FOUNDATION ANALYSIS OF SITE PROPOSED FOR TIMES SQUARE, PHASE 8, BAHRIA TOWN, ISLAMABAD

By

Aveen Zahid
Muhammad Danial Sarfraz

Department of Earth and Environmental Sciences Bahria University, Islamabad

2023

FOUNDATION ANALYSIS OF SITE PROPOSED FOR TIMES SQUARE, PHASE 8, BAHRIA TOWN, ISLAMABAD

A thesis submitted to Bahria University, Islamabad in fulfilment of the requirements for the degree of B.S in Geology

By

Aveen Zahid (01-165192-004)
Muhammad Danial Sarfraz (01-165192-009)

Department of Earth and Environmental Sciences

Bahria University, Islamabad

2023

ABSTRACT

The main objective of this study is to determine the bearing capacity of the foundation. A total of 6 boreholes were drilled at different locations to a depth of 100ft using a straight rotatory drilling machine, and soil samples were collected at different depths and sealed in airtight plastic bags. The Standard Penetration Test (SPT) was conducted following ASTM guidelines and rules. Number of tests were conducted in laboratory to assess the geotechnical behavior of the soil samples such as Grain size analysis, Atterberg Limits, Bulk Density and Natural moisture content tests were performed. Bowels equation was employed for the calculation of bearing capacity for different widths i.e., 25ft, 50ft, 75ft, and 100ft, for a safe and cost-effective foundation.

ACKNOWLEDGEMENTS

We extend our heartfelt thanks to Mr. Masood Anwar, Assistant Professor in the Department of Earth & Environmental Sciences at Bahria University Islamabad, for his unwavering support and invaluable guidance throughout this important endeavor.

We would also like to acknowledge and appreciate the contributions of Dr. Said Akbar Khan, the Head of the Department of Earth and Environmental Sciences.

We are deeply grateful to Mr. Yasir, Geophysicist at CMTL, Mr. Muhammad Ali, Lab Engineer at Geoengineers and Mr. Tauseef Project Manager at Geoengineers for generously sharing his time, expertise, and knowledge, which has been instrumental in our progress.

Furthermore, we consider ourselves fortunate to have had the constant presence and support of our parents, who have provided both financial and moral assistance, and played an integral role in the completion of this assignment and our degree program.

CONTENTS

CHAPTER 1
INTRODUCTION

CHAPTER 2
LITREATURE REVIEW

CHAPTER 3
GEOLOGY AND TECTONIC SETTING

CHAPTER 5

RESULTS AND DISCUSSION

FIGURES

TABLES

ABBREVIATONS

ASTM	The American Society of Testing Materials
SPT	Standard Penetration Tool
S	SPT Number
R	Refusal. N>50
CPT	Cone Penetration Test
C	CPT Number
UDS	Undisturbed Sample
FDT	Field Density Test
MDD	Maximum Dry Density
UCS	Unconfined Compressive Strength
DS	Disturbed Sample
GWT	Ground Water Table
BH	Bore Hole
Qa	Allowable Bearing Capacity
GM	Silty Gravel with sand and clay
SM	Silty sand with clay and gravel
NMC	Natural Moisture Content
GED	Geotechnical Engineering Department

CHAPTER 1

INTRODUCTION

1.1. Introduction

Engineering geology is the application of geological information to help in the characterization of construction sites for the planning and design of suitable foundations and consists of strong support, which can be expected to withstand all of the probable loads of the structure which are to be constructed in the future. It helps to identify geological hazards in man-made structures. The foundation of any structure is critical to its stability and safety. Engineering geology is used to determine the type of foundation that is suitable for the specific conditions, taking into consideration the soil and rock properties and the bearing capacity of the ground. The foundation is the lowest part of the building or civil structure that is in direct contact with the soil which transfers the loads from the structure to the soil. To construct a foundation, trenches are dug deeper into the soil till a hard stratum is reached. To get a stronger base a foundation concrete is poured into the trench. These trenches are then incorporated with reinforcement cages to increase the foundation strength. The projected steel rods which are installed and are projected outwards act as a bone and must be connected with the substructure above. Once the foundation has been packed correctly and secured the construction of the building can be started.

1.2. Types of Foundation

The foundation can be classified into two types, shallow foundation, and deep foundation. A shallow foundation transfers the load to the soil present in a shallow depth. The deep foundation transfers the load to a deeper depth below the ground surface.

1.2.1. Shallow Foundation

A shallow foundation is the most common type of foundation for lightweight structures as its depth is low and it is economical. Several types of the shallow foundation include:

1. Raft or Mat Foundation
2. Isolated Spread Footing
3. Strip Footing
4. Combined Footing

1.2.1.1. Raft Foundation

Raft foundations are the type of foundation that is spread across the entire area of the building to support heavy structural loads from the columns and walls. It consists of a tough concrete slab or T-beam slab placed over the entire area of the structure. This is called a raft because the building resembles like a ship that floats on a sea of soil.

Figure 1.1. Raft Foundation.

1.2.1.2. Isolated Spread Footing

Isolated spread footing is the most common type of foundation used for building construction. This foundation is constructed for a single column. They are typically used at shallow depths to spread out the loads by pillars and columns. The shape of the individual footing is square or rectangular. It consists of a foundation located at the base of the segment. They transfer the loads from the columns to the soil.

Figure 1.2. Isolated Spread Footing.

1.2.1.3. Strip Footing

Strip footing is also known as continuous or wall footing. Spread footings are those which consist of base that is wider than other load-bearing wall foundations. The wider the base of this footing more it spreads the weight from the building structure over more area and provides better stability. They are used for individual columns, walls, and bridge piers where the bearing soil layer is within 3m (10 feet) from the ground surface.

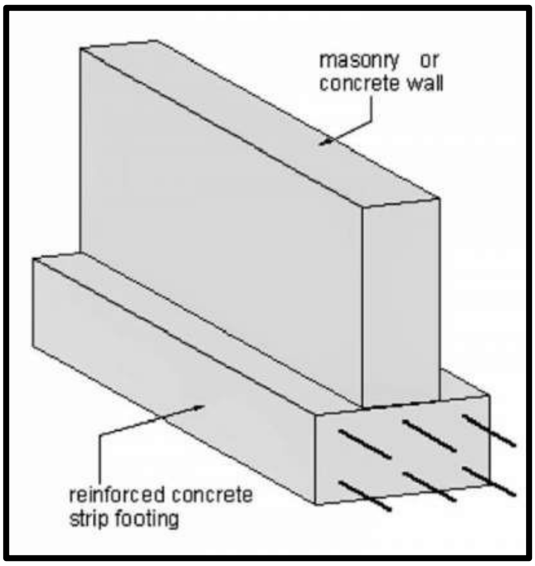

Figure 1.3. Strip Footing.

1.2.1.4. Combined Footing

The combined footing is very similar to the isolated footing. The foundation which consists of more than one column is known as combined footing. They may be square, tee-shaped, or trapezoidal. The main objective is the equal distribution of loads under the entire area of footing, for this it is necessary that the center of gravity of the footing area coincide with the center of gravity of the total loads.

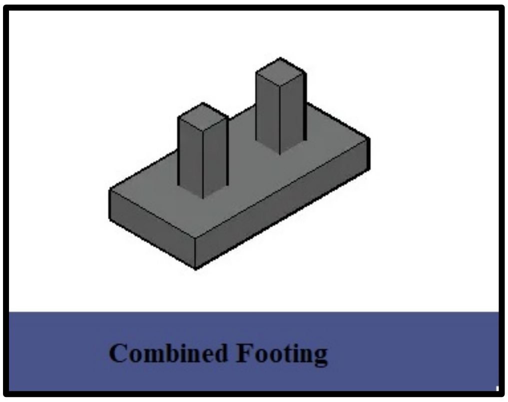

Fig.1.4. Combined Footing.

1.2.2. Deep Foundation

A deep foundation is a type of foundation that is placed at a greater depth below the ground surface and transfers structure loads to the soil at depth. The depth-to-width ratio of such a foundation is usually greater than 4 to 5. Several types of the deep foundation include:

1. Pile Foundation
2. Pier Foundation
3. Caisson Foundation.

1.2.2.1. Pile Foundation

A pile is a common type of deep foundation. They are used to reduce cost, and according to soil conditions, it is desirable to transmit loads to soil strata that shallow foundations cannot support. It is used to transfer foundation loads to deeper soil or rock strata when the bearing capacity of soil at the surface is relatively low. Piles are also used to make structures to resist against uplift and provide stability to the structure against lateral and overturning forces.

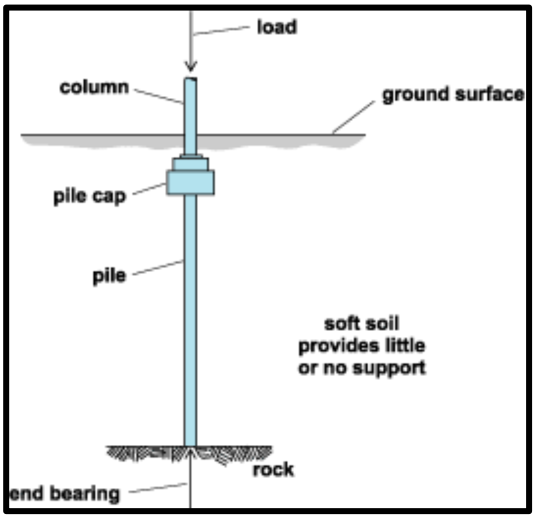

Fig.1.5. Pile Foundation.

1.2.2.2. Pier Foundation

Pier is an underground structure that transmits a massive load, which cannot be carried by shallow foundations. The pier foundation is mostly utilized in multi-story structures. It consists of a cylindrical structure that transfers heavy load from the superstructure to the soil by end bearing. It can only transfer load by bearing and not skin friction.

Pier Foundation is economic when:

- The rock strata lie under a decomposed rock layer at the top.
- When the topsoil is stiff clay that resists driving the bearing pile.
- When a heavy load is to be transferred to the soil.

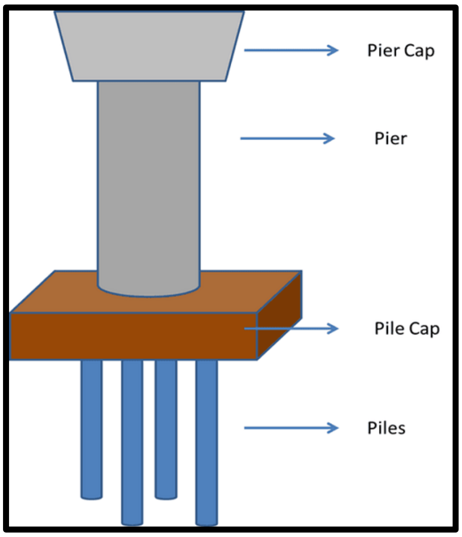

Fig.1.6. Pier Foundation.

1.2.2.3. Caisson Foundation

A caisson foundation is a hollow cylinder which is depressed into the soil up to the desired level and then it is filled with concrete, which converts to a foundation. It is mostly used as bridge piers. Caissons are sensitive, and carefully go through construction procedures with people having construction expertise. The main objective of the foundation is to provide stability to the total structure and safely transfer the total load from the structure to the soil with an ideal cost.

Caisson foundations are economic when:

- The pile cap is not required.
- Noise and vibration are needed to be reduced.
- It has to be placed beneath the water bodies.
- Highly lateral and axial loading capacity is required.

Fig.1.7. Caisson Foundation

1.3. Seismicity of the area

The twin cities district of Rawalpindi and Islamabad is among the most endangered seismic regions in Pakistan. Islamabad Pakistan's capital is surrounded by five significant faults: The Main Boundary Thrust, Kalabagh Fault, Salt Range Thrust, The Jhelum Fault, and The Himalayan Frontal Thrust. Islamabad is located near the Main Boundary Thrust (MBT) fault. On October 8^{th}, 2005 the disastrous Muzaffarabad earthquake shook the city of Islamabad and damaged many high-rise buildings. The seismic hazard in Islamabad is not constant, and it varies from sector to sector with a PGA ranging from 1.35 m/s^2 to 2.54 m/s^2. The F series of the sector is most likely prone to seismic threat and F-11 is seismically the most exposed sector in Islamabad. Earthquakes here could happen at any time, we must remain alert. As Islamabad is an active zone and high-intensity earthquakes can occur at any time due to this reason the authorities were warned against building high-rise buildings.

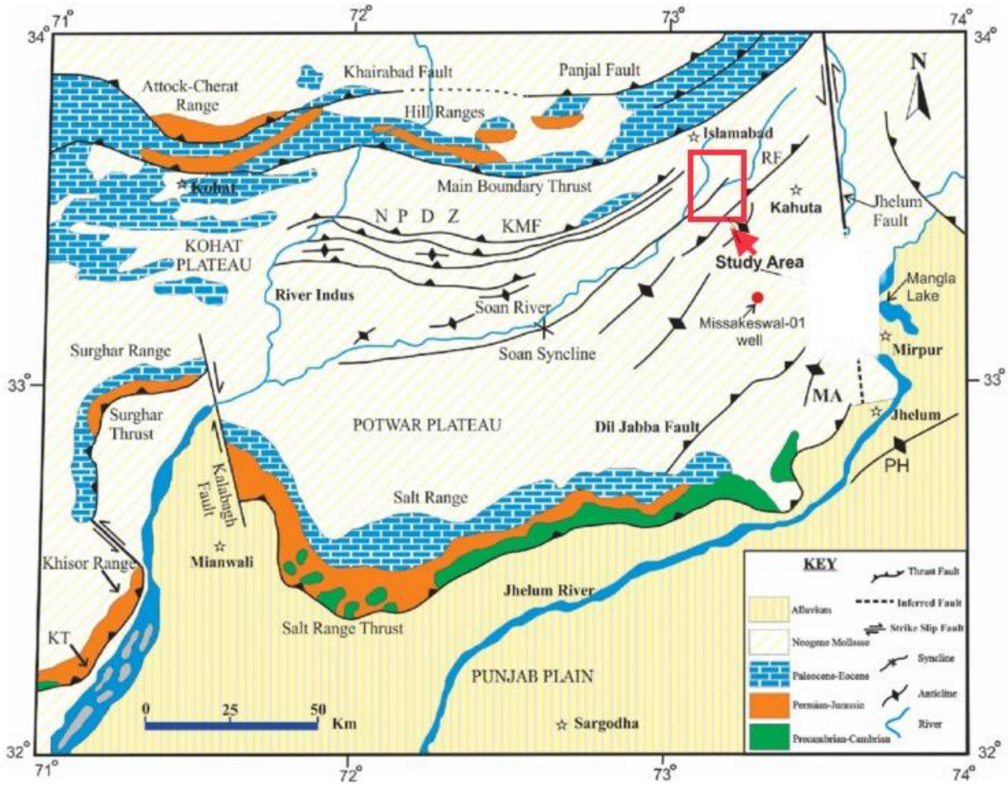

Figure 1.8: Map of the study area.

