GEOTECHNICAL INVESTIGATION REPORT FOR THE CONSTRUCTION OF MODERN AND DIFFERENT SERVICES STATIONS- TRIPOLI CITY

Tripoli, Airpoirt Road (Highway) Region – Libya

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FINAL REPORT

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1. Introduction:

1.1 General

Assari engineering consultant was engaged by (Golden Middle East Oil Services Company). Company (Assari for engineering consulting) to carry out a geotechnical investigation program to the construction of **modern and different services stations** situated at (Airport Road region) in the capital Tripoli, Libya.

The principal objective of the geotechnical investigation works was to evaluate the subsurface condition at the site (airport road region), select appropriate geotechnical design parameters and make recommendations for the design and construction of foundation and related works including the selection of most appropriate foundation types and the allowable bearing pressures for design of foundations.

This report presents the results of our investigation and analysis of the subsurface strata conditions at site of the proposed project "the construction of different services stations" which located at airport road region, Tripoli city- Libya. The work was carried out for the owner of the property (Brega Petroleum Marketing Company).

The investigations were planned by client and the field work was started in November 26th, 2021 and completed in November 28th, 2021, by Assari engineering consultant. Subsequently, the laboratory testing was conducted at Assari engineering consultant geotechnical and materials testing laboratories, Janzour, Tripoli city- Libya. The investigation study will be covered approximately 5,800.0 sq. meter (0.58 hectare). Our engineering study consisted of site reconnaissance, a review of existing soils and geologic data, and field investigation consisting of the drilling of five (05) soil borings taken to the maximum depths of 09.95 meters from existing ground level on the location of the boreholes.

The main target of the present study was to provide an evaluation of the subsurface condition encountered at the investigated boreholes. The recommendations given in this report are based on the interpretation of field and laboratory test results, and on the state-of-the-art knowledge in geotechnical engineering, design and construction. This geotechnical report is divided mainly in a shorter narrative part, describing the work done and their essential results and a comprehensive appendix with detailed drawings, tables of all test results, borehole logs (***appendix A***), the field drilling report, the photos of samples, drilling works as well as chemical test results.

1.2 Objectives of investigations

The geotechnical investigations were undertaken to meet the following objectives:

- To investigate the geotechnical and geological conditions at the site including physical and index properties of soil strata.
- To delineate the major subsoil types spread over the site area.
- To investigate the structure and homogeneity of strata as well as the physical and mechanical properties of each soil layer of the site.
- To evaluate and estimate the stability and bearing capacity of ground.
- Assessment of corrosion and suggestion of the cement type.
- To spell-out the geotechnical considerations for the design and construction of the foundations of the proposed structures.

1.3 Codes and specifications

- Moisture content (ASTM D 2216).
- Particle size distribution (ASTM D 422).
- Specific gravity (ASTM D 854).
- Atterberg limits (ASTM D 4318).

- Standard penetration tests-SPT (ASTM D-2488).
- The unified soil classification system (ASTM D 2487-17).
- The AASHTO system of soil classification (ASTM D 2487-17).
- Standard test method for pH in soil (BS 1377: Part 3:1990).
- Standard test method for chloride content in soil (BS 1377: Part 3:1990).
- Standard test method for sulphate content in soil (BS 1377: Part 3:1990).

1.4 The Scope of work

A geotechnical investigations program was prepared, keeping in view the site conditions, the project components and to fulfill the above-mentioned objectives in line with the scope of work, as described below:

1. Drilling and sampling of Five (**05**) borehole1s to a depth of **09.95** m below existing ground level. Geotechnical boreholes were drilling using rotary drilling machine (Truck Renault, YWE-D90R rig & Truck Mercedes Benz, Unimog Atlas Copco rig) project area (Airport Road region). All investigation works were performed in accordance with BS 5930:1999.

2. Performing laboratory tests to determine pertinent engineering and index properties as well as the chemical properties of the strata encountered at the project site.

3. Analyzing the field and laboratory tests data and submitting an engineering report, furnishing recommendations for the design and construction of foundations and earthwork for the proposed structures at the site.

4. Estimation of the both the ultimate and allowable resistances of soil furnishing recommendations for the design and construction of foundations and expected settlements for the construction of **modern and different services stations**.

5. Assessment of corrosion and suggestion of the cement type.

1.5 Investigation methodology

2. Location of the performed geotechnical investigation:

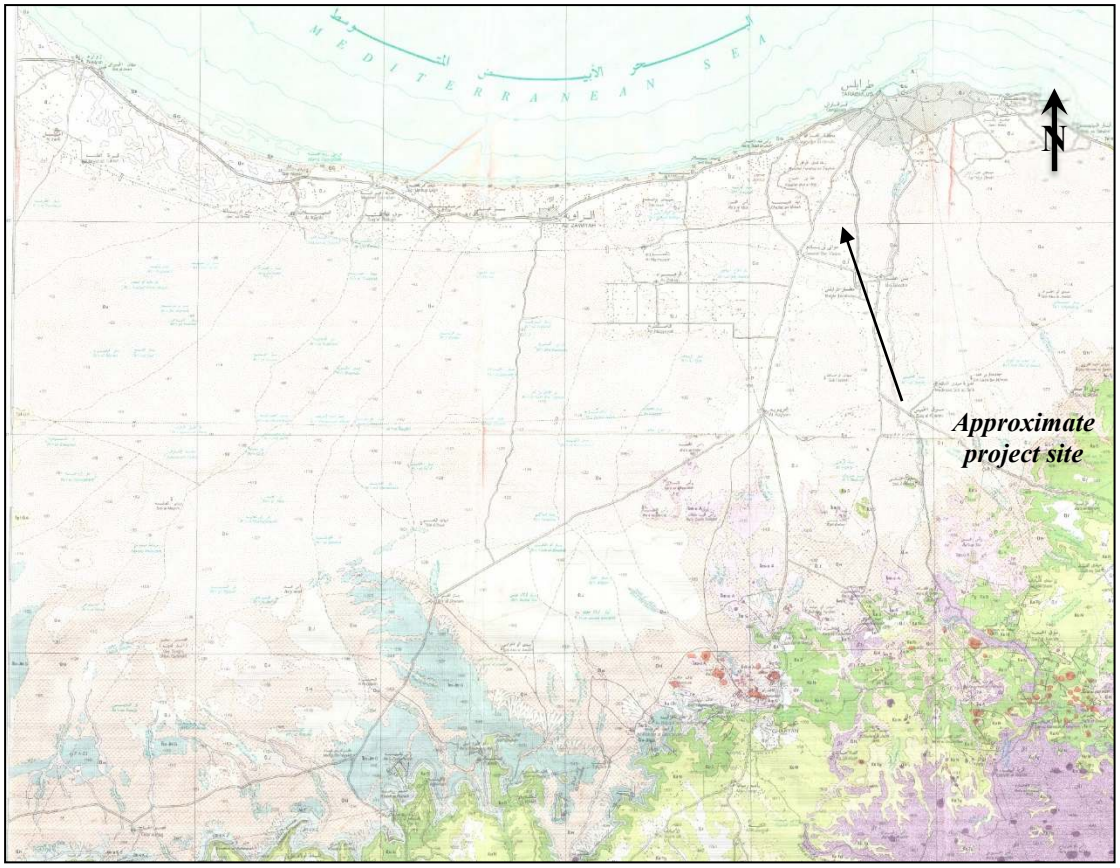
The site is located in Airport Road area, approximately 15 kilometers southern from the capital of Tripoli. Approximate site location is shown in **Figure (1)**. The investigation was carried out along sides of existing highway (Airport Rd.) with in the project area. Site topography generally comprises flat ground surface approximately and comprises a loose to medium dense fine grained SAND with silt (Backfill soil). This layer exists at ground surface and its thickness is 2.5 m below ground surface level. Five boreholes were carried out from this level as shown as in the site plan. A general site plan shows of the location of the borehole within the plot in Figure at end of the report at *Appendix D.*

Figure 1: General site plan (Approximate) Airport Road region.

3. Site description, general geology and geomorphology:

The proposed project area is located in Southern Libya (Tripoli - Airport Road area). Latitude: **33**° 0' N and longitude: **13**° 0' E. as shown in the figure (**2**). To obtain background geological information, we reviewed geological map of (Tripoli), Sheet No. NI 33-13 published by Industrial Research Center. In general, the proposed project site is located in Gefara plain - Northeastern-Libya. The Gefara in the northwest corner of Tripolitania is a triangular area of about 20,000 sq. km, bounded on the north by the Mediterranean coast and on the south by the Jabal Nefusa (Nafusah) and Jabal Garian (Gharian). Its southern edge is a high escarpment which extends eastward from the Tunisian border near Nalut to the vicinity of Horns (Al Khums) on the coast. The elevation of the Gefara ranges from 10 to 20 meters above sea level near the coast to about 200 m at the foot of the Jabal escarpment.

In site investigation region most of the surface in this area covered by materials very loose to loose fine grained sand with silt. Altogether 02 (Two) different sub-soil layers were encountered within the bored depth of the boreholes. Can be described the first unit (the first stratum) as light brown to brown fine grained Silty fine SAND (SM) to dense light brown to whitish Calcareous silty fine to medium grained SAND, some sublayers with trace gravel, the Sand deposits in found up to a depth of about 8.45 meter in all boreholes except in boreholes No. BH#01 and BH#02. These are underlained. The second unit (the second stratum) is mostly, by brownish white to brown, very stiff, low plastic sandy SILT (ML), generally to a depth of 8.45-9.95m below ground level (the maximum investigated depth of 9.95m below existing grade level). The information and detail of the sub-strata are presented in ***Appendix A***.



The average rain fall of Tripoli area is 350 mm/year, the revealing wind velocity in area about 135 - 140 km/hr.

Figure 2: Regional geological map -Tripoli, Sheet No. NI 33-13 (scale 1: 25Km).

4. Seismic attributes of the site:

The hazard map in **Figure 3** indicates that most of Libya is of rather Intermediate seismic hazard except for zones along the coast. In accordance with the geological map and seismic classification of Libya, the site has the following seismic attributes:

EARTHQUAKE ZONE = **2A** (according UBC 97 Section 16.26-16.35.), effective peak acceleration, Aa (C_a) 1.5 m/s^2 and effective peak velocity -related accel, Av (C_v) 1.5 m/s^2.

Site classification for seismic design is class (**C**) as shown in **figure** (**3**). The highest PGA value shown for Libya in the map is in a small area that corresponds approximately to the epicenter of the 1935 earthquake and is in the range 0.13g to 0.16g in UBC97 for site class C this would clearly correspond to zone 2A everywhere else along the coast in Libya the highest values reach to the range 0.10-0.13g which again is well covered by zone 2A.

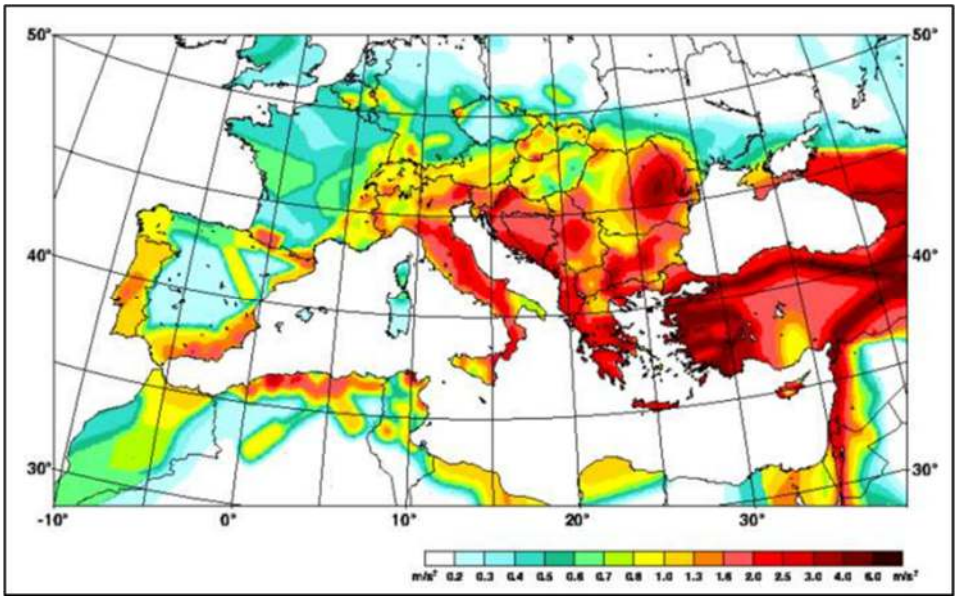


Figure 3: Seismicity in the Mediterranean basin (GSHAP, 1997).

Minimum Seismic Design: Structures and portions thereof shall, as a minimum, be designed and constructed to resist the effects of seismic ground motions as provided according UBC 97 Section 16.26-16.35. **Table (1)** shows the seismic parameters of the site:

Table 1: Seismic parameters design.

Parameter	Design Value	
Seismic zone factor	Zone:	2A
	Z:	0.15

Continued (Table 1): Seismic parameters design.		
Soil profile type	S_D:	(Stiff Soil Profile)
	S.P.T (blows/30cm):	5 to 15
	Undrained Shear Strength, su (KPa)	50 to 100
	Shear Wave Velocity, v_s (m/sec)	350 to 750
Level of seismic risk according ACI318-05	Intermediate	Seismic Zone 2
Seismic coefficient	Seismic zone factor, z:	C_a=0.22
		C_v=0.32
Seismic importance factor	Standard occupancy structures:	I=1.0
Response modification factor	Basic structure system	R=5.50

5. Field investigation (Site works):

5.1 Genera

The proposed field work consisted of exploratory drilling and sampling of the subsurface soil samples and performance of standard penetration tests (***SPT***) at designated locations. The boreholes were drilled to depth of **09.95** meters below the existing ground surface level.

The boreholes location was decided and marked in the field by "**Assari engineering consultant company**". A list of coordinates and elevations of the borehole numbers is given in **table** (**2**). The depths of the borehole were given by the client and was made according to the attached site plan.

Table 2: Coordinates and depth of boreholes, the proposal project location.

Borehole No.	Borehole Depth, m	Coordinates		Existing elevations, m
		Northing	Easting	Z
BH-01	09.95	Not available	Not available	Not available
BH-02	09.95	=	=	=
BH-03	09.95	=	=	=
BH-04	09.95	=	=	=
BH-05	09.95	=	=	=
Project site coordinates		32.744823	13.143865	=
Number of borings		**05**		
Total depths		**49.75 m**		

5.2 Execution of boreholes

The geotechnical work consisted of drilling five (**05**) boreholes to depth **09.95** meters below existing grades using hollow-stem auger method (rotary drilling). The drilling of boreholes was carried out using (**YWE-D90R and Unimog Atlas Copco**) drilling rigs. The subsurface stratum was penetrated by rotary drilling method using continuous-flight auger technique. After completion of the testing, boreholes were backfilled with a mixture of cement, bentonite, sand and water. The grout backfill materials were proportioned to a groutable /pourable consistency and the proportions varied as per the specific requirements. The borings was drilled by the use of a trucks (Renault and Mercedes Benz) mounted mobile (**YWE-D90R and Unimog Atlas Copco**) drilling rigs utilizing diamond bit and double tube core barrel. Drilling rigs is shown in **figure (4)** was used for the drilling of each boreholes. The borehole logs were prepared in the field and a description of soil samples recovered has been shown in the respective borehole logs. Field borehole logs was developed on the basis of the materials encountered at the site and were later confirmed /

modified by the laboratory test results. The borehole logs are appended in ***Appendix A*** of this report.

Unimog Atlas Copco drilling rig

YWE-D90R drilling rig

Figure 4: The boring test is being performed on the site (Airport Road area).

5.3 In-situ sampling

5.3.1 Soil sampling

The samples recovered from split spoon sampler were visually inspected and classified as per (**ASTM D-2488 and BS 5930:1999**). All the **SPT** samples obtained from the boreholes were properly labeled, preserved in polythene bags and placed in plastic jars as disturbed samples. All these samples were carefully transported to our laboratory (**Assari engineering consultant company**, **Janzour-Tripoli**) for further evaluation and testing. The actual depth for all samples and N-values S.P.T, are shown in the record of test results sheets of this geotechnical exploration.

5.4 In-situ testing

5.4.1 Standard penetration tests (SPT)

Standard penetration tests (**SPTs**) were performed generally at **1.0 m** depth intervals. These tests were performed in accordance with **ASTM D-1586** using a split spoon sampler of **35 mm** inner dia. and **50 mm** outer dia., its length is **460 mm**. The data obtained from these tests was utilized to assess the in-situ compactness/denseness of the subsurface materials. The **SPT** blow counts were recorded for a total penetration of **45cm** of **SPT** sampler. The number of blows required to drive the sampler through the last **30cm** viz. '**N**' values have been shown on the respective borehole logs, ***Appendix A***. A summary of **SPT- corrected N** values is given in **table (3)**.

Table 3: A summary of field *SPT* corrected N value.

Depth, m	BH-01	BH-02	BH-03	BH-04	BH-05
	N-value	N-value	N-value	N-value	N-value
0.0	← *Existing ground level (Natural ground surface)*				
1.45	13	12	18	22	10
2.45	5	11	7	17	6
3.45	37	13	16	32	9
4.45	23	6	30	26	18
5.45	22	20	37	37	13
6.95	15	24	21	27	38
8.45	16	18	18	22	41
9.95	20	20	18	28	25
End of boreholes					

Figures (**5.a, 5.b and 5.c**) shows the results of **SPT** corrected **N** value in a soil profile, In the field, the magnitude of $\mathbf{E_r}$ can vary from002030 to **90%**. The standard practice now in the U.S. is to express the N-value to an average energy ratio of **60%** (≈**N60**). The (**56**) raw data of the **SPT**, obtained from the in-situ measurements, have been modified, based on the overburden pressure, length of drilling rod, borehole diameter and soil sampler.

