Geotechnical Survey on the Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad

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1. INTRODUCTION

1.1. General

Consultants M/s Nissuicon, Tokyo – Japan are undertaking "THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD" under JICA. The work of geotechnical survey was entrusted to *M/s ECOS, Islamabad.*

This report presents the findings of the geotechnical investigations conducted at selected sites where Over Head Water Reservoirs (OHR) have been proposed to be installed.

These investigations were conducted by the execution of eight (8) exploratory boreholes with depth of 40m each. The site staff was mobilized from 30th Nov 2017 and concluded on 17th Dec 2017. The locations of the boreholes are presented in Table 1 & Figure 1.

Table 1: Locations of Bore holes

BH No.	Easting	Northing	Elevation	Description
1	318449.80 m E	3476603.39 m N	184.83m	Water treatment plant, Jhal
2	318572.70 m E	3476725.46 m N	186.21m	-do-
3	318624.52 m E	3476642.50 m N	183.85m	-do-
4	318503.88 m E	3476541.46 m N	184.78m	-do-
5	319677.24 m E	3477791.98 m N	184.59m	Abdullah Pur OHR
6	321248.00 m E	3477899.00 m N	184.469	Madina Town OHR No.2
7	321767.00 m E	3478035.00 m N	-	Madina Town OHR No. 1
8	320740.00 m E	3476053.00 m N	183.451	Peoples Colony OHR No. 2

Figure 1: Locations of Boreholes

This report describes the field investigations and laboratory tests conducted to accomplish the geotechnical studies for the proposed OHRs. An evaluation of foundation soils, foundation design parameters, recommendations regarding allowable bearing pressures for shallow and deep foundation, earthwork and construction considerations are provided in this report.

1.2. Purpose and Scope of Work

The primary objective of this investigation is to determine the subsurface stratigraphy of the project area for ascertaining the geotechnical design parameters required for the design and construction of foundations of proposed OHRs in the project area. For this purpose, the following aspects have been addressed:

- **a.** Determination of potential hazardous conditions including seismicity, liquefaction due to seismic force, slope instabilities, presence of any problematic soil like expansive soil, collapsible soil and so on, if there exists.
- **b.** Determination of subsurface stratigraphy within the influence zone of the proposed construction.
- **c.** Determination of physical and engineering characteristics of the soil and rock formation and presence ground water.
- **d.** Performance of geotechnical analyses to evaluate allowable bearing pressures for designing different types of foundations, total and differential settlements of various foundations, allowable capacities of deep foundations, stability of excavation, suitability of soil to be used in earthworks etc.

The scope of work for carrying out subsoil investigations at the project site included:

- **a.** Drilling of 8 boreholes in total, down to 40m depth below the existing ground level.
- **b.** Performance of standard penetration test (SPT) in the boreholes at depth interval of 2.0 m up to the investigated depth.
- **c.** Collection of undisturbed and disturbed soil samples from boreholes with appropriate sampling techniques, sample preservation and transportation to the testing laboratory.
- **d.** Performance of Permeability test at each bore hole at the depth of 3-4m.
- **e.** Performance of laboratory tests including classification and strength/settlement tests of selected soil samples in accordance with the relevant ASTM standards.
- **f.** Preparation of geotechnical investigation report which shall include the subsurface logs, laboratory test data, evaluation of field and laboratory data and recommendations for assessment of liquefaction, evaluation of settlement under foundation, allowable bearing capacity of soil & foundation types.

2. GEOLOGY AND SEISMICITY

2.1. Geology of Site Area

The district of Faisalabad is part of the alluvial plains between the Himalayan foothills and the central core of the Indian subcontinent. The alluvial deposits are typically over a thousand feet thick. The interfluves are believed to have been formed during the Late Pleistocene and feature river terraces. These were later identified as old and young floodplains of the Ravi River on the Kamalia and Chenab Plains. The old floodplains consist of Holocene deposits from the Ravi and Chenab rivers.

Faisalabad is situated in gentle sloping plains of Upper Indus Basin. These plains are covered by Quaternary Unconsolidated deposits of enormous thickness and bed rock belonging to Indian Basement exists at a greater depth. The Quaternary deposits comprised of silty clay and sand in varying proportions which are accumulated by braided tributaries of Indus river system, originating from the north-west Himalayas. The geologic study is based on general site reconnaissance and detailed geologic and geotechnical investigations. The project sites are located on nearly horizontal flood plains covered by fine grained loamy soils. Bedrock is not exposed within the project sites and its vicinity not encountered within the investigated depth of boreholes. The substrata comprised of alluvial deposits of the Indus river system. The unlined irrigation canals and distributaries including water courses are the main source of groundwater recharge. Rain fall contribution to groundwater recharge is not considerable. Ponds also slightly contribute towards the recharge.

The soil consists of young stratified silt loam or very fine sandy loam. The course of rivers within Faisalabad is winding and often subject to frequent alternations. In the rainy season, the currents are very strong. This leads to high floods in certain areas which do last for a number of days. The Rakh and Gogera canals have encouraged the water levels in the district however the belt on the Ravi River has remained narrow. The river bed does include the river channels which have shifted the sand bars and low sandy levees leading to river erosion.

2.2. Slope instability and landslides

The site area is fairly level ground and free from any slope instability and land sliding problem.

2.3. Seismicity

The Punjab Plain, in which the city is located, shows low to moderate level of seismicity which is associated with the faulting in the basement rocks covered by the deep alluvial deposits. The basement high, depicted by outcrops of basement rocks near Sargodha and extending from Sargodha to Faisalabad and further southeast towards Indian border shows a concentration of earthquakes with magnitude up to 5.5 on the Richter Scale. A moderate earthquake originating from the basement high in Punjab plain could produce appreciable ground shaking at sites due to the thick alluvial deposits. According to the Seismic Zoning Map of Pakistan, the project site falls in Zone 2A, as shown in the Fig. 2.

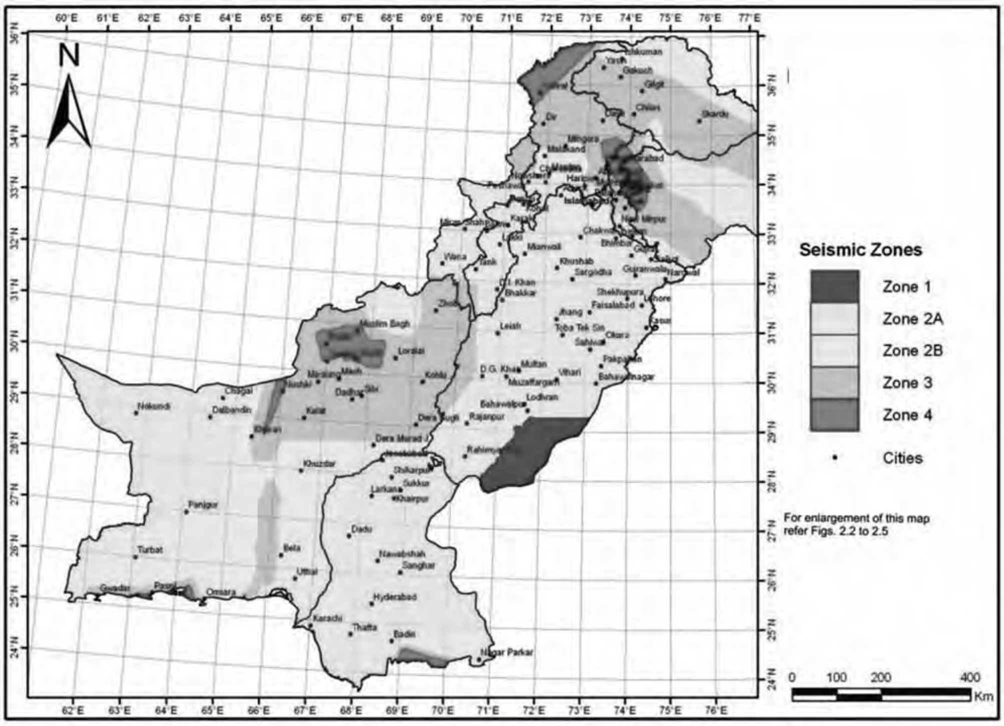

Fig. 2: Seismic Zoning Map of Pakistan (*Source:* NHA 2006)

Consequently the structures should be designed in accordance with the requirement of seismic design after due consideration to other structural design parameters.

2.4. Seismic Soil Profile Characterization

In accordance with the procedures described in Building Code of Pakistan (Seismic Provision 2007), the criteria for classification soil profiles are to be based on average shear wave velocity, average field SPT resistance, and average undrained shear strength.

Based on the above mentioned parameters derived through field and laboratory investigations for project area, the average soil profile as per Building Code of Pakistan (Seismic Provision 2007) is classified as S_D (i.e., stiff soil).

2.5. Liquefaction Potential

The liquefaction phenomenon is generally associated with loose, saturated fine sand. The subsoils at the project site within top 40 m depth are cohesive soil which exists in stiff to hard condition. Therefore, the subsoils in the project area are not prone to liquefaction due to earthquake shaking.

Also, as per Building Code, in Seismic Zones 3 and 4, when required by the building official, the potential for seismically induced soil liquefaction and soil instability shall be evaluated. Since Faisalabad lies in Seismic Zone 2A, hence no such consideration is required.

2.6. Collapse Potential

The collapse potential of soil is a phenomenon associated with the breakage of soil structure when the soil under imposed pressure undergoes large settlement due to collapse of its structure upon saturation. Generally, aeolian/wind-blown soils which are silty sand/fine sand deposited under the wind action are prone to collapse potential. The subsoils in the project area are cohesive and dense-very dense soil and do not possess any collapse potential.

2.7. Swelling/expansive Potential

Mostly the clay content is low below 5m depth. Up to depth of 5m, the liquid limit values for cohesive soils (CL) vary between 29% and 32% whereas plasticity index values are between 10 and 13. Based on Atterberg limits, the cohesive soils are low to medium plastic in nature, and generally, medium clays are low to non-swelling in nature.

3. FIELD AND LABORARORY INVESTIGATIONS

3.1 Field Investigations

The following activities were carried out in the field for the sake of geotechnical investigations at proposed locations in accordance with the scope of work.

- Drilling of 8 exploratory boreholes, each of 40m depth.
- Performance of SPTs in the boreholes at 2m interval
- Performance of Permeability test at 3-4m depth of each bore hole.
- Recovering disturbed and undisturbed soil sample from every 5m interval of borings

Followings of field investigations have been carried out at the project site:

3.1.1 Details of Boreholes

Locations & depth of bore holes are shown in Table 2:

Table 2: Details of Bore holes

Bore Hole Number	Total Depth(m)	Location
BH 1	40	Water treatment plant, Jhal
BH 2	-do-	-do-
BH 3	-do-	-do-
BH 4	-do-	-do-
BH 5	-do-	Abdullah Pur OHR
BH 6	-do-	Madina Town OHR No.2
BH 7	-do-	Madina Town OHR No. 1
BH 8	-do-	Peoples Colony OHR No. 2

3.1.2 Drilling of Exploratory Boreholes

All exploratory boreholes were drilled by using straight rotary methods with bentonite mud to stabilize bore holes. Details of exploratory boreholes along with site photographs are given in Appendix-F.

3.1.3 Standard Penetration Test

Standard Penetration Tests (SPTs) were performed in the boreholes in accordance with ASTM D-1586 at every 2m intervals uptil the final depth explored. Manual types hammer, weighing 63.5 kg was used for conducting the test. The SPT blows were recorded for penetration of 45.7 cm of split spoon samples and the number of blows required for the last 30.5 cm penetration was recorded as SPT-N values. The distribution of SPT-N values along the depth in case of all borings has been plotted and is shown in Appendix-D. The detailed description of the subsoils encountered and the depth at which SPTs were performed are plotted in a simplified manner. As a part of SPT, disturbed representative soil samples were recovered from split spoon sampler for classification tests.

3.1.4 Permeability Test

Borehole permeability tests were performed on each bore hole at 3 to 4m depth. Calculations were performed according to *(BS 5930: 1999*). At these depths, results showed that most of the soil strata fall in the class of silty sand. These results and logs are shown in Appendix-C. Permeability is a soil property indicating the ease with which water will flow through the soil. Permeability depends on the following factors:

- Particle size distribution of the soil grains
- Void ratio of the soil
- Shapes and arrangement of pores
- Degree of saturation
- Properties of the pore fluid (especially viscosity)

3.1.5 Soil Sampling

Disturbed and undisturbed soil samples were obtained during the field work from the boreholes. Disturbed soil samples from the boreholes were obtained through split spoon sampler while performing SPTs in accordance with ASTM D-1586. These samples were

placed in polythene bags and then saved into plastic boxes to ensure the save transportation. The polythene bags were clearly labeled to indicate the project name, borehole designation and depth of the sample. Undisturbed soil samples were obtained from cohesive strata encountered in the holes through Shelby tube as per ASTM D-1587. The samples were properly waxed and clearly labeled to indicate the project name, borehole designation and the depth of the sample. All the soil samples were carefully transported to laboratory for soil testing.

3.1.6 Laboratory Testing

Selected representative subsoil samples were transported to Geotechnical laboratory of University of Engineering and Technology, Lahore for the determination of physical and engineering characteristics of the subsoils. The following tests were conducted in accordance with relevant ASTM method.

- **a.** Specific Gravity
- **b.** Moisture Content
- **c.** Grain-Size Analysis & Classification (Sieve Analysis)
- **d.** Atterberg Limits (Plastic & Liquid)

- **e.** Bulk Density
- **f.** Consolidation Test
- **g.** Direst Shear Test

The laboratory test results are summarized in Appendix-B. The details of laboratory test results are presented under Appendix-A.

3.2 Discussion on Field and Laboratory Results

- Based on the SPT-N values, the consistency of cohesive soil up to 4~5 m depth, in general, exists in clayey type, the subsoil from 5 m to about 40m exists in the form of silt and sand containing dense to very dense form.
- Using grain size analyses and Atterberg Limits, soils were classified according to the Unified Soil Classification System (USCS), ASTM-2487 as indicated in Table 1. Almost all the soil samples are classified as Sand.
- The liquid limit values for cohesive soils (CL) vary between 29% and 32% whereas plasticity index values are between 10 and 13. These values of Atterberg Limits indicate that the silty clay stratum exists in medium plastic state.
- The specific gravity of various soil samples tested ranges between 2.65 and 2.70. (Table 1)
- Consolidation tests carried out on undisturbed samples collected from boreholes. The average coefficient of volume compressibility values, measured over the test pressure range, in general, between 0.018 and 0.367 m^2/MN indicating the clay to be of compressible.
- Permeability test has been performed at 3-4m depth of every bore hole which showed the value of Permeability K in m/sec from E-03 to E-04. Hence fall in Silty Sand group.

4. GEOTECHNICAL EVALUATION

4.1 General

The proposed project site lies in Urban Area of Faisalabad for the proposed OHRs. At the project area, subsurface investigations reflected dominance of the sand, which is light grey to grey, dense to very dense, fine to coarse and thickly bedded. From 20m to 30m, clay beds are also encountered in some bores that are firm and stiff. Top 4 to 5m of all boreholes are also encompassing by clays that are soft to medium firm having silt as well.

4.2 Stratigraphy

Total eight (08) boreholes were drilled at the proposed sites. Locations of all 8 boreholes are shown in Table 1.

The study of bore logs, field and laboratory test results reveals slightly variable, but generally favorable sub-soil conditions for mat/raft foundation design at depth of 4 meter, which are explained as follows:

BH-01

(0-4) m	Brown very soft to soft, low to medium plastic clay with little concretion
(4-7) m	Grey medium dense silty and fine sand
(7-25) m	Grey medium dense fine sand
(25-26) m	Brown Hard clay
(26-40) m	Grey dense to very dense, fine to medium grained sand

BH-02

(0-4) m	Brown firm to stiff low to medium plastic clay
(4-27) m	Light Grey medium to verydense silty and fine sand
(27-28) m	Light brown stiff clays
(28-40) m	Light Grey dense to very dense, fine to medium grained sand

BH-03

(0-2) m	Light brown silty clay low to medium plastic
(2-3) m	Light grey sandy silt
(3-40) m	Light grey fine to coarse sand dense to very dense

BH-04

(0-4) m	Light brown clay with silt medium plastic
(4-24) m	Light grey silty sand fine to medium grained.
(24-26) m	Light brown stiff clays
(26-40) m	Light grey medium to coarse sand dense to very dense

BH-05

(0-2) m	Light brown silty clay
(2-24) m	Light grey fine to medium grained sand loose to dense

(24-26) m	Silty clay low plastic
(26-40) m	Light grey medium to coarse sand dense to very dense

BH-06

(0-2) m	Light brown silty clay low plastic
(2-4) m	Light grey Sandy silt dry loose
(4-40) m	Light grey Fine to coarse grained sand dense to very dense.

BH-07

(0-4) m	Light brown to brown clay with silt low plastic soft
(4-40) m	Light grey fine to coarse grained sand with minor silt dense to very dense

BH-08

(0-4) m	Light brown clay plastic soft to firm
(4-6) m	light brown clayey silt with few sand non-plastic
(6-40) m	Light grey fine to coarse grained sand with minor silt dense to very dense wet

4.3 Geotechnical Design Parameters

This site is classified as Soil Profile Type SD as per Revised Seismic Provisions (2007) of Building Code of Pakistan. Faisalabad area lies in Seismic Zone '2A' with peak horizontal ground acceleration varying from 0.08 to 0.16g.

Table 3 provides information about Soil Profile type, Seismic Zone and Seismic Coefficients.

Table 3: Geotechnical Design Parameters

Seismic Zone	Soil Profile Type	Zone Factor 'Z'	Seismic Coefficient 'Ca'	Seismic Coefficient 'Cv'
2A	SD	0.15	0.22	0.32

4.4 Ground Water Table

Ground Water Table (GWT) or excessive seepage is present at this site at shallow depths like 3m to 10m for BH-01 & BH-02 and deep depths like 17m to 21m in other bore holes with details presented in Table 4.

Table 4: Ground Water Table

BH No.	GWT (m)
1	3
2	10
3	20.6

4	20.6
5	19
6	17
7	18
8	21

4.5 Foundation Settlement Evaluation

Foundation settlement has been calculated by using method proposed by Burland and Burbridge, 1985. Settlement calculation is attached as Appendix-E (Calculation Sheet 2).

5. RECOMMENDATIONS FOR FOUNDATION DESIGN

5.1 Foundation Requirement

Foundation is considered satisfactory if it fulfills the following requirements:

- It must be adequately safe against shear failure.
- It must not undergo excessive differential settlement.
- It must be placed at a depth un-affected by the influence of weather.

5.2 Foundation System

Considering the proposed structure of OHR which is about 27.5m high, top 4m soil has low strength as per bore logs. As per SPT Results, after 4 meter, Raft Foundation seems to be more appropriate types of foundations for BH-02 to BH-08.

5.3 Foundation Design

5.3.1 Raft Type Foundation

Top 2-3m soil layers are fills or weak soils which are not suitable for direct placement of foundations, particularly for heavy & tall structure. For BH 02 to 08, at 4m depth, soil properties are quite adequate to resist structure loads for RAFT type of foundation. Allowable bearing calculation has been attached as Appendix-E (Calculation Sheet 1). The calculated allowable bearing capacity of BH-02 to BH-08 are reported in Table 4.

Table 5: Allowable Bearing Capacity

BH No.	Allowable Bearing Capacity (kPa)
1	Pile Foundation is recommended
2	136
3	133
4	122
5	136
6	131
7	127
8	121

5.3.2 PILE FOUNDATION

It has been observed BH-01 site has weak soil layer for more than 6 to 8m. So it is recommended to construct pile type foundation to resist structure load. The pile capacity is calculated with respect to depth considering 1m pile diameter and is reported in Appendix F.

APPENDIX-A

Laboratory Test Results

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

SUMMARY OF THE TEST RESULTS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/ TP No.	Sample No	Depth (m)	NMC (%)	Bulk Density (kN/m^3)	Specific Gravity G_s
BH-01	1 (UDS)	1	21.68	19.21	2.7
	2 (UDS)	7	25.05	18.64	2.67
	3 (UDS)	14	17.96	14.55	2.65
	4 (UDS)	19	18.27	16.08	2.67
	5 (UDS)	25	24.24	20.55	2.65
	6 (UDS)	30	23.88	15.74	2.66
	7 (UDS)	35	25.17	13.48	2.69
	8 (UDS)	40	17.67	15.90	2.68
BH-02	9 (UDS)	3	9.61	20.48	2.7
	10 (UDS)	7	7.50	18.93	2.67
	11 (UDS)	15	7.32	16.97	2.67
	12 (UDS)	20	4.32	16.31	2.66
	13 (UDS)	25	17.34	19.79	2.65
	14 (UDS)	30	27.66	18.30	2.67
	15 (UDS)	35	14.41	12.48	2.67
	16 (UDS)	40	19.27	18.44	2.65

Prepared by:

Geotech. Engg. Lab Director Civil E.

Checked by:

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

SUMMARY OF THE TEST RESULTS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/ TP No.	Sample No	Depth (m)	NMC (%)	Bulk Density (kN/m^3)	Specific Gravity G_s
BH-03	17 (UDS)	5	2.37	16.54	2.66
	18 (UDS)	11	7.22	20.71	2.67
	19 (UDS)	15	9.19	17.99	2.67
	20 (UDS)	21	20.48	17.94	2.66
	21 (UDS)	25	21.92	20.86	2.67
	22 (UDS)	31	26.52	16.14	2.66
	23 (UDS)	35	24.92	20.47	2.65
	24 (SPT)	40	16.53		2.65
BH-04	25 (UDS)	5	4.32	16.20	2.67
	26 (UDS)	11	6.41	17.78	2.67
	27 (UDS)	15	12.36	17.35	2.67
	28 (UDS)	21	9.82	26.16	2.66
	29 (UDS)	25	17.35	19.44	2.65
	30 (UDS)	31	22.79	18.65	2.67
	31 (SPT)	36	32.67		2.66
	32 (SPT)	40	22.86		2.65

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Department of Civil Engineering
Geotechnical Engineering Laboratory

SUMMARY OF THE TEST RESULTS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/ TP No.	Sample No	Depth (m)	NMC (%)	Bulk Density (kN/m^3)	Specific Gravity G_s
BH-05	33 (UDS)	5	9.23	17.74	2.65
	34 (UDS)	11	7.28	16.47	2.65
	35 (UDS)	15	15.10	16.46	2.66
	36 (UDS)	21	23.43	18.48	2.67
	37 (UDS)	25	24.64	17.79	2.67
	38 (UDS)	31	23.30	17.50	2.67
	39 (SPT)	36	19.62		2.67
	40 (SPT)	40	20.11		2.67
BH-06	41 (UDS)	1.5	20.39	17.17	2.70
	42 (UDS)	5	21.26	16.61	2.65
	43 (UDS)	11	7.78	15.98	2.67
	44 (UDS)	15	9.63	18.34	2.68
	45 (UDS)	21	6.79	16.12	2.67
	46 (UDS)	25	18.72	18.05	2.66
	47 (SPT)	32	20.46		2.65
	48 (SPT)	36	22.78		2.67

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Department of Civil Engineering
Geotechnical Engineering Laboratory

SUMMARY OF THE TEST RESULTS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/ TP No.	Sample No	Depth (m)	NMC (%)	Bulk Density (kN/m^3)	Specific Gravity G_s
BH-07	49 (UDS)	1.5	25.79	18.24	2.7
	50 (UDS)	5	4.05	14.84	2.65
	51 (UDS)	11	4.03	19.60	2.65
	52 (UDS)	15	6.72	17.61	2.66
	53 (UDS)	21	19.32	20.24	2.67
	54 (UDS)	25	62.39	18.26	2.65
	55 (UDS)	31	18.46	19.26	2.67
	56 (SPT)	36	19.53		2.67
BH-08	57 (UDS)	5	9.14	17.10	2.65
	58 (UDS)	11	3.45	17.20	2.66
	59 (UDS)	15	17.29	18.20	2.67
	60 (UDS)	21	6.31	15.29	2.65
	61 (UDS)	25	16.68	18.44	2.65
	62 (UDS)	31	17.52	19.10	2.66
	63 (SPT)	36	34.34		2.67
	64 (SPT)	40	21.03		2.67

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Geotechnical Engg. Lab * Director * Civil Engg. Dept. UET

Checked by:

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

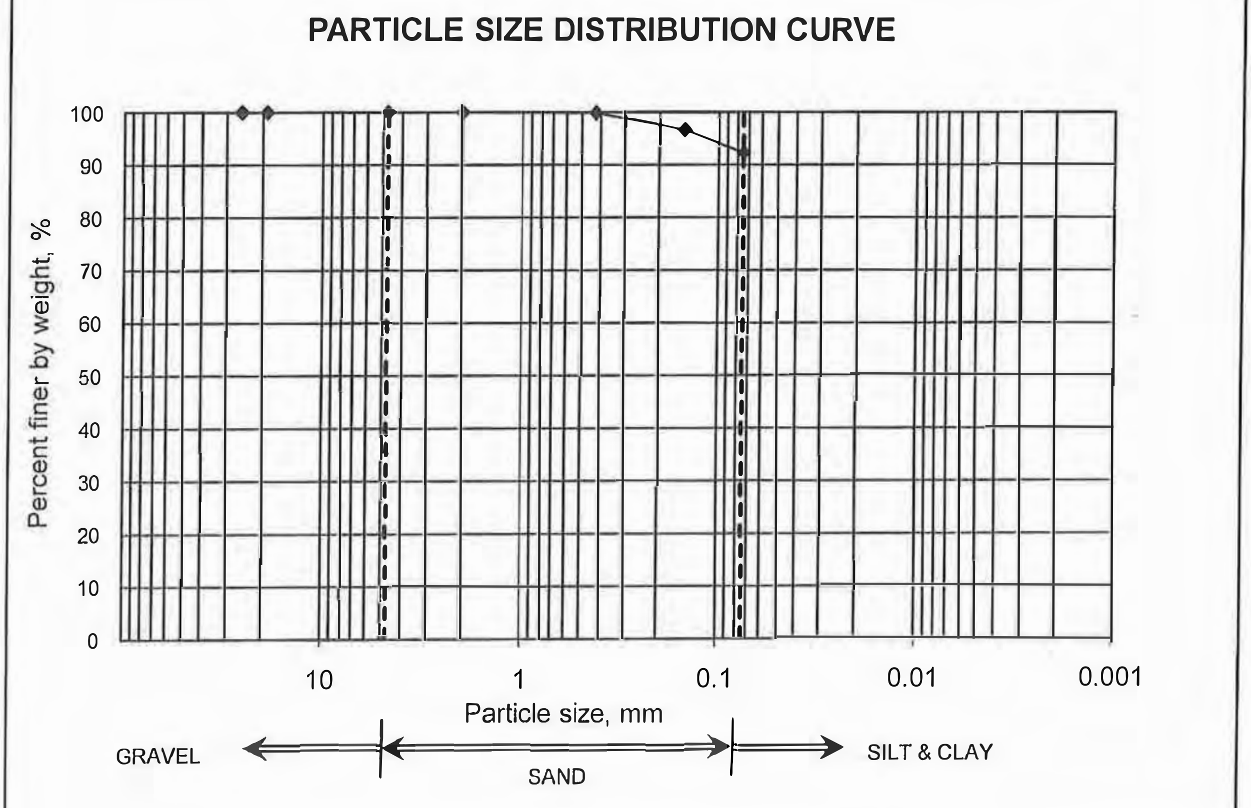
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	0 %
Sample No.	1 (UDS)	**Sand =**	8 %
Depth (m):	1.0	**Silt & Clay =**	92 %

Test Method: ASTM D422



Prepared by:

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Director

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

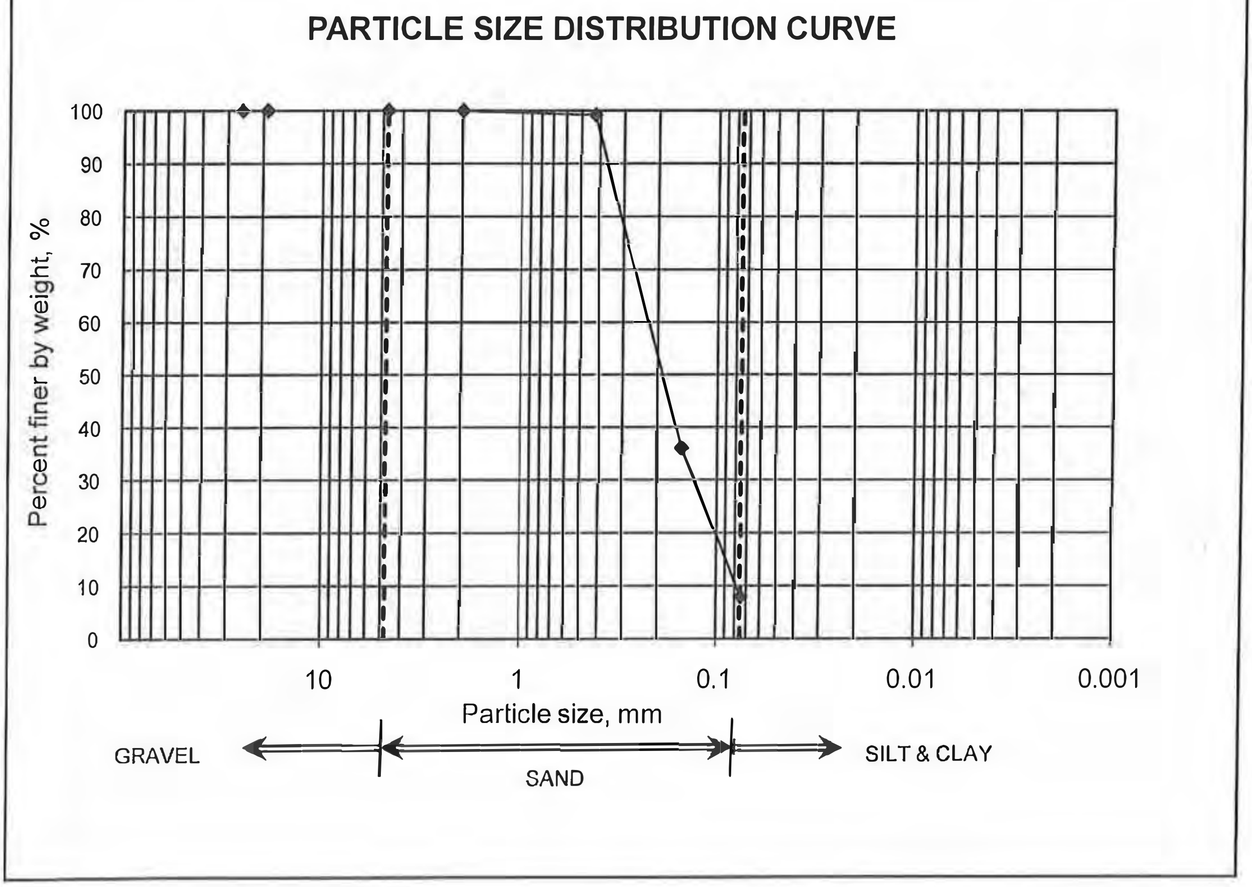
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	0 %
Sample No.	2 (UDS)	**Sand =**	92 %
Depth (m):	7.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

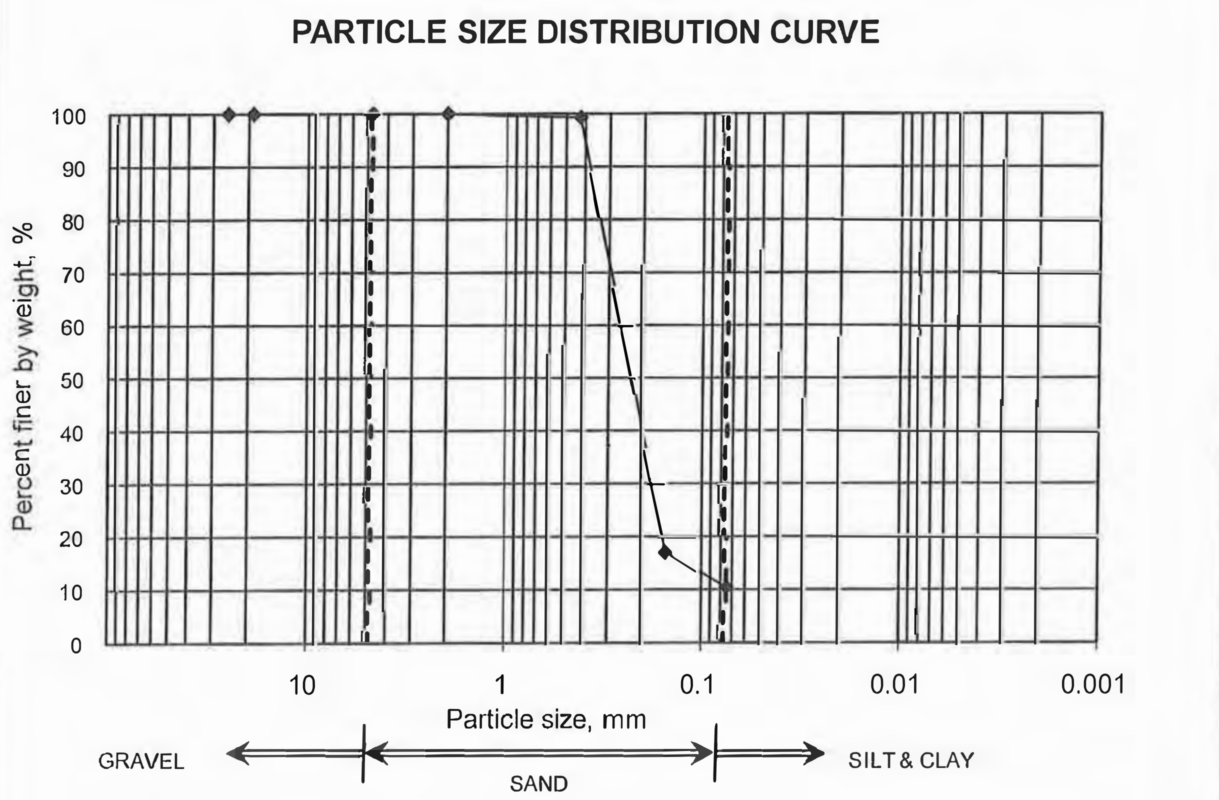
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	0 %
Sample No.	3 (UDS)	**Sand =**	90 %
Depth (m):	14.0	**Silt & Clay =**	10 %

Test Method: ASTM D422



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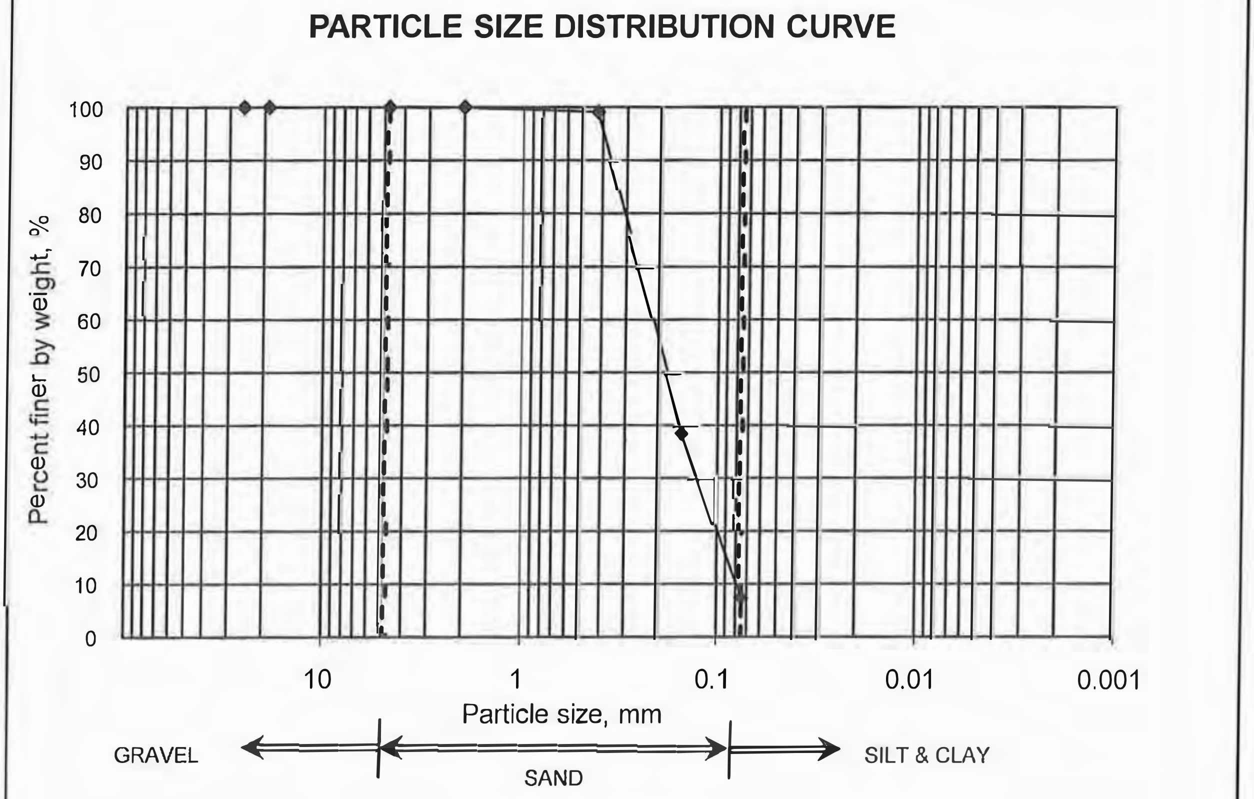
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	0 %
Sample No.	4 (UDS)	**Sand =**	93 %
Depth (m):	19.0	**Silt & Clay =**	7 %

Test Method: ASTM D422



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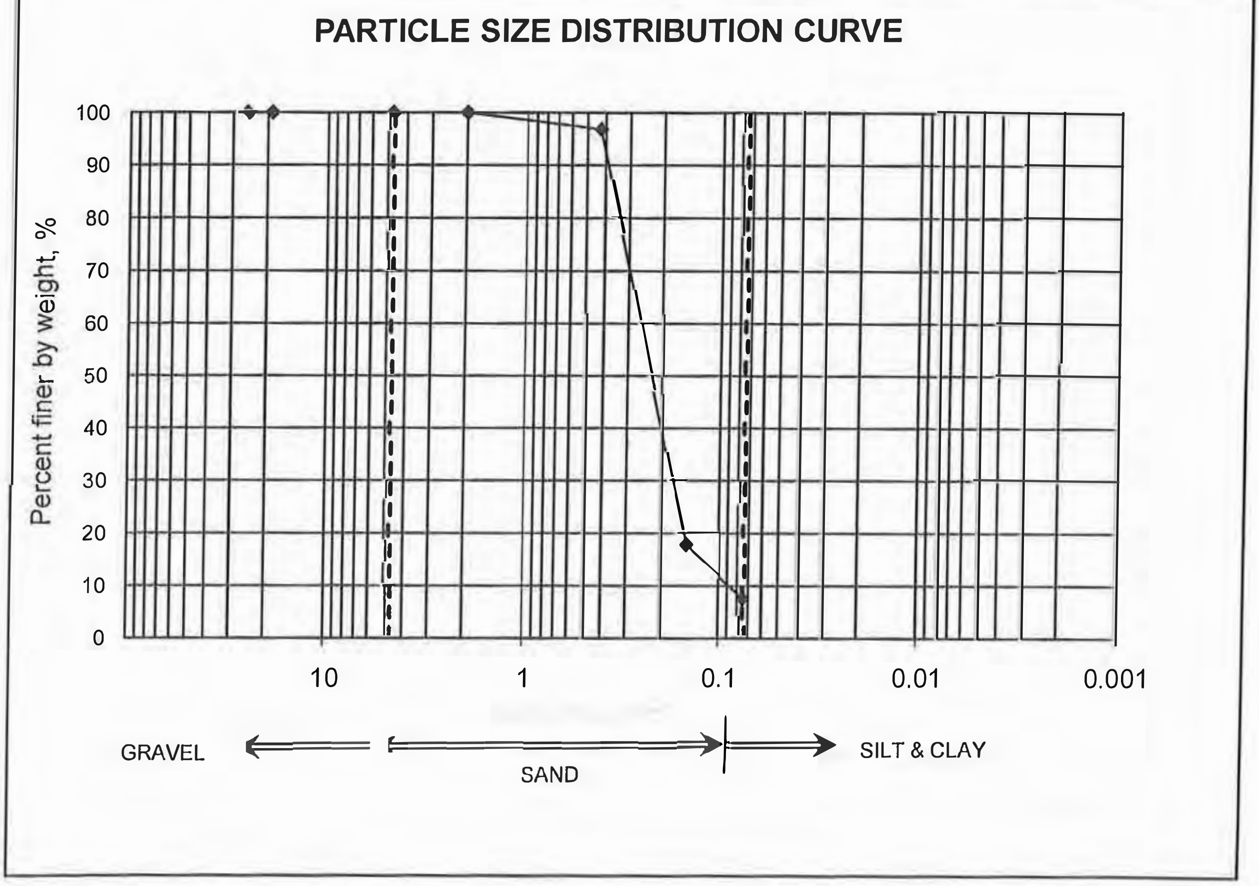
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	0 %
Sample No.	5 (UDS)	**Sand =**	92 %
Depth (m):	25.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



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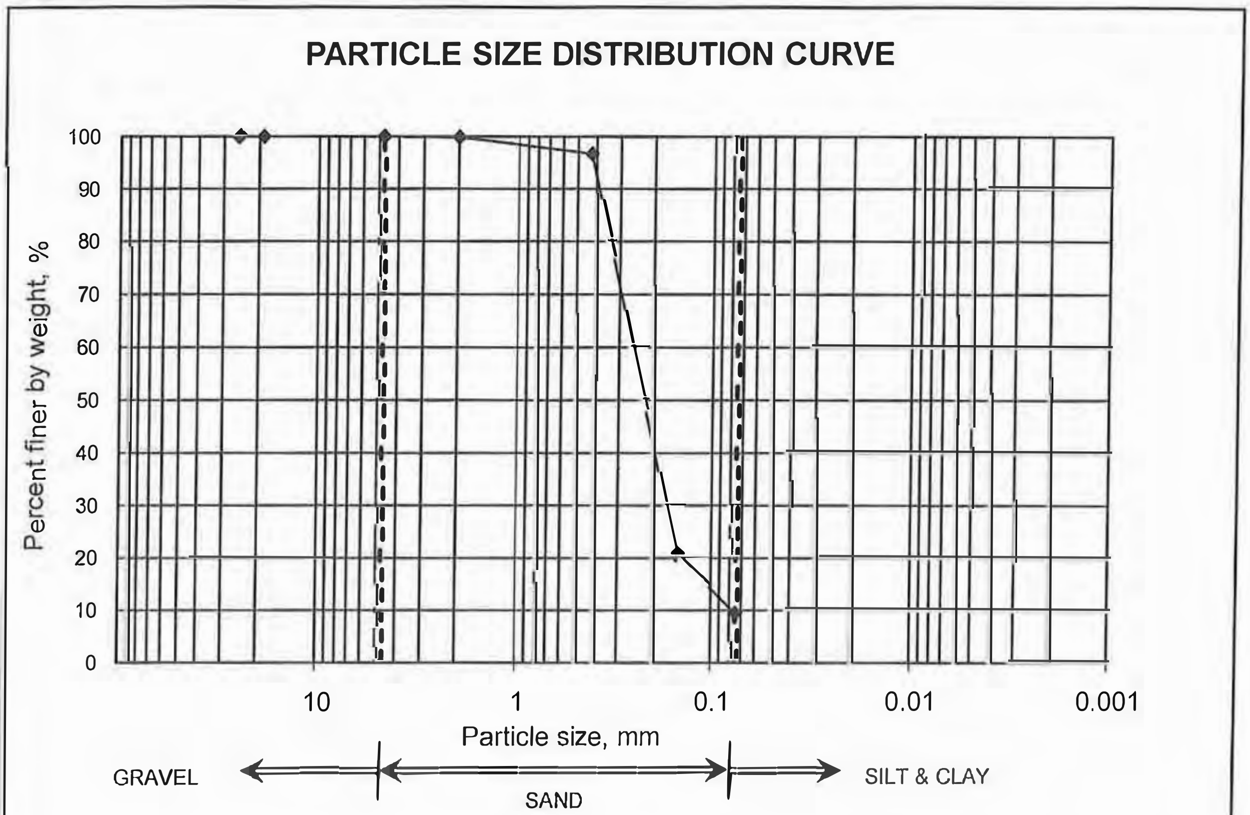
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	0 %
Sample No.	6 (UDS)	**Sand =**	91 %
Depth (m):	30.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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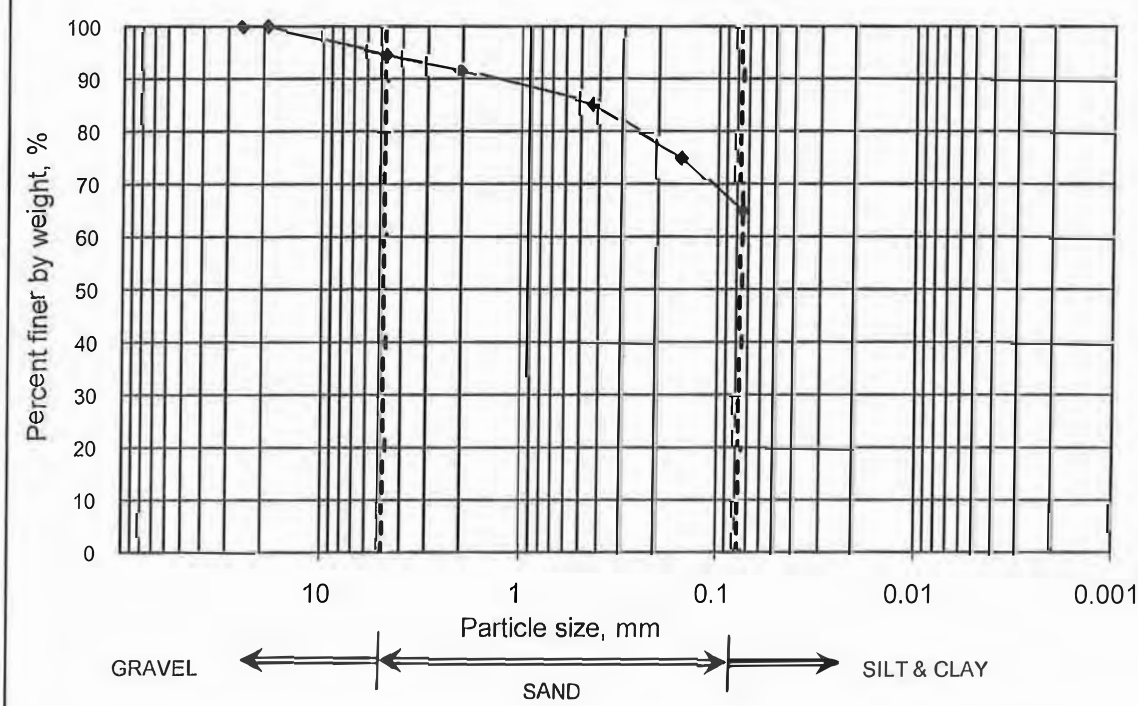
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	5 %
Sample No.	7 (UDS)	**Sand =**	30 %
Depth (m):	35.0	**Silt & Clay =**	65 %

Test Method: ASTM D422



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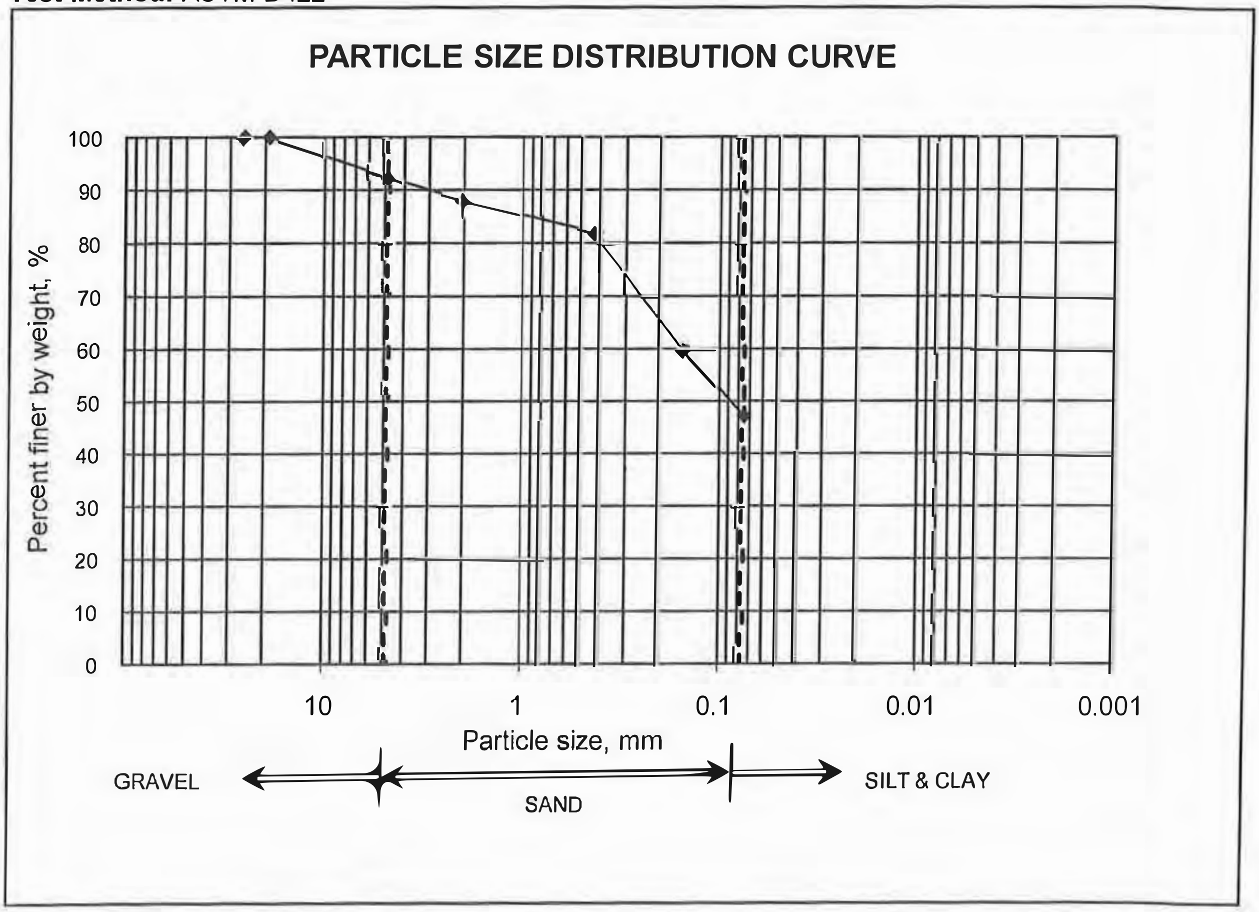
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	**Gravel =**	8 %
Sample No.	8 (UDS)	**Sand =**	45 %
Depth (m):	40.0	**Silt & Clay =**	47 %

Test Method: ASTM D422



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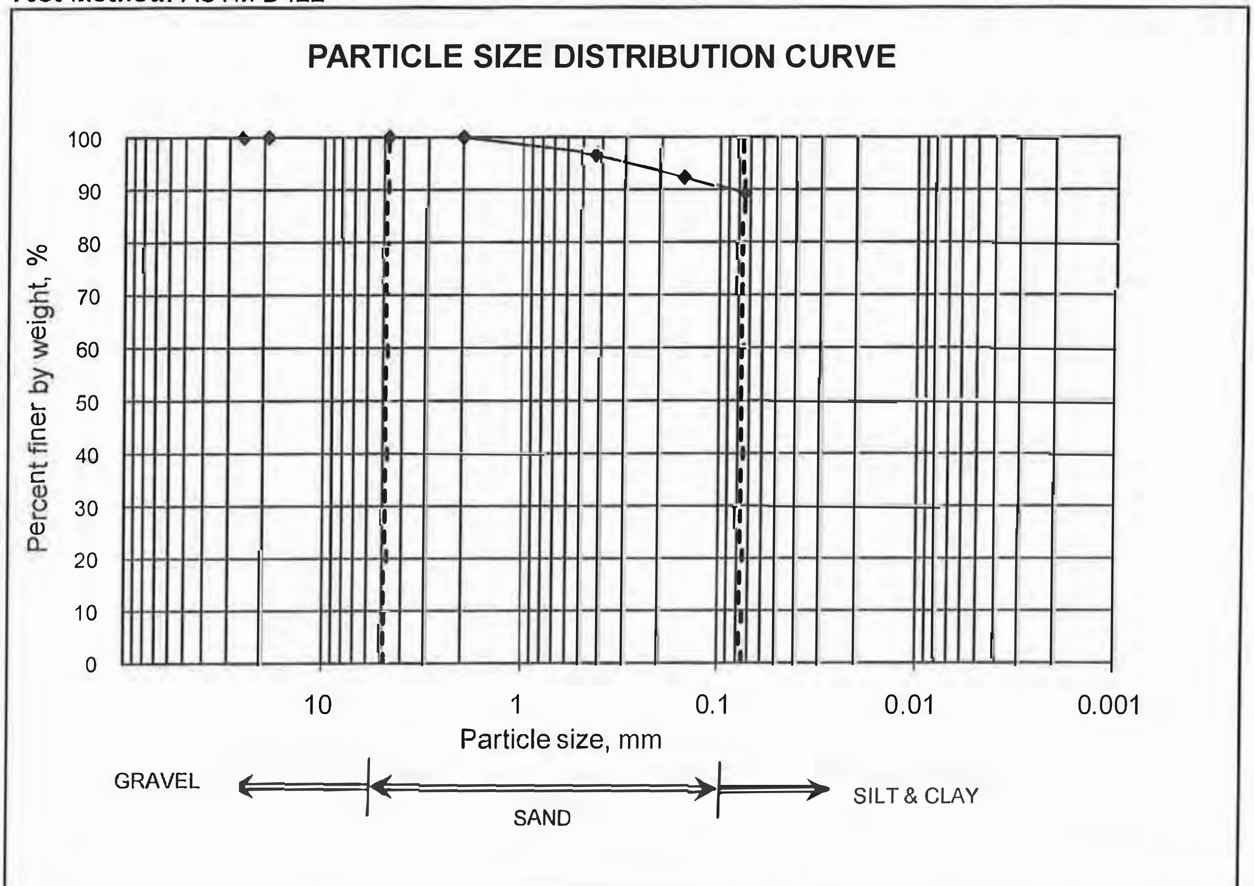
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	9 (UDS)	**Sand =**	11 %
Depth (m):	3.0	**Silt & Clay =**	89 %

Test Method: ASTM D422



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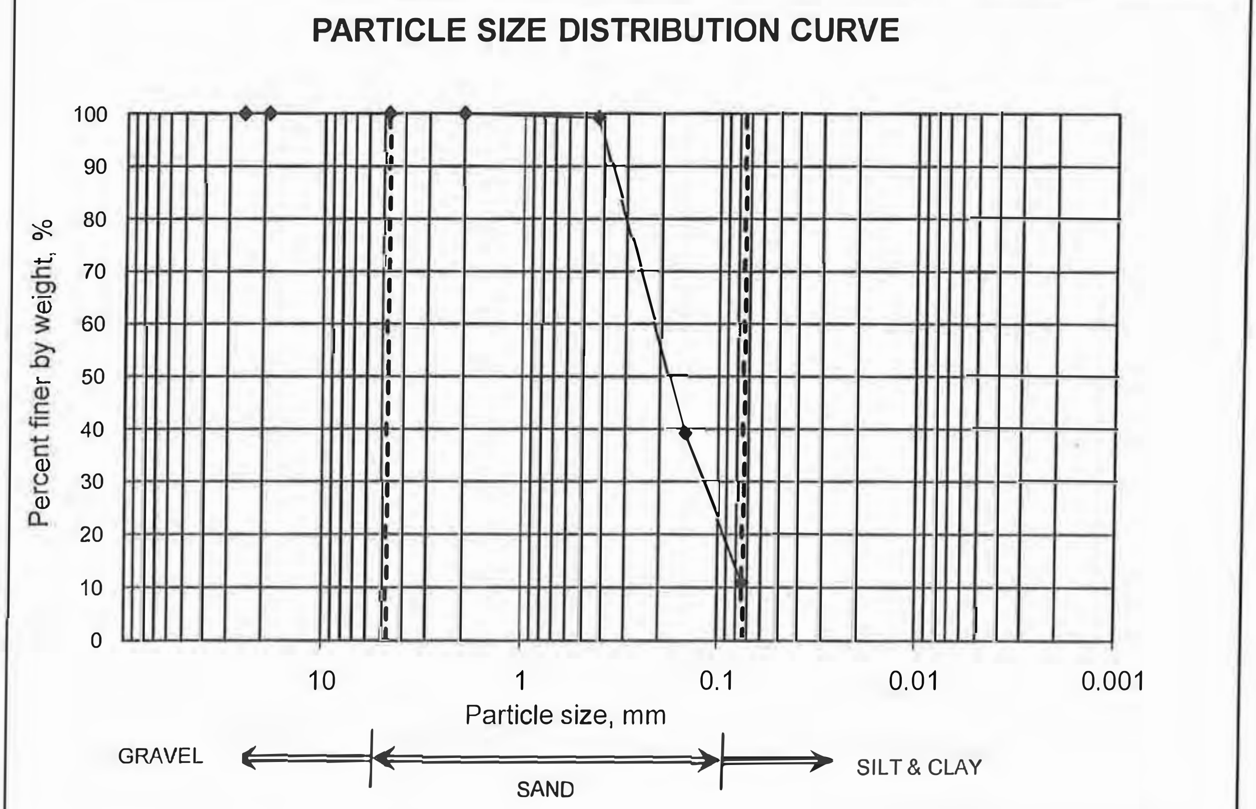
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	10 (UDS)	**Sand =**	89 %
Depth (m):	7.0	**Silt & Clay =**	11 %

Test Method: ASTM D422



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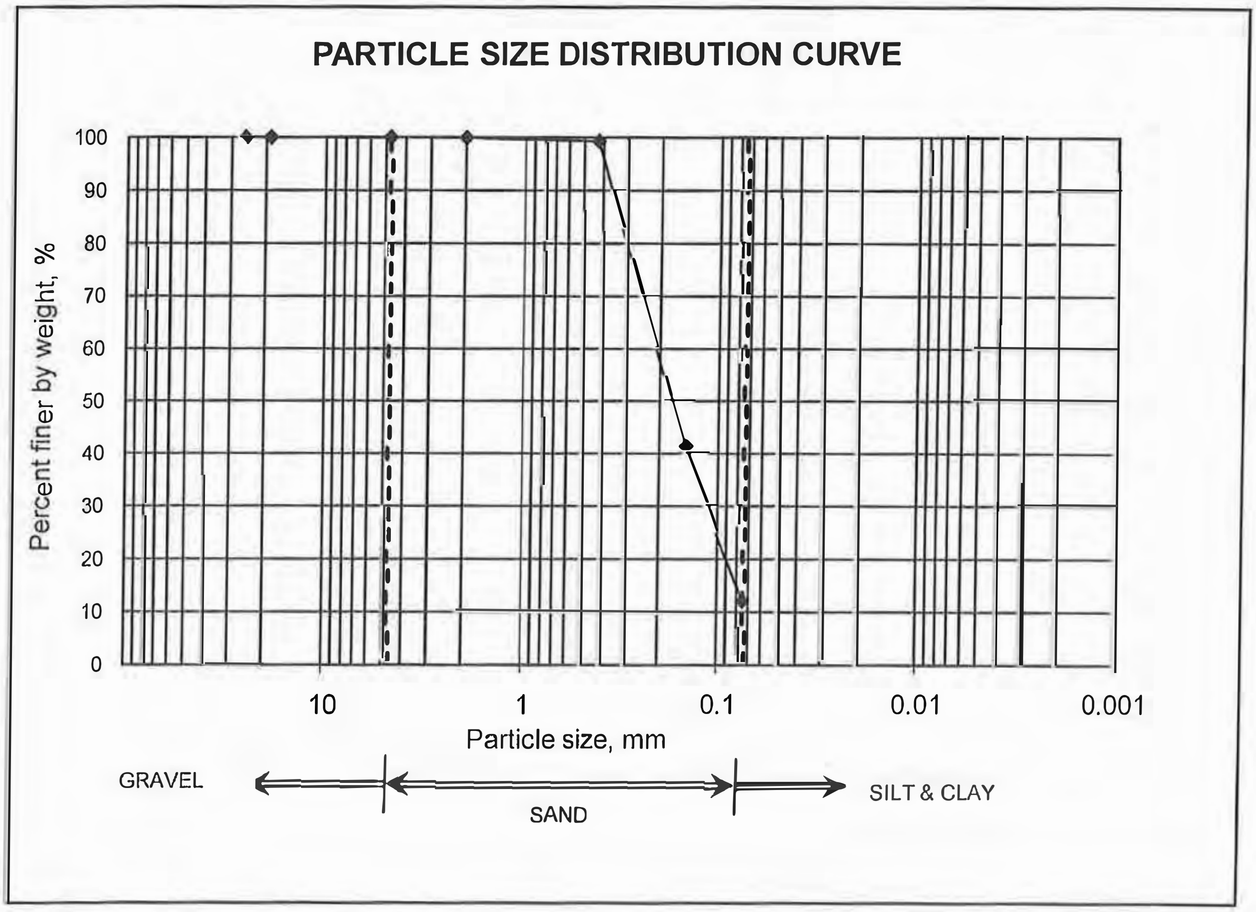
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	11 (UDS)	**Sand =**	88 %
Depth (m):	15.0	**Silt & Clay =**	12 %

Test Method: ASTM D422



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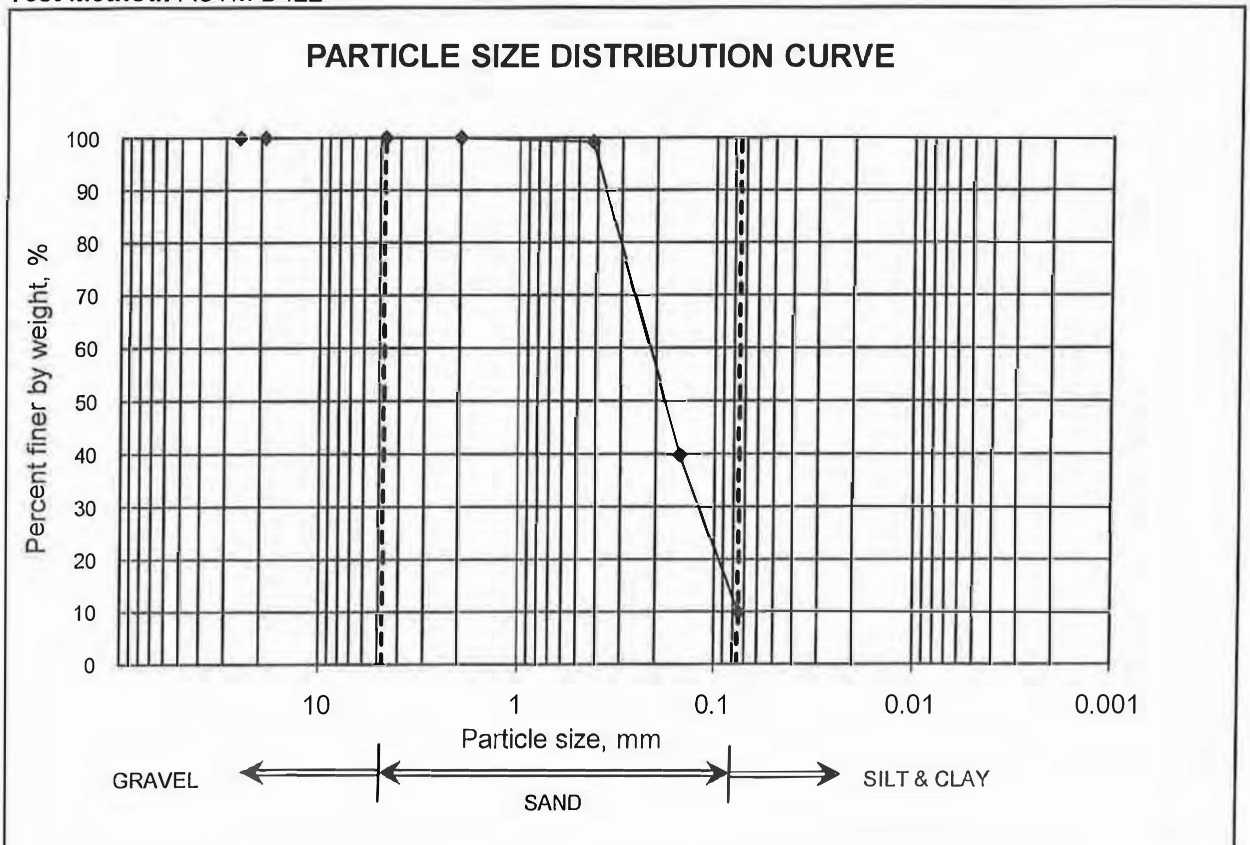
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	12 (UDS)	**Sand =**	90 %
Depth (m):	20.0	**Silt & Clay =**	10 %

Test Method: ASTM D422



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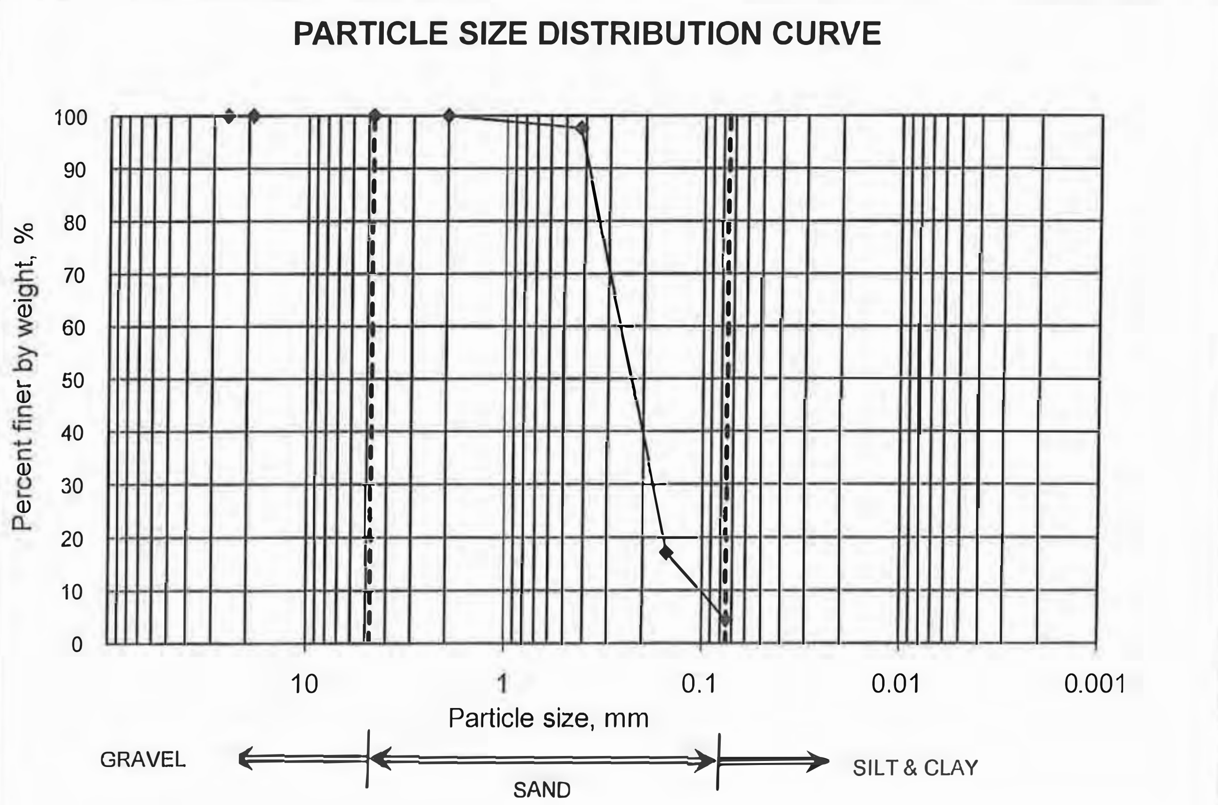
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	13 (UDS)	**Sand =**	96 %
Depth (m):	25.0	**Silt & Clay =**	4 %

Test Method: ASTM D422



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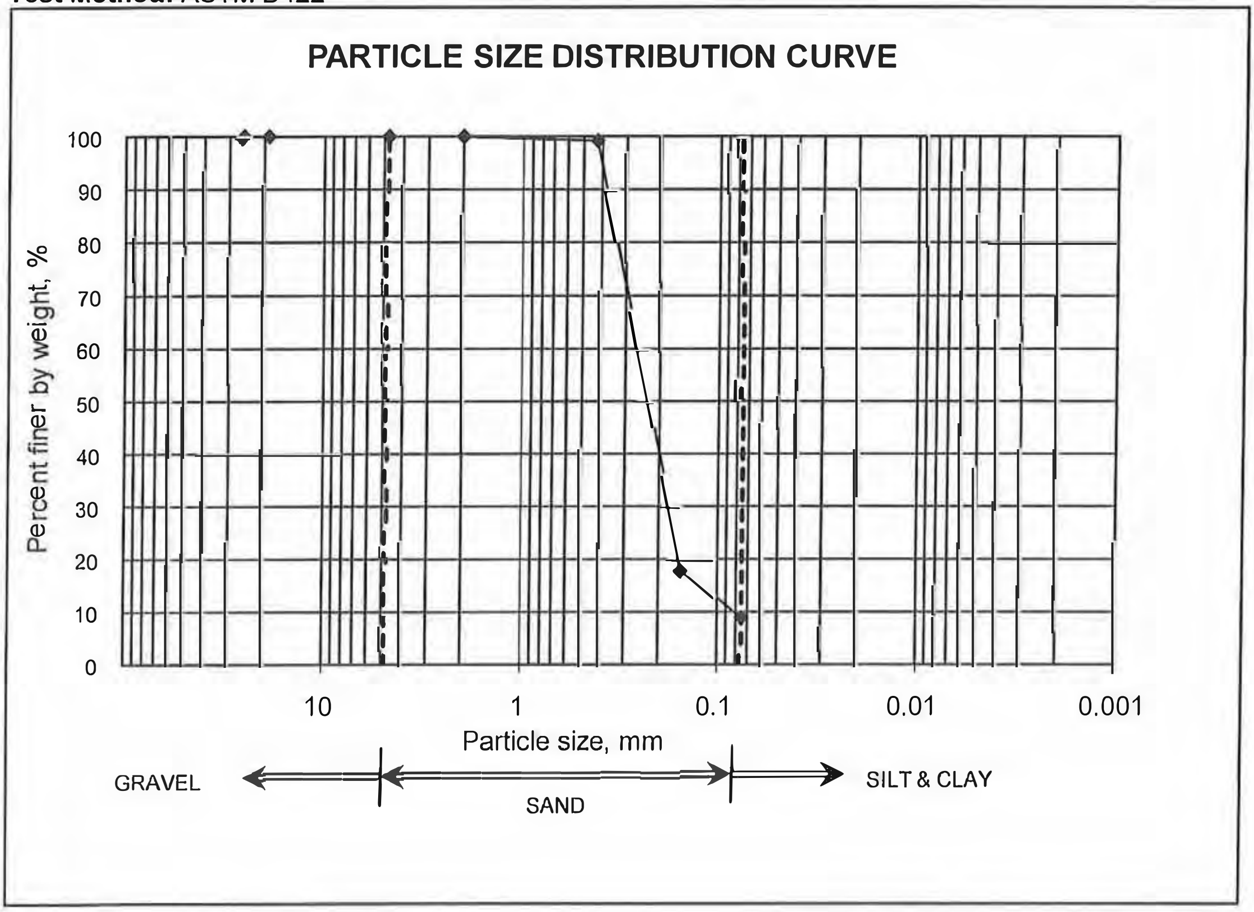
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	14 (UDS)	**Sand =**	91 %
Depth (m):	30.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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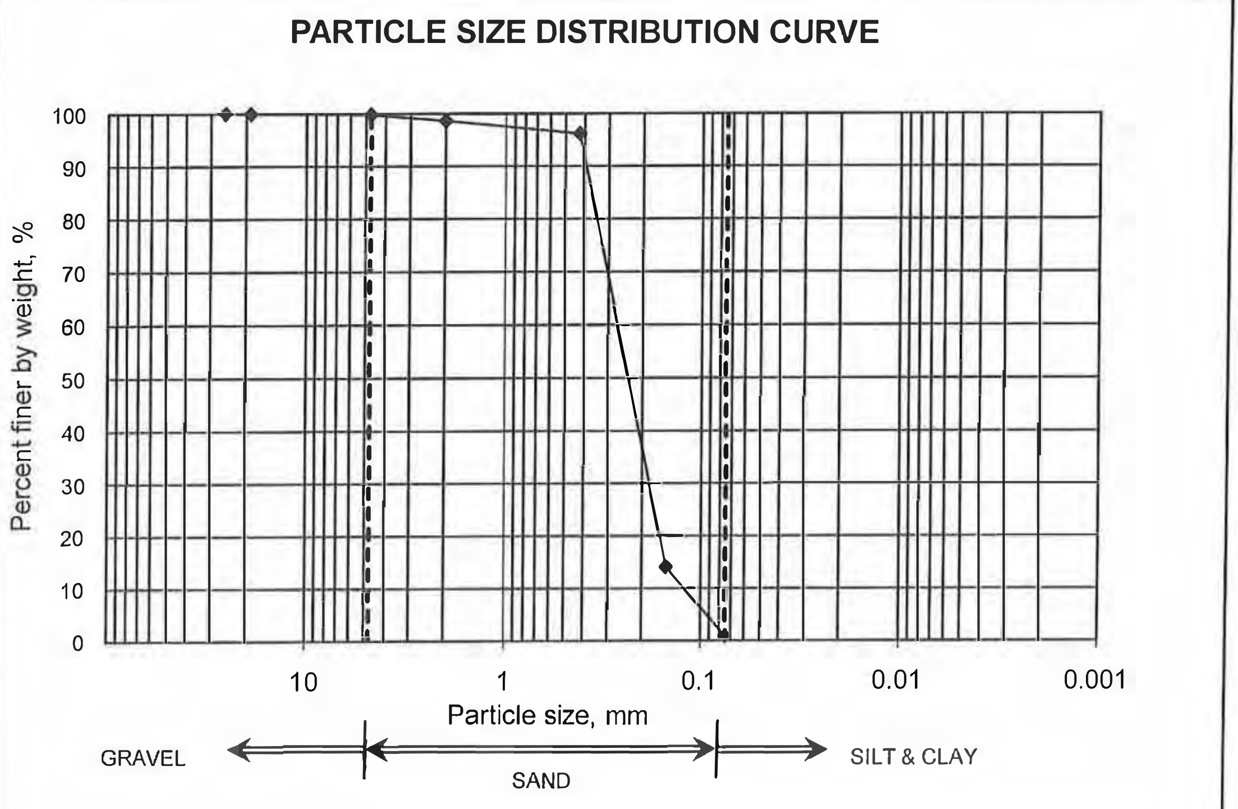
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	15 (UDS)	**Sand =**	99 %
Depth (m):	35.0	**Silt & Clay =**	1 %