1.4. Field Objectives

The main fieldwork objectives are:

1. To evaluate the geological conditions of the construction site.
2. To calculate the bearing capacity of the foundation.

1.5. Methodology

The main objectives for research work include borehole drilling and digging of disturbed and undisturbed samples, Standard Penetration Test (SPT) was performed for field testing. Some other tests were also performed in the laboratory includes, including Atterberg limits, sieve analysis, and liquid and plasticity limits, bulk density and natural moisture content. By observing and discussing the results, we drafted out the results by which the bearing capacity of the foundation was known.

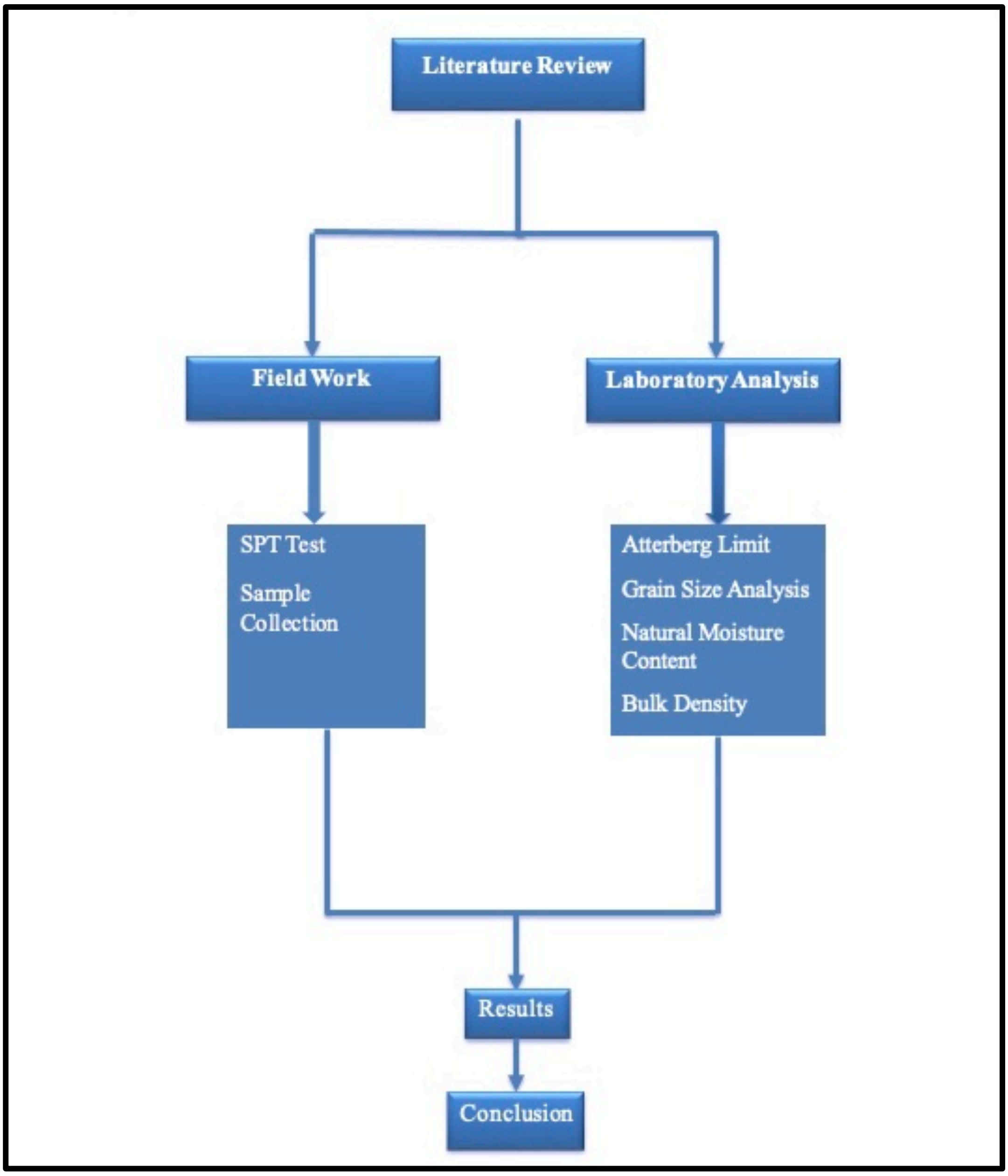

Figure 1.9: Methodology.

CHAPTER 2

LITREATURE REVIEW

2.1 History

The first human use of soil and rock as engineering materials is lost in the distant past. Neanderthal or his predecessors were the first to recognize the advantage of structural engineering as they used a log to bridge a stream, but at that time the most effort probably was made on simply staying alive. As glaciers started to melt, climatic changes raised lake levels, so people of the early Iron Age supported their lakeside dwellings on piles. Paved highways existed in Egypt for several thousand years (B.C.E), and they were mostly used by the pyramid builders for transportation of the construction material. Ancient engineers came across and solved many practical problems in soil engineering, based on experience, trial, and error. (Handy, R.L., 2007)

In Early literature, A French military engineer named Vauban in 1687, set forth practical rules and formulas for the design and construction of revetments to withstand the lateral soil pressures. In 1691 Bullet, of the French Royal Academy of Architecture, presented the first theory of lateral earth pressures which were based on the principles of mechanics. He also introduced the concept of a ‘‘sliding wedge’’ of soil against a retaining wall. (Handy, R.L., 2007)

A nineteenth-century contribution that became extremely useful in modern soil engineering was the solution by a mathematician, Boussinesq. By the use of elastic analysis, in 1885 he showed that stresses from a point load on the surface of the soil should disappear in three-dimensional space very much like ripples made from a stone thrown in water. Although soil is far from being an ideal elastic material, but the pressure measurements indicate that the Boussinesq solution is appropriate for determining pressures from the foundation and for computing lateral pressures on retaining walls from loads applied at the surface of the soil backfill. (Handy, R.L., 2007)

In 1911 a Swedish scientist, Atterberg, by observing the properties of soil which is being molded in the hands, discovered two simple tests to determine the moisture contents through which soil exhibits its plasticity characteristics. These tests for the liquid limit and plastic limit for the soil, now form the basis for engineering classification systems of soils. (Handy, R.L., 2007)

Karl Terzaghi conducted deep research on a variety of soil problems and the he proposed the term “Erdbaumechnaik” (soil mechanics) in 1925. Terghazi proposed a theory for friction in soils whose principle are now used in mechanical engineering. He also devised and constructed the first cosolidometer, a device that is now common in soil mechanics laboratories. (Handy, R.L., 2007)

Proctor in 1933, defined modern principles of soil compaction by showing a relationship between compaction energy, moisture content, and density of compacted soil. Now its tests are used in the construction of virtually all soil structures.

In the 1920s, Terghazi and Hogentogler both introduced a scheme for soil classification that became the basis for the “AASHTO classification”. (Handy, R.L., 2007)

In the 1940s Arthur Casagrande introduced a soil classification, later named the “Unified Classification” and now used by most foundation engineers. Casagrande also made improvements in the laboratory test, including a mechanical device to measure the liquid limit that is based on the concept cog-wheel invention by Leonardo da Vinci. The device is now standard equipment in all soil mechanics laboratories. (Handy, R.L., 2007)

CHAPTER 3

GEOLOGY AND TECTONIC SETTING

3.1. Geology of Islamabad and Rawalpindi

In Late Permian (around 250 million years ago) and until the Miocene (about 20 million years ago) several continental blocks were broken loose from the margin of Gondwanaland. Then they drifted across the Tethys Ocean and collided with and were accreted to the southern margin of the Eurasian plate.

In Middle Jurassic (170 million years ago), East Gondwana (African plate) separated from West Gondwana (Madagascar, Seychelles, Laxmi Ridge, Antarctica, Australia, and Indian plate). Then in Early Cretaceous (130 million years ago), India separated from Antarctica and Australia, then In Lower Cretaceous, India separated from Madagascar, Laxmi Ridge, and Seychelles and then collided with Kohistan Island Arc.

The acceleration of the Indian plate started towards the Eurasian plate as an Island continent (about 52 million years ago) and then collided with the Eurasian plate by indentation, rotational thrusting, and bending of the Indian plate with the Eurasian plate thus creating the Himalayan Tibetan Orogeny.

The collision of the Indian and Eurasian plates, propelled by the geodynamic forces is the cause of the tectonism and geology in this area. The plates are still in motion and due to these ongoing plate movements, the Himalayas are still rising.

3.2. Geological History

Islamabad consists of sedimentary rocks that are about 150 million years old and contains the geological history of the age from Mid-Jurassic to Quaternary. During this period, marine deposition was more prominent than tectonic activity. In the next 2 to 24 million years continental deposition took place with lower subsidence, then after 2 million years countless erosion and extreme tectonism occurred with minor local deposition. Before the collision between India and Eurasia, Jurassic Age dolomite and limestone were deposited on the continental side of the Indian Plate, which is known to be the oldest rock in this region. Between Chichali and Samana Suk Formations, an unconformity exists which is observed by the gap in the age. Moreover, from the Late Jurassic to Early Cretaceous, the shale consisting of glauconite and sandstone of the Chichali Formation accumulated in an anerobic and chemically reducing environment.

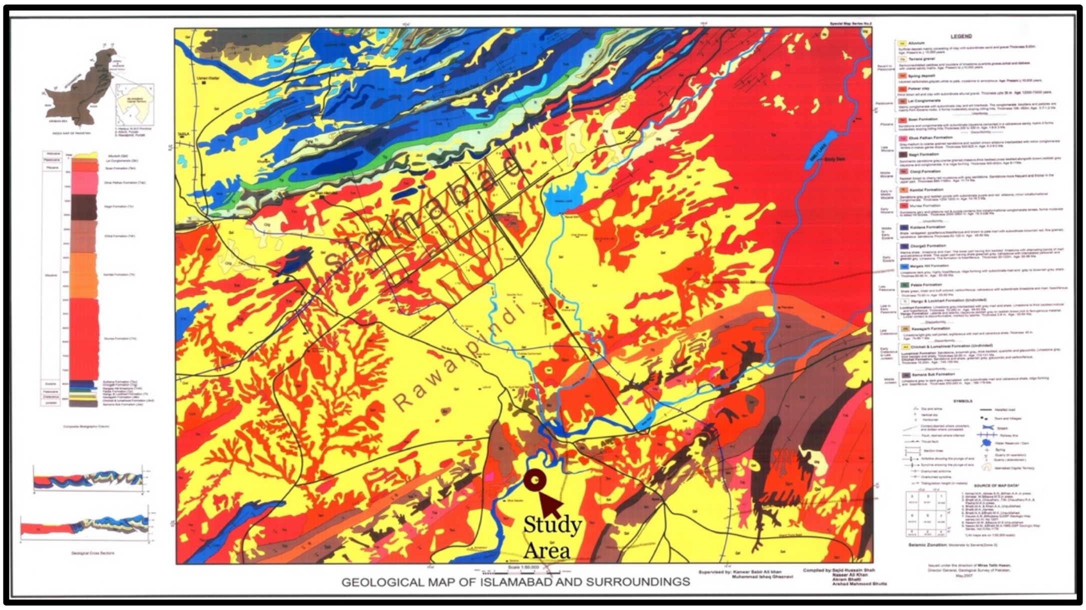

Figure 3.1: Geological Map of study area.

