wet soil, g	41.4	42
Mass of container + dry soil, g	40.5	40.9
Mass of water, g	0.9	1.1
Mass of dry soil, g	2.9	3.5
Water content, %	31.03	31.43
Average water content, %	31.23	

E8 Plastic limit test result of TP5 at D= 1.5m

Trial No	1	2
Container No	M2	13
Mass of container, g	37.4	37.1
Mass of container + wet soil, g	42.8	47.7
Mass of container + dry soil, g	41.5	45.1
Mass of water, g	1.3	2.6
Mass of dry soil, g	4.1	8
Water content, %	31.71	32.50
Average water content, %	32.10	

E9 Plastic limit test result of TP5 at D= 3.0m

Trial No	1	2
Container No	G1	X1
Mass of container, g	37	37.6
Mass of container + wet soil, g	43.8	45.8
Mass of container + dry soil, g	42.2	43.8
Mass of water, g	1.6	2
Mass of dry soil, g	5.2	6.2
Water content, %	30.77	32.26
Average water content, %	31.51	

E10 Plastic limit test result of TP6 at D= 1.5m

Trial No	1	2
Container No	A2	17.2
Mass of container, g	37.9	37.9
Mass of container + wet soil, g	44.6	49
Mass of container + dry soil, g	43	46.35
Mass of water, g	1.6	2.65
Mass of dry soil, g	5.1	8.45
Water content,%	31.37	31.36
Average water content,%	31.37	

E11 Plastic limit test result of TP6 at D= 3.0m

Trial No	1	2
Container No	N2	R1
Mass of container, g	37.2	37.6
Mass of container + wet soil, g	45.4	48.2
Mass of container + dry soil, g	43.25	45.4
Mass of water, g	2.15	2.8
Mass of dry soil, g	6.05	7.8
Water content, %	35.54	35.90
Average water content,%	35.72	

E12 Plastic limit test result of TP7 at D= 1.5m

Trial No	1	2
Container No	A2	y
Mass of container, g	37.5	37.7
Mass of container + wet soil, g	44.6	42.4
Mass of container + dry soil, g	42.9	41.3
Mass of water, g	1.7	1.1
Mass of dry soil, g	5.4	3.6
Water content,%	31.48	30.56
Average water content,%	31.02	

E13 Plastic limit test result of TP7 at D= 3.0m

Trial No	1	2
Container No	F1	v
Mass of container, g	37.7	37.6
Mass of container + wet soil, g	43.8	47.5
Mass of container + dry soil, g	42.3	45
Mass of water, g	1.5	2.5
Mass of dry soil, g	4.6	7.4
Water content,%	32.61	33.78
Average water content,%	33.20	

E14 Plastic limit test result of TP8 at D= 1.5m

Trial No	1	2
Container No	A1	A2
Mass of container, g	37.4	37.6
Mass of container + wet soil, g	42.2	44
Mass of container + dry soil, g	41.1	42.5
Mass of water, g	1.1	1.5
Mass of dry soil, g	3.7	4.9
Water content,%	29.73	30.61
Average water content,%	30.17	

E15 Plastic limit test result of TP8 at D= 3.0m

Trial No	1	2
Container No	R1	K2
Mass of container, g	37.5	37.5
Mass of container + wet soil, g	43	42.7
Mass of container + dry soil	41.6	41.4
Mass of water, g	1.4	1.3
Mass of dry soil, g	4.1	3.9
Water content,%	34.15	33.33
Average water content,%	33.74	

E16 Plastic limit test result of TP9 at D= 1.5m

Trial No	1	2
Container No	61	K6
Mass of container, g	37	37.2
Mass of container + wet soil, g	42	43.4
Mass of container + dry soil	40.8	41.9
Mass of water, g	1.2	1.5
Mass of dry soil, g	3.8	4.7
Water content,%	31.58	31.91
Average water content,%	31.75	

E17 Plastic limit test result of TP9 at D= 3.0m

Trial No	1	2
Container No	K2	G3
Mass of container, g	37.5	37.5
Mass of container + wet soil, g	41.6	42.9
Mass of container + dry soil	40.6	41.6
Mass of water, g	1	1.3
Mass of dry soil, g	3.1	4.1
Water content,%	32.26	31.71
Average water content,%	31.98	

E18 Plastic limit test result of TP10 at D= 1.5m

Trial No	1	2
Container No	63	M2
Mass of container, g	37.6	37.7
Mass of container + wet soil, g	43	46
Mass of container + dry soil, g	41.7	43.9
Mass of water, g	1.3	2.1
Mass of dry soil, g	4.1	6.2
Water content,%	31.71	33.87
Average water content,%	32.79	

