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GEOTECHNICAL INVESTIGATION REPORT FOR THE CONSTRUCTION OF OIL REFINING FACTORY - MISRATAH CITY

Misurata Free Zone (Area) – Libya

Prepared By:

Assari Engineering Consultant

Tripoli, Libya

FINAL REPORT

0	06/03/2022	Final Report	Eng. Abubaker	Eng. Ali	Eng. Ali
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1. Introduction:

1.1 General

This report presents the results of our investigation and analysis of the subsurface conditions at the site of the proposed project which located at Misurata, Misurata free zone area – Libya.

The work was carried out in accordance with the Agreement between **Golden Middle East Oil Services Co.**, and **Assari engineering consulting Co.**, the field investigation was performed on 06 to 10 March, 2022. The field investigation work was carried out mainly by drilling four (04) boreholes with depths of 10.0m, one (01) borehole with depths of 15.0m, two (02) boreholes with depths 20.0m and one (01) borehole with depth 25.0m below existing ground level at the location indicated in the attached site plan (Figure 1 *Appendix E*).

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 and rock strata.
- To delineate the major subsoil types spread over the site area.

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- To investigate the structure and homogeneity of strata as well as the physical and mechanical properties of each soil and rock 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).
- Unconfined compressive strength rock (ASTM D 2938).
- The point load index of rock (ASTM D 5731).
- The unit weight of rock were determined by the water replacement method (ASTM C127-07).
- 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 purpose and scope of work

The purpose of this geotechnical investigation is to determine the depth and characteristics of the different subsurface formations, the required foundation depth, the most suitable and

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economical type of foundation, the allowable bearing capacity, and expected settlements under the proposed structures. This report includes guidelines for earthwork construction specification, site and structure descriptions, field investigation, laboratory observations, subsurface formations and geotechnical recommendations. 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 one (01) borehole to a depth of 14.5m, one (01) borehole to a depth of 24.0m, four (04) boreholes to a depth of 10m and two (02) boreholes to a depth of 19.5m below existing ground level. Geotechnical boreholes were drilling using rotary drilling machine (Truck Renault, YWE-D90R) project area (Misratah 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 oil refining factory.
5. Assessment of corrosion and suggestion of the cement type.

1.5 Investigation methodology

Keeping in view the scope of work and specifications generally followed for the detailed geotechnical studies, a programme of field work was prepared. The exploratory borings were drilled using continuous-flight augers with a rotary drill method by straight rotary

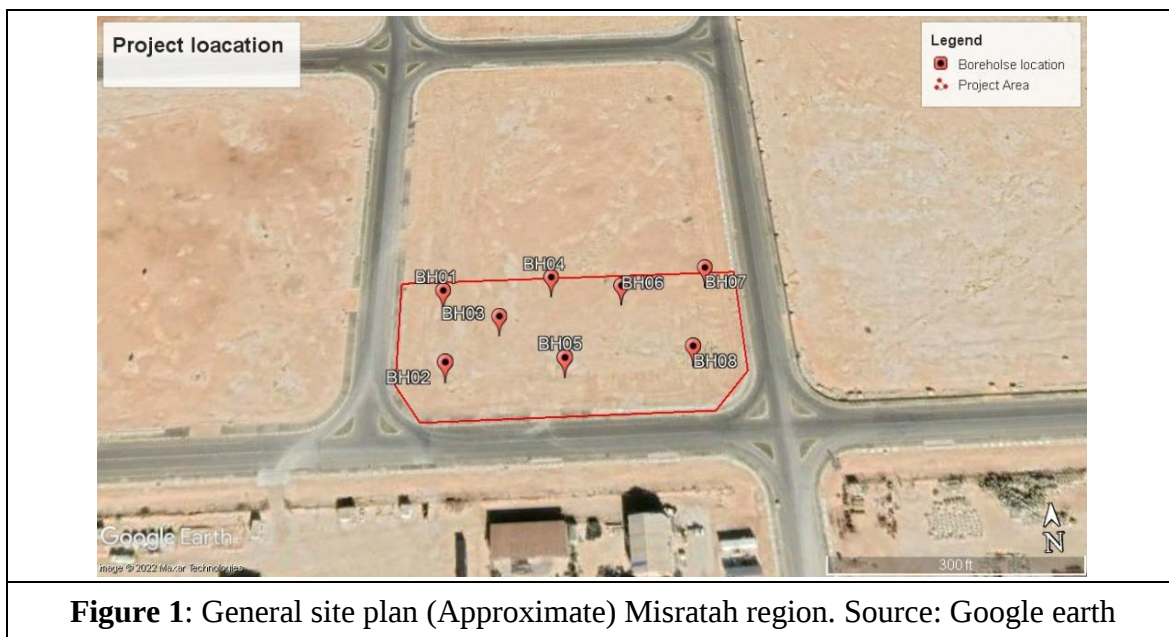
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drilling rig. Field tests i.e. standard penetration tests (SPT) were performed at designated locations in accordance with relevant ASTM and BS standards and project specifications. Soil and rock samples were collected from designated depths from boreholes using appropriate samplers for identification and subsequent laboratory testing. Selected soil and rock samples were subjected to various laboratory tests for evaluation of classification, strength and chemical characteristics of the subsurface strata. The laboratory tests were performed in accordance with the relevant ASTM and BS standards and project specifications.

2. Location of the performed geotechnical investigation:

2.1 Site description

The proposed project site is located at Misurata city, Misurata free zone - Libya. The site is bounded by paved roads, industrial areas on all four sides and is easily accessible through main roads. The project site is roughly leveled. Approximate site location is shown in **Figure (1)**.



 شركة الشرق الأوسط للخدمات النفطية المحترفين	Project: The construction of oil refining factory, Misratah.			 مهندسين استشاريين
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The site is flat and rough sandy surface ground surface covered by soil layer of Silty Sand with some gravel and Sandy Silt soil was appear in some places in the site. Eight boreholes were carried out from this level as shown as in the site plan. A general site plan shows of the location of the boreholes within the plot in Figure at end of the report at **Appendix D**.

3. General geology and geomorphology:

The proposed project area is located in Northern Libya (Misratah area). Latitude: 33° 0' N and longitude: 15° 0' E. as shown in the figure (2). To obtain background geological information, we reviewed geological map of (Misratah), Sheet No. NI 33-15 published by Industrial Research Center.

In general, the project site is located in Gargaresh deposits - Northeastern-Libya. The Gargaresh deposits in Libya cover an estimated area of about 400,000 sq. km. they form the Libyan desert, the dune areas, the immense gravel plains, and the Mediterranean coastal plains. They consist of clayey eolian sand; locally cemented, calcareous, and commonly dolomitic sandy or brecciated surface incrustations; caliche; red earth (Terra Rosa); eolian sand; alluvium; sand and associated fine sediments; saline deposits in the undrained depressions (Sabkhas); and the poorly consolidated surficial deposits of local origin composed of gravel with some silt and sand that make up the sarir or the desert pavement.

3.1 Subsurface strata:

The subsurface geologic information provided by the boring that was drilled to depth ranging from 10.0 to 24.0m below the existing ground surface level, that the subsurface strata at the site consists basically of six (6) layers that were extending from the ground surface to the maximum depth investigated.

Two unit types of strata exist in the subsurface i.e. Sandy / Silty / Gypsum mixed with clay Soil deposits overlying rocky strata as Calcarene limestone / calcareous siltstone /

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fossiliferous limestone with varying degree of weathering. The estimated geologic profile is composed of the following:

- **Fill material:** a surface layer in all boreholes, a layer of light brown to brownish white, medium dense and dry. The thickness of this layer varied from -0.50m to -1.00m below boreholes surface level.
- **Sandy Silt (ML) / Silty Sand (SM):** the layers are generally at all boreholes, very loose to loose, state of compaction, very weak cemented with trace gravel. The Silty soil layer are present in soft to medium stiff (low plasticity) state of consistency. The thickness of this layer varied from -1.0 to 5.45m below boreholes surface level except boreholes No. (03, 04 and 08) only.
- **Gypsum mixed with Silty Clay (CL -ML):** below the previous layer at borehole no. (03, 04 and 08) only, a soft to medium stiff, inorganic clays of low plasticity was encountered to depth range from -5.0m to -5.45m below the boreholes surface level.
- **Silty Gravel (GM):** a sublayer in borehole no. (01) only, a layer of brownish grey, very loose, Silty Gravel with fine sand. The thickness of this layer varied from -2.0 to -2.45m below the borehole surface level.
- **Calcarene limestone interbedded Calcareous:** a sublayer in all boreholes and down to depths varied from -5.0m to -10.0m, a layer of whitish grey to brownish grey, fine to medium grained, highly to moderately weathered, medium fractured and very close to close spaced sub horizontal to horizontal fracturing.
- **fossiliferous limestone with interbedded calcareous siltstone:** below the previous layers, and down to the maximum investigated depth, a layer of whitish grey to light grey to yellowish grey, medium grained, moderately weathered, moderately fractured and very weak to weak strength.

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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, $A_a (C_a)$ 1.5 m/s^2 and effective peak velocity -related accel, $A_v (C_v)$ 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.

The water table is salty and affected by the sea water intrusion.

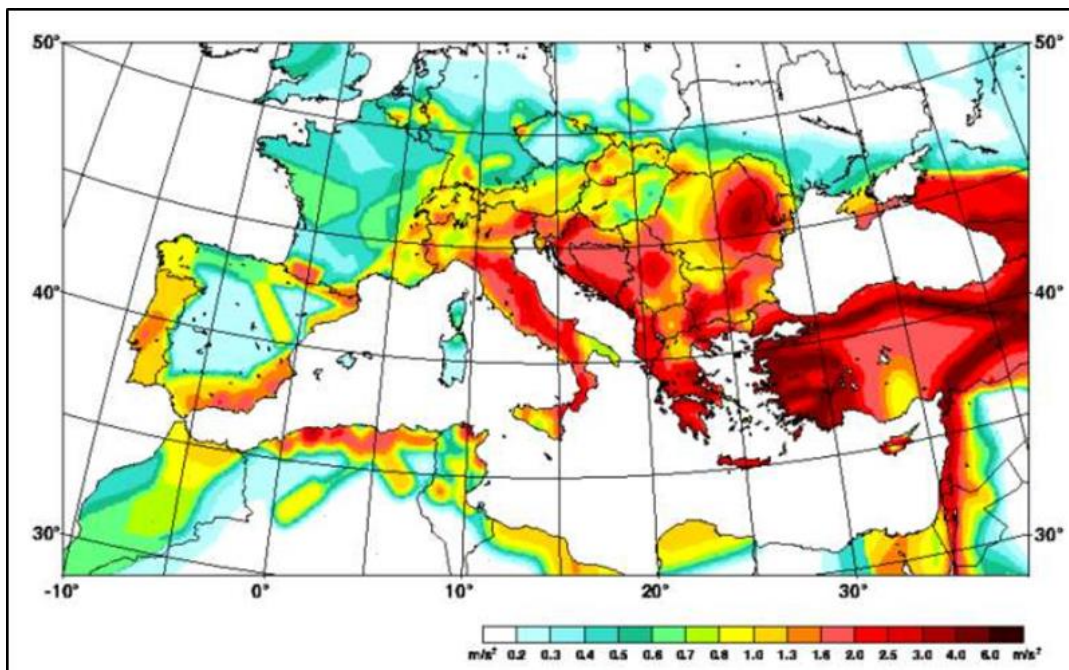


Figure 3: Seismicity in the Mediterranean basin (GSHAP, 1997).

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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
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

After the visual inspection of the site, the subsurface geotechnical investigation was performed in from 06th to 10th of March 2022. The geotechnical investigation field program

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consists eight (8) exploratory borings were drilled at the location shown on the unclosed site plan presented **Figure (1), Appendix (D)**. The proposed boreholes were drilled to a depth range from 10.0 m to 24.0 m below the boreholes level. the logs of the boreholes are shown in **Appendix (A)**, of which continues profiles of the boreholes were prepared by an experienced geotechnical engineer to present clearly all the subsurface soil encountered. The borehole 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 borehole, the proposal project location.

Borehole No.	Borehole Depth, m	Coordinates						Existing elevations, m
		Northing			Easting			Z
BH-01	10.0	32°	20'	53.63"	15°	12'	09.84"	1.0
BH-02	10.0	32°	20'	54.38"	15°	12'	09.58"	1.0
BH-03	14.5	32°	20'	53.66"	15°	12'	10.48"	1.0
BH-04	10.0	32°	20'	54.35"	15°	12'	11.70"	1.0
BH-05	10.0	32°	20'	53.74"	15°	12'	11.45"	1.0
BH-06	19.5	32°	20'	53.77"	15°	12'	12.31"	1.0
BH-07	19.5	32°	20'	53.38"	15°	12'	13.00"	1.0
BH-08	24.0	32°	20'	54.31"	15°	12'	13.57"	1.0
Number of borings		08						
Total depths		117.5 m						

5.2 Execution of boreholes

Eight (8) boreholes were executed to a depth ranging from 10 to 24m below existing grades using straight continuous-flight augers with a rotary drill. All borings were drilled by the

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use of truck (Renault) mounted Mobile YWE-D90R drilling rig utilizing auger and casing. The rig is capable is drilling in soils and rocks, and is equipped to undertake field tests such as SPT and driving casing to support the boreholes sides. Drilling rig is shown in figure (4) was used for the drilling of each boreholes.

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 borehole logs were prepared in the field and a description of soil samples recovered has been shown in the respective borehole logs. Field borehole log was developed on the basis of the materials encountered at the site and were later confirmed / modified by the laboratory test results. The borehole log is appended in **Appendix A** of this report.



Figure 4: The boring test is being performed on the site (Misurata free zone area).

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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.

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. 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)**.

5.4.2 Rock coring

Upon encountering rock or harder strata, the strata were penetrated through continuous coring using diamond core bit. The rock cores recovered were visually inspected and their percentage recovery (**REC**) and percentage Rock Quality Designation (**RQD**) values were determined. All the samples recovered from rock coring were carefully preserved in rock core boxes and sent to our laboratory at Assari Engineering Consultant Company, Janzour-Tripoli, for further evaluation and testing. A summary of percentage recovery (**TCR**) and

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percentage Rock Quality Designation (**RQD**) values for each borehole is given in appendix **A** of this report. A summary of SPT N-Values, RC and RQD with termination depth were tabulated in **table (3a and 3b)**.

Table 3a: A summary of field *SPT* corrected N value and RC and RQD.

Depth, m	BH-01			BH-02			BH-03			BH-04		
	N-value	CR	RQD	N-value	CR	RQD	N-value	CR	RQD	N-value	CR	RQD
0.0+1.0	← Existing ground level (Natural ground surface)											
1.45+1.0	10	10	-	09	-	-	08	-	-	07	-	-
2.45+1.0	03	03	-	04	-	-	04	-	-	03	-	-
3.45+1.0	02	02	-	03	-	-	03	-	-	02	-	-
4.45+1.0	03	03	-	04	-	-	04	-	-	05	-	-
5.45+1.0	03	03	-	05	-	-	03	-	-	04	-	-
7.0+1.0	-	32	13	-	32	0.0	-	38	0.0	-	33	0.0
8.5+1.0	>50	-	-	>50	-	-	-	27	0.0	-	31	0.0
10.0+1.0	>50	-	-	-	22	0.0	-	17	07	-	14	0.0
11.5+1.0	End of boreholes			End of boreholes			-	22	07	End of boreholes		
13.0+1.0							-	37	22			
14.5+1.0							-	32	07			
							End of boreholes					

Table 3b: A summary of field *SPT* corrected N value and RC and RQD.

Depth, m	BH-05			BH-06			BH-07			BH-08		
	N-value	CR	RQD	N-value	CR	RQD	N-value	CR	RQD	N-value	CR	RQD
0.0+1.0	← Existing ground level (Natural ground surface)											
1.45+1.0	07	-	-	07	-	-	07	-	-	08	-	-
2.45+1.0	04	-	-	05	-	-	05	-	-	06	-	-
3.45+1.0	03	-	-	04	-	-	02	-	-	02	-	-

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Table 3b: (Continued) Summary of SPT N-values, CR and RQD.

4.45+1.0	03	-	-	02	-	-	04	-	-	04	-	-
5.45+1.0	-	-	-	02	-	-	04	-	-	03	-	-
7.50+1.0	-	13	0.0	-	20	0.0	-	11	0.0	-	32	17
8.50+1.0	-	27	0.0	-	27	0.0	-	23	0.0	-	33	17
10.0+1.0	-	27	07	-	20	0.0	-	25	07	-	24	18
12.0+1.0	<i>End of boreholes</i>			-	31	20	-	23	19	-	30	15
13.5+1.0				-	22	11	-	40	32	-	24	15
14.5+1.0				-	24	23	-	31	17	-	38	30
16.5+1.0				-	34	0.0	-	27	14	-	40	19
18.0+1.0				-	23	0.0	-	32	07	-	-	-
19.5+1.0				-	30	0.0	-	23	0.0	-	32	21
21.0+1.0				<i>End of boreholes</i>			<i>End of boreholes</i>			-	46	38
23.0+1.0										-	33	13
24.0+1.0										-	22	13
										<i>End of boreholes</i>		

5.4.3 Ground water conditions

Groundwater was assessed in all the boreholes drilled at the site 24 hours or more, after the completion of drilling each borehole. The groundwater table was encountered in boreholes (BH-01, BH-02, BH-03, BH-04, BH-05, BH-06, BH-07 and BH-08) at a depth range of **1.50 to 1.60** meters below natural surface level during investigations in March, 2022. 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. The observed water levels are tabulated in **table (4)**.

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Table 4: Depth at groundwater encounter.

S/N	Borehole No.	Ground water level (below ground Level), m	Existing ground level, m
1.	BH-01	1.50	1.0
2.	BH-02	1.50	1.0
3.	BH-03	1.60	1.0
4.	BH-04	1.50	1.0
5.	BH-05	1.50	1.0
6.	BH-06	1.60	1.0
7.	BH-07	1.50	1.0
8.	BH-08	1.60	1.0

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 (5)**. 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 (**SSO₃**), total sulphate Dissolved (**TSO₃**), 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.

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Table 5: A summary of the laboratory tests performed on soil, rock and water samples.

Physical tests of soil samples:			
No.	Type of test	Test specifications	No of test
1.	Particle size distribution	ASTM D 421 / 422	42
2.	Moisture content	ASTM D 2216	42
3.	Specific gravity	ASTM D 854	05
4.	Atterberg limits	ASTM D 4318	04
Physical mechanical tests of rock samples:			
1.	Bulk specific gravity	ASTM C127-07	10
2.	Point load index test	ASTM D 5731	43
3.	Unconfined compressive strength	ASTM D 2938	16
4.	Unit weight of rock	---	16
Chemical tests on soil rock samples:			
Chemical tests on soil:		Test specifications	No of test
1.	Chloride content	BS 1377: Part 3:1990	09
2.	Sulphate content	BS 1377: Part 3:1990	09
3.	pH	BS 1377: Part 3:1990	09
Chemical tests on groundwater sample:			
1.	Chloride content	BS 1377: Part 3:1990	03
2.	Sulphate content	BS 1377: Part 3:1990	03
3.	pH	BS 1377: Part 3:1990	03
The details of particle size distribution results are presented in Appendix B 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 (6)** contains the date and results of the water content test on selected samples from boreholes.

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Table 6: Moisture content results.

Borehole No.	Depth, m	Moisture content, M_c (%)
BH-01	1.0-1.45	23.2
	2.0-2.45	20.6
	3.0-3.45	16.4
	4.0-4.45	19.6
	5.0-5.45	20.0
	7.0-8.95	15.3
	8.5-10.0	28.0
BH-02	1.0-1.45	6.7
	2.0-2.45	21.5
	3.0-3.45	17.2
	4.0-4.45	17.1
	5.0-5.45	15.8
BH-03	1.0-1.45	5.6
	2.0-2.45	18.1
	3.0-3.45	20.7
	4.0-4.45	19.0
	5.0-5.45	22.0
BH-04	1.0-1.45	6.3
	2.0-2.45	19.0
	3.0-3.45	28.8
	4.0-4.45	11.8
	5.0-5.45	11.8

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Continued (Table 6): Moisture content results.		
BH-05	1.0-1.45	4.8
	2.0-2.45	24.6
	3.0-3.45	16.8
	4.0-4.45	21.4
BH-06	1.0-1.45	5.1
	2.0-2.45	13.5
	3.0-3.45	25.9
	4.0-4.45	24.0
	5.0-5.45	17.7
BH-07	1.0-1.45	6.6
	2.0-2.45	10.3
	3.0-3.45	18.5
	4.0-4.45	18.5
	5.0-5.45	21.7
BH-08	1.0-1.45	5.1
	2.0-2.45	9.2
	3.0-3.45	19.7
	4.0-4.45	22.3
	5.0-5.45	18.6
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 (7)**. The procedure for determination of specific

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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 (G_s) values were found to range between **2.235 to 2.678** in borehole. The test was carried out according to ASTM D-854.

Table 7: Results of specific gravity of soil solids.

Borehole No.	Depth, m	Specific gravity, G_s (---)
BH-01	5.0-5.45	<u>2.435</u>
BH-02	4.0-4.45	<u>2.484</u>
BH-04	2.0-2.45	2.617
BH-06	1.0-1.45	2.667
BH-08	3.0-3.45	2.678
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 (8)** represents the results of the sieve analysis test.

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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 were performed on four (04) samples selected from the fine soil samples at various depths from the ground surface in accordance with ASTM D 4318. The results of liquid limit, plastic limit tests and the deduced plasticity indices are included in summarized in **table (8)**. The results of Atterberg limits are also plotted on the plasticity chart shown in the **Appendix (C)** also. The results indicated liquid limit ranging from 22% to 20%, plastic limit ranging from 19% to 28% and plasticity indices ranging from 2% to 7%.

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} ,

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D₃₀, D₆₀, 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 (42) results of the classification with Atterberg limits are shown in **table (8)**. The laboratory testing indicated (CL-ML) low plastic, silty Gypsum mixed with clay with sand, the soil was encountered at depths ranging between 3.0 m and 5.45 m in boreholes no. (BH-03, BH-04 and BH-08) below ground level in boreholes.

Table 8: 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	1.0-1.45	0.0	8.7	91.3			N.P	ML, fine grained sandy SILT	A-4
	2.0-2.45	42.8	39.8	17.4			N.P	GM, Silty GRAVEL with fine to med. grained sand	A-1-b
	3.45-3.45	3.5	70.7	28.8			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	4.0-4.45	1.0	64.2	34.8			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	5.0-5.45	0.0	56.5	43.5			N.P	SM, fine grained silty SAND	A-4
	7.0-8.95	32.7	39.2	28.1			N.P	SM, fine to med. grained silty SAND with some gravel	A-2-4

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Continued (Table 8): Grain size distribution, liquid and plastic limits results and soil classification.

BH-01	8.5-10.0	0.0	48.7	51.3			N.P	ML, fine Sandy SILT low plasticity	A-4
BH-02	1.0-1.45	0.3	87.4	12.3			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	2.0-2.45	0.0	25.3	74.7	17	19	2	CL-ML, low plasticity silty CLAY with fine sand	A-4
	3.0-3.45	0.0	35.6	64.4			N.P	ML, fine grained sandy SILT low plasticity with some gravel	A-4
	4.0-4.45	14.9	35.8	49.3			N.P	ML, fine to med. grained sandy SILT low plasticity with little gravel	A-4
	5.0-5.45	12.1	48.0	39.9			N.P	SM, fine grained silty SAND with few gravel	A-4
	7.0-8.50	2.4	85.2	12.4			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
BH-03	1.0-1.45	1.5	52.8	45.7			N.P	SM, fine grained silty SAND with trace gravel	A-4
	2.0-2.45	0.2	37.3	62.5			N.P	SM, fine grained silty SAND with ftrace gravel	A-4

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Continued (Table 8): Grain size distribution, liquid and plastic limits results and soil classification.

BH-03	3.0-3.45	0.0	29.7	70.3			N.P	SM, fine grained silty SAND with trace gravel	A-4
	4.0-4.45	1.6	36.6	61.8			N.P	SM, fine grained silty SAND with trace gravel	A-4
	5.0-5.45	5.2	35.9	58.9	20	26	6	CL-ML, low plasticity silty CLAY with fine sand and trace gravel	A-4
BH-04	1.0-1.45	3.5	81.7	14.8			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	2.0-2.45	6.7	75.5	17.8			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	3.0-3.45	0.1	14.1	85.8	22	28	6	CL-ML, low plasticity silty CLAY with fine sand and trace gravel	A-4
	4.0-4.45	0.1	20.6	79.3			N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4
	5.0-5.45	0.0	67.3	32.7			N.P	SM, fine grained silty SAND	A-2-4
BH-05	1.0-1.45	5.8	77.3	16.9			N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	2.0-2.45	0.0	18.1	81.1			N.P	ML, fine Sandy SILT low plasticity	A-4

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Continued (Table 8): Grain size distribution, liquid and plastic limits results and soil classification.

BH-05	3.0-3.45	0.0	44.4	55.6		N.P	ML, fine Sandy SILT low plasticity	A-4
	4.0-4.45	0.0	40.0	58.0		N.P	ML, fine Sandy SILT low plasticity	A-4
BH-06	1.0-1.45	3.0	82.0	15.0		N.P	SM, fine to med. grained silty SAND with trace gravel	A-2-4
	2.0-2.45	8.1	71.9	20.0		N.P	SM, fine to med. grained silty SAND with trace gravel	A-2-4
	3.0-3.45	0.0	37.8	62.2		N.P	ML, fine Sandy SILT low plasticity	A-4
	4.0-4.45	0.0	39.7	60.3		N.P	ML, fine Sandy SILT low plasticity	A-4
	5.0-5.45	0.9	51.4	47.7		N.P	SM, fine grained silty SAND with trace gravel	A-4
BH-07	1.0-1.45	4.1	80.0	15.9		N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	2.0-2.45	0.1	86.8	13.1		N.P	SM, fine grained silty SAND with trace gravel	A-2-4
	3.0-3.45	0.1	66.7	33.2		N.P	SM, fine grained silty SAND with trace gravel	A-2-4

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Continued (Table 8): Grain size distribution, liquid and plastic limits results and soil classification.

BH-07	4.0-4.45	0.1	27.2	72.7			N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4
	5.0-5.45	0.9	43.0	56.1			N.P	ML, fine Sandy SILT low plasticity with trace gravel	A-4
BH-08	1.0-1.45	1.4	83.7	14.9			N.P	SM, fine to med. grained silty SAND with trace gravel	A-2-4
	2.0-2.45	0.4	90.8	8.8			N.P	SM, poorly graded, fine grained SAND with silt and trace gravel	A-2-4
	3.0-3.45	0.0	76.9	23.1			N.P	SM, fine grained silty SAND	A-2-4
	4.0-4.45	0.0	42.1	57.9			N.P	ML, fine Sandy SILT low plasticity	A-4
	5.0-5.45	0.5	29.4	70.1	21	28	7	CL-ML, low plasticity silty CLAY with fine sand and trace gravel	A-4

6.5 Density and unit weight of rock samples

Density (ρ) is the amount of mass in a given volume and the units are (ton/m³). Unit weight (γ) is the weight of a unit volume, and the units are (N.m⁻³). Usually, because the Newton is a small force, unit weight is expressed in (kN /m³). The results of the bulk density and bulk density for the selected four rock samples were presented in **table (9)**. From the

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correlation the bulk unit weight is varied from **15.63 – 21.29** KN/m³. The bulk density ranged from **1.94-2.17** ton/m³.

Table 9: Bulk density and bulk unit weight values for the selected rock samples.

Borehole No.	Depth, m	Bulk density, ρ (ton/m ³)	Bulk unit weight, γ (KN/m ³)
BH-03	11.5-13.0	1.659	16.26
	13.0-14.5	1.654	16.22
BH-05	8.5-10.0	1.647	16.15
BH-06	10.5-12.0	1.868	18.31
	13.5-15.0	1.948	19.11
BH-07	9.0-10.5	2.171	21.29
	12.0-13.5	1.772	17.38
BH-08	6.0-7.5	1.928	18.91
	7.5-9.0	2.065	20.25
	9.0-10.5	1.594	15.63
	10.5-12.0	1.661	16.29
	13.5-15.0	2.127	20.86
	15.0-17.0.	1.897	18.60
	17.0-19.5	1.628	15.97
	19.0-21.0	1.828	17.93
	23.0-24.0	1.953	19.15

6.6 Specific gravity of rock (Particle density)

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 rock are shown in **table (10)**. The procedure for determination of specific gravity, used the wire basket method to determine the specific gravity (**G_s**). Most

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core samples have a rather narrow range of **G_s** values: **1.75** to **2.10** The test was carried out according to ASTM C127-07.

Table 10: Results of specific gravity (Particle density), water absorption and porosity.

Borehole No.	Depth, m	specific gravity, G_s (---)	water absorption (%)	Porosity n (%)
BH-03	11.5-13.0	1.83	13.1	25.68
BH-05	8.5-10.0	1.75	11.2	23.45
BH-06	12.0-13.5	1.94	14.2	25.67
	16.5-18.0	1.86	15.10	28.41
BH-07	10.5-13.5	2.09	8.5	15.06
BH-08	19.0-21.0	2.10	3.0	5.59
	15.0-17.0	2.03	7.8	14.27
	19.0-21.0	1.85	14.7	27.76
The tester certifies that the test was carried out in accordance (ASTM C127-07).				

6.7 Compression Tests (Rock strength)

6.7.1 Point load strength index test

The rock strength (Point load index) was determined in the laboratory, intact (core samples) rock core samples recovered from various test pit bottom. One type of tests was performed namely: the point load index test (ASTM D 5711). the test provides an estimate for the uniaxial compressive (UCS). The advantage of performing the point load test are: (a) It could be done. on sample with different dimension and sizes, (b) provides strength data for rock layers that are characterized by very closely spaced. The point load test is quick means of estimating the compressive strength of intact rock even if the standard sample's sizes are not available. The point load (*I_s*) should corrected for 50 mm standard core size to be used

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in the (UCS) estimation. **table (12)** include the point load index, estimated uniaxial compressive strength results for selected samples. In the point load test the specimen is placed between opposing cone- shaped platens and subjected to compression. The tensile strength $T_s (=P/D^2)$ is then derived by using the empirical expression (Reichmuth, 1968). A classification of the strength of rock, based on the results of point load tests has been published by Franklin and Broch (1972) and is shown in **table (11)**. The point load test results were used to provide a strength estimate using a minimum conversion factor of 8.

Table 11: Rock classification based on point load index values, (Franklin & Broch, 1972)

Term	Point load strength index
Extremely low strength	Less than 0.03
Very low strength	0.03-0.1
low strength	0.1-0.3
Medium strength	0.3-1.0
High strength	1.0-3.0
Very high strength	3.0-10
Extremely high strength	Over 10

Table 12: Point load test results and estimated UCS.

Borehole No.	Depth, m	Sample No.	Is(50) (MPa)	σ estimated (MPa)	Average σ estimated (MPa)
BH-01	5.5-7.0	1	2.213	17.70	10.09
		2	0.901	7.21	
		3	0.668	5.34	
BH-02	5.5-7.0	1	1.673	13.38	12.12
		2	1.574	12.59	
		3	1.298	10.39	
	8.5-10.0	1	2.296	18.37	

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Table 12: (Continued) Point load test results and estimated UCS.					
BH-02	8.5-10.0	2	5.722	45.78	32.07
BH-03	7.0-8.5	1	2.471	19.77	28.82
		2	4.734	37.87	
	8.5-10.0	1	2.988	23.91	11.07
		2	0.647	5.17	
		3	0.515	4.12	
	10.0-11.5	1	0.455	3.64	2.38
		2	0.141	1.13	
BH-04	5.5-7.0	1	1.259	10.07	5.48
		2	0.111	0.89	
	8.5-10.0	1	2.000	16.00	13.10
		2	0.924	7.39	
		3	1.991	15.92	
BH-05	5.5-7.0	1	0.541	4.32	19.97
		2	4.452	35.61	
	7.0-8.5	1	2.367	18.94	13.76
		2	1.131	9.05	
		3	1.663	13.30	
BH-06	6.0-7.5	1	1.184	1.129	5.49
		2	0.254	0.242	
	9.0-10.5	1	0.225	0.215	2.72
		2	0.487	0.464	
	15.0-16.5	1	0.602	0.574	3.56
		2	0.412	0.393	
		3	0.387	0.369	
	18.0-19.5	1	0.903	0.861	4.49
		2	0.341	0.326	
3		0.520	0.496		
BH-07	6.0-7.5	1	1.150	1.097	4.62
		2	0.242	0.231	
		3	0.426	0.406	
	15.0-16.5	1	0.651	0.621	3.81
		2	0.622	0.593	
		3	0.225	0.215	
	18.0-19.5	1	0.724	0.690	4.18
		2	0.373	0.356	
The tester certifies that the test was carried out in accordance with ASTM D 5711.					

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6.7.2 Unconfined compression strength test

Specimens of right circular cylinders having a height to diameter ratio of 2 or higher are prepared by cutting and grinding. The specimen is then compressed under a stiff compression machine with a spherical seating. The axial stress is applied with a constant strain rate around 1 $\mu\text{m/s}$ such that failure occurs within 5-10 minutes of loading. The load is measured by a load transducer. unconfined compression strength tests were performed in accordance with ASTM D 2938. The **table (13)** below summarizes unconfined compression strength test results performed on the intact core samples.