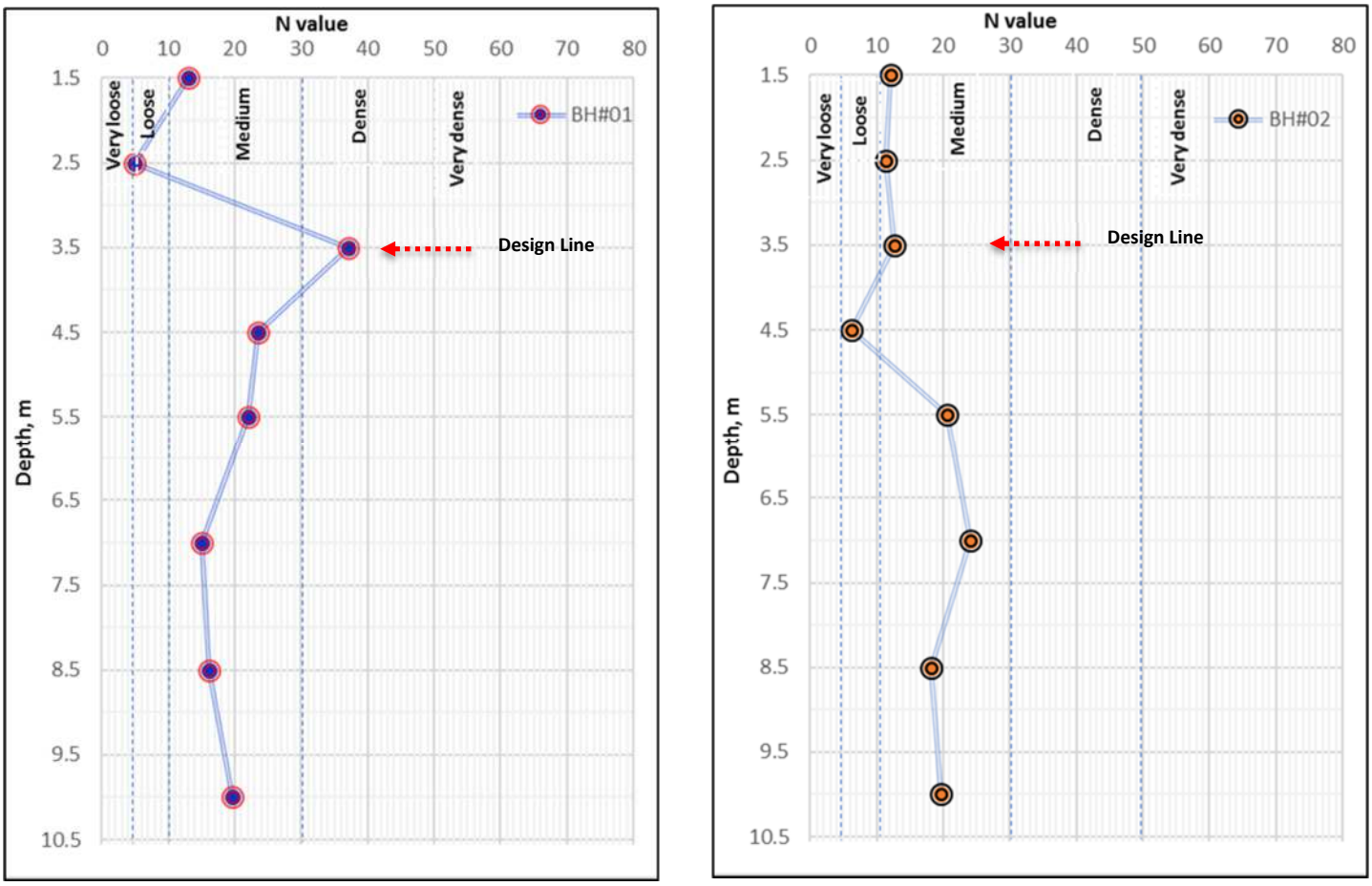


Figure 5.a: Soil profile with SPT Corrected 'N' value test diagrams.

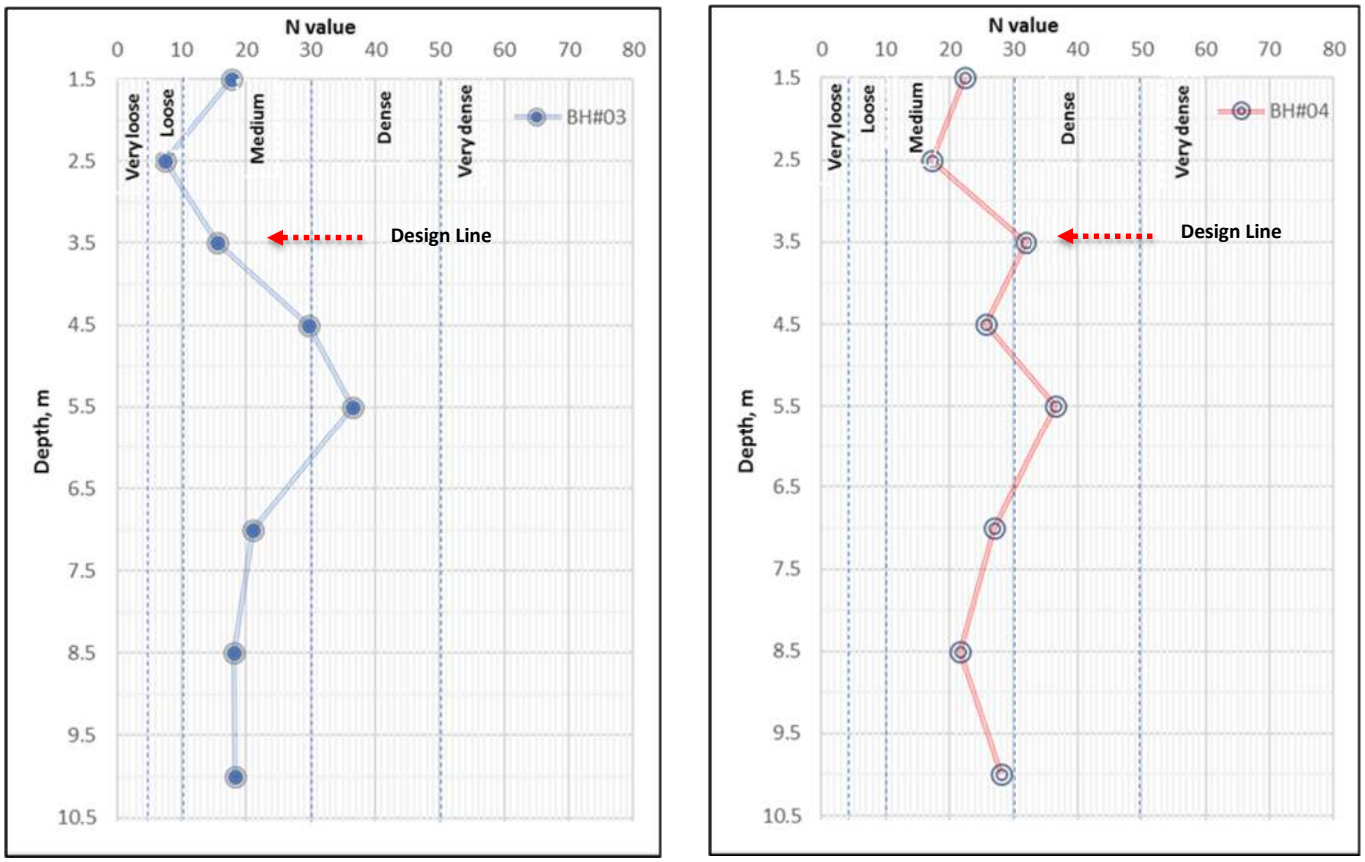


Figure 5.b: Soil profile with SPT Corrected '***N***' value test diagrams.

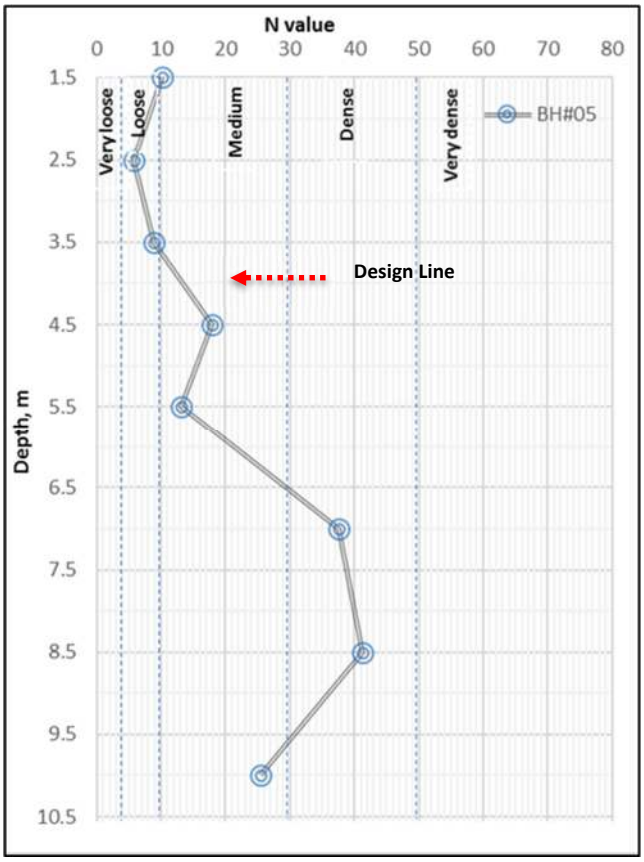


Figure 5.c: Soil profile with SPT Corrected '***N***' value test diagrams.

5.4.2 Ground water conditions

Groundwater was assessed in all the borehole drilled at the site 24 hours or more, after the completion of drilling each borehole. The groundwater table was unencountered in all boreholes at a depths **09.95** meters below natural surface level (NSL) during investigations in November, 2021. It should be noted that groundwater levels might fluctuate according to infiltration zone. Reconfirmation of ground water level is recommended prior to any work relating to the ground water regime.

6 Laboratory testing:

6.1 General

The samples retrieved from borehole was examined in the field and then transported to testing laboratory for relevant laboratory testing. The laboratory tests were conducted on selected soil samples to determine the engineering characteristics of the subsurface strata. A summary of the laboratory tests performed is as shown in **table (4)**. Laboratory tests were performed on soil samples for their physical properties; including water content determination, Atterberg limits, sieve analysis, bulk density, point load index and their engineering characteristics. Chemical testing was performed on selected sample, which included (**pH**), chloride content (**CL^-**), Soluble sulphate content (**SSO_3**), total sulphate Dissolved (**TSO_3**), Once the samples were received from the site, and the testing was performed immediately. All laboratory tests were performed in Accordance with **ASTM** and **BS** Standards.

Table 4: A summary of the laboratory tests performed.

Physical tests:			
No.	Type of test	No of test	Test specifications
1.	Particle size distribution	24	ASTM D 421 / 422
2.	Moisture content	24	ASTM D 2216
3.	Specific gravity	06	ASTM D 854
4.	Atterberg limits	04	ASTM D 4318
Chemical tests on soil samples:			
Chemical tests on soil:		No of test	Test specifications
1.	Chloride content	04	BS 1377: Part 3:1990
2.	Sulphate content	04	BS 1377: Part 3:1990
3.	pH	04	BS 1377: Part 3:1990
The details of particle size distribution & Atterberg limits results are presented in ***Appendixes B&C*** of this report.			

6.2 Natural water content

The natural moisture content and all tests that required the determination of moisture content were done by drying at 110 C° as recommended in ASTM D 2216. **Table (5)** contains the date and results of the water content test on selected samples from boreholes.

Table 5: Moisture content results.

Borehole No.	Depth, m	Moisture content, M_c (%)
BH-01	2.0-2.45	4.5
	3.0-3.45	20.4
	4.0-4.45	12.5
	5.0-5.45	14.4
	8.0-8.45	13.8
	9.0-9.95	30.7
BH-02	1.0-1.45	17.3
	2.0-2.45	15.0
	3.0-3.45	17.6
	5.0-5.45	18.6
	8.0-8.45	13.8
	9.0-9.95	9.2
BH-03	3.0-3.45	8.2
	4.0-4.45	8.4
	6.5-6.95	7.9
	9.0-9.95	13.3
BH-04	2.0-2.45	6.6

Continued (Table 5): Moisture content results.		
BH-04	3.0-3.45	4.3
	5.0-5.45	13.7
	8.0-8.45	9.6
BH-05	3.0-3.45	7.4
	4.0-4.45	6.0
	5.0-5.45	6.8
	8.0-8.45	19.6
The tester certifies that the test was carried out in accordance with ASTM D2216.		

6.3 Specific gravity of soil

The specific gravity of a given material is defined as the ratio of the weight of a given volume of the material to the weight of an equal volume of distilled water. The results of specific gravity of soil are shown in **table** (**6**). The procedure for determination of specific gravity, **G_s** described here is applicable for soils composed of particles smaller than **4.75** mm (No.4 U.S. sieve) in size. The specific gravity (**Gs**) values were found to range between **2.632 to 2.727** in borehole. The test was carried out according to ASTM D-854.

Table 6: Results of specific gravity of soil solids.

Borehole No.	Depth, m	Specific gravity, ***Gs*** (---)
BH-01	4.4-4.45	2.727
BH-02	2.0-2.45	2.655
	5.0-5.45	2.703

Continued (Table 6): Results of specific gravity of soil solids.		
BH-03	9.0-9.95	2.703
BH-04	3.0-3.45	2.632
BH-05	6.5-6.95	2.703
The tester certifies that the test was carried out in accordance with ASTM D-854.		

6.4 Classification tests

6.4.1 Soil particle distribution (Grain size analysis)

This test is for determining the grain size distribution by sieving the soil samples through a stack of sieves of decreasing mesh opening sizes and by measuring the weight retained on each sieve. Particle-size distribution test was performed on selected samples in accordance ASTM D421. The results of these tests are presented graphically on particle size distribution curves, appendix **B**. **Table (7)** represents the results of the sieve analysis test.

6.4.2 Atterberg limits (Liquid and plastic limits)

When a cohesive soil is mixed with an excessive amount of water, it will be in a somewhat liquid state and flow like a viscous liquid. However, when this viscous liquid is gradually dried, with the loss of moisture it will pass into a plastic state. The liquid limit was determined by Casagrande cup method and plastic limit was determined via "Rolling-thread" method. The liquid limit and the plastic limit are used to classify the soil and can be used to estimate the engineering properties of the soil. These limits distinguish the boundaries of the several consistent states of plastic soils. The liquid limit is the water

content (in percent) of a soil at the boundary between the liquid and plastic states. The plastic limit is the water content, in percent of soil at the boundary between the plastic and brittle states.

By obtaining the liquid and plastic limits, the plasticity index can be determined. This is the range of water content where a soil will behave plastically. Use of the plasticity index and liquid limit allows for the classification of fine-grained soils as well as the fine-grained fraction of coarser soils. Atterberg limits tests were performed in accordance with ASTM D 4318. **Table (7)** summarizes the laboratory test results.

6.4.3 Classification of soil strata

This process is called soil classification, and it helps engineers in the preliminary design stage of geotechnical engineering problems. Most soil classification standards use soil indices such as Atterberg limits (liquid limit, plastic limit), soil gradation information (D_{10}, D_{30}, D_{60}, C_u, C_c), etc. In current geotechnical engineering practice, two standards are widely used in the United States: The Unified Soil Classification System (USCS) and AASHTO (American Association of State Highway and Transportation Officials) methods.

The classification was carried out according to ASTM standard D2487. The (**24**) results of the classification with Atterberg limits are shown in **table (7)**. The laboratory testing indicated (MH) high plastic Sandy inorganic SILT (Silt and filled with recrystallized gypsum friable), so that the soil was encountered in borehole (BH-01) at depths ranging between 9.5 m and 9.95 m below ground level.

Table 7: Grain size distribution, liquid and plastic limits results and soil classification.

Borehole No.	Depth, (m)	Sieve analysis			Atterberg limits			Soils classification system	
		Gravel %	Sand %	Fines %	LL	PL	Ip	USCS system	AASHTO
BH-01	2.0-2.45	0.0	84.6	15.4			N.P	SM, fine grained silty SAND	A-2-4
	3.0-3.45	15.7	58.5	25.8			N.P	SM, fine grained silty SAND with little gravel	A-2-4
	4.0-4.45	8.1	40.1	51.8			N.P	SM, fine grained silty SAND with few gravel	A-4
	5.0-5.45	0.8	41.0	58.2			N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4
	8.0-8.45	4.0	17.0	79.0			N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4
	9.5-9.95	0.0	2.4	97.6	57	36	21	MH, fine Sandy inorganic SILT high plasticity	A-7-5
BH-02	1.0-1.45	0.0	84.6	15.4			N.P	SM, fine grained silty SAND	A-2-4
	2.0-2.45	0.2	96.4	3.6			N.P	SP, Poorly graded, fine grained silty SAND with trace gravel	A-3
	3.0-3.45	0.8	75.9	23.3			N.P	SM, fine grained silty SAND	A-2-4

Continued (Table 7): Grain size distribution, liquid and plastic limits results and soil classification.

BH-02	5.0-5.45	0.3	49.3	50.4			N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4
	8.0-8.45	3.6	34.1	62.3	40	27	13	ML, fine Sandy SILT medium plasticity with trace gravel	A-6 (7)
	9.5-9.95	0.4	60.3	39.3			N.P	SM, fine grained silty SAND with trace gravel	A-4
BH-03	3.0-3.45	0.1	83.5	16.4			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	4.0-4.45	18.4	41.5	40.1			N.P	SM, fine grained silty SAND with little gravel	A-4
	6.5-6.95	5.2	57.7	37.1			N.P	SM, fine grained silty SAND with few gravel	A-4
	9.5-9.95	2.3	26.0	71.7	31	24	7	ML, fine Sandy SILT medium plasticity with trace gravel	A-4
BH-04	2.0-2.45	1.4	53.4	45.2			N.P	SM, fine grained silty SAND with trace gravel	A-4
	3.0-3.45	5.0	58.1	36.9			N.P	SM, fine grained silty SAND with trace gravel	A-4
	5.0-5.45	0.1	26.7	73.0	37	26	11	ML, fine Sandy SILT medium plasticity with trace gravel	A-4

Continued (Table 7): Grain size distribution, liquid and plastic limits results and soil classification.

BH-04	8.0-8.45	5.1	41.5	53.4		N.P	ML, fine Sandy SILT low plasticity with few gravel	A-4
BH-05	3.0-3.45	4.8	55.9	39.3		N.P	SM, fine grained silty SAND with trace gravel	A-4
	4.0-4.45	4.2	45.9	49.9		N.P	SM, fine grained silty SAND with trace gravel	A-4
	6.5-6.95	5.0	51.7	43.3		N.P	SM, fine grained silty SAND with trace gravel	A-4
	9.5-9.95	2.5	35.7	61.8		N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4

6.5 Chemical analysis and corrosion control

The purpose of performing chemical testing for foundation soils is to provide enough data, required for assessing the degree of corrosion that would attack the concrete or the steel of reinforcement and consequently for designing the suitable control and protection for the used concrete. The interpretation of these data will be used to select the suitable cement type to be used in the concrete, and choosing the necessary isolation and protection wherever needed. Results of chemical tests of pH, chloride concentration, sulphate concentrations and total dissolved solids are included in **table (8)**.

6.5.1 Sulphate concentrations and corrosion

The total and soluble sulphate concentrations measured show a small degree of variability. Generally, corrosion is considered to be a risk if the total sulphate content is greater than

0.2 % and/or the soluble sulphate content is greater than **0.05 %**. No precaution (sulphate-resistant cement) is required if sulphate concentrations fall below these thresholds. Measured soluble sulphate concentrations in the samples tested are all less than **0.1%.** Hence, on the basis of these results, the use of sulphate resistant cement is not considered necessary for this site.

6.5.2 Chloride concentration and corrosion

Precautions against chloride induced corrosion are recommended where chloride concentrations are expected to be greater than **0.1%**. The measured chloride contents **table (8)** is less than **0.05%** which are below the threshold value. On this basis no specific precautions against chloride induced corrosion are considered necessary at this site, however it is generally good practice to apply a protective bitumen coating to all buried concrete as a precaution.

6.5.3 pH

The results of pH obtained for all samples indicated a slightly alkaline environment. The pH ranges from 9.45 to 9.47 for the studied soil for the studied soil. The results of chemical analyses are shown in **table (8)**. These results reveal that no corrosion in the foundation concrete would be expected from organic acids. The results showed the soil to be slightly alkaline in upper strata and tend towards neutrality.

Table 8: Chemical analysis of soil samples.

Borehole No.	Depth (m)	Chloride (CL%)	pH	Water soluble sulphate as (SO_3%)
BH-01	2.0-2.45	0.0032	9.45	0.0006
BH-02	4.0-4.45	0.0042	9.46	0.0012

Continued (Table 8): Chemical analysis of soil samples.				
BH-04	4.0-4.45	0.0088	9.47	0.0048
BH-05	5.0-5.45	0.0052	9.45	0.0024
Exposure condition		Negligible	Negligible	Negligible
Permissible Limits, BS 882: 1992		<0.05	4.5 min.	0.2 Max

7. Geotechnical design parameters:

7.1 General

The geotechnical design parameters described in this report are based on the engineering evaluation of the subsurface conditions determined through drilling records, in-situ and laboratory testing of the representative samples from the investigation campaign.