E19 Plastic limit test result of TP10 at D= 3.0m

Trial No	1	2
Container No	G3	T1
Mass of container, g	37.7	37.5
Mass of container + wet soil, g	44	42.6
Mass of container + dry soil, g	42.5	41.4
Mass of water, g	1.5	1.2
Mass of dry soil, g	4.8	3.9
Water content,%	31.25	30.77
Average water content,%	31.01	

Appendix F Natural moisture content test results

F1 Natural moisture content test result of TP1 at D=1.5m

Container No	A1	K2
Mass of container, g	37.4	37.6
Mass of container + wet soil, g	105.3	97.8
Mass of container + dry soil, g	87.2	82.4
Mass of water, g	18.1	15.4
Mass of dry soil, g	49.8	44.8
Water content,%	36.35	34.38
Average water content,%	35.36	

F2 Natural moisture content test result of TP1 at D=3.0m

Container No	T1	13
Mass of container, g	37.5	37.1
Mass of container + wet soil, g	94.9	102.6
Mass of container + dry soil, g	78.5	84.5
Mass of water, g	16.4	18.1
Mass of dry soil, g	41	47.4
Water content,%	40.00	38.19
Average water content,%	39.09	

F3 Natural moisture content test result of TP2 at D=1.0m

Container No	B9	K2
Mass of container, g	37.6	37.6
Mass of container + wet soil, g	130	113.6
Mass of container + dry soil, g	109.2	99.6
Mass of water, g	20.8	14
Mass of dry soil, g	71.6	62
Water content,%	29.05	22.58
Average water content,%	25.82	

F5 Natural moisture content test result of TP3 at D=1.5m

Container No	Z2	64
Mass of container, g	37.5	37.4
Mass of container + wet soil, g	81.4	96.8
Mass of container + dry soil, g	70.2	80.7
Mass of water, g	11.2	16.1
Mass of dry soil, g	32.7	43.3
Water content,%	34.25	37.18
Average water content,%	35.72	

F6 Natural moisture content test result of TP3 at D=3.0m

Container No	Y	F1
Mass of container, g	37.2	37.7
Mass of container + wet soil, g	94.7	93.8
Mass of container + dry soil, g	79.8	80.6
Mass of water, g	14.9	13.2
Mass of dry soil, g	42.6	42.9
Water content,%	34.98	30.77
Average water content,%	32.87	

F7 Natural moisture content test result of TP4 at D=1.5m

Container No	A1	K4
Mass of container, g	37.4	37.6
Mass of container + wet soil, g	84.2	114.4
Mass of container + dry soil, g	74	97.8
Mass of water, g	10.2	16.6
Mass of dry soil, g	36.6	60.2
Water content,%	27.87	27.57
Average water content,%	27.72	

F8 Natural moisture content test result of TP4 at D=3.0m

Container No	K	A2
Mass of container, g	37.6	37.6
Mass of container + wet soil, g	85.2	115.6
Mass of container + dry soil, g	74.4	98.6
Mass of water, g	10.8	17
Mass of dry soil, g	36.8	61
Water content,%	29.35	27.87
Average water content,%	28.61	

F9 Natural moisture content test result of TP5 at D=1.5m

Container No	T5	3
Mass of container, g	37.2	37.6
Mass of container + wet soil, g	97.4	137.8
Mass of container + dry soil, g	82.4	113
Mass of water, g	15	24.8
Mass of dry soil, g	45.2	75.4
Water content,%	33.19	32.89
Average water content,%	33.04	

F10 Natural moisture content test result of TP5 at D=3.0m

Container No	A12	A2
Mass of container, g	37	37.2
Mass of container + wet soil, g	123	107.4
Mass of container + dry soil, g	103.2	91.2
Mass of water, g	19.8	16.2
Mass of dry soil, g	66.2	54
Water content,%	29.91	30.00
Average water content,%	29.95	

F11 Natural moisture content test result of TP6 at D=1.5m

Container No	T6	16
Mass of container, g	37.6	37.2
Mass of container + wet soil, g	106.8	110.7
Mass of container + dry soil, g	91.2	93.8
Mass of water, g	15.6	16.9
Mass of dry soil, g	53.6	56.6
Water content,%	29.10	29.86
Average water content,%	29.48	