3.3. Stratigraphy

3.3.1. Makarwal Group (Paleocene Age)

3.3.1.1. Hangu Formation

Hangu Formation consist of continental claystone, sandstone and intercalated shale. Claystone and shale range in color from red to brown and greenish grey, thinly laminated to thin bedded. Sandstone is reddish brown to grayish green with intense burrowing observed. The Hangu formation unit is 2 to 8 m thick and it underlies conformably the Lockhart Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.1.2. Lockhart Limestone

Lockhart Formation consist of limestone of marine type with marl and shale. Limestone is light to dark grey in color with thick and fossiliferous beds. Marl consists of grayish black color. Shale is olive gray to greenish grey and consist of weekly developed cleavage. The thickness of Lockhart limestone is 70 to 280 m thick and lies under Patala Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.2. Surghar Group (Lower Cretaceous and Jurassic)

3.3.2.1. Samana Suk Formation

Samana Suk Formation is from Middle Jurassic and consist of limestone with fossils and marl. Limestone is dark gray and yellowish in color. It is medium to thick bedded. Marl is light olive to greenish gray and is thin bedded and splintery. Thickness of the formation ranges from 200-250m. It has unconformable contact with overlying Chichali Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.2.2. Chichali Formation

Chichali formation is from Lower Cretaceous to Jurassic and consist of shale and sandstone. Shale is dark to olive gray color. It is thinly bedded and consists of phosphatic nodules. Sandstone is greenish gray and is thin to medium bedded and is glauconitic. Chichali formation thickness is 34 to 50 m. Underlies the Lumshiwal Formation (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.2.3. Lumshiwal Formation

Lumshiwal Formation is from Lower Cretaceous and consists of sandstone with limestone and shale. Sandstone is dark brown to greenish gray in color with thin to thick bedded and contains quartz. Shale is silty and glauconitic. Limestone is yellowish orange and thin bedded. It Unconformably underlies Hangu Formation. Its thickness is 10-50 m. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.3. Cherat Group (Lower Eocene Age)

3.3.3.1. Margalla Hill Limestone

Margalla Hill Limestone consist of limestone, shale and marl. Limestone is dark to pale gray in color and it is medium to thick bedded. Marl is brownish gray and is firm. Shale is gray with greenish tone and brittle. Thickness ranges from 60 to 90 m. Overlying conformably with Chorgali Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.3.2. Chorgali Formation

Chorgali Formation consist of shale, limestone and marl. Divided into lower and upper parts. Lower part consists of shale that is olive in color and brittle and is interjected with limestone beds and large foraminifers are observed. Upper part consists of limestone which has a gray tint to it. It is thin to medium bedded and fossils can be observed. Marl is light gray color and thin bedded. Its thickness ranges from 30 to 120m. Overlying conformably with Kuldana Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.3.3. Kuldana Formation

Kuldana Formation consist of claystone, marl, limestone and sandstone. Claystone is interjected with gypsum. Marl consists of fibrous gypsum, is thin to medium bedded and is pale gray. Limestone is white to light brown. Sandstone is fined grained and calcareous. Thickness is 60 to 120m. Underlies Murree Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.4. Rawalpindi Group (Miocene Age)

3.3.4.1. Murree Formation

Murree Formation consist of sandstone and claystone. Sandstone is reddish to purplish gray, is thick bedded and is fined to medium grained. Claystone is purple to dark red in color and contains lenses of pseudo conglomerates. Epidote is found in Murree Formation. Its thickness ranges from 2000 to 2895m. Has contact with overlying Kamlial Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.4.2. Kamlial Formation

Kamlial Formation consist of sandstone and claystone. Sandstone is brick red, medium to coarse grained, with thick beds. Measured thickness ranges from 1200 to 1600m. Has Upper contact beneath Chinji Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.5. Siwalik Group (Pleistocene and Neogene)

3.3.5.1. Chinji Formation

Chinji Formation consist of claystone and sandstone. Claystone is brick red in color and is hard, friable. Sandstone is brownish gray color and is medium to thick bedded. Thickness ranges from 880 to 1165m. Its upper contact is conformable with Nagri Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.5.2. Nagri Formation

Nagri Formation consist of sandstone, claystone and conglomerate. It is gray color with medium to coarse grained and thick bedded and salt and pepper pattern is seen due presence of minerals magnetite and ilmenite. Claystone is orange and is sandy and silty. Its thickness ranges from 500 to 900 m. Has contact with overlying Dhok Pathan Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.5.3. Dhok Pathan Formation

Dhok Pathan consist of sandstone and claystone with lenses of conglomerate. Sandstone is fined to medium grained, light gray in color and medium bedded.

Claystone is orange red and firm, compacted. Its measured thickness is 500 to 825m. Overlain by Soan Formation. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.5.4. Soan Formation

Soan Formation consist of conglomerate and interbeds of sandstone, siltstone and claystone. Conglomerates ranges from pebbles to boulders. Sandstone is greenish gray in color and smooth. Claystone is orange color and soft. Its thickness is 200 to 300m. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

3.3.6. Lei Conglomerate (Middle Pleistocene)

Lei Conglomerate is carbonating cemented cobble conglomerate. It is flat-lying but locally folded and faulted. Its thickness is 106 m. Contains 93 percent subangular limestone clasts, 5 percent older sedimentary rocks of Siwaliks Group and 2 percent quartzite. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

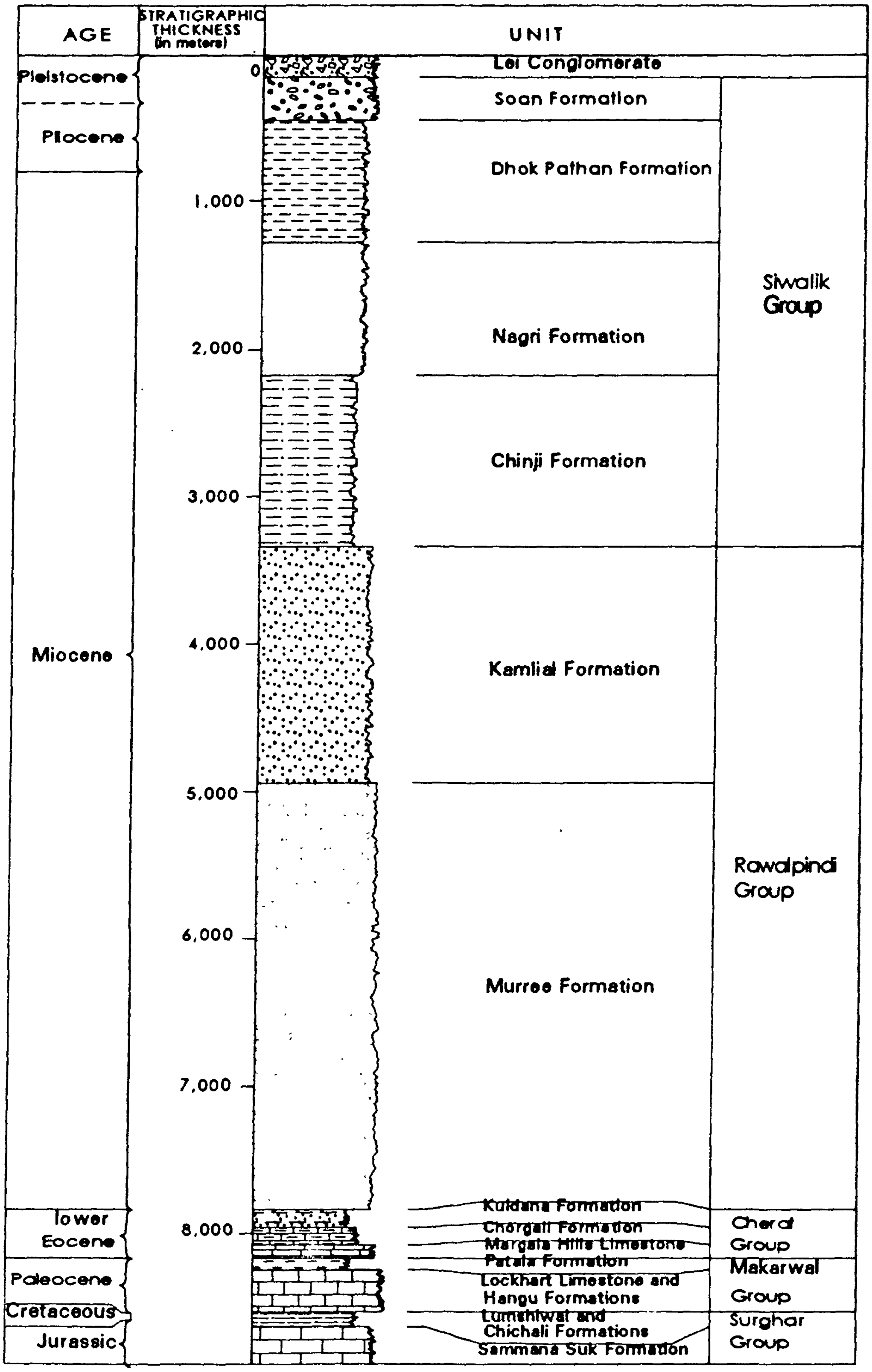

Fig 3.2: Stratigraphic section of Islamabad-Rawalpindi area. (Williams, V.S., Pasha, M.K. and Sheikh, I.M., 1999)

CHAPTER 4
MATERIALS AND METHODS

4.1. Field Investigations

Geotechnical site investigation were performed in the study area, to interpret the geological characteristics of the study area.

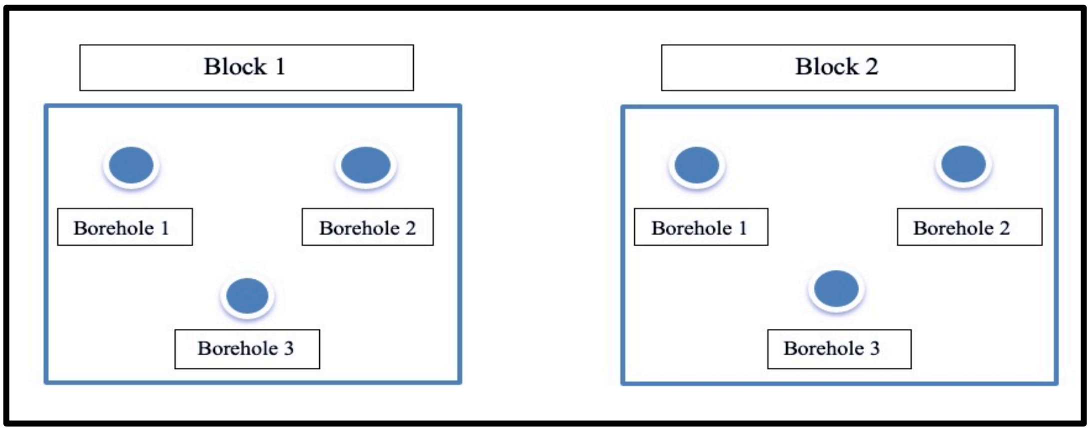

Figure 4.1: Layout of Boreholes of block 1 and 2.

4.1.1. Sequence of the investigation

Following sequence was adopted for investigation

i. Drilling of 3 boreholes in each block (block 1 and 2).
ii. Conduct of Standard Penetration Test (SPT).
iii. Collection of soil samples.

4.2. Standard Penetration Test (ASTM D1586)

Standard Penetration Test (SPT) is used to determine the bearing capacity and relative density of cohesive and non-cohesive soils. It is an economical way of getting sub-surface information. It is used for all kinds of soils.

4.2.1. Equipment Used

i. Hammer of 63.5kg
ii. Split spoon sampler
iii. Shelby Tube
iv. Guiding Rod
v. Drilling Rig
vi. Drilling Head also known as Anvil.

4.2.2. Methodology

A clean borehole is drilled in the ground, Casing is used to support the sides of borehole wall if it is required. Then the drilling tools are removed and split spoon sampler is lowered into the hole with a hammer of 63.5kg with a drop of 750mm from a certain height to have an effective penetration of 150mm, then recorded. The recorded blow count (N Values) is then correlated to different soil properties.

4.2.3. Calculation

Bearing capacity of the foundation can be calculated with Standard penetration test (SPT) and with unconfined compression strength test (UCS). Un drained shear strength of clay from SPT can be calculated with the equation:

Unconfined Compressive Strength $\qquad$ qu(tsf) = 0.125*Ncor;su = qu/2

For sandy, silty sand and fine gravely soil Meyerhof's equation is more useful to calculate the bearing capacity

qa(ksf) = (Ncor/4) (1+1/B) 2*Kd $\qquad$ for B>4ft where Kd = 1+0.33(D/B) should be (=, <) 1.33

In case where gravely soil strata is encountered the bearing capacity is calculated by using the number of blows by using formula

Qa(Ksf) = 0.116 (Ncor) $\qquad$ for B = 3 and 4ft and D/B =1

If the no. of blows are more than 50 the result is taken as refusal and the test is stopped.

4.2.4. Safety Measures

i. The sampler should work.

ii. Borehole has to be clean before performing any test.

iii. The drilling rods must be in good condition, not too long or not too small rods should be used.

iv. Cutting shoe cannot be stopped.

1

2

3

Figure 4.2: Equipment used in SPT Test. (1. Straight Rotatory drilling machine, 2. Split Spoon sampler, 3. Sample from the borehole).

4.3. Lab Testing

After performing on-site geotechnical investigation, the samples taken from borehole were taken to the testing facility for further laboratory analysis. To aid in the engineering characteristics of the underlying strata, tests were performed on the collected samples:

i. Sieve Analysis
ii. Atterberg Limit
iii. Bulk Density
iv. Moisture Content

4.4. Sieve Analysis (ASTM D6913)

For the categorization or distribution of soil, we performed sieve analysis. To conduct this test, the soil samples were first put in the binder for drying. Then the samples were passed through sieves, which are stacked in decreasing order from top to bottom.

No.200 sieve was used, with different other sieve sizes of No.4,10,20,40,60. Then the samples in every sieve are weighed and calculated and the results are plotted on the graph which showed the arrangement of soil samples.

4.4.1. Equipment

i. Scale (or balance) 0.1g accuracy.
ii. Metal pans
iii. A set of sieves, lid and receiver.
iv. Sieve shaker
v. Ceramic mortar and pestle to crush the lumped soil
vi. Binder

4.4.2. Methodology

Take 100g of sample and then place the sample in the binder for 24 hours to dry it. Then take the dried sample, grind the sample into powdered form with mortar and pestle if the soil is combined. Then pass the sample thorough the sieves which are stacked above each other in descending order with larger hole sizes above the smaller hole sizes. At the bottom sieve no.200 is placed. The sieving is conducted by the lateral and vertical motion of the sieves so as to keep the samples moving. Sieves must be cleaned before they are used and soil particles must not be turned by hands through the sieves, a brush is used. After all the samples have passed, the weight of the retained particles is then measured.

4.4.3. Calculation

To find out the overall percentage of passing of soil from each sieve, the percentage of soil that is left on the sieve is calculated. It is calculated by using the overall weight of the soil sample that is used.

% of Soil retained = weight of soil on sieve/weight of total soil * 100

4.4.4. Safety Measures

- **i.** Carefully check all the sieves must be cleaned, no particle should be sticking on the sieves mesh.
- **ii.** The warm samples are not to be used for sieving because it changes the mesh of sieve no 100 and 200.
- **iii.** Too much weight should not be put on the sieves.
- **iv.** It should be taken care that no material is lost during the process of rinsing.
- **v.** A break in the main body of the sieve should be ignored.