7.2 Bulk unit weight

The unit weights of subsurface strata can be estimated through interpretation of the SPT data and laboratory testing of the samples retrieved from boreholes. The relationship of N-values with typical effective unit weight of cohesive and non-cohesive soil is given in **table (9)**, while typical design value ranges are specified below:

Silty SAND/ with silt (SM): 17- 19 kN/m^3 (1.70 -1.90 ton/m^3)

Table 9: SPT-N values and properties of non-cohesive soils.

Non-cohesive soils				
SPT-N_{30} values	Approximate relative density, Dr %	Dry unit weight, γ (ton/m^3)	In-situ compactness	Range of angle of internal friction, φ
0 - 4	0 - 15	< 1.6	Very loose	26 - 30
5 - 10	15 - 35	1.52 - 2.0	Loose	28 - 34
11 - 30	35 - 65	1.75 - 2.1	Medium dense	30 - 35
31 - 50	65 - 85	1.90 - 2.25	Dense	33 - 38
> 50	95	> 2.10	Very dense	Up to 40

7.3 Friction angle of soil

The friction angle is estimated based on **SPT** test results and direct shear test results, taking into consideration that these **SPT** results may be affected by the presence of cementation, which in turn will increase the **SPT** test results. Accordingly, a conservative value of (φ_f**=30°**) can be considered in the geotechnical analyses. The results are presented in **table (10)** shows the friction angle of granular soils, the test results of corrected SPT are given in ***Appendix C***.

Table 10: Estimated soil friction angle (φ_f) and corrected **SPT** values.

Borehole No.	Depth (m)	Soil type	Estimated angle of internal friction (deg.)	Average soil friction angle, ϕ_f (deg.)
BH-01	1.0-1.45	Medium dense, Silty fine SAND	32.9	**33.90**
	2.0-2.45		29.0	
	3.0-3.45		39.8	
BH-02	1.0-1.45	Medium dense, Silty fine SAND	32.5	**33.20**
	2.0-2.45		32.9	
	3.0-3.45		34.1	
BH-03	1.0-1.45	Medium dense, Silty fine SAND	34.8	**33.60**
	2.0-2.45		30.7	
	3.0-3.45		35.4	
BH-04	1.0-1.45	Medium dense, Silty fine SAND	36.2	**36.90**
	2.0-2.45		35.4	
	3.0-3.45		39.2	
BH-05	1.0-1.45	Medium dense, Silty fine SAND	31.6	**31.1**
	2.0-2.45		29.6	
	3.0-3.45		32.1	
Soil friction angle of soil estimated using the correlations proposed by Kulhawy and Mayane (1990) depending on (N60) SPT value				

7.4 Elasticity modulus (deformation modulus)

Short term / immediate settlements of foundations depend upon the elastic properties of the load bearing strata, characterized by modulus of elasticity (**E_s**). However, this value is expected to increase with depth, however, been used following relation for the evaluation of **E_s** values for the various soil layers encountered at the site:

Poorly Graded SAND with Silt / Silty SAND: $E_s = 500 * (N+15)$, KPa

below is **table (11)**, showing the modulus of elasticity of sand can be estimating the relative between (N) values and Modulus of elasticity (E_s).

Table 11: Estimated modulus of deformation of soil (**E_s**) and corrected **SPT** values.

Borehole No.	Depth (m)	Soil type	corrected N_{60}	Modulus of deformation, Es (KPa)
BH-01	1.0-3.45	Loose, Silty SAND (SM)	9	12000.0
		Very loose, Silty SAND (SM)	4	9428.6
		Dense, Silty SAND (SM)	32	23571.4
BH-02	1.0-3.45	Loose, Silty SAND (SM)	8	11678.6
			9	12000.0
		Med. dense, Silty SAND (SM)	11	12964.3
BH-03	1.0-3.45	Med. dense, Silty SAND (SM)	12	13607.1
		Loose, Silty SAND (SM)	6	10392.9
		Med. dense, Silty SAND (SM)	14	14250.0

Continued (Table 11): Estimated modulus of deformation of soil (Es) and corrected SPT values.				
BH-04	1.0-3.45	Med. dense, Silty SAND (SM)	15	15214.3
			14	14250.0
			28	21321.4
BH-05	1.0-3.45	Loose, Silty SAND (SM)	7	11035.7
			5	9750.0
			8	11357.1
Estimated stress-strain modulus E_s of soil using the equation proposed by in Bowles (1996).				

7.5 Coefficient of earth pressures

The coefficients of earth pressures for granular soils are essentially functions of the angle of internal friction (φ_f), which can be estimated using the following relationships:

$K_a = (1-\sin\varphi)/ (1+\sin \varphi_f)$

$K_o = (1- \text{Sin } \varphi_f)$

$K_p = (1+ \text{Sin } \varphi_f) / (1- \text{Sin } \varphi_f)$

Where:

K_a = Coefficient of active earth pressure (---)

K_o = Coefficient of earth pressure at rest (---)

K_p = Coefficient of passive earth pressure (---)

φ_f = the angle of internal friction (deg.)

The results are presented in **table (12)** shows the coefficient of earth pressure of soil.

Table 12: The coefficient of earth pressure.

Soil parameters (Estimated from N corrected values: SPT)			
Average coefficient of earth pressure at depth 3.45 m.	At rest K_o	0.49	soil friction angle, ϕ_f (deg)
	Active K_a	0.32	31.0
	Passive K_p	3.12	

7.6 Coefficient of friction between soil and concrete/steel

The coefficients of friction are defined as the tangent of the angle of friction and following values could be used for soil and concrete. Coefficient of friction between soil and concrete= **tan 24°** (For non-cohesive strata), coefficient of friction between soil and steel = **tan 20°** (For non-cohesive strata).

8. Foundation design of soil:

8.1 Allowable bearing capacity in soil from SPT-values

For soil, **SPT-N** value are used to estimate the allowable bearing capacity of shallow foundation. The standard penetration test **SPT** was developed around 1972. It is currently the most frequently used technique in Libya to obtain subsurface information. Mayerhof and Terzaghi-Peck (1948-1967) developed criteria to correlate relative densities with SPT-values, angle of internal and unit weight of granular soils.

The calculation of the allowable bearing capacity is performed using the modified form of the allowable bearing pressure by Bowles (1977) presented in Das, 1997. The following equation is used:

q_{all} (KN/m^2) = 16.66* N ' *[(3.28B+1/3.28B)^2] * Fd for B > 1.20 (isolated footing)

q_{all} (KN/m^2) = 25* N ' *(S_e/25.4) *Fd for B ≤ 1.20

Where:

q_{all} = allowable bearing capacity of soil (KPa)

N ' = the corrected SPT value (---)

B = width of footing (m)

B = width of footing (m)

Fd= depth factor: Fd = 1 +0.33 (Df/B) <1.33 (---)

S_e = Tolerable settlement (mm)

The allowable bearing capacity equation above was built on a factor of safety of three **3.0** and a **25** mm (1inch) settlement (elastic) was considered. The calculation of the allowable bearing capacity was done for foundation depths (**D**) of 1.0, 2.0 and more than 3.0 m and **Isolated footings** of widths (**B**) equal to 1.5, 2.0 and 2.5. The results of the allowable net bearing capacity are shown in **table 13**. For structures located at the position of boreholes No. (BH#01, BH#02, BH#03 and BH#04) the allowable net bearing capacity for static loads should not exceed 150 kPa (15 ton/m^2) at the previously recommended depth of isolated foundation and 200 KPa (20 ton/m^2) for raft foundation to be placed on soil at depth of not less than 3.5 m can be used for foundation design purpose.

At the position of boreholes (BH#05) a value of 100 kPa (1.0 ton/m^2) can be conservatively considered as an allowable net bearing capacity value for static loads on the loose sand layer at the recommended depth of isolated foundation and 150 KPa (15 ton/m^2) for raft foundation to be placed on soil at depth of not less than 4.0 m can be used for foundation design purpose. The net allowable bearing pressure was calculated based on controlled procedure of **50** mm (2inch) maximum allowable settlements for mat foundation and for an influence depth of 2B. Calculations of bearing resistance and corrected standard penetration value found in ***Appendix C***.

Table 13: Estimated allowable bearing capacity of soil.

Borehole No.	Depth below existing ground surface, m	Average of N_{60}	Net allowable bearing pressure, kPa			
			Isolated footings			Mat foundation
			B = 1.5 m	B = 2.0 m	B = 2.5 m	
BH-01	1.0-3.45	18	240.65	219.44	207.19	323.37
BH-02	1.0-3.45	12	157.96	144.04	136.00	212.26
BH-03	1.0-3.45	14	177.46	161.82	152.79	238.46
BH-04	1.0-3.45	24	312.05	284.55	268.66	419.31
BH-05	1.0-3.45	08	108.62	99.04	93.51	145.95

8.3 Estimated settlements

Soils, in general, are stable if the stress level is maintained or water content remains constant. However, when stresses applied in soil mass are changed, it deforms and causes

settlement or swelling in some instances. Meyerhof (1965) compiled the observed maximum settlements for mat foundations constructed on sand and gravel. The settlement of this material (soil and weathered rock) is estimated using the following equation:

S_e (mm) =2.0* q_{net}/N'_{60}

Where:

S_e = maximum settlements approximately (mm)

q_{net} = net allowable bearing capacity of soil (KN/m^2)

N'_{60} = the corrected SPT value (---)

The estimation of settlement was performed using net allowable bearing pressure (q_{net}). **table (14)** included the settlement results.

Table 14: Estimated settlement for soil layers.

Borehole No.	Stratum type	Depth of foundation (m)	Settlement, mm	Average settlement, mm
BH-01	Loose, Silty SAND (SM)	1.0-3.45	45.3	34.93
	Very loose, Silty SAND (SM)		22.5	
	Dense, Silty SAND (SM)		37.0	
BH-02	Med. dense, Silty SAND (SM)	1.0-3.45	44.8	36.59
	Loose, Silty SAND (SM)		35.2	
	Med. dense, Silty SAND (SM)		29.7	
BH-03	Med. dense, Silty SAND (SM)	1.0-3.45	46.8	36.16

Continued (Table 14): Estimated settlement for soil layers.				
BH-03	Loose, Silty SAND (SM)	1.0-3.45	29.9	
	Med. dense, Silty SAND (SM)		31.8	
BH-04	Med. dense, Silty SAND (SM)	1.0-3.45	47.6	40.80
			38.4	
			36.4	
BH-05	Loose, Silty SAND (SM)	1.0-3.45	43.7	31.51
			25.7	
			25.1	

9. Excavation and backfilling:

The soil under the foundations of the proposed structure will be excavated to the recommended foundation level. It is to be noted that at the location of the structure the excavation for the foundations will be carried out to the mentioned depths with safe side slopes or with appropriate side supporting system whenever needed. If any made ground is encountered at the bottom of excavation, it should be completely removed. The bottom of the excavation should be homogeneous, clean of any debris or loose material as a result of excavation. The type of soil at bottom of the excavation should be checked to confirm with the type of geomaterial reported in this report.

In case of buildings that have foundations on a sand layer, the bottom of excavation should be submerged with water for three cycles. Each cycle includes submerging the site for at least 48 hours and any resulting foam or debris has to be removed and the bottom of excavation must be heavily compacted using vibratory roller or bulldozer.

Backfill operation wherever needed around and above the foundations should be carried out in lifts not exceeding **25 cm** each. The backfill should be compacted to **95 %** of the

soil maximum dry density as determined by Modified Proctor Test. Backfill materials should be granular with fines percentage less than **10%** and **P.I**. should not exceeding **7%**. Backfill materials should not contain any roots, construction debris, salts, deleterious materials, organic matters, cobbles or boulders.

10. Liquefaction:

Soil liquefaction results from loss of strength during cyclic loading, such as imposed by earthquakes. Soils most susceptible to liquefaction are clean, loose, saturated, uniformly graded, fine-grained sands. The deep sands encountered in our borings were generally medium dense. In addition, groundwater was unencountered within the **9.95 meters** depth of our borings (the maximum investigated depth below existing ground level). For these reasons and based upon engineering judgment, it is our opinion that the potential for liquefaction at the site is low during seismic shaking.

11. Conclusions and Recommendations:

- The subsurface profile revealed by the boreholes indicate the presence two substrata unit are existed in the site investigated. The **first one** is soil stratum (The top layers) comprising of light brown to brown, medium dense becoming to loose, Silty fine grained Sand (SM) with trace gravel to light brown to whitish brown, Calcareous, fine to medium grained silty SAND with little gravel. This layer is encountered in all boreholes, and appeared from ground surface to 8.0 m of all boreholes except for BH#01 and BH#02 it appeared with thickness ranging between 1.0m to 4.45m. The **second stratum** is light brown to brownish white, stiff, low to medium plastic, fine Sandy SILT (ML) with trace gravel. The layer is encountered only in B.H #01 and BH#02 at depths 5.0m, 4.0m with thickness 4.0m and 3.0m respectively, a high plastic Silt deposits is encountered only in borehole No. BH#01 at depth 9.50 m. The

sub-strata were classified according to the information and test results obtained at each borehole (***appendix A***).

- Most of soils were classified as **SM** (fine grained silty SAND), **ML** (fine Sandy SILT, low plasticity), based on USCS and, all results of soil according to unified soil classification system are presented in table (**8**).

- It is recommended to design structure (modern and different services stations), with conservative allowable soil pressures in the order of 15 ton/m^2 (150 KPa) for isolated footings and 20 ton/m^2 (200 kPa) for rigid mat foundation at depth not less than 3.5 m from the ground surface level, for structures located at the position of boreholes No. (BH#01, BH#02, BH#03 and BH#04). At the location of boreholes (BH#05) a value of 100 kPa (1.0 ton/m^2) and 15 ton/m^2 (150 kPa) for isolated footings and rigid mat foundation respectively, the recommended depth of foundation must be not less than 4.0 m from the ground surface.

- Due to occurrence of backfill soil (loose and weak) at the top 2.5 meters, backfill and compaction should be performed properly according to the standard specifications. Moreover, the compaction should include the interface between the backfill soil body and the natural surrounded soil.

- and after scraping and removing backfill soil, levelling and compacting foundation soil. The allowable bearing resistance presented in **table (13)**. the computation of bearing resistance at service limit and settlement less than or equal to 50 mm. Post compaction settlement of fine-grained soil can be expected, even when placed to compaction specifications. As such, fill material should be installed as far in advance as possible before beginning constructed the foundation for best grade integrity.

- Because of presence of seepage water and probable rise in water table in summer, side fall (collapse) is eminent. So, at the time of construction of foundation, it is strongly recommended to design the appropriate site protection measures based on the soil properties shown in this report.

- Foundations installed in accordance with the recommendations outlined in the preceding sections are not expected to exceed total settlements of **50** mm.

- During the time of the investigation and one day after the completion of the fieldworks & inspection of boreholes by piezometers indicated that the groundwater table was not encountered up to **9.95** m (maximum depth in investigation) below the existing ground level. However; fluctuation in groundwater levels should be anticipated with variations seasonal.

- Corrosion potential isn't expected from chloride on the buried concrete because the chloride content isn't high than **0.1** %. And the soluble sulphate content isn't higher According to **table (8)**. the Normal Portland cement would be used to produce the concrete.

- Insulating the foundations by using high quality insulation materials, high quality bitumen sheets can be used after the foundation footing have been coated by high quality liquid bitumen.

- According to the chemical test results, the sulphates and chlorides contents of soil above the ground water level are all less than the permissible limits according to British standard specification (BS8004). Therefore, protective measures against

chemical attacks for foundation footing above the ground water level are not required.

- If the excavation below the foundation level is necessary, the improved clean soil used for backfilling in layers of **300 mm** maximum thickness (**BS 6031**) each to be well compacted to **95 %** of modified proctor.

- The engineered fill must comprise of **A-1-a** or **A-1-b** materials as per AASHTO Soil Classification System (M-145). The fill must be placed in layers with loose lift not exceeding **20** cm in thickness. Each layer must be compacted to an in-situ density not less than **95**% of maximum proctor density. Alternatively, crushed rock fill or clean concrete can also be used.

- Excavated materials can be stockpiled for later use in backfilling, engineered fill used to raise the grade as engineering backfill should conform to the specifications, the excavated native soil classified as shown in **table 15** according to AASHTO Classification can be used for backfilling behind abutments if properly controlled and free from the deleterious substance.

Table 15: General guide specifications for backfilling materials

Specifications	Soil parameters
Backfilling materials type	(A-1-a or A-1-b) According to AASHTO
The excavated native soil	(A-2-4) According to AASHTO

Degree of compactions	A minimum relative compaction of 95% ASTM d 698-12
Layers placed	Horizontal layers not exceeding 20 cm thickness

- Through the evaluation of site location in regard with the seismic activity, it was found that the project area located within the low active zone. Therefore, the peak acceleration value could be assumed as **0.12 g**.

الخلاصة والتوصيات:

مقدمة:

لقد اشتملت الدراسة الجيوتقنية كما اشير اليها سابقاً في التقرير (باللغة الانجليزية)على حفر **(05)** جسات اختبارية وبطول اجمالى وقدره **(49.75)** متر طولي تقريباً، حيث ان الـ**(05)** جسات تم حفرها في موقع مبنى **(محطة تزويد وقود حديثة نموذجية)** وتتراوح اعماق هذه الجسات من **(1.0** الي 9.95**)** متر لكل جسة. وقد تم إجراء حوالي **(40)** اختبار اختراق قياسي ***(SPT)***. كما تضمنت الاعمال الحقلية ايضا فحص ومعاينة جميع العينات التي تم استخراجها اثناء عملية الحفر ووصفها وصف جيوتقنياً، كما اشتملت الدراسة أيضاً على اجراء الاختبارات المعملية والكيميائية اللازمة لتحديد نوع وخواص التربة الهندسية وتحديد مدى إمكانية تأثير أملاح الكبريتات والكلوريدات على الخرسانة وحديد التسليح. توصل التقرير الى عدد من الاستنتاجات والتوصيات على ضوء ما تم الحصول عليه من نتائج حقلية ومعملية، وفيما يلي مجمل هذه **الاستنتاجات والتوصيات:**

- يشير المقطع الجانبي لطبقات التربة التحت سطحية والتى اظهرتها الجسات الاختبارية، وجود وحدتين من الطبقات التحت سطحية في موقع الدراسة والتى تم فحصها. **الوحدة الاولى** (الطبقات العليا) والتى تتكون من الرمل الناعم الغريني **(SM-Silty fine SAND)** بني الى بني فاتح اللون، وتكون الكثافة النسبية من متوسطة الى منخفضة لهذا الرمل لتصبح هذه التربة عبارة تربة كلسية **(Calcareous)** بنية فاتحة الى البني المائل للبياض وتتكون عادتاً من الرمل الناعم، يحتوي هذا الرمل الناعم على نسب مختلفة من الحصى في بعض الاحيان. تم مواجهة هذه الطبقات في جميع الجسات الاختبارية، كما ويتراوح سمك هذه الطبقات من سطح الارض وحتى عمق 8 متر عند جميع الجسات بأستثناء الجسة رقم **(BH#01)** والجسة **(BH#02)** ويتراوح سمكها عند هده الجسات بين 1.0 الى 4.45 متر.

الطبقة الثانية (الوحدة الثانية) و تتكون عادة من غرين رملي منخفض الى متوسط اللدونة (ML-Sandy Silt) بني فاتح الى بني ضارب الى البياض في اللون، مع وجود نسبة ضئيلة من الحصى. تم العثور على هده الطبقات في الجسات الاختبارية رقم **(BH#01)** والجسة **(BH#02)** عند الاعماق 5 و4 متر وبسمك 4 متر و3 متر على التوالي، كما توجد رواسب غرينية **(high plastic SILT)** عالية اللدونة **(high plastic)** في الجسة **(BH#01)** على عمق 9.5 متر. تم توصيف الطبقات التحت سطحية طبقاً للمعلومات ونتائج الاختبارات والتى تم الحصول عليها من سجل الجسات في الملحق (A).