Test Method: ASTM D422



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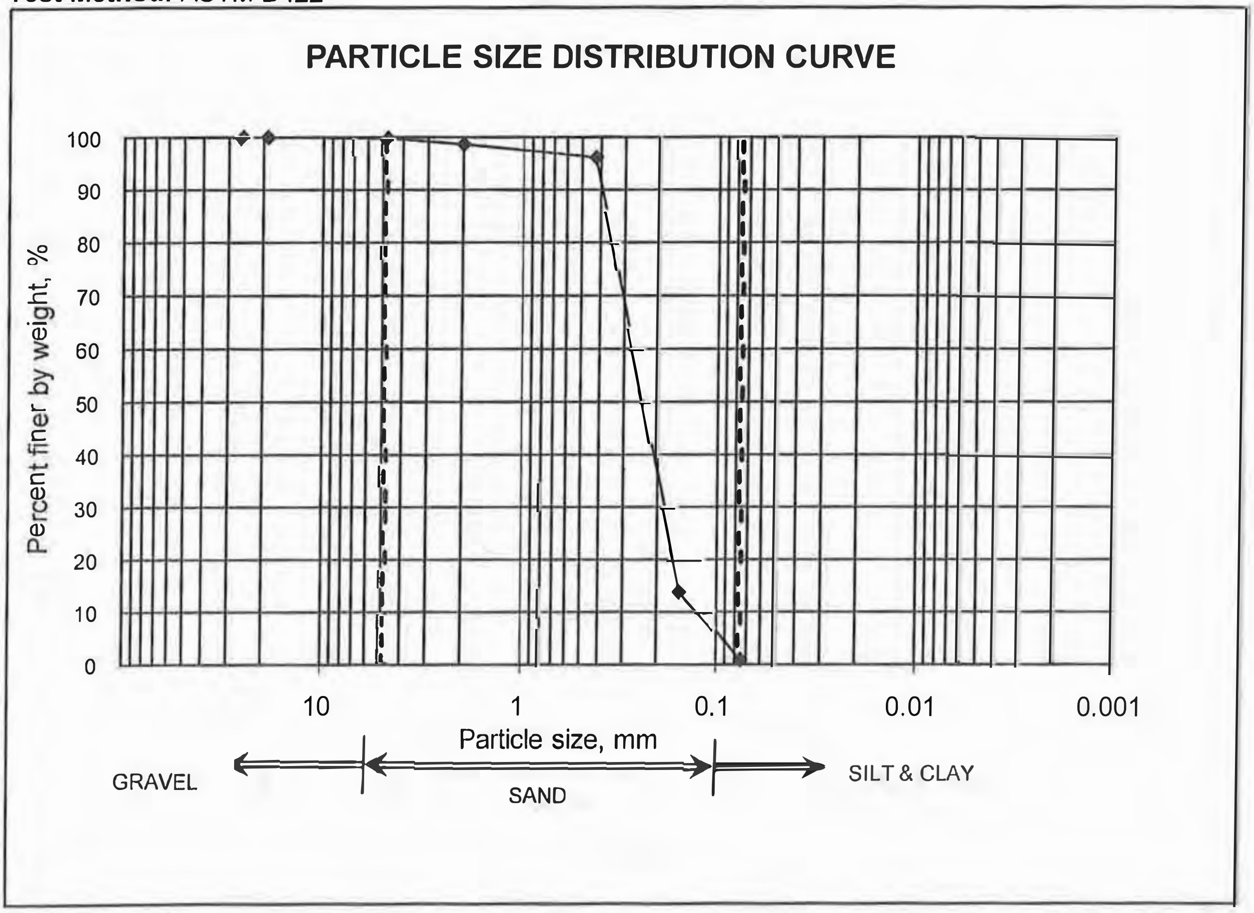
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-02	**Gravel =**	0 %
Sample No.	16 (UDS)	**Sand =**	99 %
Depth (m):	40.0	**Silt & Clay =**	1 %

Test Method: ASTM D422



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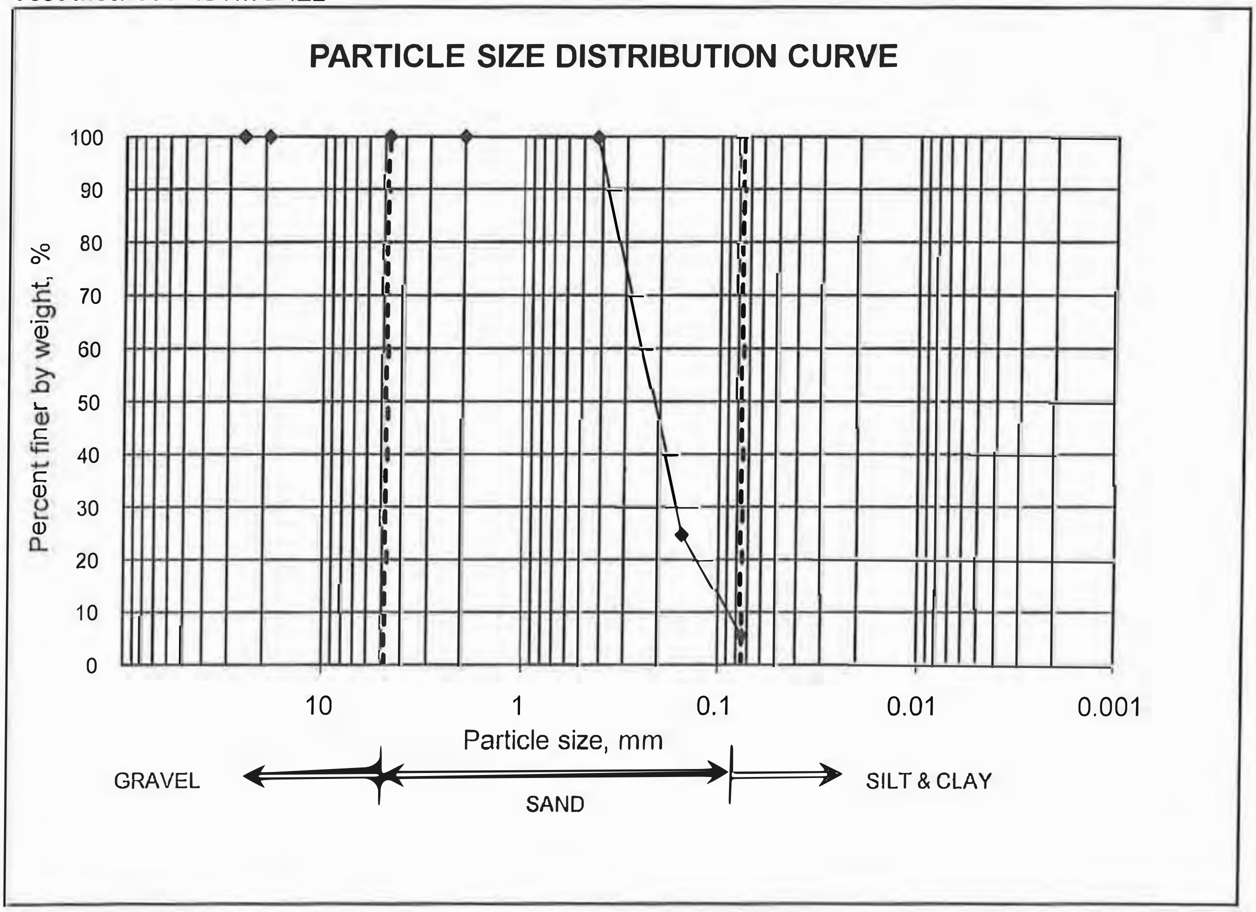
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	17 (UDS)	**Sand =**	94 %
Depth (m):	5.0	**Silt & Clay =**	6 %

Test Method: ASTM D422



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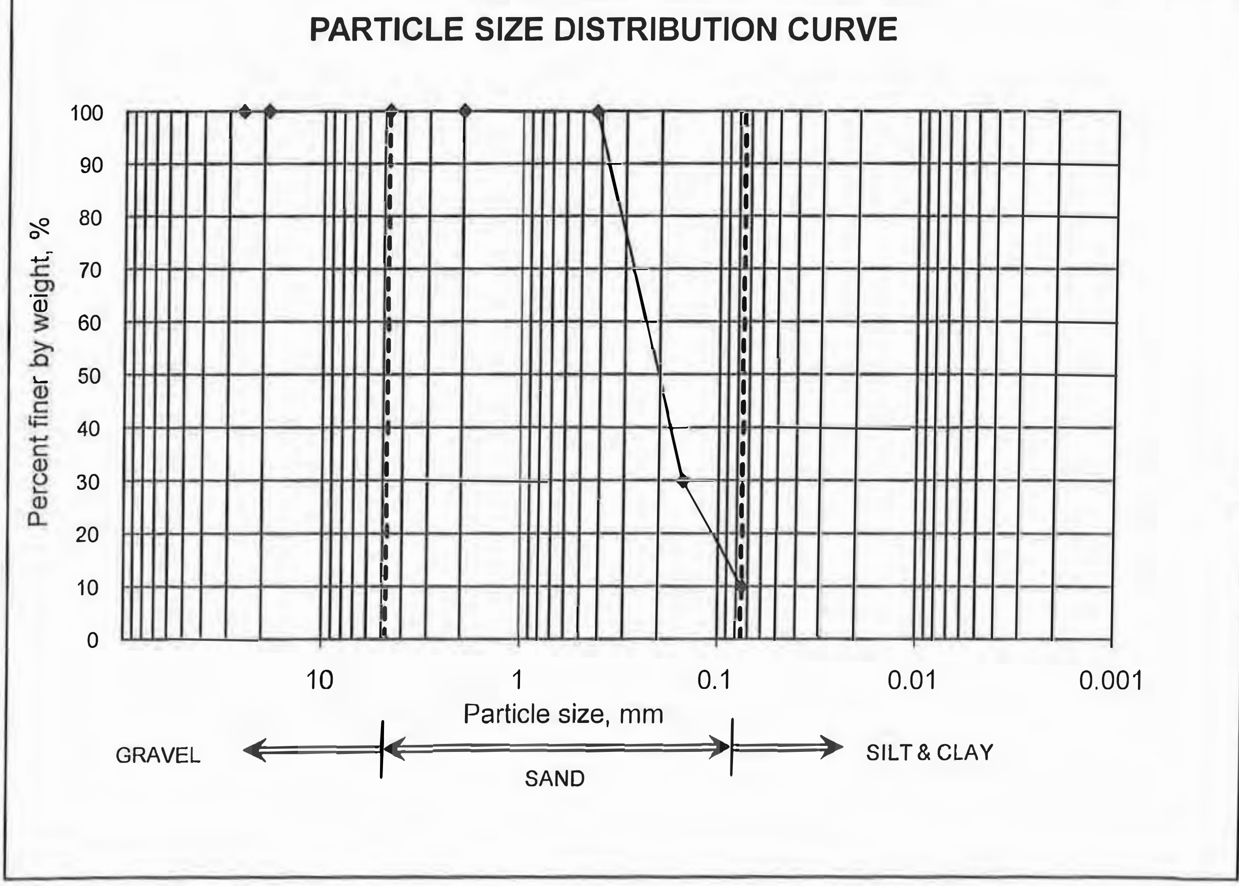
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	18 (UDS)	**Sand =**	90 %
Depth (m):	11.0	**Silt & Clay =**	10 %

Test Method: ASTM D422



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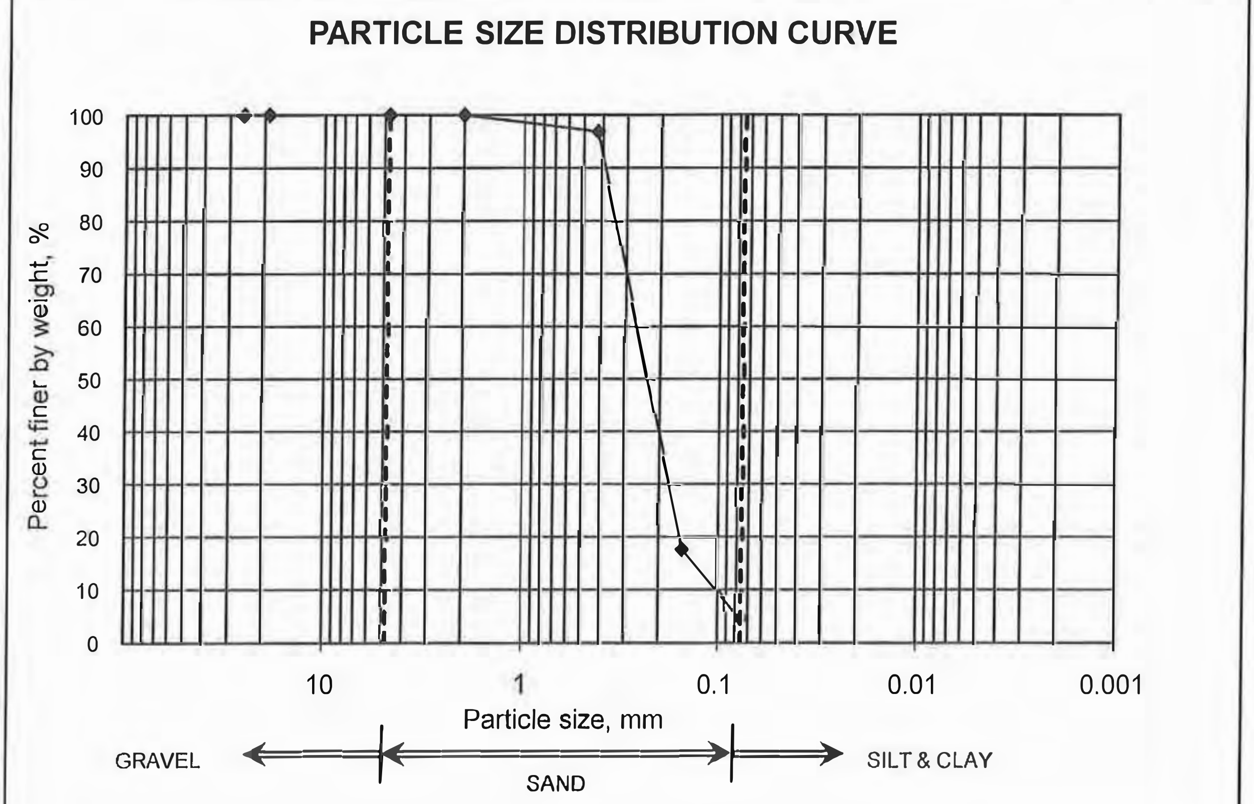
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	19 (UDS)	**Sand =**	95 %
Depth (m):	15.0	**Silt & Clay =**	5 %

Test Method: ASTM D422



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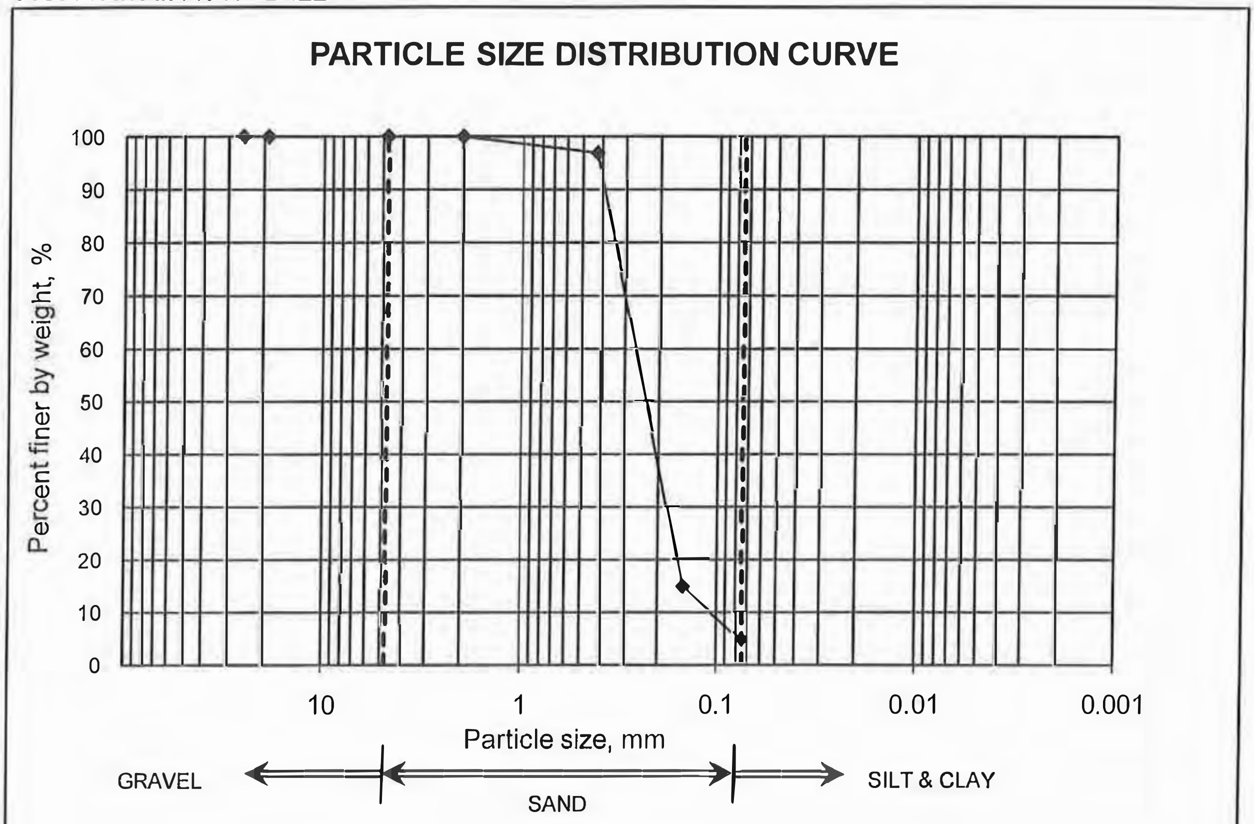
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	20 (UDS)	**Sand =**	95 %
Depth (m):	21.0	**Silt & Clay =**	5 %

Test Method: ASTM D422



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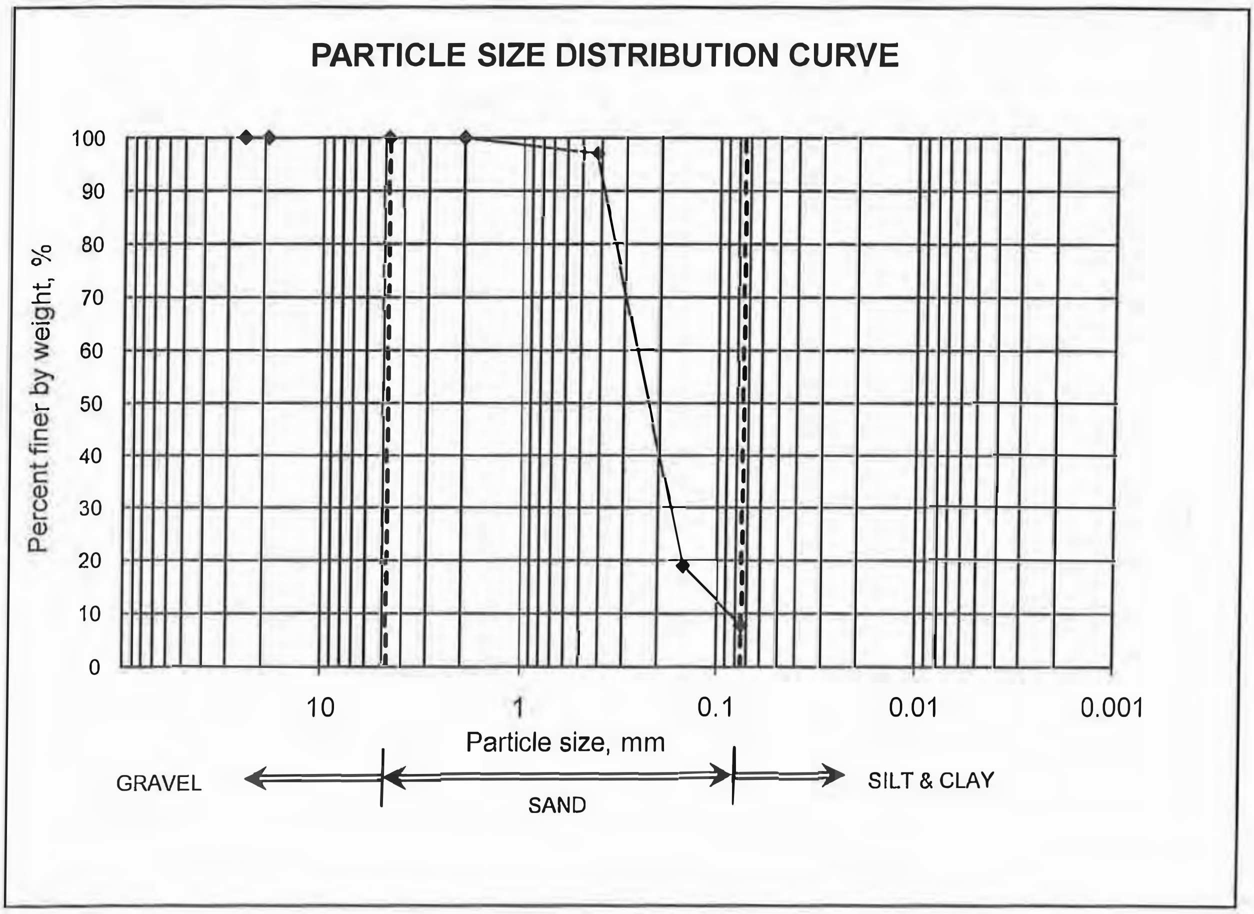
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	21 (UDS)	**Sand =**	92 %
Depth (m):	25.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



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Checked by:

Director
Geotech. ... Civil Engg. Dept. U.E.T. Lhr.

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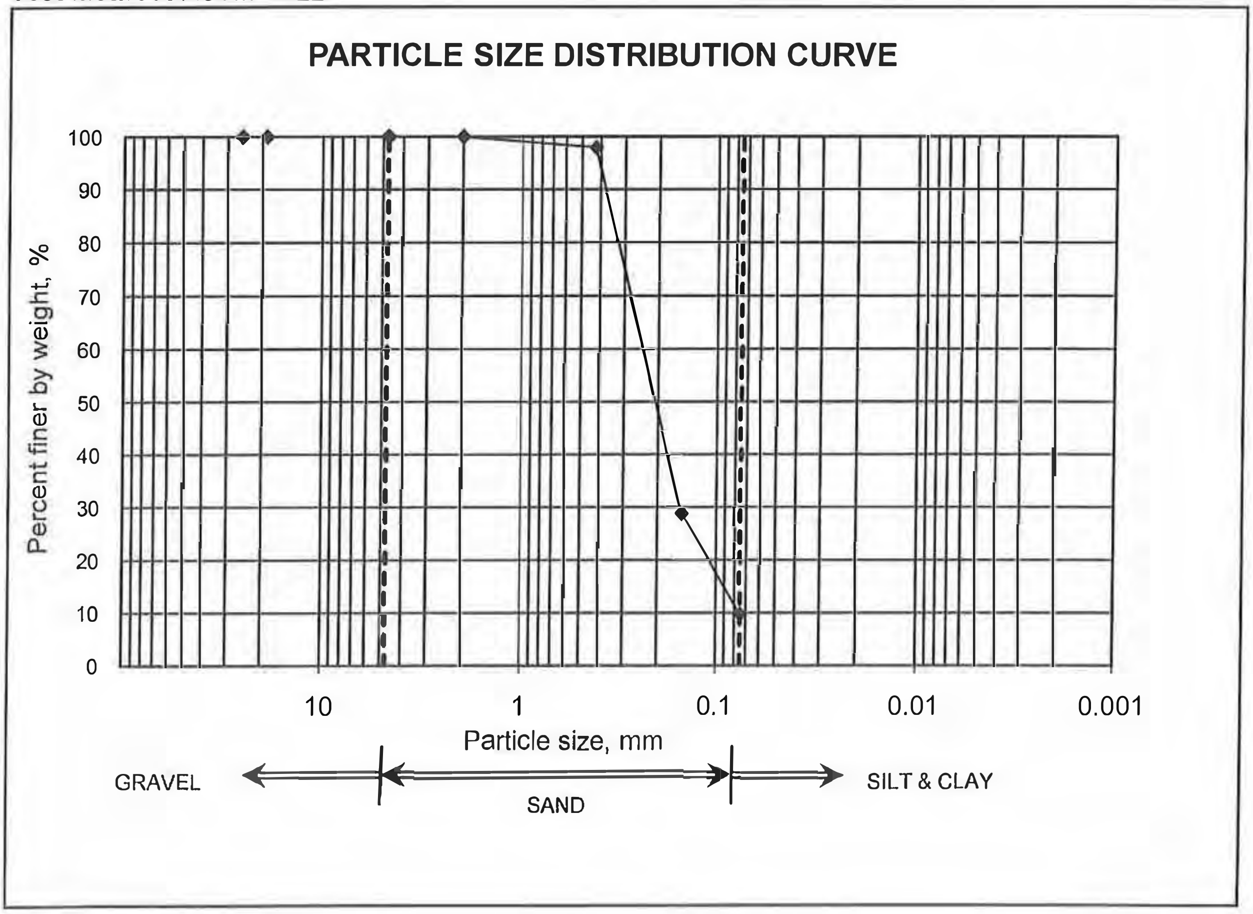
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	22 (UDS)	**Sand =**	90 %
Depth (m):	31.0	**Silt & Clay =**	10 %

Test Method: ASTM D422



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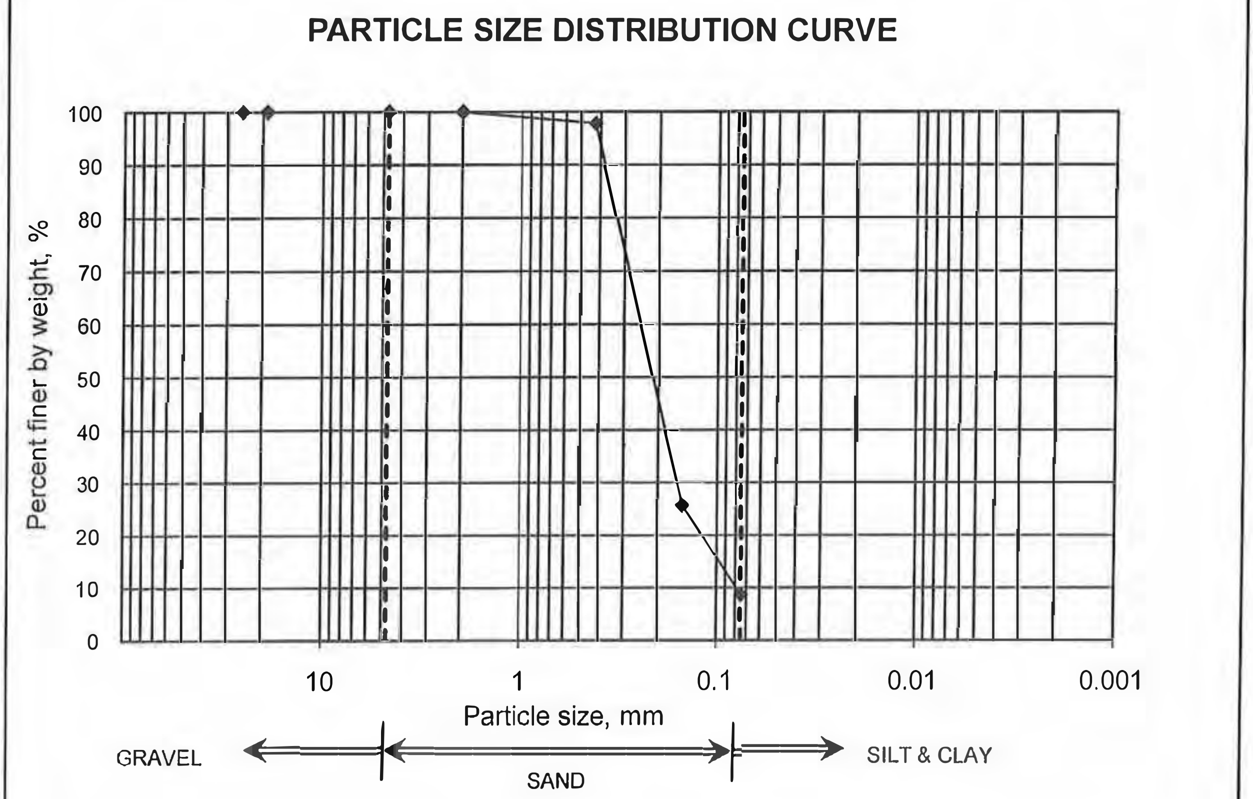
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	23 (UDS)	**Sand =**	91 %
Depth (m):	35.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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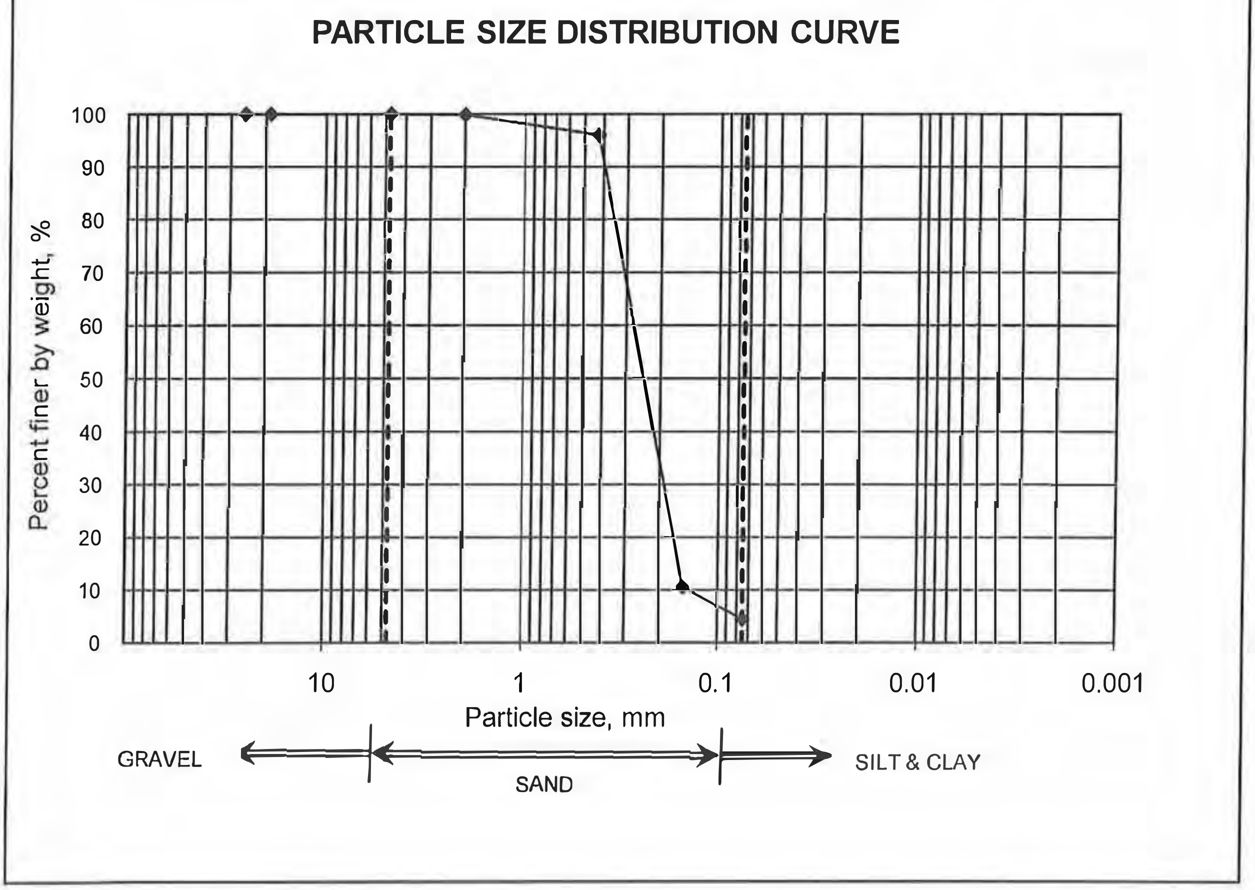
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-03	**Gravel =**	0 %
Sample No.	24 (SPT)	**Sand =**	96 %
Depth (m):	40.0	**Silt & Clay =**	4 %

Test Method: ASTM D422



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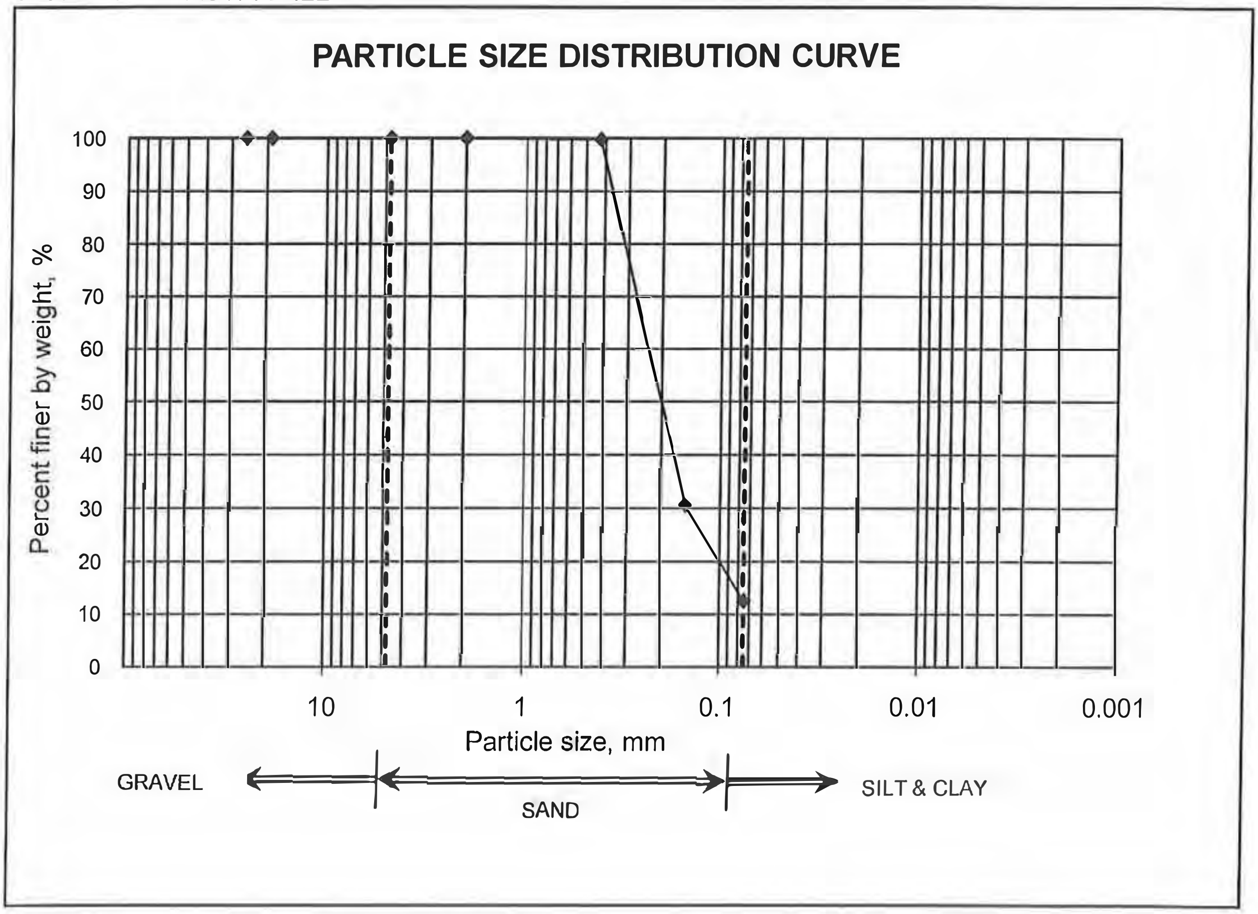
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	25 (UDS)	**Sand =**	88 %
Depth (m):	5.0	**Silt & Clay =**	12 %

Test Method: ASTM D422



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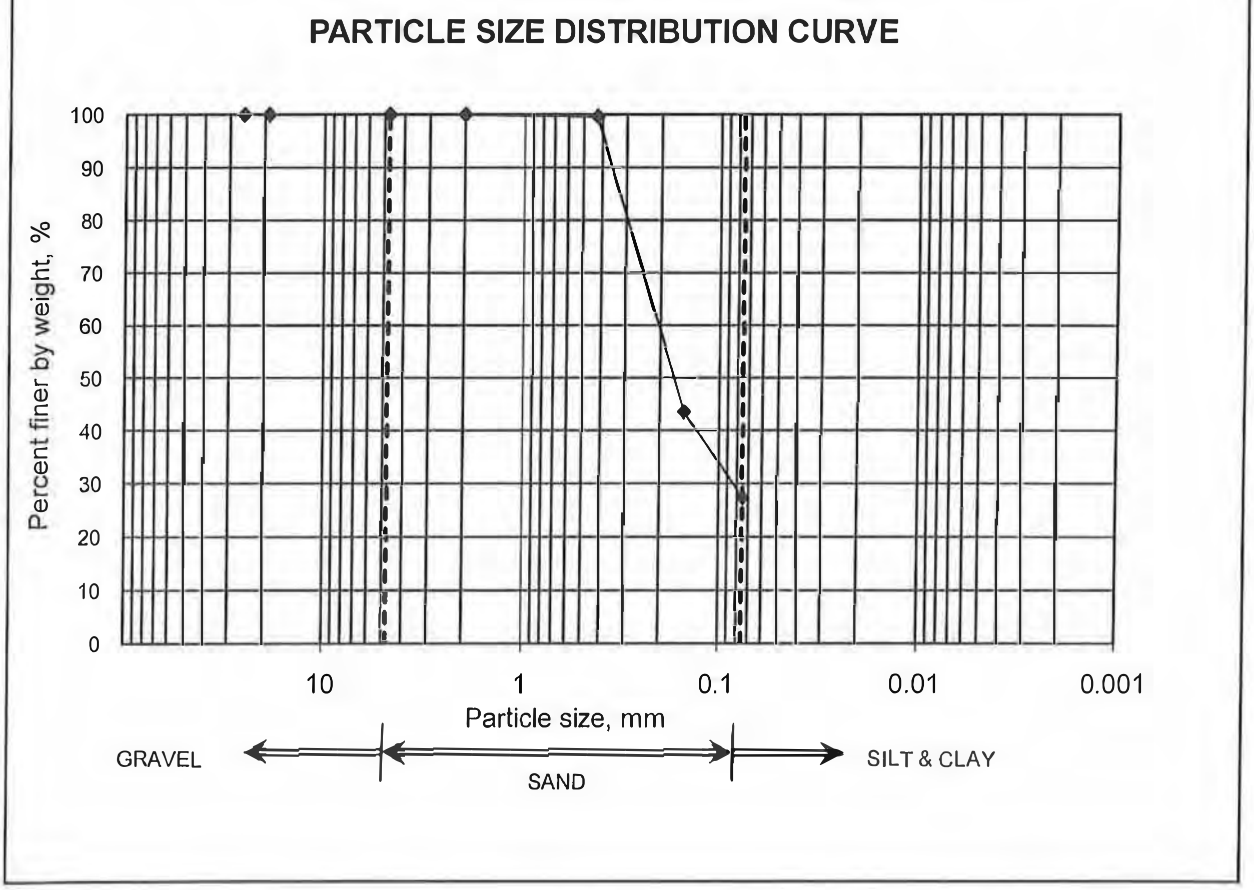
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	26 (UDS)	**Sand =**	73 %
Depth (m):	11.0	**Silt & Clay =**	27 %

Test Method: ASTM D422



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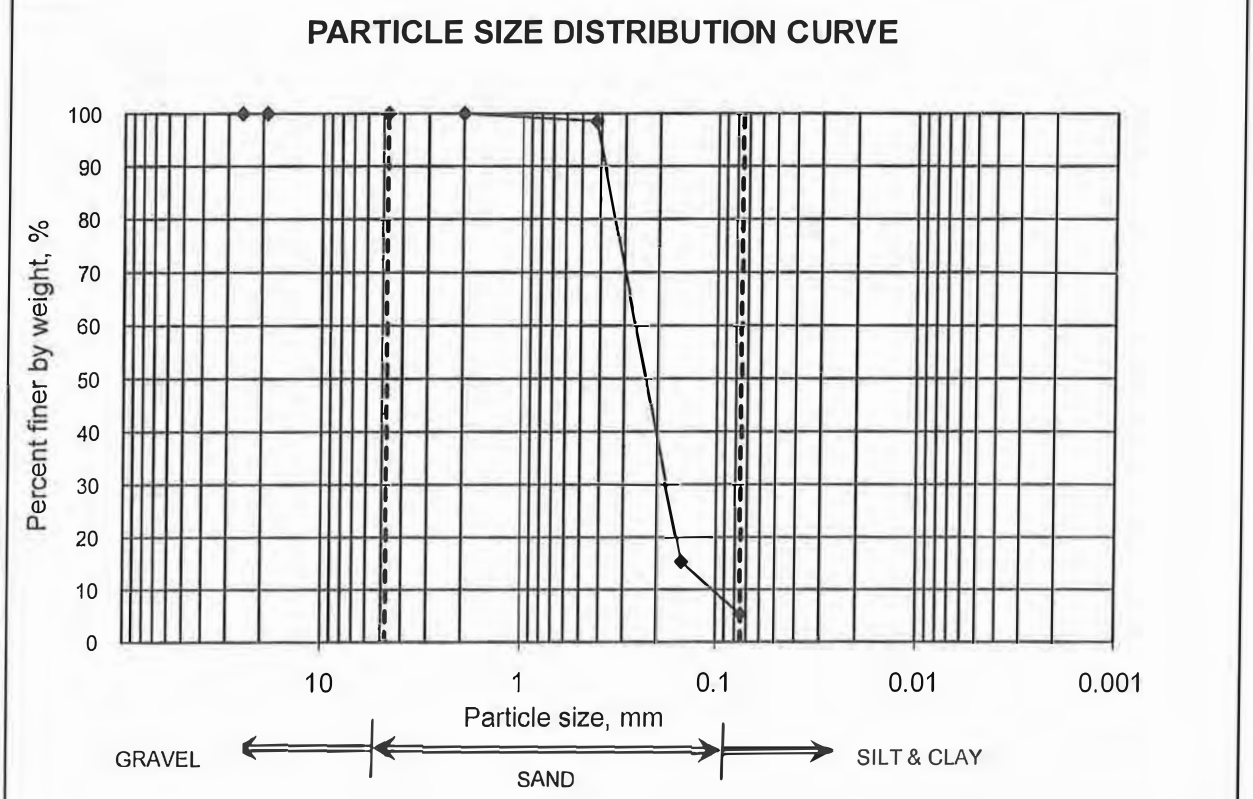
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	27 (UDS)	**Sand =**	95 %
Depth (m):	15.0	**Silt & Clay =**	5 %

Test Method: ASTM D422



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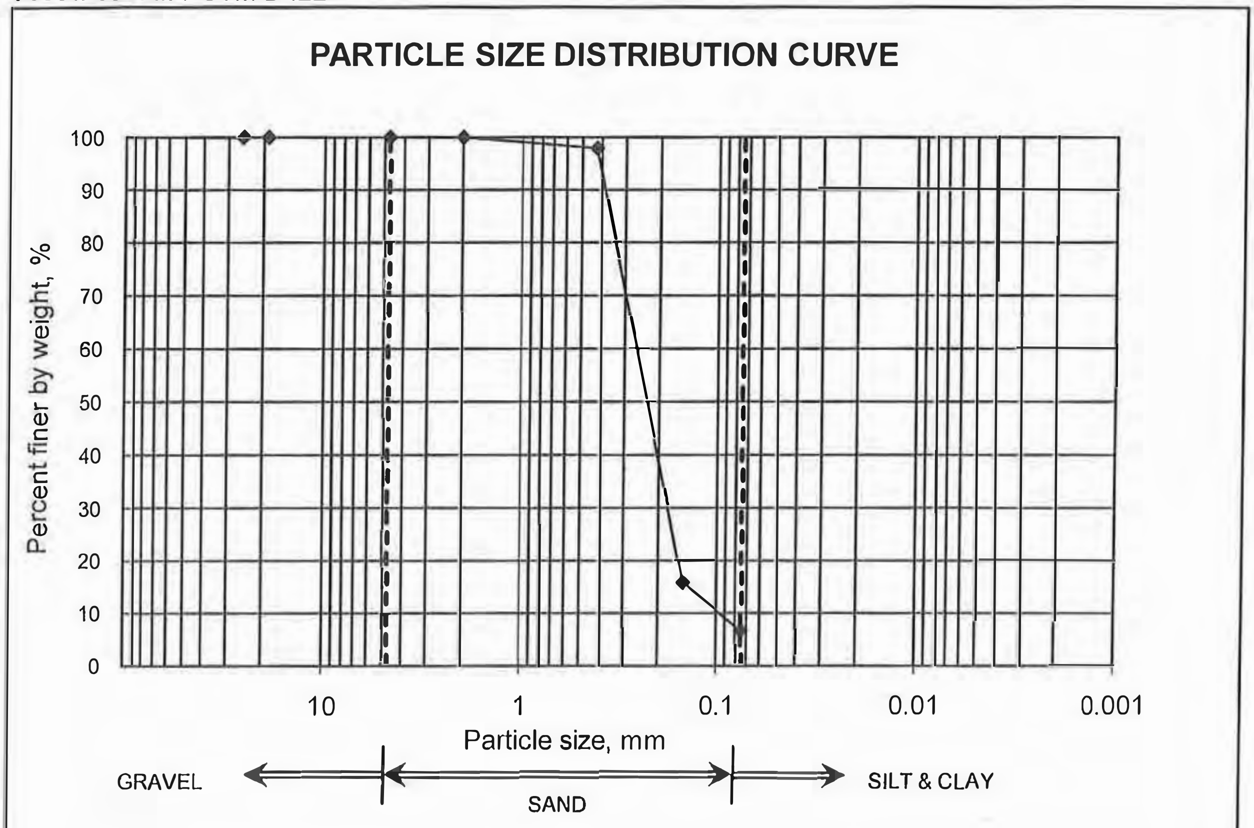
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	28 (UDS)	**Sand =**	93 %
Depth (m):	21.0	**Silt & Clay =**	7 %

Test Method: ASTM D422



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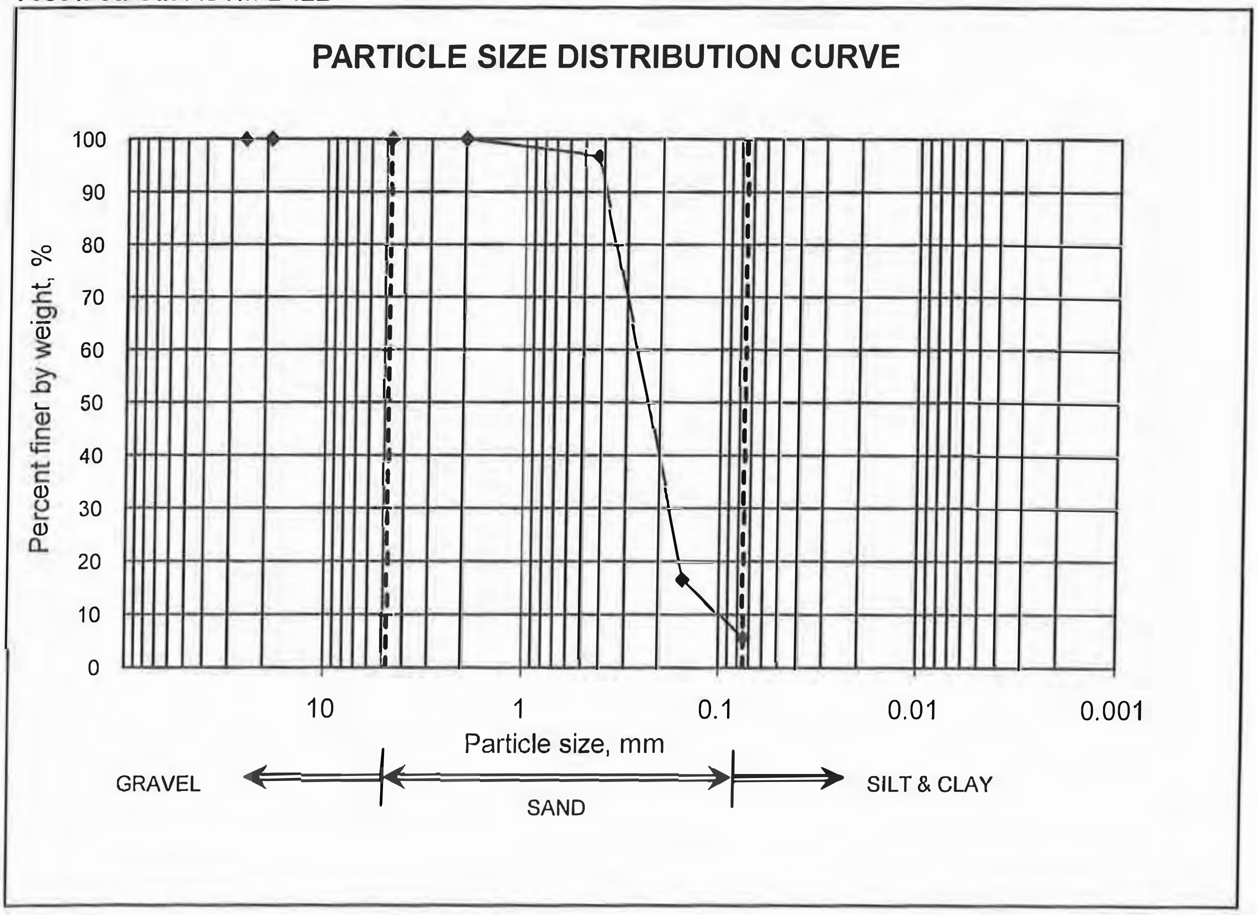
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	29 (UDS)	**Sand =**	94 %
Depth (m):	25.0	**Silt & Clay =**	6 %

Test Method: ASTM D422



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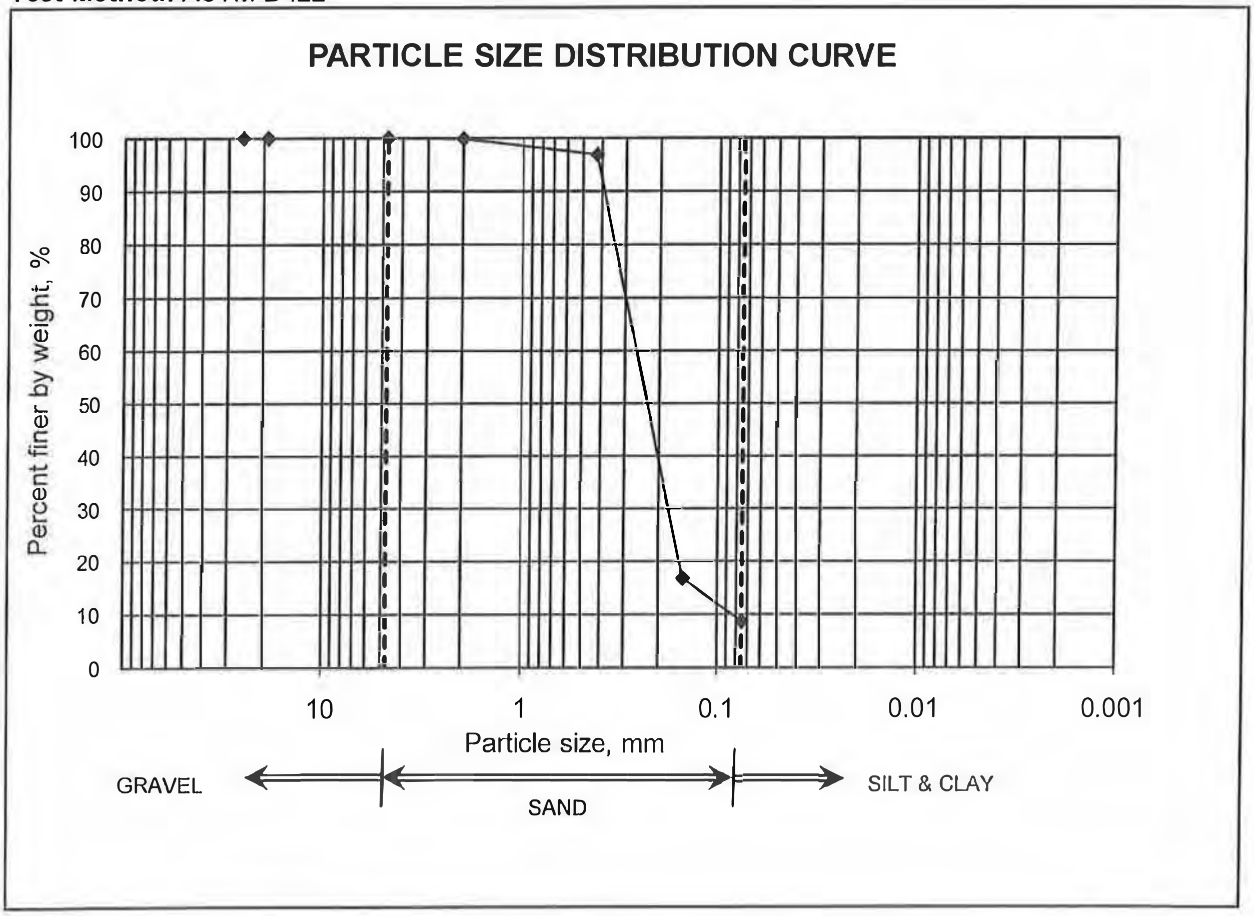
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	30 (UDS)	**Sand =**	91 %
Depth (m):	31.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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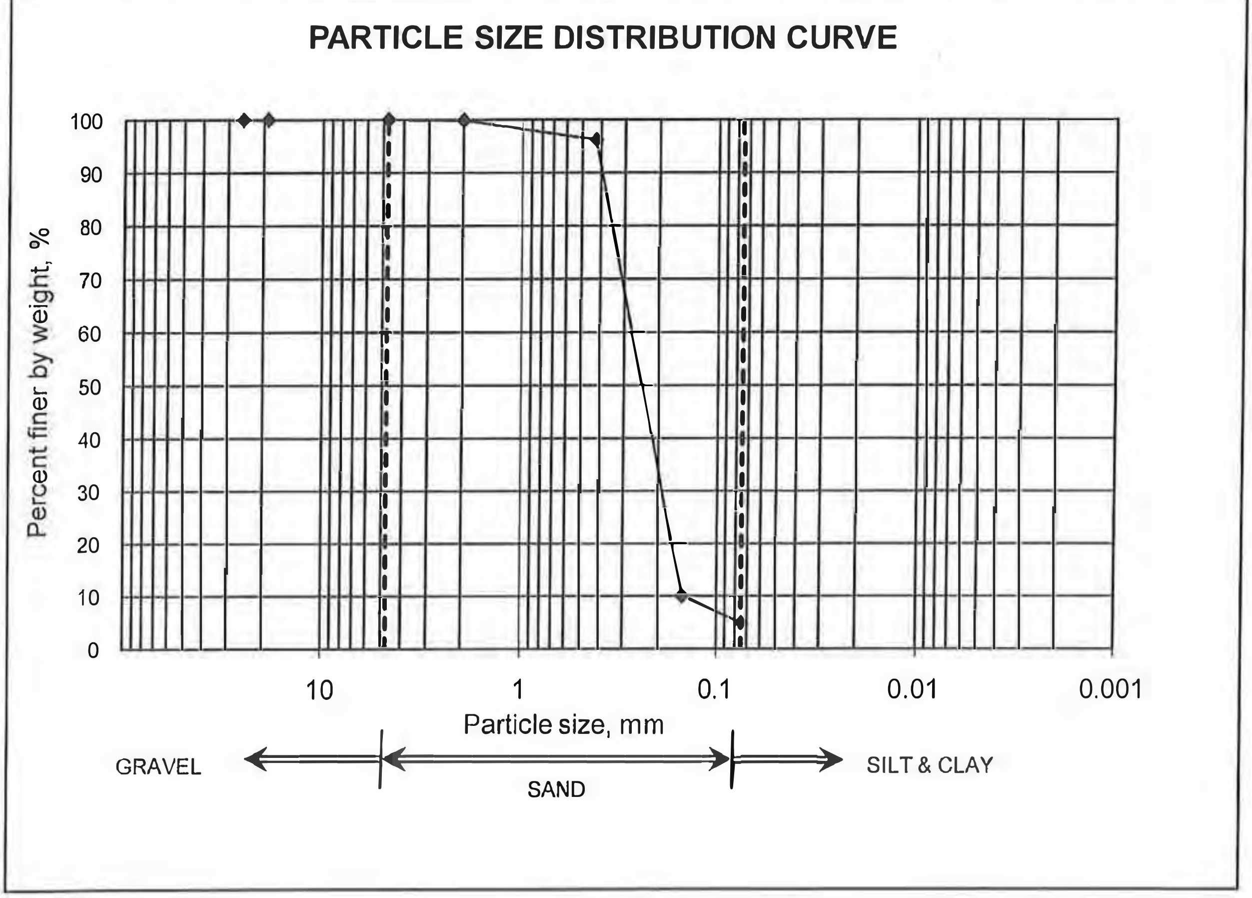
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	31 (SPT)	**Sand =**	95 %
Depth (m):	36.0	**Silt & Clay =**	5 %

Test Method: ASTM D422



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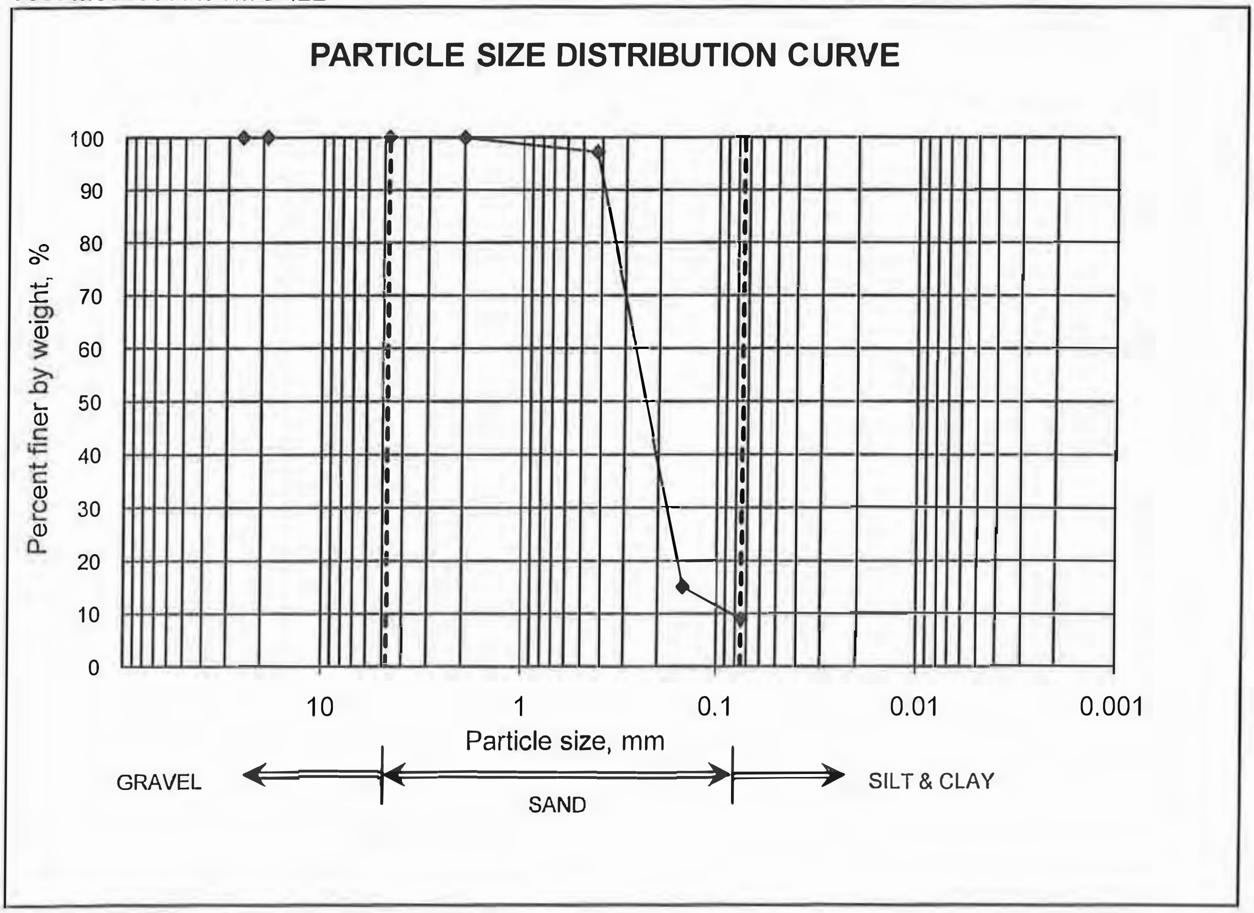
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-04	**Gravel =**	0 %
Sample No.	32 (SPT)	**Sand =**	91 %
Depth (m):	40.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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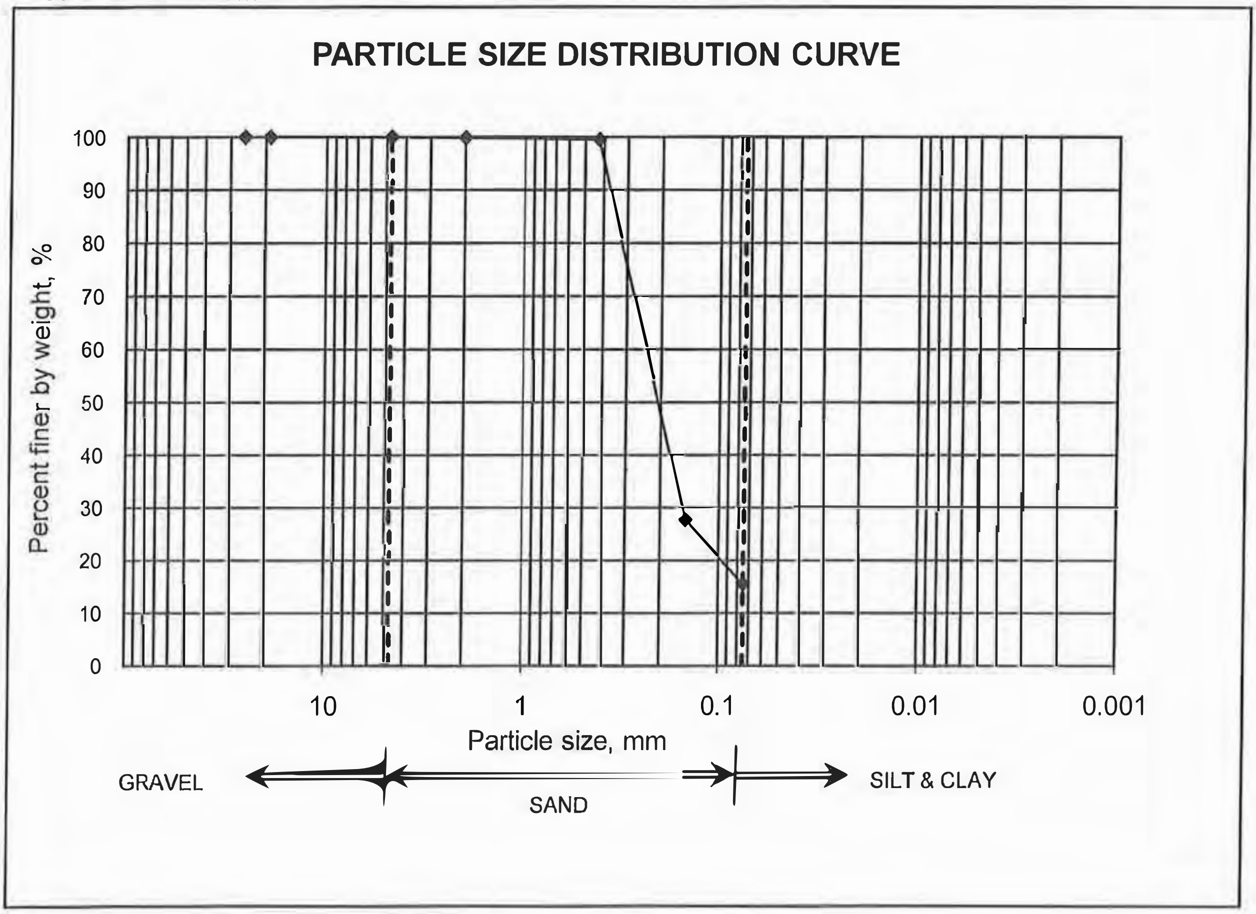
Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	33 (UDS)	**Sand =**	85 %
Depth (m):	5.0	**Silt & Clay =**	16 %

Test Method: ASTM D422



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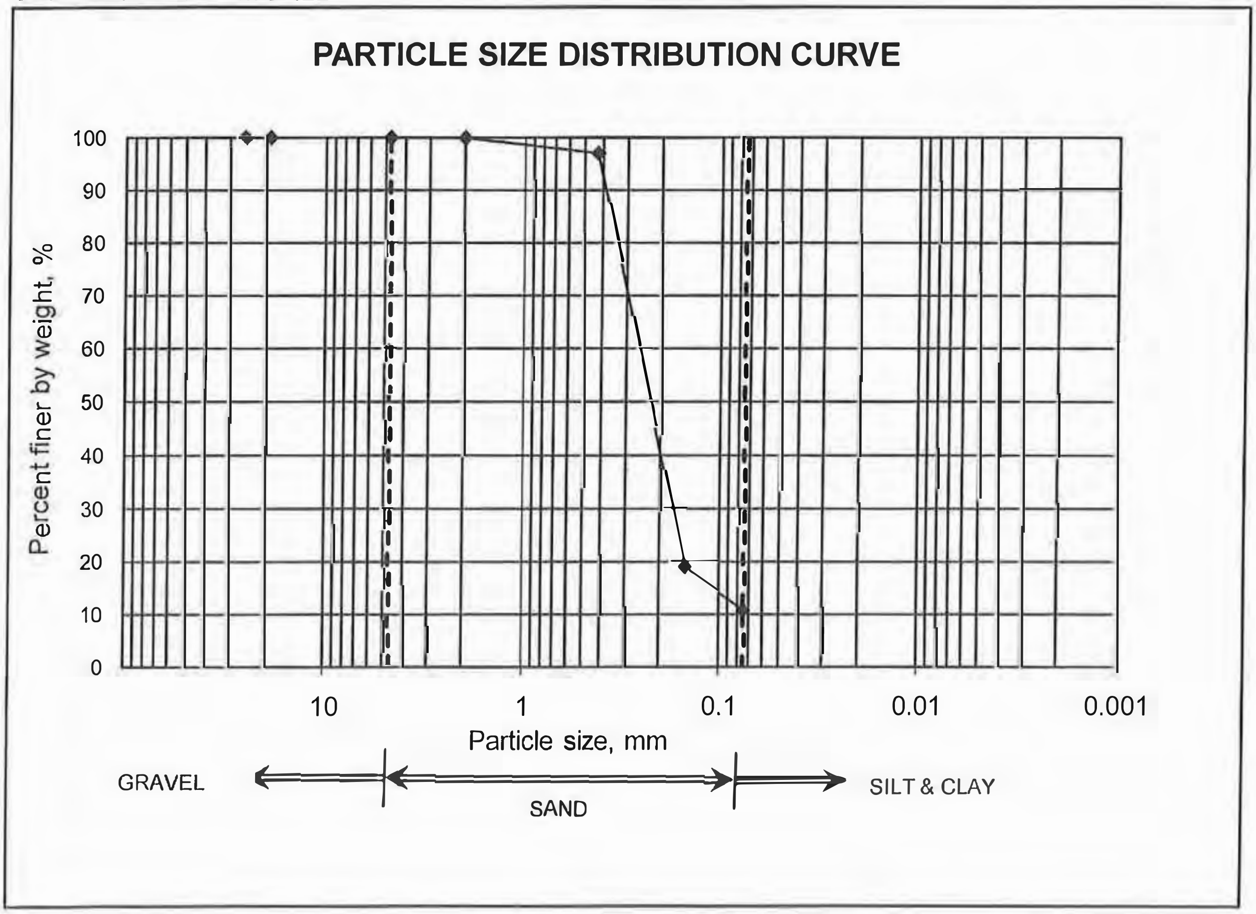
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	34 (UDS)	**Sand =**	89 %
Depth (m):	11.0	**Silt & Clay =**	11 %

Test Method: ASTM D422



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Checked by:

Director

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Department of Civil Engineering
Geotechnical Engineering Laboratory

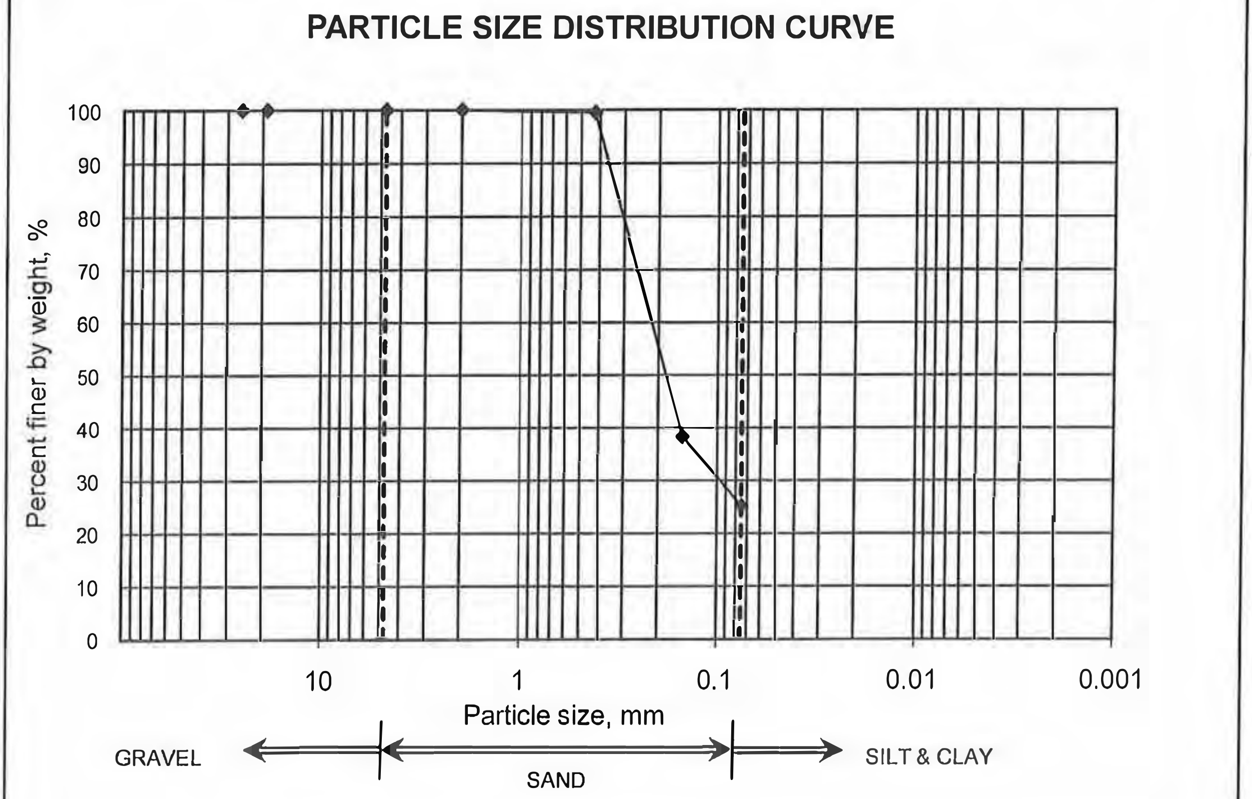
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	35 (UDS)	**Sand =**	75 %
Depth (m):	15.0	**Silt & Clay =**	25 %

Test Method: ASTM D422



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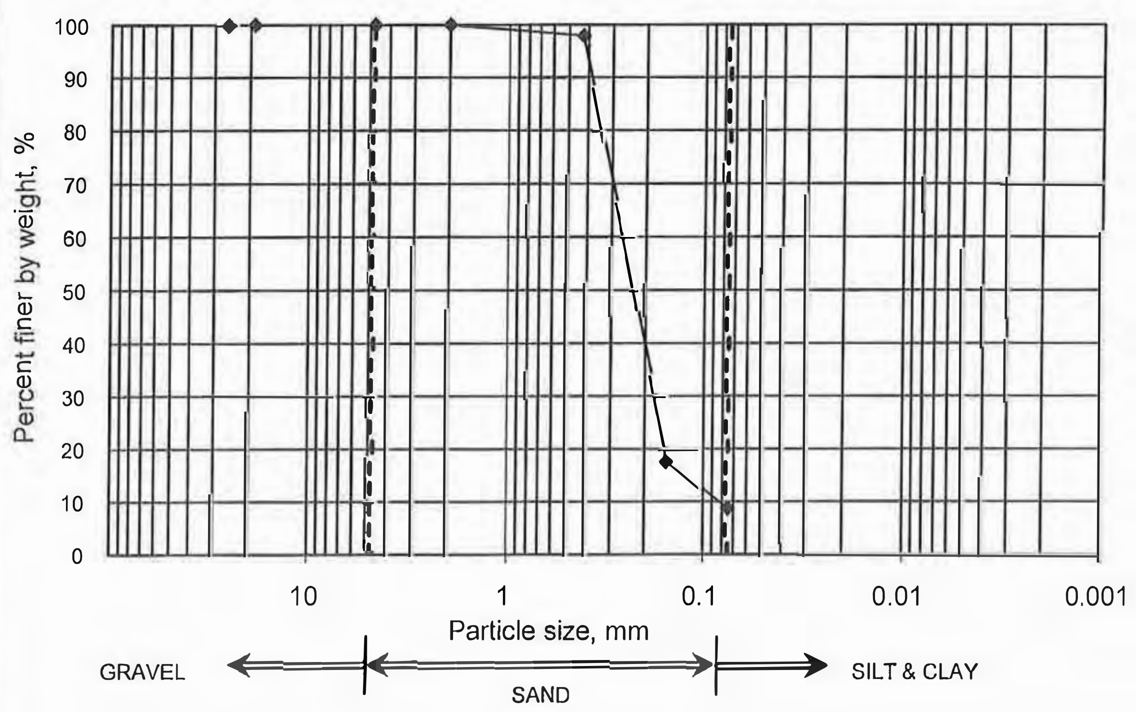
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	36 (UDS)	**Sand =**	91 %
Depth (m):	21.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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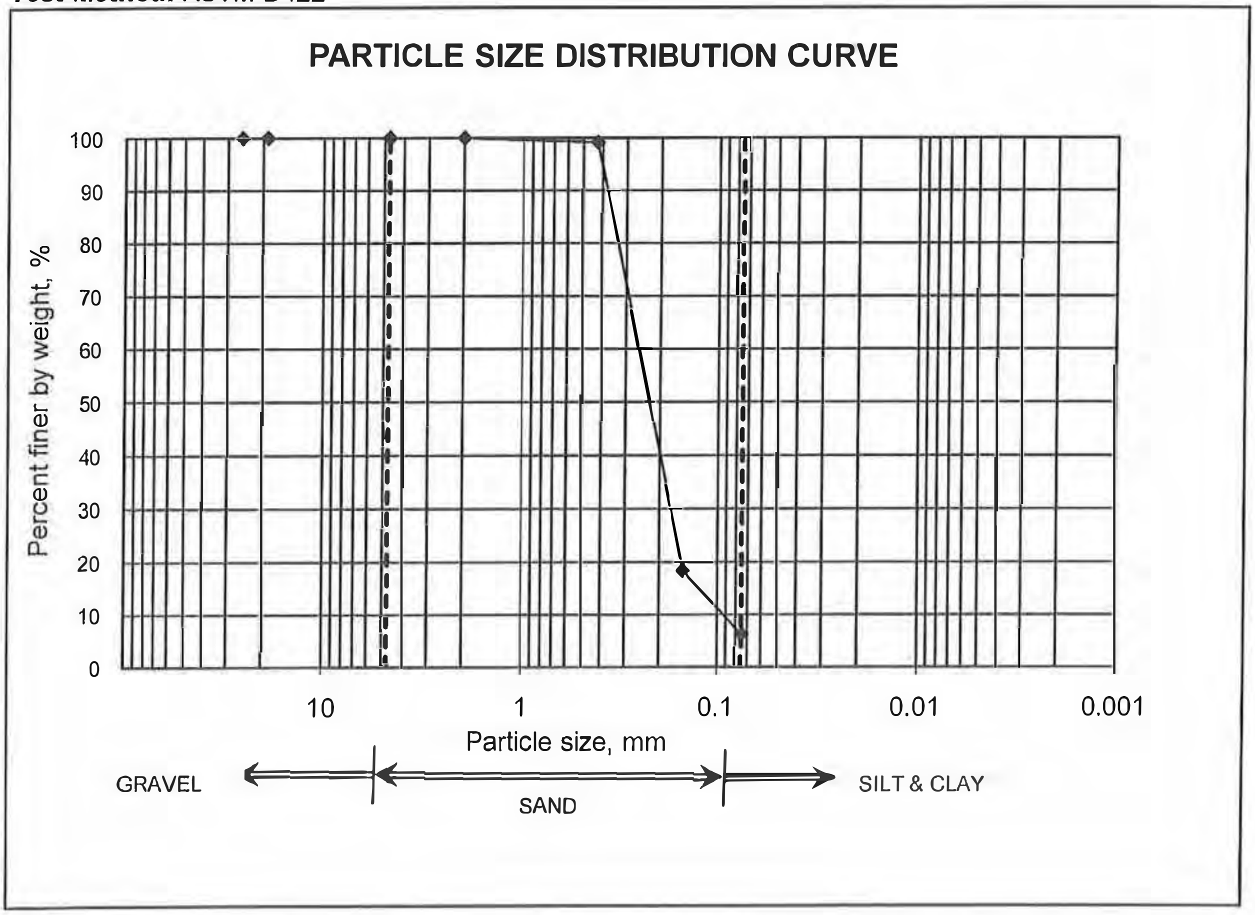
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	37 (UDS)	**Sand =**	94 %
Depth (m):	25.0	**Silt & Clay =**	6 %

