Construction of SBP New Office Building at Gujranwala

For State Bank of Pakistan, Karachi

GEOTECHNICAL INVESTIGATION REPORT

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Construction of SBP New Office Building at Gujranwala

Geotechnical Investigation Report

The report presents findings of the field investigation, laboratory testing and geotechnical recommendations for the Design and Construction of SBP New Office Building at Gujranwala

[June 2016]

ENGINEERS GUILD
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Ref No: 1022-EG2016008 June 25, 2016

Mr. Fazli Hameed

Director Engineering

State Bank of Pakistan

Karachi

SUBJECT: Submission of Geotechnical Investigation Report for the Construction of SBP New Office Building at Gujranwala

Dear Sir,

Engineers Guild is pleased to submit the report, summarizing the findings of Geotechnical Investigation for Construction of SBP New Office Building at Gujranwala.

The project site is located at Rahwali in Gujranwala along with GT Road. The location of the project site is shown in Annexure A.1 as Site Location Map. The complete field work was carried out under full time supervision and spelled out requirements of the Consultant (ESS-I-AAR, Karachi).

The purpose of our geotechnical investigation was to evaluate the suitability of the subsurface conditions for "Construction of SBP New Office Building at Gujranwala". The geotechnical analysis has been conducted based on the results of subsurface investigation, laboratory testing and our current understanding of the project. It is our professional opinion that the proposed site is geotechnically suitable for the construction of the proposed project, provided the recommendations presented in this report are incorporated into the project design and construction.

The net allowable bearing capacity for strip/square is in a range of 0.9 to 1.1 ton/sq. ft (width 1.0 to 3.0 m for strip & Square) similarly, gross allowable bearing capacity for foundation is in about 3.6 ton/sq. ft & 5 to 30 m width for mat) at a depth of 2 to 4.5 m below NSL.

We appreciate the opportunity to be of service on this project. Please do not hesitate to contact the undersigned (info@eguild.biz or +92-3334403686) if you have any questions, comments or any additional information.

Respectfully submitted

For M/s Engineers Guild, Lahore:

Usman Arshad,

Office Engineer

Construction of SBP New Office Building at Gujranwala

Geotechnical Investigation Report

Client:	**State Bank of Pakistan, Karachi**
Consultant:	**ESS-I-AAR, Karachi**
Geotechnical Consultant:	**M/s Engineers Guild**

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The analyses, conclusions and recommendations contained in this report are based on site conditions, as they existed at the time of field investigations, and further on the assumption that the exploratory boring are representative of the subsurface conditions throughout the site.

In case there is a substantial lapse of time between submission of this report and the start of construction at site, then we should be promptly informed to review our report to determine the applicability of the conclusions and recommendations.

Document History:

Job No:	**EG2016008**		**Document Reference:**						
Revision	**Purpose and Description**	**Originated**	**Checked**		**Reviewed**		**Authorized**		**Date**
0	For Issue & Review	SK	UA		UA		NK		Jun. 2016

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Executive Summary

State Bank of Pakistan, Karachi has planned Construction of SBP New Office Building at Gujranwala. The project site is located at Rahwali in Gujranwala along with GT Road. The location of the project site is shown in Annexure A.1 as Site Location Map. Keeping in view the layout of the proposed structures, State Bank of Pakistan, Karachi provided the requirement of the Geotechnical Investigation to be implemented for the design and evaluation of the proposed structure.

For evaluation of sub-surface soil parameters and safe design of foundations, it was essential to carry out Geotechnical Investigations. M/s Engineers Guild was entrusted by State Bank of Pakistan, Karachi to carry out Geotechnical Investigations at the project site under supervision and guidelines of ESS-I-AAR, Karachi.

The proposed project, involves construction of SBP New Office Building at Gujranwala. The proposed project involves construction of two multi-story buildings along with a basement, gate building / cafeteria and generator / substation building.

The Scope of Work (SOW) was defined by ESS-I-AAR, Karachi, considering the current project requirements provided by the client. A total of 6 boreholes of 20 m each were planned to assess the ground conditions.

Probabilistic Seismic Hazard Assessment (PSHA) recently carried out for revision of seismic provisions of the Building Code of Pakistan, shows that the site area falls in Zone 2A. It is therefore, recommended that the project structures should be designed to cater for the requirements of Zone 2A of Building Code of Pakistan (2007).

The sub-soil lithology comprises of Sandy Silt / Silt (ML) encountered at top generally up to 3.5m depth in firm to stiff state. The Sandy Silt / Silt was underlain by a layer of Silty Sand (SM) from 3.5m to about 10.2 m in depth in medium dense state. This layer was followed by a thick layer of Fine Sand (SW) from 10.2 m up to maximum investigated depth of 20 m below NSL in medium dense to dense state.

Groundwater was encountered in the boreholes at 9 m below NSL during field investigation at site in June 2016.

The evaluation of the net allowable bearing capacity of the Square Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 2.0 m below NSL. The bearing capacity curves are presented in Annexure B.3.1.

The evaluation of the net allowable bearing capacity of the Strip Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 2.0 m below NSL. The bearing capacity curves are presented as Annexure B.3.2.

Similarly the evaluation of gross allowable bearing capacity of the Mat Foundation has been done for a depth of foundation 4.5m below NSL. The bearing capacity curves are presented as Annexure B.3.3.

Using Procedure Given by NAVFAC 7.02, the allowable pile capacity value for a diameter of 600 mm is calculated in compression up to a length of 30 m.

1. Introduction

1.1. Scope of Report

State Bank of Pakistan, Karachi has planned SBP New Office Building at Gujranwala. The project site is located at Rahwali in Gujranwala along with GT Road. The location of the project site is shown in Annexure A.1 as Site Location Map. Keeping in view the layout of the proposed structures the State Bank of Pakistan, Karachi provided the requirement of the Geotechnical Investigation to be implemented for the design and evaluation of the proposed structure.

For evaluation of sub-surface soil parameters and safe design of foundations, it was essential to carry out Geotechnical Investigations. M/s Engineers Guild was entrusted by State Bank of Pakistan, Karachi to carry out Geotechnical Investigations at the project site.

This Geotechnical Investigation report provides detail of current site conditions and interpretation of the investigation works carried out for the design and evaluation of proposed foundations. In addition, the report also delineates the guidelines and recommendations on geotechnical aspects to be used for structural design as well as considerations for construction activity.

1.2. Objectives of Investigations

The geotechnical investigation were undertaken to meet the following objectives:

- To delineate the subsoil conditions of the site area.
- To evaluate the geotechnical design parameters for various structures

1.3. Proposed Development

The proposed project, involves construction of SBP New Office Building at Gujranwala. The proposed project involves construction of two multi-story buildings along with a basement, gate building / cafeteria and generator / substation building.

1.4. Scope of Work

The Scope of Work (SOW) was defined considering the current project requirements provided by the client. The Geotechnical Investigation was accordingly planned to assess the ground condition for supporting the proposed structure.

1.4.1. Field Investigations

The Scope of Work (SOW) was defined by ESS-I-AAR, Karachi, considering the current project requirements provided by the client. A total of 6 boreholes of 20 m each were planned to assess the ground conditions. The field investigations were performed as per the latest ASTM standards listed in Table 1-1.

Table 1-1: List of Field Tests

No.	Field Test	ASTM / BS Standard
1.	Standard Penetration Tests (SPT)	ASTM D1586-11
2.	Vane Shear Tests (VST)	ASTM D2573-08
3.	Plate Load Tests (PLT)	ASTM D1195-09

In addition to above field permeability tests were also performed at the project site in the boreholes.

1.4.2. Laboratory Tests

Samples collected from the boreholes were subjected to the following tests, as per latest ASTM, AASHTO, BS or equivalent Standards, as listed in Table 1-2:

Table 1-2: List of Laboratory Tests

No.	Laboratory Test	ASTM / BS Standard
1.	Grain Size Analysis (GSD)	ASTM D421-85(07), ASTM D422-63(07)
2.	Atterberg Limits (ATL)	ASTM D4318-00
3.	Natural Moisture Content (NMC)	ASTM D2216-10
4.	Specific Gravity (SPG)	ASTM D854-10
5.	Direct Shear Test (DST)	ASTM D3080-11
6.	Unconfined Compressive Strength (UCS)	ASTM D2166-13
7.	Oedometer Test (OED)	ASTM D2435-11
8.	Chemical Tests (CHM)	BS 1377-3:1990

2. Site Description

2.1. Location of the Project Site

The project site is located at Rahwali in Gujranwala along with GT Road. The location of the project site is shown in Annexure A.1 as Site Location Map.

2.2. Geology and Seismicity of the Area

2.2.1. Geology

The project site is located in Punjab, which is a plain of alluvial material and scattered rocks at deeper depth. A Geological Map showing the Geological distribution of the area is provided in Annexure A.3 Geological Map of the Project Area.

2.2.2. Seismicity

Probabilistic Seismic Hazard Assessment (PSHA) carried out for revision of seismic provisions of the Building Code of Pakistan, shows that the site area falls in Zone 2A. It is therefore, recommended that the project structures should be designed to cater for the requirements of Zone 2A of Building Code of Pakistan (2007).

A plan showing various zones of Pakistan as per Latest Seismic Microzonation as given in the Building code of Pakistan is attached with this report as Annexure A.4.

The Soil Profile Type based on the Building Code of Pakistan, shows that the site area comprises of S_D type soils.

2.3. Current Use of Project Area

The site area is currently open land, with boundary wall all along, which can be seen in site photographs.

2.4. Topography of Project Area

Topographically project area is plain land.

3. Subsurface Exploration

3.1. General

The field investigation was performed under full time supervision by our experienced geotechnical engineer who supervised drilling operation, sampling and logging and top supervised the laboratory testing. The field tests that were performed are listed in Table 1-1

3.2. Drilling

A total of six (6) boreholes of maximum borehole depth of twenty meters (20m) were planned at the project site. The field investigation was supported by relevant laboratory testing. The drilling and sampling work has been performed using the standards, procedures and equipment's recommended for engineering site investigation. The exact location of boreholes has been marked on the ground in the presence of the client's representative. The location of the boreholes can be seen in the geotechnical investigation plan given as Annexure A.2

3.3. Standard Penetration Tests (SPT)

Standard penetration test is by far the most popular and economical method of obtaining subsurface information. It is carried out to assess the in-situ compactness of various soil layers. Significant numbers of foundation design procedures make use of SPT results.

Testing method essentially consists of driving split spoon sampler of specified dimensions up to a distance of 46cm into the soil at bottom of borehole. A 63.5kg hammer failing free from a height of 76cm is used to drive the sampler. Number of blows required to drive the sampler were carried out in accordance with the specification of ASTM D1586-11. Continuous standard penetration test is performed wherever possible.

The SPT's were carried out at an interval of 1m in boreholes. A total of one hundred twenty (120) SPT's were performed. Annexure B.1 shows the variation of SPT blows with depth and the detail of SPT Results are given in the individual borehole logs in Annexure A.2.

3.4. Vane Shear Tests (VST)

The vane shear test apparatus consists of four stainless steel blades fixed at right angle to each other and firmly attached to a high tensile steel rod. The length of the vane is usually kept equal to twice its overall width. The diameters and length of the stainless steel rod were limited to 2.5mm and 60mm respectively.

In this test, as per ASTM D2573-08, the vane and rod are pushed into the clay, below the bottom of the bore hole, ensuring the verticality of the central rod. It is then rotated at a constant speed by suitable equipment, which measures the torque required to turn the vane at that speed. This test is performed in case of very soft to medium cohesive soils with relatively high moisture content, where conventional push methods may not be feasible.

The VST's were carried out at a maximum depth of twenty meters (20m). A total of ten (10) tests were performed at site which shows Vane Shear Strength in the range of 0.26 to 0.99 kg/cm^2. The results of these tests are given in Annexure C.2.

3.5. Plate Load Tests (PLT)

Plate Load Test is a field test, as per ASTM D1195-09, for determining the ultimate bearing capacity of soil and the likely settlement under a given load. It basically consists of loading a steel plate placed at the foundation level and recording the settlements corresponding to each load increment. The test load is gradually increased till the plate starts to sink at a rapid rate.

A test pit is dug at site up to the depth at which the foundation is proposed to be laid. The width of the pit should be at least 5 times the width of the test plate. At the centre of the pit a small square depression or hole is made whose size is equal to the size of the test plate and bottom level of which corresponds to the level of actual foundation.

The depth of the hole should be such that the ratio of depth to width of the loaded area is approximately the same as the ratio of the actual depth to width of the foundation.

The mild steel plate (also known as bearing plate) used in the test should not be less than 25 mm in thickness and its size may vary from 300 to 750 mm. The plate could be square or circular in shape. Circular plate is adopted in case of circular footing and square plate is used in all other types of footings.

The PLT's were carried out at a maximum depth of one hundred five meters (1.5m). A total of two (2) tests were performed at site, using a base plate of 300mm diameter. The maximum applied pressure on the base plate was 833kPa, which was applied in equal increments by the reaction of a hydraulic jack resisted by the load of a Kentledge. The measurement of downward movement of the plate was made by three micrometres set equally apart on the periphery of the plate. These micrometres were fixed to the reference beams which were independently supported on masonry foundations. After the maximum requisite test load was achieved, the pressure was decreased in three equal decrements. The results of these tests are given in Annexure C.3.

3.6. Field Permeability Test

Field permeability is a field test used to determine the permeability of soils. The soil permeability is a very important factor to study the behaviour of soil in its natural condition with respect to water flow. The constant head method is particularly suitable for relatively coarse grained soil such as sands and gravel. For fine grained soils such as clay-like or silty soils see Falling head permeability apparatus.

During the course of geotechnical investigations, Constant head permeability tests are performed in accordance with ASTM D2434 or British Standard 5930. During the test, the hole is sealed from side by lowering of the casing down to the require depth; therefore water infiltration could only take place at the open bottom of the hole. The test is then performed by pumping water into the hole & adjusting the rate of inflow such a way that the water level in the hole remains constant under these conditions. The inflow of water "Q" is the rate of outflow from the hole through its bottom.

In total five constant head permeability tests were performed in Silty Sand & Fine Sand strata at depth ranging from 5m to 15m. The permeability values are in the range from 1.39 E-03 cm/sec to 7.85 E-04 cm/sec. The results of permeability tests are given in Annexure C.4.

3.7. Sampling

Collection of representative samples forms an essential part of investigation program. The following types of samples have been collected for this Project.

3.7.1. Disturbed Soil Samples

Disturbed soil samples were obtained either from the Auger/bailer as the borehole was advanced or from the spilt spoon sampler after performing Standard Penetration Test (SPT). Disturbed samples were used to classify the soil type and depth of occurrence of different layers, and were preserved, for laboratory testing. All the samples obtained from the boreholes were properly preserved in polythene bags and labelled as disturbed samples. The entire sampling, preservation and transportation of the samples were carried out as per latest ASTM standards.

3.7.2. Undisturbed Soil Samples

A total of three (3) undisturbed soil samples were recovered from the boreholes, using Shelby samplers. After determining the in-situ density, the samples were properly waxed, labelled and preserved before transportation to the laboratory.

3.7.3. Ground Water Samples

The groundwater table was encountered at a depth of about 9 below NSL, during geotechnical investigations carried out at site. A total of one (1) water sample were collected from the boreholes.

4. Laboratory Test Results

In addition to field testing, a number of laboratory tests, as listed in Table 1-2, were also conducted on selected soil samples. Results of these tests are helpful in classification of soil, determining engineering properties such as classification, compactness and suitability for construction material; the same is given in the Annexure B.2.1, which contains laboratory test results.

Brief description of all the laboratory tests and testing standards is given in the following sections.

4.1. Grain Size Analysis

Soil is an uncemented aggregate of mineral grains and decayed matter with liquid and gas in the empty spaces between the solid particles, which consists of an assemblage of discrete of particles of various sizes and shapes. This analysis consists of shaking the soil sample through a set of sieves, which decrease in opening sizes from top to bottom. The object is to group these particles into separate size ranges and to determine the relative proportions by dry weight, of each size range.

Grain size analysis is been conducted in two stages. Particles size distribution of coarse-grained soils is performed by sieve analysis while hydrometer analysis is conducted to establish distribution of fine-grained soils. Grain size analysis is carried out as per ASTM D422-63(07).

Based on the results of these analyses and the Atterberg limits, the soil is classified into groups and sub-groups according to their engineering behaviour. Generally two elaborate classification systems are used which are the American Association of State Highway and Transportation Officials (AASHTO) classification system and the Unified Soil Classification System (USCS). The AASHTO classification system (AASHTO M145 or ASTM D3282-09) is used mostly by highway departments for road design, whereas the USCS system (ASTM D2487-11) is used by geotechnical engineers for foundation design etc.

A total of thirty (30) sieve analyses were conducted on the samples collected from the site.

The classification test results indicate that the subsoil mostly comprises of ML, SM, SW, SW-SM groups on the basis of USCS System. The soils classified as granular indicated fines (passing # 200 sieve) ranging from 3% to 49% based on sieve analysis conducted in our own laboratory. The fine content in the cohesive soils were indicated as 51% to 85%.

4.2. Atterberg Limits

Atterberg limits, as described in ASTM D4318-00, are a basic measure of the critical water contents of a fine-grained soil, such as its shrinkage limit, plastic limit, and liquid limit. As a dry, clayey soil takes on increasing amounts of water, it undergoes dramatic and distinct changes in behaviour and consistency. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic and liquid. In each state, the consistency and behaviour of a soil is different and consequently so are its engineering properties.

Plastic limit (PL) is the moisture content at which the soil passes from the semisolid to the plastic state, as the moisture content is increased. It is determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface.

Liquid Limit (LL) is the moisture content at which a soil passes from the plastic state to a liquid state as the water content is increased.

Plasticity Index (PI) is the difference of moisture content at liquid and plastic limits (PI=LL-PL). A plot of PI against LL provides the bases for classification of cohesive soils. It also provides insight into several soil characteristics such as compressibility and strength.

A total of ten (10) Atterberg limit tests performed on the soil samples indicated that the liquid limit (LL) ranged from 0 to 0 and plasticity index (PI) varied from 0 to 0, while nine (9) none of the samples showed a non-plastic (NP) behaviour.

4.3. Natural Moisture Content

Moisture content of soil is the ratio of the amount of water present in a soil sample to the solid mass of the soil. The knowledge of the in situ natural moisture content will give an idea of the state of soil in the field. It is essential in in establishing a correlation between soil behaviour and its index properties and determining the bearing capacity and settlement. The standard procedure is given in ASTM D2216-10.

The laboratory tests performed on five (5) relatively undisturbed soil samples and field density tests extracted up to a maximum depth of 15m below NSL have yielded natural moisture content ranging from 5% to 25%.

4.4. Specific Gravity

Specific gravity is the ratio of the density of a substance to the density (mass of the same unit volume) of a reference substance. In case of soils, this is taken with reference to the density of water. It is an important weight-volume property that is helpful in classifying soils and in finding other weight-volume properties like void ratio, porosity, and unit weight.

Specific gravity varies with temperature and pressure therefore the sample must be corrected to a standard reference temperature and pressure. The procedure for determining specific gravity is described in ASTM D854-10.

A total of five (5) samples were used to determine the specific gravity of the soil samples. The results indicated that the specific gravity has a variation between 2.57 and 2.68.

4.5. Direct Shear Test

Direct shear test, according to ASTM D3080-11, is a laboratory to measure the shear strength properties of soil. It is performed on three or four specimens from a relatively undisturbed soil sample. A specimen is placed in a shear box which has two stacked rings to hold the sample; the contact between the two rings is at approximately the mid-height of the sample. A confining stress is applied vertically to the specimen, and the upper ring is pulled laterally until the sample fails, or through a specified strain. The load applied and the strain induced is recorded at frequent intervals to determine a stress-strain curve for each confining stress. This test is commonly used for dry or saturated sandy soils.

A total of ten (10) direct shear tests were performed on the relatively undisturbed non to low cohesive soil samples in addition to remoulded samples extracted from bore holes. The results indicated angles of internal friction (Ø) varying from 27° to 33° with the corresponding cohesion intercept ranging from 0.015 to 0.02 kg/cm^2. This indicates soil with low value of angle of internal friction due to higher content of fines in the upper crust and higher angle of internal friction in deeper depth.

4.6. Unconfined Compressive Strength

The objective of the unconfined compression test is to determine the unconsolidated undrained strength of a cohesive soil in an inexpensive manner. Fine-grained soils are usually tested in compression. Undisturbed specimens are cut from tube samples and disturbed specimens are loaded in compression, recording load and deflection measurements. The unconfined test uses axial loading without lateral confining pressures, making it the simplest and relatively quickest laboratory method of estimating strength of soil. Standard Procedure is given in ASTM D2166-13.

A total of ten (10) unconfined compressive strength tests were performed on the relatively undisturbed cohesive soil samples extracted from boreholes. The results show that the unconfined compressive strength of soils varies from 0.35 to 0.75kg/cm² with the corresponding compressive failure strain values ranging from 3.8% to 4.2%.

4.7. Oedometer Test (OED)

An oedometer test is a kind of geotechnical investigation performed in geotechnical engineering that measures a soil's consolidation properties. Oedometer tests, as described in ASTM D2435-11, are performed by applying different loads to a soil sample and measuring the deformation response. The results from these tests are used to predict how a soil in the field will deform in response to a change in effective stress.

Oedometer tests are designed to simulate the one-dimensional consolidation and drainage conditions that soils experience in the field. To simulate these conditions, rigid confining rings are used to prevent lateral displacement of the soil sample.

Porous stones are placed on the top and bottom of the sample to allow drainage in the vertical direction. To better simulate one-dimensional strain, a diameter-to-height ratio in the sample of 3:1 or more is used. Because the process of consolidation involves movement of water out of a soil, it is important to prevent drying of the soil.

Consolidation tests were performed on five (5) samples along the alignment at the structure locations. As per E-Log vs. P Curves were also developed. The compression index (C_C) varied from 0.11 to 0.225 and the initial void ratio (e_0) from 0.453 to 0.713.

4.8. Chemical Tests

The chemical tests are performed, as per BS 1377 Part 3, to check the acidity of the soil and the quantities of aggressive materials in the ground, such as Sulphates, Chlorides and Organic materials which may attack buried concrete or metal.

Chemical tests carried out on two (2) soil samples indicated soluble Sulphates content ranging from 0.06% to 0.07%, chloride content from 0.04% to 0.05% and organic content from 0.015% to 0.92%.

Chemical tests carried out on two (2) water samples indicated that total soluble solids varied as 59 to 60ppm, Sulphates contents from 70 to 77ppm, chloride contents from 60 to 65ppm and pH values from 7.04 to 7.08.

4.9. Density Tests

A total of five samples were tested for density which revealed the unit weight/dry density in a range of 1.75 to 1.85g/cc.

5. Ground Conditions and Engineering Properties

5.1. Lithology of Project Area

The sub-soil lithology comprises of

- Sandy Silt / Silt was encountered at top generally up to 3.5 m depth in firm to stiff state,

- A layer of Silty Sand (SM) from 3.5m to about 10.2 m in depth in medium dense state.

- A thick layer of Fine Sand (SW) from 10.2 m up to maximum investigated depth of 20m below NSL in medium dense to dense state.

5.2. Ground Conditions

The ground conditions consist of the following general conditions summarized below in Table 5-1.

Table 5-1: Summary of Ground Conditions

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description Title	Description
1	0.00	3.40	SANDY SILT/SILT	Brown, Firm, Sandy Silt/Silt, Non Plastic
1	3.40	10.20	SILTY SAND	Gray, Medium Dense to Dense, Silty Sand, Trace Mica
1	10.20	20.00	FINE SAND	Gray, Medium Dense to Dense, Fine Sand, Trace Mica
2	0.00	3.50	SANDY SILT/SILT	Brown, Firm to Stiff, Sandy Silt/Silt, Non Plastic
2	3.50	10.20	SILTY SAND	Gray, Medium Dense, Silty Sand, Trace Mica
2	10.20	20.00	FINE SAND	Gray, Medium Dense, Fine Sand, Trace Mica
3	0.00	3.30	SANDY SILT/SILT	Brown, Firm to Stiff, Sandy Silt/Silt, Non Plastic
3	3.30	10.20	SILTY SAND	Gray, Medium Dense, Silty Sand, Trace Mica, Trace Concretion
3	10.20	20.00	FINE SAND	Gray, Medium Dense, Fine Sand, Trace Mica, Trace Concretion
4	0.00	2.90	SANDY SILT/SILT	Brown, Firm to Stiff, Sandy Silt/Silt,

Borehole No.	Top Depth (m)	Bottom Depth (m)	Description Title	Description
				Non Plastic
4	2.90	10.20	SILTY SAND	Gray, Medium Dense, Silty Sand, Trace Mica
4	10.20	20.00	FINE SAND	Gray, Medium Dense, Fine Sand, Trace Mica, Trace Concretion
5	0.00	3.00	SANDY SILT/SILT	Brown, Firm, Sandy Silt/Silt, Non Plastic
5	3.00	10.20	SILTY SAND	Gray, Medium Dense, Silty Sand, Trace Mica
5	10.20	20.00	FINE SAND	Gray, Medium Dense to Dense, Fine Sand, Trace Mica, Trace Concretion
6	0.00	3.00	SANDY SILT/SILT	Brown, Firm, Sandy Silt/Silt, Non Plastic
6	3.00	10.20	SILTY SAND	Gray, Medium Dense, Silty Sand, Trace Mica
6	10.20	20.00	FINE SAND	Gray, Medium Dense to Dense, Fine Sand, Trace Mica, Trace Concretion

5.3. Groundwater Table

Groundwater was encountered in the boreholes at 9 m below NSL during field investigation at site in June 2016.

5.4. Geotechnical Design Parameters

5.4.1. Summary of Design Parameters

Table 5-2 summarizes the recommended layer thicknesses used in parameters selection and design recommendation evaluated.

Table 5-2: Summary of Design Parameters

Material Type	Depth below NSL D (m)	Bulk Density / Submerged Density (g/cm^3)	Coefficient of Volume Compressibility (m_v)	Angle of Internal Friction Phi (°)	Cohesion C (kg/cm^2)	Young's Modulus E (MPa)
Sandy Silt/Silt	0-3.0	1.75 / 0.75	0.010	-	0.45	3
Silty Sand	3.0-10.	1.75/0.75		30		5

Material Type	Depth below NSL D (m)	Bulk Density / Submerged Density (g/cm³)	Coefficient of Volume Compressibility (m_v)	Angle of Internal Friction Phi (°)	Cohesion C (kg/cm²)	Young's Modulus E (MPa)
Fine Sand	10-20	1.75/0.75		32		8

5.4.2. Discussion on Design Parameters

The design parameters have been evaluated considering results of field geotechnical investigation, laboratory testing, experience, and judgment of author of this report in the similar ground. The ground condition reveals mostly Cohesive Soils at the foundation laying depth of about 4.5m below NSL.

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5.4.3. Geotechnical Design Criteria

The foundations of all the structures should meet the following design criteria:

- These should be safe against shear failure of the supporting ground. A factor of safety of 3 is adopted for this purpose.
- These should not settle excessively under the service loads. A limit of 25mm has been put on the total settlement of individual foundations. Similarly, the angular distortion between the two adjacent foundations should not exceed 1/500.
- If mat foundation is adopted, it should not settle beyond limits under the service loads. A limit of 50mm has been put on the total settlement of foundations (corresponds to a differential settlement of about 35mm between the centre and edge of the mat foundation).
- The bedding of pipelines should be rigid enough to remain stable. This should be attained by compacting the pipe bedding to at least 95% Modified Proctor Compaction (70% Relative density).

6. Engineering Considerations

6.1. Earthworks

6.1.1. Ground Preparation

The topsoil at site mostly belongs to vegetative material. Initial site preparation will require removal of such contaminated/vegetative topsoil. Such soil may be used in the landscaping.

6.1.2. Excavation

The excavation required for the construction of foundation up to a shallow depth of about **4.5**m, can be made without provision of either supporting system or can be excavated at a sloping angle to be decided by hit and trial during construction at site. The provision of dewatering must be kept in the scope of work of construction due to possibility of rainy season, during construction.

6.2. Foundations

6.2.1. Proposed Structures

The proposed structures are expected to be low to medium level loading. Usually this kind of building can be supported on shallow foundation.

Based on information regarding type of structure, heights, spread, architectural foundation placement level, number and location of structures, an experience based analysis has been carried out by the author of this report. Considering the ground conditions as revealed during geotechnical investigation at site, it is recommended to support the smaller buildings on square/strip foundation and larger buildings on mat or deep foundation to be decided by the structural engineer based on structural applied pressures.

6.2.2. Design of Shallow Foundations

The evaluation of the net allowable bearing capacity of the Square Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 2.0 m below NSL. The bearing capacity curves are presented in Annexure B.3.1.

The evaluation of the net allowable bearing capacity of the Strip Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 2.0 m below NSL. . The bearing capacity curves are presented as Annexure B.3.2.

Similarly the evaluation of gross allowable bearing capacity of the Mat Foundation has been done for a depth of foundation 4.5m below NSL. The bearing capacity curves are presented as Annexure B.3.3.

6.2.3. Modulus of Subgrade Reaction

Modulus of sub-grade reaction K_s can be evaluated using the evaluated allowable bearing pressure, respective structural pressure, and factor of safety (FOS). The expression for its calculation is given below:

- For Strip and Square Footings with 25.4mm (1 inch) tolerable settlement

$$K_s = \frac{Evaluated\ Net\ Allowable\ Bearing\ Pressure}{Settlement\ (25.4mm) under\ maximum\ structural\ pressure} \times Factor\ of\ Safety$$

- For Raft / Mat Footings with 50.8 mm (2 inch) tolerable settlement

$$K_s = \frac{Evaluated\ Net\ Allowable\ Bearing\ Pressure}{Settlement\ (50.8\ mm) under\ maximum\ structural\ pressure} \times Factor\ of\ Safety$$

6.2.4. Placement of Granular Fill

The soil exposed at the foundation level for any structure during construction, if found different from that described in report, shall be reported to the qualified geotechnical engineer for site confirmation / validation. Similarly, If any soft and loose material encountered, at foundation excavation level, during construction, then it should be further excavated and replaced with suitable granular material in proper compaction.

The availability of the sound ground must be confirmed before placement of the foundation pad. An experienced engineer should confirm the soundness of the excavation base.

The excavated surface must be proof compacted to at least 95% of the Modified AASHTO Dry Density before placement of foundation.

The suitable granular material, if used, should comprise granular material, free draining, well graded, non-plastic and having particle size in a range of 0.075 mm to maximum 75 mm. The maximum content of fines should be limit to 10%. The minimum compaction requirement for granular back fill or proof rolling below foundation base should be at least 95% Modified AASHTO dry density or 75 % Relative Density.

6.2.5. Design of Deep Foundations

Using Procedure Given by NAVFAC 7.02, the allowable pile capacity value for a diameter of 600 mm is calculated in compression up to a length of 30 m. The details are shown in the figure attached to the report as Annexure B.3.4.

6.2.6. Pile Load Test

It is recommended that at least one (1) full scale test (at least 3 times the design load) must be carried out to confirm the design of pile foundation as per Standard Procedure defined by ASTM D1143-07.

6.3. Lateral Earth Pressure

6.3.1. Static Earth Pressure Coefficients

In case of buried structures and retaining walls, use of cohesion-less backfill is recommended. The evaluation of static earth pressure on buried wall / retaining walls depends upon the movement allowed for in the design, configuration of the wall, backfill geometry and the type of soil used as backfill. For smooth vertical walls with horizontal backfill, the following simplified expressions can be used for determination of coefficients of Lateral Earth Pressure.

- Coefficient of Active Earth Pressure

$$K_\alpha = \frac{(1 - Sin\emptyset')}{(1 + Sin\emptyset')}$$

- Coefficient of Earth Pressure at Rest

$$K_0 = (1 - Sin\,\emptyset')$$

- Coefficient of Passive Earth Pressure

$$K_p = \frac{(1 + Sin\emptyset')}{(1 - Sin\emptyset')}$$

Where $\emptyset'$ is effective Angle of Internal Friction of backfill soil.

The effective Angle of Friction of typical granular soils available in Punjab may be used as 30 degree.

6.3.2. Dynamic Earth Pressure Coefficients

For evaluation of earth pressure under earthquake conditions, the equations proposed by Mononobe-Okabe may be used.

6.4. Construction of Roads & Embankments

6.4.1. Formation of Subgrade and Embankment

Subgrade consisting of Silty Sand / Sandy Silt usually belongs to A4 material is found at site as per test investigation at site. Therefore A-4 soils should be used for subgrade construction for pavements.

Three points soaked California Bearing Ratio (CBR) tests, where performed, on A-4 soil samples of subgrade material. The CBR and swell values were determined. The CBR value of A-4 material at 95% MDD is in general range of 7 to 10 at 95% MDD. Therefore, it is recommended to adopt an average design CBR of existing subgrade as 8, which is above the minimum CBR value requirements of the subgrade material as per NHA Specifications.

6.4.2. Borrow Placement and Compaction

Before placement of the Earth fill/borrow fill, in-situ soil should be proof-rolled to achieve a minimum compaction level of 90% Modified AASHTO density.