- تم تصنيف معظم التربة في موقع المشروع على انها تربة من الرمل الناعم ونسبة من الغرين **(SM, Silty fine SAND)** وتكون عند بعض الطبقات عبارة عن طمي مخلوط برمل الناعم وهي قليلة **(ML, fine Sandy Silt, low plasticity)** تم تصنيف التربة طبقاً لنظام **(USCS)**، وجميع نتائج تصنيف التربة وفقاً لنظام الموحد للتربة موضح في الجدول رقم (8).

- يوصي التقرير بتصميم المبنى (محطة تزويد وقود حديثة نموذجية) بضغط معتدل مسموح به للتربة في حدود **150** كيلوباسكال **(15** طن/م^2) للاساسات المنفصلة **(isolated footings)** و**200** كيلوباسكال **(30** طن/م^2) للاساسات نوع الحصيرة القاسية **(rigid raft foundation)** على عمق لايقل عن 3.5 متر من منسوب مستوى سطح الارض، للمنشآت الموجودة في مواقع الجسات رقم **(BH#01, BH#02, BH#03 and BH#04)**. في موقع الجسة رقم **(BH#05)** تكون قيمة ضغط التربة المعتدلة المسموح بها **100** كيلوباسكال **(10** طن/م^2) و**150** كيلوباسكال **(15** طن/م^2) للاساسات الحصيرة القاسية على التوالي ويجب ألايقل العمق الموصى به للأساسات عن 4.0 متر من سطح الارض.

- نظراً لوجود تربة الردم (سائبة وضعيفة) على عمق 2.5 متر، يجب أن يتم الردم ودمك التربة بشكل صحيح وفقاً للمواصفات القياسية الموصى بها. علاوة على ذلك ، يجب أن يشتمل الدمك على السطح البيني بين جسم تربة الردم والتربة الطبيعية المحيطة وبعد كشط وازالة تربة الردم و تسوية و دمك تربة التاسيس.

- مقاومة التحيمل المسموح بها للتربة موضحة في الجدول (13). كما تم حساب قدرة تحميل التربة على اساس اقصى هبوط مسموح به 50 مم. يمكن توقع هبوط ما بعد دمك التربة ذات الحبيبات الدقيقة، حتى عند وضعها وفقًا لمواصفات الدمك. على هذا النحو، يجب تثبيت مواد االردم مسبقًا قدر الإمكان قبل البدء في إنشاء الأساسات لتحقيق أفضل درجات سلامة.

- حسب ما تم ذكره في البند السابق (عند نفس المقطع الدى تم حساب عنده قدرة التحميل)، لا يتوقع أن تتجاوز اجمالي الهبوط قيمة قدرها 50 مم للقواعد من نوع اللبشة.

- بسبب وجود المياه المتسربة والارتفاع المحتمل في منسوب المياه الجوفية في الشتاء، يكون السقوط الجانبي (الانهيار) بارزًا في وقت إنشاء الأساسات، لذلك يوصى بشدة بتصميم تدابير حماية الموقع المناسبة بناءً على خصائص التربة الموضحة في هذا التقرير.

- خلال فترة التحري الجيوتقني في الموقع وبعد الانتهاء منها بيوم واحد من الاستكشاف الجيوتقني لكل موثع، تم التأكد من منسوب المياه الجوفية بواسطة اجهزة قياس منسوب المياه الجوفية **(piezometers)**. وقد أشارت إلى عدم وجود او لم يصادف العثور علي منسوب المياه الجوفية حتى عمق (10.95 متر) من منسوب سطح الارض الطبيعي في جميع الجسات الاستكشافية، ومع ذلك يجب توقع التقلبات في مستويات المياه الجوفية مع التغيرات الموسمية.

- ليس من المتوقع حدوث تآكل من املاح الكلوريدات على الخرسانة المدفونة لأن محتوى الكلوريد لم يزيد عن 0.1٪. ومحتوى الكبريتات الذائبة ليس أعلى من ذلك حسب ماهو في الجدول

(10) وذلك حسب المواصفات القياسية البريطانية (BS)، اما بخصوص قيم الاس الهيدروجيني (pH) من 9.45 الى .479 وهي تدل على ان الوسط المحيط بقواعد الاساسات شبه متعادل ولا يوجد تاثير حامضي ولا تاثير قلوي على الخرسانة وبذلك يمكن استخدام الاسمنت البورتلاندي العادي لإنتاج الخرسانة.

- يجب عزل الاساسات بأستخدام مواد عالية الجودة، يمكن استخدام صفائح من البيتومين عالي الجودة أو طلاء القواعد بالبيتومين السائل عالي الجودة.

- اذا كان من الضروري الحفر تحت منسوب الاساسات يجب استخدام تربة صالحة للردم تحت الاساسات بطبقات لايقل سمك الطبقة عن **300** مم طبقاً للمواصفة البريطانية **(BS 6031)** بحيث يتم دمكها الى جيداً حتى **95%** من اقصى كثافة معملية (بروكتور المعدل).

- يجب أن تكون مواد الردم تحت التصنيف **(A-1-a)** و**(A-1-b)** وفقًا لنظام تصنيف التربة **(AASHTO Soil Classification System: M-145)**. ويجب توضع مواد الردم بشكل سائب على شكل طبقات لايقل سمكها عن **20** سم ودمك كل طبقة في الموقع بحيث لاتقل عن **95%** من أقصى كثافة جافة معملية، في بعض الحالات يمكن استخدام دكة حجرية او الكسر الصخري أو طبقة نظافة خرسانية.

- فيما يخص النشاط الزلزالي تبين أن منطقة الدراسة تقع ضمن نطاق النشاط الزلزالي المنخفض لك ، يمكن افتراض قيمة التعجيل تساوي (g12).

<u>ملاحظة:</u> هذه الخلاصة والتوصيات هي ترجمة بالعربية لتوصيات والخلاصة في التقرير النهائي باللغة الانجليزية لمشروع انشاء **محطة تزويد وقود حديثة نموذجية** في منطقة طريق المطار بمدينة طرابلس، وأن جميع النتائج التى تم الاعتماد عليها في هذه الورقة موجودة فقط في النسخة باللغة الانجليزية.

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APPENDIX 'A'
BOREHOLE LOGS
(Field Data)

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : Unimog atlas copco
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-01	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 26/12/2021
Date Completed : 26/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS		--	N.A.	N.A.	N.A.	Light brown Silty fine grained Sand (Backfill soil), non plastic fines, dry, very weak cementation.	
1.0	DS		14	N.A.	N.A.	N.A.	Medium dense, light brown, silty fine grained SAND (Backfill soil), weak cementation, non plastic, dry. No. of blows: (05)(06)(08)	
2.0	DS		06	N.A.	N.A.	N.A.	(SM) Loose, light brown, fine grained silty SAND (Backfill soil). Gravel (0.0%), Sand (84.6%), Fines (15.4%),weak cementation, non plastic, dry. No. of blows: (02)(03)(03)	
3.0	DS		Over50	N.A.	N.A.	N.A.	(SM) Very dense, light brown to brownish white, Calcareous, fine to medium grained silty SAND with little gravel. Gravel (15.7%), Sand (78.6%), Fines (25.8%), non plastic, moist. No. of blows: (Over 50)	
4.0	DS		30	N.A.	N.A.	N.A.	(ML) Light brown to brownish white, fine Sandy SILT whit few fine gravel.Gravel(1.8%), Sand (40.1%), Fines (51.8%), very stiff, low plasticity, moist. No. of blows: (11)(14)(16)	
							Continue Next Page.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

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Prepared By: Assari Engineering Consultant

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : Unimog atlas copco
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-01	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 26/12/2021
Date Completed : 26/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		30	N.A.	N.A.	N.A.	(ML) Light brown to brown, fine Sandy SILT whit trace gravel.Gravel (0.8%), Sand (41.0%), Fines (58.2%), very stiff, low plasticity, moist. No. of blows: (11)(14)(16)	
6.0	DS		20	N.A.	N.A.	N.A.	Light brown to brown, fine Sandy SILT whit trace gravel, very stiff, low plasticity, moist. No. of blows: (07)(10)(10)	
7.0	DS		23	N.A.	N.A.	N.A.	(ML) Light brown to whitish brown, fine to medium grained Sandy SILT whit trace gravel.Gravel (4.0%), Sand (17.0%), Fines (79.2%), very stiff, low plasticity, moist. No. of blows: (07)(11)(12)	
8.0								
9.0	DS		30	N.A.	N.A.	N.A.	(MH) Brown to dark brown, inorganic SILT wit trace of fine sand.Gravel (0.0%), Sand (2.4%), Fines (97.6%), hard, high plasticity (high compressibility), moist. No. of blows: (07)(09)(21)	
10.0							End of borehole at 9.95m depth.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery. RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 2 of 2

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : Unimog atlas copco
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-02	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 26/12/2021
Date Completed : 26/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS		--	N.A.	N.A.	N.A.	Light brown Silty fine grained Sand (Backfill soil), non plastic fines, dry, very weak cementation.	
1.0	DS		13	N.A.	N.A.	N.A.	(SM) Medium dense, light brown, silty fine grained SAND (Backfill soil). Gravel (0.0%), Sand (84.6%), Fines (15.4%),weak cementation, non plastic, moist. No. of blows: (02)(04)(09)	
2.0	DS		14	N.A.	N.A.	N.A.	(SP) Medium dense, light brown, poorly graded, fine grained SAND (Dune Sand) with trace gravel (Backfill soil). Gravel (0.2%), Sand (96.2%), Fines (3.6%), weak cementation, non plastic, moist. No. of blows: (03)(05)(09)	
3.0	DS		17	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to brown, fine grained silty SAND with trace gravel. Gravel (0.8%), Sand (83.1%), Fines (23.3%), non plastic, weak cementation, moist. No. of blows: (04)(07)(10)	
4.0	DS		08	N.A.	N.A.	N.A.	Loose, light brown to brown, silty fine grained SAND with trace gravel, non plastic, weak cementation, moist. No. of blows: (02)(03)(05)	
							Continue Next Page.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 1 of 2

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : Unimog atlas copco
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-02	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 26/12/2021
Date Completed : 26/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		28	N.A.	N.A.	N.A.	(ML) Light brown to whitish brown, fine Sandy SILT whit trace gravel.Gravel (0.3%), Sand (49.3%), Fines (50.4%),Very stiff, low plasticity, moist. No. of blows: (08)(11)(17)	
6.0	DS		32	N.A.	N.A.	N.A.	Light brown to whitish brown, fine grained Sandy SILT whit trace gravel, hard, low plasticity, moist. No. of blows: (12)(14)(18)	
7.0	DS		26	N.A.	N.A.	N.A.	(ML) Light brown to whitish brown, fine to medium grained Sandy inorganic SILT whit trace gravel.Gravel (3.6%), Sand (34.1%), Fines (62.3%), very stiff, low plasticity (medium compressibility), moist. No. of blows: (03)(11)(15)	
8.0								
9.0	DS		30	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to brown, fine grained silty SAND with trace gravel. Gravel (0.4%), Sand (60.3%), Fines (39.3%), non plastic, weak cementation, dry. No. of blows: (07)(13)(17)	
10.0							End of borehole at 9.95m depth.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 2 of 2

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : YWE-D90R
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-03	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 28/12/2021
Date Completed : 28/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS		---	N.A.	N.A.	N.A.	Light brown Silty fine grained Sand (Backfill soil), non plastic fines, dry, very weak cementation.	
1.0	DS		19	N.A.	N.A.	N.A.	Medium dense, light brown to brown, silty fine grained SAND (Backfill soil). Weak cementation, non plastic, dry. No. of blows: (05)(10)(09)	
2.0	DS		09	N.A.	N.A.	N.A.	Loose, light brown to brown, silty fine grained SAND (Backfill soil). Weak cementation, non plastic, dry. No. of blows: (04)(05)(04)	
3.0	DS		21	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to brown, fine grained silty SAND with trace gravel. Gravel (0.1%), Sand (83.5%), Fines (16.4%), non plastic, weak cementation, dry. No. of blows: (04)(07)(10)	
4.0	DS		38	N.A.	N.A.	N.A.	(SM) Dense, light brown to whitish brown, Calcareous, fine to medium grained silty SAND with little gravel. Gravel (18.4%), Sand (41.5%), Fines (40.1%), non plastic, weak cementation, dry. No. of blows: (08)(18)(20)	
							Continue Next Page.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

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BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : YWE-D90R
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-03	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 28/12/2021
Date Completed : 28/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		Over 50	N.A.	N.A.	N.A.	Very dense, light brown, Calcareous, fine to medium grained silty SAND with little gravel, non plastic, dry. No. of blows: (12)(35/10)(Refused)	
6.0	DS		28	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to brown, fine grained silty SAND with few gravel. Gravel (5.2%), Sand (57.7%), Fines (37.1%), non plastic, weak cementation, dry. No. of blows: (07)(11)(17)	
7.0	DS		26	N.A.	N.A.	N.A.	Medium dense, light brown to brown, fine grained silty SAND with few gravel, non plastic, weak cementation, dry. No. of blows: (07)(11)(15)	
8.0	DS		28	N.A.	N.A.	N.A.	(ML) Light brown to brown, fine to medium grained Sandy inorganic SILT whit trace gravel.Gravel (2.6%), Sand (26.0%), Fines (71.7%), very stiff, low plasticity (medium compressibility), moist. No. of blows: (07)(13)(15)	
9.0								
10.0							End of borehole at 9.95m depth.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 2 of 2

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : YWE-D90R
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-04	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 27/12/2021
Date Completed : 27/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS		--	N.A.	N.A.	N.A.	Light brown Silty fine grained Sand (Backfill soil), non plastic fines, dry, very weak cementation.	
1.0	DS		24	N.A.	N.A.	N.A.	Medium dense, light brown to brown, silty fine grained SAND (Backfill soil). Weak cementation, non plastic, dry. No. of blows: (06)(12)(12)	
2.0	DS		21	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to whitish brown, fine grained silty SAND with trace gravel. Gravel (1.4%), Sand (53.4%), Fines (45.2%), non plastic, weak cementation, dry. No. of blows: (09)(10)(11)	
3.0	DS		43	N.A.	N.A.	N.A.	(SM) Dense, light brown to whitish brown, Calcareous, fine grained silty SAND with trace gravel. Gravel (5.0%), Sand (58.1%), Fines (36.9%), non plastic, weak cementation, dry. No. of blows: (13)(23)(20)	
4.0	DS		33	N.A.	N.A.	N.A.	Dense, light brown to whitish brown, Calcareous, fine grained silty SAND with trace gravel, non plastic, weak cementation, dry. No. of blows: (07)(18)(15)	
							Continue Next Page.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
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BOREHOLE LOG

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Golden Middle East Oil Services Company

Project Number : 20165
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Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : YWE-D90R
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-04	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 27/12/2021
Date Completed : 27/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		Over 50	N.A.	N.A.	N.A.	(ML) Light brown to brown, fine to medium grained Sandy inorganic SILT whit trace gravel.Gravel (0.1%), Sand (26.9%), Fines (73.0%), hard, low plasticity (medium compressibility), moist. No. of blows: (Over 50)	
6.0	DS		36	N.A.	N.A.	N.A.	Dense, light brown to brown, fine grained silty SAND with few gravel, non plastic, weak cementation, dry. No. of blows: (17)(16)(20)	
7.0	DS		31	N.A.	N.A.	N.A.	(ML) Light brown to brown, fine to medium grained Sandy inorganic SILT whit few gravel.Gravel (5.1%), Sand (41.5%), Fines (53.4%), hard, low plasticity (low compressibility), dry. No. of blows: (07)(13)(18)	
8.0								
9.0	DS		43	N.A.	N.A.	N.A.	Light brown to brown, fine to medium grained Sandy inorganic SILT whit trace grave. Hard, low plasticity (ow compressibility), dry. No. of blows: (17)(23)(20)	
10.0							End of borehole at 9.95m depth.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 2 of 2

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : Unimog atlas copco
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-05	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 27/12/2021
Date Completed : 27/12/2021

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS		--	N.A.	N.A.	N.A.	Light brown Silty fine grained Sand (Backfill soil), non plastic fines, dry, very weak cementation.	
1.0	DS		11	N.A.	N.A.	N.A.	Medium dense, light brown, silty fine grained SAND (Backfill soil). Weak cementation, non plastic, dry. (Dune Sand) .No. of blows: (03)(04)(07)	
2.0	DS		07	N.A.	N.A.	N.A.	Loose, light brown, silty fine grained SAND (Backfill soil). Weak cementation, non plastic, dry. (Dune Sand) .No. of blows: (02)(03)(04)	
3.0	DS		12	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to brown, fine grained silty SAND with trace gravel. Gravel (4.8%), Sand (55.9%), Fines (39.3%), non plastic, weak cementation, dry. No. of blows: (02)(03)(09)	
4.0	DS		23	N.A.	N.A.	N.A.	(SM) Medium dense, light brown to whitish brown, fine grained silty SAND with trace gravel. Gravel (4.2%), Sand (45.9%), Fines (49.9%), non plastic, weak cementation, dry. No. of blows: (07)(11)(12)	
							Continue Next Page.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 1 of 2

BOREHOLE LOG

Assari / Engineering Consultant

Golden Middle East Oil Services Company

Project Number : 20165
Project Name : The construction of different services station
Project Location : Road (highway) airport
Drilling Company : Assari Engineering Consultant Co.
Cleint : Golden Middle East Oil Services Company
Rig Type : Unimog atlas copco
Drilling Method : hollow-stem auger method
Site Supervisor : Eng.Abubakr Anakoa

Borehole No.	Coordinates
BH-05	N : E :

Soil Classification System : U.S.C.S
Weather Condation : Partly cloudy and cool
Ground Surface Elevation, m :
Ground Water Table, m : Not encountered
Date Begun : 27/12/2021
Date Completed : 27/12/2021

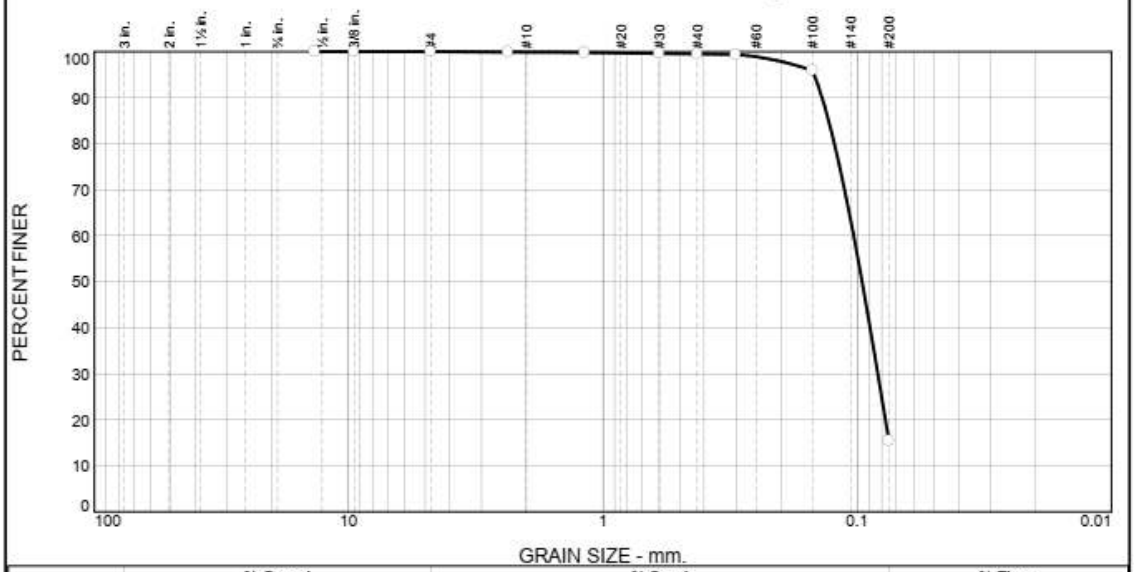
Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		18	N.A.	N.A.	N.A.	Medium dense, light brown to whitish brown, fine grained silty SAND with trace gravel. Non plastic, weak cementation, dry. No. of blows: (03)(08)(10)	
6.0	DS		Over 50	N.A.	N.A.	N.A.	(SM) Very dense, light brown to whitish brown, Calcareous, fine grained silty SAND with trace gravel. Gravel (5.0%), Sand (51.7%), Fines (43.3%), non plastic, Compacted, dry. No. of blows: (20)(Over 50)	
7.0	DS		Over 50	N.A.	N.A.	N.A.	Very dense, light brown to whitish brown, Calcareous, fine grained silty SAND with trace gravel. Gravel (5.0%), Sand (51.7%), Fines (43.3%), non plastic, Compacted, dry. No. of blows: (13)(27)(32)	
9.0	DS		39	N.A.	N.A.	N.A.	(ML) Light brown to whitish brown, fine to medium grained Sandy inorganic SILT whit trace gravel.Gravel (2.5%), Sand (35.7%), Fines (61.8%), hard, low plasticity (low compressibility), moist. No. of blows: (13)(17)(22)	
10.0							End of borehole at 9.95m depth.	