4.4.5. Constraints

The sieve analysis is a good method for samples having round or spherical shaped grains, but is not good method for flat or elongated shaped samples. As it is likely to cause an error in the case of sieve no. 100 because the sample requires more shaking process in order to pass out.

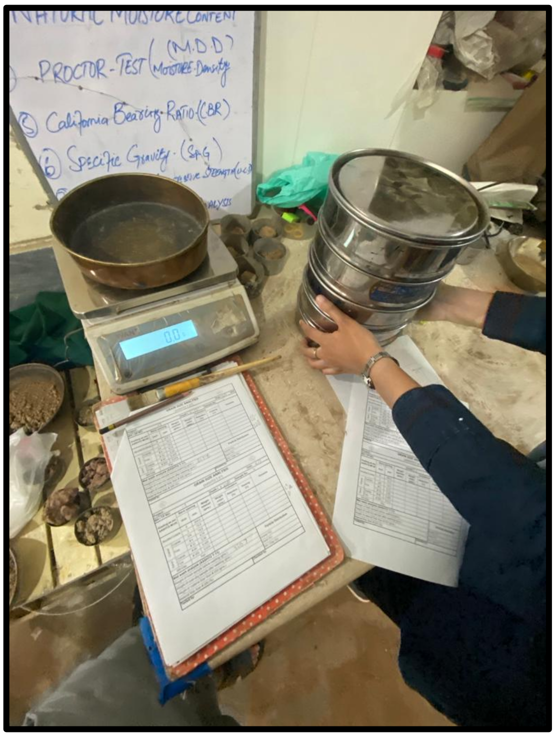

Figure 4.3: Performing Sieve Analysis.

4.5. Atterberg Limit and Plasticity Chart

4.5.1. Atterberg Limit (ASTM D4318)

The Atterberg limit test was introduced by a Swedish chemist Albert Atterberg. He was the first to develop a classification system to determine the moisture content at which fined grained clays and silt soils transition between different phases. This test is used to distinguish between silt and clay in its different type and determines the Plastic Limit (PL) and Liquid Limit (LL) of the soil sample. It is performed on the soil sample that will pass through sieve no.40 as per ASTM D 4318-00. The soil is of four types, depending on the moisture content:

Solid, Semi-solid, Plastic and Liquid. As per definition, Plastic Limit is the level of moisture content at which the fined-grained soil cannot be remolded without cracking and Liquid Limit is the moisture content point at which the soil enters the liquid phase. The test is used in the classification of soil and to determine its plasticity characteristics and evaluates the shrink/swell of the soil. Theses limit can be identified by:

- **i.** Plastic Limit Test.
- **ii.** Liquid Limit Test.

4.5.2. Plastic Limit Test (ASTM D4318)

- **Instruments**

a. Porcelain dish

b. Spatula

c. Glass Surface for rolling

d. Balance

e. Drying oven

f. Sieve no.40 with pan.

- **Methodology**

To perform the test, the soil is taken in a dish and mixed with water until the soil becomes soft enough to be shaped into a ball. Then roll the soil with fingers or palm on the glass plate with sufficient pressure to roll the sample into threads in 90 strokes per minute. Continue this rolling to a thread of 3mm until the cracks start to appear, after which it stops rolling. The sample is then weighed to determine the amount of moisture content and the amount of water is determined for each trial after the can is in the binder for 17 hours.

- **Constraints**

This test is performed to find out the liquid limitation, but it reduces or eliminates the soils natural bonding capacity. Which makes it impossible to identify it.

4.5.3. Liquid Limit Test (ASTM D4318)

- **Instruments**

a. Porcelain dish

b. Spatula

c. Grooving tool

d. Balance

e. Liquid limit apparatus

f. Drying oven

- **Methodology**

Take a sample of about 100g and pass it through the no.40 sieve, then mix it with distilled water to make a uniform paste of hard consistency. Then adequate amount of this paste is placed in the Casagrande cup and spread it to a depth of 10mm. Then the soil paste in the cup of the device is divided with a groove with the help of a grooving tool, whose thickness was around 12mm. Then the cup containing the prepared sample will be lifted and dropped by the turning lever at a rate of two revolutions per second until the groove is closed. The number of blows that closes the groove are recorded. Then a sample is taken to determine the moisture content and then the can is put in the binder for 17 hours. The procedure is repeated with the remaining soil in the cup and number of blows are recorded to determine the moisture content.

- **Safety Measures**

i. The apparatus shall be wash and dried for the preparation of the next trial.

ii. Counting of blows has to be counted only till the groove is closed.

Figure 4.4: Casagrande cup experiment for Liquid limit test.

4.6. Bulk Density Test (ASTM D7263)

Bulk Density is the weight of a soil sample per unit volume. It depends on the organic matter present in the soil, soil texture, density of soil minerals and their packing arrangement.

- **Instruments**
  1. A cylindrical steel core cutter.
  2. Steel dolly.
  3. 10 kg steel mallet or sledgehammer.
  4. Balance.
  5. Drying Oven.

- **Methodology**

First expose and clean the soil layer which is to be tested. Then place the steel dolly on top of the cutter and by using the hammer, force the cutter up to few millimeters into the soil surface. The repeat the procedure till desired number of soils samples is obtained. Then dig out the soil sample without disturbing the samples, trim the edges with cutter edge using a spatula. For subsurface soil samples same procedure is applied but after digging a pit up to required depth. Then weigh the cutter having the wet core to nearest gram on the balance. If the soil comes out easily from the cutter, put it in the tray and dry to constant weight at 105C, will take several days to dry. If the soil does not come out of the cutter allow it to dry on the cutter. Weigh the dry soil with cutter and cutter itself separately. Then measure the internal volume of cutter to the nearest 0.5mm.

- **Calculation**

Bulk density is given as ρ = m / V

where,

'ρ' is the bulk density given in mg/m^3

'm' is the mass of the dry soil sample in gram (g), and

'V' is the volume of the core (cm^3)

4.7. Natural Moisture Content (ASTM D4643)

- **Instruments**
  1. Aluminum dishes
  2. Dry oven
  3. Electronic balance.

- **Methodology**

First calculate the weight of the two aluminum dishes. Then put 50g of moist soil in both the dishes than calculate its weight. We will have the moist weight of the soil sample. Dry the soil at 105C overnight in the oven. Then take out the dishes from the oven and allow them to cool. Then weight the dishes with oven dry soil, we will have weight of the dry soil.

- **Calculation**

$$\%\text{ moisture content (MC)} = \frac{\text{weight of moist soil (M)} - \text{weight of dry soil (D)}}{\text{weight of dry soil (D)}}$$

CHAPTER 5
RESULTS AND DISCUSSION

5.1. Results

The following methods were used to investigate the study area:

- Total 6 boreholes were drilled up to depth of 100 feet from existing ground level (EGL) with rotary drilling equipment.
- Performing in-situ testing.
- Collecting rock samples
- Laboratory testing.

5.2. SPT Results

5.2.1. Subsurface Strata

Following is the general stratigraphy of the study area, determined by site investigations and laboratory test.

1. Soft to stiff soil profile was observed and subsoil consist of Clay with some silt and concretions and gravel clayish mudstone.
2. Filling material was not encountered up to 5-16ft at the time of investigation.

5.2.2. Ground Water Table

Water table was 5-7 meters away from drilling site

5.2.3. SPT Logs

In Block 1 the SPT trend of borehole 1 increases from 5 to 30m depth, then the fluctuations are very thin after 30m (almost constant). In borehole 2 the SPT trend increases from 5 to 65m depth, then the trend remains constant after 65m. In borehole 3 the SPT increases from 8 to 65m depth, then it becomes constant after 65m. (Figure:5.1).

In Block 2 the SPT trend of borehole 1 increases from 3 to 30m, after 30m the trend becomes constant. In borehole 2 it increases from 10 to 50 m then becomes constant. In borehole 3 SPT increases from 12 to 40m. (Figure 5.2).

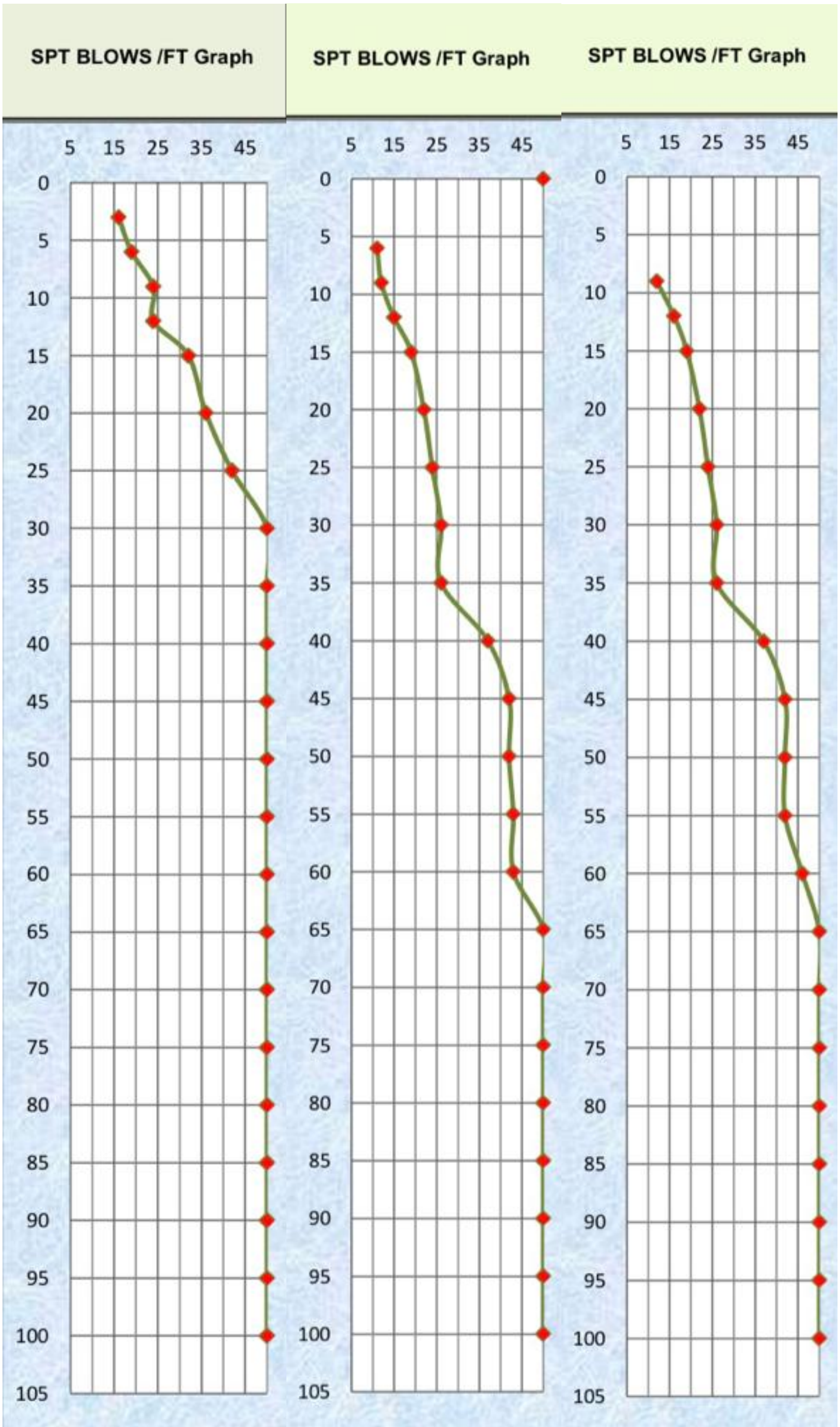

Figure 5.1: Logs showing the SPT results of Borehole 1,2 and 3 of Block 1.

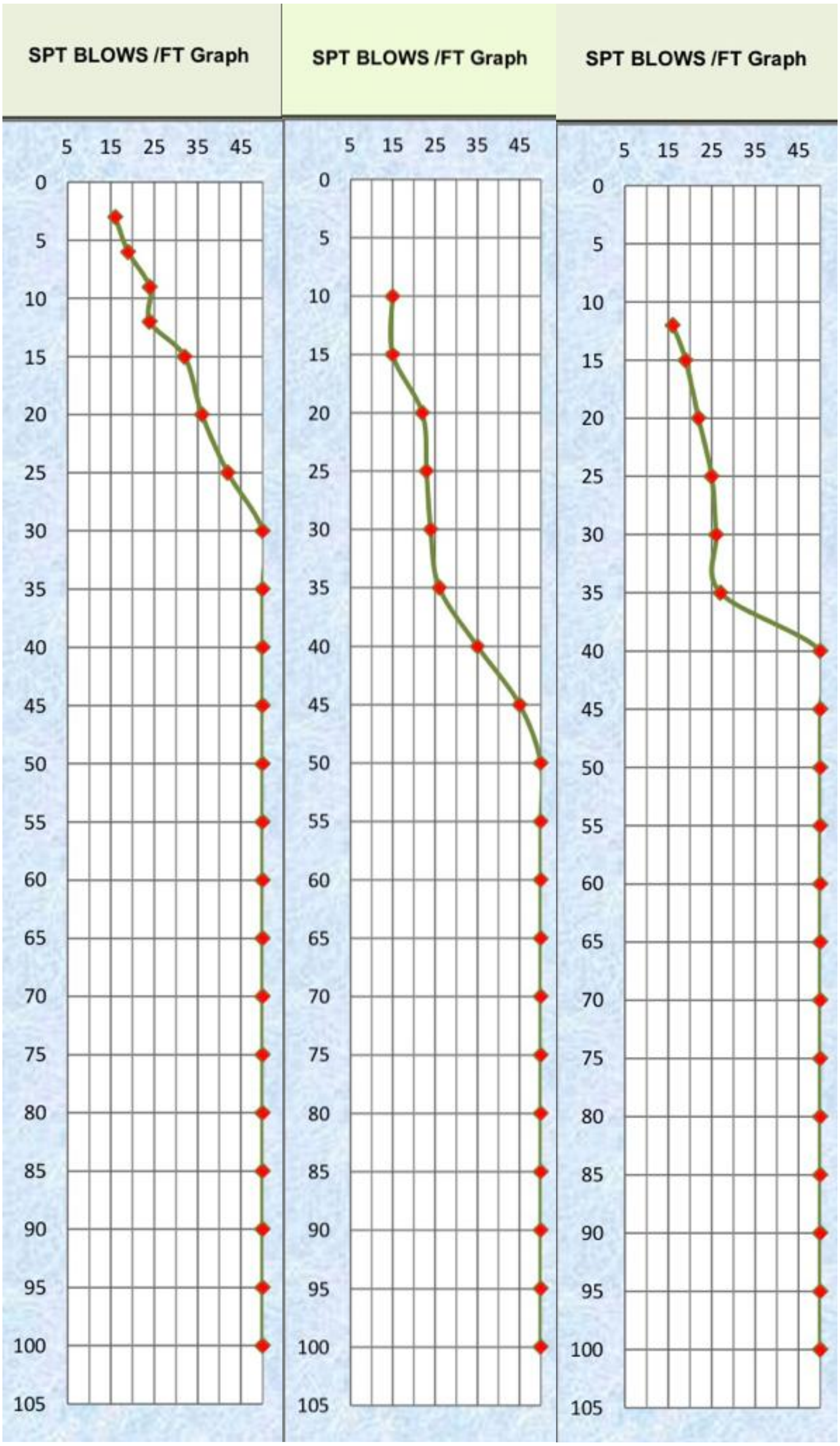

Figure 5.2: Logs showing SPT results of borehole 1, 2 and 3 of Block 2.