The following maximum layer thickness, minimum compaction is recommended for various elements of embankment:

Table 6-1: Borrow Compaction Parameters

Material Type	Material Type	Maximum Compacted Layer Thickness (cm)	Recommended Modified AASHTO Compaction (%)
(a). A-4 or better soil as Embankment & Subgrade			
Top 30cm	A-4 or better	15	95
30cm – 75cm	A-4 or better	20	93
Below 75cm	A-4 or better	20	90

6.5. Construction Materials for Base/Subbase Material

Crushed base and subbase materials conventionally consist of a blend of natural or processed aggregates such as crushed stone fragments, gravel, and rock dust. To meet the grading requirement, blending is usually required based on the availability of various natural sources. The design CBR for these materials shall be governed by the project specifications. However, it would be desirable to use materials with minimum CBR values of 50 and 80, respectively, for these courses.

6.6. Constraints and Risks

6.6.1. Damp Proofing and Surface Drainage

Principle constraints include following:

- Proper paving should be provided along the periphery of the Structure.
- All the backfilling of the foundation above concrete pad should be done with cohesive material to avoid seepage of water in the foundation base. Alternatively, the top 30cm of any backfilling should be carried out with non-swelling cohesive soil.
- Adequate water proofing/damp proofing shall be provided for the structure. To avoid problem regarding moisture, it is recommended to adopt water-reducing admixtures in concrete.
- Cementitious coatings should also be provided to avoid moisture movement through the concrete.

6.6.2. Liquefaction Potential

Liquefaction is a loss of the shear strength of a soil that occurs when the ground experiences strong ground shaking. The phenomenon may result in large total and/or differential settlement beneath Structures founded on the liquefying soils. In order for the potential effects of liquefaction to be manifested at the ground surface, the soils generally have to be granular, loose to moderately dense, saturated relatively near the ground surface, and must be subjected to a sufficient magnitude and duration of shaking.

According to the soil revealed at the project Site, subsurface soils mainly belongs to either cohesive / silty material or granular, with higher content of fines which reduce chances of rapid dissipation of pore water pressure. Thus the potential for significant, large-scale liquefaction effects and associated dynamic settlement to cause damage is very low.

6.6.3. Cement Type

Based on chemical testing results on soil and water on samples collected from the site, it is recommended to use Ordinary Portland Cement (OPC).

6.6.4. Contaminated Land

The spillage of fuels, oils or other contaminants on the site should be prohibited and servicing of tools, plants, and machinery during the construction period should be managed to prevent pollution, while large numbers of machines are operating on the site.

6.6.5. Quality Control

The following precautions must be ensured for better quality control at site for construction stage:

- The water cement ratio of the concrete should be monitored properly for better quality of concrete.
- The compaction works should be supervised by experienced geotechnical engineer. The compaction of the area under foundation and other major load bearing locations should be certified by a licensed professional engineer for its laying as per specifications.
- It is recommended that the geotechnical investigation agency would be provided with the finalized layout/master plan of the site before adopting any recommendations for the design of foundation or any other aspect related to the use of geotechnical design parameter.

7. Earth Resistivity Survey

7.1. General

In order to design the earthing system for the electrical installations, the measurements of soil electrical resistivity values are required; therefore soil resistivity testing was carried out at the site proposed for the SBP building in Gujranwala Cantt.

The purpose of the soil resistivity testing is to determine the electrical resistivity values of the subsoil up to a depth of about 20 meters which could be used for the design of the earthing system.

7.2. Instrumentation and Field Procedure

The electrical resistivity measurements of the subsurface material were taken in the field by resistivity measuring instrument Terrameter SAS-1000 of ABEM, Sweden and using the Wenner electrode array. Then Terrameter directly records the value of V/I in ohms. In order to study the variation of resistivity with depth, Vertical Electric Sounding (VES) technique was employed. In this technique, apparent resistivity values are obtained for various depths by increasing the current electrodes spacing at the ground surface, keeping the centre of electrode array fixed at the observation point.

7.3. Results

The field resistivity curve at ERS-1 (Fig. 3) shows first a decreasing trend, then shows an increasing trend and finally shows a deceasing trend at larger electrode spacing. The field resistivity curve at ERS-2 (Fig. 4) shows first an increasing trend and finally shows a deceasing trend at larger electrode spacing. The average (apparent) resistivity up to a depth of 5 meters varies from 214.18 to 244.95 ohm-meters. The average (apparent) resistivity up to a depth of 10 meters varies from 237.05 to 245.89 ohm-meters representing predominance of high resistivity material at shallow depth.

The results of electrical resistivity testing obtained at two observation points in the site area are presented in Table-1 in the form true resistivity earth layering model. From these results, it can be inferred that the subsurface material up to 20 meters depth shows three to four resistivity layers with large variation of true resistivity values ranging from 20.7 to 659.2 ohm-meters.

At ERS-1, top very thin (0.9 meter thickness) layer have resistivity of 659.2 ohm-meters representing dry and hard surface material. Below this another thin layer (0.8 meter thickness) is present with a low resistivity of 38.5 ohm-meters. Below this up to 8.2 meters depth, a layer with high resistivity of 652.6 ohm-meters is present. Below 8.2 meters depth, a layer with low resistivity of 23.9 ohm-Meters is present representing sand below water table.

At ERS-2, top thin (1.7 meter thickness) layer have resistivity of 123.2 ohm-meters representing dry surface material. Below this up to 7.6 meters depth, a layer with high resistivity of 487.2 ohm-meters is present, representing dry hard sand above water table. Below 7.6 meters depth, a layer with low resistivity of 20.7 ohm-meters is present representing sand below water table.

Electrical resistivity measurements at two observation points in the site area show nearly uniform subsurface condition. The material above water table shows high resistivity values. The material below water table (average about 8 meters depth) shows low electrical resistivity ranging from 23.9 to 20.7 ohm-meters which is favourable for earthing design.

The detail report on resistivity survey is given as Electricity Resistivity Survey Annexure E.

8. Conclusions

In summary it is concluded that

- The sub-soil lithology comprises of Sandy Silt / Silt (ML) encountered at top generally up to 3.5m depth in firm to stiff state. The Sandy Silt / Silt was underlain by a layer of Silty Sand (SM) from 3.5m to about 10.2 m in depth in medium dense state. This layer was followed by a thick layer of Fine Sand (SW) from 10.2 m up to maximum investigated depth of 20 m below NSL in medium dense to dense state.
- Groundwater was encountered in the boreholes at 9 m below NSL during field investigation at site in June 2016.
- The evaluation of the net allowable bearing capacity of the Square Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 2.0 m below NSL. . The bearing capacity curves are presented in Annexure B.3.1.
- The evaluation of the net allowable bearing capacity of the Strip Foundation has been done using approach given by Terzaghi, Elastic theory and other established correlations. The analysis has been carried out for a depth of 2.0 m below NSL. . The bearing capacity curves are presented as Annexure B.3.2.
- Similarly the evaluation of gross allowable bearing capacity of the Mat Foundation has been done for a depth of foundation 4.5m below NSL. The bearing capacity curves are presented as Annexure B.3.3.
- Using Procedure Given by NAVFAC 7.02, the allowable pile capacity value for a diameter of 600 mm is calculated in compression up to a length of 30 m. The details are shown in the figure attached to the report as Annexure B.3.4.
- Proper paving should be provided along the periphery of the Structure.
- All the backfilling of the foundation above concrete pad should be done with cohesive material to avoid seepage of water in the foundation base. Alternatively, the top 30cm of any backfilling should be carried out with non-swelling cohesive soil.
- Adequate water proofing/damp proofing shall be provided for the structure. To avoid problem regarding moisture, it is recommended to adopt water-reducing admixtures in concrete.
- If any soft and loose material encountered, at foundation excavation level, during construction, then it should be further excavated and replaced with suitable granular material in proper compaction.
- Cementitious coatings should also be provided to avoid moisture movement through the concrete.
- Electrical resistivity measurements at two observation points in the site area show nearly uniform subsurface condition. The material above water table shows high resistivity values. The material below water table (average about 8 meters depth) shows low electrical resistivity ranging from 23.9 to 20.7 ohm-meters which is favourable for earthing design.

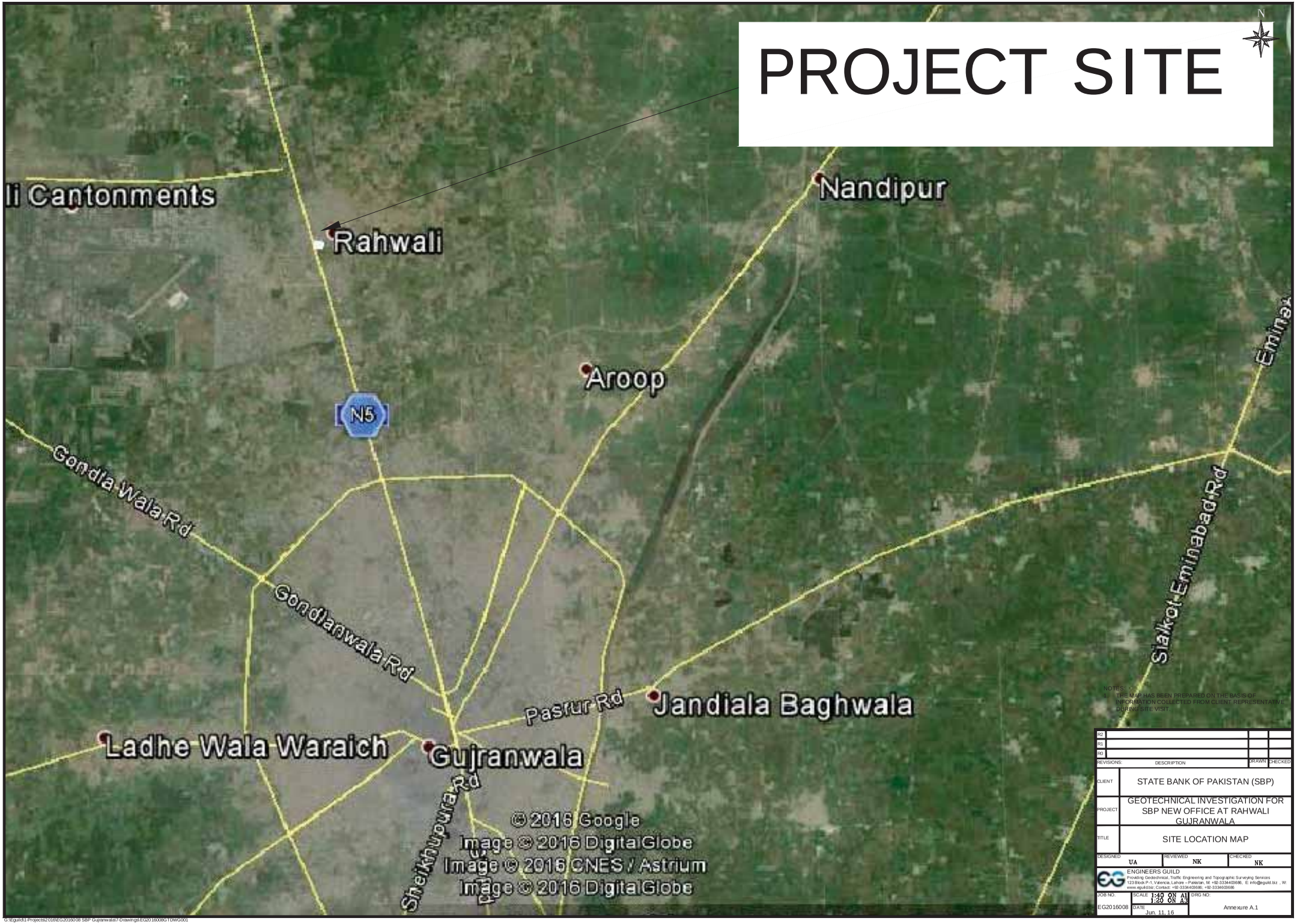
9. References

Following References and specialized Software have been utilized in the development of this report:

- Foundation Analysis and Design by Joseph E. Bowles
- Winlog & Winfence (softwares for generation of graphical borehole logs and subsurface profiles)
- NovoSPT a software from Novotech (for assessment and correlation of standard penetration resistance data for analysis and design)
- Building Code of Pakistan as given on Pakistan Engineering Council Website
- ASTM Book volume 4.08 (Soils and Rocks)
- Geotechnical Earthquake Engineering by Kramer

Annexure A. Drawings

A.1. Site Location Map



NOTES:
1. THE MAP HAS BEEN PREPARED ON THE BASIS OF INFORMATION COLLECTED FROM CLIENT REPRESENTATIVE DURING SITE VISIT

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R1			
R0			
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CLIENT	STATE BANK OF PAKISTAN (SBP)		
PROJECT	GEOTECHNICAL INVESTIGATION FOR SBP NEW OFFICE AT RAHWALI GUJRANWALA		
TITLE	SITE LOCATION MAP		
DESIGNED: UA	REVIEWED: NK	CHECKED: NK	

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JOB NO.	SCALE	DRG NO:
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	DATE: Jun, 11, 16	

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A.2. Geotechnical Investigation Plan

NOTES:
1. THE MAP HAS BEEN PREPARED ON THE BASIS OF INFORMATION COLLECTED FROM CLIENT'S REPRESENTATIVE DURING SITE VISIT.
2. THE LOCATION OF THE BOREHOLES WAS PROVIDED BY CLIENT.

REVISIONS:	DESCRIPTION	DRAWN	CHECKED
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R1			
R0			

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PROJECT	GEOTECHNICAL INVESTIGATION FOR SBP NEW OFFICE AT RAHWALI GUJRANWALA
TITLE	GEOTECHNICAL INVESTIGATION PLAN

DESIGNED	REVIEWED	CHECKED
UA	NK	NK

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JOB NO.	SCALE	DRG NO:
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	DATE: Jun. 11, 16	

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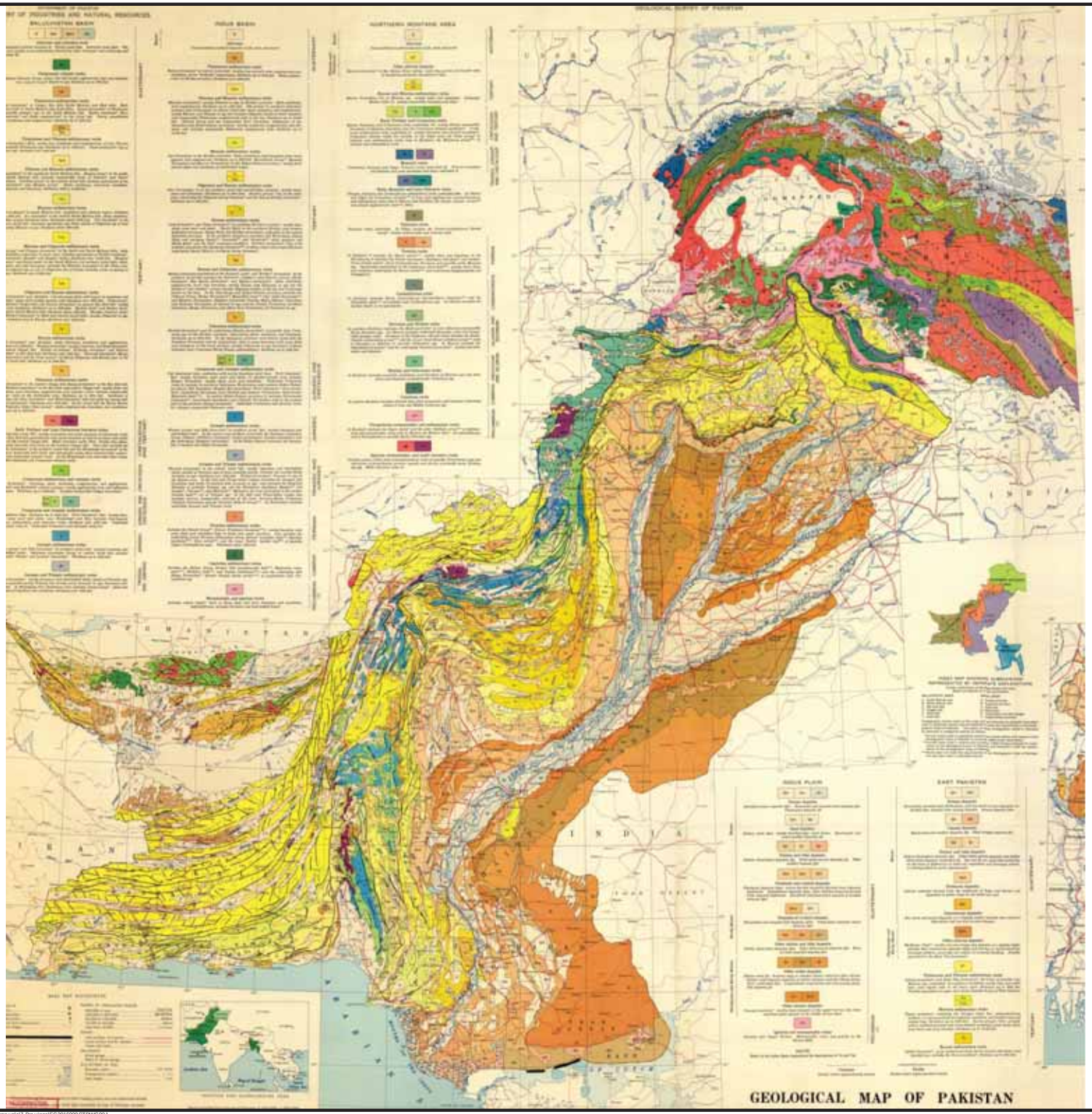
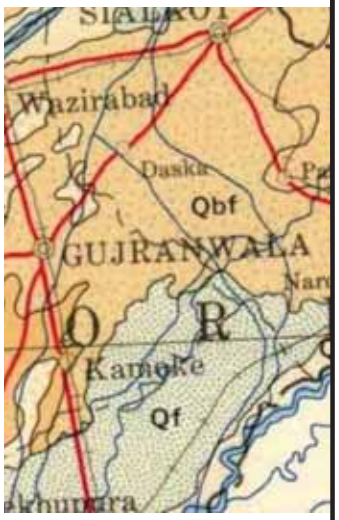
A.3. Geological Map of the Project Area



ENLARGE VIEW OF PROJECT AREA



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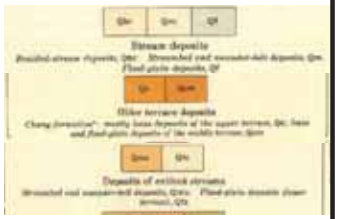

NOTES:

1. THE MAP HAS BEEN PREPARED ON THE BASIS OF INFORMATION COLLECTED FROM CLIENT REPRESENTATIVE DURING SITE VISIT.
2. THE LOCATION OF THE SITE IS BASED OF AREA LOCATION ONLY.

R2			
R1			
R0			
REVISIONS:	DESCRIPTION	DRAWN	CHECKED
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PROJECT	GEOTECHNICAL INVESTIGATION FOR SBP NEW OFFICE AT RAHWALI GUJRANWALA		
TITLE	GEOLOGICAL MAP OF PROJECT AREA		
DESIGNED: UA	REVIEWED: NK	CHECKED: NK	

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JOB NO.: EG2016008	SCALE: 1:40 ON A1 1:20 ON A3	DRG NO.: Annexure A.3
	DATE: Jun, 11, 16	

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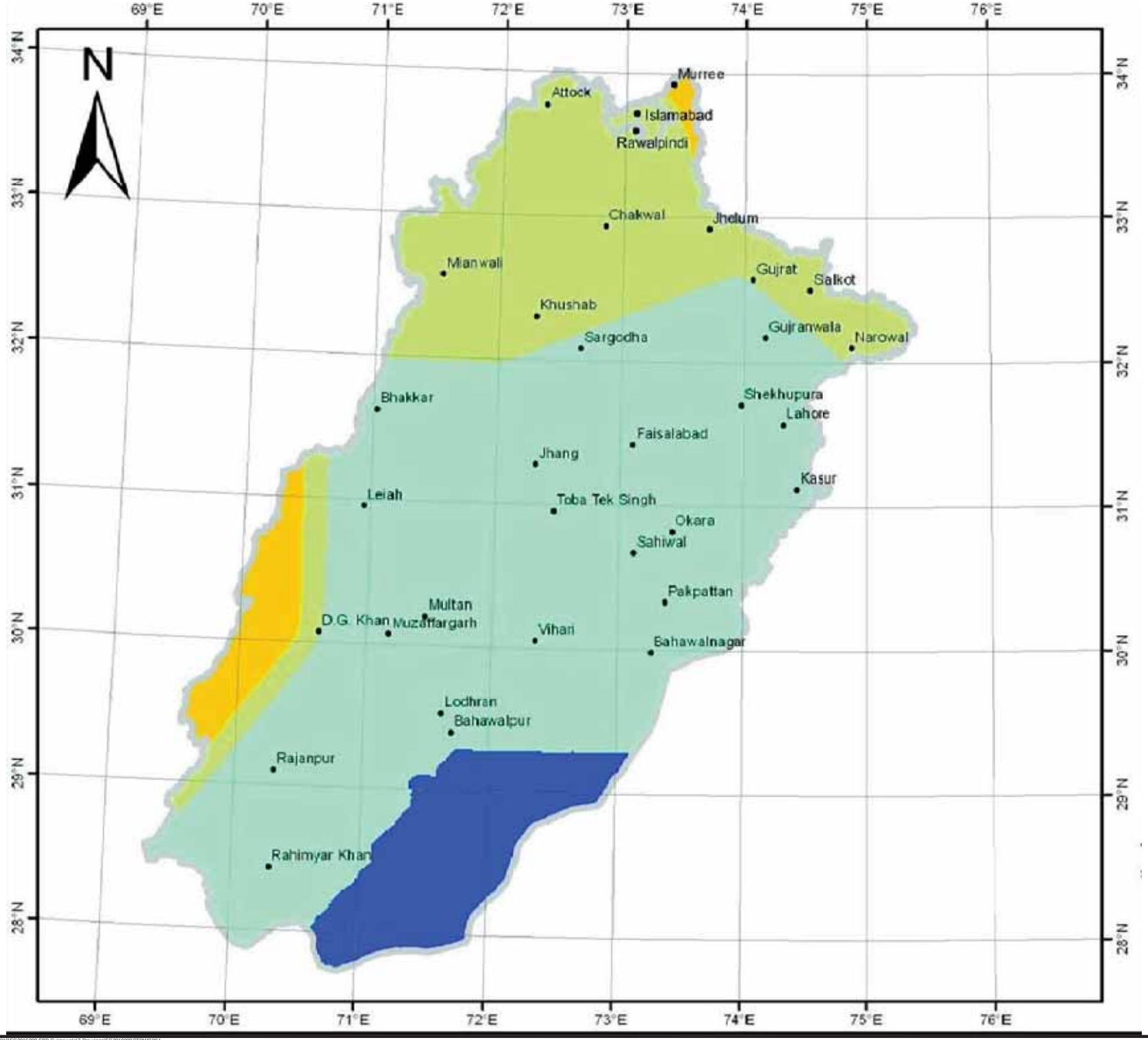
A.4. Seismic Map of Pakistan



ENLARGE VIEW OF PROJECT AREA

Seismic Zones

- Zone 1
- Zone 2A
- Zone 2B
- Zone 3
- Cities

NOTES:
1. THE MAP HAS BEEN PREPARED ON THE BASIS OF INFORMATION COLLECTED FROM CLIENT REPRESENTATIVE DURING SITE VISIT.
2. THE LOCATION OF THE SITE IS BASED OF AREA LOCATION ONLY.

REVISIONS:	DESCRIPTION	DRAWN	CHECKED
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R1			
R0			

CLIENT	STATE BANK OF PAKISTAN (SBP)
PROJECT	GEOTECHNICAL INVESTIGATION FOR SBP NEW OFFICE AT RAHWALI GUJRANWALA
TITLE	SEISMIC MAP OF PROJECT AREA

DESIGNED	REVIEWED	CHECKED
UA	NK	NK

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JOB NO.	SCALE	DRG NO:
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DATE: Jun. 11, 16		

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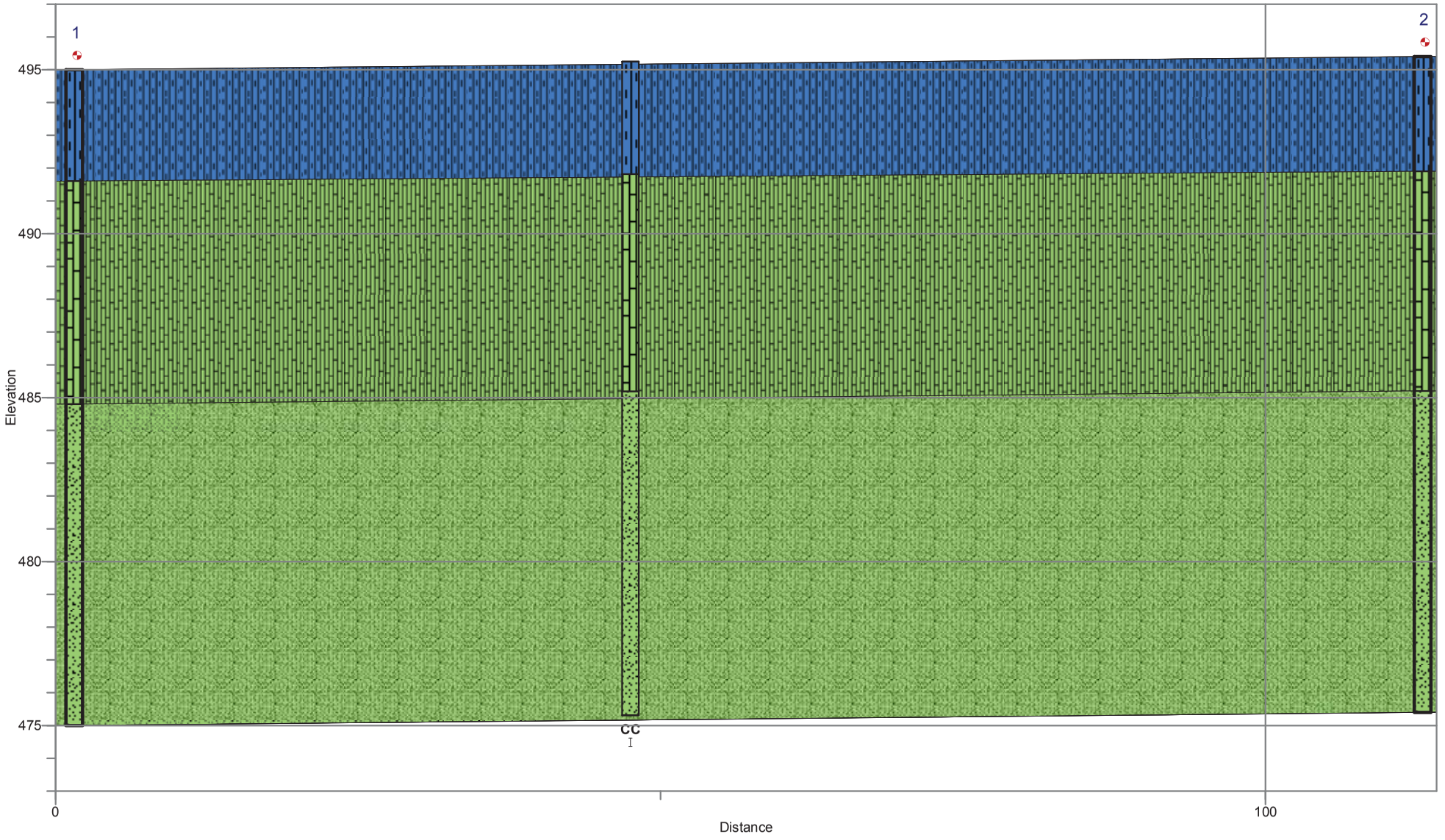
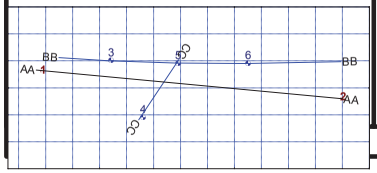
A.5. Subsurface Soil Profile





Legend

SANDY SILT/SILT

SILTY SAND

FINE SAND

Scale Bar

0 10

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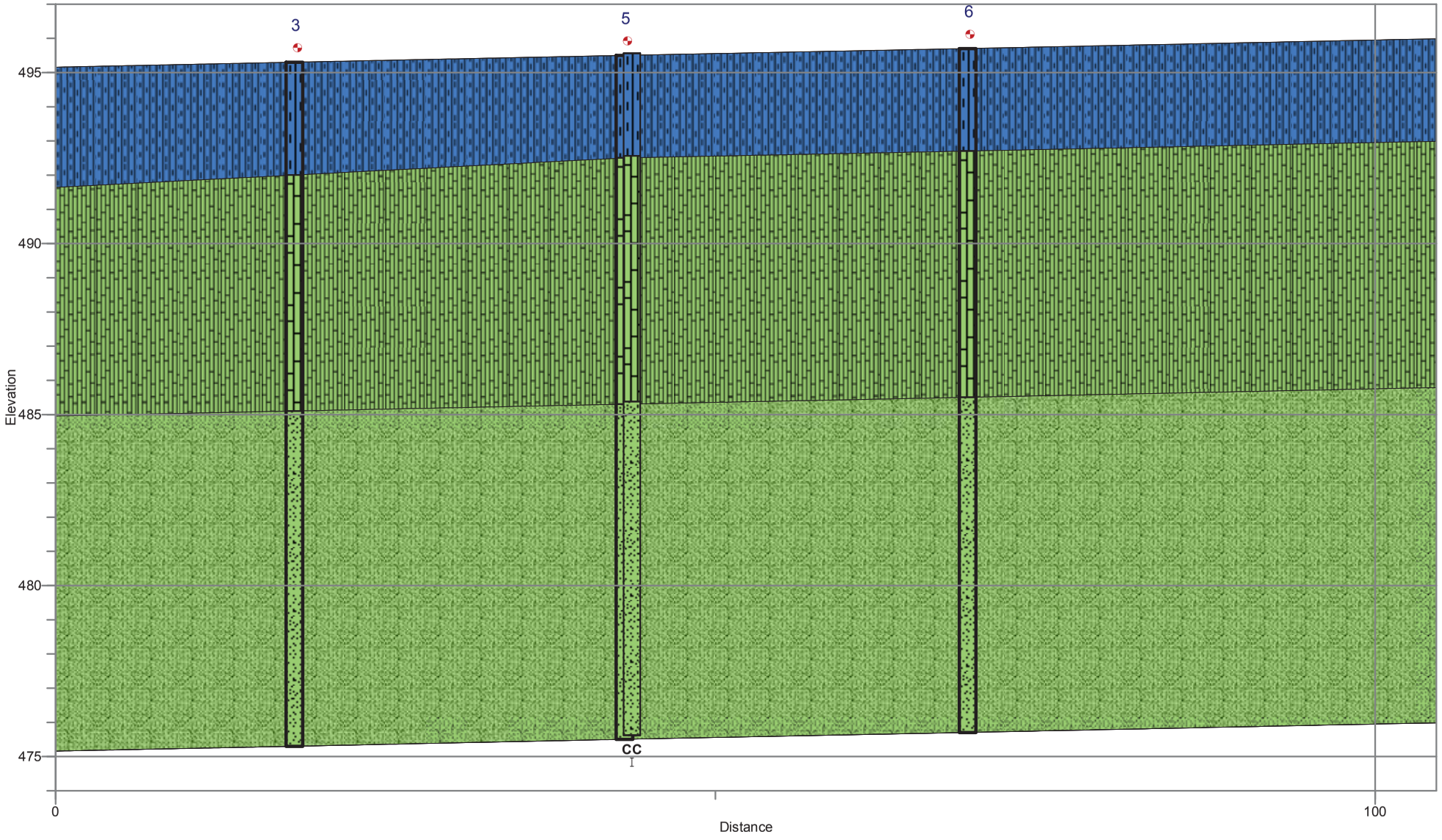
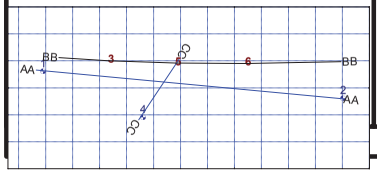
Subsurface Soil Profile

Project Name:	
Client Name:	Project Number:
Drawn By:	Date:





Legend

SANDY SILT/SILT

SILTY SAND

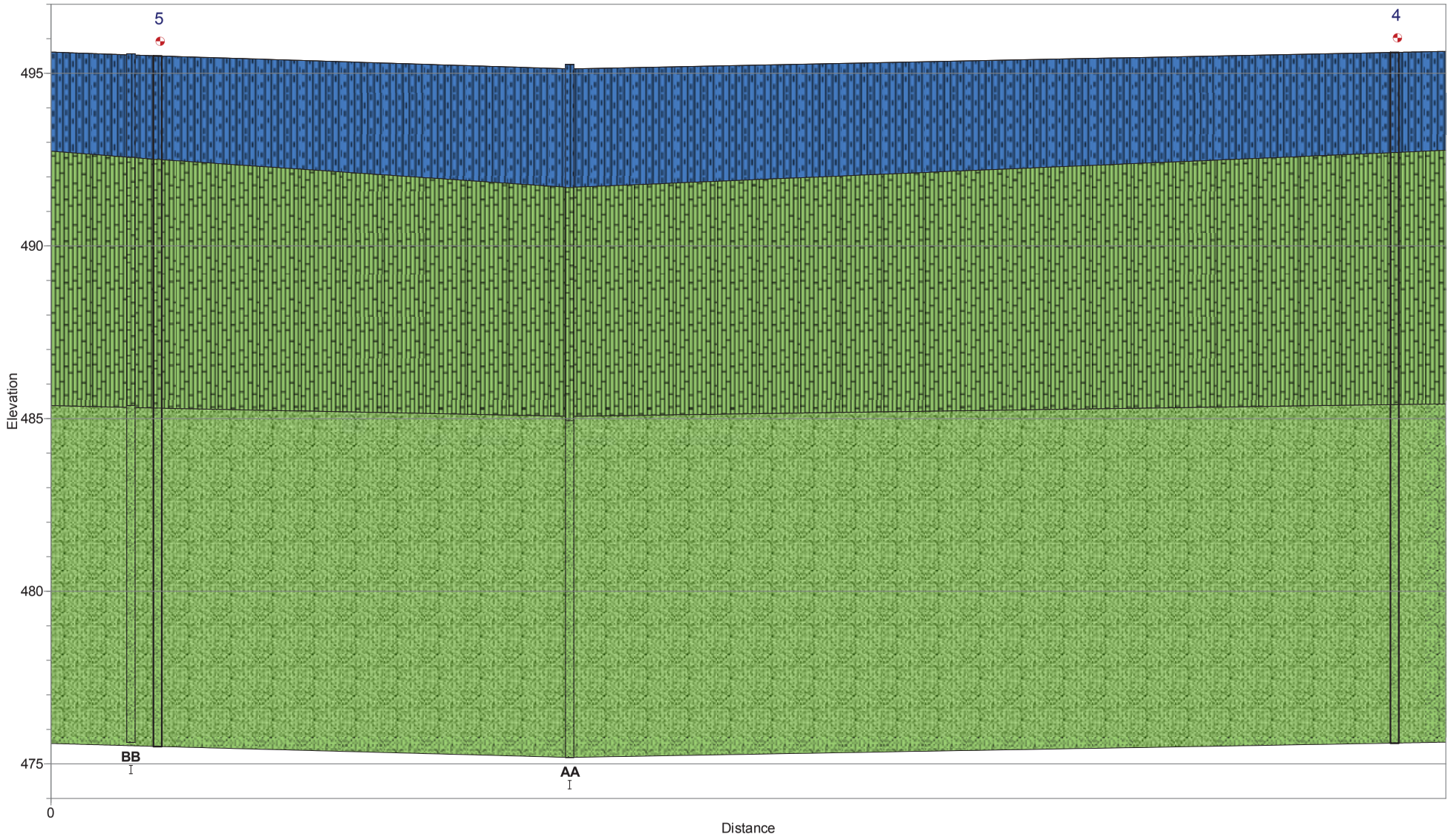
FINE SAND

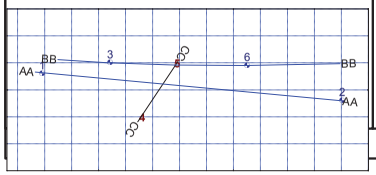
Scale Bar

0 10

ENGINEERS GUILD
123, Block P-1, Valencia Town, Lahore
Subsurface Soil Profile

Project Name:	
Client Name:	Project Number:
Drawn By:	Date:





Legend

SANDY SILT/SILT

SILTY SAND

FINE SAND

Scale Bar

0 3

ENGINEERS GUILD
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Subsurface Soil Profile

Project Name:	
Client Name:	Project Number:
Drawn By:	Date:

Annexure B. Figures

B.1. Variation of SPT Blows with Depth

Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

B.2. Summary of Laboratory Test Results

B.2.1. Laboratory Classification Testing

SOIL CLASSIFICATION BY ASTM D2487 AND AASHTO SYSTEM

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Consultant: M/s ESS-I-AAR, Karachi

Client Name: M/s State Bank of Pakistan

Contractor: N.A

Geotechnical Agency: Engineers Guild

Date: Friday, June 17, 2016

Sample with "*" are classed on the basis of Atterberg limit test of the similar or adjacent sample.