F12 Natural moisture content test result of TP6 at D=3.0m

Container No	A2	62
Mass of container, g	37.2	37.6
Mass of container + wet soil, g	100.5	87.4
Mass of container + dry soil, g	81.8	73.2
Mass of water, g	18.7	14.2
Mass of dry soil, g	44.6	35.6
Water content,%	41.93	39.89
Average water content,%	40.91	

F13 Natural moisture content test result of TP7 at D=1.5m

Container No	N2	Z2
Mass of container, g	37.1	37.4
Mass of container + wet soil, g	91.6	87.5
Mass of container + dry soil, g	79.5	76.4
Mass of water, g	12.1	11.1
Mass of dry soil, g	42.4	39
Water content,%	28.54	28.46
Average water content,%	28.50	

F14 Natural moisture content test result of TP7 at D=3.0m

Container No	R1	G1
Mass of container, g	37.6	37
Mass of container + wet soil, g	77.8	84.3
Mass of container + dry soil, g	68.9	74.1
Mass of water, g	8.9	10.2
Mass of dry soil, g	31.3	37.1
Water content,%	28.43	27.49
Average water content,%	27.96	

F15 Natural moisture content test result of TP8 at D=1.5m

Container No	13	A2
Mass of container, g	37.2	37.6
Mass of container + wet soil, g	79	95.5
Mass of container + dry soil, g	70	83.4
Mass of water, g	9	12.1
Mass of dry soil, g	32.8	45.8
Water content,%	27.44	26.42
Average water content,%	26.93	

F16 Natural moisture content test result of TP8 at D=3.0m

Container No	K2	K4
Mass of container, g	37.6	37.6
Mass of container + wet soil, g	68.5	82.4
Mass of container + dry soil, g	61.7	72.4
Mass of water, g	6.8	10
Mass of dry soil, g	24.1	34.8
Water content,%	28.22	28.74
Average water content,%	28.48	

F17 Natural moisture content test result of TP9 at D=1.5m

Container No	Z1	Z2
Mass of container, g	37.6	37.6
Mass of container + wet soil, g	102.4	88.7
Mass of container + dry soil, g	87.3	76.5
Mass of water, g	15.1	12.2
Mass of dry soil, g	49.7	38.9
Water content,%	30.38	31.36
Average water content,%	30.87	

F18 Natural moisture content test result of TP9 at D=3.0m

Container No	V3	V2
Mass of container, g	37.2	37.6
Mass of container + wet soil, g	90.1	82.4
Mass of container + dry soil, g	77.3	71.3
Mass of water, g	12.8	11.1
Mass of dry soil, g	40.1	33.7
Water content,%	31.92	32.94
Average water content,%	32.43	

F19 Natural moisture content test result of TP10 at D=1.5m

Container No	A12	C7
Mass of container, g	37	37.6
Mass of container + wet soil, g	120.3	108.7
Mass of container + dry soil, g	102.5	92.8
Mass of water, g	17.8	15.9
Mass of dry soil, g	65.5	55.2
Water content,%	27.18	28.80
Average water content,%	27.99	

F20 Natural moisture content test result of TP10 at D=3.0m

Container No	13	T5
Mass of container, g	37.2	37.2
Mass of container + wet soil, g	91	81.7
Mass of container + dry soil, g	78.5	70.9
Mass of water, g	12.5	10.8
Mass of dry soil, g	41.3	33.7
Water content,%	30.27	32.05
Average water content,%	31.16	

Appendix G Specific gravity test results

G1 Specific gravity test result of TP1 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	57.9	55.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.9	80.6
Weight of density bottle + dry soil +water(gm)	173.6	171.2
Weight of density bottle + water (gm)	157.9	155.6
Volume of sample (cc)	9.3	9.4
Temperature, °c	24	24
Specific gravity	2.686	2.657
Average specific gravity	2.67	

G2 Specific gravity test result of TP1 at D=3.0m

Density bottle number	3	4
Weight of empty , clean density bottle (gm)	57.3	54.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.3	79.6
Weight of density bottle + dry soil +water(gm)	172.8	170
Weight of density bottle + water (gm)	157.3	154.6
Volume of sample	9.5	9.6
Temperature, °c	24	24
Specific gravity	2.629	2.602
Average specific gravity	2.62	

G3 Specific gravity test result of TP2 at D=1m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	56.8	58.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	81.8	83.6
Weight of density bottle + dry soil +water(gm)	172.4	174.1
Weight of density bottle + water (gm)	156.9	158.6
Volume of sample (cc)	9.5	9.5
Temperature, °c	24	24
Specific gravity	2.629	2.629
Average specific gravity	2.63	