DS: Disturbed Sample. TCR:Total Core Recovery. SCR: Solid Core Recovery.
RQD: Rock Quality Designation. SL:Sample lose ST:Shelby Tube Sample
N.A. : Not Applicable.

Sheet : 2 of 2

APPENDIX 'B'
Particle Size Distribution
(ASTM D 422)

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.0	0.1	0.4	84.1	15.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	100.0		
#8	99.9		
#16	99.8		
#30	99.6		
#40	99.5		
#50	99.4		
#100	95.9		
#200	15.4		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 0.1374 D_{85}= 0.1294 D_{60}= 0.1032
D_{50}= 0.0956 D_{30}= 0.0829 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

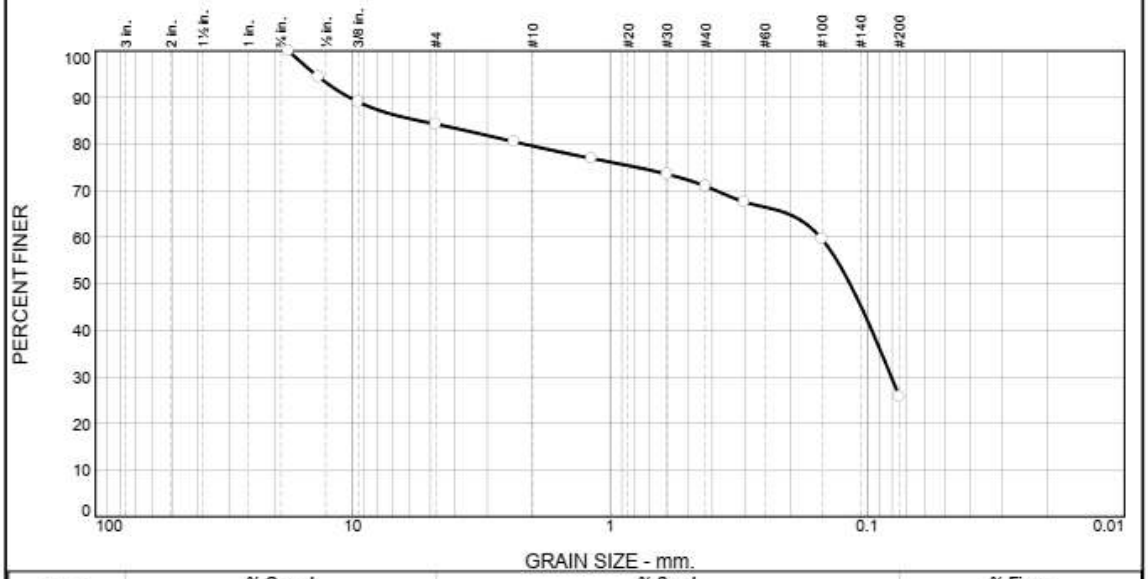
Title:

Source of Sample: BH#1 **Depth:** 2.0-2.45m **Date Sampled:**
Sample Number: 1

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	15.7	4.7	8.7	45.1	25.8

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.7"	100.0		
0.535"	94.4		
3/8"	89.1		
#4	84.3		
#8	80.5		
#16	76.9		
#30	73.5		
#40	70.9		
#50	67.6		
#100	59.6		
#200	25.8		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 10.2910 D_{85}= 5.4988 D_{60}= 0.1521
D_{50}= 0.1167 D_{30}= 0.0806 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: Date Tested: 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

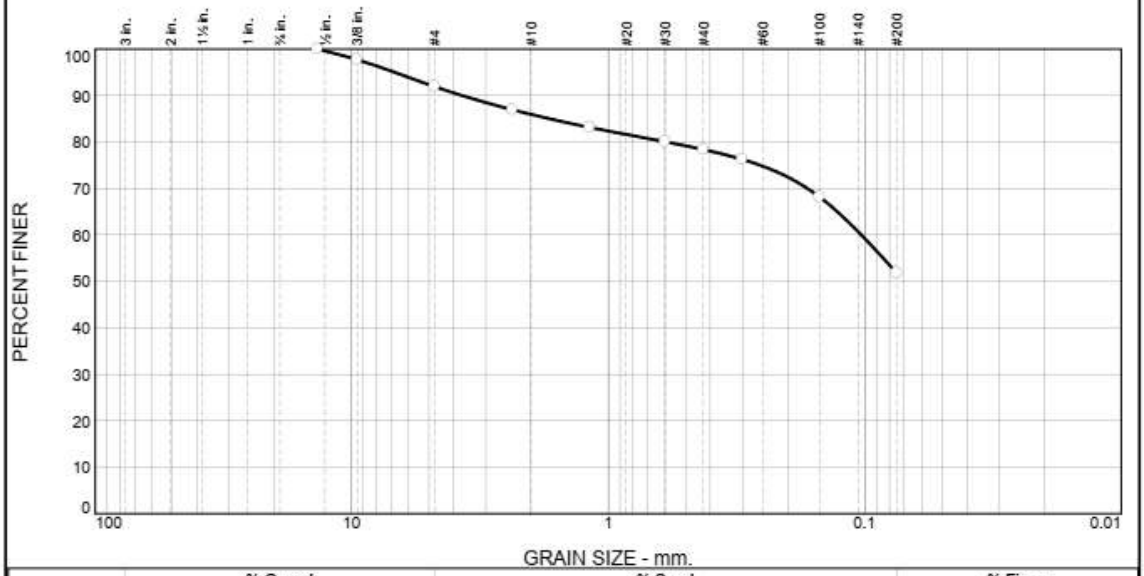
Title:

Source of Sample: BH#1 **Depth:** 3.0-3.45m **Date Sampled:**
Sample Number: 2

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	8.1	6.0	7.6	26.5	51.8

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	97.7		
#4	91.9		
#8	86.9		
#16	83.1		
#30	80.0		
#40	78.3		
#50	76.2		
#100	68.2		
#200	51.8		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 3.7171 D_{85}= 1.6959 D_{60}= 0.1031
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

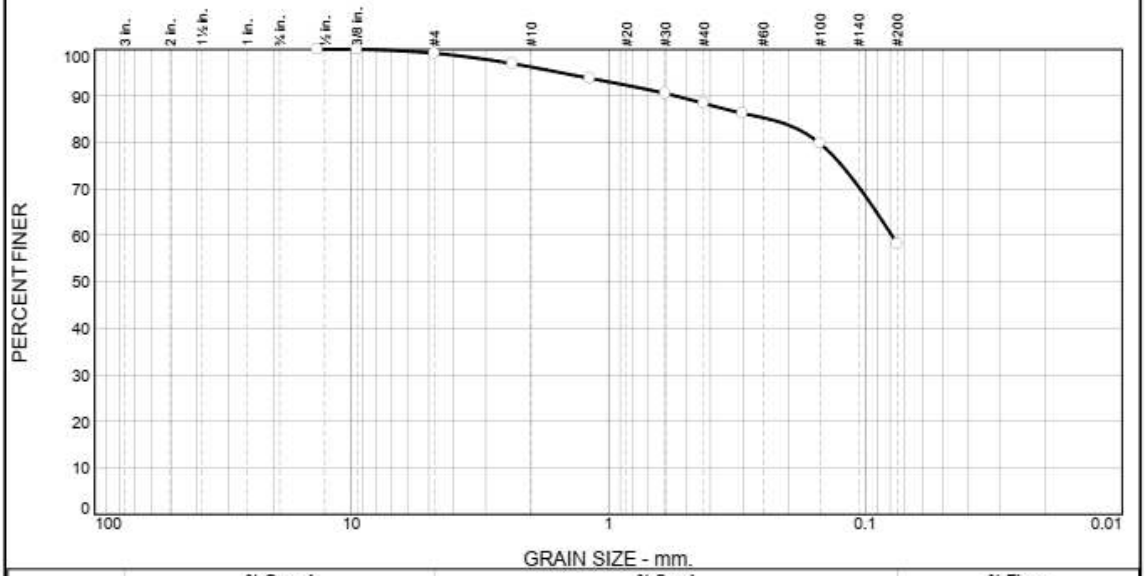
Title:

Source of Sample: BH#1 **Depth:** 4.0-4.45m **Date Sampled:**
Sample Number: 3

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.8	3.0	7.8	30.2	58.2

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.2		
#8	96.9		
#16	93.8		
#30	90.5		
#40	88.4		
#50	86.3		
#100	79.8		
#200	58.2		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.5481 D_{85}= 0.2364 D_{60}= 0.0787
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

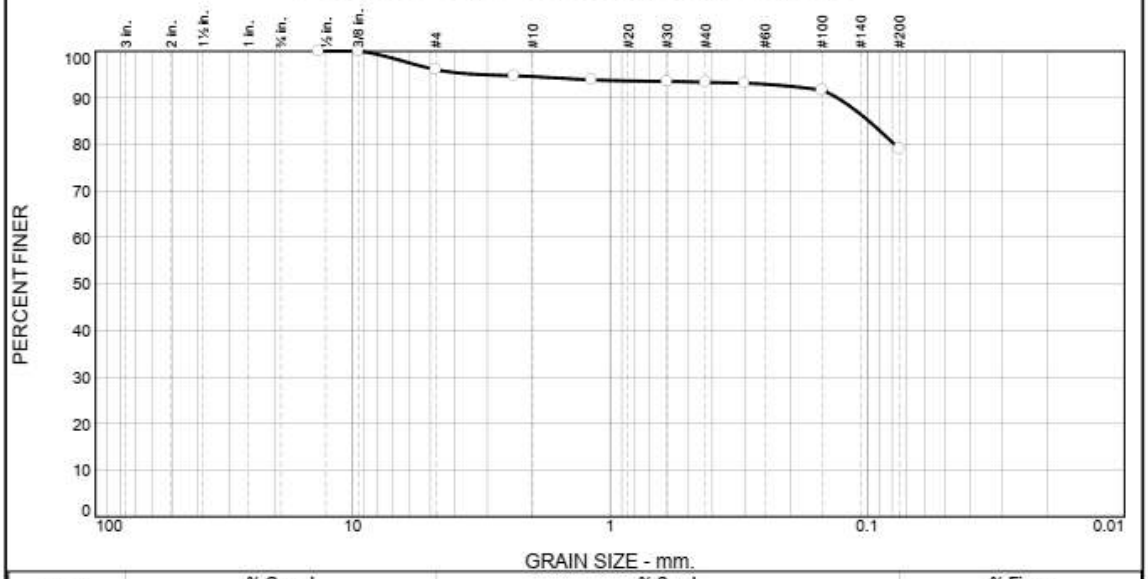
Title:

Source of Sample: BH#1 **Depth:** 5.0-5.45m **Date Sampled:**
Sample Number: 4

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	4.0	1.4	1.3	14.3	79.0

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	96.0		
#8	94.7		
#16	93.9		
#30	93.5		
#40	93.3		
#50	93.2		
#100	91.7		
#200	79.0		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.1308 D_{85}= 0.0987 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

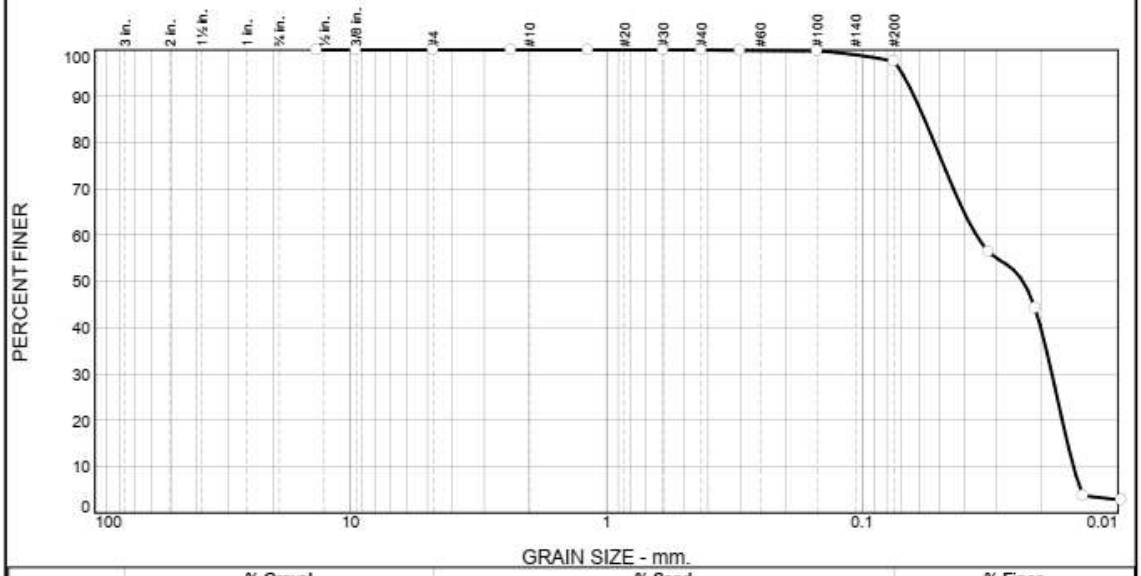
Title:

Source of Sample: BH#1 **Depth:** 8.0-8.45m **Date Sampled:**
Sample Number: 5

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.0	0.0	0.0	2.4	97.6

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	100.0		
#8	100.0		
#16	100.0		
#30	100.0		
#40	100.0		
#50	99.9		
#100	99.8		
#200	97.6		
0.0320 mm.	56.4		
0.0211 mm.	44.2		
0.0137 mm.	3.7		
0.0097 mm.	2.8		

* (no specification provided)

Material Description

Sandy silt high plasticity

Atterberg Limits (ASTM D 4318)

PL= 36 LL= 57 PI= 21

Classification

USCS (D 2487)= MH AASHTO (M 145)= A-7-5(27)

Coefficients

D_{90}= 0.0626 D_{85}= 0.0570 D_{60}= 0.0358
D_{50}= 0.0235 D_{30}= 0.0181 D_{15}= 0.0157
D_{10}= 0.0149 C_u= 2.40 C_c= 0.61

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

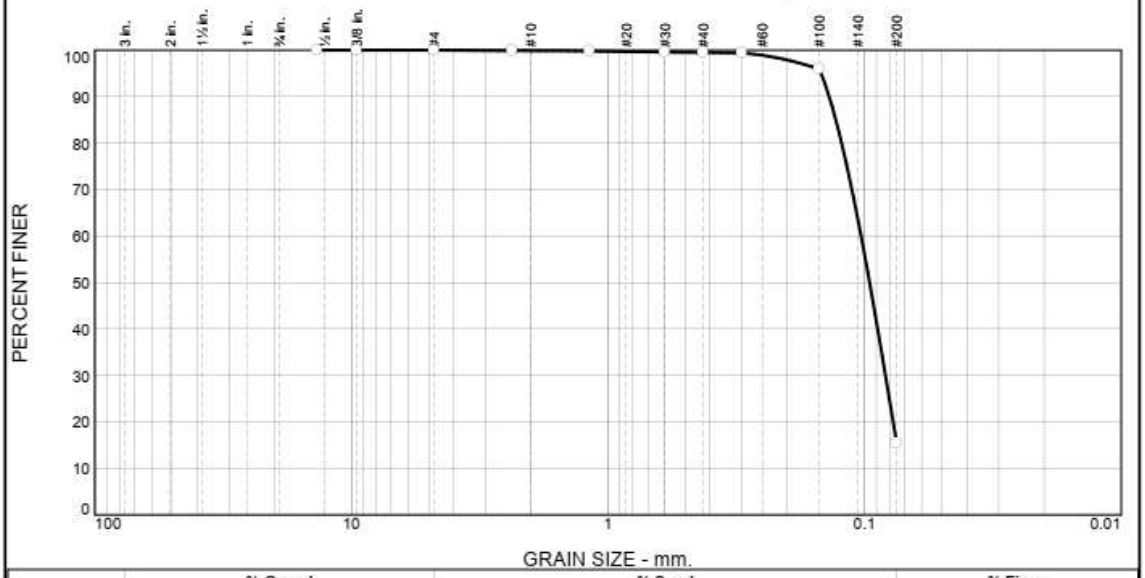
Title:

Source of Sample: BH#1 **Depth:** 9.5-9.95m **Date Sampled:**
Sample Number: 6

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.0	0.1	0.4	84.1	15.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	100.0		
#8	99.9		
#16	99.8		
#30	99.6		
#40	99.5		
#50	99.4		
#100	95.9		
#200	15.4		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 0.1374 D_{85}= 0.1294 D_{60}= 0.1032
D_{50}= 0.0956 D_{30}= 0.0829 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

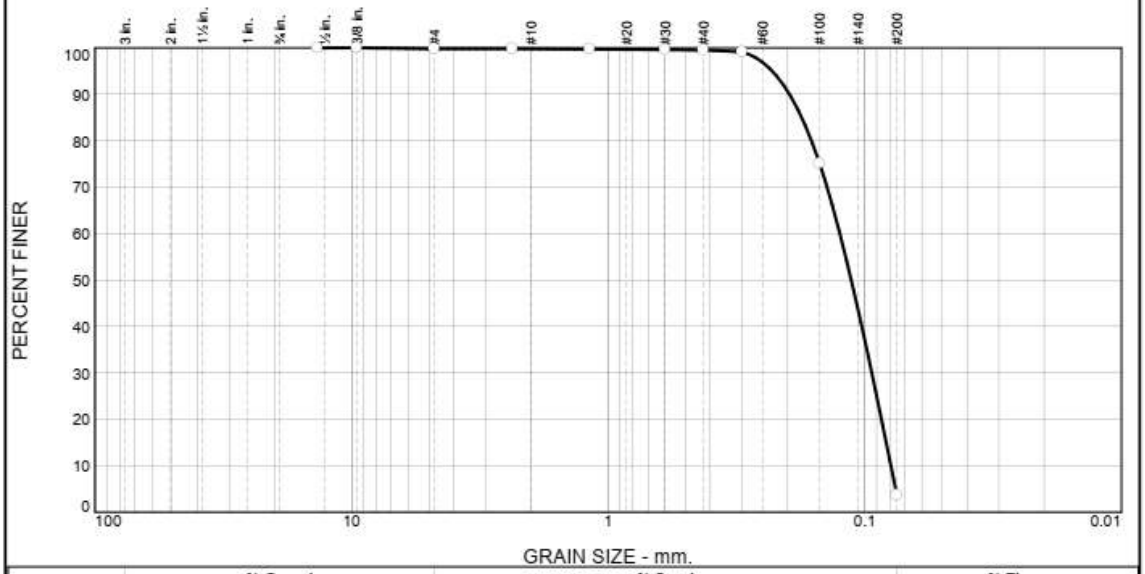
Title:

Source of Sample: BH#2 **Depth:** 1.0-1.45m **Date Sampled:**
Sample Number: 1

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.2	0.0	0.3	95.9	3.6

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.8		
#8	99.8		
#16	99.7		
#30	99.6		
#40	99.5		
#50	99.1		
#100	75.1		
#200	3.6		

* (no specification provided)

Material Description

Poorly graded sand with silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SP AASHTO (M 145)= A-3

Coefficients

D_{90}= 0.1966 D_{85}= 0.1762 D_{60}= 0.1251
D_{50}= 0.1130 D_{30}= 0.0940 D_{15}= 0.0826
D_{10}= 0.0791 C_u= 1.58 C_c= 0.89

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

Title:

Source of Sample: BH#2 **Depth:** 2.0-2.45m **Date Sampled:**

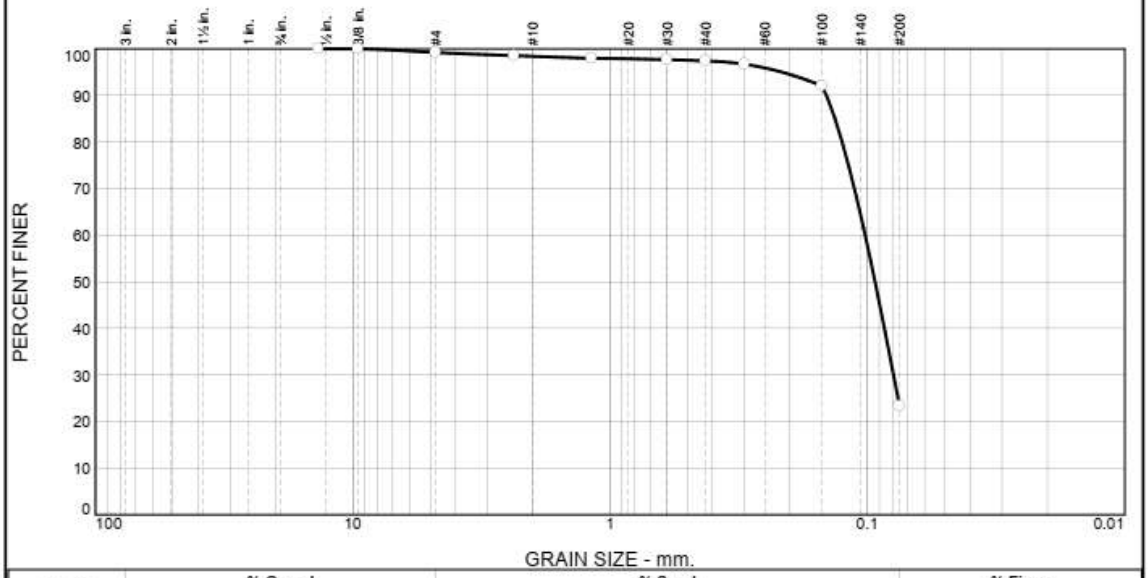
Sample Number: 2

Client: Golden Middle East Oil Services Company

Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.8	0.8	1.0	74.1	23.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.2		
#8	98.5		
#16	98.0		
#30	97.7		
#40	97.4		
#50	96.7		
#100	92.0		
#200	23.3		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 0.1444 D_{85}= 0.1337 D_{60}= 0.1021
D_{50}= 0.0934 D_{30}= 0.0792 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

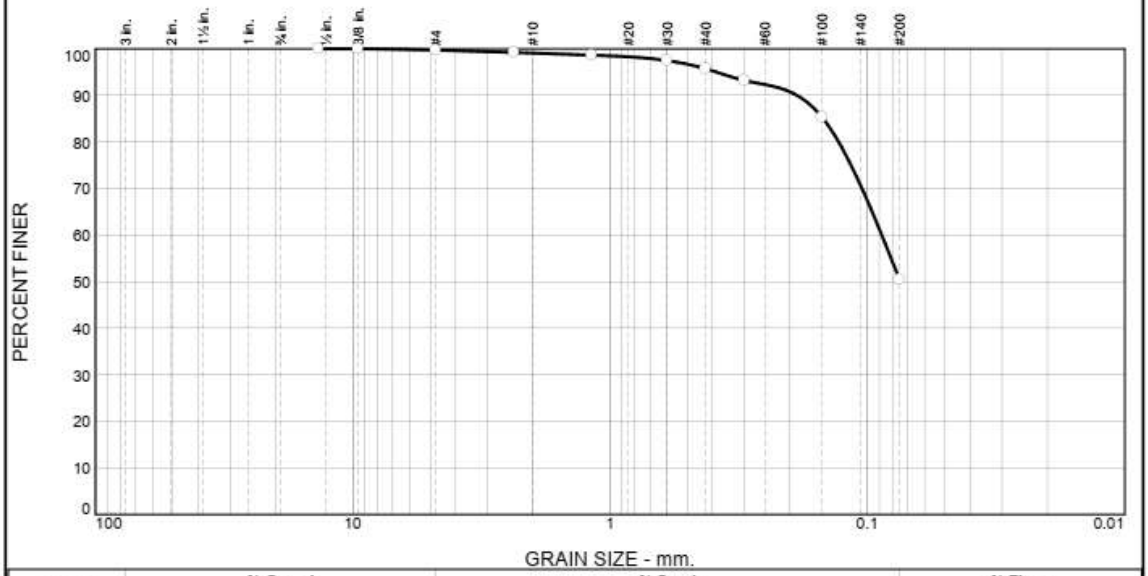
Title:

Source of Sample: BH#2 **Depth:** 3.0-3.45m **Date Sampled:**
Sample Number: 3

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.3	0.6	3.4	45.3	50.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.7		
#8	99.2		
#16	98.6		
#30	97.5		
#40	95.7		
#50	93.2		
#100	85.3		
#200	50.4		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.1876 D_{85}= 0.1485 D_{60}= 0.0879
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

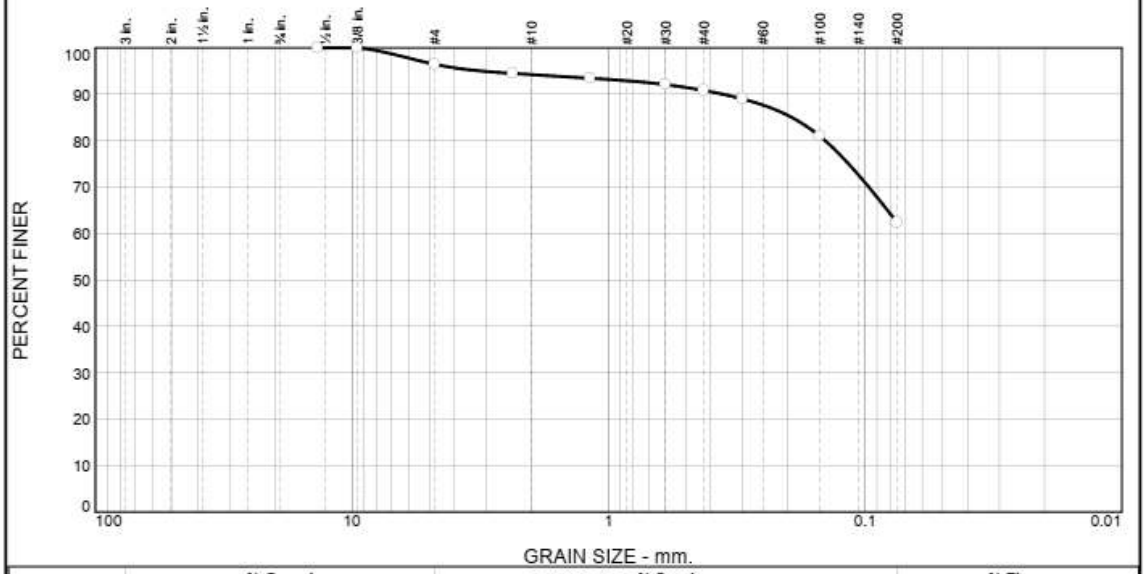
Title:

Source of Sample: BH#2 **Depth:** 5.0-5.45m **Date Sampled:**
Sample Number: 4

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	3.6	2.2	3.4	28.5	62.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	96.4		
#8	94.5		
#16	93.5		
#30	92.1		
#40	90.8		
#50	89.0		
#100	80.9		
#200	62.3		

* (no specification provided)

Material Description

Sandy silt low plasticity

Atterberg Limits (ASTM D 4318)

PL= 27 LL= 40 PI= 13

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-6(7)

Coefficients

D_{90}= 0.3583 D_{85}= 0.1932 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

Title:

Source of Sample: BH#2 **Depth:** 8.0-8.45m **Date Sampled:**

Sample Number: 5

Client: Golden Middle East Oil Services Company

Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report

% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.4	1.2	3.7	55.4	39.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.6		
#8	98.6		
#16	97.7		
#30	96.1		
#40	94.7		
#50	92.2		
#100	78.5		
#200	39.3		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.2435 D_{85}= 0.1845 D_{60}= 0.1038
D_{50}= 0.0884 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

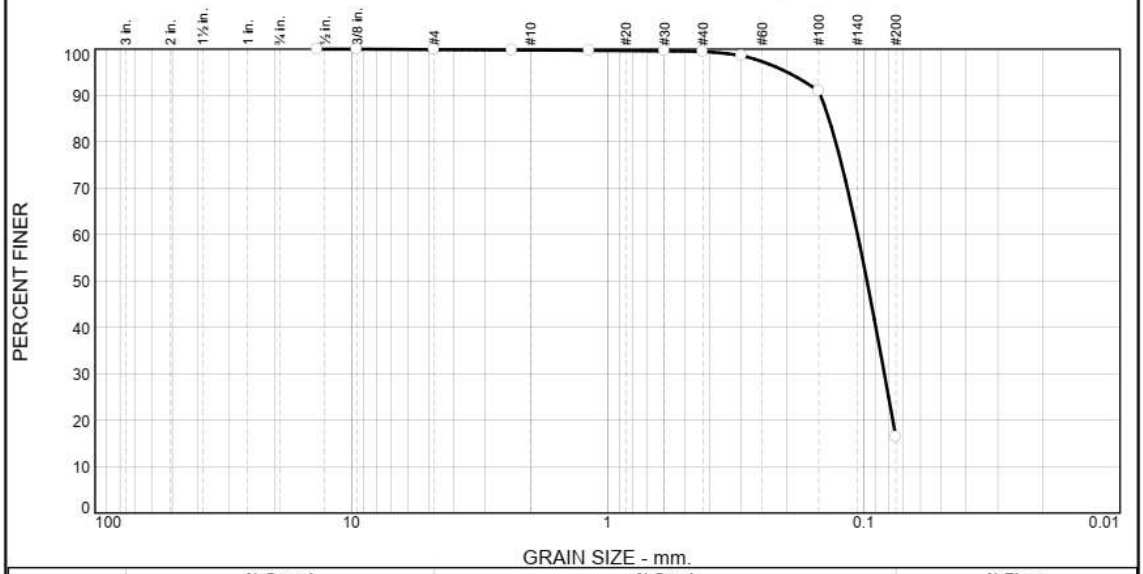
Title:

Source of Sample: BH#2 **Depth:** 9.5-9.95m **Date Sampled:**
Sample Number: 6

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.1	0.1	0.3	83.1	16.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.9		
#8	99.8		
#16	99.7		
#30	99.6		
#40	99.5		
#50	98.6		
#100	91.0		
#200	16.4		

* (no specification provided)

Material Description

Silty Sand low plasticity

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-2-4(0)

Coefficients

D_{90}= 0.1474 D_{85}= 0.1369 D_{60}= 0.1057
D_{50}= 0.0972 D_{30}= 0.0831 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

Title:

Source of Sample: BH#3 **Depth:** 3.0-3.45m **Date Sampled:**

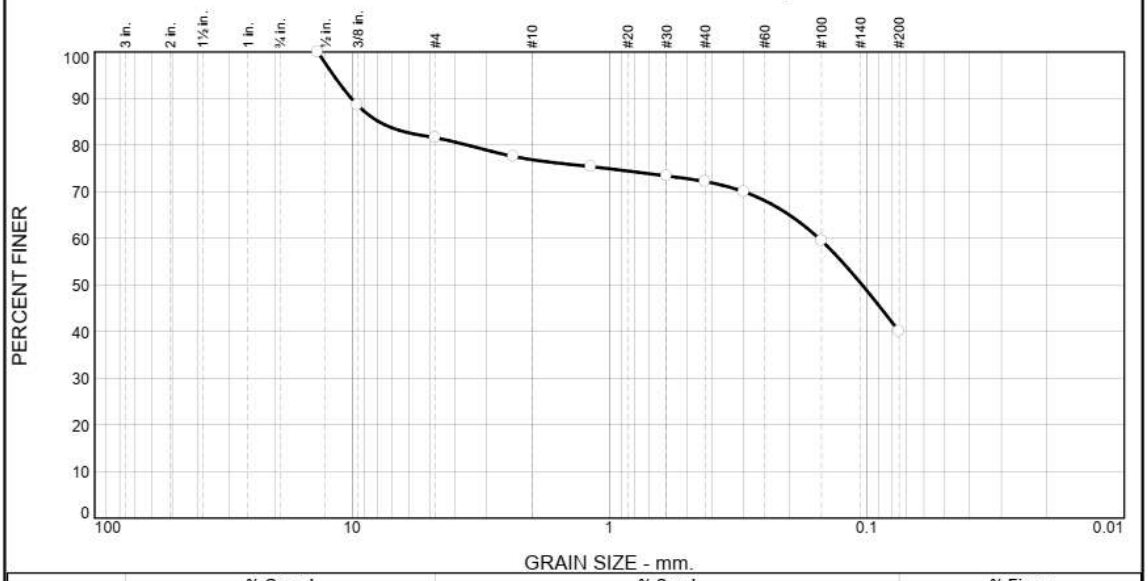
Sample Number: 1

Client: Golden Middle East Oil Services Company

Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	18.4	4.7	4.7	32.1	40.1

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	88.6		
#4	81.6		
#8	77.6		
#16	75.4		
#30	73.4		
#40	72.2		
#50	70.0		
#100	59.5		
#200	40.1		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 10.0527 D_{85}= 7.8463 D_{60}= 0.1534
D_{50}= 0.1042 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

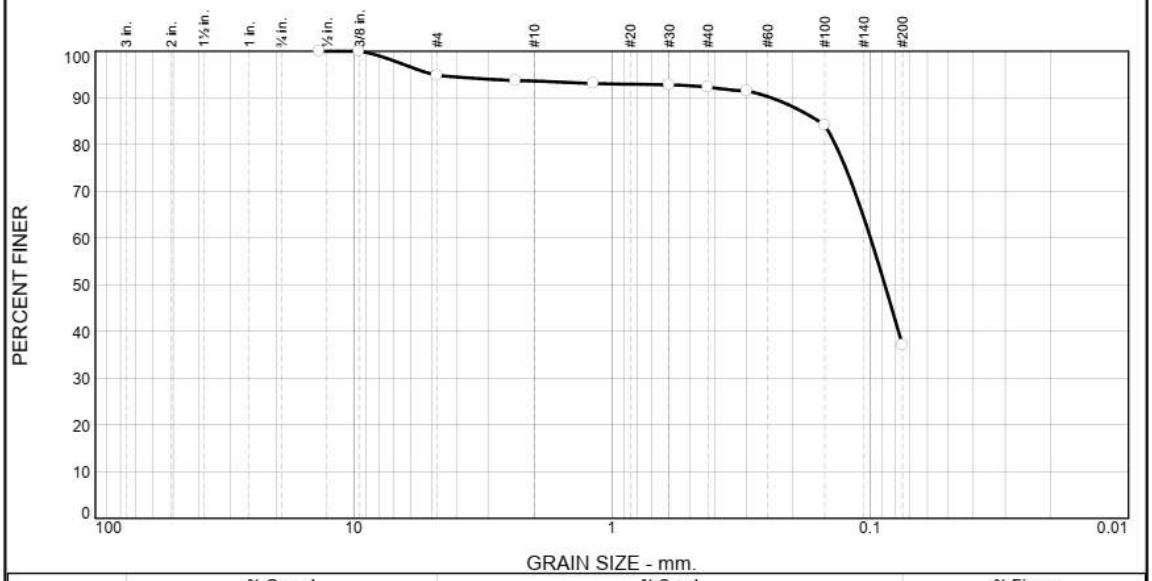
Title:

Source of Sample: BH#3 **Depth:** 4.0-4.45m **Date Sampled:**
Sample Number: 2

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	5.2	1.2	1.3	55.2	37.1

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	94.8		
#8	93.7		
#16	93.1		
#30	92.8		
#40	92.3		
#50	91.5		
#100	84.2		
#200	37.1		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.2406 D_{85}= 0.1579 D_{60}= 0.0997
D_{50}= 0.0878 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

Title:

Source of Sample: BH#3 **Depth:** 6.5-6.95m **Date Sampled:**

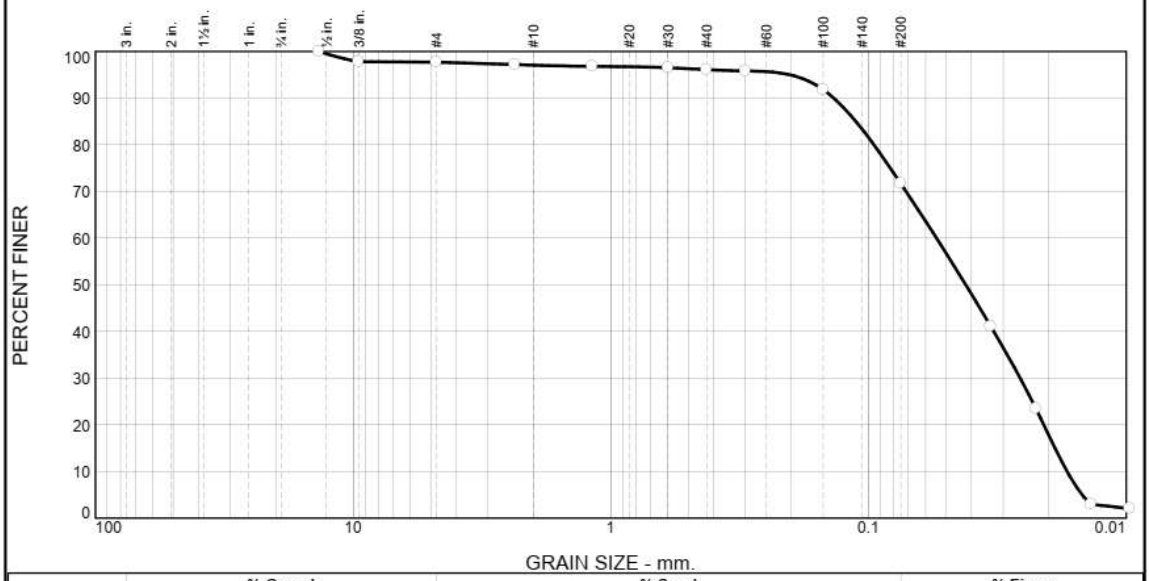
Sample Number: 3

Client: Golden Middle East Oil Services Company

Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	2.3	0.6	1.0	24.4	71.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	97.8		
#4	97.7		
#8	97.2		
#16	96.8		
#30	96.5		
#40	96.1		
#50	95.8		
#100	91.8		
#200	71.7		
0.0335 mm.	41.1		
0.0224 mm.	23.5		
0.0137 mm.	3.0		
0.0097 mm.	2.0		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= 24 LL= 31 PI= 7