Sr No.	Borehole/ Testpit No.	Sample No.	Depth (m)	% Passing				LL	PL	PI	% Silt/ Clay	% Sand	% Gravel	SOIL CLASSIFICATION AS PER USCS REFERENCE ASTM D2487		SOIL CLASSIFICATION AS PER AASHTO
				#4	#10	#40	# 200									
1	BH-1	SPT-1	1.00	100	100	99	51	-	-	-	51	49	-	(ML)	Sandy Silt	(A-4) Silty Soils
2	BH-1	SPT-3	3.00	100	99	98	20	-	-	-	20	80	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
3	BH-1	UDS-1	5.00	100	100	99	19	-	-	-	19	81	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
4	BH-1	SPT-8	8.00	100	100	81	8	-	-	-	8	92	-	(SW-SM)	Well Graded Sand with Silt	(A-1-b) Gravel and Sand
5	BH-1	SPT-16	16.00	100	100	96	4	-	-	-	4	96	-	(SW)	Well Graded Sand	(A-1-b) Gravel and Sand
6	BH-2	SPT-2	2.00	100	100	99	14	-	-	-	14	86	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
7	BH-2	SPT-4	4.00	86	78	76	73	-	-	-	73	13	14	(ML)	Silt with Gravel	(A-4) Silty Soils

SOIL CLASSIFICATION BY ASTM D2487 AND AASHTO SYSTEM

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Consultant: M/s ESS-I-AAR, Karachi

Client Name: M/s State Bank of Pakistan

Contractor: N.A

Geotechnical Agency: Engineers Guild

Date: Friday, June 17, 2016

Sample with "*" are classed on the basis of Atterberg limit test of the similar or adjacent sample.

Sr No.	Borehole/ Testpit No.	Sample No.	Depth (m)	% Passing				LL	PL	PI	% Silt/ Clay	% Sand	% Gravel	SOIL CLASSIFICATION AS PER USCS REFERENCE ASTM D2487		SOIL CLASSIFICATION AS PER AASHTO
				#4	#10	#40	# 200									
8	BH-2	SPT-9	9.00	100	97	94	21	-	-	-	21	79	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
9	BH-2	SPT-14	14.00	83	73	70	3	-	-	-	3	80	17	(SW)	Well Graded Sand with Gravel	(A-1-b) Gravel and Sand
10	BH-3	SPT-3	1.00	100	99	97	55	-	-	-	55	45	-	(ML)	Sandy Silt	(A-4) Silty Soils
11	BH-3	SPT-2	2.00	100	98	97	53	-	-	-	53	47	-	(ML)	Sandy Silt	(A-4) Silty Soils
12	BH-3	SPT-9	9.00	100	91	89	42	-	-	-	42	58	-	(SM)	Silty Sand	(A-4) Silty Soils
13	BH-3	SPT-17	17.00	79	64	62	12	-	-	-	12	67	21	(SW-SM)	Well Graded Sand with Silt and	(A-1-b) Gravel and Sand
14	BH-4	SPT-2	2.00	100	99	98	40	-	-	-	40	60	-	(SM)	Silty Sand	(A-4) Silty Soils

SOIL CLASSIFICATION BY ASTM D2487 AND AASHTO SYSTEM

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Consultant: M/s ESS-I-AAR, Karachi

Client Name: M/s State Bank of Pakistan

Contractor: N.A

Geotechnical Agency: Engineers Guild

Date: Friday, June 17, 2016

Sample with "*" are classed on the basis of Atterberg limit test of the similar or adjacent sample.

Sr No.	Borehole/ Testpit No.	Sample No.	Depth (m)	% Passing				LL	PL	PI	% Silt/ Clay	% Sand	% Gravel	SOIL CLASSIFICATION AS PER USCS REFERENCE ASTM D2487		SOIL CLASSIFICATION AS PER AASHTO
				#4	#10	#40	# 200									
15	BH-4	SPT-5	5.00	100	100	97	42	-	-	-	42	58	-	(SM)	Silty Sand	(A-4) Silty Soils
16	BH-4	UDS-1	7.00	100	100	93	21	-	-	-	21	79	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
17	BH-4	SPT-8	9.50	100	100	98	6	-	-	-	6	94	-	(SW-SM)	Well Graded Sand with Silt	(A-1-b) Gravel and Sand
18	BH-4	UDS-2	10.00	100	100	93	17	-	-	-	17	83	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
19	BH-4	SPT-12	15.50	100	100	100	34	-	-	-	34	66	-	(SM)	Silty Sand	(A-2-4) Silty and Clayey Gravel and Sand
20	BH-4	SPT-15	20.00	100	100	100	4	-	-	-	4	96	-	(SW)	Well Graded Sand	(A-1-b) Gravel and Sand
21	BH-5	SPT-1	1.00	100	99	99	85	-	-	-	85	15	-	(ML)	Silt with Sand	(A-4) Silty Soils

SOIL CLASSIFICATION BY ASTM D2487 AND AASHTO SYSTEM

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Consultant: M/s ESS-I-AAR, Karachi

Client Name: M/s State Bank of Pakistan

Contractor: N.A

Geotechnical Agency: Engineers Guild

Date: Friday, June 17, 2016

Sample with "*" are classed on the basis of Atterberg limit test of the similar or adjacent sample.

Sr No.	Borehole/ Testpit No.	Sample No.	Depth (m)	% Passing				LL	PL	PI	% Silt/ Clay	% Sand	% Gravel	SOIL CLASSIFICATION AS PER USCS REFERENCE ASTM D2487		SOIL CLASSIFICATION AS PER AASHTO
				#4	#10	#40	# 200									
22	BH-5	SPT-2	2.00	100	97	96	49	-	-	-	49	51	-	(SM)	Silty Sand	(A-4) Silty Soils
23	BH-5	SPT-6	6.50	100	100	98	6	-	-	-	6	94	-	(SW-SM)	Well Graded Sand with Silt	(A-1-b) Gravel and Sand
24	BH-5	SPT-10	12.50	100	100	94	15	-	-	-	15	85	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
25	BH-5	SPT-13	17.00	100	76	61	9	-	-	-	9	91	-	(SW-SM)	Well Graded Sand with Silt	(A-1-b) Gravel and Sand
26	BH-6	SPT-1	1.00	100	97	96	55	-	-	-	55	45	-	(ML)	Sandy Silt	(A-4) Silty Soils
27	BH-6	SPT-3	3.00	100	100	100	21	-	-	-	21	79	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand
28	BH-6	SPT-4	4.00	100	99	98	10	-	-	-	10	90	-	(SW-SM)	Well Graded Sand with Silt	(A-1-b) Gravel and Sand

SOIL CLASSIFICATION BY ASTM D2487 AND AASHTO SYSTEM

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Consultant: M/s ESS-I-AAR, Karachi

Client Name: M/s State Bank of Pakistan

Contractor: N.A

Geotechnical Agency: Engineers Guild

Date: Friday, June 17, 2016

Sample with "*" are classed on the basis of Atterberg limit test of the similar or adjacent sample.

Sr No.	Borehole/ Testpit No.	Sample No.	Depth (m)	% Passing				LL	PL	PI	% Silt/ Clay	% Sand	% Gravel	SOIL CLASSIFICATION AS PER USCS REFERENCE ASTM D2487		SOIL CLASSIFICATION AS PER AASHTO
				#4	#10	#40	# 200									
29	BH-6	SPT-11	11.00	100	100	92	7	-	-	-	7	93	-	(SW-SM)	Well Graded Sand with Silt	(A-1-b) Gravel and Sand
30	BH-6	SPT-16	16.00	100	79	73	14	-	-	-	14	86	-	(SM)	Silty Sand	(A-1-b) Gravel and Sand

B.2.2. Summary of Strength Related Test Results

SUMMARY OF STRENGTH/SETTLEMENT RELATED TESTS RESULTS

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Consultant: M/s ESS-I-AAR, Karachi

Client Name: M/s State Bank of Pakistan

Contractor: N.A

Geotechnical Agency: M/s Engineers Guild, Lahore

Date: 24-06-2016

Sr. No.	Borehole No.	Sample No.	Depth	Moisture Density Results		Unconfined Compression Test		Direct Shear Test		Consolidation		
			(m)	NMC	Dry Density	Compressive Strength	Failure Strain	C	Φ	"cv"	initial void ratio "e_o"	Swell Pressure
				%	g/cc	kg/cm^2	(%)	kPa	(Degree)	cm^2/sec	(%)	(%)
1	BH-1	UDS-1	5.00	-	-	-	-	6.00	31.80	-	-	-
2	BH-4	UDS-1	7.00	-	-	-	-	5.30	32.00	-	-	-
3	BH-4	UDS-2	10.00	-	-	-	-	2.40	32.90	-	-	-

B.2.4. Summary of Chemical Test Results on Soil

Engineers Guild, Lahore

Chemical Test Results on Soil Samples

Client: M/s State Bank of Pakistan

Project: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Date: 22-06-2016

Borehole No.	Sample No.	Depth (m)	Sulphate Content (%)	Chloride Content (%)	pH Value
BH-4	UDS-1	7.0	0.06%	0.04%	-
BH-1	UDS-1	5.0	0.07%	0.05%	-
BH-4	WS-1		70 ppm	60 ppm	6.9
BH-2	WS-1		77 ppm	65 ppm	7.2

Tested by: Sikandar Hayat	**Checked by:** Muhammad Wasim

B.3. Allowable Bearing Capacity Curve

B.3.1. Square/Rectangular Foundation

Construction of SBP New Office Building at Gujranwala
Calculation of Bearing Capacity

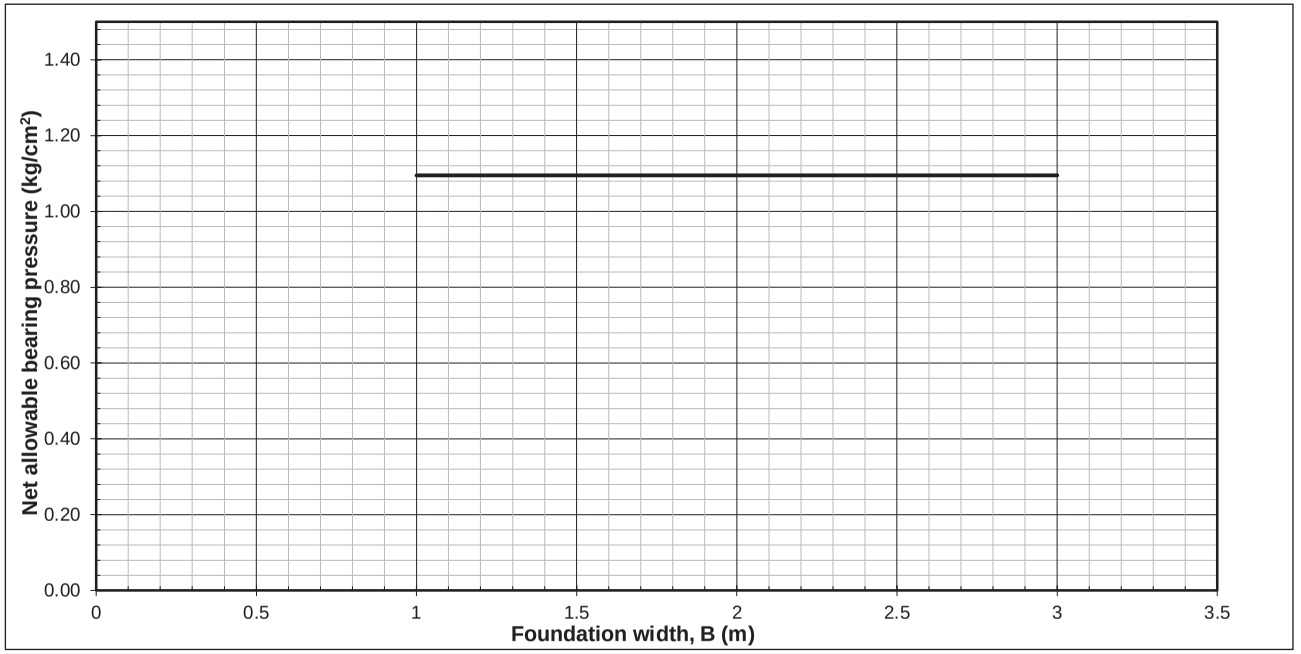
Figure B.3.1

Foundation Type	0	1 for strip & 0 for square
Foundation Width B (m)	1.00	OK
Foundation Length (m)	1.00	
Foundation Depth, D (m)	2.0	
Depth of Influence (Di) (m)	1.50	
Factor of Safety FOS	3.00	
Depth of Water Table (Dw) m	9.00	
Vertical Reaction (V) KN	-	
Horizontal Reaction (H) KN	-	
Moment (M) KN.m	-	
Load due to Embedment (Ve) KN	41.17	

Total Tolerable Settlement = 25 mm

Square/Rectangular Foundation

Special Notes: The Foundation must be inspected by Experienced Geotechnical Engineer, and must be placed on sound ground. The Grannular Cushion if required to be placed as per specification mentioned in the Section 6.2.4 of the Geotechnical Investigation Report.



B.3.2. Strip Foundation

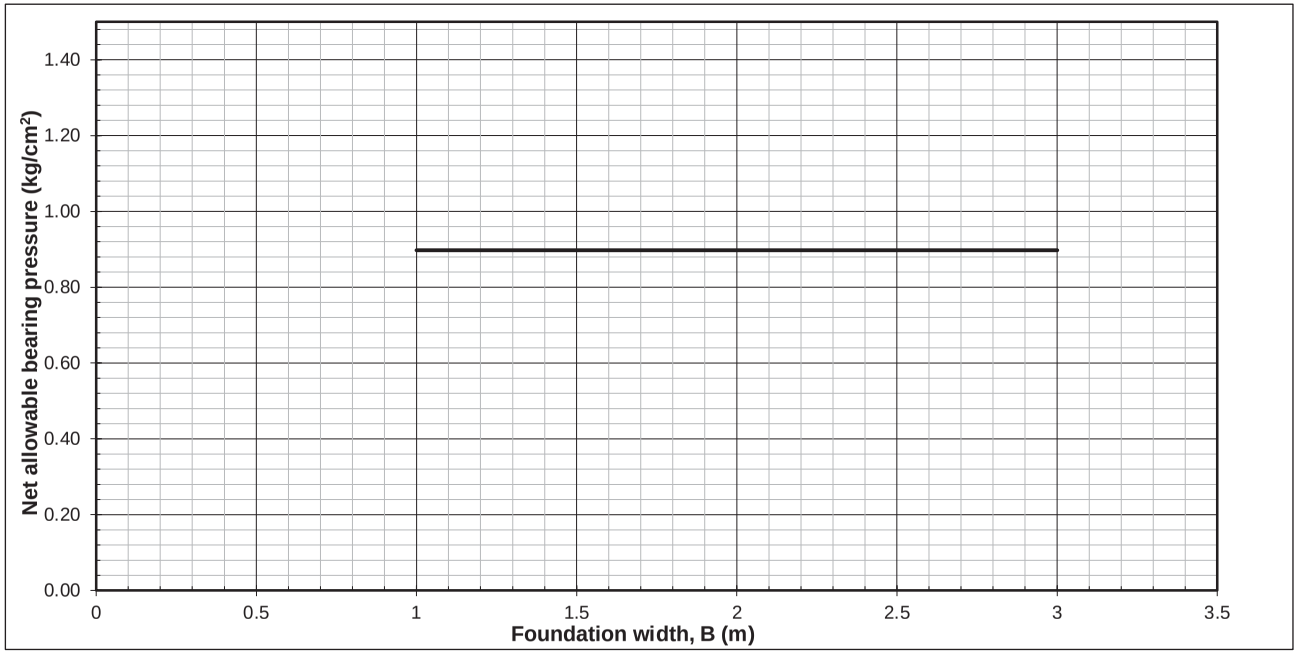
Construction of SBP New Office Building at Gujranwala
Calculation of Bearing Capacity

Figure B.3.2

Foundation Type	1	1 for strip & 0 for square
Foundation Width B (m)	1.00	OK
Foundation Length (m)	1.00	
Foundation Depth, D (m)	2.0	
Depth of Influence (Di) (m)	1.50	
Factor of Safety FOS	3.00	
Depth of Water Table (Dw) m	9.00	
Vertical Reaction (V) KN	-	
Horizontal Reaction (H) KN	-	
Moment (M) KN.m	-	
Load due to Embedment (Ve) KN	41.17	

Total Tolerable Settlement = 25 mm Strip Foundation

Special Notes: The Foundation must be inspected by Experienced Geotechnical Engineer, and must be placed on sound ground. The Grannular Cushion if required to be placed as per specification mentioned in the Section 6.2.4 of the Geotechnical Investigation Report.



B.3.3. Mat Foundation

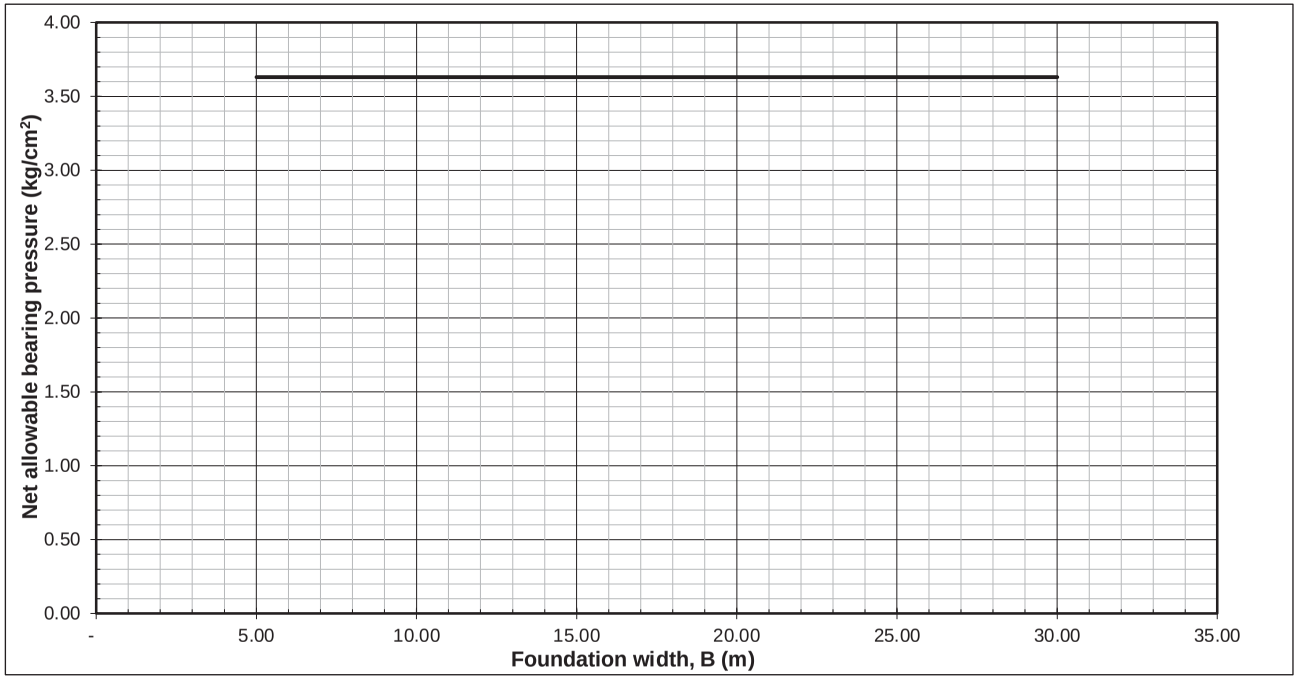
Construction of SBP New Office Building at Gujranwala
Calculation of Bearing Capacity

Figure B.3.3

Foundation Type	0	1 for strip & 0 for square
Foundation Width B (m)	5.00	OK
Foundation Length (m)	5.00	
Foundation Depth, D (m)	4.5	
Depth of Influence (Di) (m)	7.50	
Factor of Safety FOS	3.00	
Depth of Water Table (Dw) m	9.00	
Vertical Reaction (V) KN	-	
Horizontal Reaction (H) KN	-	
Moment (M) KN.m	-	
Load due to Embedment (Ve) KN	2,102.16	

Total Tolerable Settlement = 50 mm Mat Foundation

Special Notes: The Foundation must be inspected by Experienced Geotechnical Engineer, and must be placed on sound ground. The Grannular Cushion if required to be placed as per specification mentioned in the Section 6.2.4 of the Geotechnical Investigation Report.



B.3.4. Pile Foundation

Project Name Construction of SBP New Office Building at Gujranwala

Description Calculation & Design of Pile Foundation

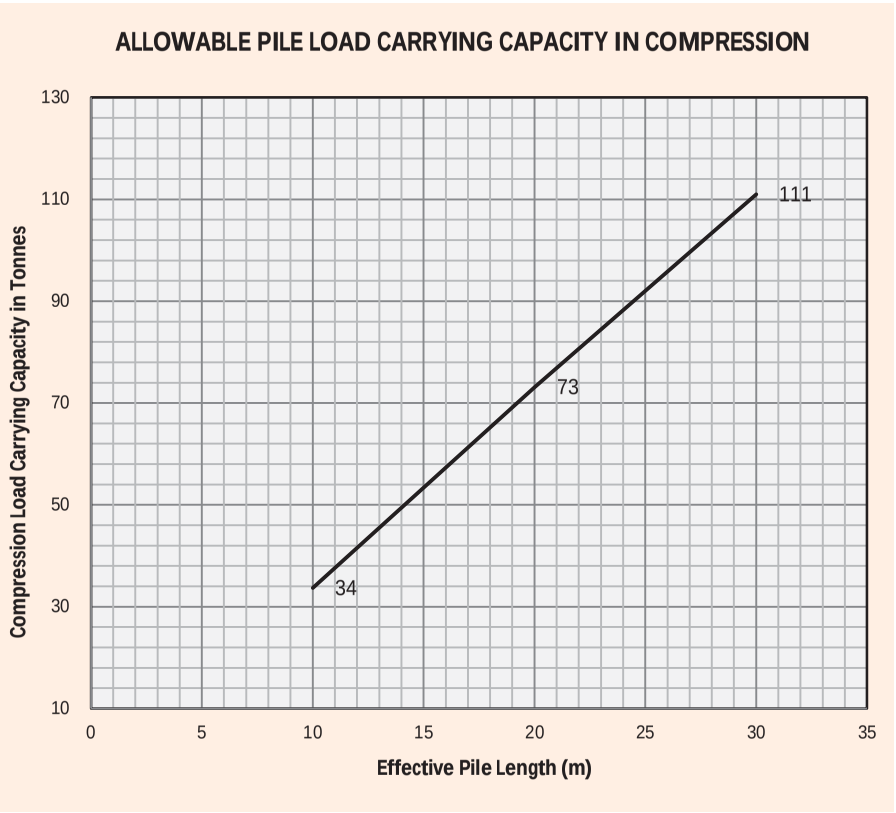
Pile Diameter (m)	0.60		Enter Values
Pile Cut-Off Below NSL (m)	5.00		Processing
Critical Depth Zone D1 (m)	5.20		Results
Critical Depth Zone D2 (m)	4.80		
Critical Depth Zone D3 (m)	2.00		
Critical Depth Zone D4 (m)			
Critical Depth (Lc) (m)	12.00	20 Dia	
Factor of Safety	2.50		
Depth of water Table (Dw) m	9		
Base Area A_T (m^2)	0.283		
Group Efficiency	0.00		

Notes:
1- No group efficiency factor used, it will be decided by Structural Engineer on the basis of arrangement of piles in the group.
2. Effective Length of Pile will start from 1m below NSL.
3. The pile length to be confimed by performing Full Scale Pile Load Test before construction of working piles.

*Layer Thicknesses below cut-off level

*Layer break will be provided for GWT depth

Parameters	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
Soil Type	Sand	Sand	Sand	Sand	Sand	
H (m)	5.2	4.8	50			0
N	10	15	15			
C (t/m2)	0	0	0			
α	0	0	0			
ϕ (Δεγ.)	29	32	34			
Unit Weight kg/cm^3						
δ (Δεγ.)	21.75	24.00	25.50	0.00	0.00	0.00
δ (ραδ.)	0.3796	0.4188	0.4450	0.0000	0.0000	0.0000
K	0.8	0.8	0.8			
Nq	10	10	10			
Nc						



Trial Details and Summary of Calculations

Trial No.	Length (m)	Skin Friction (tons)	Tip Capacity (tons)	Gross Capacity (tons)	Safety Factor	Group Efficency Factor	All'ble Capacity (tons)	Average Shaft Resistance ton/sft
Trial 1	10	49	35	84	2.50	Not App.	33.68	1.79
Trial 2	20	144	39	183	2.50	Not App.	73.12	1.94
Trial 3	30	238	39	277	2.50	Not App.	110.98	1.96

Reference: NAVFAC Design Manual 7.02, Chapter 5 pp 7.2-177

Annexure C. Site Investigation Logs

C.1. Borehole Logs

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Borehole/Augerhole No. 1

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 03-06-2016	**End Date: 04-06-2016**	**Elevation: 495**
Easting: 0421278	**Northing: 3568006**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
495.0	0	Ground Surface			0						
		SANDY SILT/SILT Brown, Firm, Sandy Silt/Silt, Non Plastic									
494.0	1			1	1		3	3	3	6	SS
493.0	2			2	2		2	3	3	6	SS
492.0	3			3	3		1	2	3	5	SS
		SILTY SAND Gray, Medium Dense to Dense, Silty Sand, Trace Mica									
491.0	4			4	4		4	6	8	14	SS
490.0	5			5	5		5	10	12	22	SS
											UDS
489.0	6			6	6		4	8	13	21	SS
488.0	7			7	7		8	11	19	30	SS
487.0	8			8	8		8	10	12	22	SS
486.0	9			9	9		5	6	8	14	SS
485.0	10			10	10		7	8	10	18	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon	NQ - Rock Core, 1-7/8"
ST - Shelby Tube	UDS - Undisturved Sample
AWG - Rock Core, 1-1/8"	CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger	SR - Straight Rotary
HA/LP - Hand Auger/Light Percussion	RC - Rock Core
HP - Heavy Percussion	

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Borehole/Augerhole No. 1

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 03-06-2016	**End Date: 04-06-2016**	**Elevation: 495**
Easting: 0421278	**Northing: 3568006**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
		FINE SAND Gray, Medium Dense to Dense, Fine Sand, Trace Mica		10						18	
484.0	11			11	11		5	7	14	21	SS
483.0	12			12	12		8	12	12	24	SS
482.0	13			13	13		7	11	14	25	SS
481.0	14			14	14		8	14	16	30	SS
480.0	15			15	15		9	12	17	29	SS
479.0	16			16	16		8	14	19	33	SS
478.0	17			17	17		4	12	10	22	SS
477.0	18			18	18		4	8	9	17	SS
476.0	19			19	19		3	9	6	15	SS
475.0	20	**BOTTOM OF BOREHOLE**		20	20		4	5	7	12	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
Rotary
HA/LP - Hand Auger/Light Percussion
HP - Heavy Percussion
SR - Straight
RC - Rock Core

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Borehole/Augerhole No. 2

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 02-06-2016	**End Date: 03-06-2016**	**Elevation: 495.4**
Easting: 0421389	**Northing: 3567996**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
495.4	0	Ground Surface			0						
495.0	0	**SANDY SILT/SILT** Brown, Firm to Stiff, Sandy Silt/Silt, Non Plastic			0						
	1			1	1		4	5	8	13	SS
494.0											
	2			2	2		3	3	4	7	SS
493.0											
	3			3	3		3	4	4	8	SS
492.0											
	4	**SILTY SAND** Gray, Medium Dense, Silty Sand, Trace Mica		4	4		5	8	10	18	SS
491.0											
	5			5	5		4	8	12	20	SS
490.0											
	6			6	6		5	8	9	17	SS
489.0											
	7			7	7		4	8	11	19	SS
488.0											
	8			8	8		6	9	12	21	SS
487.0											
	9			9	9		7	10	13	23	SS
486.0											
	10			10	10		6	12	12	24	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon	NQ - Rock Core, 1-7/8"
ST - Shelby Tube	UDS - Undisturved Sample
AWG - Rock Core, 1-1/8"	CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger	SR - Straight Rotary
HA/LP - Hand Auger/Light Percussion	RC - Rock Core
HP - Heavy Percussion	

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Borehole/Augerhole No. 2

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 02-06-2016	**End Date: 03-06-2016**	**Elevation: 495.4**
Easting: 0421389	**Northing: 3567996**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
485.0		**FINE SAND** Gray, Medium Dense, Fine Sand, Trace Mica		10						24	
	11			11	11		8	11	15	26	SS
484.0											
	12			12	12		6	10	13	23	SS
483.0											
	13			13	13		4	7	12	19	SS
482.0											
	14			14	14		7	9	13	22	SS
481.0											
	15			15	15		3	5	9	14	SS
480.0											
	16			16	16		3	5	7	12	SS
479.0											
	17			17	17		4	6	7	13	SS
478.0											
	18			18	18		3	5	6	11	SS
477.0											
	19			19	19		3	3	7	10	SS
476.0											
	20	**BOTTOM OF BOREHOLE**		20	20		5	6	8	14	SS
475.0											

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon	NQ - Rock Core, 1-7/8"
ST - Shelby Tube	UDS - Undisturved Sample
AWG - Rock Core, 1-1/8"	CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger	SR - Straight Rotary
HA/LP - Hand Auger/Light Percussion	RC - Rock Core
HP - Heavy Percussion	