Test Method: ASTM D422



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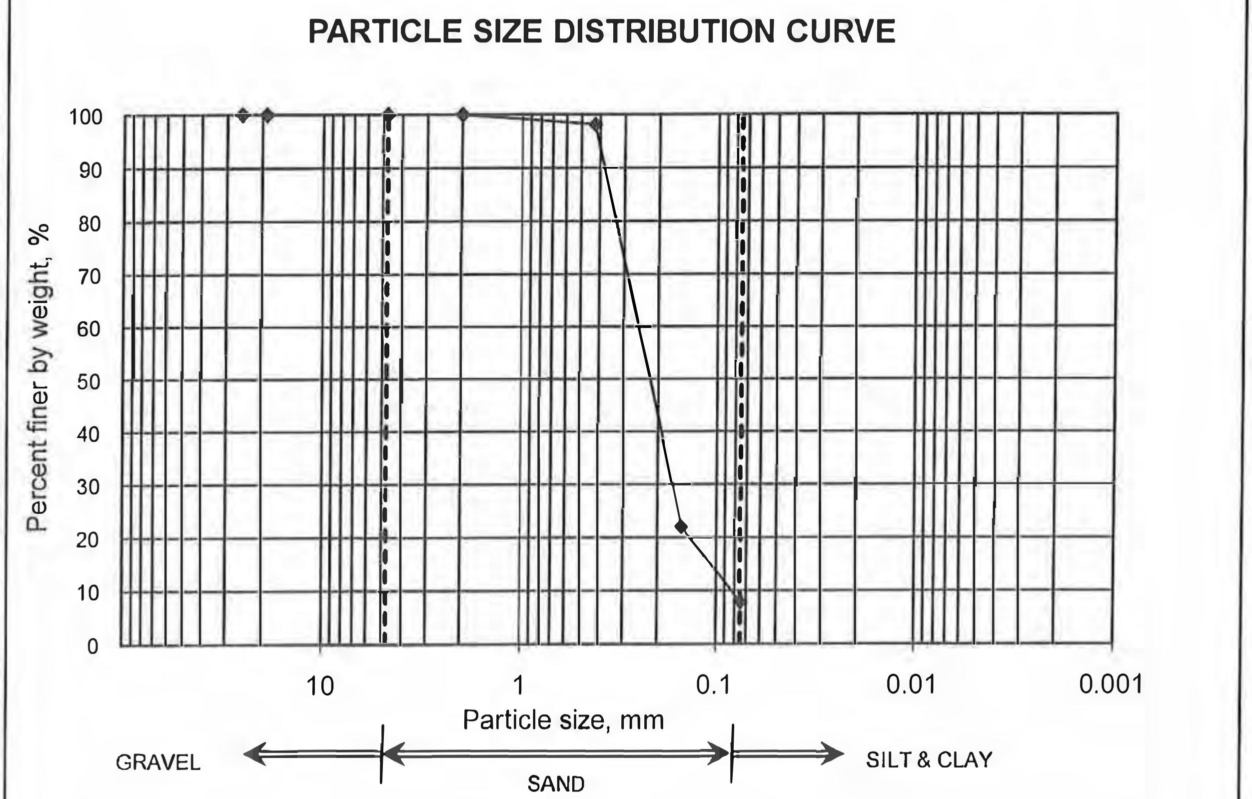
Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	38 (UDS)	**Sand =**	92 %
Depth (m):	31.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



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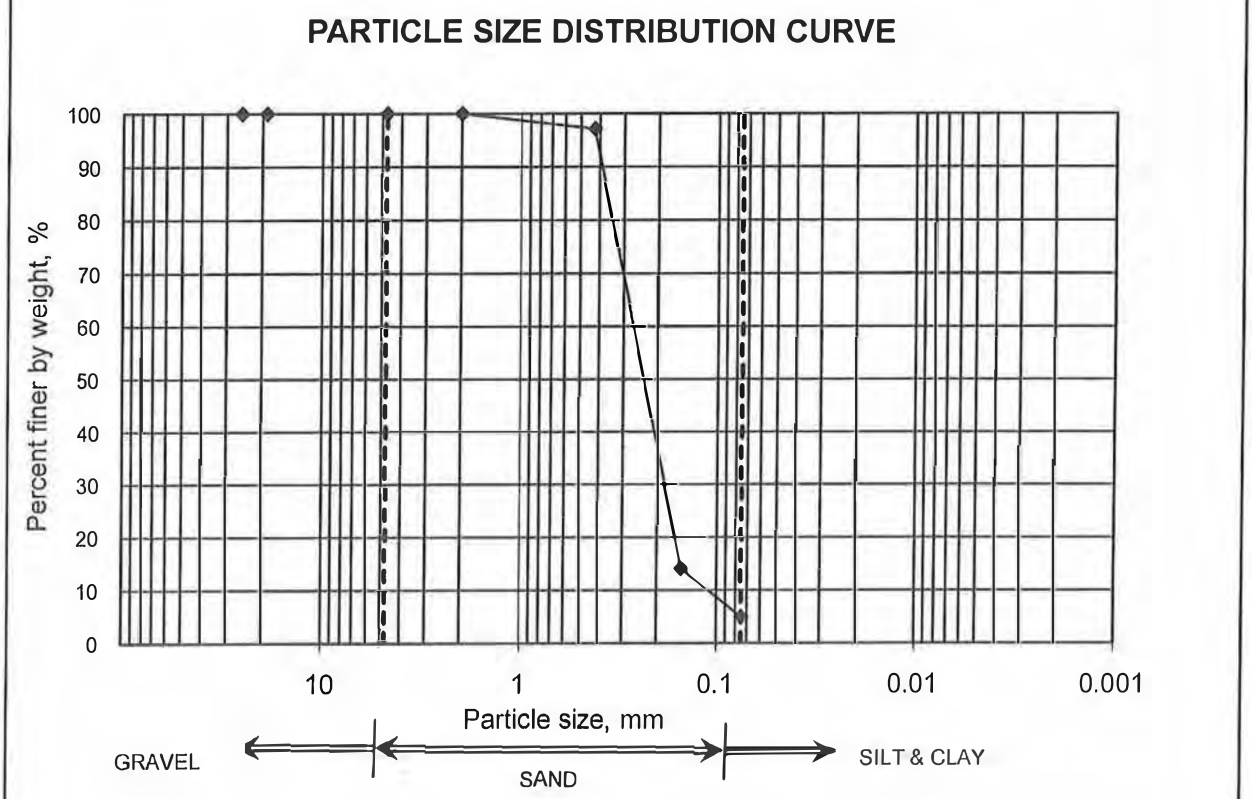
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	39 (SPT)	**Sand =**	95 %
Depth (m):	36.0	**Silt & Clay =**	5 %

Test Method: ASTM D422



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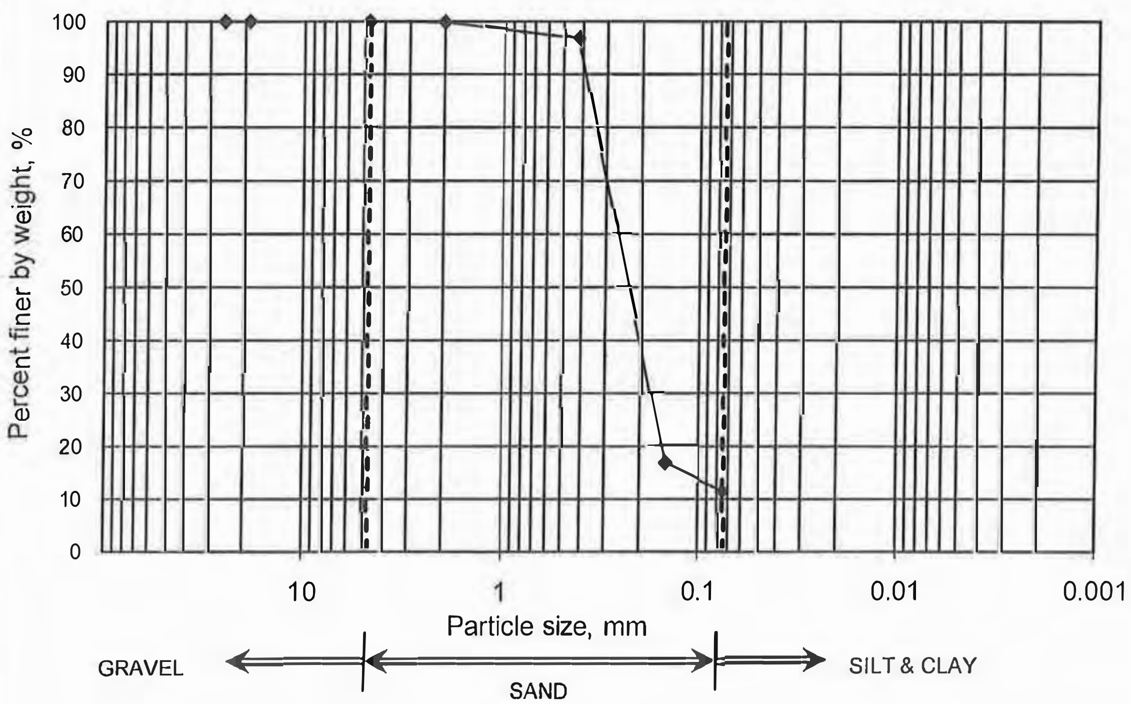
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-05	**Gravel =**	0 %
Sample No.	40 (SPT)	**Sand =**	88 %
Depth (m):	40.0	**Silt & Clay =**	12 %

Test Method: ASTM D422

PARTICLE SIZE DISTRIBUTION CURVE



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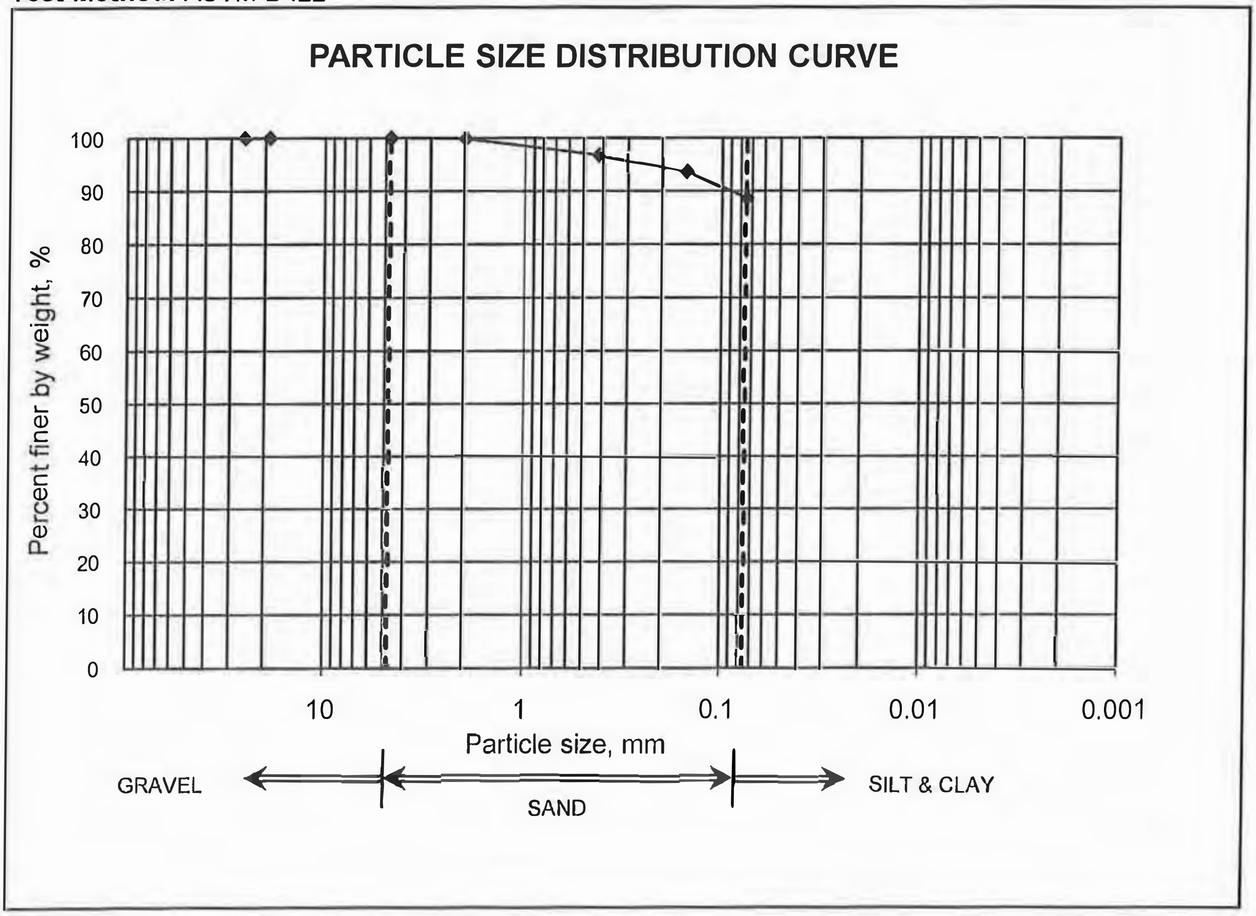
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	41 (UDS)	**Sand =**	11 %
Depth (m):	1.5	**Silt & Clay =**	89 %

Test Method: ASTM D422



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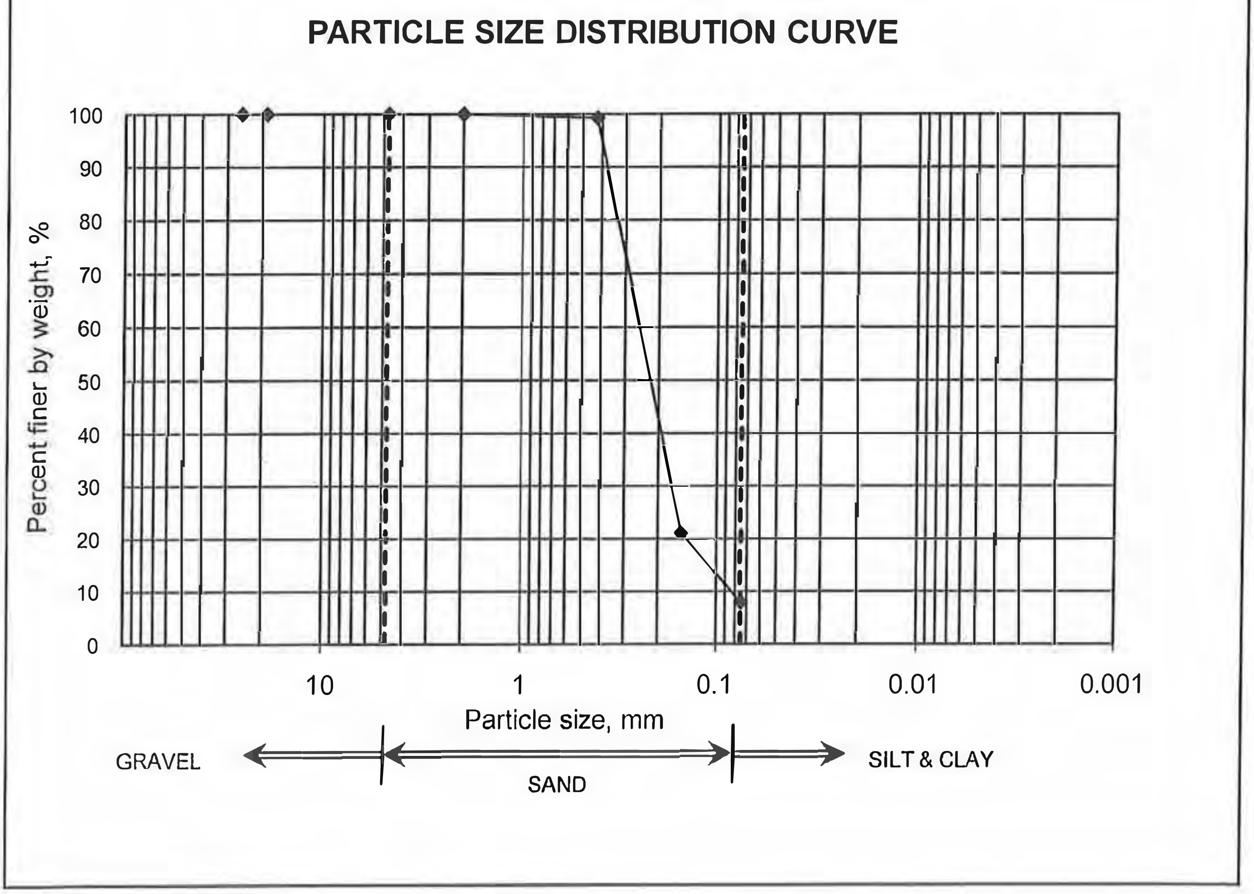
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	42 (UDS)	**Sand =**	92 %
Depth (m):	5.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



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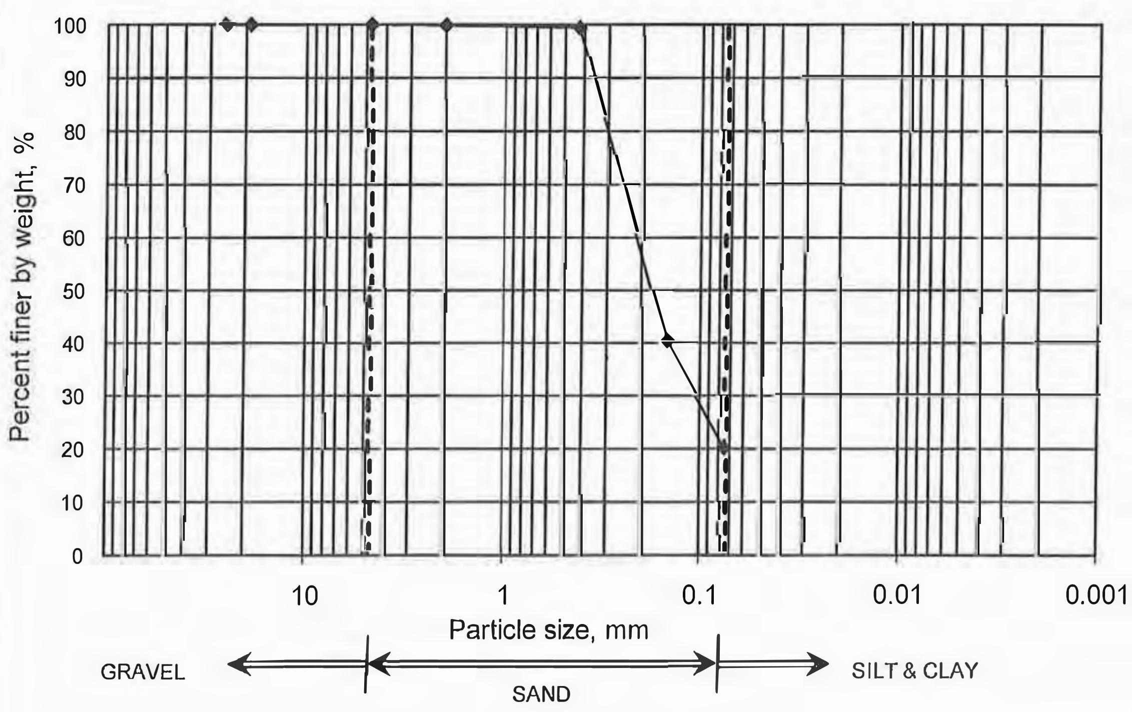
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	43 (UDS)	**Sand =**	80 %
Depth (m):	11.0	**Silt & Clay =**	20 %

Test Method: ASTM D422



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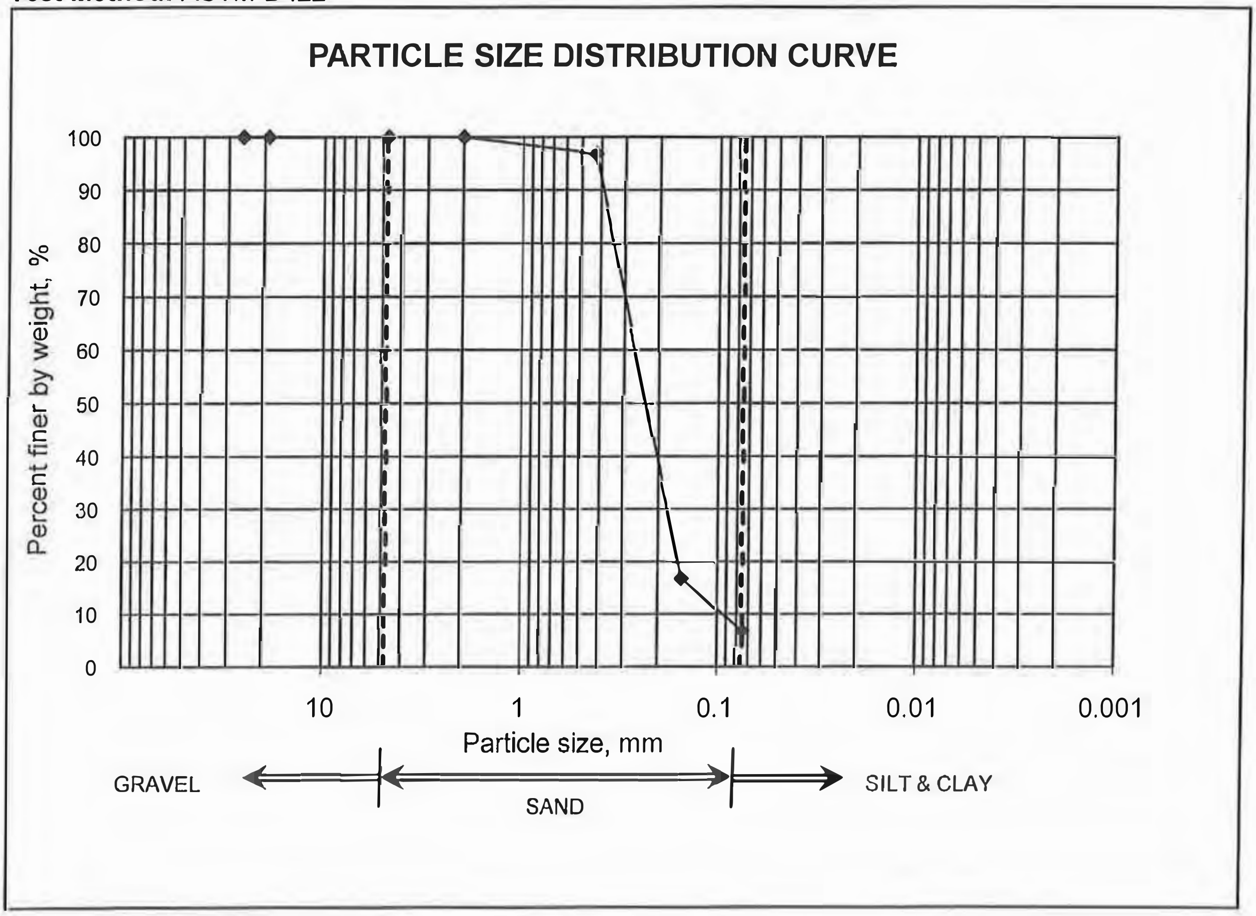
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	44 (UDS)	**Sand =**	93 %
Depth (m):	15.0	**Silt & Clay =**	7 %

Test Method: ASTM D422



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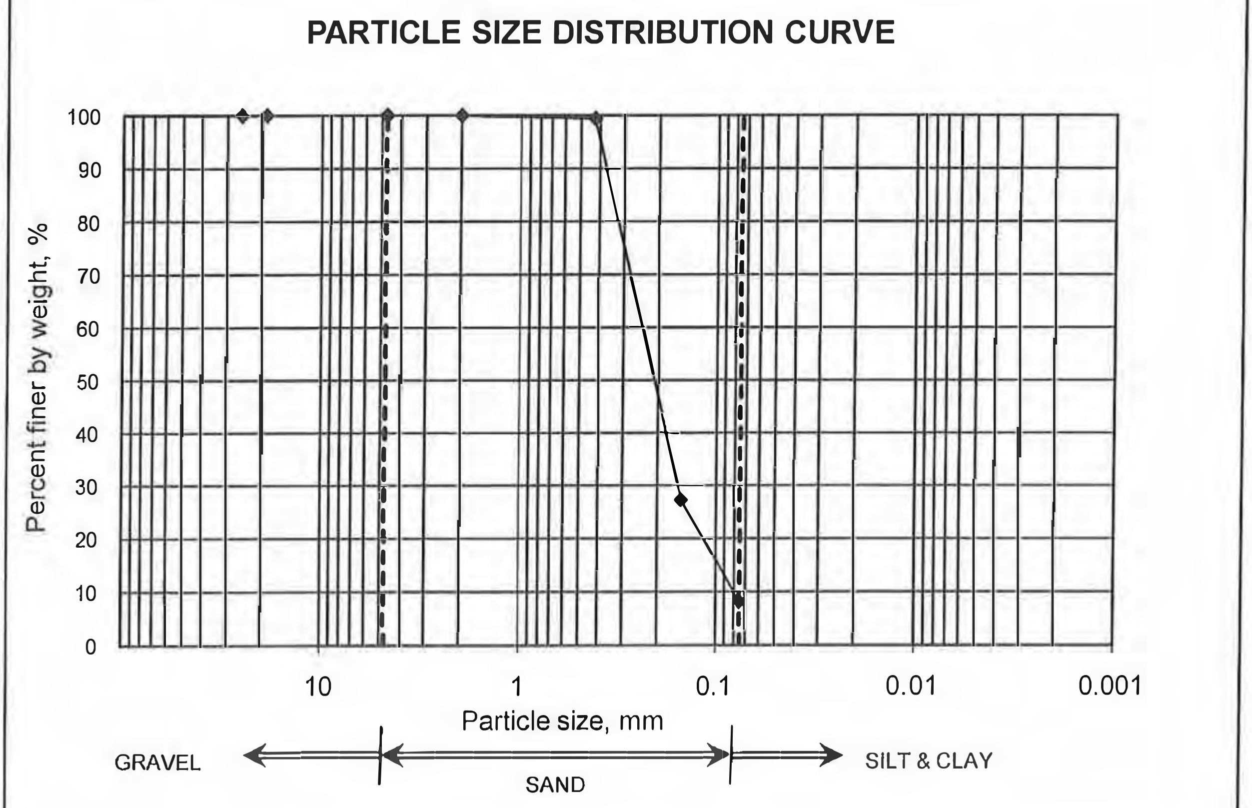
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	45 (UDS)	**Sand =**	92 %
Depth (m):	21.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



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Checked by:

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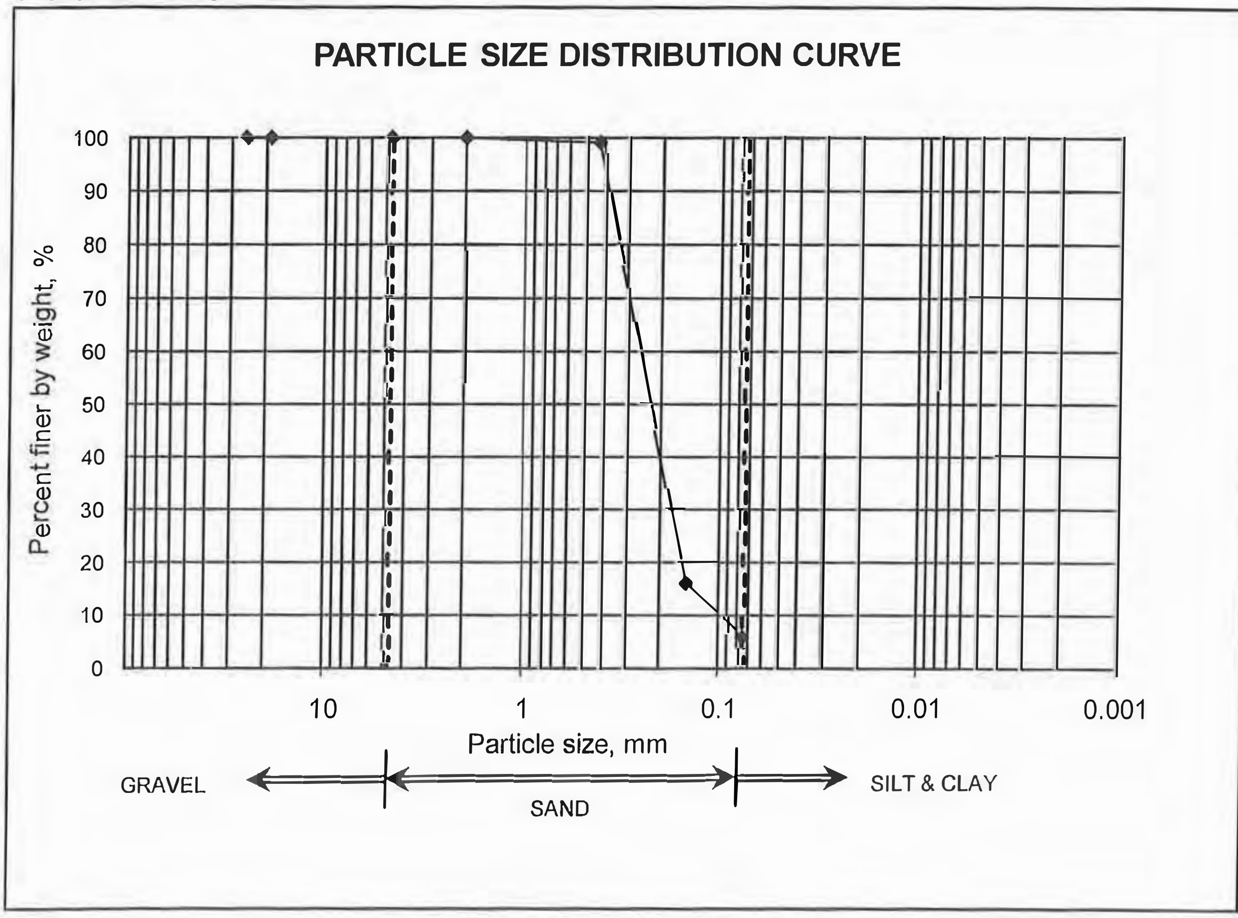
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	46 (UDS)	**Sand =**	94 %
Depth (m):	25.0	**Silt & Clay =**	6 %

Test Method: ASTM D422



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Checked by:

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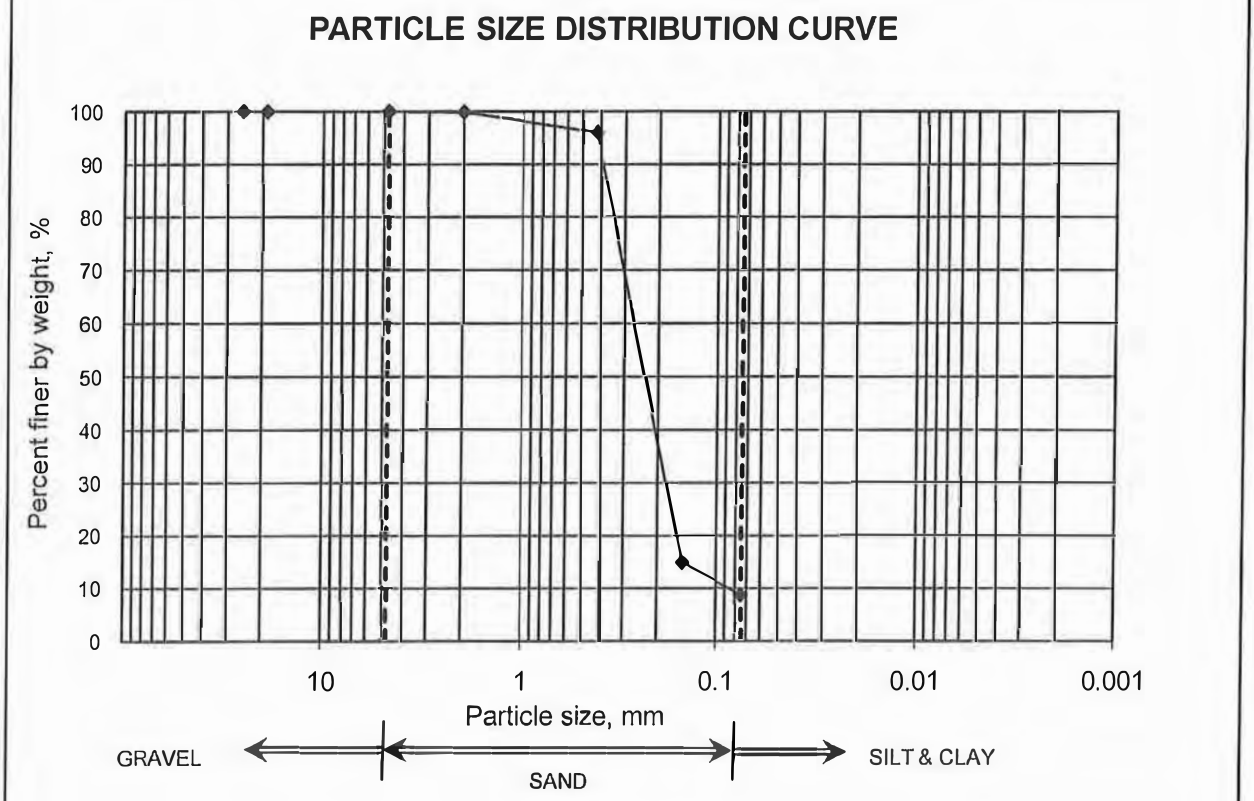
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	47 (SPT)	**Sand =**	91 %
Depth (m):	32.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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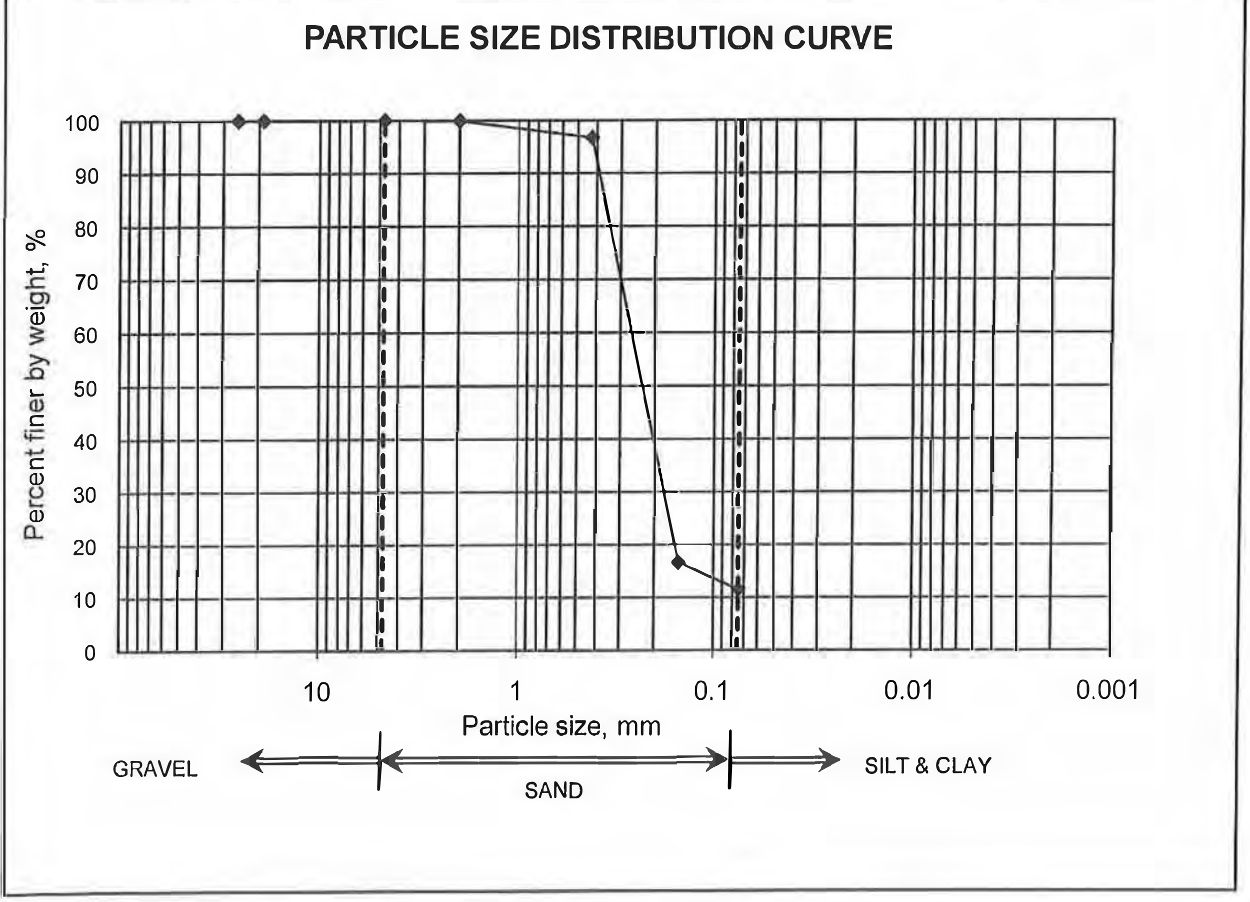
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-06	**Gravel =**	0 %
Sample No.	48 (SPT)	**Sand =**	89 %
Depth (m):	36.0	**Silt & Clay =**	11 %

Test Method: ASTM D422



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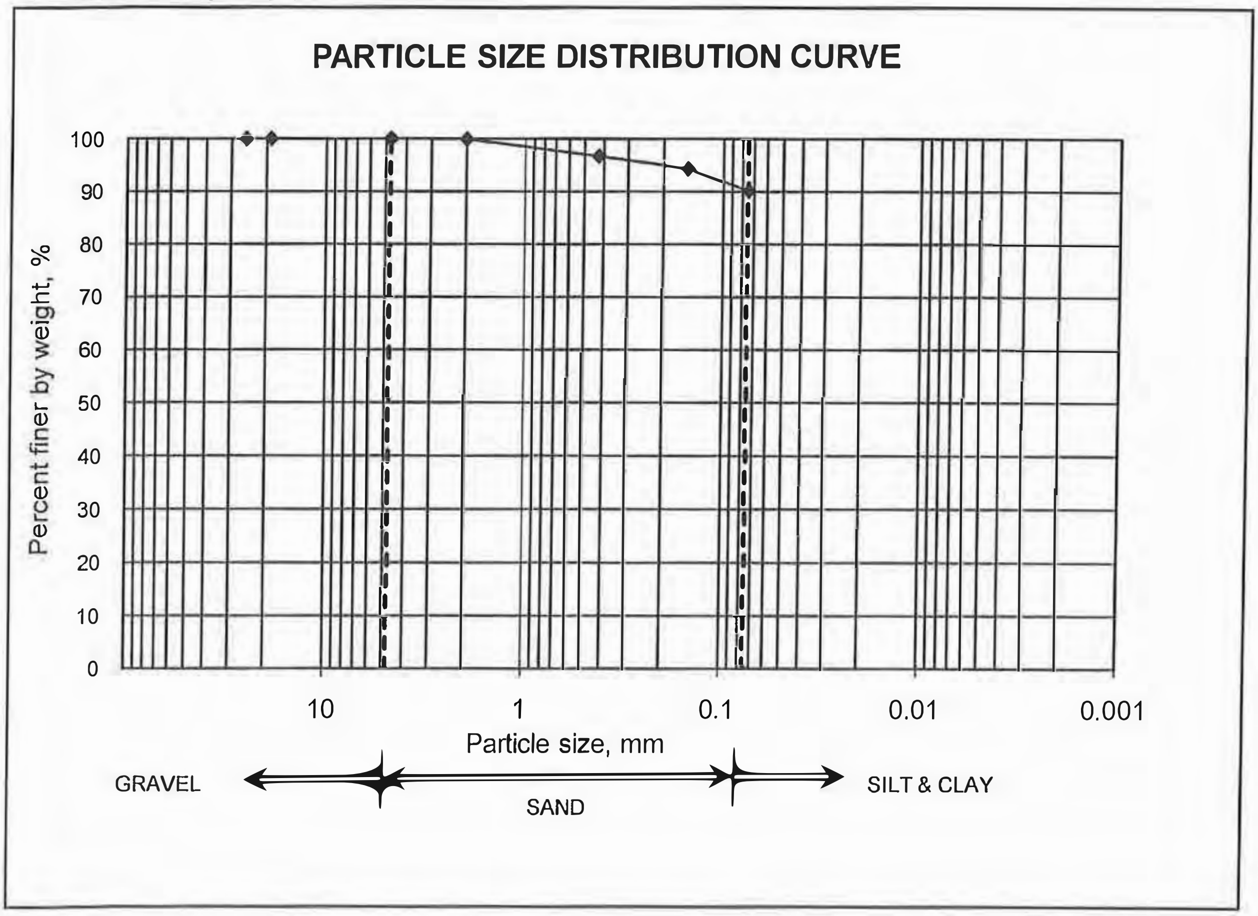
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	49 (UDS)	**Sand =**	10 %
Depth (m):	1.5	**Silt & Clay =**	90 %

Test Method: ASTM D422



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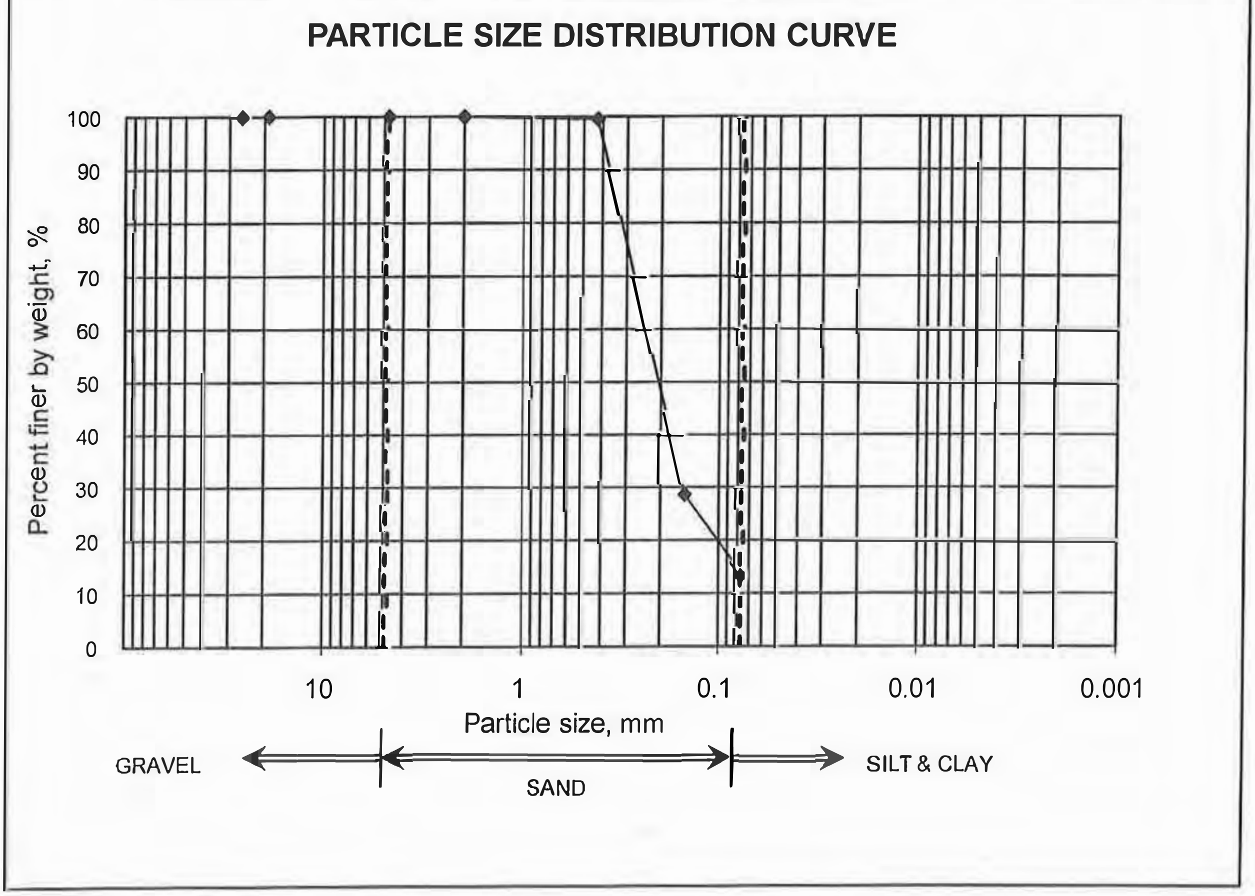
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	50 (UDS)	**Sand =**	87 %
Depth (m):	5.0	**Silt & Clay =**	13 %

Test Method: ASTM D422



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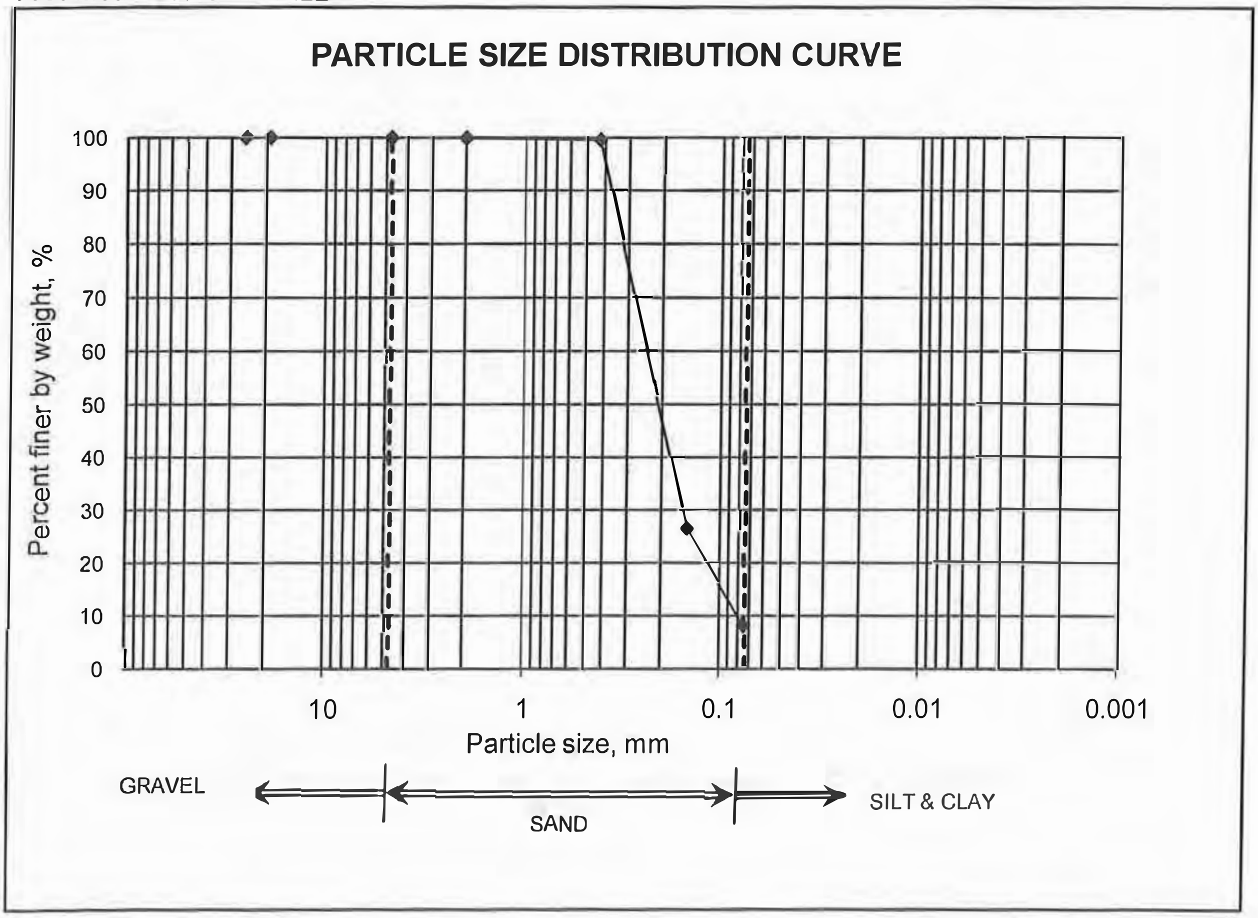
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	51 (UDS)	**Sand =**	92 %
Depth (m):	11.0	**Silt & Clay =**	8 %

Test Method: ASTM D422



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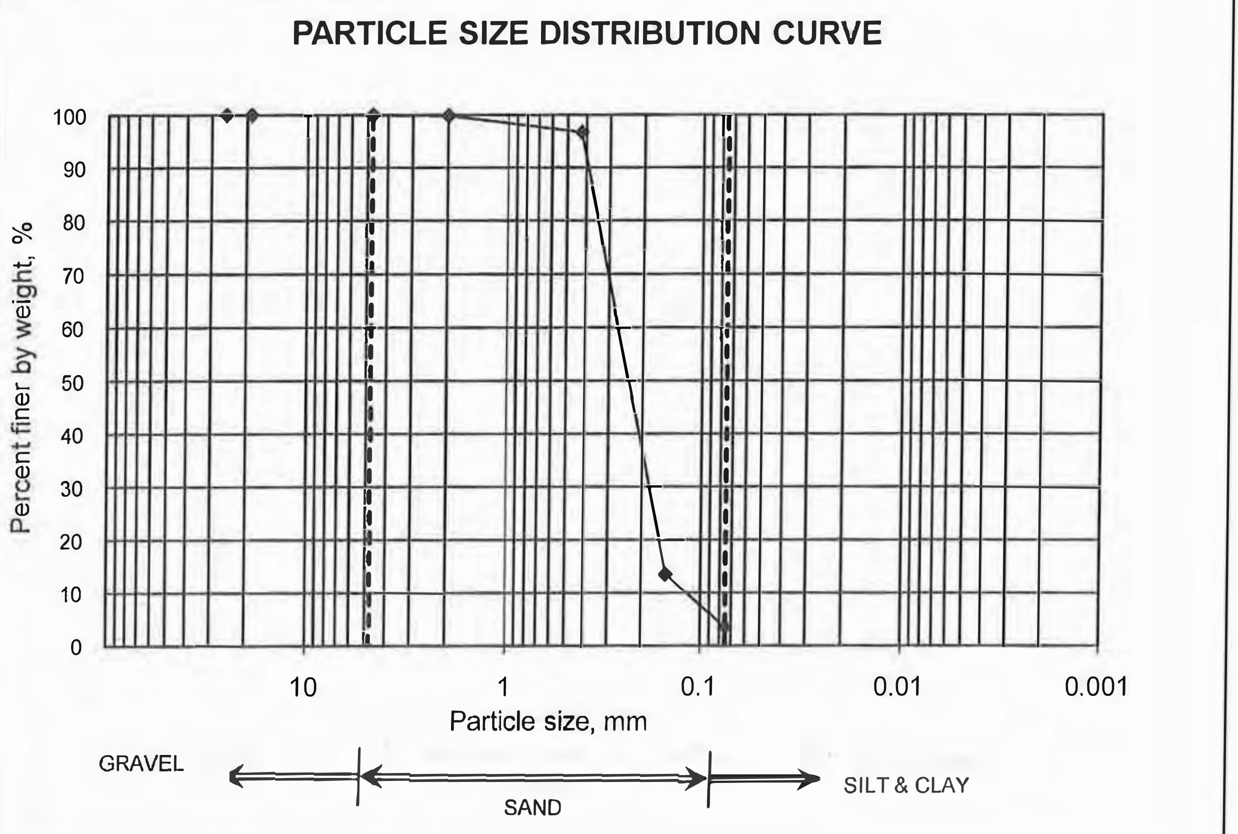
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	52 (UDS)	**Sand =**	97 %
Depth (m):	15.0	**Silt & Clay =**	3 %

Test Method: ASTM D422



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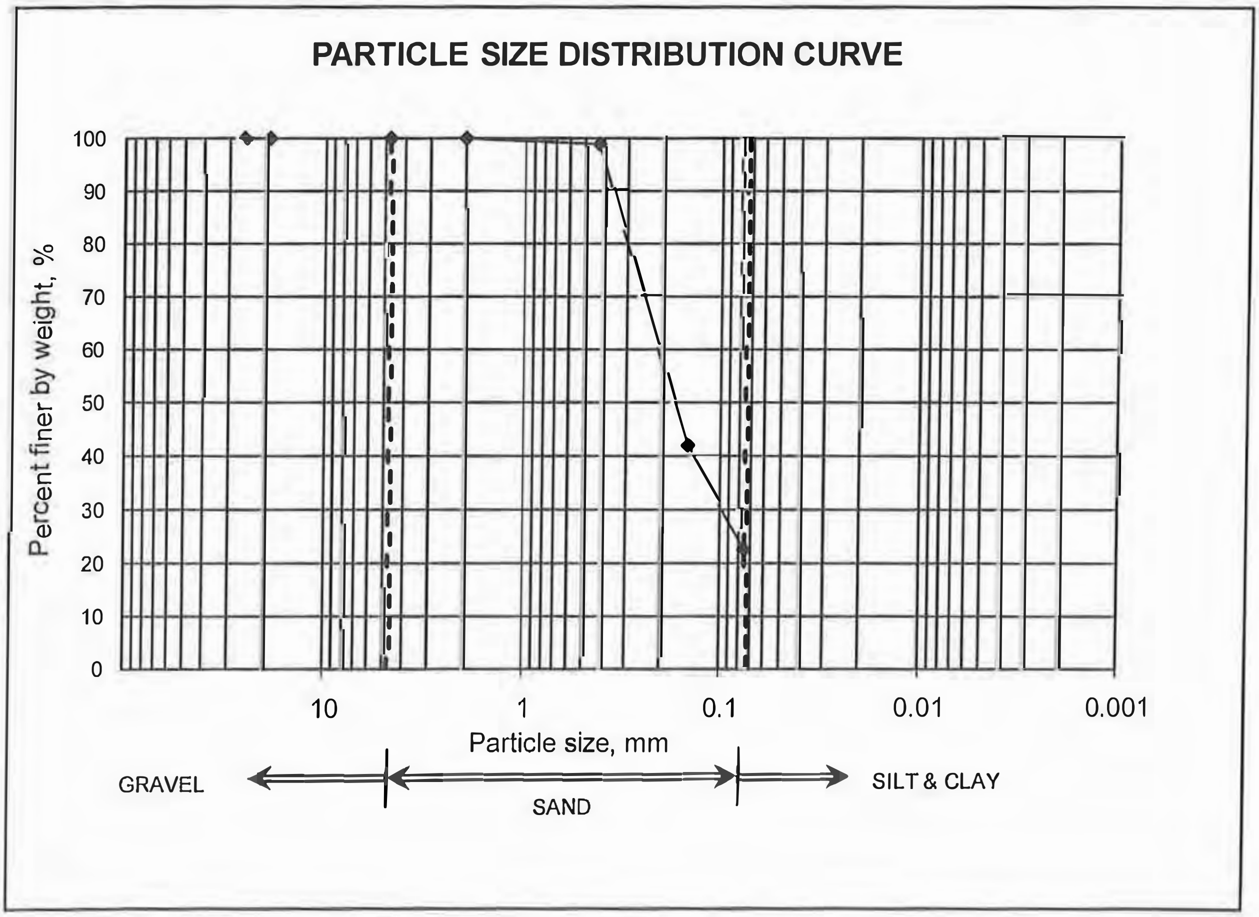
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	53 (UDS)	**Sand =**	77 %
Depth (m):	21.0	**Silt & Clay =**	23 %

Test Method: ASTM D422



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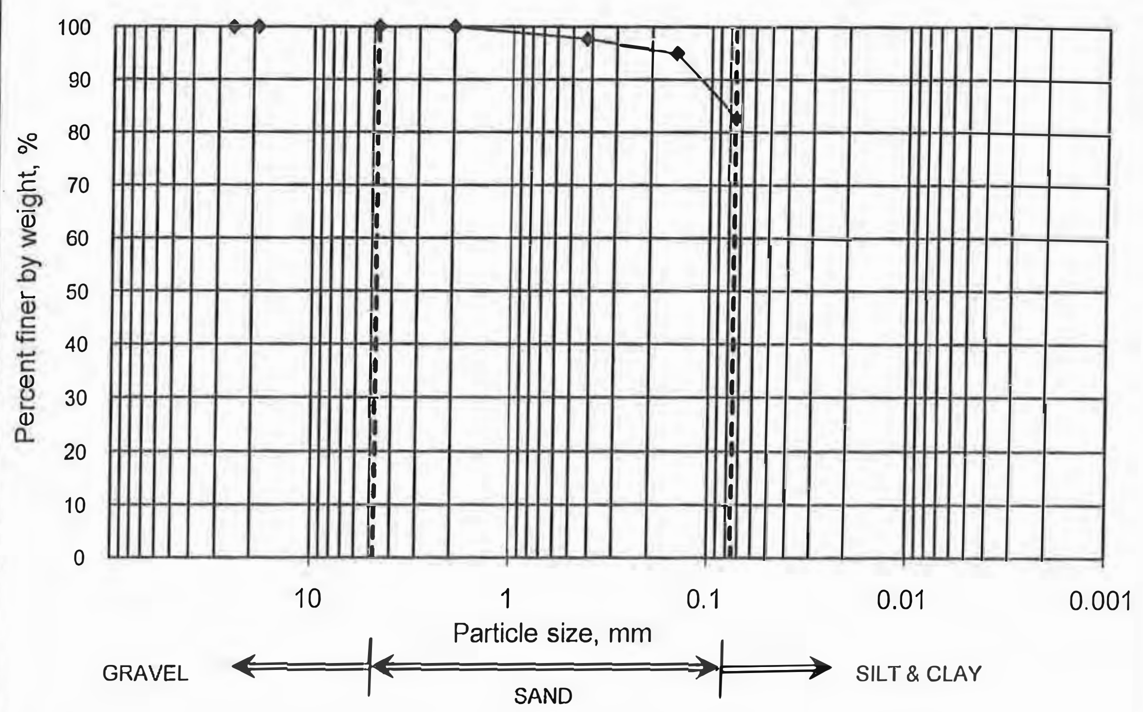
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	54 (UDS)	**Sand =**	17 %
Depth (m):	25.0	**Silt & Clay =**	83 %

Test Method: ASTM D422



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PARTICLE SIZE DISTRIBUTION

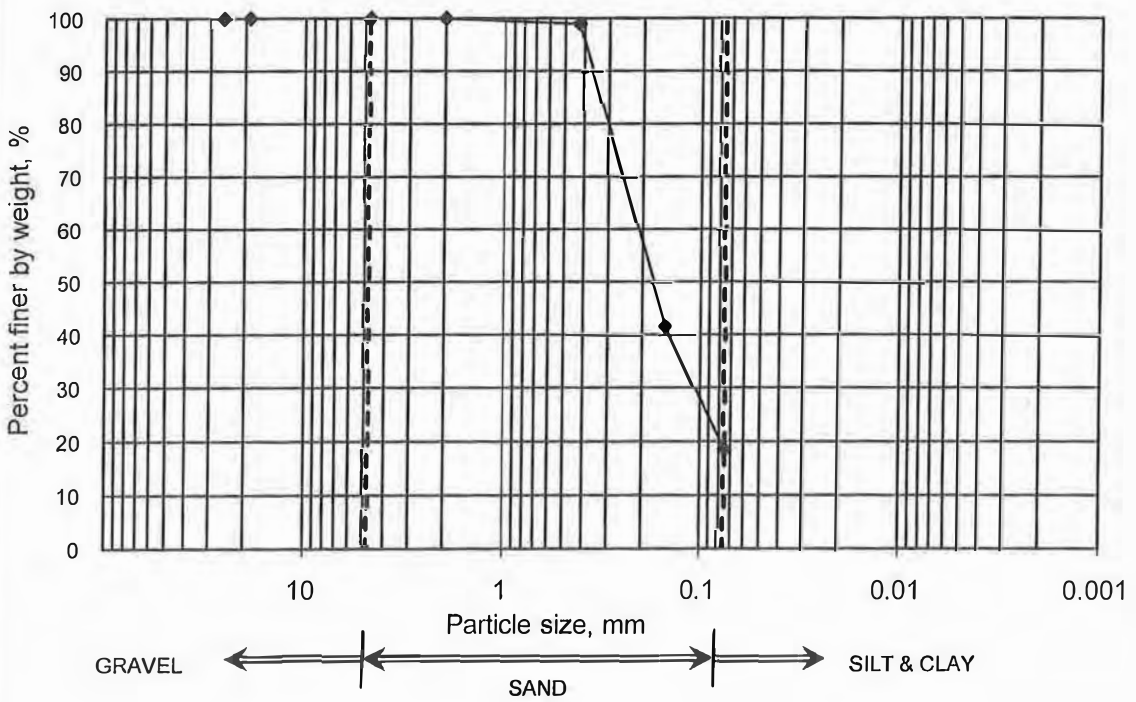
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	55 (UDS)	**Sand =**	82 %
Depth (m):	31.0	**Silt & Clay =**	18 %

Test Method: ASTM D422

PARTICLE SIZE DISTRIBUTION CURVE



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PARTICLE SIZE DISTRIBUTION

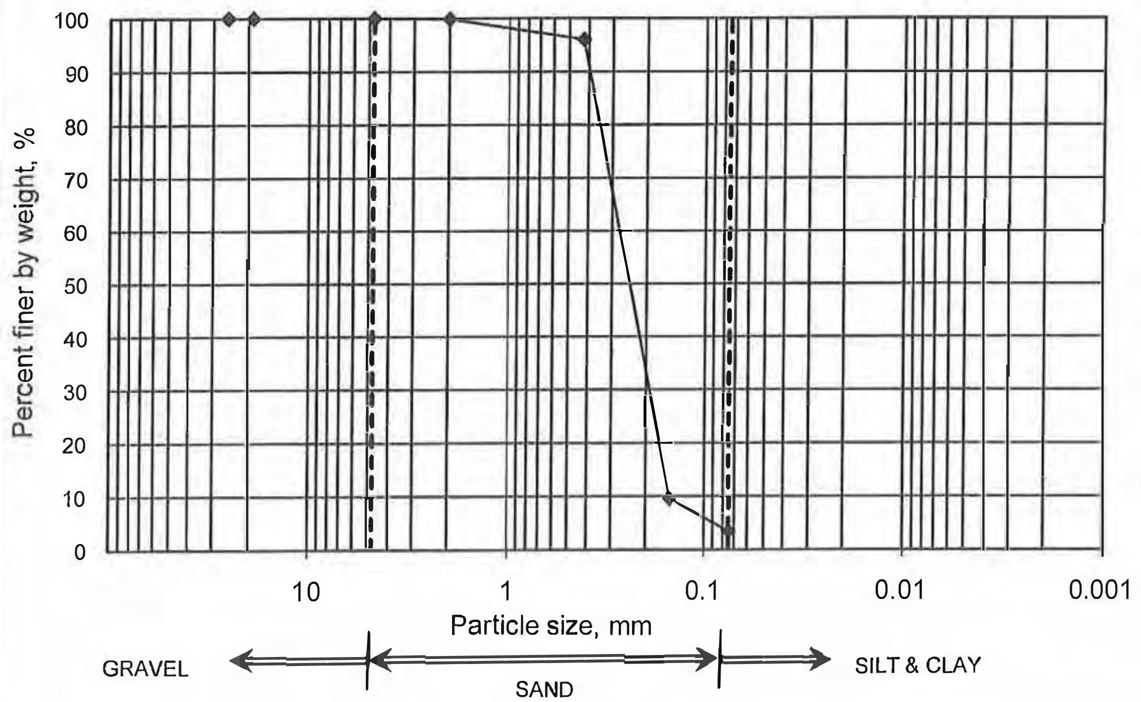
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-07	**Gravel =**	0 %
Sample No.	56 (SPT)	**Sand =**	97 %
Depth (m):	36.0	**Silt & Clay =**	3 %

Test Method: ASTM D422

PARTICLE SIZE DISTRIBUTION CURVE



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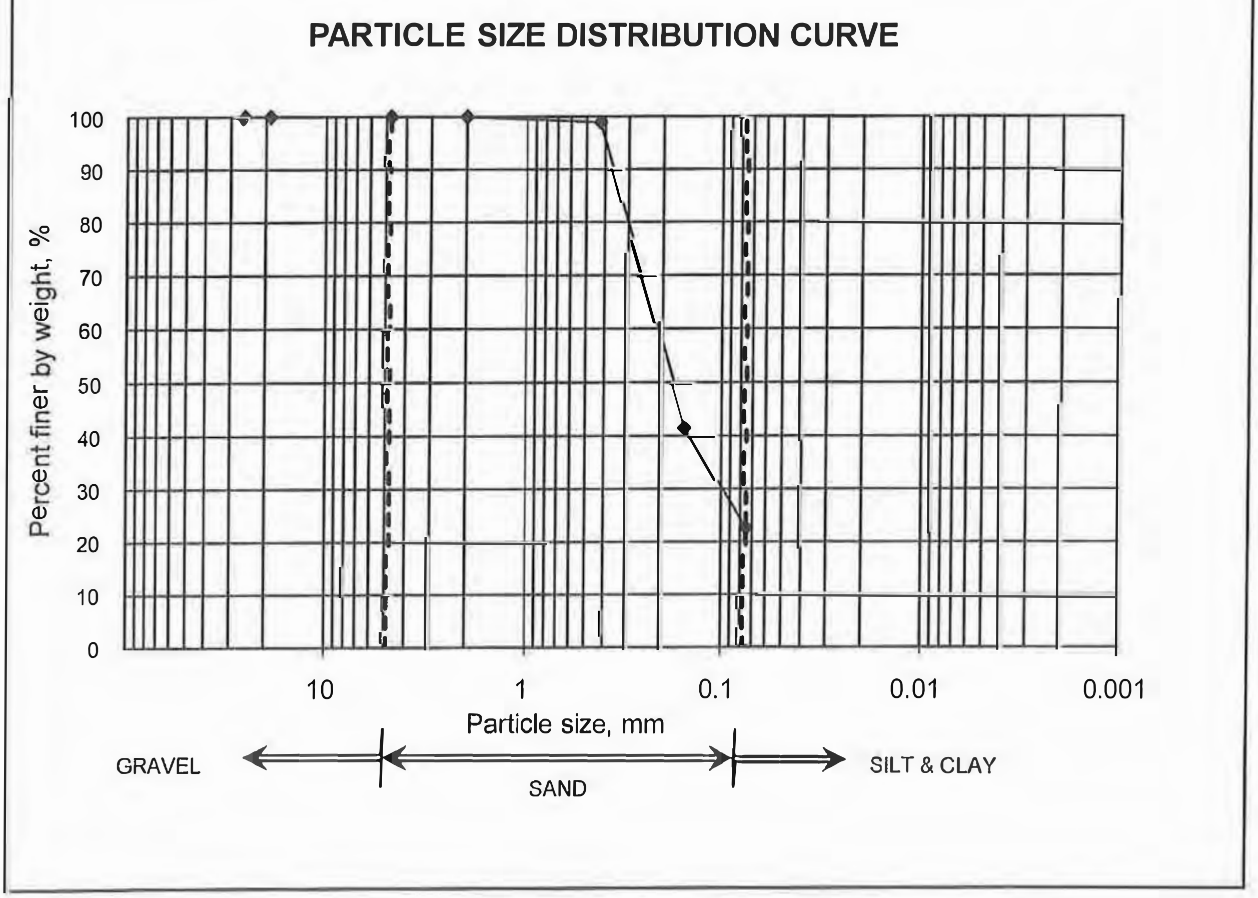
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	57 (UDS)	**Sand =**	77 %
Depth (m):	5.0	**Silt & Clay =**	23 %

Test Method: ASTM D422



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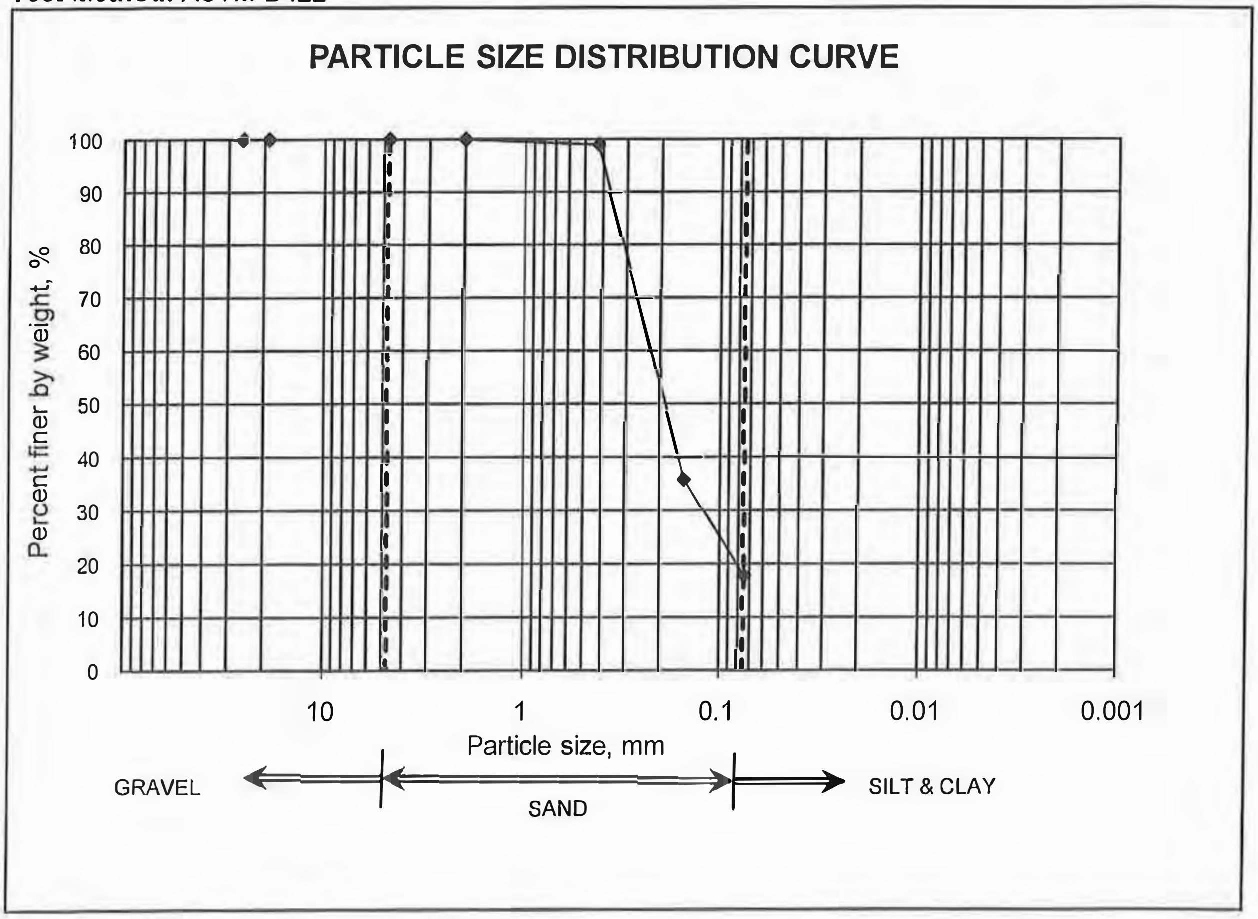
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	58 (UDS)	**Sand =**	82 %
Depth (m):	11.0	**Silt & Clay =**	18 %

Test Method: ASTM D422



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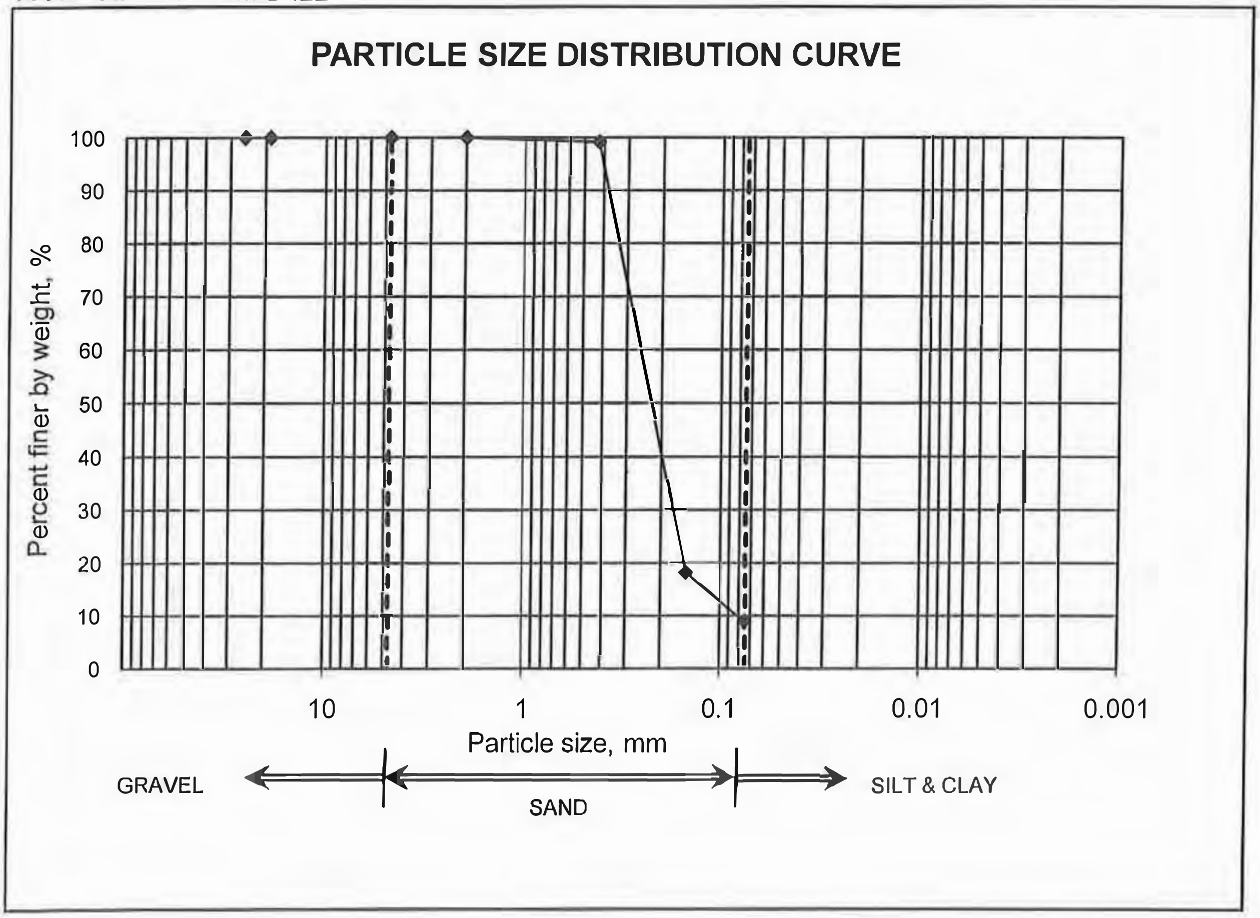
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	59 (UDS)	**Sand =**	91 %
Depth (m):	15.0	**Silt & Clay =**	9 %

Test Method: ASTM D422



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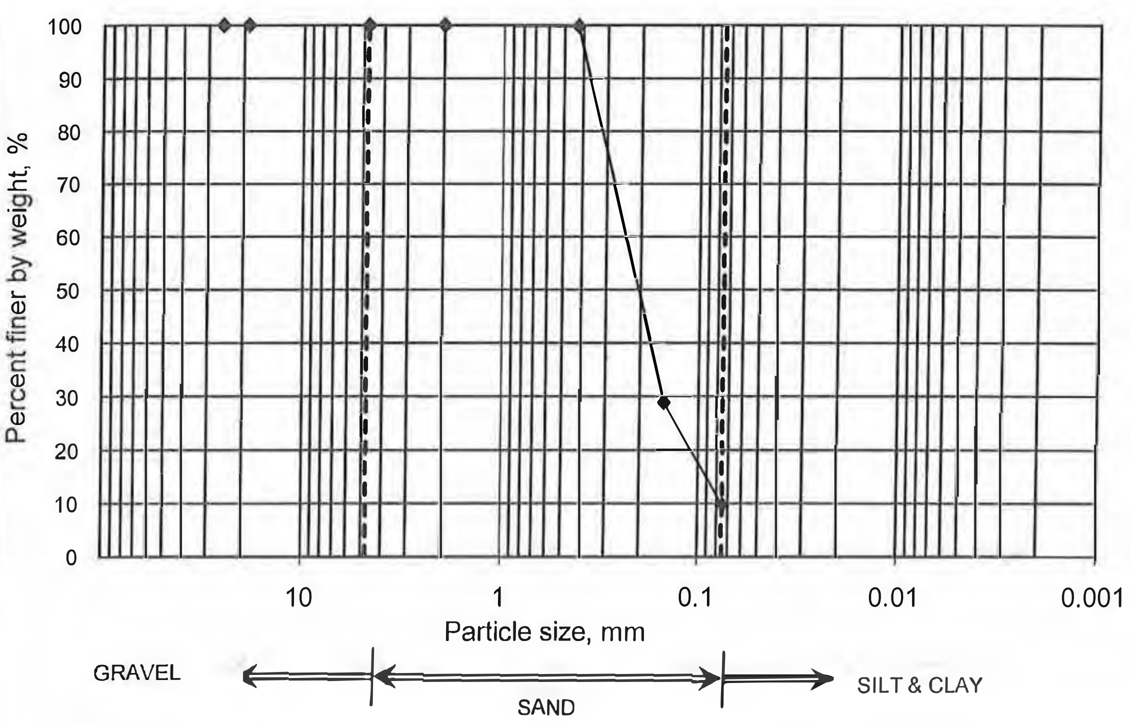
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	60 (UDS)	**Sand =**	90 %
Depth (m):	21.0	**Silt & Clay =**	10 %