Table 13: The unconfined compression strength, UCS.

Borehole No.	Depth, m	Sample No.	Load (KN)	Unconfined compr. strength (MPa)	Corrected of U.C.S (MPa)	Strength classification
BH-03	11.5-13.0	1	16.1	8.23	8.19	moderately weak
	13.0-14.5	2	2.5	1.36	1.36	weak
BH-05	8.50-10.0	1	5.5	2.76	2.72	weak
BH-06	10.5-12	1	6.5	3.37	3.36	weak
	13.5-15.0	2	40.5	20.64	20.59	moderately strong
BH-07	9.0-10.5	1	31.3	16.09	16.02	
	12.0-13.5	2	2.6	1.34	1.34	weak
BH-08	6.0-7.50	1	24.0	12.605	12.59	moderately strong
	7.5-9.0	2	27.7	14.618	14.60	
	9.0-10.5	3	1.50	0.786	0.785	very weak
	10.5-12.0	4	2.50	1.305	1.30	weak
	13.5-15.0	5	17.1	8.720	8.69	weak
	15.0-17.0	6	8.50	4.466	4.45	
	17.0-19.5	7	2.07	1.077	1.08	very weak
	19.0-21.0	8	6.46	3.338	3.33	weak
	23.0-24.0	9	6.33	3.310	3.31	

The tester certifies that the test was carried out in accordance with ASTM D 2938.

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Thus, the rock encountered here can be classified as '**very weak to moderately strong**' as per the chart given in **BS 5930** and reproduced below:

Table 14: Classification of uniaxial compressive strength (BS 5930).

Term	Compressive Strength, (MN/m ²)
Very weak	Less than 1.25
Weak	1.25 to 5
Moderately weak	5 to 12.5
Moderately strong	12.5 to 50
Strong	50 to 100
Very Strong	100 to 200
Extremely Strong	Greater than 200

6.7.3 Rock strata characterization (Rock mass conditions)

The subsurface soil and rock information that was provided by (8) boreholes drilled to mentioned depths revealed the site consists of sequence layers, (shown in **Appendix A:** Borehole logs from 1 to 8). The geological conditions of the study area are complicated. In general, the subsoil can be subdivided into 5 main layers. They vary both in thickness and geotechnical properties (see 3.1).

Generally, the subsurface strata (the top layer) consist of silty very loose / soft soil layers with mixed gypsum and clay. These soil deposits are underlain by moderately to highly weathered Calcareous limestone interbedded calcareous siltstone rock.

The rock stratum lithology at this site comprise of rock under various degree of weathering and fracturation at different depth. the rock strata encountered in the boreholes can be categorised as of 'very low to low' and 'very weak to moderately strength' quality up to the depth explored.

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Table 15: Design parameters and engineering properties of rock mass (Bieniawski, 1979).

S. No	Parameter/properties of rock mass	Rock mass rating (Rock class)				
		100–81 (I)	80–61 (II)	60–41 (III)	40–21 (IV)	<20 (V)
1.	Classification of rock mass	Very good	Good	Fair	Poor	Very poor
2.	Cohesion of rock mass (MPa)*	>0.4	0.3–0.4	0.2–0.3	0.1–0.2	<0.1
3.	Angle of internal friction of	>45°	35°–45°	25°–35°	15°–25°	<15°

The Rock Quality Description (RQD) which is a quantitative measure of the fractured state of rock and indirectly gives an index to quality of rock mass has been computed from the recovered core of individual drilling runs in the borehole (Ref. Borehole records– **Appendix A**). The result can be correlated by referring to the following table given in BS 5930 (ASTM special publication 984, 91-101).

Table 16: Rock descriptive terms based on **R.Q.D.** values are as follow.

RQD (%)	Rock description
0 – 25	Very poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

6.8 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

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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 (17)**.

6.8.1 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 considered necessary for this site. Also, any alternative precaution might be used after having approved from the consultant engineer, (see table 26 *appendix F*).

6.8.2 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 (17)** is more than **0.05%** which are above the threshold value. On this basis specific precautions against chloride induced corrosion are considered necessary at this site, the result showed that some boreholes (BH-04 and BH-07) have chloride content is greater than **> 0.1**, however it is generally good practice to apply a protective bitumen coating to all buried concrete as a precaution.

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6.8.3 pH

The results showed the soil to be slightly alkaline in upper strata and tend towards neutrality at deeper strata, with a pH in the order of 7.84 – 8.58. The results of chemical analyses are shown in **table (17)**. These results reveal that no corrosion in the foundation concrete would be expected from organic acids.

Table 17: Chemical analysis of soil samples.

Borehole No.	Depth (m)	Chloride (CL, %)	pH	Water soluble sulphate as (SO ₃ , %)
BH-01	2.0-2.45	0.0210	8.29	0.0543
BH-02	1.0-1.45	0.0028	8.42	0.0152
BH-03	3.0-3.45	0.0248	8.40	<u>0.2439</u>
BH-04	1.0-1.45	<u>0.0520</u>	8.58	0.0627
BH-05	2.0-2.45	0.0269	8.57	0.0083
	5.5-7.0	0.0383	7.84	0.0410
BH-06	2.0-2.45	0.0085	8.20	0.0263
BH-07	4.0-4.45	<u>0.1153</u>	8.30	0.0963
BH-08	2.0-2.45	0.0218	8.45	0.0179
Exposure condition		Negligible	Negligible	Negligible
Permissible Limits, BS 882: 1992		<0.05	4.5 min.	0.2 Max

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The chemical analysis carried out on the ground water sample collected from the boreholes show the following results:

Table 18: Chemical analysis of ground water sample.

Borehole No.	Depth (m)	Chloride (CL %)	pH	Water soluble sulphate As (SO ₃ %)
BH#01	1.50	<u>0.0760</u>	7.18	<u>0.1175</u>
BH#05	1.50	0.0301	7.46	<u>0.0523</u>
BH#07	1.50	<u>0.1153</u>	7.20	<u>0.1575</u>
Exposure condition		Negligible	Negligible	Must be precaution against Sulfate aggressiveness
Specifications limits		<0.05 (BS 4027 ASTM C 150)	6-8	<0.01 (ACI 201.2R-01)

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 (19)**, while typical design value ranges are specified below:

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Silty SAND/ with silt (SM): 17- 19 kN/m³ (1.70 -1.90 ton/m³)

Limestone rocks: 21 - 23 kN/m³ (2.10 – 2.30 ton/m³)

Table 19: The relationship between the various soil parameters.

Description		Very loose	Loose	Medium dense	Dense	Very dense
Relative density, Dr		0	0.15	0.35	0.65	0.85
N/30cm (SPT)	Fine	1-2	3-6	7-15	16-30	>40
	Medium	2-3	4-7	8-20	21-40	
	Coarse	3-6	5-9	10-25	26-45	>45
Φ°	Fine	26-28	28-30	30-34	33-38	<50
	Medium	27-28	30-32	32-36	36-42	
	Coarse	28-30	30-34	33-34	40-50	
γ _{sat} (t/m ³)		1.1-1.6	1.4-1.8	1.7-2.0	1.7-2.2	2.0-2.3

The table is referring to foundation analysis and design, Joseph E. Bowles.

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 ($\phi_r=30^\circ$) can be considered in the geotechnical analyses. The results are presented in **table (20)** shows the friction angle of granular soils, the test results of corrected SPT are given in **Appendix C**.

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Table 20: 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	1.0-5.45	SM /ML	31.9	29.4
			27.6	
			26.8	
			27.8	
			32.6	
BH-02	1.0-5.45	SM /ML	31.4	29.0
			28.3	
			27.6	
			28.6	
			29.4	
BH-03	1.0-5.45	SM /ML	30.8	28.6
			28.3	
			27.6	
			28.6	
			27.8	
BH-04	1.0-5.45	SM /ML	30.2	28.5
			27.6	
			26.8	
			29.4	
			28.6	
BH-05	1.0-4.45	SM /ML	30.2	28.5
			28.3	
			27.6	
			27.8	
BH-06	1.0-4.45	SM /ML	30.2	29.1
			29.0	
			28.3	
			27.0	

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Table 20: (Continued) Estimated soil friction angle (ϕ_f) and corrected SPT values.				
BH-06	1.0-4.45	SM /ML	27.0	
BH-07	1.0-4.45	SM /ML	30.2	28.7
			29.0	
			26.8	
			28.6	
			28.6	
BH-08	1.0-4.45	SM /ML	30.8	28.7
			29.6	
			26.8	
			28.6	
			27.8	
Soil friction angle of soil estimated using the correlations proposed by Kulhawy and Mayane (1990) depending on (N_{60}) 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:

$$E_s = 500 * (N+15), \text{ kPa}$$

Elastic, Sandy SILT:

$$E_s = 1200 * (N), \text{ kPa}$$

Limestone rock:

$$E_s = 100, \text{ MPa}$$

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below is **table (21)**, showing the modulus of elasticity of sand can be estimating the relative between (N) values and modulus of elasticity (E_s).

Table 21: Estimated modulus of deformation of soil (E_s) and corrected SPT values.

Borehole No.	Depth (m)	Soil type	Modulus of deformation, E_s (MPa)	Average of E_s (MPa)
BH-01	1.0-5.45	SM /ML	11.25	9.43
	3.0-3.45		8.25	
	4.0-4.45		8.775	
	5.0-5.45		11.75	
BH-02	1.0-5.45	SM /ML	10.88	7.40
	2.0-2.45		3.60	
	3.0-3.45		8.63	
	4.0-4.45		4.08	
	5.0-5.45		9.63	
BH-03	1.0-5.45	SM /ML	10.5	8.10
	2.0-2.45		9.0	
	3.0-3.45		8.63	
	4.0-4.45		9.2	
	5.0-5.45		3.06	
BH-04	1.0-5.45	SM /ML	10.13	7.90

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Table 21: (Continued) Estimated modulus of deformation of soil (E_s) and corrected **SPT** values.

BH-04	2.0-2.45	SM /ML	8.63	
	3.0-3.45		1.80	
	4.0-4.45		9.63	
	5.0-5.45		9.20	
BH-05	1.0-1.45	SM /ML	10.125	9.10
	2.0-2.45		9.0	
	3.0-3.45		8.63	
	4.0-4.45		8.775	
BH-06	1.0-1.45	SM /ML	10.13	9.0
	2.0-2.45		9.4	
	3.0-3.45		9.0	
	4.0-4.45		8.35	
	5.0-5.45		8.35	
BH-07	1.0-1.45	SM /ML	10.13	9.20
	2.0-2.45		9.4	
	3.0-3.45		8.25	
	4.0-4.45		9.20	
	5.0-5.45		9.20	

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Table 21: (Continued) Estimated modulus of deformation of soil (E_s) and corrected **SPT** values.

BH-08	1.0-1.45	SM /ML	10.5	8.20
	2.0-2.45		9.8	
	3.0-3.45		8.25	
	4.0-4.45		9.20	
	5.0-5.45		3.06	

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:

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

$$K_o = (1 - \sin \varphi_f)$$

$$K_p = (1 + \sin \varphi_f) / (1 - \sin \varphi_f)$$

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 (22)** shows the coefficient of earth pressure of soil.

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Table 22: The coefficient of earth pressure.

Soil parameters (Estimated from N corrected values: SPT)			
Average coefficient of earth pressure at depth 5.45 m.	At rest K_o	0.52	soil friction angle, ϕ_f (deg)
	Active K_a	0.35	28.5
	Passive K_p	2.82	

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 = $\tan 24^\circ$ (For non-cohesive strata), coefficient of friction between soil and steel = $\tan 20^\circ$ (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. Meyerhof and Terzaghi-Peck (1948-1967) developed criteria to correlate relative densities with SPT-values, angle of internal and unit weight of granular soils.

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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:

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

$$q_{all} \text{ (KN/m}^2\text{)} = 25 * N' * (S_e/25.4) * F_d \quad \text{for } B \leq 1.20$$

Where:

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

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

B = width of footing (m)

B = width of footing (m)

F_d = depth factor: $F_d = 1 + 0.33 (D_f/B) < 1.33$ (---)

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 5.0 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 (23)**. the allowable net bearing capacity for static loads should not exceed **49.24 kPa (4.9ton/m²)** at the previously recommended depth of foundation. The net allowable bearing pressure was calculated and found equal to **76.85 KPa (7.7 ton/m²)** based on controlled procedure of **50 mm** (2inch) maximum allowable

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settlements for mat foundation and for an influence depth of 2B. Calculations of bearing resistance and corrected standard penetration value found in **Appendix D**.

Table 23: Estimated allowable bearing capacity of soil.

Borehole No.	Depth below existing ground surface, m	Corrected 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	1.0-5.45	05	68.87	62.80	59.30	92.55
BH-02	1.0-5.45	05	62.61	57.09	53.91	84.13
BH-03	1.0-5.45	04	55.48	50.59	47.77	74.55
BH-04	1.0-5.45	04	52.22	47.62	44.96	70.17
BH-05	1.0-4.45	04	54.95	50.11	47.31	73.83
BH-06	1.0-5.45	04	50.30	45.87	43.31	67.59
BH-07	1.0-5.45	04	54.87	50.04	47.24	73.74
BH-08	1.0-5.45	04	58.22	53.08	50.12	78.23
Average:		04	57.19	52.15	49.24	76.85
Calculation of allowable bearing capacity for mat foundation using Meyerhof equation Peck EL TL, 1974 (Canadian foundation engineering manual, 2006).						

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8.2 Estimated rock allowable bearing capacity (heavily fractured rock)

When the rock mass is heavily fractured ($C=40\text{KPa}$), it is better to treat rock as soil/dense gravelly material (Tomlinson 1986). For estimating the ultimate bearing capacity of a strip footing resting on rock crust surface can be determined by using Terzaghi's bearing capacity equation, as shown below:

$$q_{ult.} = C N_c + \gamma_b D_f N_q + 0.5 \gamma_b B N_\gamma \dots \text{Terzaghi's BC Equation}$$

$$q_{all} = q_{ult} / F.S$$

Where:

C: cohesion of rock (KPa)

$q_{ult.}$: the ultimate bearing capacity, (KPa)

q_{all} : allowable bearing capacity, (KPa)

FS: Factor of safety = (3)

γ_b : density of rock mass, KN/m^3

N_c , N_q and N_γ : bearing capacity factors depending on ϕ friction angle. For $\phi = 20$ degree,

$N_c = 17.69$, $N_q = 7.44$ and $N_\gamma = 3.64$

The allowable bearing capacity of crushing rock or gravelly soil is equal to 285 KPa.

8.3 Estimated rock allowable bearing capacity (intact rock)

The bearing capacity for rocks was assessed by using the test result for determining the unconfined compression strength and point load index, according to the Canadian Geotechnical Society (CGS, 2006) the following formulas were used:

$$q_{all} = q_{uc} * (K_{sp}/F.S)$$

Where :

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q_{uc} = unconfined compression strength of rock

K_{sp} = an empirical coefficient and ranges from 0.1 to 0.4

FS = the factor of safety

To account for discontinuities, Bowles (1996) suggested that the ultimate bearing capacity q_u should be modified as:

$$q_u = q_{uc} * (RQD)^2$$

The results of the allowable net bearing capacity are shown in table (24). the allowable net bearing capacity for static loads should not exceed **330 kPa (33.65 ton/m²)** at the previously recommended depth of foundation.

Table 24: Estimated allowable bearing capacity of rock.

Borehole No.	Depth of foundation (m)	Allowable bearing, q_{all} (KPa)	Remark
BH-02	5.5-7.0	606.0	Estimated q_{uc}
	8.5-10.0	400.91	Estimated q_{uc}
BH-03	7.0-8.5	360.25	Estimated q_{uc}
	8.5-10.0	553.30	Estimated q_{uc}
	10.0-11.5	198.74	Estimated q_{uc}
	11.5-13.0	512.03	---
	13.0-14.5	113.35	---
BH-04	5.5-7.0	342.53	Estimated q_{uc}
	8.5-10.0	655.21	Estimated q_{uc}
BH-05	5.5-7.0	332.80	Estimated q_{uc}
	7.0-8.5	558.79	Estimated q_{uc}
	8.5-10.0	226.72	---
BH-06	6.0-7.5	457.24	Estimated q_{uc}
	9.0-10.5	226.31	Estimated q_{uc}
	10.5-12.0	279.94	---

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Table 24: (Continued) Estimated allowable bearing capacity of rock.			
BH-06	13.5-15.0	343.20	---
	15.0-16.5	296.92	Estimated q_{uc}
	18.0-19.5	374.0	Estimated q_{uc}
BH-07	6.5-7.0	385.39	Estimated q_{uc}
	9.0-10.5	202.05	---
	12.0-13.5	167.22	---
	15.0-16.5	317.65	Estimated q_{uc}
	18.0-19.5	348.70	Estimated q_{uc}
BH-08	6.0-7.5	419.39	---
	7.5-9.0	486.69	---
	9.0-10.5	<u>65.401</u>	---
	10.5-12.0	108.67	---
	13.5-15.0	289.68	---
	15.0-17.0.	370.75	---
	17.0-19.5	<u>89.67</u>	---
	19.5-21.0	277.28	---
	23.0-24.0	275.49	---

8.4 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:

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

Where:

S_e = maximum settlements approximately (mm)

q_{net} = net allowable bearing capacity of soil (KN/m²)

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

The estimation of settlement was performed using net allowable bearing pressure (q_{net}). **table (25)** included the settlement results.

Table 25: Estimated settlement for soil layers.

Stratum type	Depth of foundation (m)	Settlement, mm	Average settlement, mm
SM /ML	1.0-5.45	<u>52.0</u>	41.3
		45.8	
		39.4	
		36.0	
		33.4	

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.

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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 silty and sandy soil encountered in our borings were generally very loose to loose state of compaction. In addition, groundwater was encountered at a depth range of **1.5 to 1.6 meters** below existing ground level in all the boreholes. For these reasons and based upon engineering judgment, it is our opinion that the potential for liquefaction at the site is high 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, loose becoming to very loose, Silty fine grained Sand (SM) with trace gravel, light brown to brownish grey, soft, low plastic Sandy Silt (ML), thin soil layers of gypsum mixed with silty Clay (CL -ML) in the upper approximately 1.0 m - 5.45 m depth below the existing ground level underlain by Calcarene limestone with cross bedding of yellowish grey calcareous siltstone. The **second stratum** is a highly to moderately rocky stratum underneath the top soil at depth of about 5.0 to 24.0 meter (except for the layer of the depth 5.45, 3.45 and 5.45

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m in borehole no. BH-03, BH-04 and BH-08 respectively). These types of rocks are generally characterized by their light grey - whitish grey to yellowish grey in colour. low rock quality designation (RQD) value, indicating the very poor to poor fracture state of these rock layers, moderately to high weathered, fine to medium grained, moderately strength to low. Therefore, these sedimentary rocks can be classified as fair to very poor to poor class according to the rock mass rating (RMR) scale. Unconfined compression strength values of the rock materials of sub-strata are less than 20.0 MPa. The soil and rock stratum were classified according to the information and test results obtained at each borehole **appendix A** and can be seen (section 3.1).

- Most of soils were classified as **SM** (fine grained silty SAND), **ML** (fine Sandy SILT, low plasticity). This layer is encountered in all boreholes, and **ML-CL** low plasticity Silty CLAY (Gypsum mixed with clay) with Sand at some locations in borehole no (BH-03, BH-04 and BH-08), **GM** (silty gravel with fine to medium grained sand). The layer is encountered only in borehole no (BH-01) at depth 2.0-2.45. based on USCS and, all results of soil according to unified soil classification system are presented in **table (8)**.
- The choice of the type of foundation will depend primarily on the type and weight of the structure, the strength of the underlying stress influenced strata and on the position of the groundwater table, if found.
- The choice of the type of foundation will depend primarily on the type and weight of the structure, the strength of the underlying stress influenced strata and on the position of the groundwater table, if found. It is evident from the borehole log of the boreholes as well as from the soil (top layers) characteristics of each soil layers in all boreholes at depths 1.0 to 5.45m which are soft and weak with the found of ground water, that

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the isolated footing or mat foundation cannot serve the required bearing capacity to cater the foundation loads, at the mentioned depths. The allowable bearing capacity in soil locations is determined based on the standard penetration test results. The allowable bearing resistance of soil layers presented in **table (23)**.

- It is recommended to design building (oil refining factory), with conservative allowable rock pressures in the order of 33.65 ton/m² (330 kN/m²) for foundation at depth not less than 6.0 m from the ground surface level, and after scraping and removing topsoil, leveling and compacting foundation soil.
- Because of presence of ground water and probable rise in water table, 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 expected to exceed total settlements of **50 mm** (see table 25).
- 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 encountered at a depth range of **1.50 to 1.60 m** below the existing ground level. However; fluctuation in groundwater levels should be anticipated with variations seasonal. For these reasons, long term ground water levels may differ from those described in this report (can be see section 5.4.2).
- Therefore, it is recommended to protect the foundations from any expected drainage water and to make a system for the drainage of surface and ground water and to protect the system from any external factors.

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- Before placing foundations, make sure that all excavated surfaces are firm and free of any loose or undesirable soils. This should be checked by an experienced geotechnical engineer. In case loose/undesirable soils are encountered, the same must be replaced with engineered fill or crushed rock fill or lean concrete up to the desired foundation level. Select fill should be placed up to 500 mm thicknesses beneath foundation level.
- Before placing the concrete. We recommend using a layer of crushed stone with a thickness of not less than 35 cm, which is composed of 1 to 6 in., and then compaction it with a roller weighing 25 tons, longitudinal and crosswise several times.
- Where the foundations are intended to be placed at or below the ground water level, requirements of BS 8500 or ACI 318 for durability of reinforced concrete should be strictly considered.
- Corrosion potential is expected from chloride on the buried concrete because the chloride content isn't high than **0.1 %**. And the soluble sulphate content is slightly higher According to **tables (17 and 18)**, 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.
- To avoid possible attack of deleterious salts on concrete and reinforcement, the type five (**Class5**) cement would be used to produce the concrete with water cement ratio

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(W/C) less than **0.45** (superplastsizer must be adding) and the cement content more than **350 kg/m³** with bitumen coating and assaulted sheet or any other effective coating, as mentioned in **table (26)** of this report.

Table 26: Recommendations for sulphate-resistant “normal-weight concrete”

Degree of exposure	Water-soluble sulphate (SO ₄) in soil sample percent	sulphate (SO ₄) in groundwater samples-mg/L	Minimum specified 28-day compressive strength, (MPa) as cylinder	Minimum water-cement ratio	Portland cement type to be used
Very severe	Over 2	Over 10000	35	0.40	V
Severe	0.2-2.0	1500-10000	32	0.45	V
Moderate	0.1-0.2	150-1500	30	0.47	II or V
Normal	Less than 0.1	Less than 150	25	0.50	I

- 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 27** according to AASHTO

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Classification can be used for backfilling behind abutments if properly controlled and free from the deleterious substance.

Table 27: 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**.

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12. REFERENCES:

- American Concrete Institute ACI 201. 2R-01 supersedes ACI 201.2R-92 (Re-approved 1997) and became effective September 6, 2000.
- ASTM 1996 American society for testing and materials (ASTM).
- Standards. (2001), "**Soil and Rock**" ASTM Book of Standards, Volume 04.08, March 2001.
- Baraj M. Das, 2012, "**Principles of foundation engineering**" eighth diction, Global Engineering Company.
- Baraj M. Das, 2002, "**Soil Mechanics Laboratory Manual**" sixth edition, oxford university press.
- Bell, F. G. (1993), "**Engineering Geology**", Blackwell Scientific Publications, London, 559 P.
- Bell, F. G. (1992), "**Engineering in Rock Masses**", Butterworth Heinemann, London.
- BS 5930 (1980), "**Code of Practice for Site Investigation**", British standards Institution. 128 P.
- Canadian geotechnical Society, (2006), "**Canadian Foundation Manual**", 4th, BiTech Published Ltd.
- Isao, I. (2015), "**Soil Mechanics Fundamentals and Applications**", Second Edition, Taylor & Francis Group, USA.
- Joseph E. Bowles, 1994, "**foundation analysis and design**" fifth edition, the Mc Graw- Hill Companies, Inc.
- M. Carter and S. P. Bentley, "**Correlations of Soil Properties**", First Edition, Bookcraft (Bath)Ltd, Great Britain, pp. 50-54, 1991.
- Robertson P.K. (1985) "**In situ Testing and its Application to Foundation Engineering**" 1985 Canadian Geotechnical Colloquium, Canadian Geotechnical Journal Vol. 23, n° 4, 1986.
- Washington State Department of Transportation (WSDOT), "**Geotechnical Design Manual**" December 2013.

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APPENDIX 'A'

BOREHOLE LOGS

(Field Data)

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BOREHOLE LOG

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Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abuabakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>8H-01</td><td>N :32°20'53.63" E :15°12'09.84"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condtion : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 06/03/2022 Date Completed : 06/03/2022	Borehole No.	Coordinates	8H-01	N :32°20'53.63" E :15°12'09.84"
Borehole No.	Coordinates				
8H-01	N :32°20'53.63" E :15°12'09.84"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS	--	N.A.	N.A.	N.A.	N.A.	Light brown to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense. Estimated ground elevation.	
1.0	DS	10	N.A.	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, medium grained Sandy SILT. Gravel (0.0%), Sand (8.7%), Fines (91.3%), stiff, inorganic fines low plasticity, moist. No. of blows: (06)(05)(05)	
2.0	DS	03	N.A.	N.A.	N.A.	N.A.	(GM) Brownish grey to whitish grey, Silty GRAVEL with fine to medium grained Sand. Gravel (42.8%), Sand (39.8%), Fines (17.4%), very loose, sub-angular gravel, very weak cementation, low plastic fines, moist. No. of blows: (08)(02)(01)	
3.0	DS	02	N.A.	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, fine to medium grained silty SAND with trace gravel Gravel (3.5%), Sand (71.2%), Fines (25.8%), very loose, very weak cementation, non plastic, moist. No. of blows: (01)(01)(01)	
4.0	DS	03	N.A.	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, fine to medium grained silty SAND with trace gravel Gravel (1.0%), Sand (64.2%), Fines (34.8%), very loose, very weak cementation, non plastic, moist. No. of blows: (01)(02)(01)	

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

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Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	BH-01	N :32°20'53.63" E :15°12'09.84"
Project Location : Misratah (Misurata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company :Assari Engineering Consultant Co.	Weather Conduction : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.50	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 06/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 06/03/2022	

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		03	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, fine to medium grained silty SAND. Gravel (0.0%), Sand (56.5%), Fines (43.5%), very loose, very weak cementation, non plastic, moist. No. of blows: (01)(01)(02)	
6.0	C		N.A.	32	13	0.0	Whitish grey to light grey Calcareous limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass. Recovered as fragments of calcarenite limestone.	
7.0								
8.0	DS		Over 50	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, Calcareous, fine to medium grained silty SAND with some gravel (Residual Soil). Gravel (32.7%), Sand (39.2%), Fines (28.1%). Very dense, highly cemented Sand by carbonates, non plastic, moist. No. of blows: (Over 50)	
9.0	DS		Over 50	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, fine grained Sandy SILT. Gravel (0.0%), Sand (8.7%), Fines (91.3%), stiff, low plasticity, moist. No. of blows: (Over 50)	
10.0							End of borehole at 10.0m depth.	

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

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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	8H-02	N : 32°20'54.38" E : 15°12'09.58"
Project Location : Misratah (Misurata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company : Assari Engineering Consultant Co.	Weather Condition : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.50	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 07/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 07/03/2022	

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense. Estimated ground elevation.	
1.0	DS	09	09	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (3.5%), Sand (87.4%), Fines (12.3%), loose, very weak cementation, non plastic, moist. No. of blows: (04)(05)(04)	
2.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, medium grained Sandy SILT. Gravel (0.0%), Sand (25.3%), Fines (74.7%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (04)(02)(02)	
3.0	DS	03	03	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (35.6%), Fines (64.4%), soft, inorganic fines low plasticity, moist. No. of blows: (03)(02)(01)	
4.0	DS	04	04	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, fine to medium grained silty SAND with few gravel. Gravel (14.1%), Sand (35.8%), Fines (49.3%), very loose to loose, very weak cementation, non plastic, moist. No. of blows: (02)(02)(02)	

Continue Next Page.

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

Sheet : 1 of 2

	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
Golden Middle East Oil Services Co. "Contractor"	Page: 66 of 155	Misratah City, LIBYA	Date: 06/03/2022
			Assari engineering consulting



Assari / Engineering Consultant

BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th> <th>Coordinates</th> </tr> <tr> <td>BH-02</td> <td>N : 32°20'54.38" E : 15°12'09.58"</td> </tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 07/03/2022 Date Completed : 07/03/2022	Borehole No.	Coordinates	BH-02	N : 32°20'54.38" E : 15°12'09.58"
Borehole No.	Coordinates				
BH-02	N : 32°20'54.38" E : 15°12'09.58"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS	05	N.A.	N.A.	N.A.		(SM) Brownish grey to whitish grey, Calcareous, fine to medium grained silty SAND with little gravel. Gravel (12.1%), Sand (48.0%), Fines (39.9%), loose, very weak cementation, non plastic, moist. No. of blows: (04)(05)(04)	
6.0	C		32	18	0.0		Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, fragments Calcarene limestone subangular.	
7.0								
8.0	DS	Over 50	N.A.	N.A.	N.A.		(SM) Brownish grey to whitish grey, Calcareous, fine to medium grained silty SAND with trace gravel. Gravel (2.4%), Sand (85.2%), Fines (12.4%). Very dense, highly cemented Sand by carbonates, non plastic, moist. No. of blows: (Over 50)	
9.0	C		22	04	0.0		Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, fragments Calcarene limestone subangular.	
10.0							End of borehole at 10.0m 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


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GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 67 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misrata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-03</td><td>N :32°20'53.66" E :15°12'10.48"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.60 Date Begun : 07/03/2022 Date Completed : 08/03/2022	Borehole No.	Coordinates	BH-03	N :32°20'53.66" E :15°12'10.48"
Borehole No.	Coordinates				
BH-03	N :32°20'53.66" E :15°12'10.48"				

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense. Estimated ground elevation.	
1.0	DS	08	08	N.A.	N.A.	N.A.	(SM) Brownish grey to whitish grey, Calcareous fine to medium grained silty SAND with trace gravel. Gravel (1.5%), Sand (52.8%), Fines (45.7%), loose, very weak cementation, non plastic, dry. No. of blows: (05)(04)(04)	
2.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, fine to medium grained Sandy SILT with trace gravel. Gravel (0.2%), Sand (37.3%), Fines (62.5%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (04)(02)(02)	
3.0	DS	03	03	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (29.7%), Fines (70.3%), soft, inorganic fines low plasticity, moist. No. of blows: (---)(01)(02)	
4.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Brownish grey to whitish grey, fine to medium grained Sandy SILT with trace gravel. Gravel (1.6%), Sand (36.6%), Fines (61.8%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (02)(02)(02)	

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 3

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 68 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misrata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-03</td><td>N :32°20'53.66" E :15°12'10.48"</td></tr> </table> Soil Classification System : U.S.C.S Weather Conduction : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.60 Date Begun : 07/03/2022 Date Completed : 08/03/2022	Borehole No.	Coordinates	BH-03	N :32°20'53.66" E :15°12'10.48"
Borehole No.	Coordinates				
BH-03	N :32°20'53.66" E :15°12'10.48"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		03	N.A.	N.A.	N.A.	(CL-ML) Grey to whitish grey, Silty Clay with Sand and few fine gravel. Gravel (5.2%), Sand (35.9%), Fines (58.9%), Gypsum mixed with clay, soft to medium stiff, inorganic clays of low plasticity, moist. No. of blows: (03)(02)(01)	
6.0	C		N.A.	38	10	0.0	Whitish grey to brownish grey Calcarene limestone, moderately to highly weathered, crushed rock, moderately strong to strong, very low RQD, medium fractured rock mass, the upper layer of calcarenite limestone were recovered as subangular to subrounded to subangular gravel-sized fragments.	
7.0	C		N.A.	27	09	0.0	Whitish grey to brownish grey Calcarene limestone, moderately to highly weathered, crushed rock, moderately strong to strong, very low RQD, medium fractured rock mass, fragments calcarenite limestone subangular.	
8.0								
9.0	C		N.A.	17	17	7.0	Whitish grey to brownish grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone at lower layer.	
10.0							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 : 2 of 3

	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
Golden Middle East Oil Services Co. "Contractor"	Page: 69 of 155	Misratah City, LIBYA	Date: 06/03/2022
			Assari engineering consulting

BOREHOLE LOG

Assari / Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	8H-03	N : 32°20'53.66" E : 15°12'10.48"
Project Location : Misratah (Misurata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company : Assari Engineering Consultant Co.	Weather Condition : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.60	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 07/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 08/03/2022	

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
10.0	C	N.A.	22	18	07		Whitish grey to brownish grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
11.0								
12.0	C	N.A.	37	27	22		Whitish grey to brownish grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
13.0								
14.0	C	N.A.	32	19	07		Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, fragments calcarenite limestone subangular calcareous siltstone.	
15.0							End of borehole at 14.5m depth.	