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Borehole/Augerhole No. 3

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 03-06-2016	**End Date: 05-06-2016**	**Elevation: 495.3**
Easting: 0421303	**Northing: 3568010**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
495.3	0	Ground Surface			0						
		SANDY SILT/SILT Brown, Firm to Stiff, Sandy Silt/Silt, Non Plastic									
494.0	1			1	1		7	9	10	19	SS
493.0	2			2	2		4	7	9	16	SS
492.0	3			3	3		3	5	7	12	SS
		SILTY SAND Gray, Medium Dense, Silty Sand, Trace Mica, Trace Concretion									
491.0	4			4	4		4	5	8	13	SS
490.0	5			5	5		3	4	7	11	SS
489.0	6			6	6		4	5	8	13	SS
488.0	7			7	7		5	6	8	14	SS
487.0	8			8	8		5	7	11	19	SS
486.0	9			9	9		7	11	11	22	SS
	10			10	10		2	4	7	11	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
Rotary
HA/LP - Hand Auger/Light Percussion
HP - Heavy Percussion
SR - Straight
RC - Rock Core

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Borehole/Augerhole No. 3

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 03-06-2016	**End Date: 05-06-2016**	**Elevation: 495.3**
Easting: 0421303	**Northing: 3568010**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
		FINE SAND Gray, Medium Dense, Fine Sand, Trace Mica, Trace Concretion		10						11	
484.0	11			11	11		2	11	13	24	SS
483.0	12			12	12		5	10	13	23	SS
482.0	13			13	13		4	10	11	21	SS
481.0	14			14	14		6	9	9	18	SS
480.0	15			15	15		6	10	11	21	SS
479.0	16			16	16		4	7	9	16	SS
478.0	17			17	17		6	8	10	18	SS
477.0	18			18	18		6	10	10	20	SS
476.0	19			19	19		4	5	9	14	SS
475.0	20	**BOTTOM OF BOREHOLE**		20	20		5	6	7	13	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
Rotary
HA/LP - Hand Auger/Light Percussion
HP - Heavy Percussion
SR - Straight
RC - Rock Core

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Borehole/Augerhole No. 4

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 01-06-2016	**End Date: 02-06-2016**	**Elevation: 495.6**
Easting: 0421315	**Northing: 3567989**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
495.6	0	Ground Surface			0						
495.0	1	**SANDY SILT/SILT** Brown, Firm to Stiff, Sandy Silt/Silt, Non Plastic		1	1		4	5	6	11	SS
494.0	2			2	2		2	3	4	7	SS
493.0	3	**SILTY SAND** Gray, Medium Dense, Silty Sand, Trace Mica		3	3		2	3	7	10	SS
492.0	4			4	4		2	3	8	11	SS
491.0	5			5	5		5	7	9	16	SS
490.0	6			6	6		5	8	10	18	SS
489.0	7			6	7						UDS-1
488.0	8			7	8		8	12	13	25	SS
487.0	9			8	9		6	8	12	20	SS
486.0	10			9	10						UDS-2

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon	NQ - Rock Core, 1-7/8"
ST - Shelby Tube	UDS - Undisturved Sample
AWG - Rock Core, 1-1/8"	CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger	SR - Straight Rotary
HA/LP - Hand Auger/Light Percussion	RC - Rock Core
HP - Heavy Percussion	

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Borehole/Augerhole No. 4

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 01-06-2016	**End Date: 02-06-2016**	**Elevation: 495.6**
Easting: 0421315	**Northing: 3567989**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
485.0	11	**FINE SAND** Gray, Medium Dense, Fine Sand, Trace Mica, Trace Concretion		10	11		7	9	12	21	SS
484.0	12				12						
483.0	13			11	13		4	7	11	18	SS
482.0	14			12	14		4	6	10	16	SS
481.0	15				15						
480.0	16			13	16		4	6	7	13	SS
479.0	17			14	17		6	5	10	15	SS
478.0	18				18						
477.0	19			15	19		3	5	9	14	SS
476.0	20	**BOTTOM OF BOREHOLE**		16	20		4	7	9	16	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
Rotary
HA/LP - Hand Auger/Light Percussion
HP - Heavy Percussion
SR - Straight
RC - Rock Core

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Borehole/Augerhole No. 5

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 01-06-2016	**End Date: 01-01-2016**	**Elevation: 495.5**
Easting: 0421328	**Northing: 3568009**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
495.5	0	Ground Surface			0						
495.0	1	**SANDY SILT/SILT** Brown, Firm, Sandy Silt/Silt, Non Plastic		1	1		1	3	4	7	SS
494.0	2			2	2		1	2	3	5	SS
493.0	3	**SILTY SAND** Gray, Medium Dense, Silty Sand, Trace Mica		3	3		1	3	5	8	SS
492.0	4			4	4		4	5	6	11	SS
491.0	5			5	5		5	7	10	17	SS
490.0	6			6	6		5	9	14	23	SS
489.0	7			7	7		4	6	9	15	SS
488.0	8			8	8		5	7	12	19	SS
487.0	9				9						
486.0	10				10						

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
Rotary
HA/LP - Hand Auger/Light Percussion
HP - Heavy Percussion
SR - Straight
RC - Rock Core

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Borehole/Augerhole No. 5

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 01-06-2016	**End Date: 01-01-2016**	**Elevation: 495.5**
Easting: 0421328	**Northing: 3568009**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
485.0		**FINE SAND** Gray, Medium Dense to Dense, Fine Sand, Trace Mica, Trace Concretion									
	11			9	11		7	9	12	21	SS
484.0											
	12			10	12		7	10	14	24	SS
483.0											
	13				13						
482.0											
	14			11	14		9	12	15	27	SS
481.0											
	15				15						
480.0				12			8	14	15	29	SS
	16				16						
479.0											
	17			13	17		10	15	18	33	SS
478.0											
	18				18						
477.0				14			9	16	16	32	SS
	19				19						
476.0											
	20	**BOTTOM OF BOREHOLE**		15	20		10	17	20	37	SS

STD. PENETRATION TEST DATA (blows/.30m)

1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
HA/LP - Hand Auger/Light Percussion
HP - Heavy Percussion
SR - Straight Rotary
RC - Rock Core

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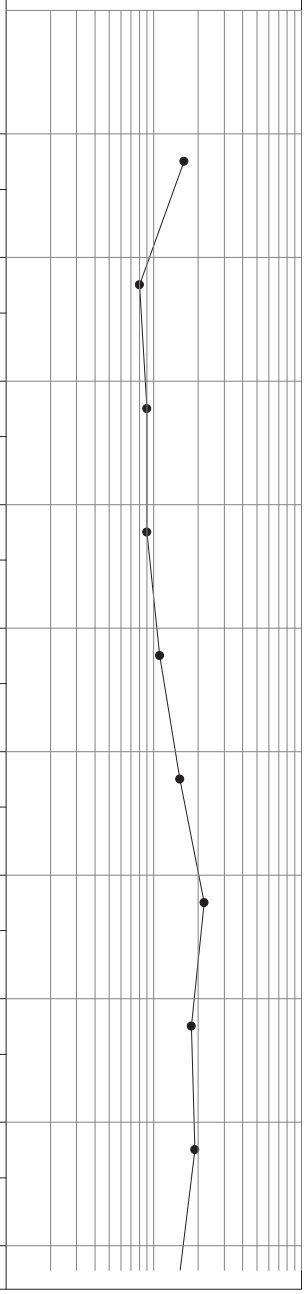
Borehole/Augerhole No. 6

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 01-06-2016	**End Date: 04-06-2016**	**Elevation: 495.7**
Easting: 0421354	**Northing: 3568009**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
495.7	0	Ground Surface			0						
495.0	1	**SANDY SILT/SILT** Brown, Firm, Sandy Silt/Silt, Non Plastic		1	1		6	8	8	16	SS
494.0	2			2	2		3	4	4	8	SS
493.0	3	**SILTY SAND** Gray, Medium Dense, Silty Sand, Trace Mica		3	3		2	4	5	9	SS
492.0	4			4	4		3	4	5	9	SS
491.0	5			5	5		4	5	6	11	SS
490.0	6			6	6		3	6	9	15	SS
489.0	7			7	7		5	10	12	22	SS
488.0	8			8	8		4	8	10	18	SS
487.0	9			9	9		5	7	12	19	SS
486.0	10			10	10		4	7	8	15	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100



LEGEND

SAMPLER TYPE

SS - Split Spoon
ST - Shelby Tube
AWG - Rock Core, 1-1/8"
NQ - Rock Core, 1-7/8"
UDS - Undisturved Sample
CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger
SR - Straight Rotary
HA/LP - Hand Auger/Light Percussion
RC - Rock Core
HP - Heavy Percussion

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Borehole/Augerhole No. 6

Project: SBP New Office Building at Rahwali Gujranwala
Consultant: ESS-I-AAR, Karachi
Client: State Bank of Pakistan (SBP)

Start Date: 01-06-2016	**End Date: 04-06-2016**	**Elevation: 495.7**
Easting: 0421354	**Northing: 3568009**	**Notes:**
Supervisor: M. Ramazan	**Construction Contractor: N.A**	
Groundwater Level: 9.0 m	**Drilling Method: Staright Rotary**	

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Graphic Log	Sample No.	Depth (m)	Sample Symbol	1st 15 cm	2nd 15 cm	3rd 15 cm	N Value	Sample Type
485.0	11	**FINE SAND** Gray, Medium Dense to Dense, Fine Sand, Trace Mica, Trace Concretion		11	11		7	9	14	23	SS
484.0	12			12	12		5	9	16	25	SS
483.0	13			13	13		7	10	12	22	SS
482.0	14			14	14		5	7	14	21	SS
481.0	15			15	15		6	11	13	24	SS
480.0	16			16	16		8	14	14	28	SS
479.0	17			17	17		6	13	17	30	SS
478.0	18			18	18		11	13	14	27	SS
477.0	19			19	19		9	10	13	23	SS
476.0	20	**BOTTOM OF BOREHOLE**		20	20		6	12	14	26	SS

STD. PENETRATION TEST DATA (blows/.30m)
1 — 100

LEGEND

SAMPLER TYPE

SS - Split Spoon	NQ - Rock Core, 1-7/8"
ST - Shelby Tube	UDS - Undisturved Sample
AWG - Rock Core, 1-1/8"	CT - Continuous Tube

DRILLING METHOD

HA - Hand Auger	SR - Straight Rotary
HA/LP - Hand Auger/Light Percussion	RC - Rock Core
HP - Heavy Percussion	

C.2. Vane Shear Test Results

SUMMARY OF VANE SHEAT TEST RESULTS

Project Name: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Client Name: M/s State Bank of Pakistan

Geotechnical Agency: M/s Engineers Guild, Lahore

Sr. No.	BH No.	Depth (m)	Vane Shear (Kg/cm^2)	Remarks
1.0	1.0	1.0	0.45	
2.0	1.0	2.0	0.40	
3.0	1.0	3.0	0.99	
4.0	4.0	1.0	0.75	
5.0	4.0	2.0	0.81	
6.0	4.0	3.0	0.35	
7.0	4.0	4.0	0.35	
8.0	6.0	1.0	0.29	
9.0	6.0	2.0	0.26	
10.0	6.0	3.0	0.33	

C.3. Plate Load Test Results

RESULT OF PLATE LOAD TEST

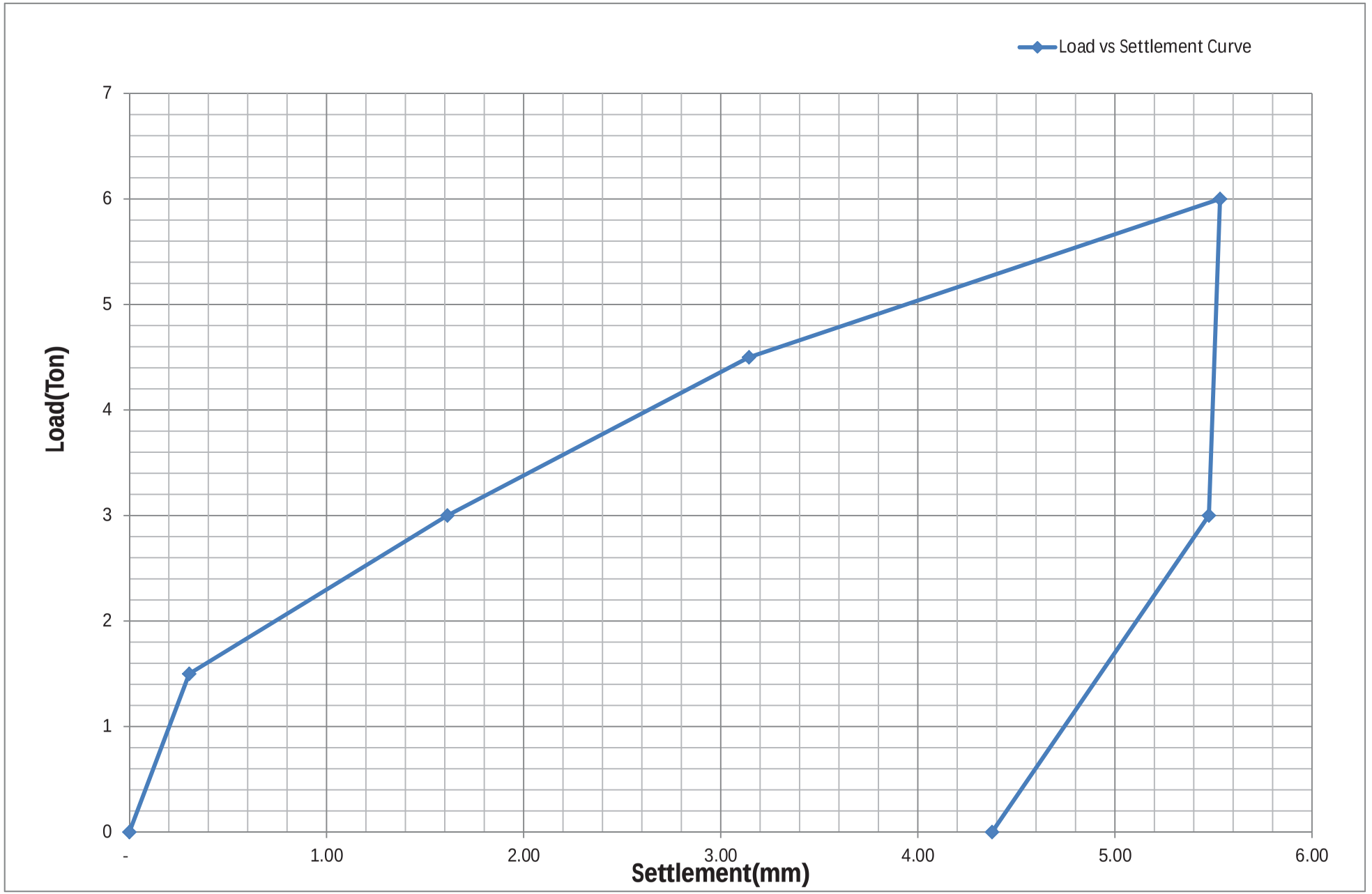
Project : SBP Office Building, Gujranwala **Test No :** 1

Date	Time (min)	%age of Design Load	LOAD Tons	Settlemet in mm				REMARKS	
				G1	G2	G3	Average		
LOADING									
13-Jun-16		0	0	0	0	0	0		
	1	25	1.5	0.50	0.26	0.04	0.27		
	2	25	1.5	0.50	0.26	0.04	0.27		
	4	25	1.5	0.50	0.26	0.04	0.27		
	8	25	1.5	0.54	0.26	0.04	0.28		Test Load : 6.0 Ton
	15	25	1.5	0.55	0.26	0.04	0.28		
	30	25	1.5	0.58	0.26	0.07	0.30		
	1	50	3.0	1.87	1.71	0.71	1.43		
	2	50	3.0	1.90	1.78	0.88	1.52		
	4	50	3.0	1.91	1.82	0.88	1.54		
	8	50	3.0	1.95	1.83	0.99	1.59		Test Started on :
	15	50	3.0	1.99	1.89	0.88	1.59		6/13/2016
	30	50	3.0	2.03	1.92	0.89	1.61		Test Completed on :
	1	75	4.5	2.37	2.22	1.89	2.16		6/13/2016
	2	75	4.5	3.40	3.31	1.90	2.87		Gross settlement
	4	75	4.5	3.51	3.38	2.02	2.97		5.53
	8	75	4.5	3.59	3.41	2.02	3.01		Net Settlement
	15	75	4.5	3.70	3.50	2.10	3.10		4.38
	30	75	4.5	3.75	3.57	2.11	3.14		Rebound
	1	100	6.0	5.75	5.61	3.70	5.02		1.16
	2	100	6.0	5.67	5.66	4.01	5.11		
	4	100	6.0	5.77	5.78	4.02	5.19		
	8	100	6.0	5.89	5.88	4.05	5.27		
	15	100	6.0	6.01	6.01	4.14	5.39		
	30	100	6.0	6.16	6.17	4.27	5.53		
UNLOADING									
	1	50	3.0	6.10	6.16	4.26	5.51		
	2	50	3.0	6.01	6.16	4.26	5.48		
	4	50	3.0	6.01	6.16	4.26	5.48		
	8	50	3.0	6.01	6.16	4.26	5.48		
	15	50	3.0	6.01	6.16	4.26	5.48		
	30	50	3.0	6.01	6.16	4.26	5.48		

RESULT OF PLATE LOAD TEST

Project : **SBP Office Building, Gujranwala** **Test No :** 1

Date	Time (min)	%age of Design Load	LOAD Tons	Settlemet in mm				REMARKS	
	1	100	0.0	4.73	5.30	3.92	4.65		
	2	100	0.0	4.60	5.23	3.30	4.38		
	4	100	0.0	4.60	5.23	3.30	4.38		
	8	100	0.0	4.60	5.23	3.30	4.38		
	15	100	0.0	4.60	5.23	3.30	4.38		
	30	100	0.0	4.60	5.23	3.30	4.38		


Load vs Settlement Curve
Load(Ton)
0
1
2
3
4
5
6
7
-
1.00
2.00
3.00
4.00
5.00
6.00
Settlement(mm)

RESULT OF PLATE LOAD TEST

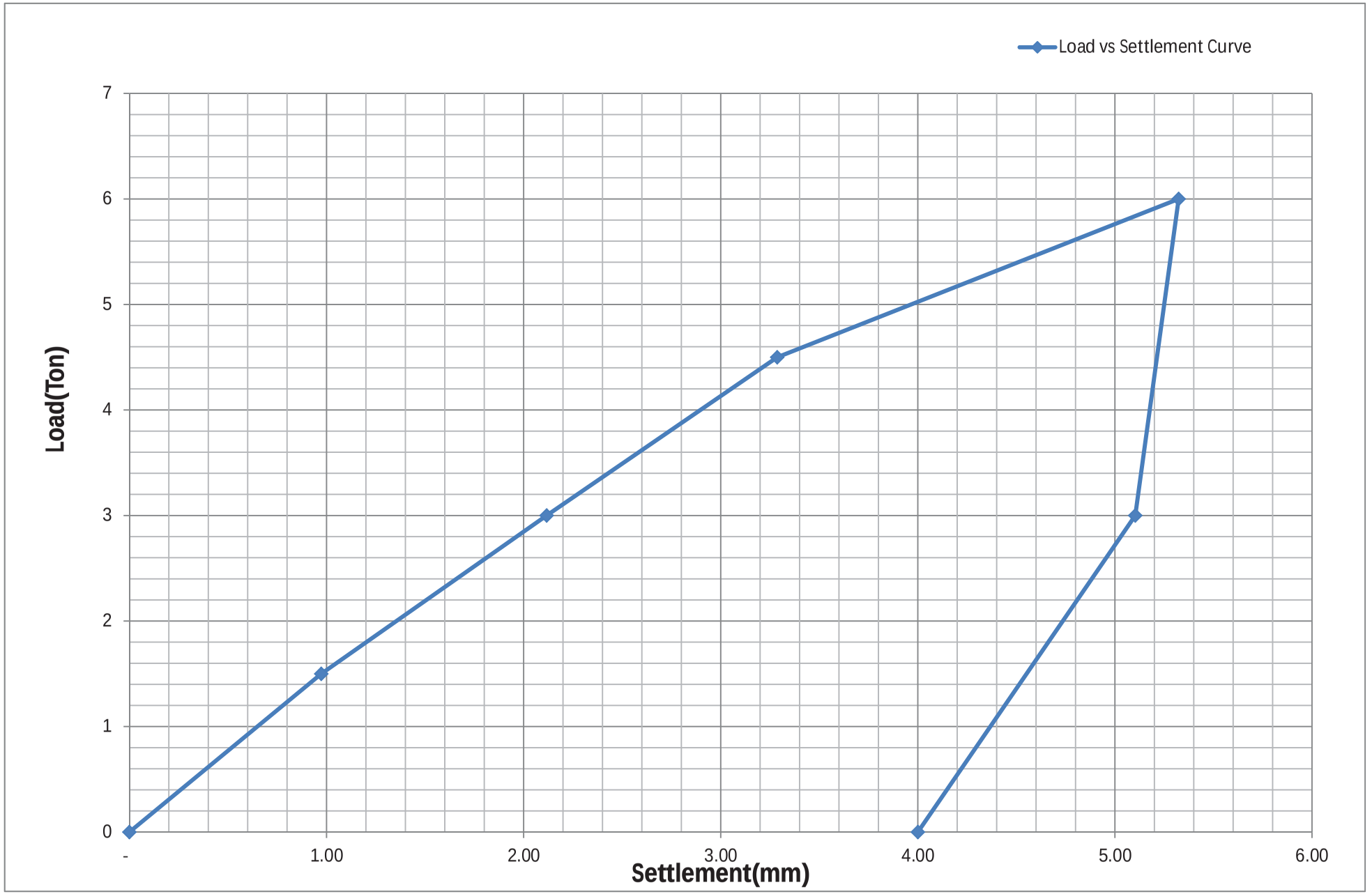
Project : SBP Office Building, Gujranwala **Test No :** 2

Date	Time (min)	%age of Design Load	LOAD Tons	Settlemet in mm				REMARKS	
				G1	G2	G3	Average		
LOADING									
13-Jun-16		0	0	0	0	0	0		
	1	25	1.5	1.05	0.90	0.65	0.87		
	2	25	1.5	1.17	0.91	0.67	0.92		
	4	25	1.5	1.20	0.93	0.68	0.94		
	8	25	1.5	1.21	0.94	0.69	0.95		Test Load : 6.0 Ton
	15	25	1.5	1.24	0.94	0.70	0.96		
	30	25	1.5	1.27	0.94	0.71	0.97		
	1	50	3.0	2.50	1.75	1.54	1.93		
	2	50	3.0	2.57	1.80	1.57	1.98		
	4	50	3.0	2.61	1.81	1.62	2.01		
	8	50	3.0	2.65	1.83	1.68	2.05		Test Started on :
	15	50	3.0	2.68	1.83	1.68	2.06		6/13/2016
	30	50	3.0	2.75	1.89	1.71	2.12		Test Completed on :
	1	75	4.5	3.79	2.69	2.51	3.00		6/13/2016
	2	75	4.5	3.91	2.75	2.55	3.07		Gross settlement
	4	75	4.5	3.99	2.77	2.63	3.13		5.32
	8	75	4.5	4.10	2.77	2.70	3.19		Net Settlement
	15	75	4.5	4.15	2.78	2.77	3.23		4.00
	30	75	4.5	4.24	2.78	2.84	3.29		Rebound
	1	100	6.0	5.56	4.65	4.51	4.91		1.32
	2	100	6.0	5.60	4.65	4.63	4.96		
	4	100	6.0	5.67	4.66	4.69	5.01		
	8	100	6.0	5.67	4.66	4.71	5.01		
	15	100	6.0	5.75	4.69	4.80	5.08		
	30	100	6.0	6.10	4.97	4.90	5.32		
UNLOADING									
	1	50	3.0	6.05	4.45	4.81	5.10		
	2	50	3.0	6.05	4.45	4.81	5.10		
	4	50	3.0	6.05	4.45	4.81	5.10		
	8	50	3.0	6.05	4.45	4.81	5.10		
	15	50	3.0	6.05	4.45	4.81	5.10		
	30	50	3.0	6.05	4.45	4.81	5.10		

RESULT OF PLATE LOAD TEST

Project : **SBP Office Building, Gujranwala** **Test No :** 2

Date	Time (min)	%age of Design Load	LOAD Tons	Settlemet in mm				REMARKS	
	1	100	0.0	4.80	3.30	3.90	4.00		
	2	100	0.0	4.80	3.30	3.90	4.00		
	4	100	0.0	4.80	3.30	3.90	4.00		
	8	100	0.0	4.80	3.30	3.90	4.00		
	15	100	0.0	4.80	3.30	3.90	4.00		
	30	100	0.0	4.80	3.30	3.90	4.00		


Load vs Settlement Curve
Load(Ton)
0
1
2
3
4
5
6
7
-
1.00
2.00
3.00
4.00
5.00
6.00
Settlement(mm)

C.4. Field Permeability Test Results

FIELD PERMEABILITY TEST

BS-5930 (1981)

TEST NO.	1.0	**BOREHOLE NO.**	1	**DATE**	04-06-2016
DEPTH OF TEST(m)	5.0	**LOCATION**	Borehole-1		
CASING DIA(cm)	8	**BOTTOM OF CASING**	500	**WATER TABLE(cm)**	900
CASING ABOVE NSL(cm)	71	**METHOD OF TEST**	Constant Head		
PROJECT	Construction of SBP New ofice building at Gujranwala				
TYPE OF SOIL	Silty Sand	**TESTED BY**	Engr. Usman		

Elapsed Time (min)	Flow (Liter)	Depth of water from top of casing (cm)
2	32.00	100.00
2	7.00	92.00
2	6.00	85.00
2	5.54	66.00
2	4.00	64.00
2	4.00	60.00
2	3.74	59.80
2	3.51	57.00
2	3.31	53.00
2	3.00	52.00
5	3.00	116.00
5	5.43	110.00
5	6.00	112.00
5	5.75	92.00
10	5.00	180.00
10	9.54	66.00
60	**106.82**	

q = (Total Flow)/(Total elapsed Time)	29.68	cm^3/sec
F = (2.75) X (Casing inner Dia in cm)	22	cm
H_C = (Total Head in cm)	971	cm
K = q/[(F) x (H_c)] (For Flush Bottom)	1.39E-03	cm/sec

Reviewd by:	

FIELD PERMEABILITY TEST

BS-5930 (1981)

TEST NO.	1.0	**BOREHOLE NO.**	3	**DATE**	04-06-2016
DEPTH OF TEST(m)	5.0	**LOCATION**	Borehole-3		
CASING DIA(cm)	8	**BOTTOM OF CASING**	500	**WATER TABLE(cm)**	900
CASING ABOVE NSL(cm)	108	**METHOD OF TEST**	Constant Head		
PROJECT	Construction of SBP New ofice building at Gujranwala				
TYPE OF SOIL	Silty Sand	**TESTED BY**	Engr. Usman		

Elapsed Time (min)	Flow (Liter)	Depth of water from top of casing (cm)
2	1.32	4.00
2	0.22	5.90
2	0.34	6.20
2	0.38	5.80
2	0.30	6.50
2	0.32	5.90
2	0.35	3.30
2	0.34	6.50
2	0.33	6.50
2	0.35	5.60
5	0.29	15.00
5	0.74	16.10
5	0.80	16.90
5	0.88	19.50
10	1.00	45.00
10	2.47	49.00
60	**10.43**	

q = (Total Flow)/(Total elapsed Time)	2.90	cm^3/sec
F = (2.75) X (Casing inner Dia in cm)	22	cm
H_C = (Total Head in cm)	1008	cm
K = q/[(F) x (H_c)] (For Flush Bottom)	1.31E-04	cm/sec

Reviewd by:	

FIELD PERMEABILITY TEST

BS-5930 (1981)

TEST NO.	2.0	**BOREHOLE NO.**	3	**DATE**	04-06-2016
DEPTH OF TEST(m)	10.0	**LOCATION**	Borehole-3		
CASING DIA(cm)	8	**BOTTOM OF CASING**	1000	**WATER TABLE(cm)**	900
CASING ABOVE NSL(cm)	70.6	**METHOD OF TEST**	Constant Head		
PROJECT	Construction of SBP New ofice building at Gujranwala				
TYPE OF SOIL	Silty Sand	**TESTED BY**	Engr. Usman		

Elapsed Time (min)	Flow (Liter)	Depth of water from top of casing (cm)
2	7.00	24.50
2	1.56	24.00
2	1.51	21.00
2	1.41	21.00
2	1.25	19.80
2	1.24	20.40
2	1.25	20.00
2	1.22	19.30
2	1.18	18.70
2	1.00	19.40
5	1.00	44.00
5	2.34	42.30
5	2.28	43.00
5	2.22	39.70
10	2.18	74.00
10	3.66	71.30
60	**32.30**	

q = (Total Flow)/(Total elapsed Time)	8.97	cm^3/sec
F = (2.75) X (Casing inner Dia in cm)	22	cm
H_C = (Total Head in cm)	970.6	cm
K = q/[(F) x (H_c)] (For Flush Bottom)	4.20E-04	cm/sec

Reviewd by:	

FIELD PERMEABILITY TEST

BS-5930 (1981)

TEST NO.	3.0	**BOREHOLE NO.**	3	**DATE**	04-06-2016
DEPTH OF TEST(m)	15.0	**LOCATION**	Borehole-3		
CASING DIA(cm)	8	**BOTTOM OF CASING**	1500	**WATER TABLE(cm)**	900
CASING ABOVE NSL(cm)	56	**METHOD OF TEST**	Constant Head		
PROJECT	Construction of SBP New ofice building at Gujranwala				
TYPE OF SOIL	Silty Sand	**TESTED BY**	Engr. Usman		

Elapsed Time (min)	Flow (Liter)	Depth of water from top of casing (cm)
2	10.70	56.00
2	3.00	53.00
2	2.81	46.00
2	2.46	35.00
2	1.79	34.00
2	1.84	35.30
2	2.28	33.90
2	1.78	33.00
2	1.83	32.00
2	1.61	29.80
5	1.70	74.40
5	3.76	79.80
5	3.70	79.79
5	4.00	69.00
10	3.70	133.00
10	5.53	133.50
60	**52.49**	

q = (Total Flow)/(Total elapsed Time)	14.58	cm^3/sec
F = (2.75) X (Casing inner Dia in cm)	22	cm
H_C = (Total Head in cm)	956	cm
K = q/[(F) x (H_c)] (For Flush Bottom)	6.93E-04	cm/sec

Reviewd by:	

FIELD PERMEABILITY TEST

BS-5930 (1981)

TEST NO.	1.0	**BOREHOLE NO.**	6	**DATE**	04-06-2016
DEPTH OF TEST(m)	5.0	**LOCATION**	Borehole-6		
CASING DIA(cm)	8	**BOTTOM OF CASING**	500	**WATER TABLE(cm)**	900
CASING ABOVE NSL(cm)	101	**METHOD OF TEST**	Constant Head		
PROJECT	Construction of SBP New ofice building at Gujranwala				
TYPE OF SOIL	Silty Sand	**TESTED BY**	Engr. Usman		

Elapsed Time (min)	Flow (Liter)	Depth of water from top of casing (cm)
2	3.72	15.00
2	0.85	47.00
2	2.80	52.00
2	3.35	52.00
2	3.30	55.00
2	3.33	54.00
2	3.40	49.60
2	3.00	50.00
2	3.00	48.00
2	2.80	45.00
5	2.95	101.00
5	5.61	95.00
5	5.44	94.00
5	5.00	94.30
10	5.29	168.00
10	8.41	164.40
60	**62.25**	

q = (Total Flow)/(Total elapsed Time)	17.30	cm^3/sec
F = (2.75) X (Casing inner Dia in cm)	22	cm
H_C = (Total Head in cm)	1001	cm
K = q/[(F) x (H_c)] (For Flush Bottom)	7.85E-04	cm/sec

Reviewd by:	

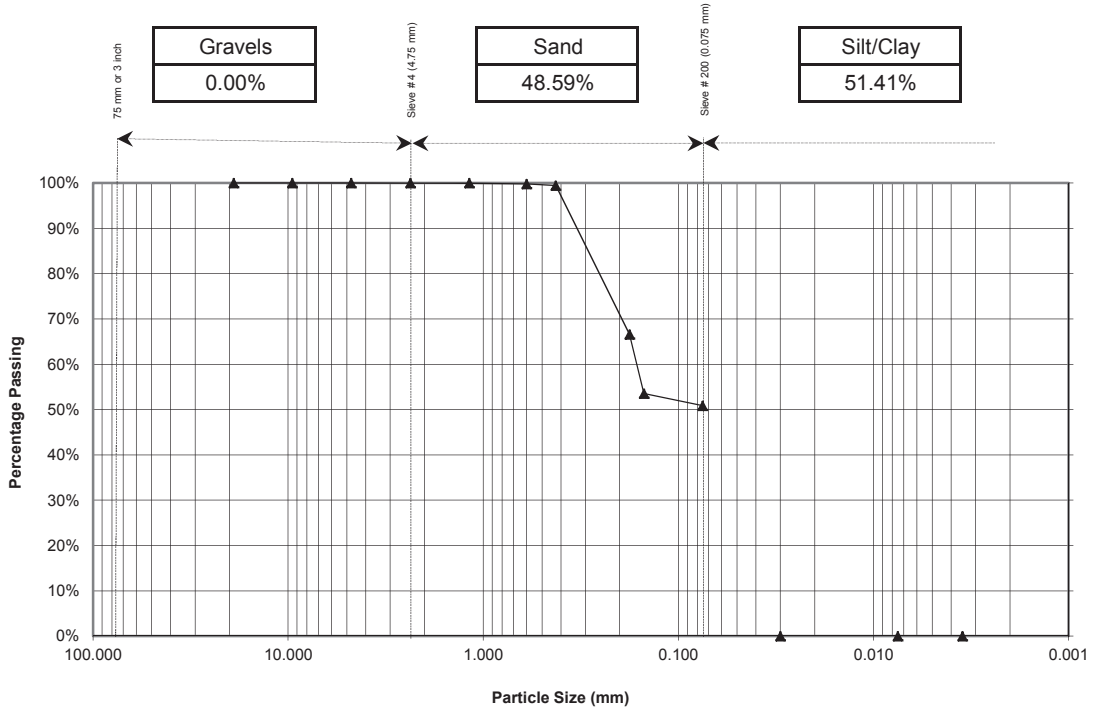
Annexure D. Laboratory Test Data

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 - SPT-1
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-1 - SPT-1