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(4)

Coefficients

D_{90}= 0.1364 D_{85}= 0.1119 D_{60}= 0.0545
D_{50}= 0.0420 D_{30}= 0.0258 D_{15}= 0.0189
D_{10}= 0.0170 C_u= 3.21 C_c= 0.72

Remarks

Date Received: **Date Tested:** 29/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

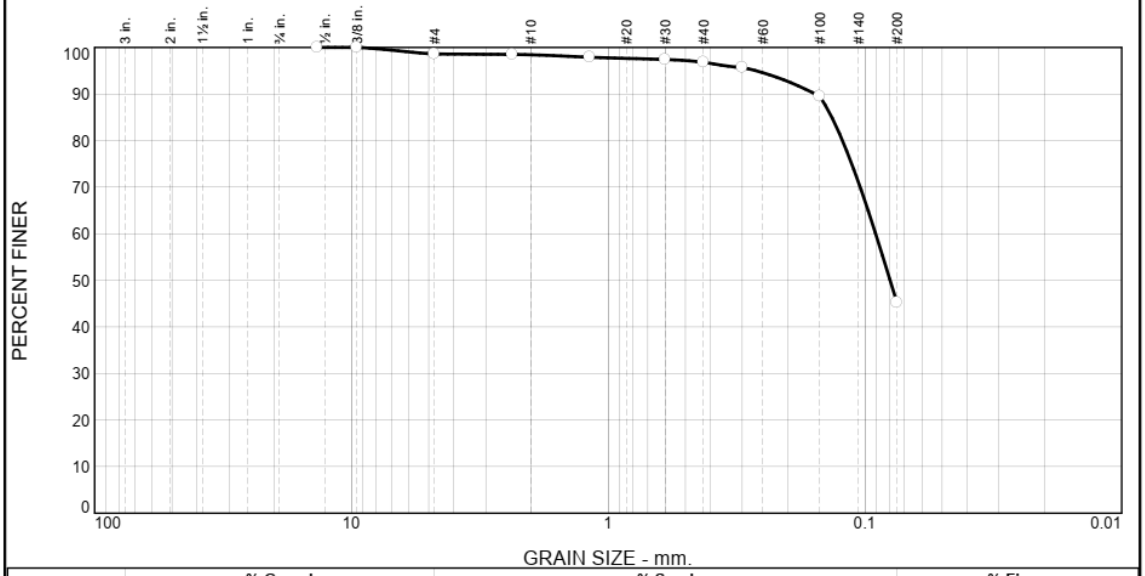
Title:

Source of Sample: BH#3 **Depth:** 9.5-9.95m **Date Sampled:**
Sample Number: 4

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	1.4	0.2	1.6	51.6	45.2

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	98.6		
#8	98.5		
#16	97.9		
#30	97.4		
#40	96.8		
#50	95.7		
#100	89.5		
#200	45.2		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.1561 D_{85}= 0.1345 D_{60}= 0.0908
D_{50}= 0.0797 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

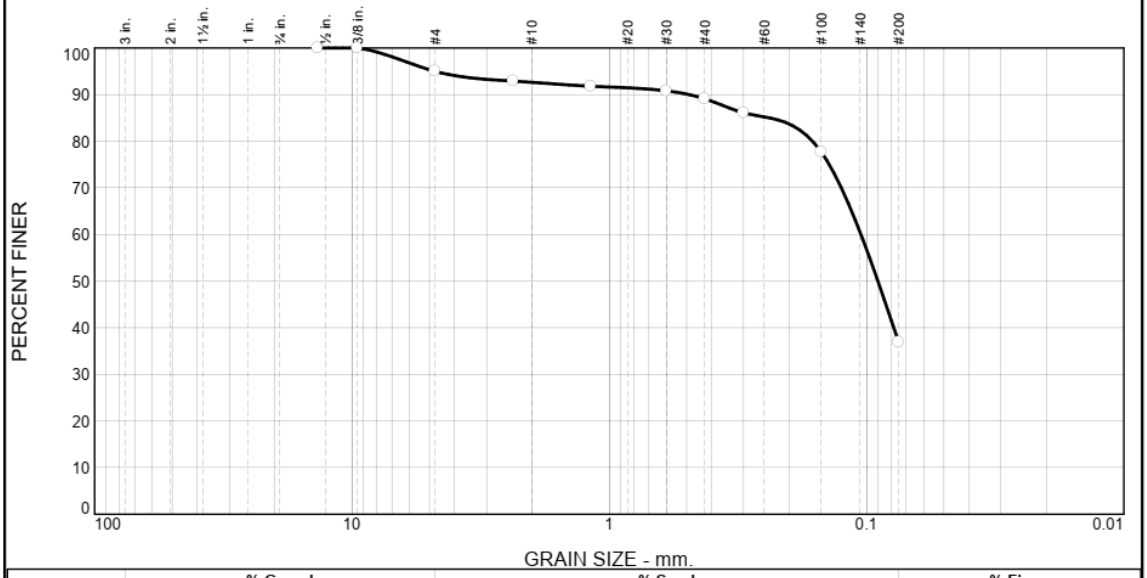
Title:

Source of Sample: BH#4 **Depth:** 2.0-2.45m **Date Sampled:**
Sample Number: 1

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	5.0	2.4	3.5	52.2	36.9

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	95.0		
#8	92.9		
#16	91.8		
#30	90.8		
#40	89.1		
#50	86.1		
#100	77.7		
#200	36.9		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.4885 D_{85}= 0.2383 D_{60}= 0.1051
D_{50}= 0.0903 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

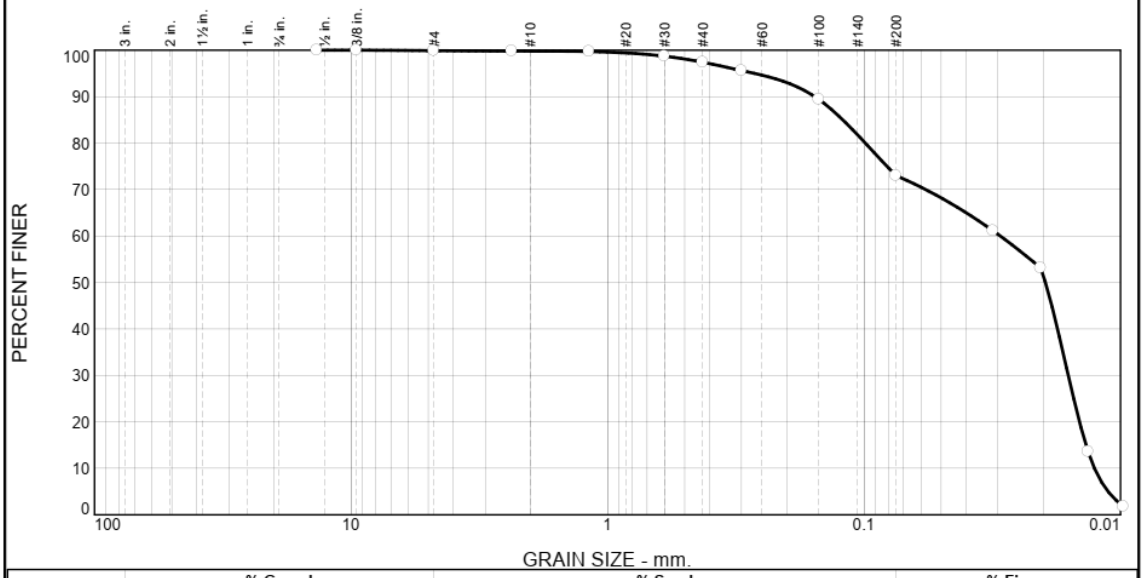
Title:

Source of Sample: BH#4 **Depth:** 3.0-3.45m **Date Sampled:**
Sample Number: 2

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	0.1	0.1	2.4	24.4	73.0

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	99.9		
#8	99.8		
#16	99.7		
#30	98.7		
#40	97.4		
#50	95.6		
#100	89.4		
#200	73.0		
0.0314 mm.	61.1		
0.0205 mm.	53.1		
0.0134 mm.	13.6		
0.0098 mm.	1.8		

* (no specification provided)

Material Description

Sandy silt low plasticity

Atterberg Limits (ASTM D 4318)

PL= 26 **LL=** 37 **PI=** 11

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-6(8)

Coefficients

D_{90}= 0.1556 D_{85}= 0.1209 D_{60}= 0.0294
D_{50}= 0.0196 D_{30}= 0.0160 D_{15}= 0.0136
D_{10}= 0.0126 C_u= 2.33 C_c= 0.69

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

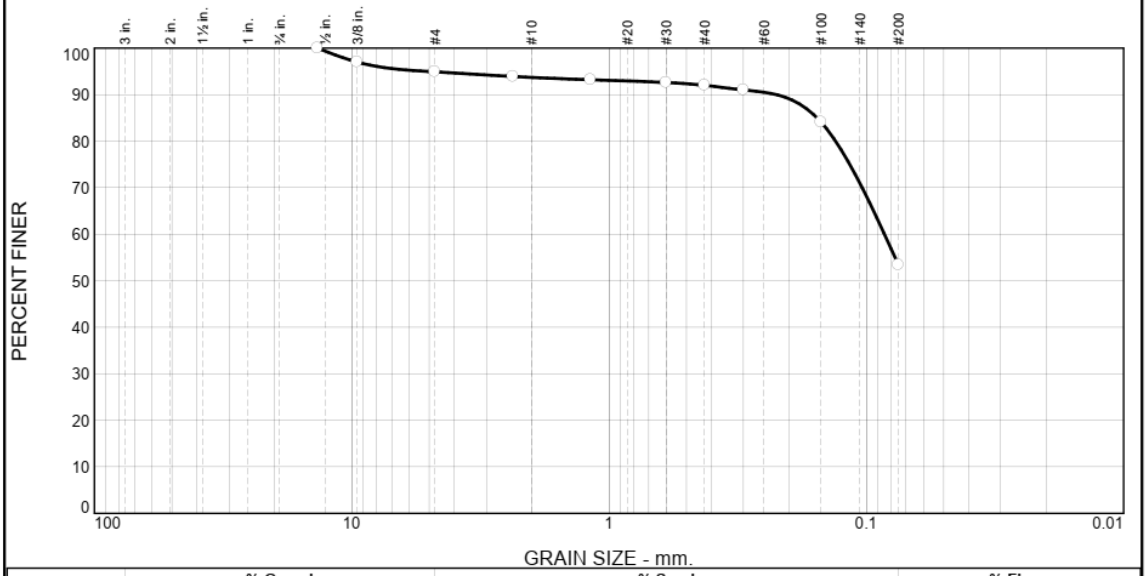
Title:

Source of Sample: BH#4 **Depth:** 5.0-5.45m **Date Sampled:**
Sample Number: 3

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	5.1	1.2	1.7	38.6	53.4

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	97.0		
#4	94.9		
#8	93.9		
#16	93.2		
#30	92.6		
#40	92.0		
#50	91.0		
#100	84.1		
#200	53.4		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.2234 D_{85}= 0.1554 D_{60}= 0.0850
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

Title:

Source of Sample: BH#4 **Depth:** 8.0-8.45m **Date Sampled:**

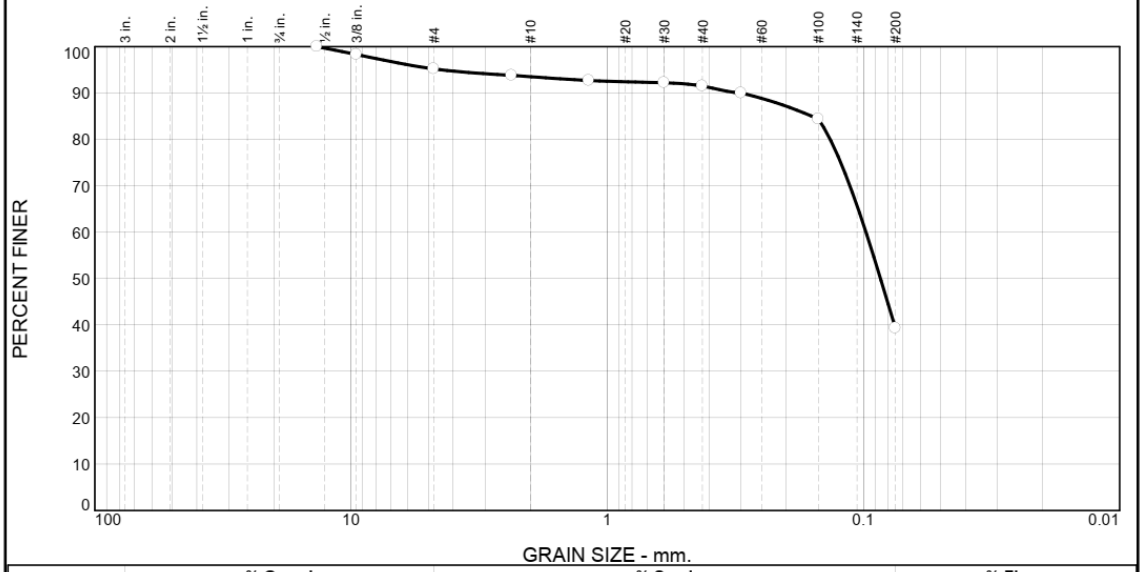
Sample Number: 4

Client: Golden Middle East Oil Services Company

Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	4.8	1.7	2.0	52.2	39.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	98.3		
#4	95.2		
#8	93.8		
#16	92.7		
#30	92.2		
#40	91.5		
#50	90.0		
#100	84.4		
#200	39.3		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.3000 D_{85}= 0.1589 D_{60}= 0.0978
D_{50}= 0.0858 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

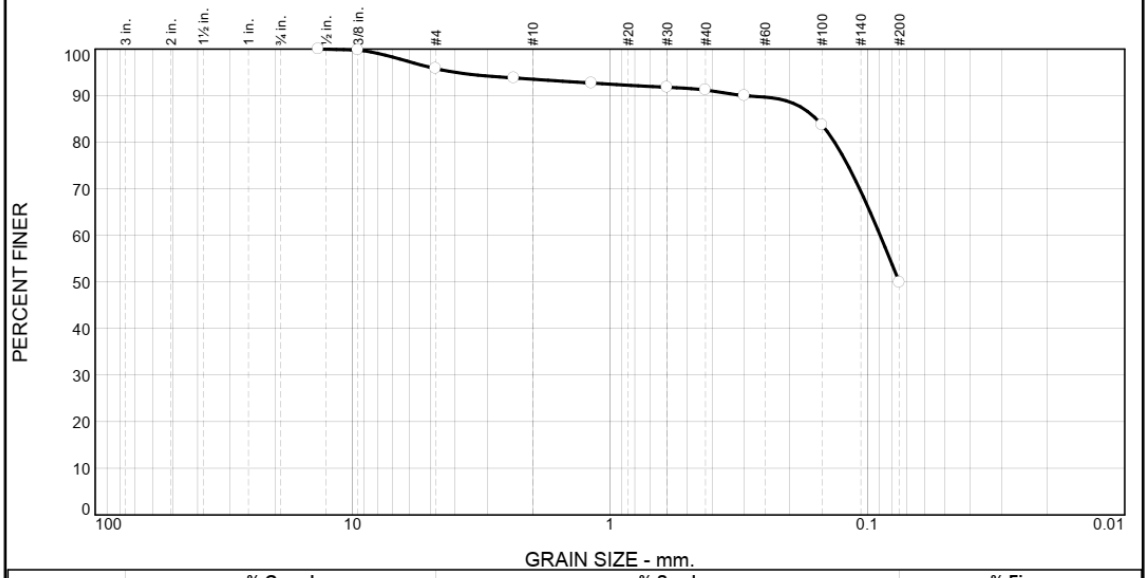
Title:

Source of Sample: BH#5 **Depth:** 3.0-3.45m **Date Sampled:**
Sample Number: 1

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	4.2	2.3	2.3	41.3	49.9

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	99.8		
#4	95.8		
#8	93.8		
#16	92.7		
#30	91.8		
#40	91.2		
#50	90.0		
#100	83.7		
#200	49.9		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.3000 D_{85}= 0.1577 D_{60}= 0.0891
D_{50}= 0.0751 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

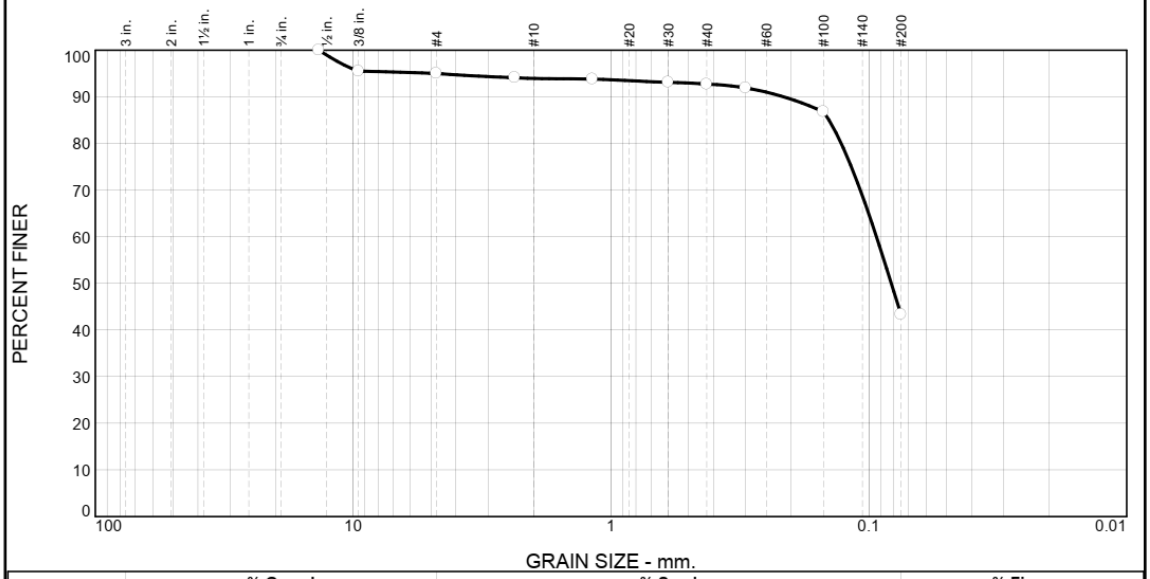
Title:

Source of Sample: BH#5 **Depth:** 4.0-4.45m **Date Sampled:**
Sample Number: 2

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	5.0	1.1	1.2	49.4	43.3

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	95.5		
#4	95.0		
#8	94.1		
#16	93.8		
#30	93.1		
#40	92.7		
#50	91.9		
#100	86.8		
#200	43.3		

* (no specification provided)

Material Description

Silty Sand

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= SM AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.2141 D_{85}= 0.1428 D_{60}= 0.0934
D_{50}= 0.0818 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

