Expression of Interest (EOI)
For

Selection of Investor(s) / Developer(s) for setting up HYBRID RENEWABLE ENERGY POWER PLANT of 50 MWs based on Solar Power, Wind Power and BESS along with related 132 KV transmission and 11 KV distribution system as per Feasibility Report at Education City Project, Deh-Chuahar, Gadap, District Malir, Karachi.

EOI No. : PIU/EC/R.E/2024-25

PROJECT IMPLEMENTATION UNIT,
EDUCATION CITY PROJECT, GOVERNMENT OF SINDH
1ST Floor, Block A, Finance & Trade Centre, Shahra-e-Faisal, Karachi

(PIU reserves the right to cancel this request for EOI and / or invite afresh with or without amendments to this request for EOI, without liability or any obligation for such request for EOI and without assigning any reason. Information provided at this stage is indicative and PIU reserves the right to amend / add further details in the EOI document.)

PROJECT IMPLEMENTATION UNIT,
EDUCATION CITY PROJECT, GOVERNMENT OF SINDH

1	Name of the work	Selection of Investor(s) / Developer(s) for setting up HYBRID RENEWABLE ENERGY POWER PLANT of 50 MWs based on Solar Power, Wind Power and BESS as per Feasibility Report at Education City Project, Deh-Chuahar, Gadap, District Malir, Karachi.
2	Tentative quantity (MWs)	**50 MWs**
3	Mode	**B2B on BOOT basis**
3	Completion of work	**12 Months**
4	Project Duration with O&M	**20 (Twenty) Years**
5	Date of publication of EoI	**29th January 2025**
6	De-briefing	**In case requested by the interested developer(s)/Investor(s)**
7	Last date & time for receipt of proposal	13th February 2025 at 1700 hrs
8	Submission of original with two copies	Original and 2 copies
9	EoI Opening Date	1400 hrs on 14th February 2025
10	Name & address of office inviting tender	Project Director, Project Implementation Unit, Education City Project, 1st Floor, Block A, FTC Building, Shahra-e-Faisal Karachi.

Any corrigendum/addendum and details can be seen on website: http:// educationcity.gost.pk

Project Director
Education City Project

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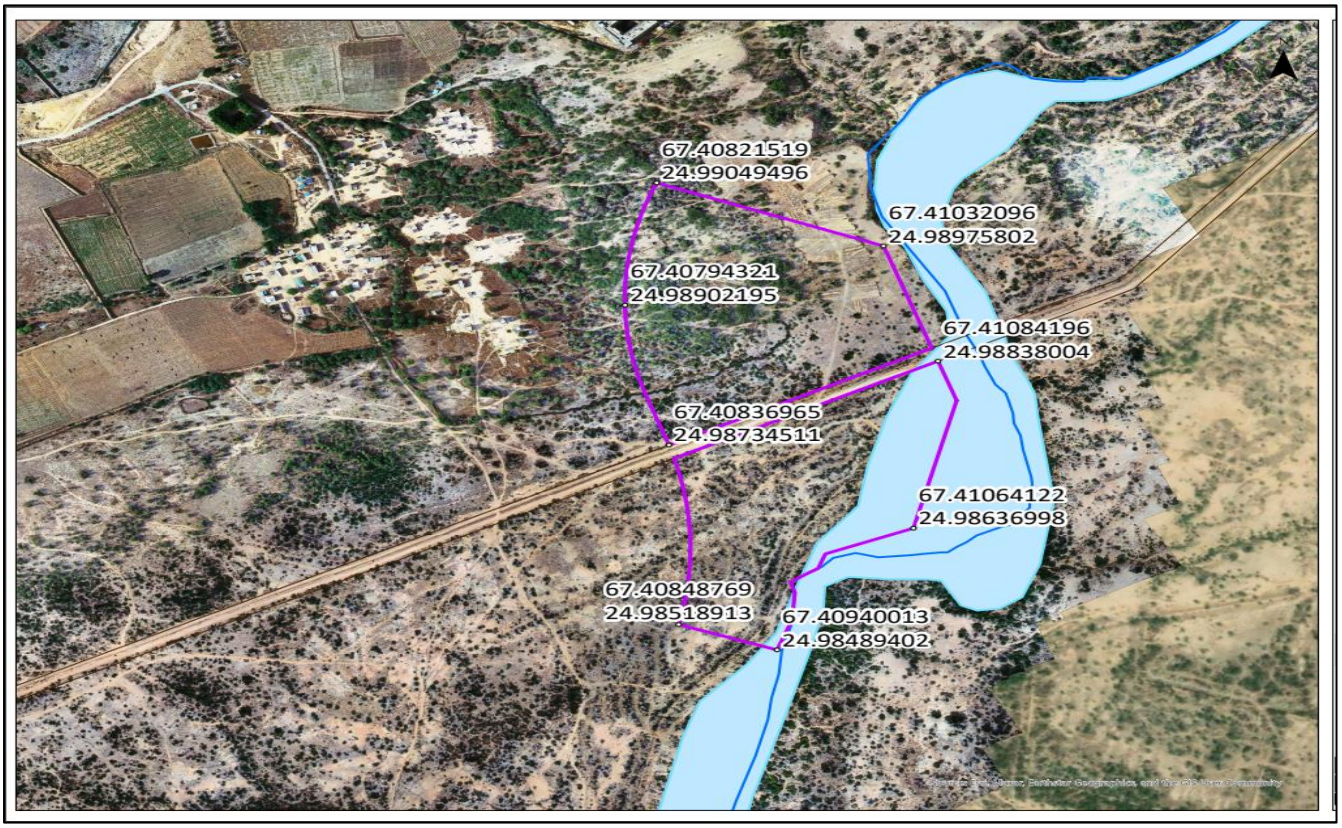
Introduction & Objective

Project Implementation Unit (PIU), Education city Project intends to invite Expression of Interest from eligible Investor(s)/ developer(s)/ company(ies) /consortia of companies duly registered with FBR/SRB for the development of Hybrid Renewable Energy Power Plant of 50 MWs based on Solar Power, Wind Power and BESS along with related 132 KV transmission and 11 KV distribution system (Project) at Education City Project, Deh Chuhar, Gadap, District Malir, Karachi on Business to Business (B2B) method with Operation and Maintenance of the same for 20 years under Build Own Operate Transfer (BOOT) Mode. The project will provide electricity to stakeholders housed in Education City project.

Eligible Investor(s)/ developer(s)/ company(ies) / consortia of companies will have to prove their experience in the construction and operation of Hybrid Renewable Power Projects (as per feasibility study) as outlined in the eligibility criteria mentioned in Expression of Interest proposal (Proposal document), which can be collected from the office of undersigned during office hours from _____

Interested investor(s) /developer(s)/ company(ies)/ consortia of companies need to have all applicable licenses required by Government of Sindh and Government of Pakistan for the development and operation & maintenance of Hybrid Renwable Energy Power plant in Education City as per feasibility study. Feasibility study is part of this document at Annexure "A"

Details of Proposed Site and Substation Location:



City: **Karachi**, District: **Malir,** Town: **Gadap**, Deh: **Chuhar** , Area in Acres: **40 Acres**

Salient features of EOI:

- PIU Shall invite bids from prospective developer(s)/ investor(s) who are willing to setup Hybrid Renewable Energy Power Plant of 50 MWs based on Solar Power, Wind Power and BESS along with related 132 KV transmission and 11 KV distribution system (Project) at Education City Project, Deh Chuhar, Gadap, District Malir, Karachi in BOOT mode.

- PIU shall provide feasibility study consist of necessary data required for setup the project. The feasibility study is a part of this document.

- The scope of the Developer(s) /Investor(s) will include the Construction of Hybrid Renewable Energy Power Plant with operation and maintenance and the evacuation of the power to stakeholders of Education City through transmission utilities and distribution network.

- The developer(s)/Investor(s) will bear the total project cost including design, supply/manufacturing, installation, erection & commissioning of the plant and undertake operation & maintenance of the plant throughout the duration that is 20 years.

- The evacuation arrangement can be as per recommendation mentioned in the Master Plan.

- The Developer(s)/ Investor(s) will draft the Energy Purchase Agreement (EPA) to be executed with stakeholders (B2B) and Energy Facilitation Agreement to be executed with PIU on behalf of Education City Board as per guidelines mentioned in the Feasibility Study.

- The Developer(s)/ Investor(s) will be asked to submit their concept note and project execution methodology along with the following,

    - Project Methodology.
    - Financial Cost and Per Unit cost/tariff for end users.
    - Bidder's technical and financial capability.
    - Prospective Developer(s)/ Investor(s) may propose suggested view against the EoI.

PIU Scope of Work:

- PIU will provide access of land to selected Developer(s)/ Investor(s) after the approval of the Education City Board;
- PIU will provide the relevant data as per feasibility study to the successful Developer(s)/ Investor(s);
- PIU will introduce the successful Developer(s)/ Investor(s) to stakeholders for EPA;
- PIU through consultant will supervise the project from construction till completion;
- All possible technical details about the site and project is available in Feasibility report, which is a part of this document at Annexure "A".

Bidders Scope of Work:

- The scope of work includes Design, Engineering, Installation, Finance, Supply, Erection, Execution, Evacuation of power, Testing and Commissioning of Hybrid Renewable Energy Power Plant of 50 MWs based on Solar, Wind and BESS along with related 132 KV transmission and 11 KV distribution system feeders for 20 years on BOOT basis;
- The project(s) would be technology agnostic within the technology approved by the Government of Pakistan. Only commercially established and operational technologies can be used, to minimize the technology risk and to achieve the timely commissioning of the Project;
- Obtaining all requisite regulatory consents, clearances, licenses, permits from provincial government and federal government and maintaining them in full force and effect during the project term;
- Undertake necessary site preparation for installation of equipment and maintain the site/premises throughout contract period;
- Connecting the Power Project with the Interconnection Facilities at each Delivery Point;
- Drafting of EPA (B2B) agreement(s) as per guidelines mentioned in the feasibility study;
- Bidders shall enter into EPA (B2B) agreement with stakeholders of Education City project;
- Operation & Maintenance of the plant throughout the period for ensuring generation of required power;
- Undertake all necessary and reasonable safety precautions with respect to providing the Installation Work, Wind Power. Solar Power, and System Operations that shall comply with all Applicable Laws pertaining to the health and safety of persons and real and personal property;
- The Developer(s)/ Investor(s) shall submit their proposal along with Project execution methodology, technical and financial eligibility for the project;
- Developer(s)/Investor(s) are required to use equipment of Tier 1 as approved by Government of Pakistan
- Developer needs to utilize substations and switchgears as per the specifications provided by PIU
- Developer need to design the generation, transmission and distribution system with the provision for scalability for feeding the future requirement of load upto 300 MW.

Pre-Qualifying Requirements (PQRs)/ Eligibility Conditions

GENERAL

- The Developer(s)/ Investor(s) shall be a body incorporated in Pakistan under relevant authorities. A copy of certificate of incorporation shall be furnished along with the bid in support of above;
- The firm should not be blacklisted by any Federal and/or provincial Govt Bodies or authorities. A certificate/ affidavit in this regard shall be furnished on stamp paper;
- Developer(s)/ Investor(s) shall hold the relevant license for installation of Renewable Power Projects in Pakistan;
- **Bidders, in case of a Joint Venture, shall submit the Joint Venture agreement clearly indicating the lead firm.**

TECHNICAL

i. The Bidder must have the development experience of cumulative capacity of grid connected renewable project of 50 MW out of which one project should be of 10 MW.at single location under BOOT/PPP mode.

ii. The applicant should have the experience of successful Operation & Maintenance (O&M) of grid connected ground mounted solar & wind power project of 10 MW capacity or above against single contract, for a period of at least Six (06) months, ending on the last date of the month, prior to the original submission date of this EOI.

iii. The Bidder shall also submit documentary proof of achievement of performance generation guarantee and performance of at least one hybrid power plant of 10 MW which shall be certified from the Developer or the power off-taker of that particular hybrid renewable power plant.

iv. Bidder shall submit, in support to the above, the list of projects commissioned along with their work order/ LOI and the commissioning certificates along with the certificate of plant being in operation. In case the bidder wants to meet the eligibility criterion through its own power plant, then certificate from Chartered Accountant to that effect will be required to be submitted.

FINANCIAL

Bidders must have to submit audited financial statement for last 3 years in which bidders should have positive net worth.

The applications (EOI) of firms should be accompanied by following documentary evidence in support meeting the above criteria / profile:

i. Photo-copies of audited balance sheet and profit & loss statements for last three years.
ii. Photo-copies of GST/SRB & Income Tax certificates.

iii. Photo-copies of orders/contracts (showing values of projects & work-share of Bidder) and performance certificates of previous supplies/ projects executed (In case of projects executed by a foreign firm/partner in a foreign country, if value / other information cannot be given for confidentiality, the Bidder shall submit maximum possible relevant information to satisfy its credentials).

iv. To demonstrate the required turnover and net worth a certificate from the chartered accountant is required.

EVALUATION CRITERIA

- Technical 70 Marks and Financial 30 Marks
- Interested bidders are requested to submit two envelopes. Clearly mentioning "Technical Proposal" and Financial Proposal"
- Bidder(s) scoring 70% in technical proposal shall be found eligible for the opening of Financial Proposals
- The least unit price for end user/tariff quoted by the technical qualified bidder in accordance to the feasibility study will be taken as base price.

I- TECHNICAL

(A) General Experience (20 Marks)

- Installation of More than 2 Renewable Energy Power Plants of 10MWs and more: 20 Marks
- Installation of 2 Renewable Energy Power Plants of 10MWs and more: 15 Marks
- Installation of 1 Renewable Energy Power Plant of 10MWs and more: 10 Marks

(B) Operation and Maintenance (O&M) (20 Marks)

- O&M of More than 2 Renewable Energy Power Plants of 10MWs and more: 20 Marks
- O&M of 2 Renewable Energy Power Plants of 10MWs and more: 10 Marks
- O&M of 1 Renewable Energy Power Plant of 10MWs and more: 05 Marks

(C) Execution of Renewable Energy Project under PPP/BOOT mode (20 Marks)

- Execution of More than 2 Renewable Energy Power Plants of 10MWs and more under PPP/BOOT mode : 20 Marks
- Execution of 02 Renewable Energy Power Plants of 10MWs and more under PPP / BOOT mode: 10 Marks
- Execution of 01 Renewable Energy Power Plant of 10MWs and more under PPP / BOOT mode: 05 Marks

(D) Professional Experience (25 Mark)

- BE/ ME/ BSc./ Msc. In Renewable Energy Engineering with minimum experience of 10 years
- (10 Marks)
- BE/ ME/ BSc./ Msc. In Civil engineering with minimum 10 years of relevant (05 Marks)
- BE/ ME/ BSc./ Msc. In Electrical engineering with minimum 10 years of relevant (05 Marks)
- BE/ ME/ BSc./ Msc. In Mechanical engineering with minimum 10 years of relevant (05 Marks)

(E) Methodology (15 Marks)

Interested Developer(s)/ Investor(s) shall submit the detail methodology of the project which shall consist of details of equipment to be used in the construction of hybrid renewable energy power plant.

II- FINANCIAL PROPOSAL

Financial proposal should be consist of overall project cost along with financial modeling of project for next 20 years and per unit cost to end user/ tariff on the basis of feasibility study.

Submission of EOI:

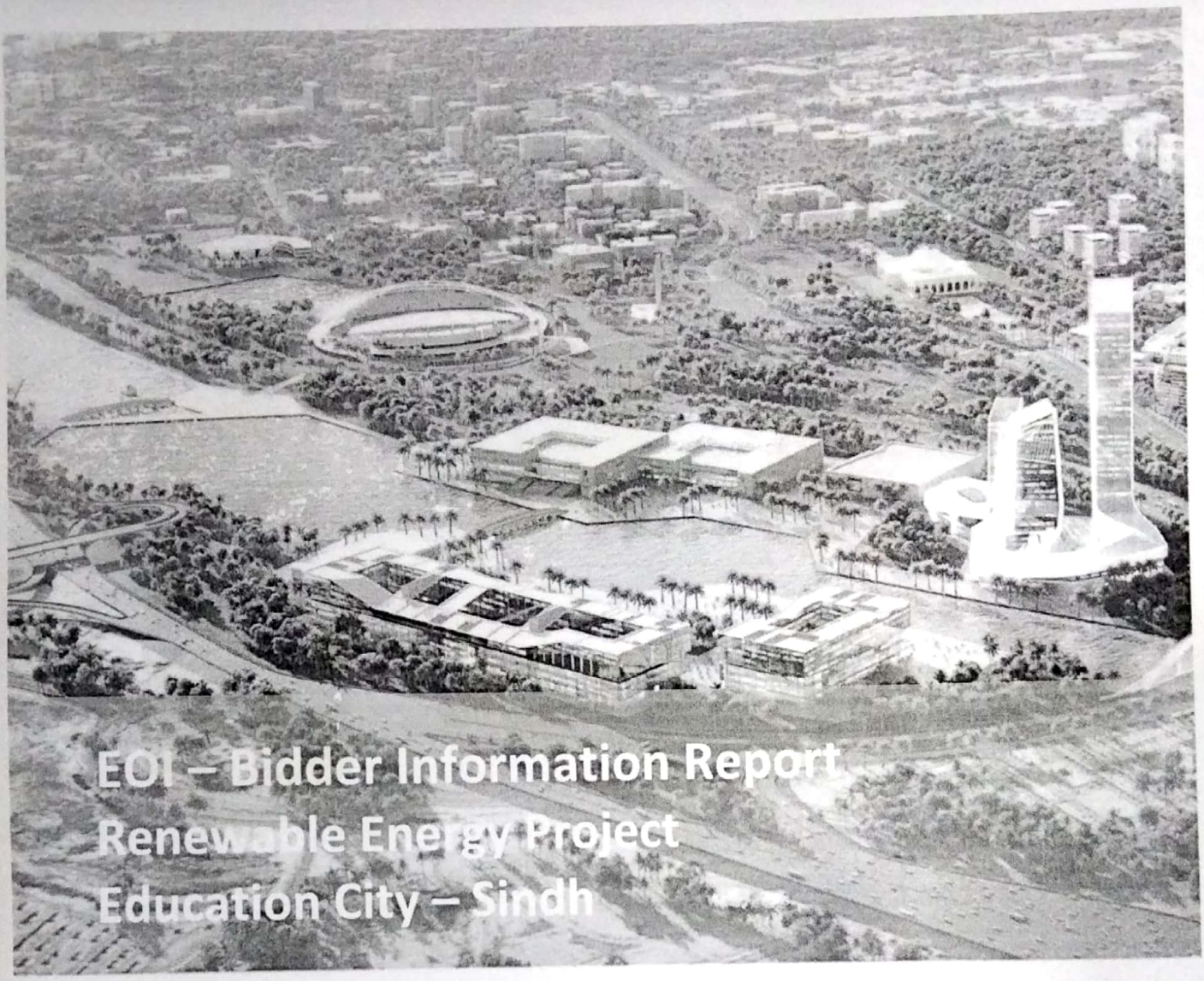
Interested Bidders are required to submit the response with the complete information in all respect as required in the EOI. The furnished information shall be supported with relevant documents if any.

- All applications shall be submitted in English.
- The interested Bidders /Companies/developer(s)/Investor(s) are requested to submit their **project execution methodology and required details as required in this document**.
- The EOI is to be submitted in the manner prescribed below:
- The applicant shall prepare 1(One) Original set with two copies of the submittals as detailed below in hard copy format.
    a. Covering Letter
    b. Company Profile with Past Experience and Financial Position as required in Eligibility and Evaluation Criteria
    c. Financial Proposal

Disclaimer:

Prospective respondent to this EOI acknowledges and agrees that:

- PIU has issued this EOI with the best intention to explore the market for eligible and interested bidders and has no compulsions to enter into definitive contractual agreements. This EOI does not guarantee conversion of this EOI into any definitive contractual agreements.
- It is also agreed that PIU in its sole discretion, may reject any and all proposals made by respondent(s), may change the conditions relating to the EOI or cancel this EOI at any time without assigning any reason without indulging into any litigation.
- Prospective respondent(s) acknowledge and agree that response to the EOI is purely voluntary action on their part and for any expenditure on this account shall be borne by the respondent(s).
- The applicant shall bear all cost associated with the preparation and submission of the response to this EOI.



EOI – Bidder Information Report
Renewable Energy Project
Education City – Sindh

Client:

The Education City

Investment Department Sindh

Deh Chuhar, District Malir, Karachi

Consultant:

Energy Futures Consulting (SMC-PVT) Ltd.

March 24, 2024

www.energyfuturesconsulting.com

Education City Project
Investment Department
Government of Sindh

Bankable Technical and Commercial Feasibility for industrial clients complying to all relevant standards.

ENERGY FUTURES CONSULTING uses its years of experience in designing, executing and testing large scale industrial RE installations to produce state of the art designs that focus on longevity and performance, the two key consideration that are important for solar/wind/storage microgrid projects, so it can complete the forecasted life. We closely monitor international R&D activities in solar PV/wind and storage to recommend the most innovative and efficient products analyzing all development in the LCOE scale (Rs/kWh). We also provide support with negotiations with key supplier and service providers as our years of experience has helped us understand costs of numerous items. Testing & Inspection, feasibilities & planning of RE system and overall system performance is one of our core expertise, using a range of tools and equipment, we make sure the system installed and delivered is of the highest standard fulfilling all relevant technical certifications. This also helps in signing off sustainable and commercially viable PPA contracts.

Education City Project
Investment Department
Government of Sindh

Education City Project
Investment Department
Government of Sindh

Title:	EOI – Bidder Information Report
Client Details	The Education City – Investment Department Sindh
Dated	April 07, 2024 (Rev-01)
Prepared By	Samir Ahmed – Principal Consultant samir.ahmed@energyfuturesconsulting.com Energy Futures Consulting (SMC-Pvt.) Ltd. Fortune Center, Shahrah-e-Faisal, Karachi. www.energyfuturesconsulting.com
Checked By	Abdullah Ansari Salman Tawfik

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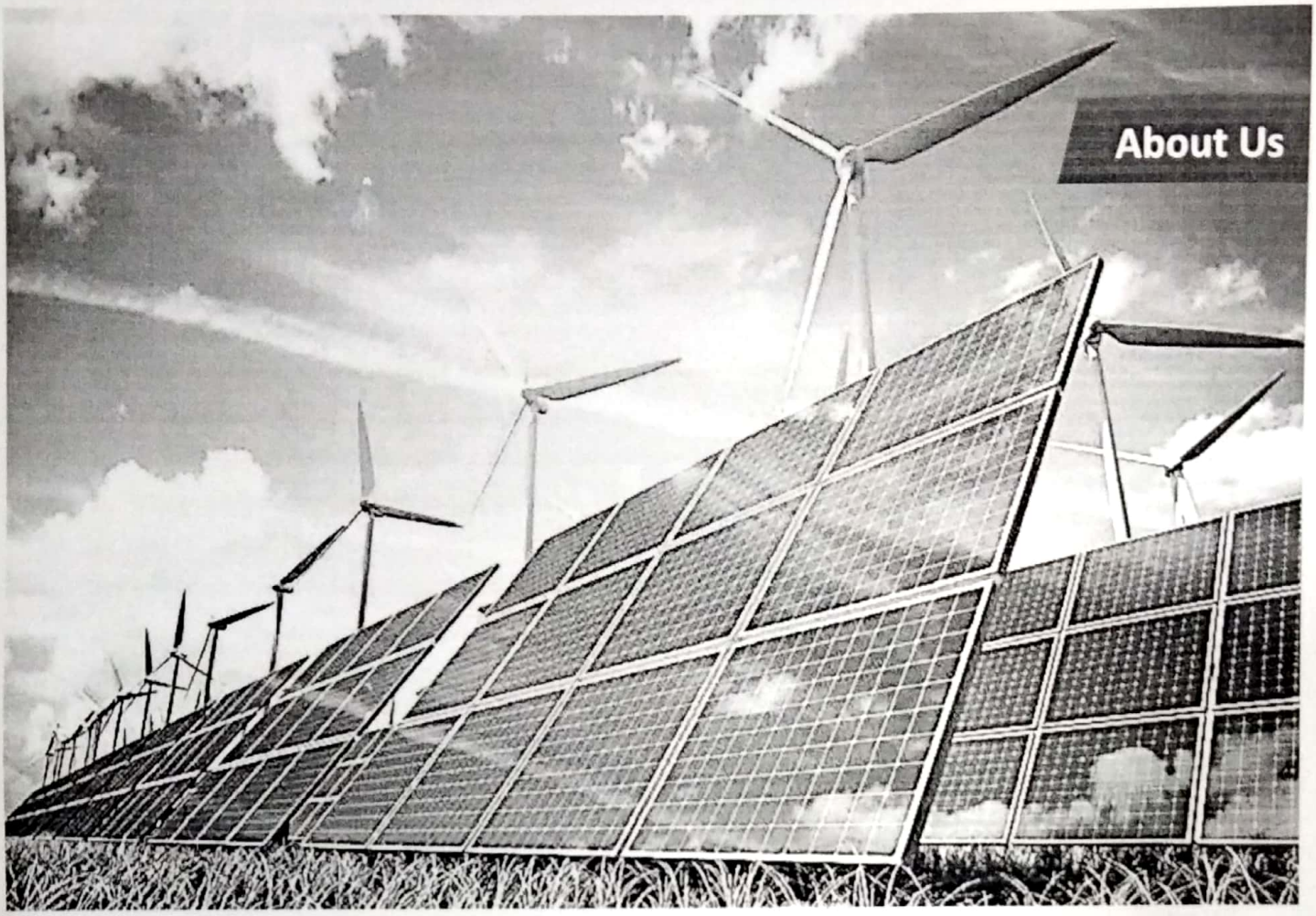
Government of Sindh



About Us

ENERGY FUTURES
CONSULTING

Energy sustainability, accessibility and affordability are one of the most important challenges of our times. We live in an age where energy & water is not only grossly used by domestic, commercial & industrial consumers but also have a major impact on the environment we live in. Keeping in perspective the challenge at hand, Energy Futures Consulting was founded and strives to redesign the energy landscape for our future generations.

Energy Futures Consulting is an organization which focuses on renewable energy and energy efficiency consulting for our clients. Our clients range from commercial and industrial units, international & local financial institutions and third-party verification/certification companies. Our focus is on distributed and central renewable energy projects using technologies like solar PV, solar thermal (CSP), wind, biomass and waste to energy. In energy efficiency we focus to provide consulting & implementation services for reducing resource consumption for our clients. We not only help our clients reduce their operational costs by understanding their actual use of energy & water but also redesign/optimize the process involving its consumption. This helps our clients achieve global certifications like LEED & ISO 50002 in the process.

Energy Futures Consulting are experts in drafting detailed energy roadmaps with achievable short term and long-term plans for commercial & industrial organizations. These sustainability plans reflect the immediate response that our planet requires from all organizations as a moral and ethical responsibility. The energy road map first works on efficiency and then on clean energy generation while improving affordability and accessibility. The result is an end to end plan along with energy targets/KPI's for the organization to strive for. Energy Futures Consulting also provides technical inspection services for renewable energy projects and commercial PPA contract drafting. Energy Futures Consulting also provide expert energy & water efficiency audit & implementation services.

Energy Futures Consulting is also striving to help power distribution companies & regulatory agencies to develop an energy transition roadmap from conventional centralized power generation units to more distributed power sources. Guidance on how to locate and size different intermittent renewable energy projects within the distribution & transmission system and to develop contingencies to increase the reliability of the system and quality of power for the consumers.

The Energy Futures Consulting team comprises of renewable energy and energy efficiency technical and commercial experts having years of experience in design, commissioning and testing renewable energy projects and carrying out detailed audits and implementation plans. The focus is also on developing monitoring, verification and control systems to further quantify savings and efficiency improvements.

Energy Futures Consulting's core values include finding ways to reduce impact of man-made carbon emissions on the planet, customer satisfaction and high standards of integrity and ethics.

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Definitions

Consortium means the unincorporated joint venture formed between the Members for the Project as per this Agreement;

Main Sponsor means the lead investor in the Project(s) and the Member which will take the lead in the management of the Association's affairs under this Agreement;

Power Purchase Agreement (PPA) shall mean the Agreement to be entered into by and between the SPV and the Power Purchaser;

Special Purpose Vehicle (SPV) shall mean a corporate entity incorporated under the laws of Pakistan by the successful bidder determined pursuant to the Bidding Process for the Project(s);

Abbreviations

A	Amperes
AC	Alternating Current
AEDB	Alternative Energy Development Board
AISC	American Institute of Steel Construction
ASC	Automatic Sustainable Controller
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing Materials
BAU	Business as Usual
BE	Bachelors in Engineering
BESS	Battery Energy Storage System
BOQ	Bill of Quantities
BOS	Balance of System
BS	Bachelors in Science
CAD	Computer-aided Design
CCTV	Closed Circuit Television
CoVID	Corona Virus Disease
Cu	Copper
CV	Curriculum Vitae
DC	Direct Current
EMS	Energy Management System
EPC	Engineering Procurement and Construction
FBR	Federal Board of Revenue
HDG	Hot Dip Galvanized

HSE	Health Safety and Environment
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
kV	kilo-Volt
kVA	kilo-Volt Amps
kW	kilo-Watt
kWh	kilo-Watt Hours
kWp	kilo-Watt peak
LEED	Leadership in Energy and Environmental Design
Li	Lithium
LOI	Letter of Intent
LRFD	Load and Resistance Factor Design
LT	Low Tension
Ltd	Limited
LV	Low Voltage
MoM	Minutes of Meeting
MPPT	Maximum Power Point Tracking
MV	Medium Voltage
MW	Mega-Watt
O&M	Operations and Maintenance
OCPD	Over-Current Protection Device
OEM	Original Equipment Manufacturers
OVP	Over-Voltage Protective Device
PCC	Point of Common Coupling
PCS	Power Conditioning/Conversion System
PEC	Pakistan Engineering Council
PID	Potential Induced Degradation
PKR	Pakistan Rupee
PR	Performance Ratio
PV	Photovoltaic
PVEL	PV Evolution Labs
RCC	Reinforced Cement Concrete

RMS	Resource Monitoring System
RTU	Remote Terminal Unit
SLD	Single Line Diagram
SOP	Standard Operating Procedure
SPD	Surge Protective Device
TCP	Transmission Control Protocol
TCPR	Temperature Corrected Performance Ratio
TOR	Terms of Reference
UDL	Uniform Distributed Load
V	Volts

1. Introduction

The current government's flagship initiative to equip the youth with information, skills, and institutions that invest in our priceless human resources, this is the Education City (EC) Project. It is expected to have top-notch infrastructure and will serve as a center of excellence. By establishing the EC, the government of Sindh hopes to make an ambitious and visionary investment in the people and economy of the nation, living up to its tagline, "From Brain Drain to Brain Gain."