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	99%	54%	51%

Remarks

Tested By: Imtiaz Ahmad Signature :

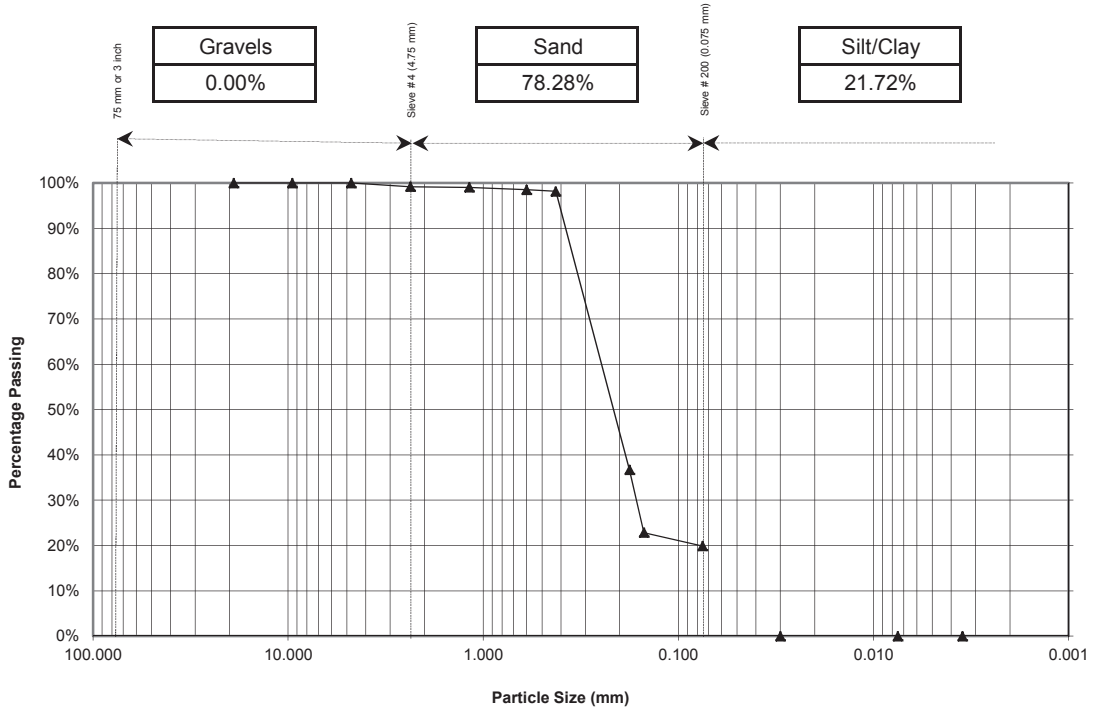
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 - SPT-3
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	3.0 m
Borehole/TP No.:	BH-1 - SPT-3

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	99%	98%	23%	20%

Remarks

Tested By: Imtiaz Ahmad Signature :

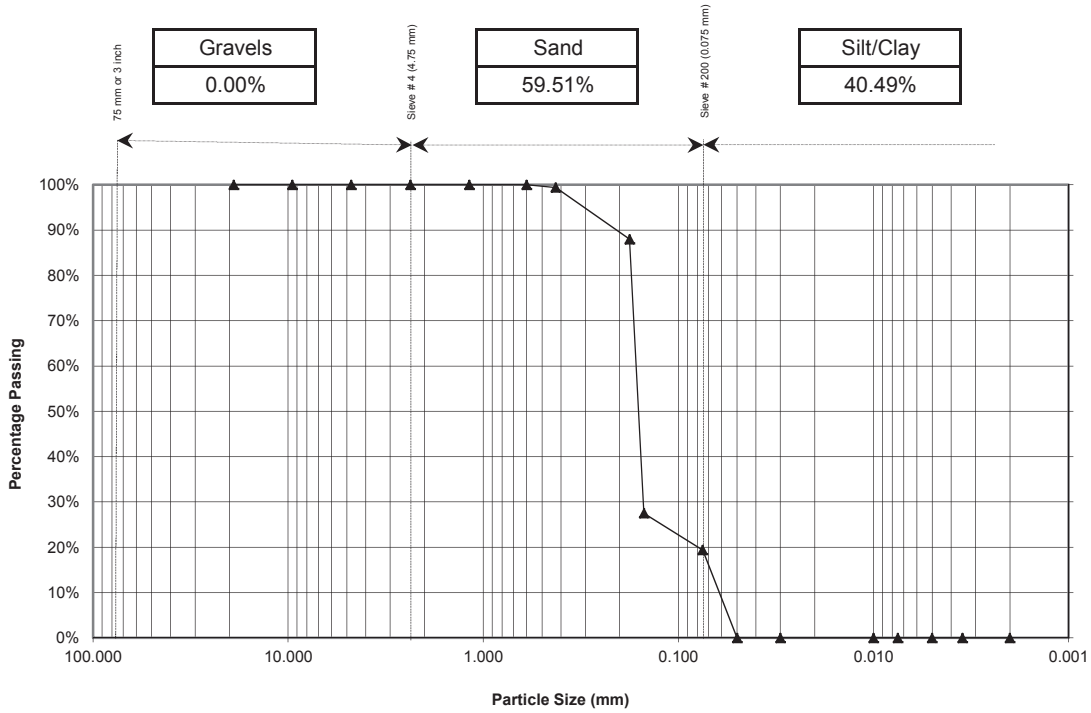
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 - UDS-1
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	5.0 m
Borehole/TP No.:	BH-1 - UDS-1

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	99%	28%	19%

Remarks

Tested By: Imtiaz Ahmad Signature :

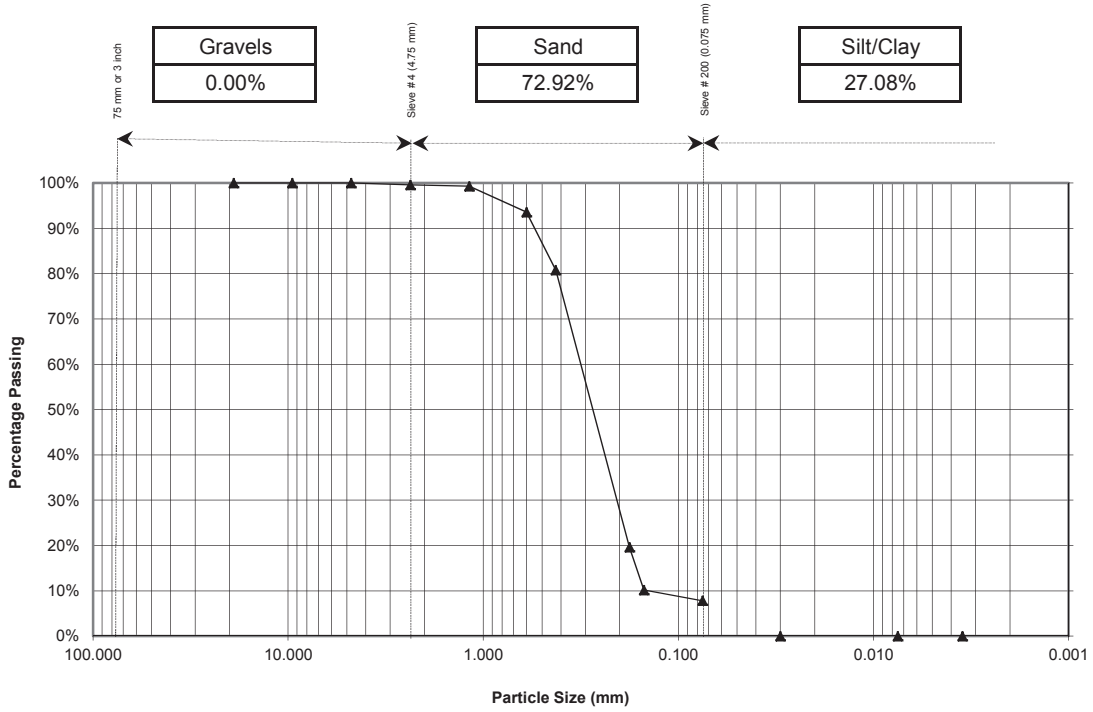
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 - SPT-8
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	8.0 m
Borehole/TP No.:	BH-1 - SPT-8

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	81%	10%	8%

Remarks

Tested By: Imtiaz Ahmad Signature :

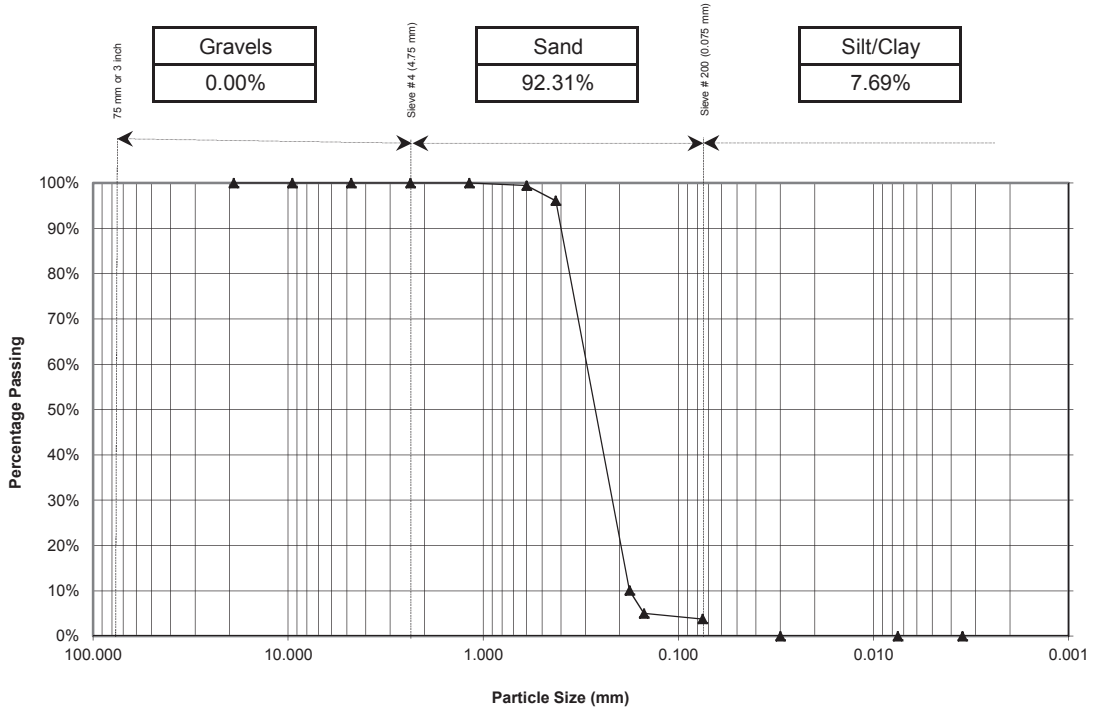
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 - SPT-16
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	16.0 m
Borehole/TP No.:	BH-1 - SPT-16

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	96%	5%	4%

Remarks

Tested By: Imtiaz Ahmad Signature :

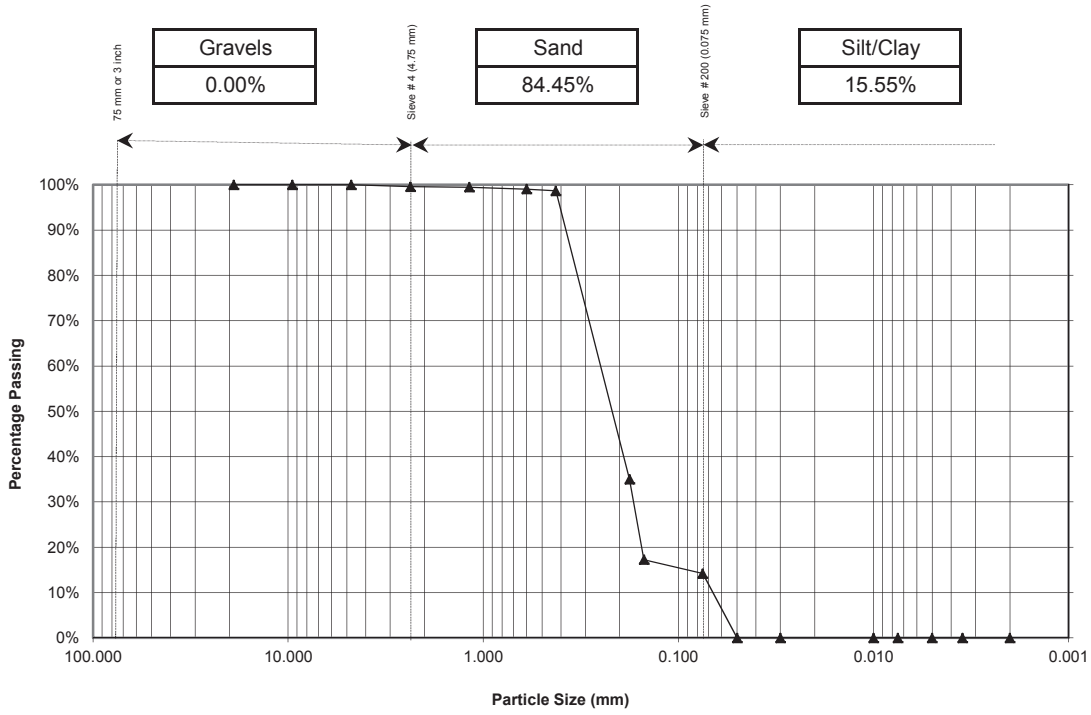
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-2 - SPT-2
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-2 - SPT-2

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	99%	17%	14%

Remarks

Tested By: Imtiaz Ahmad Signature :

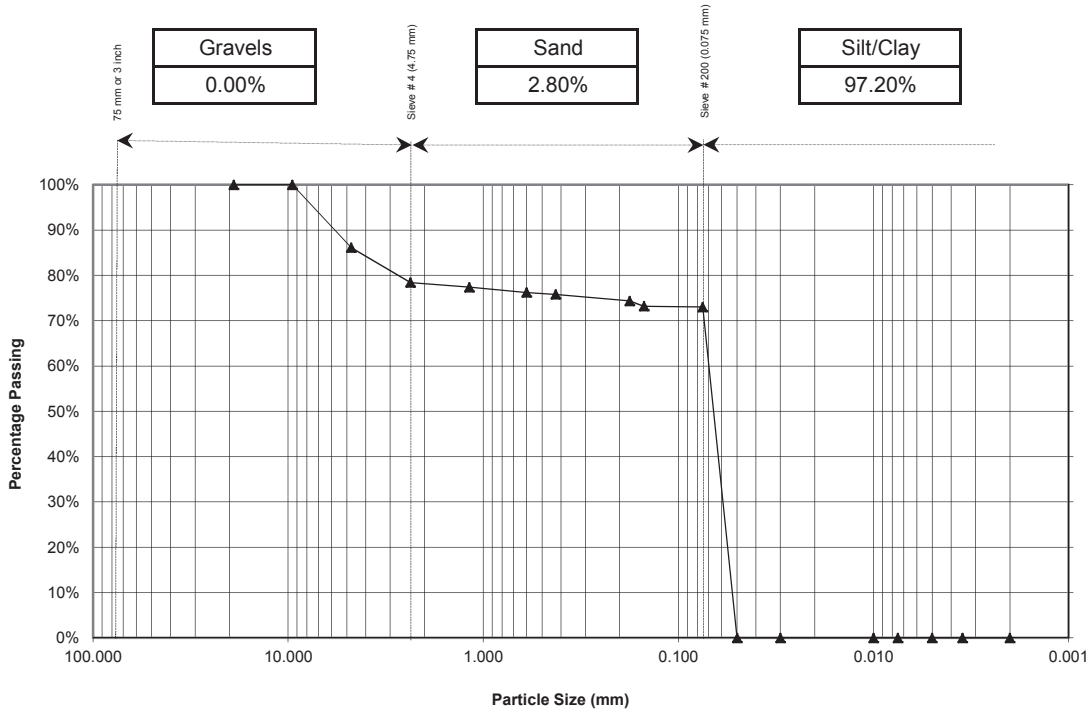
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-2 - SPT-4
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	4.0 m
Borehole/TP No.:	BH-2 - SPT-4

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	86%	78%	76%	73%	73%

Remarks

Tested By: Imtiaz Ahmad Signature :

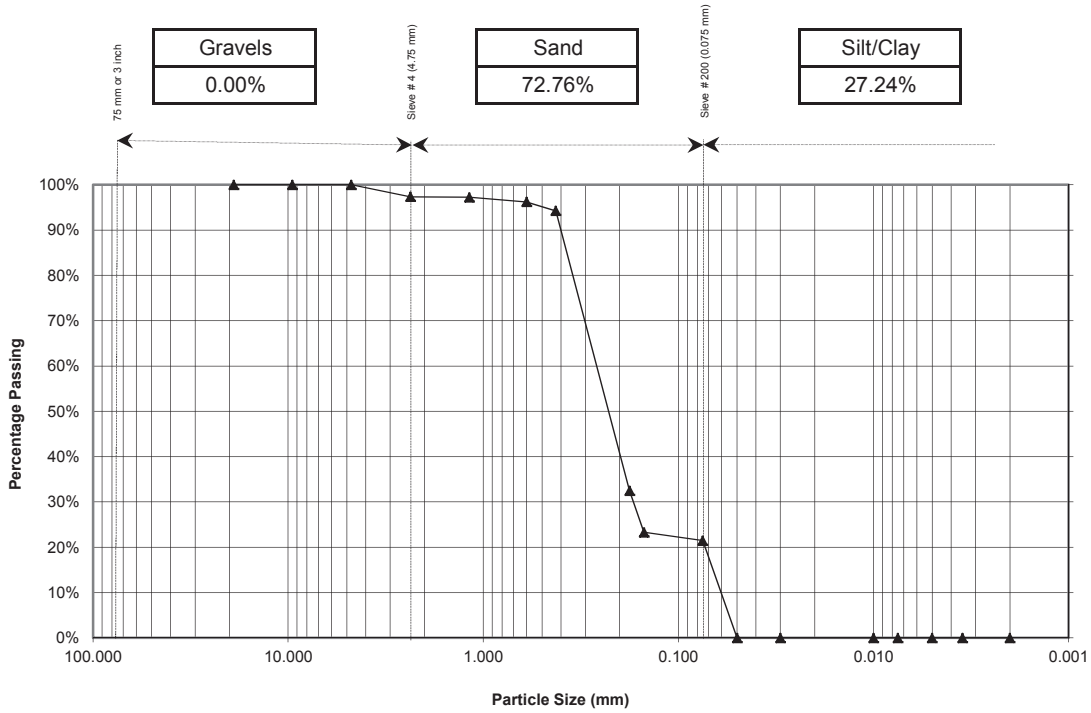
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-2 - SPT-9
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	9.0 m
Borehole/TP No.:	BH-2 - SPT-9

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	97%	94%	23%	21%

Remarks

Tested By: Imtiaz Ahmad Signature :

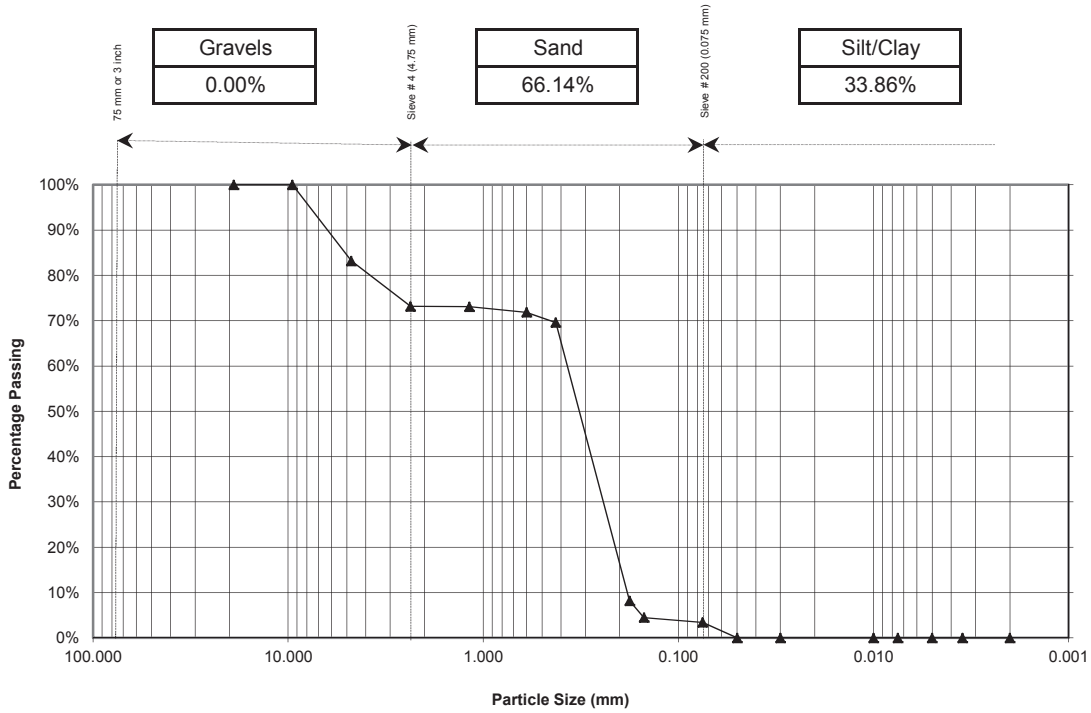
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-2 - SPT-14
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	14.0 m
Borehole/TP No.:	BH-2 - SPT-14

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	83%	73%	70%	5%	3%

Remarks

Tested By: Imtiaz Ahmad Signature :

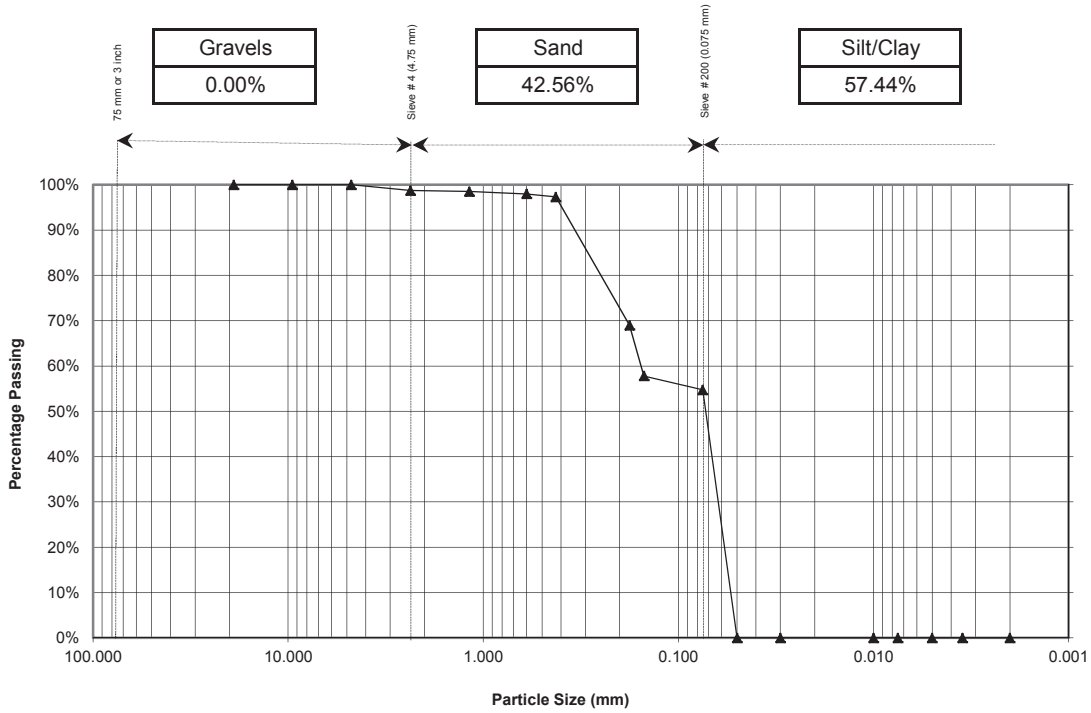
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-3 - SPT-1
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-3 - SPT-1

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	99%	97%	58%	55%

Remarks

Tested By: Imtiaz Ahmad Signature :

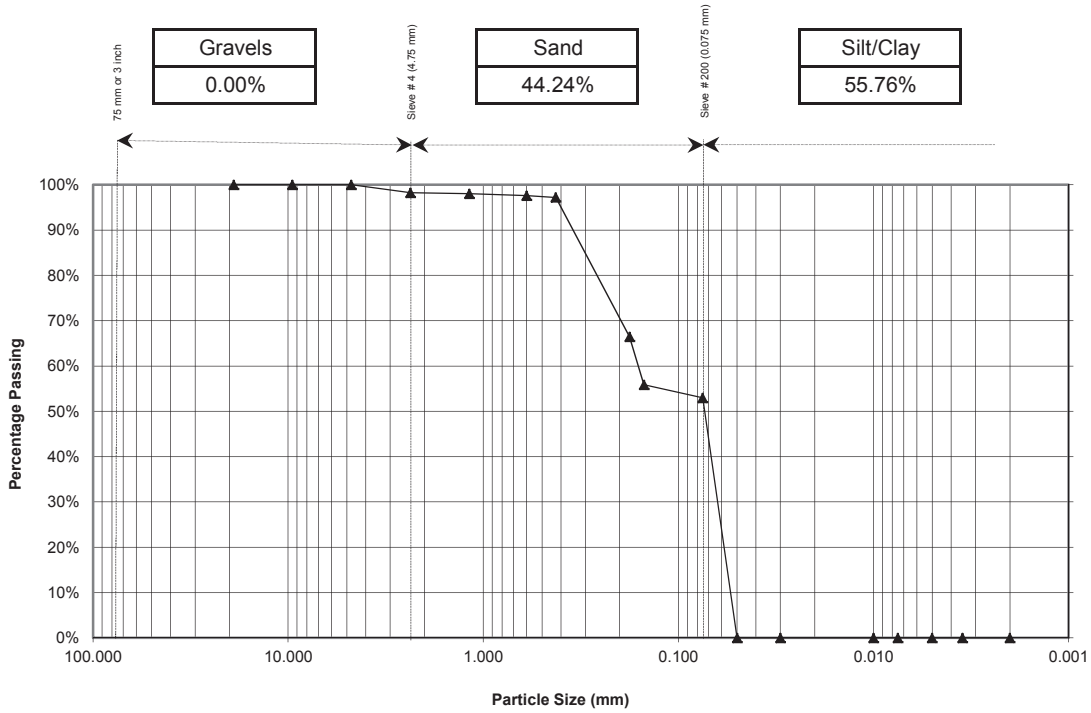
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-3 - SPT-2
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-3 - SPT-2

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	98%	97%	56%	53%

Remarks

Tested By: Imtiaz Ahmad Signature :

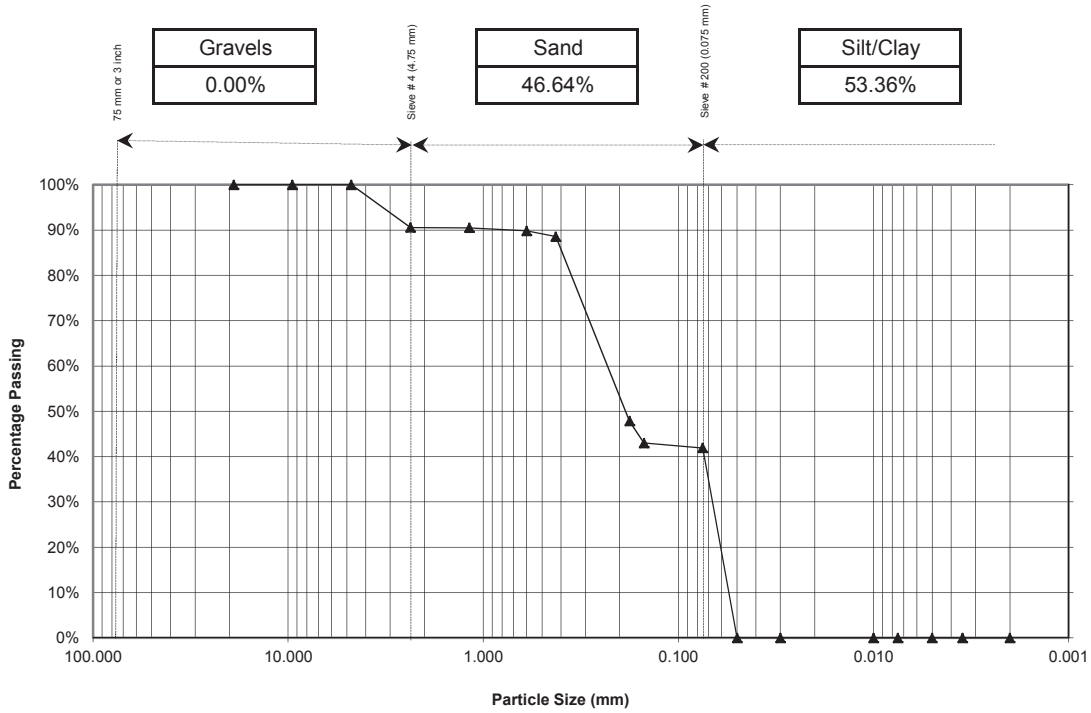
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-3 - SPT-9
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	9.0 m
Borehole/TP No.:	BH-3 - SPT-9

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	91%	89%	43%	42%

Remarks

Tested By: Imtiaz Ahmad Signature :

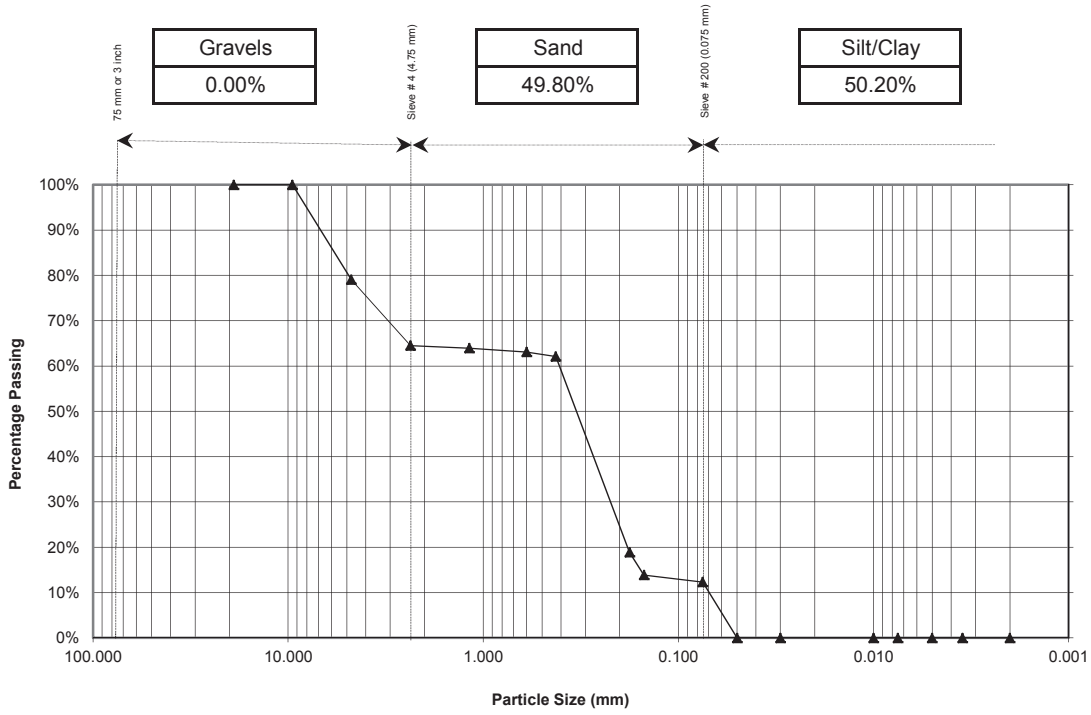
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-3 - SPT-17
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	17.0 m
Borehole/TP No.:	BH-3 - SPT-17

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	79%	64%	62%	14%	12%

Remarks

Tested By: Imtiaz Ahmad Signature :