Test Method: ASTM D422

PARTICLE SIZE DISTRIBUTION CURVE



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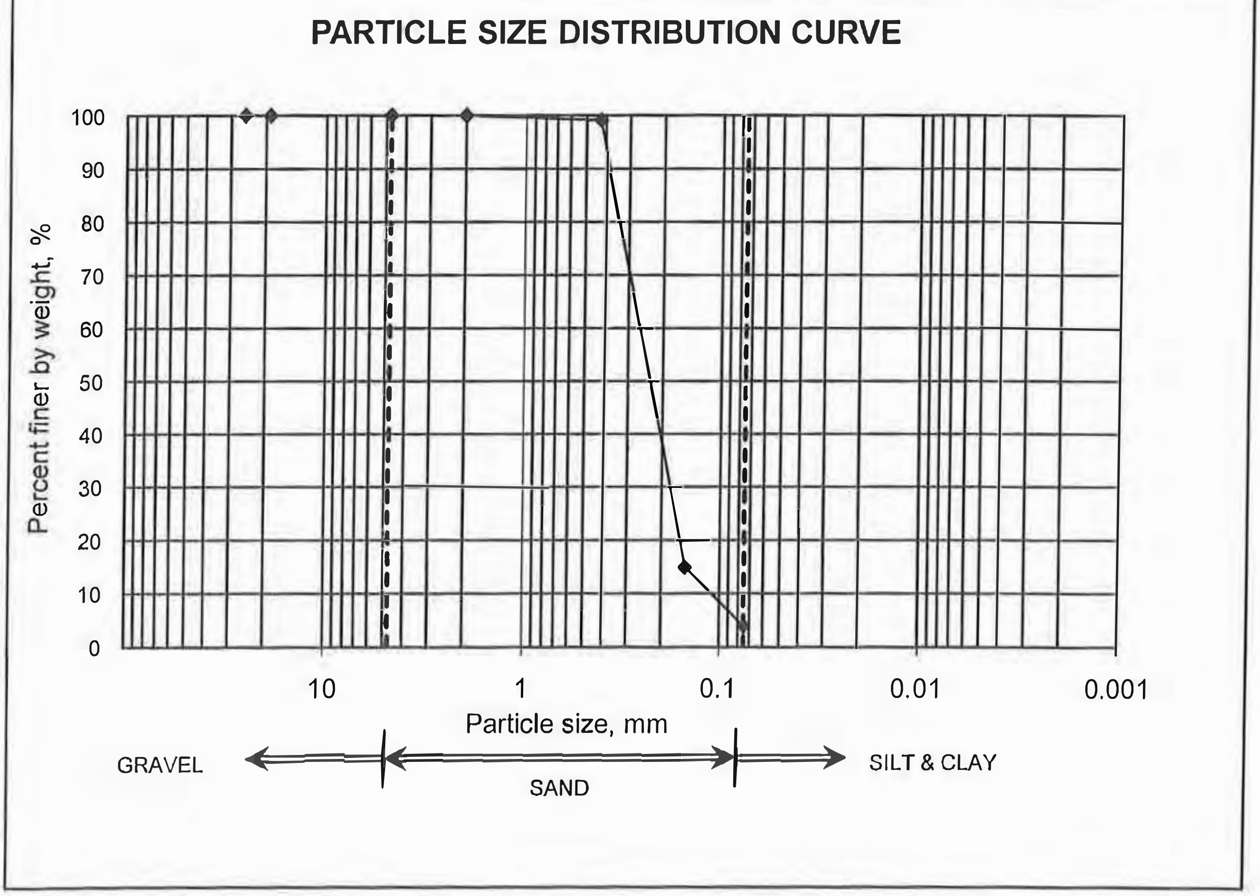
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	61 (UDS)	**Sand =**	96 %
Depth (m):	25.0	**Silt & Clay =**	4 %

Test Method: ASTM D422



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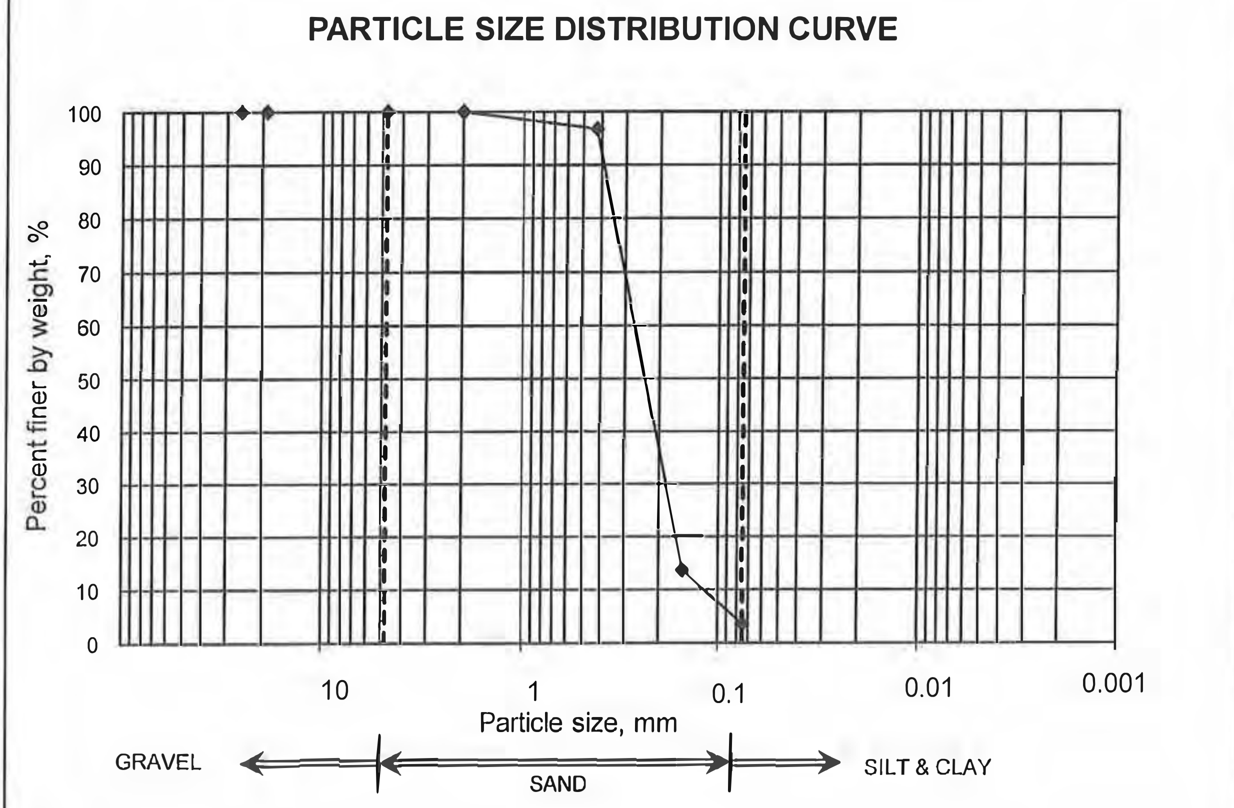
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	62 (UDS)	**Sand =**	96 %
Depth (m):	31.0	**Silt & Clay =**	4 %

Test Method: ASTM D422



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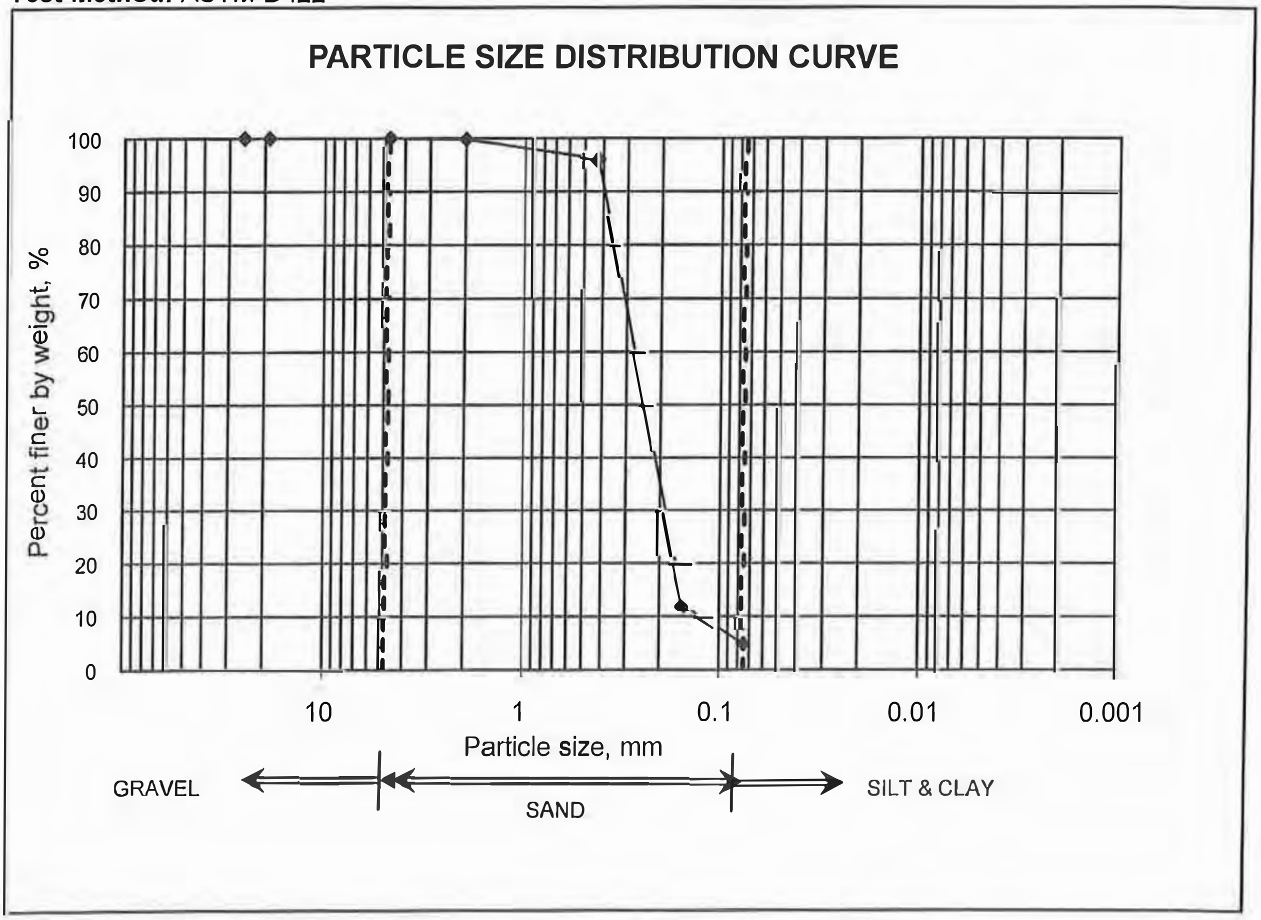
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	63 (SPT)	**Sand =**	95 %
Depth (m):	36.0	**Silt & Clay =**	5 %

Test Method: ASTM D422



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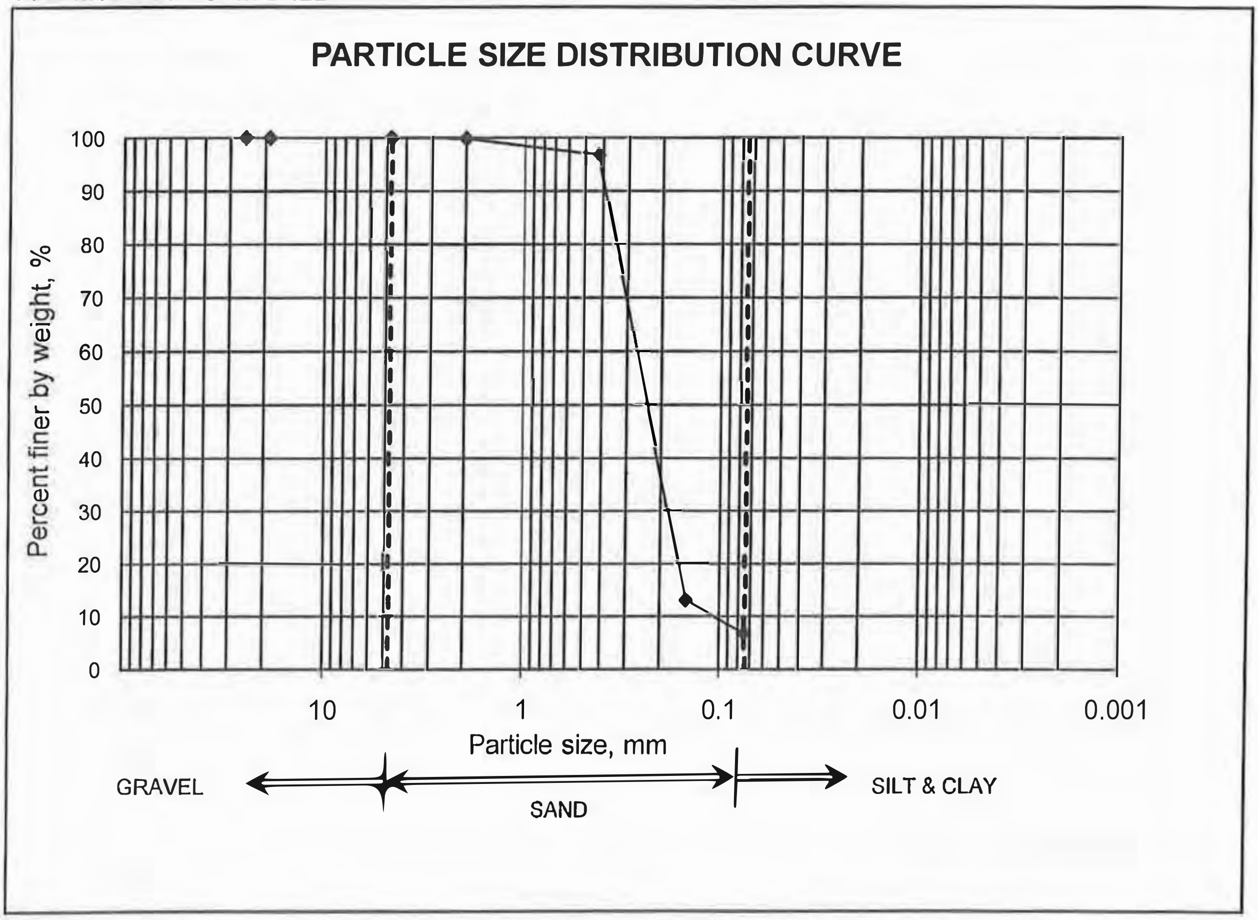
PARTICLE SIZE DISTRIBUTION

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-08	**Gravel =**	0 %
Sample No.	64 (SPT)	**Sand =**	93 %
Depth (m):	40.0	**Silt & Clay =**	7 %

Test Method: ASTM D422



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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-01

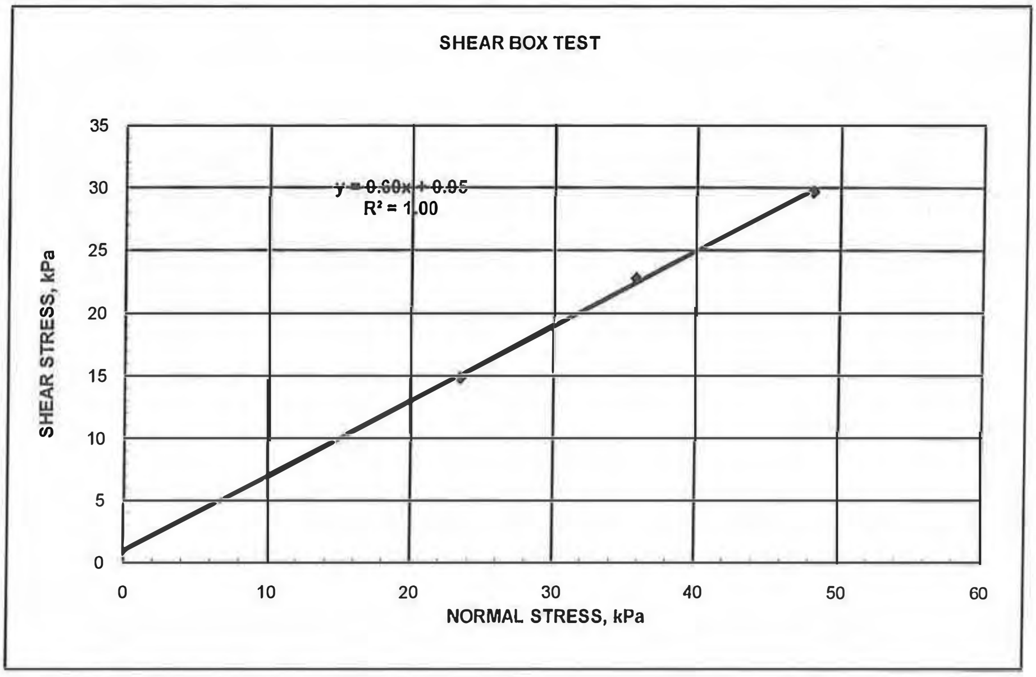
Sample No. 2 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 7.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	23	22.7
38.94	48.13	30	29.7



Cohesion = 1.0 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-01

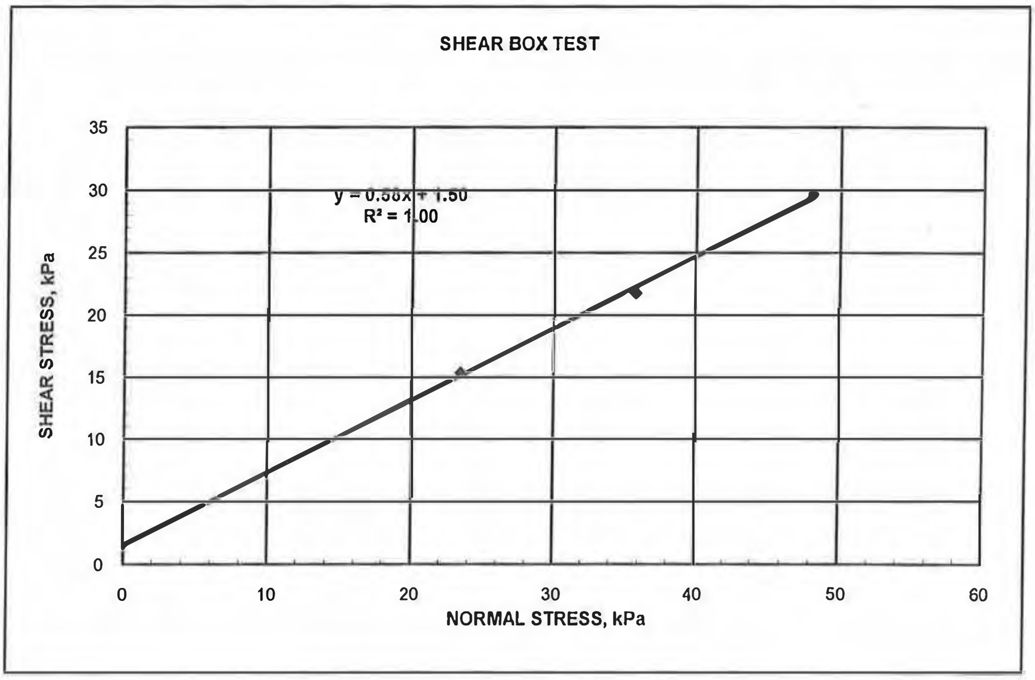
Sample No. 3 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 14.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15.5	15.3
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 1.5 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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Director

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-01

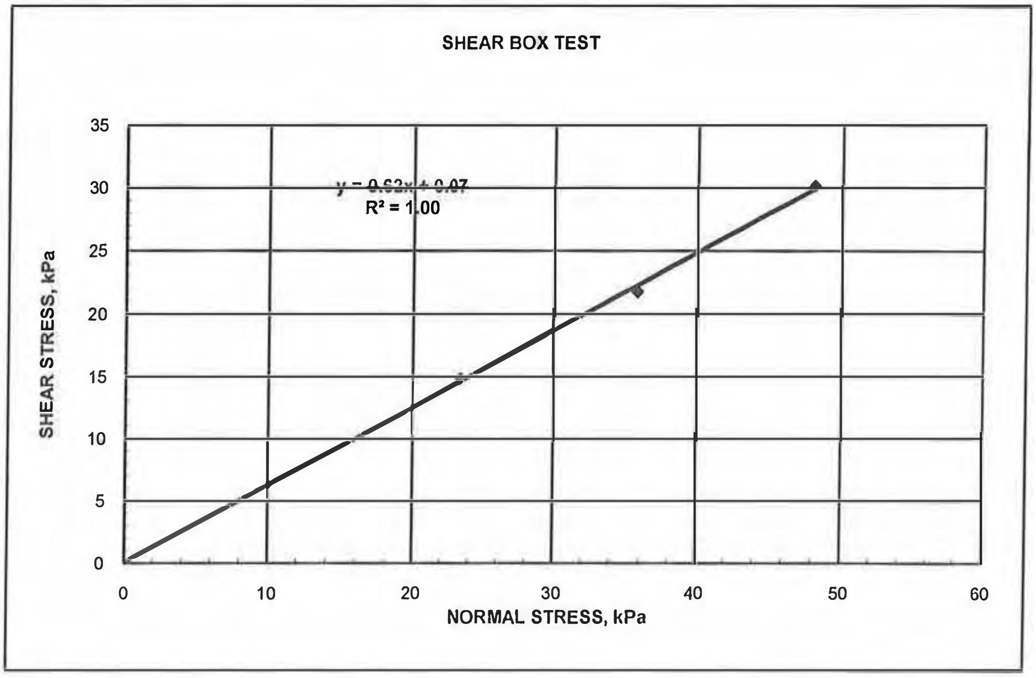
Sample No. 4 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 19.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30.5	30.2



Cohesion = 0.1 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-01

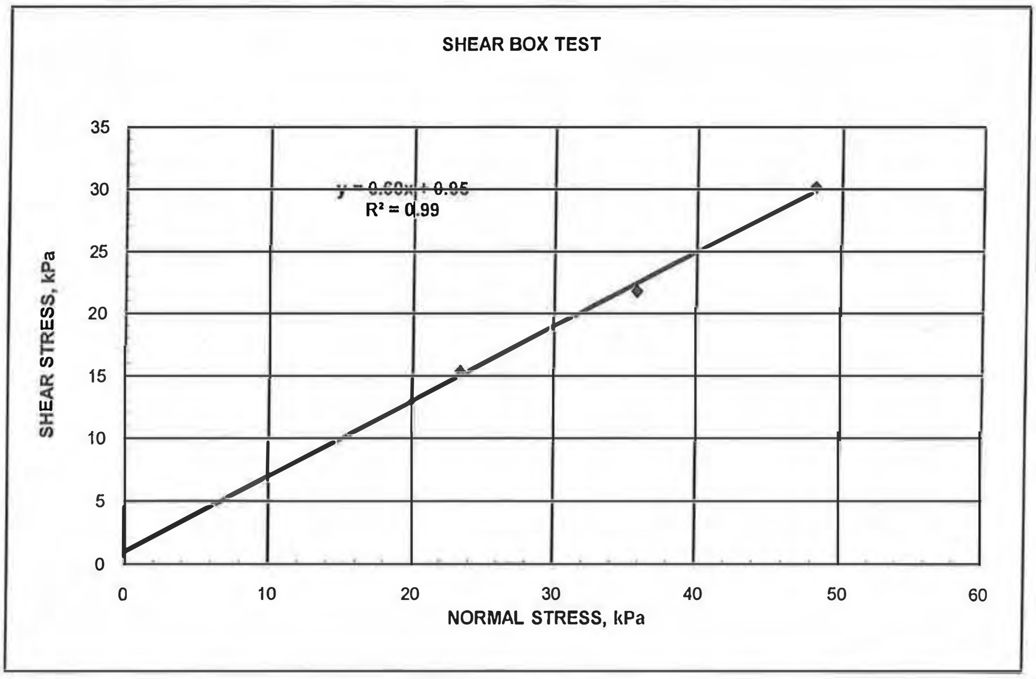
Sample No. 5 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15.5	15.3
28.94	35.77	22	21.8
38.94	48.13	30.5	30.2



Cohesion = 1.0 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-01

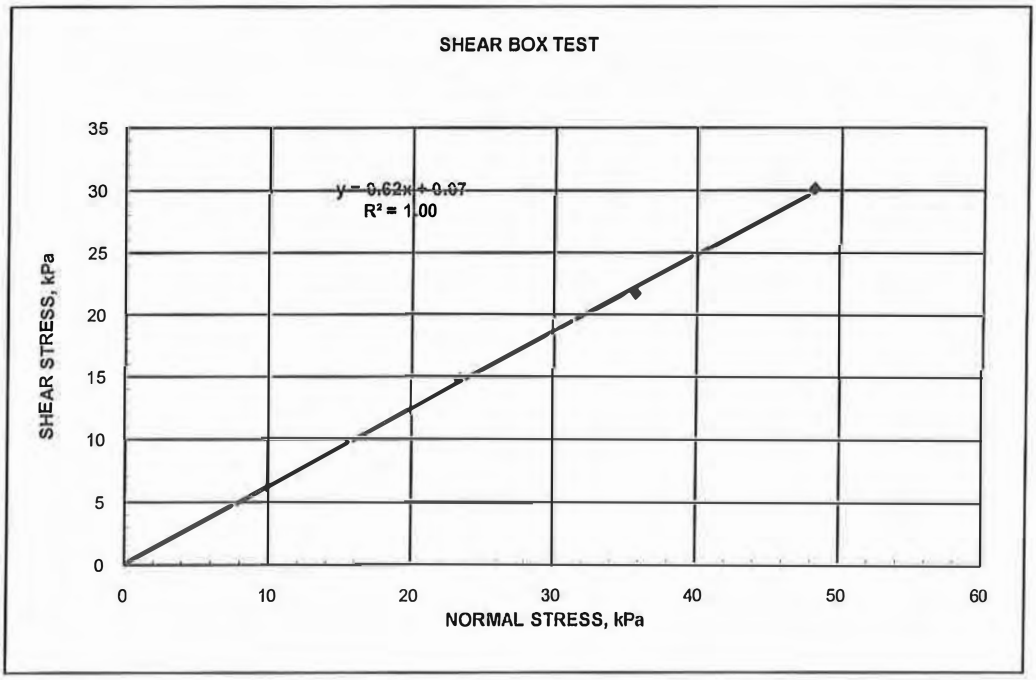
Sample No. 6 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 30.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30.5	30.2



Cohesion = 0.1 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-01

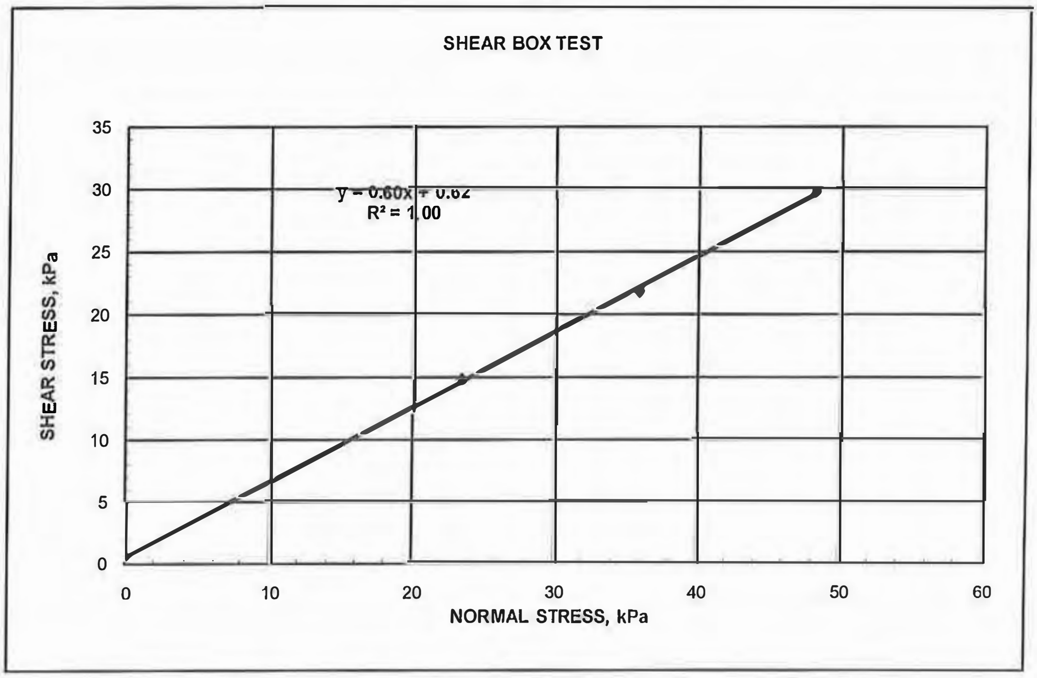
Sample No. 7 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 35.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

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BH/TP No. BH-01

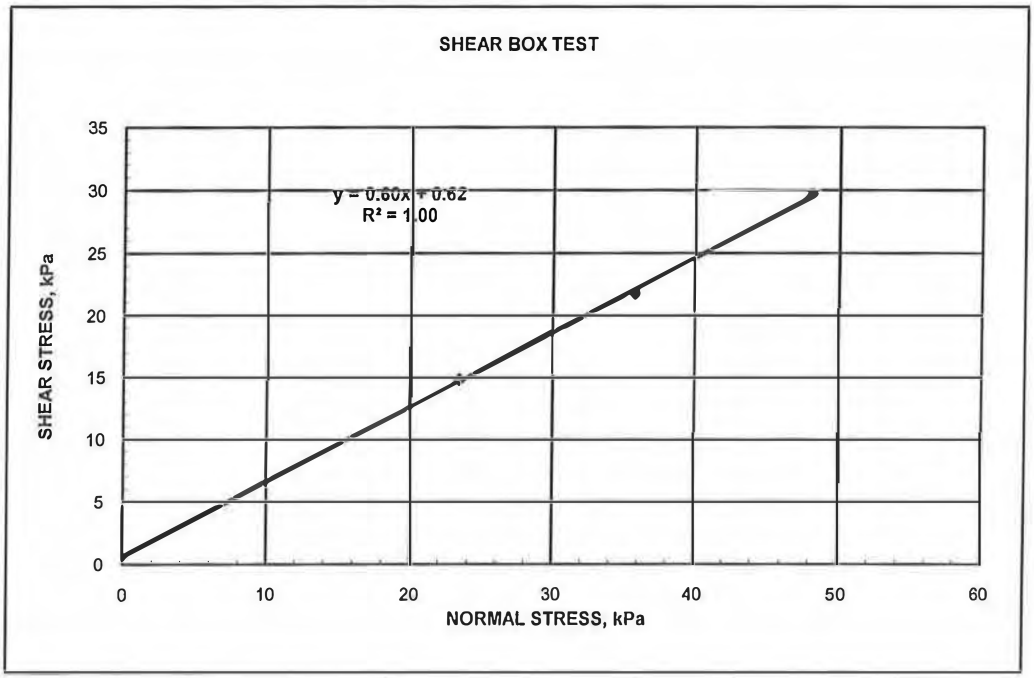
Sample No. 8 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 40.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

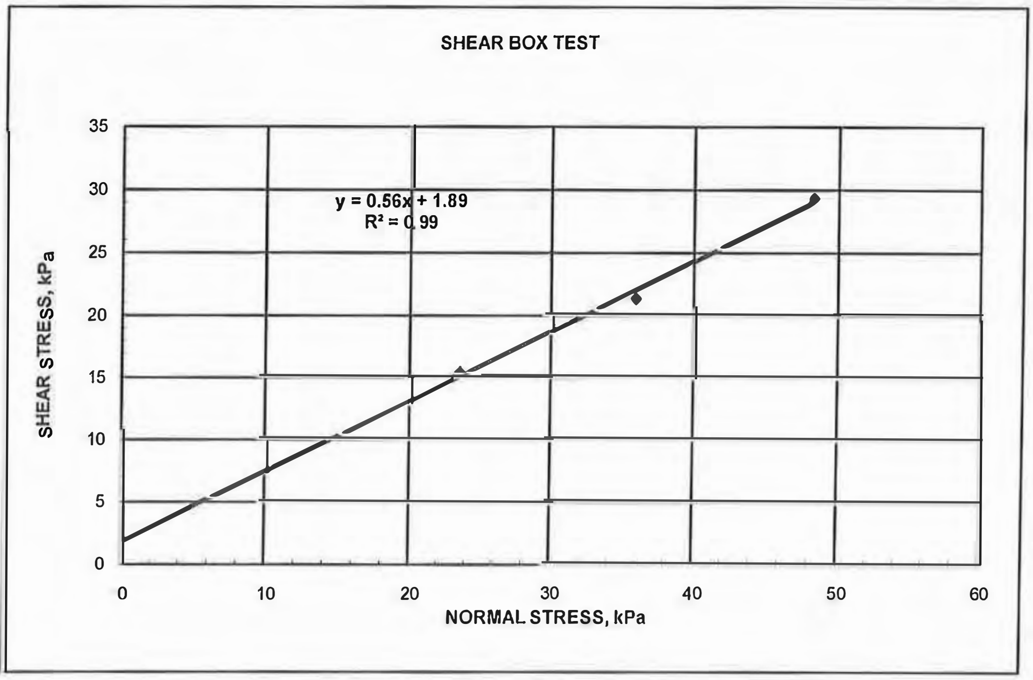
Sample No. 10 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 7.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15.5	15.3
28.94	35.77	21.5	21.3
38.94	48.13	29.5	29.2



Cohesion = 1.9 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

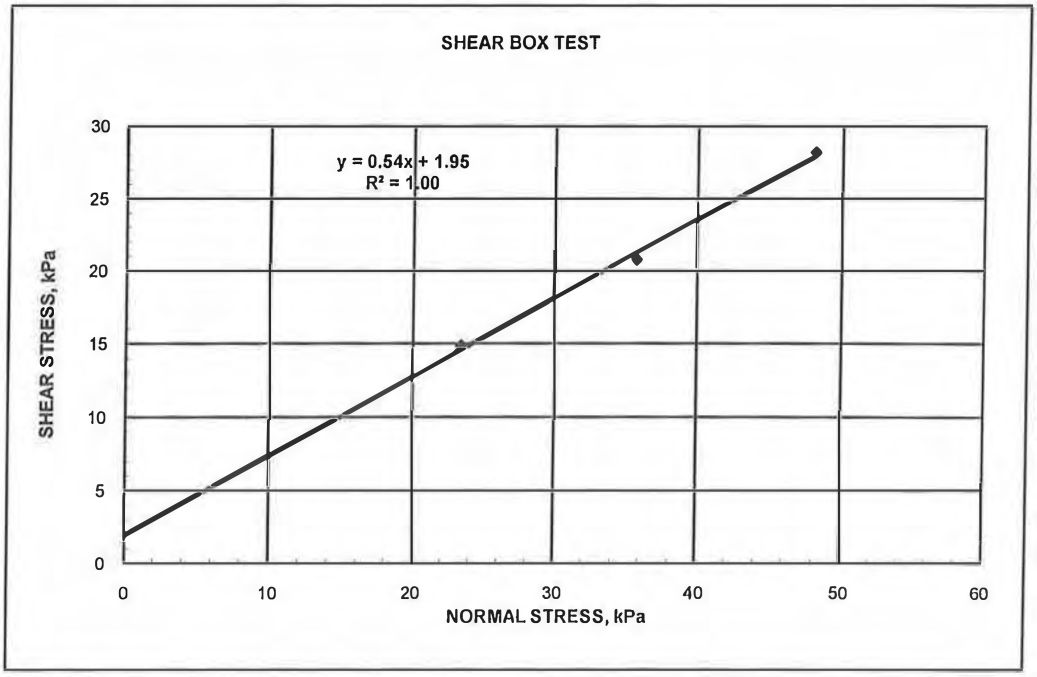
Sample No. 11 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	21	20.8
38.94	48.13	28.5	28.2



Cohesion = 2.0 kPa Angle of Internal Friction, ϕ = 28 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

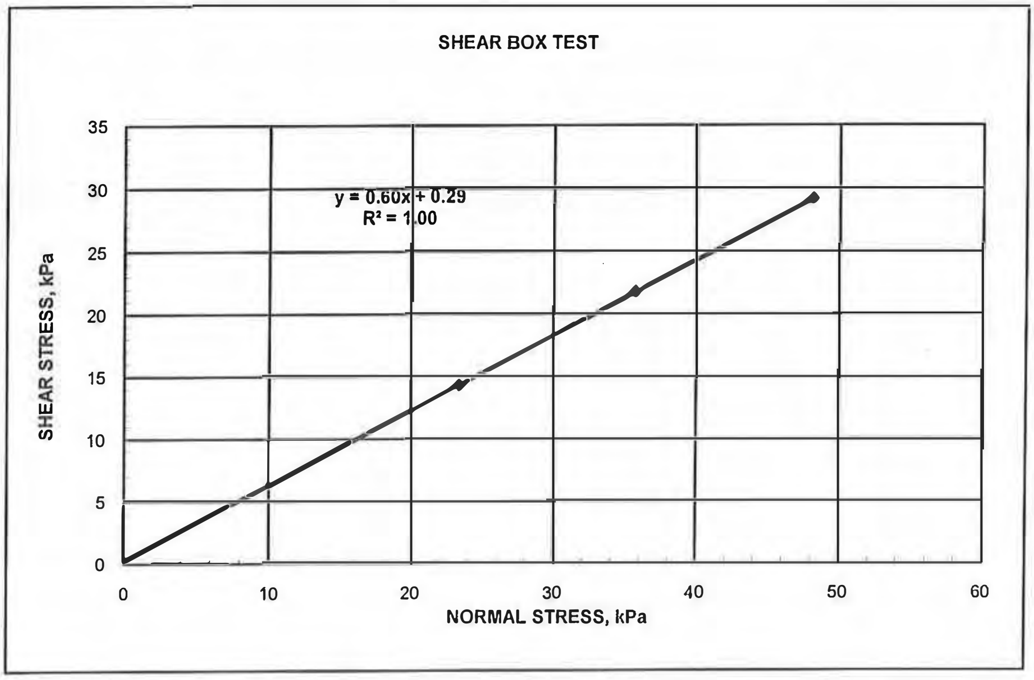
Sample No. 12 (UDS) **Remoulded Dry Density =** **16.8** kN/m³

Depth (m): 20.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m³
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	14.5	14.3
28.94	35.77	22	21.8
38.94	48.13	29.5	29.2



Cohesion = 0.3 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

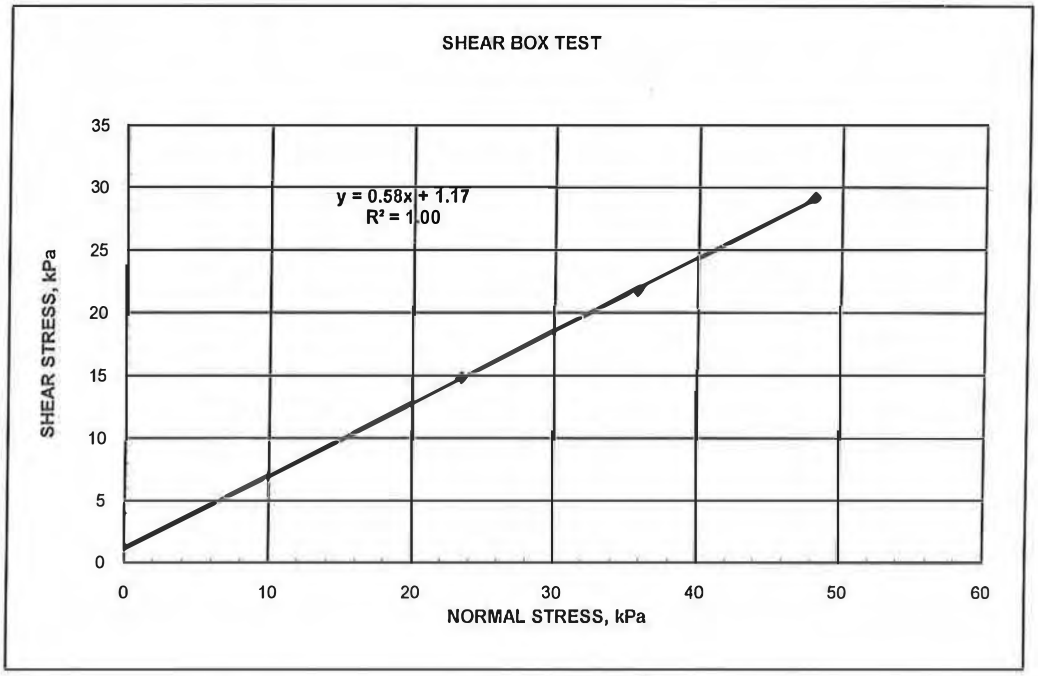
Sample No. 13 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	29.5	29.2



Cohesion = 1.2 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

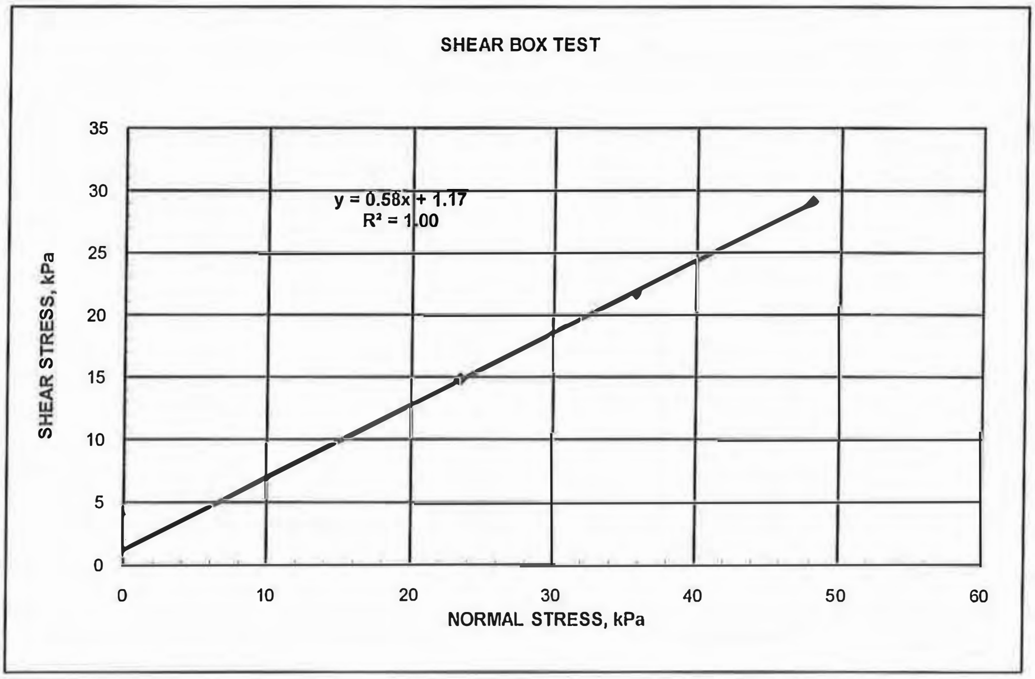
Sample No. 14 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 30.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	29.5	29.2



Cohesion = 1.2 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

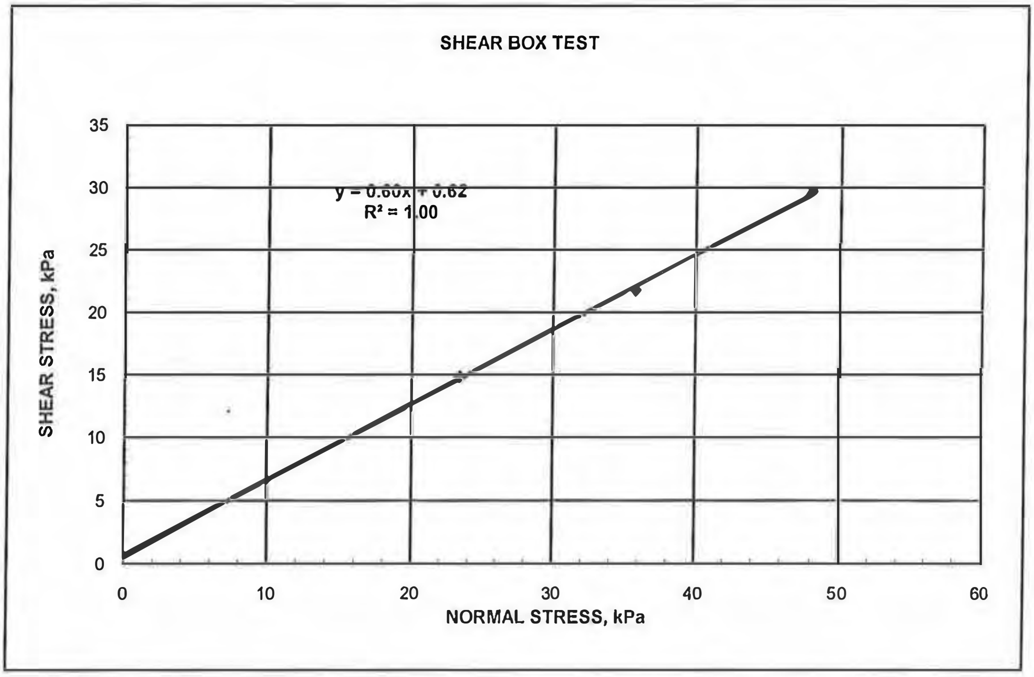
Sample No. 15 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 35.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-02

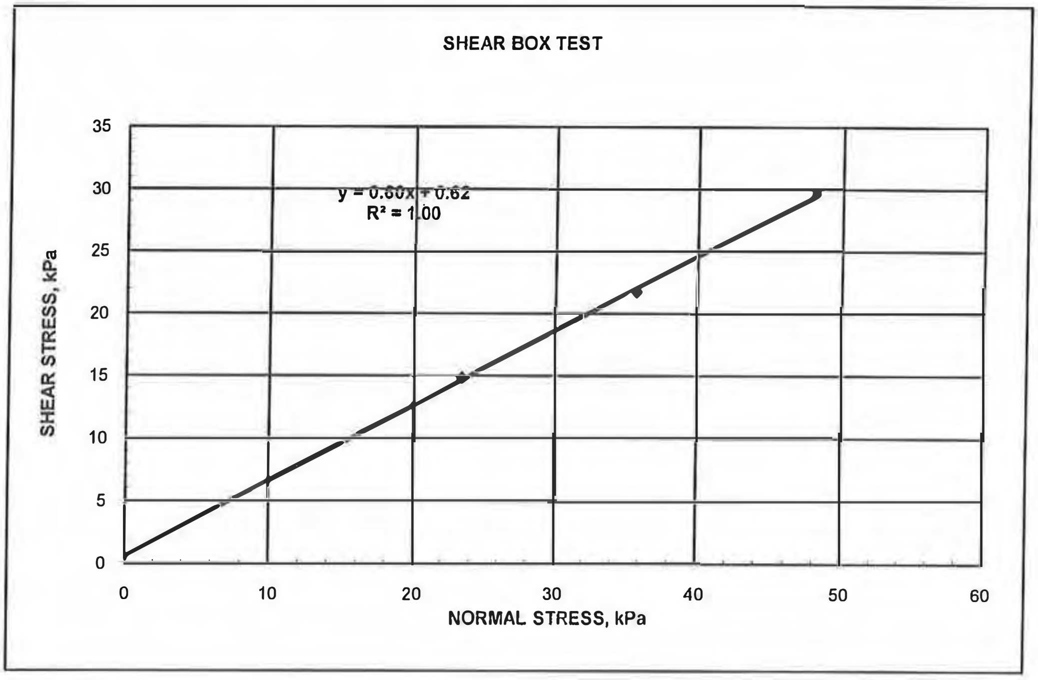
Sample No. 16 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 40.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-03

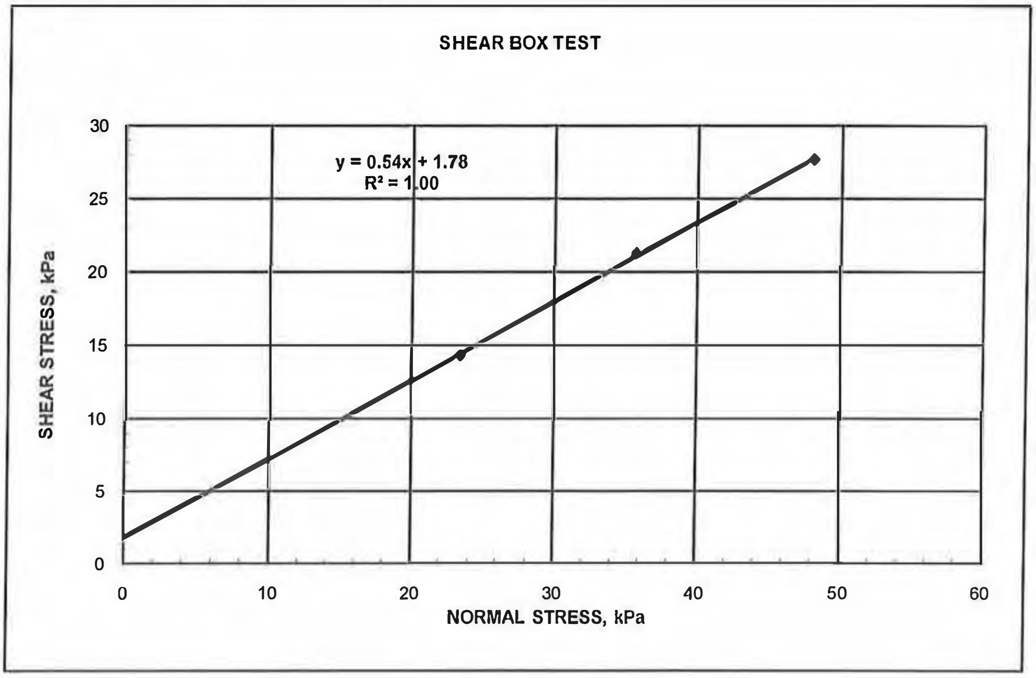
Sample No. 17 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 5.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	14.5	14.3
28.94	35.77	21.5	21.3
38.94	48.13	28	27.7



Cohesion = 1.8 kPa Angle of Internal Friction, ϕ = 28 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-03

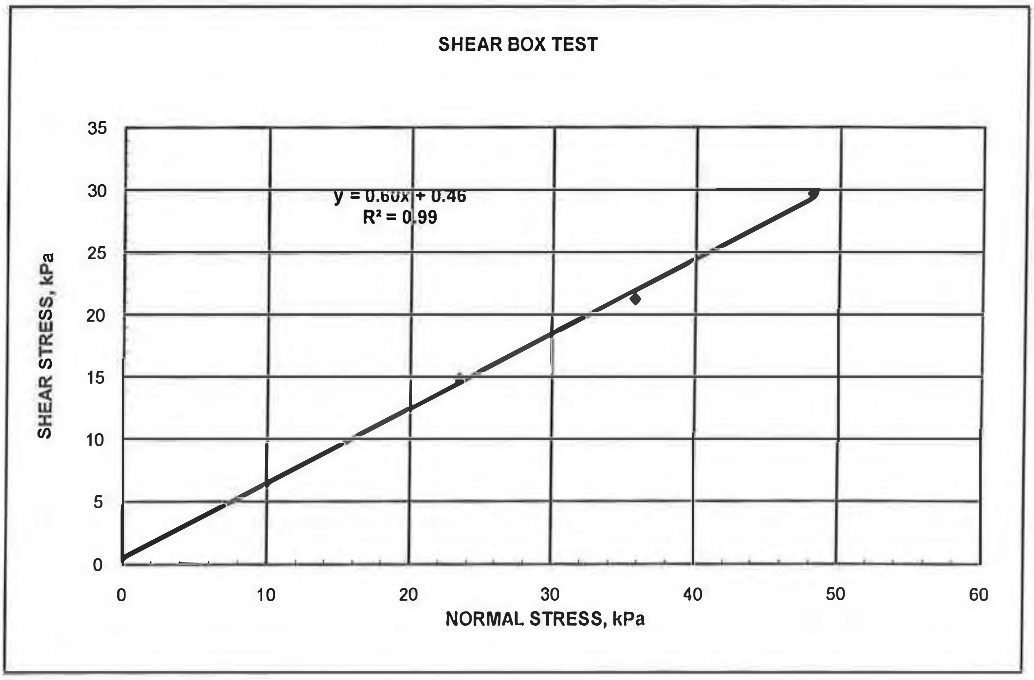
Sample No. 18 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 11.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	21.5	21.3
38.94	48.13	30	29.7



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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Checked by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-03

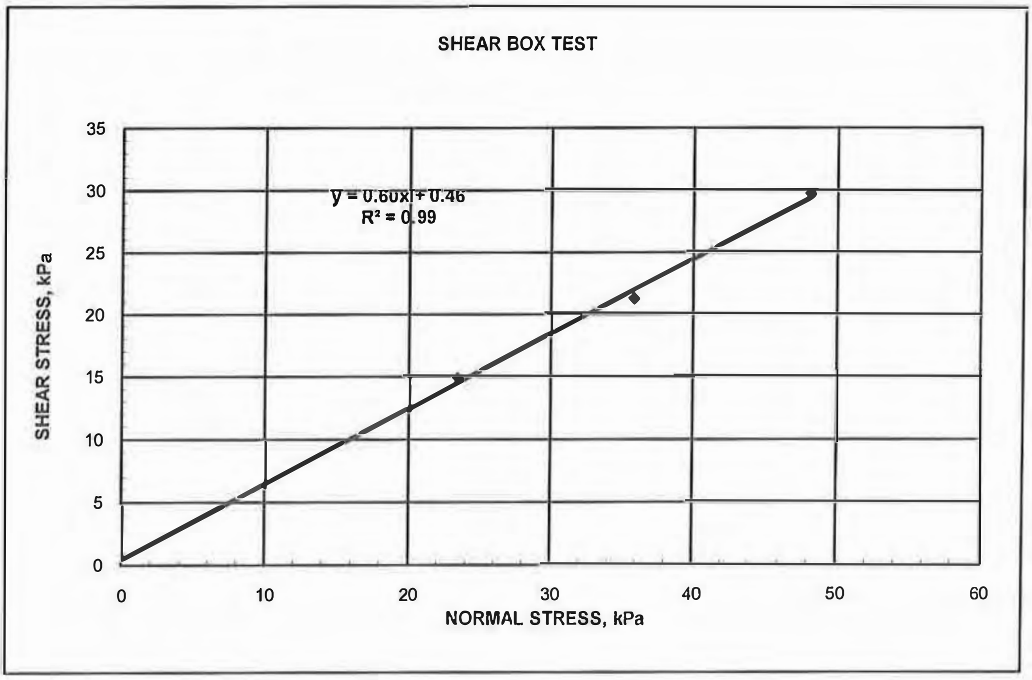
Sample No. 19 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	21.5	21.3
38.94	48.13	30	29.7



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-03

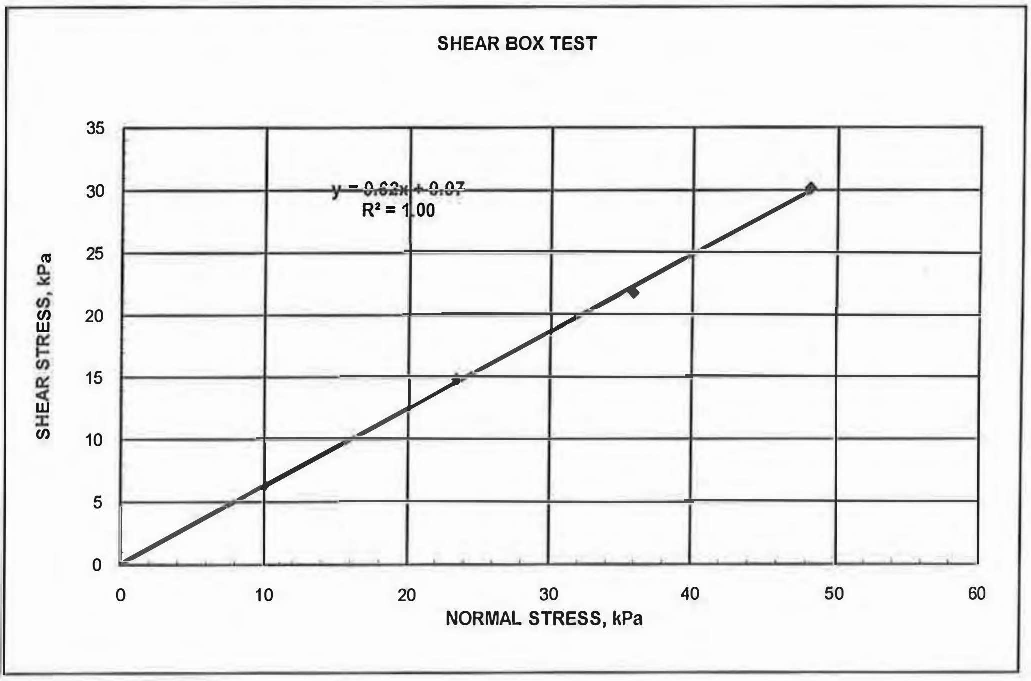
Sample No. 20 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 21.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30.5	30.2



Cohesion = 0.1 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-03

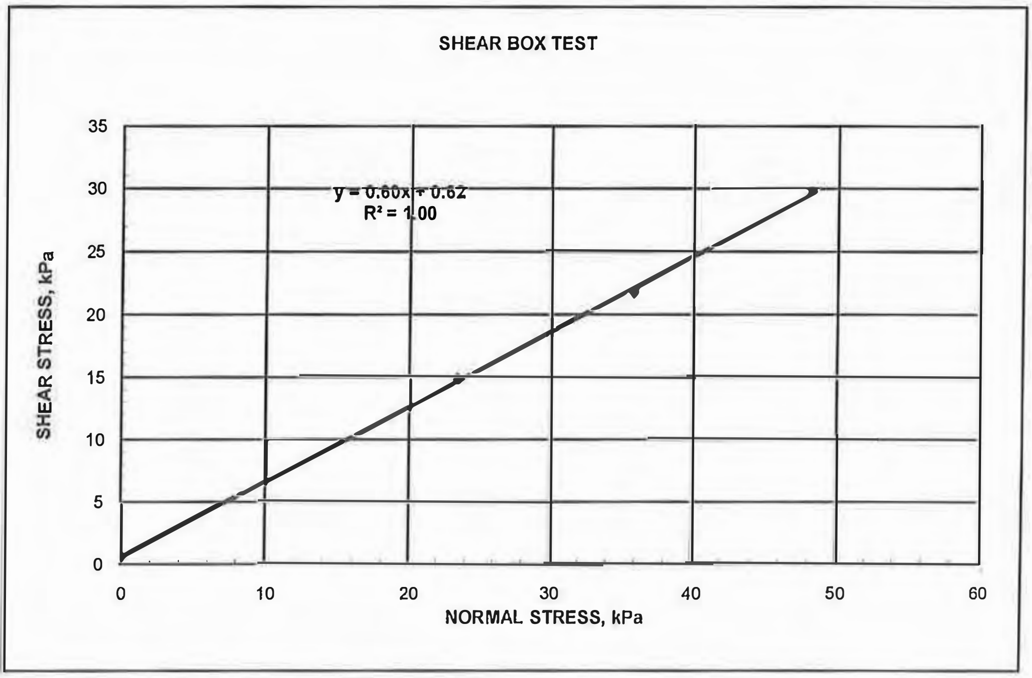
Sample No. 21 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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Checked by:

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Client: M/S ECOS Ltd

BH/TP No. BH-03

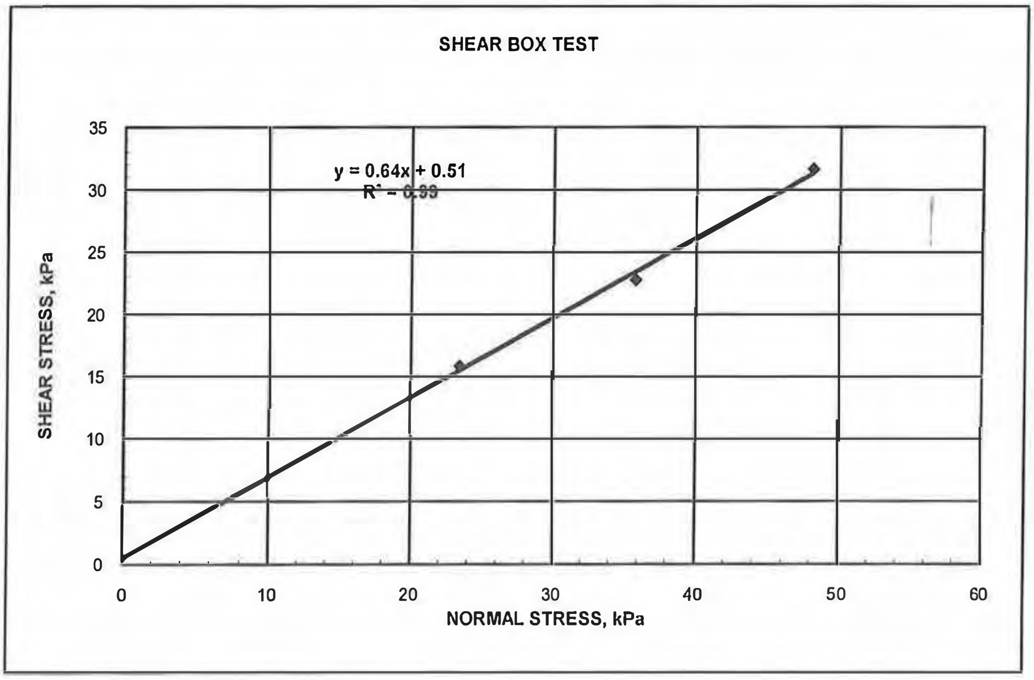
Sample No. 22 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 31.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	23	22.7
38.94	48.13	32	31.6



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

Director

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

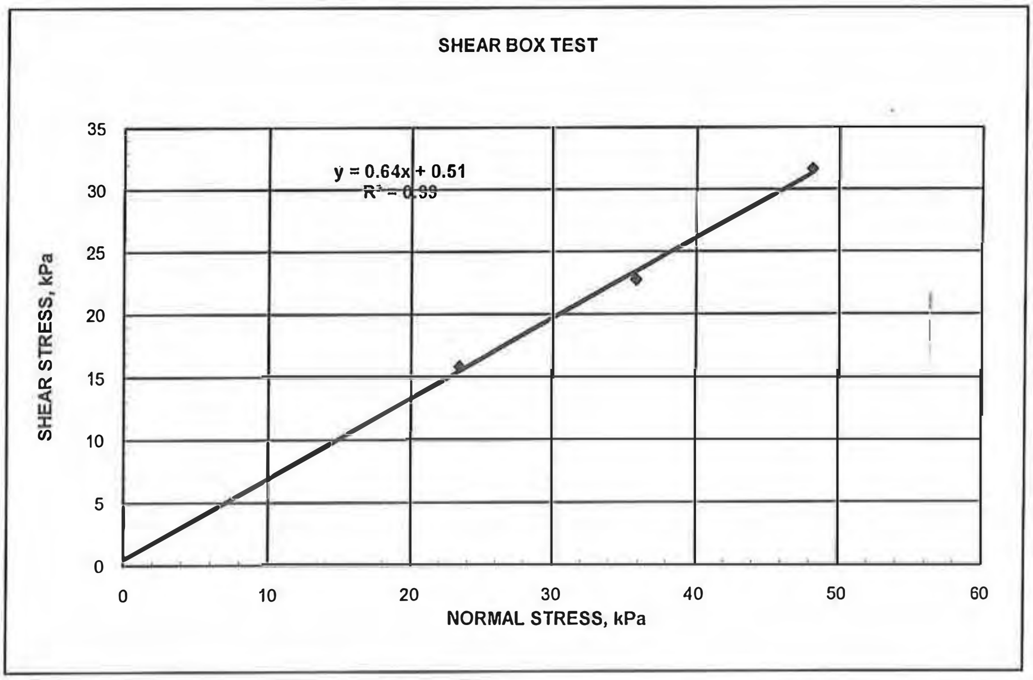
Client: M/S ECOS Ltd

BH/TP No. BH-03
Sample No. 23 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 35.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	23	22.7
38.94	48.13	32	31.6



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

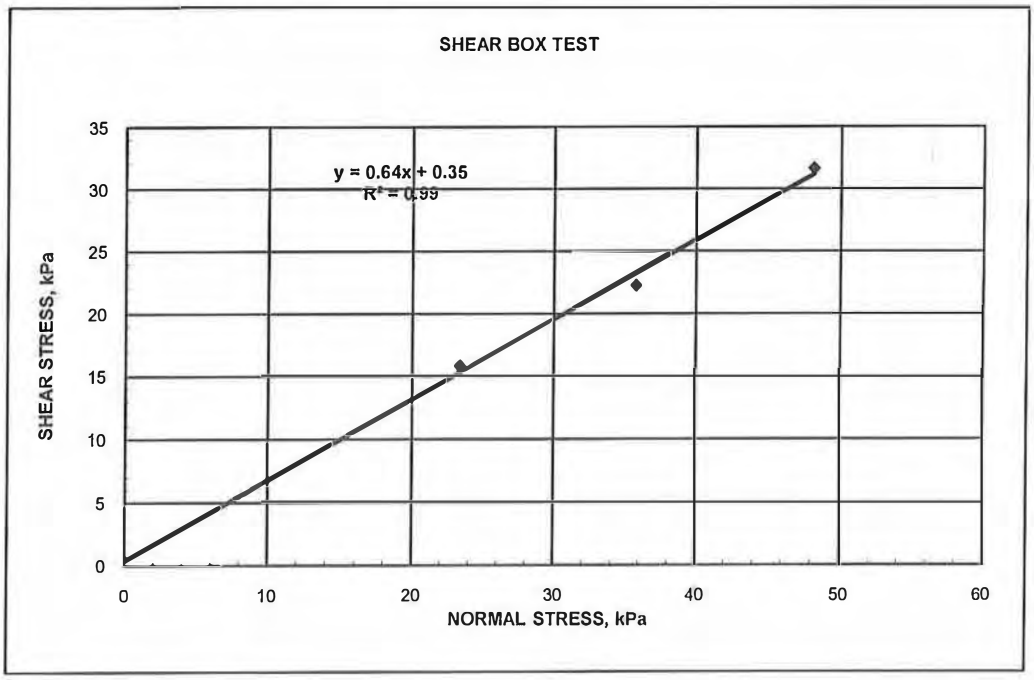
Client: M/S ECOS Ltd

BH/TP No. BH-03
Sample No. 24 (SPT) **Remoulded Dry Density =** **16.8** kN/m^3
Depth (m): 40.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	22.5	22.2
38.94	48.13	32	31.6



Cohesion = 0.4 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

Geotech. Engg. Lab Director Civil Engg. Dept. UET Lhr.

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-04

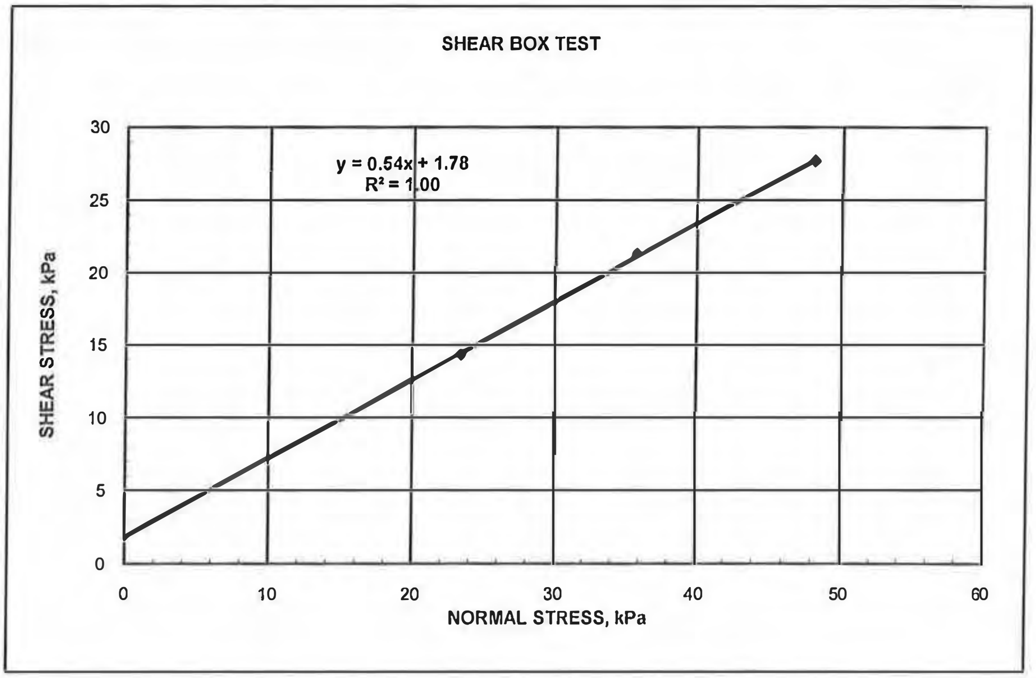
Sample No. 25 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 5.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	14.5	14.3
28.94	35.77	21.5	21.3
38.94	48.13	28	27.7



Cohesion = 1.8 kPa Angle of Internal Friction, ϕ = 28 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-04

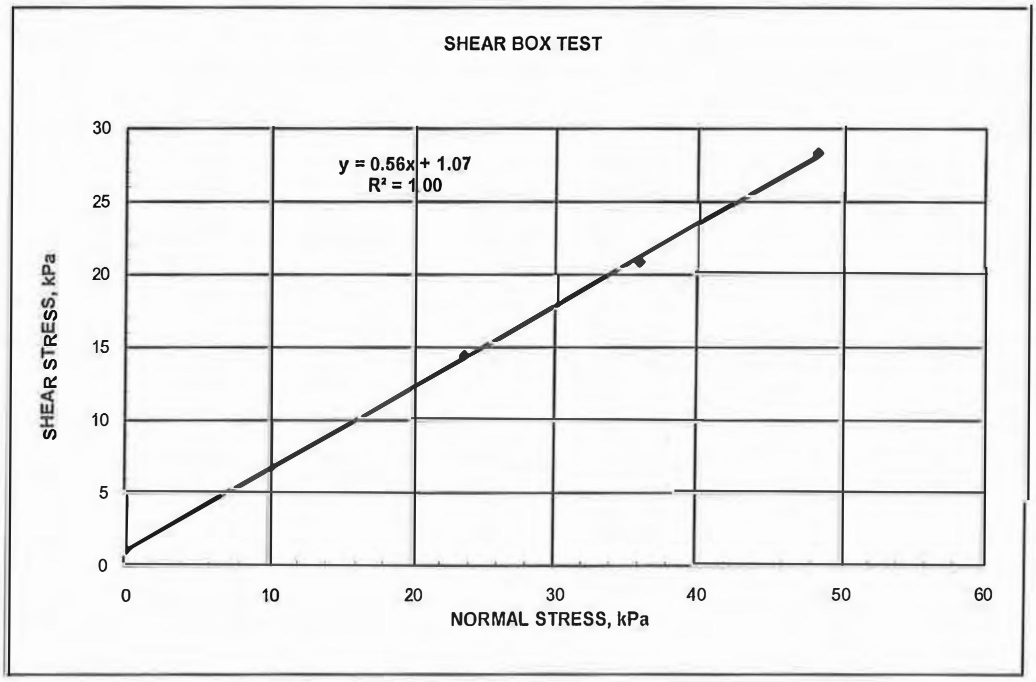
Sample No. 26 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 11.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	14.5	14.3
28.94	35.77	21	20.8
38.94	48.13	28.5	28.2



Cohesion = 1.1 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Civil Engg Dept UET Lhr.

University of Engineering & Technology, Lahore
Department of Civil Engineering
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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-04

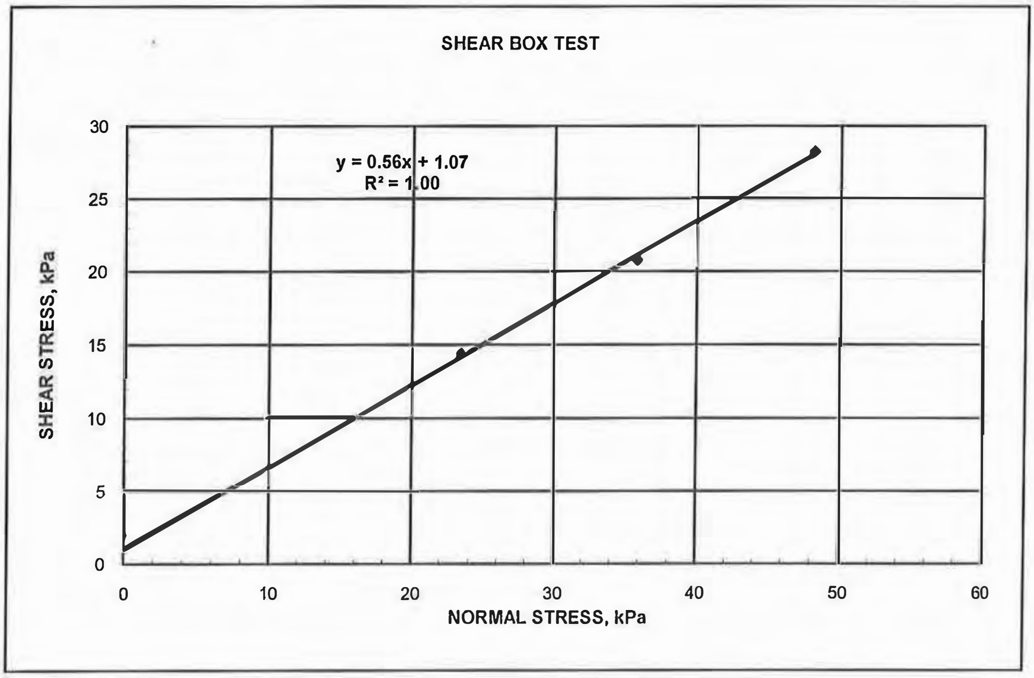
Sample No. 27 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	14.5	14.3
28.94	35.77	21	20.8
38.94	48.13	28.5	28.2



Cohesion = 1.1 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-04

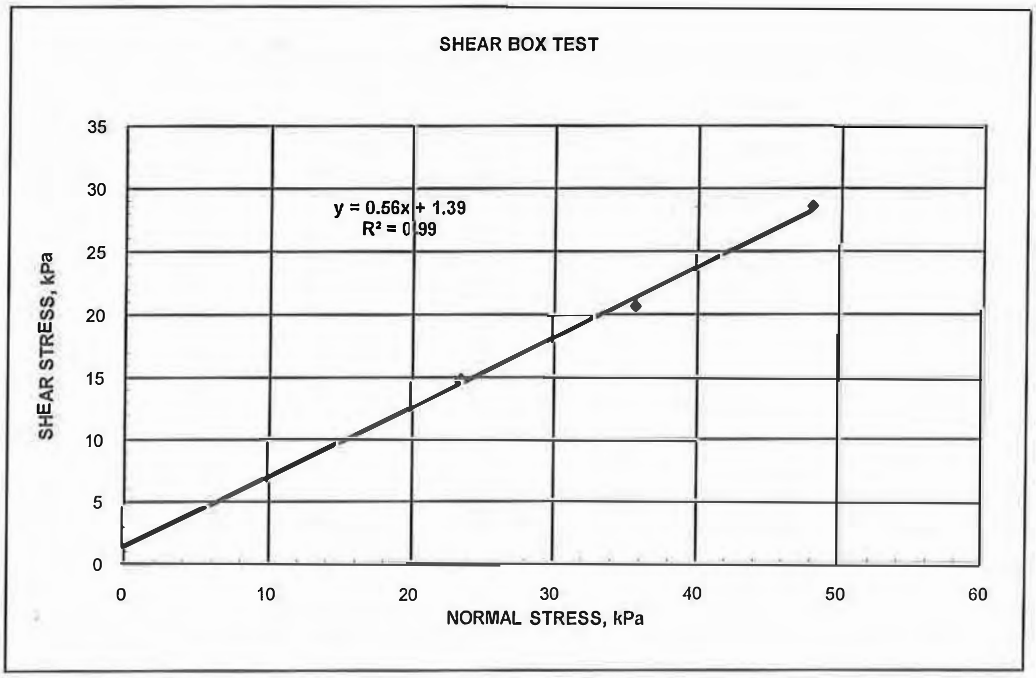
Sample No. 28 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 21.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	21	20.8
38.94	48.13	29	28.7



Cohesion = 1.4 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-04

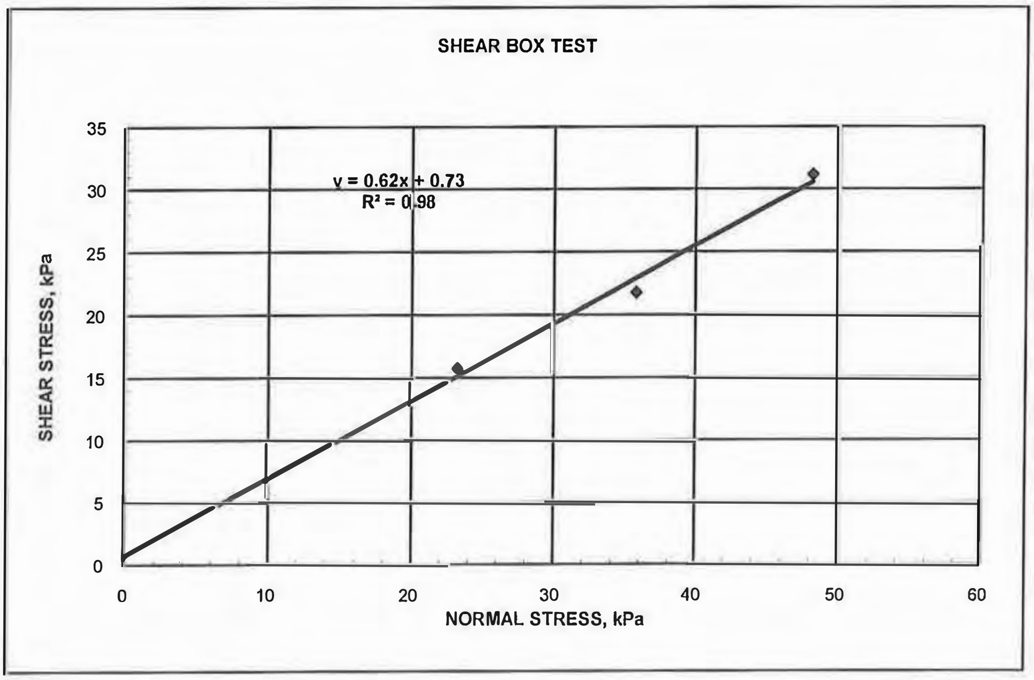
Sample No. 29 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	16	15.8
28.94	35.77	22	21.8
38.94	48.13	31.5	31.1



Cohesion = 0.7 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECDS Ltd

BH/TP No. BH-04

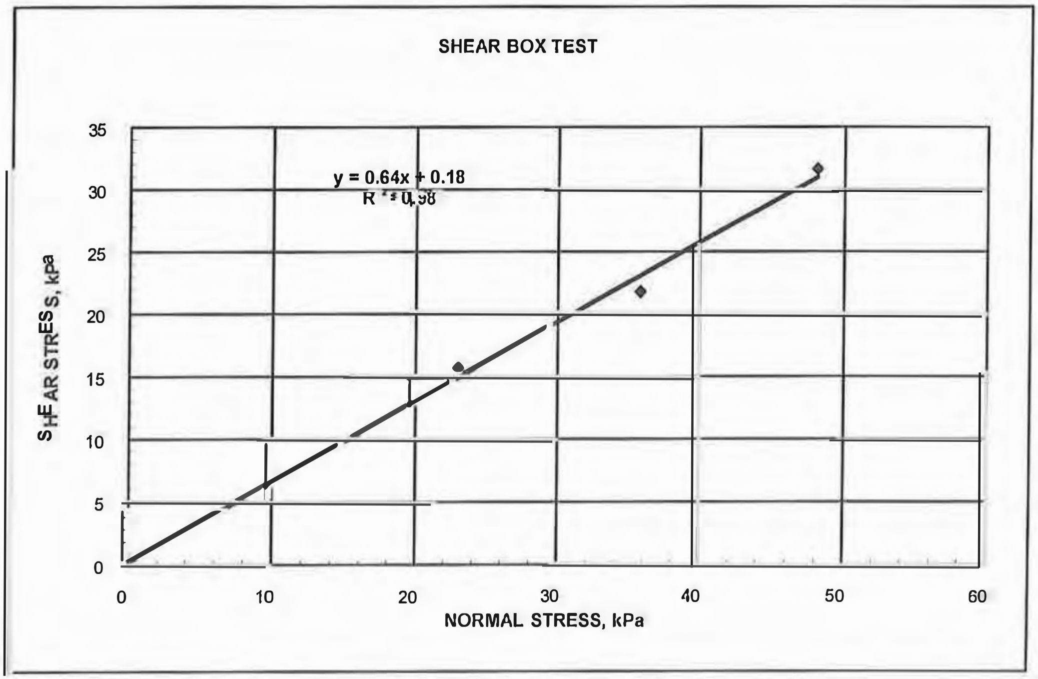
Sample No. 30 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 31.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	22	21.8
38.94	48.13	32	31.6



Cohesion = 0.2 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

Geotech Lab * Director * Civil Engg Deptt UET Lhr.