The EC will continue to have a significant influence and inspire many others with its impressive accomplishments. The project's goal is to offer an excellent setting and resources for learning and teaching, supported by top-notch educational institutions and technology research centers. Over 50 domestic and international institutions are being planned to be part of this prestigious project.

This project is expected to draw a requirement of 50MW power to run. With the mandate of Renewable Maximization, the power mix of the Education City would be a mix of Solar, Wind and Battery Storage. Generators would also be made part of the system mix to ensure a healthy and robust power supply. Keeping a long-term view, it is also envisioned that a 132KV Grid Station would also be needed to be constructed to ensure reduction of power cost and ensure uninterrupted power supply.

2. Site Location

The Government of Sindh has earmarked 8,921 acres of land in Deh Chuhar, District Malir, Karachi on link road between National and Super Highway for Education City project.

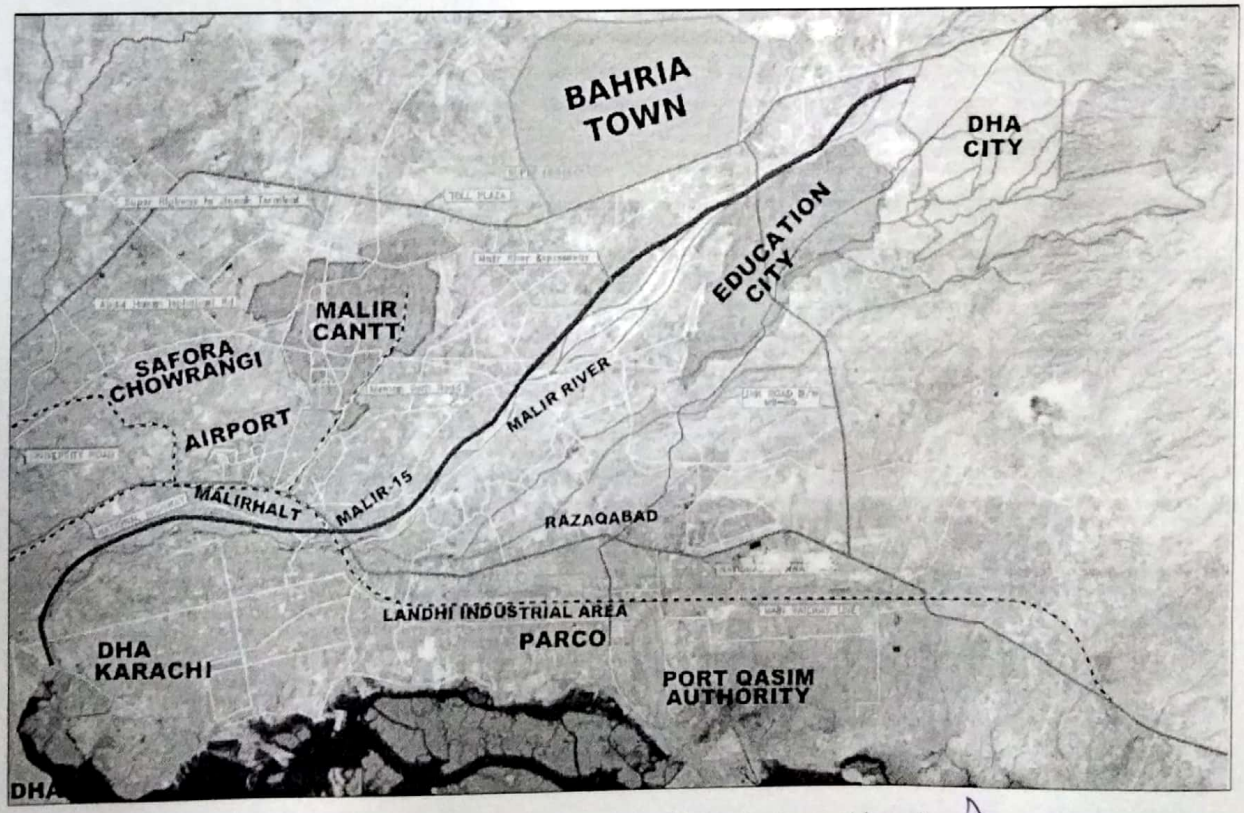

Figure 1: Location of Education City (https://educationcity.gos.pk/maps/)

The project site is located at Deh-Chuhur, Gadap, Malir, Karachi in the neighbourhood of Lal Bux Gabol Goth. Nearby landmarks include The Valley View Resort and Gabol General Store.

3. Site Accessibility

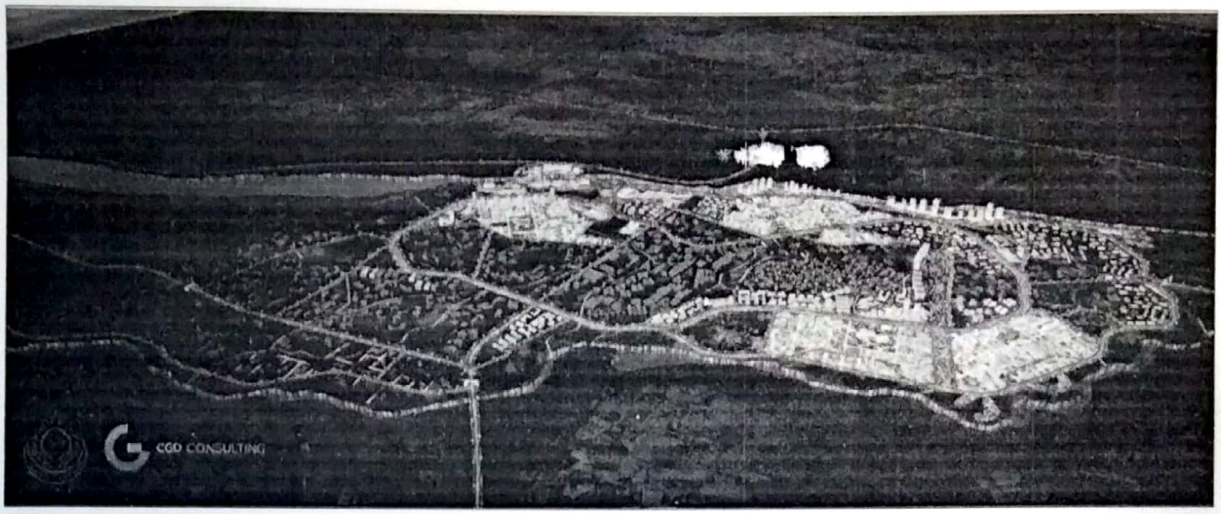

Figure 2: Designer's rendition of Education City with a view at night time (Courtesy: CDG Consulting)

Some key accessibility features of EC are as follows:

i. Within 50km distance from Karachi (Saddar)
ii. Linked with Karachi and rest of the country via Super Highway and National Highway
iii. Within 40km distance of major hospitals of Karachi
iv. 27km distance from Jinnah Terminal (airport) via link road
v. 33km distance from Port Qasim
vi. All major industrial zones of Karachi are within 50km distance from EC
vii. The proposed Water Front is at the Malir River which is passing only 4.5 KM from Education City's adjoining areas

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4. Site Characteristics and Detailed Assessment

The topography of the plot is not plain with major changes in elevation observed across the site. Figure 3 shows the google image of the site.

Figure 3: Google Image of the Neighbourhood Area

The sub-surface deposits (according to the Geotechnical Investigation), consist of:

- Sand
- Sandstone

Groundwater was not encountered up to the maximum explored depth of 15.0 meters below the existing ground level in the boreholes drilled at the site.

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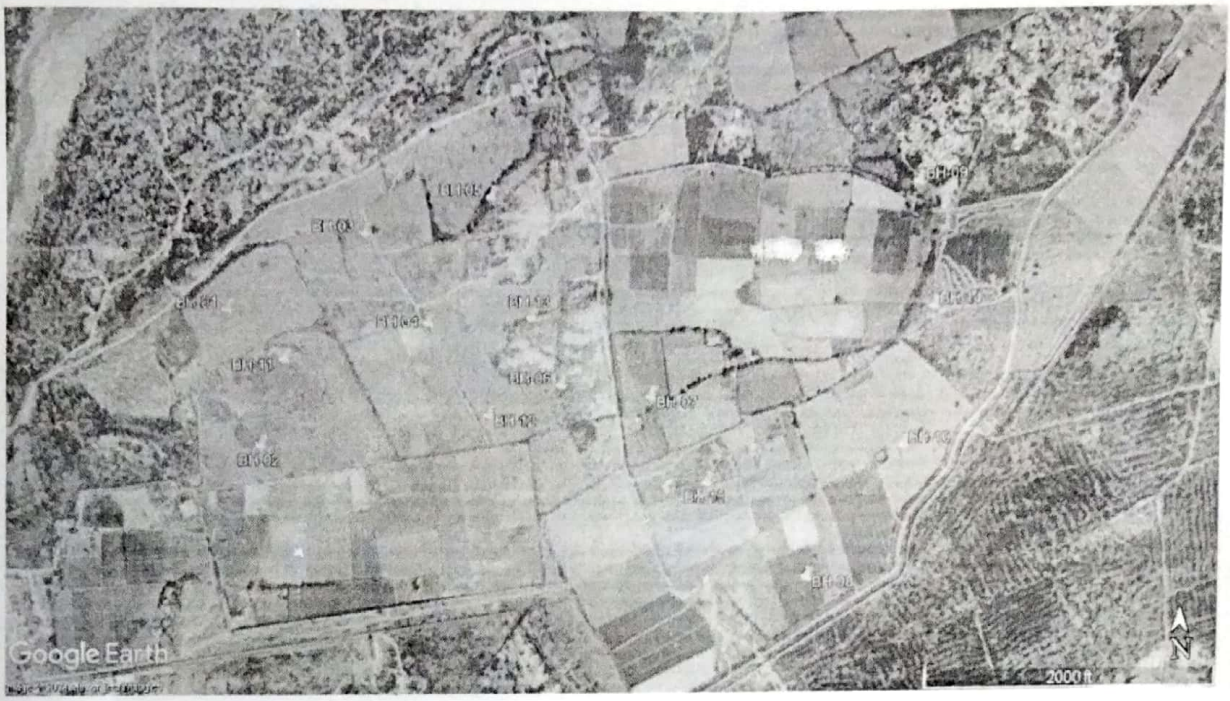

Client:	Borehole Location Plan	
Education City	S-24-1022 Geotechnical Investigation for Installation of Solar Power Plant and WTGs at Education City, Deh-Chuhur, Gadap, Malir, Karachi	STS Soil Testing Services

Figure 4: Borehole Location Plan of STS

Scope of work included fifteen (15) boreholes; ten (10) up to the depth of 5.0 meters and five (05) up to the depth of 15.0 meters below existing ground level. Soil and rock samples were collected during the field investigation. Laboratory testing on these samples has been carried out in the lab and includes determination of index properties through grain-size analysis, natural moisture content & density etc. Chemical characteristics of soil and rock samples have also been assessed through determination of sulphate content, chloride content and pH.

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5. Digital Elevation Plan

Using satellite terrain data, a digital elevation plan was developed to identify the natural slopes and its direction. This can form the basis to a more detailed topographical and hydrological analysis. See digital elevation plan below developed by extracting terrain elevation data.

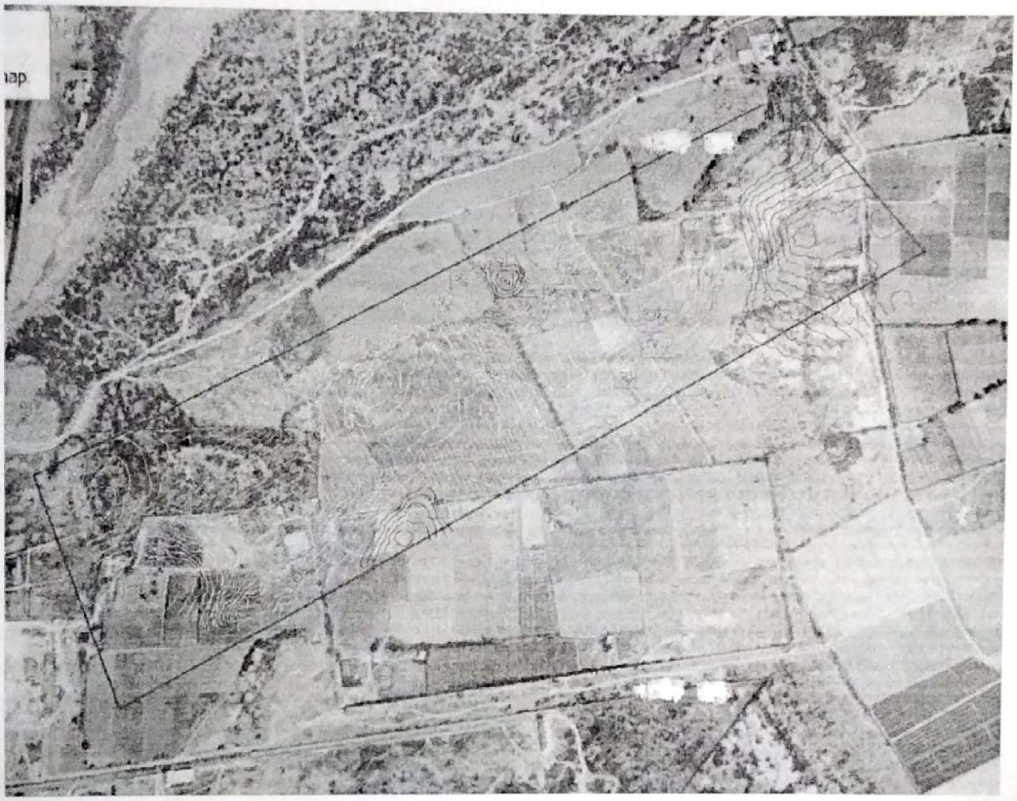

Figure 5: Google Image of site showing contours

6. Environmental Conditions

The Proposed Master Plan of Education City, when reviewed, was found to be very innovative, as measures were already taken to keep the Environmental Impact balance due to the construction and upcoming anthropogenic activities. Some key features or considerations of this project are as follows:

i. All institutes are bound to generate at least 30% of power through alternate source of energy (wind, solar, may be biogas or any other means), hence carbon dioxide emission reduction is already planned.
ii. All street lights are planned to be powered through Solar based power, hence no impact for Street Lighting.
iii. The natural available resources are planned to be fully utilized without damaging the Natural resources. An optimization of use of water resources are planned to balance the water resources and not to use the water resources to damage environment.
iv. The entire Master Plan is established between the Malir Rivers and Sukhon River and some old perennial tributaries are vertically connected between the two important rivers.
v. The planning is done in such a way to restore all such tributaries and allow the natural water flow and planting urban forest in the right of way of the tributaries which will be working as lungs (consuming carbon emissions and providing fresh oxygen) for the proposed education city.
vi. The natural water will definitely flow because the level difference between the two Rivers are approx. 40 feet from Malir to Sukhan. Once the natural flow of water will be restored, the urban forest will grow, which would help aesthetic beauty, ecological balance and capture tons of carbon dioxide from the anthropogenic activities.
vii. The Water Front at Malir River will be the retained water for the entire year which will help replenish the depleting ground water, overflow to the tributaries and channels will improve the green cover and agricultural fields.
viii. In addition to the above the roofs of the institutes will be designed for roof gardens, use of storm water and minimum heat refraction will be proposed for the top floors. In such way the latent heat of island (heat absorb by the concrete structure and emit the heat during the night hours) will be controlled in the area. The strategy is to maintain the temperature of the area as it is now at the baseline level. The temperature control is not area specific it depends on the overall climatic conditions but at least indoor environment of the buildings will be controlled through good practices.
ix. Complete wastewater treatment and recycling for the green areas, current Municipal Water demand to start the project will be 19 MGD, 80% expected wastewater generation and all the treated wastewater will be used in planting so the gaseous emissions from wastewater will be controlled through treatment and recycling. Currently in Karachi there is indiscriminate dumping of untreated wastewater into the water bodies which creates problems like eutrophication (excessive wild growth of vegetation in canals and water bodies which consumes the food and nutrients required for water life hence the water life is damaged). In the proposed master plan, a strategic water plan and wastewater treatment is available which saves the internal environment of Education City. If the plants run on alternate energy power will further reduce its environmental impacts.
x. Institutes will be bound to initiate the source separation and source collection of Solid Waste. The Solid Waste being generated will be collected as three types of wastes (recyclables, organic waste and the remnants). 70% of the waste will be reused and recycled. The remaining 30% of the unwanted material will only be disposed of at the already operational landfill site (Gond Pass) situated at the Surjani Town. According to a report Pakistan per person per capita emits 1.5 kg methane per annum due to the indiscriminate dumping of waste, here the Master Plans covers proper treatment, recycling, reuse and disposal of waste which will reduce the environmental impacts.
xi. All agricultural parcels are intact and untouched in the proposed Master Plan, no crop yield disturbance and no any ecological agricultural disturbances are expected. The villages are taken care and no one is shifted and disturb, the plan is to improve the live style of the residents of such villages and improve basic amenities like water supply, wastewater and solid waste management. The villagers will be part of business plan to sell the commodity items like eggs, vegetables, milk, meat in the local market to better earn livelihood. Once such consumables items are available within the Education City there is no any carbon emissions in getting these items transported from 100 miles far areas. The carbon balance will be maintained.

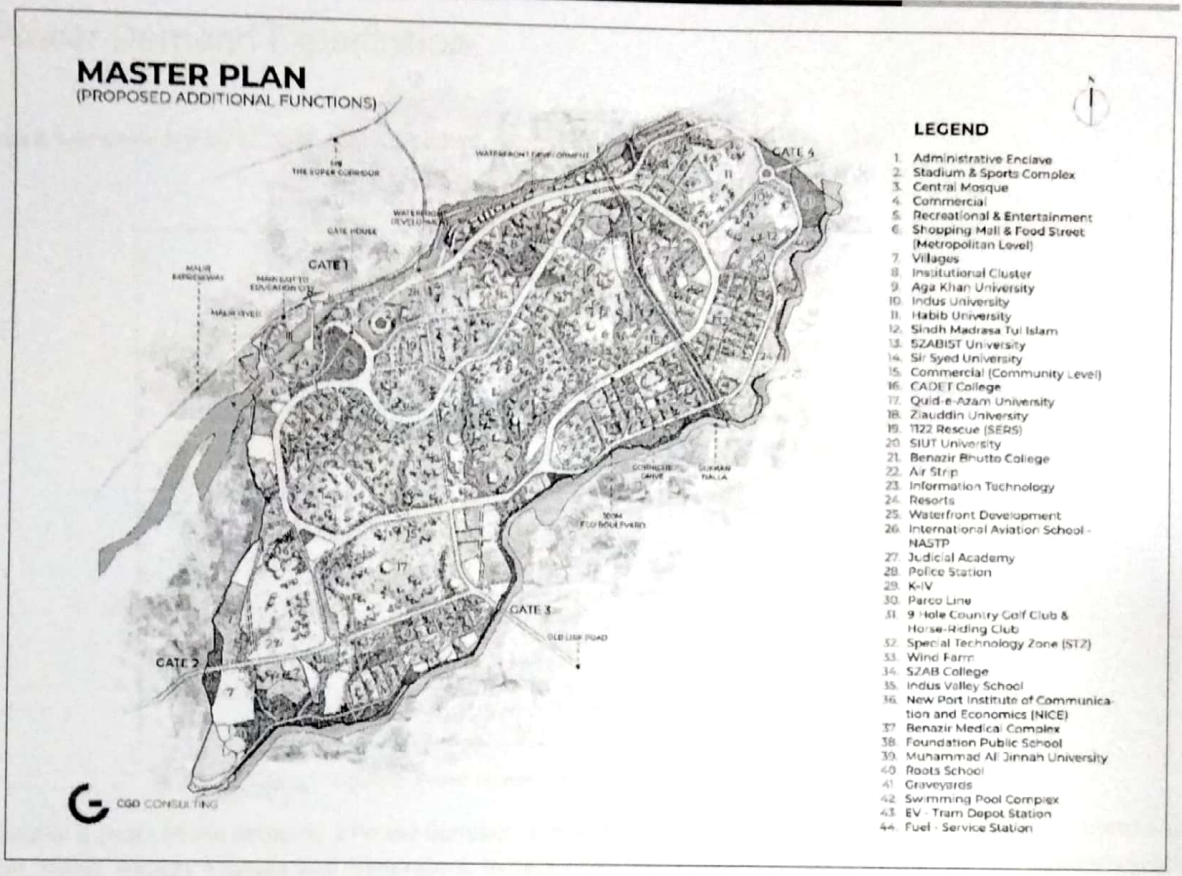

Figure 6: Master Plan for Education City (https://ed[illegible]city.gos.pk/maps/)

Schedule of land use of the project components are provided below:

Table 1: Land utilization by purpose for Education City

Land Use	Area	Percentage
Institutions	4,437.00	49.63 %
Residential (Including settlements)	206.82 791.29	11.17 %
Commercial	380.62	4.26 %
Recreational/ Protected Open Spaces Water Bodies	670.17 570.95 218.25	16.33 %
Amenities	197.50	2.21 %
Graveyards	118.89	1.33 %
Urban Farming	159.88	1.79 %
Roads, Services etc.	1,187.97	13.28 %
Total	**8,939.34**	**100.00 %**

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7. Power Demand Expectation

A forecast was provided by EC Management which formed the basis of the demand side.

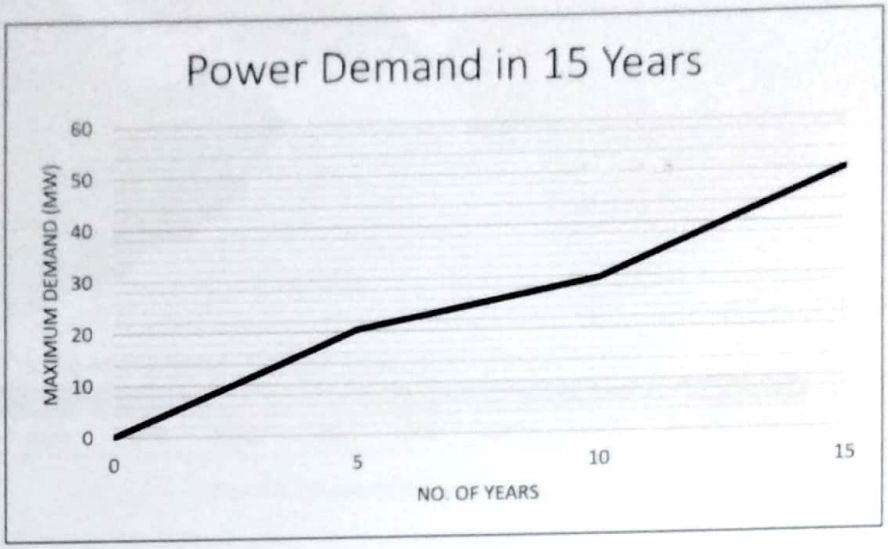

Figure 7: Power Demand Forecast in MWs over 15 years

In the initial 5 years of the setup by a Power Supplier, a maximum demand of 20MW would be catered to, using a mix of Solar, Wind, Battery Storage and Generators. In case of excess supply and low demand, EC Management would ensure evacuation and offtake. In the subsequent years, with the increase of demand, the Power Supplier needs to ensure increase in supply capacity along with reliability and quality of supply.

8. Site Potential

8.1. Solar Power

8.1.1. Resource Assessment

Table 2: Yearly Map Irradiance Data

Specific photovoltaic power output	PVout_specific	1694.7	kWh/kWp
Direct normal irradiation	DNI	1593.4	kWh/m²
Global horizontal irradiation	GHI	1980.2	kWh/m²
Diffuse horizontal irradiation	DIF	912.2	kWh/m²
Global tilted irradiation at optimum angle	GTI_opta	2178.1	kWh/m²
Air temperature	TEMP	26.3	°C
Optimum tilt of PV modules	OPTA	28/180	°
Terrain elevation	ELE	97	m

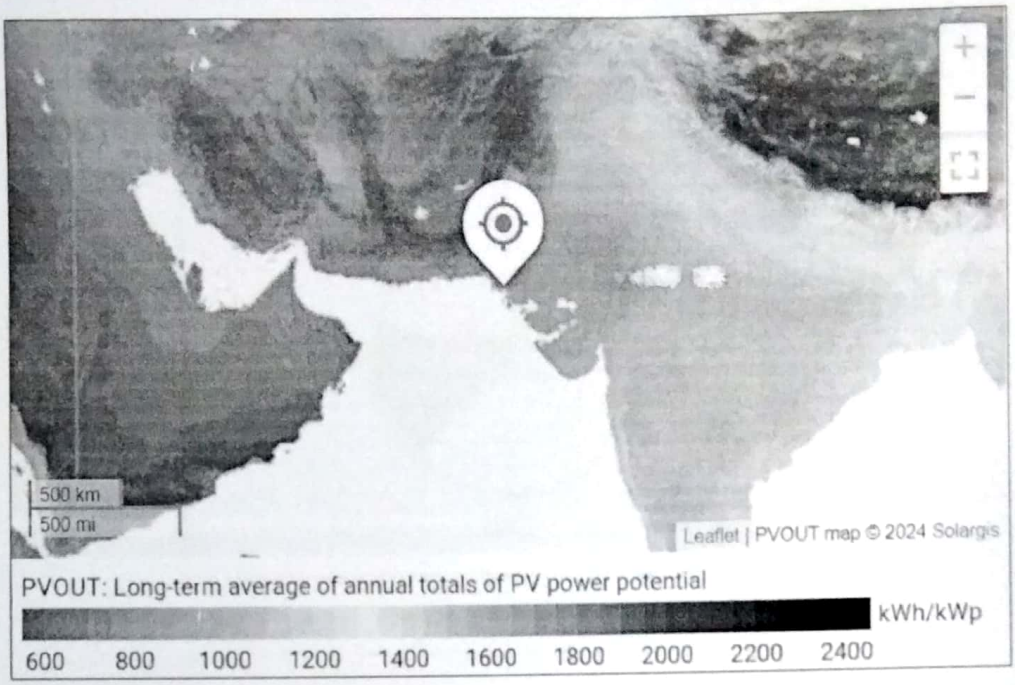

Figure 8: PV Output Map representing the site yield

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8.2. Wind Power

8.2.1. Resource Assessment

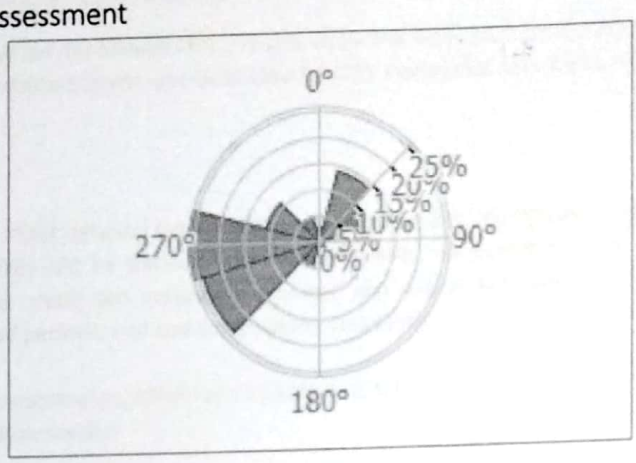

Figure 9: Wind Frequency Rose

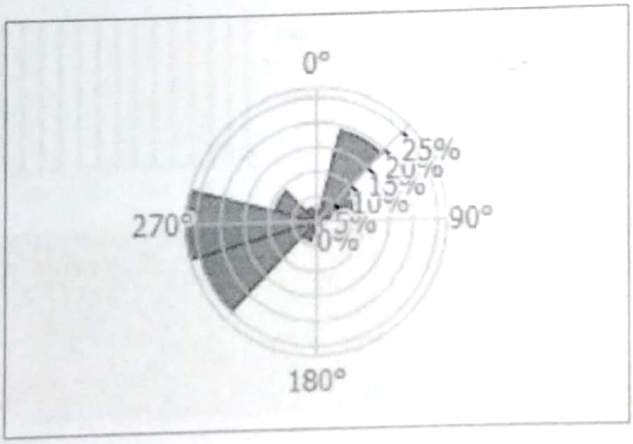

Figure 10: Wind Speed Rose

Table 3: Monthly Average Wind Speed Data

Month	Wind Speed (m/s)
Jan	4.76
Feb	5.21
Mar	5.66
Apr	6.36
May	7.51
Jun	7.65
Jul	7.6
Aug	6.96
Sep	6.12
Oct	4.75
Nov	4.36
Dec	4.53

9. Technology Recommendations

Based on above technical comparison of performance parameters in datasheets and EFC's own independent field-testing experience, we recommend the following technologies

i. For Solar PV system, use N-type Bifacial PERC modules of either Jinko or Trina modules with fix tilt PV system
ii. For Wind Energy Conversion System, use Goldwind 4.8 MW Horizontal Axis Wind Turbines which use the PMSG technology.