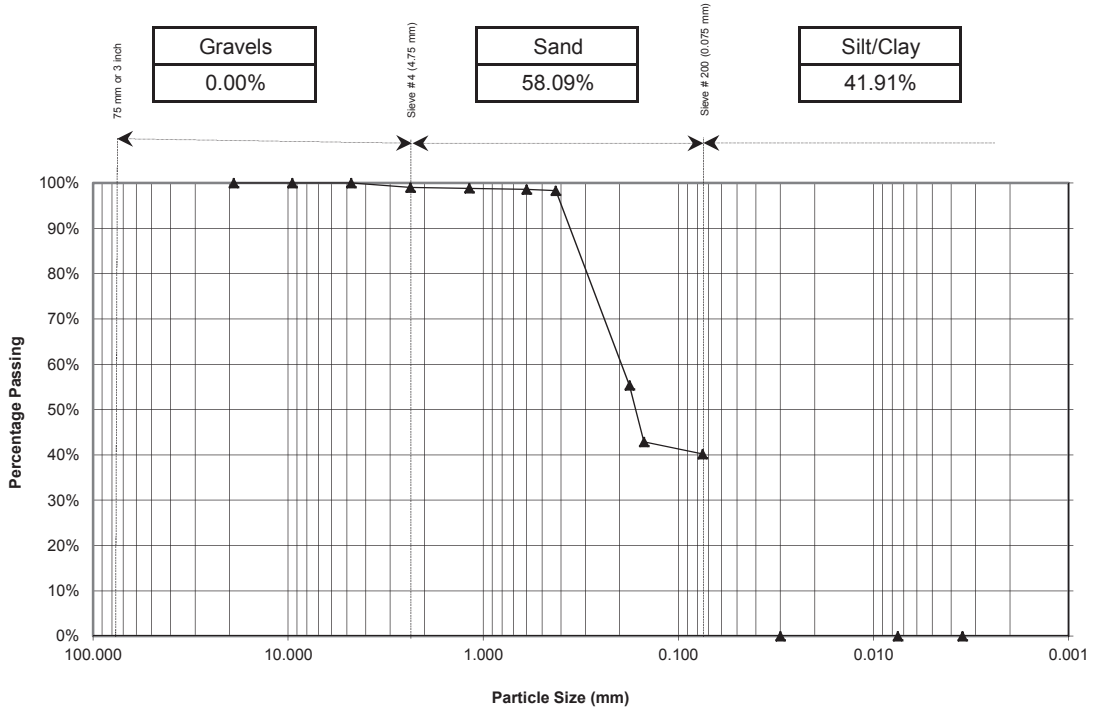
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - SPT-2
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-4 - SPT-2

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	99%	98%	43%	40%

Remarks

Tested By: Imtiaz Ahmad Signature :

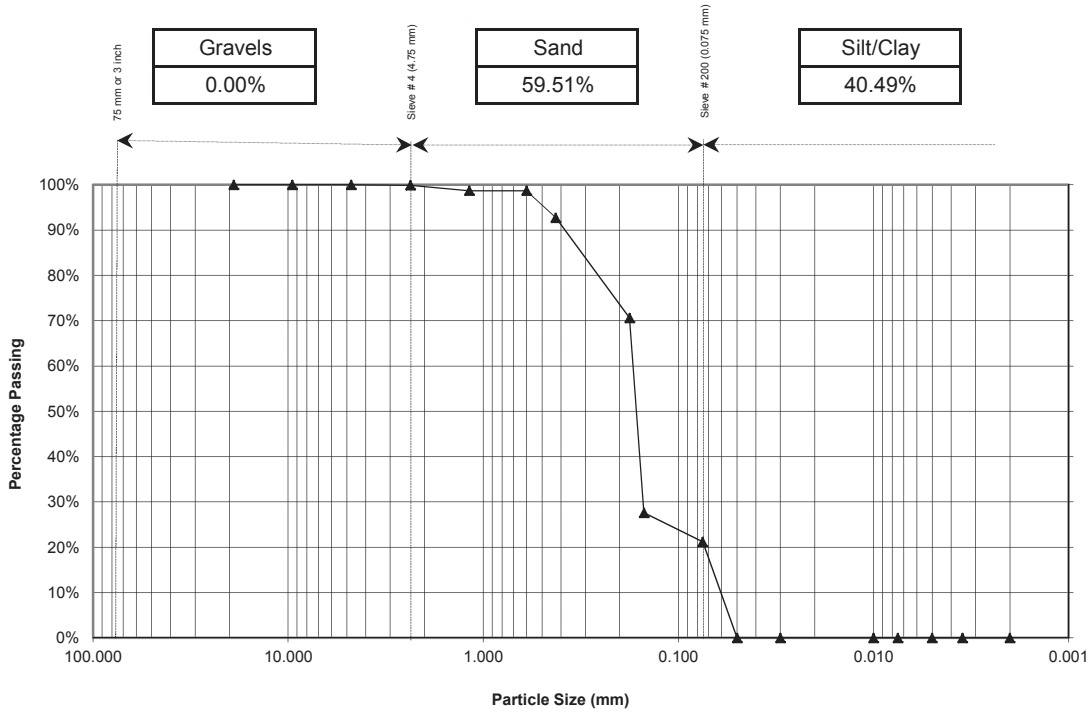
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - UDS-1
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	7.0 m
Borehole/TP No.:	BH-4 - UDS-1

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	93%	28%	21%

Remarks

Tested By: Imtiaz Ahmad Signature :

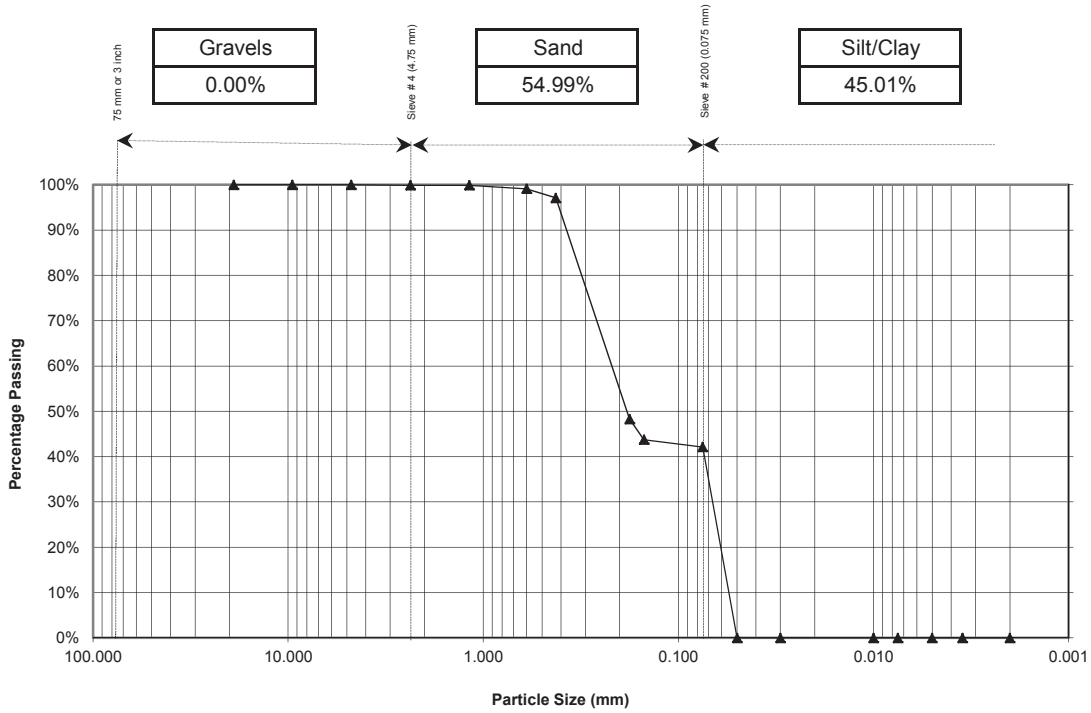
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - SPT-5
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	5.0 m
Borehole/TP No.:	BH-4 - SPT-5

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	97%	44%	42%

Remarks

Tested By: Imtiaz Ahmad Signature :

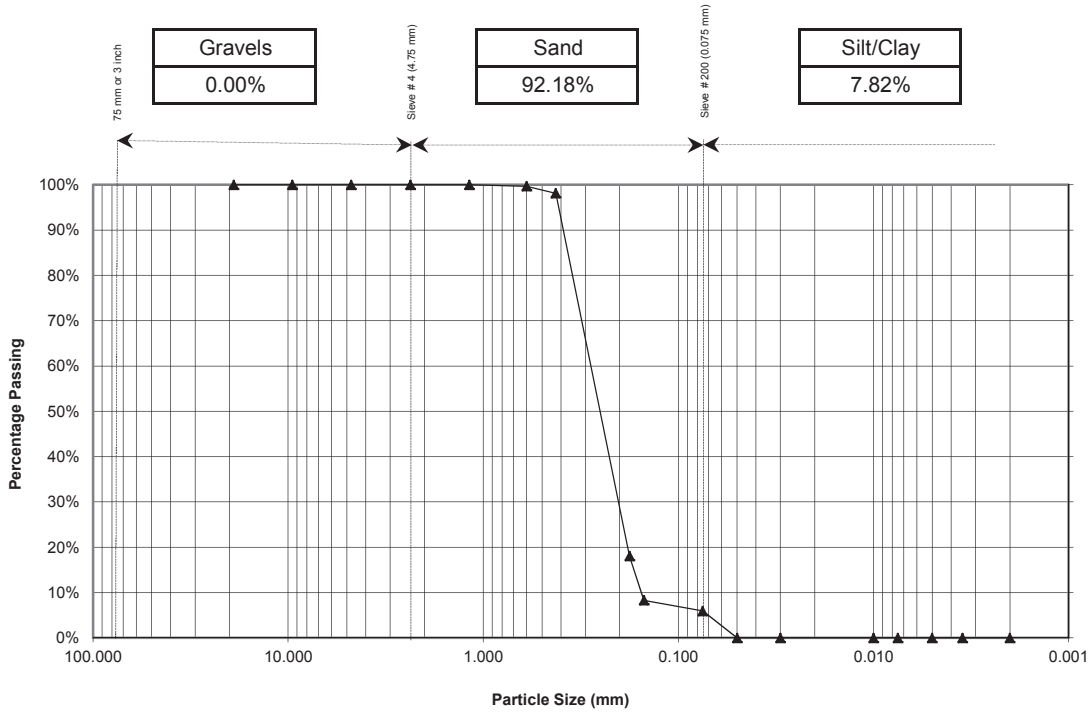
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - SPT-8
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	9.5 m
Borehole/TP No.:	BH-4 - SPT-8

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	98%	8%	6%

Remarks

Tested By: Imtiaz Ahmad Signature :

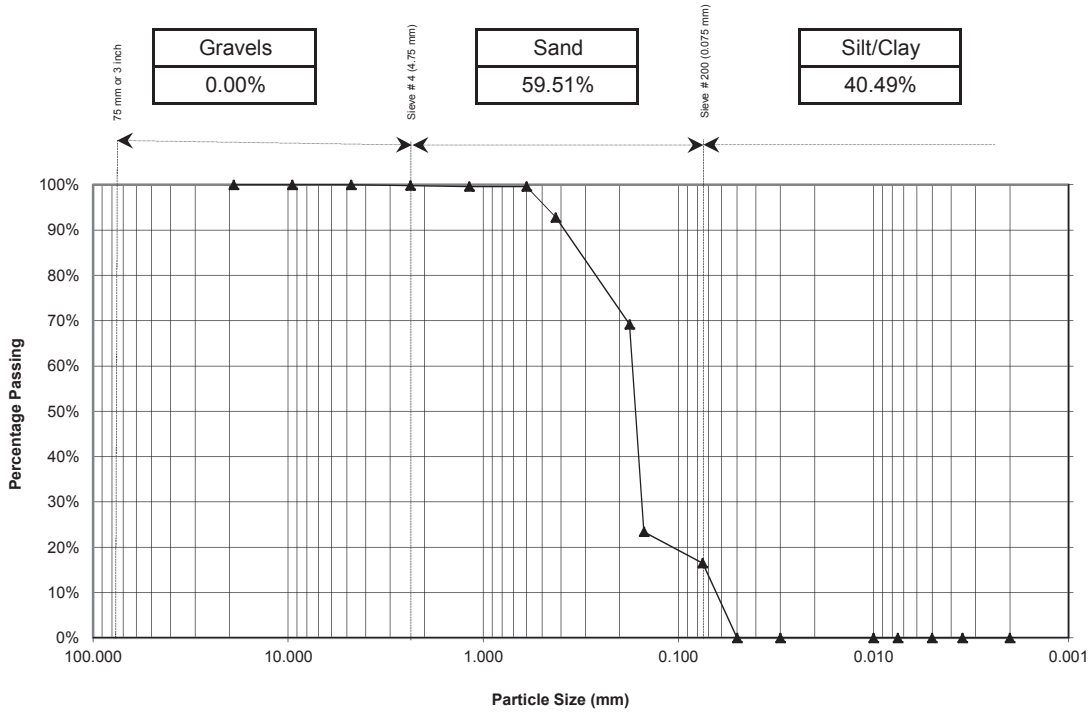
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - UDS-2
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	10.0 m
Borehole/TP No.:	BH-4 - UDS-2

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	93%	23%	17%

Remarks

Tested By: Imtiaz Ahmad Signature :

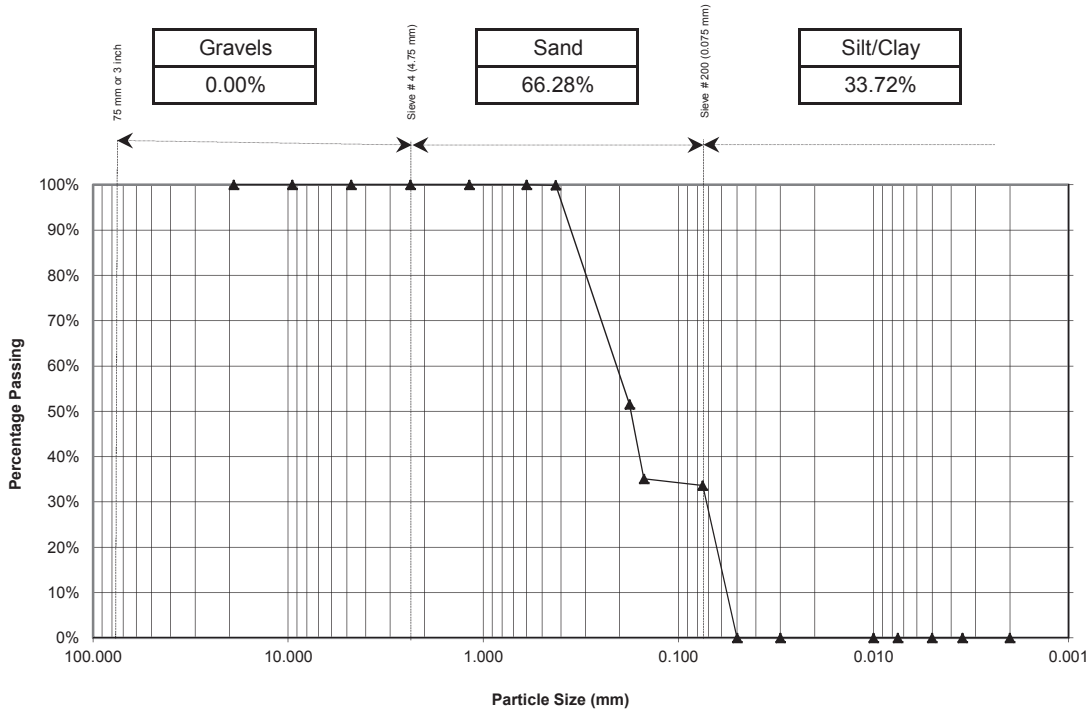
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - SPT-12
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	15.5 m
Borehole/TP No.:	BH-4 - SPT-12

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	100%	35%	34%

Remarks

Tested By: Imtiaz Ahmad Signature :

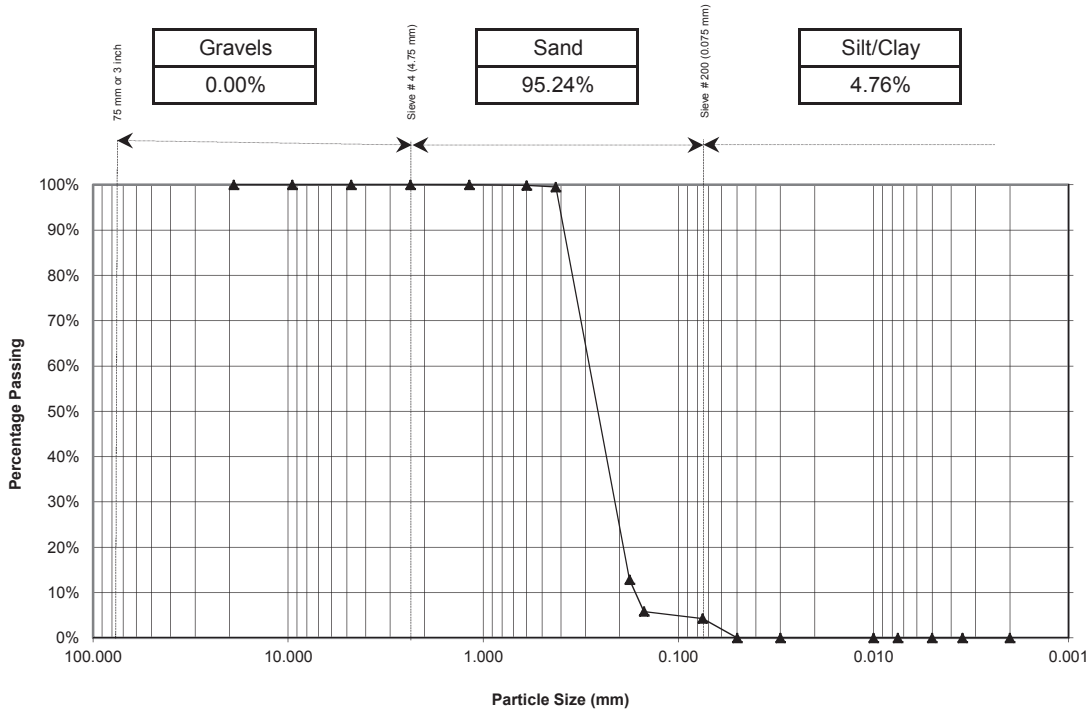
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 - SPT-15
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	20.0 m
Borehole/TP No.:	BH-4 - SPT-15

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	100%	6%	4%

Remarks

Tested By: Imtiaz Ahmad Signature :

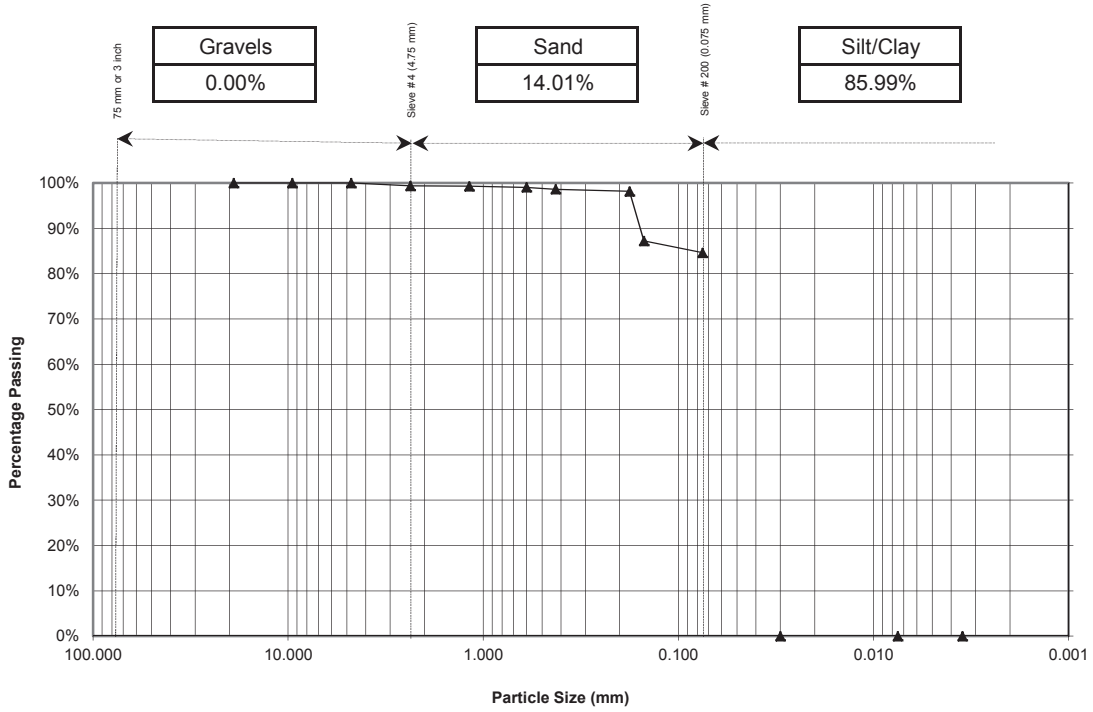
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 - SPT-1
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-5 - SPT-1

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	99%	99%	87%	85%

Remarks

Tested By: Imtiaz Ahmad Signature :

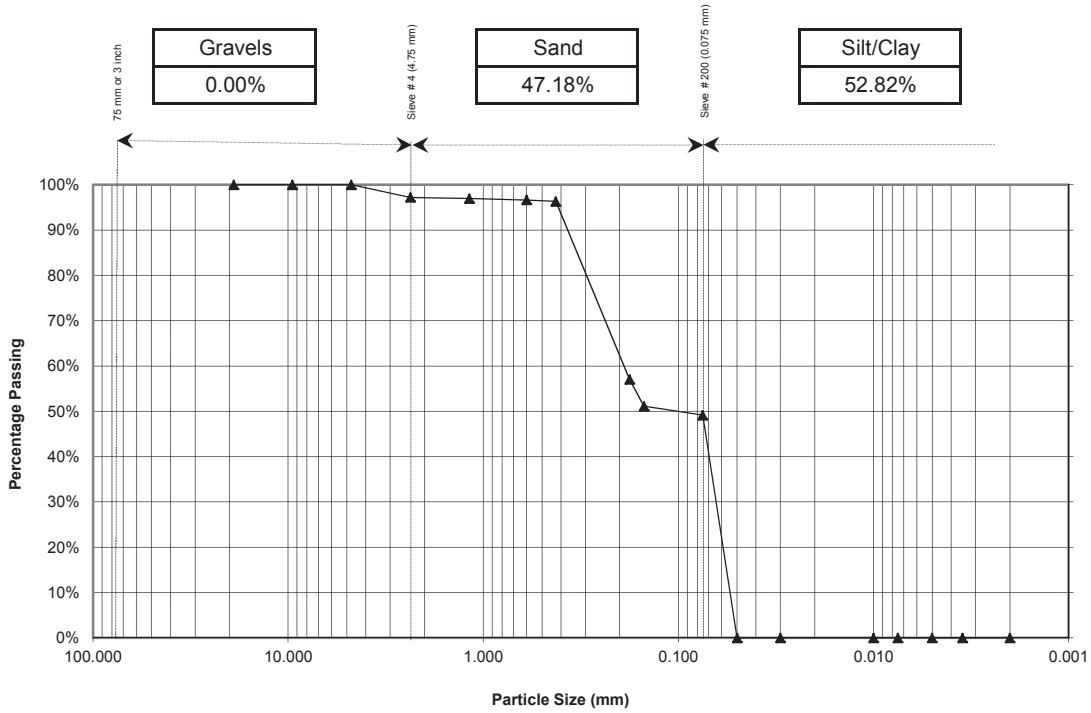
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 - SPT-2
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-5 - SPT-2

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	97%	96%	51%	49%

Remarks

Tested By: Imtiaz Ahmad Signature :

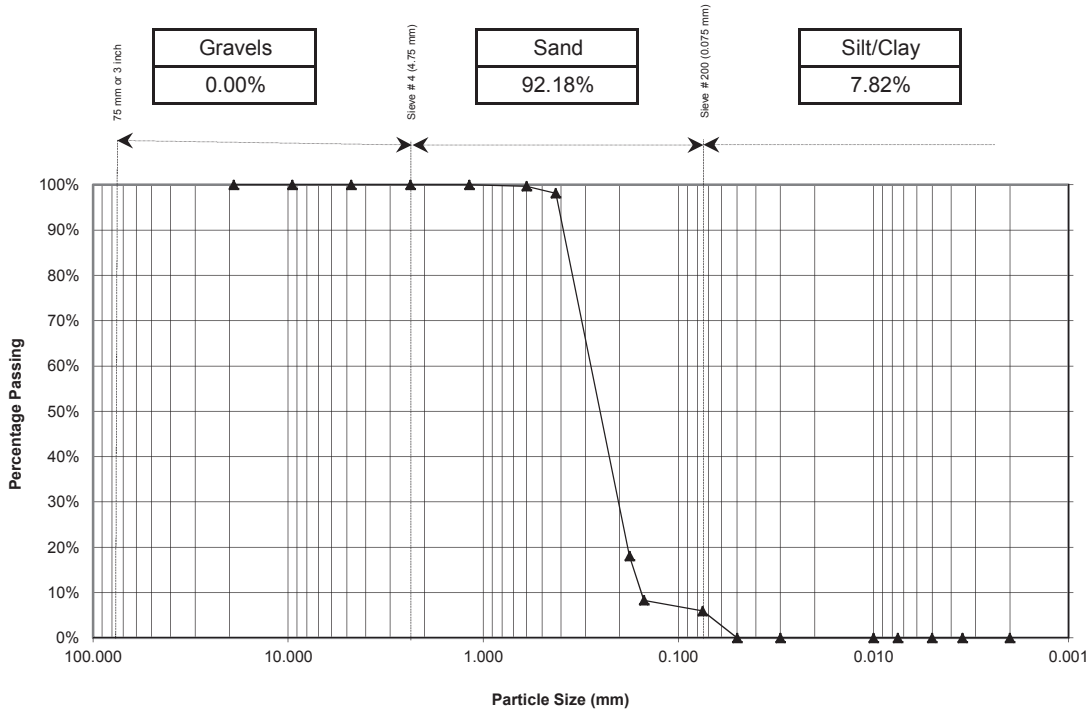
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 - SPT-6
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	6.5 m
Borehole/TP No.:	BH-5 - SPT-6

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	98%	8%	6%

Remarks

Tested By: Imtiaz Ahmad Signature :

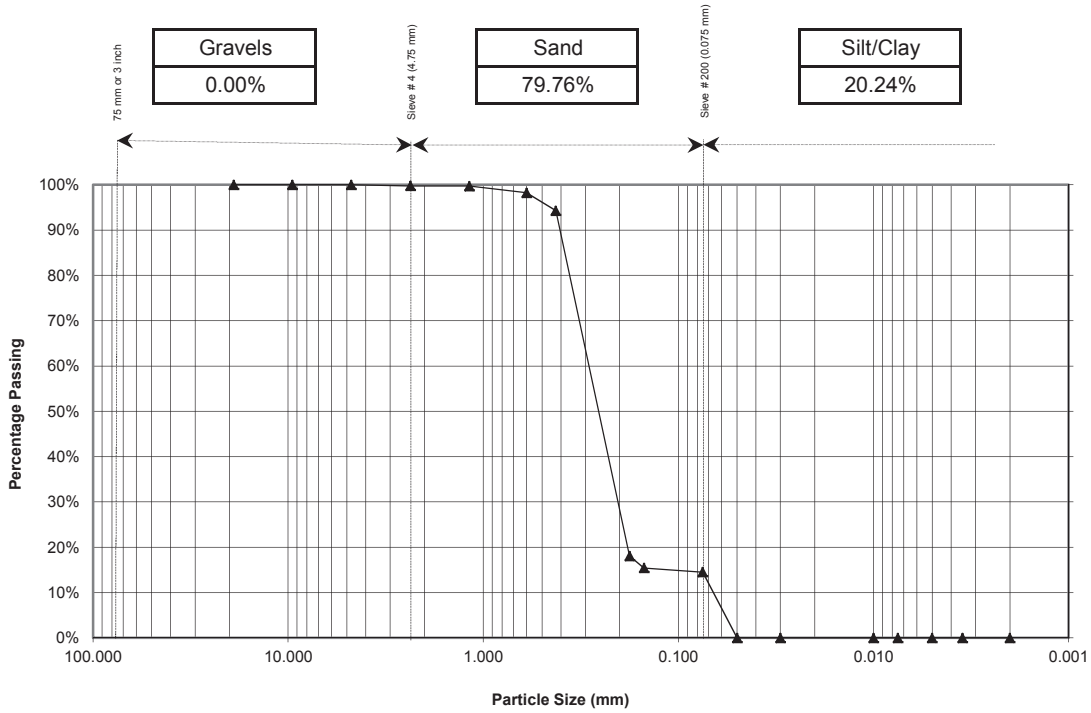
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 - SPT-10
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	12.5 m
Borehole/TP No.:	BH-5 - SPT-10

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	94%	15%	15%

Remarks

Tested By: Imtiaz Ahmad Signature :

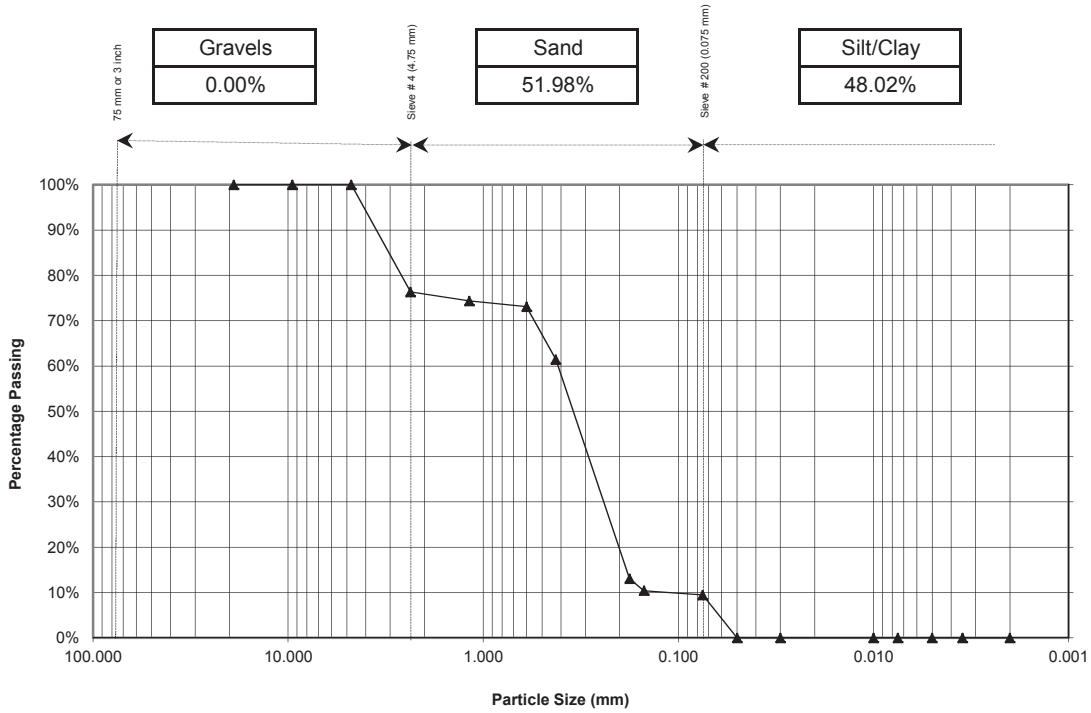
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 - SPT-13
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	17.0 m
Borehole/TP No.:	BH-5 - SPT-13

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	76%	61%	10%	9%

Remarks

Tested By: Imtiaz Ahmad Signature :

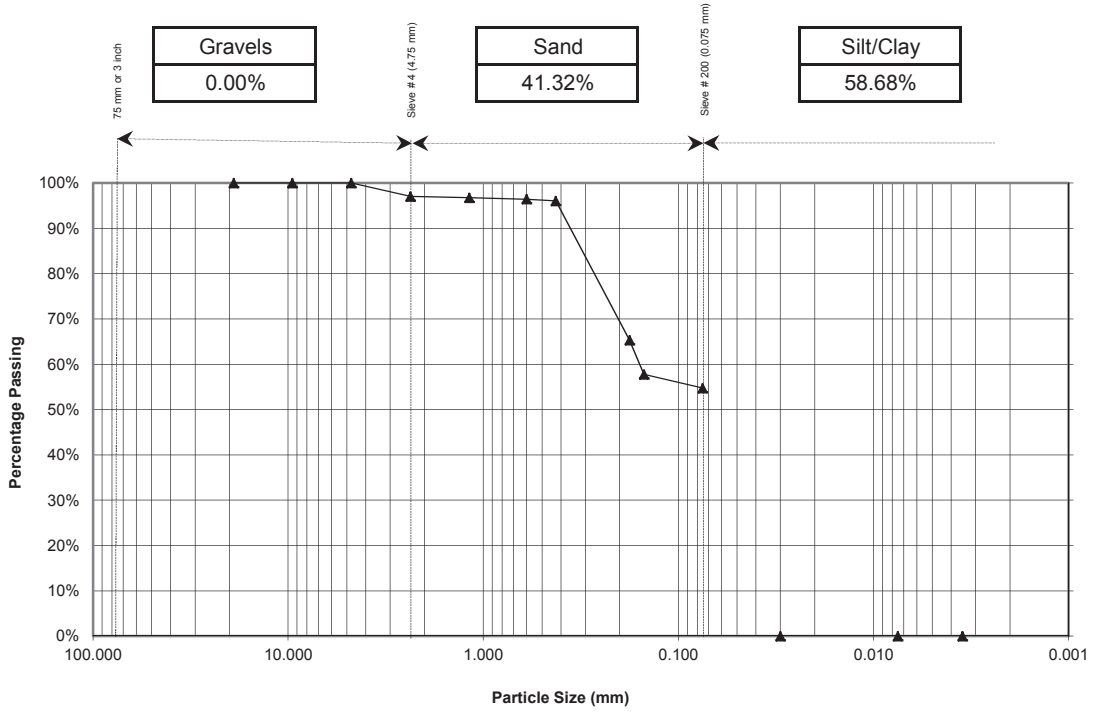
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-6 - SPT-1
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-6 - SPT-1