5.3. Sieve Analysis (Grain size %), Atterberg limit, Natural Moisture Content and Bulk Density results

5.3.1. Block 1

Bore Hole # 1

Depth (ft)	Blows	Grain Size (%)					Atterberg's Limits			NMC %	Bulk's Density (Pcf)	Classification
	N Value	GRAVELS	SAND	SILTY/CLAY	Friction Angle	Undrain Cohesion	LL.	P.L	P.I			
		%	%	%	ǿ	(Kpa)	(%)	(%)	(%)			
3	Filling upto 4.0 ft Depth											
6	13	2	10	88			30	18	12	--	119.00	CL
9	14	65	11	24			29	18	11	--	127.00	GC
12	16	60	18	22			SAME AS ABOVE			--	128.00	GC
15	18	--	--	--			SAME AS ABOVE			--	-	GC
20	19	--	--	--			SAME AS ABOVE			--	-	GC
25	20	--	--	--			SAME AS ABOVE			--	-	GC
30	24	--	--	--			SAME AS ABOVE			--	-	GC
35	26	--	--	--			SAME AS ABOVE			--	-	GC
40	27	3	19	78			30	19	11	10.00	119.90	CL
45	28	13	5	82			SAME AS ABOVE			9.80	120.50	CL
50	36	--	--	--			SAME AS ABOVE					GC
55	R	--	--	--			SAME AS ABOVE			-	-	GC
60	R	--	--	--			SAME AS ABOVE			-	-	GC
65	R	--	--	--			SAME AS ABOVE			WT	-	GM
70	R	--	--	--			NON PLASTIC			WT	-	GM
75	R	--	--	--			NON PLASTIC			WT	-	GM
80	R	--	--	--			NON PLASTIC			WT	-	GM
85	R	--	--	--			NON PLASTIC			WT	-	GM
90	R	--	--	--			NON PLASTIC			WT	-	GM
95	R	--	--	--			NON PLASTIC			WT	-	GM
100	R	--	--	--			NON PLASTIC			WT	-	GM

Figure 5.3: Block 1 Borehole 1 lab results.

Bore Hole # 2

Depth (ft)	Blows N Value	Grain Size (%) GRAVELS %	SAND %	SILTY/CLAY %	Friction Angle ó	Undrain Cohesion (Kpa)	Atterberg's Limits LL. (%)	P.L (%)	P.I (%)	NMC %	Bulk's Density (Pcf)	Classification
3	Filling upto 5.0 ft Depth											
6	11	2	16	82			30	19	11	8.80	119.00	CL
9	12	13	6	81			SAME AS ABOVE			8.80	119.00	CL
12	15	1	17	82			SAME AS ABOVE			9.20	127.00	CL
15	19	68	13	19			SAME AS ABOVE			9.60	126.00	GC
20	22	4	17	79			SAME AS ABOVE			9.80	126.00	CL
25	24	57	17	26			SAME AS ABOVE			10.20	121.00	GC
30	26	56	20	24			SAME AS ABOVE			10.60	-	GC
35	26	57	18	25			28	18	10	10.80	-	GC
40	37	52	24	24			SAME AS ABOVE			8.50	128.00	GC
45	42	53	24	23			SAME AS ABOVE			8.50	129.00	GC
50	42	48	32	20			SAME AS ABOVE			8.60	-	GC
55	43	52	28	20			SAME AS ABOVE			8.50	-	GC
60	43	68	12	20			SAME AS ABOVE			8.50	-	GC
65	R	69	10	21			SAME AS ABOVE			8.60	-	GC
70	R	68	10	22			SAME AS ABOVE			8.70	-	GC
75	R	67	10	23			SAME AS ABOVE			8.80	-	GC
80	R	68	10	22			SAME AS ABOVE			8.40	-	GC
85	R	67	14	19			SAME AS ABOVE			WT	-	GC
90	R	72	23	5			NON PLASTIC			WT	-	GP-GM
95	R	66	19	15			NON PLASTIC			WT	-	GM
100	R	65	20	15			NON PLASTIC			WT	-	GM

Figure 5.4: Block 1 Borehole 2 lab results.

Bore Hole # 3

Depth (ft)	Blows	Grain Size (%)					Atterberg's Limits			NMC %	Bulk's Density (Pcf)	Classification
	N Value	GRAVELS	SAND	SILTY/CLAY	Friction Angle	Undrain Cohesion	LL.	P.L	P.I			
		%	%	%	ó	(Kpa)	(%)	(%)	(%)			
3	Filling upto 8.0 ft Depth											
6												
9	12	62	15	23			28	18	10	8.70	130.00	GC
12	16	63	13	24			SAME AS ABOVE			8.80	132.00	GC
15	19	69	18	13			28	18	10	8.90	-	GC
20	22	70	15	15			NON PLASTIC			6.50	135.00	GM
25	24	65	11	24			SAME AS ABOVE			6.70	-	GM
30	26	5	15	80			28	18	10	10.20	120.00	CL
35	26	62	12	26			SAME AS ABOVE			-	-	GC
40	37	65	10	25			SAME AS ABOVE			-	-	GC
45	42	66	8	26			SAME AS ABOVE			-	-	GC
50	42	56	19	25			SAME AS ABOVE			-	-	GC
55	42	54	20	26			SAME AS ABOVE			-	-	GC
60	46	68	12	20			SAME AS ABOVE			-	-	GC
65	R	69	13	18			SAME AS ABOVE			-	-	GC
70	R	68	13	19			SAME AS ABOVE			-	-	GC
75	R	67	14	19			SAME AS ABOVE			WT	-	GC
80	R	68	10	22			SAME AS ABOVE			WT	-	GC
85	R	67	17	16			NON PLASTIC			WT	-	GM
90	R	70	13	17			NON PLASTIC			WT	-	GM
95	R	72	12	16			NON PLASTIC			WT	-	GM
100	R	68	16	16			NON PLASTIC			WT	-	GM

Figure 5.5: Block 1 Borehole 3 lab results.

5.3.2. Block 2

Bore Hole # 1

Depth (ft)	Blows	Grain Size (%)					Atterberg's Limits			NMC %	Bulk's Density (Pcf)	Classification
	N Value	GRAVELS	SAND	SILTY/CLAY	Friction Angle	Undrain Cohesion	LL.	P.L	P.I			
		%	%	%	ǿ	(Kpa)	(%)	(%)	(%)			
	Filling upto 6.0 ft Depth											
9	14	65	11	24			26	18	8	6.50	129.00	GC
12	16	60	18	22			SAME AS ABOVE			8.20	-	GC
15	18	--	--	--			SAME AS ABOVE			--	-	CL
20	22	--	--	--			SAME AS ABOVE			--	-	GC
25	26	--	--	--			SAME AS ABOVE			--	-	GC
30	28	--	--	--			SAME AS ABOVE			--	-	GC
35	32	--	--	--			SAME AS ABOVE			--	-	GC
40	33	--	--	--			28	19	9	--	-	GC
45	34	--	--	--			SAME AS ABOVE			--	-	GC
50	42	--	--	--			SAME AS ABOVE			--	-	GC
55	46	--	--	--			SAME AS ABOVE			--	-	GC
60	R	74	11	15			NON PLASTIC			--	134.00	GM
65	R	--	--	--			NON PLASTIC			--	-	GM
70	R	--	--	--			NON PLASTIC			WT	-	GM
75	R	--	--	--			NON PLASTIC			WT	-	GM
80	R	--	--	--			NON PLASTIC			WT	-	GM
85	R	--	--	--			NON PLASTIC			WT	-	GM
90	R	--	--	--			NON PLASTIC			WT	-	GM
95	R	--	--	--			NON PLASTIC			WT	-	GM
100	R	--	--	--			NON PLASTIC			WT	-	GM

Figure 5.6: Block 2 Borehole 1 lab results.

Bore Hole # 2

Depth (ft)	Blows	Grain Size (%)					Atterberg's Limits			NMC %	Bulk's Density (Pcf)	Classification
	N Value	GRAVELS	SAND	SILTY/CLAY	Friction Angle	Undrain Cohesion	LL.	P.L	P.I			
		%	%	%	ó	(Kpa)	(%)	(%)	(%)			
3	Filling upto 8.0 ft Depth											
6												
9												
10	15	58	14	28			28	18	10	8.20	129.00	GC
15	15	-	-	-			SAME AS ABOVE			6.00	130.00	GC
20	22	-	-	-			SAME AS ABOVE			6.50		GC
25	23	-	-	-			29	18	11	7.20	121.00	CL
30	24	-	-	-			SAME AS ABOVE			9.50		GC
35	26	4	16	80			SAME AS ABOVE			-	-	CL
40	35	-	-	-			SAME AS ABOVE			-	-	GC
45	45	-	-	-			SAME AS ABOVE			-	-	GC
50	R	-	-	-			SAME AS ABOVE			-	-	GC
55	R	-	-	-			SAME AS ABOVE			-	-	GC
60	R	-	-	-			SAME AS ABOVE			-	128.50	GC
65	R	-	-	-			SAME AS ABOVE			WT	-	GC
70	R	85	12	3			NON PLASTIC			WT	-	GP-GM
75	R	82	13	5			NON PLASTIC			WT	-	GP-GM
80	R	-	-	-			28	18	10	WT	-	GC
85	R	-	-	-			SAME AS ABOVE			WT	-	GC
90	R	-	-	-			SAME AS ABOVE			WT	-	GC
95	R	-	-	-			SAME AS ABOVE			WT	-	GC
100	R	-	-	-			SAME AS ABOVE			WT	-	GC

Figure 5.7: Block 2 Borehole 2 lab results.

Bore Hole # 3

Depth (ft)	Blows N Value	Grain Size (%) GRAVELS	SAND	SILTY/CLAY	Friction Angle	Undrain Cohesion	Atterberg's Limits LL.	P.L	P.I	NMC %	Bulk's Density (Pcf)	Classification
		%	%	%	ó	(Kpa)	(%)	(%)	(%)			
	Filling upto 11.0 ft Depth											
12	16	53	21	26			26	17	9	9.80	128.00	GC
15	19	52	23	25			SAME AS ABOVE			9.80	127.00	GC
20	22	2	19	79			30	18	12	10.20	120.00	CL
25	25	0	20	80			SAME AS ABOVE			10.60	120.00	CL
30	26	2	18	80			SAME AS ABOVE			10.80	121.00	CL
35	27	65	12	23			SAME AS ABOVE			9.60	129.00	GC
40	R	63	13	24			SAME AS ABOVE			11.50	-	GC
45	R	62	13	25			SAME AS ABOVE			11.50	-	GC
50	R	6	69	25			SAME AS ABOVE			-	-	CL
55	R	58	16	26			SAME AS ABOVE			-	-	GC
60	47	58	16	26			SAME AS ABOVE			13.20	-	GC
65	R	56	19	25			SAME AS ABOVE			WT	-	GC
70	R	75	9	16			NON PLASTIC			WT	-	GM
75	R	75	10	15			NON PLASTIC			WT	133.00	GM
80	R	70	16	14			NON PLASTIC			WT	-	GM
85	R	65	20	15			NON PLASTIC			WT	-	GM
90	R	70	14	16			NON PLASTIC			WT	-	GM
95	R	75	7	18			NON PLASTIC			WT	-	GM
100	R	68	13	19			NON PLASTIC			WT	-	GM

Figure 5.8: Block 2 Borehole 3 lab results.