10. Load Profiles

HomerPro allows users to input detailed load profiles, representing the energy consumption patterns over specific time intervals. These profiles can be derived from historical data, measured data, or representative models. By incorporating load profiles, users can accurately simulate and assess the energy system's response to varying demands, identify peak load periods, and size components accordingly.

While analyzing the different scenarios, 20MW and 50MW loads had to be simulated to ascertain the RE requirements. Following were the simulation results:

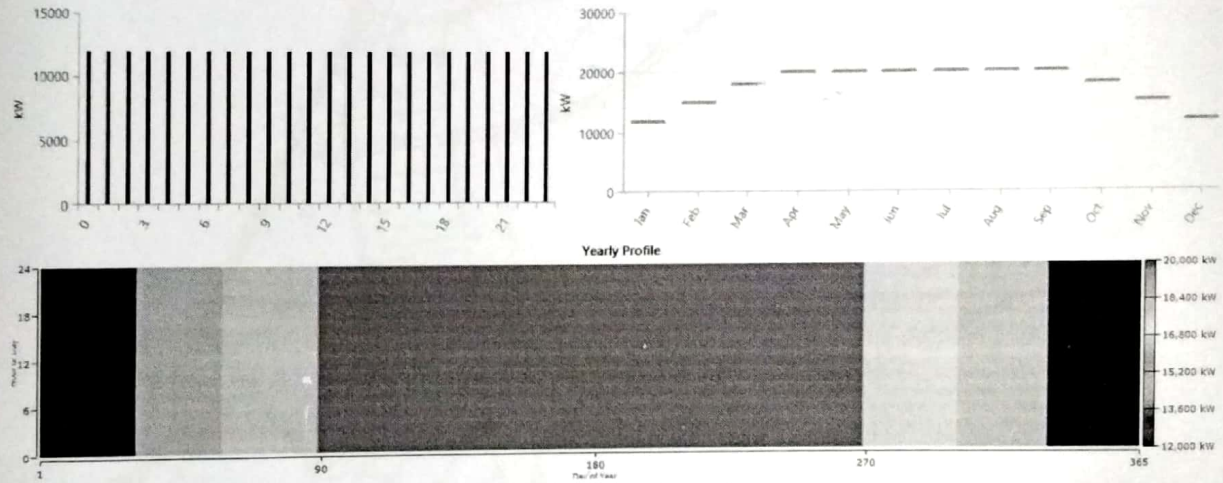

Figure 11: 20MW Load Simulation (Ref: Annexure B)

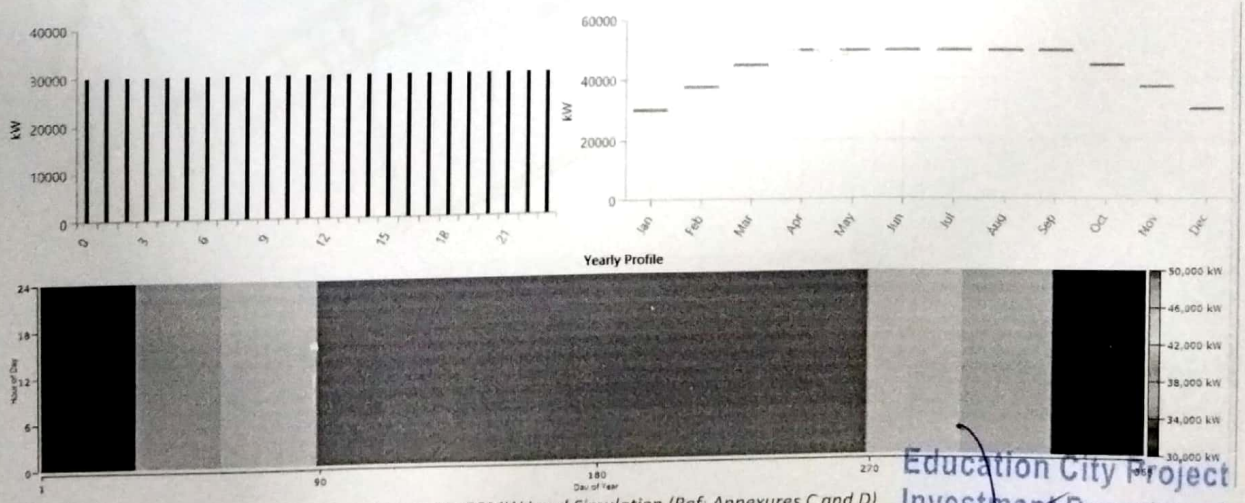

Figure 12: 50MW Load Simulation (Ref: Annexures C and D)

11.Recommended System Size

Following sizes were selected:

Table 4: Recommended Sizes of Energy Sources

Energy Source	Sizes in MW
Solar PV	15 MW
Wind Power Plant	19.2 MW
Substation	11kV

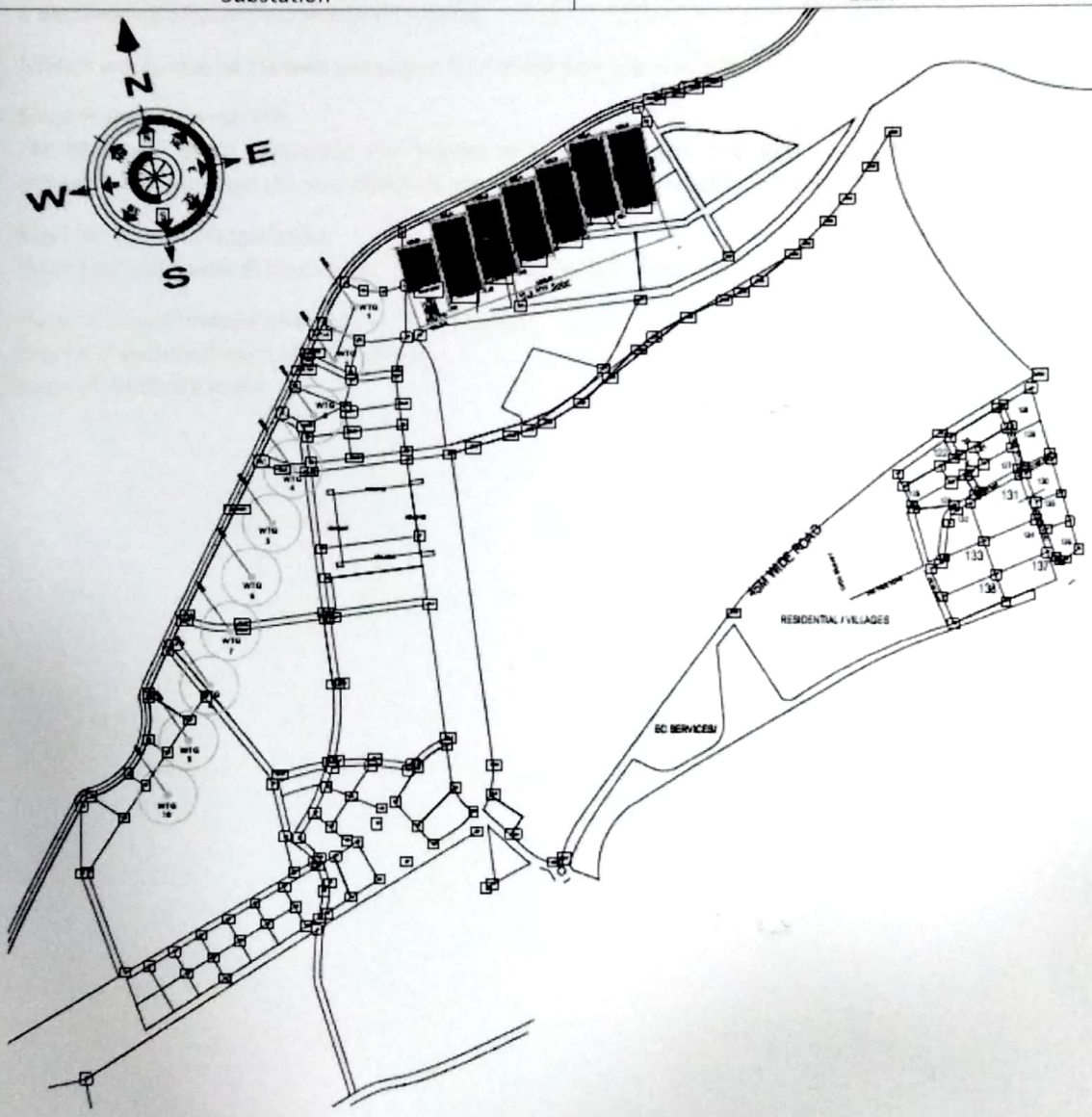

Figure 13: Tentative Placement of Solar and Wind

12.Road Map

After the acceptance of this Feasibility Report, the subsequent processes that will take place shall be conducted pursuant to the SPRA guideline and entails the following stages:

i. Stage I: Expression of Interest
   Expression of Interest advertisements would be issued locally and in international media to call domestic and international bidders. In response to the EOI, the bidders would be requested to submit a detailed document showcasing their capabilities, competence and resources. Apart from this, they would also be required to submit a detailed technical and commercial proposal.

   Bidders would also be allowed to request for Pre-bid meeting, if required.

ii. Stage II: Evaluation of Bids
   The EC Board would evaluation the bidders to prequalify them and then evaluate their bid technically and commercially. Amongst the qualified bids, the bidder with the lowest commercial bid would be selected.

iii. Stage III: Contract Negotiation
   Negotiation between Bidder and EC to finalize all terms & conditions before proceeding to award

iv. Stage IV: Project Award and Head of Terms Signing
v. Stage V: Financial Close and PPA Signing
vi. Stage VI: COD of Project

13.Transmission and Distribution Network

13.1. General Layout

Education City management would be ensuring a robust and dedicated infrastructure for transmission and distribution of power from the Power Seller to the end user across the Education City.

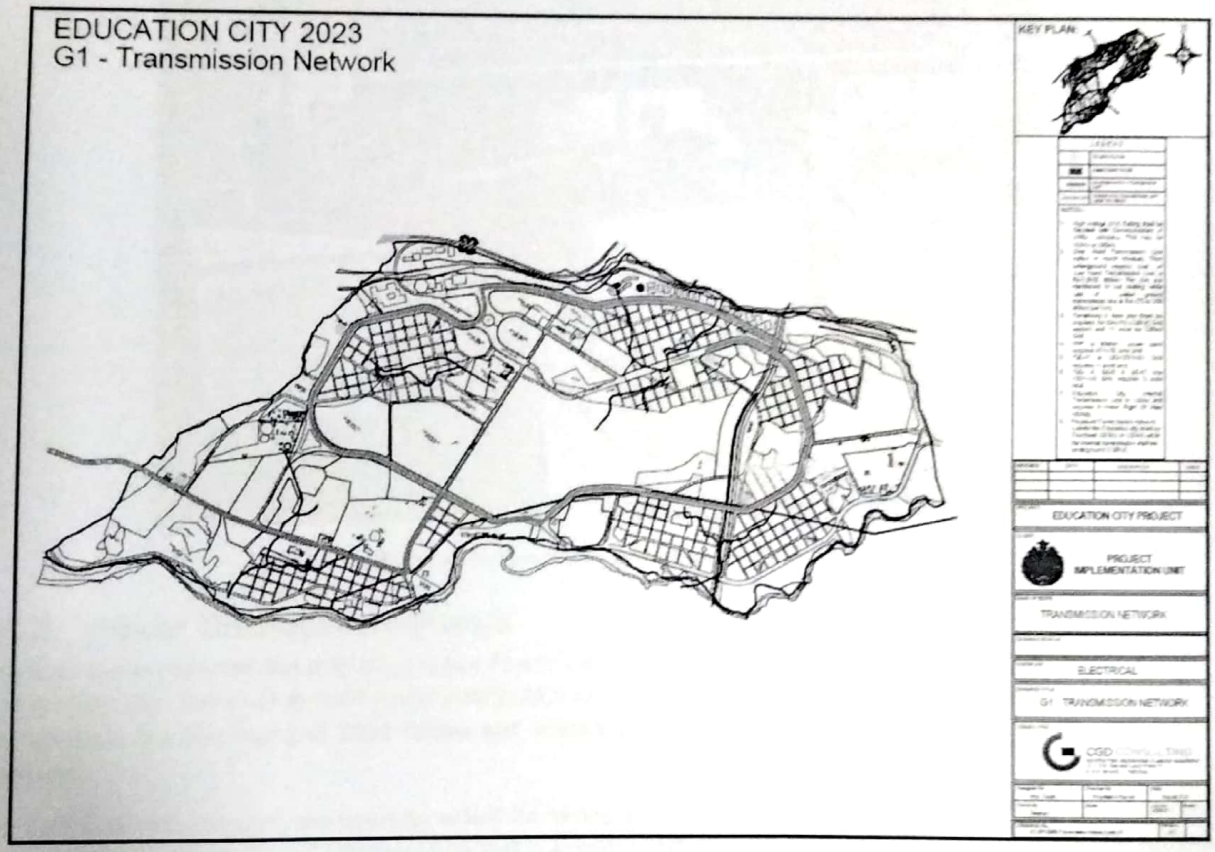

Figure 14: Transmission and Distribution Network example (https://educationcity.gos.pk/maps/)

The distribution voltages across Education City would be as per the requirement of end user i.e. 400V, 11kV etc, depending upon the load (MW) requirement of the end user.

Furthermore, the complete transmission and distribution network should be monitored with a real time SCADA system, that would ensure identification of system related faults, power management and rerouting of emergency power in case of a problem. All these activities would be controlled through a Load / Power Despatch Centre.

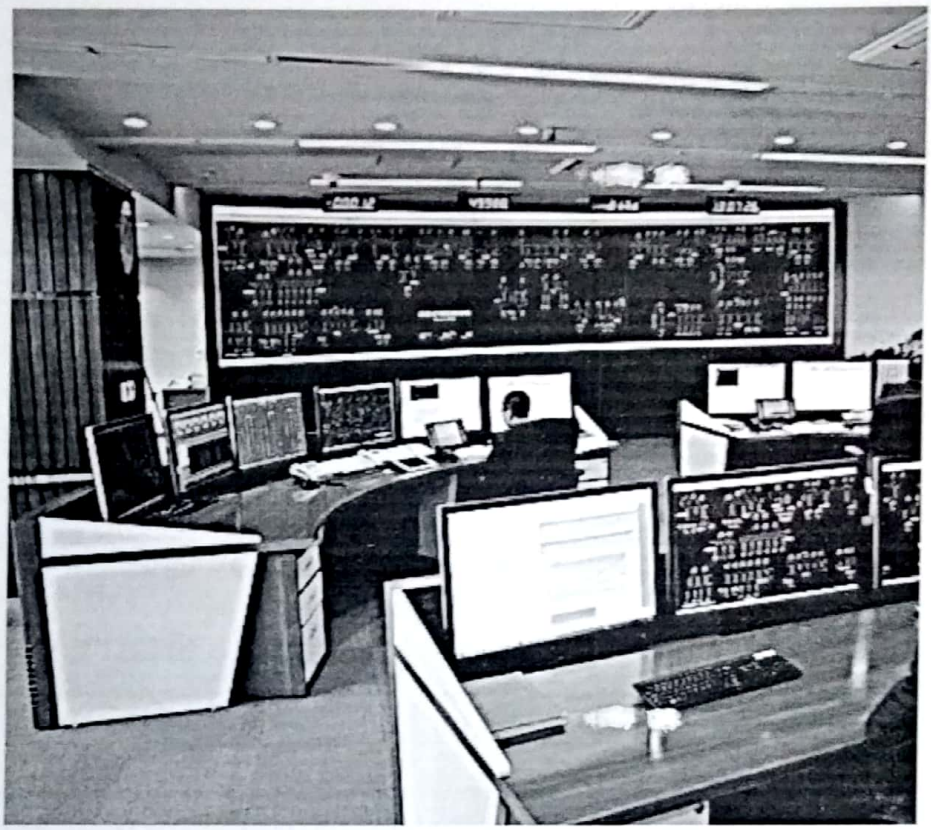

Figure 15: Example of a Load / Power Despatch Centre

13.2. Power Distribution Network

The Operator is expected not only to generate Power but also create its own distribution network for all the tenants of Education City. The underground power distribution system civil infrastructure would be created by Education City Management but the laying of 11kV Cables and related 11kV Switchgear would be installed by the prospective operator.

For each bulk user / tenant, the operator would be having an outgoing 11kV feeder at their end, with a 11kV cable that would be laying in the civil infrastructure that is already created by Education City. At the tenants' premises, the operator would be installing one incoming / outgoing type 11kV switchgear along with metering system. The 11kV sub-station would be constructed by the tenant but the ownership would be with the operator.

For each tenant, the operator would prepare cost estimate for laying the 11kV cable and installing the 11kV switchgear. The tenant would be having the following options:

i. Procure the material themselves and pay the operator for installation
ii. Get complete work done by the operator and pay upfront
iii. Get complete work done by the operator and make 5 year lease agreement

14. Billing Calculation Methodology

The operator would be billing the customer not only for the units that the customer consumes but also for the connection cost.

A typical 20-year PPA would look like the table below:

Year	PPA	Connectivity Lease Amount
01	USD xxx / kWh	USD xxx (Lease + O&M)
02	USD xxx / kWh	USD xxx (Lease + O&M)
03	USD xxx / kWh	USD xxx (Lease + O&M)
04	USD xxx / kWh	USD xxx (Lease + O&M)
05	USD xxx / kWh	USD xxx (Lease + O&M)
06	USD xxx / kWh	USD xxx (O&M Only)
07	USD xxx / kWh	USD xxx (O&M Only)
08	USD xxx / kWh	USD xxx (O&M Only)
~	~	~
20	USD xxx / kWh	USD xxx (O&M Only)

15.Power Purchase Agreement

Education City requires prospective bidders to enter into a 20-year Power Purchase Agreement with its tenants. The bidders (domestic or international) can be:

- A Corporation, in which case the Corporation is the Main Sponsor, or
- A Consortium, led by a Corporation as the Main Sponsor

The Bidders must be able to demonstrate experience of complete development, ownership and successful operations of renewable energy project(s) and/or thermal utility scale IPP project(s) with a minimum cumulative capacity of at least 50 MW which has been developed, commissioned and being operated anywhere in the world over the last 10 years provided that at least one project should have a minimum capacity of 05MW.

The PPA should ensure a 24/7 availability of power to the Education City's tenants with a penalty for non-conformance.

However, in case of excess power, the Education City management would ensure evacuation for the Power Seller.

Salient features and suggested TORs for a Power Purchase Agreement have been mentioned in Annexures.

16.Investment by Foreign Organization

Although domestic organizations are requested to participate in these types of investment projects, it would be prudent to also encourage foreign organizations to participate in such projects, thus becoming a source for Foreign Direct Investment for the country.

In order to encourage such investments, it would advised that a much stronger approach be taken to persuade investors. As per Pakistan's Investment Policy 2013, foreign investors can repatriate profits, dividends, or any other funds in the currency of the country from which the investment was originated. The funding is now considered using SOFR which earlier was LIBOR based.

Even the first 2 months of year 2024 have been an encouraging sign, showing a healthy increase in repatriation of profits. This should be a good sign for investors to show that Pakistan means business.

The Special Investment Facilitation Council (SIFC) of Pakistan is another initiative that is created to facilitate international investors and to ensure ease of doing business. This initiative is expected to not only bring investments from abroad but knowledge that would be needed to upgrade our infrastructure and help Pakistan move ahead into the Greener Future.

17.Key Studies to be covered by Power Seller

The bidders should be encouraged to do their own studies to satisfy themselves. These can be listed as follows to name a few:

i. Hydrology Study
ii. Soil Investigation (Geotechnical Study)
iii. Land Topography
iv. All Electrical Studies
    - Load Flow
    - Short Circuit
    - Breaker Coordination
    - Harmonic/Transient

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Geotechnical and Environmental Impact studies have already been conducted and report is attached in Annexures.

18.Legal / Regulatory Requirements

All legal and regulatory requirements that are applicable for this project shall be met by the bidders, e.g.

- Electric Power Supply / Distribution License
- License to handle and store fossil fuel at site for generators
- PEC Operator License / AEDB
- SPV registration

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19.Potential Risks and Recommendations

Based on the physical site survey conducted, the following are some important considerations

	Low Risk, Solvable
	Medium Risk, Solvable
	Significant Risk, Solvable
	Significant Risk, Not Solvable

Table 5: Risk Identification Color Coding

Risk Name	Description and Mitigation	Profile
Existing Settlements	Existing Camel Farms and settlements will have to be displaced.	
Sand	Fine sand which is typical for this location will result in increased soiling losses. Hence layout and PV module orientation to be planned accordingly.	
Water Availability	Water is scarce at site and the possibility of ground water presence to be analyzed. Water requirement solar PV cleaning for stable operations will be a key consideration for this project. Underground water to be used.	
Water Quality	The water quality (TDS levels & PH levels) of underground water to be analyzed before use.	
Rock Hills	Bordering elevated rock formation will result in some horizon losses for the solar PV project in the early and late hours of the day.	
Internal Road	Road access to be planned across the project site and will have to be planned to take into consideration the O&M requirement of the solar PV project. The other key consideration will be the hydrology study based no which the roads will have to be elevated with properly designed embankments.	
Soft Soils	Soft soils to be taken into consideration so that it doesn't settle with the passage of time.	
Topography & Elevation	The project site has considerable elevation difference from one end to the other. Planning the land for preventing water stagnation and flow and shadow avoidance will be key consideration of the project site. A detailed topography survey needs to be conducted and design & planning to be done accordingly.	
Solar PV Module	High temperatures will potentially result in excessive PV module power degradation. The design and BOM of PV module to be planned accordingly.	
Sand Abrasion	Soil and Sand can result in abrasion of metallic surfaces and issues in functioning of electronic equipment.	
Transmission Line	With Solar PV only, the planned electrical infrastructure will only be utilized in day times whereas with solar/wind the electrical offtake infrastructure can be utilized throughout the day and hence giving a much better utilization. Potentially impacting investment preposition of transmission line.	
Sandstorm	The deserts are potential location for sandstorms, in this scenario the sand can ingress in multiple equipment and cause disruption. Hence it is required that design should require certain ingress protection levels to mitigate this impact.	

Annexure – A: Terms of References of a Typical PPA

i. This PPA agreement is a "take or pay" agreement for this project. The "take or pay" applies to the numbers committed in the "Performance Commitment Table".

ii. The term of the PPA is 20 years and will start from Commercial Operation Date (COD) for project is completed. Seller to officially notify 30 days prior to the COD for the solar project.

iii. This project will be done on a BOOT basis and it will be Seller's responsibility to transfer asset to the buyer in working condition without fault in any civil, electrical or mechanical equipment after the 20 years term at PKR 1000/= value.

iv. A flat tariff will be quoted for the RE project in PKR/kWh. The price structure of the quoted tariff will be shared with Buyer.

v. All bidders are required to specify the time required for financial closure after the signing of the term sheet.

vi. Successful Bidder will be required to submit a PKR X Million performance security (in the form of a bank guarantee from a Commercial Bank to the Buyer) between the LOI and the FC. The buyer needs to protect the submitted bids and tariffs for which a PKR X million bank guarantee would be required from the shortlisted Bidder. After the FC a bank guarantee of PKR X million will be returned. An alternate mechanism for securing ongoing performance liability can also be structured to be included in the final contract (i.e. on ongoing payments).

vii. Successful Bidder will be required to provide a detailed project timeline for solar PV project, after award of LOI.

viii. Seller shall issue the monthly bill of the total energy produced and supplied to the Buyer through Solar PV and buyer will make the payment of both bills within 30 days (due date) from the date of issuance. In case of late payment after the due date, a late payment penalty will be applicable on the Buyer at the rate of one-month KIBOR + 2% per annum.

ix. All bidders are required to disclose the source of their planned/proposed financing.

x. Transfer of PPA contract to another party: Bidder shall have the right at any time to assign its rights and obligations under the PPA to any of its subsidiary/parent, associated companies or Third party acceptable to Buyer, or its lenders with the consent of Buyer by giving prior written notice, however, Buyer rights and interests in respect of the Solar Project and/or the related documents shall remain the same, intact, valid and enforceable.

xi. Bidders are required to share a 20-year energy generation performance commitment plan in (kWh) solar on a monthly basis. A "Performance Commitment Table" in (kWh) is to be shared in accordance to the schedule A of the RFP.

xii. In the event of underperformance of solar assets, the assessment will be conducted using the 'Performance Commitment Table,' comparing it to the actual measured performance. Any shortfall, resulting in an actual savings loss for the buyer compared to the current grid price, will be calculated as Underperformance LD Amount in accordance with the schedule B of the RFP.

xiii. A performance security in the form of a bank guarantee covering a value of PKR XX million to be submitted (from a Commercial Bank acceptable to the Buyer) or else otherwise agreed, within 10 days after COD to ensure generation commitments. This performance guarantee will be valid for the term of the project. Renewal will be the responsibility of the seller.

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xiv. For underperformance determined against the "performance commitment table" for reasons not related to the weather resource availability (like excessive solar downtime, solar equipment failures, lack of proper O&M, etc) then an official warning will be shared by the buyer to the seller and an additional (1) one year remediation period will be allowed for the seller to improve operations/equipment, if however, the seller is still not able to achieve the required level of performance as identified under the "performance commitment table" (for reasons not related to weather resource availability), this will be constituted as a breach of contract and liable to Termination.

xv. For limitation of liability for seller please note the following:

- Amount of LD charged due to loss resulting from non-performance of asset (which does not include weather related matters) will not exceed 10% of annual committed payments.

xvi. Under a termination of the PPA contract due to underperformance (for reasons not related to weather resource), the seller will be required to clear the solar equipment at the site within 3 months of termination. Failure of which, the Buyer will have the right to sell the equipment on behalf of the Seller and adjust the Seller against expenses incurred. The Seller will also specify the Buyer's right to sell equipment in the contract with their lender provided asset is not moved in 3 months.

xvii. Non-payment or non-clearance of monthly invoices after 3 months continuous will also constitute a breach of contract (Termination) and the buyer will have to clear all dues and additionally pay the exit price as defined and agreed in the PPA contract.

xviii. Any additional revenue realized due to REC's or environmental attributes will be equally shared between the Seller and Buyer after all expenses.

xix. The bidder will be connected in parallel with gensets and the grid. In the event Buyer is not able to offtake committed generation units then the bidder will have the option to sell those curtailed units to the grid. The bidder will only charge the differential amount against curtailed units as defined below;

Buyer payable against Curtailed Units = Amount of curtailed units - Amount accrued by selling the curtailed units to grid

If the amount accrued by selling the curtailed units to grid exceeds the total amount of curtailed units due to not being consumed/off taken by Buyer, the bidder will not charge against them to Buyer. A ledger will be maintained for this across the term of the contract. Control Period for this accounting will be for the term of the contract.

xx. The buyer will ensure 100% offtake of the performance commitment table (kWh) for the solar project. Hence the "take or pay" agreement is applicable for whatever units are specified in the performance commitment table by the bidder. Minimum capacity payments will be derived from the performance commitment table. Performance shortfall not related to weather will qualify for LD's and adjusted capacity payment.

xxi. Any curtailment due to the unavailability of load will be recorded by the seller and will be recorded in the monthly bill as a separate head i.e., as "Actual Used Units" and "Curtailed Units" separately.

xxii. The buyer will only pay for curtailed units if the total consumed units are less than the minimum off-take defined in the performance commitment table and will pay only until the committed unit's amount is achieved.

xxiii. Any additional generation consumed by the buyer "Actual Used Units" above the committed energy amounts will not be charged to the buyer.

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xxiv. If project COD is delayed due to the seller, the seller will compensate the Buyer for its lost savings amount.

xxv. If project COD is delayed due to the buyer, the buyer will compensate the Seller for units not produced otherwise.

xxvi. Successful Bidder shall be required to submit an actionable timeline before the term sheet signing, identifying roles and responsibilities between the buyer and seller. The buyer intends to support the process where it can.

xxvii. Obtaining the GL and achieving FC is the sole responsibility of the seller. Any cost, studies, in particular, Environmental Impact Assessment (EIA) report, Grid Interconnection study and Sindh Environmental Protection Agency approval and other NOC documents or other items required to achieve GL will be the responsibility of the seller. Buyer to support where required where possible in the best interest of the project. Both parties support each other in achieving a quick turnaround for achieving the COD for the project. All studies required for the project will be the responsibility of the Seller.

xxviii. If the Buyer ceases to conduct business operations at the Project Site / Premises, or otherwise vacates the Project Site / Premises prior to the expiration of the Term, the Buyer shall provide the Seller with mutually agreeable substitute premises for the relocation of the Equipment and until such time, shall continue to pay against the performance offtake commitment table. The Buyer shall provide written notice at least 60 (sixty) days prior to the date that it intends to make the substitution. The Buyer shall pay all costs associated with the relocation of the Equipment, including all costs and expenses incurred by or on behalf of the Seller in connection with the removal of the Equipment from the Project Site and installation and testing of the Equipment at the substitute site and all applicable transit fees and expenses at the substitute site. The Parties hereby agree that in case the Buyer does not provide mutually agreeable substitute premises for the relocation of the Equipment within a period of 30 (thirty) days from the date after the Buyer ceases to conduct business operations at the

Project Site / Premises, or otherwise vacates the Project Site / Premises, the buyer shall be liable to pay to the seller the Exit Price calculated as per the formula provided below. After payment of such Exit Price, the ownership of the Equipment shall stand transferred to the Buyer on an as-is, where-is basis, and the Seller shall not provide any warranty or other guarantee regarding the performance of the Equipment, provided, however, that the Seller shall assign to the Buyer any manufacturer warranties that are in effect as of the purchase, and which are assignable pursuant to their terms.

xxix. The site and asset security will be the seller's responsibility. The buyer will help in whatever way possible to ensure security protocol compliance. Hence all required insurances should be required related to the safety of the plant.

xxx. The roof clearance and suitability of the site will be the responsibility of the buyer.

xxxi. It will be the seller's responsibility to carry out an EIA and identify any environmental hazard or any other identification that may impact the O&M or installation of the asset after the site has been cleared/handed over.

xxxii. Provision of water for PV panel cleaning is the responsibility of the Buyer from the designated connection point. In case of any additional pressure or piping from the designated point will be the scope of the seller.

xxxiii. In case of any disputes, the management of the Buyer and Seller will attempt to resolve the issue in the best interest of the project. However, if a resolution cannot be reached, the matter shall be resolved under the Islamic Republic of Pakistan's laws.

xxxiv. All applicable non-adjustable and adjustable taxes will be listed by the Seller in the Bid Submission documents.