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

Sheet : 3 of 3

	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
Golden Middle East Oil Services Co. "Contractor"	Page: 70 of 155	Misratah City, LIBYA	Date: 06/03/2022
			Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1" style="width: 100%;"> <tr> <th>Borehole No.</th> <th>Coordinates</th> </tr> <tr> <td>BH-04</td> <td>N :32°20'54.35" E :15°12'11.70"</td> </tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 08/03/2022 Date Completed : 08/03/2022	Borehole No.	Coordinates	BH-04	N :32°20'54.35" E :15°12'11.70"
Borehole No.	Coordinates				
BH-04	N :32°20'54.35" E :15°12'11.70"				

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense. Estimated ground elevation.	
1.0	DS	07	07	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (3.5%), Sand (81.7%), Fines (14.8%), loose, very weak cementation, non plastic, moist. No. of blows: (03)(03)(04)	
2.0	DS	03	03	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine grained silty SAND with few gravel. Gravel (6.7%), Sand (75.5%), Fines (17.8%), very loose, very weak cementation, non plastic, moist. No. of blows: (03)(01)(02)	
3.0	DS	02	02	N.A.	N.A.	N.A.	(CL-ML) Grey to whitish grey, Silty Clay with Sand and trace fine gravel. Gravel (0.1%), Sand (14.1%), Fines (85.8%), Gypsum mixed with clay, very soft to soft, inorganic clays of low plasticity, moist. No. of blows: (01)(01)(01)	
4.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT with trace gravel. Gravel (0.1%), Sand (20.6%), Fines (79.3%), medium stiff, inorganic fines low plasticity, moist. No. of blows: (03)(02)(03)	
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

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 71 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting



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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abuabakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-04</td><td>N : 32°20'54.35" E : 15°12'11.70"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 08/03/2022 Date Completed : 08/03/2022	Borehole No.	Coordinates	BH-04	N : 32°20'54.35" E : 15°12'11.70"
Borehole No.	Coordinates				
BH-04	N : 32°20'54.35" E : 15°12'11.70"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
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5.0	DS		04	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND. Gravel (0.0%), Sand (67.3%), Fines (32.7%), loose, very weak cementation, non plastic, moist. No. of blows: (02)(03)(01)	
6.0	C		N.A.	33	12	0.0	Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone, fragments Calcarene limestone subangular.	
7.0	C		N.A.	31	09	0.0	Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, fragments calcarenite limestone subangular.	
8.0								
9.0	C		N.A.	14	13	0.0	Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone, fragments calcarenite limestone subangular.	
10.0							End of borehole at 10.0m depth.	

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

Sheet : 2 of 2

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GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 72 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>8H-05</td><td>N :32°20'53.74" E :15°12'11.45"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 08/03/2022 Date Completed : 09/03/2022	Borehole No.	Coordinates	8H-05	N :32°20'53.74" E :15°12'11.45"
Borehole No.	Coordinates				
8H-05	N :32°20'53.74" E :15°12'11.45"				

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense. Estimated ground elevation.	
1.0	DS	07	07	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with few gravel. Gravel (5.8%), Sand (77.3%), Fines (16.9%), loose, very weak cementation, non plastic, dry. No. of blows: (04)(04)(03)	
2.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (18.1%), Fines (81.9%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (06)(02)(02)	
3.0	DS	03	03	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (44.4%), Fines (55.6%), soft, inorganic fines low plasticity, moist. No. of blows: (01)(02)(01)	
4.0	DS	03	03	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (42.0%), Fines (85.0%), soft, inorganic fines low plasticity, moist. No. of blows: (01)(01)(02)	
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.

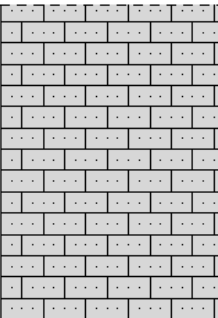
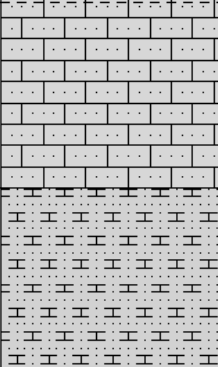
Sheet: 1 of 2

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 73 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	BH-05	N :32°20'53.74" E :15°12'11.45"
Project Location : Misratah (Misurata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company :Assari Engineering Consultant Co.	Weather Conduction : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.50	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 08/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 09/03/2022	

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	C	N.A.	13	08	0.0	0.0	Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
6.0							Whitish grey to light grey Calcarene limestone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
7.0							Whitish grey to light grey Calcarene limestone to yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak.	
8.0	C	N.A.	27	19	0.0	0.0		
9.0	C	N.A.	23	19	07	07		
10.0							End of borehole at 10.0m 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

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GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
Golden Middle East Oil Services Co. "Contractor"	Page: 74 of 155	Misratah City, LIBYA	Date: 06/03/2022
			Assari engineering consulting

BOREHOLE LOG

Assari / Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.AbuBakr Anakoa	<table border="1" style="width: 100%;"> <tr> <th>Borehole No.</th> <th>Coordinates</th> </tr> <tr> <td>8H-06</td> <td>N : 32°20'53.77" E : 15°12'12.31"</td> </tr> </table> Soil Classification System : U.S.C.S Weather Condtion : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.60 Date Begun : 08/03/2022 Date Completed : 09/03/2022	Borehole No.	Coordinates	8H-06	N : 32°20'53.77" E : 15°12'12.31"
Borehole No.	Coordinates				
8H-06	N : 32°20'53.77" E : 15°12'12.31"				

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense. Estimated ground elevation.	
1.0	DS	07	N.A.	N.A.	N.A.		(SM) Brownish grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (3.0%), Sand (82.0%), Fines (15.0%), loose, very weak cementation, non plastic, dry. No. of blows: (03)(04)(03)	
2.0	DS	05	N.A.	N.A.	N.A.		(SM) Brownish grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (8.1%), Sand (71.9%), Fines (20.0%), loose, very weak cementation, non plastic, moist. No. of blows: (05)(02)(03)	
3.0	DS	04	N.A.	N.A.	N.A.		(ML) Light grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (37.8%), Fines (62.2%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (02)(02)(02)	
4.0	DS	02	N.A.	N.A.	N.A.		(ML) Light grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (39.7%), Fines (60.3%), very soft to soft, inorganic fines low plasticity, moist. No. of blows: (02)(01)(01)	
5.0	DS	02	N.A.	N.A.	N.A.		(SM) Light grey to whitish grey, Calcareous, fine grained silty SAND with trace gravel. Gravel (0.9%), Sand (51.4%), Fines (47.7%), very loose, very weak cementation, non plastic, moist. No. of blows: (01)(01)(01)	

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 3


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GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
Golden Middle East Oil Services Co. "Contractor"	Page: 75 of 155	Misratah City, LIBYA	Date: 06/03/2022
			Assari engineering consulting



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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	BH-06	N : 32°20'53.77" E : 15°12'12.31"
Project Location : Misratah (Misurata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company : Assari Engineering Consultant Co.	Weather Condition : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.60	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 08/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 09/03/2022	

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
6.0	C	N.A.	20	07	0.0	0.0	Whitish grey to light grey Calcarene limestone with cross bedding of calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone (upper layer), fragments Calcarene limestone subangular.	
7.0								
8.0	C	N.A.	27	07	0.0	0.0	Whitish grey to light grey Calcarene limestone with cross bedding of calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone, fragments Calcarene limestone subangular.	
9.0								
10.0	C	N.A.	20	20	0.0	0.0	Whitish grey to light grey Calcarene limestone with cross bedding of calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone, fragments Calcarene limestone subangular.	
11.0	C	N.A.	31	29	20.0	20.0	Whitish grey to light grey Calcarene limestone to yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak.	
12.0							Continue Next Page.	

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

Sheet : 2 of 3

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	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 76 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting



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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abuabkr Anakoa	<table> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-06</td><td>N : 32°20'53.77" E : 15°12'12.31"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.60 Date Begun : 08/03/2022 Date Completed : 09/03/2022	Borehole No.	Coordinates	BH-06	N : 32°20'53.77" E : 15°12'12.31"
Borehole No.	Coordinates				
BH-06	N : 32°20'53.77" E : 15°12'12.31"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
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12.0							Whitish grey to light grey Calcarene limestone with cross bedding of calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone, fragments Calcarene limestone subangular.	
13.0	C		N.A.	22	20	11		
14.0	C		N.A.	24	24	23	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass. the lower layer were recovered as medium to coarse angular to sub angular gravel and cobble sized rock fragments.	
15.0								
16.0	C		N.A.	34	22	0.0	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass.	
17.0	C		N.A.	23	23	0.0	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, fragments fossiliferous limestone subangular.	
18.0								
19.0	C		N.A.	30	21	0.0	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, fragments fossiliferous limestone subangular.	
20.0							End of borehole at 19.5m 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 : 3 of 3



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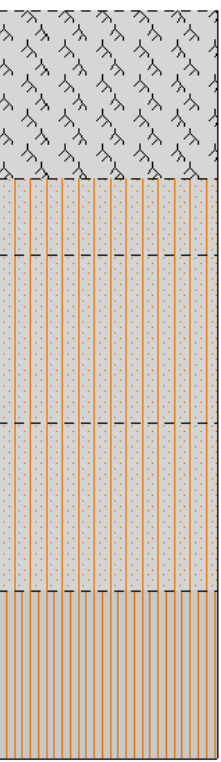
GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 77 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari / Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	8H-07	N : 32°20'53.38" E : 15°12'13.00"
Project Location : Misratah (Misurata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company : Assari Engineering Consultant Co.	Weather Condition : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.50	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 09/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 10/03/2022	

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense.	
1.0	DS	07	07	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (4.1%), Sand (80.0%), Fines (15.9%), loose, very weak cementation, non plastic, dry. No. of blows: (02)(05)(02)	
2.0	DS	05	05	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (0.1%), Sand (86.8%), Fines (13.1%), loose, very weak cementation, non plastic, moist. No. of blows: (04)(03)(02)	
3.0	DS	02	02	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (0.1%), Sand (66.7%), Fines (33.2%), very loose, very weak cementation, non plastic, moist. No. of blows: (02)(01)(01)	
4.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT with trace gravel. Gravel (0.1%), Sand (27.2%), Fines (72.7%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (02)(03)(01)	
Continue Next Page.								

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

Sheet : 1 of 3

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 78 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misrata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-07</td><td>N :32°20'53.38" E :15°12'13.00"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 09/03/2022 Date Completed : 10/03/2022	Borehole No.	Coordinates	BH-07	N :32°20'53.38" E :15°12'13.00"
Borehole No.	Coordinates				
BH-07	N :32°20'53.38" E :15°12'13.00"				

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 to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense.	
1.0	DS	07	07	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (4.1%), Sand (80.0%), Fines (15.9%), loose, very weak cementation, non plastic, dry. No. of blows: (02)(05)(02)	
2.0	DS	05	05	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (0.1%), Sand (86.8%), Fines (13.1%), loose, very weak cementation, non plastic, moist. No. of blows: (04)(03)(02)	
3.0	DS	02	02	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (0.1%), Sand (66.7%), Fines (33.2%), very loose, very weak cementation, non plastic, moist. No. of blows: (02)(01)(01)	
4.0	DS	04	04	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT with trace gravel. Gravel (0.1%), Sand (27.2%), Fines (72.7%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (02)(03)(01)	
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 3

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-07</td><td>N : 32°20'53.38" E : 15°12'13.00"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condtion : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 09/03/2022 Date Completed : 10/03/2022	Borehole No.	Coordinates	BH-07	N : 32°20'53.38" E : 15°12'13.00"
Borehole No.	Coordinates				
BH-07	N : 32°20'53.38" E : 15°12'13.00"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
12.0							Whitish grey to light grey Calcarene limestone to yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak.	
13.0			N.A.	22	20	11		
14.0			N.A.	24	24	23	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass.	
15.0								
16.0			N.A.	34	22	0.0	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass.	
17.0			N.A.	23	23	0.0	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass.	
18.0								
19.0			N.A.	30	21	0.0	Whitish grey to light grey fossiliferous limestone and weak calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass.	
20.0							End of borehole at 19.5m 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 : 3 of 3


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GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 80 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting



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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-08</td><td>N : 32°20'54.31" E : 15°12'13.57"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condtion : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.50 Date Begun : 10/03/2022 Date Completed : 10/03/2022	Borehole No.	Coordinates	BH-08	N : 32°20'54.31" E : 15°12'13.57"
Borehole No.	Coordinates				
BH-08	N : 32°20'54.31" E : 15°12'13.57"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
0.0	DS	--	N.A.	N.A.	N.A.	N.A.	Light brown to brownish white silty medium grained Sand with some gravel (top soil), non plastic fines, moist, medium dense.	
1.0	DS	08	N.A.	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine to medium grained silty SAND with trace gravel. Gravel (1.4%), Sand (80.7%), Fines (14.9%), loose, very weak cementation, non plastic, dry. No. of blows: (04)(04)(04)	
2.0	DS	06	N.A.	N.A.	N.A.	N.A.	(SP) Light grey to whitish grey, poorly graded, fine grained SAND with Silt and trace gravel (Dune Sand). Gravel (0.4%), Sand (90.8%), Fines (8.8%), loose, very weak cementation, non plastic, dry. No. of blows: (02)(03)(03)	
3.0	DS	02	N.A.	N.A.	N.A.	N.A.	(SM) Light grey to whitish grey, fine grained silty SAND. Gravel (0.0%), Sand (76.8%), Fines (23.1%), very loose, very weak cementation, non plastic, moist. No. of blows: (02)(01)(01)	
4.0	DS	04	N.A.	N.A.	N.A.	N.A.	(ML) Light grey to whitish grey, fine to medium grained Sandy SILT. Gravel (0.0%), Sand (42.1%), Fines (57.9%), soft to medium stiff, inorganic fines low plasticity, moist. No. of blows: (02)(03)(01)	
Continue Next Page.								

DS: Disturbed Sample. TCR: Total Core Recovery. SCR: Solid Core Recovery.
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GEOTECHNICAL INVESTIGATIONS FINAL REPORT

	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 81 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

BOREHOLE LOG

Assari /Engineering Consultant
Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misrata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.Abubakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-08</td><td>N :32°20'54.31" E :15°12'13.57"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.6 Date Begun : 10/03/2022 Date Completed : 10/03/2022	Borehole No.	Coordinates	BH-08	N :32°20'54.31" E :15°12'13.57"
Borehole No.	Coordinates				
BH-08	N :32°20'54.31" E :15°12'13.57"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
5.0	DS		03	N.A.	N.A.	N.A.	(CL-ML) Grey to whitish grey, Silty Clay with Sand and trace fine gravel. Gravel (0.5%), Sand (29.4%), Fines (70.1%), Gypsum mixed with clay, soft, inorganic clays of low plasticity, moist. No. of blows: (01)(01)(02)	
6.0	C		N.A.	32	30	17	Whitish grey to light grey Calcarene limestone with cross bedding of yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
7.0								
8.0	C		N.A.	33	32	17	Whitish grey to light grey Calcarene limestone with cross bedding of yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
9.0								
10.0	C		N.A.	24	24	18	Whitish grey to light grey Calcarene limestone to yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak.	
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 : 2 of 4

	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168 Project Name : The construction of oil refining factory Project Location : Misratah (Misurata free zone) area Drilling Company : Assari Engineering Consultant Co. Cleint : Golden Middle East Oil Services Co. Rig Type : YWE-D90R Drilling Method : Continuous-flight augers with a rotary drill Site Supervisor : Eng.AbuBakr Anakoa	<table border="1"> <tr> <th>Borehole No.</th><th>Coordinates</th></tr> <tr> <td>BH-08</td><td>N : 32°20'54.31" E : 15°12'13.57"</td></tr> </table> Soil Classification System : U.S.C.S Weather Condaton : Partly cloudy and cool Ground Surface Elevation, m : --- Ground Water Table, m : 1.6 Date Begun : 10/03/2022 Date Completed : 10/03/2022	Borehole No.	Coordinates	BH-08	N : 32°20'54.31" E : 15°12'13.57"
Borehole No.	Coordinates				
BH-08	N : 32°20'54.31" E : 15°12'13.57"				

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
11.0	C		N.A.	30	27	15	Whitish grey to light grey calcareous siltstone, moderately to highly weathered, crushed rock, low strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak.	
12.0	C		N.A.	24	30	15	Whitish grey to light grey Calcareous limestone to yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak.	
13.0	C		N.A.	38	30	30	Whitish grey to light grey fossiliferous limestone with interbedded of yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
14.0	C		N.A.	40	32	19	Whitish grey to light grey fossiliferous limestone with cross bedding of yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, medium strength, very low RQD, medium fractured rock mass, pockets of very weak to weak calcareous siltstone.	
15.0								
16.0								
17.0							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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	Project: The construction of oil refining factory, Misratah.		
	N° Job: 226	N° Revision: 0.0	
Golden Middle East Oil Services Co. "Contractor"	Page: 83 of 155	Misratah City, LIBYA	Date: 06/03/2022
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BOREHOLE LOG



Golden Middle East Oil Services Company

Project Number : 20168	Borehole No.	Coordinates
Project Name : The construction of oil refining factory	BH-08	N :32°20'54.31" E :15°12'13.57"
Project Location : Misratah (Misrata free zone) area	Soil Classification System : U.S.C.S	
Drilling Company :Assari Engineering Consultant Co.	Weather Conduction : Partly cloudy and cool	
Cleint : Golden Middle East Oil Services Co.	Ground Surface Elevation, m : ---	
Rig Type : YWE-D90R	Ground Water Table, m : 1.6	
Drilling Method : Continuous-flight augers with a rotary drill	Date Begun : 10/03/2022	
Site Supervisor : Eng.Abubakr Anakoa	Date Completed : 10/03/2022	

Depth, m	Sample Type	GWT, m	SPT N-Value	TCR %	SCR %	RQD %	Description	Lithology
17.0							Whitish grey to light grey Calcarenite limestone and yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak (Gargaresh Formation).	
18.0	C	N.A.	32	32	21			
19.0							Whitish grey to light grey Calcarenite limestone and yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak (Gargaresh Formation).	
20.0	C	N.A.	46	46	38			
21.0							Whitish grey to light grey Calcarenite limestone and yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak (Gargaresh Formation).	
22.0	C	N.A.	23	23	13			
23.0							Whitish grey to light grey Calcarenite limestone and yellowish grey calcareous siltstone, moderately to highly weathered, crushed rock, low to medium strength, very low RQD, medium fractured rock mass, recovered of calcareous siltstone were very weak to weak (Gargaresh Formation).	
24.0	C	N.A.	22	22	13			
End of borehole at 24.0m depth.								

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

Sheet : 4 of 4

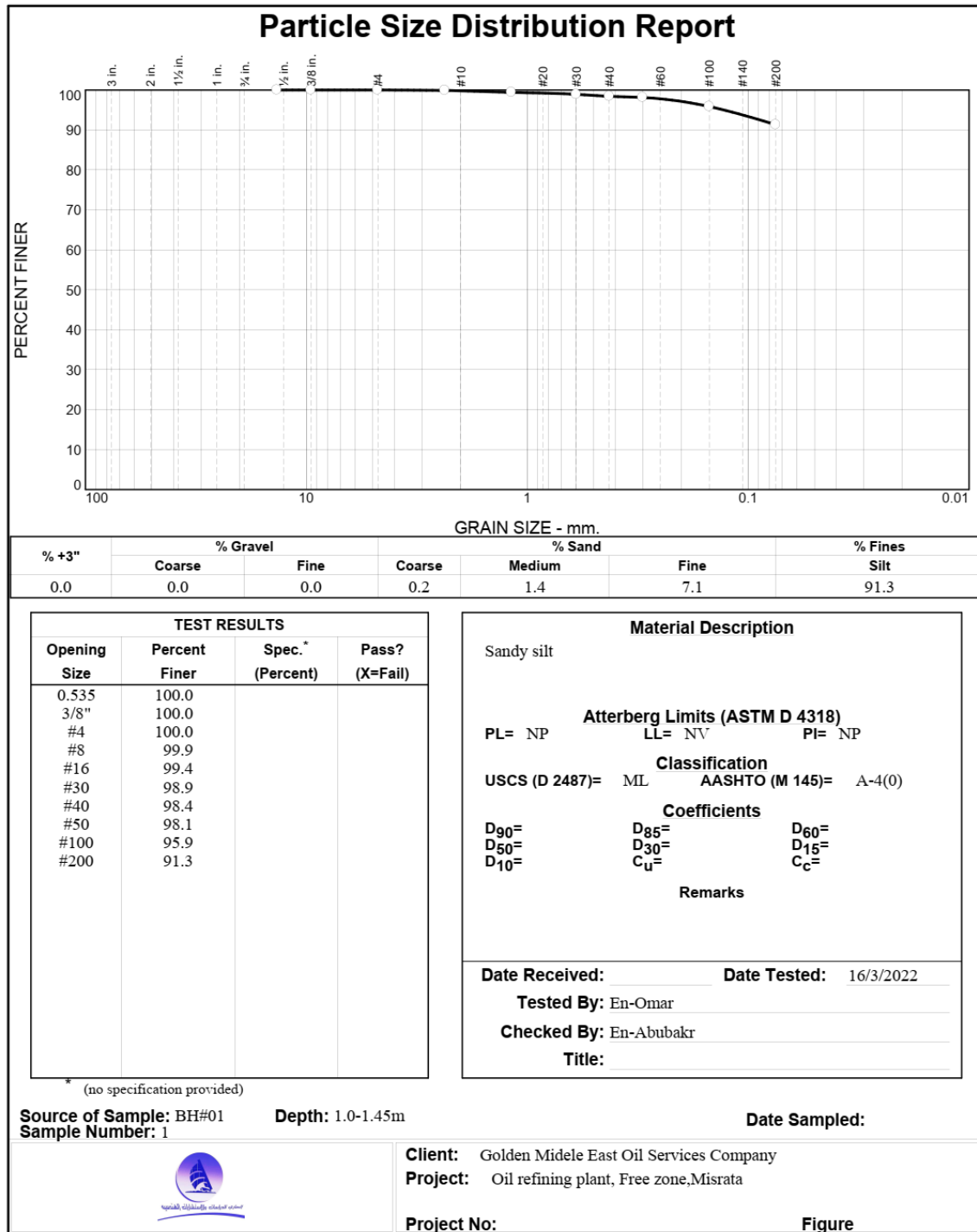
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E-mail: Assari.gec@yahoo.com

Address: Janzour – 12 km- Tripoli- Libya
Prepared By: Assari Engineering Consultant
GEOTECHNICAL INVESTIGATIONS FINAL REPORT

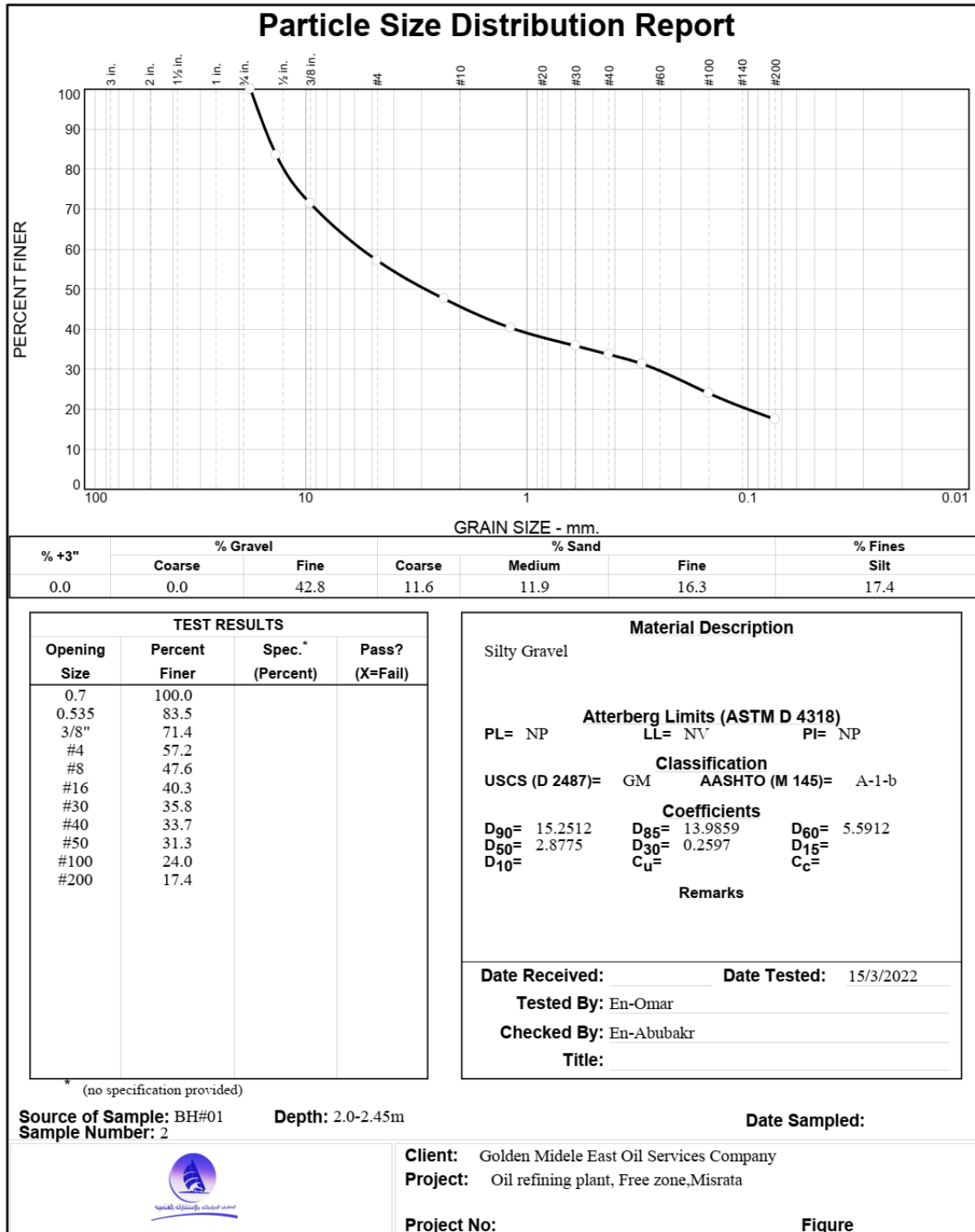
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	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 84 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting

APPENDIX 'B'
Sieve Analysis
(Lab. Test Results)
ASTM D 422

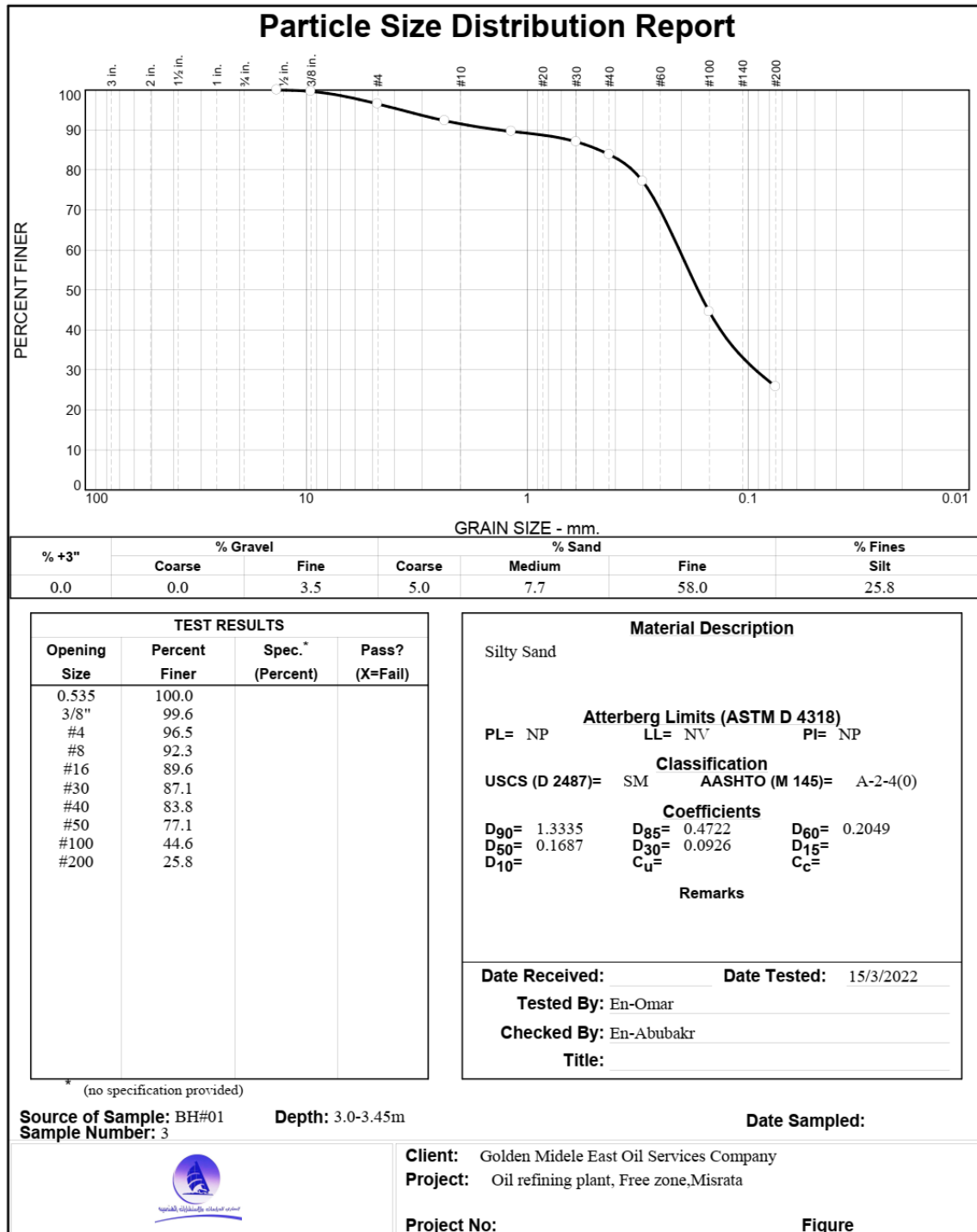
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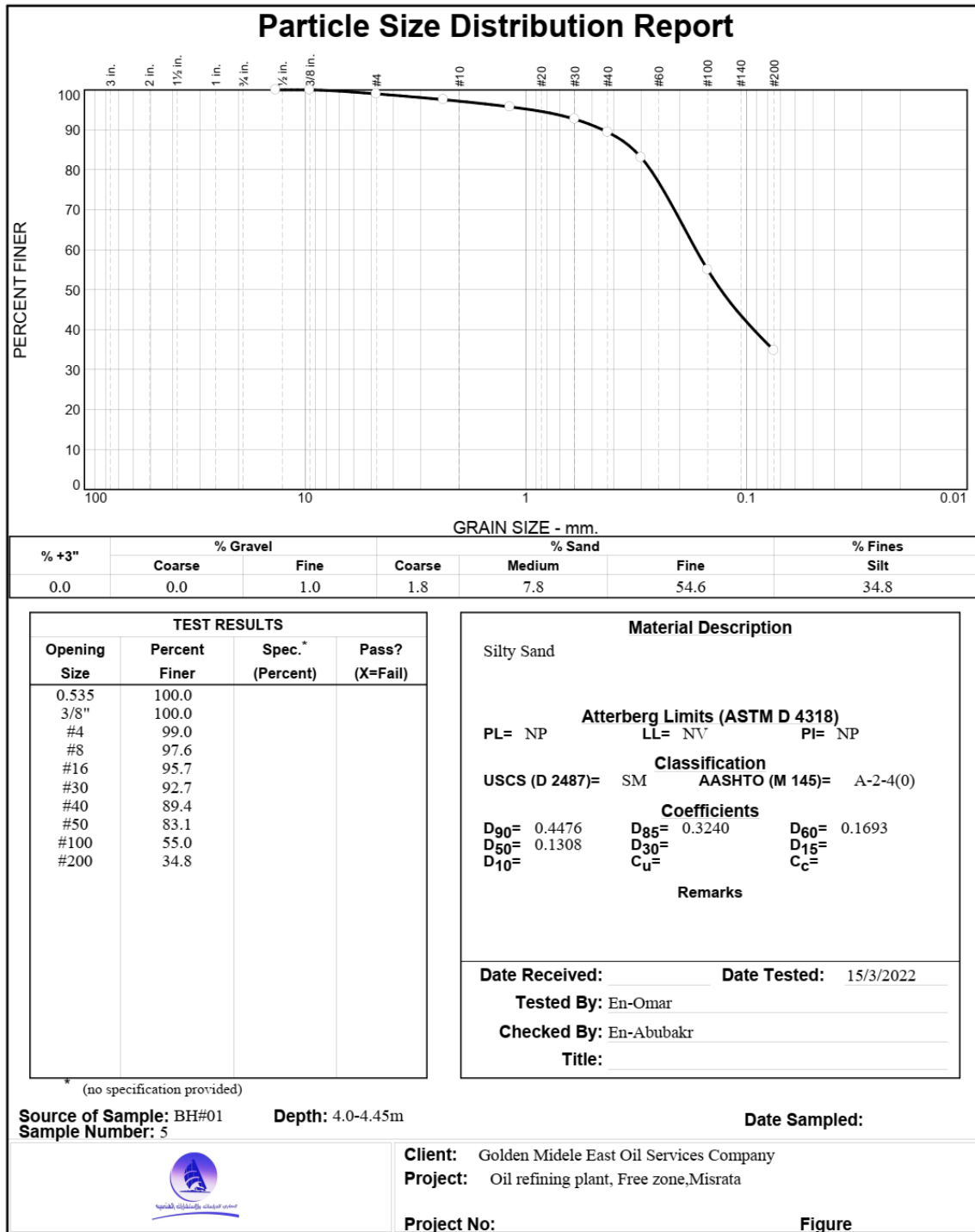
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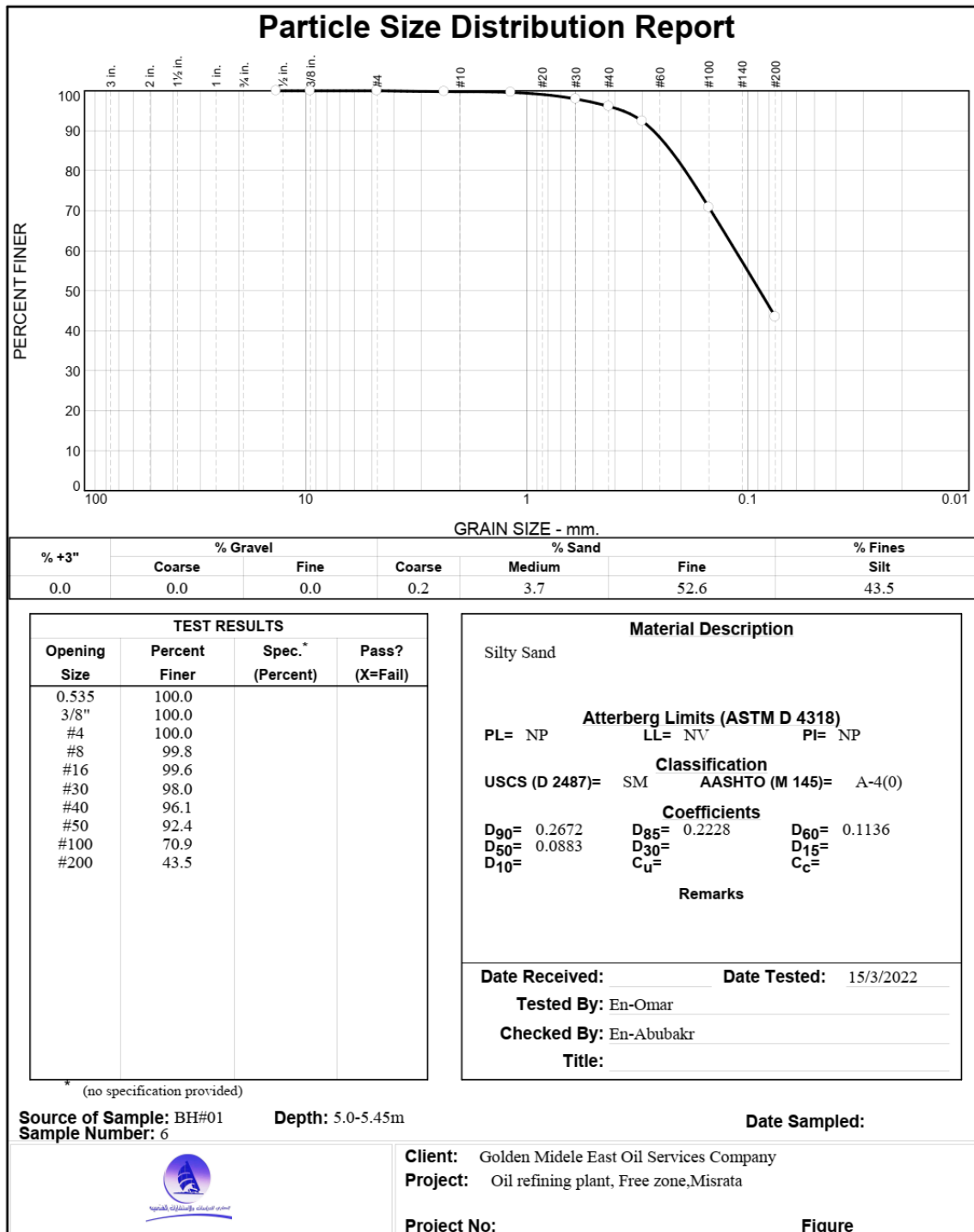
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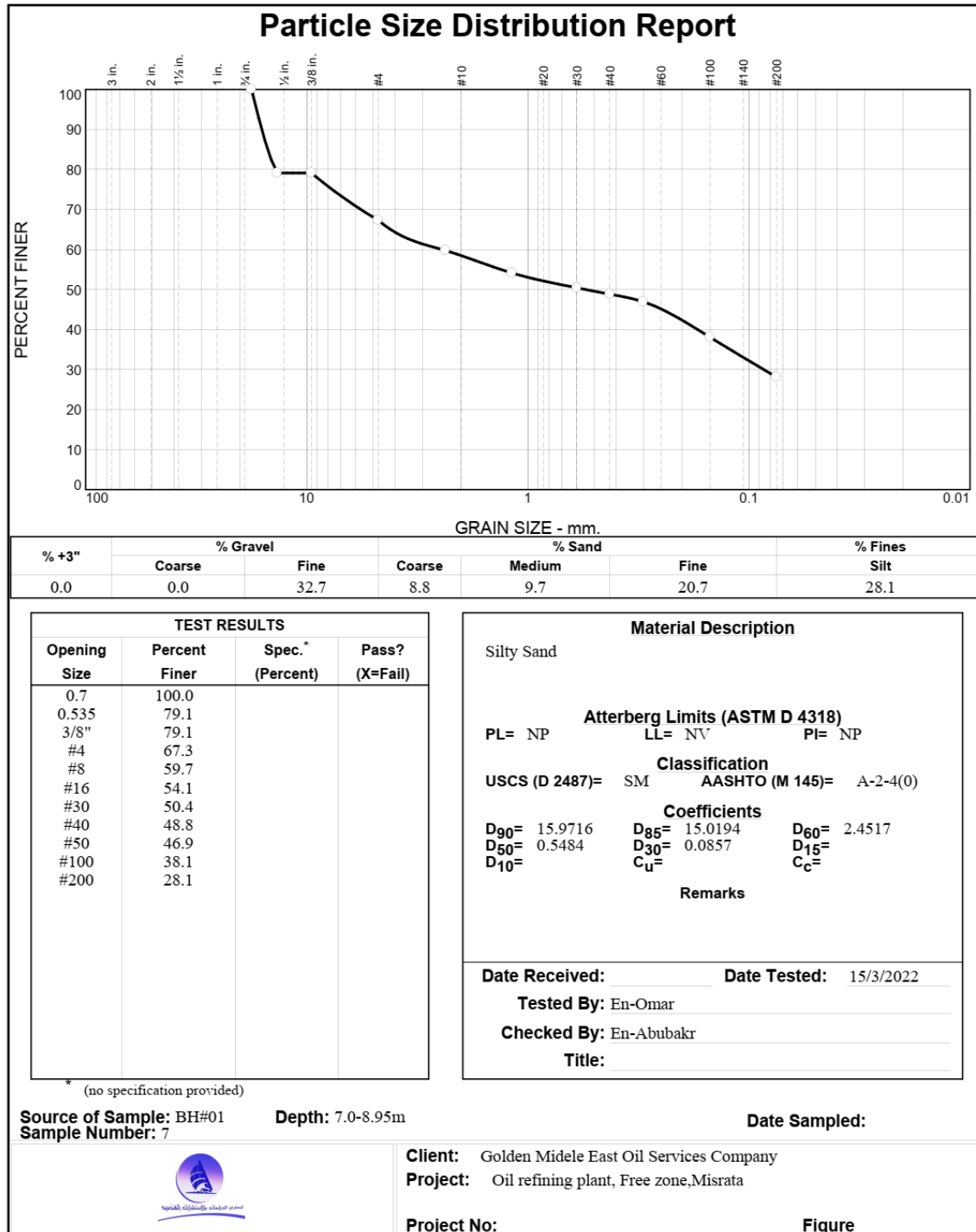
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Golden Middle East Oil Services Co. "Contractor"	Page: 88 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting



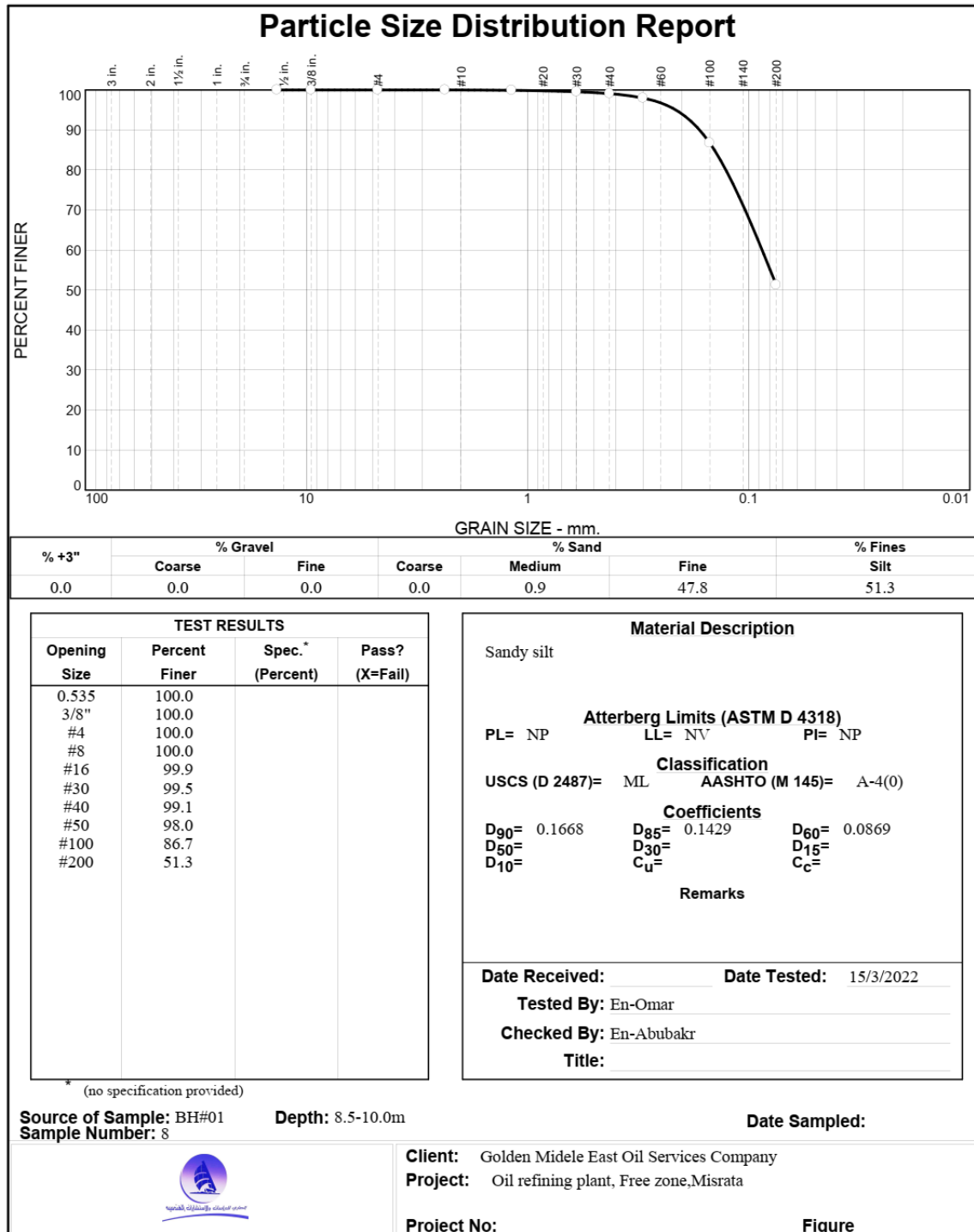
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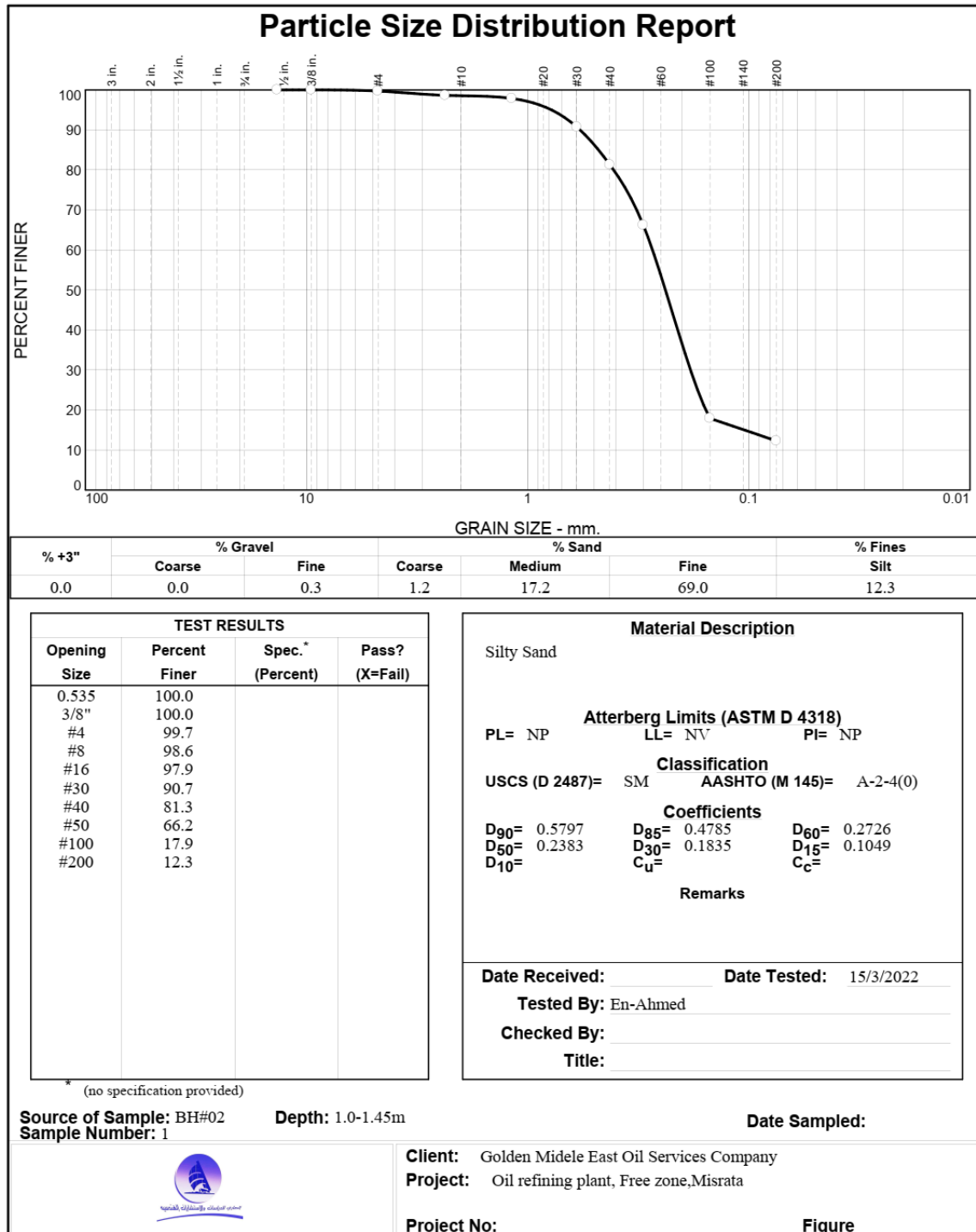
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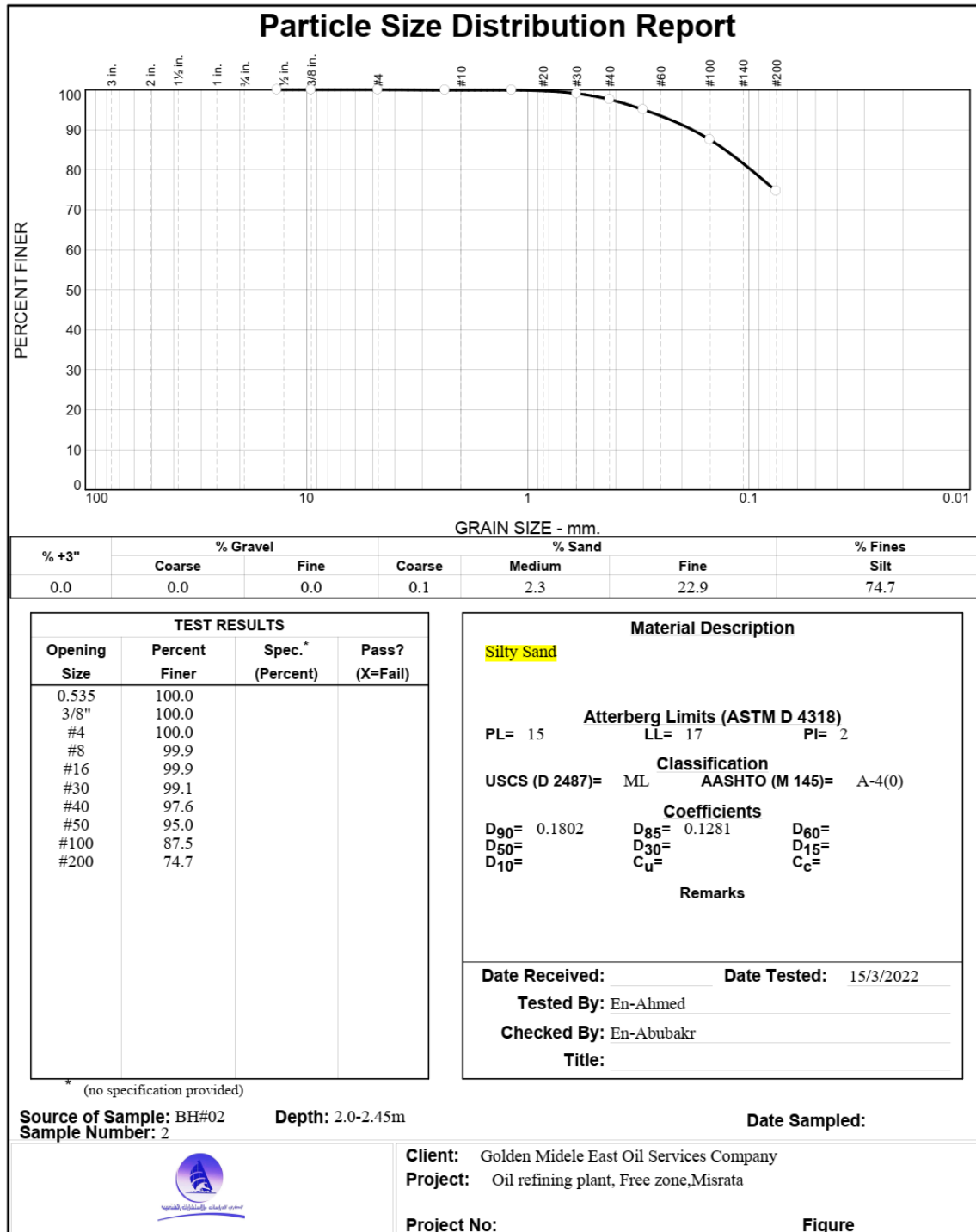
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Golden Middle East Oil Services Co. "Contractor"	Page: 91 of 155	Misratah City, LIBYA	Date: 06/03/2022 Assari engineering consulting