5.6. Bearing Capacity Analysis

Meyerhof (1976) suggested that SPT may use field observations to determine the bearing capacity. The following is the formula to calculate the ultimate bearing capacity using the SPT method

$Q_x = N/F_1 \times kd$ (Less than 4ft)

$Q_{q=} N_{55}/F_2(B+F_3/B)^2$ kd (Greater than 4ft)

$N_{60} = E_m\, C_B\, C_S\, C_R\, C\, N/0.60$

$N_{60} = 0.60x1\ x1x\ 0.73\ xN/0.60$

$N_{55} = 60/55x(N_{60})$

Qa = Allowable Bearing Capacity

N60 = Corrected N-value

N55 = Corrected N-value

5.6.1. Block 1 Borehole 1 at width 25 ft:

Table 5.1. Block 1 Borehole 1 at width 25 ft:

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	13	10.6	25	1.08	2.67
2	9	14	11.5	25	1.12	2.77
3	12	16	13.1	25	1.16	3.06
4	15	18	14.7	25	1.20	3.32
5	20	19	15.5	25	1.26	3.33
6	25	20	16.4	25	1.33	3.33
7	30	24	19.6	25	1.40	3.80
8	35	26	21.3	25	1.46	3.93
9	40	27	22.1	25	1.53	3.91
10	45	28	22.9	25	1.59	3.89
11	50	36	29.5	25	1.66	4.80
12	55	36	29.5	25	1.73	4.61
13	60	36	29.5	25	1.79	4.44
14	65	36	29.5	25	1.86	4.29
15	70	36	29.5	25	1.92	4.14
16	75	36	29.5	25	1.99	4.00
17	80	36	29.5	25	2.06	3.87
18	85	36	29.5	25	2.12	3.75
19	90	36	29.5	25	2.19	3.64
20	95	36	29.5	25	2.25	3.53
21	100	36	29.5	25	2.32	3.43

5.6.2. Block 1 Borehole 1 at width 50 ft:

Table 5.2. Block 1 Borehole 1 at width 50 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	13	10.6	50	1.04	2.66
2	9	14	11.5	50	1.06	2.81
3	12	16	13.1	50	1.08	3.16
4	15	18	14.7	50	1.10	3.49
5	20	19	15.5	50	1.13	3.57
6	25	20	16.4	50	1.17	3.65
7	30	24	19.6	50	1.20	4.26
8	35	26	21.3	50	1.23	4.49
9	40	27	22.1	50	1.26	4.55
10	45	28	22.9	50	1.30	4.59
11	50	36	29.5	50	1.33	5.76
12	55	36	29.5	50	1.36	5.62
13	60	36	29.5	50	1.40	5.49
14	65	36	29.5	50	1.43	5.36
15	70	36	29.5	50	1.46	5.24
16	75	36	29.5	50	1.50	5.12
17	80	36	29.5	50	1.53	5.01
18	85	36	29.5	50	1.56	4.91
19	90	36	29.5	50	1.59	4.81
20	95	36	29.5	50	1.63	4.71
21	100	36	29.5	50	1.66	4.62

5.6.3. Block 1 Borehole 1 at width 75 ft:

Table 5.3. Block 1 Borehole 1 at width 75 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	13	10.6	75	1.03	2.66
2	9	14	11.5	75	1.04	2.83
3	12	16	13.1	75	1.05	3.19
4	15	18	14.7	75	1.07	3.55
5	20	19	15.5	75	1.09	3.67
6	25	20	16.4	75	1.11	3.78
7	30	24	19.6	75	1.13	4.45
8	35	26	21.3	75	1.15	4.73
9	40	27	22.1	75	1.18	4.82
10	45	28	22.9	75	1.20	4.91
11	50	36	29.5	75	1.22	6.20
12	55	36	29.5	75	1.24	6.09
13	60	36	29.5	75	1.26	5.98
14	65	36	29.5	75	1.29	5.88
15	70	36	29.5	75	1.31	5.78
16	75	36	29.5	75	1.33	5.69
17	80	36	29.5	75	1.35	5.59
18	85	36	29.5	75	1.37	5.50
19	90	36	29.5	75	1.40	5.42
20	95	36	29.5	75	1.42	5.33
21	100	36	29.5	75	1.44	5.25

5.6.4. Block 1 Boreholes 1 at width 100ft:

Table 5.4. Block 1 Borehole 1 at width 100ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	13	10.6	100	1.02	2.66
2	9	14	11.5	100	1.03	2.84
3	12	16	13.1	100	1.04	3.21
4	15	18	14.7	100	1.05	3.58
5	20	19	15.5	100	1.07	3.72
6	25	20	16.4	100	1.08	3.86
7	30	24	19.6	100	1.10	4.56
8	35	26	21.3	100	1.12	4.86
9	40	27	22.1	100	1.13	4.98
10	45	28	22.9	100	1.15	5.09
11	50	36	29.5	100	1.17	6.45
12	55	36	29.5	100	1.18	6.36
13	60	36	29.5	100	1.20	6.27
14	65	36	29.5	100	1.21	6.18
15	70	36	29.5	100	1.23	6.10
16	75	36	29.5	100	1.25	6.02
17	80	36	29.5	100	1.26	5.94
18	85	36	29.5	100	1.28	5.87
19	90	36	29.5	100	1.30	5.79
20	95	36	29.5	100	1.31	5.72
21	100	36	29.5	100	1.33	5.65

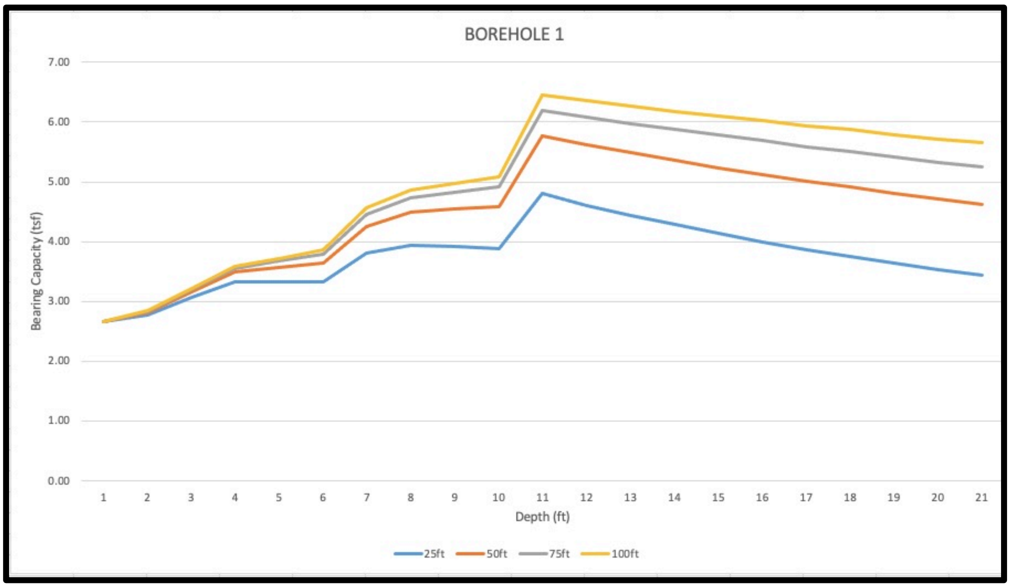

Figure 5.9: Graphical representation of Bearing Capacity of Block 1 Borehole 1 at different depths with width 25, 50, 75, 100 ft.

5.6.5. Block 1 Borehole 2 at width 25 ft:

Table 5.5. Block 1 Borehole 2 at width 25 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	11	9.0	25	1.08	2.26
2	9	12	9.8	25	1.12	2.37
3	12	15	12.3	25	1.16	2.86
4	15	19	15.5	25	1.20	3.51
5	20	22	18.0	25	1.26	3.85
6	25	24	19.6	25	1.33	3.99
7	30	26	21.3	25	1.40	4.12
8	35	26	21.3	25	1.46	3.93
9	40	37	30.3	25	1.53	5.36
10	45	42	34.4	25	1.59	5.83
11	50	42	34.4	25	1.66	5.60
12	55	43	35.2	25	1.73	5.51
13	60	43	35.2	25	1.79	5.31
14	65	43	35.2	25	1.86	5.12
15	70	43	35.2	25	1.92	4.94
16	75	43	35.2	25	1.99	4.78
17	80	43	35.2	25	2.06	4.63
18	85	43	35.2	25	2.12	4.48
19	90	43	35.2	25	2.19	4.35
20	95	43	35.2	25	2.25	4.22
21	100	43	35.2	25	2.32	4.10

5.6.6. Block 1 Borehole 2 at width 50 ft:

Table 5.6. Block 1 Borehole 2 at width 50 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	11	9.0	50	1.04	2.25
2	9	12	9.8	50	1.06	2.41
3	12	15	12.3	50	1.08	2.96
4	15	19	15.5	50	1.10	3.68
5	20	22	18.0	50	1.13	4.14
6	25	24	19.6	50	1.17	4.38
7	30	26	21.3	50	1.20	4.62
8	35	26	21.3	50	1.23	4.49
9	40	37	30.3	50	1.26	6.23
10	45	42	34.4	50	1.30	6.89
11	50	42	34.4	50	1.33	6.72
12	55	43	35.2	50	1.36	6.71
13	60	43	35.2	50	1.40	6.56
14	65	43	35.2	50	1.43	6.40
15	70	43	35.2	50	1.46	6.26
16	75	43	35.2	50	1.50	6.12
17	80	43	35.2	50	1.53	5.99
18	85	43	35.2	50	1.56	5.86
19	90	43	35.2	50	1.59	5.74
20	95	43	35.2	50	1.63	5.62
21	100	43	35.2	50	1.66	5.51

5.6.7. Block 1 Borehole 2 at width 75 ft:

Table 5.7. Block 1 Borehole 2 at width 75ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	11	9.0	75	1.03	2.25
2	9	12	9.8	75	1.04	2.42
3	12	15	12.3	75	1.05	2.99
4	15	19	15.5	75	1.07	3.74
5	20	22	18.0	75	1.09	4.25
6	25	24	19.6	75	1.11	4.54
7	30	26	21.3	75	1.13	4.82
8	35	26	21.3	75	1.15	4.73
9	40	37	30.3	75	1.18	6.61
10	45	42	34.4	75	1.20	7.36
11	50	42	34.4	75	1.22	7.23
12	55	43	35.2	75	1.24	7.27
13	60	43	35.2	75	1.26	7.15
14	65	43	35.2	75	1.29	7.02
15	70	43	35.2	75	1.31	6.90
16	75	43	35.2	75	1.33	6.79
17	80	43	35.2	75	1.35	6.68
18	85	43	35.2	75	1.37	6.57
19	90	43	35.2	75	1.40	6.47
20	95	43	35.2	75	1.42	6.37
21	100	43	35.2	75	1.44	6.27

5.6.8. Block 1 Borehole 2 at width 100 ft:

Table 5.8. Block 1 Borehole 2 at width 100 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	6	11	9.0	100	1.02	2.25
2	9	12	9.8	100	1.03	2.43
3	12	15	12.3	100	1.04	3.01
4	15	19	15.5	100	1.05	3.78
5	20	22	18.0	100	1.07	4.31
6	25	24	19.6	100	1.08	4.63
7	30	26	21.3	100	1.10	4.94
8	35	26	21.3	100	1.12	4.86
9	40	37	30.3	100	1.13	6.82
10	45	42	34.4	100	1.15	7.63
11	50	42	34.4	100	1.17	7.52
12	55	43	35.2	100	1.18	7.59
13	60	43	35.2	100	1.20	7.49
14	65	43	35.2	100	1.21	7.39
15	70	43	35.2	100	1.23	7.29
16	75	43	35.2	100	1.25	7.19
17	80	43	35.2	100	1.26	7.10
18	85	43	35.2	100	1.28	7.01
19	90	43	35.2	100	1.30	6.92
20	95	43	35.2	100	1.31	6.83
21	100	43	35.2	100	1.33	6.75

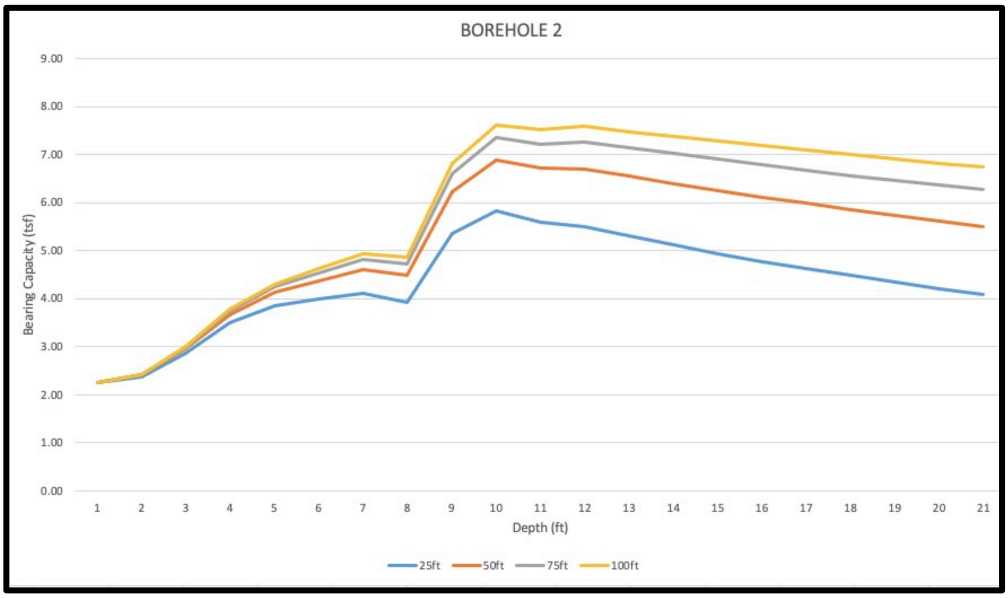

Figure 5.10: Graphical representation of Bearing Capacity of Block 1 Borehole 2 at different depths with width 25, 50, 75, 100 ft.