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	97%	96%	58%	55%

Remarks

Tested By: Imtiaz Ahmad Signature :

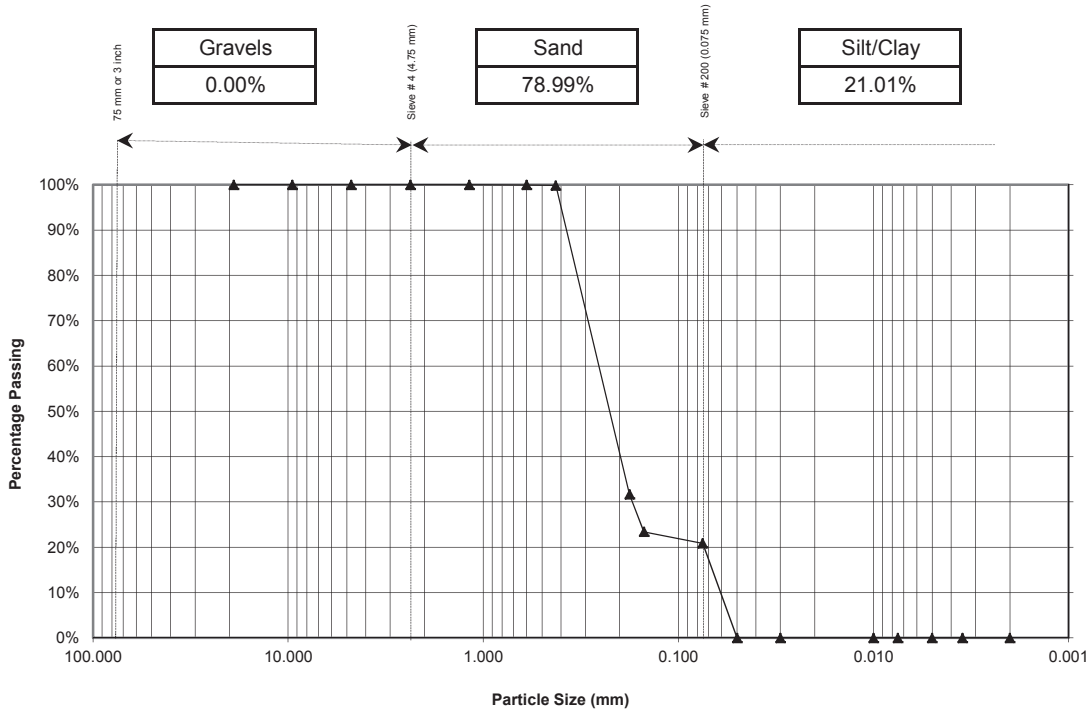
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-6 - SPT-3
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	3.0 m
Borehole/TP No.:	BH-6 - SPT-3

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	100%	23%	21%

Remarks

Tested By: Imtiaz Ahmad Signature :

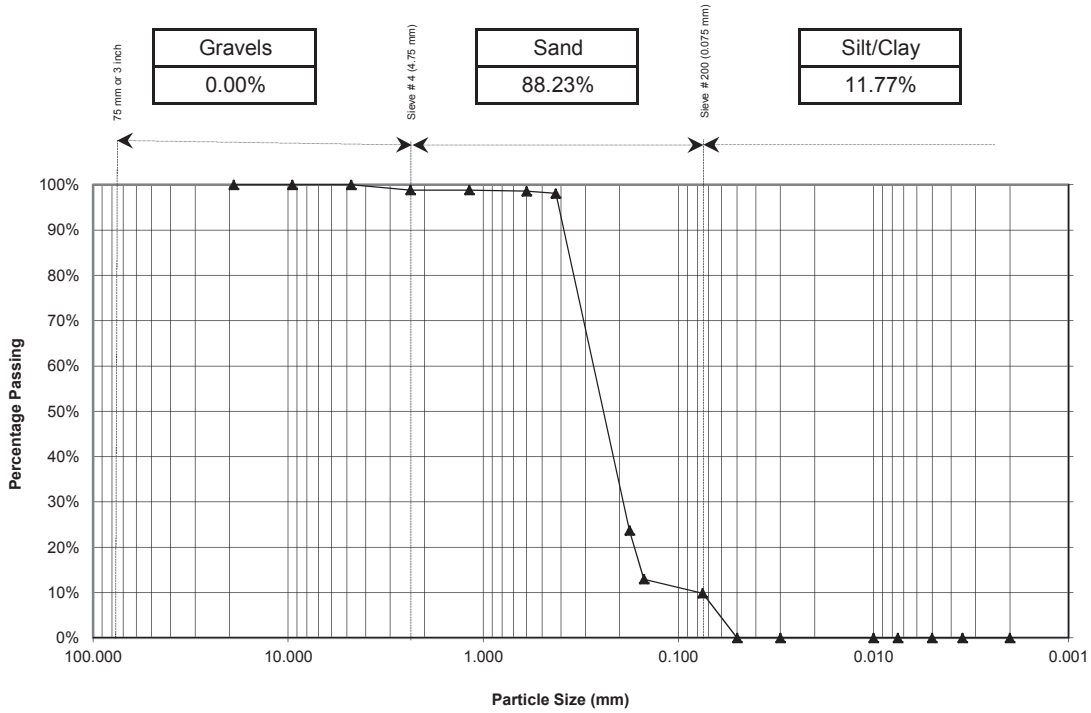
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-6 - SPT-4
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	4.0 m
Borehole/TP No.:	BH-6 - SPT-4

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	99%	98%	13%	10%

Remarks

Tested By: Imtiaz Ahmad Signature :

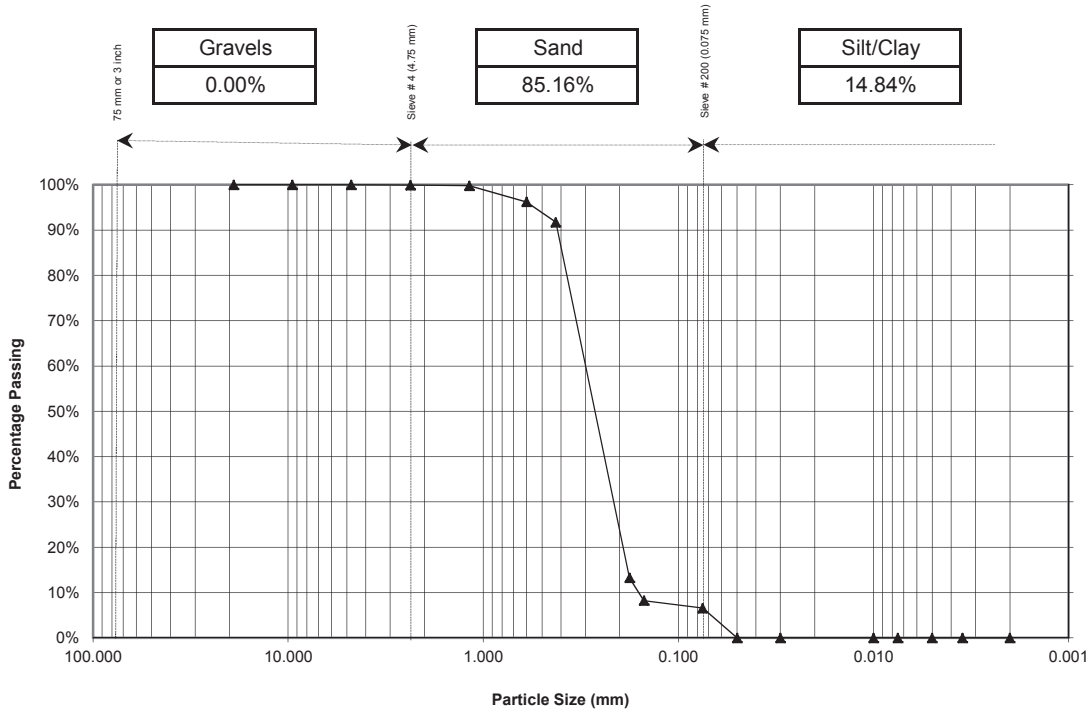
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-6 - SPT-11
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	11.0 m
Borehole/TP No.:	BH-6 - SPT-11

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	100%	92%	8%	7%

Remarks

Tested By: Imtiaz Ahmad Signature :

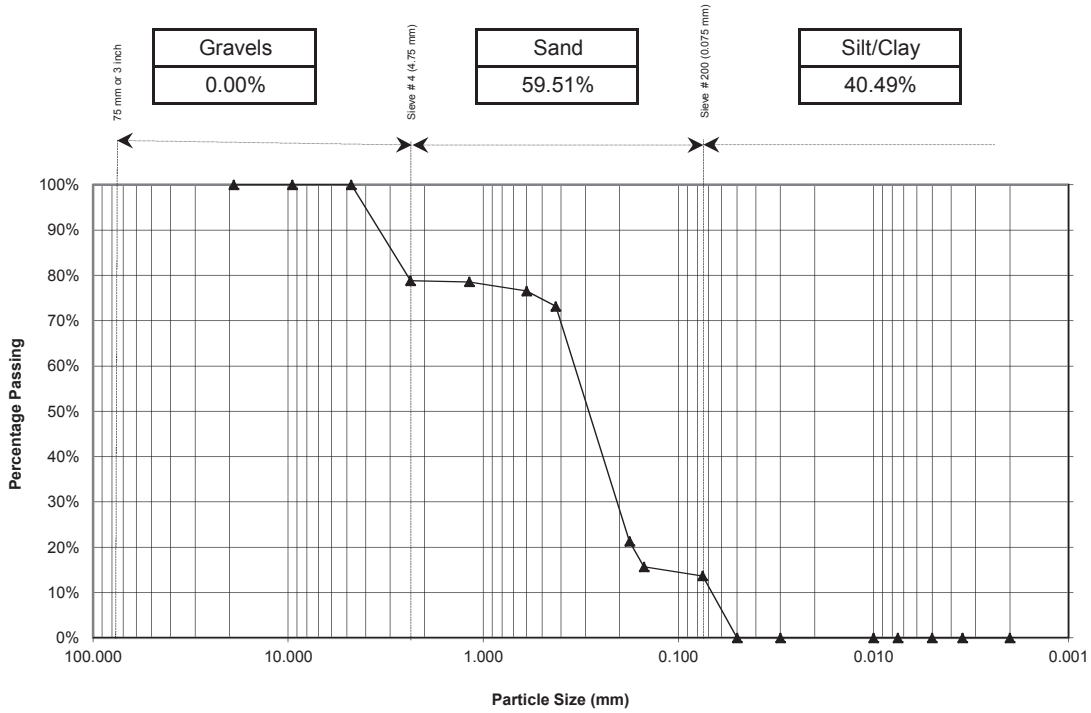
Checked By: Usman Arshad Signature :

Engineers Guild, Lahore

GRAIN SIZE DISTRIBUTION TEST RESULT SHEET
ASTM D6913 - 04(2009)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-6 - SPT-16
Sample Type:	Disturbed
Date Tested:	18/6/2016
Depth (m):	16.0 m
Borehole/TP No.:	BH-6 - SPT-16

DISTRIBUTION OF VARIOUS PARTICLE SIZES



Sieve No.	9.5 mm	4	10	40	100	200
Passing (%)	100%	100%	79%	73%	16%	14%

Remarks

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

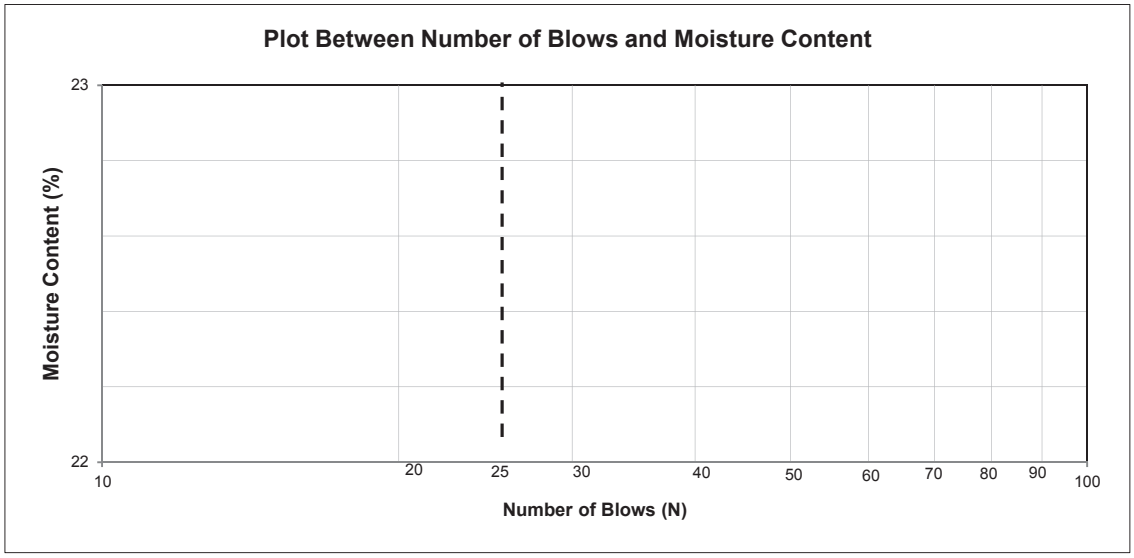
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 SPT-1
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-1 SPT-1

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

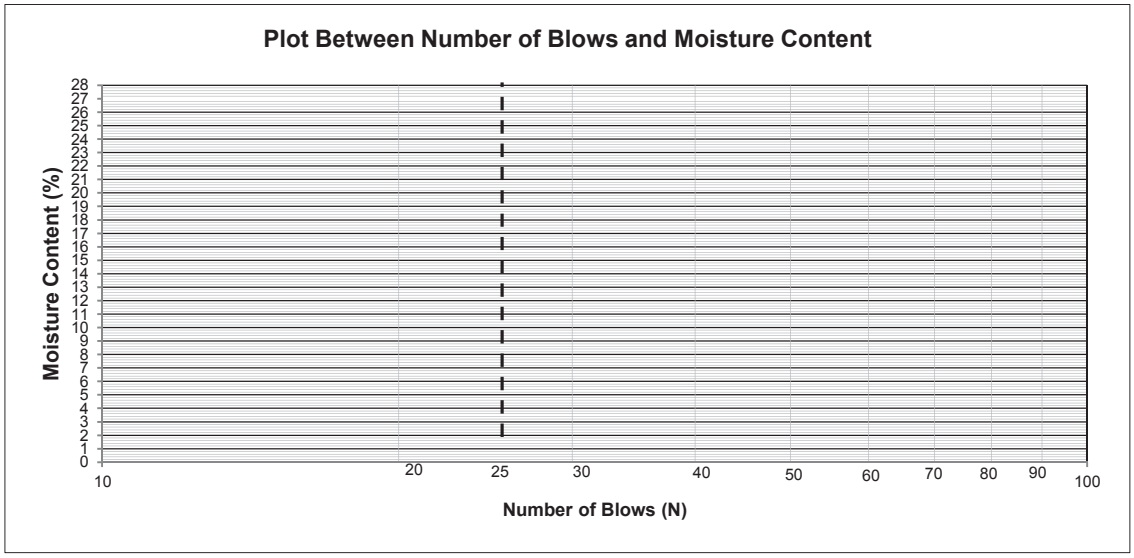
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-1 SPT-3
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	3.0 m
Borehole/TP No.:	BH-1 SPT-3

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

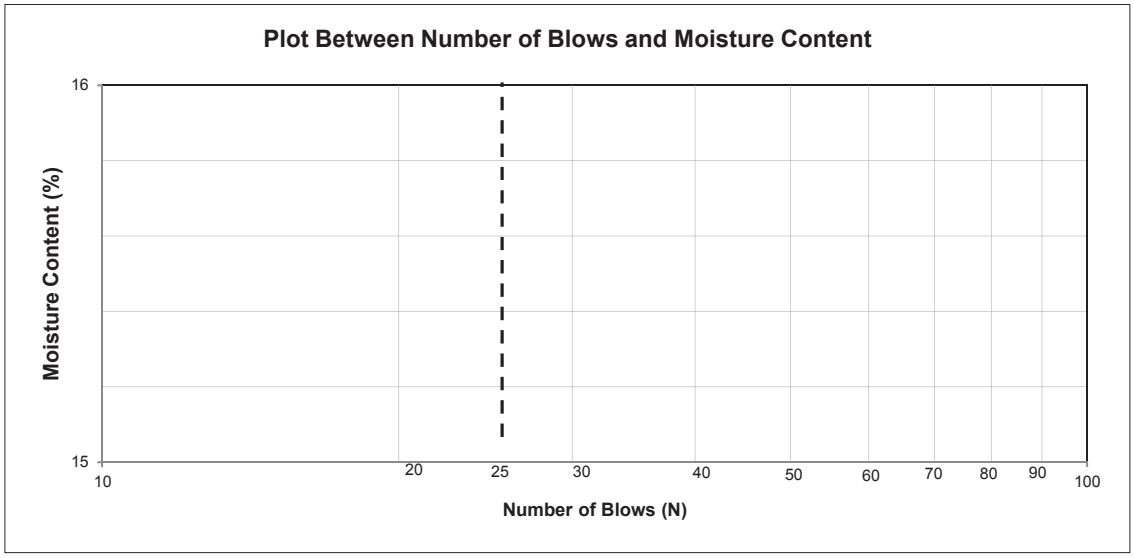
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-2 SPT-2
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-2 SPT-2

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

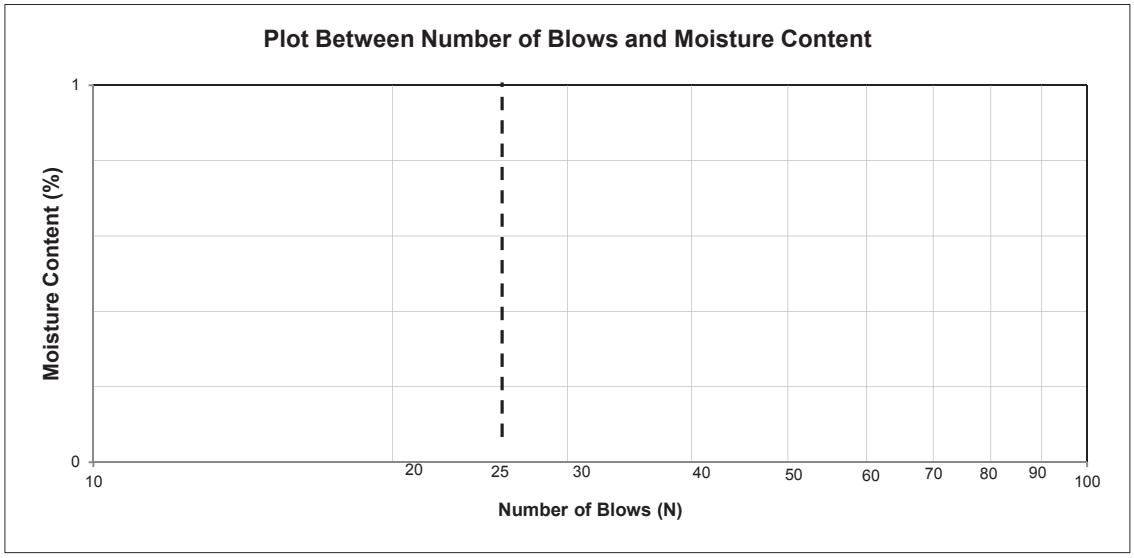
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-3 SPT-1
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-3 SPT-1

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

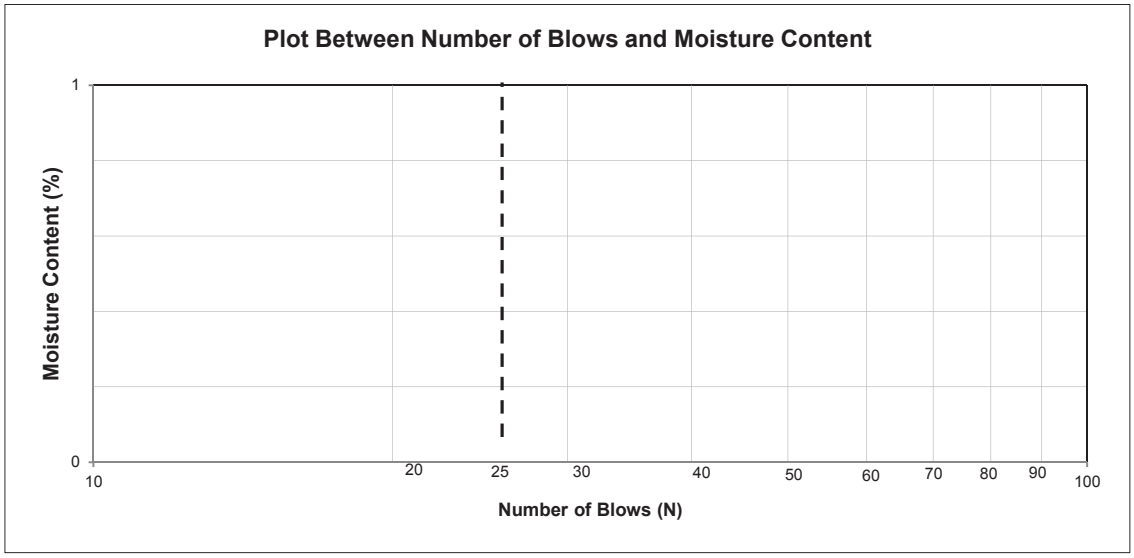
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-3 SPT-2
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-3 SPT-2

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

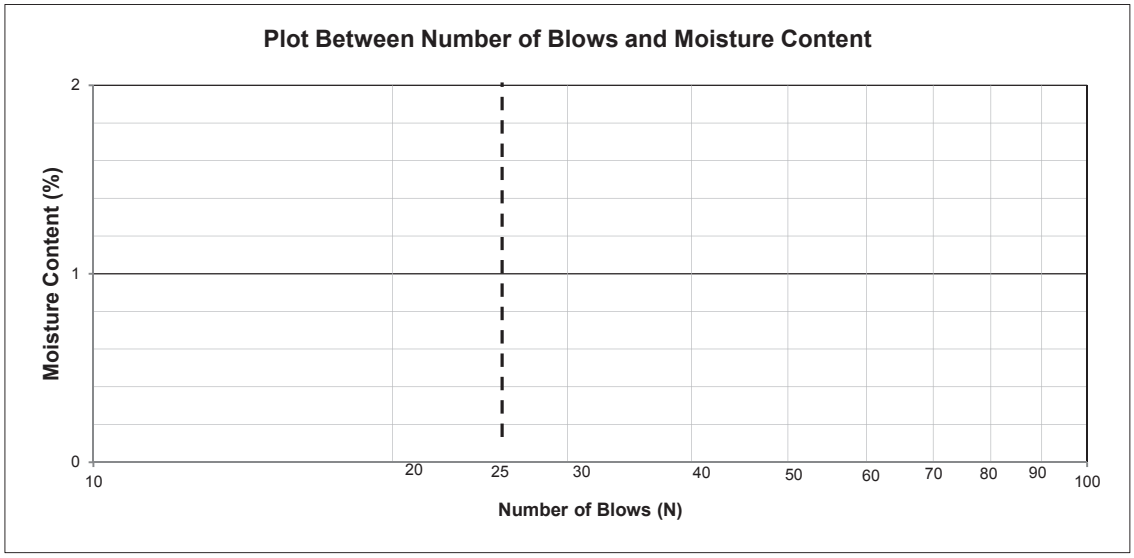
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-4 SPT-2
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-4 SPT-2

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

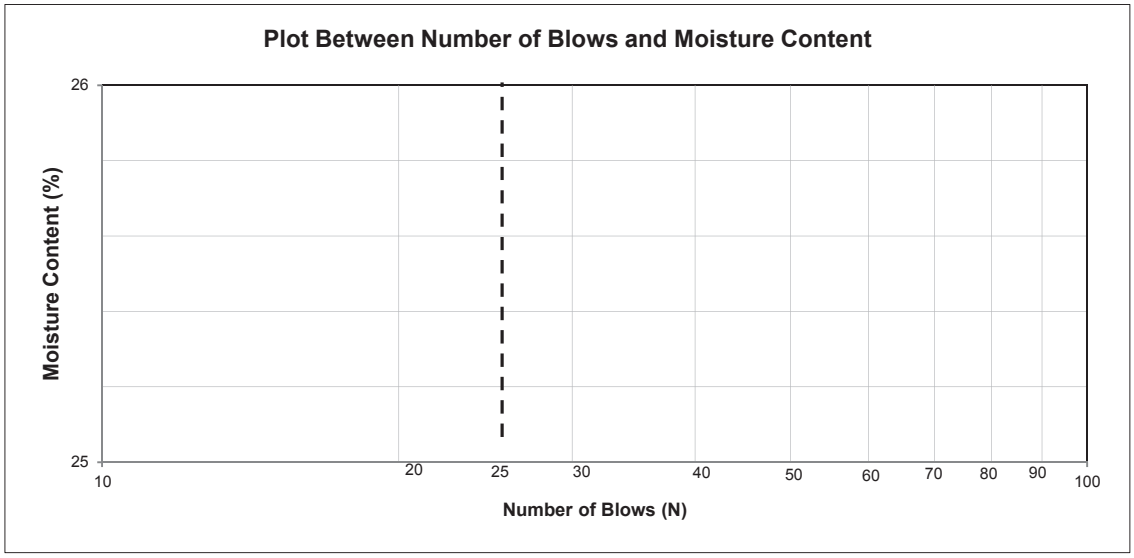
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 SPT-1
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	1.0 m
Borehole/TP No.:	BH-5 SPT-1

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

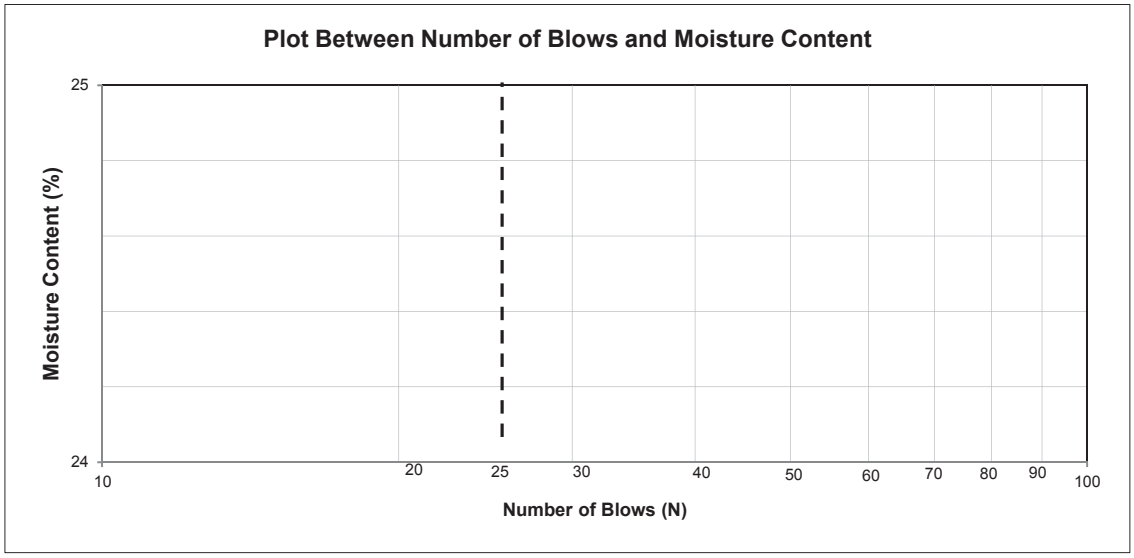
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-5 SPT-2
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	2.0 m
Borehole/TP No.:	BH-5 SPT-2

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

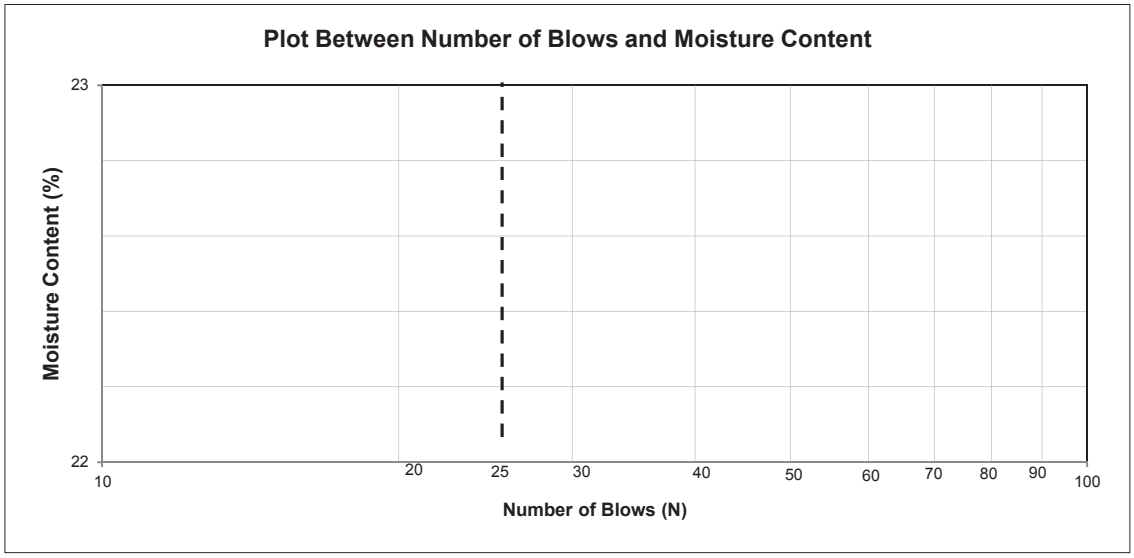
Engineers Guild, Lahore

LIQUID AND PLASTIC LIMIT TEST RESULT SHEETS
ASTM (D-4318)

Project Name:	Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala
Client Name:	M/s State Bank of Pakistan
Consultant Name:	M/s ESS-I-AAR, Karachi
Sample Number:	BH-6 SPT-1
Sample Type:	Disturbed
Date Tested:	20/6/2016
Depth (m):	1 m
Borehole/TP No.:	BH-6 SPT-1

LIQUID LIMIT TEST RESULTS

Moisture Content (%)	0.00	0.00	0.00
No. of Blows (N)	0	0	0



PLASTIC LIMIT TEST RESULTS

Moisture Content (%)	0.000

FINAL RESULTS

LIQUID LIMIT %	***0***
PLASTIC LIMIT %	***0***
PLASTICITY INDEX %	***Non Plastic***

Tested By: Imtiaz Ahmad Signature :

Checked By: Usman Arshad Signature :

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Chemical Test Results on Soil Samples

Client: M/s State Bank of Pakistan

Project: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala

Date: 22-06-2016

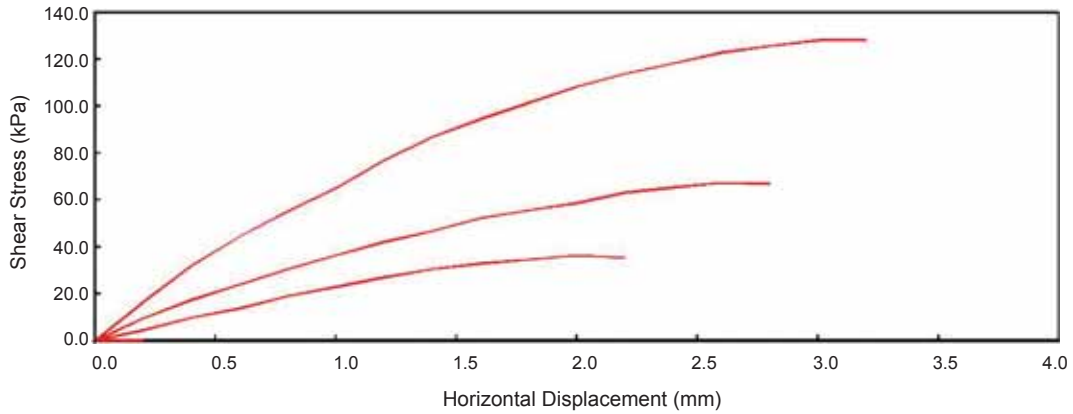
Borehole No.	Sample No.	Depth (m)	Sulphate Content (%)	Chloride Content (%)	pH Value
BH-4	UDS-1	7.0	0.06%	0.04%	-
BH-1	UDS-1	5.0	0.07%	0.05%	-
BH-4	WS-1		70 ppm	60 ppm	6.9
BH-2	WS-1		77 ppm	65 ppm	7.2