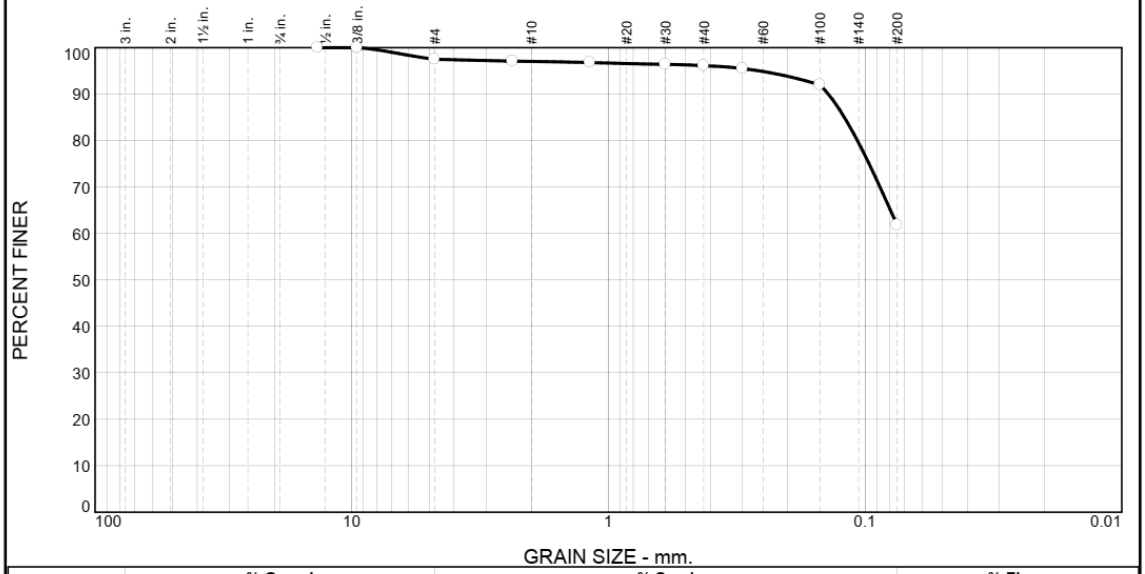
Title:

Source of Sample: BH#5 **Depth:** 6.5-6.95m **Date Sampled:**
Sample Number: 3

Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines
	Coarse	Fine	Coarse	Medium	Fine	Silt
0.0	0.0	2.5	0.5	0.9	34.3	61.8

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
0.535"	100.0		
3/8"	100.0		
#4	97.5		
#8	97.1		
#16	96.8		
#30	96.4		
#40	96.1		
#50	95.5		
#100	92.0		
#200	61.8		

* (no specification provided)

Material Description

Sandy silt

Atterberg Limits (ASTM D 4318)

PL= NP LL= NV PI= NP

Classification

USCS (D 2487)= ML AASHTO (M 145)= A-4(0)

Coefficients

D_{90}= 0.1390 D_{85}= 0.1204 D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 30/12/2021

Tested By: En-Omar

Checked By: En-Abubakr

Title:

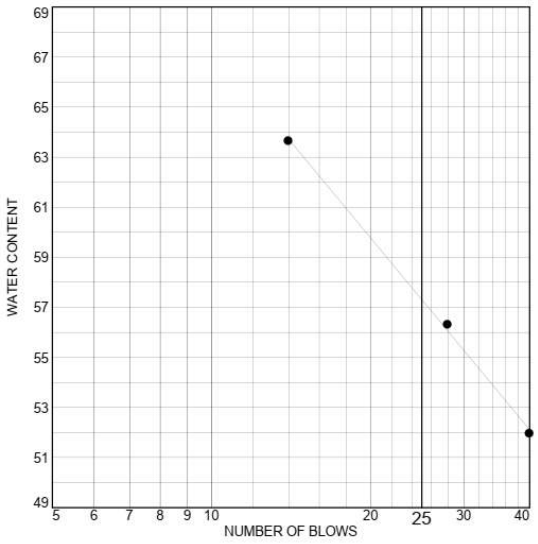
Source of Sample: BH#5 **Depth:** 9.5-9.95m **Date Sampled:**
Sample Number: 4

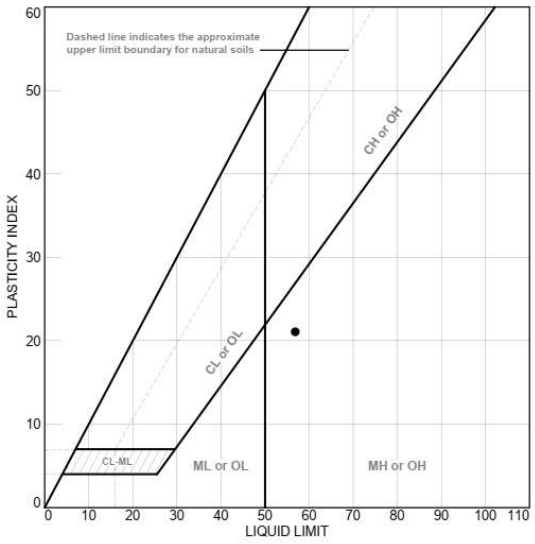
Client: Golden Middle East Oil Services Company
Project: Modren Fuel Station at Airport road

Project No: **Figure**

APPENDIX 'C'
Liquid and Plastic limits (ASTM D 4318)

LIQUID AND PLASTIC LIMITS TEST REPORT



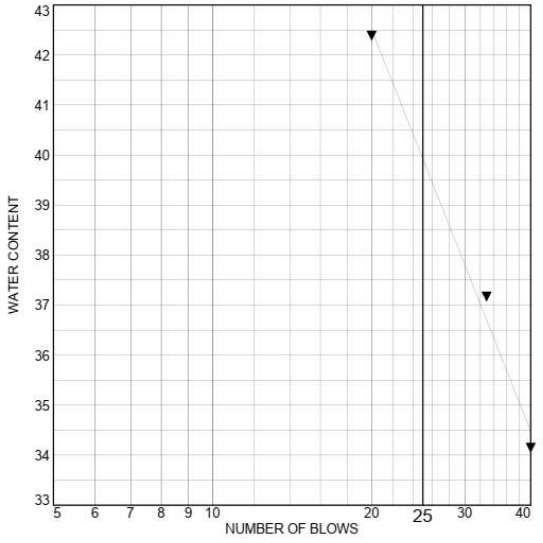


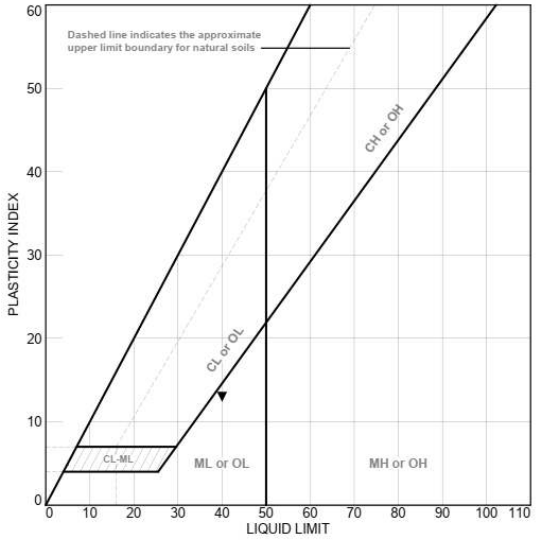
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
BH#1	6	9.5-9.95m		MH	Sandy silt high plasticity	30.7	57	21

Client Golden Middle East Oil Services Company
Project Modren Fuel Station at Airport road

Project No. | Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



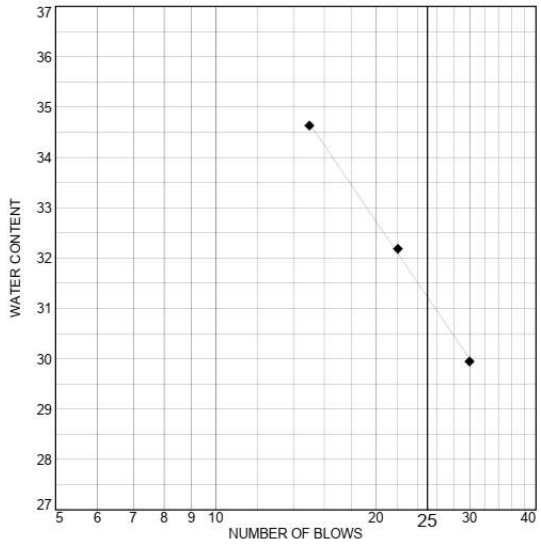


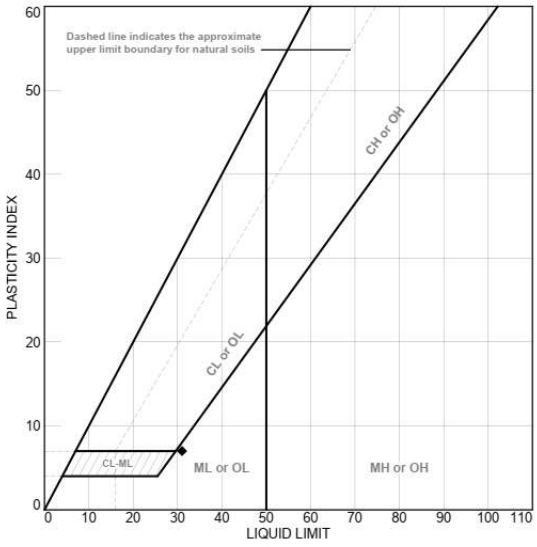
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	BH#2	1	1.0-1.45m		SM	Silty Sand	17.3	NV	NP
■	BH#2	2	2.0-2.45m		SP	Poorly graded sand with silt	15.0	NV	NP
▲	BH#2	3	3.0-3.45m		SM	Silty Sand	17.6	NV	NP
◆	BH#2	4	5.0-5.45m		ML	Sandy silt	18.6	NV	NP
▼	BH#2	5	8.0-8.45m		ML	Sandy silt low plasticity	13.8	40	13

Client Golden Middle East Oil Services Company
Project Modren Fuel Station at Airport road

Project No. Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



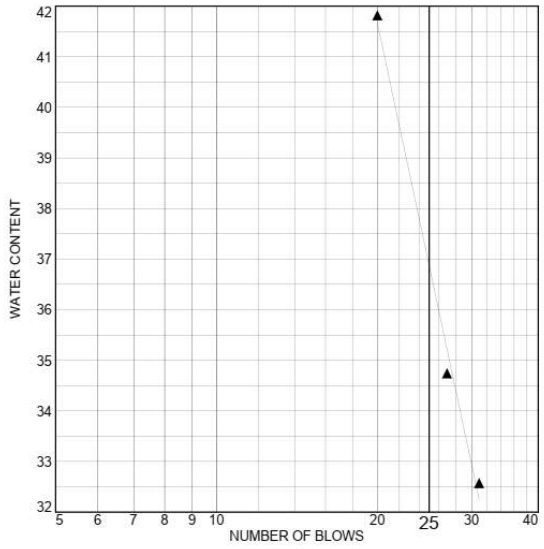


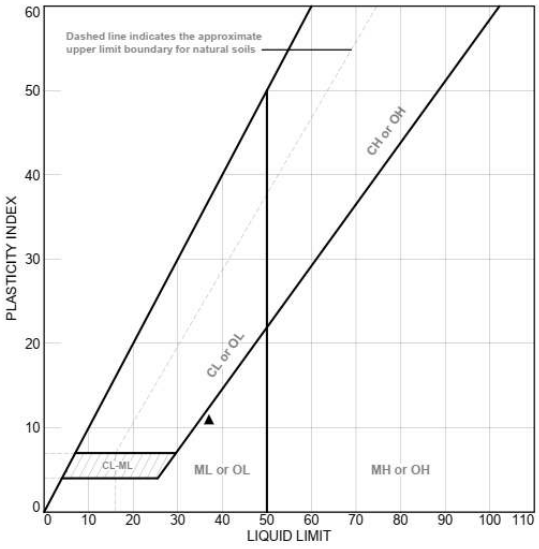
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	BH#3	1	3.0-3.45m		SM	Silty Sand	8.2	NV	NP
■	BH#3	2	4.0-4.45m		SM	Silty Sand	8.4	NV	NP
▲	BH#3	3	6.5-6.95m		SM	Silty Sand	7.9	NV	NP
◆	BH#3	4	9.5-9.95m		ML	Sandy silt low plasticity	13.3	31	7

Client Golden Middle East Oil Services Company
Project Modren Fuel Station at Airport road

Project No. Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	BH#4	1	2.0-2.45m		SM	Silty Sand	6.6	NV	NP
■	BH#4	2	3.0-3.45m		SM	Silty Sand	4.3	NV	NP
▲	BH#4	3	5.0-5.45m		ML	Sandy silt low plasticity	13.7	37	11
◆	BH#4	4	8.0-8.45m		ML	Sandy silt	9.6	NV	NP

Client Golden Middle East Oil Services Company
Project Modren Fuel Station at Airport road

Project No. Figure

APPENDIX 'D'
Allowable bearing capacity of soil (ABC)

Summary of foundation design parameters

BH No.	Depth, z (m)	N corrected	Assumed breadth of Foundation, B (m)			Mat foundation q_{all} (KN/m^2)	Estimated, ϕ°
			B=1.5m q_{all} (KN/m^2)	B=2.0m q_{all} (KN/m^2)	B=2.5m q_{all} (KN/m^2)		
			B > 1.20				
BH-01	0.0	←Existing ground level					
	1.45	13	170.50	155.47	146.79	229.10	32.9
	2.45	5	64.25	58.59	55.32	86.33	29.0
	3.45	37	487.21	444.27	419.46	654.67	39.8
	4.45	23	306.93	279.88	264.25	412.42	38.2
	5.45	22	287.51	262.17	247.53	386.34	38.2
	6.95	15	196.88	179.53	169.50	264.55	36.5
	8.45	16	210.37	191.83	181.12	282.68	37.4
	9.95	20	256.91	234.27	221.18	345.22	38.7
BH-02	0.0	←Existing ground level					
	1.45	11	149.92	136.70	129.07	201.45	32.9
	2.45	13	165.65	151.05	142.62	222.59	34.1
	3.45	6	81.85	74.63	70.47	109.98	30.7
	4.45	20	268.35	244.70	231.03	360.58	37.8
	5.45	24	315.00	287.24	271.20	423.28	39.0
	6.95	18	237.81	216.85	204.74	319.56	38.0
	8.45	20	256.91	234.27	221.18	345.22	38.7
	9.95	12	158.32	144.37	136.30	212.74	32.5
BH-03	0.0	←Existing ground level					
	1.45	18	231.39	211.00	199.21	310.92	34.8
	2.45	7	96.37	87.88	82.97	129.50	30.7
	3.45	16	204.63	186.59	176.17	274.96	35.4
	4.45	30	388.77	354.51	334.71	522.40	39.2

BH-03	5.45	37	479.19	436.96	412.55	643.90	40.3
	6.95	21	275.63	251.34	237.30	370.37	38.4
	8.45	18	237.81	216.85	204.74	319.56	38.0
	9.95	18	239.78	218.65	206.44	322.20	38.4
BH-04	0.0	←Existing ground level					
	1.45	22	292.28	266.52	251.64	392.74	36.2
	2.45	17	224.87	205.06	193.60	302.17	35.4
	3.45	32	419.00	382.07	360.73	563.02	39.2
	4.45	26	337.62	307.86	290.67	453.67	38.6
	5.45	37	479.19	436.96	412.55	643.90	40.3
	6.95	27	354.38	323.15	305.10	476.19	39.5
	8.45	22	283.55	258.56	244.12	381.01	38.9
	9.95	28	368.24	335.78	317.03	494.81	40.1
BH-05	0.0	←Existing ground level					
	1.45	10	133.96	122.16	115.33	180.01	31.6
	2.45	6	74.96	68.35	64.53	100.72	29.6
	3.45	9	116.93	106.62	100.67	157.12	32.1
	4.45	18	235.31	214.57	202.59	316.19	36.7
	5.45	13	172.51	157.30	148.52	231.80	35.2
	6.95	38	492.19	448.82	423.75	661.37	41.0
	8.45	41	539.65	492.09	464.61	725.15	42.7
	9.95	25	333.98	304.55	287.54	448.78	39.8

End of boring

Notes:

- The calculation of the allowable bearing capacity of separated footing for 25 mm or less than settlement is performed using the modified formula of the allowable bearing pressure by Bowles (1997).
- The calculation of the allowable bearing capacity of Mat foundation performed for 50mm or less than settlement using the modified formula of the allowable bearing pressure by Canadian foundation engineering manual, 2006 (Meyerhof equation).

APPENDIX 'E'
Photos of drilling and Samples

Photo No. 1: Borehole#01 (Airport Road, Tripoli city). Date:27/12/21

Photo No. 2: Borehole#02 (Airport Road, Tripoli city). Date:27/12/21

Photo No. 3: Borehole#03 (Airport Road, Tripoli city). Date:27/12/21

Photo No. 4: Borehole#04 (Airport Road, Tripoli city). Date:27/12/21

Photo No. 5: Borehole#05 (Airport Road, Tripoli city). Date:27/12/21

Photo No 6: samples series along depth, BH#01 (Airport Road, Tripoli city- Site).

Photo No 7: samples series along depth, BH#02 (Airport Road, Tripoli city- Site).

Photo No 8: samples series along depth, BH#03 (Airport Road, Tripoli city- Site).

Photo No 9: samples series along depth, BH#04 (Airport Road, Tripoli city- Site).

Photo No 10: samples series along depth, BH#05 (Airport Road, Tripoli city- Site).

Fig. No 11: General site plan (site location).

APPENDIX 'F'

Requirement for concrete exposed to sulphate attack

Requirements for concrete exposed to sulphate attack
Recommendations are for concrete in a near-neutral groundwater
for acid conditions refer to BRE Current Paper CP 23/77

Concentrations of sulphates expressed as SO_3				Type of cement	Requirements for dense fully compacted concrete made with aggregates meeting the requirements of BS 882 or 1047	
Class	In soil: Total SO_3	In soil: SO_3 in 2:1 water : soil extract	In ground-water		Minimum cement (1) content	Maximum water/cement (1) ratio
[-]	[%]	[g/l]	[g/l]	[-]	[kg/m^3]	[-]
1	Less than 0.2	Less than 1.0	Less than 0.3	Ordinary Portland cement (OPC) or Rapid Hardening Portland Cement (RHPC) or combinations of either cement with slag (3) or pfa (4) Portland Blastfurnace Cement (PBFC) — Plain (2) concrete	250	0 70
				Reinforced concrete	300	0 60
2	0.2 to 0.5	1.0 to 1.9	0.3 to 1.2	OPC or RHPC or combinations of either cement with slag or pfa PBFC	330	0 50
				OPC or RHPC combined with minimum 70% or maximum 90% slag (5) OPC or RHPC combined with minimum 25% or maximum 40% pfa (6)	310	0 55
				Sulphate Resisting Portland cement (SRPC)	290	0 55
3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	OPC or RHPC combined with minimum 70% or maximum 90% slag OPC or RHPC combined with minimum 25% or maximum 40%	380	0 45
				SRPC	330	0 50
4	1.0 to 2.0	3.1 to 5.6	2.5 to 5.0	SRPC	370	0 45
5	Over 2	Over 5.6	Over 5.0	SRPC + protective coating (7)	370	0 45

(1) Inclusive of content of pfa or slag. These cement content relate to 20 mm nominal maximum size aggregate. In order to maintain the cement content of the mortal at similar values, the minimum cement contents given should be increased by 50 kg m^3 for 10 mm nominal maximum size aggregate and may be decreased by 40 kg m^3 for 40 mm nominal maximum size aggregate.
(2) When using strip foundations and trench fill for low-rise building in Class 1 sulphate conditions further relaxation in the cement content and water cement ratio is permissible.
(3) Ground granulated blastfurnance slag A new BS is in preparation.
(4) Selected or classified pulverized-fuel ash to BS 3892.
(5) Per cent by weight of slag cement mixture.
(6) Per cent by weight of pfa cement mixture.
(7) See BS CP 102 .1973: Protection of buildings against water from the ground.

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Rev.	Date	Description	Prepared	Verified	Approved
		Project: The construction of modern and different services stations			
		Client: Golden Middle East Oil Services Co.			
		Location: Airport Road area, Tripoli -Libya			
00	27/12/21	Issue for approval	Eng. Abubaker	Eng. Ali	Eng. Ali