5.6.9. Block 1 Borehole 3 at width 25 ft:

Table 5.9. Block 1 Borehole 3 at width 25 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	12	9.8	25	1.12	2.37
2	12	16	13.1	25	1.16	3.06
3	15	19	15.5	25	1.20	3.51
4	20	22	18.0	25	1.26	3.85
5	25	24	19.6	25	1.33	3.99
6	30	26	21.3	25	1.40	4.12
7	35	26	21.3	25	1.46	3.93
8	40	37	30.3	25	1.53	5.36
9	45	42	34.4	25	1.59	5.83
10	50	42	34.4	25	1.66	5.60
11	55	42	34.4	25	1.73	5.38
12	60	46	37.6	25	1.79	5.68
13	65	46	37.6	25	1.86	5.48
14	70	46	37.6	25	1.92	5.29
15	75	46	37.6	25	1.99	5.11
16	80	46	37.6	25	2.06	4.95
17	85	46	37.6	25	2.12	4.80
18	90	46	37.6	25	2.19	4.65
19	95	46	37.6	25	2.25	4.52
20	100	46	37.6	25	2.32	4.39

5.6.10. Block 1 Borehole 3 at width 50 ft:

Table 5.10. Block 1 Borehole 3 at width 50ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	12	9.8	50	1.06	2.41
2	12	16	13.1	50	1.08	3.16
3	15	19	15.5	50	1.10	3.68
4	20	22	18.0	50	1.13	4.14
5	25	24	19.6	50	1.17	4.38
6	30	26	21.3	50	1.20	4.62
7	35	26	21.3	50	1.23	4.49
8	40	37	30.3	50	1.26	6.23
9	45	42	34.4	50	1.30	6.89
10	50	42	34.4	50	1.33	6.72
11	55	42	34.4	50	1.36	6.56
12	60	46	37.6	50	1.40	7.01
13	65	46	37.6	50	1.43	6.85
14	70	46	37.6	50	1.46	6.70
15	75	46	37.6	50	1.50	6.55
16	80	46	37.6	50	1.53	6.41
17	85	46	37.6	50	1.56	6.27
18	90	46	37.6	50	1.59	6.14
19	95	46	37.6	50	1.63	6.02
20	100	46	37.6	50	1.66	5.90

5.6.11. Block 1 Borehole 3 at width 75 ft:

Table 5.11. Block 1 Bore hole 3 at width 75 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	12	9.8	75	1.04	2.42
2	12	16	13.1	75	1.05	3.19
3	15	19	15.5	75	1.07	3.74
4	20	22	18.0	75	1.09	4.25
5	25	24	19.6	75	1.11	4.54
6	30	26	21.3	75	1.13	4.82
7	35	26	21.3	75	1.15	4.73
8	40	37	30.3	75	1.18	6.61
9	45	42	34.4	75	1.20	7.36
10	50	42	34.4	75	1.22	7.23
11	55	42	34.4	75	1.24	7.10
12	60	46	37.6	75	1.26	7.64
13	65	46	37.6	75	1.29	7.51
14	70	46	37.6	75	1.31	7.39
15	75	46	37.6	75	1.33	7.26
16	80	46	37.6	75	1.35	7.15
17	85	46	37.6	75	1.37	7.03
18	90	46	37.6	75	1.40	6.92
19	95	46	37.6	75	1.42	6.81
20	100	46	37.6	75	1.44	6.71

5.6.12. Block 1 Borehole 3 at width 100 ft:

Table 5.12. Block 1 Borehole 3 at width 100 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	12	9.8	100	1.03	2.43
2	12	16	13.1	100	1.04	3.21
3	15	19	15.5	100	1.05	3.78
4	20	22	18.0	100	1.07	4.31
5	25	24	19.6	100	1.08	4.63
6	30	26	21.3	100	1.10	4.94
7	35	26	21.3	100	1.12	4.86
8	40	37	30.3	100	1.13	6.82
9	45	42	34.4	100	1.15	7.63
10	50	42	34.4	100	1.17	7.52
11	55	42	34.4	100	1.18	7.42
12	60	46	37.6	100	1.20	8.01
13	65	46	37.6	100	1.21	7.90
14	70	46	37.6	100	1.23	7.80
15	75	46	37.6	100	1.25	7.69
16	80	46	37.6	100	1.26	7.59
17	85	46	37.6	100	1.28	7.50
18	90	46	37.6	100	1.30	7.40
19	95	46	37.6	100	1.31	7.31
20	100	46	37.6	100	1.33	7.22

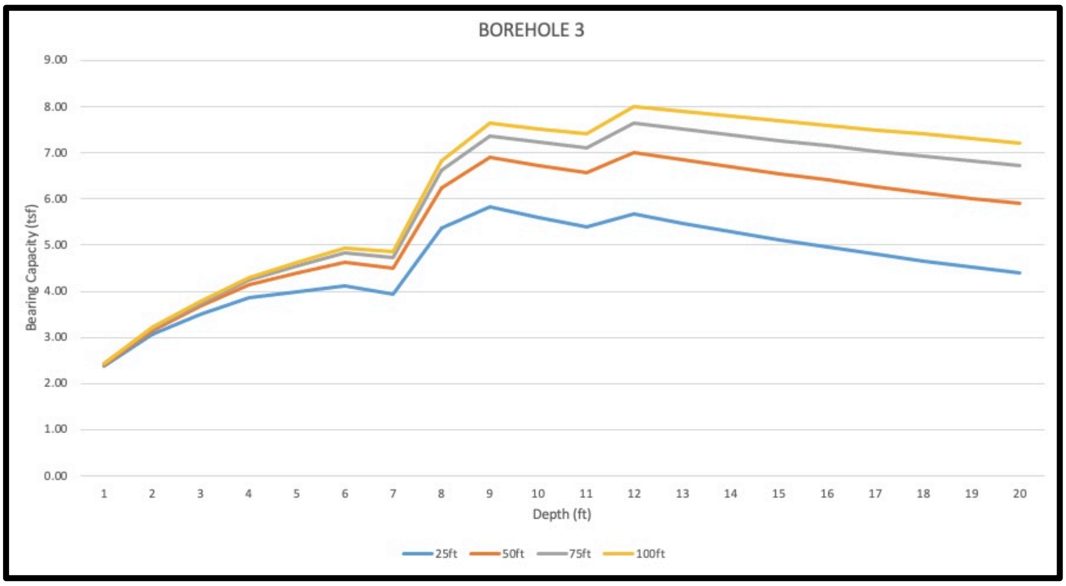

Figure 5.11: Graphical representation of Bearing Capacity of Block 1 Borehole 3 at different depths with width 25, 50, 75, 100 ft

5.6.13. Block 2 Borehole 1 at width 25 ft:

Table 5.13. Block 2 Borehole 1 at width 25 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	14	11.5	25	1.12	2.77
2	12	16	13.1	25	1.16	3.06
3	15	18	14.7	25	1.20	3.32
4	20	22	18.0	25	1.26	3.85
5	25	26	21.3	25	1.33	4.32
6	30	28	22.9	25	1.40	4.44
7	35	32	26.2	25	1.46	4.84
8	40	33	27.0	25	1.53	4.78
9	45	34	27.8	25	1.59	4.72
10	50	42	34.4	25	1.66	5.60
11	55	46	37.6	25	1.73	5.90
12	60	46	37.6	25	1.79	5.68
13	65	46	37.6	25	1.86	5.48
14	70	46	37.6	25	1.92	5.29
15	75	46	37.6	25	1.99	5.11
16	80	46	37.6	25	2.06	4.95
17	85	46	37.6	25	2.12	4.80
18	90	46	37.6	25	2.19	4.65
19	95	46	37.6	25	2.25	4.52
20	100	46	37.6	25	2.32	4.39

5.6.14. Block 2 Borehole 1 at width 50 ft:

Table 5.14. Block 2 Borehole 1 at width 50 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	14	11.5	50	1.06	2.81
2	12	16	13.1	50	1.08	3.16
3	15	18	14.7	50	1.10	3.49
4	20	22	18.0	50	1.13	4.14
5	25	26	21.3	50	1.17	4.75
6	30	28	22.9	50	1.20	4.97
7	35	32	26.2	50	1.23	5.53
8	40	33	27.0	50	1.26	5.56
9	45	34	27.8	50	1.30	5.58
10	50	42	34.4	50	1.33	6.72
11	55	46	37.6	50	1.36	7.18
12	60	46	37.6	50	1.40	7.01
13	65	46	37.6	50	1.43	6.85
14	70	46	37.6	50	1.46	6.70
15	75	46	37.6	50	1.50	6.55
16	80	46	37.6	50	1.53	6.41
17	85	46	37.6	50	1.56	6.27
18	90	46	37.6	50	1.59	6.14
19	95	46	37.6	50	1.63	6.02
20	100	46	37.6	50	1.66	5.90

5.6.15. Block 2 Borehole 1 at width 75 ft:

Table 5.15. Block 2 Borehole 1 at width 75 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	14	11.5	75	1.04	2.83
2	12	16	13.1	75	1.05	3.19
3	15	18	14.7	75	1.07	3.55
4	20	22	18.0	75	1.09	4.25
5	25	26	21.3	75	1.11	4.92
6	30	28	22.9	75	1.13	5.20
7	35	32	26.2	75	1.15	5.82
8	40	33	27.0	75	1.18	5.89
9	45	34	27.8	75	1.20	5.96
10	50	42	34.4	75	1.22	7.23
11	55	46	37.6	75	1.24	7.78
12	60	46	37.6	75	1.26	7.64
13	65	46	37.6	75	1.29	7.51
14	70	46	37.6	75	1.31	7.39
15	75	46	37.6	75	1.33	7.26
16	80	46	37.6	75	1.35	7.15
17	85	46	37.6	75	1.37	7.03
18	90	46	37.6	75	1.40	6.92
19	95	46	37.6	75	1.42	6.81
20	100	46	37.6	75	1.44	6.71

5.6.16. Block 2 Borehole 1 at width 100 ft:

Table 5.16. Block 2 Borehole 1 at width 100 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	9	14	11.5	100	1.03	2.84
2	12	16	13.1	100	1.04	3.21
3	15	18	14.7	100	1.05	3.58
4	20	22	18.0	100	1.07	4.31
5	25	26	21.3	100	1.08	5.01
6	30	28	22.9	100	1.10	5.32
7	35	32	26.2	100	1.12	5.99
8	40	33	27.0	100	1.13	6.08
9	45	34	27.8	100	1.15	6.18
10	50	42	34.4	100	1.17	7.52
11	55	46	37.6	100	1.18	8.12
12	60	46	37.6	100	1.20	8.01
13	65	46	37.6	100	1.21	7.90
14	70	46	37.6	100	1.23	7.80
15	75	46	37.6	100	1.25	7.69
16	80	46	37.6	100	1.26	7.59
17	85	46	37.6	100	1.28	7.50
18	90	46	37.6	100	1.30	7.40
19	95	46	37.6	100	1.31	7.31
20	100	46	37.6	100	1.33	7.22

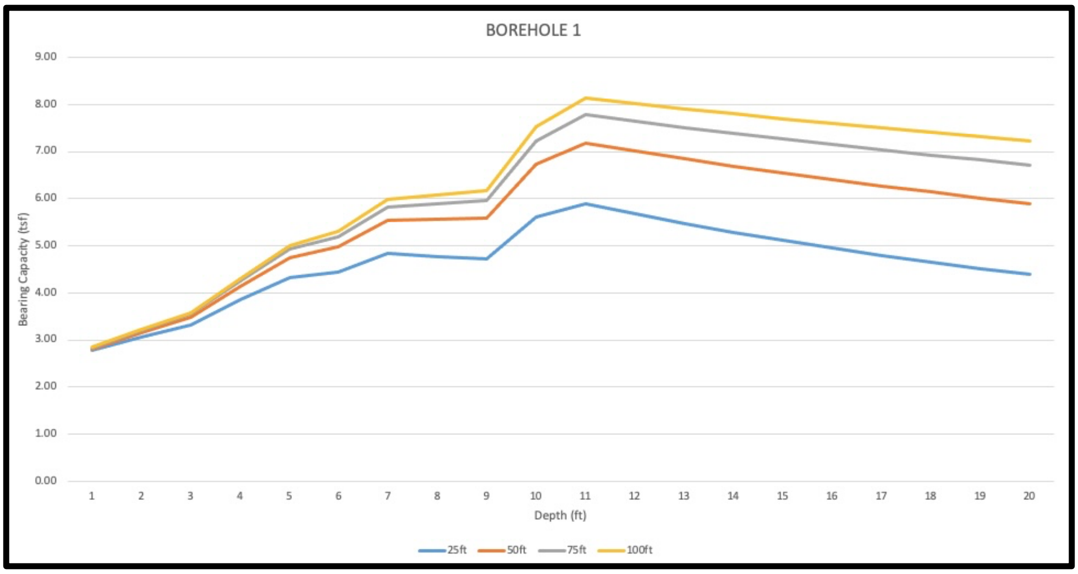

Figure 5.12: Graphical representation of Bearing Capacity of Block 2 Borehole 1 at different depths with width 25, 50, 75, 100 ft.