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Annexure – B: True-Up sheet for PPA Tariff Determination

Bidders are required to fill out the True-Up sheet, using the specified format below. The sheet covers operational, financial, and technical assumptions, as well as project cost assumptions, to determine the PPA Tariff

Operational Assumptions	Unit	True Up-Stop Date	Comment
Admin Cost (PKR)	PKR	at Signing of TS	
O&M Cost Per MW per Annum	PKR	at EPA	
YoY O&M Escalation	%	at TS	
Insurance during operations (% of Exit Price)	%	at EPA	
Annual Agency Fee (Bank Charges)	PKR	at EPA	
Valuation Report (after three years)	PKR	at EPA	
PROJECT COST			
EPC Cost	$/MW	Foreign component to be trued up at L/C retirement	
EPC Local	PKR/MW	Local cost on EPA (At signing on EPA, it is assumed that EPC/ O&M contracts will be locked)	
Taxes on EPC	PKR/Watt	ongoing till last payment schedule with EPC	
Insurance During Construction	PKR/Watt	at EPA	
Internal Project Development Cost	PKR/Watt	at Signing of TS	
Project Development - Third Party	PKR/Watt	at EPA (additional expenses after EPA shall be mutually agreed b/w the Parties)	
Interest During Construction	PKR/Watt	at COD	
Financing Assumptions			
Exchange Rate	Rs/$	at USD LC Retirement	
Inflation/cost escalation	%	at Signing of TS	
Debt Portion	%	at EPA	
Debt Tenure (Incl. Grace Period)	Years	at EPA	
Grace Period	Months	at EPA	
SBP Base Rate / Financing	%	at EPA	
SBP Spread	%	at EPA	
Portion of Debt Funded by SBP IFRE	%	at EPA	
SBP IFRE Funding Amount	PKR Mn	at EPA	
3M KIBOR	%	as per actual	
Commercial Loan Spread	%	at EPA	
Guarantee Fee	%	at EPA	
Technical Assumption			
Production Regime			
Capacity Utilization Factor (P90)	%	at EPA	
Plant Availability	%	at EPA	

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Annexure – B: List of OEMs

General list of OEMs that are recommended for the project are as follows:

- Solar PV Modules
  - Jinko Solar
  - Longi Solar
  - Trina Solar
  - JA Solar
- Solar Inverters
  - Huawei
  - Sungrow
- Wind Turbines
  - Goldwind
  - Vestas
  - GE
  - Nordex
  - Siemens Gamesa

Annexure – C: Environment Impact Study Guidelines

Attached as a separate file

Annexure – D: Geotechnical Investigation for Education City

Attached as a separate file

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GUIDELINES FOR PERFORMING ENVIRONMENTAL ASSESSMENT FOR PROPOSED ALTERNATE ENERGY PROJECTS FOR EDUCATION CITY

EDUCATION CITY KARACHI

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EDUCATION CITY ENVIRONMENTAL IMPACT ASSESSMENT INCLUDING THE PROPOSED WATER FRONT AT MALIR RIVER

INTRODUCTION

Aa comprehensive Environmental Impact Assessment Report reviewing the existing and proposed Master Plan and as per the site needs, institutional arrangements, covering the regulations and with keen of sustainable development and mitigating any negative environmental impacts of project is prepared and under the process of approval from Sindh Environmental Protection Agency.

The Pakistan Environmental Protection Act 1997 makes it mandatory to acquire an NOC from the provincial EPA for the project. The EPA requires an EIA study of the project to issue NOC based on the baseline of environmental impacts documented in the EIA report.

The Environmental Impact Assessment has been prepared during entire Strategic Planning Stage of Education City Project in order to obtain Environmental blanket Approval /NOC from Environmental Protection Agency EPA-Sindh. In accordance with the Sindh Environmental Protection Act, distinct Environmental Impact Assessment and **NOC approval will be required for owners during construction stage of each of the sub project such as educational institutions, river channelization, roads, alternate energy projects, housings, urban forest development and commercial and residential buildings etc.**

The Proposed Project "Education City is a development project consisting of 8.921 acres out with different project development the basic power requirements are met mostly with the Alternate Source of Energy (Wind Energy Potential and Solar Based Power production) might be the most appropriate alternate energy options for the Education City Project. In addition all institutes are bound to met the power requirements atleast 30% from Alternate Energy Projects.

No life without power at Education City is the Slogan for developing the power projects keeping in view the maximum Alternate Energy with very low Carbon Impacts with positive environmental impacts.

This small paper is prepared to check the Positive and Negative impacts of the upcoming Alternate Energy Projects.

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1.1. Project Salient Features

Table 2.1 Salient Features of the Project	
The Project	Education City (EC)
Project Location	DehChuhar, Gaddap DistrictMalir, Karachi
Project area	8,921 acres
Salient features	⌑ Approximately 8,921 acres of land was notified as Education City. ⌑ Core elements of EIA are to access the local and international educational and health institutions requirements its impacts and mitigation measures that will provide solutions to Pakistan's challenge of higher education. ⌑ Opportunity and attraction to remain and study in Pakistan. Educational institutions will create the opportunity for private R&D businesses as a component of EC. ⌑ Residential and commercial development though restricted for the purpose of Education City only, will provide 'quality of life' or 'character of community' that is typical ofeducational communities. ⌑ Land has been earmarked for institutions ⌑ Utility management plan for Water Supply, Wastewater and Solid Waste Management and Power Supply. ⌑ Construction of water front at Malir River.

1.1.1. Project Description

The Education City (EC) Project is a hallmark of the present Government to empower the youth with knowledge, skills and institutions making investment in our valuable Human Resources. It is going to be hub of excellence with world class infrastructure. The Government of Sindh is aimed to make an ambitious and visionary investment in our people and economy by creating the EC. The Government of Sindh has resolved that development and advancement will only come with an internationally recognized Educational System which may be achieved by fostering the interaction of various disciplines, culture and ideas. EC will have a far-reaching impact into the future and will serve as a model of achievement for many to follow. Education City project aims to provide a superb environment and facilities for both teaching and studying, backed by outstanding learning institutions and technological research centres. Besides, the project will accommodate at least 150,000 students, generate direct employment approximately 200,000 and will trigger the enormous economic activity in the province.

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1.1.1.1. Location of the Project

The Government of Sindh has earmarked 8,921 acres of land in DehChuhar, Gaddap District Malir, Karachi for Education City project, on link road between National Highway and Super Highway. It is an ideal location for establishing such educational institutions with large campuses because of spacious and well-established landscape.

The proposed Water Front is at the Malir River which in length the river is passing only 4.5 Kilometer from Education City adjoining areas.

1.1.1.2. Need of the Project and Rationale

- Realizing that a nation's greatest resource is its human resource, Education City is being developed with a view to meeting the challenges of an ever-changing and complex world and to make Sindh and its capital Karachi a leader in quality education as well as research and development. It is intended to be a hub for the imparting and generation of knowledge in the presence of world-class infrastructure and campus facilities and a pool of highly qualified academics. It shall provide a chance to collaborate with like-minded people and the opportunity to transform ideas into reality.
- The concept of Education City has evolved out of the desire of successive Governments to empower the people by imparting them with the knowledge and skills comparable with the best international standards. Education City aims to be a nerve-centre of excellence, which would bring together the best of the intellect in the country and from abroad and to provide an environment most conducive to learning.

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Chapter 2 Environmental Impact Analysis

2.1. Overview of EIA

With the development of industrialization, global warming has caused irreversible damage to the environment that human beings depend on in terms of sea level rise, food crises, water shortages and so on. Scientific research shows that greenhouse gas (GHG) emissions are the main cause of global warming and climate change. Components of the Project

Based on the Master Plan, the project involves the following components:

- Institutions
- Residential
- Settlements
- Commercial
- Recreational **(including water front at Malir River)**
- Protected Open Spaces
- Amenities
- Graveyards
- Urban Farming
- Water bodies
- Roads

Schedule of land use of the project components are provided below:

Table 2.1: Schedule of land use

Land Use	Area	Percentage
Institutions	4437.00	49.63 %
Residential (Including settlements)	206.82 791.29	11.17 %
Commercial	380.62	4.26 %
Recreational/ Protected Open Spaces Water Bodies	670.17 570.95 218.25	16.33 %
Amenities	197.50	2.21 %
Graveyards	118.89	1.33 %
Urban Farming	159.88	1.79 %
Roads, Services etc.	1187.97	13.28 %
Total	**8939.34**	**100.00 %**

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2.2. Review of Existing Master Plan for Education City

The Proposed Master Plan reviewed by the team of consultants found that at the Planning level some very innovative measures are already taken to keep the Environmental Impact balance due to the construction and upcoming anthropogenic activities, the following are the Environmental considerations

- The natural available resources are planned to be fully utilized without damaging the Natural resources. An optimization of use of water resources are planned to balance the water resources and not to use the water resources to damage environment. Strategies are adopted to conserve all old perennial infrastructure the best example of restoration is
- The entire Master Plan is established between the Malir Rivers and Sukhon River and some old perennial tributaries are vertically connected between the two important rivers. There is a potential natural water flow which is currently clogged due to low flow or small natural encroachments,
- The planning is done in such a way to restore all such tributaries and allow the natural water flow and planting urban forest in the right of way of the tributaries which will be working as lungs (consuming carbon emissions and providing fresh oxygen) for the proposed education city.
- The natural water definitely flow because the level difference between the two Rivers are approx 40 feet from Malir to Sukhan (see contour maps). Once the natural flow of water will be restored, providing food to grow the urban forest which helps aesthetic beauty, ecological balance and capture tons of carbon dioxide from the anthropogenic activities.
- The natural channels are already in-place to avoid any pumping which is the main cause for damaging the environment. The machines vibration and noise disturb the fauna of any areas. Once the water is naturally flows and help the forest and plants to grow helping the entire natural ecosystem development.
- All street lights are planned to be powered through Solar based power, hence no impact for Street Lighting.
- All institutes are bound to generate at least 30% of power through alternate source of energy (wind, solar, may be biogas or any other means), hence carbon dioxide emission reduction is already planned.
- Power generation through alternate source of energy will create a very positive impacts in and around the Education City. If the power is generated for self sustainability in terms of power requirement of Education City no grid transfer from outside areas will save the capital investment, environmental hazards and carbon impacts of power generation from furnace oil.

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- The Master Plans show the Water Bodies in Blue color and Urban Forest running parallel in green color.
- The Water Front at Malir River will be the retained water for the entire year which will help replenish the depleting ground water, overflow to the tributaries and channels will improve the green cover and agricultural fields.
- The positive impacts of the water front is aesthetic improvements, biodiversity improvements, water supply etc.
- Planned green areas and portion for trees will be separate planned in the individual master plan of the particular institutes. The negative Environmental impacts if any will be curb in providing green spaces within the premises of particular institutes. The land will remain available to soak storm water into ground to replenish the ground water and help in overall ecosystem of area.
- In addition to the above the roofs of the institutes will be designed for roof gardens, use of storm water and minimum heat refraction will be proposed for the top floors. In such way the latent heat of island (heat absorb by the concrete structure and emit the heat during the night hours) will be controlled in the area. The strategy is to maintain the temperature of the area as it is now at the baseline level. The temperature control is not area specific it depends on the overall climatic conditions but alteast indoor environment of the buildings will be controlled through good practices.
- Complete wastewater treatment and recycling for the green areas, current Municipal Water demand to start the project will be 19 MGD, 80% expected wastewater generation and all the treated wastewater will be used in planting so the gaseous emissions from wastewater will be controlled through treatment and recycling. Currently in Karachi there is indiscriminate dumping of untreated wastewater into the water bodies which creates problems like eutrophication (excessive wild growth of vegetation in canals and water bodies which consumes the food and nutrients required for water life hence the water life is damaged). In the proposed master plan a strategic water plan and wastewater treatment is available which saves the internal environment of Education City. If the plants run on alternate energy power will further reduce its environmental impacts.
- Institutes will be bound to initiate the source separation and source collection of Solid Waste. The Solid Waste being generated will be collected as three types of wastes (recyclables, organic waste and the remnants). 70% of the waste will be reused and recycled. The remaining 30% of the unwanted material will only be disposed of at the already operational landfill site (Gond Pass) situated at the Surjani Town. According to a report Pakistan per person per capita emits 1.5 kg methane per annum due to the indiscriminate dumping of waste, here the Master Plans covers proper treatment, recycling, reuse and disposal of waste which will reduce the environmental impacts.

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- All agricultural parcels are intact and untouched in the proposed Master Plan, no crop yield disturbance and no any ecological agricultural disturbances are expected. The villages are taken care and no one is shifted and disturb, the plan is to improve the live style of the residents of such villages and improve basic amenities like water supply, wastewater and solid waste management. The villagers will be part of business plan to sell the commodity items like eggs, vegetables, milk, meat in the local market to better earn livelihood. Once such consumables items are available within the Education City there is no any carbon emissions in getting these items transported from 100 miles far areas. The carbon balance will be maintained.

Further Environmental assessment is underway and a strategy will be adopted to curb the carbon emissions from the Education City and in future any improvement is required through amendments in the Byelaws will be done. The construction of water front will be done with planned desilting mechanism and would not impact any negative impacts on the water flows and Education City establishment.

a) Safeguards

During the construction phase, environmental safeguard considerations which include prevention and mitigation of pollution, sustainable management of natural resources, limits the use of pesticides and Greenhouse gas emissions and the conservation of biodiversity will be prioritized.

b) Health and safety

Health and safety of every personnel during the construction phase will be prioritized.

c) Monitoring

Monitoring of every phase and all activities will be conducted to make sure that environmental laws of Sindh Environmental Protection Agency are being properly followed.

2.3. Key Considerations for Alternate Energy Projects

According to the Sindh Environmental Protection Agency, Environmental Assessment Schedule promulgated in 2021 all alternate energy projects will only be executed after seeking approval of Initial Environmental Examination or Environmental Impact Assessment. The hair line difference of both assessments is the Public Consultation. For Environmental Impact Assessment the proponent/project executer has to be called upon a public consultation / stakeholder consultation for approval of the initiative.

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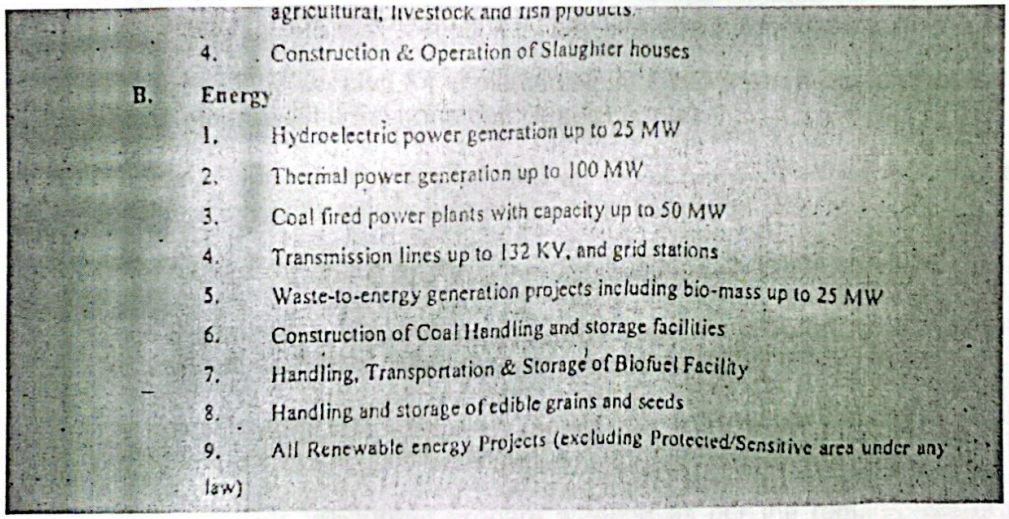
Only after seeking approval from SEPA the work at site must be initiated. As Alternate Energy project will be executed through some funding from private sectors so there is a requirement at the end of the private sector to prepare a comprehensive environmental assessment report after the feasibility studies once approved to be submitted to SEPA office through Education City management for approval and further roll out of the project development.

The Environmental Assessment Schedule falls in both the Category is provided below for better understanding

The below figure illustrates the falling of Energy Project under Initial Environmental Examination as the proposed project area does not fall in protected/sensitive area



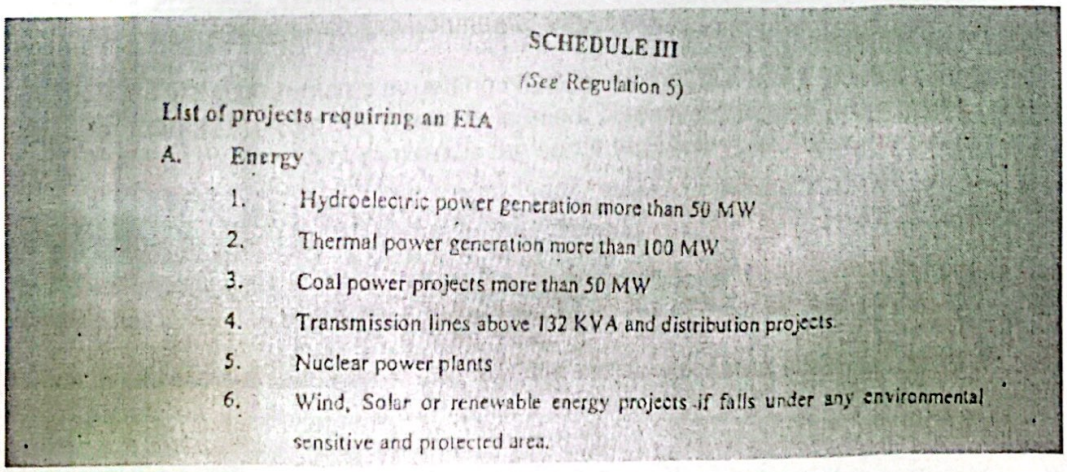
agricultural, livestock and fish products.

4. Construction & Operation of Slaughter houses

B. Energy

1. Hydroelectric power generation up to 25 MW
2. Thermal power generation up to 100 MW
3. Coal fired power plants with capacity up to 50 MW
4. Transmission lines up to 132 KV, and grid stations
5. Waste-to-energy generation projects including bio-mass up to 25 MW
6. Construction of Coal Handling and storage facilities
7. Handling, Transportation & Storage of Biofuel Facility
8. Handling and storage of edible grains and seeds
9. All Renewable energy Projects (excluding Protected/Sensitive area under any law)

The below figure illustrates the falling of Energy Project under Environmental Impact Assessment as the proposed project area does fall in protected/sensitive area



SCHEDULE III

(See Regulation 5)

List of projects requiring an EIA

A. Energy

1. Hydroelectric power generation more than 50 MW
2. Thermal power generation more than 100 MW
3. Coal power projects more than 50 MW
4. Transmission lines above 132 KVA and distribution projects
5. Nuclear power plants
6. Wind, Solar or renewable energy projects if falls under any environmental sensitive and protected area.

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STEPS TO BE TAKEN BY THE PRIVATE COMPANIES TO CARRYOUT ENVIRONMENTAL ASSESSMENT TO INSTALL ALTERNATE ENERGY PROJECTS AT THE EDUCATION CITY

1. Carryout a complete feasibility studies for the proposed alternate energy project with performing only environmental screening during the feasibility stage.

2. Environmental screening means to look the project area with respect to the land utilization (if the land is adopted which has some agriculture parcels with some yield) it will have negative impacts. The placement of solar panels shall not be done in such a way which can impact the flora and fauna life.

3. in case the land adopted for implementation of alternate energy project is barren and no other use the Environmental impact is less.

4. In case of wind energy project, the air travel funnel shall be looked into the consideration as air strip is also proposed at Education City.

5. Other hazards of storing and transferring power supply to the areas.

6. Once the project qualifies to the feasibility stage the company need to engage a Technical consultant to prepare an Environmental Assessment Report.

7. The consultant will first screen the project falls in Schedule II or Schedule III and perform the assignment accordingly.

8. The consultants will further prepare a report as per the requirement of Sindh Environmental Protection Agency and assist the proponent in getting NOC.

9. The physical, biological environment as per the project requirements will be carried out along with Environmental Monitoring.

10. The Total time requires in getting NOC in case of IEE is 03 months and for EIA is 06 months so keep the timelines in mind. Usually during the project execution the material procurement also takes the same time hence concurrent activities will be performed.

All the development planning, design and other consideration will be considered through a Environmental Impact lens, it is very necessary to develop new areas around Karachi which currently has no or very little Environmental impacts as the land is naturally built up.

Hence the consultants will try level best to adopt the best possible strategies, solutions, plans and design to adopt the best Climate Resilient solutions and guide the company to install the project with minimum environmental negative impacts.

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SOIL TESTING SERVICES

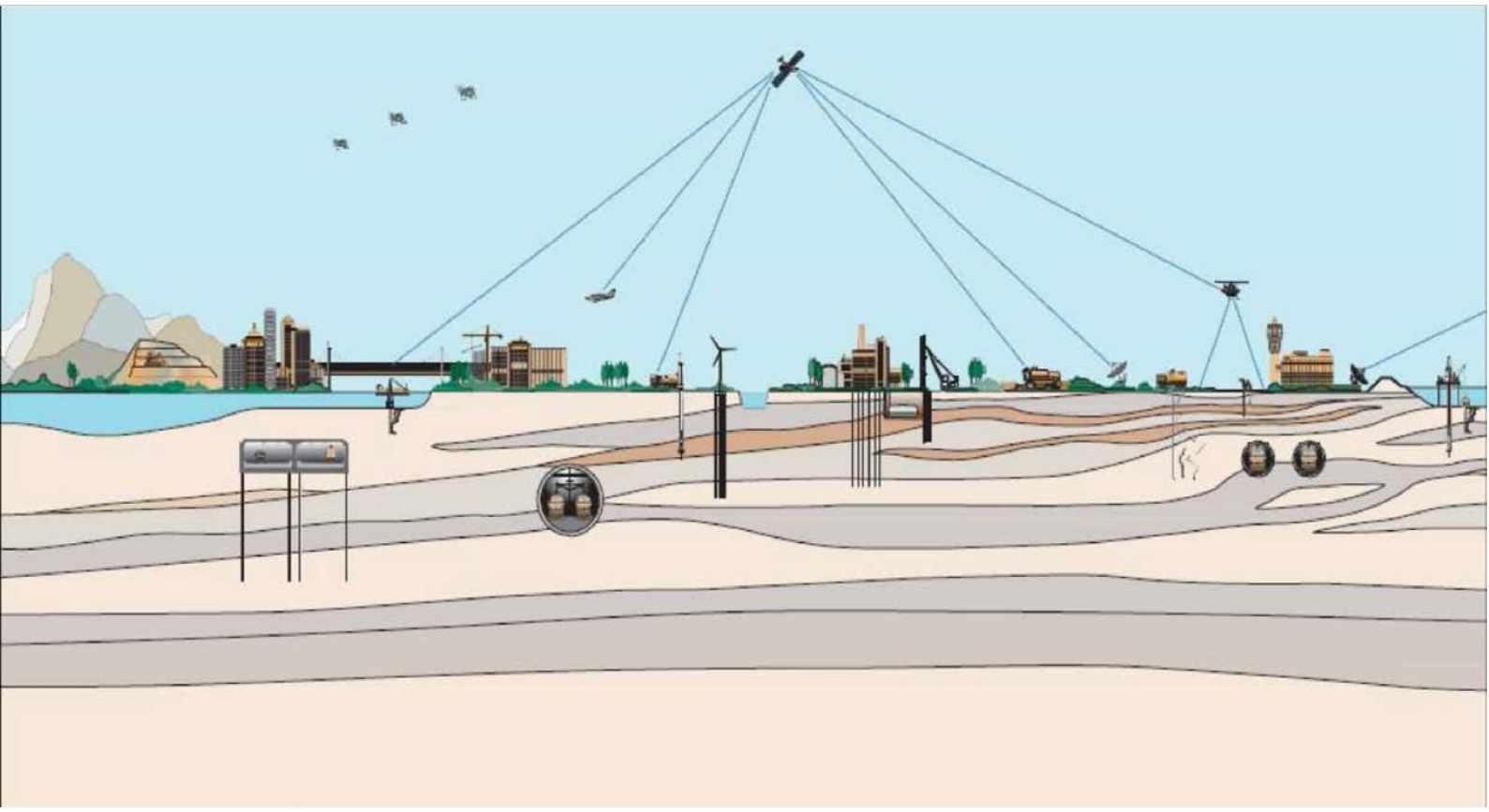
Geotechnical Engineers and Testing Laboratory

Report No. S-24-1022

GEOTECHNICAL INVESTIGATION FOR INSTALLATION OF SOLAR POWER PLANT AND WTGS AT EDUCATION CITY, DEH-CHUHUR, GADAP, MALIR, KARACHI

(REV. 0.0, DATED: FEBRUARY 16, 2024)

CLIENT: EDUCATION CITY



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SOIL TESTING SERVICES	Geotechnical Investigation Report	Revision	
		#	Date
	Report No.: Vol I	00	16/02/2024

PROJECT: Geotechnical Investigation for Installation of Solar Power Plant and WTGs at Education City, Deh-Chuhur, Gadap, Malir, Karachi

	NAME	SIGNATURE	DATE
PREPARED BY: (Project Engineer)	Safi Ul Hasan		
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APPROVED BY: (General Manager)	Naveed Anwer		

ISSUE/REVISION INDEX

Issue Code	Revision					Revision Details
	No.	By	Rev'd.	App.	Date	
RD	00	SUH	ZA	NA	16/02/2024	

Issue Codes: RC = Released for Construction, RD = Released for Design, RF = Released for Fabrication, RI = Released for Information, RP = Released for Purchase, RPA = Released for Permit Application, RQ = Released for Quotation, RR = Released for Review and Comments.

EXECUTIVE SUMMARY

Geotechnical Investigation for Installation of Solar Power Plant and WTGs at Education City, Deh-Chuhur, Gadap, Malir, Karachi was carried out in order to determine geotechnical parameters of subsurface deposits. Scope of work included fifteen (15) boreholes; ten (10) up to the depth of 5.0 meters and five (05) up to the depth of 15.0 meters below existing ground level. Soil and rock samples were collected during field investigation. Laboratory testing of these samples has been carried out in the Soil Testing Services laboratory, Karachi.

The deposition of the area mainly consists of *'medium dense to very dense*, sand' and *'extremely weak, distinctly weathered,* sandstone'. Ground water table was not encountered up to the maximum explored depth of 15.0 meters below the existing ground level in the boreholes drilled at the site at the time of this geotechnical investigation.

Keeping these conditions under consideration:

- Allowable bearing pressures have been given for shallow foundations at a depth of 1.0 – 5.0 meters below the existing ground level.
- Allowable pile capacities are also provided for different diameters and various lengths of piles.
- Earth pressure parameters have been provided for earth retaining structures.
- Seismic soil profile has been taken as *'S_C'* for the foundations in accordance with PBC-21.

The exposure of underground concrete to aggressive chemicals is found to be '*negligible'* for sulphates and chlorides which have influenced the selection of cement for underground concreting and it is recommended to use *Ordinary Portland Cement (OPC)*.

CONTENTS

S.NO. SECTION PAGE NO.

1. INTRODUCTION

Planning for Installation of Solar Power Plant and WTGs at Education City, Deh-Chuhur, Gadap, Malir, Karachi is underway. In order to determine the geotechnical parameters of the subsurface deposits, *M/s. Soil Testing Services (STS)* were entrusted by *M/s. Education City* to perform the geotechnical investigation at the project site.

Scope of work included fifteen (15) boreholes; ten (10) up to the depth of 5.0 meters and five (05) up to the depth of 15.0 meters below existing ground level. Elevation of the drilling platform at each borehole point was noted with respect to the adjacent road level and is mentioned in borehole logs attached in Appendix B. Standard penetration tests were carried out at regular intervals in the borehole along with the collection of soil samples via split spoon sampler. Borehole in rock were advanced through continuous coring. Rock core samples were extracted with the help of double tube core barrels. Groundwater samples were also collected from the borehole drilled at the site. The samples retrieved from the field work were tested in the laboratory and this report is prepared from the information obtained from the field and laboratory tests.

The report consists of five chapters with *Chapter 2* describing the site's existing condition, *Chapter 3* discusses the subsurface deposits in detail, *Chapter 4* includes the recommendations for foundation design, and *Chapter 5* contains a summary of conclusions regarding the ground conditions, with respect to geotechnical engineering for this project.