G4 Specific gravity test result of TP2 at D=3m

Density bottle number	3	4
Weight of empty , clean density bottle (gm)	57.9	55.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.9	80.6
Weight of density bottle + dry soil +water(gm)	173.7	171.5
Weight of density bottle + water (gm)	157.9	155.6
Volume of sample (cc)	9.2	9.1
Temperature, °c	25.5	25.5
Specific gravity	2.714	2.744
Average specific gravity	2.73	

G5 Specific gravity test result of TP3 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	56.8	58.6
Weight of sample(gm)	25	25
Weight of empty density bottle + dry soil (gm)	81.8	83.6
Weight of density bottle + dry soil +water(gm)	172.7	174.4
Weight of density bottle + water (gm)	156.9	158.6
Volume of sample (cc)	9.2	9.2
Temperature, °c	26	26
Specific gravity	2.714	2.714
Average specific gravity	2.71	

G6 Specific gravity test result of TP3 at D=3.0m

Density bottle number	3	4
Weight of empty , clean density bottle (gm)	57.3	54.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.3	79.6
Weight of density bottle + dry soil +water(gm)	173.1	170.5
Weight of density bottle + water (gm)	157.3	154.6
Volume of sample (cc)	9.2	9.1
Temperature, °c	25.5	25.5
Specific gravity	2.714	2.744
Average specific gravity	2.73	

G7 Specific gravity test result of TP4 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	56.8	58.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	81.8	83.6
Weight of density bottle + dry soil +water(gm)	172.8	174.5
Weight of density bottle + water (gm)	156.9	158.6
Volume of sample (cc)	9.1	9.1
Temperature, °c	25.5	25.5
Specific gravity	2.744	2.744
Average specific gravity	2.74	

G8 Specific gravity test result of TP4 at D=3.0m

Density bottle number	3	4
Weight of empty , clean density bottle (gm)	57.9	55.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.9	80.6
Weight of density bottle + dry soil +water(gm)	173.9	171.5
Weight of density bottle + water (gm)	157.9	155.6
Volume of sample (cc)	9	9.1
Temperature, °c	25.5	25.5
Specific gravity	2.774	2.744
Average specific gravity	2.76	

G9 Specific gravity test result of TP5 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	57.9	55.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.9	80.6
Weight of density bottle + dry soil +water(gm)	174.1	171.6
Weight of density bottle + water (gm)	158	155.7
Volume of sample (cc)	8.9	9.1
Temperature, °c	26	25.5
Specific gravity	2.805	2.744
Average specific gravity	2.77	

G10 Specific gravity test result of TP5 at D=3.0m

Density bottle number	3	4
Weight of empty , clean density bottle (gm)	57.9	55.6
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.9	80.6
Weight of density bottle + dry soil +water(gm)	174	171.7
Weight of density bottle + water (gm)	158	155.7
Volume of sample (cc)	9	9
Temperature, °c	26	26
Specific gravity	2.774	2.774
Average specific gravity	2.77	

G11 Specific gravity test result of TP6 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	54.6	56.8
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	79.6	81.8
Weight of density bottle + dry soil +water(gm)	170.9	173.2
Weight of density bottle + water (gm)	154.7	156.9
Volume of sample (cc)	8.8	8.7
Temperature, °c	25.5	26
Specific gravity	2.837	2.870
Average specific gravity	2.85	

G12 Specific gravity test result of TP6 at D=3.0m

Density bottle number	3	4
Weight of empty , clean density bottle (gm)	54.6	56.8
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	79.6	81.8
Weight of density bottle + dry soil +water(gm)	171	173.1
Weight of density bottle + water (gm)	154.8	157
Volume of sample (cc)	8.8	8.9
Temperature, °c	25.5	25.5
Specific gravity	2.837	2.805
Average specific gravity	2.82	

G13 Specific gravity test result of TP7 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	57.8	55.5
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.8	80.5
Weight of density bottle + dry soil +water(gm)	173.9	171.5
Weight of density bottle + water (gm)	158	155.8
Volume of sample (cc)	9.1	9.3
Temperature, °c	23	23
Specific gravity	2.745	2.686
Average specific gravity	2.72	

G14 Specific gravity test result of TP7 at D=3.0m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	57.8	55.5
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.8	80.5
Weight of density bottle + dry soil +water(gm)	173.8	171.7
Weight of density bottle + water (gm)	158	155.8
Volume of sample (cc)	9.2	9.1
Temperature, °c	23	23
Specific gravity	2.715	2.745
Average specific gravity	2.73	