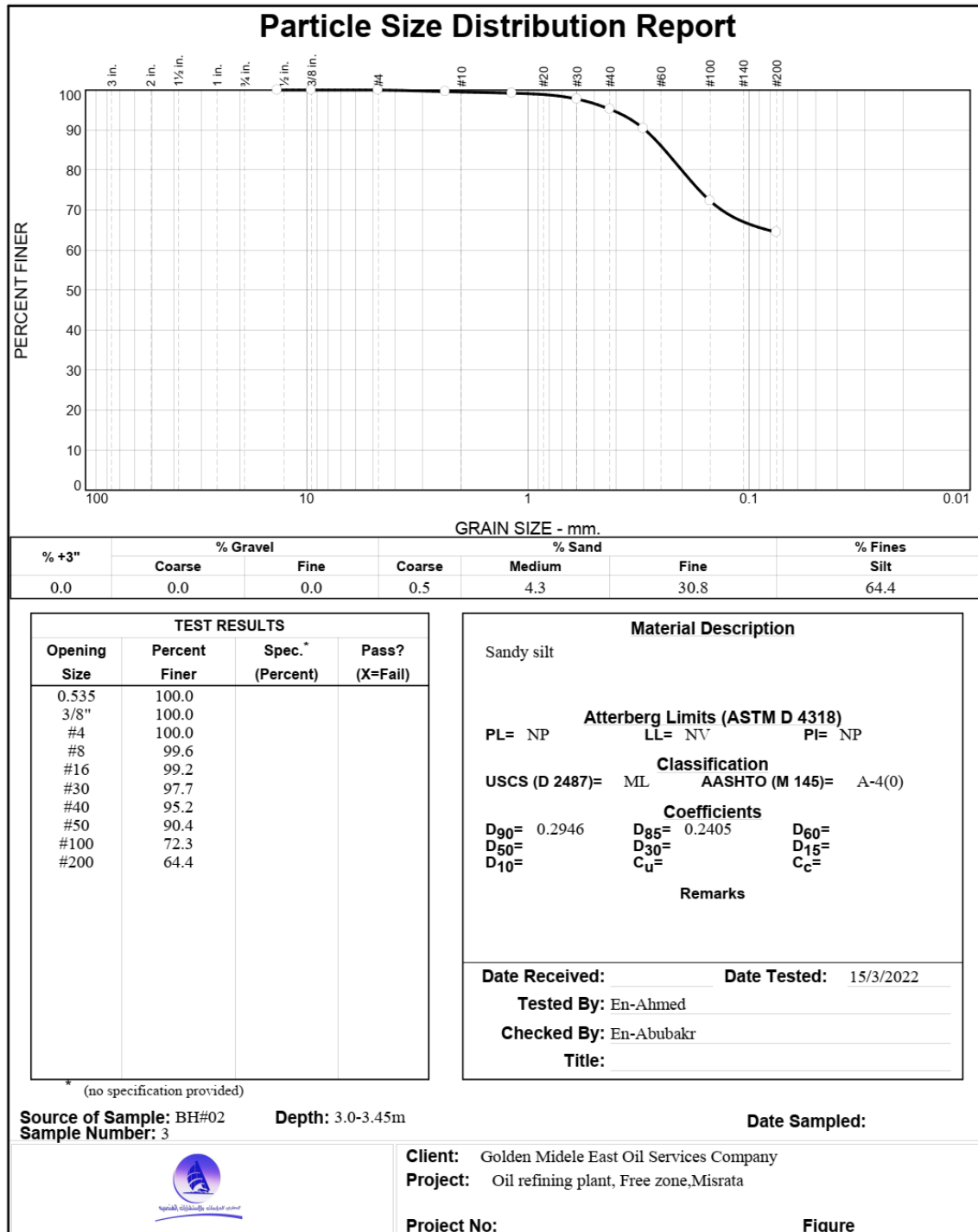
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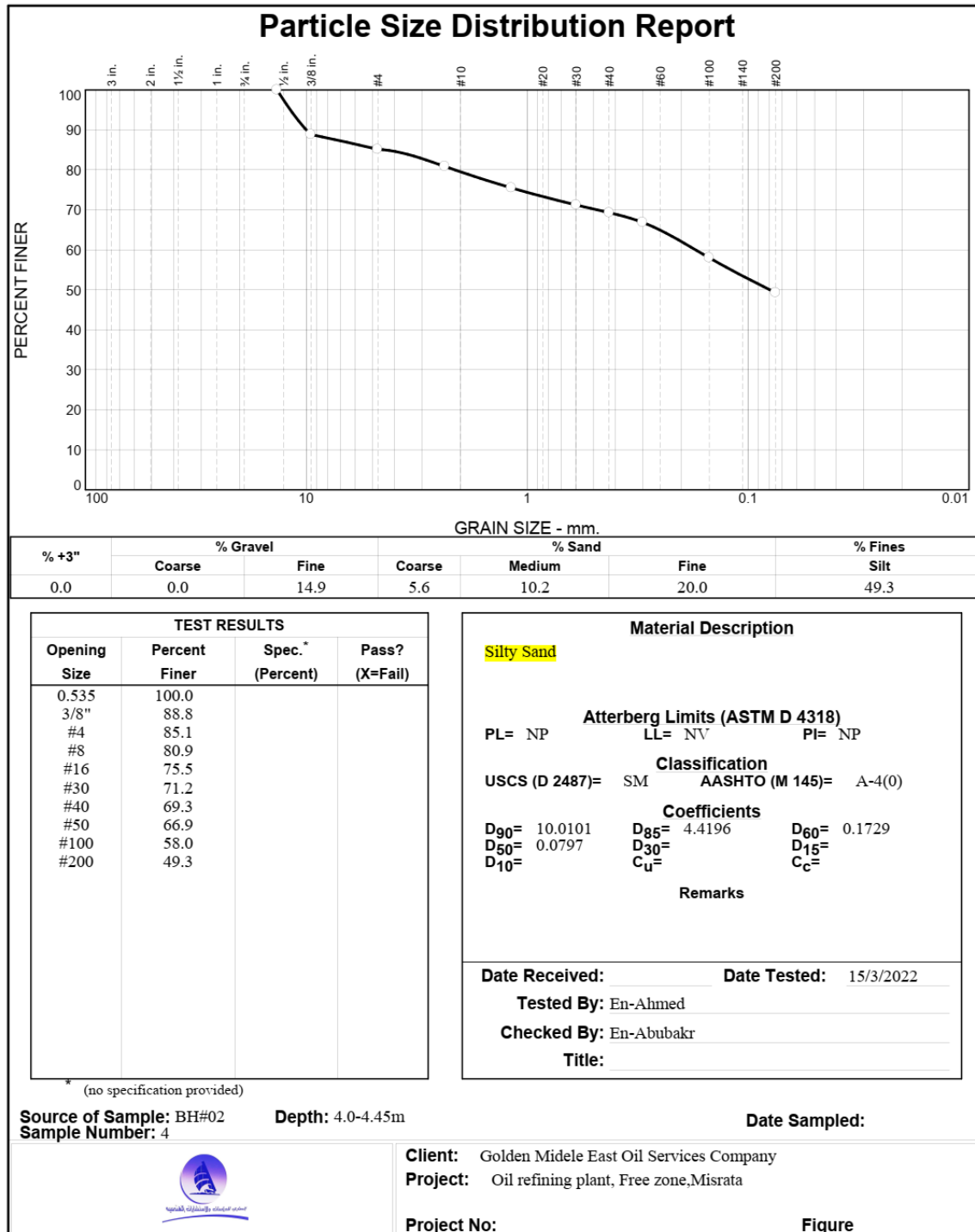
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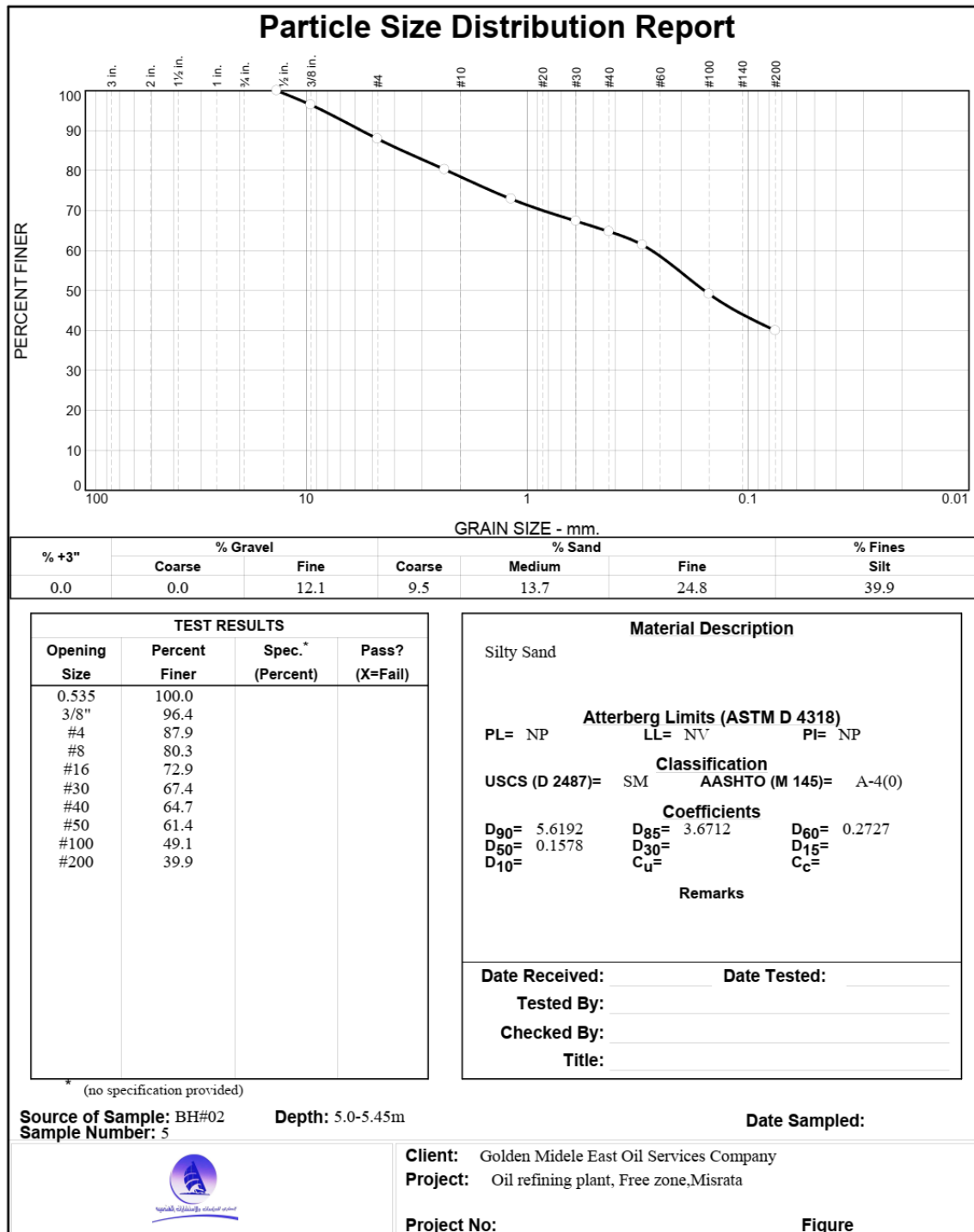
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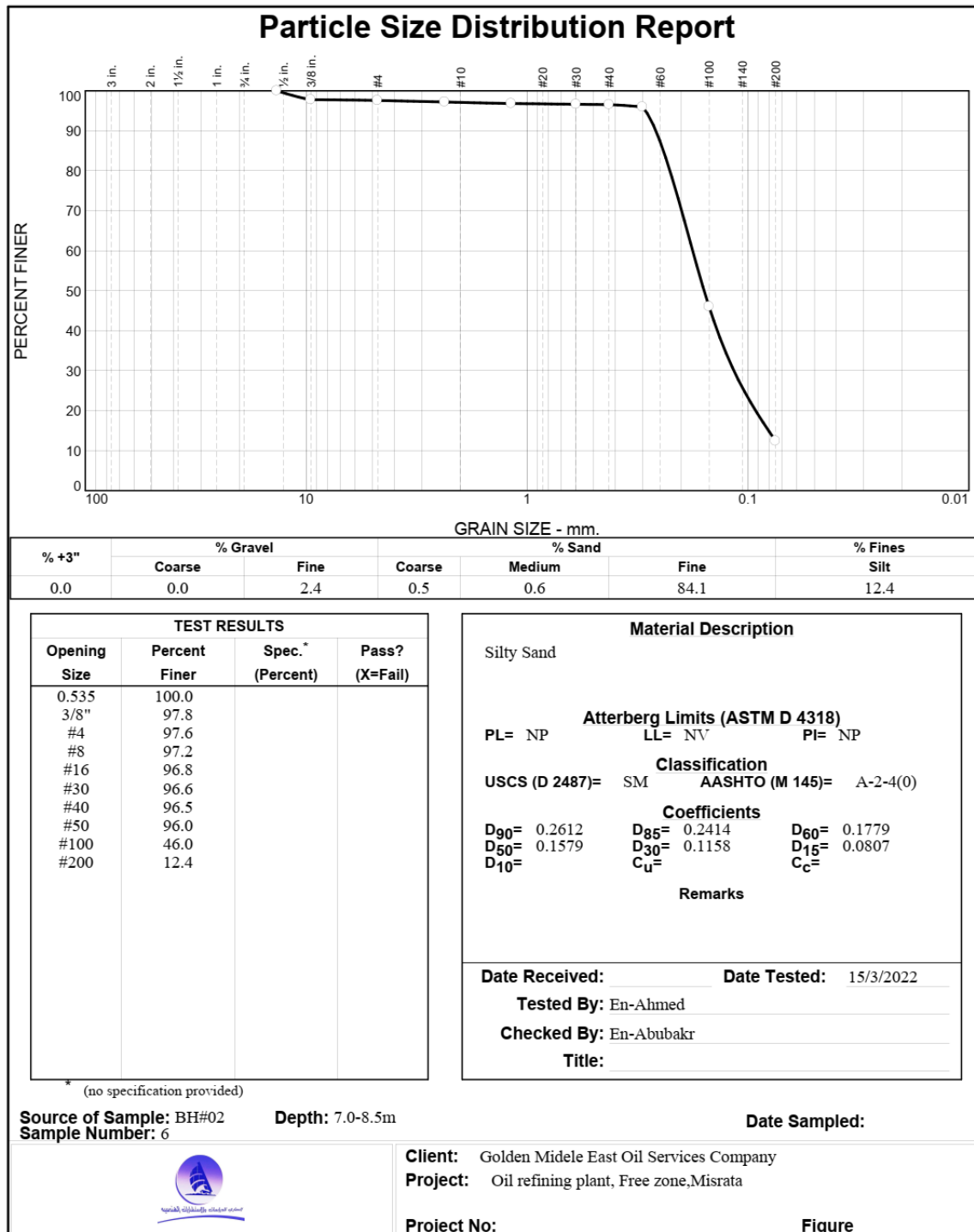
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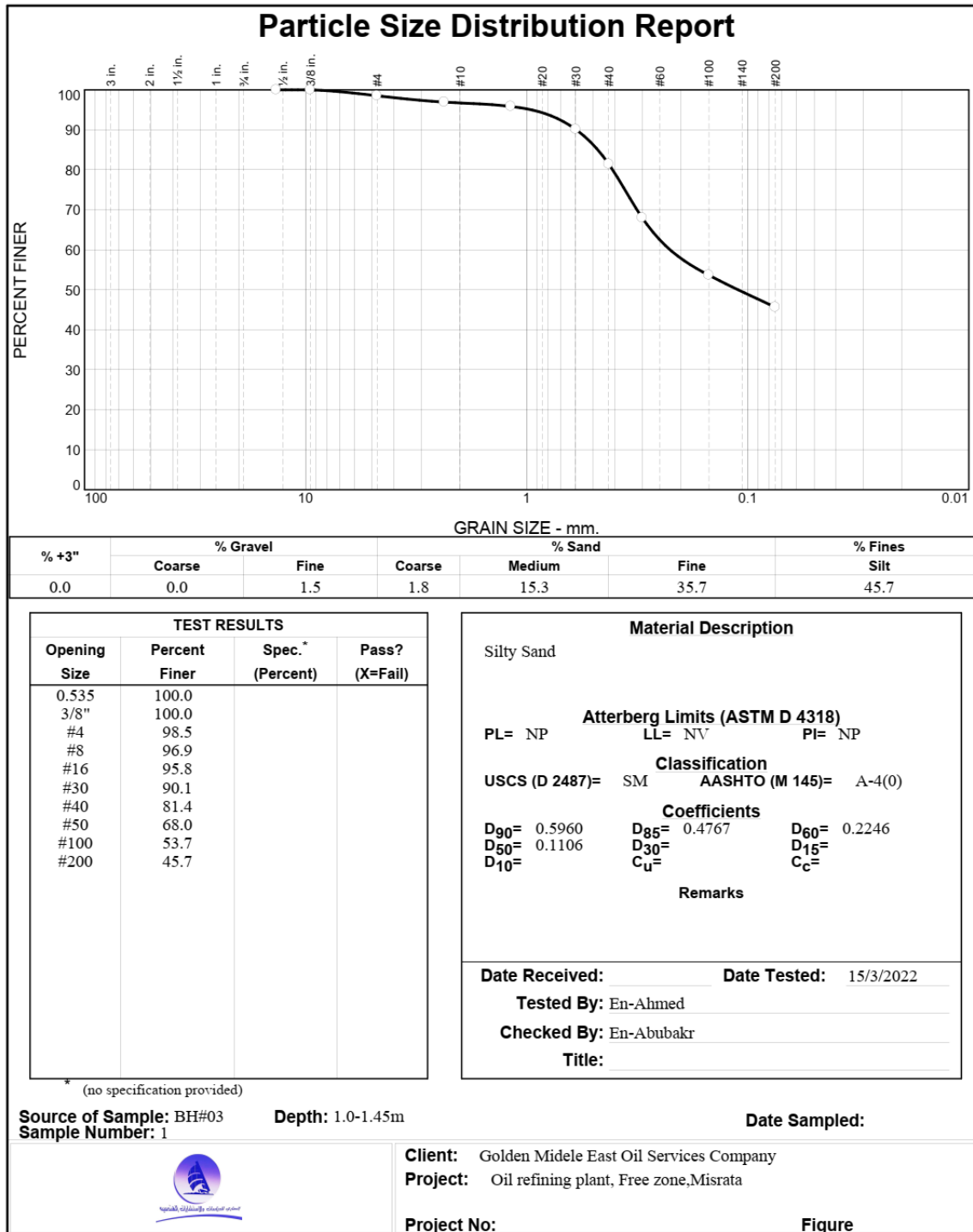
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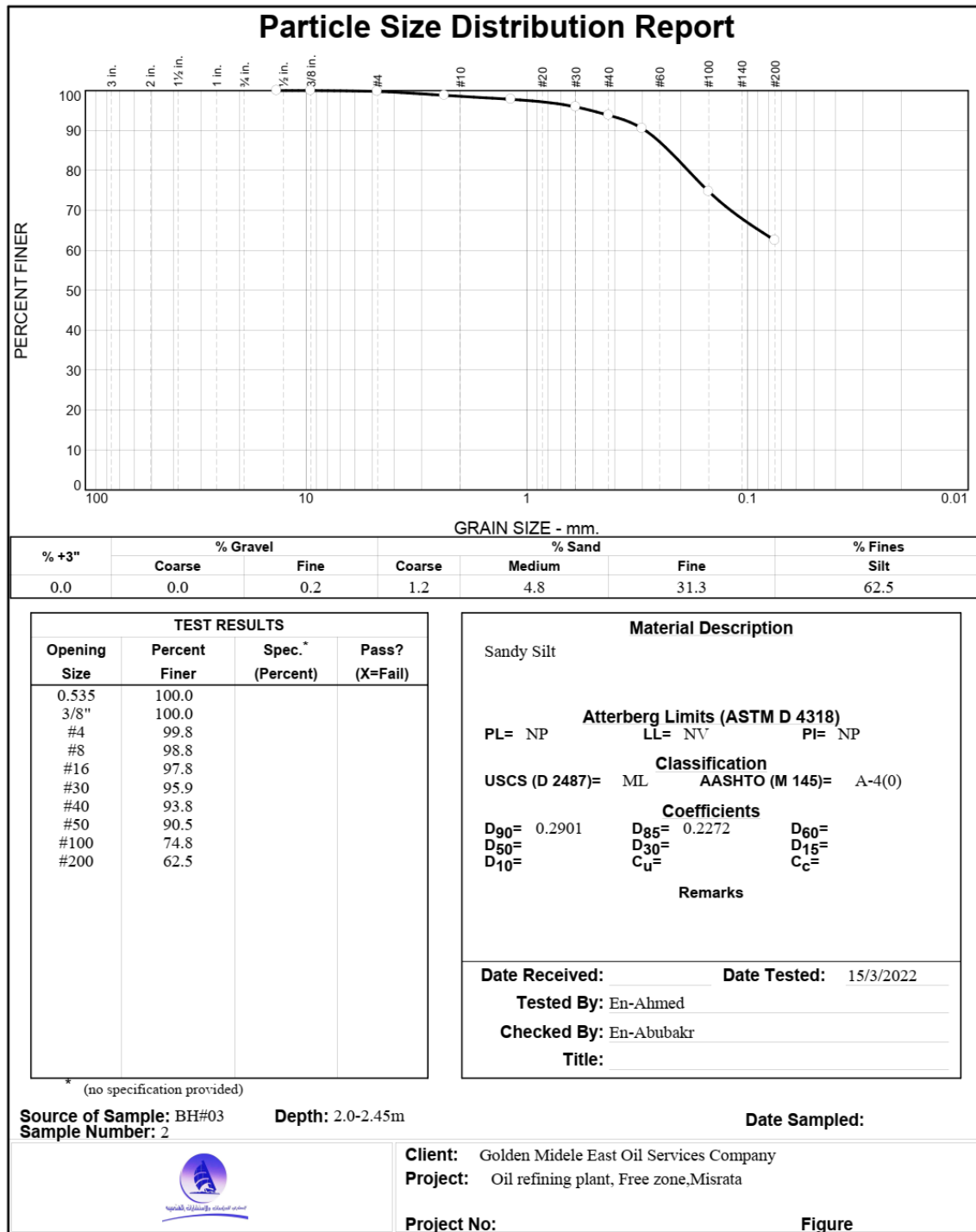
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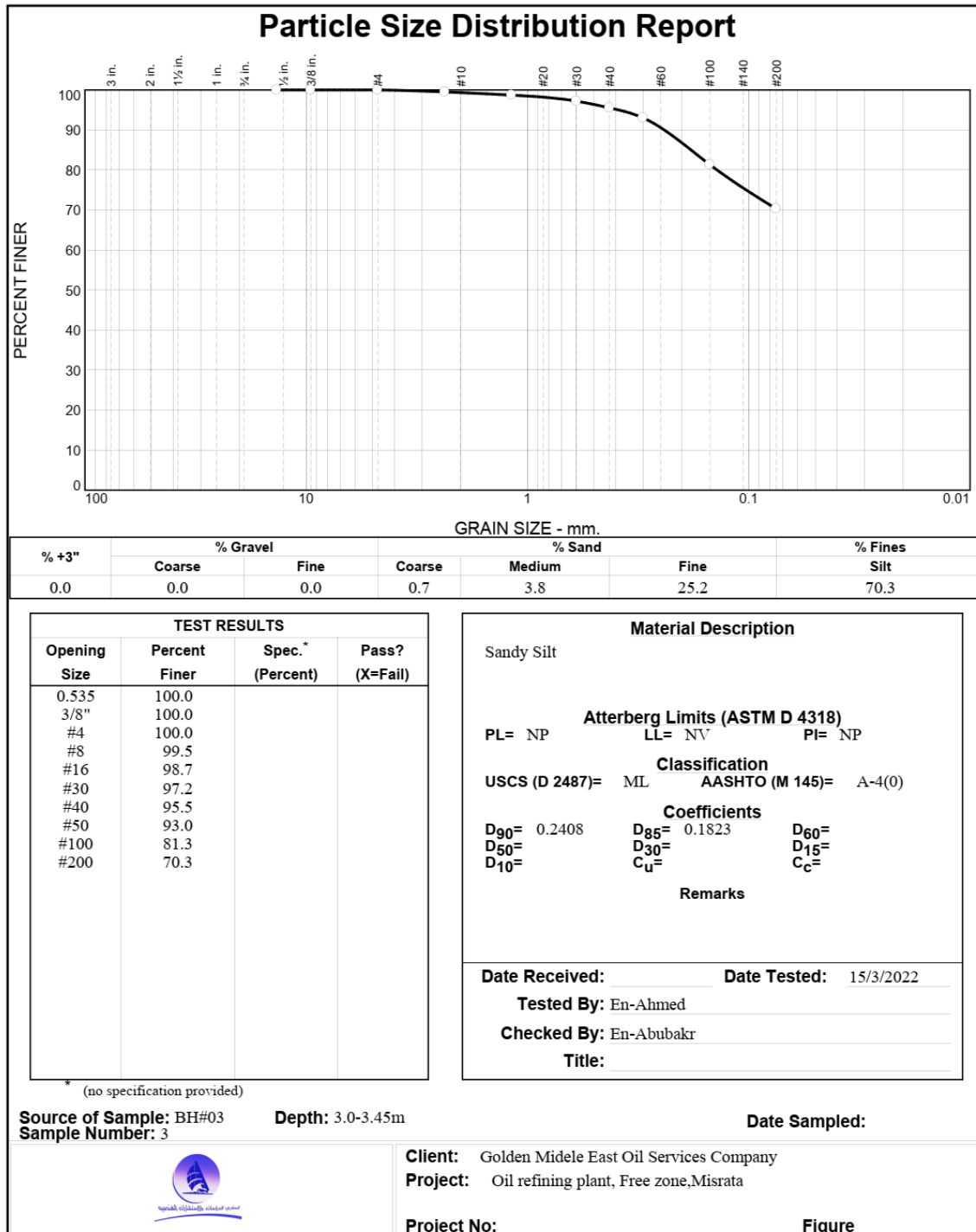
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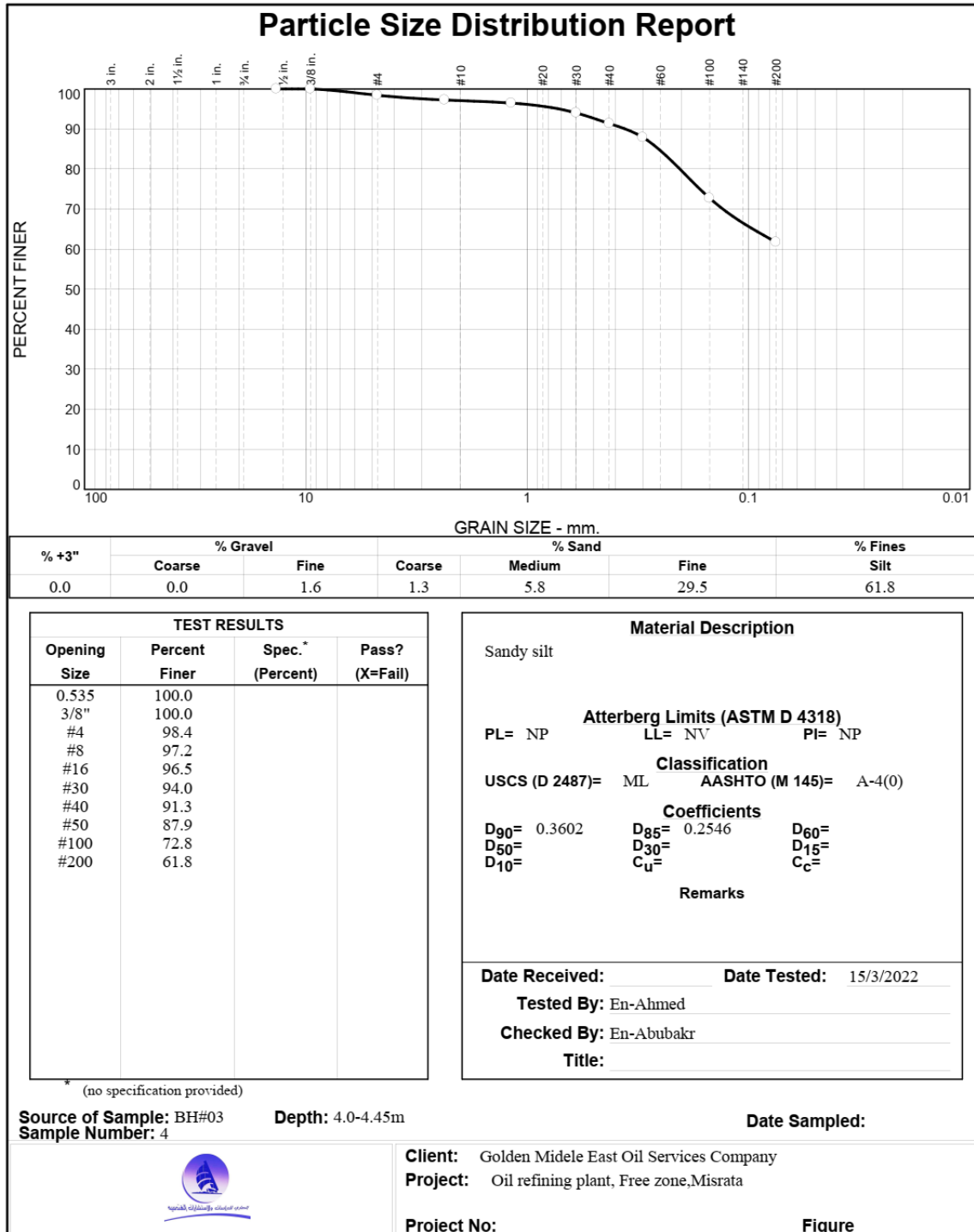
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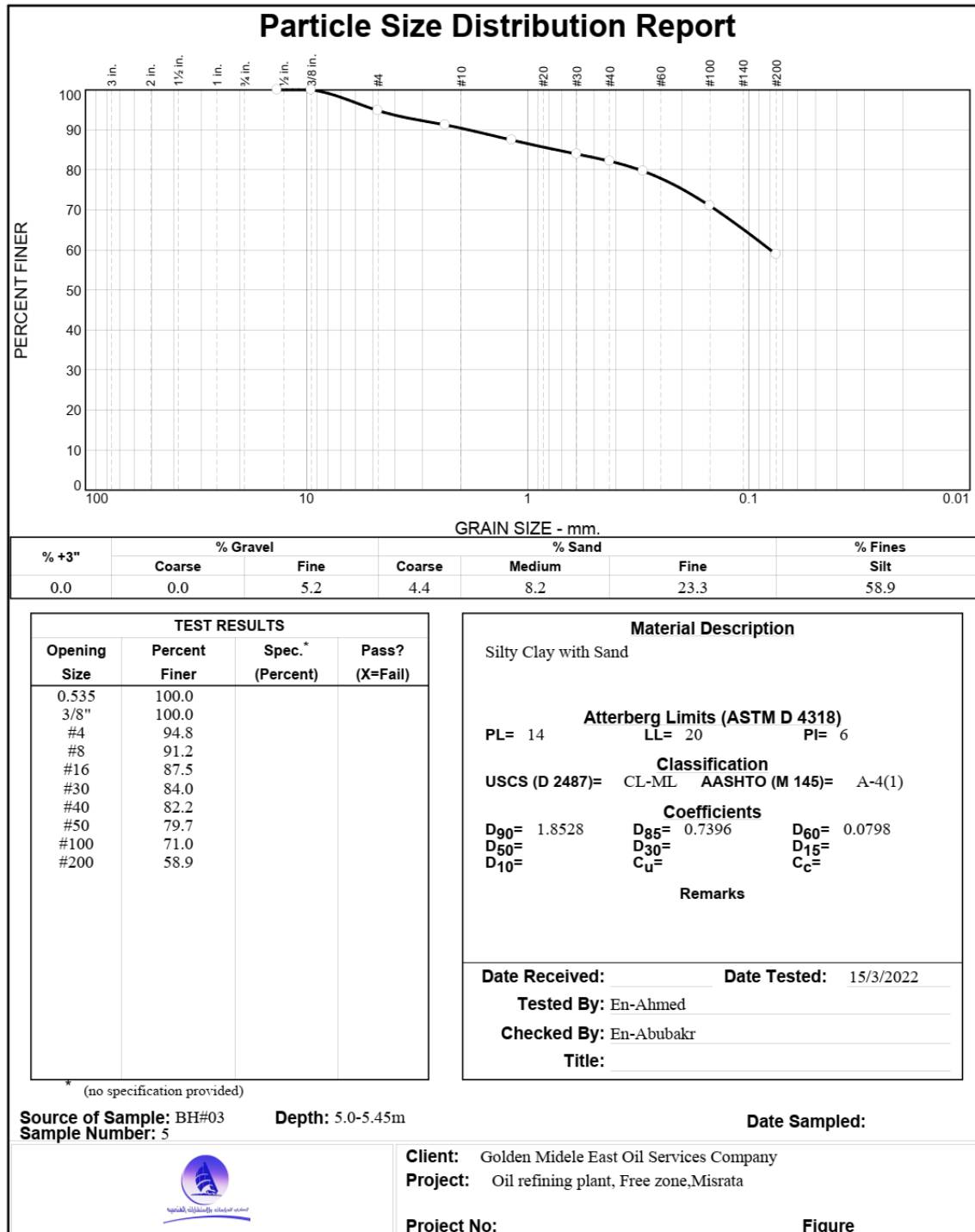
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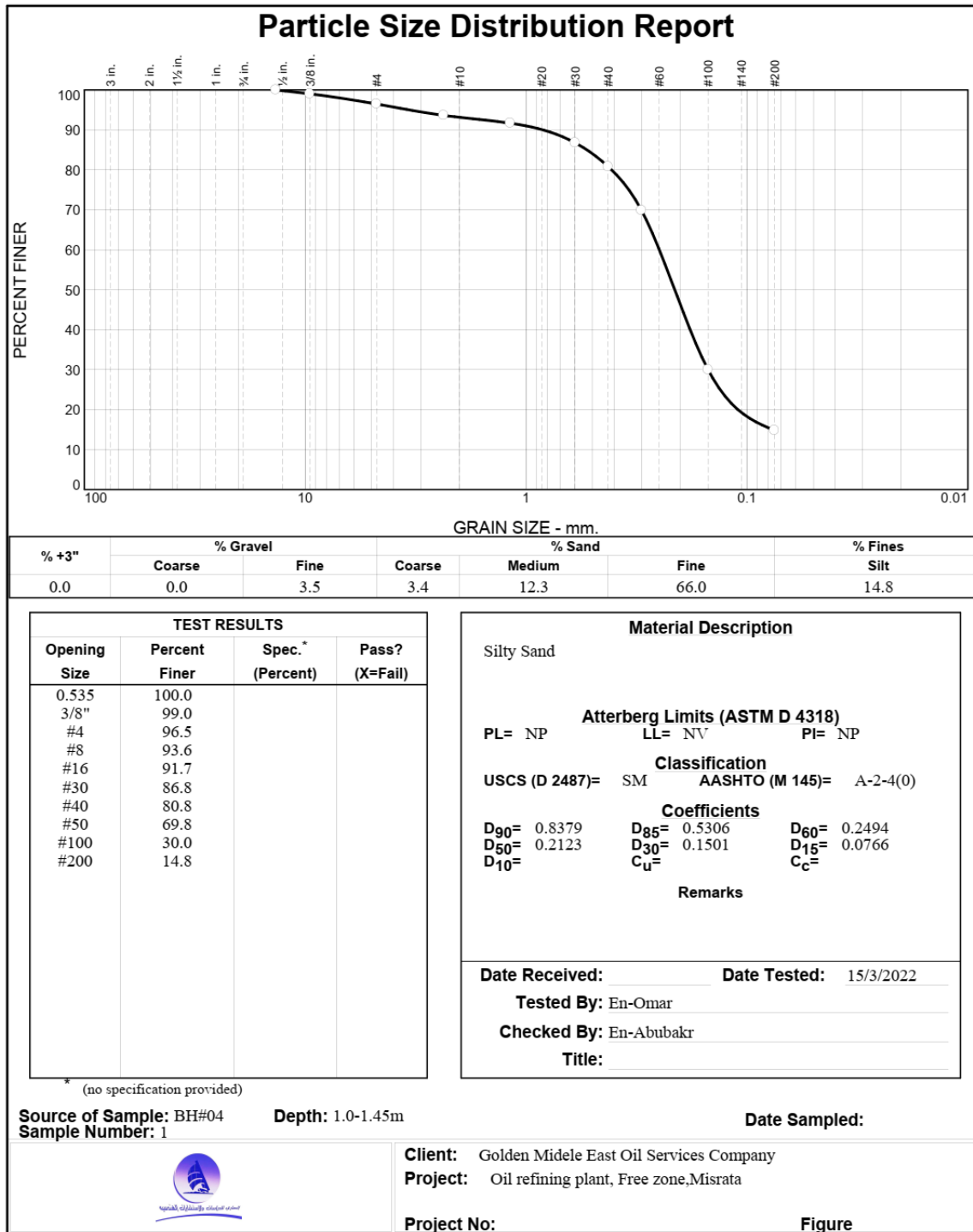
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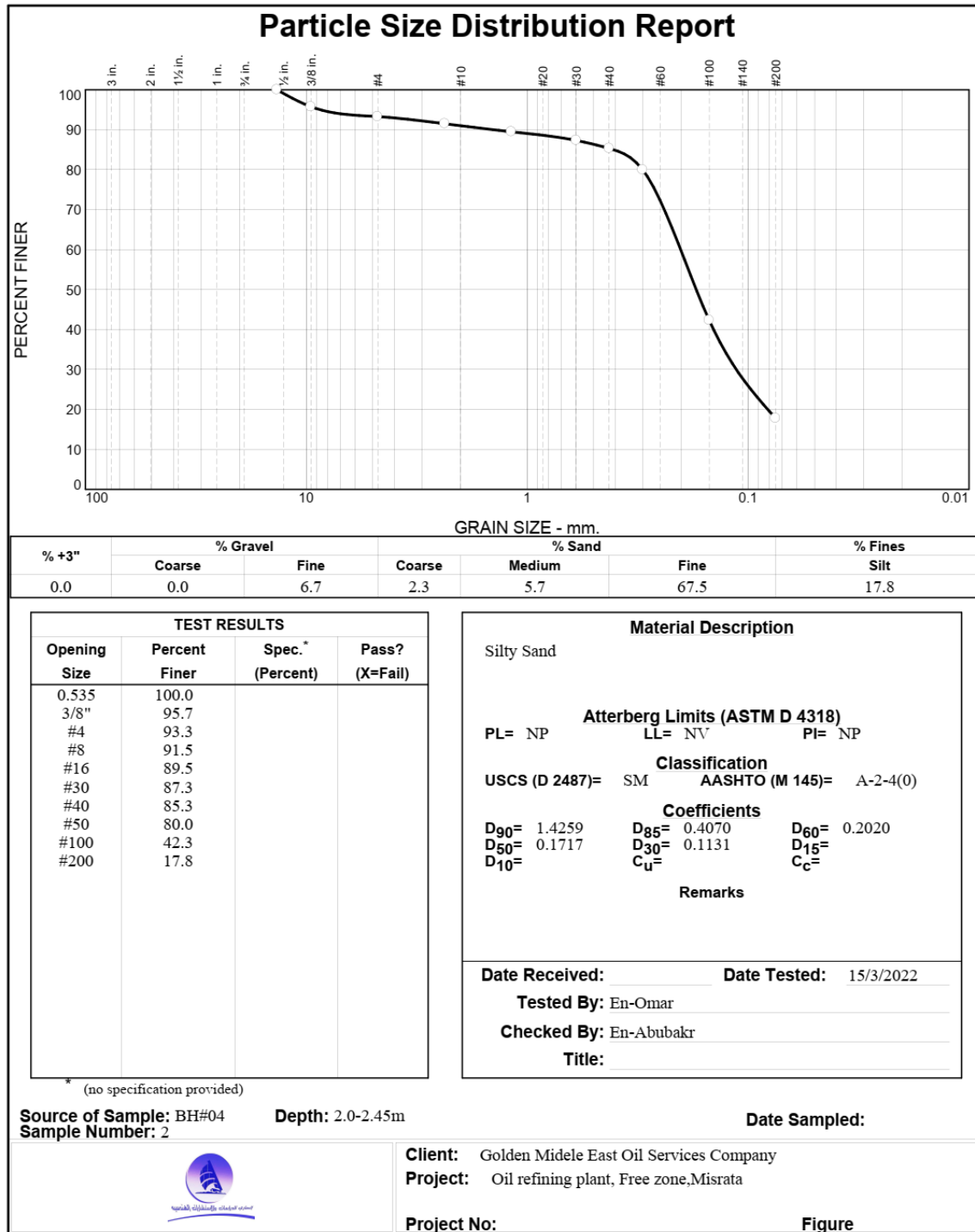
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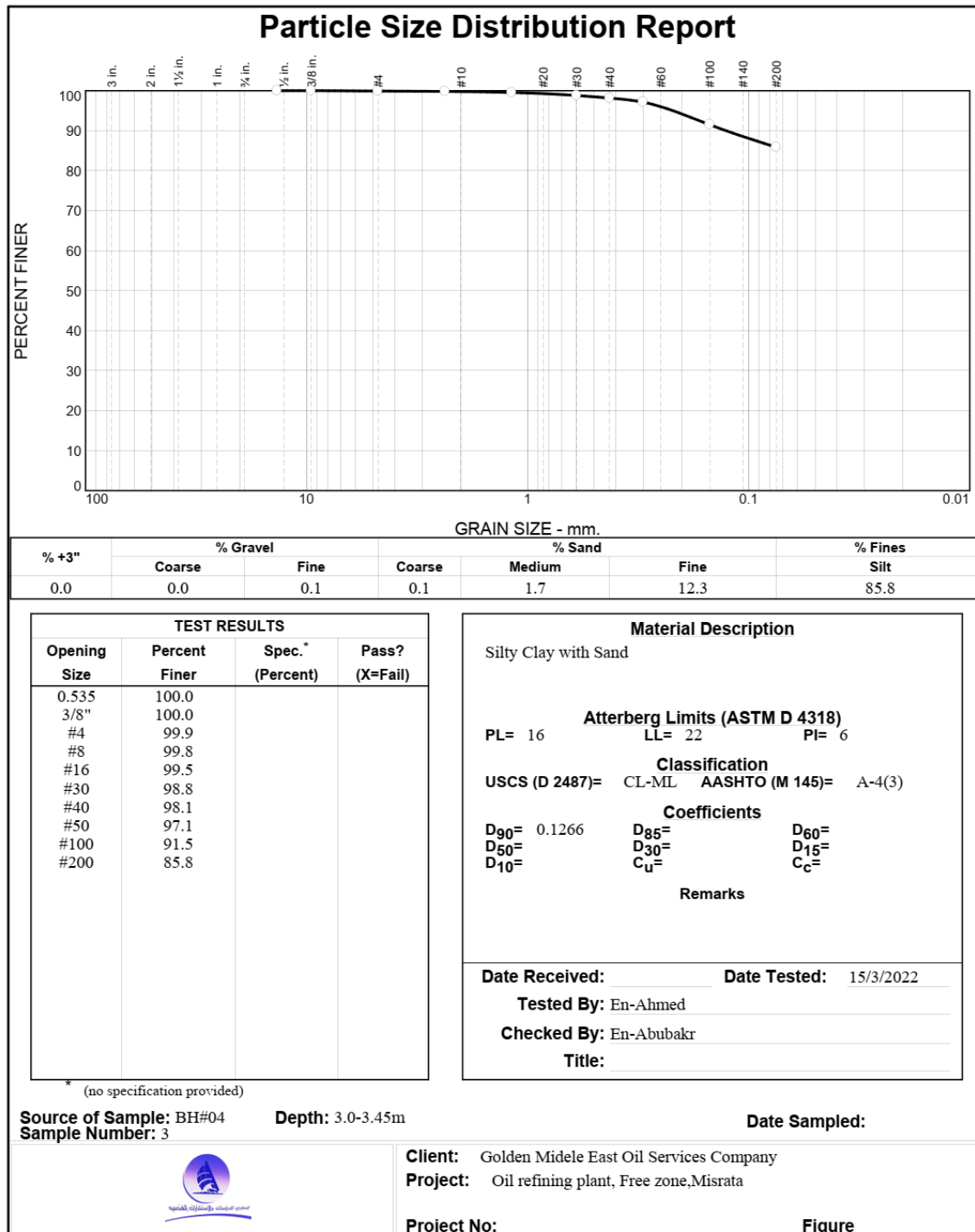
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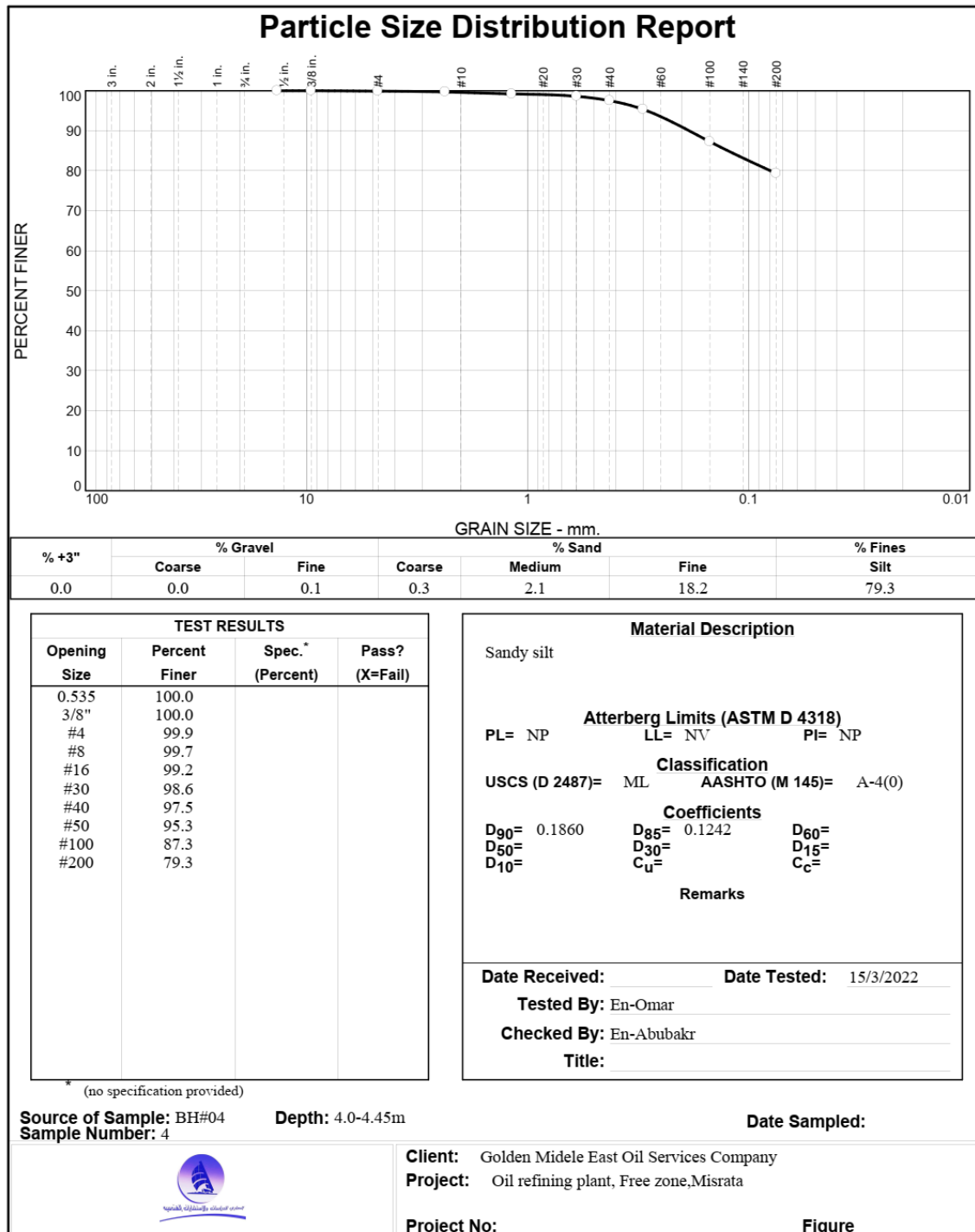