2. THE SITE

The project site is located at Deh-Chuhur, Gadap, Malir, Karachi in the neighbourhood of Lal Bux Gabol Goth. Nearby landmarks include The Valley view Resort and Gabol General Store.

The topography of the plot is not plain with major changes in elevation observed across the site. Figure 2.1 shows the google image of the site.

Fig 2.1: Google image of the the Neighbourhood area (Courtesy: Google Earth)

3. GROUND CONDITIONS

The subsurface deposits up to the explored depth consist of the following units:

- Sand
- Sandstone

Following sub-sections describe the strength characteristics of the geological unit and the groundwater conditions. Rocks are classified as per BS-5930.

3.1 SAND

Deposits of sand were encountered in all of boreholes drilled at site. State of compactness according to SPT 'N' counts has been determined to be '*medium dense to very dense'*. The grain size analysis has been carried out of samples collected from these deposits. Unified Classification System (UCS) classifies these deposits as *'SM'*, *'SW-SM' & 'SP-SM'.* Table 3.1 summarizes the details of these deposits.

Table 3.1 Deposits of Sand

Borehole No.	Depth (meters)
BH-01	0.0 – 5.0
BH-02	0.0 – 5.0
BH-03	0.0 – 5.0
BH-04	0.0 – 5.0
BH-05	0.0 – 5.0
BH-06	0.0 – 5.0
BH-07	0.0 – 5.0
BH-08	0.0 – 5.0
BH-09	0.0 – 5.0
BH-10	0.0 – 5.0
BH-11	0.0 – 15.0
BH-12	0.0 – 15.0

Borehole No.	Depth (meters)
BH-13	0.0 – 7.0
BH-14	0.0 – 15.0
BH-15	0.0 – 10.0

3.2 SANDSTONE

Deposits of *distinctly weathered* sandstone were encountered in two (02) of the boreholes drilled at the site. Disturbed and undisturbed rock core samples were collected from these deposits which were tested for moisture content, density and unconfined compression test. According to BS 5930, these deposits are classified as *'extremely weak'* rock. Table 3.2 summarizes the details of these deposits.

Table 3.2 Deposits of Sandstone

Borehole No.	Depth (meter)
BH-13	7.0 – 15.0
BH-15	10.0 – 15.0

3.3 GROUNDWATER CONDITIONS

Groundwater was not encountered up to the maximum explored depth of 15.0 meters below the existing ground level in the boreholes drilled at the site at the time of this geotechnical investigation.

4. ENGINEERING DESIGN CONSIDERATIONS

Foundation type for a structure depends on the expected loads taken by the foundation and the type of soil underlying it. The characteristics of the subsurface soil deposits have been discussed in the previous section. Keeping in view the subsoil conditions prevailing at the site and the loads expected to be transferred to the foundations, recommendations for both shallow and deep foundations are provided. Following sections discuss recommendations for shallow and deep foundations in detail.

4.1 DESIGN PARAMETERS

For the purpose of analysis, considering similar soil condition and field investigated locations, two (02) design profiles are made for analysis.

Table 4.1: List of Design Soil Profiles

Profile No.	Boreholes Covered	Proposed Foundation Type
Profile 01	BH-01, BH-02, BH-03, BH-04, BH-05, BH-06, BH-07, BH-08, BH-09 & BH-10	Pile Foundation & Pad Foundation
Profile 02	BH-11, BH-12, BH-13, BH-14 & BH-15	Circular Raft Foundation

The design soil parameters are based on grain size, material type, SPT N-values, field and laboratory testing data and water table conditions. Our recommended design soil parameters used for each profile in our analysis are presented below in *Table 4.2 & 43.*

Table 4.2: Engineering Design Parameters (Profile-01)

Layer Depth From EGL (Existing Ground Level) (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.0	1.0	1.0	29	Sand	-	30	18.0	22,000
1.0	5.0	4.0	50	Sand	-	34	19.5	32,500

Table 4.3: Engineering Design Parameters (Profile-02)

Layer Depth From EGL (Existing Ground Level) (m)		Layer Thickness (m)	Design SPT-N	Material Type	Cohesion, C, (KPa)	Angle of Internal friction (Φ), (degree)	Unit Weight co-related with SPT N (kN/m^3)	Modulus of Elasticity, E (kN/m^2)
Top	Bottom							
0.0	3.0	3.0	35	Sand	-	30	18.0	25,000
3.0	7.5	4.5	50	Sand	-	34	19.0	32,500
7.5	11.5	4.0	25	Sand	-	34	18.5	20,000
11.5	15.0	3.5	50	Sand	-	36	19.5	32,500

4.2 ALLOWABLE BEARING PRESSURES

The allowable bearing pressure has been calculated following shear strength determination through in-situ field tests and settlement analysis. *Table 4.4* & 4.5 give the net allowable bearing pressures for circular raft and pad foundations, respectively.

Table 4.4: Net Allowable Bearing Pressures for Circular Raft Foundation

Profile No.	Minimum Embedment Below Existing Ground Level (meter)	Circular Raft Foundation (kPa / tsf)
02	3.0	300.0 / 3.00
	4.0	350.0 / 3.50
	5.0	400.0 / 4.00

Table 4.5: Net Allowable Bearing Pressures Pad Foundation

Profile No.	Minimum Embedment Below Existing Ground Level (meter)	Pad Foundation (kPa / tsf)
01	1.0	150.0 / 1.50
	1.5	200.0 / 2.00

Proper drainage shall be provided to avoid infiltration of water into the foundation soil. It should be ensured that the foundation is not placed on the fill material. The settlement of

pad and raft foundations due to net allowable pressure has been estimated to be within the allowable limit of 25mm (1-inch) and 50mm (2-inches), respectively.

4.3 MODULUS OF SUBGRADE REACTION

Designing of floor slab system requires the modulus of subgrade reaction at the depth at which it is to be placed. Table 4.6 shows the values of modulus of subgrade reaction for given pressure.

Table 4.6 Modulus of subgrade reaction based on allowable bearing pressure

Profile No.	Minimum Embedment below Existing Ground Level (meter)	k_s for Shallow Foundation (MN/m^3 / tcf)
01	1.0	18.0 / 54.0
	1.5	24.0 / 72.0
02	3.0	18.0 / 54.0
	4.0	21.0 / 63.0
	5.0	24.0 / 72.0

4.4 EARTH RETAINING STRUCTURE

All measures shall be taken to provide safety to adjacent structures. Properly designed earth retaining structure must be constructed prior to deep excavation.

Earth pressure parameters required for the design of structure to retain the excavation are given in *Table 4.7.*

Table 4.7 Earth pressure parameters

Strata	Φ' (Undisturbed)	k_a (Coefficient of active earth pressure)	k_p (Coefficient of passive earth pressure)
Sand	30°	0.333	3.000

4.5 DEEP FOUNDATIONS - ALLOWABLE PILE CAPACITIES

The ultimate compressive capacity, Q, for a given bored concrete pile penetration is taken as the sum of the skin friction on the pile wall, Qs, and the end bearing on the pile tip, Qp, so that:

$$Q = Q_s + Q_p = \Sigma f A_s + q A_p$$

Where A_s and A_p represent, respectively, the embedded surface and pile end area; f and q represent, respectively, the unit skin friction and unit end bearing. When computing ultimate tensile capacity, the end bearing term in the above equation is neglected. Therefore, the value of the ultimate tensile capacity is the same value as the ultimate compression capacity due to skin friction Qs.

The design parameters for calculating pile capacities have been derived from shear strength determination, through in-situ field tests and laboratory tests of collected rock samples. The results of analysis for 0.15, 0.20, 0.25 and 0.30 meter diameter drilled concrete piles are presented below in *Table 4.8.*

Table 4.8: Allowable Pile Capacities

Profile No.	Diameter (mm)	Length (m) below Existing Ground Level	Tension (kN)	Compression (kN)
02	150	2.0	2	9
		3.0	5	16
		4.0	9	25
		5.0	14	35
	200	2.0	3	15
		3.0	7	27
		4.0	12	40
		5.0	19	55
	250	2.0	4	22
		3.0	8	39

Profile No.	Diameter (mm)	Length (m) below Existing Ground Level	Tension (kN)	Compression (kN)
02	250	4.0	15	59
		5.0	24	80
	300	2.0	4	31
		3.0	10	55
		4.0	18	81
		5.0	29	110

The design approach followed is based on FOS and as per this design approach, the settlement criteria of “Net settlement not to exceed 1% of the pile diameter at working load and Total penetration of the base not to exceed 10% of the pile diameter at test load” shall be fulfilled.

4.6 RECOMMENDED DRILLING METHOD AND CONFIRMATORY TESTING

The recommended drilling method for the construction of bored cast in-situ piles is straight rotary. Tentative pile capacity values given in table 4.8 have been computed by static formulae which suffer from limitations. As such capacity values shall be verified by full scale load tests under the guidance of geotechnical engineer. Pile capacity shall be suitably adjusted if warranted by results of load tests. This report will be valid only if requirement of pile load tests is fulfilled.

The test pile should be loaded to 2.0 to 2.5 times the Specified Working Load (SWL) and the working pile should be loaded to 1.5 times the Specified Working Load (SWL). The calculations for allowable pile capacities for 150, 200, 250 and 300 mm diameter bored cast in-situ piles are presented in appendix E of this report.

4.7 PILE CONSTRUCTION

Allowable pile capacities have been derived from combination of end bearing and skin friction components. It is, therefore, essential to adopt the following construction methodology to satisfy following requirements:

1. Excessive disturbance to sub-surface along shaft and pile tip shall be avoided during the course of drilling.
2. The bottom of pile shall be cleaned of all loose materials which may accumulate during the course of drilling.

Pile concreting shall be undertaken only when above conditions are fulfilled. It is understood that subsurface materials will be carefully examined during pilling and it shall be ensured that all piles are placed in proper stratum. This exercise will serve as safeguard against variations in quality and level of occurrence of dense stratum.

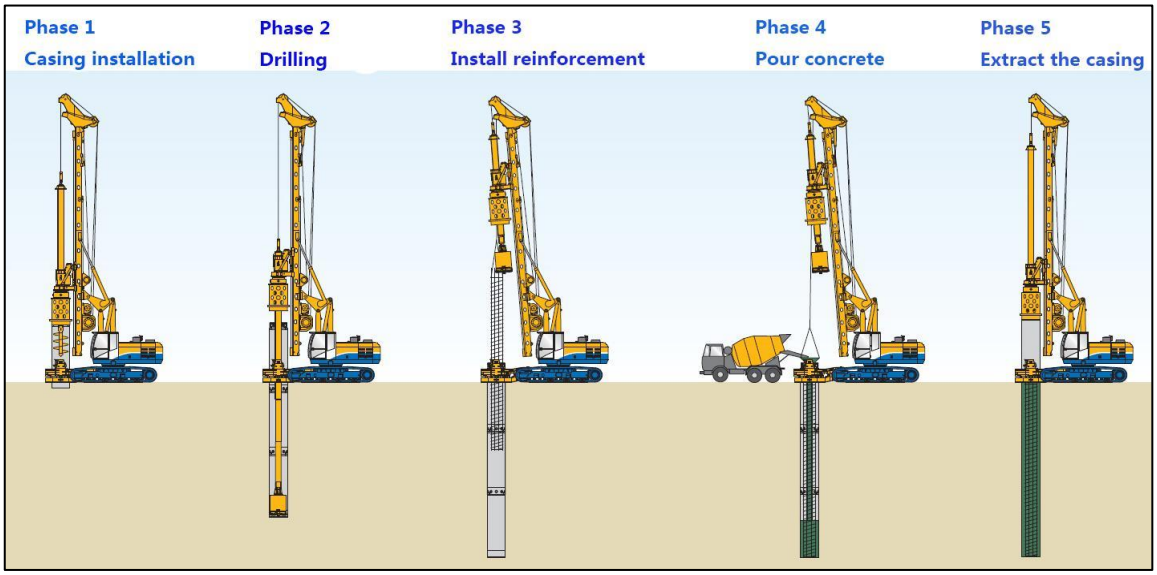


Fig 4.1: Construction of cast in situ piles by straight rotary

4.8 SEISMIC GROUND MOTION PARAMETERS (BCP – 2021)

4.8.1 SITE CLASS

Chapter 16 of BCP – 2021 defines the site class definition in accordance with Chapter 20 ASCE-7 to be used for determining site coefficients. Based on the field data obtained from sub-soil exploration, the soil class will be taken as **"S_C"**.

4.8.2 SHORT PERIOD SPECTRAL RESPONSE ACCELERATION (S_s)

Chapter 16 of BCP – 2021, Section 1613.2.1 deals with the mapped values for 0.2-seconds spectral acceleration corresponding to Maximum Considered Earthquake (MCE) defined as the ground motion level with 2% probability of exceedance in 50 years (2745 years return period). The S_s for project site will be taken as 0.8572.

4.8.3 LONG PERIOD SPECTRAL RESPONSE ACCELERATION (S_1)

Chapter 16 of BCP – 2021, Section 1613.2.1 deals with the mapped values for 1-second spectral acceleration corresponding to Maximum Considered Earthquake (MCE) defined as the ground motion level with 2% probability of exceedance in 50 years (2745 years return period). The S_1 for project site will be taken as 0.2268.

4.9 TYPE OF CEMENT

Tests on collected samples obtained from the boreholes indicate '*negligible'* exposure to sulphate and chloride. Under these conditions it is recommended to use *Ordinary Portland Cement (OPC)* for all underground concrete works.

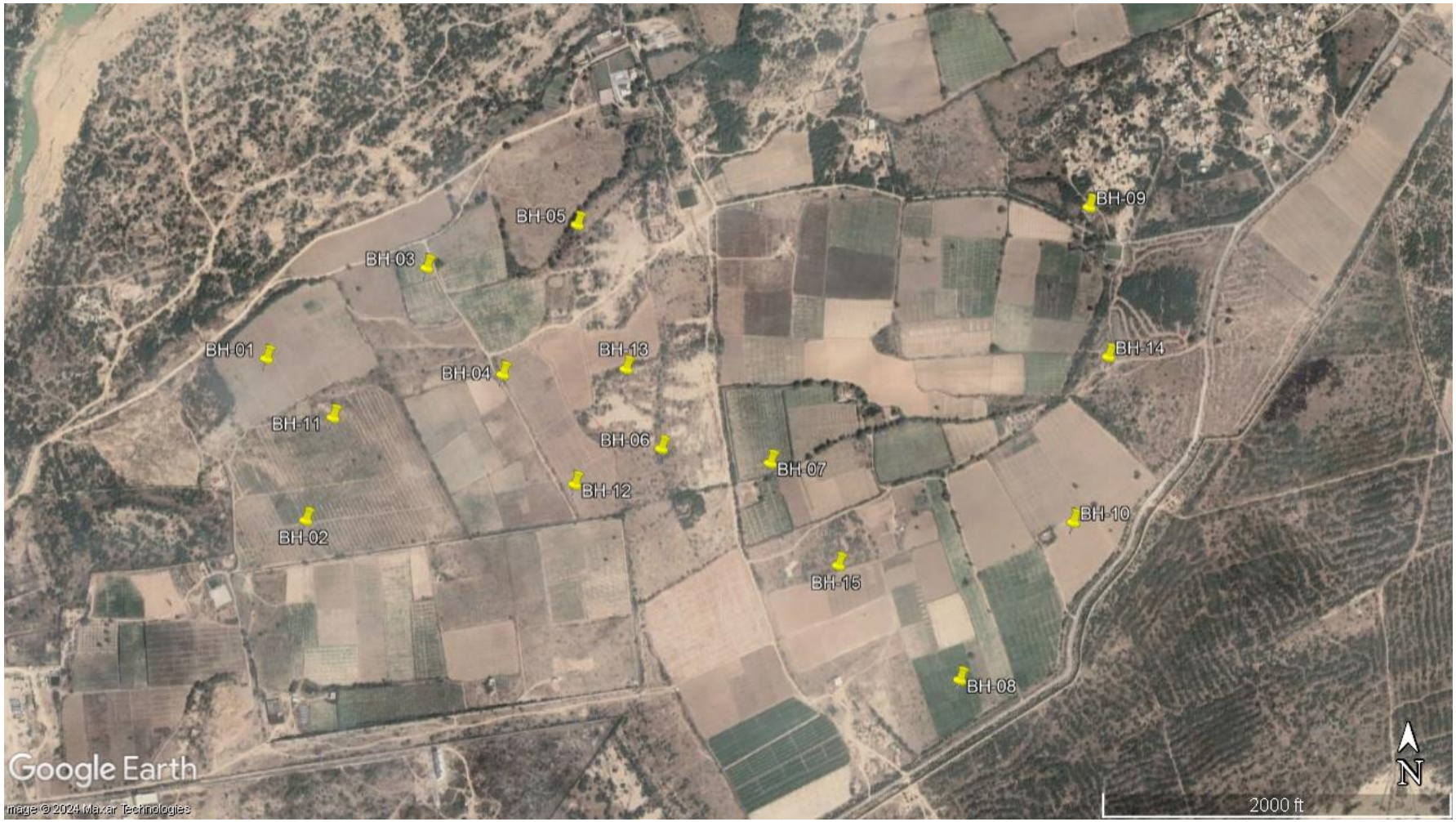
5. CONCLUSIONS

Geotechnical Investigation for Installation of Solar Power Plant and WTGs at Education City, Deh-Chuhur, Gadap, Malir, Karachi was carried out in order to determine geotechnical parameters of subsurface deposits. Scope of work included fifteen (15) boreholes; ten (10) up to the depth of 5.0 meters and five (05) up to the depth of 15.0 meters below existing ground level. Soil and rock samples were collected during the field investigation. Laboratory testing on these samples has been carried out in the lab and includes determination of index properties through grain-size analysis, natural moisture content & density etc. Chemical characteristics of soil and rock samples have also been assessed through determination of sulphate content, chloride content and pH.

Keeping in view, the results from field and laboratory tests and the expected loads being transferred to the founding stratum, recommendations for both shallow foundation and deep foundation are provided. Exposure to chloride and sulphate salts is '*negligible'* for collected samples*,* therefore, *Ordinary Portland Cement (OPC)* may be used for all underground concreting works.

Appendix A

Borehole Location Plan



Client:

Education City

Borehole Location Plan

S-24-1022

Geotechnical Investigation for Installation of Solar Power Plant and WTGs at Education City, Deh-Chuhur, Gadap, Malir, Karachi

Soil Testing Services

Appendix B

Borehole Logs

Mud Rotary Log BH - 01

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 07.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt & gravel*			0																						0	
1		U		* 50		1	SM A-2-4(0)	16.4	68.5	15.1		NLL	-	NPI	5.9	1.68	1.8								7.4	0.013	0.22	1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt, traces of gravel*	* 50		3	SW-SM A-2-4(0)	8.4	79.9	11.7		NLL	-	NPI	7.2	1.71	1.8											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-02

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 08.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, dense to very dense, fine to coarse grained, little silt, traces to little gravel*			0																						0	
1		U		* 43		1	SM A-2-4(0)	2.1	79.4	18.5		NLL	-	NPI	7.2	1.67	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U		* 50		3	SM A-2-4(0)	12.4	74.5	13.1		NLL	-	NPI	8	1.75	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
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- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-03

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 06.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt, traces of gravel*			0																						0	
1		U		* 50		1	SW-SM A-2-4(0)	3.6	84.7	11.7		NLL	-	NPI	8.1	1.71	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt & gravel*	* 50		3	SM A-2-4(0)	12.1	69.3	18.6		NLL	-	NPI	9.1	1.74	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
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- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-04

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 07.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, medium dense, silty, fine grained, traces of gavel*			0																						0	
1		U		* 29		1	SM A-4(0)	1.1	61.3	37.6		NLL	-	NPI	10.5	1.65	1.8											1	SPT - 1
2		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, some silt, traces of gravel*	* 50		2																						2	SPT - 2
3		U		* 50		3	SM A-2-4(0)	7.8	71.5	20.7		NLL	-	NPI	7.6	1.72	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
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- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-05

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 07.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt & gravel*			0																						0	
1		U		* 50		1	SP-SM A-2-4(0)	14.9	74	11.1		NLL	-	NPI	6.9	1.68	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, some silt, little gravel*	* 50		3																						3	SPT - 3
4		U		* 50		4	SM A-2-4(0)	18.9	59.9	21.2		NLL	-	NPI	7.5	1.78	1.9											4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
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- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-06

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 01.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, traces of silt & gravel*			0																						0	
1		U		* 50		1	SP-SM A-2-4(0)	2.6	89.5	7.9		NLL	-	NPI	8.5	1.7	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fineto coarse grained, little silt, traces of gravel*	* 50		3	SM A-2-4(0)	9.1	78.1	12.8		NLL	-	NPI	9.9	1.73	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
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- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-07

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 01.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little to some silt, traces to little gravel*			0																						0	
1		U		* 50		1	SM A-2-4(0)	15.1	70.4	14.5		NLL	-	NPI	6.3	1.69	1.8								7.4	0.016	0.25	1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U		* 50		3	SM A-2-4(0)	6.4	70.1	23.5		NLL	-	NPI	10.1	1.73	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
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- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-08

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 02.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, traces to little silt, traces of gravel*			0																						0	
1		U		* 50		1	SP-SM A-2-4(0)	8.4	80.7	10.9		NLL	-	NPI	6.6	1.71	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U		* 50		3	SP-SM A-2-4(0)	3.4	87.4	9.2		NLL	-	NPI	9.2	1.75	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
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- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-09

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 08.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, dense to very dense, fine to medium grained, some silt, traces of gravel*			0																						0	
1		U		* 45		1	SM A-2-4(0)	1.2	71.3	27.5		NLL	-	NPI	10.3	1.67	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little gravel, traces of silt*	* 50		3																						3	SPT - 3
4		U		* 50		4	SW-SM A-2-4(0)	11.7	79.3	9		NLL	-	NPI	8.1	1.72	1.9											4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-10

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 5 (m)
GWL : - (m)
Drill Date : 06.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little to some silt, traces to little gravel*			0																						0	
1		U		* 50		1	SM A-2-4(0)	3.9	74	22.1		NLL	-	NPI	6.1	1.7	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U		* 50		3	SM A-2-4(0)	18.7	66.7	14.6		NLL	-	NPI	10	1.75	1.9											3	SPT - 3
4		U		* 50		4																						4	SPT - 4
5		U	End of Log @ 5 (m)	* 50		5																						5	SPT - 5

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-11

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m)
GWL : - (m)
Drill Date : 09.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	USCS / AASHTO	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, medium dense to dense, silty, fine grained, traces of gravel*																								0	
1		U		* 30		SM A-4(0)	1.1	60.3	38.6		NLL	-	NPI	11.1	1.66	1.8											1	SPT - 1
2		U		* 43																							2	SPT - 2
3		U	**SAND** *Yellowish brown, dense to very dense, fine to coarse grained, little silt & gravel*	* 46																							3	SPT - 3
4		U		* 50		SM A-2-4(0)	14.1	73.1	12.8		NLL	-	NPI	8.1	1.69	1.8											4	SPT - 4
5		U		* 50																							5	SPT - 5
6		U		* 50																							6	SPT - 6
7		U	**SAND** *Yellowish brown, medium dense to very dense, fine to coarse grained, some gravel, little silt*	* 50		SW-SM A-2-4(0)	21.4	67.4	11.2		NLL	-	NPI	12.6	1.68	1.9											7	SPT - 7
8																											8	
9		U		* 20																							9	SPT - 8
10																											10	

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-11

Project Info.

Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.

Depth : 15 (m)
GWL : - (m)
Drill Date : 09.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.

Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
10		U	**SAND** *Yellowish brown, medium dense to very dense, fine to coarse grained, some gravel, little silt*	* 30		10																						10	SPT - 9
11						11																						11	
12		U	**SAND** *Yellowish brown, dense to very dense, fine to coarse grained, some silt, traces of gravel*	* 38		12	SM A-2-4(0)	3.4	76.5	20.1		NLL	-	NPI	9.3	1.72	1.9											12	SPT - 10
13		U		* 50		13																						13	SPT - 11
14						14																						14	
15		U	End of Log @ 15 (m)	* 50		15																						15	SPT - 12

Sample Types: Disturbed; Undisturbed; Shelby / U4; Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Comp. Qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

Mud Rotary Log BH-12

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m)
GWL : - (m)
Drill Date : 08.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, dense to very dense, fine to coarse grained, some silt, traces of gravel, little clay at places*			0																						0	
1		U		* 45		1	SM A-2-4(0)	6.4	69.2	24.4		NLL	-	NPI	10.6	1.72	1.9								7.3	0.012	0.29	1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, some gravel, little silt*	* 50		3																						3	SPT - 3
4		U		* 50		4	SW-SM A-2-4(0)	22.3	66.6	11.1		NLL	-	NPI	9.1	1.76	1.9											4	SPT - 4
5		U		* 50		5																						5	SPT - 5
6		U		* 50		6																						6	SPT - 6
7		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little gravel, traces of silt*	* 50		7	SP-SM A-2-4(0)	14.5	77.7	7.8		NLL	-	NPI	13.4	1.77	2											7	SPT - 7
8						8																						8	
9		U		* 50		9																						9	SPT - 8
10						10																						10	

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-12

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m) Elevation : Equal to Exist. R/L
GWL : - (m) Easting :
Drill Date : 08.02.2024 Northing :
Logged By : MSA Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sieve Analysis Test: Sand (%)	Sieve Analysis Test: Silt (%)	Sieve Analysis Test: Clay (%)	Atterberg Limits: LL (%)	Atterberg Limits: PL (%)	Atterberg Limits: PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	Direct Shear Test: C (kg/cm2)	Direct Shear Test: Fi (o)	qu (kg/cm2)	Consolidation: Cc	Consolidation: Cs	Consolidation: Pc (kg/cm2)	Chemical Tests: PH	Chemical Tests: SO3	Chemical Tests: CL	Depth (m)	Remarks & Comments
10		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little gravel, traces of silt*	* 50		10																						10	SPT - 9
11						11																						11	
12		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little gravel, traces of silt*	* 50		12	SW-SM A-2-4(0)	18.7	71.9	9.4		NLL	-	NPI	16.2	1.7	2												12	SPT - 10
13		U		* 50		13																						13	SPT - 11
14						14																						14	
15		U	End of Log @ 15 (m)	* 50		15																						15	SPT - 12

Sample Types
- ● Disturbed
- + Undisturbed
- ☐ Shelby / U4
- ■ Core Cutter
- SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-13

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m)
GWL : - (m)
Drill Date : 02.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt, traces to little gravel*			0																						0	
1		U		* 50		1	SM A-2-4(0)	6.4	80.3	13.3		NLL	-	NPI	7.8	1.69	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U		* 50		3																						3	SPT - 3
4		U		* 50		4	SM A-2-4(0)	11.2	74.2	14.6		NLL	-	NPI	11.2	1.75	1.9											4	SPT - 4
5		U		* 50		5																						5	SPT - 5
6		U		* 50		6																						6	SPT - 6
7		■	**SANDSTONE** *Grey to brownish grey, extremely weak, distinctly weathered, loosely cemented, poorly compacted, very poor quality of friable*			7																						7	Run - 1
8		+				8									5.6	1.97	2.1				7.41							8	CR - 30% / RQD - 10% UDC - 1 (7.80 - 7.95m)
9		■				9																						9	Run - 2 CR - 41% / RQD - Nil
10						10																						10	

Sample Types
● Disturbed
+ Undisturbed
☐ Shelby / U4
■ Core Cutter
U SPT Sample
Water Sample
Groundwater Level

Abbreviations
LL : Liquid Limit
PL : Plastic Limit
PI : Plastic Index
NPI : None PI
C : Cohesion
Phi : Friction Angle
C' : Cohesion (CU)
Phi' : Friction Angle (CU)
Cc : Cc
Cs : Cs
Pc : Pre-Consolidation Pressure
K : Permeability Coeff.
w : Moisture Content
qu : Unconfined Comp. Qu
F : Fast
S : Slow
CD : Consolidated, Drained
UU : Unconsolidated, Undrained
CU : Consolidated, Undrained

Mud Rotary Log BH-13

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth: 15 (m)
GWL: - (m)
Drill Date: 02.02.2024
Logged By: MSA
Elevation: Equal to Exist. R/L
Easting:
Northing:
Method: Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
10		■	**SANDSTONE** *Grey to brownish grey, extremely weak, distinctly weathered, loosely cemented, poorly compacted, very poor quality of friable*			10																						10	Run - 3 CR - 20% / RQD - Nil
11						11																						11	
12		■				12									6	2.06	2.2				9.46							12	Run - 4 CR - 46% / RQD - 18% UDC - 2 (12.50 - 12.61m)
13		+				13																						13	
14		U				14																						14	Run - 5 CR - 34% / RQD - 13% UDC - 3 (13.90 - 14.01m)
15		+	End of Log @ 15 (m)			15																						15	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; U SPT Sample; Water Sample; ▽ Groundwater Level

Abbreviations:
LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI
C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU)
Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.
w : Moisture Content; qu : Unconfined Comp. Qu; F : Fast; S : Slow
CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

Mud Rotary Log BH-14

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m)
GWL : - (m)
Drill Date : 09.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, medium dense to dense, silty, fine grained,*			0																						0	
1		U		* 12		1	SM A-2-4(0)		69.2	30.8		NLL	-	NPI	10.3	1.64	1.8											1	SPT - 1
2		U		* 26		2																						2	SPT - 2
3		U		* 31		3																						3	SPT - 3
4		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little to some silt, traces of gravel*	* 50		4	SM A-2-4(0)	6.4	81.2	12.4		NLL	-	NPI	8.5	1.71	1.9											4	SPT - 4
5		U		* 50		5																						5	SPT - 5
6		U		* 50		6																						6	SPT - 6
7		U		* 50		7	SM A-2-4(0)	1.8	68.4	29.8		NLL	-	NPI	10.4	1.77	2											7	SPT - 7
8						8																						8	
9		U		* 50		9																						9	SPT - 8
10						10																						10	

Sample Types
- Disturbed
- Undisturbed
- Shelby / U4
- Core Cutter
- SPT Sample
- Water Sample
- Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-14

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m)
GWL : - (m)
Drill Date : 09.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
10		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little to some silt, traces of gravel*	* 50		10																						10	SPT - 9
11						11																						11	
12		U		* 50		12	SM A-2-4(0)	5.7	81.3	13		NLL	-	NPI	16.8	1.71	2											12	SPT - 10
13						13																						13	
14		U		* 50		14																						14	SPT - 11
15			End of Log @ 15 (m)			15																						15	
		U		* 50																									SPT - 12

Sample Types
- ● Disturbed
- + Undisturbed
- ☐ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-15

Project Info.
Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.
Depth : 15 (m)
GWL : - (m)
Drill Date : 05.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.
Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
0			**SAND** *Yellowish brown, very dense, fine to coarse grained, little silt, traces of gravel*			0																						0	
1		U		* 50		1	SW-SM A-2-4(0)	6.7	81.8	11.5		NLL	-	NPI	6	1.73	1.8											1	SPT - 1
2		U		* 50		2																						2	SPT - 2
3		U	**SAND** *Yellowish brown, very dense, fine to coarse grained, little to some silt, traces of gravel*	* 50		3																						3	SPT - 3
4		U		* 50		4	SM A-2-4(0)	3.6	72.5	23.9		NLL	-	NPI														4	SPT - 4
5		U		* 50		5									11.1	1.7	1.9											5	SPT - 5
6		U		* 50		6																						6	SPT - 6
7		U		* 50		7	SM A-2-4(0)	2.1	84.2	13.7		NLL	-	NPI	9.1	1.74	1.9											7	SPT - 7
8						8																						8	
9		U		* 50		9																						9	SPT - 8
10						10																						10	

Sample Types
- ● Disturbed
- + Undisturbed
- ☐ Shelby / U4
- ■ Core Cutter
- U SPT Sample
- Water Sample
- ▽ Groundwater Level

Abbreviations
- LL : Liquid Limit
- PL : Plastic Limit
- PI : Plastic Index
- NPI : None PI
- C : Cohesion
- Phi : Friction Angle
- C' : Cohesion (CU)
- Phi' : Friction Angle (CU)
- Cc : Cc
- Cs : Cs
- Pc : Pre-Consolidation Pressure
- K : Permeability Coeff.
- w : Moisture Content
- qu : Unconfined Comp. Qu
- F : Fast
- S : Slow
- CD : Consolidated, Drained
- UU : Unconsolidated, Undrained
- CU : Consolidated, Undrained

Mud Rotary Log BH-15

Project Info.