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

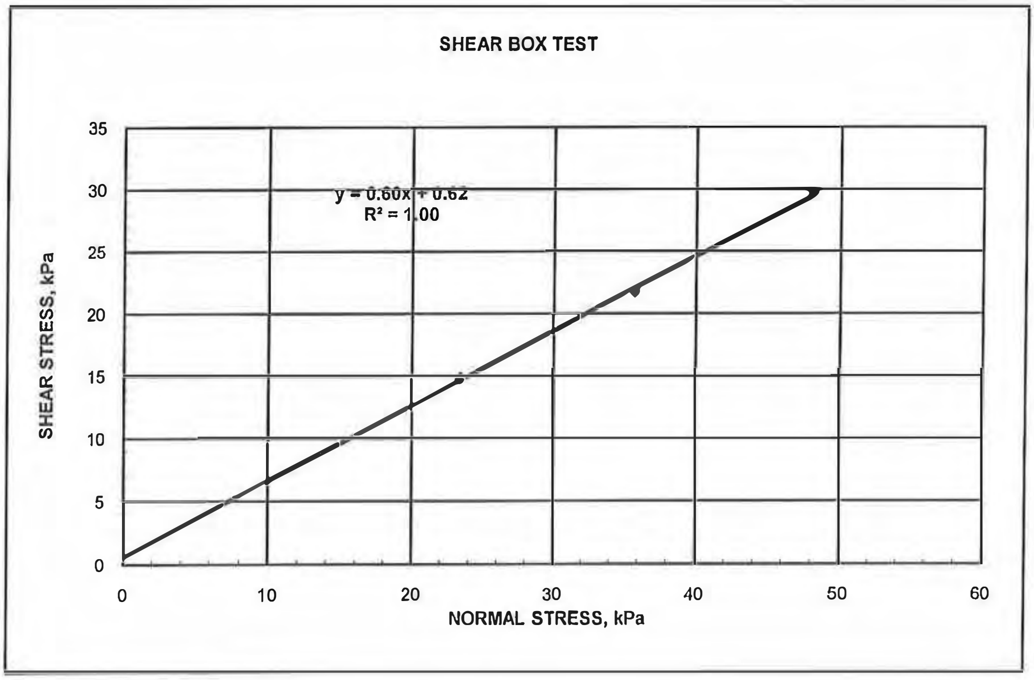
Client: M/S ECOS Ltd

BH/TP No. BH-04
Sample No. 31 (SPT) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 36.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.2 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

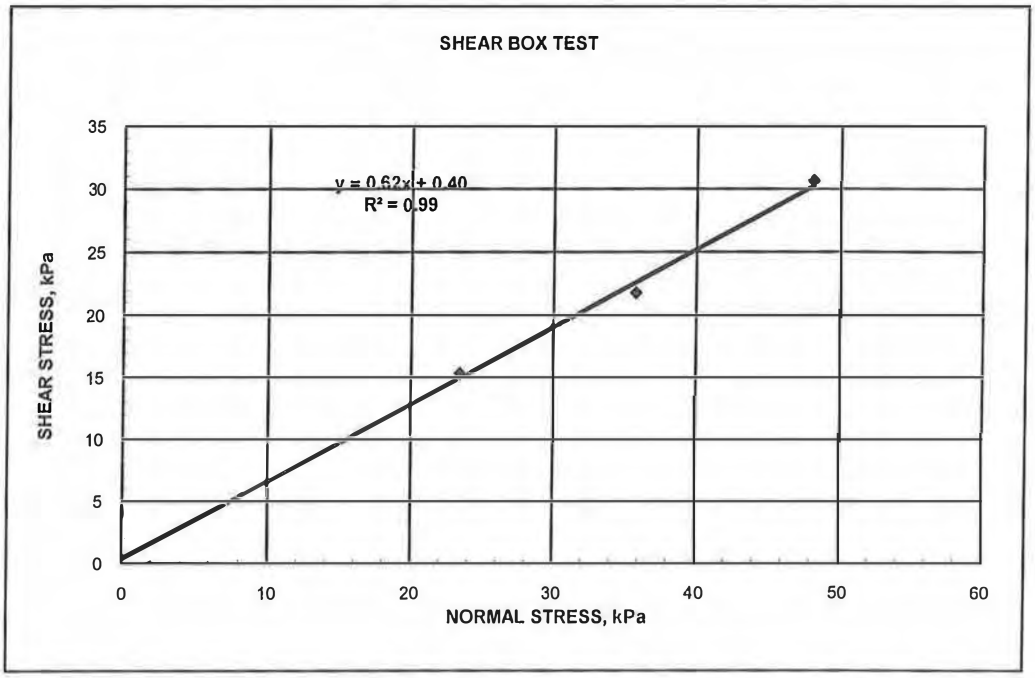
Client: M/S ECOS Ltd

BH/TP No. BH-04
Sample No. 32 (SPT) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 40.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15.5	15.3
28.94	35.77	22	21.8
38.94	48.13	31	30.7



Cohesion = 0.4 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

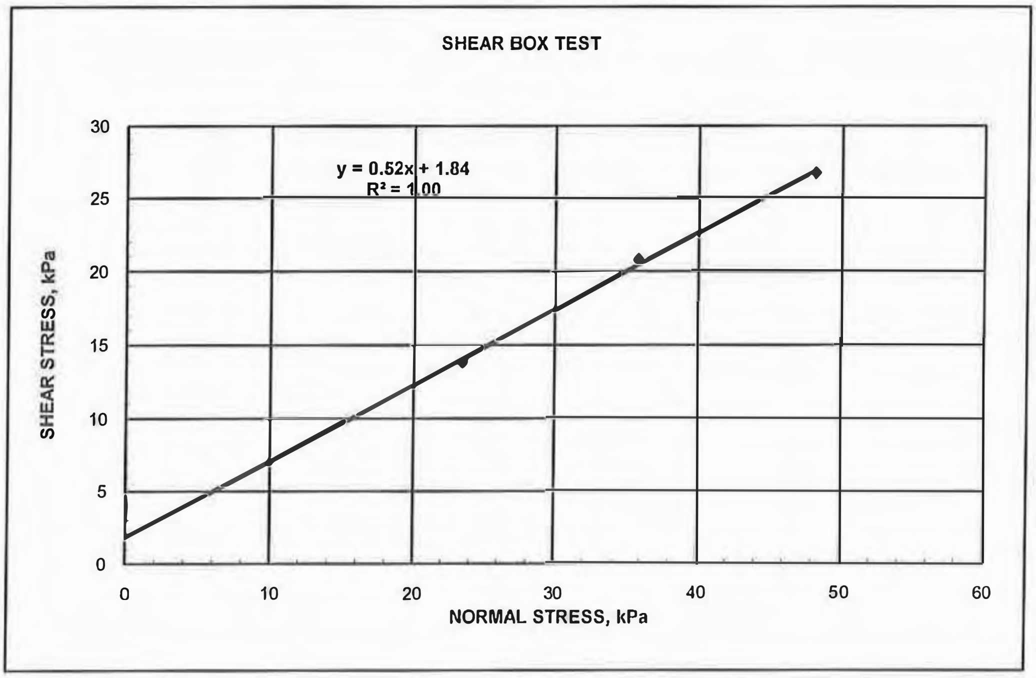
Client: M/S ECOS Ltd

BH/TP No. BH-05
Sample No. 33 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 5.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	14	13.8
28.94	35.77	21	20.8
38.94	48.13	27	26.7



Cohesion = 1.8 kPa Angle of Internal Friction, ϕ = 27 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-05

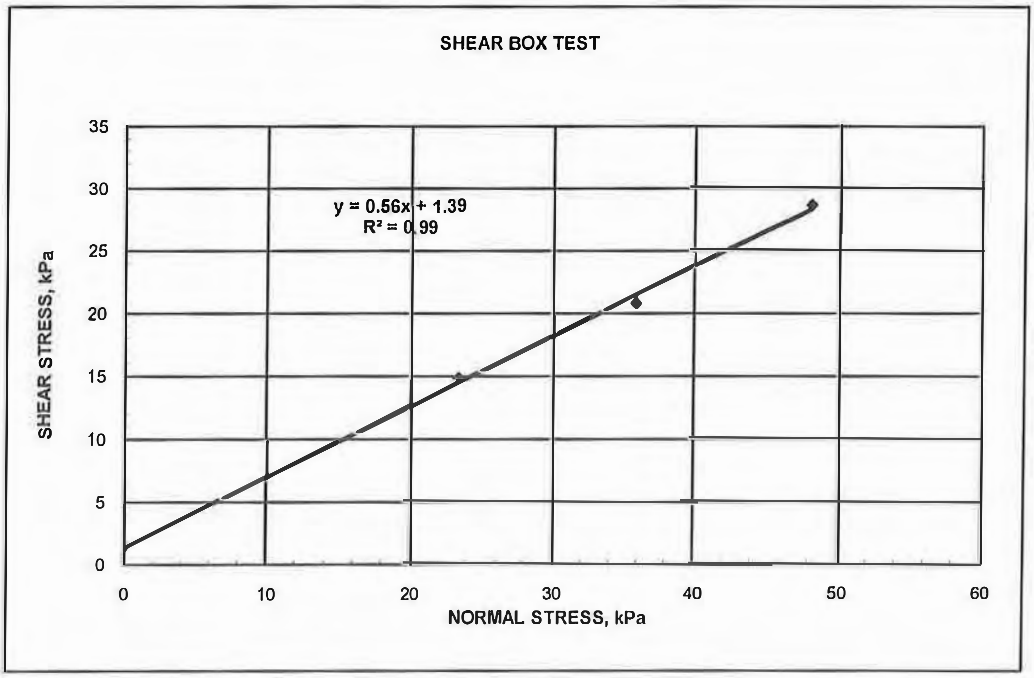
Sample No. 34 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 11.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	21	20.8
38.94	48.13	29	28.7



Cohesion = 1.4 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-05

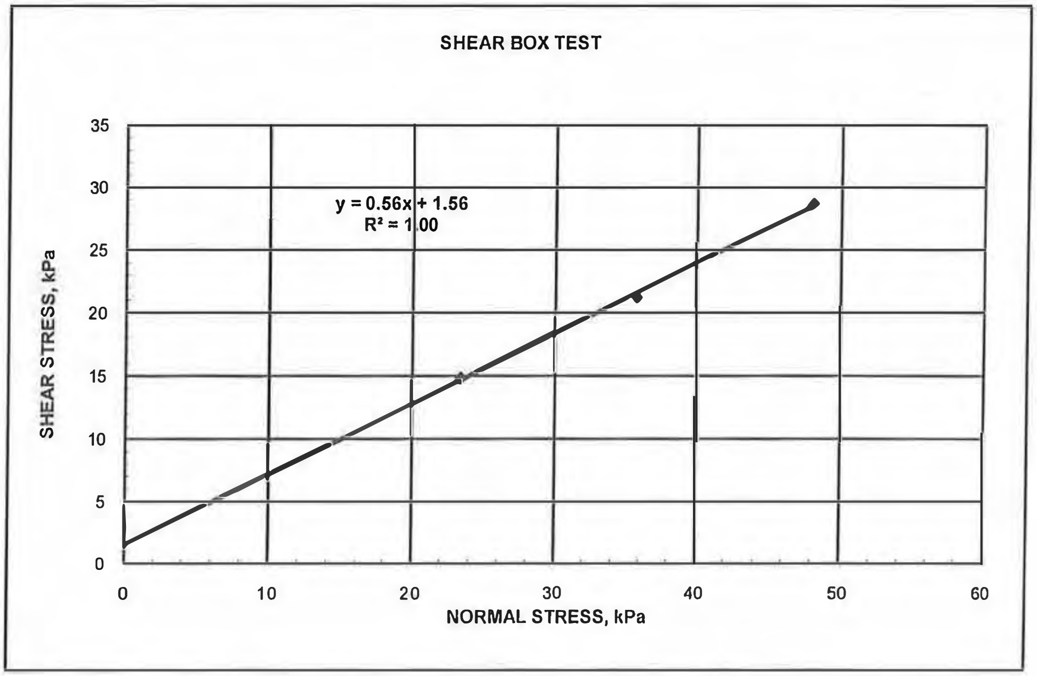
Sample No. 35 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	21.5	21.3
38.94	48.13	29	28.7



Cohesion = 1.6 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

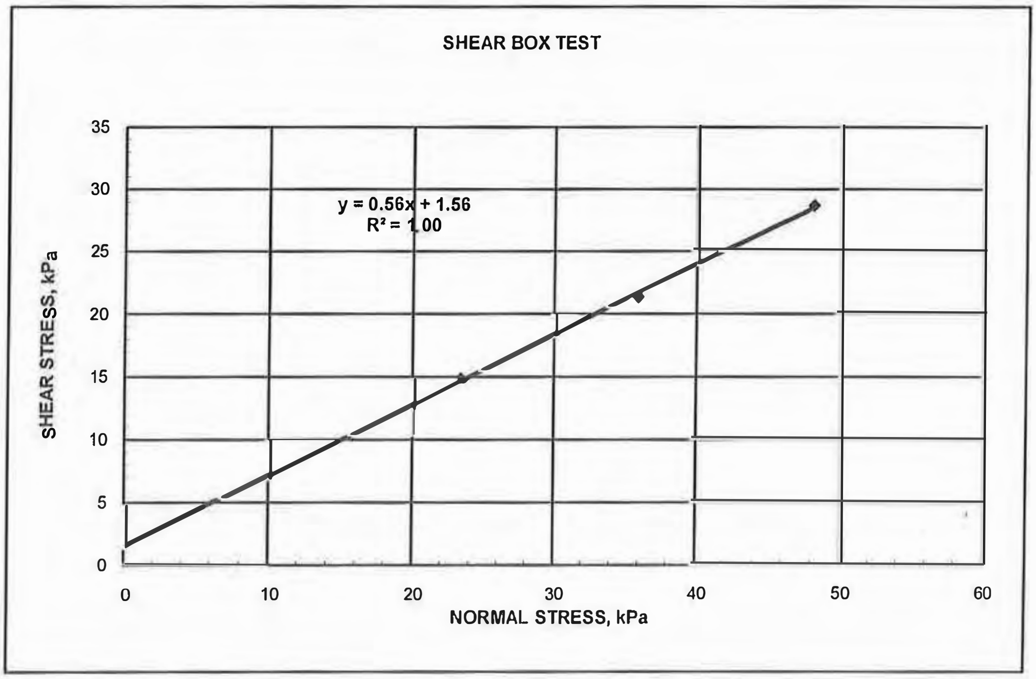
Client: M/S ECOS Ltd

BH/TP No. BH-05
Sample No. 36 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3
Depth (m): 21.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	21.5	21.3
38.94	48.13	29	28.7



Cohesion = 1.6 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

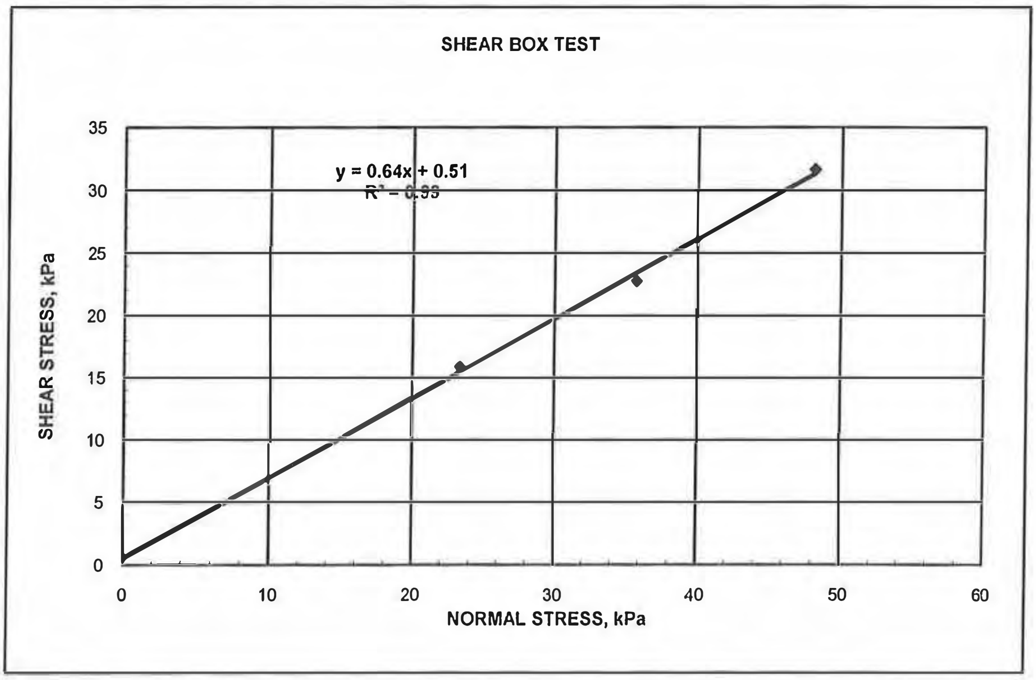
Client: M/S ECOS Ltd

BH/TP No. BH-05
Sample No. 37 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	23	22.7
38.94	48.13	32	31.6



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by: Checked by:

Director

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-05

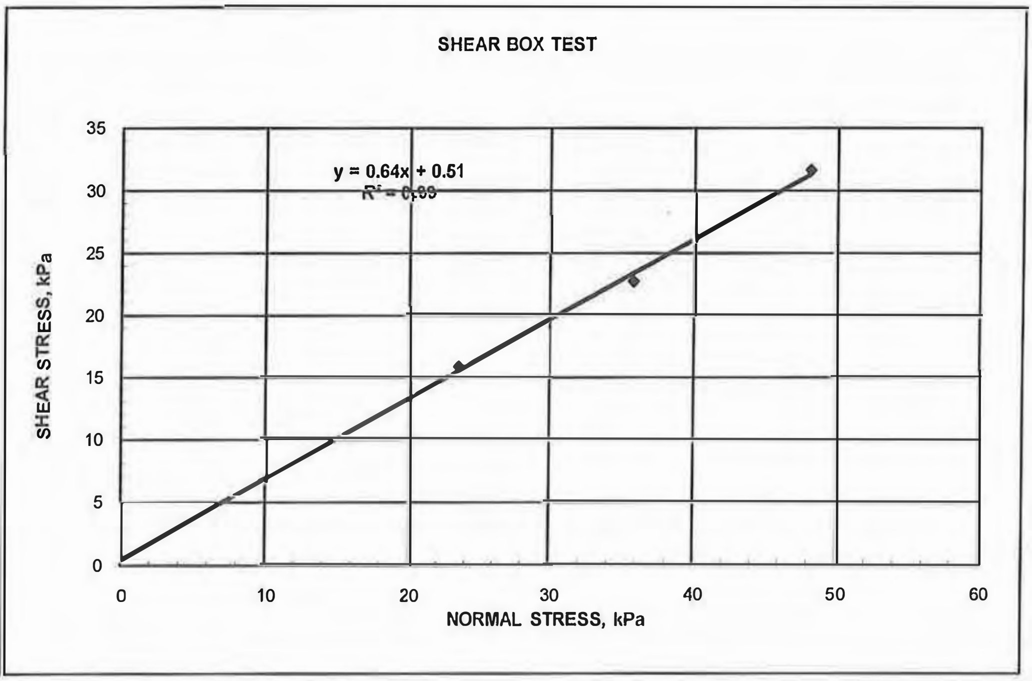
Sample No. 38 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 31.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	23	22.7
38.94	48.13	32	31.6



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

Geotech. Engg. Lab * Director * Civil Engg Dept UET LHR

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-05

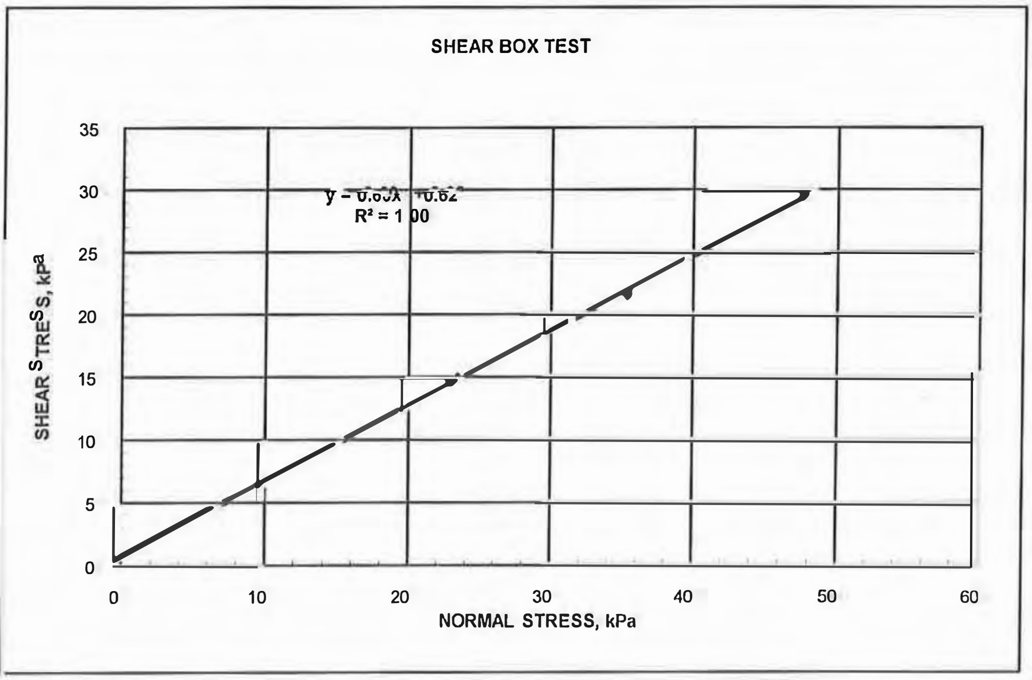
Sample No. 39 (SPT) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 36.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

Geotech Engg Lab Director Civil Engg Dept UET Lhr.

University of Engineering & Technology, Lahore
Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

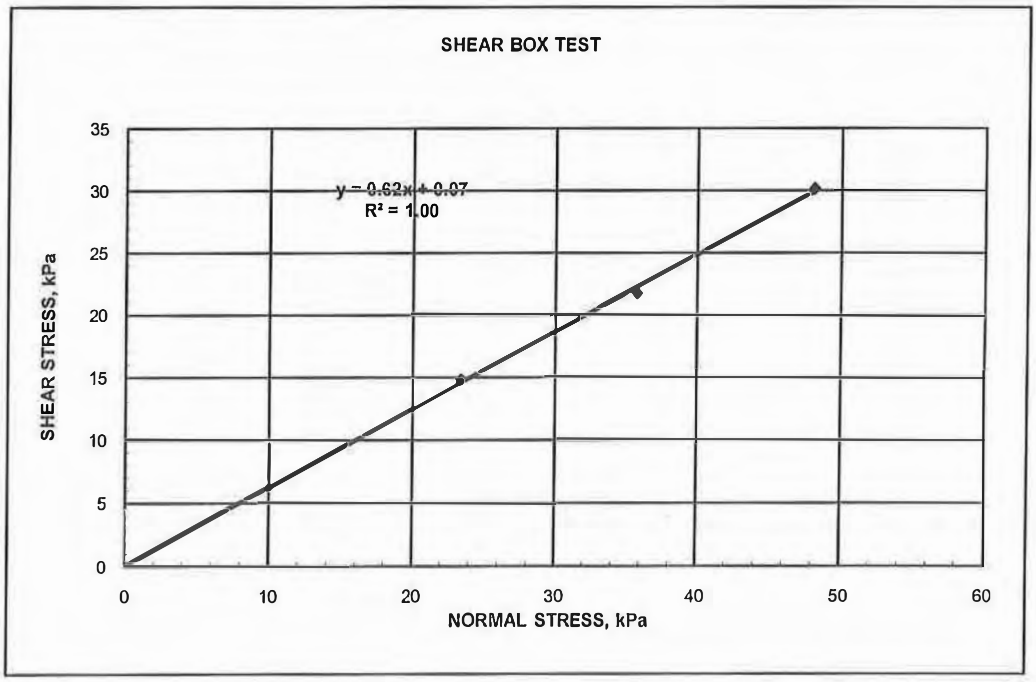
Client: M/S ECOS Ltd

BH/TP No. BH-05
Sample No. 40 (SPT) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 40.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30.5	30.2



Cohesion = 0.1 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-06

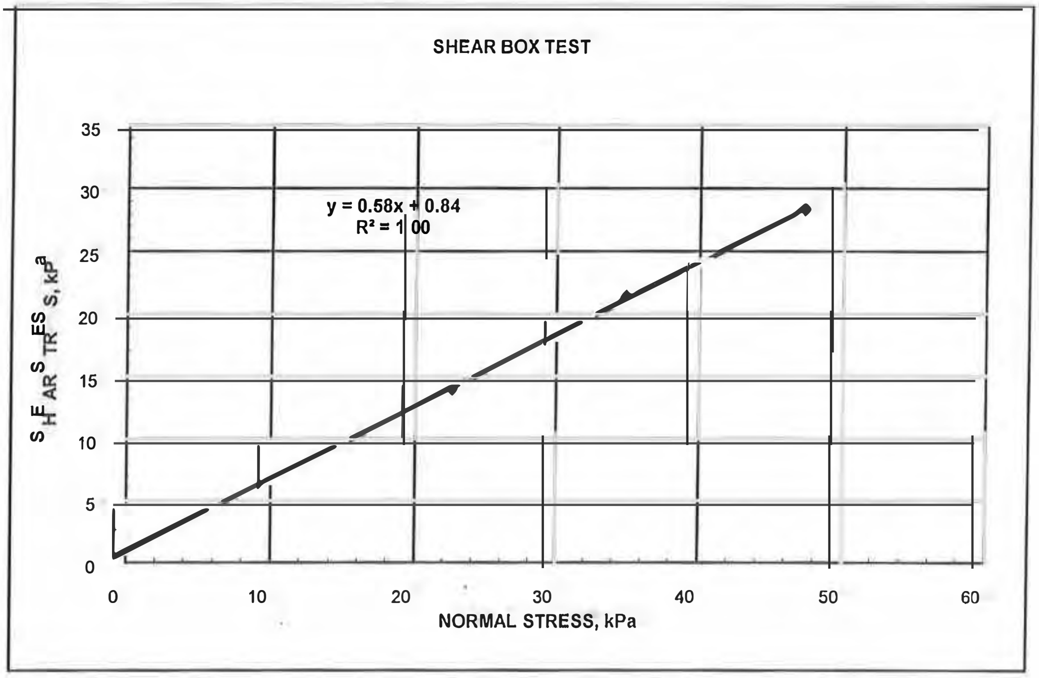
Sample No. 42 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 5.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	14.5	14.3
28.94	35.77	22	21.8
38.94	48.13	29	28.7



Cohesion = 0.8 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-06

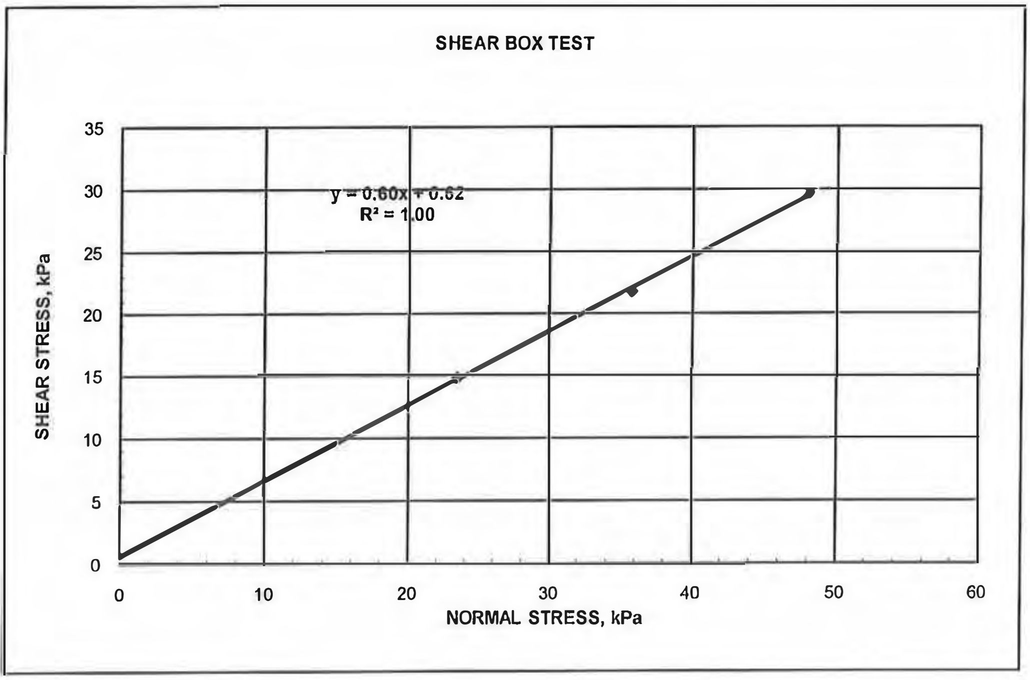
Sample No. 43 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 11.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

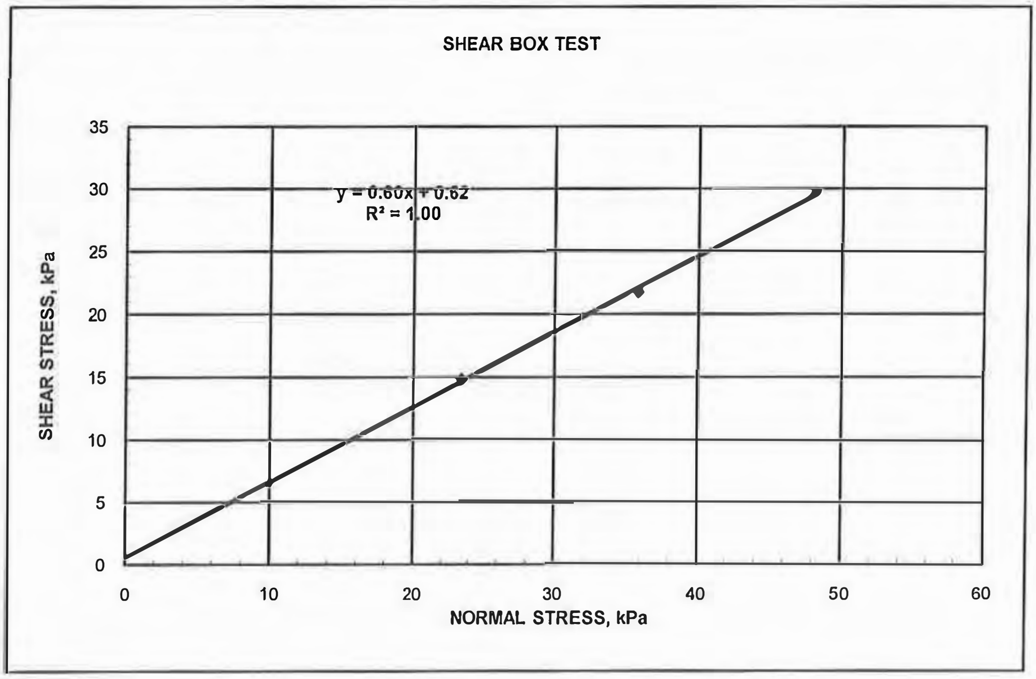
Client: M/S ECOS Ltd

BH/TP No. BH-06
Sample No. 44 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3
Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-06

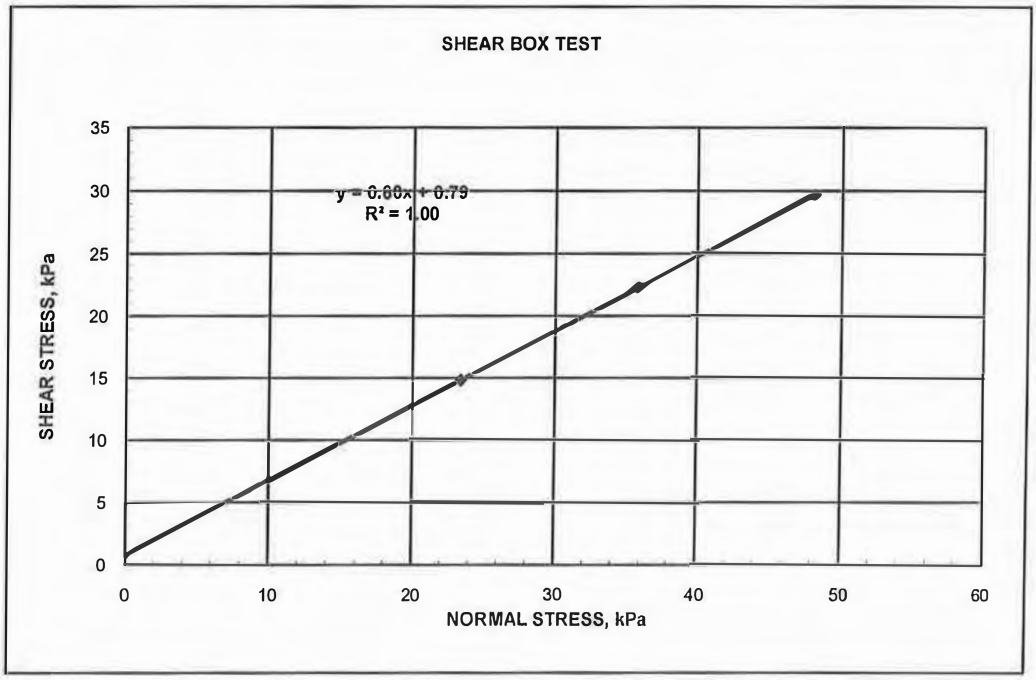
Sample No. 45 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 21.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22.5	22.2
38.94	48.13	30	29.7



Cohesion = 0.8 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-06

Sample No. 46 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

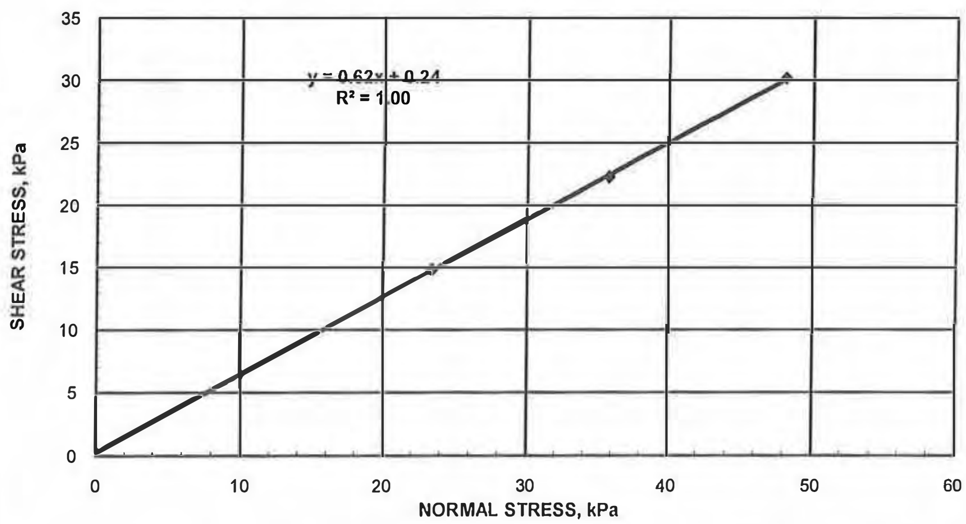
Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22.5	22.2
38.94	48.13	30.5	30.2

SHEAR BOX TEST



Cohesion = 0.2 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECDS Ltd

BH/TP No. BH-06

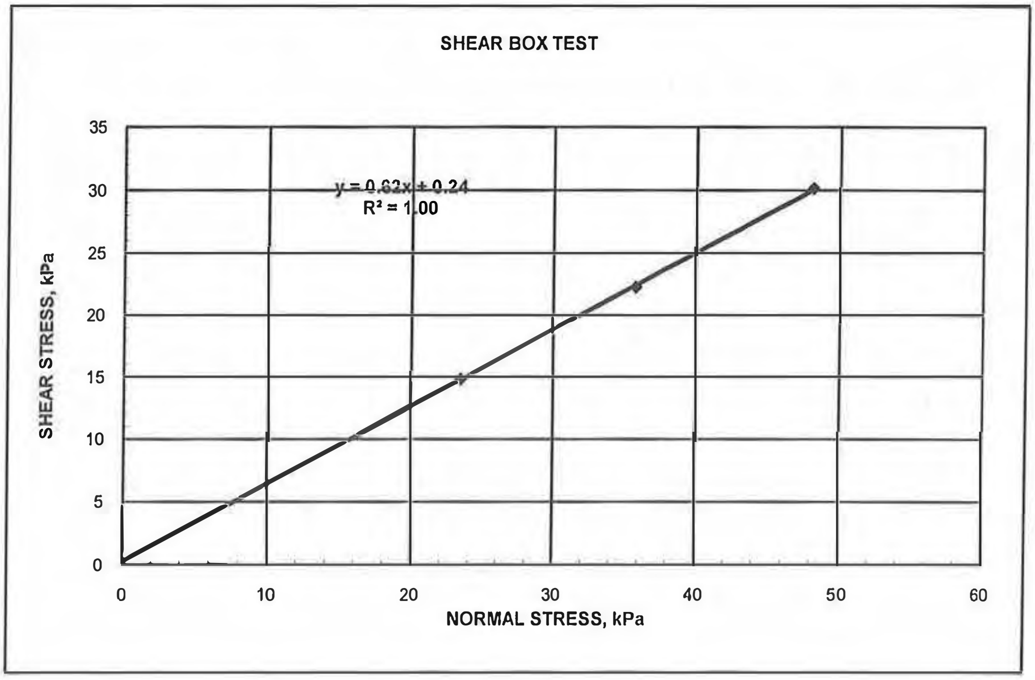
Sample No. 47 (SPT) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 32.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22.5	22.2
38.94	48.13	30.5	30.2



Cohesion = 0.2 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-06

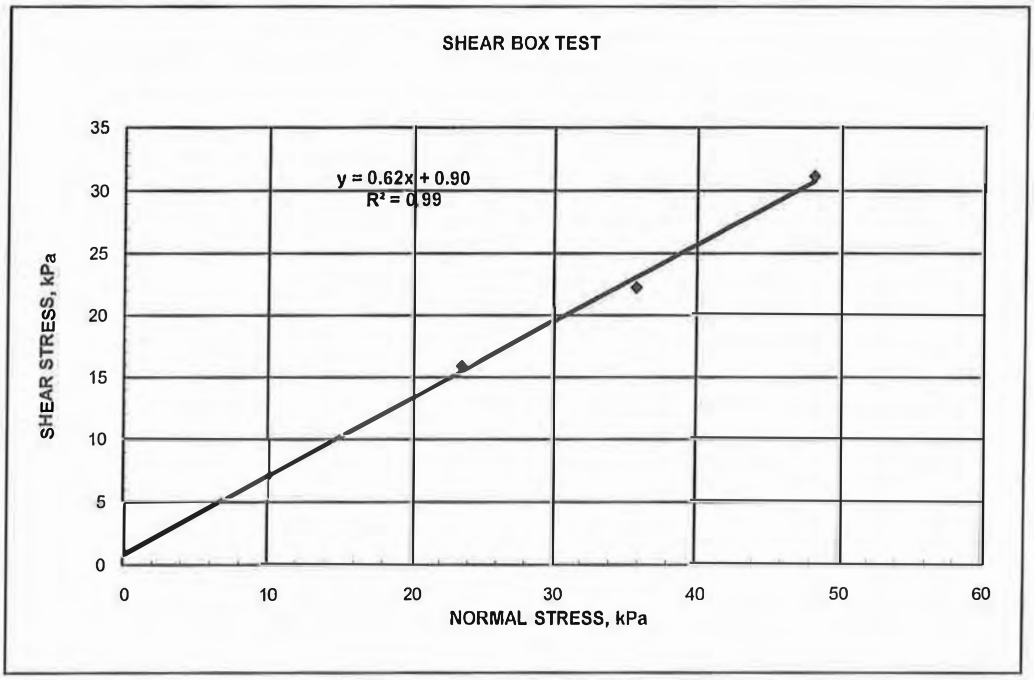
Sample No. 48 (SPT) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 36.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	16	15.8
28.94	35.77	22.5	22.2
38.94	48.13	31.5	31.1



Cohesion = 0.9 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

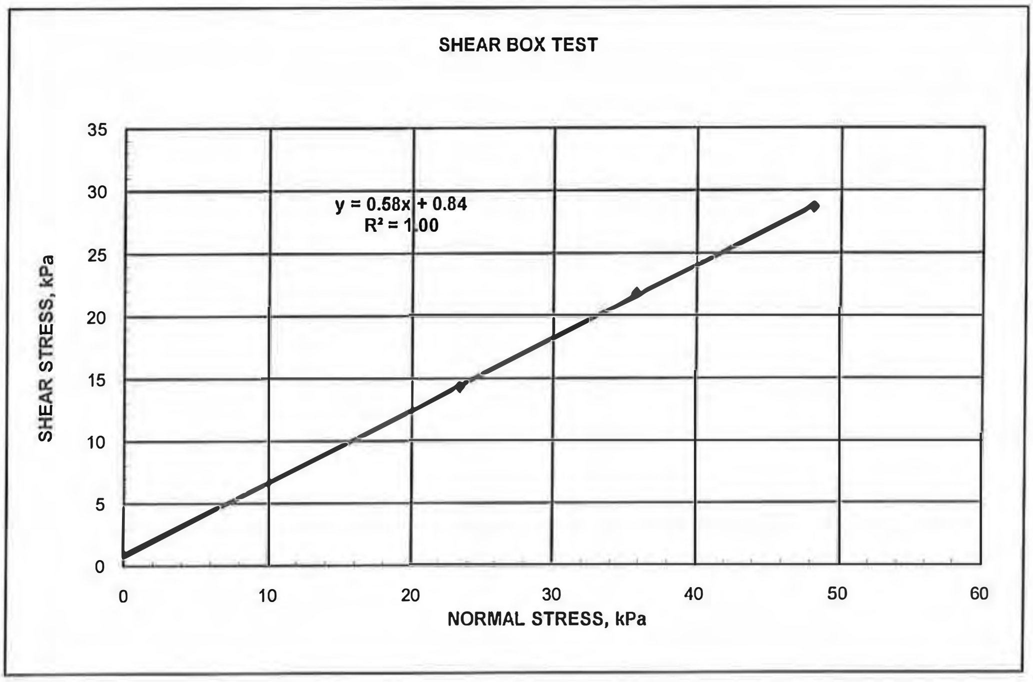
Client: M/S ECOS Ltd

BH/TP No. BH-07
Sample No. 50 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3
Depth (m): 5.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	14.5	14.3
28.94	35.77	22	21.8
38.94	48.13	29	28.7



Cohesion = 0.8 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-07

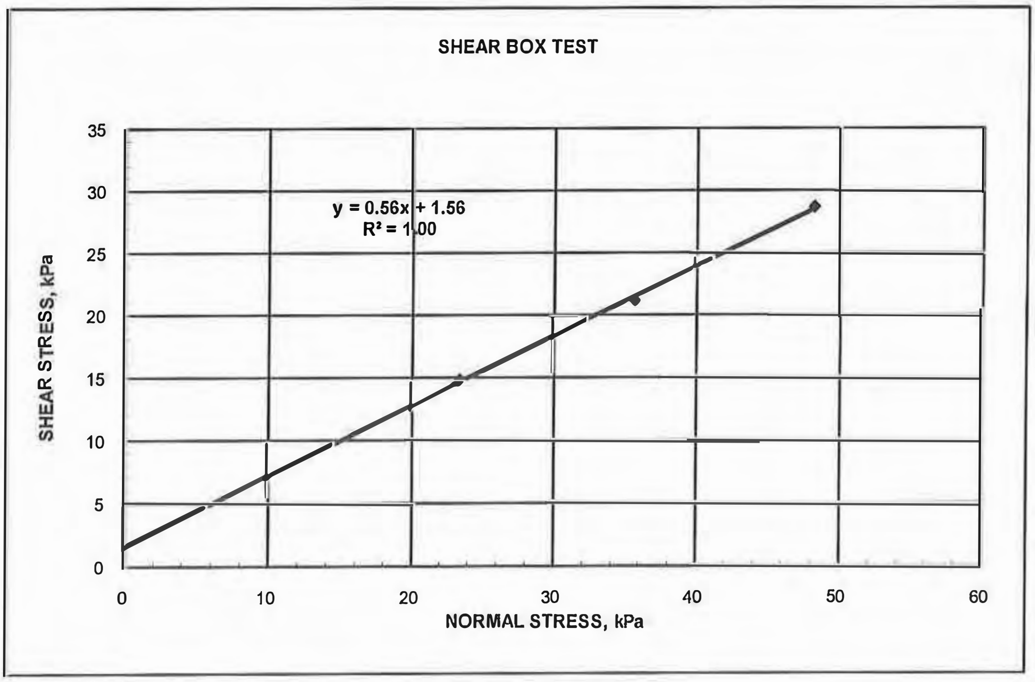
Sample No. 51 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 11.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	21.5	21.3
38.94	48.13	29	28.7



Cohesion = 1.6 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

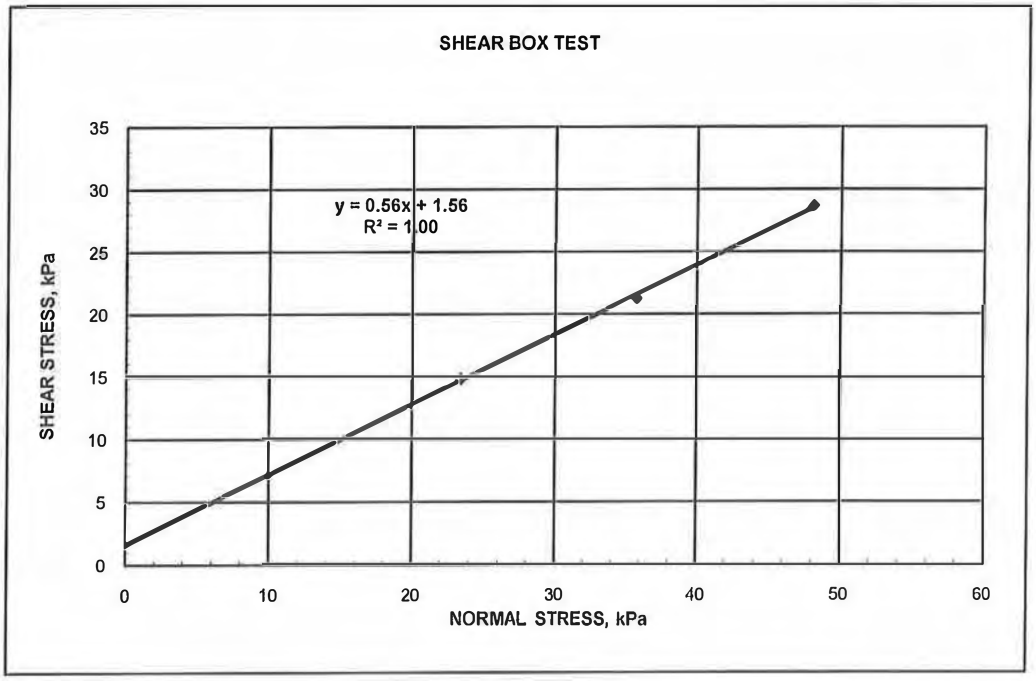
Client: M/S ECOS Ltd

BH/TP No. BH-07
Sample No. 52 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3
Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	21.5	21.3
38.94	48.13	29	28.7



Cohesion = 1.6 kPa Angle of Internal Friction, ϕ = 29 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-07

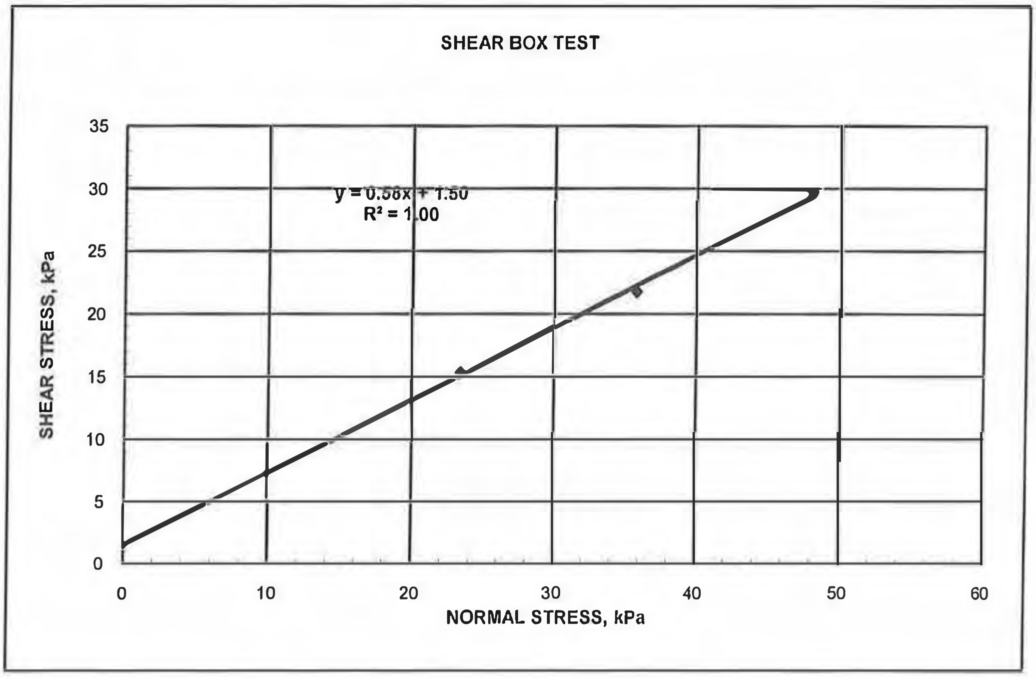
Sample No. 53 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 21.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15.5	15.3
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 1.5 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-07

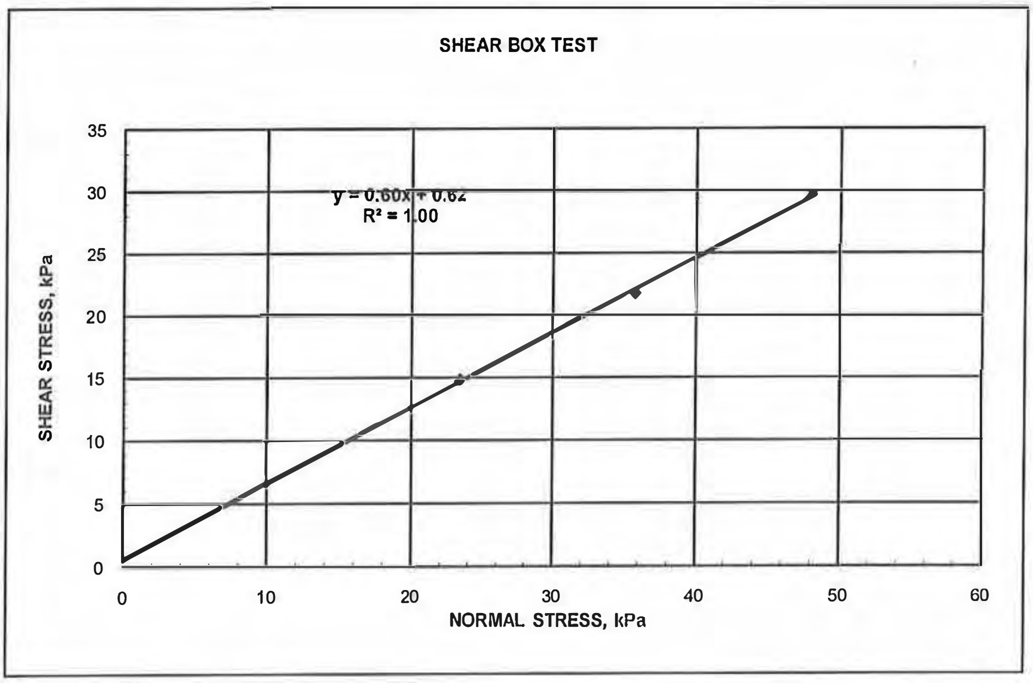
Sample No. 54 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-07

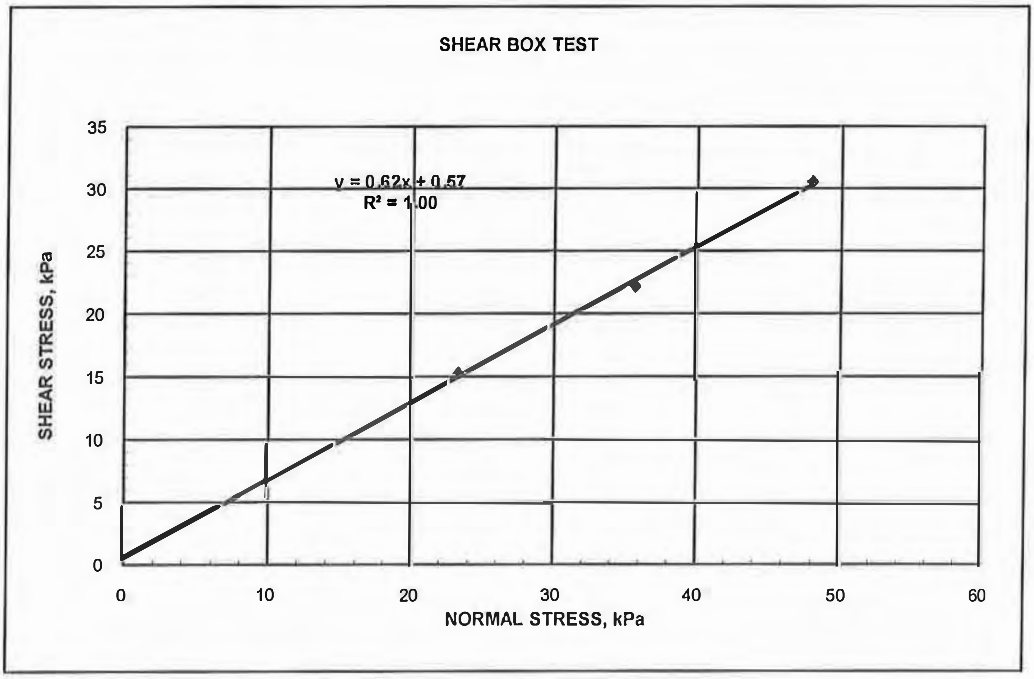
Sample No. 55 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 31.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15.5	15.3
28.94	35.77	22.5	22.2
38.94	48.13	31	30.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

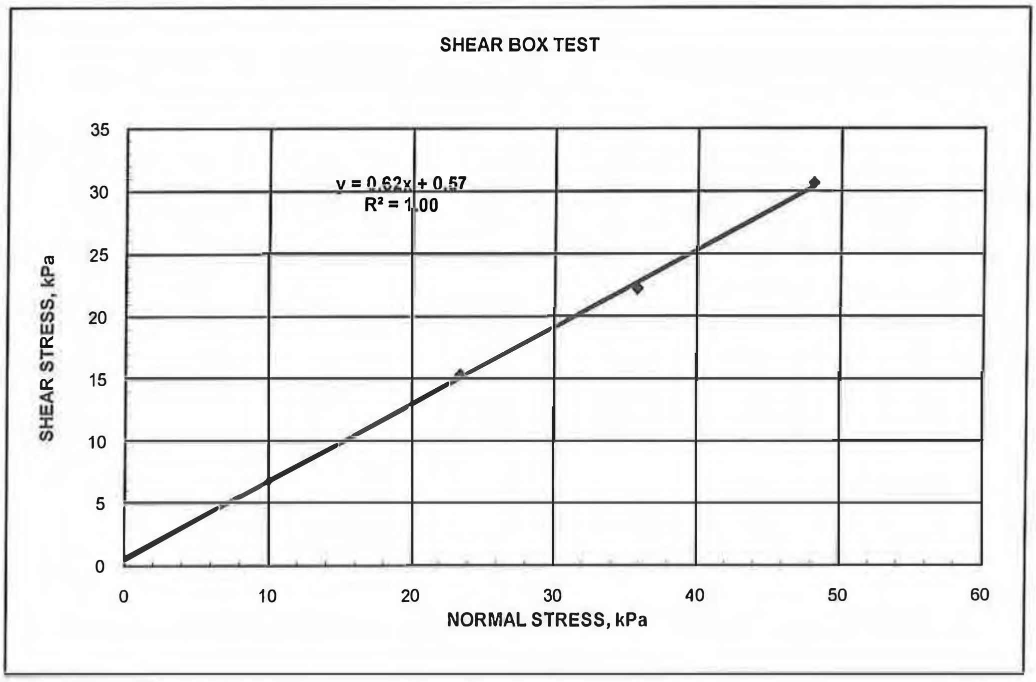
Client: M/S ECOS Ltd

BH/TP No. BH-07
Sample No. 56 (SPT) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 36.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15.5	15.3
28.94	35.77	22.5	22.2
38.94	48.13	31	30.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-08

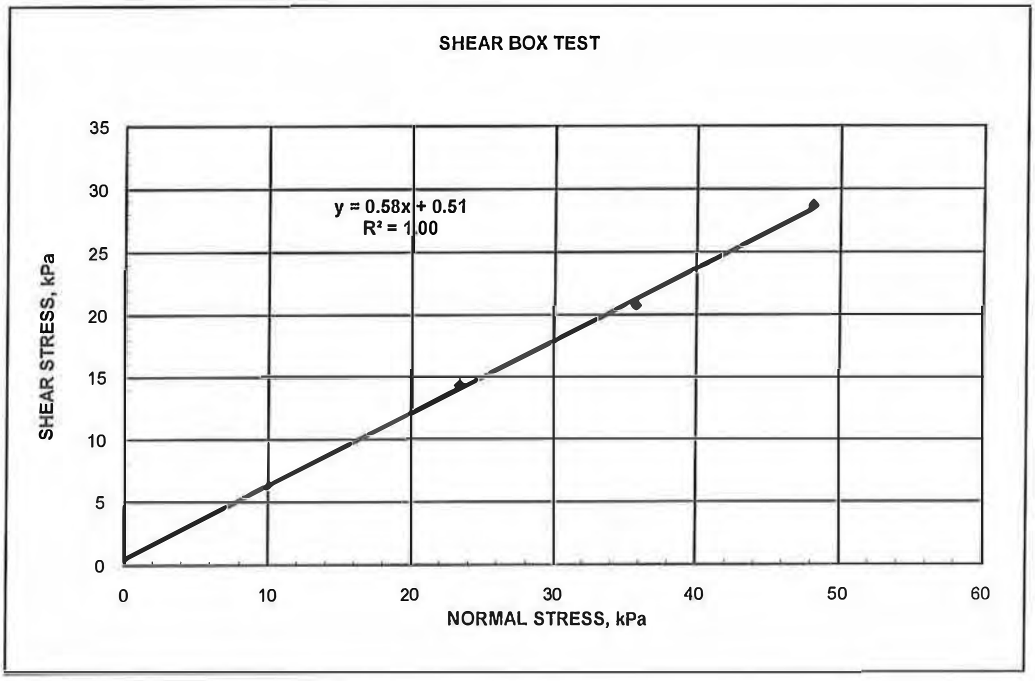
Sample No. 57 (UDS) **Remoulded Dry Density =** 16.8 kN/m³

Depth (m): 5.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m³
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	14.5	14.3
28.94	35.77	21	20.8
38.94	48.13	29	28.7



Cohesion = 0.5 kPa Angle of Internal Friction, ϕ = 30 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-08

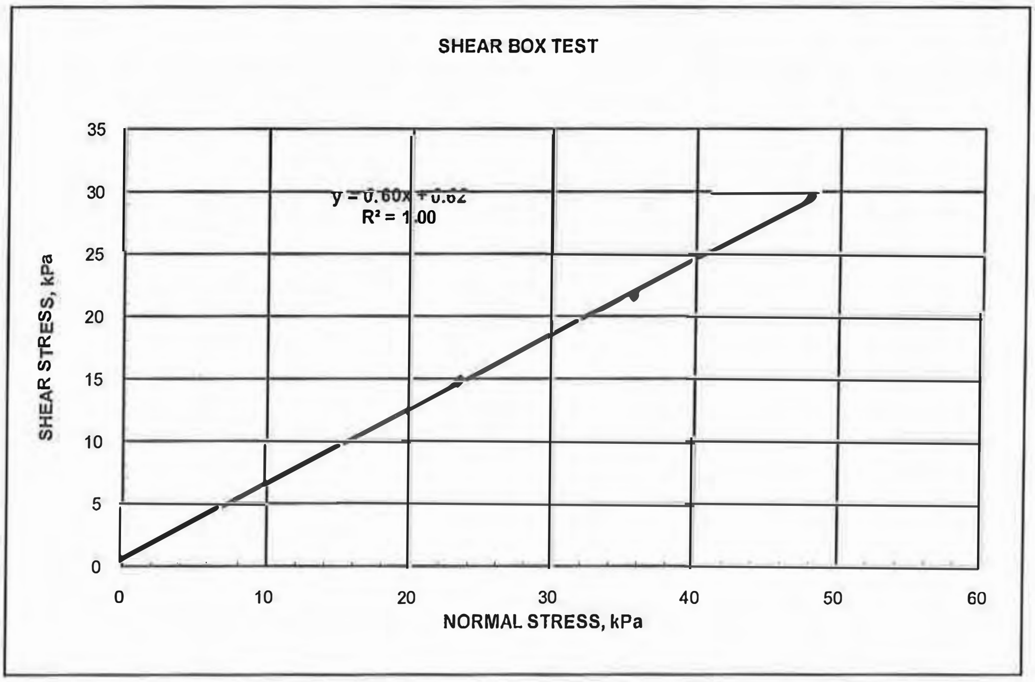
Sample No. 58 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 11.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

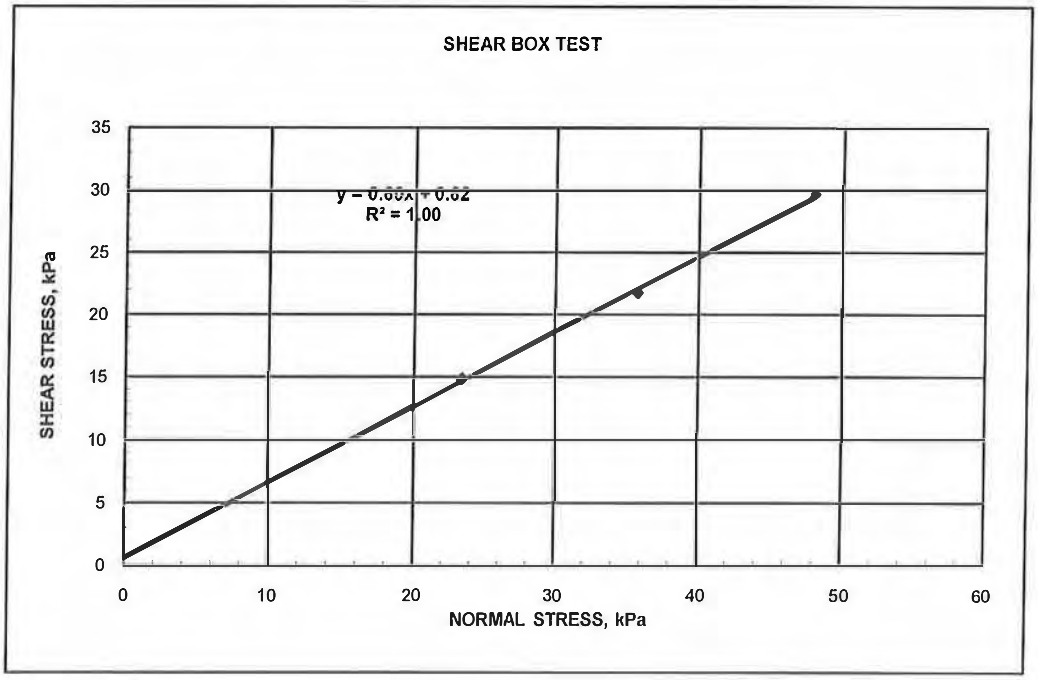
Client: M/S ECOS Ltd

BH/TP No. BH-08
Sample No. 59 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3
Depth (m): 15.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-08

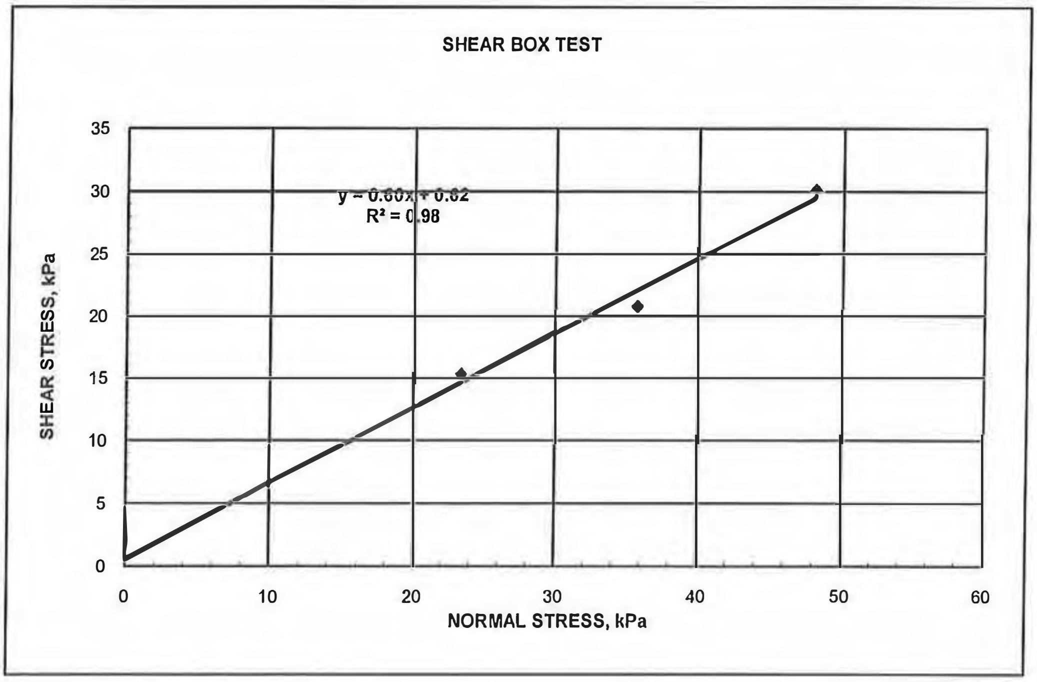
Sample No. 60 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 21.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15.5	15.3
28.94	35.77	21	20.8
38.94	48.13	30.5	30.2



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

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Director
Civil Engg. Dept. UET Lhr.

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-08

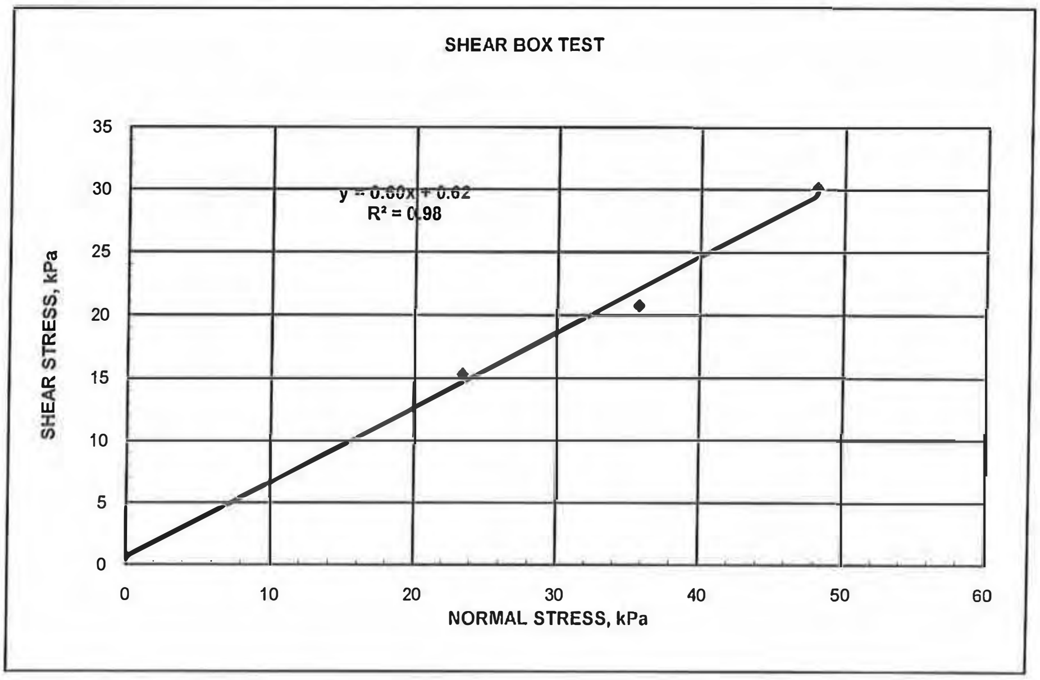
Sample No. 61 (UDS) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 25.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress	
		divisions	kPa
18.94	23.41	15.5	15.3
28.94	35.77	21	20.8
38.94	48.13	30.5	30.2



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

Prepared by:

Checked by:

Director

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Department of Civil Engineering
Geotechnical Engineering Laboratory

DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-08

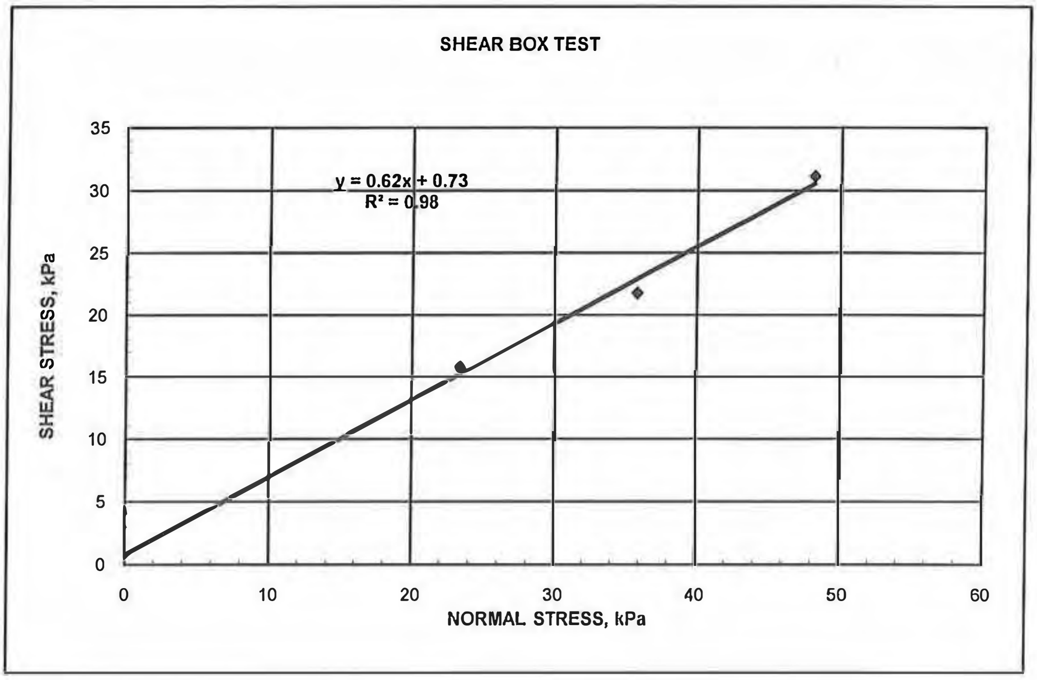
Sample No. 62 (UDS) **Remoulded Dry Density =** 16.8 kN/m^3

Depth (m): 31.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	16	15.8
28.94	35.77	22	21.8
38.94	48.13	31.5	31.1



Cohesion = 0.7 kPa Angle of Internal Friction, ϕ = 32 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-08

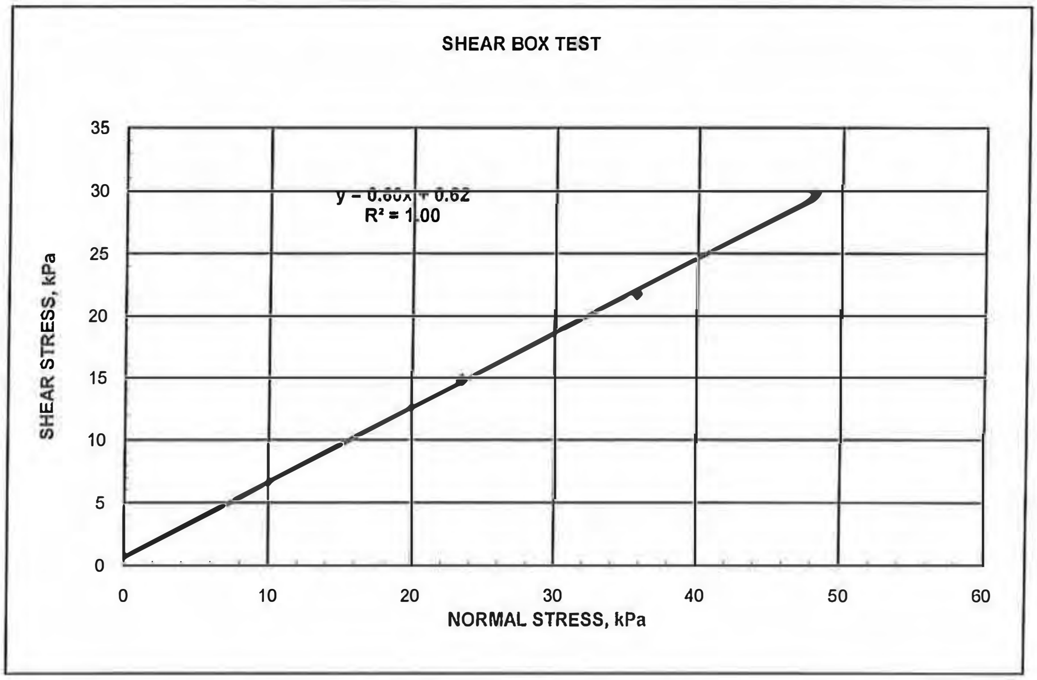
Sample No. 63 (SPT) **Remoulded Dry Density =** **16.8** kN/m^3

Depth (m): 36.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load	Normal Stress	Peak Shear Stress	
lb.	kPa	divisions	kPa
18.94	23.41	15	14.8
28.94	35.77	22	21.8
38.94	48.13	30	29.7



Cohesion = 0.6 kPa Angle of Internal Friction, ϕ = 31 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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DIRECT SHEAR BOX TEST

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

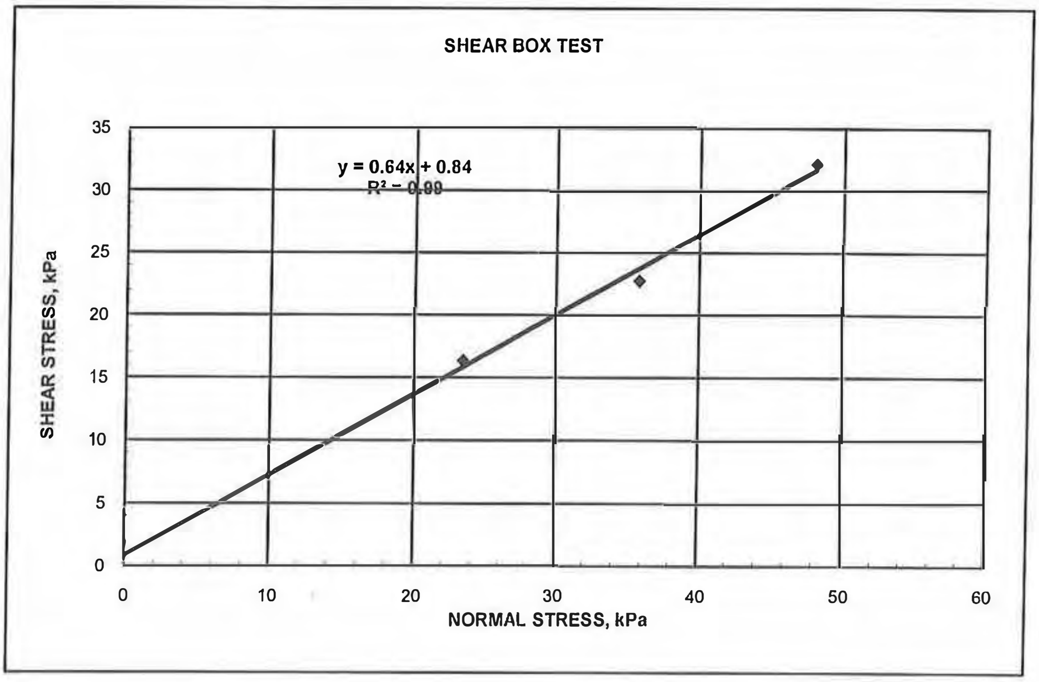
Client: M/S ECOS Ltd

BH/TP No. BH-08
Sample No. 64 (SPT) **Remoulded Dry Density =** **16.8** kN/m^3
Depth (m): 40.0

Test Data **Test Method: ASTM D3080**

Box width	6	cm	Dry Density	16.80	kN/m^3
Box length	6	cm	Wt of hanger	8.94	lb
Box height	2	cm	PR Factor	0.8	lb/Division

Normal Load lb.	Normal Stress kPa	Peak Shear Stress divisions	Peak Shear Stress kPa
18.94	23.41	16.5	16.3
28.94	35.77	23	22.7
38.94	48.13	32.5	32.1



Cohesion = 0.8 kPa Angle of Internal Friction, ϕ = 33 degrees

Note: Test was conducted on remoulded sample at NMC condition.
Test was performed on remoulded sample on material finer than 4.75mm.