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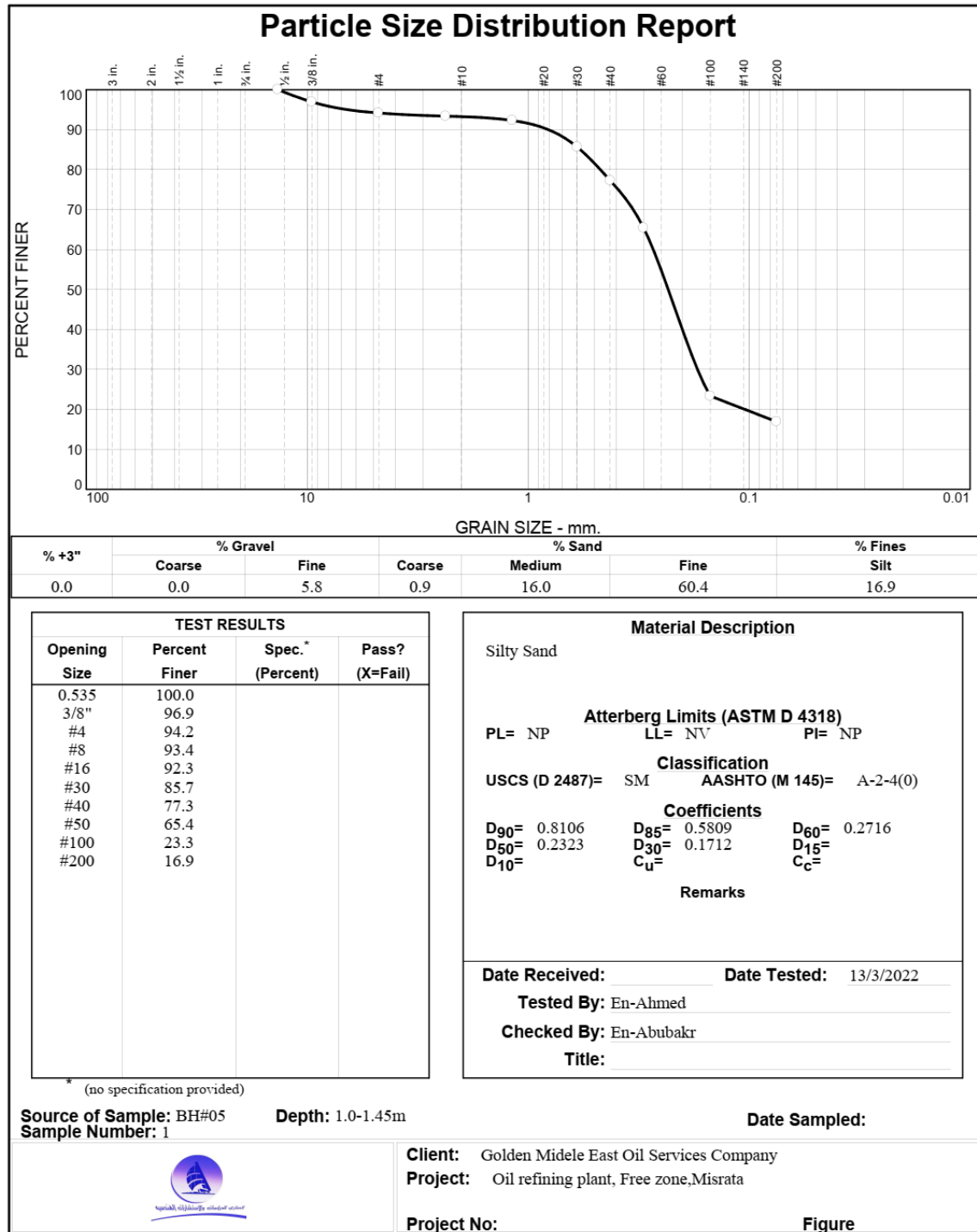
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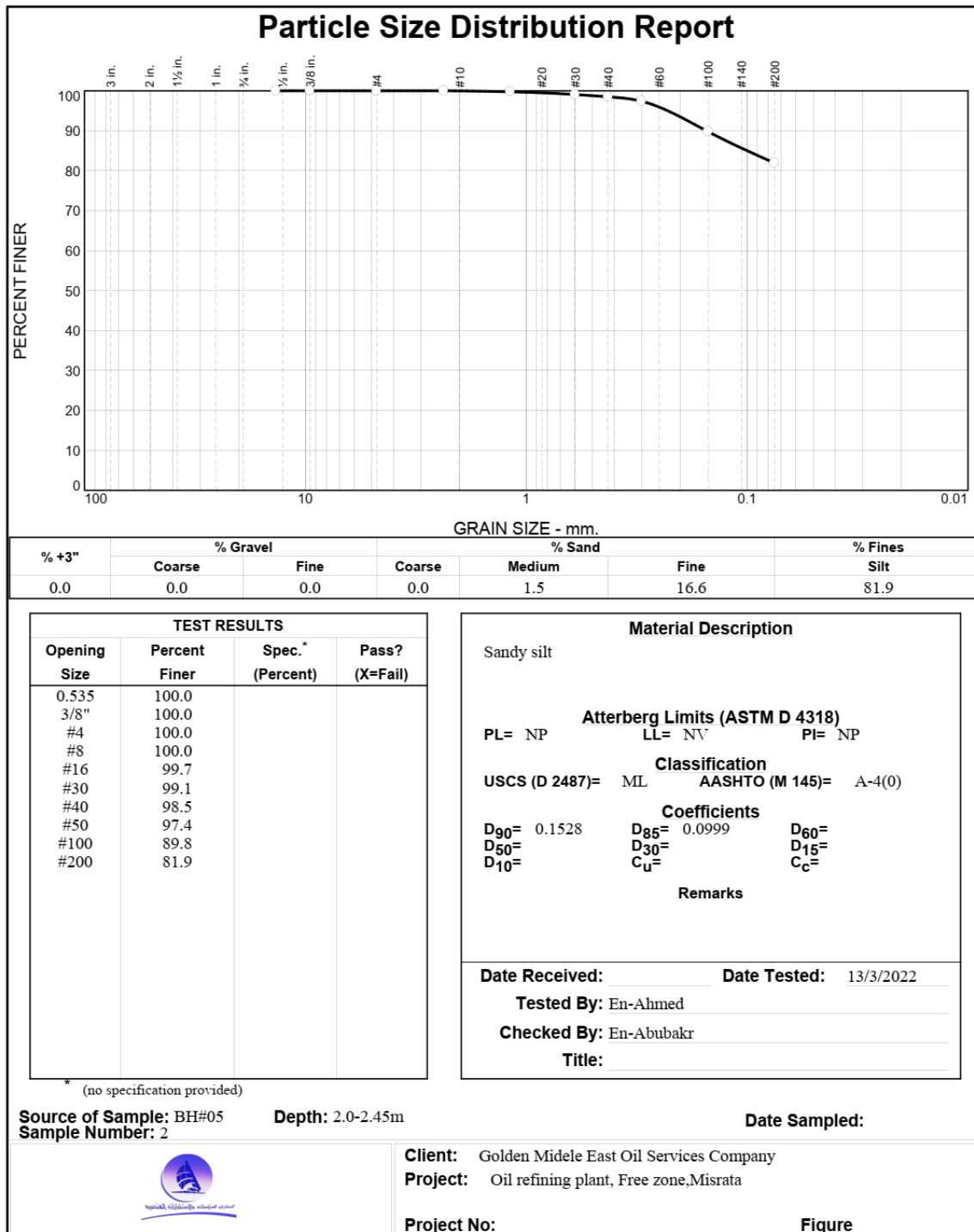
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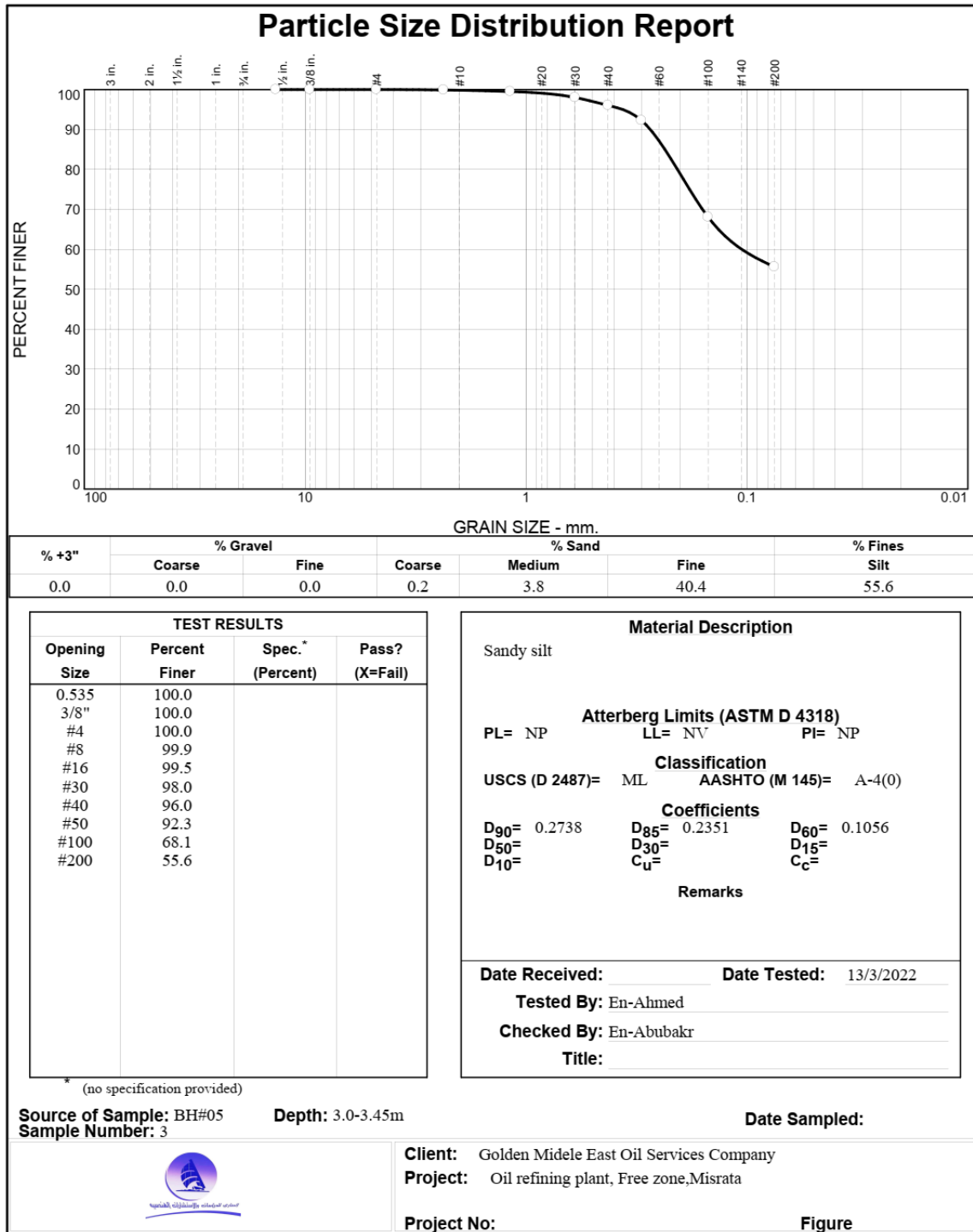
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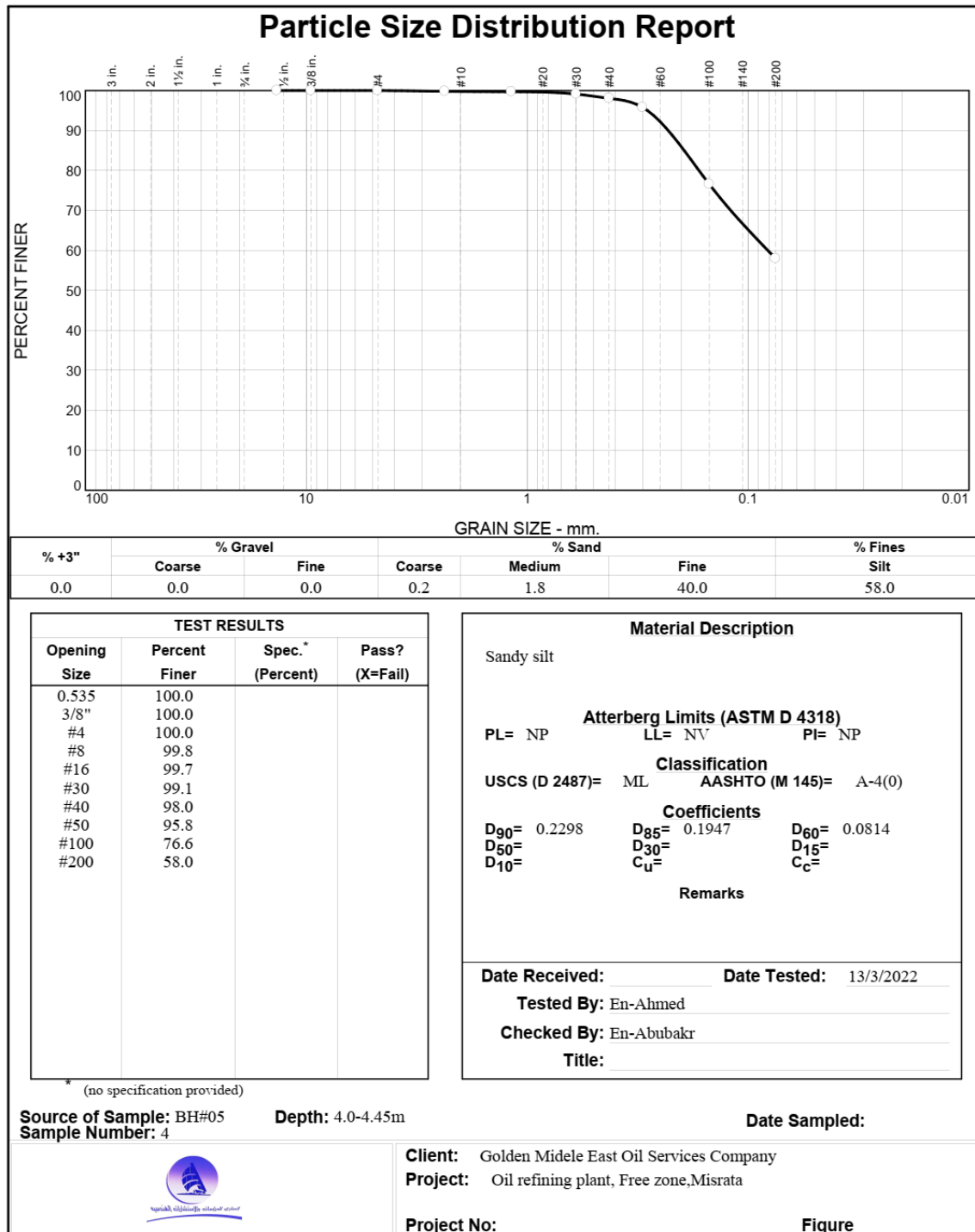
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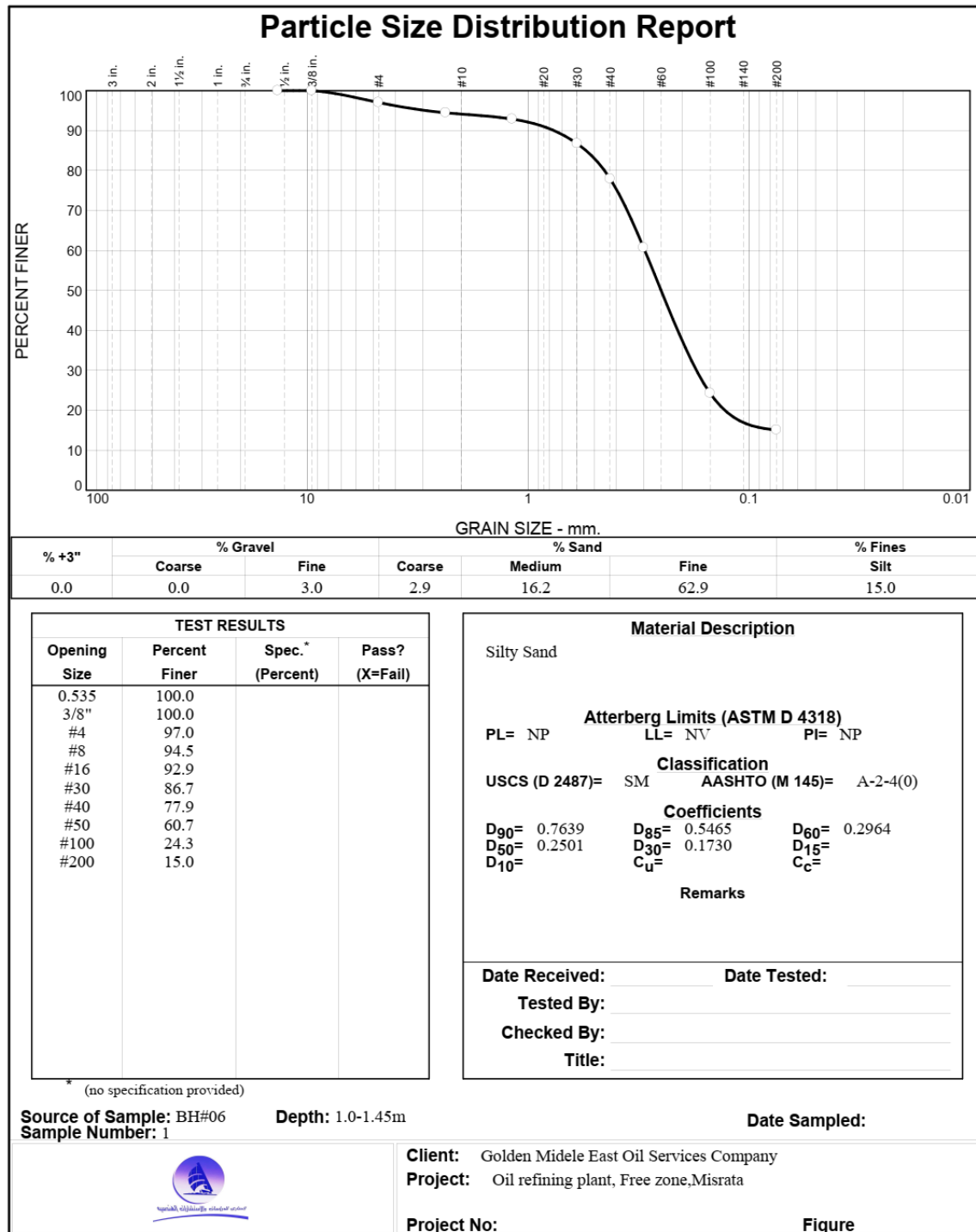
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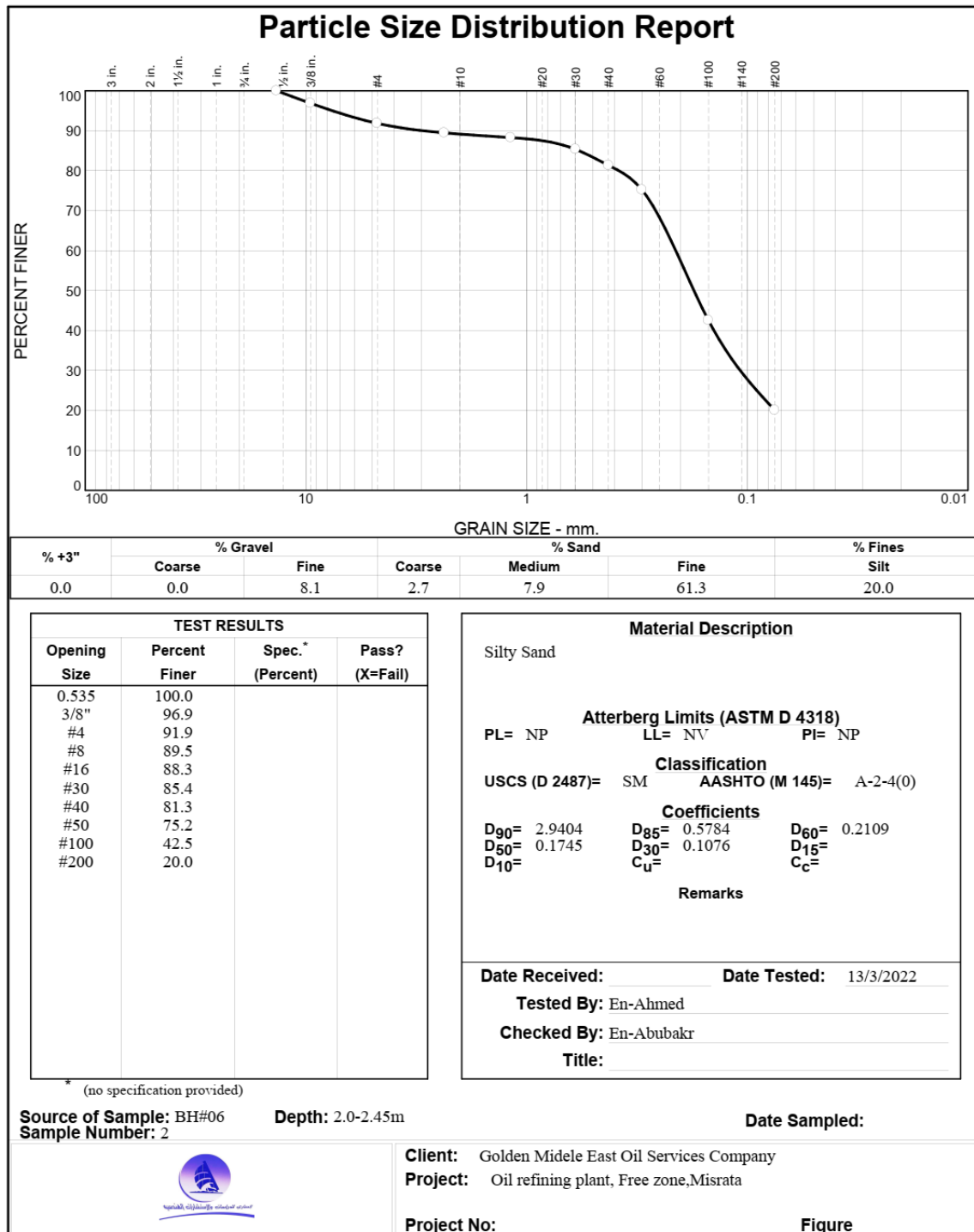
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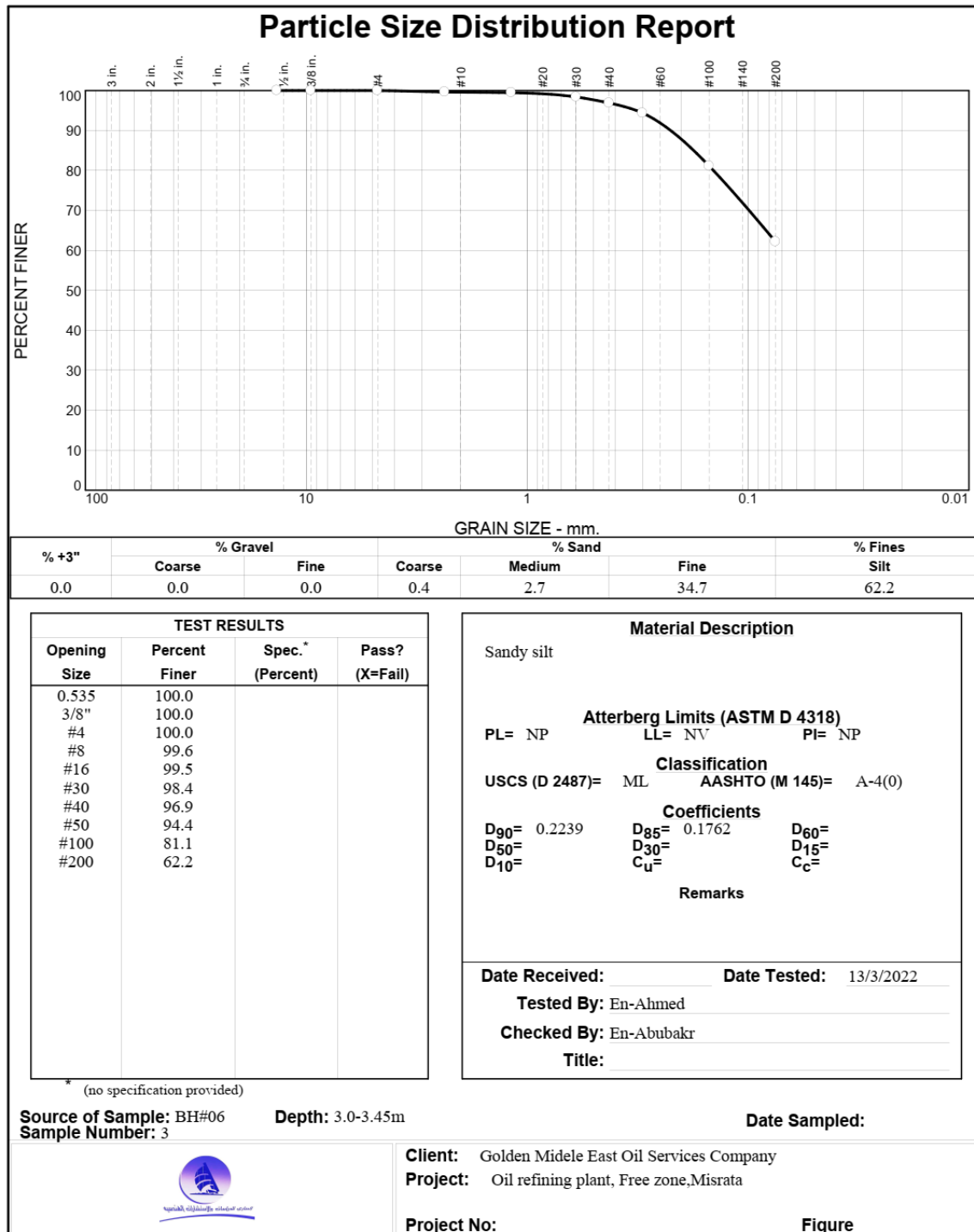
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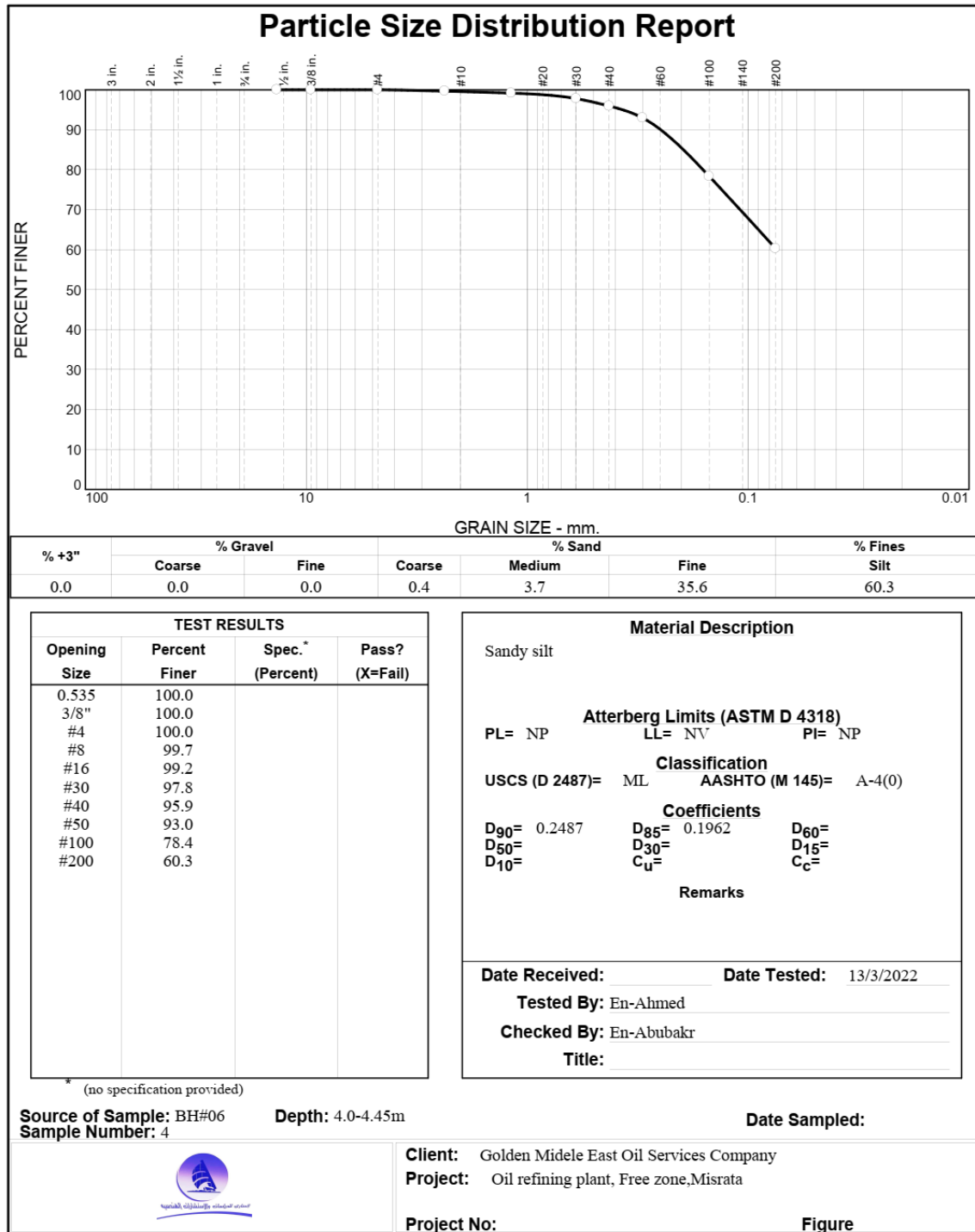
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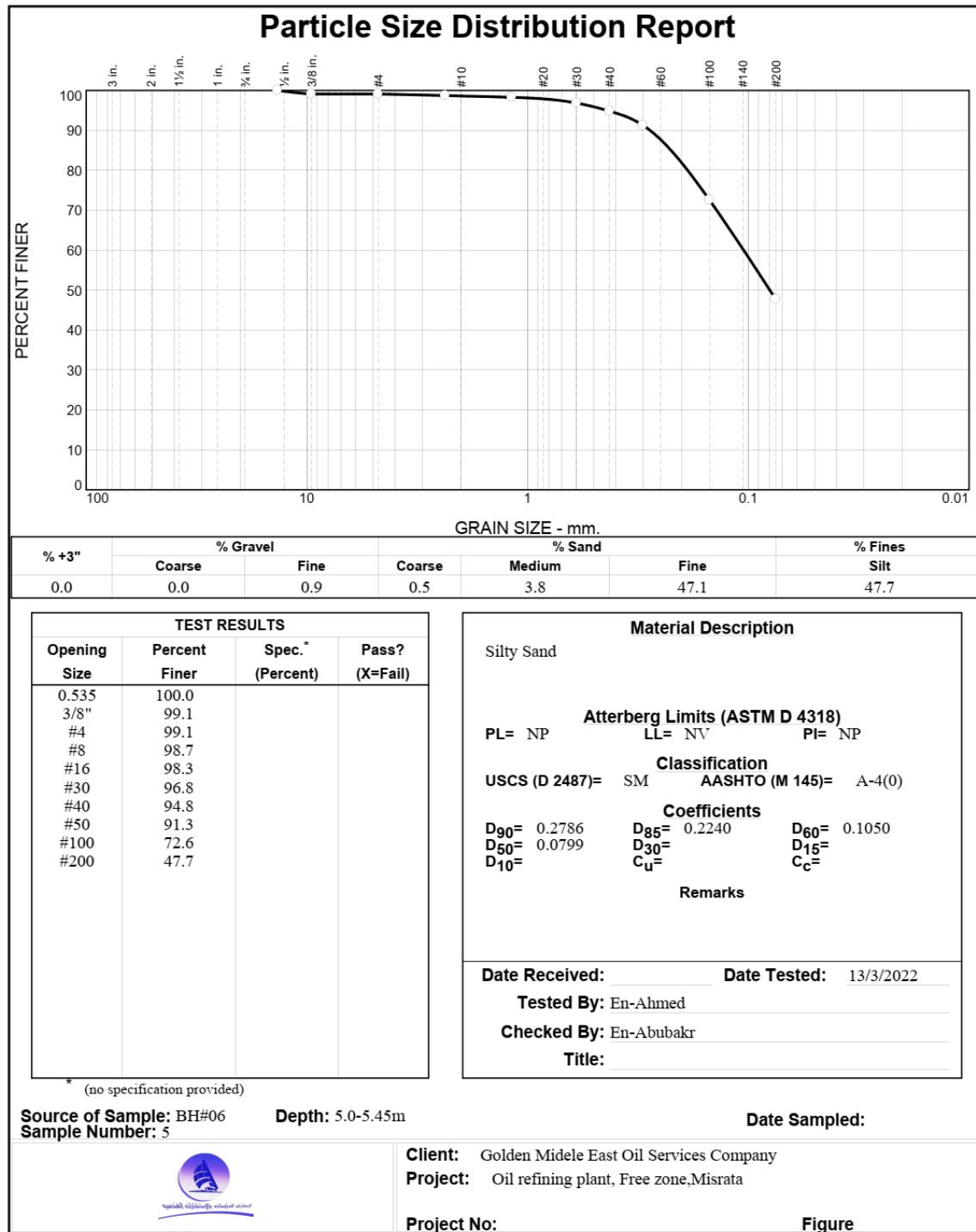
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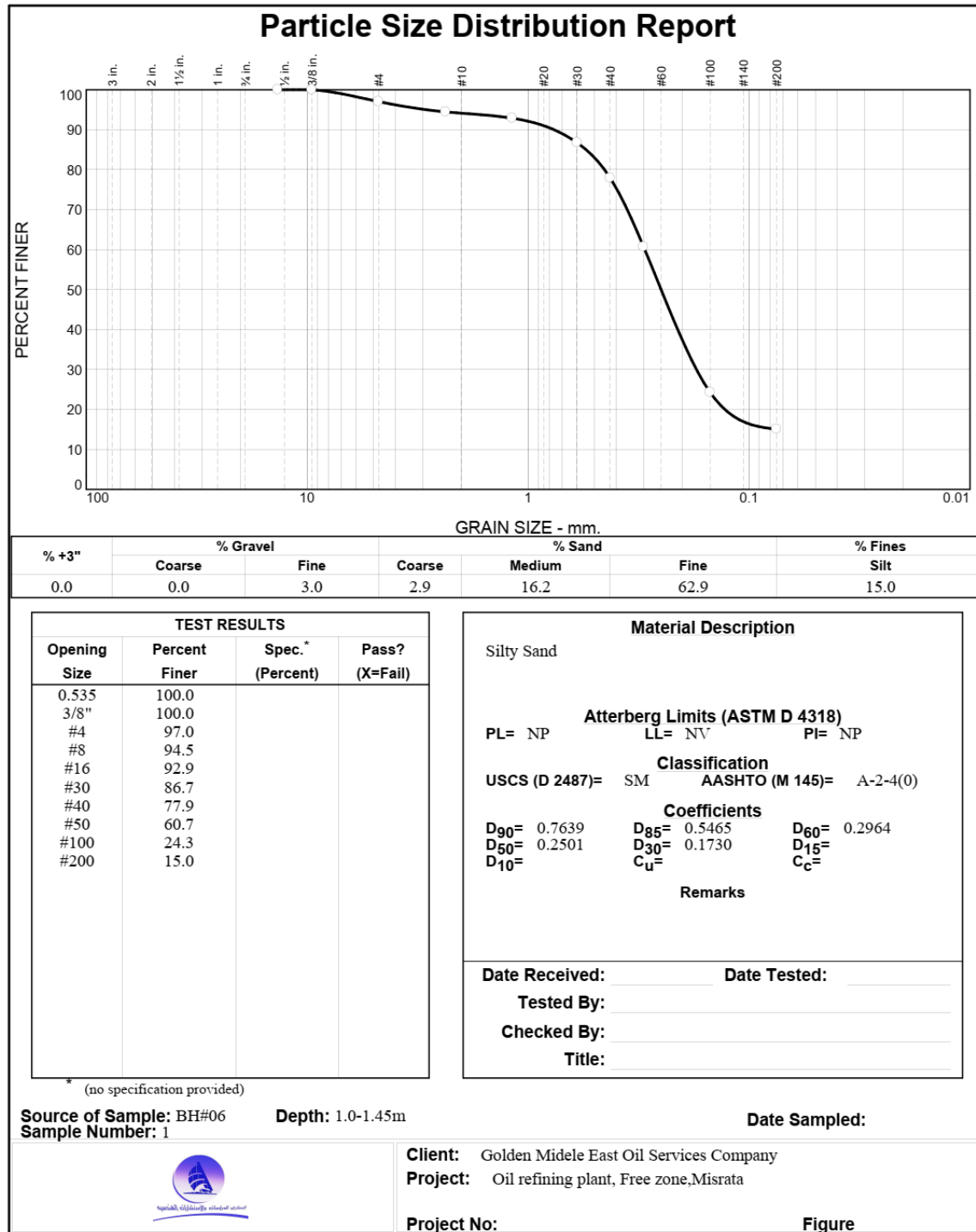
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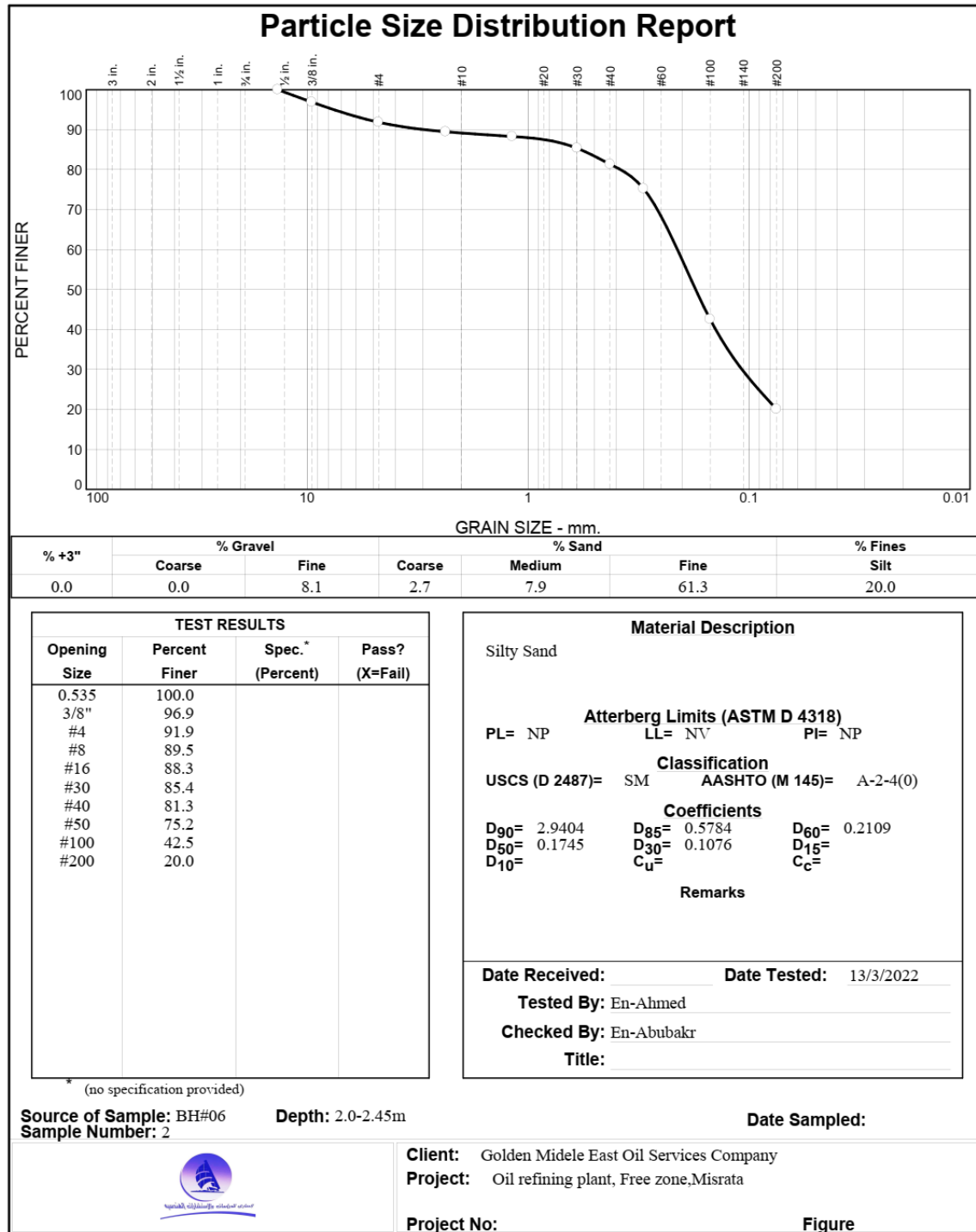
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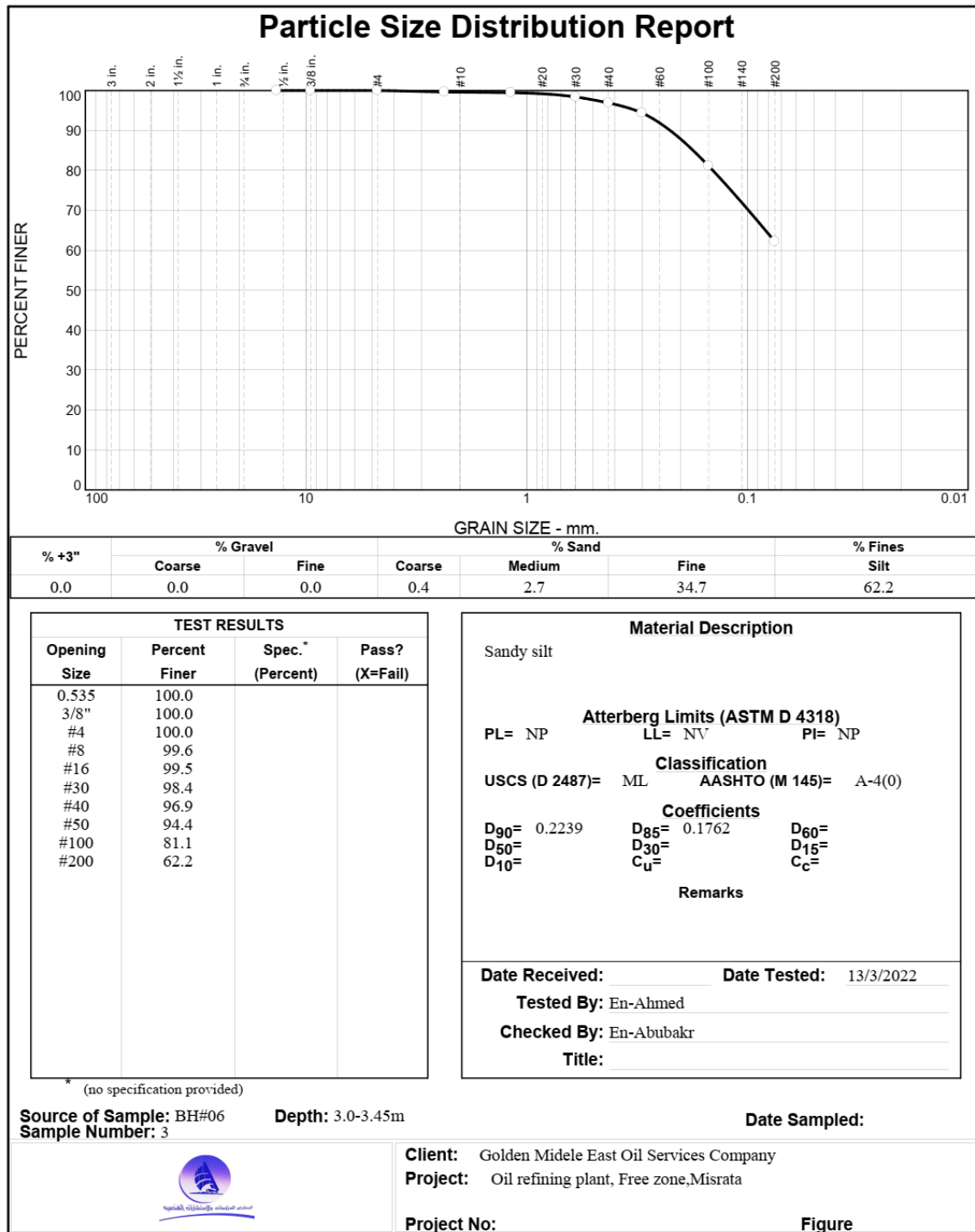
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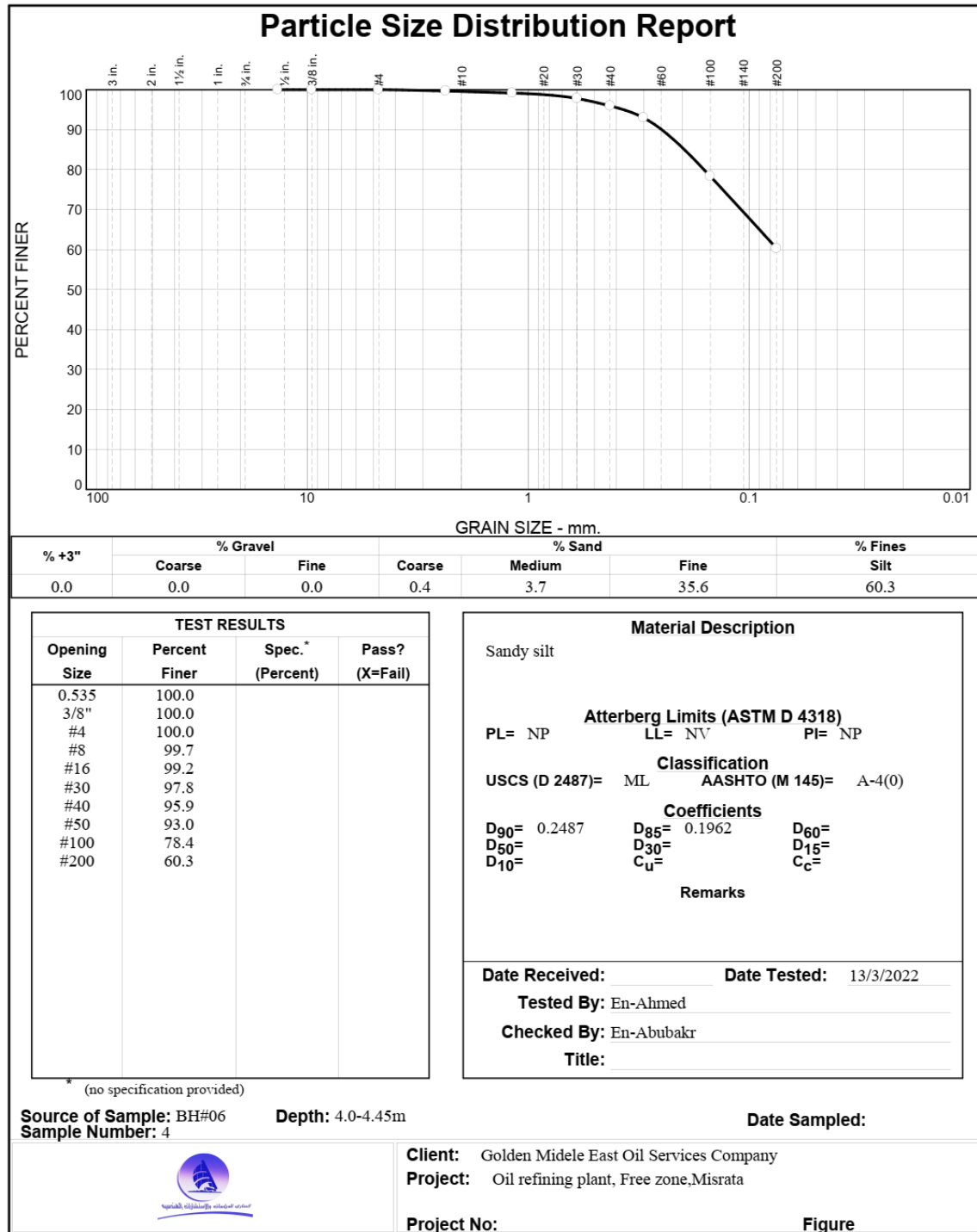