Project : Geotechnical Investigation Works
Client : Education City
Location : Gadap, Karachi
Job No. : S-24-1022

Borehole Info.

Depth : 15 (m)
GWL : - (m)
Drill Date : 05.02.2024
Logged By : MSA
Elevation : Equal to Exist. R/L
Easting :
Northing :
Method : Mud Rotary

Company Info.

Geotechnical Engineers & Material Testing Laboratory
www.sts.com.pk

Depth (m)	GWL (m)	Sample Type	Lithology Description	Field Tests (* SPT 10 20 30 40 50)	Symbol	Depth (m)	USCS / AASHTO	Sieve Analysis Test: Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Atterberg Limits: LL (%)	PL (%)	PI (%)	w (%)	Dry Unit Weight (gr/cm3)	Bulk	Direct Shear Test: Test Type	C (kg/cm2)	Fi (o)	qu (kg/cm2)	Consolidation: Cc	Cs	Pc (kg/cm2)	Chemical Tests: PH	SO3	CL	Depth (m)	Remarks & Comments
10		■	**SANDSTONE** *Grey to brownish grey, extremely weak, distinctly weathered, loosely cemented, poorly compacted, very poor quality of friable*			10																						10	Run - 1 CR - 35% / RQD - 18% UDC - 1 (11.15 - 11.27m)
11		+				11																						11	
12		■				12																						12	Run - 2 CR - 46% / RQD - 8% UDC - 2 (13.30 - 13.40m)
13		+ ■				13									6.7	2.05	2.2				9.01							13	Run - 3 CR - 39% / RQD - Nil
14						14																						14	
15			End of Log @ 15 (m)			15																						15	

Sample Types: ● Disturbed; + Undisturbed; ☐ Shelby / U4; ■ Core Cutter; SPT Sample; Water Sample; Groundwater Level

Abbreviations: LL : Liquid Limit; PL : Plastic Limit; PI : Plastic Index; NPI : None PI; C : Cohesion; Phi : Friction Angle; C' : Cohesion (CU); Phi' : Friction Angle (CU); Cc : Cc; Cs : Cs; Pc : Pre-Consolidation Pressure; K : Permeability Coeff.; w : Moisture Content; qu : Unconfined Comp. Qu; F : Fast; S : Slow; CD : Consolidated, Drained; UU : Unconsolidated, Undrained; CU : Consolidated, Undrained

Appendix C

Laboratory Test Results

Summary of Lab. Tests

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Sieve Analysis Test

Borehole	Sample Depth (m)	Soil Class	D10 mm	D30 mm	D60 mm	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Cobble (%)	LL	PL
BH - 01	1	SM A-2-4(0)		0.405	1.378		15.1	68.5	16.4		-	-
BH - 01	3	SW-SM A-2-4(0)		0.422	1.573		11.7	79.9	8.4		-	-
BH-02	1	SM A-2-4(0)		0.455	1.335		18.5	79.4	2.1		-	-
BH-02	3	SM A-2-4(0)		0.275	1.012		13.1	74.5	12.4		-	-
BH-03	1	SW-SM A-2-4(0)		0.335	1.381		11.7	84.7	3.6		-	-
BH-03	3	SM A-2-4(0)		0.222	1.054		18.6	69.3	12.1		-	-
BH-04	1	SM A-4(0)			0.159		37.6	61.3	1.1		-	-
BH-04	3	SM A-2-4(0)		0.302	1.188		20.7	71.5	7.8		-	-
BH-05	1	SP-SM A-2-4(0)		0.268	1.815		11.1	74	14.9		-	-
BH-05	4	SM A-2-4(0)		0.375	1.857		21.2	59.9	18.9		-	-
BH-06	1	SP-SM A-2-4(0)	0.084	0.22	0.673		7.9	89.5	2.6		-	-
BH-06	3	SM A-2-4(0)		0.159	0.62		12.8	78.1	9.1		-	-
BH-07	1	SM A-2-4(0)		0.21	2.161		14.5	70.4	15.1		-	-
BH-07	3	SM A-2-4(0)		0.158	0.784		23.5	70.1	6.4		-	-
BH-08	1	SP-SM A-2-4(0)		0.197	0.624		10.9	80.7	8.4		-	-
BH-08	3	SP-SM A-2-4(0)	0.078	0.176	0.512		9.2	87.4	3.4		-	-
BH-09	1	SM A-2-4(0)		0.084	0.233		27.5	71.3	1.2		-	-
BH-09	4	SW-SM A-2-4(0)	0.091	0.476	1.499		9	79.3	11.7		-	-
BH-10	1	SM A-2-4(0)		0.113	0.694		22.1	74	3.9		-	-
BH-10	3	SM A-2-4(0)		0.486	2.526		14.6	66.7	18.7		-	-
BH-11	1	SM A-4(0)			0.155		38.6	60.3	1.1		-	-
BH-11	4	SM A-2-4(0)		0.483	1.955		12.8	73.1	14.1		-	-
BH-11	7.5	SW-SM A-2-4(0)		0.652	2.437		11.2	67.4	21.4		-	-
BH-11	12	SM A-2-4(0)		0.224	1.42		20.1	76.5	3.4		-	-
BH-12	1	SM A-2-4(0)		0.102	0.799		24.4	69.2	6.4		-	-
BH-12	4	SW-SM A-2-4(0)		0.467	2.432		11.1	66.6	22.3		-	-

Summary of Lab. Tests

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Borehole	Sample Depth (m)	Soil Class	D10 mm	D30 mm	D60 mm	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Cobble (%)	LL	PL
BH-12	7.5	SP-SM A-2-4(0)	0.095	0.418	2.086		7.8	77.7	14.5		-	-
BH-12	12	SW-SM A-2-4(0)	0.084	0.498	2.097		9.4	71.9	18.7		-	-
BH-13	1	SM A-2-4(0)		0.482	1.533		13.3	80.3	6.4		-	-
BH-13	4	SM A-2-4(0)		0.362	1.893		14.6	74.2	11.2		-	-
BH-14	1	SM A-2-4(0)			0.177		30.8	69.2			-	-
BH-14	4	SM A-2-4(0)		0.387	1.579		12.4	81.2	6.4		-	-
BH-14	7.5	SM A-2-4(0)		0.076	0.914		29.8	68.4	1.8		-	-
BH-14	12	SM A-2-4(0)		0.175	1.05		13	81.3	5.7		-	-
BH-15	1	SW-SM A-2-4(0)		0.381	1.327		11.5	81.8	6.7		-	-
BH-15	4	SM A-2-4(0)		0.098	0.867		23.9	72.5	3.6		-	-
BH-15	7.5	SM A-2-4(0)		0.174	1.37		13.7	84.2	2.1		-	-

Density & Moisture Test

Borehole	Sample Depth (m)	Soil Class	Moisture Content (%)	Dry Density (gr/cm3)
BH - 01	1	SM A-2-4(0)	5.89	1.68
BH - 01	3	SW-SM A-2-4(0)	7.22	1.71
BH-02	1	SM A-2-4(0)	7.19	1.67
BH-02	3	SM A-2-4(0)	8.03	1.75
BH-03	1	SW-SM A-2-4(0)	8.13	1.71
BH-03	3	SM A-2-4(0)	9.08	1.74
BH-04	1	SM A-4(0)	10.49	1.65
BH-04	3	SM A-2-4(0)	7.62	1.72
BH-05	1	SP-SM A-2-4(0)	6.87	1.68
BH-05	4	SM A-2-4(0)	7.49	1.78
BH-06	1	SP-SM A-2-4(0)	8.52	1.7
BH-06	3	SM A-2-4(0)	9.95	1.73
BH-07	1	SM A-2-4(0)	6.31	1.69
BH-07	3	SM A-2-4(0)	10.05	1.73

Summary of Lab. Tests

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Borehole	Sample Depth (m)	Soil Class	Moisture Content (%)	Dry Density (gr/cm3)
BH-08	1	SP-SM A-2-4(0)	6.59	1.71
BH-08	3	SP-SM A-2-4(0)	9.16	1.75
BH-09	1	SM A-2-4(0)	10.28	1.67
BH-09	4	SW-SM A-2-4(0)	8.06	1.72
BH-10	1	SM A-2-4(0)	6.11	1.7
BH-10	3	SM A-2-4(0)	10.03	1.75
BH-11	1	SM A-4(0)	11.13	1.66
BH-11	4	SM A-2-4(0)	8.05	1.69
BH-11	7.5	SW-SM A-2-4(0)	12.59	1.68
BH-11	12	SM A-2-4(0)	9.34	1.72
BH-12	1	SM A-2-4(0)	10.58	1.72
BH-12	4	SW-SM A-2-4(0)	9.06	1.76
BH-12	7.5	SP-SM A-2-4(0)	13.39	1.77
BH-12	12	SW-SM A-2-4(0)	16.18	1.7
BH-13	1	SM A-2-4(0)	7.76	1.69
BH-13	4	SM A-2-4(0)	11.17	1.75
BH-13	7.8		5.6	1.97
BH-13	12.61		6	2.06
BH-14	1	SM A-2-4(0)	10.27	1.64
BH-14	4	SM A-2-4(0)	8.53	1.71
BH-14	7.5	SM A-2-4(0)	10.38	1.77
BH-14	12	SM A-2-4(0)	16.82	1.71
BH-15	1	SW-SM A-2-4(0)	5.97	1.73
BH-15	5		11.13	1.7
BH-15	7.5	SM A-2-4(0)	9.06	1.74
BH-15	13.3		6.7	2.05

Unconfined Compression Test

Borehole	Sample Depth (m)	Soil Class	Diameter (cm)	Height (cm)	qu (kg/cm2)
BH-13	7.8		5.263	9.652	7.41

Summary of Lab. Tests

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Borehole	Sample Depth (m)	Soil Class	Diameter (cm)	Height (cm)	qu (kg/cm2)
BH-13	12.61		5.24	9.682	9.46
BH-15	13.3		5.236	10.024	9.01

Chemical Test Results

Borehole	Sample Depth (m)	Soil Class	#	Value
BH - 01	1	SM A-2-4(0)	9	0.22
BH - 01	1	SM A-2-4(0)	6	0.013
BH - 01	1	SM A-2-4(0)	2	7.39
BH-07	1	SM A-2-4(0)	9	0.25
BH-07	1	SM A-2-4(0)	6	0.016
BH-07	1	SM A-2-4(0)	2	7.41
BH-12	1	SM A-2-4(0)	9	0.29
BH-12	1	SM A-2-4(0)	6	0.012
BH-12	1	SM A-2-4(0)	2	7.34

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

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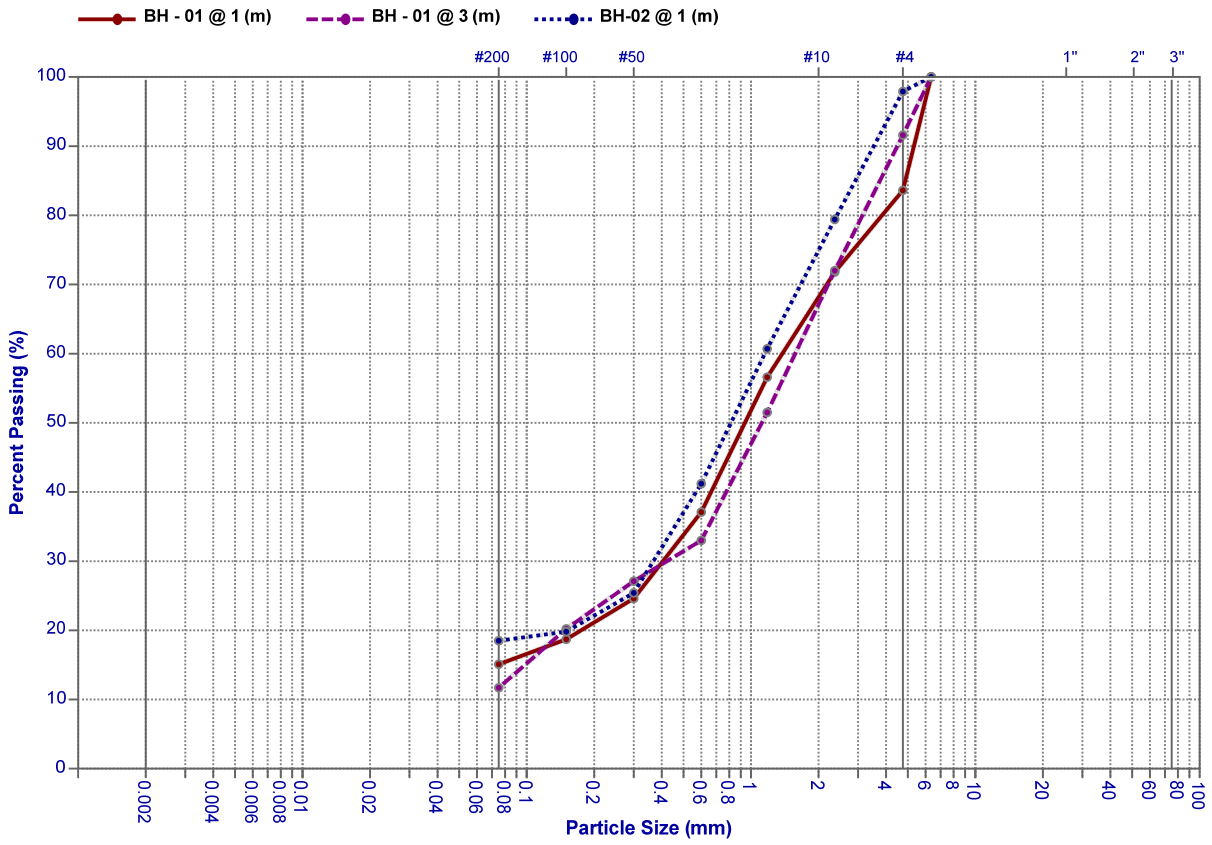

Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	15.1	68.5	16.4	-
-	11.7	79.9	8.4	-
-	18.5	79.4	2.1	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH - 01	1	-	0.405	0.939	1.378	1.566	-	-	-	N/A	SM	A-2-4(0)
BH - 01	3	-	0.422	1.117	1.573	1.49	-	-	-	N/A	SW-SM	A-2-4(0)
BH-02	1	-	0.367	0.814	1.152	1.559	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

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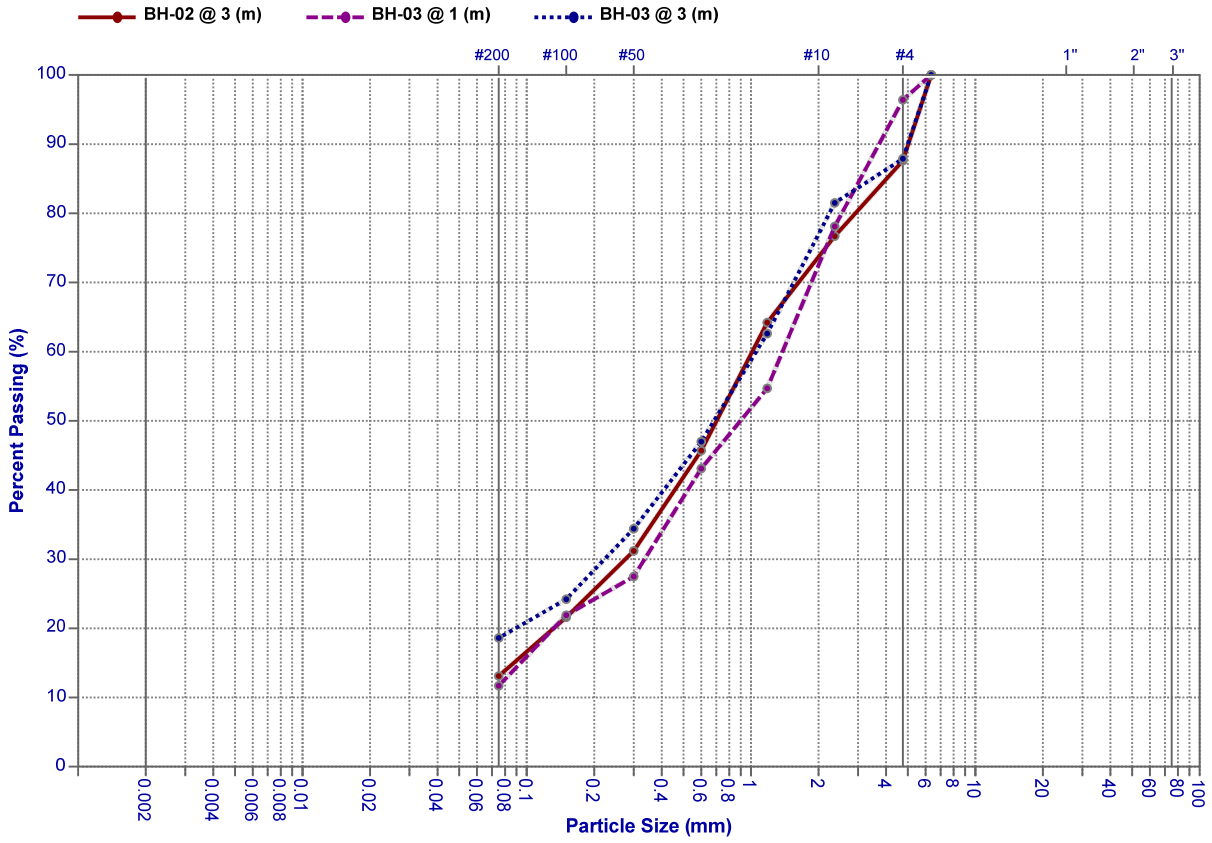

Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	13.1	74.5	12.4	-
-	11.7	84.7	3.6	-
-	18.6	69.3	12.1	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-02	3	-	0.275	0.702	1.012	0.983	-	-	-	N/A	SM	A-2-4(0)
BH-03	1	-	0.335	0.897	1.381	1.069	-	-	-	N/A	SW-SM	A-2-4(0)
BH-03	3	-	0.222	0.683	1.054	0.623	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

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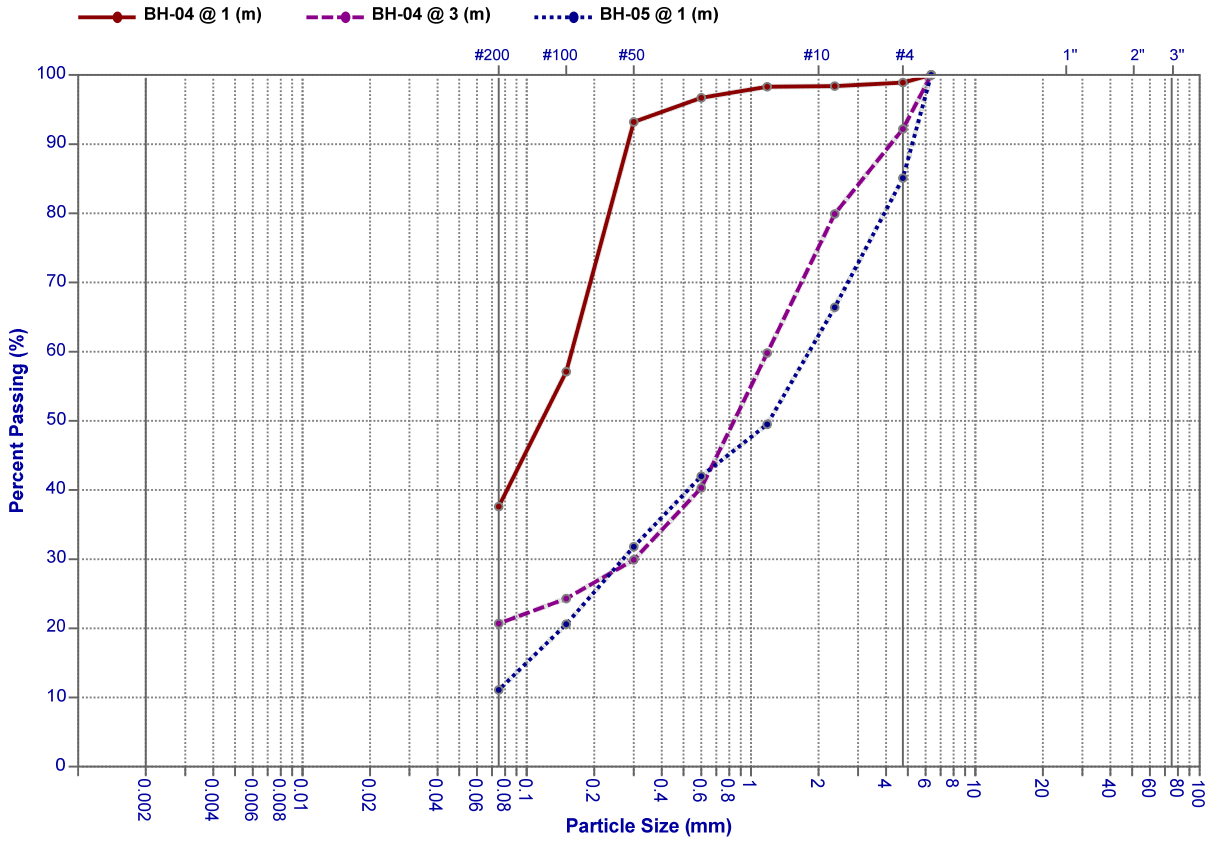

Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	37.6	61.3	1.1	-
-	20.7	71.5	7.8	-
-	11.1	74	14.9	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-04	1	-	-	0.117	0.159	-	-	-	-	N/A	SM	A-4(0)
BH-04	3	-	0.302	0.84	1.188	1.024	-	-	-	N/A	SM	A-2-4(0)
BH-05	1	-	0.268	1.204	1.815	0.521	-	-	-	N/A	SP-SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

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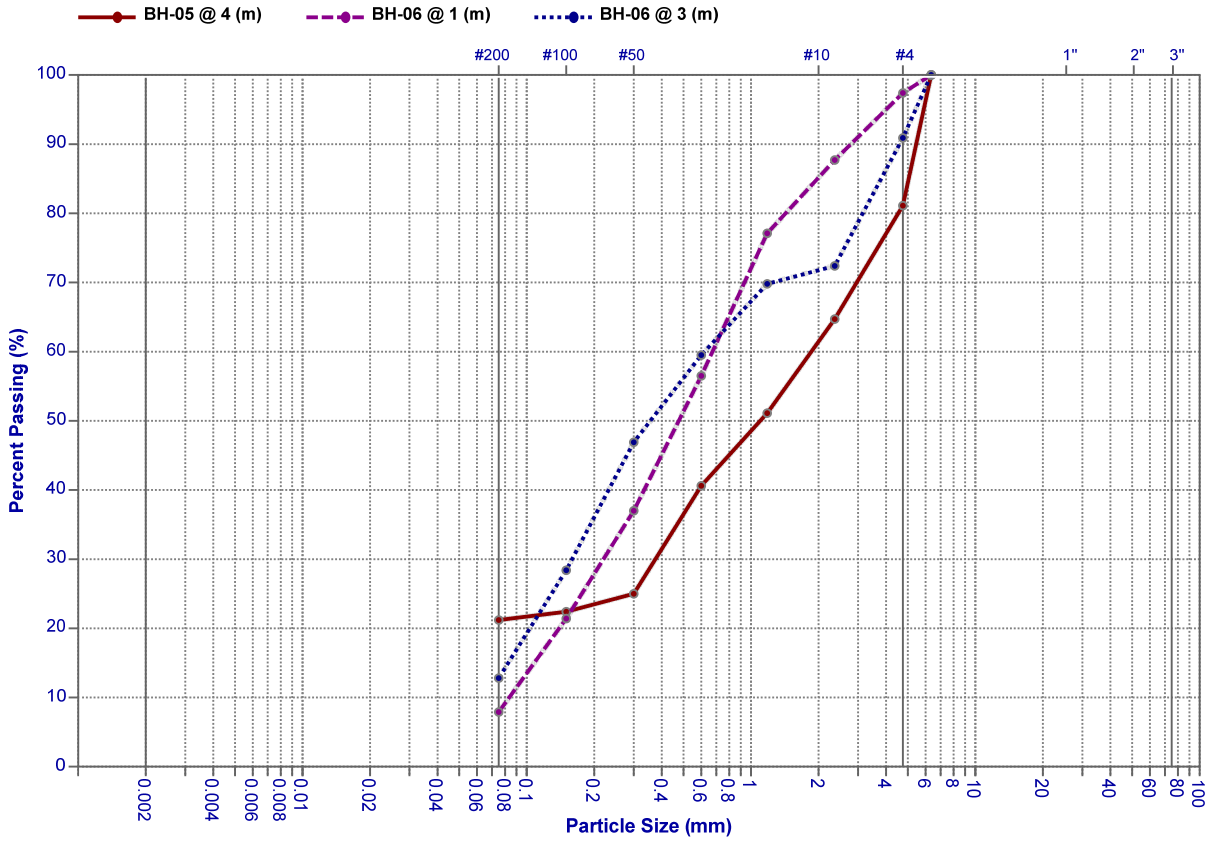

Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	21.2	59.9	18.9	-
-	7.9	89.5	2.6	-
-	12.8	78.1	9.1	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-05	4	-	0.375	1.099	1.857	1.01	-	-	-	N/A	SM	A-2-4(0)
BH-06	1	0.084	0.22	0.476	0.673	0.856	8.012	-	-	N/A	SP-SM	A-2-4(0)
BH-06	3	-	0.159	0.356	0.62	0.537	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