5.6.17. Block 2 Borehole 2 at width 25 ft:

Table 5.17. Block 2 Borehole 2 at width 25 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	10	15	12.3	25	1.13	2.93
2	15	15	12.3	25	1.20	2.77
3	20	22	18.0	25	1.26	3.85
4	25	23	18.8	25	1.33	3.83
5	30	24	19.6	25	1.40	3.80
6	35	26	21.3	25	1.46	3.93
7	40	35	28.6	25	1.53	5.07
8	45	45	36.8	25	1.59	6.25
9	50	45	36.8	25	1.66	6.00
10	55	45	36.8	25	1.73	5.77
11	60	45	36.8	25	1.79	5.56
12	65	45	36.8	25	1.86	5.36
13	70	45	36.8	25	1.92	5.17
14	75	45	36.8	25	1.99	5.00
15	80	45	36.8	25	2.06	4.84
16	85	45	36.8	25	2.12	4.69
17	90	45	36.8	25	2.19	4.55
18	95	45	36.8	25	2.25	4.42
19	100	45	36.8	25	2.32	4.29

5.6.18. Block 2 Borehole 2 at width 50 ft:

Table 5.18. Block 2 Borehole 2 at width 50 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	10	15	12.3	50	1.07	2.99
2	15	15	12.3	50	1.10	2.90
3	20	22	18.0	50	1.13	4.14
4	25	23	18.8	50	1.17	4.20
5	30	24	19.6	50	1.20	4.26
6	35	26	21.3	50	1.23	4.49
7	40	35	28.6	50	1.26	5.89
8	45	45	36.8	50	1.30	7.38
9	50	45	36.8	50	1.33	7.20
10	55	45	36.8	50	1.36	7.03
11	60	45	36.8	50	1.40	6.86
12	65	45	36.8	50	1.43	6.70
13	70	45	36.8	50	1.46	6.55
14	75	45	36.8	50	1.50	6.41
15	80	45	36.8	50	1.53	6.27
16	85	45	36.8	50	1.56	6.13
17	90	45	36.8	50	1.59	6.01
18	95	45	36.8	50	1.63	5.89
19	100	45	36.8	50	1.66	5.77

5.6.19. Block 2 Borehole 2 at width 75 ft:

Table 5.19. Block 2 Borehole 2 at width 75 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	10	15	12.3	75	1.04	3.02
2	15	15	12.3	75	1.07	2.96
3	20	22	18.0	75	1.09	4.25
4	25	23	18.8	75	1.11	4.35
5	30	24	19.6	75	1.13	4.45
6	35	26	21.3	75	1.15	4.73
7	40	35	28.6	75	1.18	6.25
8	45	45	36.8	75	1.20	7.89
9	50	45	36.8	75	1.22	7.75
10	55	45	36.8	75	1.24	7.61
11	60	45	36.8	75	1.26	7.48
12	65	45	36.8	75	1.29	7.35
13	70	45	36.8	75	1.31	7.23
14	75	45	36.8	75	1.33	7.11
15	80	45	36.8	75	1.35	6.99
16	85	45	36.8	75	1.37	6.88
17	90	45	36.8	75	1.40	6.77
18	95	45	36.8	75	1.42	6.67
19	100	45	36.8	75	1.44	6.56

5.6.20. Block 2 Borehole 2 at width 100 ft:

Table 5.20. Block 2 Borehole 2 at width 100 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	10	15	12.3	100	1.03	3.03
2	15	15	12.3	100	1.05	2.98
3	20	22	18.0	100	1.07	4.31
4	25	23	18.8	100	1.08	4.43
5	30	24	19.6	100	1.10	4.56
6	35	26	21.3	100	1.12	4.86
7	40	35	28.6	100	1.13	6.45
8	45	45	36.8	100	1.15	8.18
9	50	45	36.8	100	1.17	8.06
10	55	45	36.8	100	1.18	7.95
11	60	45	36.8	100	1.20	7.84
12	65	45	36.8	100	1.21	7.73
13	70	45	36.8	100	1.23	7.63
14	75	45	36.8	100	1.25	7.53
15	80	45	36.8	100	1.26	7.43
16	85	45	36.8	100	1.28	7.33
17	90	45	36.8	100	1.30	7.24
18	95	45	36.8	100	1.31	7.15
19	100	45	36.8	100	1.33	7.06

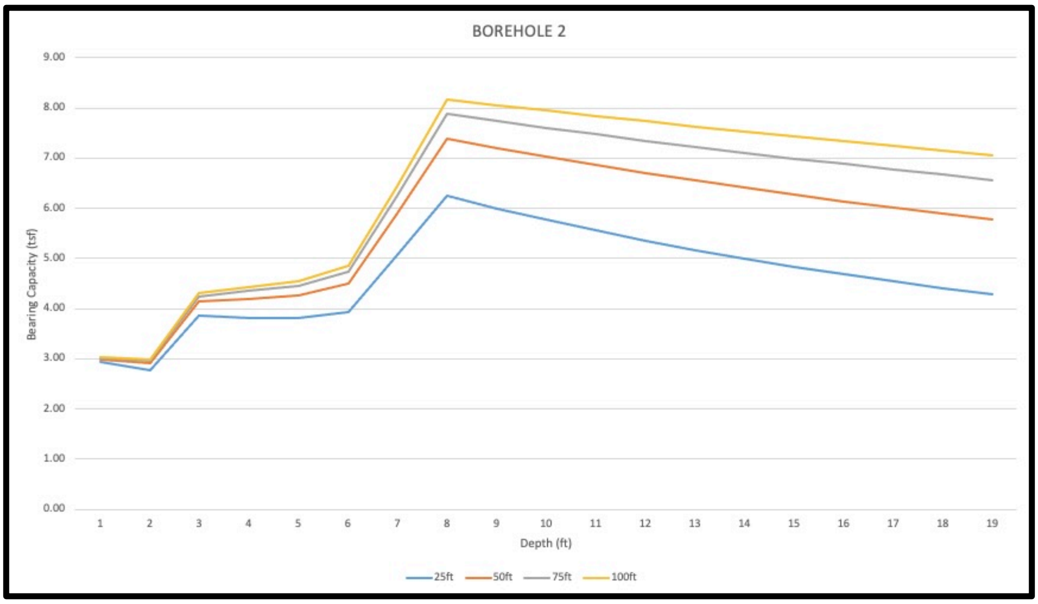

Figure 5.13: Graphical representation of Bearing Capacity of Block 2 Borehole 2 at different depths with width 25, 50, 75, 100 ft.

5.6.21. Block 2 Borehole 3 at width 25 ft:

Table 5.21. Block 2 Borehole 3 at width 25 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	12	16	13.1	25	1.16	3.06
2	15	19	15.5	25	1.20	3.51
3	20	22	18.0	25	1.26	3.85
4	25	25	20.5	25	1.33	4.16
5	30	26	21.3	25	1.40	4.12
6	35	27	22.1	25	1.46	4.09
7	40	27	22.1	25	1.53	3.91
8	45	27	22.1	25	1.59	3.75
9	50	27	22.1	25	1.66	3.60
10	55	27	22.1	25	1.73	3.46
11	60	47	38.5	25	1.79	5.80
12	65	47	38.5	25	1.86	5.60
13	70	47	38.5	25	1.92	5.40
14	75	47	38.5	25	1.99	5.23
15	80	47	38.5	25	2.06	5.06
16	85	47	38.5	25	2.12	4.90
17	90	47	38.5	25	2.19	4.75
18	95	47	38.5	25	2.25	4.61
19	100	47	38.5	25	2.32	4.48

5.6.22. Block 2 Borehole 3 at width 50 ft:

Table 5.22. Block 2 Borehole 3 at width 50 ft:

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	12	16	13.1	50	1.08	3.16
2	15	19	15.5	50	1.10	3.68
3	20	22	18.0	50	1.13	4.14
4	25	25	20.5	50	1.17	4.57
5	30	26	21.3	50	1.20	4.62
6	35	27	22.1	50	1.23	4.67
7	40	27	22.1	50	1.26	4.55
8	45	27	22.1	50	1.30	4.43
9	50	27	22.1	50	1.33	4.32
10	55	27	22.1	50	1.36	4.22
11	60	47	38.5	50	1.40	7.16
12	65	47	38.5	50	1.43	7.00
13	70	47	38.5	50	1.46	6.84
14	75	47	38.5	50	1.50	6.69
15	80	47	38.5	50	1.53	6.55
16	85	47	38.5	50	1.56	6.41
17	90	47	38.5	50	1.59	6.27
18	95	47	38.5	50	1.63	6.15
19	100	47	38.5	50	1.66	6.03

5.6.23. Block 2 Borehole 3 at width 75 ft:

Table 5.23. Block 2 Borehole 3 at width 75.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	12	16	13.1	75	1.05	3.19
2	15	19	15.5	75	1.07	3.74
3	20	22	18.0	75	1.09	4.25
4	25	25	20.5	75	1.11	4.73
5	30	26	21.3	75	1.13	4.82
6	35	27	22.1	75	1.15	4.91
7	40	27	22.1	75	1.18	4.82
8	45	27	22.1	75	1.20	4.73
9	50	27	22.1	75	1.22	4.65
10	55	27	22.1	75	1.24	4.57
11	60	47	38.5	75	1.26	7.81
12	65	47	38.5	75	1.29	7.68
13	70	47	38.5	75	1.31	7.55
14	75	47	38.5	75	1.33	7.42
15	80	47	38.5	75	1.35	7.30
16	85	47	38.5	75	1.37	7.18
17	90	47	38.5	75	1.40	7.07
18	95	47	38.5	75	1.42	6.96
19	100	47	38.5	75	1.44	6.86

5.6.24. Block 2 Borehole 3 at width 100 ft:

Table 5.24. Block 2 Borehole 3 at width 100 ft.

Sr No.	Depth (ft)	SPT (N)	N55	Width (B)	Kd	Qa
1	12	16	13.1	100	1.04	3.21
2	15	19	15.5	100	1.05	3.78
3	20	22	18.0	100	1.07	4.31
4	25	25	20.5	100	1.08	4.82
5	30	26	21.3	100	1.10	4.94
6	35	27	22.1	100	1.12	5.05
7	40	27	22.1	100	1.13	4.98
8	45	27	22.1	100	1.15	4.91
9	50	27	22.1	100	1.17	4.84
10	55	27	22.1	100	1.18	4.77
11	60	47	38.5	100	1.20	8.19
12	65	47	38.5	100	1.21	8.07
13	70	47	38.5	100	1.23	7.97
14	75	47	38.5	100	1.25	7.86
15	80	47	38.5	100	1.26	7.76
16	85	47	38.5	100	1.28	7.66
17	90	47	38.5	100	1.30	7.56
18	95	47	38.5	100	1.31	7.47
19	100	47	38.5	100	1.33	7.37

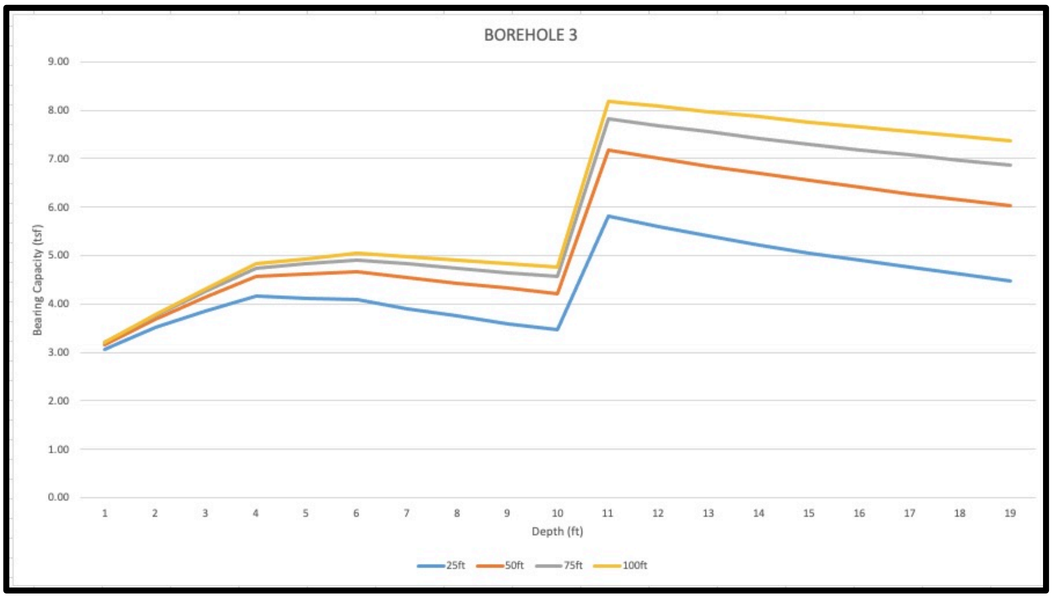

Figure 5.14: Graphical representation of Bearing Capacity of Block 2 Borehole 3 at different depths with width 25, 50, 75, 100 ft.

CONCLUSIONS

Three boreholes of 100ft depth for block 1 and 2 were drilled to evaluate the site geological conditions. Fill material was found at the depth of 4ft to 11ft from the natural ground surface in block 1 & 2. Coarse grained soils were majorly found in all the boreholes with some clayey and silty contents. SPT refusals were found beyond 65ft on average.

Bearing capacity for block 1 and 2 is calculated against varying foundation widths i.e., 25ft, 50ft, 75ft and 100ft. Increasing trend of bearing capacity is found with increasing foundation width. On average maximum bearing capacity was found at 11ft depth.

The average allowable bearing capacity (Q_a) in block 1 was found at the depth of 45ft whereas in the block 2 average value was at the depth of 60ft.

REFRENCES

Adhami, N. Z., Ilyas, M., & Ahmad, M. (1980). Seismotectonic studies of the Rawalpindi region: Islamabad. National Engineering Services of Pakistan (NESPAK), Pakistan Atomic Energy Commission, 139.

Williams, V. S., Pasha, M. K., & Sheikh, I. M. (1999). Geologic Map of the Islamabad-Rawalpindi Area, Punjab, Northern Pakistan. The Survey.

Handy, R. L. (2007). Geotechnical engineering: soil and foundation principles and practice. McGraw-Hill Education.

Meyerhof, G. G. (1951). The ultimate bearing capacity of foudations. Geotechnique, 2(4), 301-332.

ASTM C29 / C29M-17a 2017 Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate (West Conshohocken, PA: ASTM Inter.)

ASTM D 4318 (2000) Standard test methods for liquid limit, plastic limit and plasticity index of soils. Annual Book of American Society for Testing and Material standards, West Conshohocken, USA, pp 561–572

ASTM. (2009). Standard test methods for particle-size distribution (Gradation) of soils using sieve analysis. ASTM D6913.

Kramarenko, V. V., Nikitenkov, A. N., Matveenko, I. A., Molokov, V. Y., & Vasilenko, Y. S. (2016, September). Determination of water content in clay and organic soil using microwave oven. In IOP Conference Series: Earth and Environmental Science (Vol. 43, No. 1, p. 012029). IOP Publishing.

Reese, L. C., Isenhower, W. M., & Wang, S. T. (2005). Analysis and design of shallow and deep foundations (Vol. 10). John Wiley & Sons.

Tomlinson, M. J., & Boorman, R. (2001). Foundation design and construction. Pearson education.