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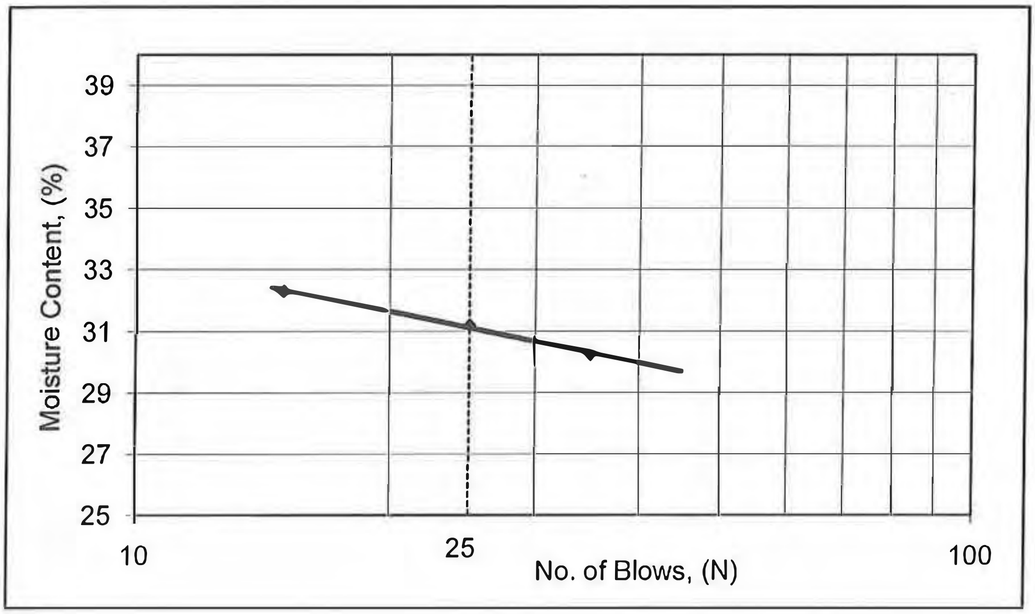
ATTERBERG LIMITS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No.	BH-01	Blows	w (%)
Sample No.	1 (UDS)	15	32.30
Depth (m):	1.0	25	31.20
		35	30.25

Test Method: ASTM D4318



Liquid Limit (%)	=	31
Plastic Limit (%)	=	20
Plasticity Index	=	11

Prepared by:

Checked by:

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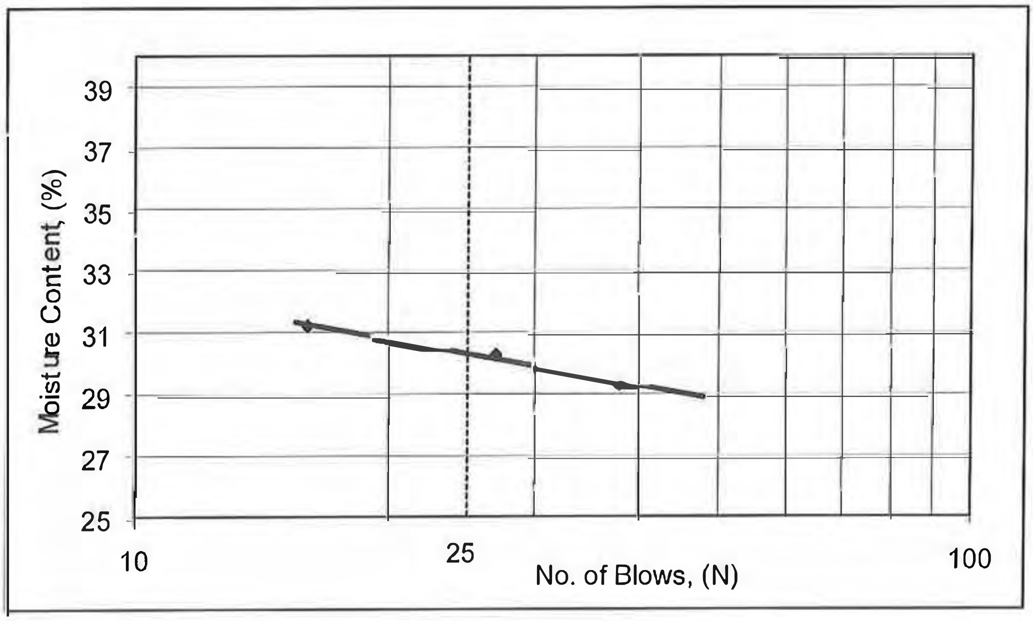
ATTERBERG LIMITS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

		Blows	w (%)
BH/TP No.	BH-02		
Sample No.	9 (UDS)	16	31.20
Depth (m):	3.0	27	30.26
		38	29.32

Test Method: ASTM D4318



Liquid Limit (%) = 30
Plastic Limit (%) = 20
Plasticity Index = 10

Prepared by:

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Geotechnical Engineering Laboratory

ATTERBERG LIMITS

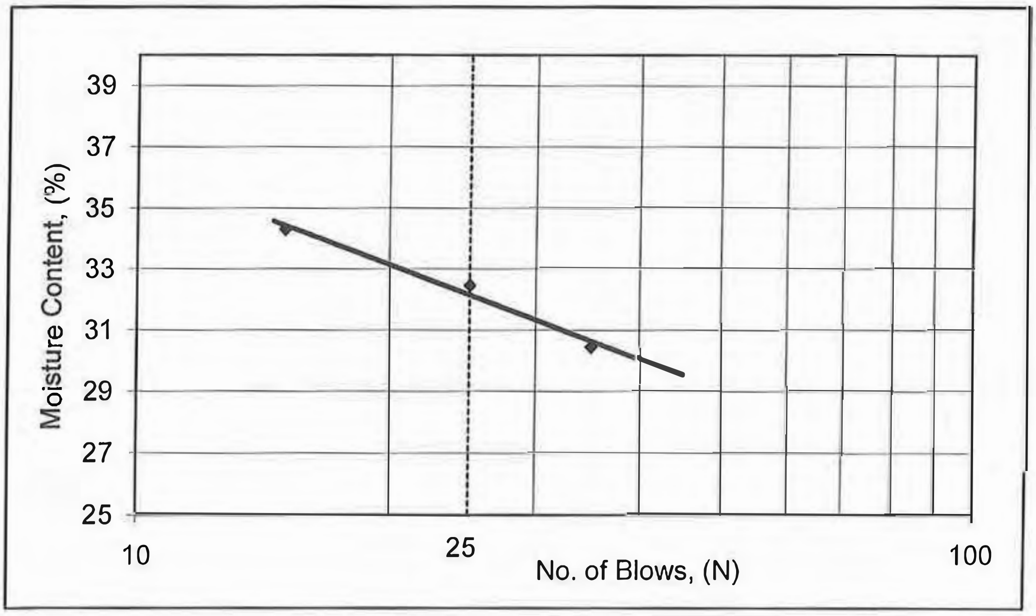
Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

BH/TP No. BH-06
Sample No. 41 (UDS)
Depth (m): 1.5

Blows	w (%)
15	34.30
25	32.45
35	30.45

Test Method: ASTM D4318



Liquid Limit (%)	=	32
Plastic Limit (%)	=	19
Plasticity Index	=	13

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Checked by:

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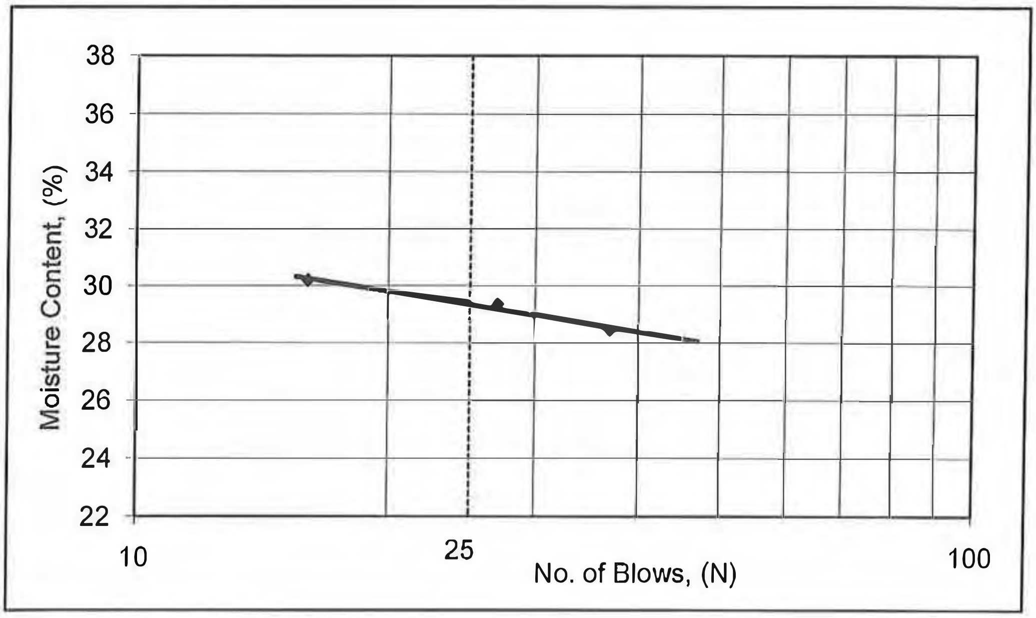
ATTERBERG LIMITS

Project: Geotechnical Investigation for WASA Master Plan, Faisalabad

Client: M/S ECOS Ltd

		Blows	w (%)
BH/TP No.	BH-07	16	30.20
Sample No.	49 (UDS)	27	29.35
Depth (m):	1.5	37	28.45

Test Method: ASTM D4318



Liquid Limit (%)	=	29
Plastic Limit (%)	=	19
Plasticity Index	=	10

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Checked by:

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Civil Engg Dept UET Lhr.

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CONSOLIDATION TEST

Sample BH-1,UDS-1,Depth, 1.0 m **Project:** Geotechnical Investigation for WASA Master Plan, Faisalabad

Initial						**Final**					
Ring dia =	38.1	mm	Gs=	2.7		Ring dia =	38.1	mm	Gs=	2.7	
Ring ht =	19.05	mm	e_o=	0.541		Soil ht =	17.04	mm	e_f =	0.378	
Volume =	21.719	cc	S_o=	69.55	%	Volume =	19.43	cc	S_f =	137.13	%
wt of ring=	51.74	gm	Hs=	12.36	mm	wt of ring=	51.74	gm	Hs=	12.36	mm
ring+soil =	95.1	gm				ring+soil =	92.94	gm			
m.c. =	13.93	%				f.m.c. =	19.21	%			
Bulk den =	19.6	kN/m^3				Bulk den =	20.8	kN/m^3			
Dry dens=	17.2	kN/m^3				Dry dens=	17.5	kN/m^3			

Load	Pressure	D Reading	Change	Acc Cha	Ht of sam	Strain	Void Ratio	C_c	a_v	$E = 1/m_v$
kg	kPa	*0.01mm	mm	mm	mm	%	e		m^2/MN	MPa
0.0	0.0	1000.0	0.000	0.000	19.05	0.00	0.541			
0.6	53.7	950.0	0.500	0.500	18.55	2.62	0.500			
1.1	107.3	926.0	0.240	0.740	18.31	3.88	0.481	0.0645	0.362	4.1
2.3	214.6	902.0	0.240	0.980	18.07	5.14	0.462	0.0645	0.181	8.3
4.5	429.3	876.0	0.260	1.240	17.81	6.51	0.441	0.0699	0.098	15.3
9.1	858.6	843.0	0.330	1.570	17.48	8.24	0.414	0.0887	0.062	24.1
18.1	1717.2	808.0	0.350	1.920	17.13	10.08	0.386	0.0940	0.033	45.5
36.3	3434.4	758.0	0.500	2.420	16.63	12.70	0.345	0.1343	0.024	63.7
9.1	858.6	762.0	0.040	2.380	16.67	12.49	0.348			
2.3	214.6	764.0	0.020	2.360	16.69	12.39	0.350			
0.6	53.7	777.0	0.130	2.230	16.82	11.71	0.360			
0.0	0.0	799.0	0.220	2.010	17.04	10.55	0.378			

Prepared By:

Geotech. Engg. Lab * Director * Civil Engg. Dept. UET

Checked By:

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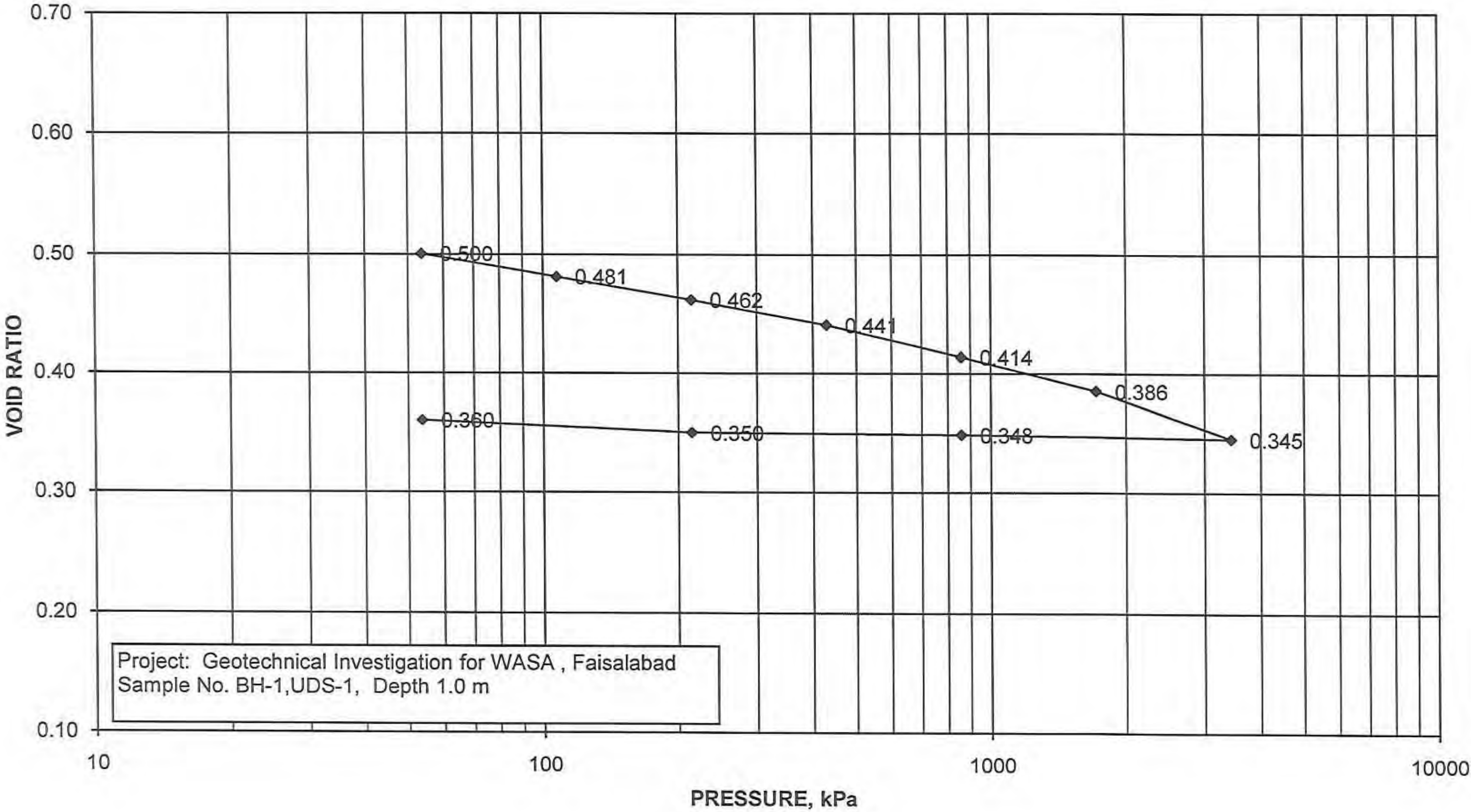
CONSOLIDATION TEST



Project: Geotechnical Investigation for WASA , Faisalabad
Sample No. BH-1,UDS-1, Depth 1.0 m

Prepared By:

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CONSOLIDATION TEST

Sample BH-2,UDS-9,Depth, 3.0 m **Project:** Geotechnical Investigation for WASA Master Plan, Faisalabad

Initial						**Final**					
Ring dia =	38.1	mm	Gs=	2.69		Ring dia =	38.1	mm	Gs=	2.69	
Ring ht =	19.05	mm	e_o=	0.500		Soil ht =	17.30	mm	e_f =	0.363	
Volume =	21.719	cc	S_o=	74.87	%	Volume =	19.72	cc	S_f =	178.91	%
wt of ring=	51.74	gm	Hs=	12.70	mm	wt of ring=	51.74	gm	Hs=	12.70	mm
ring+soil =	96.1	gm				ring+soil =	94.76	gm			
m.c. =	13.93	%				f.m.c. =	24.12	%			
Bulk den =	20.0	kN/m^3				Bulk den =	21.4	kN/m^3			
Dry dens=	17.6	kN/m^3				Dry dens=	17.2	kN/m^3			

Load	Pressure	D Reading	Change	Acc Cha	Ht of sam	Strain	Void Ratio	C_c	a_v	$E = 1/m_v$
kg	kPa	*0.01mm	mm	mm	mm	%	e		m^2/MN	MPa
0.0	0.0	1000.0	0.000	0.000	19.05	0.00	0.500			
0.6	53.7	945.0	0.550	0.550	18.50	2.89	0.457			
1.1	107.3	920.0	0.250	0.800	18.25	4.20	0.437	0.0654	0.367	4.0
2.3	214.6	892.0	0.280	1.080	17.97	5.67	0.415	0.0733	0.205	7.1
4.5	429.3	862.0	0.300	1.380	17.67	7.24	0.392	0.0785	0.110	13.2
9.1	858.6	835.0	0.270	1.650	17.40	8.66	0.371	0.0706	0.050	29.4
18.1	1717.2	805.0	0.300	1.950	17.10	10.24	0.347	0.0785	0.028	52.9
36.3	3434.4	766.0	0.390	2.340	16.71	12.28	0.316	0.1020	0.018	81.5
9.1	858.6	770.0	0.040	2.300	16.75	12.07	0.319			
2.3	214.6	790.0	0.200	2.100	16.95	11.02	0.335			
0.6	53.7	800.0	0.100	2.000	17.05	10.50	0.343			
0.0	0.0	825.0	0.250	1.750	17.30	9.19	0.363			

Prepared By:

Geotecl. Engg. Lab Director Civil Engg. UET

Checked By:

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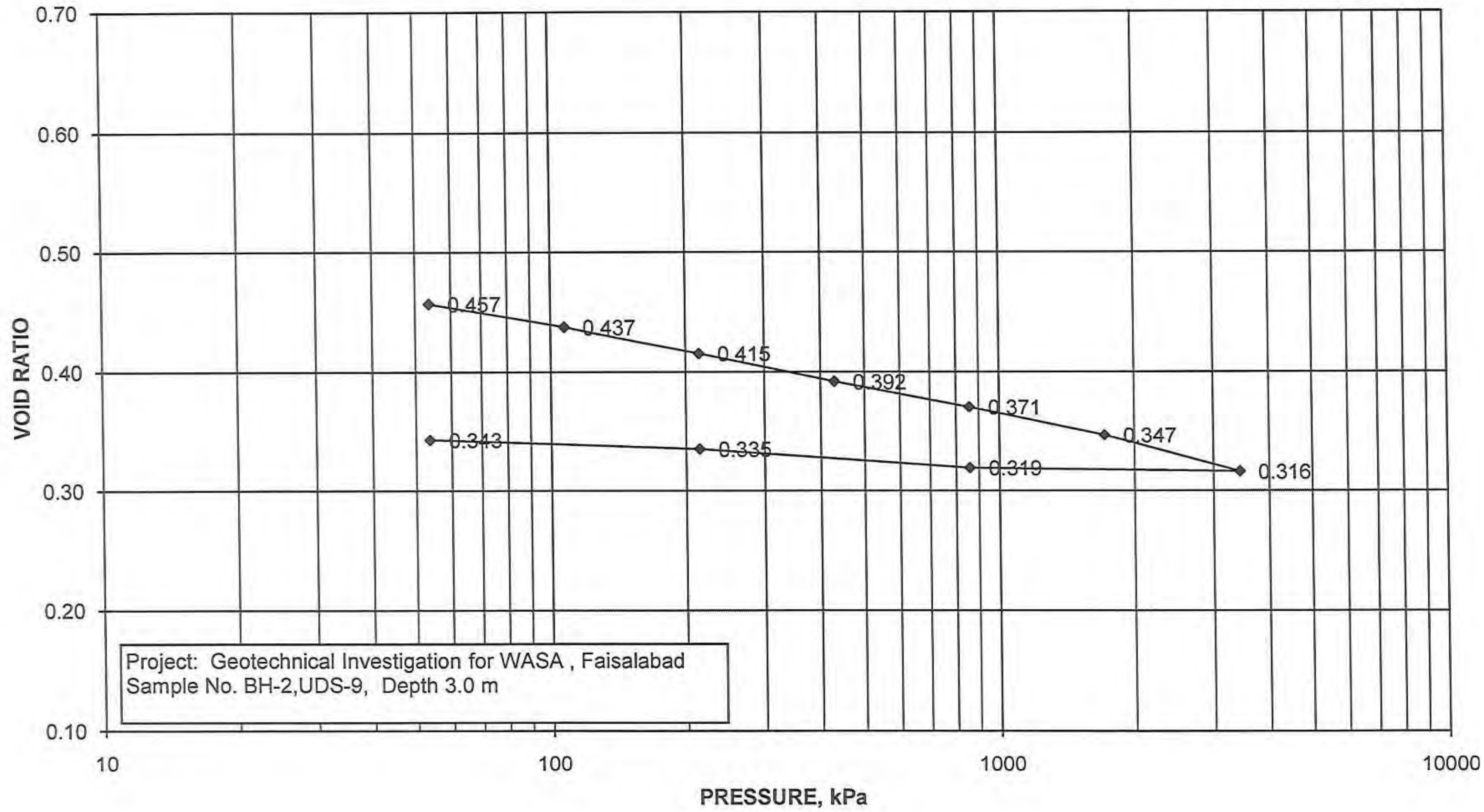
CONSOLIDATION TEST



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CONSOLIDATION TEST

Sample BH-6,UDS-41,Depth, 1.5 m **Project:** Geotechnical Investigation for WASA Master Plan, Faisalabad

Initial						Final					
Ring dia =	38.1	mm	Gs=	2.7		Ring dia =	38.1	mm	Gs=	2.7	
Ring ht =	19.05	mm	e_o=	0.532		Soil ht =	16.90	mm	e_f =	0.359	
Volume =	21.719	cc	S_o=	70.75	%	Volume =	19.27	cc	S_f =	128.92	%
wt of ring=	52.28	gm	Hs=	12.44	mm	wt of ring=	52.28	gm	Hs=	12.44	mm
ring+soil =	95.9	gm				ring+soil =	94.47	gm			
m.c. =	13.93	%				f.m.c. =	17.13	%			
Bulk den =	19.7	kN/m^3				Bulk den =	21.5	kN/m^3			
Dry dens=	17.3	kN/m^3				Dry dens=	18.3	kN/m^3			

Load	Pressure	D Reading	Change	Acc Cha	Ht of sam	Strain	Void Ratio	C_c	a_v	$E = 1/m_v$
kg	kPa	*0.01mm	mm	mm	mm	%	e		m^2/MN	MPa
0.0	0.0	1000.0	0.000	0.000	19.05	0.00	0.532			
0.6	53.7	933.0	0.670	0.670	18.38	3.52	0.478			
1.1	107.3	912.0	0.210	0.880	18.17	4.62	0.461	0.0561	0.315	4.7
2.3	214.6	886.0	0.260	1.140	17.91	5.98	0.440	0.0694	0.195	7.6
4.5	429.3	859.0	0.270	1.410	17.64	7.40	0.418	0.0721	0.101	14.6
9.1	858.6	828.0	0.310	1.720	17.33	9.03	0.393	0.0828	0.058	25.5
18.1	1717.2	783.0	0.450	2.170	16.88	11.39	0.357	0.1202	0.042	35.1
36.3	3434.4	730.0	0.530	2.700	16.35	14.17	0.315	0.1416	0.025	59.6
9.1	858.6	741.0	0.110	2.590	16.46	13.60	0.323			
2.3	214.6	754.0	0.130	2.460	16.59	12.91	0.334			
0.6	53.7	768.0	0.140	2.320	16.73	12.18	0.345			
0.0	0.0	785.0	0.170	2.150	16.90	11.29	0.359			

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Checked By:

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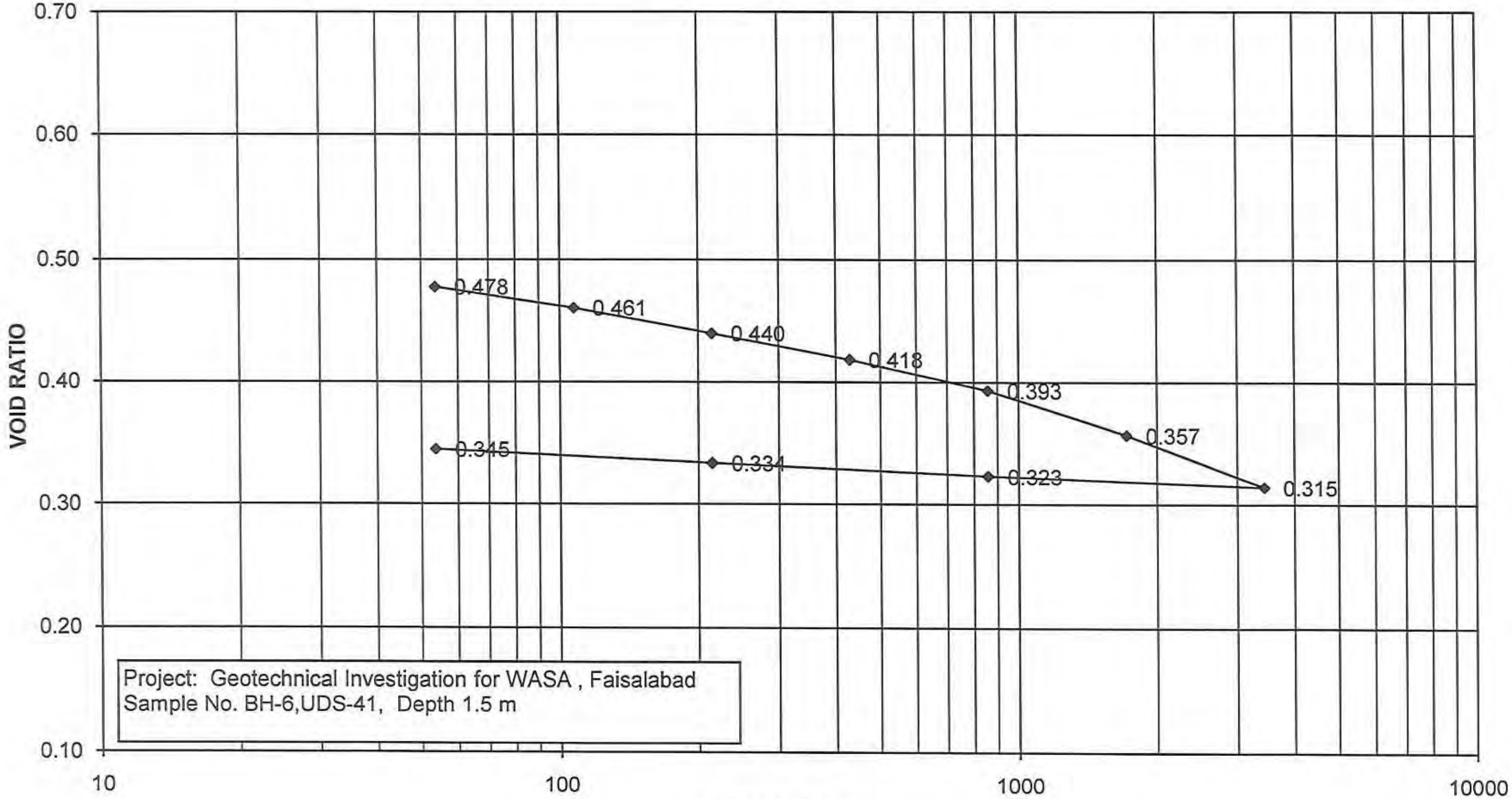
CONSOLIDATION TEST



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CONSOLIDATION TEST

Sample BH-7,UDS-49,Depth, 1.5 m **Project:** Geotechnical Investigation for WASA Master Plan, Faisalabad

Initial						Final					
Ring dia =	38.1	mm	Gs=	2.69		Ring dia =	38.1	mm	Gs=	2.69	
Ring ht =	19.05	mm	e_o=	0.713		Soil ht =	16.73	mm	e_f =	0.504	
Volume =	21.719	cc	S_o=	52.57	%	Volume =	19.07	cc	S_f =	142.91	%
wt of ring=	51.74	gm	Hs=	11.12	mm	wt of ring=	51.74	gm	Hs=	11.12	mm
ring+soil =	90.6	gm				ring+soil =	89.36	gm			
m.c. =	13.93	%				f.m.c. =	26.79	%			
Bulk den =	17.6	kN/m^3				Bulk den =	19.3	kN/m^3			
Dry dens=	15.4	kN/m^3				Dry dens=	15.3	kN/m^3			

Load	Pressure	D Reading	Change	Acc Cha	Ht of sam	Strain	Void Ratio	C_c	a_v	$E = 1/m_v$
kg	kPa	*0.01mm	mm	mm	mm	%	e		m^2/MN	MPa
0.0	0.0	1000.0	0.000	0.000	19.05	0.00	0.713			
0.6	53.7	939.0	0.610	0.610	18.44	3.20	0.658			
1.1	107.3	920.0	0.190	0.800	18.25	4.20	0.641	0.0568	0.318	5.2
2.3	214.6	905.0	0.150	0.950	18.10	4.99	0.627	0.0448	0.126	13.2
4.5	429.3	885.0	0.200	1.150	17.90	6.04	0.609	0.0597	0.084	19.8
9.1	858.6	855.0	0.300	1.450	17.60	7.61	0.582	0.0896	0.063	26.4
18.1	1717.2	800.0	0.550	2.000	17.05	10.50	0.533	0.1643	0.058	28.8
36.3	3434.4	709.0	0.910	2.910	16.14	15.28	0.451	0.2718	0.048	34.8
9.1	858.6	710.0	0.010	2.900	16.15	15.22	0.452			
2.3	214.6	714.0	0.040	2.860	16.19	15.01	0.456			
0.6	53.7	734.0	0.200	2.660	16.39	13.96	0.474			
0.0	0.0	768.0	0.340	2.320	16.73	12.18	0.504			

Prepared By:

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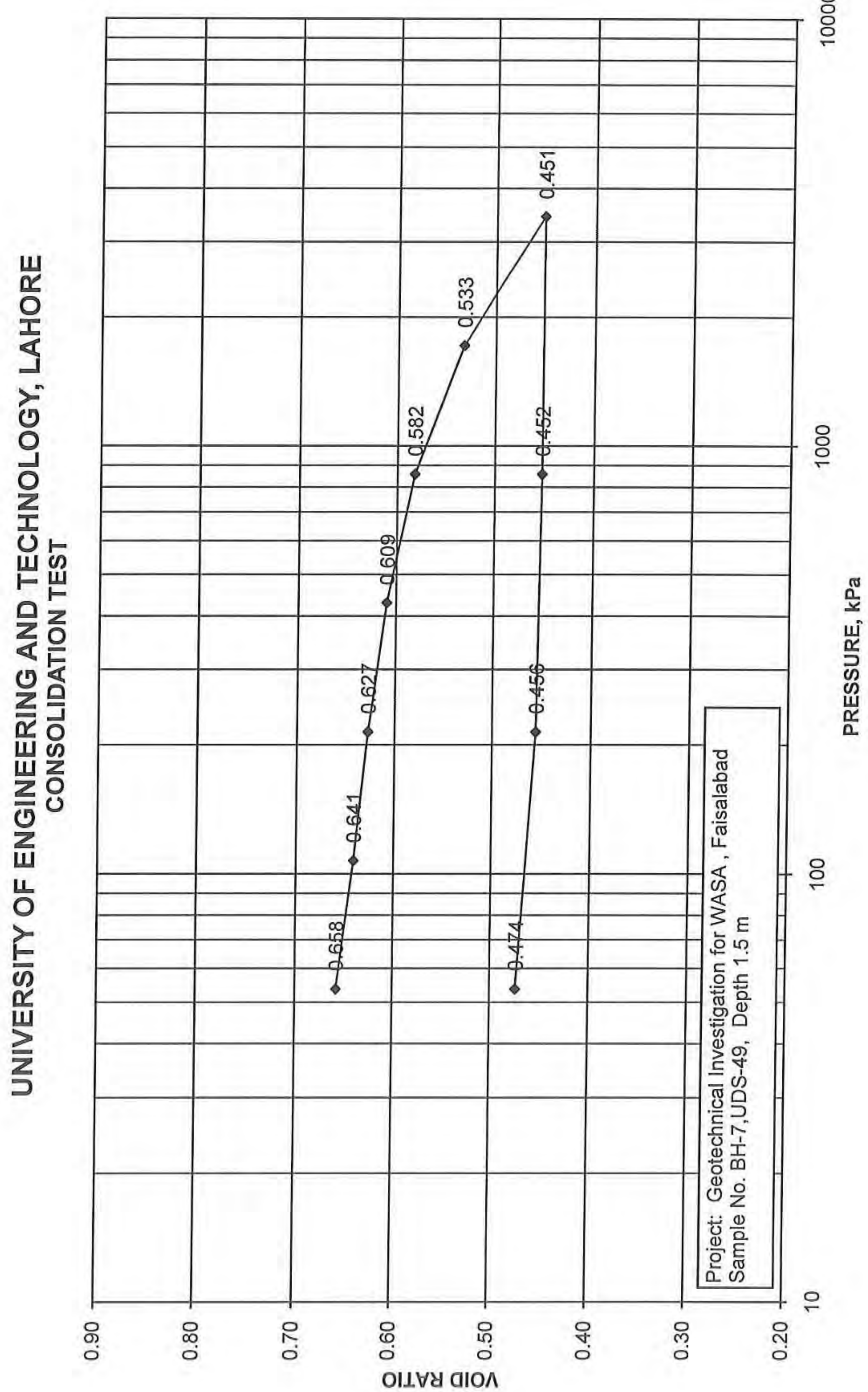
Checked By:



Prepared By:

Checked By:

APPENDIX-B

Summarized Laboratory
Test Results

BH #	Sample #	Depth	NMC(%)	Bulk Density kN/m3	Specific Gravity	Particle Size Distribution			Atterberg Limits			Permeability cm/sec (@4m)
						Gravel	Sand	Silt & Clay	L.L	P.L	P.I	
BH-1	1 (UDS)	1	21.68	19.21	2.7	0	8	92	31	20	11	5.13 E-04
	2 (UDS)	7	25.05	18.64	2.67	0	92	8	-	-	-	-
	3 (UDS)	14	17.96	14.55	2.65	0	90	10	-	-	-	-
	4 (UDS)	19	18.27	16.08	2.67	0	93	7	-	-	-	-
	5 (UDS)	25	24.24	20.55	2.65	0	92	8	-	-	-	-
	6 (UDS)	30	23.88	15.74	2.66	0	91	9	-	-	-	-
	7 (UDS)	35	25.17	13.48	2.69	5	30	65	-	-	-	-
	8 (UDS)	40	17.67	15.9	2.68	8	45	47	-	-	-	-
BH-2	9 (UDS)	3	9.61	20.48	2.7	0	11	89	30	20	10	1.466 E-03
	10 (UDS)	7	7.5	18.93	2.67	0	89	11	-	-	-	-
	11 (UDS)	15	7.32	16.97	2.67	0	88	12	-	-	-	-
	12 (UDS)	20	4.32	16.31	2.66	0	90	10	-	-	-	-
	13 (UDS)	25	17.34	19.79	2.65	0	96	4	-	-	-	-
	14 (UDS)	30	27.66	18.3	2.67	0	91	9	-	-	-	-
	15 (UDS)	35	14.41	12.48	2.67	0	99	1	-	-	-	-
	16 (UDS)	40	19.27	18.44	2.65	0	99	1	-	-	-	-
BH-3	17 (UDS)	5	2.37	16.54	2.66	0	94	6	-	-	-	4.27 E-04
	18 (UDS)	11	7.22	20.71	2.67	0	90	10	-	-	-	-
	19 (UDS)	15	9.19	17.99	2.67	0	95	5	-	-	-	-
	20 (UDS)	21	20.48	17.94	2.66	0	95	5	-	-	-	-
	21 (UDS)	25	21.92	20.86	2.67	0	92	8	-	-	-	-
	22 (UDS)	31	26.52	16.14	2.66	0	90	10	-	-	-	-
	23 (UDS)	35	24.92	20.47	2.65	0	91	9	-	-	-	-
	24 (SPT)	40	16.53	-	2.65	0	96	4	-	-	-	-
BH-4	25 (UDS)	5	4.32	16.2	2.67	0	88	12	-	-	-	1.04 E-03
	26 (UDS)	11	6.41	17.78	2.67	0	73	27	-	-	-	-
	27 (UDS)	15	12.36	17.35	2.67	0	95	5	-	-	-	-
	28 (UDS)	21	9.82	26.16	2.66	0	93	7	-	-	-	-
	29 (UDS)	25	17.35	19.44	2.65	0	94	6	-	-	-	-
	30 (UDS)	31	22.79	18.65	2.67	0	91	9	-	-	-	-
	31 (SPT)	36	32.67	-	2.66	0	95	5	-	-	-	-
	32 (SPT)	40	22.86	-	2.65	0	91	9	-	-	-	-

BH-5	33 (UDS)	5	9.23	17.74	2.65	0	85	15	-	-	-	3.71 E-04
	34 (UDS)	11	7.28	16.47	2.65	0	89	11	-	-	-	-
	35 (UDS)	15	15.1	16.46	2.66	0	75	25	-	-	-	-
	36 (UDS)	21	23.43	18.48	2.67	0	91	9	-	-	-	-
	37 (UDS)	25	24.64	17.79	2.67	0	94	6	-	-	-	-
	38 (UDS)	31	23.3	17.5	2.67	0	92	8	-	-	-	-
	39 (SPT)	36	19.62	-	2.67	0	95	5	-	-	-	-
	40 (SPT)	40	20.11	-	2.67	0	88	12	-	-	-	-
BH-6	41 (UDS)	1.5	20.39	17.17	2.7	0	11	89	32	19	13	1.43 E-04
	42 (UDS)	5	21.26	16.61	2.65	0	92	8	-	-	-	-
	43 (UDS)	11	7.78	15.98	2.67	0	80	20	-	-	-	-
	44 (UDS)	15	9.63	18.34	2.68	0	93	7	-	-	-	-
	45 (UDS)	21	6.79	16.12	2.67	0	92	8	-	-	-	-
	46 (UDS)	25	18.72	18.04	2.66	0	94	6	-	-	-	-
	47 (SPT)	32	20.46	-	2.65	0	91	9	-	-	-	-
	48 (SPT)	36	22.78	-	2.67	0	89	11	-	-	-	-
BH-7	49 (UDS)	1.5	25.79	18.24	2.7	0	10	90	29	19	10	2.94 E-04
	50 (UDS)	5	4.05	14.84	2.65	0	87	13	-	-	-	-
	51 (UDS)	11	4.03	19.6	2.65	0	92	8	-	-	-	-
	52 (UDS)	15	6.72	17.61	2.66	0	97	3	-	-	-	-
	53 (UDS)	21	19.32	20.24	2.67	0	77	23	-	-	-	-
	54 (UDS)	25	62.39	18.26	2.65	0	17	83	-	-	-	-
	55 (UDS)	31	18.46	19.26	2.67	0	82	18	-	-	-	-
	56 (SPT)	36	19.53	-	2.67	0	97	3	-	-	-	-
BH-8	57 (UDS)	5	9.14	17.1	2.65	0	77	23	-	-	-	6.6 E-04
	58 (UDS)	11	3.45	17.2	2.66	0	82	18	-	-	-	-
	59 (UDS)	15	17.29	18.2	2.67	0	91	9	-	-	-	-
	60 (UDS)	21	6.31	15.29	2.65	0	90	10	-	-	-	-
	61 (UDS)	25	16.68	18.44	2.65	0	96	4	-	-	-	-
	62 (UDS)	31	17.52	19.1	2.66	0	96	4	-	-	-	-
	63 (SPT)	36	34.34	-	2.67	0	95	5	-	-	-	-
	64 (SPT)	40	21.03	-	2.67	0	93	7	-	-	-	-

APPENDIX-C

Permeability Test logs

ECOS

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	450	Site:	WTP- Jhal	Borehole #	1
(a) Bottom borehole (cm)	400	Location	BH # 1	Date:	06-12-2017
(b) Bottom of casing (cm)	400	Job No.	1	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	sunny	Consultant:	
(e) Initial groundwater level(cm)	390	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	50	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)
1			3
2			1
3			0.5
5			1.5
7			1.10
10			1.5
15			2.25
20			2.00
30			3.75
40			3.00
50			2.50
60			2.50
			24.60

Formula / Calculation

$$K = \frac{q}{FDH} \text{ cm/sec}$$

Where:
K= Permeability (cm/sec)
q= Constant rate of inflow (cm^3/sec)
F= Shape Factor which depends upon the condition at the base of bore hole
D= Internal diameter of casing (cm)
H= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)

$$q = \frac{\text{meter reading} \times 1000}{\text{time elapsed} \times 60 \text{ sec}}$$

q **= 6.833** (cm^3/sec
H **= 440**
F **= 2.75**
D **= 11**

K (cm/sec) **= 0.0005134 = 5.13 E-04**

Remarks:

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	455	Site:	WTP- Jhal	Borehole #	2
(a) Bottom borehole (cm)	411	Location	BH # 2	Date:	7-12-2017
(b) Bottom of casing (cm)	411	Job No.	4	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	sunny	Consultant:	
(e) Initial groundwater level(cm)	Nil	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	44	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			1.5	**K =** $\frac{q}{\mathbf{FDH}}$ cm/sec
2			1	*Where:*
3			1.5	**K**= Permeability (cm/sec)
5			2.5	**q**= Constant rate of inflow (cm^3/sec)
7			5.00	**F**= Shape Factor which depends upon the condition at the base of bore hole
10			5.00	**D**= Internal diameter of casing (cm)
15			8.00	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
20			6.75	
30			11.75	**q =** $\frac{\textbf{meter reading} \times 1000}{\textbf{time elapsed} \times 60 \textbf{ sec}}$
40			9.10	
50			10.0	
60			10.50	
			72.6	

q **= 20.177** (cm^3/sec
H **= 455**
F **= 2.75**
D **= 11**

K (cm/sec) **= 0.0001466 = 1.46 E-03**

Remarks:

ECOS

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	450	Site:	WTP- Jhal	Borehole #	3
(a) Bottom borehole (cm)	410	Location	BH#3	Date:	7-12-2017
(b) Bottom of casing (cm)	410	Job No.	3	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	sunny	Consultant:	
(e) Initial groundwater level(cm)	Nil	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	40	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			1	$K = \frac{q}{FDH}$ cm/sec
2			0.6	*Where:*
3			0.65	**K**= Permeability (cm/sec)
5			0.85	**q**= Constant rate of inflow (cm^3/sec)
7			0.80	**F**= Shape Factor which depends upon the condition at the base of bore hole
10			1.0	**D**= Internal diameter of casing (cm)
15			1.55	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
20			3.75	
30			3.50	$q = \frac{\text{meter reading} \times 1000}{\text{time elapsed} \times 60 \text{ sec}}$
40			3.25	
50			3.00	
60			3.00	
			20.95	

q = **5.819** (cm^3/sec

H = **450**

F = **2.75**

D = **11**

K (cm/sec) **= 0.000427 = 4.27E-04**

Remarks:

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	464	Site:	WTP- Jhal	Borehole #	4
(a) Bottom borehole (cm)	400	Location	BH# 4	Date:	7-12-2017
(b) Bottom of casing (cm)	383	Job No.	2	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	sunny	Consultant:	
(e) Initial groundwater level(cm)	207	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	64	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			1.5	**K =** $\frac{q}{FDH}$ cm/sec
2			1	
3			1	*Where:*
5			1.70	**K**= Permeability (cm/sec)
7			1.30	**q**= Constant rate of inflow (cm^3/sec)
10			2.00	**F**= Shape Factor which depends upon the condition at the base of bore hole
15			3.50	**D**= Internal diameter of casing (cm)
20			4.00	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
30			6.50	**q =** $\frac{\textbf{meter reading} \times \textbf{1000}}{\textbf{time elapsed} \times \textbf{60 sec}}$
40			6.00	
50			5.25	
60			5.00	
			38.75	

q **= 10.7638** (cm^3/sec
H **= 464**
F **= 2.02**
D **= 11**

K (cm/sec) **= 0.001044 = 1.04E-03**

Remarks:

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	381	Site:	Abdullah Pur OHR	Borehole #	5
(a) Bottom borehole (cm)	343	Location	BH # 5	Date:	11-12-2017
(b) Bottom of casing (cm)	334	Job No.	5	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	cloudy	Consultant:	
(e) Initial groundwater level(cm)	Nil	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	38	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			0.75	**K =** $\frac{q}{FDH}$ cm/sec
2			0.45	*Where:*
3			0.50	**K**= Permeability (cm/sec)
5			0.90	**q**= Constant rate of inflow (cm^3/sec)
7			0.70	**F**= Shape Factor which depends upon the condition at the base of bore hole
10			0.90	**D**= Internal diameter of casing (cm)
15			1.45	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
20			1.40	
30			2.40	**q =** $\frac{\text{meter reading} \times 1000}{\text{time elapsed} \times 60 \text{ sec}}$
40			2.15	
50			2.00	
60			1.80	
			15.4	

q **= 4.277** (cm^3/sec
H **= 381**
F **= 1.75**
D **= 11**

K (cm/sec) **= 0.0005831 = 5.837E-04**

Remarks:

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	376	Site:	MT OHR # 2	Borehole #	6
(a) Bottom borehole (cm)	364	Location	BH#6	Date:	13-12-2017
(b) Bottom of casing (cm)	364	Job No.	6	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	cloudy	Consultant:	
(e) Initial groundwater level(cm)	Nil	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	12	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			0.25	**K =** $\frac{q}{FDH}$ cm/sec
2			0.05	*Where:*
3			0.05	**K**= Permeability (cm/sec)
5			0.20	**q**= Constant rate of inflow (cm^3/sec)
7			0.23	**F**= Shape Factor which depends upon the condition at the base of bore hole
10			0.25	**D**= Internal diameter of casing (cm)
15			1.45	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
20			1.45	
30			0.95	**q =** $\frac{\textbf{meter reading} \times 1000}{\textbf{time elapsed} \times 60\ \textbf{sec}}$
40			1.05	
50			1.00	
60			0.925	
			5.86	

q = **1.6277** (cm^3/sec
H = **376**
F = **2.75**
D = **11**

K (cm/sec) **= 0.000143107 = 1.43E-04**

Remarks:

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	510	Site:	MT OHR # 1	Borehole #	7
(a) Bottom borehole (cm)	430	Location	BH # 7	Date:	15-12-2017
(b) Bottom of casing (cm)	430	Job No.	7	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	cloudy	Consultant:	
(e) Initial groundwater level(cm)	Nil	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	80	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			0.85	$K = \frac{q}{FDH}$ cm/sec
2			0.55	
3			0.50	*Where:*
5			0.85	**K**= Permeability (cm/sec)
7			0.80	**q**= Constant rate of inflow (cm^3/sec)
10			1.10	**F**= Shape Factor which depends upon the condition at the base of bore hole
15			1.60	**D**= Internal diameter of casing (cm)
20			1.250	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
30			2.760	$q = \frac{\text{meter reading} \times 1000}{\text{time elapsed} \times 60\ \text{sec}}$
40			2.10	
50			2.00	
60			2.00	
			16.36	

q = **4.544** (cm^3/sec

H = **510**

F = **2.75**

D = **11**

K (cm/sec) = **0.000294539 = 2.94E-04**

Remarks:

ECOS

CONSTANT HEAD PERMEABILITY TEST
Geotechnical Investigation
WASA Master Plan, Faisalabad

Depth below top of casing/ standpipe to (cm)	430	Site:	PC OHR # 2	Borehole #	8
(a) Bottom borehole (cm)	420	Location	BH # 8	Date:	16-12-2017
(b) Bottom of casing (cm)	420	Job No.	8	Sheet #	1 of 1
(c) Top of filter (m)	Nil	Ground Elevation		Client:	
(d) Centre of piezometer tip (m)	Nil	Weather	cloudy	Consultant:	
(e) Initial groundwater level(cm)	Nil	Type of Test (inflow / outflow)		Contractor:	Geoworkers
(f) Height of casing/stand pipe above surface (cm)	10	Internal diameter of casing/standpipe (d) (cm)	11	Geologist:	
(g)Elevation of casing/ standpipe(m)		Length of filter(mm)		Checked by:	
		Type of piezometer		Crew operator:	

Test Record

Time Elapsed (min)	Meter Reading (m3)	Flow (m3)	Flow (Ltrs)	Formula / Calculation
1			0.50	**K =** $\frac{q}{FDH}$ cm/sec
2			0.70	*Where:*
3			0.70	**K**= Permeability (cm/sec)
5			1.35	**q**= Constant rate of inflow (cm^3/sec)
7			1.10	**F**= Shape Factor which depends upon the condition at the base of bore hole
10			1.90	**D**= Internal diameter of casing (cm)
15			2.90	**H**= Constant water head at the top of casing above the natural ground water table/ bottom of the test section (cm)
20			2.75	
30			4.40	**q =** $\frac{\text{meter reading} \times 1000}{\text{time elapsed} \times 60 \text{ sec}}$
40			4.75	
50			4.80	
60			24.40	
			30.25	

q **= 8.4027** (cm^3/sec
H **= 430**
F **= 2.75**
D **= 11**

K (cm/sec) **= 0.000669 = 6.6E-04**

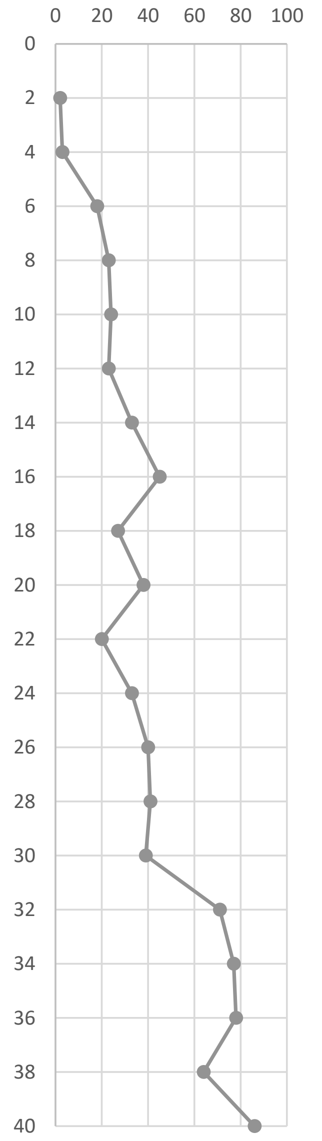
Remarks:

APPENDIX-D

Borehole logs

ECOS Ltd.; GEOTECHNICAL SERVICES

BORE HOLE LOG		
	Location: WTP- Jhal	Project: WASA Master Plan
	Bore Hole No.: 01	Fig No.
	Type of Boring: Rotary	Date Started: 30-11-17
	Termination Depth: 40 m	Date Completed: 02-12-17
	Ground Water Table: 3 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values 150 mm	150 mm	150 mm	N-Values	N- Profile	Recovery SPT (cm)	CR %	RQD %	Remarks
2	clay	CL		DS		1	1	1	2		29			
4	Silty clay	CL-ML		DS		1	1	2	3		27			
6	Silty sand	SM		DS		5	9	9	18		30			
8	Fine graind sand	SW		DS		8	11	12	23		23			
10	do	SW		DS		8	10	14	24		36			
12	do	SW		DS		9	11	12	23		33			
14	do	SW		DS		10	14	19	33		34			
16	do	SW		DS		18	22	23	45		36			
18	do	SW		DS		10	12	15	27		40			
20	do	SW		DS		17	20	18	38		38			
22	do	SW		DS		12	10	10	20		40			
24	do	SW		DS		12	12	21	33		40			
26	Silty clay	CL-ML		DS		9	13	27	40		25			
28	Silty sand	SM		DS		10	14	27	41		30			
30	Medium graind sand	SW		DS		11	19	20	39					
32	do	SW		DS		11	26	45	71		27			
34	do	SW		DS		13	27	50	77		35			
36	Med-course sand	SW		DS		14	28	50	78		28			
38	do	SW		DS		20	26	38	64					
40	do	SW		DS		30	36	50	86					

Checked By: ____________________________

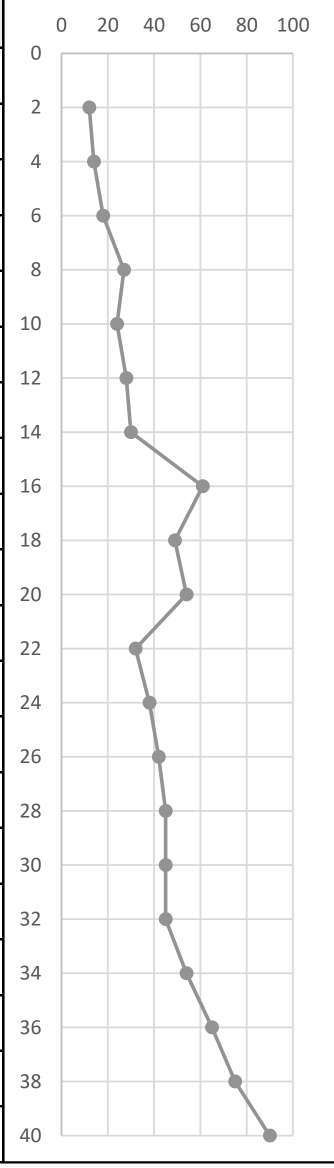
ECOS Ltd.; GEOTECHNICAL SERVICES

BORE HOLE LOG

Location: WTP- Jhal	Project: WASA Master Plan
Bore Hole No.: 02	Fig No.
Type of Boring: Rotary	Date Started: 03-12-2017
Termination Depth: 40 m	Date Completed: 04-12-17
Ground Water Table: 10 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values 150 mm	150 mm	150 mm	N-Values	Recovery SPT (cm)	CR %	RQD %	Remarks
2	clay	CL		DS		5	5	7	12	39			
4	Silty clay	CL-ML		DS		5	6	8	14	33			
6	Silty sand	SM		DS		6	7	11	18	36			
8	Fine graind sand	SW		DS		8	13	14	27	30			
10	do	SW		DS		9	11	13	24	29			
12	do	SW		DS		9	11	16	28	30			
14	do	SW		DS		10	14	16	30	31			
16	do	SW		DS		25	30	31	61	35			
18	do	SW		DS		20	24	25	49	34			
20	do	SW		DS		17	25	29	54	30			
22	do	SW		DS		15	16	16	32	22			
24	do	SW		DS		16	18	20	38	25			
26	do	SW		DS		8	17	25	42	32			
28	Clay	CL		DS		15	14	31	45	27			
30	Medium graind sand	SW		DS		16	19	26	45	39			
32	do	SW		DS		18	21	24	45	28			
34	do	SW		DS		22	26	28	54	38			
36	Med-course sand	SW		DS		25	30	35	65	28			
38	do	SW		DS		30	45	40	75	25			
40	do	SW		DS		40	40	50	90	14			

N- Profile



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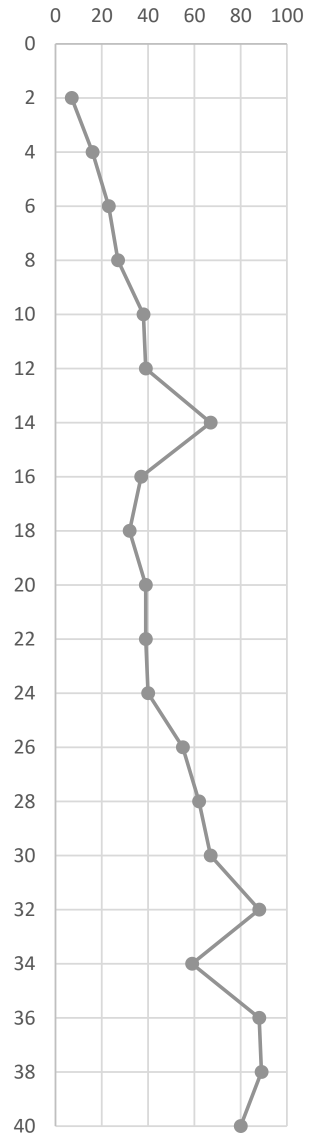
BORE HOLE LOG		
	Location: WTP- Jhal	Project: WASA Master Plan
	Bore Hole No.: 03	Fig No.
	Type of Boring: Rotary	Date Started: 05-12-2017
	Termination Depth: 40 m	Date Completed: 06-12-2017
	Ground Water Table: 20.6 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values 150 mm	150 mm	150 mm	N-Values	N- Profile	Recovery SPT (cm)	CR %	RQD %	Remarks
2	clay	CL		DS		2	3	4	7		30			
4	Silty Sand	SM		DS		2	6	10	16		20			
6	Silty sand	SM		DS		8	11	12	23		32			
8	Fine graind sand	SW		DS		10	12	15	27		29			
10	do	SW		DS		12	18	20	38		27			
12	do	SW		DS		12	17	22	39		29			
14	do	SW		DS		22	32	35	67		35			
16	do	SW		DS		17	17	29	37		35			
18	do	SW		DS		11	14	18	32		32			
20	do	SW		DS		22	26	23	39		32			
22	do	SW		DS		15	18	21	39		32			
24	do	SW		DS		15	19	21	40		30			
26	do	SW		DS		15	20	35	55		28			
28	Silty sand	SM		DS		23	30	32	62		35			
30	Medium graind sand	SW		DS		19	29	38	67		33			
32	do	SW		DS		14	38	50	88		30			
34	do	SW		DS		20	29	30	59		32			
36	Med-course sand	SW		DS		11	36	50	88		40			
38	do	SW		DS		20	39	50	89		35			
40	do	SW		DS		12	30	50	80		38			



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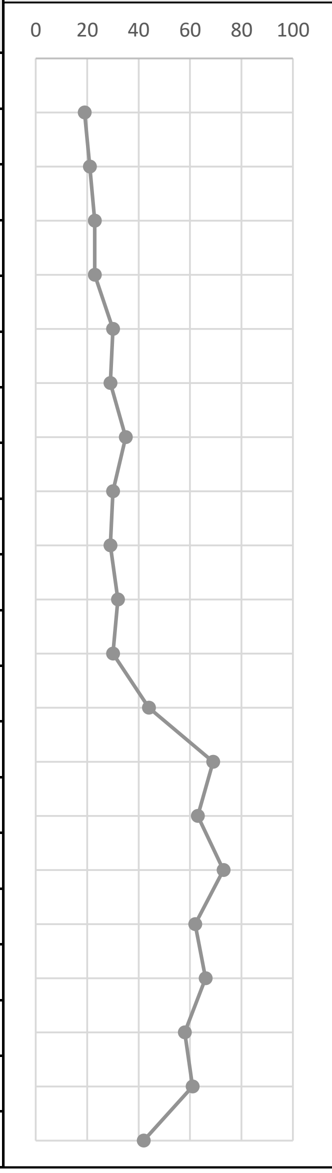
BORE HOLE LOG		
	Location: WTP- Jhal	Project: WASA Master Plan
	Bore Hole No.: 04	Fig No.
	Type of Boring: Rotary	Date Started: 07-12-2017
	Termination Depth: 40 m	Date Completed: 08-12-17
	Ground Water Table: 20.60 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values			N-Values	N- Profile	Recovery			Remarks
						150 mm	150 mm	150 mm			SPT (cm)	CR %	RQD %	
2	clay	CL		DS		4	9	10	19		35			
4	Silty clay	CL		DS		5	9	12	21		39			
6	Silty sand	SM		DS		10	10	13	23		33			
8	Fine graind sand	SW		DS		7	11	12	23		30			
10	do	SW		DS		9	14	16	30		33			
12	do	SW		DS		11	14	15	29		33			
14	do	SW		DS		9	16	19	35		28			
16	do	SW		DS		13	15	15	30		34			
18	do	SW		DS		11	13	16	29		38			
20	do	SW		DS		17	17	15	32		28			
22	do	SW		DS		11	14	16	30		32			
24	do	SW		DS		18	21	23	44		35			
26	Silty clay	CL		DS		10	35	34	69		31			
28	Silty sand	SM		DS		24	27	36	63		32			
30	Medium graind sand	SW		DS		25	34	39	73		28			
32	do	SW		DS		11	27	35	62		25			
34	do	SW		DS		25	29	37	66		33			
36	Med-course sand	SW		DS		27	30	28	58		25			
38	do	SW		DS		25	30	31	61		33			
40	do	SW		DS		19	18	24	42		34			



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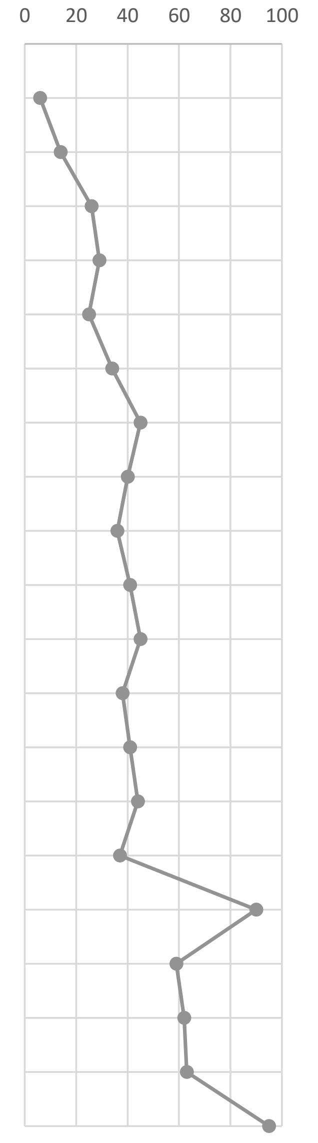
BORE HOLE LOG

Location: Abdullah Pur OHR	Project: WASA Master Plan
Bore Hole No.: 05	Fig No.
Type of Boring: Rotary	Date Started: 10-12-2017
Termination Depth: 40 m	Date Completed: 11-12-2017
Ground Water Table: 19 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values 150 mm	150 mm	150 mm	N-Values	SPT (cm)	CR %	RQD %	Remarks
2	Silty clay	CL-ML		DS		3	2	4	6	30			
4	Silty Sand	SM		DS		5	6	8	14	34			
6	Silty sand	SM		DS		8	12	14	26	32			
8	Fine graind sand	SW		DS		10	13	16	29	34			
10	do	SW		DS		11	13	12	25	30			
12	do	SW		DS		13	15	19	34	29			
14	do	SW		DS		20	22	23	45	30			
16	Claye Silt	ML		DS		16	19	21	40	35			
18	Fine graind sand	SW		DS		10	17	19	36	35			
20	do	SW		DS		7	14	27	41	33			
22	do	SW		DS		9	15	30	45	22			
24	do	SW		DS		14	22	16	38	38			
26	Silty clay	CL-ML		DS		4	15	26	41	25			
28	Silty sand	SM		DS		18	20	24	44	34			
30	Medium graind sand	SW		DS		14	15	22	37	29			
32	do	SW		DS		13	40	50	90	25			
34	do	SW		DS		10	20	39	59	29			
36	Med-course sand	SW		DS		12	33	29	62	32			
38	do	SW		DS		19	26	33	63	28			
40	do	SW		DS		30	45	50	95	32			

N- Profile



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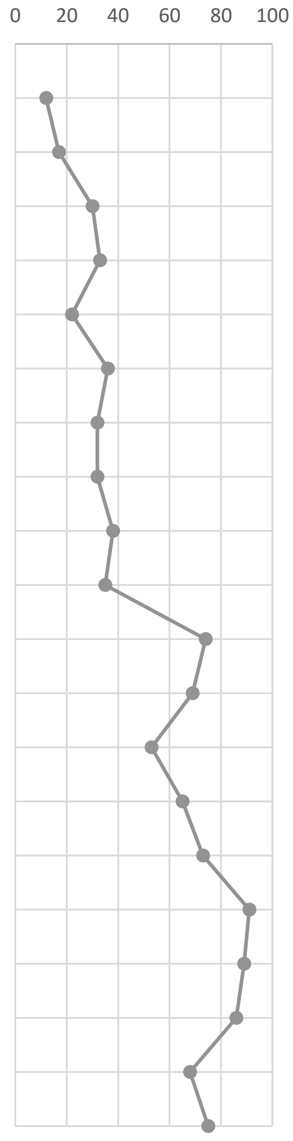
BORE HOLE LOG		**Location: Madina Town OHR NO.2**								**Project: WASA Master Plan**					
		Bore Hole No.: 06								**Fig No.**					
		Type of Boring: Rotary								**Date Started: 13-12-2017**					
		Termination Depth: 40 m								**Date Completed: 14-12-2017**					
		Ground Water Table: 17								**Logger: Umer**					
Depth(m)	**Sample Description**	**Classification Symbol**	**Legend**	**Sample Type**	**Moisture**	**Penetration Values**			**N-Values**	**N- Profile**	**Recovery**				**Remarks**
						150 mm	**150 mm**	**150 mm**		0 20 40 60 80 100	**SPT (cm)**	**CR %**	**RQD %**		
2	clay	CL		DS		4	5	7	12		25				
4	Clayey Silt	ML		DS		5	7	10	17		30				
6	Silty sand	SM		DS		11	14	16	30		35				
8	Silty sand	SM		DS		10	16	17	33		22				
10	Fine graind sand	SW		DS		9	10	12	22		31				
12	do	SW		DS		15	15	21	36		33				
14	do	SW		DS		11	14	18	32		28				
16	do	SW		DS		15	10	22	32		30				
18	do	SW		DS		15	17	21	38		30				
20	do	SW		DS		13	17	18	35		28				
22	do	SW		DS		9	29	45	74		27				
24	do	SW		DS		22	34	35	69		33				
26	do	SW		DS		12	18	35	53		27				
28	do	SW		DS		18	28	37	65		27				
30	Medium graind sand	SW		DS		20	31	42	73		35				
32	do	SW		DS		30	41	50	91		35				
34	do	SW		DS		29	42	47	89		48				
36	Med-course sand	SW		DS		30	37	49	86		28				
38	do	SW		DS		30	33	35	68		26				
40	do	SW		DS		32	35	40	75		22				



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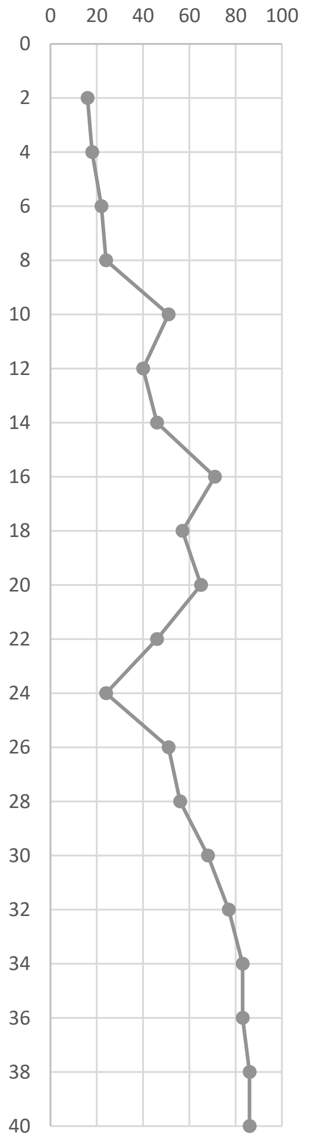
BORE HOLE LOG		
	Location: Madina Town OHR No.1	Project: WASA Master Plan
	Bore Hole No.: 07	Fig No.
	Type of Boring: Rotary	Date Started: 15-12-2017
	Termination Depth: 40 m	Date Completed: 16-12-17
	Ground Water Table: 18 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values 150 mm	150 mm	150 mm	N-Values	N- Profile	Recovery SPT (cm)	CR %	RQD %	Remarks
2	clay	CL		DS		8	8	8	16		28			
4	clay	CL		DS		4	8	10	18		27			
6	Silty Sand	SM		DS		8	10	12	22		32			
8	Fine graind sand	SW		DS		8	5	19	24		27			
10	do	SW		DS		19	26	25	51		25			
12	do	SW		DS		13	18	22	40		36			
14	do	SW		DS		25	24	22	46		28			
16	do	SW		DS		18	26	45	71		25			
18	do	SW		DS		11	18	29	57		42			
20	do	SW		DS		12	30	35	65		32			
22	do	SW		DS		8	21	25	46		25			
24	do	SW		DS		6	10	14	24		31			
26	do	SW		DS		16	25	26	51		27			
28	do	SM		DS		21	27	29	56		30			
30	Medium graind sand	SW		DS		22	31	37	68		25			
32	do	SW		DS		27	34	43	77		27			
34	do	SW		DS		28	35	48	83		30			
36	Med-course sand	SW		DS		30	38	45	83		26			
38	do	SW		DS		31	39	47	86		20			
40	do	SW		DS		31	36	50	86		21			



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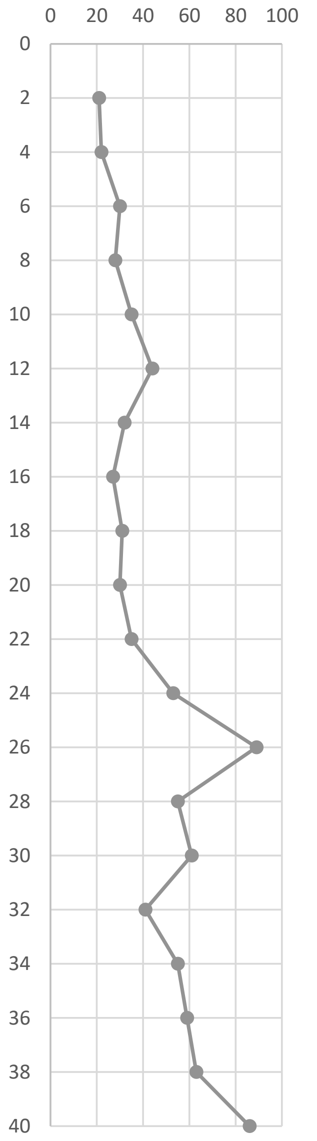
BORE HOLE LOG		
	Location: PC OHR No. 2	Project: WASA Master Plan
	Bore Hole No.: 08	Fig No.
	Type of Boring: Rotary	Date Started: 16-12-2017
	Termination Depth: 40 m	Date Completed: 17-12-2017
	Ground Water Table: 21 m	Logger: Umer

Depth(m)	Sample Description	Classification Symbol	Legend	Sample Type	Moisture	Penetration Values 150 mm	150 mm	150 mm	N-Values	N- Profile	Recovery SPT (cm)	CR %	RQD %	Remarks
2	Clay	CL		DS		5	9	12	21		22			
4	Clay	CL		DS		6	10	12	22		23			
6	clayey silt	ML-CL		DS		8	14	16	30		28			
8	Fine graind sand	SW		DS		9	12	18	28		26			
10	do	SW		DS		13	16	19	35		22			
12	do	SW		DS		18	21	23	44		25			
14	do	SW		DS		13	13	19	32		29			
16	do	SW		DS		7	11	16	27		20			
18	do	SW		DS		8	12	19	31		31			
20	do	SW		DS		8	12	18	30		35			
22	do	SW		DS		9	13	20	35		20			
24	Med-course sand	SW		DS		10	18	35	53		25			
26	do	SW		DS		7	39	50	89		26			
28	do	SM		DS		19	25	30	55		24			
30	do	SW		DS		19	33	28	61		27			
32	do	SW		DS		12	15	26	41		40			
34	do	SW		DS		12	20	35	55		35			
36	do	SW		DS		11	22	37	59		30			
38	do	SW		DS		13	24	39	63		25			
40	do	SW		DS		14	36	50	86		30			