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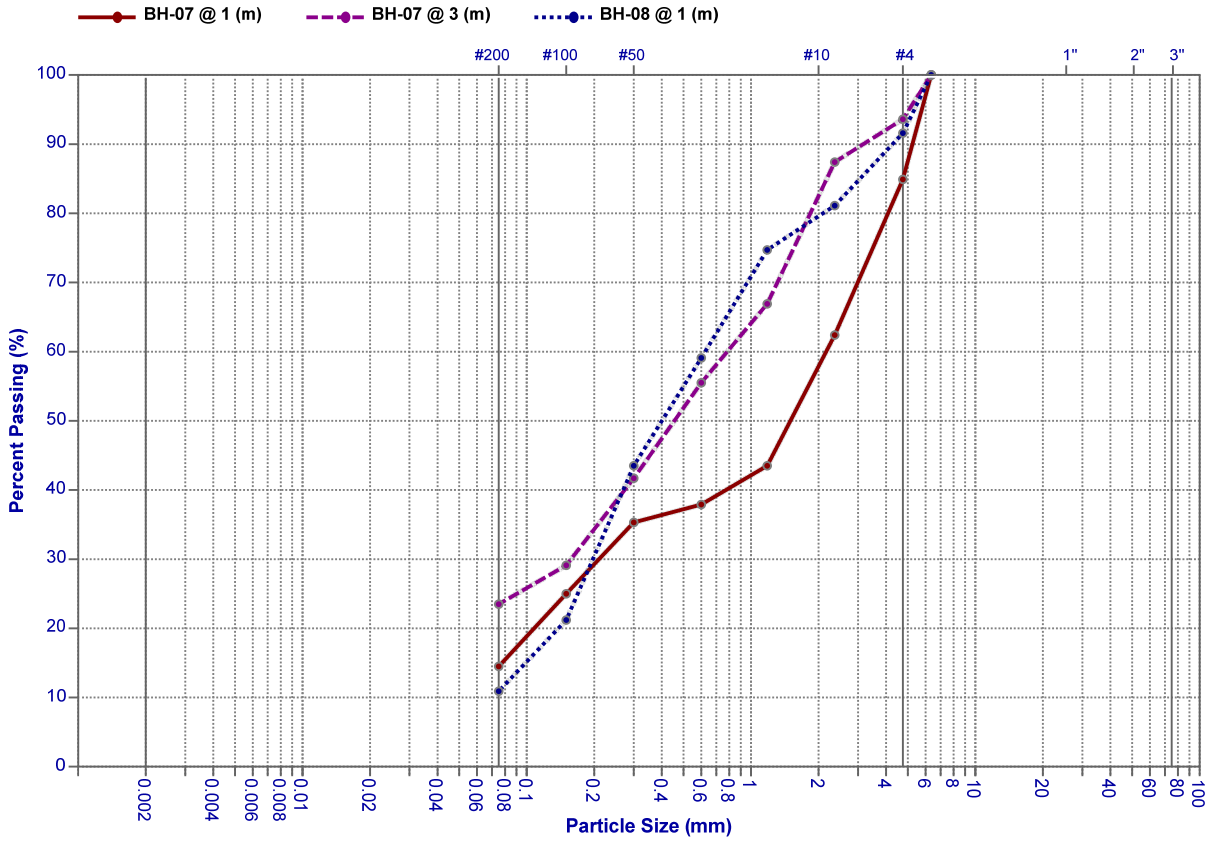


Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	14.5	70.4	15.1	-
-	23.5	70.1	6.4	-
-	10.9	80.7	8.4	-

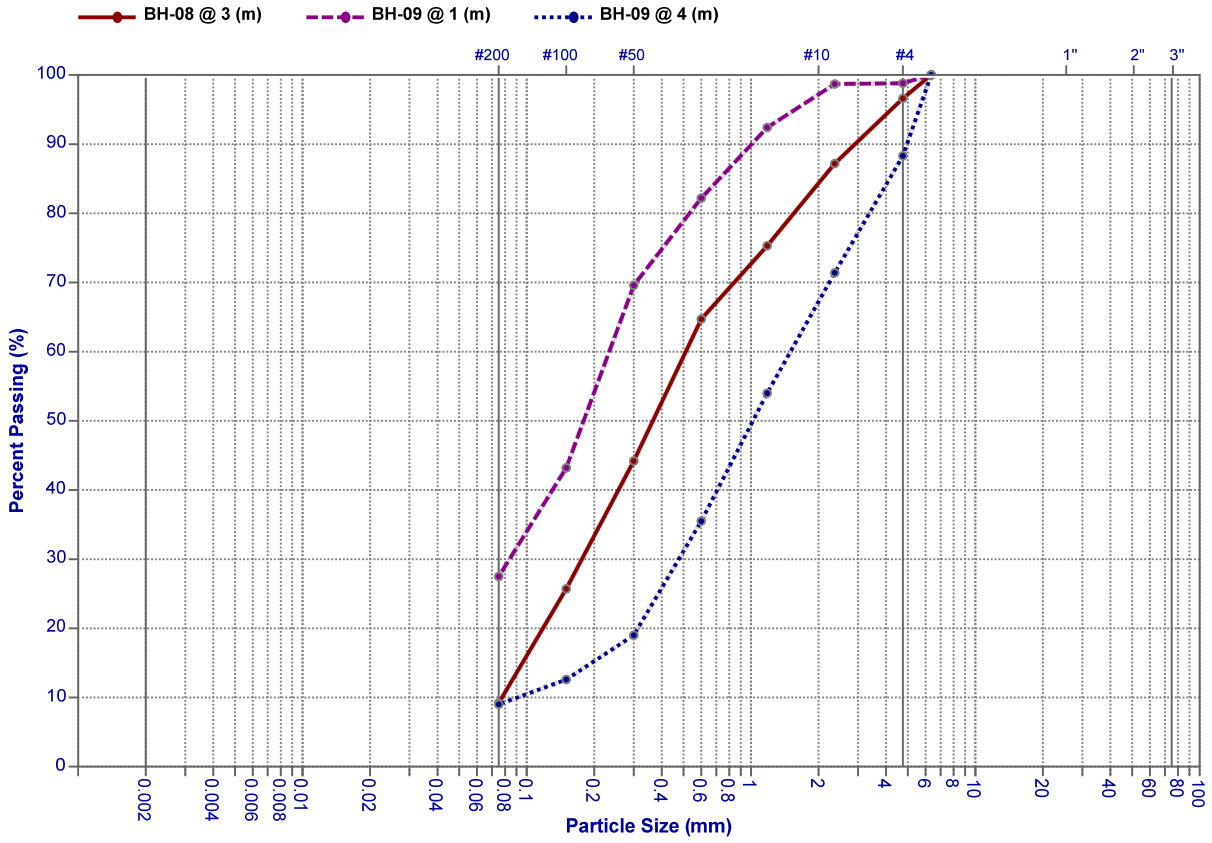
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-07	1	-	0.21	1.498	2.161	0.269	-	-	-	N/A	SM	A-2-4(0)
BH-07	3	-	0.158	0.455	0.784	0.425	-	-	-	N/A	SM	A-2-4(0)
BH-08	1	-	0.197	0.4	0.624	0.818	-	-	-	N/A	SP-SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	9.2	87.4	3.4	-
-	27.5	71.3	1.2	-
-	9	79.3	11.7	-

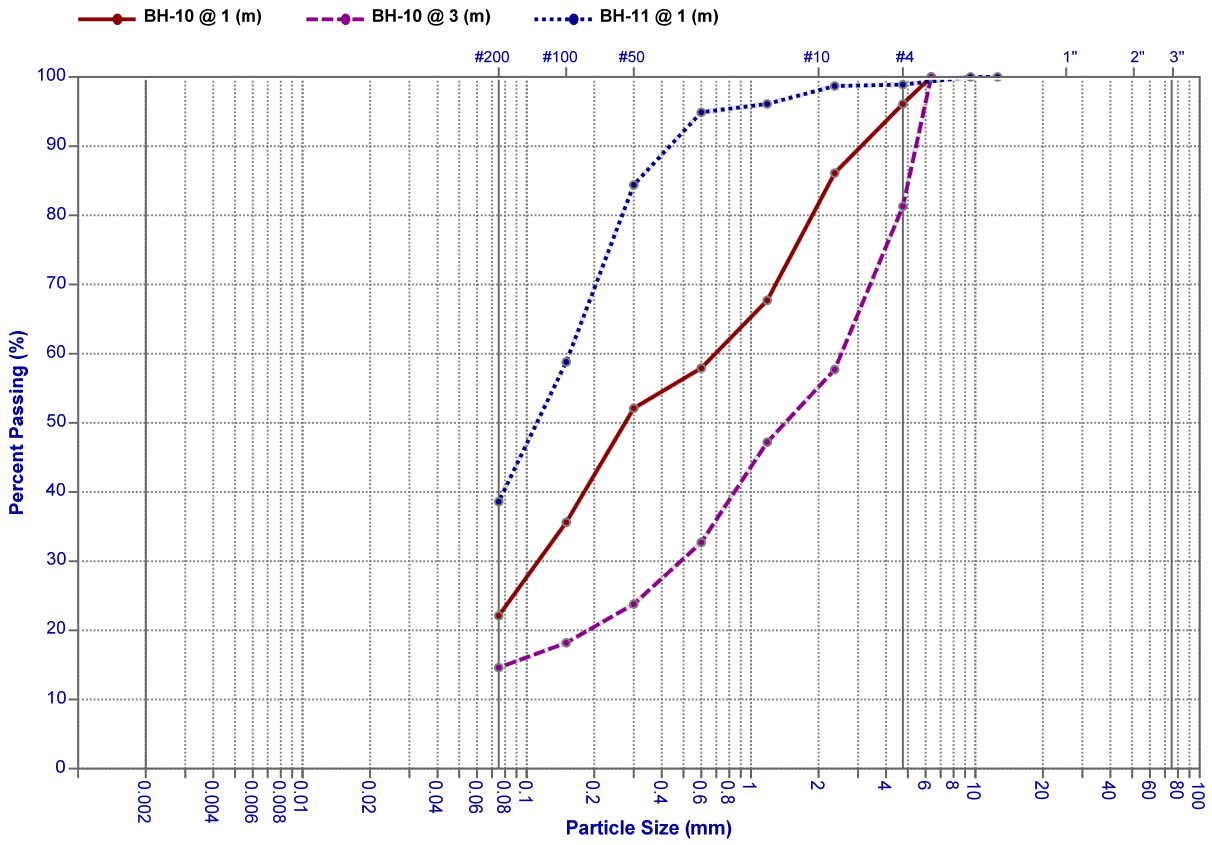
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-08	3	0.078	0.176	0.365	0.512	0.776	6.564	-	-	N/A	SP-SM	A-2-4(0)
BH-09	1	-	0.084	0.179	0.233	0.404	-	-	-	N/A	SM	A-2-4(0)
BH-09	4	0.091	0.476	1.019	1.499	1.661	16.473	-	-	N/A	SW-SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	22.1	74	3.9	-
-	14.6	66.7	18.7	-
-	38.6	60.3	1.1	-

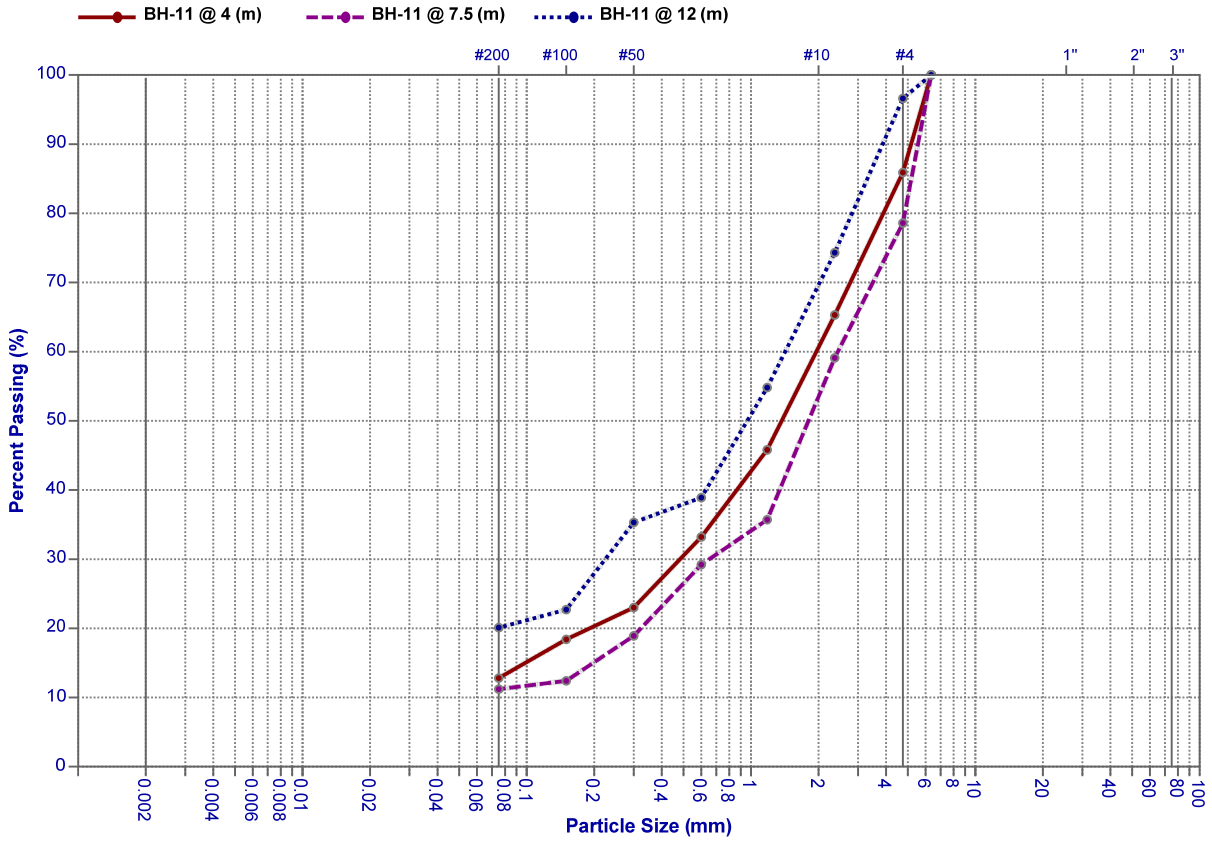
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-10	1	-	0.113	0.275	0.694	0.245	-	-	-	N/A	SM	A-2-4(0)
BH-10	3	-	0.486	1.42	2.526	1.23	-	-	-	N/A	SM	A-2-4(0)
BH-11	1	-	-	0.111	0.155	-	-	-	-	N/A	SM	A-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	12.8	73.1	14.1	-
-	11.2	67.4	21.4	-
-	20.1	76.5	3.4	-

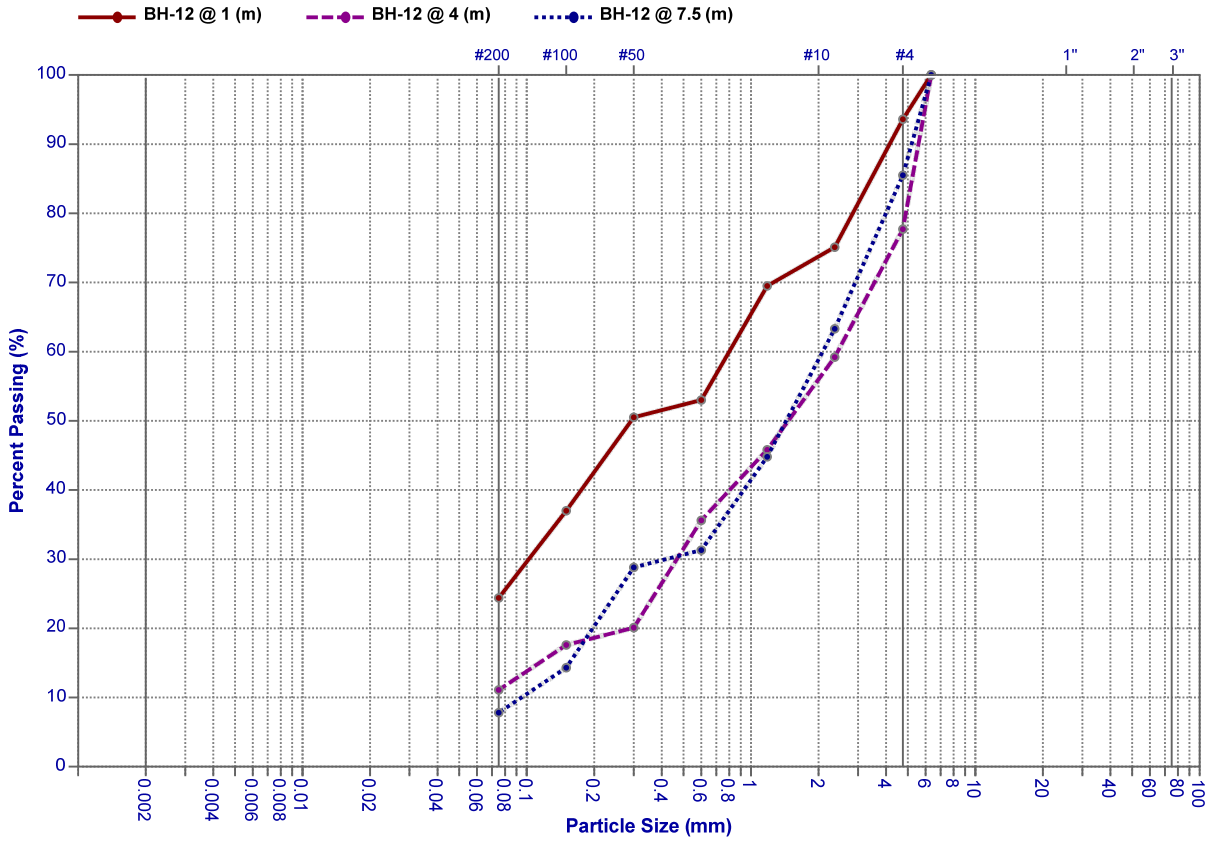
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-11	4	-	0.483	1.37	1.955	1.57	-	-	-	N/A	SM	A-2-4(0)
BH-11	7.5	-	0.652	1.802	2.437	2.295	-	-	-	N/A	SW-SM	A-2-4(0)
BH-11	12	-	0.224	0.962	1.42	0.471	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	24.4	69.2	6.4	-
-	11.1	66.6	22.3	-
-	7.8	77.7	14.5	-

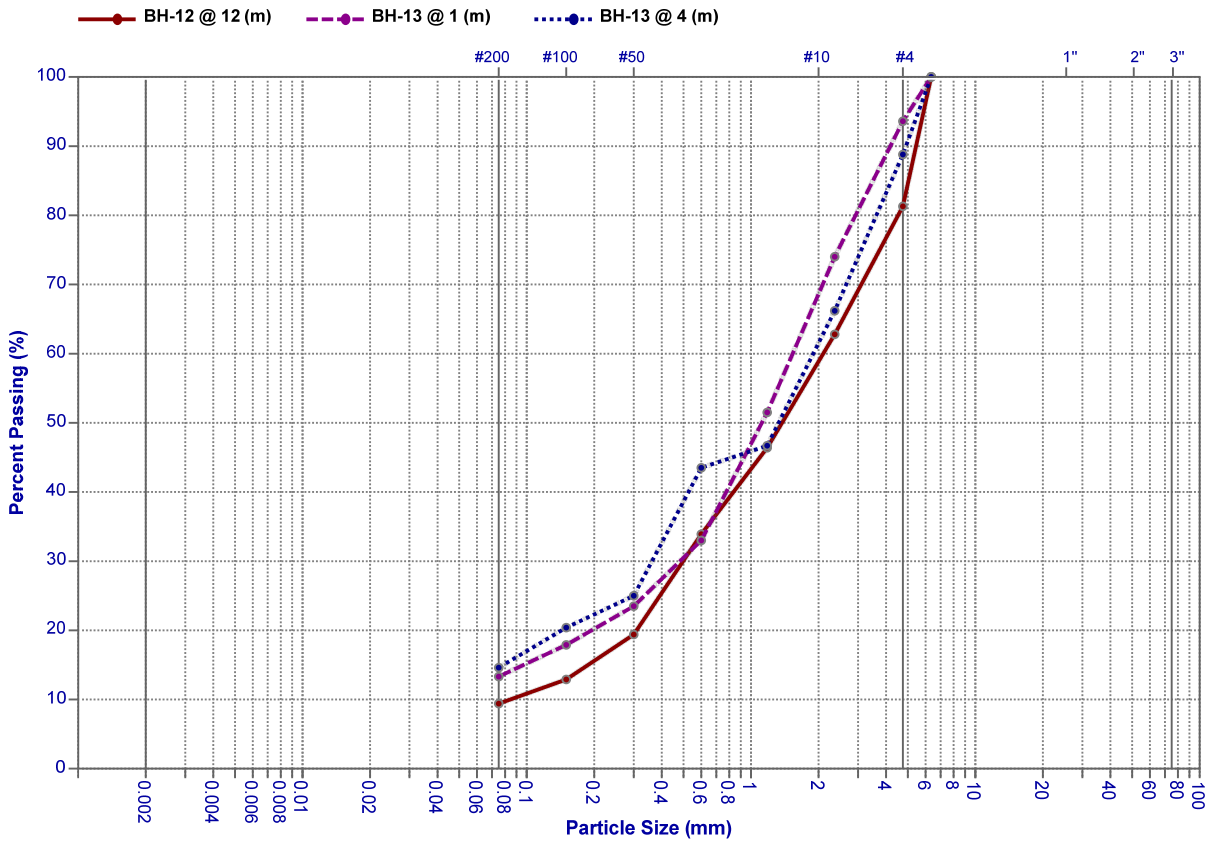
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-12	1	-	0.102	0.292	0.799	0.174	-	-	-	N/A	SM	A-2-4(0)
BH-12	4	-	0.467	1.466	2.432	1.18	-	-	-	N/A	SW-SM	A-2-4(0)
BH-12	7.5	0.095	0.418	1.434	2.086	0.882	21.958	-	-	N/A	SP-SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	9.4	71.9	18.7	-
-	13.3	80.3	6.4	-
-	14.6	74.2	11.2	-

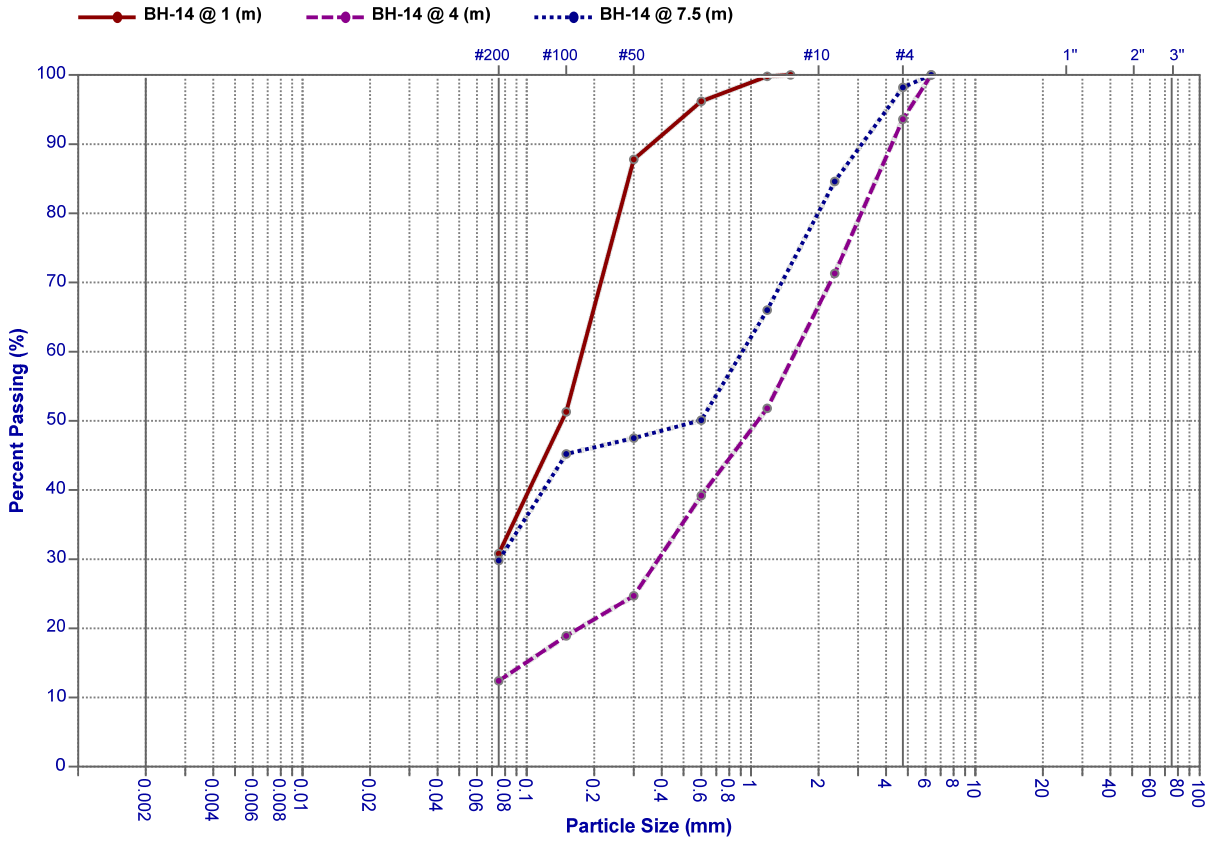
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-12	12	0.084	0.498	1.374	2.097	1.408	24.964	-	-	N/A	SW-SM	A-2-4(0)
BH-13	1	-	0.482	1.117	1.533	1.994	-	-	-	N/A	SM	A-2-4(0)
BH-13	4	-	0.362	1.327	1.893	0.911	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	30.8	69.2	-	-
-	12.4	81.2	6.4	-
-	29.8	68.4	1.8	-

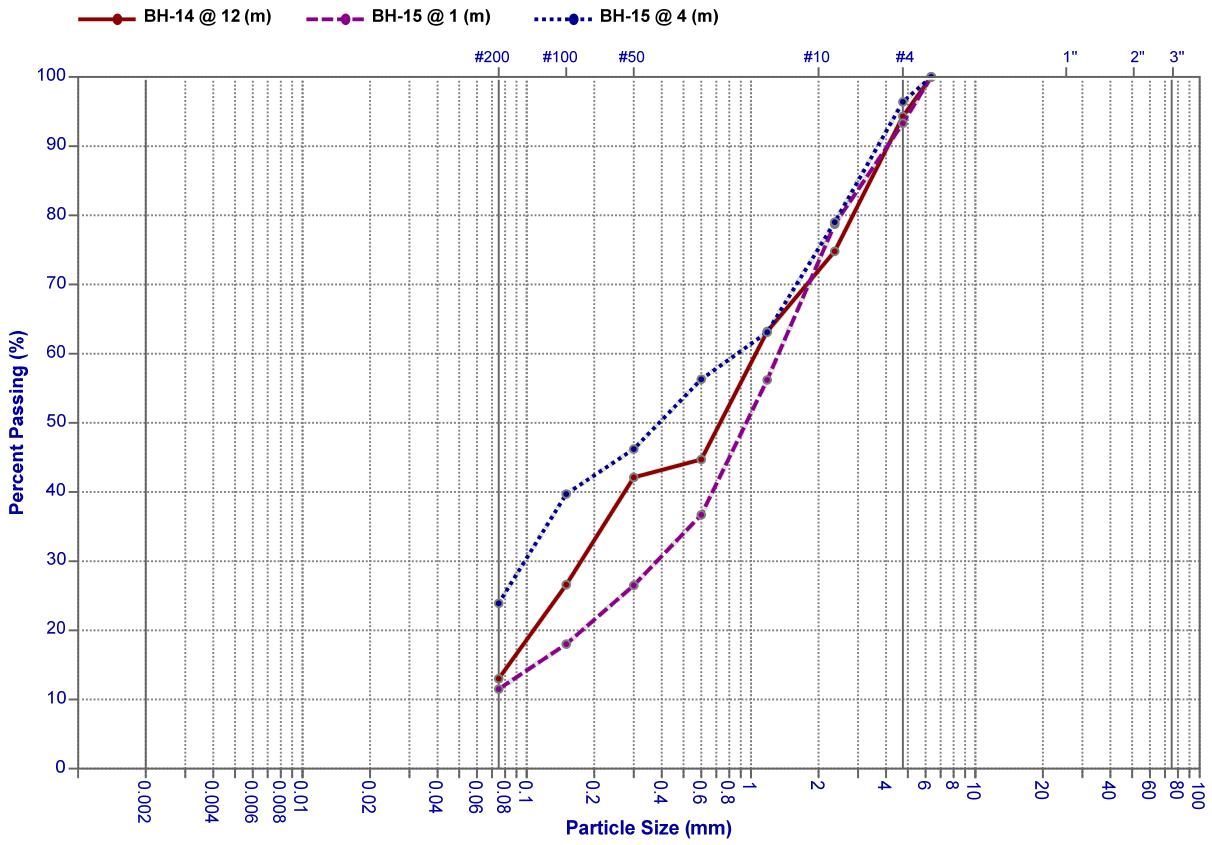
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-14	1	-	-	0.144	0.177	-	-	-	-	N/A	SM	A-2-4(0)
BH-14	4	-	0.387	1.071	1.579	1.248	-	-	-	N/A	SM	A-2-4(0)
BH-14	7.5	-	0.076	0.584	0.914	0.084	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	13	81.3	5.7	-
-	11.5	81.8	6.7	-
-	23.9	72.5	3.6	-