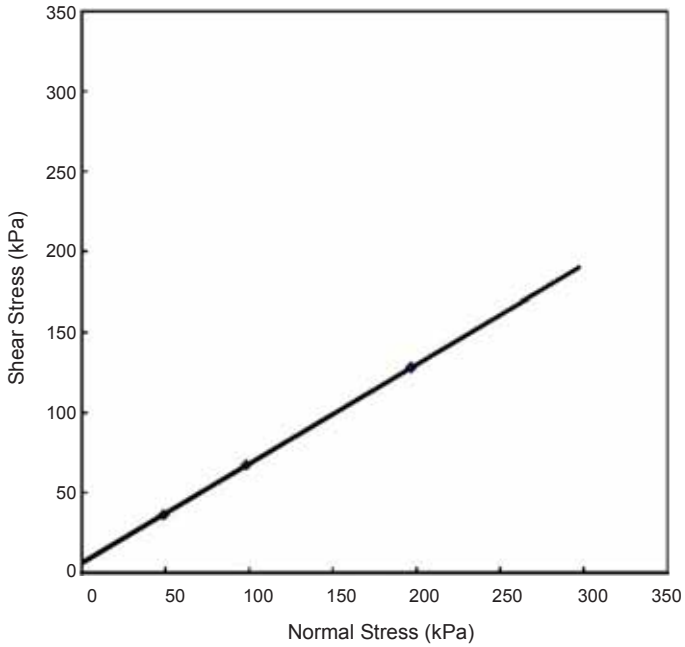
Tested by: Sikandar Hayat	**Checked by:** Muhammad Wasim

Engineers Guild, Lahore

DIRECT SHEAR TEST

Client: M/s State Bank of Pakistan Project: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala		
	Sample Type : Remolded	Test Condition Soaked
Borehole No. BH-1	Sample No. UDS-1	Depth: 5.0 meter





y = 0.6206x + 6.2254

LINEAR REGRESSION

Angle of Internal Friction = 31.8 Degrees

Cohesion = 6.0 kPa

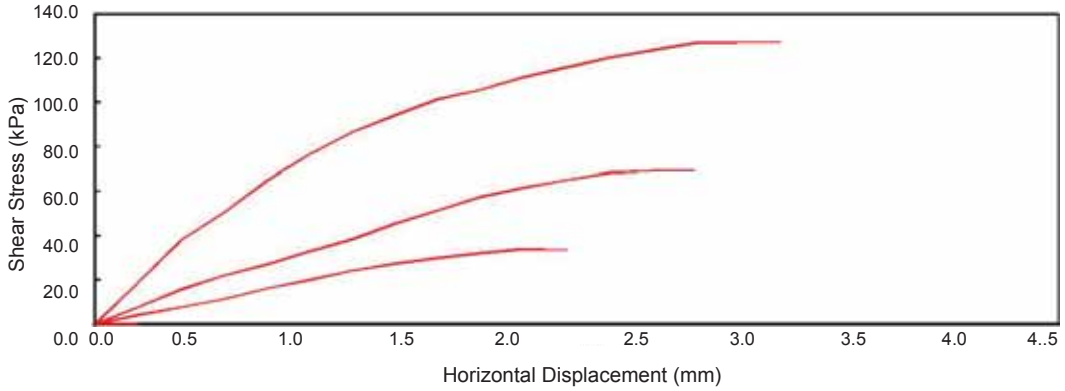
Note: Responsibility of sampling, packing and sealing rests with the client

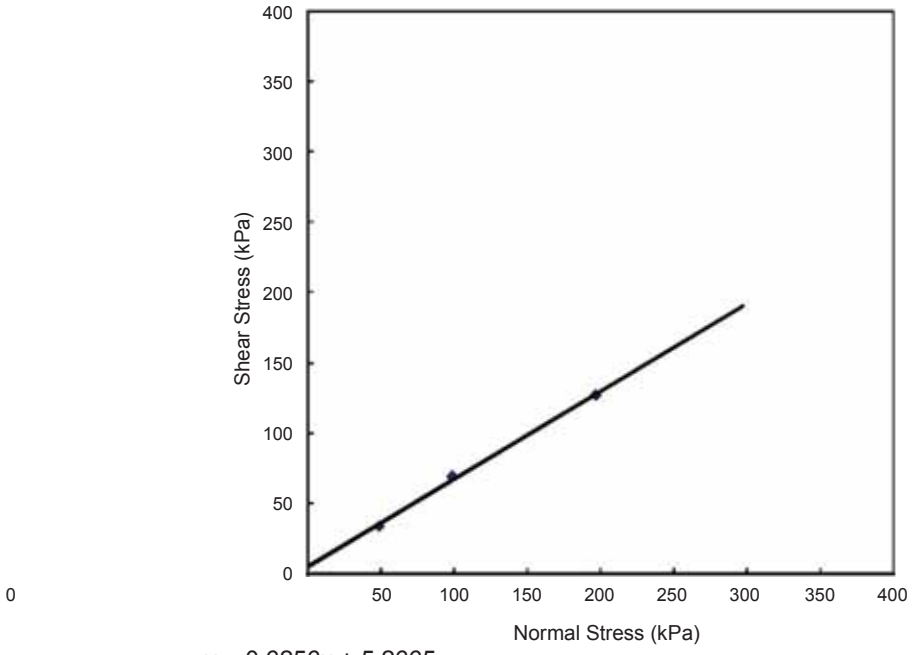
Tested by: Sikandar Hayat	Checked by: Muhammad Wasim

Engineers Guild, Lahore

DIRECT SHEAR TEST

Client: M/s State Bank of Pakistan Project: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala		
	Sample Type : Remolded	Test Condition Soaked
Borehole No. BH-4	Sample No. UDS-1	Depth: 7.0 meter





y = 0.6256x + 5.2665

LINEAR REGRESSION

Angle of Internal Friction = 32.0 Degrees

Cohesion = 5.3 kPa

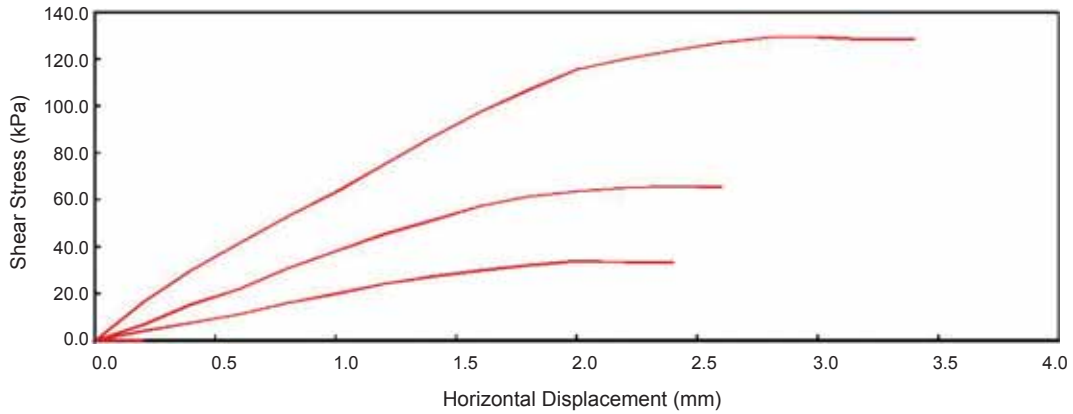
Note: Responsibility of sampling, packing and sealing rests with the client

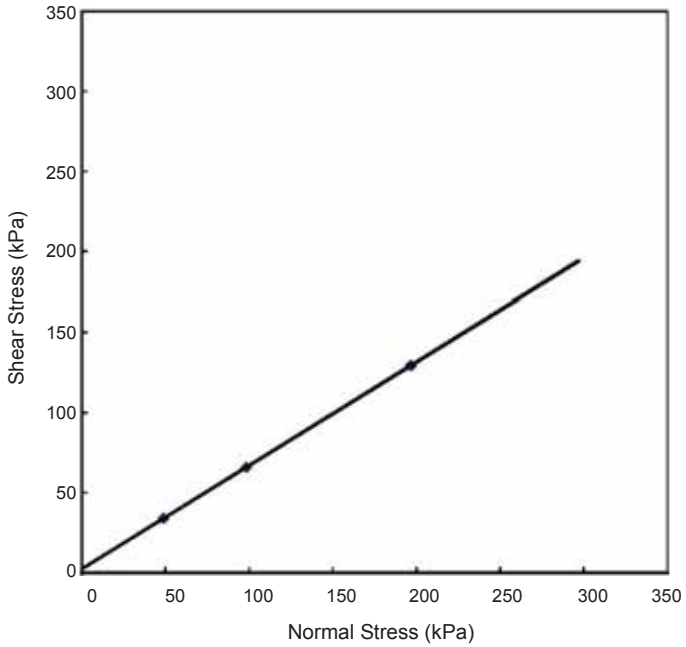
Tested by: Sikandar Hayat	Checked by: Muhammad Wasim

Engineers Guild, Lahore

DIRECT SHEAR TEST

Client: M/s State Bank of Pakistan Project: Geotechnical Investigation for Construction of SBP New Office Building at Rahwali Gujranwala		
	Sample Type : Remolded	Test Condition Soaked
Borehole No. BH-4	Sample No. UDS-2	Depth: 10.0 meter





y = 0.6467x + 2.4361

LINEAR REGRESSION

Angle of Internal Friction = 32.9 Degrees

Cohesion = 2.4 kPa

Note: Responsibility of sampling, packing and sealing rests with the client

Tested by: Sikandar Hayat	Checked by: Muhammad Wasim

Annexure E. Electricity Resistivity Survey

STATE BANK OF PAKISTAN BUILDING GUJRANWALA CANTT.

REPORT ON
SOIL RESISTIVITY TESTING

TABLE OF CONTENTS

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	2.1	Principles of Resistivity Testing	1
	2.2	Instrumentation and Field Procedure	3
	2.3	Interpretation and Evaluation of Resistivity Data	3
3.	RESULTS		4
4.	CONCLUSIONS		5

TABLE
FIGURES
ANNEXURE

TABLE

TABLE-1 Results of Soil Resistivity Testing

FIGURES

FIG. 1 Location Plan – Resistivity Testing
FIG. 2 Schematic Diagram Earth Resistivity Survey
FIG. 3 Field Resistivity Curve at ERS - 1
FIG. 4 Field Resistivity Curve at ERS - 2

ANNEXURE

Soil Resistivity Testing - Field Data Sheets

STATE BANK OF PAKISTAN BUILDING GUJRANWALA CANTT.

REPORT ON
SOIL RESISTIVITY TESTING

1. INTRODUCTION

State Bank of Pakistan is planning to construct a multi-storey building on G. T Road, Opposite Rahwali Gate of Gujranwala Cantonment in Punjab-Pakistan. In order to design the earthing system for the electrical installations, the measurements of soil electrical resistivity values are required, therefore soil resistivity testing was carried out at the site proposed for the SBP building in Gujranwala Cantt.

The purpose of the soil resistivity testing is to determine the electrical resistivity values of the subsoil up to a depth of about 20 meters which could be used for the design of the earthing system.

Shallow electrical resistivity measurements using Wenner electrode configuration were conducted at two locations within the site area. The fieldwork was carried out on June 05, 2016. The locations of electrical resistivity observation points are shown in Fig. 1.

The details of field methodology, analysis of the data collected, results of the resistivity testing and conclusions are presented in this report.

2. ELECTRICAL RESISTIVITY TESTING

2.1 Principles of Resistivity Testing

Among the various geophysical methods of subsurface exploration, electrical resistivity method has been successfully employed for measurement of electrical resistivity of subsurface material and groundwater investigations, particularly where electrical resistivity contrast exists between the water bearing formation and surrounding soils or rock.

Considering the variable electrical properties of the subsoil, the technique of electrical resistivity testing makes use of measuring the current and potential differences of various subsoil materials at the surface. In general, current is conducted electrolytically in the soil containing interstitial fluids. The resistivity is controlled by porosity, water content, as well as the quantity of dissolved salts. Clay minerals, however, are capable of storing electrical charges and current conduction in clay minerals is electronic as well as electrolytic. Thus the resistivity of soil depends directly on the amount of contained electrolyte and clay minerals and is inversely related to the porosity and degree of saturation of the formation. Therefore, resistivity of soil varies considerably not only from formation to formation, but also within the same layer. In particular, the resistivity variations can be large in

unconsolidated sediments. It has generally been observed that the resistivity increases progressively from fine grained to coarse grained material in the order of clay, silty clay, clayey silt, silt, sandy silt, silty sand, sand, gravel and boulder.

During the resistivity testing, commutated direct or very low frequency (less than 1 Hz) current is introduced into the ground through two current electrodes C1 and C2 inserted in the ground surface as shown schematically on Fig. 2.

The potential electrodes P1 and P2 are inserted in the ground between the outer current electrodes C1 and C2 such that all the electrodes are aligned along a straight line. The potential difference is measured between the two potential electrodes.

By measuring the current (I) flowing between the two current electrodes C1 and C2 and the associated potential difference (V) between the potential electrodes P1 and P2, the resistivity (R) is computed by the following well-known Ohm's law;

R = K* V/I

where

K = Geometric factor of the electrode arrangement
V = Potential difference in millivolts
I = Current passing through ground in milliamperes

In homogeneous subsurface conditions, the above relation gives the true resistivity of the subsurface material, but in anisotropic and inhomogeneous conditions, it represents weighted average resistivity of the formations through which the current passes. Since the subsoil is normally inhomogeneous and anisotropic, the resistivity value computed from the above equation is called apparent resistivity and is denoted by "Ra".

Therefore

Ra = K* V/I

The apparent resistivity values are obtained for various depths below the surface by expanding the current and potential electrodes from its centre along a straight line, while spacing between the electrodes is maintained.

Following are the technical requirements for carrying out the resistivity testing:

- Electrical resistivity contrast should exist between the formations under study.

- While carrying out the electrical resistivity testing using Wenner configuration, about three times the space along a straight line is required to achieve the estimated depth of investigation.

- Resistivity values of the alluvial strata and bedrock in an area could be established if the subsurface lithology through at least one borehole or tubewell is known in or around the area having similar geological conditions.

- If the earth consists of thin alternate layers, the resistivity obtained at the surface would be the average effect of these alternate layers.

2.2 Instrumentation and Field Procedure

The electrical resistivity measurements of the subsurface material were taken in the field by resistivity measuring instrument Terrameter SAS-1000 of ABEM, Sweden and using the Wenner electrode array. The Terrameter directly records the value of V/I in ohms. In order to study the variation of resistivity with depth, Vertical Electric Sounding (VES) technique was employed. In this technique, apparent resistivity values are obtained for various depths by increasing the current electrodes spacing at the ground surface, keeping the centre of electrode array fixed at the observation point.

Electrical resistivity testing was carried out two (2) observation points, designated as ERS-1 and ERS-2, the locations of which are shown in Fig. 1. The distance between ERS-1 and ERS-2 is about 25 meters.

The resistivity measurements were made as per ASTM Designation G-57-95 and IEEE 81 (1983) Standard. At each observation point, apparent resistivity measurements were taken at electrode spacing of 1, 2, 3, 4, 5, 7, 10, 15 and 20 meters. The field resistivity data obtained at two observation points are presented in Annexure. From the field data, field resistivity curves were obtained by plotting observed resistivity values against electrode spacing. The field resistivity curves are shown in Fig. 3 and Fig. 4 for ERS-1 and ERS-2 respectively.

2.3 Interpretation and Evaluation of Resistivity Data

The apparent resistivity values obtained in the field versus depth were plotted on the logarithmic scale. The interpretation of resistivity sounding makes use of the method of curve matching in which the field curve is compared with a set of standard curves or with the curve plotted with a computer software. The standard curves as well as computer curves correspond to a system of subsurface layers and their specific electrical resistivity, which could be correlated with the lithological and hydrogeological characteristics of the subsurface material of a particular area. The final interpretation makes use of the available local geological and/or borehole data.

Among the various curve matching techniques, partial curve matching technique using auxiliary point method was employed to determine the approximate true resistivity model. For this purpose, a set of Ebert auxiliary graphs (Orellana and Mooney 1966) was used. Final analysis of the field resistivity curves was made by employing computer software IX1D of Interpex, USA which yields possible earth layer model from the field resistivity curve using automatic iterative method.

3. RESULTS

The field resistivity curve at ERS-1 (Fig. 3) shows first a decreasing trend, then shows an increasing trend and finally shows a deceasing trend at larger electrode spacing. The field resistivity curve at ERS-2 (Fig. 4) shows first an increasing trend and finally shows a deceasing trend at larger electrode spacing. The average (apparent) resistivity up to a depth of 5 meters varies from 214.18 to 244.95 ohm-meters. The average (apparent) resistivity up to a depth of 10 meters varies from 237.05 to 245.89 ohm-meters representing predominance of high resistivity material at shallow depth.

The results of electrical resistivity testing obtained at two observation points in the site area are presented in Table-1 in the form true resistivity earth layering model. From these results, it can be inferred that the subsurface material up to 20 meters depth shows three to four resistivity layers with large variation of true resistivity values ranging from 20.7 to 659.2 ohm-meters.

At ERS-1, top very thin (0.9 meter thickness) layer have resistivity of 659.2 ohm-meters representing dry and hard surface material. Below this another thin layer (0.8 meter thickness) is present with a low resistivity of 38.5 ohm-meters. Below this up to 8.2 meters depth, a layer with high resistivity of 652.6 ohm-meters is present. Below 8.2 meters depth, a layer with low resistivity of 23.9 ohm-meters is present representing sand below water table.

At ERS-2, top thin (1.7 meter thickness) layer have resistivity of 123.2 ohm-meters representing dry surface material. Below this up to 7.6 meters depth, a layer with high resistivity of 487.2 ohm-meters is present, representing dry hard sand above water table. Below 7.6 meters depth, a layer with low resistivity of 20.7 ohm-meters is present representing sand below water table.

Electrical resistivity measurements at two observation points in the site area show nearly uniform subsurface condition. The material above water table shows high resistivity values. The material below water table (average about 8 meters depth) shows low electrical resistivity ranging from 23.9 to 20.7 ohm-meters which is favorable for earthing design.

4. CONCLUSIONS

Based on the results of electrical resistivity testing carried out at two observation points in the site area of SBP building on G. T. Road opposite Gujranwala Cantonment, following conclusions are drawn:

a) The true resistivity of the subsurface material up to about 20 meters depth in the site area varies from 20.7 to 659.2 ohm-meters.
b) The subsurface material above water table predominantly shows high resistivity values.
c) The subsurface material below about 8 meters shows low resistivity ranging from 23.9 to 20.7 ohm-meters which is favorable for earthing.
d) The design of earthing system for electrical installations should be made according to the resistivity values given in Table-1.

TABLE

TABLE - 1

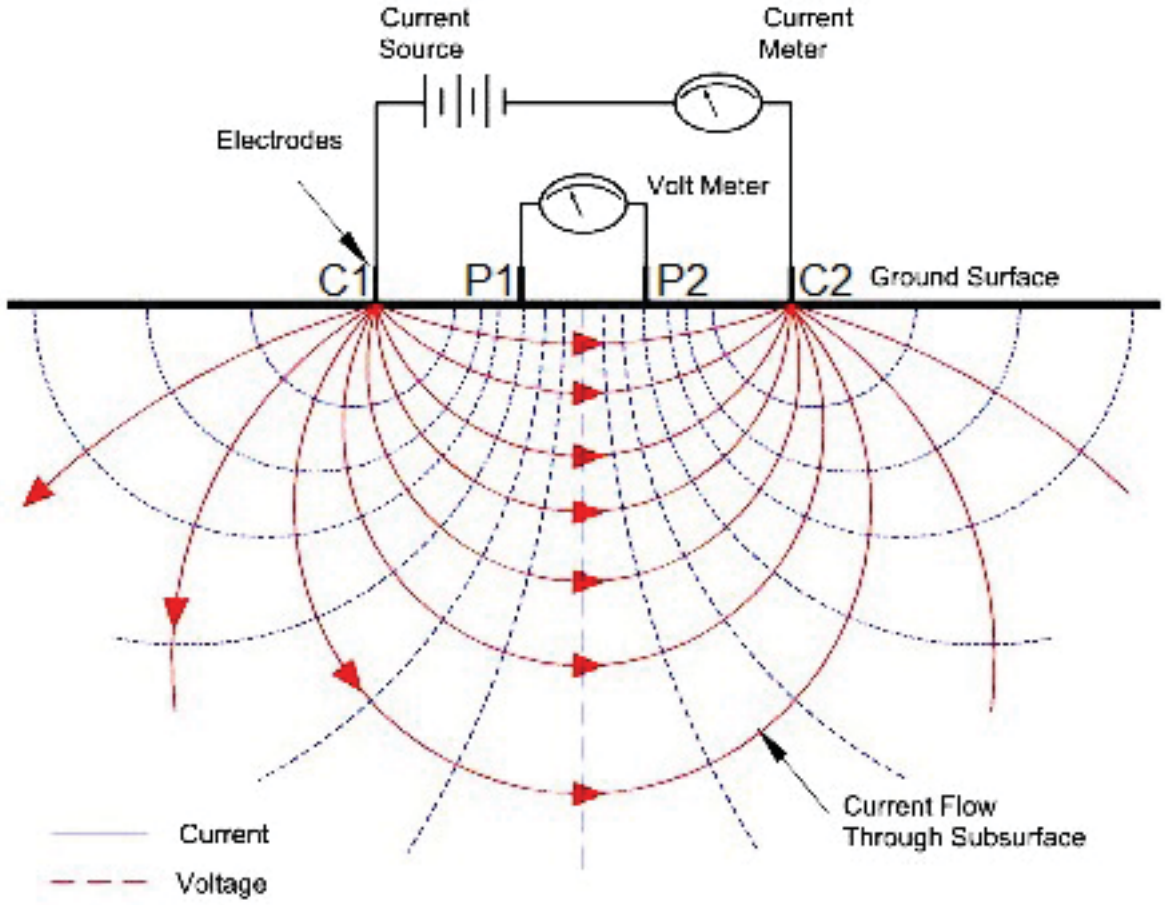
STATE BANK OF PAKISTAN BUILDING GUJRANWALA CANTT.
RESULTS OF SOIL RESISTIVITY TESTING

Observation Point No.	Depth (meter)	Layer Thickness (meter)	True Resistivity (ohm - meter)
ERS - 1	0.0 - 0.9	0.9	659.2
	0.9 - 1.7	0.8	38.5
	1.7 - 8.2	6.5	652.6
	8.2 - 20.0	11.8	23.9
ERS - 2	0.0 - 1.7	1.7	123.8
	1.7 - 7.6	5.9	487.2
	7.6 - 20.0	12.4	20.7

FIGURES


FIG. 1
BH-1
BH-2
BH-3
BH-4
BH-5
BH-6
ERS-1
ERS-2
© 2016 Google
Image © 2016 DigitalGlobe
STATE BANK OF PAKISTAN (SBP)
GEOTECHNICAL INVESTIGATION FOR SBP NEW OFFICE AT RAHWALI GUJRANWALA
GEOTECHNICAL INVESTIGATION PLAN
ENGINEERS GUILD
Annexure A.2

Fig. 2



SCHEMATIC DIAGRAM
EARTH RESISTIVITY SURVEY

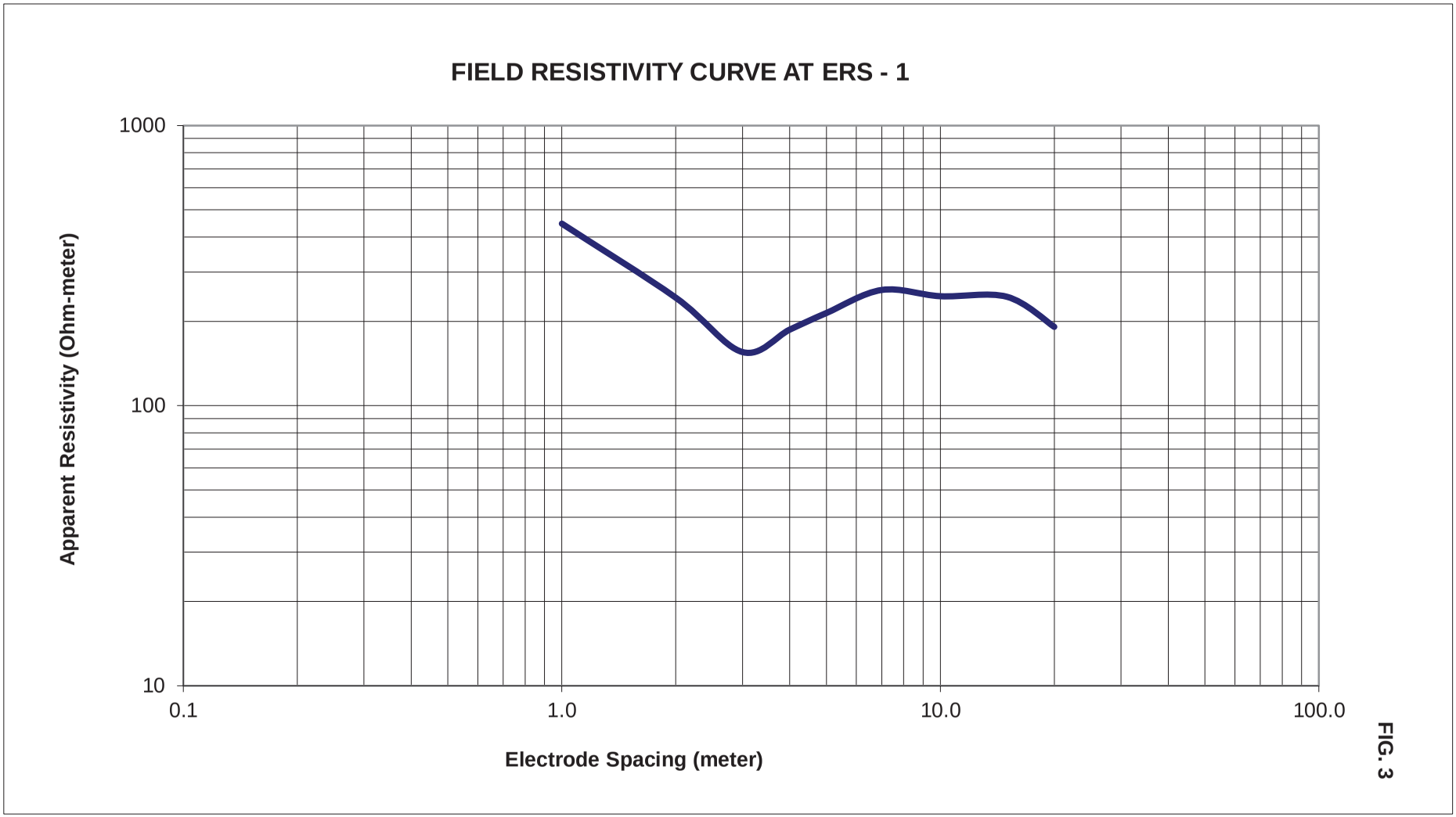

FIELD RESISTIVITY CURVE AT ERS - 1
1000
100
10
Apparent Resistivity (Ohm-meter)
0.1
1.0
10.0
100.0
Electrode Spacing (meter)

FIG. 3

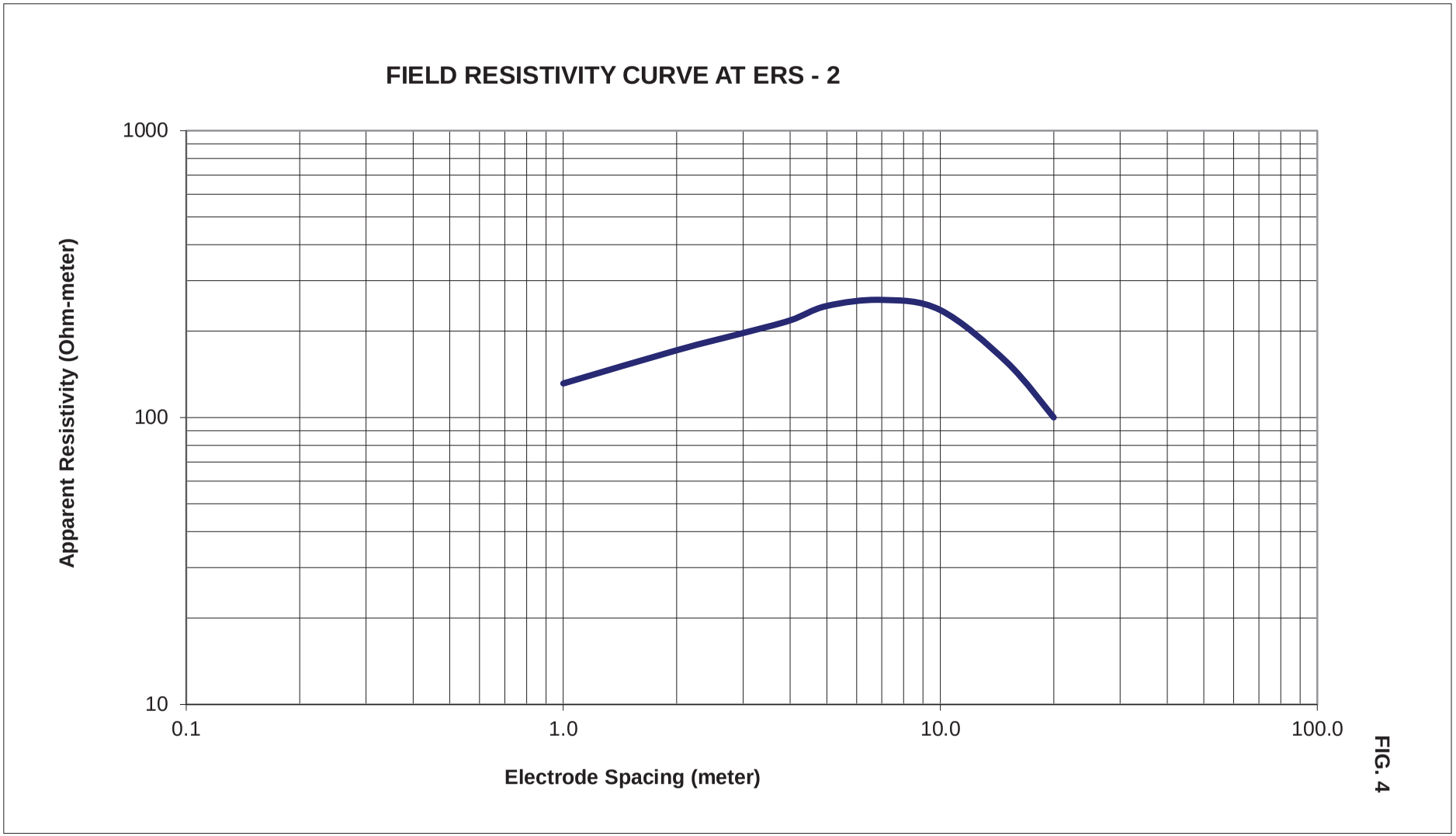

FIELD RESISTIVITY CURVE AT ERS - 2
1000
100
10
Apparent Resistivity (Ohm-meter)
0.1
1.0
10.0
100.0
Electrode Spacing (meter)

FIG. 4

ANNEXURE

Soil Resistivity Testing

Field Data Sheets

ELECTRICAL RESISTIVITY SURVEY
FIELD DATA SHEET

PROJECT: SBP Building Gujranwala Cantt
ER TEST NO: ERS - 1
LOCATION: Near Borehole BH-3
DATE: 05-06-2016
COORDINATES:
CONFIGURATION: WENNER
TEMPERATURE: 41 °C
ELEVATION:
GEOPHYSICIST: M. Javed

READING NO.	ELECTRODE SPACING "a" (m)	ELECTRODE CONSTANT	RESISTANCE R=V/I (Ohms)	APPARENT RESISTIVITY (Ohm-m)	REMARKS
1	1	6.28	71.1120	446.58	
2	2	12.56	19.3380	242.89	
3	3	18.84	8.2473	155.38	
4	4	25.12	7.4374	186.83	
5	5	31.4	6.8211	214.18	
6	7	43.96	5.8884	258.85	
7	10	62.8	3.9155	245.89	
8	15	94.2	2.5983	244.76	
9	20	125.6	1.5219	191.15	

ELECTRICAL RESISTIVITY SURVEY
FIELD DATA SHEET

PROJECT: SBP Building Gujranwala Cantt
ER TEST NO: ERS - 2
LOCATION: Near Borehole BH-4
DATE: 05-06-2016
COORDINATES:
CONFIGURATION: WENNER
TEMPERATURE: 41 °C
ELEVATION:
GEOPHYSICIST: M. Javed

READING NO.	ELECTRODE SPACING "a" (m)	ELECTRODE CONSTANT	RESISTANCE R=V/I (Ohms)	APPARENT RESISTIVITY (Ohm-m)	REMARKS
1	1	6.28	20.9150	131.35	
2	2	12.56	13.6600	171.57	
3	3	18.84	10.4590	197.05	
4	4	25.12	8.6851	218.17	
5	5	31.40	7.8009	244.95	
6	7	43.96	5.8506	257.19	
7	10	62.80	3.7747	237.05	
8	15	94.20	1.6572	156.11	
9	20	125.6	0.7959	99.96	

Annexure F. Site Photographs

by Engineers Guild
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Photo Album

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(About the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes missing			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)		IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
			DRY STRENGTH	**DILATANCY**	**TOUGHNESS**			
		SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None		ML	SILT
			Medium to High	None	Medium		CL	CLAY
			Low to medium	Slow to very slow	Low		OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium		MH	SILT
			High	None	High		CH	CLAY
			Medium to High	None	Low to medium		OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit W_L less than 35%. • Modium plasticity – W_L between 35% and 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	**A surface or crack across which the soil** has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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