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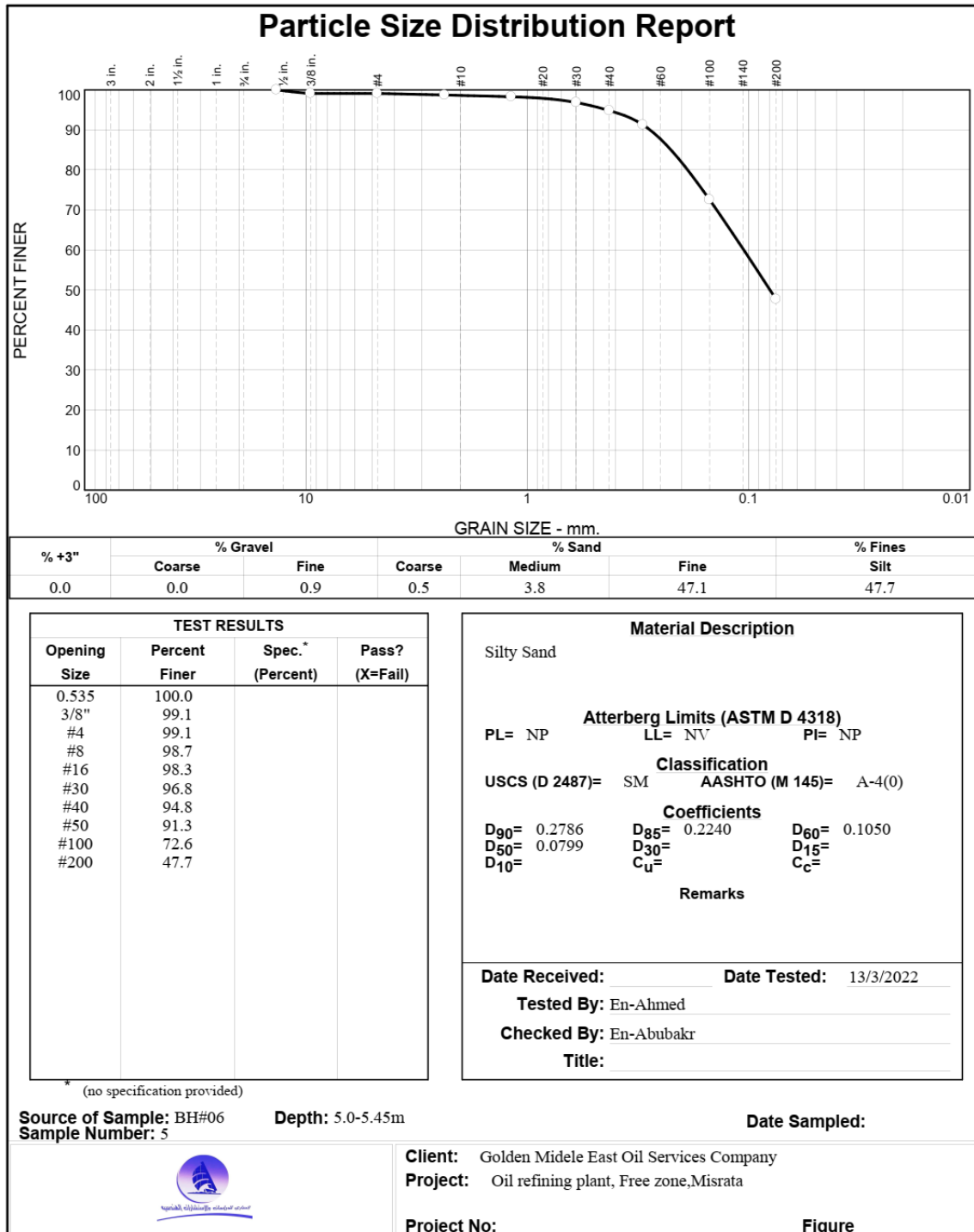
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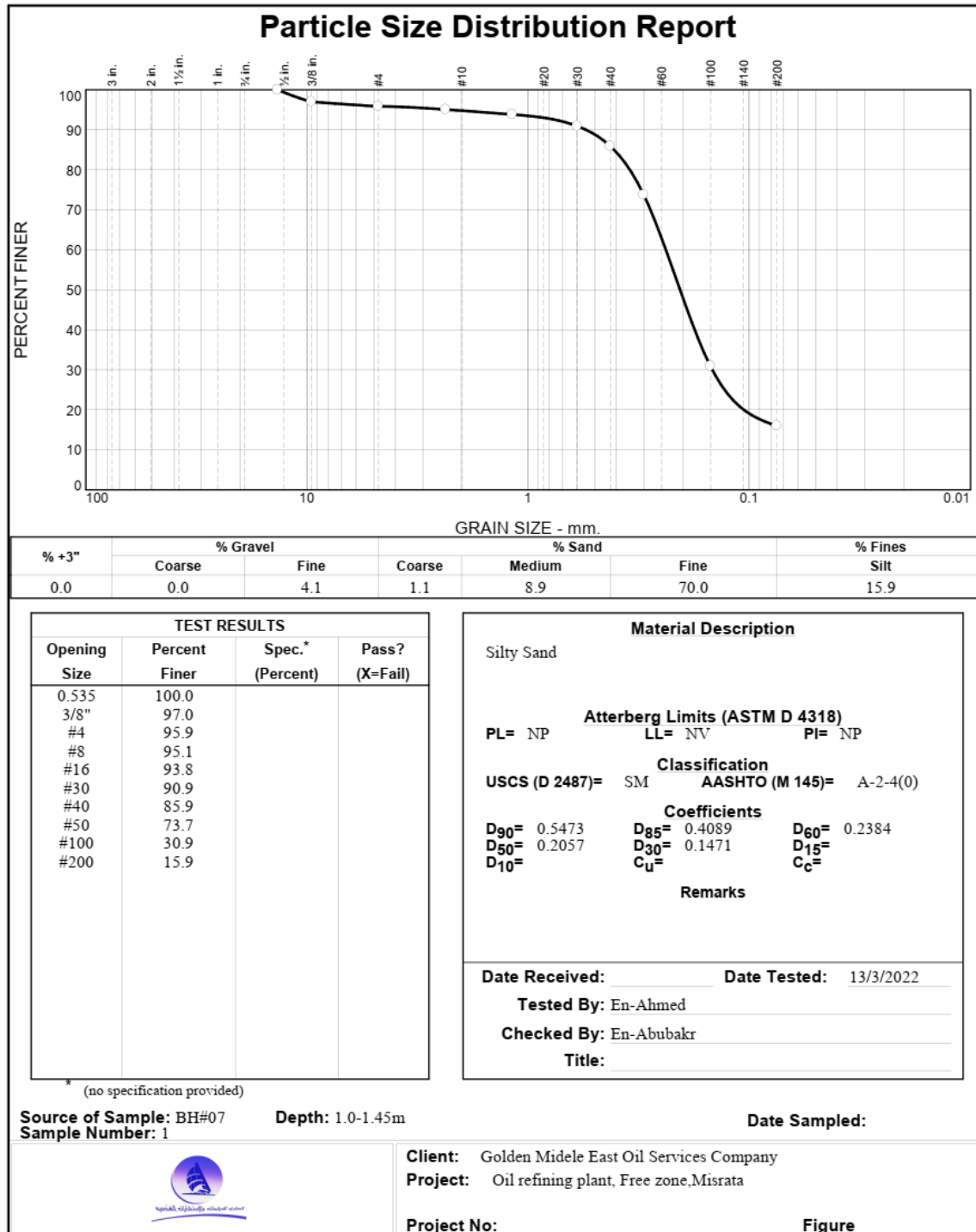
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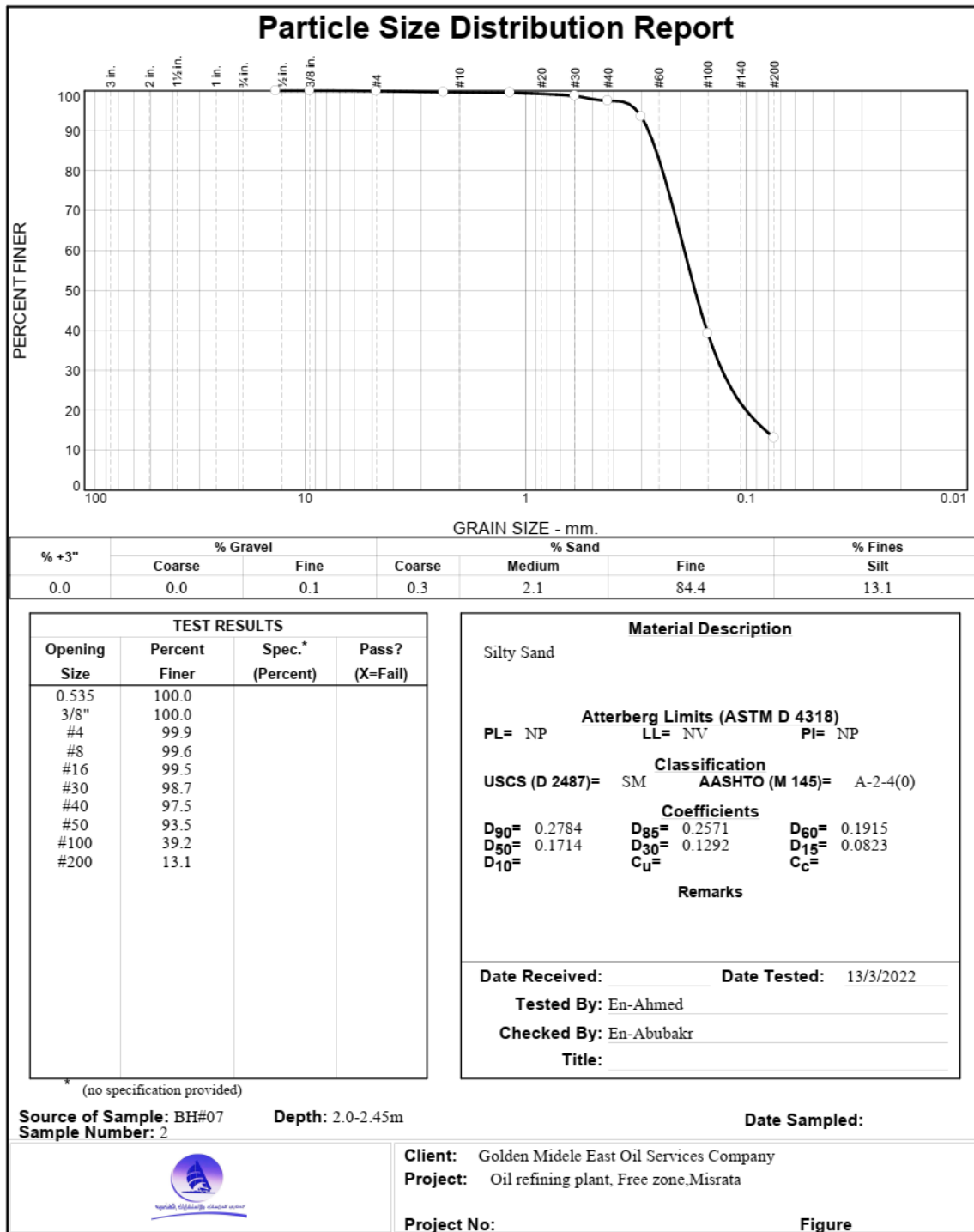
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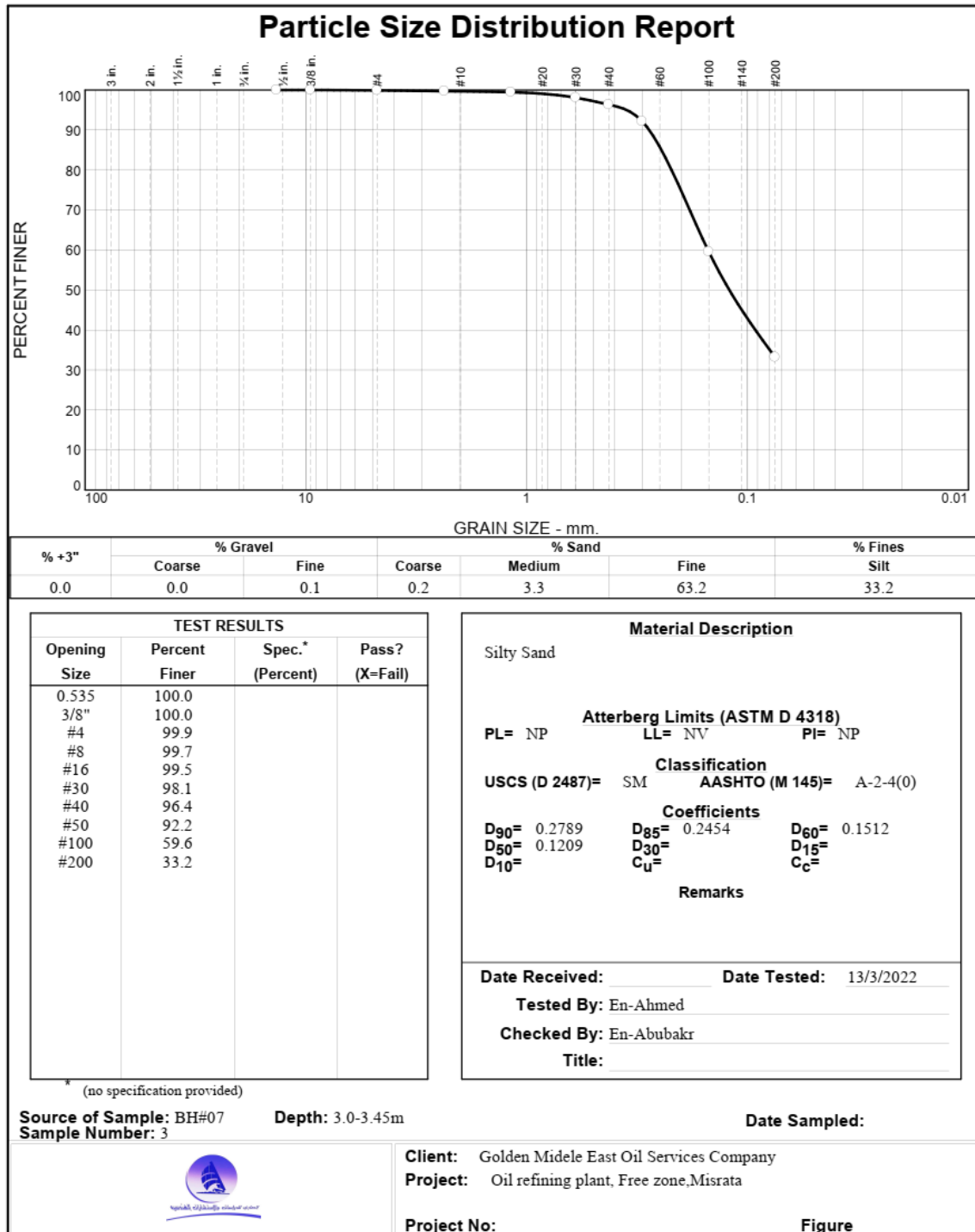
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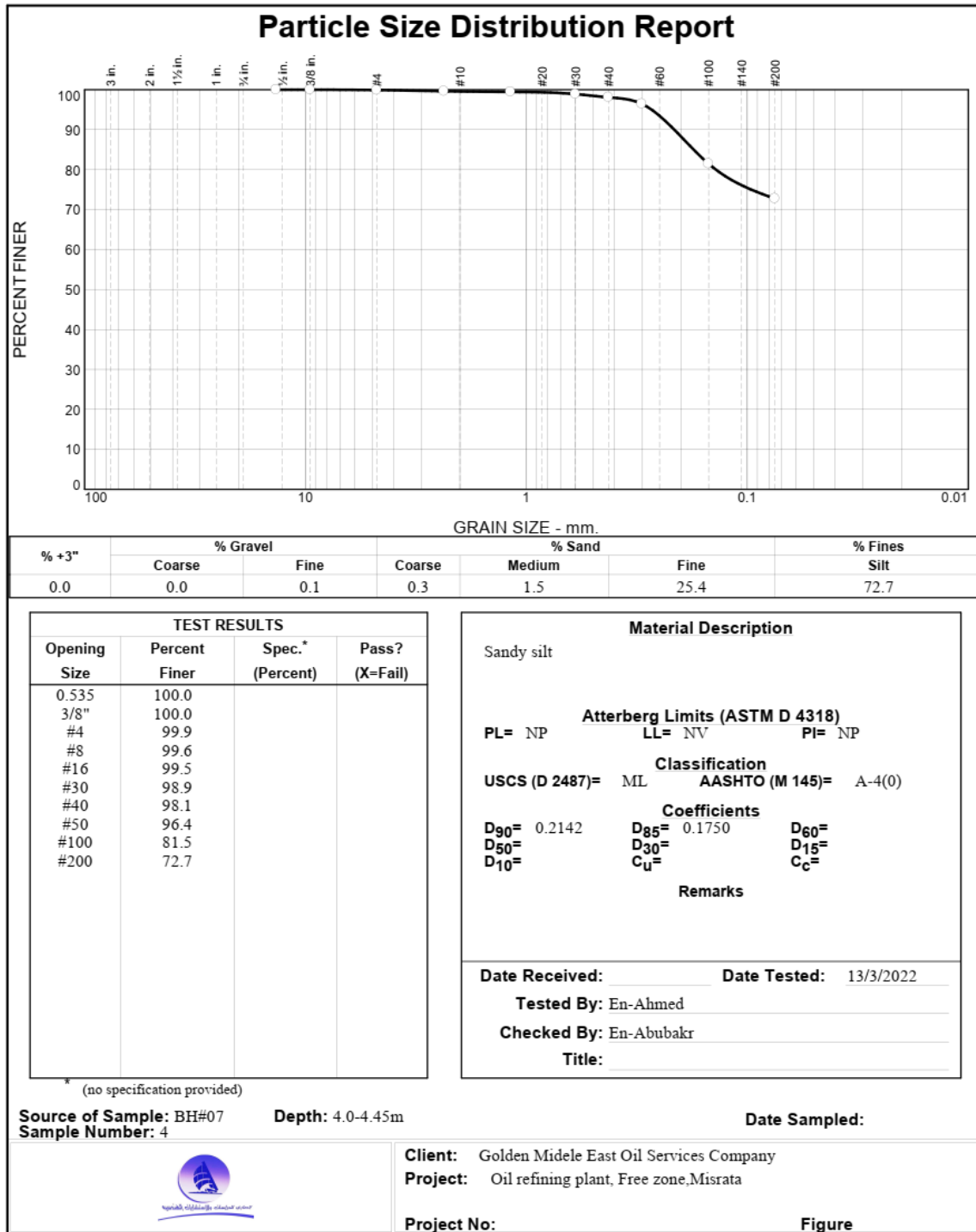
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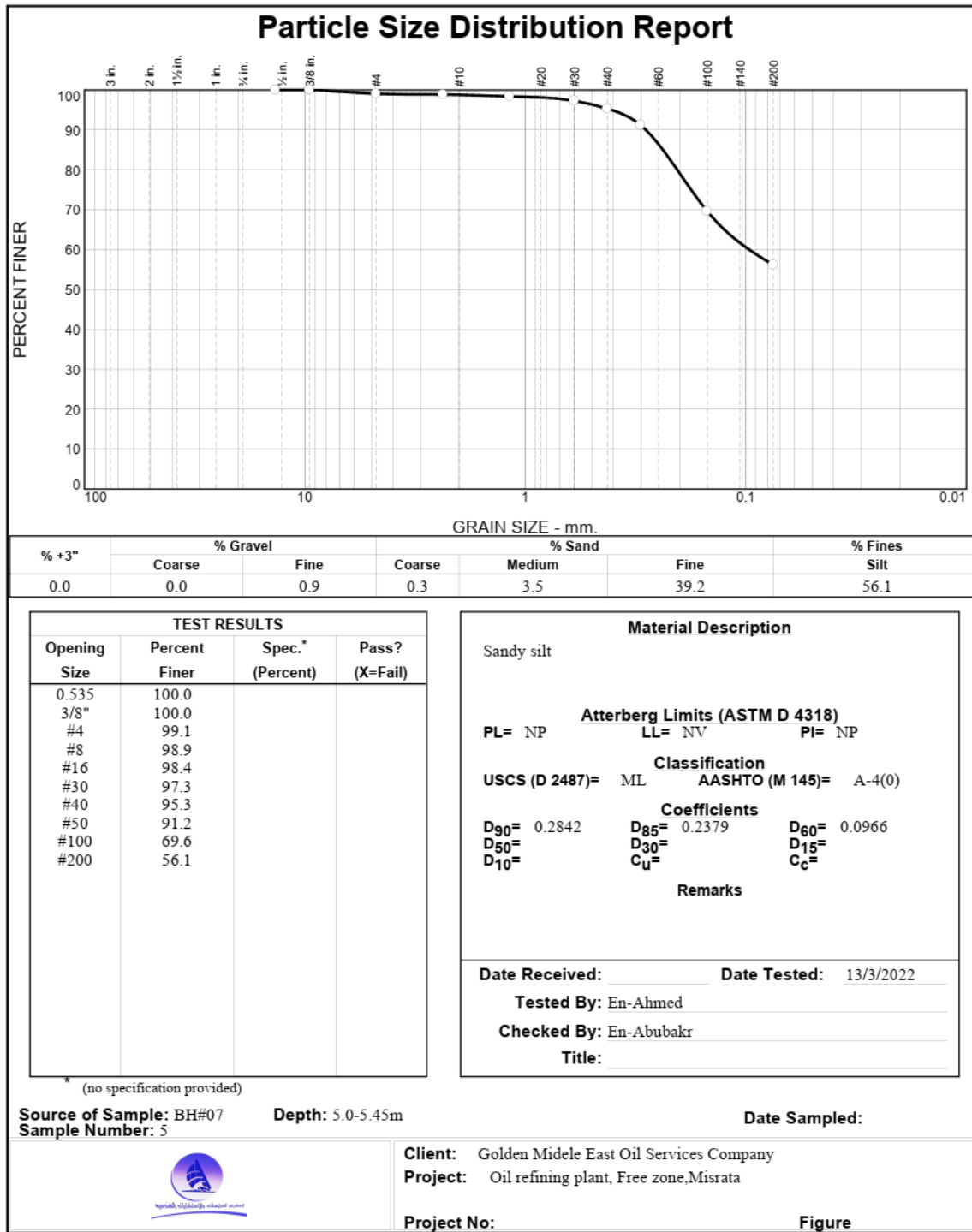
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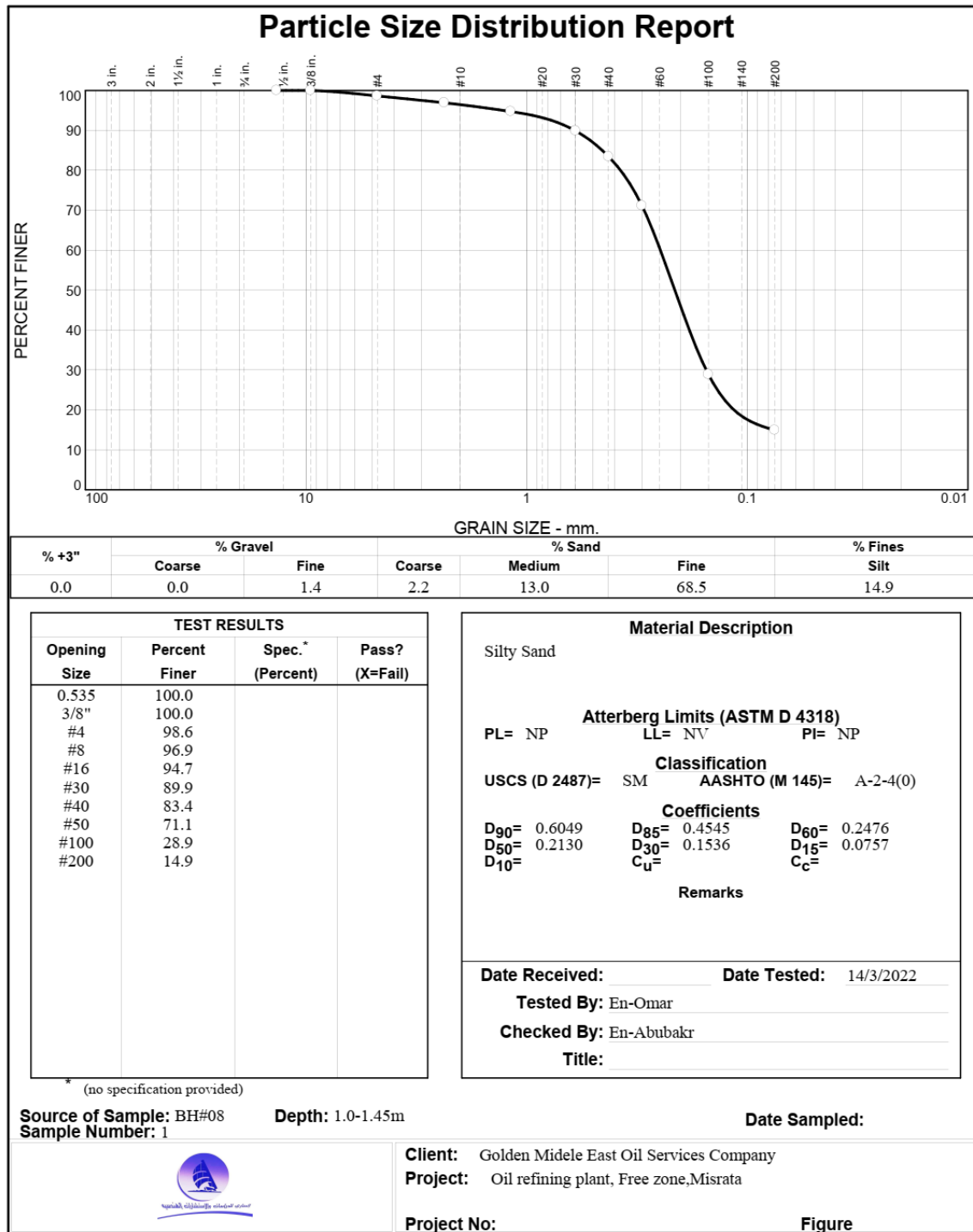
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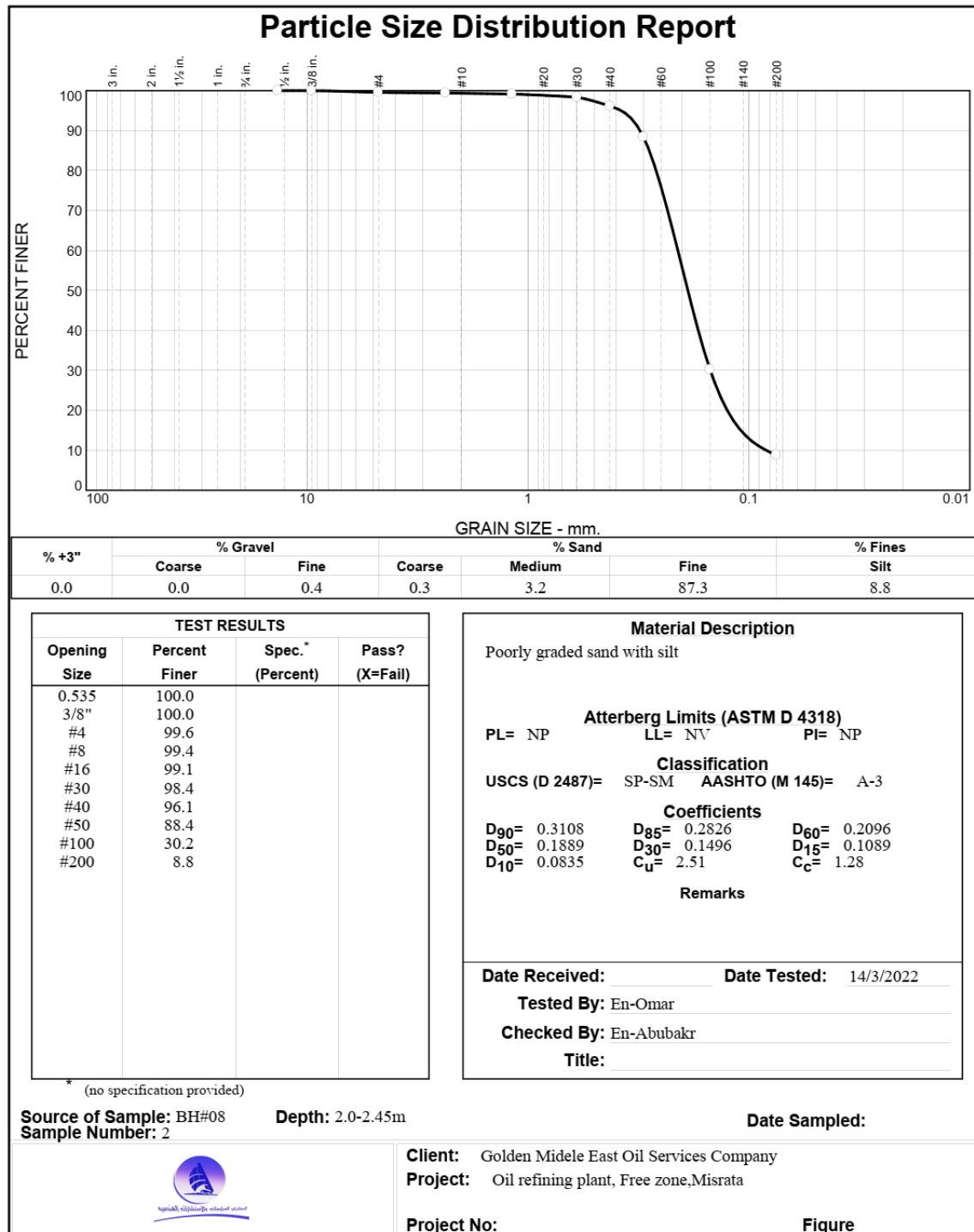
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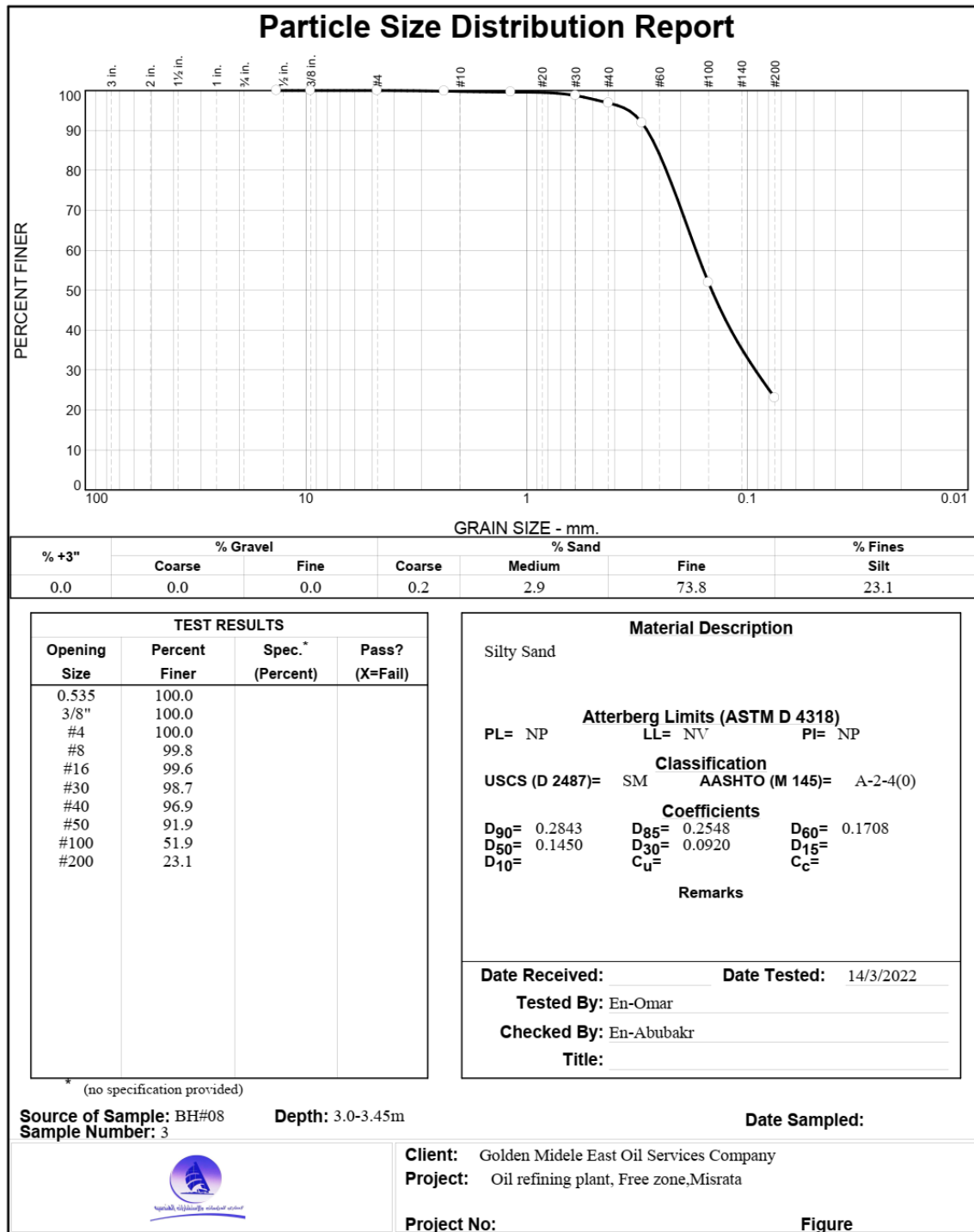
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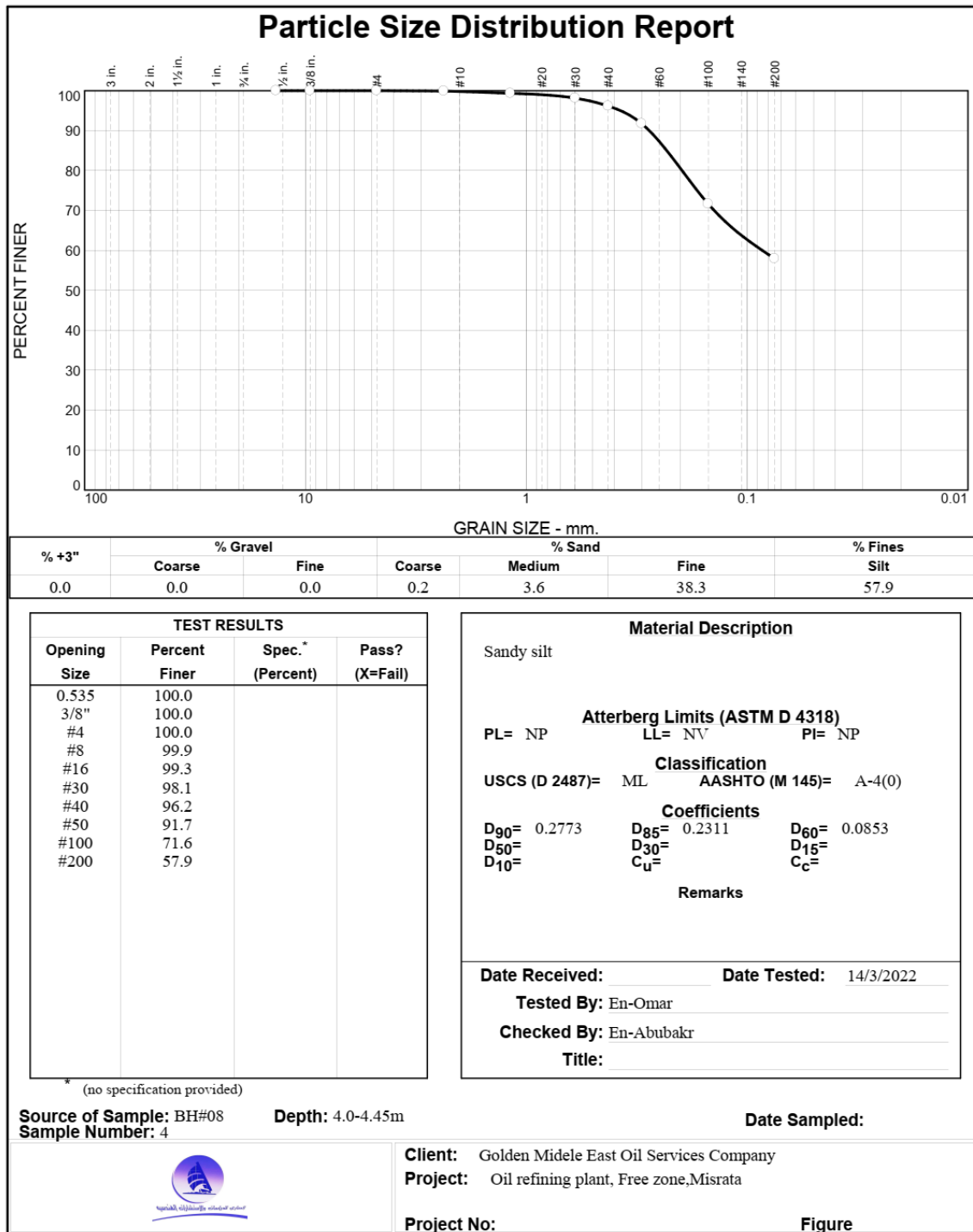
	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
Golden Middle East Oil Services Co. "Contractor"	Page: 127 of 155	Misratah City, LIBYA	Date: 06/03/2022	Assari engineering consulting