G15 Specific gravity test result of TP8 at D=1.5m

Density bottle number	4	5
Weight of empty , clean density bottle (gm)	54.6	56.9
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	79.6	81.9
Weight of density bottle + dry soil +water(gm)	170.9	174.6
Weight of density bottle + water (gm)	154.7	158.6
Volume of sample (cc)	8.8	9
Temperature, °c	23	23
Specific gravity	2.839	2.758
Average specific gravity	2.80	

G16 Specific gravity test result of TP8 at D=3.0m

Density bottle number	4	5
Weight of empty , clean density bottle (gm)	54.6	56.9
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	79.6	81.9
Weight of density bottle + dry soil +water(gm)	170.9	174.7
Weight of density bottle + water (gm)	154.7	158.6
Volume of sample (cc)	8.8	8.9
Temperature, °c	23	23
Specific gravity	2.839	2.807
Average specific gravity	2.82	

G17 Specific gravity test result of TP9 at D=1.5m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	57.8	55.5
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.8	80.5
Weight of density bottle + dry soil +water(gm)	173.9	171.6
Weight of density bottle + water (gm)	158	155.8
Volume of sample (cc)	9.1	9.2
Temperature, °c	23	23
Specific gravity	2.745	2.715
Average specific gravity	2.73	

G18 Specific gravity test result of TP9 at D=3.0m

Density bottle number	4	5
Weight of empty , clean density bottle (gm)	54.6	56.9
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	79.6	81.9
Weight of density bottle + dry soil +water(gm)	170.8	173.2
Weight of density bottle + water (gm)	154.8	157
Volume of sample (cc)	9	8.8
Temperature, °c	23	23
Specific gravity	2.776	2.839
Average specific gravity	2.81	

G19 Specific gravity test result of TP10 at D=1.5m

Density bottle number	4	5
Weight of empty , clean density bottle (gm)	54.6	56.9
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	79.6	81.9
Weight of density bottle + dry soil +water(gm)	170.6	172.7
Weight of density bottle + water (gm)	154.8	157
Volume of sample (cc)	9.2	9.3
Temperature, °c	23	23
Specific gravity	2.715	2.686
Average specific gravity	2.70	

G20 Specific gravity test result of TP10 at D=3.0m

Density bottle number	1	2
Weight of empty , clean density bottle (gm)	57.8	55.5
Weight of sample (gm)	25	25
Weight of empty density bottle + dry soil (gm)	82.8	80.5
Weight of density bottle + dry soil +water(gm)	174	171.8
Weight of density bottle + water (gm)	158	155.8
Volume of sample (cc)	9	9
Temperature, °c	23	23
Specific gravity	2.776	2.776
Average specific gravity	2.78	

Appendix H Free swell test results

H1 Free swell test result of TP1 at D=1.5m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	19.9	20	19.95	99.5

H2 Free swell test result of TP1 at D=3.0m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	17	17	17	70

H3 Free swell test result of TP2 at D=1.0m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	16.5	17	16.75	67.5

H4 Free swell test result of TP3 at D=1.5m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	14.5	14.25	42.5

H5 Free swell test result of TP3 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	14	14	40

H6 Free swell test result of TP4 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	14.4	14.2	42

H7 Free swell test result of TP4 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	14	14	40

H8 Free swell test result of TP5 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	14.5	14.25	42.5

H9 Free swell test result of TP5 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	13.5	13.5	13.5	35

H10 Free swell test result of TP6 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	12.5	13	12.75	27.5

H11 Free swell test result of TP6 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	13	13	13	30

H12 Free swell test result of TP7 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	16	16	16	60

H13 Free swell test result of TP7 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	16.5	17	16.75	67.5

H14 Free swell test result of TP8 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14.5	14.5	14.5	45

H15 Free swell test result of TP8 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	13.5	13.5	13.5	35

H16 Free swell test result of TP9 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	14.5	14.25	42.5

H17 Free swell test result of TP9 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	13.5	14	13.75	37.5

H18 Free swell test result of TP10 at D=1.5 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	13.5	13.5	13.5	35

H19 Free swell test result of TP10 at D=3.0 m

Initial volume	Final volume			Free swell Index
	Sample one	Sample two	Average	
(cc)	(cc)	(cc)	(cc)	(%)
10	14	15	14.5	45