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APPENDIX-F

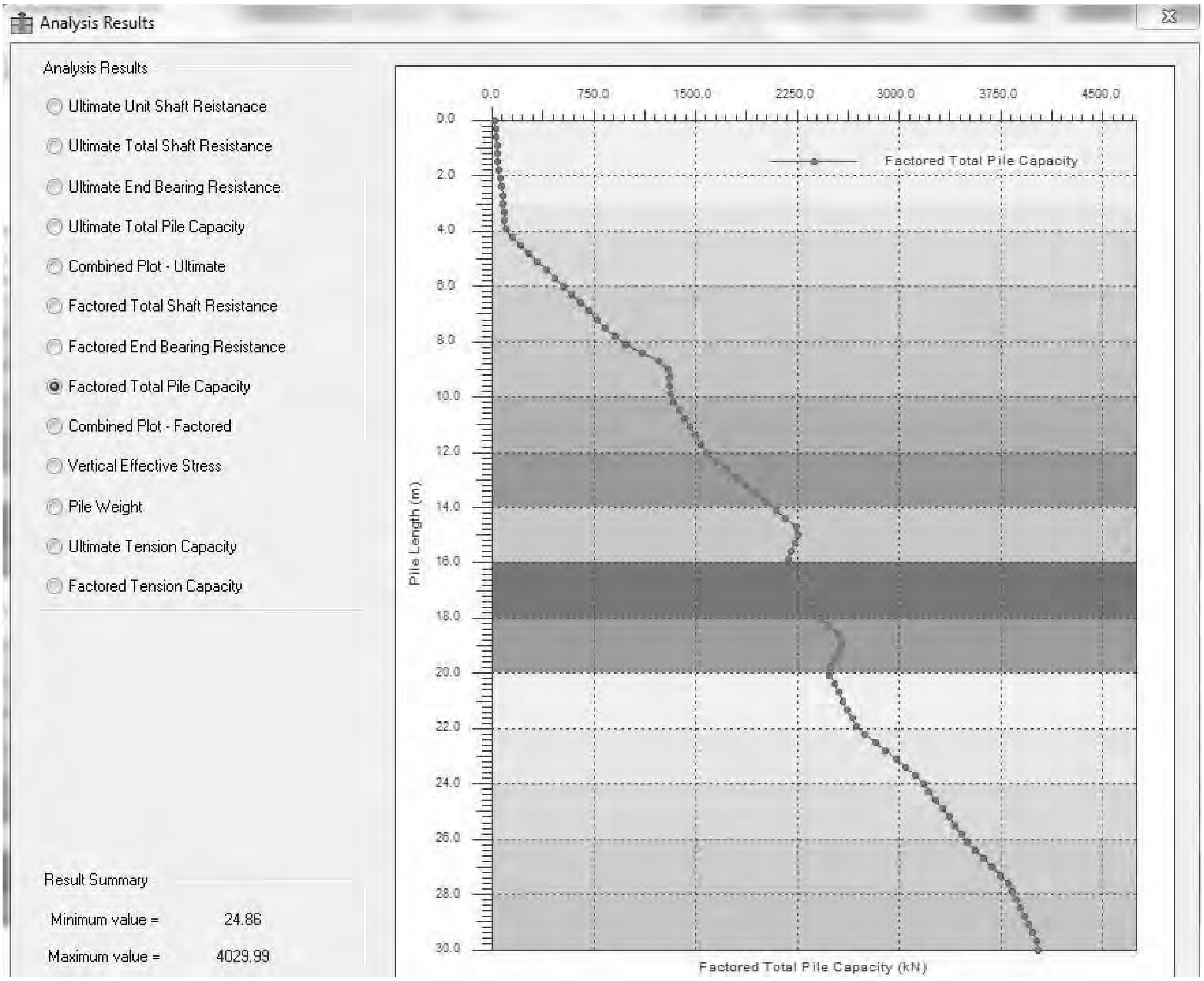
(Calculation Sheet 1)

Bearing Capacity Calculations for BH -01 to BH -08

BH-01

Foundation Type: Pile Foundation Pile
Diameter =1 m
Pile Length =30m
Pile Capacity = 4000 KN

PILEAXL Results



Bearing Capacity Calculations for BH 02 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \,.\, R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	14		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
Rɣ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	29	mm	From Sheet 2
qna=	Net Allowable Bearing Capacity	136.0764	Kpa	

Bearing Capacity Calculations for BH 03 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \,.\, R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	16		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
Rɣ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	24	mm	From Sheet 2
qna=	Net Allowable Bearing Capacity	133.0904	Kpa	

Bearing Capacity Calculations for BH 04 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \,.\, R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	21		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
Rɣ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	16	mm	From Sheet 2
qna=	Net Allowable Bearing Capacity	122.8527	Kpa	

Bearing Capacity Calculations for BH 05 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \, . \, R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	14		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
Rγ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	29	mm	From Sheet 2
qna=	Net Allowable Bearing Capacity	136.0764	Kpa	

Bearing Capacity Calculations for BH 06 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \, . \, R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	17		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
Rγ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	22	mm	From Sheet 2
qna=	Net Allowable Bearing Capacity	131.3841	Kpa	

Bearing Capacity Calculations for BH 07 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \, . \, R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	18		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
Rγ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	20	mm	From Sheet 2
qna=	Net Allowable Bearing Capacity	127.9716	Kpa	

Bearing Capacity Calculations for BH 08 (Raft Type Foundation)				
$$q_{na} = 34.3\,(N-3)\left(\frac{b+0.3}{2b}\right)^2 R_\gamma \cdot R_d$$				Teng Equation
N=	Standard penetration value corrected for overburden pressure and other applicable factors	22		
Df=	Depth of footing	4	m	
b=	width of footing	19.41	m	
R_γ=	correction factor for location of water table	1		
Rd=	Depth factor	1.206079		
ΔHa=	Maximum differential settlement	15	mm	From Sheet 2
q_{na}=	Net Allowable Bearing Capacity	121.573	Kpa	

APPENDIX-F

(Calculation Sheet 2)

Settlement Calculation

BH-02

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N'	Manual	
SPT N' value, N' =	14	
Is N constant/increasing OR decreasing with depth?	Constant	
Thickness of sand/gravel beneath foundation, H_s =	10	m
Average gross effective applied pressure, q' =	100	kN/m^2
Is load STATIC or FLUCTUATING?	Fluctuating	
Max previous effective overburden pressure, σ'_{vo} =	69.64	kN/m^2
Breadth of foundation, B =	19.41	m
Length of foundation, L =	19.41	m
Time, t =	20	years

CALCULATION

mean compressibility index, I_c =	0.043		$I_c = 1.71/N^{1.4}$
depth of influence, z_i =	9.2	m	for const/incr N, $z_i = B^{0.75}$
			for decr N, z_i = Min of 2B and H_s
correction factor for thickness of layer, f_l =	1.0		$z_i>H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else f_l = 1.0
correction factor for L/B, f_s =	1.00		$f_s = (1.25*L/B/(L/B+0.25))^2$
creep ratio, R =	0.8		static loads R=0.2, fluctuating loads R=0.8
time dependent settlement ratio, R_3 =	0.7		static loads R_3=0.3, fluctuating loads R_3=0.7
correction factor for time, f_t =	2.36		$f_t = 1+R_3+R*\log(t/3)$
Initial average settlement, ρi =	**18**	**mm**	for $q'>=\sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$
			for $q'<\sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$
Average settlement at time t, ρ_t =	**43**	**mm**	$\rho_t=f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} =	0.018	$I_c = 0.55/N^{1.3}$ estimate
upper bound compressibility index, I_{ub} =	0.11	$I_c = 7.5/N^{1.6}$ estimate

Probable limits of accuracy of ρ_i =	8	to	47	mm
Probable limits of accuracy of ρ_t =	18	to	111	mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t =	29	mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

Settlement Calculation

BH-03

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N'	Manual	
SPT N' value, N' =	16	
Is N constant/increasing OR decreasing with depth?	Constant	
Thickness of sand/gravel beneath foundation, H_s =	10	m
Average gross effective applied pressure, q' =	100	kN/m^2
Is load STATIC or FLUCTUATING?	Fluctuating	
Max previous effective overburden pressure, σ'_{vo} =	69.64	kN/m^2
Breadth of foundation, B =	19.41	m
Length of foundation, L =	19.41	m
Time, t =	20	years

CALCULATION

mean compressibility index, I_c =	0.035		$I_c = 1.71/N^{1.4}$
depth of influence, z_i =	9.2	m	for const/incr N, $z_i = B^{0.75}$
			for decr N, z_i = Min of 2B and H_s
correction factor for thickness of layer, f_l =	1.0		$z_i>H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else f_l = 1.0
correction factor for L/B, f_s =	1.00		$f_s = (1.25*L/B/(L/B+0.25))^2$
creep ratio, R =	0.8		static loads R=0.2, fluctuating loads R=0.8
time dependent settlement ratio, R_3 =	0.7		static loads R_3=0.3, fluctuating loads R_3=0.7
correction factor for time, f_t =	2.36		$f_t = 1+R_3+R*\log(t/3)$
Initial average settlement, ρi =	**15**	**mm**	for $q'>=\sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$
			for $q'<\sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$
Average settlement at time t, ρ_t =	**36**	**mm**	$\rho_t=f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} =	0.015	$I_c = 0.55/N^{1.3}$ estimate
upper bound compressibility index, I_{ub} =	0.089	$I_c = 7.5/N^{1.6}$ estimate

Probable limits of accuracy of ρ_i =	6	to	38	mm
Probable limits of accuracy of ρ_t =	15	to	89	mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t =	24	mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

Settlement Calculation

BH-04

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N'	Manual	
SPT N' value, N' =	21	
Is N constant/increasing OR decreasing with depth?	Constant	
Thickness of sand/gravel beneath foundation, H_s =	10	m
Average gross effective applied pressure, q' =	100	kN/m^2
Is load STATIC or FLUCTUATING?	Fluctuating	
Max previous effective overburden pressure, σ'_{vo} =	69.64	kN/m^2
Breadth of foundation, B =	19.41	m
Length of foundation, L =	19.41	m
Time, t =	20	years

CALCULATION

mean compressibility index, I_c =	0.024		$I_c = 1.71/N^{1.4}$
depth of influence, z_i =	9.2	m	for const/incr N, $z_i = B^{0.75}$
			for decr N, z_i = Min of 2B and H_s
correction factor for thickness of layer, f_l =	1.0		$z_i > H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else f_l = 1.0
correction factor for L/B, f_s =	1.00		$f_s = (1.25*L/B/(L/B+0.25))^2$
creep ratio, R =	0.8		static loads R=0.2, fluctuating loads R=0.8
time dependent settlement ratio, R_3 =	0.7		static loads R_3=0.3, fluctuating loads R_3=0.7
correction factor for time, f_t =	2.36		$f_t = 1+R_3+R*\log(t/3)$
Initial average settlement, ρi =	**10**	**mm**	for $q' >= \sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$
			for $q' < \sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$
Average settlement at time t, ρ_t =	**24**	**mm**	$\rho_t = f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} =	0.011	$I_c = 0.55/N^{1.3}$ estimate
upper bound compressibility index, I_{ub} =	0.057	$I_c = 7.5/N^{1.6}$ estimate

Probable limits of accuracy of ρ_i =	4	to	25	mm
Probable limits of accuracy of ρ_t =	11	to	58	mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t = 16 mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

Settlement Calculation

BH-05

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N'	Manual	
SPT N' value, N' =	14	
Is N constant/increasing OR decreasing with depth?	Constant	
Thickness of sand/gravel beneath foundation, H_s =	10	m
Average gross effective applied pressure, q' =	100	kN/m^2
Is load STATIC or FLUCTUATING?	Fluctuating	
Max previous effective overburden pressure, σ'_{vo} =	69.64	kN/m^2
Breadth of foundation, B =	19.41	m
Length of foundation, L =	19.41	m
Time, t =	20	years

CALCULATION

mean compressibility index, I_c =	0.043		$I_c = 1.71/N^{1.4}$
depth of influence, z_i =	9.2	m	for const/incr N, $z_i = B^{0.75}$
			for decr N, z_i = Min of 2B and H_s
correction factor for thickness of layer, f_l =	1.0		$z_i>H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else f_l = 1.0
correction factor for L/B, f_s =	1.00		$f_s = (1.25*L/B/(L/B+0.25))^2$
creep ratio, R =	0.8		static loads R=0.2, fluctuating loads R=0.8
time dependent settlement ratio, R_3 =	0.7		static loads R_3=0.3, fluctuating loads R_3=0.7
correction factor for time, f_t =	2.36		$f_t = 1+R_3+R*\log(t/3)$
Initial average settlement, ρi =	18	mm	for $q'>=\sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$
			for $q'<\sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$
Average settlement at time t, ρ_t =	43	mm	$\rho_t=f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} =	0.018	$I_c = 0.55/N^{1.3}$ estimate
upper bound compressibility index, I_{ub} =	0.11	$I_c = 7.5/N^{1.6}$ estimate

Probable limits of accuracy of ρ_i =	8	to	47	mm
Probable limits of accuracy of ρ_t =	18	to	111	mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t = 29 mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

Settlement Calculation

BH-06

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N'	Manual	
SPT N' value, N' =	17	
Is N constant/increasing OR decreasing with depth?	Constant	
Thickness of sand/gravel beneath foundation, H_s =	10	m
Average gross effective applied pressure, q' =	100	kN/m^2
Is load STATIC or FLUCTUATING?	Fluctuating	
Max previous effective overburden pressure, σ'_{vo} =	69.64	kN/m^2
Breadth of foundation, B =	19.41	m
Length of foundation, L =	19.41	m
Time, t =	20	years

CALCULATION

mean compressibility index, I_c =	0.032		$I_c = 1.71/N^{1.4}$
depth of influence, z_i =	9.2	m	for const/incr N, $z_i = B^{0.75}$ for decr N, z_i = Min of 2B and H_s
correction factor for thickness of layer, f_l =	1.0		$z_i>H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else f_l = 1.0
correction factor for L/B, f_s =	1.00		$f_s = (1.25*L/B/(L/B+0.25))^2$
creep ratio, R =	0.8		static loads R=0.2, fluctuating loads R=0.8
time dependent settlement ratio, R_3 =	0.7		static loads R_3=0.3, fluctuating loads R_3=0.7
correction factor for time, f_t =	2.36		$f_t = 1+R_3+R*\log(t/3)$
Initial average settlement, ρi =	14	mm	for $q'>=\sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$ for $q'<\sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$
Average settlement at time t, ρ_t =	33	mm	$\rho_t=f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} =	0.014	$I_c = 0.55/N^{1.3}$ estimate
upper bound compressibility index, I_{ub} =	0.081	$I_c = 7.5/N^{1.6}$ estimate

Probable limits of accuracy of ρ_i =	6	to	34	mm
Probable limits of accuracy of ρ_t =	14	to	81	mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t =	22	mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

Settlement Calculation

BH-07

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N'	Manual		
SPT N' value, N' =	18		
Is N constant/increasing OR decreasing with depth?	Constant		
Thickness of sand/gravel beneath foundation, H_s =	10	m	
Average gross effective applied pressure, q' =	100	kN/m^2	
Is load STATIC or FLUCTUATING?	Fluctuating		
Max previous effective overburden pressure, σ'_{vo} =	69.64	kN/m^2	
Breadth of foundation, B =	19.41	m	
Length of foundation, L =	19.41	m	
Time, t =	20	years	

CALCULATION

mean compressibility index, I_c =	0.03		$I_c = 1.71/N^{1.4}$
depth of influence, z_i =	9.2	m	for const/incr N, $z_i = B^{0.75}$
			for decr N, z_i = Min of 2B and H_s
correction factor for thickness of layer, f_l =	1.0		$z_i>H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else $f_l = 1.0$
correction factor for L/B, f_s =	1.00		$f_s = (1.25*L/B/(L/B+0.25))^2$
creep ratio, R =	0.8		static loads R=0.2, fluctuating loads R=0.8
time dependent settlement ratio, R_3 =	0.7		static loads R_3=0.3, fluctuating loads R_3=0.7
correction factor for time, f_t =	2.36		$f_t = 1+R_3+R*\log(t/3)$
Initial average settlement, ρi =	13	mm	for $q'>=\sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$
			for $q'<\sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$
Average settlement at time t, ρ_t =	30	mm	$\rho_t=f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} =	0.013		$I_c = 0.55/N^{1.3}$ estimate	
upper bound compressibility index, I_{ub} =	0.074		$I_c = 7.5/N^{1.6}$ estimate	
Probable limits of accuracy of ρ_i =	5	to	31	mm
Probable limits of accuracy of ρ_t =	13	to	74	mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t = 20 mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

Settlement Calculation

BH-08

Settlement estimate based on Burland and Burbridge, 1985.

INPUT

Manual OR Calculated value of N' Manual

SPT N' value, N' = 22

Is N constant/increasing OR decreasing with depth? Constant

Thickness of sand/gravel beneath foundation, H_s = 10 m

Average gross effective applied pressure, q' = 100 kN/m^2

Is load STATIC or FLUCTUATING? Fluctuating

Max previous effective overburden pressure, σ'_{vo} = 69.64 kN/m^2

Breadth of foundation, B = 19.41 m

Length of foundation, L = 19.41 m

Time, t = 20 years

CALCULATION

mean compressibility index, I_c = 0.023 — $I_c = 1.71/N^{1.4}$

depth of influence, z_i = 9.2 m — for const/incr N, $z_i = B^{0.75}$

for decr N, z_i = Min of 2B and H_s

correction factor for thickness of layer, f_l = 1.0 — $z_i > H_s$, $f_l = H_s/z_i*(2-H_s/z_i)$ else f_l = 1.0

correction factor for L/B, f_s = 1.00 — $f_s = (1.25*L/B/(L/B+0.25))^2$

creep ratio, R = 0.8 — static loads R=0.2, fluctuating loads R=0.8

time dependent settlement ratio, R_3 = 0.7 — static loads R_3=0.3, fluctuating loads R_3=0.7

correction factor for time, f_t = 2.36 — $f_t = 1+R_3+R*\log(t/3)$

Initial average settlement, ρi =	10	mm

for $q' >= \sigma'_{vo}$, $\rho_i = f_s*f_l*(q'-2/3\sigma'_{vo})*B^{0.7}*I_c$

for $q' < \sigma'_{vo}$, $\rho_i = f_s*f_l*q'*B^{0.7}*I_c/3$

Average settlement at time t, ρ_t =	23	mm

$\rho_t = f_t*\rho_i$

The probable limits of accuracy can be assessed by taking upper and lower limits of Ic

lower bound compressibility index, I_{lb} = 0.01 — $I_c = 0.55/N^{1.3}$ estimate

upper bound compressibility index, I_{ub} = 0.053 — $I_c = 7.5/N^{1.6}$ estimate

Probable limits of accuracy of ρ_i = 4 to 23 mm

Probable limits of accuracy of ρ_t = 10 to 54 mm

Maximum differential settlement can be crudely estimated as 2/3 total settlement

Max differential settlement, diff. ρ_t =	15	mm

Notes : Method based on case studies with quartzitic sand and gravel. Sites where coral (calcite) or other mineralogically unusual sand and gravel deposits should not be analysed using this method unless the deformation properties can be demonstrated to be similar to quartzitic deposits.

APPENDIX-F

Details of Exploratory Boreholes along with Site Photographs

Bore Hole 1

[30-11-2017 to 06-12-17]

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-01 **[30-11-2017 to 06-12-17]** **Water Treatment Plant, Jhal**

PHOTO SHOOTING DATE: 30-11-17

SITE VIEW

Site Preparation

Setting up Rotary Machine

View from Southern Site

Drilling Firm Staff
a) Irfan
(Geologist)
b) Abid
(Driller)

Consultant Staff
a) Muhammad Umar
(Senior Geologist)
b) Muhammad Majid
(Assistant Geologist)

PHOTO SHOOTING DATE: 06-12-17

SITE VIEW

Performance of On-site Permeability Test

Measurement of water inflow at different time intervals

Drilling Firm Staff
a) Irfan
(Geologist)
b) Abid
(Driller)

Consultant Staff
a) Muhammad Umar
(Senior Geologist)
b) Muhammad Majid
(Assistant Geologist)

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

Bore Hole 2

[03-12-2017 to 04-12-17]

ECOS

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-02 **[03-12-2017 to 04-12-17]** **Water Treatment Plant, Jhal**

PHOTO SHOOTING DATE: 03-12-17

SITE VIEW

Performing SPT Test.

View from West

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PHOTO SHOOTING DATE: 04-12-17

SITE VIEW

Measurement of SPT Recovery

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

Bore Hole 3

[05-12-2017 to 06-12-17]

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-03 [05-12-2017 to 06-12-17] Water Treatment Plant, Jhal

PHOTO SHOOTING DATE: 05-12-17

SITE VIEW

Performing SPT Test.

View from South-East

Drilling Firm Staff
a) Irfan
(Geologist)
b) Abid
(Driller)

Consultant Staff
a) Muhammad Umar
(Senior Geologist)
b) Muhammad Majid
(Assistant Geologist)

PHOTO SHOOTING DATE: 06-12-17

SITE VIEW

Measurement of Ground Water table

Drilling Firm Staff
a) Irfan
(Geologist)
b) Abid
(Driller)

Consultant Staff
a) Muhammad Umar
(Senior Geologist)
b) Muhammad Majid
(Assistant Geologist)

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

Bore Hole 4

[07-12-17]

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-04 **[07-12-17]** **Water Treatment Plant, Jhal**

PHOTO SHOOTING DATE: 07-12-17

SITE VIEW

Performing SPT Test.

View from East

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PHOTO SHOOTING DATE: 07-12-17

SITE VIEW

Collection of Samples

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

Bore Hole 5

[10-12-2017 to 11-12-17]

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-05 [10-12-2017 to 11-12-17] Abdullah Pur OHR

PHOTO SHOOTING DATE: 10-12-17

SITE VIEW

Drilling on site

View from South

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PHOTO SHOOTING DATE: 11-12-17

SITE VIEW

Performance of Permeability test

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

Bore Hole 6

[13-12-17]

ECOS

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-06 **[13-12-17]** **Madina Town OHR No. 2**

PHOTO SHOOTING DATE: 13-12-17

SITE VIEW

Drilling on site

View from North-East

Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PHOTO SHOOTING DATE: 13-12-17

SITE VIEW

Performance of Permeability test

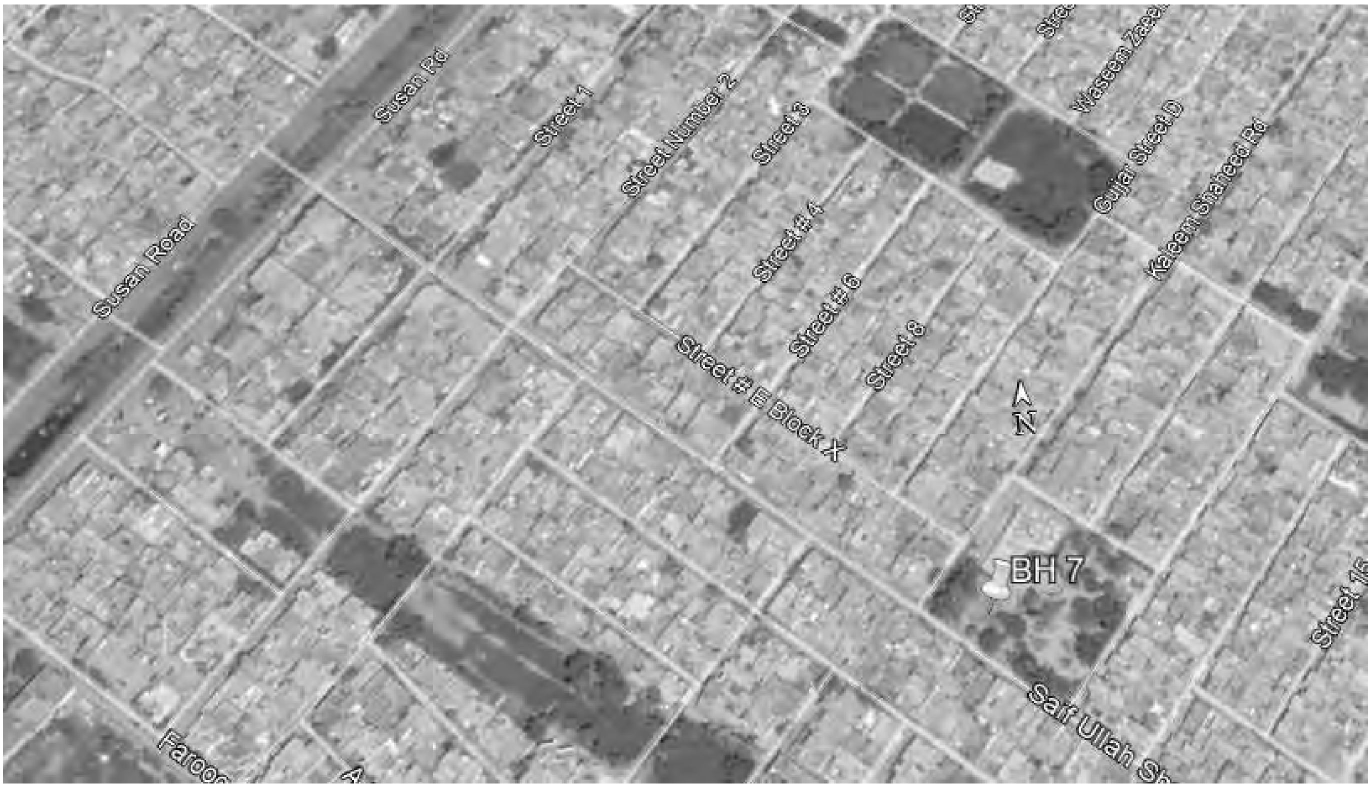
Drilling Firm Staff
a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff
a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

Bore Hole 7

16-12-17



ECOS

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-07 **16-12-17** **Madina Town OHR No. 1**

PHOTO SHOOTING DATE: 16-12-17

SITE VIEW

Drilling on site

View from West

Drilling Firm Staff

a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff

a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PHOTO SHOOTING DATE: 16-12-17

SITE VIEW

Preparation for permeability test

Drilling Firm Staff

a) Irfan (Geologist)
b) Abid (Driller)

Consultant Staff

a) Muhammad Umar (Senior Geologist)
b) Muhammad Majid (Assistant Geologist)

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

Bore Hole 8

[16-12-2017 to 17-12-17]

ECOS

PROJECT : - Geotechnical Investigation of WASA Master Plan of Faisalabad

BH-08 **[16-12-2017 to 17-12-17]** **Peoples Colony OHR No. 2**

PHOTO SHOOTING DATE: 16-12-17

SITE VIEW

Pulling out of bores

View from West

Drilling Firm Staff

a) Irfan (Geologist)

b) Abid (Driller)

Consultant Staff

a) Muhammad Umar (Senior Geologist)

b) Muhammad Majid (Assistant Geologist)

PHOTO SHOOTING DATE: 17-12-17

SITE VIEW

Drilling on site

Drilling Firm Staff

a) Irfan (Geologist)

b) Abid (Driller)

Consultant Staff

a) Muhammad Umar (Senior Geologist)

b) Muhammad Majid (Assistant Geologist)

Boring in Progress at Abdullah Pur OHR

Boring at Madina Town OHR

Boring At Peoples Colony OHR

Boring At Water Treatment Plant, Jhal

SPT Recovery Measurement

Water Head Measurement during Permeability Test

Performance of Permeability Test

Labeling and Preservations of SPT Samples

Measurement of Bore Hole Depth

Labeling and Preservation of Undisturbed Samples

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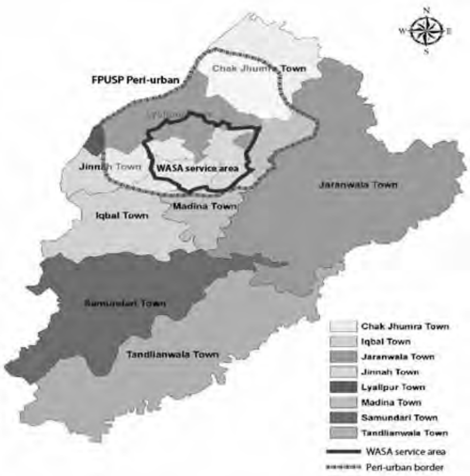
WATER AND SANITATION AGENCY, FAISALABAD

The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad

Initial Environmental Examination Report



FINITE ENGINEERING

WATER AND SANITATION AGENCY, FAISALABAD

The Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad

Initial Environmental Examination Report

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1 Introduction

1.1 Project Background

This report presents Initial Environmental Examination of Priority Projects identified under the M/P which is under preparation for developing/improving water supply sources, sewerage and drainage services in Faisalabad. WASA-F in collaboration with JICA technical assistance has initiated to formulate M/P for the water sector's development in the city.

Faisalabad is the third largest city of Pakistan having a population of 2.8 million (2015) with an average growth rate of 1.8% per annum, the population is expected to increase to about 3.3 million in 2023 and 4.2 million in 2038. Water supply sources cannot keep pace with the growing population. Against the demand of 650,000m^3/day, the supply is 501,000m^3/day. Around 98% of water source is dependent on groundwater being recharged from irrigation canals and rivers and mainly pumped up via tube wells around Jhang Branch Canal and Chenab River.

WASA-F has been making efforts to improve the situation. The first development Master Plan (M/P) was formulated by WASA Faisalabad in 1976 with the help of Asian Development Bank (ADB) and was last revised in 1993 in cooperation with World Bank (WB). Due to shortage of budget and lack of ground water resources, only a small part of plan has been implemented.

To improve and review the water supply, sewerage and drainage in the Faisalabad city, the government of Pakistan requested the government of to provide support in formulating a long-term/Master plan for the development facilities of appropriate water supply resources, sewerage and drainage services/ system on sustainable basis. In response to a request made by the Government of Punjab, Government of Japan agreed to provide the technical assistance to carry out a comprehensive study for the formulation of master plan for water supply, sewerage and drainage in Faisalabad (hereinafter referred to as "the Project").h

1.1.1 Master Plan Project

Master Plan envisaged integrated development/ improvement of water sources and sewerage system in Faisalabad. The base year of the project is 2015 and the target year is 2038. Besides, the institutional capacity of WASA-F is also proposed to be enhanced for implementing M/P Projects. Stage- wise approach has been suggested for implementation of the project (M/P). In the first instance priority projects for the development and improvement of the water supply sources would be implemented in Faisalabad.

1.1.2 Priority Projects identified in M/P

This includes priority projects proposed under Master Plan, which are classified into six categories for the development/ construction of existing/new water supply sources and improvement of water supply services and operations on sustainable basis during the plan period. The projects thus identified are described in section 2 of this report.

1.1.3 Brief Output of Priority Projects

Proper execution of priority projects would result in achieving improved water supply, water pressure, and establishment of data management/data base. As a result of implementation of priority projects, the output of water supply (1000 m^3/day and MGD) proposed to be achieved during the M/P period is presented in the following table:

Table 1: *Proposed Water Supply*

Sr. No.	Year	1000 m^3/day	Million Gallons per Day
1.	2018-2023	484.1	106.5
2.	2024-2028	295.5	65
3.	2029-2033	204.7	45
4.	2034-2038	438.7	96.5

1.2 Purpose of Initial Environmental Examination Report

This Initial Environmental Examination demonstrates an assessment of the predicted impacts induced on the environment by the priority projects of the M/P for Water Supply, Sewerage and Drainage in Faisalabad being implemented by WASA-F with the technical assistance of JICA.

Punjab EPA Regulations/ JICA Guidelines require consideration of environmental issues/ assessment as a result of implementation of priority projects. It is anticipated that these projects fall under the category G of Schedule 1 of EPA Regulations 2000. Initial Environmental Evaluation has been carried out as per requirement for environmental category B projects.

The IEE is based largely on the line survey (Route Survey) conducted at the locations where the priority projects are planned and secondary data sources related to socio-economic conditions. Consultative process has been initiated with stakeholders from various government departments, CDGF, semi-government/ private organizations, public representatives, professionals etc.

Environmental Management and Monitoring Plan have also been prepared as a part of the report.

1.3 Structure of IEE Report

This report comprises of the following:

1. Introduction
2. Project description
3. Policy, Legal and Administrative Framework
4. Assessment of Baseline Environmental & Social Conditions
5. Assessment of Potential Impacts & Mitigation Measures
6. Stakeholder Consultation
7. Environmental Management and Monitoring Plan (EMMP)
8. Conclusions and Recommendations

2 Project Description

Water resources have been scarce in Faisalabad and depletion trend continued unabated over the years. Water supply demand fell short of demand due to rapid growth of population and increase in urbanization. The total demand of water in the city was 650,000m3/day in 2015, against which the supply was 501,000m3/day i.e. almost one–fourth of demand could not be met. Due to scarcity of water resources and delay in the development of water supply facilities, only 60% of the households in the city have access to municipal water supply. The topography of Faisalabad is flat/plain area. As such sewage and storm water cannot be disposed of from the city through gravity flow without the use of multistage pumping which is quite expensive. In 2015, the Faisalabad city generated approximately 280 MGD sewage water. Three types of connections registered with WASA Faisalabad as sewer connections are available for the disposal of domestic, commercial and Industrial waste water in the city. The domestic connections are 70% of the households; remaining 30% households having no sewer connections (Ref: EIA Report for Provision of sewerage system in sewerage deficient areas, Faisalabad, April 2015).

The situation regarding development/ improvement of water sector in Faisalabad; comprising water supply, sewerage/ drainage facilities has been deteriorated and could not keep pace with the rapidly growing population, industrialization, urbanization during the past years. In order to assess the declining trend of water supply sources and capacity lagged sewerage/ drainage services, Government of Pakistan requested the Government of Japan to provide the technical assistance to carry out a comprehensive study for the formulation of master plan for water supply, sewerage and drainage in Faisalabad (hereinafter referred to as “the Project"). JICA being the official agency responsible for implementation and technical co-operation programs on behalf of the Government of Japan dispatched a survey team. JICA survey team conducted a detailed planning survey for the project and signed a Record of Discussion with Government of Punjab in March 2016 before the commencement of work on the master plan project.

2.1 The Project

Master plan for water supply, sewerage & drainage in Faisalabad is mainly concerned with the formulation of a strategy for the providing a viable system of water supply resources, sewerage services and drainage structure on sustainable basis, to meet the existing as well as future demand of the residents in & around Faisalabad. The current project is largely built upon the review of the past development work recommended/implemented in the master plan which was prepared in 1976 with ADB support and revised in 1993 with the World Bank assistance. Since then, it has never been reviewed for over 20 years.

In addition, the review would also make an assessment of current situation regarding water resources, water quality, and efficacy of drainage/sewerage facilities, natural & socio-economic conditions. Furthermore, the project would put forward the proposals for urban/land use development, organizational structure/financial management and revenue generation schemes for WASA-F and public awareness survey.

2.2 Objective and Scope of M/P

Principle objectives of M/P are:

- To formulate strategy for WASA-F and enhance its institutional capacity to undertake development/ improvement projects of M/P.
- To provide clean water and meet the current and future public demand.
- To improve revenue generation opportunities for WASA-F and quality of life.

Main facets of the M/P Project in Faisalabad are:

- Augmentation of Water Supply sources
- Expansion/ construction of existing/new Sewerage Lines
- Extension/ development of drainage system's capacity

The M/P would cover the following:

- Area enclosed within the boundary of Peri-Urban Structure Plan of Faisalabad
- Transitional zone between Faisalabad city and its hinterland and serve as interface between the urban, rural and natural areas
- WASA-F expanded service area

2.3 Description of Priority Projects

There are six categories of priority projects proposed in M/P. This includes:

1. Water Source Development (including New WTP Construction)
2. Mechanical and Electrical Replacements
3. Reservoir Constructions and Rehabilitations (i.e. OHR & GR)
4. Transmission and Arterial Main Extension
5. Distribution Network Improvement
6. Service Connection

2.3.1 Criteria for Priority Projects

Criteria adopted for selection of priority projects have been outlined as under:

1. Water Source Development (including New WTP Construction)
    - Following urgent implementation of the projects within the first 6 years beginning in 2018.
    - Provision of large volumes of water to the areas having water shortage.
    - Ensuring water source development through reliable data and information.
    - No land acquisition/ resettlement requirement envisaged for the project.
    - Minimizing the overall impact on the environment to preserve the water resources.
2. Mechanical and Electrical Replacements
    - For improvement and keeping operation rate of the facility urgent requirement of mechanical and electrical replacements due to intense degradation and low capacity.
3. Reservoir Constructions and Rehabilitations
    - Construction of overhead Reservoirs (OHR) and Ground Reservoirs under this project for water transmission from WTP.

4. Transmission and Arterial Main Extension
    - Facilitating easy water supply from the selected WTP to GRs and OHRs.
5. Distribution Network Improvement
    - Under this category, components for extension or Renewal of components along with WTP expansion.
    - Improving effective water use, rational operation and overall maintenance to contributing towards sustainable water supply system and management.
6. Service Connection
    - Increasing capacity through construction/ expansion of WTP to install connections

2.3.2 Selection of Priority Projects:

Based on the above criteria, the priority projects thus selected for development of water supply source facilities and mechanical & electrical replacements are tabulated below:

Table 2: *Proposed Water Supply Facilities on M/P and Selection of Priority Projects*

Water Supply Facilities to be implemented for M/P			2018-2023	2024-2028	2029-2033	2034-2038	Selected Priority Project
WTP/Well	Chiniot Wellfield	Well Chiniot (M&E Replacement)	204.6 (45)				
	JBC and JBC Wellfield	Well JBC		45.5 (10.0)	45.5 (10.0)		
		Well JBC (M&E Replacement)		90.9 (20)			
		WTP Jhang	90.9 (20)			181.8 (40)	
		WTP Jhang (M&E Replacement)				90.9 (20)	
	RBC and RBC Wellfield	WTP Old JK Renewel	22.7 (5.0)	22.7 (5.0)			Θ
		WTP Old JK Renewel (M&E Replacement)				45.5 (10.0)	
		WTP New JK (Expansion)	22.7 (5.0)				
		WTP New JK (M&E Replacement)			45.5 (10)		
	GBC and GBC Wellfield	WTP Gugera	113.7 (25)	113.7 (25)	113.7 (25)		
		WTP Gugera (M&E Replacement)				113.7 (25)	
		Well GBC	22.7 (5)	22.7 (5.0)			
	Wala	WTP Allama Iqbal	6.8 (1.5)				
		WTP Gulfishan/Millat (M&E				6.8 (1.5)	

		Replacement)					

Unit: 1000 m^3/day (MGD in parentheses)
Source: JICA Mission Team

The priority/high priority projects concerning the development/improvement of Transmission Main and Arterial Main Pipeline facilities as well as distribution network facilities including the primary main, secondary, tertiary pipeline along with reduction in Non-Revenue Water (NRW) and installation of water meters as summarized in the table below:

Table 3: *Proposed Improving Transmission & Distribution Facilities*

Water Supply Facilities to be Implemented for M/P			2018 -2023	2024 -2028	2029 -2033	2034 -2038	Selected Priority Project
Transmission and Distribution Network Improvement	**Transmission And Distribution Network**	New Transmission Mains	137 km	78 km	38 km	36 km	
		Extension of Arterial Mains (High-priority)	**8 km**				◎
		Extension of Arterial Mains	137 km	78 km	38 km	36 km	
		Extension of Distribution Networks (High-priority)	**18.7 km**				◎
		Extension of Distribution Networks	1,777 km	759 km	766 km	936 km	
		New GRs and OHRs (High-priority)	**3 units**				◎
		New GRs and OHRs	23 units	10 units	10 units	13 units	
		House Connections	184,900 units	154,100 Units	123,000 units	110,000 units	
	NRW Reduction	Replacement Old Pipes (ASP,CIP,GIP)	161 km	134 km	134 km	134 km	
		Installation of New Meters (High-priority)	**22,230 units**				◎
		Installation of New Meters	194,990 units	162,510 Units	129,180 units	115,500 units	

		Change of Existing Meters			10,140 units	162,510 units	
	Rehabilitati on & Replacement	Exist. PSs & Reservoirs (M&E Equipment)	1 set		1 set		
		Existing Distribution Network	161 km	134 km	134 km	134 km	

Source: JICA Mission Team

This IEE pertains to the priority projects including projects with high priority.

2.4 Renewal of Old JK WTP:

One of the projects having top priority pertains to the renewal of Old Jhal Khanuana WTP. The existing Jhal Khanuana Water Treatment Plant (herein after JK WTP) constructed in 1935 was rehabilitated twice in 1983 and in 2012 respectively by WASA-F. With the increase in population of Faisalabad manifold, WASA-F cannot meet the water demand of consumers. JK WTP is the slow sand filter type with the original capacity is 3.5 MGD. Currently it is operating and producing treated water by only one tenth volume of its original capacity. The selected priority project contains the following: components:

- Renewal of Old JK WTP is proposed to be carried out by substituting slow sand filtration system with the rapid sand filtration system as well as increasing the capacity from 3.5 MGD to 10.0 MGD.
- GRs/OHRs will receive the treated water to be supplied from the JK WTP through arterial main
- Distribution Main, which is composed of the primary main, secondary and tertiary pipeline, will supply the treated water from OHRs to consumers.

Water supply facilities proposed at Old JK WTP under this priority project are divided into two areas for which phase-wise construction has been planned. In phase 1three pairs of GRs and OHRs are required to be constructed.

Abdullah Pur OHR and Medina Town OHR No.2 will be operated in Phase 1 water supply area. People Colony OHR No.2 will be operated in Phase 2 water supply area. The location of JK WTP, three OHRs, Arterial main and the distribution area of the priority project are shown in Figure below:

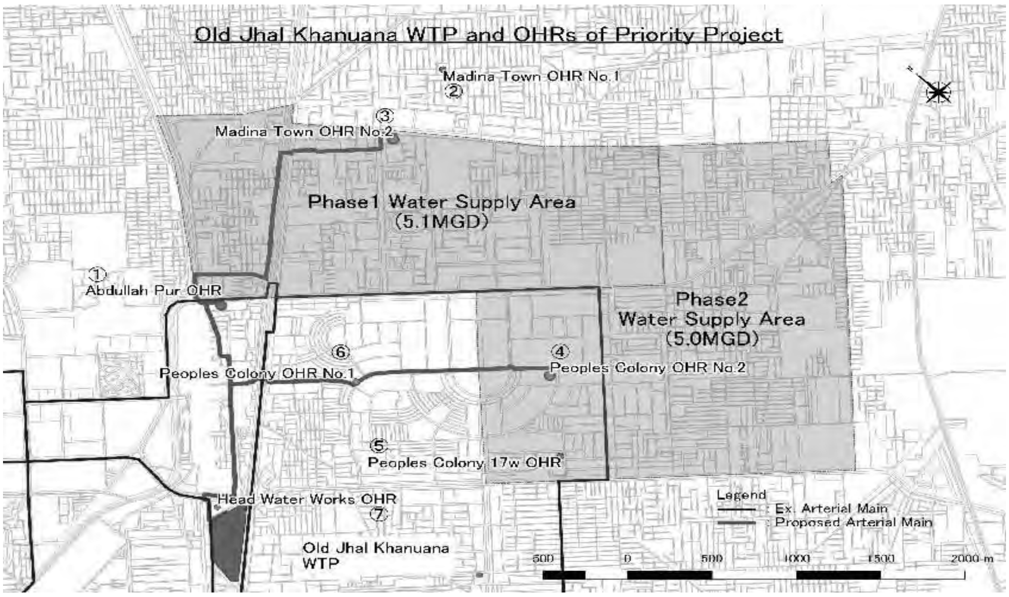


Figure 1: JK WTP, OHRs and Supply Area

FINITE ENGINEERING

3 Policy, Legal and Administrative Framework

This section deals with the current policy as well as legal and administrative framework related to carry out Initial Environmental Examination/Environmental Impact Assessment (IEE/EIA) of the project. Like other projects, the Project for Water Supply, Sewerage and Drainage Master Plan of Faisalabad, before its commencement, is required to go through an Environmental Assessment, in accordance with the provisions of the Punjab Environmental Protection (Amendment) Act 2012.

3.1 Existing Legislation and Legal Framework

The Federal Ministry of Environment was responsible authority for policy making on environmental protection in Pakistan but after 18th Amendment in the Constitution, the Provincial Governments have taken over the subject of Environment. This EIA study has been carried out in the light of the policy guidelines of the Preparation of IEE/EIA Reports under the procedures and practices formulated by the Pak EPA and adopted by the Punjab Environmental Protection Agency (EPA).

3.2 Organization for Environmental Management

3.2.1 Federal government institutions

Ministry of Climate Change is the main government organization at Federal level responsible for protection of environment and resource protection. The Ministry works in collaboration with the Pakistan Environment Protection Council (PEPC) and the Federal and Provincial Environmental Protection Agencies (EPA) under Pakistan Environmental Protection Act 1997 (PEPA 1997). The PEPC and Federal EPA are primary responsible for administering the provisions of the PEPA 1997. The PEPC oversees the functioning of the Federal Environmental Protection Agencies.

The functions and powers of the PEPC include formulation of national environmental policy, enforcement of PEPA 1997. Basic functions of Pak EPA are to enforce PEPA (1997) rules and regulation, compare or revise and establish National Environmental Quality Standards (NEQS) with the approval of PEPC.

Pak-EPA has overall jurisdictions over Environmental Impact Assessment or Initial Environmental Examination (EIA/ IEE) issues. The jurisdiction of the Federal EPA is applicable to the projects as under:

- On Federal land;
- Military projects;
- Involving trans-country impacts
- Bearing trans-province impacts
- Monitoring &Evaluation

3.2.2 Provincial government institutions

Each provincial government has its own environmental protection institution responsible for pollution control. The provincial Environmental Protection Agencies or Environmental Protection Departments (EPA/EPD) are the provincial counterparts of Federal EPA, which is authorized to delegate powers to provincial EPA/ EPD.

The reports covering IEEs and EIAs are submitted to the concerned provincial EPA/EPD for approval.

3.2.3 Environment protection department, Punjab

The Punjab Government has established Environment Protection Department (EPD) administratively controlled by the Secretary, Government of Punjab. The EPD has its independent Minister. According to the provisions of the Punjab Environmental Protection (Amendment) Act, 2012, EPD has a significant role in policy making and implementation of the environmental laws in the Punjab Province.

At the district level District Environment Officer (DOE) is the responsible person to look after the environmental issues in all the sectors. The issues identified by the DEO are reported to the provincial EPA/EPD for legal proceeding. The DEO can take action against any development activity contributing in the environmental degradation of the country.

3.3 Environmental legislation and policies

3.3.1 Pakistan Environmental Protection Ordinance, 1983

Pakistan Environmental Protection Ordinance, 1983 was the first piece of legislation designed specifically for the protection of the environment. The promulgation of this ordinance was followed, in 1984 by the establishment of the Federal EPA, the primary government institution dealing with environmental issues. Provincial EPAs were also established at about the same time.

3.3.2 National Conservation Strategy, 1992

The Pakistan National Conservation Strategy, 1992 is the principal policy document for environmental issues in the country that was developed and approved by the Government of Pakistan. This strategy works on a ten-year planning and implementation cycle. It deals with fourteen (14) core areas such as maintaining soils in cropland, protecting watershed, conserving biodiversity, managing urban waste, preserving the cultural heritages and so on.

Project specific mitigation prescriptions cannot be expressed in the Strategy, however, the principles of environmental protection, conservation and management provided in the Strategy have to be used as guidelines during the planning and execution of project.

3.3.3 Pakistan Environmental Protection Act (PEPA) of 1997

Pakistan Environmental Protection Act (PEPA) of 1997 was enacted repealing the Pakistan Environmental Protection Ordinance, 1983. The PEPA 1997 provides the framework for implementation of National Conservation Strategy 1992, protection and conservation of species, wildlife habitats and biodiversity, conservation of renewable resources, establishment of standards for the quality of the ambient, water and land, establishment of Environmental Tribunals, appointment of Environmental

Magistrate, Initial Environmental Examinations (IEE), Environmental Impact Assessment (EIA), promotion of public education and awareness of environmental issues through mass media.

The PEPA, 1997 is the basic legislative tool empowering the Government to frame regulations for the protection of the environment. The PEPA, 1997 is also applicable to a board range of issues and extends to air, water, soil, and noise pollution, as well as to handling of hazardous wastes. Penalties have been prescribed for those contravening the provisions of the Act.

3.3.4 National Environmental Quality Standards (NEQS)

In order to control of the environmental pollution, the Government of Pakistan has laid down National Environmental Quality standards (NEQS), 2000 for municipal and industrial liquid effluent, industrial gaseous emissions, motor vehicle exhaust and noise.

3.3.5 Federal EPA environmental assessment procedures

Federal EPA has published a set of environmental guidelines and procedures for conducting environmental assessments and the environmental management of different types of development projects. The guidelines are applicable to various development projects.

3.3.6 PAK- EPA (Review of IEE and EIA) regulations, 2000

These regulations clearly define the categories of the projects requiring an IEE or EIA, review fees by EPA, filling process of the environmental reports, public participation, decisions by EPA, conditions of approval, compliance of reports and monitoring of the environmental parameters etc.

3.3.7 National Environmental Policy, 2005

The National Environmental Policy provides an over reaching framework for addressing the environmental issues facing Pakistan, particularly pollution of fresh water bodies and coastal waters, air pollution, lack of proper waste management, deforestation, loss of biodiversity, desertification, natural disasters and climate change.

The goal and objectives of the Policy are as follows:

a. Goals

The National Environmental Policy aims to protect, conserve and restore Pakistan's environment in order to improve the quality of life of citizens through sustainable development.

b. Objectives

- Conservation, restoration and efficient management of environmental resources
- Integration of environmental considerations in policy making and planning processes
- Capacity building of government agencies and other stakeholders at all levels

- Meeting international obligations effectively in line with the national aspirations
- Creation of demand for environment through mass awareness and community mobilization

3.3.8 National Drinking Water Policy, 2009

The National Drinking Water Policy was approved by the Cabinet on 28th September 2009, making Pakistan one of the few countries of the world having a national level Policy on the safe drinking water. The Policy aims to improve the quality of life of the people of Pakistan by reducing the incidence of death and illness caused by water-borne diseases. Toward this end, the Policy provides specific guidelines for increasing access to safe drinking water, protection and conservation of surface and groundwater resources, water treatment and safety, appropriate technologies and standardization, community participation, public awareness etc. The Policy also suggests various legislative measures to ensure its effective implementation, including enforcement of the National Drinking Water Quality Standards. It stipulates that the respective tiers of the government will devise strategies and action plans in pursuit of the Policy.

3.3.9 Drinking Water Quality Standards

In pursuance of the statutory requirement under clause (c) of sub-section (1) of section (6) of the Pakistan Environmental Protection Act, 1997 (XXXIV of 1997), the Pakistan Environmental Protection Agency with prior approval of the Pakistan Environmental Protection Council, has published the National Standards for Drinking Water Quality (2010).

WHO Drinking water quality guidelines and USEPA standards will be used for bench marking purpose along with the National Standards for Drinking water quality effective from January, 2013.

3.3.10 Air Quality Standards

In pursuance of the statutory requirement under clause (e) of sub-section (1) of section (6) of the Pakistan Environmental Protection Act, 1997(XXXIV of 1997), the Pakistan Environmental Protection Agency with prior approval of the Pakistan Environmental Protection Council, has revised the NEQS for Ambient Air in 2010. USEPA standards along with NEQS effective from January, 2013.

3.3.11 Noise Quality Standards

In pursuance of the statutory requirement under clause (c) of sub-section (1) of section (6) of the Pakistan Environmental Protection Act, 1997 (XXXIV of 1997), the Pakistan Environmental Protection Agency with prior approval of the Pakistan Environmental Protection Council, has revised the NEQS for Noise (2010). These standards are established for four different categories which include residential area, commercial area, industrial area and silent zone. These standards vary according to the day and night timing, day time hours are 6:00 am to 10:00 pm and night time hours are 10:00 pm to 6:00 am. USEPA standards and World Bank guidelines along with National Environmental Quality Standards for Noise effective from January, 2012 are used as bench mark purpose.

3.4 Land Acquisition Act, 1894

At present, the only legislation relating to land acquisition and compensation is the Land Acquisition Act (LAA) of 1894. The LAA is, however, limited to a cash compensation policy for the acquisition of land and built-up property, and damage to other assets, such as crops, trees, and infrastructure. The LAA does not consider the rehabilitation and resettlement of non-titled populations.

Section IV of Land Acquisition Act states that “Whenever it appears to the Collector of the District that land in any locality is needed or is likely to be needed for any public purpose or for a Company, a notification to that effect shall be published in the official Gazette, and the Collector shall cause public notice of the substance of such notification to be given at convenient places in the said locality”.

3.5 JICA Guidelines for Environmental and Social Considerations 2010

JICA Guidelines for Environmental and Social Considerations 2010 are to encourage project proponents etc. to have appropriate consideration for environmental and social impacts, as well as ensure that JICA support for an examination of environmental and social consideration are conducted accordingly. The guidelines outline JICA responsibilities and procedures, along with its requirements for project proponents etc. in order to facilitate the achievement of these objectives. In doing so, JICA endeavours to ensure transparency, predictability and accountability in its support for an examination of environmental and social considerations.

4 Assessment of Baseline Environmental & Social Conditions

An environmental baseline review reflects the conditions of the project area/site location before the start of the project and forms an important part of Environmental & social Assessment. A baseline for the Master plan project (herein after called as the project) was established, based on current data gathered from range of sources and review of documents. Prior to baseline review of Project area, it is worth mentioning the main facets of M/Pas provided below:

An overview to assess the environmental and social baseline conditions prevailing in the project area was undertaken, based on secondary data sources. This information is available from the environmental studies previously conducted in the region for other projects. The overview of major environmental components includes the following:

- Physical environment
- Biological environment
- Cultural environment
- Socioeconomic environment

4.1 Physical Environment:

4.1.1 Geology & Topography

Faisalabad district is situated in one of the most fertile agricultural lands in Punjab and is also surrounded by slightly rolling flat planes in North East Punjab. The city is located between the River Chenab flowing almost 30 km in the North West and River Ravi which is almost 40 km off the city in the South East. The soil of Faisalabad consists of alluvial deposits mixed with loess having calcareous characteristics, making it very fertile.

4.1.2 Hydrology

More than 80% of the total area of Punjab Province is alluvial plain (Indus plain). The Indus River and its four tributaries (Jhelum, Chenab, Ravi, and Sutlej tributaries) flow through the plain. The plains between two rivers are called Doabs, and the Faisalabad City area is located at the so-called Rechna Doab.

4.1.3 Land Use

Land Use in Built-up Area

A mixed type pattern/profile prevails in the Faisalabad City. The Land Use in project site is characterized by residential areas, commercial/industrial land and agricultural fields. There appears to be lack of planning in the rational development of existing land uses in the built-up area of Faisalabad city. Industrial units developed inside built-up areas since independence till late 1990, remains detrimental to physical environment particularly contaminating ground water and air quality. All the land uses in the city have been aligned along the road/rail network. The main land use pattern of the city is analysed in Table 5.

Table 4: *Land Use Spatial Distribution Built Up Areas*

Land Use	Area (Sq. Km)	%
Residential Area	56.08	46.49
Commercial	2.56	2.31
Industrial Area	6.09	5.05
Educational Area	4.41	3.65
Open Space	1.96	1.62
Public Buildings	4.76	3.94
Grave Yards	1.04	0.86
Agriculture Area	41.54	34.44
Major Roads	2.19	1.81
Total	**120.65**	**100**

Source: FPUSP Report

Land Use in Peri-Urban Area

Existing land use in Peri-Urban area is predominantly composed of cultivated agricultural lands, scattered built up including small rural dwellings & industrial clusters along main roads and brick kiln sites. However, in Peri-Urban area well connected with road network, rural character is beginning to change with the start of urban development. The land use distribution in Peri-Urban area is summarized in Table 6.

Table 5: *Land Use Distribution in Peri- Urban Area*

Existing Land Use Distribution			
Sr.#	**Land Use**	**Area (Sq. Km)**	**%**
1	**Agriculture**	6.37	83.11
2	**Commercial**	4.14	0.54
3	**Community Facility**	2.50	0.33
4	**Dairy & Livestock**	1.83	0.24
5	**Empty**	53.48	6.97
6	**Industry**	20.42	2.66
7	**Residential**	42.85	5.59
8	**Transportation**	4.28	0.56
	Total	**767.05**	**100**

Source: FPUSP Report

4.1.4 Meteorology

Temperature

Due to its high evaporation Faisalabad features a hot desert climate during summer and cold & dry in winter. The summer season sets from April to October and winter season lasts from November to March. The mean temperatures of these months are provided in Table 7.

Table 6: *Mean Temperature during summer & winter*

Weather	Mean Temperature	
	Max	**Min**
Summer	47ºC	28ºC
Winter	22ºC	4ºC

Rainfall

- The average yearly rainfall is about 300 mm (12 in) and is highly seasonal with approximately half of the yearly rainfall in the two months; July and August.
- Relative humidity in Faisalabad varies between 31.9% and 69%.
- Winter witnesses very little rains. However, flood can occur in district areas adjacent to river, Chenab and Ravi respectively.

4.1.5 Environmental Pollution

Ambient Air Quality

Ambient Air quality data to determine in terms of Air pollution such as vehicular emission obtained from the publication of Pakistan Bureau of Statistic, Government of Pakistan Islamabad is presented in Table 8.

Table 7: *Ambient Air Quality Data of the Project Area*

Name of City	Location	Type of site	Date	Ozone	SO2 Ug/m³	Co mg/m³	No Ug/m³	NOx Ug/m³	PM2.5 ug/m3	Humidity %	W. Speed M/sec	NMHC
*NAAQS				180 for 1hr	120 for 24 hrs	5 for 8hrs	40 for 24 hrs	80 for 24 hrs	40 for 24 hrs			240 US standard

1	2	3	4	5	6	7	8	9	10	11	12	13
Faisalabad	**Peoples**	**Residential Area**	25.11.08	60	161	4.8	-	472	240	56.6	1.6	2900
Faisalabad	**Katchery**	**Commercial**	27.11.08	58	140	5.52	-	380	235	55	1.52	3700
Faisalabad	**Bus Stand**	**Busy Road Side**	29.11.08	57	176	3.03	-	450	230	55.9	1.2	3500

**NAAQS National Ambient Air Quality Standard [Source: - Environment Protection Agency Laboratories Govt. of Punjab, Lahore. Compendium on Environment Statistics of Pakistan, 2015]*

Noise

Noise level tests at the proposed grid station in the west of Faisalabad and near the grid station at Toba Tek Singh; have been conducted for an EIA report of Faisalabad 500 kV Grid Station and Transmission Line Project. The results are listed in **エラー! 参照元が見つかりません。**.

Table 8: *Noise Test Results of the Project Area*

Source	Noise Level dB (A)
NEQS	75
Faisalabad west	48
Toba Tek Sing	58.7

Solid Waste Management

The City District Government of Faisalabad (CDGF) is responsible for the municipal solid wastes management. CDGF is confronted with issues for the management of solid wastes such as, increasing quantum of solid wastes, low wastes collection rate, unsafe waste disposal and low customer satisfaction. As per CDGF estimate, solid waste of 1250 ton is produced daily in Faisalabad. The level of waste collection disposal is very low. As per study (GHK/NESPAK 2009), only 50 % of the total waste is collected and disposed, while the rest left open in the streets and along the roads.

Waste is dumped in low-lying depressions at various points around the city Faisalabad. During last five years, two dumping sites have been established at Chak Muhammad Wala on the Jaranwala Road and Chak 237 RB (Khudian Waraichan).

Industrial solid wastes contain toxic & hazardous chemicals causing water-borne diseases and overall air pollution.

4.1.6 Water resources

Surface Water Resources

River Chenab along with Jhang Branch Canal, Rakh Branch Canal and Gugera Branch Canal are the major surface water source of project area. It is perennial source and flows throughout the year. It also causes floods in the monsoon season, when it receives excessive rainfall water from upstream.

Ground Water

The city of Faisalabad is underlain by the deep permeable aquifer formed within the alluvial plane of the River Ravi and Chenab, which is the part of Greater Indus Plain. Ground water is the principal source of municipal water supply in Faisalabad. This is also the case in the immediate vicinity of the site. The City's drinking water is obtained from groundwater aquifer by means of tube wells located throughout the area. Groundwater is pumped from 400-800 feet and is generally good for direct consumption. About 83% of the city's population is consuming groundwater for drinking purposes.

The project area lies in the district of Faisalabad where the groundwater table normally exists 40 to 50 ft. below the ground level and contains high level of salinity.

Water Quality

Subsoil water in overall Faisalabad District is brackish. The only available sweet water zones are along canals and near Chenab. Water drawn directly from canals ought to be treated before it is fit and safe for drinking. The existing production capacity of WASA is 65 million gallons per day, almost all of which is drawn from wells located in the old bed of the River Chenab. From the well field, water is pumped to a terminal reservoir near Sargodha Road from which it is pumped directly into supply. Water is normally supplied for a total of about 6 hours per day to all parts of the system simultaneously. Water Quality test for drinking has been carried out on the basis of primary data (collected through survey in Faisalabad city) and the results are presented in Table 10.

***Table 9:** Drinking Water Results*

Field Measurement and Observation Record (Tap Water)								Analysis Results
Season : Dry Season								
Date	Sample ID	Longitude	Latitude	Residual Chlorine (Cl_2, mg/L)	EC (µS/Cm)	Nitrate Nitrogen (NO_3^--N)	E. coli	Remarks
WHO Standards for Drinking Water						0	50	
15/Oct/16	TW O-18	Provided by JICA Team Member in WASA-F		0	556	7.2	Nil	No Filter PH: 7.6
	TW O-19			0	421	1.4	Nil	Filter, Local underground pump PH: 7.6
	TW O-20			0	441	1.9	Nil	Filter, Local Ground Resource PH: 7.3
	TW O-21			0	395	1.3	Nil	Mineral water Gourmet PH: 7.3

Sanitation, Sewerage and Drainage

The existing sewerage connections, drainage & disposal are quite old and prone to overflows. The open channels meant to drain out storm water are being used as sewer mains. WASA Faisalabad is responsible for the disposal of the waste water from residential areas of the city. The capacity of WASA disposal system has not been augmented in line with population growth of the city.

Faisalabad District as a whole is served by open drains to which sludge water is discharged directly. Most black water from toilets is discharged to household septic tanks from which effluent is also discharged to open drains. Sewerage coverage is highest in Faisalabad City, where WASA records reveal that there are 193,000 sewer connections, some of which are from households that obtain water from shallow tube wells rather than the piped reticulation system. Mostly sewers are built by government but in many peripheral areas they are financed and managed by developers, community groups and elected representatives.

Local sewers discharge to four trunk sewers and a number of smaller collector sewers which lead to four main pumping stations and around 30 smaller pumping stations. Most of the smaller stations have been installed in an ad-hoc way in response to need and cannot be operated efficiently. Around 20 mgd of waste water is treated in a large waste stabilization pond treatment facility located off the Narwala Road on the north-west side of the city. All other sewage is discharged to agricultural drains namely; the Paharang Drain to the north-west and the Madhuanan Drain to the south-east. About 50% of the total wastewater flow from the city and about 100 mgd of it is used for irrigation of agricultural land.

The textile industries produce liquid effluents that may be toxic and certainly have a high biochemical oxygen demand. These should ideally be treated on-site by individual industry or in facilities shared by a number of industries, before discharge to public sewers. At present only four treatment plant exist in the industries. The tests regarding household water waste and industrial affluent/water waste carried out on the basis of primary data collected through survey in 2016 are shown in Table 11

Table 10: *Waste Water Results*

Season: Wet Season						
	Location	**NEQS for Waste water**	**Chenab River**	**Jhang Branch Canal (JBC)**	**Rakh Branch Canal (RBC)**	**Gugera Branch Canal**
Field Record	**Sample ID**		**SW 1**	**SW 2**	**SW 3**	**SW 4**
	Date		23-Sept -2016	23-Sept -2016	23-Sept -2016	24-Sept -2016
	Time		12:27 PM	11:28 AM	10:24 Am	9:39 AM
	Latitude		31˚45.486'N	31˚35.155'N	31˚24.31'N	31˚19.184'N
	Longitude		72˚57.018'E	73˚2.489'E	73˚5.226'E	73˚23.853'E
	Temperature °C		31.94	26.6	27	26.12

	Ph		8.63	8.25	8.24	8.11
	EC (µS/Cm)		296	178	193	189
	DO (ppm)		3.75	5.98	5.64	6.24
Analysis Results	**Color (m-1)**	**NG**	1.1	4.1	5.5	13.0
	TDS (mg/l)	**3500**	222	145	140	152
	COD (mg/l)	**150**	38	23	32	41
	Sodium (mg/l)	**NG**	48	21	55	211
	Sulphate (mg/l)	**60**	28	20	22	29
	Calcium (mg/l)	**NG**	31	23	21	31
	Fluoride (mg/l)	**20**	3.0	3.9	4.8	1.3
	Turbidity (FAU)	**NG**	8	38	57	65
	Chlorides (mg/l)	**1000**	60	50	70	20
	Total Alkalinity (mg/l)	**NG**	110	90	70	95
	Magnesium (mg/l)	**NG**	11	9.7	8.7	7
	Manganese (mg/l)	**1.5**	<0.010	< 0.010	< 0.010	< 0.010
	Total Hardness (mg/l)	**NG**	82	98	88	106
	Ammonium (NH4-N) (mg/l)	**40**	11	19	15	13
	Nitrate Nitrogen (NO3--N) (mg/l)	**NG**	3.3	4.8	5.5	4.1
	Nitrite Nitrogen (NO2--N) (mg/l)	**NG**	0.11	0.12	0.19	0.18

	Iron (mg/l)	2.0	0.32	1.89	1.83	1.9
	Zinc (mg/l)	5.0	< 0.05	< 0.05	< 0.05	< 0.05
	Lead (mg/l)	0.5	< 0.010	< 0.010	< 0.010	< 0.010
	Nickel (mg/l)	1.0	< 0.02	< 0.02	< 0.02	< 0.02
	Copper (mg/l)	1.0	< 0.002	< 0.002	< 0.002	< 0.002
	Barium (mg/l)	1.5	< 0.70	< 0.70	< 0.70	< 0.70
	Cyanide (mg/l)	2.0	< 0.002	< 0.002	< 0.002	< 0.002
	Mercury (mg/l)	0.0	< 0.001	< 0.001	< 0.001	< 0.001
	Selenium (µg/l)	0.5	0.370	0.086	0.353	0.250
	Cadmium (mg/l)	**0.1**	< 0.002	< 0.002	< 0.002	< 0.002
	Antimony (mg/l)	**NG**	0.186	0.288	0.139	0.123
	Chromium (mg/l)	**1.0**	0.40	0.27	0.30	< 0.01
	Aluminum (mg/l)	**NG**	<0.020	0.19	<0.020	< 0.02
	E. coli (cfu/100 ml)	**NG**	24	72	120	39
	Standard Plate Count Bacteria (cfu/ml)	**NG**	510	620	510	2.1×10^3
	Remarks		6 Point Composite Sample	3 Point Composite Sample	3 Point Composite Sample	3 Point Composite Sample

4.2 Biological Environment

Faisalabad district located in alluvial plain is highly fertile. A number of plants and animal species are found in road sides, houses and agricultural fields are described below:

Flora

Table 11: *Plant Species in Faisalabad*

Sr. No.	Plant Name	Scientific Name
1	**Jangli Kikar**	Wild Acacia niloica
2	**Peepal**	Ficus Religeosa
3	**Amaltas**	Accasia Fistula
4	**Rose**	Rosa Indica
5	**Sufaida**	Eucalyptus
6	**Aak**	Calotropis
7	**Sheeshum**	DilbergiaSisso
8	**Jandh**	(Prosopis cineraria)
9	**Naturally Grown Shrubs**	

Fauna

Table 12: *Mammals & Birds in Faisalabad*

Sr. No.	Mammal Name	Scientific Name
1	**Jackals**	Canisaureus
2	**Foxes**	SSP. Vulpes
3	**Field Rats**	Rattusnorvegitus
Sr. No.	**Bird Name**	**Scientific Name**
1	**Shikra**	Accipiter badius
2	**Crow**	Corvussplendens
3	**Great Grey Owl**	Strixnebulosa
4	**Pigeon**	Columbia livia
5	**Sparrow Hawk**	Accipiter Nisus
6	**Dove**	Stratopielia SSP
7	**Parrot**	Psittaculakramerl

Source: EIA Report of Faisalabad Grid and Transmission Line Project - 2015

There are no migratory birds and endangered species found in the Faisalabad.

4.3 Cultural/ Historical Sites

Famous sites of cultural/archaeological significance in Faisalabad are as under:

- Clock Tower (Ghanta Ghar)
- Agriculture University
- Bagh-e-Jinnah
- Government College University (GCU)
- Haveli Dera

4.4 Socioeconomic Environment

4.4.1 Health

Health Care Facilities

Health facilities in terms of number of existing Hospitals, Dispensaries, Clinics, Rural Health Centers, Basic Health Units etc. along with the number of beds available in all these hospitals, health centers etc. are presented in Table 14.

Table 13: *Hospitals with Beds Available*

Description		**Faisalabad City**	**Faisalabad City District**
Hospitals	No.	25	19
	Beds	3790	3521
Dispensaries	No.	104	41
	Beds	0	0
R.H. Centers	No.	17	5
	Beds	264	18
B.H. Units	No.	173	4
	Beds	334	6
M.C.H. Centers	No.	14	7
	Beds	0	0

*Source: * Punjab Development Statistics 2015*

Child Mortality Rate

The Infant Mortality Rate (IMR) and children under 5 years Mortality Rate (U5MR) in terms of deaths per 1000 live births illustrate the level of improved health care facilities for the newly born babies and children of 5 years & less. The IMR and U5MR are shown in Table 15.

Table 14: *Infant Mortality Rate (IMR) & Children under 5 Mortality Rate (U5MR)*

Sr. No.	Item	Unit	Punjab	Faisalabad
1.	IMR	Deaths per 1000 live births	82	82
2.	U5MR	Deaths per 1000 live births	104	103

Source: Punjab Development Statistics 2015

Incidence of Disease

Most prevalent communicable diseases in the Faisalabad District as reported in Punjab Development Statistics are listed in Table 16.

Table 15: *Communicable/ Water-borne diseases in Faisalabad District*

Sr. No.	Disease	Punjab	Faisalabad
1.	Had cough for more than last three weeks	2.2	0.6
2.	Diagnosed with Tuberculosis during last one year	0.4	0.3
3.	Diagnosed with Hepatitis during last one year	1.2	0.9
4.	Prevalence of diarrhea	16.0	11.0
5.	Incidence of fever (Last two weeks)	20.8**	19.7

*Source: Punjab Development Statistics 2015 & MICS** 2014 (Number of children Age 0-59 months, Faisalabad Division: 3.272)*

4.4.2 Educational Facilities

Faisalabad is one of the most literate cities of Pakistan, with more colleges and universities than many other cities in the country. Faisalabad is one of the Pakistan's largest producers of professionals in the fields of science, technology, IT, engineering, medicine, nuclear sciences, pharmacology, agriculture and irrigation sciences, telecommunication, biotechnology and microelectronics. The literacy rate and an assessment of education facilities are summarized as under:

Literacy Rate (10 years and above)

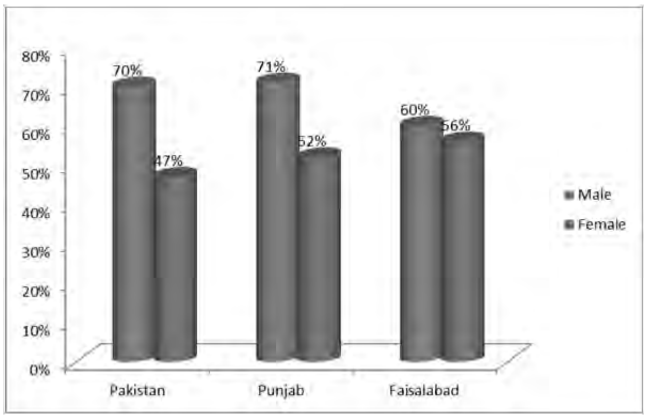
Table 16: *Literacy Rate (10 years and above)*

Area/ Province	Total	Male	Female
Pakistan*	58%	70%	47%
Punjab*	61%	71%	52%
Faisalabad**	60%	60%	56%

**Pakistan Economic Survey 2014-2015*

***Scheme provision of sewerage system in sewer deficient areas, Faisalabad, 2015**EIA report for ADP*

Graphical Presentation of above data is illustrated in the following figure:



4.4.3 Overall Assessments

The Overall education situation based on number of schools, Mosques, Primary, Middle and High levels, student enrolments and teaching staff is presented in Table 18.

Table 17: *Educational Institutions*

School Level	**Number of Schools 2013-14**		**Enrolments 2013-14**		**Teachers 2013-14**	
	Boys	Girls	Boys	Girls	Boys	Girls
Mosques	1	0	17	17	1	0
Primary	750	582	133233	100720	2422	2348
Middle	171	315	74326	95789	1592	3282
High	205	231	157737	149440	4311	4277

4.4.4 Other Data

Facilities regarding road network, cultivated land, manufacturing industries and employment are listed in the following tables:

Table 18: *Road Networks*

Total	**3726.73**
Provincial highways	394.15
R&B Sector	261.68
Farm to Market roads	1127.83

Sugar Cess Roads	534.75
District Council roads	1408.32

Table 19: *Road Accidents*

Categories	**Accidents**	**Causalities**
Total	154	248
Fatal/ killed	119	132
Non-fatal/ Injured	135	116

Table 20: *Motor Vehicles*

Total	**1038083**
Motor cars, Jeeps and Station wagons	85714
Motor cycles and Scooters	881098
Trucks	4593
Pickups/ Delivery Vans	8399
Mini Buses/ Buses/ Flying/ Luxury Coaches	5571
Taxis	1929
Auto Rikshaws	20510
Tractors	30186
Other Vehicles	83

Table 21: *Agriculture/ Livestock*

Cultivated Area	**474**
Uncultivated Area (including Forests 1000 hectares)	110
Cropped Area	683
Livestock (No. Of Cattles and Buffaloes (Thousands))	1116

Table 22: *Mode of Irrigation (in thousand hectares)*

Total	**691**
Canals	403
Wells	4

Tube Wells	27
Canal Wells	6
Canal Tube Wells	251
Others	0

Table 23: *Labour Force & Employment*

No. Of Factories (2014)	Estimated Employment (2014)
1890	183625

5 Assessment of Potential Impacts & Mitigation Measures

5.1 Scoping:

Scoping is a Process of identifying the content & extent of environmental information/input to be submitted to the concerned authorities under environmental evaluation procedure. It is developed in the form of a matrix indicating the impact level during construction &operational stages of the project.

Initial assessment of likely natural, ecological and social impacts of the Priority Projects was made and is shown in the matrix form in Table 25.

Table 24: *Scoping Matrix*

	Factor			Planning			Construction							Operation		
	Item		Overall Evaluation	Study of actual water supply situation	Preparation of accurate pipeline map	Development of database of all customers	Construction of Ground Reservoir (GR)	Installation of valves & service pipes	Leakage detection & repair	Installation/replacement of water meters	Installation of own power generator	Operation of vehicles, construction machines	Traffic control	Maintenance of water supply facilities	Improvement of WASA-F water supply services	Improvement of WASA-F billing collection
Pollution Control	1	Air Pollution/dust pollution	B-				B-	B-			C-	B-	B-			
	2	Water Pollution	B-				B-	B-	B-	B-				B+	B+	
	3	Construction/Material Waste	B-				B-	B-	B-	C-	C-		C-	C-		
	4	Soil Contamination	D					B-				B-		B+		
	5	Noise & Vibration	B-				B-				B-	B		B-		
	6	Ground/land Subsidence	C-					C-	C-		C-			B-		
	7	Offensive Odour	D				D			D				B-		
	8	Sunshine Obstruction	C-								C-					
	9	Greenhouse Effect Gas Emissions	B-				D				B-					
	10	Bottom Sediments	D				D									
Natural Env.	11	Climate & Meteorological Phenomenon	D								D					
	12	Geology	D													
	13	Coastal Zone	D													
	14	Natural Disaster	D													
	15	Protected Areas	D													
	16	Ecosystem	B-				B-	B-								
	17	Hydrological Situation	B-				B-	B-								
	18	Topography & Geographical	B-				B-		B-							

		Features														
Social Environment	19	Involuntary Resettlement	D													
	20	Land Acquisition	B-				B-	B-								
	21	General, Regional/ City Plan	A+											A+		
	22	Social Infrastructures & Services	A+				B-						B-		A+	
	23	Religious Facilities	B-	B-				B-		B-						
	24	Sensitive Facilities (Schools, hospitals etc.)	C-	D			C-	C-						C-		
	25	Gender	B+												B+	
	26	Children's Rights	D													
	27	Public Health	A+				C-	C-		C-					A+	
	28	The poor	A+				B+	B+	B+						A+	C-
	29	Ethnic Minorities and Indigenous people	D													
	30	Local Economy and Employment	B+				B+	B+	B+					B+	B+	B+
	31	Land Use & Utilisation of Local Resources	B-				B-	B-	B-					D		
	32	Water Usage and Water Rights	C-	C-			D							C-		
	33	Existing Social Infrastructures & Services	A+				B-			B-		B-	B-		A+	
	34	Social Institutions such as Local Decision-Making Institutions	D													
	35	Misdistribution of Benefit and Damage	D	B-			B-			B-						
	36	Local Conflicts of Interest	B-				B-	B-	B-	B-	B-			B+		
	37	Cultural Heritage	D			C										
	38	Landscape	B-				B-	B-	B-	B-	B-			A+		
	39	Infectious Diseases such as HIV/AIDS	D				B-									
	40	Working Conditions/ Accidents	B-				B-	B-	B-	B-	B-	B-	B-			

Notes:
A: Significant impact is expected (+: Positive impact, -: Negative impact)
B: Moderate/ Some impact is expected (+: Positive impact, -: Negative impact: Temporary)
C: Negligible/ Extent of impact is unknown, further examination will be required (+: Positive impact, -: Negative impact)
D: Blank-No impact is expected

5.2 Potential Impacts and their Mitigation Measures:

The potential impacts induced by the priority projects are mentioned below along with their mitigation measures to maximize the reduction of negative impacts on the environmental and social surrounding.