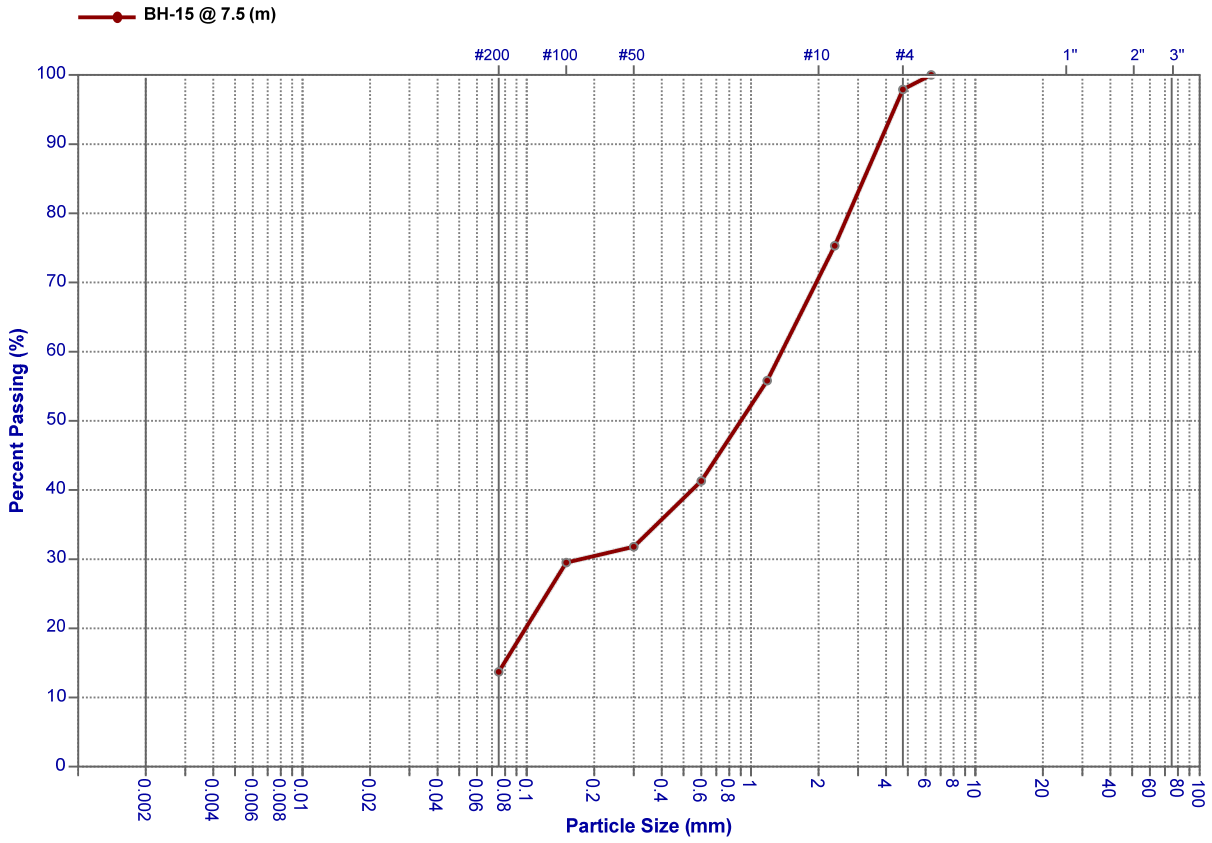
Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-14	12	-	0.175	0.728	1.05	0.384	-	-	-	N/A	SM	A-2-4(0)
BH-15	1	-	0.381	0.952	1.327	1.439	-	-	-	N/A	SW-SM	A-2-4(0)
BH-15	4	-	0.098	0.389	0.867	0.148	-	-	-	N/A	SM	A-2-4(0)

Sieve Analysis Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM C136



Particle Distribution (%)

Clay	Silt	Sand	Gravel	Cobble
-	13.7	84.2	2.1	-

Classification

Borehole	Sample Depth (m)	D10 (mm)	D30 (mm)	D50 (mm)	D60 (mm)	Cc	Cu	LL (%)	PI (%)	Disp. (%)	USCS	AASHTO
BH-15	7.5	-	0.174	0.9	1.37	0.291	-	-	-	N/A	SM	A-2-4(0)

Density & Moisture Test

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM D4643, D2216

Borehole	Sample Depth (m)	Moisture Content (%)	Dry Density (gr/cm3)	Wet Density (gr/cm3)
BH - 01	1	5.89	1.68	1.78
BH - 01	3	7.22	1.71	1.83
BH-02	1	7.19	1.67	1.79
BH-02	3	8.03	1.75	1.89
BH-03	1	8.13	1.71	1.85
BH-03	3	9.08	1.74	1.9
BH-04	1	10.49	1.65	1.82
BH-04	3	7.62	1.72	1.85
BH-05	1	6.87	1.68	1.8
BH-05	4	7.49	1.78	1.91
BH-06	1	8.52	1.7	1.84
BH-06	3	9.95	1.73	1.9
BH-07	1	6.31	1.69	1.8
BH-07	3	10.05	1.73	1.9
BH-08	1	6.59	1.71	1.82
BH-08	3	9.16	1.75	1.91
BH-09	1	10.28	1.67	1.84
BH-09	4	8.06	1.72	1.86
BH-10	1	6.11	1.7	1.8
BH-10	3	10.03	1.75	1.93
BH-11	1	11.13	1.66	1.84
BH-11	4	8.05	1.69	1.83
BH-11	7.5	12.59	1.68	1.89
BH-11	12	9.34	1.72	1.88
BH-12	1	10.58	1.72	1.9
BH-12	4	9.06	1.76	1.92
BH-12	7.5	13.39	1.77	2.01
BH-12	12	16.18	1.7	1.98
BH-13	1	7.76	1.69	1.82
BH-13	4	11.17	1.75	1.95
BH-13	7.8	5.6	1.97	2.08
BH-13	12.61	6	2.06	2.18
BH-14	1	10.27	1.64	1.81
BH-14	4	8.53	1.71	1.86
BH-14	7.5	10.38	1.77	1.95
BH-14	12	16.82	1.71	2
BH-15	1	5.97	1.73	1.83
BH-15	5	11.13	1.7	1.89
BH-15	7.5	9.06	1.74	1.9
BH-15	13.3	6.7	2.05	2.19

Unconfined Compression Test

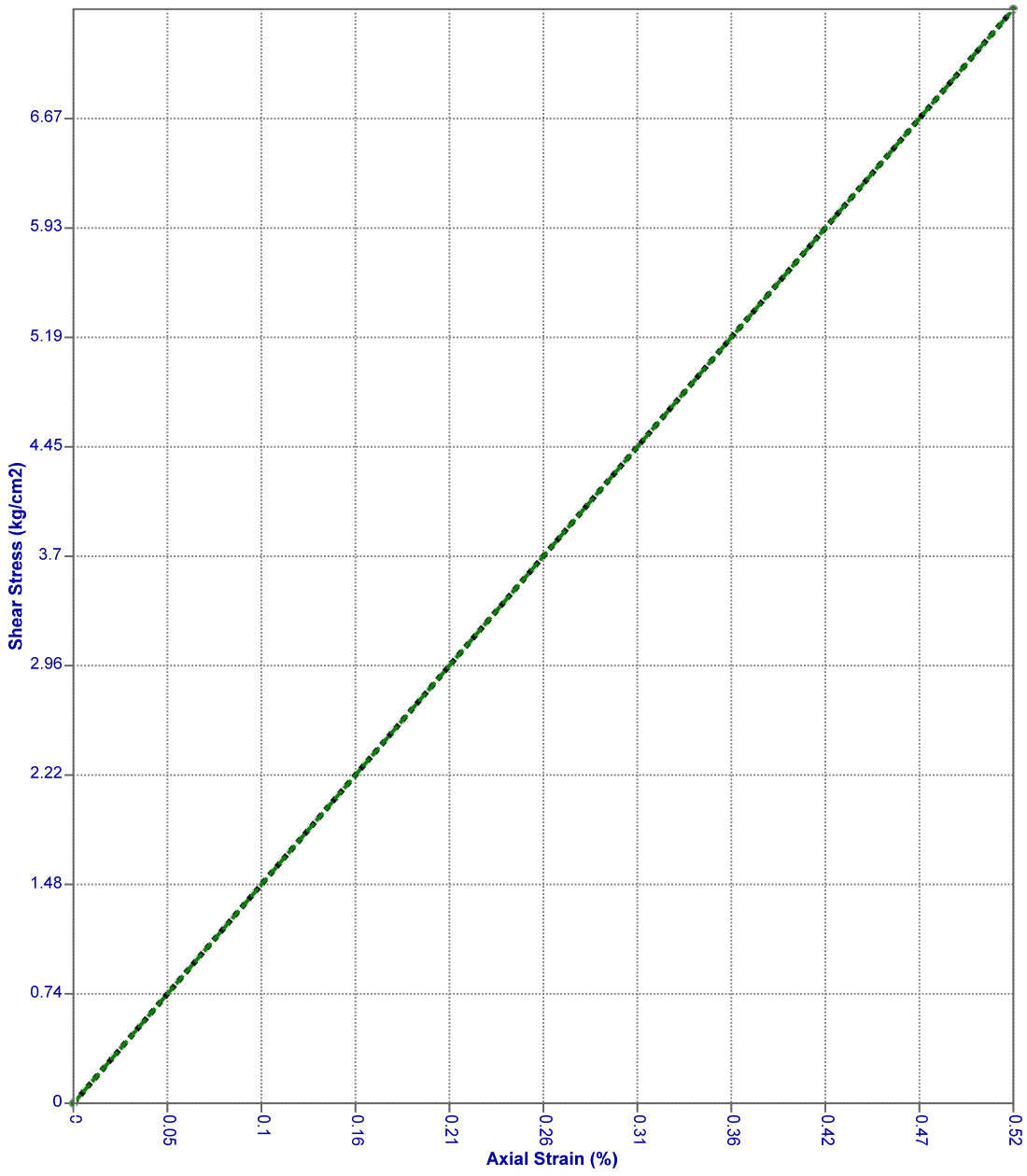
Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Borehole : BH-13
Sample Depth : 7.8 (m)
Sample Type : Undisturbed

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Comp. Qu (kg/cm2)	Su (kg/cm2)
5.263	9.652	1	Moist	5.6	1.97	7.41	3.7



USCS Soil Description :
AASHTO Soil Description :

Tested By :

Unconfined Compression Test

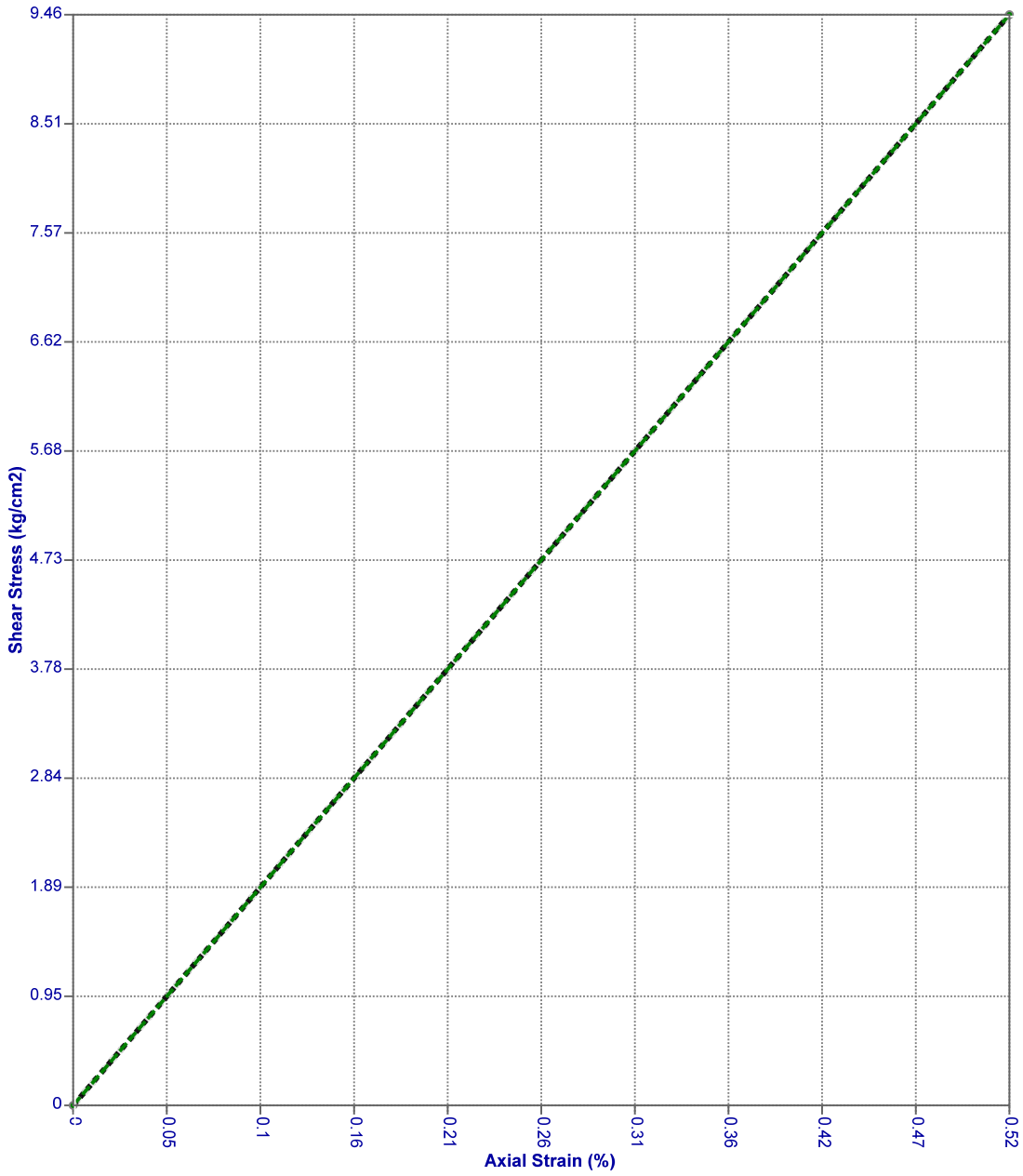
Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Borehole : BH-13
Sample Depth : 12.61 (m)
Sample Type : Undisturbed

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Comp. Qu (kg/cm2)	Su (kg/cm2)
5.24	9.682	1	Moist	6	2.06	9.46	4.73



USCS Soil Description :
AASHTO Soil Description :

Tested By :

Unconfined Compression Test

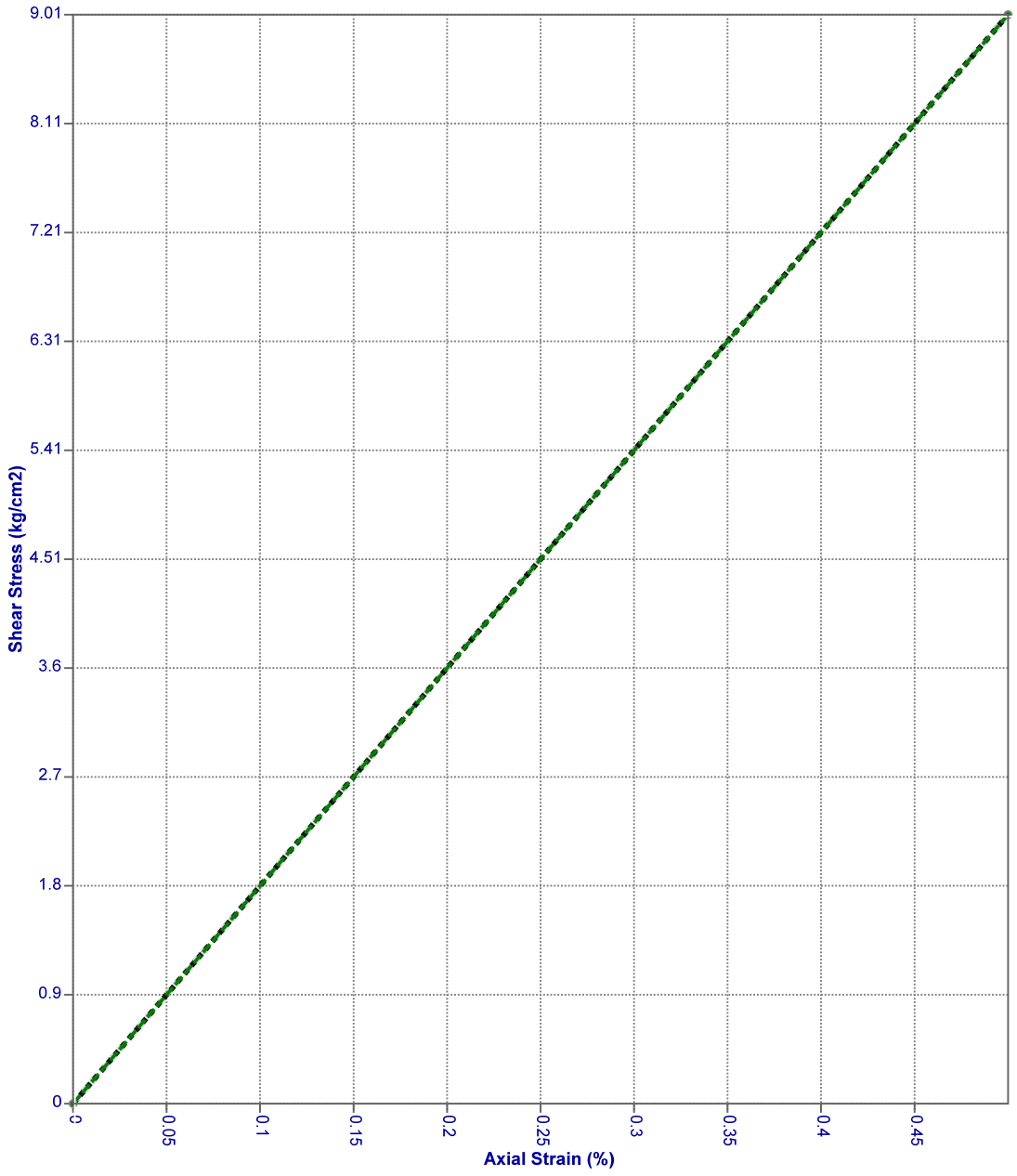
Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

Borehole : BH-15
Sample Depth : 13.3 (m)
Sample Type : Undisturbed

ASTM D2166

Test Results

Diameter (cm)	Height (cm)	Loading rate (mm/min)	Moisture Status	Moisture Content (%)	Dry Density (gr/cm3)	Unconfined Comp. Qu (kg/cm2)	Su (kg/cm2)
5.236	10.024	1	Moist	6.7	2.05	9.01	4.51



USCS Soil Description :
AASHTO Soil Description :

Tested By :

Chemical Test Results

Project : Geotechnical Investigation Works
Client : Education City
Job No.: S-24-1022
Location : Gadap, Karachi

ASTM D516, D512, D1293

Borehole	Sample Depth (m)	Description	Value
BH - 01	1		7.39
BH-07	1	pH value	7.41
BH-12	1		7.34
BH - 01	1		0.013
BH-07	1	Sulphate Content (%)	0.016
BH-12	1		0.012
BH - 01	1		0.22
BH-07	1	Chloride Content (%)	0.25
BH-12	1		0.29

Appendix D

General Information on Testing Procedures

A. DRILLING, FIELD TESTING & SAMPLING

The field testing program consisted of drilling works, and in-situ testing including Standard Penetration Test (SPT), collection of soil samples using soil sampler and water samples. The following sections describe these activities in further detail.

A.1. DRILLING METHOD

Borehole was drilled by using rotary/wash boring method; in this method soil or rock is cut by the constant rotation of various types of bits. Drilling fluid, which is either water or bentonite slurry, is circulated through drilling rods. The returning fluid lifts loosened material.

The drilling in rock was carried out by double tube core barrels in conjunction with carbide or diamond bit. In a double tube core barrel the outer barrel is rotated by the drill rods, while, the inner barrel, which is mounted on a swivel, does not rotate during the drilling process. The core cut by the coring bit passes into the inner barrel. Core was prevented from dropping out by a steel core catcher. It was then extruded and wrapped with waxed bandage tape, to preserve the natural moisture of the recovered core.

Details of the boreholes are given in Table A.1.

Table A.1 Detail of Boreholes

Borehole No.	Borehole Depth (meters)	Water table Depth (meters)
BH-01	5.0	Not Encountered
BH-02	5.0	Not Encountered
BH-03	5.0	Not Encountered
BH-04	5.0	Not Encountered
BH-05	5.0	Not Encountered
BH-06	5.0	Not Encountered
BH-07	5.0	Not Encountered

Borehole No.	Borehole Depth (meters)	Water table Depth (meters)
BH-08	5.0	Not Encountered
BH-09	5.0	Not Encountered
BH-10	5.0	Not Encountered
BH-11	15.0	Not Encountered
BH-12	15.0	Not Encountered
BH-13	15.0	Not Encountered
BH-14	15.0	Not Encountered
BH-15	15.0	Not Encountered

Figure A-1: Drilling Works in Progress

A.2. FIELD TESTING

Field testing carried out at the site includes Standard Penetration Test (SPT). Soil samples were extracted from all the boreholes with the help of “SPT sampler for all types of soils”.

Following sections indicate the processes carried out in each of the field tests.

A.2.1. STANDARD PENETRATION TESTS

The standard penetration tests (SPT) were carried out at interval of 1.5 meter in the overburden above the bedrock. The standard penetration test was carried out by “Safety” type sliding hammer. Split-spoon sampler was used in cohesive and fine granular soils to conduct SPT.

The standard penetration test was carried out by an assembly of the following parts:

- Drive-weight assembly, consisting of a drive head and a 63.5kg impact hammer, a hammer fall guide and the drop system. The drop mechanism will ensure a constant free fall of 760mm.
- Drive rods connect the drive-weight assembly to the sampler.
- The split spoon sampler was used to carry out the test, along with retrieving disturbed samples.

The base of the borehole was made clean and reasonably undisturbed at the test elevation. Following precautions were taken during the testing sequence:

- The level of water or bentonite slurry was maintained at a sufficient level above the groundwater level, to ensure any entry of water through the bottom of the borehole.
- The casing was not driven below the level at which the test will start.

The test was executed in the following steps:

- The sampler and the drive rods were lowered in the borehole and the hammer assembly added to it.
- The sampler is penetrated over seating drive of 150mm and the numbers of blows are recorded.
- In the same way the sampler is driven over a test drive of 300mm in two increments of 150mm.
- The numbers of blows are recorded during each of the last two increments.

- The test was deemed finished when total number of blows equal to 50 was reached.

The standard penetration test was carried out in accordance with the procedure given in BS 1377-9:1990.

Figure A-2: Performance of standard penetration test

A.3. SAMPLING

Sampling forms an essential part of the geotechnical investigation process and good sampling is essential for proper laboratory testing of samples for determining strength and compressibility characteristics of soil.

A.3.1. SPT SAMPLES

Samples were recovered from standard penetration testing. The samples were recovered in split-spoon sampler and then stored in plastic bags. The storage of split-spoon samples in bags ensured retention of natural moisture of the samples which were later tested for gradation, consistency and chemical characteristics.

Figure A-3: Soil sample in split spoon sampler

A.3.2. ROCK CORE SAMPLES

Rock core samples were collected from the deposits through coring. Double tube core barrel (HQ size) was used to collect these samples. The samples were recovered in core barrel, packed in aluminium foil, and then stored in rock core boxes. The storage of rock core samples in aluminium foil ensured retention of natural moisture. Natural moisture content, density, etc. of these samples was determined in the laboratory.

B. LABORATORY TESTING

Laboratory testing was carried out on retrieved samples. The following section enlists and gives details of relevant tests carried out on selected samples as required for determining the subsurface conditions and correlating with the information obtained from field testing and sampling.

B.1. GRAIN SIZE ANALYSIS

The purpose of grain size analysis is to determine the sizes of the assemblage of particles that make up the soil. The grain size analysis is conducted in two parts: for particles above the "# 200 US sieve", sieve analysis is carried out by passing the selected soil sample from various sieves. For particles finer than the "# 200 US sieve", hydrometer analysis is carried out. The combined process of determination of the size of particles is termed as the grain size analysis.

The results are appended with the report in Appendix C. Grain size analysis of soil samples was carried out as per *ASTM D 422 / ASTM C 136*.

B.2. NATURAL MOISTURE CONTENT

Natural moisture content is the quantity of water contained in a soil or rock sample. It is the ratio of the weight of water to the weight of solids in a given volume of soil or rock sample. Natural moisture content of samples was determined in accordance with *ASTM 2216-05.*

B.3. DENSITY

The weight per unit volume of the solid portion of soil is called particle (dry) density. Whereas, the oven dry weight of a unit volume of soil inclusive of pore spaces is called bulk (wet) density. The bulk density of a soil is always smaller than its particle density. Density of samples was determined in accordance with the procedure described in ASTM D 7263-09.

B.4. UNCONFINED COMPRESSION TEST

Unconfined compressive strength test involves axially loading a cylindrical rock core or undisturbed clay sample to failure. The term unconfined is used because the lateral force on the sample is zero. The unconfined compressive strength test was carried out in

accordance with ASTM D 7012. The strength of the retrieved samples tested came out ranging between 7.41 Kg/cm2 – 9.46 Kg/cm2. The results of the unconfined compression test are summarized in Appendices.

B.5. CHEMICAL TESTS

Sulphate in groundwater or soil can attack concrete placed in the ground or on surface. A reaction takes place between the sulphate and the aluminate compounds present in the cement, causing crystallisation of complex compounds. The expansion, which accompanies crystallisation, induces stresses in the concrete, which results in mechanical disintegration. In moist conditions, such as exposure to seawater, the presence of chloride ion, Cl^-, presents a serious possibility of the corrosion of the reinforcement. The presence of $Ca(OH)_2$ provides a strong alkaline environment in which a thin film of iron oxide is formed on the metal surface which protects it against corrosion. However, if the concrete is permeable to the extent that the soluble chlorides can reach up to the reinforcing steel, then in the presence of water and oxygen, the corrosion of the reinforcement will take place. Rust occupies more volume than the original steel, and hence the ensuing expansion of concrete, results in cracking and spalling.

Due to adverse effect of sulphates and chlorides on the quality of concrete it is essential to conduct chemical tests on soil and groundwater. This helps in quantifying the expected exposure of concrete to these chemicals and in devising precautionary measures to ensure integrity of concrete. The following chemical tests were carried out on soil and rock samples:

- Chloride content
- Sulphate content
- pH

Chemical tests were carried out in accordance with *ASTM C 1580-09, and D 4972-01*. The selection of cement for underground concreting and is discussed in *Chapter 4*.

Table B.1 ACI standards for concrete for sulphate exposure

Sulphate Exposure	Water Soluble Sulphates in Soil (%)	Sulphate in Water (mg/L)	Cement Type
Negligible	0.00-0.10	0- 150	OPC
Moderate	0.10-0.20	150- 1500	Type II
Severe	0.20-2.00	1500-10000	Type V
Very Severe	Over 2.00	Over 10000	Type V plus pozzolan

Appendix E

Pile Capacity Calculations

(A) - CALCULATION OF ALLOWABLE SKIN FRICTION: 150mm

Depth	Soil Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Cohesionless	0.15	1	18.0	9.0	30	-	-	-	-	-	22.5	0.41	0.617	2.0	1	1
1-2	Cohesionless	0.15	1	19.5	27.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	2	2
2-3	Cohesionless	0.15	1	19.5	47.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	3	5
3-4	Cohesionless	0.15	1	19.5	66.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	4	9
4-5	Cohesionless	0.15	1	19.5	86.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	5	14

(B) - CALCULATION OF ALLOWABLE SKIN FRICTION: 200mm

Depth	Soil Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Cohesionless	0.20	1	18.0	9.0	30	-	-	-	-	-	22.5	0.41	0.617	2.0	1	1
1-2	Cohesionless	0.20	1	19.5	27.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	2	3
2-3	Cohesionless	0.20	1	19.5	47.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	4	7
3-4	Cohesionless	0.20	1	19.5	66.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	5	12
4-5	Cohesionless	0.20	1	19.5	86.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	7	19

(C) - CALCULATION OF ALLOWABLE SKIN FRICTION: 250mm

Depth	Soil Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Cohesionless	0.25	1	18.0	9.0	30	-	-	-	-	-	22.5	0.41	0.617	2.0	1	1
1-2	Cohesionless	0.25	1	19.5	27.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	3	4
2-3	Cohesionless	0.25	1	19.5	47.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	5	8
3-4	Cohesionless	0.25	1	19.5	66.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	7	15
4-5	Cohesionless	0.25	1	19.5	86.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	9	24

(D) - CALCULATION OF ALLOWABLE SKIN FRICTION: 300mm

Depth	Soil Encountered	Diameter of Pile (m)	Length of Layer (m)	Effective σ for this layer	Effective overburden (kN/m^2)	phi	c (kN/m^2)	q_{uc} (kN/m^2)	α adhesion	α reduction-rock	β correction	δ	tan δ	k_s	FOS	Q_{skin} (kN)	$Q_{skin\ (Cum)}$ (kN)
0-1	Cohesionless	0.30	1	18.0	9.0	30	-	-	-	-	-	22.5	0.41	0.617	2.0	1	1
1-2	Cohesionless	0.30	1	19.5	27.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	3	4
2-3	Cohesionless	0.30	1	19.5	47.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	6	10
3-4	Cohesionless	0.30	1	19.5	66.8	30	-	-	-	-	-	22.5	0.41	0.617	2.0	8	18
4-5	Cohesionless	0.30	1	19.5	86.3	30	-	-	-	-	-	22.5	0.41	0.617	2.0	10	29

ALLOWABLE END BEARING RESISTANCE :

Socket Strata	Diameter of Pile (mm)	Pile Length (m) Below Existing Ground Level	N_q	Effective Overburden (kN/m2)	FOS	Q_{END} (kN)
Cohesionless	150.0	2.0	40.0	27.8	3.0	7
Cohesionless	150.0	3.0	40.0	47.3	3.0	11
Cohesionless	150.0	4.0	40.0	66.8	3.0	16
Cohesionless	150.0	5.0	40.0	86.3	3.0	20
Cohesionless	200.0	2.0	40.0	27.8	3.0	12
Cohesionless	200.0	3.0	40.0	47.3	3.0	20
Cohesionless	200.0	4.0	40.0	66.8	3.0	28
Cohesionless	200.0	5.0	40.0	86.3	3.0	36

ALLOWABLE END BEARING RESISTANCE :

Socket Strata	Diameter of Pile (mm)	Pile Length (m) Below Existing Ground Level	N_q	Effective Overburden (kN/m2)	FOS	Q_{END} (kN)
Cohesionless	250.0	2.0	40.0	27.8	3.0	18
Cohesionless	250.0	3.0	40.0	47.3	3.0	31
Cohesionless	250.0	4.0	40.0	66.8	3.0	44
Cohesionless	250.0	5.0	40.0	86.3	3.0	56
Cohesionless	300.0	2.0	40.0	27.8	3.0	26
Cohesionless	300.0	3.0	40.0	47.3	3.0	45
Cohesionless	300.0	4.0	40.0	66.8	3.0	63
Cohesionless	300.0	5.0	40.0	86.3	3.0	81

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