5.2.1 Land Use

The impact of priority projects on land use on area of constructing/laying pipeline is negligible. However, there is likely insignificant loss of greenery.

5.2.2 Encroachment, Landscape and Physical Dislocation

The priority project for laying pipeline is so designed to avoid encroachments/dislocation of the people. There should be no disturbance to the households and construction of pipeline is unlikely to make an adverse impact on the houses near the site. No significant landscape impacts are expected. Surplus/ excavated materials during construction may create hurdle and unpleasant odour.

Mitigation Measures:

Compensation (if any) needs to be paid to the households for the loss/damage to their property. Disposal of surplus construction/ excavated materials is the responsibility of contractor so that no obnoxious material spreading offensive odour or impeding people's movement is used/ produced at the site.

5.2.3 Air Quality and Noise Level

Due to the construction/excavation, air and noise pollution associated with health risks may increase. Air quality may be deteriorated due to dust and smoke emission from exhaust of traffic congestion as a result of construction. Moreover, Earth haulage trucks generate dust, particularly during transportation of loading and unloading processes. These impacts are temporary and moderately negative in nature.

The cumulative effects of several machines can be significant. Noise and vibration at the construction sites would be a major consideration for schools or hospitals situated nearby the construction site.

Mitigation Measures:

- Water needs to be sprinkled/sprayed on all dust generated work to control dust pollution. Moreover, coordination needs to be made with traffic police to avoid traffic congestion during construction.
- Haul-trucks carrying sand, aggregate and other loose materials should be covered with tarpaulin to contain spread of dusty materials
- Where necessary, dust emissions need to be reduced by a regular sprinkling of water for keeping the dust settled, at least twice a day.
- Ensure proper tuning & maintenance of the construction vehicles/ power generators to minimize exhaust emissions.
- Construction workers should be provided with masks for protection against the inhalation of dust.
- NEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery should be enforced during construction works. Contractor should make sure that all equipment and vehicles are tested for emissions. Regular maintenance of equipment and vehicles will also control the incomplete combustion.
- To minimize such impacts, the contractor for project should be requested by the construction supervision consultants (engineer) to provide evidence and certification that all equipment to be used for

construction is fitted with the necessary air pollution and noise dampening devices to meet EPA requirements.

- Noise needs to be controlled by monitoring at a distance of 100m from the boundary wall of any residential unit/schools/hospitals or public place and while following the NEQS of 45dB (A).
- Providing the construction workers with suitable hearing protection like ear cap, or earmuffs and training them in their use.
- Contractors should comply with submitted work schedule, preferably restricting construction vehicles movement during night times.
- Use of low noise machinery, or machinery with noise shielding and absorption.

5.2.4 Physical Cultural Resources

No physical cultural resource is falling within the proposed alignment of the pipe lines; hence impact is zero.

5.2.5 Land Acquisition and Resettlement

The land may be required for the proposed construction of Ground Reservoir and installation of water pipes (if any).

Mitigation Measures:

Compensation needs to be made to the owner.

5.2.6 Emergency Management

Emergency management in case of natural and man-made disaster is a major concern. Increased incidents of disasters are only anticipated due to power failure and fire etc.

Mitigation Measures:

During construction activities, contractor should ensure the provision of medicines, first aid kits, emergency vehicles, etc. at the work place. All workers should wear safety gadgets like; safety boots, helmets, gloves, and protective masks. Goggles must be used during welding and grinding. Complete equipment control system, fire escape stairs and secured access system supplemented with close circuit surveillance equipment/alarms would be included in the design of the proposed project. Adequate water distribution facilities need to be set-up with standby system for sufficient supply of water from nearby tube well for fire fighting during emergency.

5.2.7 Waste Disposal Site

Disposal of waste materials needs to be negotiated through local authority prior to the commencement of construction. The identified waste during the construction of proposed project may include construction waste, chemical waste and filling material, debris/general refuse. This normally happens when these materials are transported in open or loosely capped containers. If the waste is not handled properly it could be a nuisance and cause diseases. Domestic waste contains a high percentage of readily degradable hydrocarbons which releases a bad odor when it undergoes decomposition, especially in hot and humid conditions. Construction waste classified as inert waste which could be a problem to dispose.

Mitigation Measures

- All waste from the construction activities should be disposed of on state land with the approval of the designated engineer and should be disposed of according to the Waste Management Plan, as a part of the Environment Management Plan.
- Domestic waste generated should be collected and temporarily stored at the designated bonded area within the camp area before being disposed of at the designated site by the contractor.
- A temporary domestic waste storage area should be prepared, maintained and visually inspected on a regular basis by the principal contractor to prevent the land adjacent to the waste disposal site from becoming contaminated.
- The location of construction waste disposal site should ensure that there is no need of tree cutting, crop destruction or private land acquisition requirement.
- Construction waste should not be mixed with domestic waste as the construction waste could be reused as a fill material or disposed of separately.
- Moreover, waste materials should be managed properly so as to prevent the attraction or breeding of insects or rodents, and to eliminate harmful conditions to public health or which create safety hazards, odours, or public nuisance.

5.2.8 Damage to Paths, Access Roads and Cross Drains

Damage to Infrastructure (i.e. road drains etc.) and main tracks constructed by local authorities/ inhabitants during construction and operation process should be avoided. Although no damage to paths and access road is anticipated.

Mitigation Measures

- Effective sign-posting can reinforce safe driving instructions to the drivers for example maximum load limit, type of vehicle allowed, speed limit etc.
- It is a Contractor's contractual obligations to impose strict control over operators and drivers of all types of construction vehicles.
- Should any damage take place, the contractor is obligated to carry out repair work immediately.

5.2.9 Soil Contamination

Materials and chemicals to be used during construction may potentially cause soil contamination. The existing sewerage/drainage lines are likely to get choked with excavated material.

Mitigation measures

- Solid waste generated at construction sites need to be properly treated and safely disposed of only in demarcated waste disposal sites.
- Separate bins for recyclable materials should be provided.
- All garbage or other putrid waste should be securely wrapped in recycled papers or similar material bags.
- All cans, bottles, or other food containers would be rinsed free of food particles and drained before being placed in collection containers.
- Excavation work should be so managed to avoid existing sewerage/ drainage and other lines.

5.2.10 Water Resources

Water supply lines and other sources are may be damaged during excavation and may cause contamination of water bodies, groundwater etc. The siltation may be anticipated during construction activities.

Mitigation measures

Excavation and backfill or filing material needs to be carefully/properly used/ handled to avoid damage to water lines, water contamination and choking.

5.2.11 Contamination of Surface Water

River Chenab is far away from the project area hence project activities would cause no impact on it. The ROW of pipeline traverses through the existing canal (Rakh branch). It is anticipated that the project activities may cause any temporary but significant impact on the surface water.

Mitigation measures

Earth work (excavation & filling) may be carefully planned to prevent infiltration of mud & excavated/backfill material into water body.

5.2.12 Soil Erosion

Soil erosion may occur near the canal or other water body sites as a result of improper runoff drawn from the equipment and improper management of construction activities.

Mitigation Measures

Good engineering practices would help control soil erosion both at the construction sites and in peripheral areas. Controlled and well managed vehicular movement, excavation, vegetation and regular water sprinkling will reduce the chances of soil erosion.

5.2.13 Occupational Health and Safety

Health risks and work safety problems may occur at the workplace/sites if the working conditions provide unsafe and/or unfavourable working environment due to storage, handling and transport of hazardous construction material. The health and safety issues are also associated with the operation of construction machinery and equipment, which may cause minor and severe injuries to workers.

Mitigation measures

- Obligatory insurance against accidents for labourer's/workers;
- Providing basic medical training to specified work staff and basic medical service and supplies to workers;
- During construction activities, contractor should ensure the provision of medicines, first aid kits, emergency vehicles, etc. at the work place. All workers should wear safety gadgets like; safety boots, helmets, gloves, and protective goggles.
- Emergency number shall be placed at worksites;
- Display no thoroughfare sign at construction site.
- Protection devices (ear muffs) should be provided to the workers doing job in the vicinity of high noise generating machines.

5.2.14 Community Health/ Accidents

The construction activities and vehicular movement at construction sites and access roads may also cause road side accidents particularly inflicting local communities who are not familiar with presence of heavy equipment and machinery. This is a temporary and minor negative impact.

Mitigation Measures

- Provision of proper safety and diversion signage, particularly at sensitive/ accident-prone spots;
- During construction work, pedestrian and vehicular passages should be provided; and
- Use of water should not disturb public water availability and source of water should be selected carefully
- Display of Work at Progress or other cautionary sign at construction site.

5.2.15 Flora

The priority project area (within 20m from centre line) contains vegetation including trees, and greenery. There is no protected area, as per identification of National Conservation Strategy, inside or anywhere near the project. There are no significant issues anticipated in project area.

Mitigation Measures

Cutting of trees, loss/ damage to greenery/ vegetation needs to be avoided during construction. The contractor is required to spray water twice or thrice a day (as per need) to avoid dispersal of dust on the adjacent flora.

5.2.16 Fauna

The trees provide nesting and resting places to the fauna. The cutting of these trees will have a negative impact on the fauna as well. However, no trees need to be cut according to the nature of the project. During the construction phase, noise and movement of heavy machinery may disturb the fauna of the area as the reptiles like lizard, snakes etc. As there are no endangered species present near the project area so there is no potential impact on the endangered species by the execution of the project.

Mitigation Measures

Although no significant adverse impacts on ecological environment are envisaged during construction phase of the project but due care is observed while using toxic chemicals during construction stage in order to avoid impact on fauna.

5.2.17 Socio-Economic Environment

Construction activities need to be scheduled in a manner so as to cause minimum disturbance to movement of vehicular traffic as well as the people & their business. However, this impact is temporary and moderate negative in nature.

Mitigation Measures

- Tariff for providing improved facilities by WASA-F needs to be fixed at affordable rate depending on consumption.
- Alternate employment opportunities may be provided to the existing vendors of supplying water as their business may adversely affected or suspended due to improved facilities/increased capacities.

6 Stakeholder Consultation

Initial Environmental Examination (IEE) process forms a part of the JICA-WASA M/P Project. Under this component, consultative process has been initiated with stakeholders from various government departments, CDGF, semi-government/ private organizations, public representatives, university professors/ professionals, NGOs, FCCI, etc. The objective of the consultative process, among others, was to seek the opinion or feedback to be incorporated in the final report of M/P.

Since this IEE pertains to the impact assessment of priority projects to be implemented to improve the water supply sources as identified in the M/P. This report therefore confines the consultations with stakeholders to the improvement of water supply services under priority projects proposed in Faisalabad.

A gist of observations/ clarifications (including presentation made regarding water supply services) transpired in the meeting is highlighted below:

6.1 Proceedings of 1st SHM

Date : 28th September, 2017
Venue : Conference Room, WASA Faisalabad.
List of participants : Attached as **Appendix-1**.

6.1.1 Summary of Presentation made in the meeting

An overview of M/P for formulating a strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad was presented in the meeting. The information provided is summarized as under:

Water Supply

Water supply sources comprise of ground water and surface water in Faisalabad. The sources of ground water are government owned tube wells/ private wells and river water (Chenab River/RBC, JBC and GBC). WASA-F is responsible for delivery, maintenance and management of water supply system. The current water supply situation is highlighted below:

- Actual Water Supply in 2017 : 247000 m3 /day
- Total Water Demand in 2015 : 287000 m3 /day
- Current Water supply service: 6 hours or less from
- Insufficient water quantity with low pressure

Issues

- Over/illegal pumping from tube wells causes groundwater depletion
- Mostly pipes do not have water meters
- Water containing high salinity content
- Low operation rate of water treatment plants (JKWTP-empty filters)

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- Intermittent low operation of pumps (6hr/day) at terminal reservoir & pumping station along with Inability of manage water distribution

Targets Proposed in M/P

- Total Water Demand estimated in 2038: 1252000 m3/day
- Water supply service/operation : 24/7
- Sufficient water pressure : 12m
- Sufficient water quantity: 145litres/capita/day
- Safe water quality: WHO guidelines by establishing water quality system in WASA
- Step-wise development (groundwater + surface water) based on the future demand

Considering the above planning, two scenarios were studied for the development of water sources to achieve the future demand & other targets in the M/P. Scenario-1 mostly provides for short and medium terms proposals which mainly aims at development of well fields and canals (JBC, RBC, GBC), whilst Scenario-2 apart from taking intake from canal water on short term basis, primarily focuses on development of well field, of Chenab River. In financial terms Scenario-1 is cost effective, whereas Scenario-2 involves huge investment.

In summary two scenarios are compared as under:

Table 25: *Comparative analysis of Scenario-1 & Scenario-2*

	Scenario-1 **JBC, RBC, GBC**	**Scenario-2** **Chenab River**
Water source	Irrigation Canals	Intake from Chiniot Dam
Water rights	Irrigation Dept.	Irrigation Dept. & WAPDA
Intake facilities	Relatively medium-small scale	Relatively Large scale
Transmission pipes	Relatively small size & short distance	Relatively large size & long distance
Environmental impacts	Medium impacts	Large impacts

Environmental & Social Considerations

- Environmental Impacts
  - Water usage or water right
  - Depletion of groundwater
  - Generation of sludge & wastewater from WTPs
- Social Impacts
  - Land acquisition for the TR & OHR/GR sites
  - Evacuation & demolition during construction stage
- Other considerations
  - Traffic congestion during construction stage
  - Noise & vibration
  - Air pollution

6.1.2 Discussions held in the SHM-1

- Two scenarios for the supply of water to Faisalabad were discussed. Whereas, Scenario-1(water supply from existing JBC, RBC, GB), would cater for water demand for only 20 years, the Scenario-2 (water supply from Chenab River) would provide long term solution (50 years) with one-time investment i.e. at much higher cost than that of Scenario-1. As such the Scenario -2 would be a better option.
- It was clarified that the final decision would depend upon the availability of finances to implement Scenario-2. The Irrigation Department would be consulted in the matter. Scenario-2 would further be examined in light of Feasibility study of Chiniot dam, currently being prepared.
- On a query it was explained that issue regarding redesigning the canal area where Water Pumping Radar (WPR) is proposed to be installed, would be resolved through discussions with Irrigation Department.
- It was ensured that adequate proposals were incorporated in M/P to enhance WASA's institutional capability to handle increase in water supply system's capacity from 63 MGD in 2015 to 275 MGD in 2038.

6.2 Proceedings of Workshop/ 2nd SHM

JICA Mission Team (JMT) in consultation with all the concerned departments and stakeholders involved in the formulation of Master Plan has prepared an Interim Report in November 2017. The Interim Report provided an overall overview of M/P and divulged upon priority projects for planned development and improvement of water supply, sewerage and drainage facilities in the city.

In order to update all the concerned departments, one day workshop together with second SHM was organized by WASA-F/JMT.

Date : 20th December, 2017
Venue : Serena Hotel Faisalabad.
List of participants : Attached as **Appendix-2**.

Proceedings of the workshop/second meeting (herein after called as second SHM), in this IEE report is limited only to the priority projects for the improvement of water services in Faisalabad. The summarized version of presentation made as well as discussions held in the second SHM is highlighted below:

6.2.1 Summary of presentation made in the workshop/ meeting

Master Plan including ensuing strategy for the development/improvement of water supply services system in Faisalabad presented in the first SHM already was also discussed in the second SHM. Besides the information regarding existing situation, planned proposals for water supply services as provided above, following additional details have been divulged in the second meeting.

Direction of Water Supply planning

- Securing Water Resources
  - Step-wise development (ground & water) considering the future demand
- Improvement of Water Supply Services
  - Supply zones, transmission & distribution network, distribution centers
  - Method for improvement of service level, from vicious to virtuous cycle
- Proposed Priority Project include:
  - Old Jhal Khaluana WTP Renewal (10 MGD) with New DCs Construction
  - New Transmission and Distribution Network with Water Meter Procurement
  - Stepwise Development: Phase 1 (5 MGD) and Phase 2 (5 MGD)

Planned Water Supply Service (2038)

- Served Population (domestic): 4,146,000
- Connection (domestic): 572,000
- Water Demand: 275 MGD
- Production Capacity: 277 MGD
- Coverage Area: 2 360 km2
- Use of Groundwater: 16%

Key Features:

- Step-wised development of new water sources based on short term plan for 2023, midterm plan for 2023-2028/2033 & long term plan for 2028/33-2038
- Service area divided into seven (7) supply zones with respect to water source. This includes :
  - 4 Zones from Terminal Reservoirs (TRs):
  - 1 existing TR & 3 new TRs
  - 1 Zone from RBC
  - 1 Zone from New JK WTP
  - 1 Zone from Old JK WTP
- 56 water distribution centres (WDC) are proposed to be established serving respective Administrative Zones (including 20 on private land) with OHR of 25m height & capacity=2000m^3
- Utilization of ground water would be substantially reduced from present 85% to 16% in 2038

  Components of priority projects proposed include WDC, Water Treatment Plant, Distribution & Transmission Main Lines, & Meters

6.2.2 Discussions held in Workshop/ SHM-2

- It was agreed to incorporate the proposal to conduct a detailed study before installation of Water Treatment Plant (WTP) for Surface Water (S/W), in the Master Plan (M/P).
- M/P proposed Stage-wise development schemes under Scenario-1 including priority projects for the rehabilitation & improvement of existing old WTP and the installation of new WTP. The proposed development of water supply service system would be achieved under Short Term Plan ending on 2023, Medium Term Plan on 2028, & Long-Term Plan targeting 2038.

- In order to ensure the stability in the flow of surface water flow and to meet the required demand during the canal closure period, the options examined in M/P are as under:
  - To develop surface water source by acquiring direct intake water from an irrigation canal & constructing new water treatment plants facilities. However, the direct intake solution may involve constraints like incurring high cost and taking long time to negotiate with the Irrigation Department.
  - Duration of standard closing period of at least 18 days increased to almost one month in recent years. This period should be reduced to minimum of 15-18 days.
  - Adjustment should be made by shifting/staggering the closing period of two canals i.e. JBC and GBC to avoid overlapping.
  - WASA-F signed an agreement with Government of Denmark to carry out a feasibility study regarding reuse of waste water after treatment.
- Regarding the quality of the surface water through canals, it was clarified that water treatment was being carried out following the WHO standards-currently in use all over the world and provide a robust criterion for checking the quality of water taken from the surface water sources i.e. canals, rivers etc.
- On a question about the Risk Analysis undertaken on the basis of depleted surface water sources, it was responded that that there was a scarcity of water resources in Pakistan including Punjab/Faisalabad as compared to the other countries. M/P emphasized the need for back-up support for the sustainable water supply from the surface water sources especially the canal water and did not carry out Risk Analysis, being theoretical exercise.

Considering the importance attached to assessment of water quality, it was agreed to incorporate the Water Quality index in the final report of M/P

7 Environmental Management and Monitoring Plan (EMMP)

The Environmental Management and Monitoring Plan (EMMP) present the overarching approach environment management and monitoring during the planning, construction and operation phase of the priority projects.

Table 26: *Environmental Management and Monitoring Plan*

Activity	Mitigation Measure(s)	Monitoring Indicators	Monitoring and Reporting Frequency	Responsibility
Construction				
Earth work (excavation, filling/backfill (where necessary) For pipe works	▪ Minimize disturbance of native flora, trees, etc., during construction; ▪ Avoid use of hazardous material. Any use should follow health and safety procedures to protect people and the environment; ▪ Store topsoil for re-spreading. If vegetation is to be removed during wet periods, disturb ground only just before actual construction;	Loss of vegetation/trees, soil erosion & stability, dust pollution and occupational health of workers and community	Weekly	The site Environmental Engineer will ensure these measures and Supervision Consultant will monitor
Impacts relating to construction of the Pipe line	General ▪ Limit construction time to daylight hours in sensitive areas such as residential/hospital areas, where construction is required. In order to avoid traffic interruptions, notification are to be sent out to all potentially affected land owners, shopkeepers etc. ▪ Send out prior notification to the relevant concerned authorities as & when essential services such as water or electricity/phone lines are to be affected	The area to be cleared must be clearly demarcated and this footprint strictly maintained/followed. Top soil accumulation		The Contractor/ Supervision Consultant, if any. Environmental section of WAS-F to coordinate.

	during the construction process. ▪ Place the top soil on one side of the excavated ground for reuse			
Access Management During Construction	<u>Construction Traffic</u> ▪ Strictly control the access of all construction and material delivery vehicles especially during wet weather to avoid slurry/disturbance to the movement of people & general traffic due to accumulation of water <u>Access</u> ▪ Position entry and exit points strategically to ensure minimal effects on traffic; ▪ Clearly signpost site routes and issue to all suppliers and Sub-Contractors. ▪ Police assistance for traffic control	There might be probability of any incident caused by construction vehicle movements/Vehicular Traffic/Traffic Jams	Weekly Daily during construction	Site Environmental Engineer and Supervision Consultant in coordination with WASA environmental section
Impacts related to Soil and Geology	<u>Soil Erosion</u> ▪ Sensitive areas need to be identified prior to construction so that the necessary precautions can be implemented ▪ Re-vegetate disturbed surface immediately after the construction activities are completed <u>Soil Contamination</u> ▪ The construction contractor needs to arrange to remove all construction related contaminated topsoil ▪ The construction contractor will be responsible for remedying any polluted topsoil	Canal site soil may be susceptible to potential erosion	Monthly	Site Environmental Engineer and Supervision Consultant keeping liaison with Irrigation Department

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Operation of work place/labor camps	▪ Set up labour camp away from residential/commercial. No open fires are allowed within the construction camp and no wood from surrounding vegetation may be used to create a fire. area to avoid disturbance ▪ Provide adequate parking for site staff and visitors. This should not inconvenience or serve as a nuisance for neighbours; ▪ Choose location for Wastage/Chemical (in this case oil, Chlorine etc.), storage area by considering distances to water bodies and water erosion potential of the soil. Impervious surfaces should be provided where necessary; ▪ Designate, demarcate, fence off and secure all storage areas to minimize the risk of crime; storage areas should be safe from access by unauthorized persons; ▪ Provide fire prevention facilities at all storage facilities; ▪ Hazardous materials such as oils, fuels, chemicals, etc. must not be allowed to contaminate the subsurface or enter into drainage systems. Siting of hazardous material storage areas should be approved by the Project Manager. ▪ Immediately contain,	Labour camp site Existence of Storage facilities Setting up of a demarcated area Existence of firefighting equipment/facilities Choked drainage /sewerage pipes Track of oil spillage	Weekly	The Site Environmental Engineer in liaison with Supervision Consultant and other contractor's staff

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	recover and clean up any spillages that may occur during the construction phase. All spillages must be reported to the Environmental Officer and Project Manager. ▪ Rehabilitate all storage areas after construction has been completed on site and all excess material has been removed. Such areas shall be rehabilitated to their natural state. Any spilled concrete shall be removed and soil compacted during construction shall be ripped, levelled and re-vegetated;	Areas cleared from all impediments		
Air Quality	<u>Dust Control</u> ▪ The Contractor shall be responsible for dust control on site to ensure no nuisance is caused to a Landowner or neighbouring communities, traffic & general public; ▪ Any complaints emanating from the lack of dust control shall be attended immediately by the contractor.	Dust pollution within and around the project area.	Weekly	The site Environmental Engineer will ensure these measures and Supervision Consultant
Noise & vibration on Surrounding Areas	▪ All heavy equipment and machinery shall be fitted in full compliance with the national and local regulations and with effective silencing apparatus to minimize noise. ▪ As a rule, the operation of heavy equipment shall	Noise & vibration due to Construction activities, affecting the immediate environment.	Weekly	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures

	be conducted in daylight hours. ▪ With regard to unavoidable very noisy construction activities in the vicinity of noise sensitive areas, the contractor and his Staff should liaise with local residents on how best to minimize impact, and the local population should be kept informed of the nature and duration of intended activities			
Use of Equipment and Machinery	▪ Minimize use of heavy machinery; ▪ Prevent fuel tank leaks by (a) monitoring and cross-checking fuel level deliveries and use, (b) checking pipes and joints for leaks, ▪ Equipment should not be parked under the dense vegetation and trees to avoid soil compaction and damage to the roots of the trees. ▪ Ensuring enforcement of NEQS applicable to gaseous emissions generated by construction vehicles, equipment and machinery during construction works. ▪ Efforts should be made to coordinate with traffic police along the road to avoid traffic congestion as far as possible; ▪ Provision of signboards directing the drivers about the diversion. ▪ Contractor staff could be trained and put on the	Soil stability and erosion Site monitoring Traffic congestion	Daily	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures. Police to coordinate with project authorities

	duty to manage the traffic during the construction activities taking place along the road.			
Impact on Health and Safety	<u>Emergency response plan</u> Upon completion of the construction phase, an emergency response risk assessment should be undertaken and specific contingency plans incorporated for the crisis management plan to ensure the safety of the staff and surrounding land owners and users in case of an emergency.	Safety Hazards during maintenance	Monthly	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures
Waste Management	▪ Training of working force in the storage and handling of materials and chemicals that can potentially cause soil contamination & emergency procedures; ▪ Solid waste generated during construction sites will be safely disposed in demarcated waste disposal sites and the contractor will provide a proper waste management plan; ▪ Burning of waste will be prohibited ▪ Protection of groundwater reserves from any source of contamination such as the construction and oily waste that will degrade its potable quality; ▪ The solid waste will be disposed off in designated landfill sites to sustain the water quality for domestic requirements; ▪ Water required for	Odour, Littering Debris Appearance of dirt in water	Daily	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures

	construction is obtained in such a way that the water availability and supply to nearby communities remain unaffected;	Scarcity of water		
Construction labor	▪ Use local or regional labor; ▪ Provide adequate quantities and good quality of food and fuel for cooking ▪ Wastage of water should be reduced by training the workers involved in water use; ▪ Source of water should be carefully selected. Water use should not disturb the existing community water supplies ▪ If the water is stored for drinking purpose, drinking water should meet the NEQS standards and if it is used for construction purpose then it should be clearly demarcated. ▪ No domestic pets or livestock are allowed on the site.	Surface & ground water pollution and conflicts with the local Inhabitants	At beginning of project	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures
Material handling, use and storage	▪ Used empty cement bags should be collected and stored to deliver these to recycling plant; ▪ Contaminated water storage facilities should not be allowed to over flow and appropriate protection from rain should be implemented. ▪	Dust pollution and sedimentation loading, spills and wastage	▪ Monthly in dry season and weekly in wet season	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures
Security of People against Man-made and	▪ There should be an Emergency Response Plan which must be followed in	Security lapse, Occurrence of any natural or man-made	Monthly	The site Environmental Engineer and

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Natural hazards	case of any emergency. ▪ There should be a proper disposal of debris & excavated material/drainage system to avoid slurry/flooding in case of heavy rainfall	hazard.		Supervision Consultant shall ensure implementation of mitigation measures
Impacts on Ecology	<u>Existing Vegetation</u> ▪ Existing indigenous vegetation must be retained where possible. ▪ Materials should not be delivered to the site prematurely which could result in additional areas being cleared or affected; ▪ No vegetation to be used for firewood. ▪	matters related to construction activities	Weekly	The site Environmental Engineer and Supervision Consultant shall ensure implementation of mitigation measures
Operation and Maintenance Phase				
Impacts Associated with construction site decommissioning	<u>Removal of equipment</u> Remove all structures including the construction camp. Check for any previous construction related chemical soil contamination and cleanup. Return the ground conditions within the sites close to their original state by undertaking the necessary landscaping. <u>Associated infrastructure</u> ▪ The site is to be cleared of all litter. ▪ Fences, barriers and demarcations associated with the construction phase are to be removed from the site unless	Manage/Keep the site to its original position within and around the transmission line	Weekly	Construction/Maintenance Contractor, Site Engineer, WASA-F(Proponent),

	stipulated otherwise by the Engineer. ▪ All residual stockpiles must be removed or spread on site as directed by the Engineer			
Impacts Associated with water pipe line Operation and Maintenance	<u>Maintenance</u> ▪ All applicable standards, legislation, policies and procedures must be adhered to during operation; ▪ Periodic inspection of the Pipe lines should be carried out to monitor their status.		Monthly	WASA-F
Impacts on Biodiversity	▪ Indigenous vegetation should be maintained along the routes and all exotic species removed as they appear and disposed off appropriately. ▪ Vegetative re-establishment shall, as far as possible, make use of indigenous or locally occurring plant varieties	Disarray of greenery/vegetation or mushroom growth of alien/wild species	Monthly	WASA-F
Impact on Health and Safety	<u>Emergency response plan</u> Upon completion of the construction phase, an emergency response risk assessment should be undertaken and specific contingency plans incorporated for the crisis management plan to ensure the safety of the staff and surrounding land owners and users in case of an emergency.	Safety Hazards during maintenance	Monthly	WASA-F

8 Conclusion and Recommendations

The conclusions of Initial Environmental Assessment Report are summarized as under:

- Construction activities (building ground reservoir, installation of valves, replacement of pipes etc.) would cause moderate negative impacts on the natural environment which are of temporary nature.
- Metering system would induce a positive impact by improving the revenue collection of WASA-F.
- Water supply vendors may face temporary decline in their revenue due to improved water supply system.

Recommendations regarding the priority projects are as follows:

- Construction vehicles and heavy machines should be properly maintained and operated to minimize air pollutants, noise and vibration.
- Meticulous attention should be paid during the pipe installation and leakage repair works so that no contaminated water can enter into the service pipe.
- Construction workers need to be guided in proper use of surplus soil and not to leave the construction wastes in the construction sites.
- Affordability to pay water charge of the poor should be taken into account on the establishment of tariff system.
- The project manager should continue to assist the local communities as a social responsibility.
- Access to the public infrastructures needs to be made available with the effort of accommodating the traffic along the road as far as practically possible.
- Accidents associated with construction should be properly managed. Safety of the construction workers should be ensured as a priority for the management.
- Adequate consumption needs to be made for land acquisition (if any) as per Land Acquisition Act, 1894, for the construction of Ground Reservoir under the priority projects.

In conclusion, IEE revealed that no significant impact would be caused during the construction/operation of priority projects, identified in M/P for the improvement of water supply and services in 3 areas of Faisalabad.

The present IEE report is enough to meet the administrative and legal framework. Therefore, the environmental approval may be accorded for the priority projects.

Appendix-1

Stakeholder Meeting on Master Plan of WASA Faisalabad
JICA Master Plan Study Team
28 September 2017
Conference Room, WASA - F
Attendance Sheet

***Table 27:** Attendance Sheet - SHM-1*

Sr. No	Name	Designation & Department
1	Faqir Muhammad Ch.	MD – WASA
2	Khalid Javed	Municipal Officer (Infrastructures)
3	Dr. Haroon Rashid	Lecturer Dept of Struct & Env. Engg Uni of Agri. Fsd.
4	M. Naeem	MSE Specialist (The Urban Unit)
5	Gul Hafeez	SIDS The Urban Unit
6	Rana Kashif Ali	S.D.O Irrigation Dept
7	Asif Gillani	Environment Specialist (The Urban Unit, FSD)
8	Shaukat Hayat	DD EPA FSD
9	Waseem Ahmad Hashmi	DMD (S) WASA
10	Muhmmad Khalid	DMD € Wasa
11	Adnan Nisar	Director P&D Wasa
12	Shoaib Rashid	Director RMO 1
13	Zahid Pervez	Director (Admin.)
14	Ejaz Latif	Dir (ODM) W
15	Ryunan Matsue	JICA Mission Team
16	Harutoshi UCHIDA	JICA Mission Team
17	Kiyoko Takamizawa	JICA Mission Team
18	Naoto Takatoi	JICA Mission Team
19	Kaora Suzuki	JICA Mission Team
20	Itsuro Matsubara	JICA Mission Team
21	Yasuhiro Matsuoka	JICA Mission Team
22	Akira Kohara	JICA Mission Team
23	Dr. Shahid Nasir	Finite Engineering
24	Hafiz M. Awais	Asst. Director
25	Roohan	DD (Tech)/ W. R

26	Asad Ali	Deputy Director (FFP)
27	Sultan Azam	JMT
28	Kamran Raza	(O&M) E
29	Syed Shujja Haider	Project Coordinator JMT
30	Shahid Iqbal	Finite Engineering
31	Irfan Mannan	V. Chairman WASA
32	Ishtiaq Ahmad Khan	IRC Specialist (The Urban Unit)

Appendix-2

2nd Workshop/ Stakeholder Meeting on Master Plan of WASA
JICA Master Plan Study Team
12/20/2017
Conference Hall, Serena Hotel Faisalabad
Attendance Sheet

Table 28: Attendance Sheet - SHM-2

Sr. No.	Name	Designation & Department
1	Muhammad Shabbir Afzal	Deputy Director Agriculture (Ext) Faisalabad
2	Prof Dr. M Arshad	Chairman Department of Irrigation & Drainage University of Agriculture FSD (UAF)
3	Dr. R Naiz Ahmed	Director, Water Management UAF
4	Dr. Lubna Anjum	Lecturer, Dept. of Irrigation & Drainage Agri. Engg. UAF
5	Engr. Wajeeha Qamer	Assistant Professor, Civil Engineering Dept. NFC IEFR FSD
6	Engr. Abubaker Ijaz	Duty Director (Tech), Energy Management Cell Water Resources, WASA FSD
7	Abul Ghaffar Naveed	Deputy Director, WASA, FSD
8	Aamer Aziz	Additional DG FDA
9	Dr. Muhammad Asif Shazad	District Health Officer, Preventive Services, FSD
10	Muhammad Saleem Bhathi	SE LCC East Irrigation, FSD
11	Dr. Shaid Nasir	Director Finite Engineering, (Pvt) ltd.
12	Ms Kiyoko Akamizawa	JICA M/P Mission Team
13	Shujjaa Haider	Project Coordinator, JICA Mission Team
14	Sultan Azam	JICA M/P Team
15	Ghulam Murtaze	SELCC West Irrigation, FSD
16	Syed Faisal Hassan	Engr. Operation & Maintenance SNGPL
17	Kamran Raza	WASA (O&M), FSD
18	M Farhan Akram	DD WASA, FSD
19	M Abdullah	Project Coordinator, WWF
20	Ali Shan Arif Makhdum	Environmental Officer, WWF
21	Mubasher Ahmad	Technical Skills Training Specialist (check department/ Address)

	Cheema	
22	Zia Mustafa	Water Specialist, Aljagdi Academy, Urban Unit (Check Aljagdi)
23	Ejaz Latif	Director (O&M) WASA, FSD
24	Muhammad Ali	Deputy Director (Tech), P&D Department
25	G. Mustafa	Psychologist (Check designation & department)
26	Faqir Hussain Babar	Director, PHS, WASA FSD
27	Shahbaz latif	DDR (I&C), WASA FSD
28	Zahid Pervaiz	Director Rev (IDL), WASA FSD
29	Burira Anam (check name)	AD (GIS), WASA, FSD
30	Samreen Ashraf	AD (GIS), WASA, FSD
31	Farhat Adibbia (check name)	SRO, WASA, FSD
32	Shahida Rehman	AD, WASA, FSD
33	Muhammad Shaukat Ali	Ex DMD, WASA, FSD
34	Shoaib Rashid	Director Rev (Domestic), WASA FSD
35	Haroon Rasheed	Director Admin, WASA FSD
36	Muhammad Khalid	DMD, WASA, FSD
37	Waseem Ahmed Hashmi	DMD.D.(S) WASA, FSD
38	Adnan Nisar Khan	Director, WASA, FSD
39	Rana Asif Muhmood	Chief Engineer, Irrigation Dept. FSD ZONE
40	Faqir Muhammad CH	MD-WASA, FSD
41	Irfan Mannan	Vice Chairman - WASA, FSD
42	Hoshino Takashi	Team Leader, JICA Mission Team
43	M.Riaz Kamoka	U-C Chairman
44	Gul Hafeez	SIDS - Urban Unit
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46	Saqib Raza	WASA, FSD
47	Usman Latif	WASA, FSD
48	M.Maqsood Ahmed	WASA, FSD
49	Atiq-ur-Rehman	WASA, FSD

50	Abdul Raouf Butt	WASA, FSD
51	Muhammad Ashraf	Resident Engineer
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54	M.Fasial Mirza	Research Associate
55	Azhar Azeez	PRO, WASA, FSD
56	Laiba Tanveer	Survey-Assistant, JICA Mission team
57	Asad Ali	Deputy director, (FFP), WASA Faisalabad
58	Ghulam Shabbir	Deputy Director (P&D)
59	Umar Iftikhar Khan	DD (Admin) WASA, FSD
60	Shahid Iqbal	Consultant, Finite Engg. (pvt.) Ltd, Islamabad

WATER & SANITATION AGENCY, FAISALABAD

THE PROJECT FOR WATER SUPPLY, SEWERAGE AND DRAINAGE MASTER PLAN OF FAISALABAD

Report of Stakeholder Meetings and Workshop on Master Plan of WASA – Faisalabad

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1 INTRODUCTION

This report presents proceedings of 1st & 2nd Stakeholder meetings (SHM) including a workshop, held respectively as a part of the project for water supply, sewerage, & drainage Master Plan (M/P) of Faisalabad being implemented by WASA-F with JICA technical assistance. The first stakeholder meeting (SHM) was organized by JICA Team, to review the progress made in the project and to seek the feedback from the participants attending the meeting. Subsequently, a workshop and the second SHM were simultaneously organized by WASA-F to apprise the various departments/stakeholders, representatives of city government etc. of the priority projects to be initiated, progress & achievements made under M/P project.

2 BACKGROUND

Water resources have been scarce in Faisalabad and depletion trend continued unabated over the years. Water supply demand fell short of demand due to rapid growth of population and increase in urbanization. The total demand of water in the city was 650,000m^3/day in 2015, against which the supply was 501,000m^3/day i.e. almost one–fourth of demand could not be met. Due to scarcity of water resources and delay in the development of water supply facilities, only 60% of the households in the city have access to municipal water supply. The topography of Faisalabad is flat/plain area. As such sewage and storm water cannot be disposed of from the city through gravity flow without the use of multistage pumping which is quite expensive. In 2015, the Faisalabad city generated approximately 280 MGD sewage water. Three types of connections registered with WASA Faisalabad as sewer connections, are available for the disposal of domestic, commercial and Industrial waste water in the city. The domestic connections are 70% of the households; remaining 30% households having no sewer connections (Ref: EIA Report for Provision of sewerage system in sewerage deficient areas, Faisalabad, April 2015).

To review and improve the water supply, sewerage and drainage in the Faisalabad city, the government of Pakistan requested the government of Japan to provide support in formulating a long-term/Master plan for the development facilities of appropriate water supply resources, sewerage and drainage services/ system on sustainable basis. In response to a request made by the Government of Punjab, Government of Japan agreed to provide the technical assistance to carry out a comprehensive study for the formulation of master plan for water supply, sewerage and drainage in Faisalabad (hereinafter referred to as “the Project"). JICA being the official agency responsible for implementation and technical co-operation programs on behalf of the Government of Japan dispatched a survey team. JICA survey team conducted a detailed planning survey for the project and signed a Record of Discussion with Government of Punjab in March 2016 before the commencement of work on the Master Plan project.

3 THE PROJECT

Master plan for water supply, sewerage & drainage in Faisalabad is mainly concerned with the formulation of a strategy for the providing a viable system of water supply resources, sewerage services and drainage structure on sustainable basis, to meet the existing as well as future demand of the residents in & around Faisalabad. The current project is largely built upon the review of the past development work recommended/implemented in the master plan which was prepared in 1976 with ADB support and revised in 1993 with the World Bank assistance. Since then, it has never been reviewed for over 20 years.

In addition, the review would also make an assessment of current situation regarding water resources/quality, sewerage/drainage facilities, natural and socio-economic environments. Furthermore, the project would put forward the proposals for urban/land use development, organizational structure/financial management and revenue generation schemes for WASA-F and public awareness survey.

4 OBJECTIVES

Main objectives of The Project are:

- An integrated master plan would help evolve a strategy, whereby enabling WASA-F to undertake projects for the development of water supply, sewerage and drainage facilities in Faisalabad city.
- Master plan on implementation would ensure provision of clean water to public in accordance with their current & future demand
- Accomplishment of targets/tasks set forth in the master plan would result in the improvement of revenue generation opportunities for WASA as well as quality life/standard of living of city dwellers.
- The project would enhance the sewerage & drainage facilities, thereby promoting hazard free environment for Faisalabad city and surrounding areas.
- To identify priority projects on a short-term basis for the selected areas
-
- of Faisalabad;

- To promote the institutional capacity development for ensuring execution of the projects identified in the master plan.

5 SCOPE

Detailed Scope of work is provided in the main report. However, the main facets of the M/P Project are summarized as under:

- An overview of current situation.
- Assessment of project implementation capacity of WASA-F.
- Improvement of Institutional capacity building and development of WASA-F management.
- Identification of long term investment plans including selection of short term priority projects to be proposed to improve water supply, sewerage and drainage facilities in Faisalabad City.

6 PROCEEDINGS OF 1ST SHM

Initial Environmental Examination (IEE) process forms a part of the JICA-WASA M/P Project. Under this component, the first stakeholder meeting (SHM) was organized by JICA Mission Team (JMT). The date, venue, objectives the meeting are as under:

Date	: 28th September, 2017
Venue	: Conference Room, WASA Faisalabad.
List of participants	: Attached as **Appendix-1**.

The objectives of the SHM are:

- To provide key stakeholders with information regarding the findings of the study and proposed long-term plan of water supply and sewerage in Faisalabad under the project.
- To provide an overview of the environmental and social assessment and Public Participation Process (PPP) being followed for the proposed project.
- To provide an opportunity for key stakeholders to seek clarity and provide input into the project.
- To record comments raised and include them in the Interim Report of the project.

Agenda of the meeting including presentations made are as under:

- Overview/ Scope of M/P
- Environmental and Social Considerations
- Discussion
- way forward

6.1 Summary of Presentation made in the meeting

An overview of M/P for formulating a strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad was presented in the meeting. The information provided is summarized as under:

Water Supply

Water supply sources comprise of ground water and surface water in Faisalabad. The sources of ground water are government owned tube wells/ private wells and river water (Chenab River/RBC, JBC and GBC). WASA-F is responsible for delivery, maintenance and management of water supply system. The current water supply situation is highlighted below:

- Actual Water Supply in 2017 : 247000 m3 /day
- Total Water Demand in 2015 : 287000 m3 /day
- Current Water supply service: 6 hours or less from
- Insufficient water quantity with low pressure

Issues

- Over/illegal pumping from tube wells causes groundwater depletion
- Mostly pipes do not have water meters
- Water containing high salinity content
- Low operation rate of water treatment plants (JKWTP-empty filters)
- Intermittent low operation of pumps (6hr/day) at terminal reservoir & pumping station along with Inability of manage water distribution

Targets Proposed in M/P

- Total Water Demand estimated in 2038: 1252000 m3/day
- Water supply service/operation : 24/7
- Sufficient water pressure : 12m
- Sufficient water quantity: 145litres/capita/day
- Safe water quality: WHO guidelines by establishing water quality system in WASA
- Step-wise development (groundwater + surface water) based on the future demand

Considering the above planning, two scenarios were studied for the development of water sources to achieve the future demand & other targets in the M/P. Scenario-1 mostly provides for short and medium terms proposals which mainly aims at development of well fields and canals (JBC, RBC, GBC), whilst Scenario-2 apart from taking intake from canal water on short term basis, primarily focuses on development of well field, of Chenab River. In financial terms Scenario-1 is cost effective, whereas Scenario-2

involves huge investment.
In summary two scenarios are compared as under:

Table: Comparative analysis of Scenario-1 & Scenario-2

	Scenario-1 JBC, RBC, GBC	Scenario-2 Chenab River
Water source	Irrigation Canals	Intake from Chiniot Dam
Water rights	Irrigation Dept.	Irrigation Dept. & WAPDA
Intake facilities	Relatively medium-small scale	Relatively Large scale
Transmission pipes	Relatively small size & short distance	Relatively large size & long distance
Environmental impacts	Medium impacts	Large impacts

Environmental & Social Considerations

- Environmental Impacts
  - Water usage or water right
  - Depletion of groundwater
  - Generation of sludge & wastewater from WTPs
- Social Impacts
  - Land acquisition for the TR & OHR/GR sites
  - Evacuation & demolition during construction stage
- Other considerations
  - Traffic congestion during construction stage
  - Noise & vibration
  - Air pollution

Sewerage & Drainage

The vast majority of industrial effluent is discharged "raw" without any treatment into two main drains that are Paharang drain to the North West and Madhuana drain to the South East. Paharang Drain eventually discharges to the Chenab River and Madhuana Drain to the Ravi River; both drains are managed by the Irrigation Department.

In order to assess the quality of water being discharged into Main Drains and to estimate the results of planned sewerage system on reduction of pollution loads, a survey along Main Drains within target area of the project and that of Chenab & Ravi Rivers is conducted. Sampling method and flow rate measurement to estimate the pollution loads is summarized as under:

- Water Quality Analysis on Main Drains
  - Sampling points: Madhuana Drain 4, Paharang Drain 10
  - Parameters: Temp, pH, SS, BOD, COD, SS, NO2-, NO3-, NH4+, T-N, T-P, Oil, SO4-, CN-, Phenol, Cu, Zn, As, Cr, Pb, Cr, Hg, Ni, Coliform (total 24)
- Water Quality Analysis on Main Rivers
  - Sampling points: Chenab River 2, Ravi River 2
  - Parameters: Temp, pH, EC, SS, DO, BOD, COD, SS, NH4+, Coliform (total 8)
- Flow rate Measuring (to estimate the pollution loads)
  - Velocity & Section area at drains and rivers
  - Pumping operation at pump stations

Major Conclusions of the survey:

- Water quality of Main drains as well as that of rivers exceeds NEQS/WHO guidelines.
- Drain and river water is heavily polluted with domestic & industrial waste water.

Planning Proposed for Domestic Waste Water in M/P

- Basic Planning
  - Expansion of sanitary sewer network
  - On-site sanitation facilities for the low populated areas

- Sewers & Pumping Stations
  - Increase of the capacity of sewers
  - Installation of sewer pipes collecting WW instead of open drainage channels

- Wastewater Treatment Plants (WWTP)
  - Renovation of Chokera WWTP
  - Preparation of appropriate sites for new WWTPs

Treated WW shall be used for agricultural purposes

Planning Proposed for Industrial Waste Water in M/P

- Main issues
  - Acceptance of industrial WW to sewerage system of WASA-F
  - Installation/operation of pre-treatment facilities in factories

- . Regulation to control the IWW quality
  - Strengthening regulations & observing compliance
  - COD, TDS & toxics shall be reduced by pre-treatment
  - Dedicating penalty for violation

- . Monitoring of IWW

    - Data collection for enhanced registration & inspection system
    - Improvement of WASA-F lab to analyze key parameters

Establishment of sustainable monitoring system

Environmental & Social Considerations

- Environmental Impacts
    - Hydrological situation/water quality (to be improved)
    - Generation of sludge from WWTPs
- Social Impacts
    - Land acquisition for the WWTP sites
    - Evacuation & demolition during construction stage
- Other considerations
    - Traffic congestion during construction stage
    - Noise & vibration
    - Air pollution

6.2 Discussion/ Minutes of SHM-1

Questions & Answer including observations/clarifications made in the meeting are summarized as under:

Mr. Rohan Javed (DDT), WASA

Mr. Rohan shared his opinion on the two scenarios discussed in the presentation. According to him, for Scenario-1 (JBC, RBC, GB), the proposal has to be first discussed with the Irrigation department because the rights of canal water belongs to them. Also, Scenario-1 will solve the problem of water supply for only 20 years. Whereas, the cost of Scenario-2 is much higher than the Scenario-1 as it provides one-time investment and long-term solution catching the need of the Faisalabad for 50 years. Also, the water from the Chenab River can be supplied in accordance to the demand and volume can be increased with the increase in requirement. So, in the light of explanation provided by him, he supported the Scenario-2 to be opted.

MD, WASA, responded that the Scenario-2 is very costly as the investment required for long term to solve the water issue. However, the final decision will depend upon the availability of finances for this project. He also mentioned that east zone of the Faisalabad city possesses more pollution as compared to the west zone and there is more need to establish waste water treatment plant in east zone as compared to west zone. He requested JICA Study Team to verify their results in east and west zone.

JICA Study Team Member, Ms. Takamizawa, however informed that Scenario-1 is better because of low cost as compared to Scenario-2. Also, the feasibility of Scenario-2 depends upon the construction of

Chiniot dam. She said that the JICA Study Team will further examine the Scenario-2 in detail after verifying the feasibility of Chiniot dam.

Rana Kashif Ali, S.D.O, Irrigation Department

Irrigation department highlighted their concerns about the installation of Water Pumping Radar (WPR) on the canals as proposal would require the redesigning of that part of the canal where WPR are to be installed. He was of the view that installation of WPR equipment should be undertaken under a separate project.

MD, WASA, said that in order to resolve this issue, detailed discussion would need to be held with Irrigation department.

Gul Hafeez, SIDS, The Urban Unit, Govt. of Punjab

Mr. Gul highlighted the issue regarding the institutional capacity building of WASA and suggested that the JICA Study Team should consider it while finalizing their proposal/ recommendation in the report.

JICA Study Team ensured that the strengthening of WASA is included in the scope of work of M/P.

Mr. Hafeez further states that the capacity of water supply system is proposed to be raised from 63 MGD in 2015 to 275 MGD in 2038. WASA would not be able to handle this capacity. JICA Study Team clarified that the water supply system of Faisalabad would be upgraded/ developed to cope with the augmentation of the capacity.

For the industrial waste disposal and the environmental issues, WASA should setup their Non-Environmental Cell.

Mr. Shahid Iqbal from FINITE highlighted that firstly priority projects under Master Plan would be identified, then the requirement to mitigate the environmental issues would be incorporated in the IEE/ EIA reports to be submitted for the approval of EPA which supervises/ oversees every environmental issue.

When the Master Plan will be completed, then EIA and IEE reports will be prepared and will be submitted to EPA for their approval.

Asif Kiyani (EPA)

Mr. Asif Kiyani supports the Scenario-2 and appreciates Mr. Rohan observations on both scenarios. He raised a question about how to control pollution including solid waste.

JICA Study Team states that existing solid waste management is not included in their scope of work. But they will give comments and provide guidance to manage it. They also emphasize to educate the citizens about solid waste management.

Ms. Takamizawa (JICA Study Team)

Ms. Takamizawa mentioned the stakeholders to whom she wants to discuss the details of the Master Plan Project. MD, WASA assisted her on that question.

Closing Remarks from Mr. Irfan (Vice Chairman, WASA)

Mr. Irfan pays his tribute to JICA, Government of Japan for conducting this Master Plan Project and for looking after the needs of Faisalabad city and regards their spirit. He emphasized on the importance of the Faisalabad city as one of the major Industrial city of Pakistan. He also mentioned another Tender for up gradation of Terminal Reservoir in Faisalabad City, worth 1.6 billion Pak Rupees. He discussed the installation of new public stations and lines in the city. After the construction of 2nd Treatment Plant, WASA will be able to provide 100% potable water to the local people of the city. Mr. Irfan also emphasize on the installation of waste water treatment plant on both east and west side of the city.

Way Forward

- Finalization of Interim Report
- Planning & design of priority project
- Cost estimation of M/P & priority project
- Financial evaluation
- IEE level survey of priority project
- Stakeholder & public consultation
- Completion of Draft Final Report

7 PROCEEDINGS OF WORKSHOP/ 2nd SHM

JICA Mission Team (JMT) in consultation with all the concerned departments and stakeholders involved in the formulation of Master Plan has prepared an Interim Report in November 2017. The Interim Report provided an overall overview of M/P and divulged upon priority projects for planned development and improvement of water supply, sewerage and drainage facilities in the city.

In order to update all the concerned departments, one day workshop together with second SHM was organized by WASA-F/JMT.

Date : 20th December, 2017
Venue : Serena Hotel Faisalabad.
List of participants : Attached as **Appendix-2**.

The objectives of the Workshop/ SHM are:

- To provide information regarding findings of M/P & proposed long term plan of water supply, sewerage and drainage in Faisalabad.
- To provide an overview of the environmental and social assessment and public participation process for proposed projects.
- To provide clarification to queries of participants & seek their contribution for the improvement of Master Plan.
- To record comments raised & incorporate them in the draft Final Report of M/P project.

Agenda of the meeting including presentations made are as under:

- Overview/Scope of M/P relating to
  - Water Supply
  - Sewerage & drainage
- Environmental and Social Considerations
- Discussion

7.1 Summary of Presentation made in the workshop/meeting

Master Plan including ensuing strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad presented in the first SHM already was also discussed in the workshop/second SHM (herein after called as second meeting). Besides the information regarding existing situation, planned proposals in M/P etc.as provided above in para 6.1, following additional details have been divulged in the second meeting.

Direction of Water Supply planning

- Securing Water Resources
  - Step-wise development (ground & water) considering the future demand
- Improvement of Water Supply Services
  - Supply zones, transmission & distribution network, distribution centers
  - Method for improvement of service level, from vicious to virtuous cycle
- Proposed Priority Project to be initiated in three areas; Sitara Sapna city, Sarfaraz colony and Medina Town. This includes:
  - Old Jhal Khaluana WTP Renewal (10 MGD) with New DCs Construction

- o New Transmission and Distribution Network with Water Meter Procurement
- o Stepwise Development: Phase 1 (5 MGD) and Phase 2 (5 MGD)

Planned Water Supply Service (2038)

- Served Population (domestic): 4,146,000
- Connection (domestic): 572,000
- Water Demand: 275 MGD
- Production Capacity: 277 MGD
- Coverage Area: 2 360 km2
- Use of Groundwater: 16%

Key Features:

- Step-wised development of new water sources based on short term plan for 2023, midterm plan for 2023-2028/2033 & long term plan for 2028/33-2038
- Service area divided into seven (7) supply zones with respect to water source. This includes :
  - o 4 Zones from Terminal Reservoirs (TRs):
  - o 1 existing TR & 3 new TRs
  - o 1 Zone from RBC
  - o 1 Zone from New JK WTP
  - o 1 Zone from Old JK WTP
- 56 water distribution centers (WDC) are proposed to be established serving respective Administrative Zones (including 20 on private land) with OHR of 25m height & capacity=2000m^3
- Utilization of ground water would be substantially reduced from present 85% to 16% in 2038
- Components of priority projects proposed in above three areas include WDC, Water Treatment Plant, Distribution & Transmission Main Lines, & Meters

Direction of Sewerage/Drainage planning

Domestic WW Management

Basic Planning Policy

- o Domestic wastewater to be collected by sewer pipes and conveyed to
- o WWTP not discharged to the open drainage channels.
- o Installation of interceptor sewers to maximize the capacity of sewerage network

Improvement of Sewer Network & Pumping Stations

- o Increase of the capacity of sewer network
- o Minimizing the number of pumping stations by deeper pipe installations
- o Use of existing disposal pumps as storm-water pumps where possible

Wastewater Treatment Plants (WWTP)

- Renovation of Chokera WWTP
- Preparation of appropriate sites for new WWTPs
- Industrial WW to be treated separately

Planned Sewerage/Drainage Service (2038)

Domestic
Served Population: 4,292,000 (Including FDA City, Sadar & Khurrianwala)
Wastewater Flow: 130 MGD
Pollution Load: 242 ton/d-BOD
Industrial
Wastewater Flow: 646 MGD
Pollution Load: 584 – 659 ton/d-BOD
Design Sewer Flow: 190 MGD
Capacity of WWTP: 190 MGD
Water Quality (BOD): 80 mg/l
Coverage Area: 2 379 km2
Key Features:

- Industrial Wastewater Volume to be accepted by the WASA-F Sewerage System:
  - About 20% of Total Design Ave. Daily Flow in 2038

Industrial WW Management

Acceptance of Industrial WW to WASA-F Sewerage System

- Current ratio of Total volume of Industrial WW to non-industrial WW is 1:3
  in WASA area.
- Installation/operation of pre-treatment facilities in factories

Regulations to Control Industrial WW Quality

- Strengthening regulations & observing compliance
- COD, TDS & toxics shall be reduced by pre-treatment
- Enforcement of penalty for violation

Monitoring of Industrial WW

- Data collection for enhanced registration & inspection system
- Improvement of WASA-F lab to analyze key parameters
- Establishment of sustainable monitoring system

Recommendations for Industrial WW management

- Industrial WW is harmful to biological WW treatment process. It is very difficult for WASA-F Sewerage System to accept all amount of industrial WW. It is therefore recommended:
- Separate Industrial WWTP for Khurrianwala
- Shifting of major Industrial Estates to M3 in future
- Large sized factories should treat their own Industrial WW in compliance with NEQS

- WASA-f may accept industrial WW once their effluent quality is complied with quality agreed to by the WASA-F.
- To establish the **Industrial Wastewater Management Unit in WASA-F-** responsible for application, monitoring and inspection of industrial units served by WASA-F sewerage under **the Sewerage and Drainage Faisalabad Regulation (2015).**

Environmental & Social Considerations

In addition to the impacts described in the above section (first SHM proceedings), it is worthwhile to state that land would be required for Construction of:

- OHRs proposed on public/private land with area of one Centre amounts to 1500m^2
- TR near Narwala Road Bypass Satiana Road with area of one reservoir of 10000m^2
- Gugera WTP &TR & Jhang WTP with area for one WTP of 10acre
- Chokera WWTP with 550 acres & Mew West WWTP with 710 acres
- Eastern WWTP with required area of 1100 acres

It is also imperative to carry out effective coordination with stakeholders for

- Identification of Project Affected Persons (PAPs)
- Public consultation and compensation where necessary
- Permissions regarding road & transport, canal, environment
- Arrangement of construction waste & sludge disposal
- Technical assistance from universities
- Scarcity of water resources in Faisalabad
- Importance of water saving
- Proper disposal of waste no to sewerage or drainage
- Enforcement of regulations and observation of compliance

7.2 Discussion/ Minutes of Work-Shop & SHM-2

A gist of discussions in the form of Questions & Answers including observations/clarifications made as well as input provided by the participants in the workshop is presented below:

Q.1

Whether or not any study has been undertaken to assess/examine the extent of contamination both in surface water (S/W), & underground water (U/G) because of presence of lot of Silt, toxic industrial effluent, particularly Arsenic particles. If not, it would be more appropriate to carry out a detailed study before the installation of Water Treatment Plant (WTP).

Answer

Mostly the U/G water was found to be contaminated with chemical including Arsenic particles. It is planned to provide WTP for S/W while WTP has not been considered to be installed for U/G water. It is, however, agreed to incorporate the proposal to conduct a detailed study before installation of WTP, in the Master Plan (M/P).

Q.2

Treatment of surface water containing Industrial Waste/toxic material is a major problem which has become very severe in intensity in the city. The presentation made by DD WASA-F does not indicate as to how many treatment plants are required. Is there any plan for a specified number of treatment plants proposed to be installed in M/P for Faisalabad?

Answer

It was informed that M/P has proposed stage-wise development schemes under Scenario-1 including priority projects for the rehabilitation & improvement of existing old WTP and the installation of new WTP. Under Scenario-1, the water Supply Service system is proposed to the developed through integration of canal water while the system under Scenario-II is based on the use of Chenab river water. The Scenario-I, being cost effective, is proposed in the development of water supply service system as under:

Water Source/Development Project	Design Capacity (MGD)	Name of Water Sources	Term	Target Year
Surface Water				
Renewal of Old JKWTP	10	RBC	Short Term	2023
New JKWTP	05	RBC	Short Term	2020/ 2023
Jhang WTP-1	20	JBC(upper)	Mid Term	2028
Jhang WTP-2	40	JBC (upper)	Long Term	2038
Gugera WTP-1	25	GBC(lower)	Mid Term	2023
Gugera WTP-2	25	GBC(lower)	Mid Term	2028
Gugera WTP-3	25	GBC (Lower)	Long Term	2033
Ground Water				
JBC new well	10	JBC (Upper)	Mid Term	2028
JBC exp-well	10	JBC (Upper)	Mid Term	2033
Gugera-1-well	05	GBC (Lower)	Mid Term	2023
Gugera-2-well	05	GBC(Lower)	Mid Term	2028

Under the priority projects, the existing old JKWTP constructed in 1935 with slow sand filtration plant having original capacity of 3.5 MGD, is proposed to be rehabilitated /renewed through installation of rapid sand filtration system. This would augment the capacity from 3.5 MGDE to 10 MGD, to cater for the consumer demand which has been growing rapidly manifold since then.

Q.3

Water of Gugera Branch Canal (GBC) is highly contaminated. What measures are being proposed to resolve this problem?

Answer

Both surface water and ground water have been proposed to be purified through rapid sand filtration system. A total of three (3) WTP for surface water and two WTP for ground water are proposed to be constructed at GBC (Lower), as evident from the above table.

Q.4

Water supply gets affected or suspended during the closure of canals. How the demand would be met during this period. What proposals are being made to ensure sustainable operations of the water treatment plant during the closing period of canals? Haphazard

Answer

Irrigation Canal is an important source of surface water. Being a direct source of irrigation water, the maintenance of canals is considered imperative. Three (3) branches of canal water, (JBC-upper, RBC & GBC-lower) are affected due to the closure of LCC feeder and lower channel canals respectively. Considering the standard closing period, the effect of canal closure can be minimized through construction of water supply network so as to complement each other for the closure period of few days. To ensure the stability in the flow of surface water and to meet the required demand during the canal closure period, the option is to develop surface water source by constructing new water treatment plants facilities by acquiring direct intake water from an irrigation canal. However, the direct intake solution may involve constraints like incurring high cost and taking long time to negotiate with the Irrigation Department. Furthermore, the duration of standard closing period is at least 18 days which has increased to almost one month in recent years. This period needs to be reduced to minimum of 15-18 days. It was informed that adjustment needs to be made to avoid overlapping of the closing periods of two canals JBC & GBC, which can be made by shifting/staggering the closing period of JBC and GBC.

It may be proposed to Irrigation Department that more water can be withdrawn from canals like JBC during the closing period of other canals such as GBC. The negotiation for procuring direct intake of water of 25 MGD from GBC and 20 MGD from others with the Irrigation Department is in progress. It was further pointed out that reuse of waste water after treatment is also under consideration. An agreement with Government of Denmark has been signed for carrying out a feasibility study in this regard.

Comment

There is no procedure/method that can be followed medically for extracting Arsenic from the human body if water containing Arsenic is used. It would be more appropriate to eliminate Arsenic contents in the drinkable underground or surface water.

Answer

As compared to Lahore, no such problem exists in Faisalabad. The Arsenic contents amount to 10 microgram/liter in the water in Faisalabad city which is below than the WHO standard.

Installation of RO plants is under way to overcome this problem in Lahore.

Comment/Question 5

Competition seems to be observed between Agriculture and Water Irrigation sectors in Punjab/Pakistan. With the increase in population this competition also increased while the quality of drinking water is continued deteriorating which is of major concern for the public/water users. The question is to what extent the treatment should be carried out for the improvement of quality of the canal water.

Answer

Regarding the quality of the surface water through canals, it was clarified that water treatment is being carried out following the WHO standards which are being used all over the world and provide robust criteria for checking the quality of water taken from the surface water sources i.e. canals, rivers etc. It was further divulged that treated canal water is being used for both drinking and irrigation purpose. An example of Vietnam was quoted, where treatment is performed for drinking water only. Regarding contamination in water being used for household purposes, efforts are being made to supply clean/treated water on regular basis. The performance of WASA-F in this regard is being improved on sustainable basis and day by day.

Comments

In the use of water resources, preference/priority seems to be given to the surface water sources, which are estimated to be gradually depleting. The sustainability of water supply sources especially that of surface water, is considered to be a real challenge. The Irrigation Department had not been able to supply water for drinking and even for irrigation purposes on sustainable basis. Whether any Risk Analysis has been undertaken in the M/P, to ensure sustainability?

Answer

Team leader of JICA study team responded that there was a scarcity of water resources in Pakistan including Punjab/Faisalabad as compared to the other countries like Thailand, Laos etc. where rivers are large and water is abundantly available. In Pakistan the availability of water on sustainable basis is a critical issue and poses big challenge. The Risk Analysis is a theoretical matter; however, the M/P underscores the need of backup support for the sustainable water supply from the surface water sources especially the canal water. Referring to planned water intake from canals, about 160MGD of treated water has been proposed to be taken from three branches of canals (Jhang BC, Rakh BC & Gugera BC), which amount to 5% of total canal water in 20 years. It was further brought out that an agreement with Irrigating Department was reached to supply 20 MGD waste water after treatment.

Q.6

Weather, WASA-F possesses, their own water distribution centers (WDC) if so, how many are owned by WASA in Faisalabad.

Answer

A water distribution center consists of Overhead Reservoir (OHR) + Ground Reservoir (GR). Currently Seven (7) WDCs are functioning at following sites in the Faisalabad city:

Abdullah pur	:	1
Medina Town	:	2
People's Colony	:	3
Head water works	:	1
Total	:	7

A total 56 WDCs are planned to be established with each OHR is 25 m in height. Of these, 20 WDCs (OHR/GR) are proposed to set up on private land, while the rest would be constructed on public land.

Explaining the water supply facilities, WASA-F apprised the participants, with the aim of producing portable water to each and every home situated within its operational area. WASA-F has been suffering from the budgetary constraints for implementing the water source development projects for drinking purpose. The network has been developed whose O& M cost is on high side but the revenue fell short of the cost because of low/poor recovery of outstanding dues. At present, the water requirement of Faisalabad City stands at 130 gallons per person per day and WASA-F has not been able to meet this demand. Nor is WASA-F now maintaining 24/7 water supply in the city. This can only be accomplished with the cooperation of water users who would be willingly paying water charges on regular basis.

Q.7

Is the saline/waste water acceptable after treatment for drinking?

Answer

It was explained that after proper treatment through water treatment plant as well as following RO method for eliminating Chemical/toxic elements, the water can be used for drinking, other household activities and irrigation purposes.

Q.8

Water contamination issue exists due to mixing of water supply and drainage/ sewerage pipe lines. The reason among others is that two pipelines are laid very close to each other and that too on one side of the streets. This issue needs to be resolved on priority basis.

Answer

It was responded that both water supply lines and sewerage pipes are very old and laid very close to each other. Due to lack of maintenance and wear & tear, the condition of pipe lines has deteriorated with the passage of time, consequently the contents of the pipes got intermingled with each other. WASA-F is striving hard to get rid of this problem and it is expected to resolve this issue in a period of six months.

Comments/Question 9

It appeared from the presentation that M/P has emphasized to follow projects with proper engineering design/techniques for the provision of clean water to the city. No mention regarding Water Quality Index seems to be made in the M/P. Water Quality Index, being an important issue especially in view of the fact that quality of water is changed on hourly basis, needs to be addressed in the M/P.

Answer

It was clarified that water Quality Index depends upon a number of items. WASA-F has already been affiliated with American Association regarding clean water supply system. In this regard WASA-F is following the parameters presented by the American Association and shares information with them.

However, considering the importance attached to assessment of water quality, it was agreed to incorporate the Water Quality index in the final report of M/P.

Q.10

There are many industries situated in and around Faisalabad. How many industries have installed the treatment plants for processing the industrial effluent/waste water?

Answer

It was elaborated that the issue regarding availability of treatment plant and its operation in the industries has been studied in detail and included in the Interim Report of M/P. Majority of the industries (about 70%) have been shifted to Industrial Estate and few (i.e. 30%) are still working in and around city.

Most of the Industries have their own treatment plants, which are not operating most of the time. No proper monitoring system has been established so far to judge the performance of treatment plants owned by the industries.

It was informed that WASA-F (Government of Punjab) have signed an agreement with Government of Denmark to undertake a Feasibility study of processing / treatment of industrial waste water and its disposal through drainage. The study is estimated to cost Rs 15 billion, of which 35% would be provided as a grant and remaining 65% loan by the Danish Government.

Comment

In order to derive the desired benefits from the project for providing water supply, sewerage & drainage system in Faisalabad as identified in M/P, it is imperative to ensure implementation of projects & recommendations as planned both for long term and short-term solutions.

Answer

WASA-F Authorities ensured that with the support of government, other organizations, public representatives and academic institutions, every effort would be made to arrange and provide finances required for the implementation of projects recommended in the M/P.

Moreover, WASA-F invited the participants of workshop particularly the professionals from the Agricultural University, WWF, etc., to share information regarding studies (to be carried out or already completed).

The case in point is the provision of comprehensive treatment plant for Kurianwala city, for which concept paper is required to be shared with the WASA-F for review/examination.

It was also revealed that the Geo-Tag study regarding sewerage system for Faisalabad has been prepared by the Agricultural University of Faisalabad. WASA-F while appreciating the technical input being made for the sewerage/drainage development in the city, requested the concerned organization to share a copy of this study with JICA study team as the very objective of this meeting is to share views and, disseminate knowledge for the improvement and development of water supply, sewerage in Faisalabad.

Regarding the participation of public Representation in the workshop, it was explained that Vice Chairman WASA-F is a public representative and attending the workshop. In this regard it was informed that design of Dhoriwala Nula has been remodeled to overcome the problem of choking of sewerage system in the area during monsoon. Similarly, the sewerage system of Khannawala which becomes choked during monsoon has been planned to be improved on priority basis to overcome the problem.

8 FINDINGS OF SHM'S/ WORKSHOPS

- The most important stakeholders are mainly governmental Departments, such as WASA-F, Irrigation Department, CDGF/District Offices, FDA, EPD, Concerned Provincial Departments/Punjab EPA etc. Many have been deeply involved in the planning process and contributed towards the formulation of M/P. The stakeholders include the sectors that would influence the implementation of M/P. For example, EPD/Punjab EPA would evaluate the environmental management of the projects although it did not participate in the planning process, and FDA would review the management of land use of the M/P project. In nutshell, it is preempted that all of these stakeholders would be able to greatly gain from the meetings/ workshop.
- Feedback received from the stakeholders/ participants would largely contribute towards the better improvement and development of M/P in the planning process/stage. The suggestions/proposals made by the stakeholders especially professionals/ professors from WASA-F, Irrigation Department and Faisalabad Agricultural university would not only help formulating the practical approach for implementation of M/P recommendations but also provide short/medium term plans to meet the ever-growing water demand.

- In conclusion, the SHM/ workshop has provided good opportunity to integrate the opinions of the stakeholders into decision making.

Water Sources Development Plan, two alternative scenarios of water source development plan were examined: Scenario-1) development of well field and canals (JBC, RBC, GBC), and Scenario-2) development of well field, canal and Chenab River.

APPENDIX-1

Stakeholder Meeting on Master Plan of WASA Faisalabad
JICA Master Plan Study Team
28 September 2017
Conference Room, WASA - F
Attendance Sheet

Sr. No	Name	Designation & Department
1	Faqir Muhammad Ch.	MD - WASA
2	Khalid Javed	Municipal Officer (Infrastructures)
3	Dr. Haroon Rashid	Lecturer Dept of Struct & Env. Engg Uni of Agri. Fsd.
4	M. Naeem	MSE Specialist (The Urban Unit)
5	Gul Hafeez	SIDS The Urban Unit
6	Rana Kashif Ali	S.D.O Irrigation Dept
7	Asif Gillani	Environment Specialist (The Urban Unit, FSD)
8	Shaukat Hayat	DD EPA FSD
9	Waseem Ahmad Hashmi	DMD (S) WASA
10	Muhmmad Khalid	DMD € Wasa
11	Adnan Nisar	Director P&D Wasa
12	Shoaib Rashid	Director RMO 1
13	Zahid Pervez	Director (Admin.)
14	Ejaz Latif	Dir (ODM) W
15	Ryunan Matsue	JICA Mission Team
16	Harutoshi UCHIDA	JICA Mission Team
17	Kiyoko Takamizawa	JICA Mission Team
18	Naoto Takatoi	JICA Mission Team
19	Kaora Suzuki	JICA Mission Team
20	Itsuro Matsubara	JICA Mission Team
21	Yasuhiro Matsuoka	JICA Mission Team
22	Akira Kohara	JICA Mission Team
23	Dr. Shahid Nasir	Finite Engineering
24	Hafiz M. Awais	Asst. Director
25	Roohan	DD (Tech)/ W. R
26	Asad Ali	Deputy Director (FFP)
27	Sultan Azam	JMT
28	Kamran Raza	(O&M) E
29	Syed Shujja Haider	Project Coordinator JMT
30	Shahid Iqbal	Finite Engineering

Sr. No	Name	Designation & Department
31	Irfan Mannan	V. Chairman WASA
32	Ishtiaq Ahmad Khan	IRC Specialist (The Urban Unit)

APPENDIX-2

2nd Workshop/ Stakeholder Meeting on Master Plan of WASA
JICA Master Plan Study Team
12/20/2017
Conference Hall, Serena Hotel Faisalabad
Attendance Sheet

Sr. No.	Name	Designation & Department
1	Muhammad Shabbir Afzal	Deputy Director Agriculture (Ext) Faisalabad
2	Prof Dr. M Arshad	Chairman Department of Irrigation & Drainage University of Agriculture FSD (UAF)
3	Dr. R Naiz Ahmed	Director, Water Management UAF
4	Dr. Lubna Anjum	Lecturer, Dept. of Irrigation & Drainage Agri. Engg. UAF
5	Engr. Wajeeha Qamer	Assistant Professor, Civil Engineering Dept. NFC IEFR FSD
6	Engr. Abubaker Ijaz	Duty Director (Tech), Energy Management Cell Water Resources, WASA FSD
7	Abul Ghaffar Naveed	Deputy Director, WASA, FSD
8	Aamer Aziz	Additional DG FDA
9	Dr. Muhammad Asif Shazad	District Health Officer, Preventive Services, FSD
10	Muhammad Saleem Bhathi	SE LCC East Irrigation, FSD
11	Dr. Shaid Nasir	Director Finite Engineering, (Pvt) ltd.
12	Ms Kiyoko Akamizawa	JICA M/P Mission Team
13	Shujjaa Haider	Project Coordinator, JICA Mission Team
14	Sultan Azam	JICA M/P Team
15	Ghulam Murtaze	SELCC West Irrigation, FSD
16	Syed Faisal Hassan	Engr. Operation & Maintenance SNGPL
17	Kamran Raza	WASA (O&M), FSD
18	M Farhan Akram	DD WASA, FSD
19	M Abdullah	Project Coordinator, WWF
20	Ali Shan Arif Makhdum	Environmental Officer, WWF
21	Mubasher Ahmad Cheema	Technical Skills Training Specialist (check department/ Address)
22	Zia Mustafa	Water Specialist, Aljagdi Academy, Urban Unit (Check Aljagdi)
23	Ejaz Latif	Director (O&M) WASA, FSD

Sr. No.	Name	Designation & Department
24	Muhammad Ali	Deputy Director (Tech), P&D Department
25	G. Mustafa	Psychologist (Check designation & department)
26	Faqir Hussain Babar	Director, PHS, WASA FSD
27	Shahbaz latif	DDR (I&C), WASA FSD
28	Zahid Pervaiz	Director Rev (IDL), WASA FSD
29	Burira Anam (check name)	AD (GIS), WASA, FSD
30	Samreen Ashraf	AD (GIS), WASA, FSD
31	Farhat Adibbia (check name)	SRO, WASA, FSD
32	Shahida Rehman	AD, WASA, FSD
33	Muhammad Shaukat Ali	Ex DMD, WASA, FSD
34	Shoaib Rashid	Director Rev (Domestic), WASA FSD
35	Haroon Rasheed	Director Admin, WASA FSD
36	Muhammad Khalid	DMD, WASA, FSD
37	Waseem Ahmed Hashmi	DMD.D.(S) WASA, FSD
38	Adnan Nisar Khan	Director, WASA, FSD
39	Rana Asif Muhmood	Chief Engineer, Irrigation Dept. FSD ZONE
40	Faqir Muhammad CH	MD-WASA, FSD
41	Irfan Mannan	Vice Chairman - WASA, FSD
42	Hoshino Takashi	Team Leader, JICA Mission Team
43	M.Riaz Kamoka	U-C Chairman
44	Gul Hafeez	SIDS - Urban Unit
45	Hafiz M.Awais Jamal	Asst. Director (Project), WASA, FSD
46	Saqib Raza	WASA, FSD
47	Usman Latif	WASA, FSD
48	M.Maqsood Ahmed	WASA, FSD
49	Atiq-ur-Rehman	WASA, FSD
50	Abdul Raouf Butt	WASA, FSD
51	Muhammad Ashraf	Resident Engineer
52	Muhammad Nouman Noor	Assistant Director (Tech), water Resources Directorate, WASA FSD
53	M.Farhan ali	Deputy Director, I.T, WASA, FSD

Sr. No.	Name	Designation & Department
54	M.Fasial Mirza	Research Associate
55	Azhar Azeez	PRO, WASA, FSD
56	Laiba Tanveer	Survey-Assistant, JICA Mission team
57	Asad Ali	Deputy director, (FFP), WASA Faisalabad
58	Ghulam Shabbir	Deputy Director (P&D)
59	Umar Iftikhar Khan	DD (Admin) WASA, FSD
60	Shahid Iqbal	Consultant, Finite Engg. (pvt.) Ltd, Islamabad