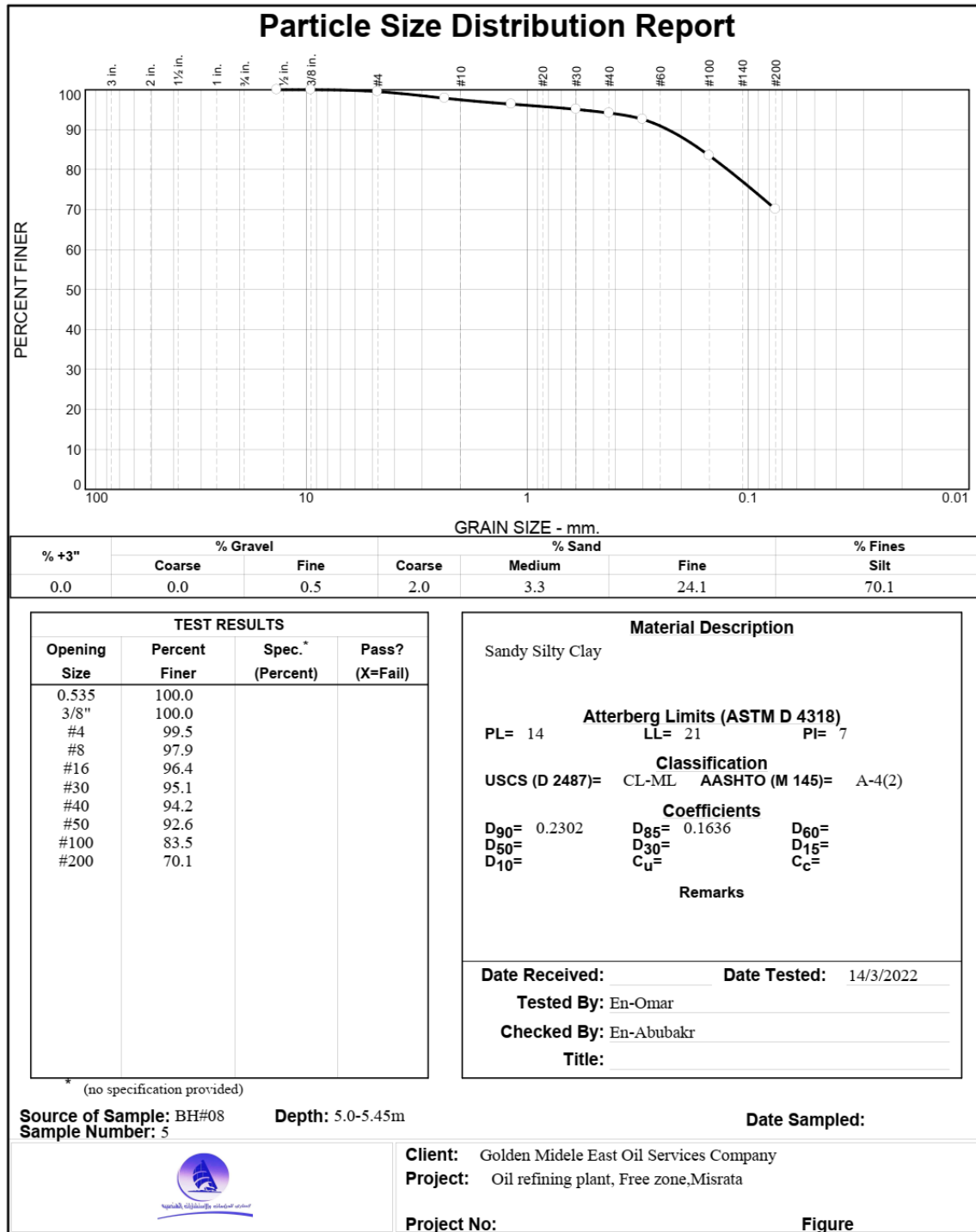
	Project: The construction of oil refining factory, Misratah.			
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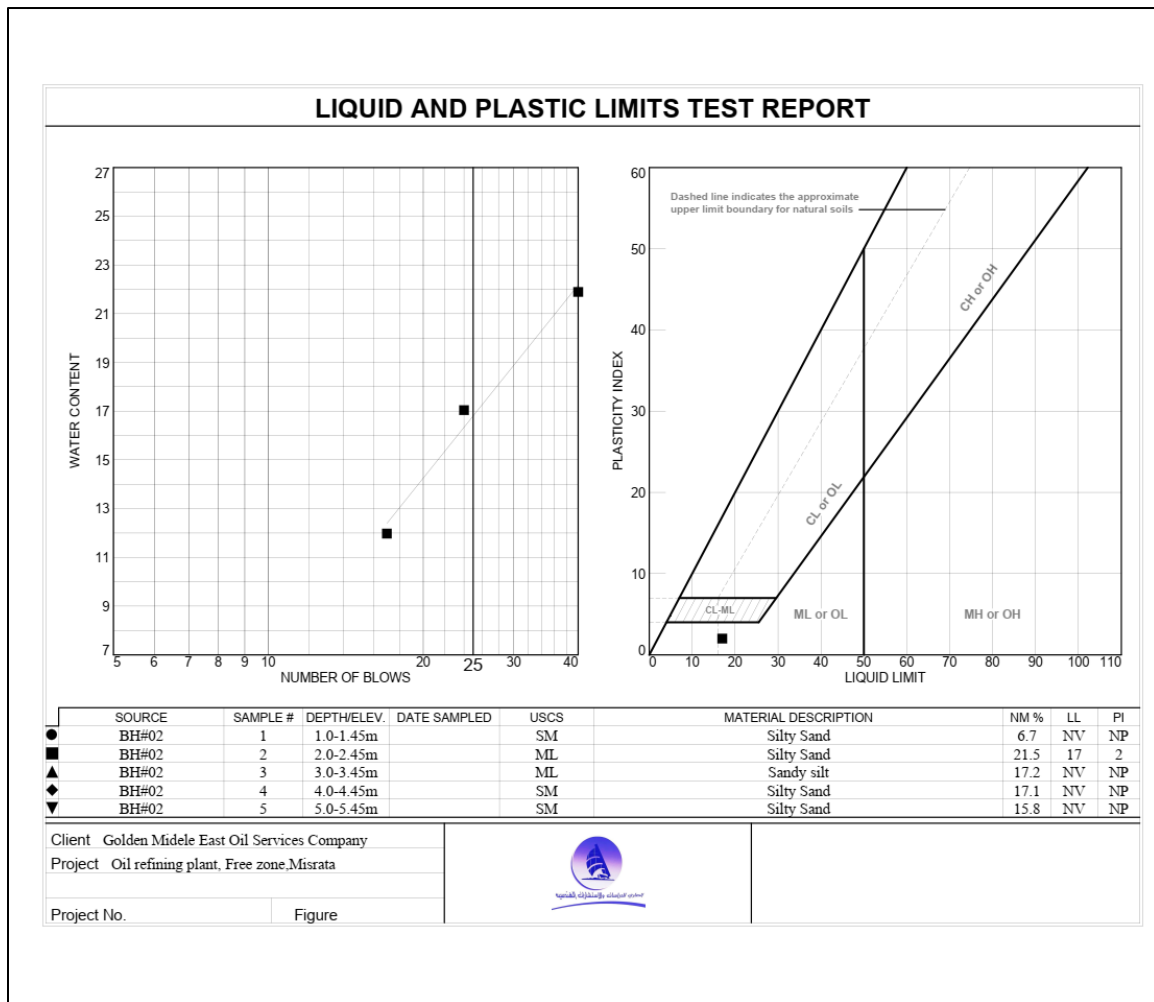
	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
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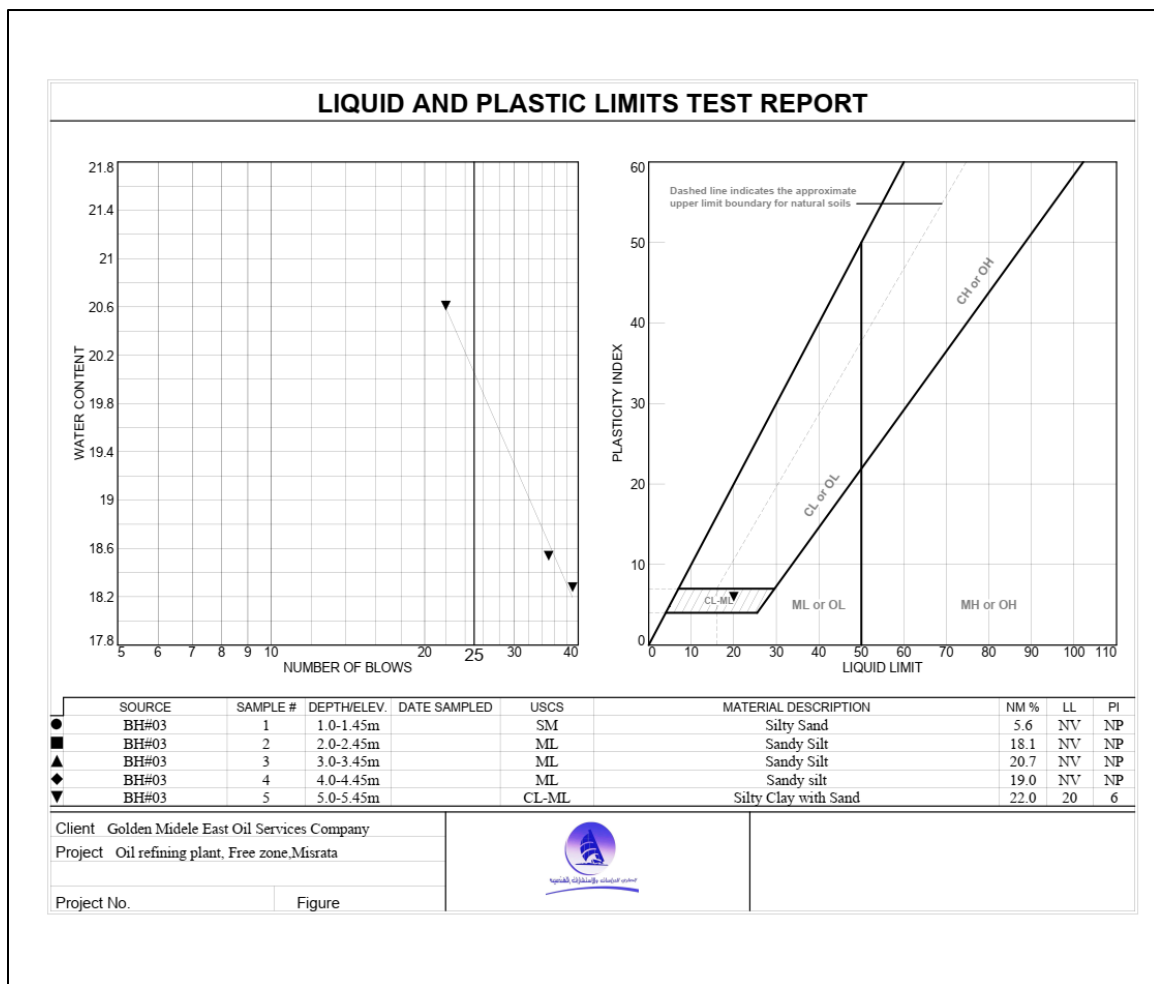
	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
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APPENDIX 'C'
Liquid and Plastic limits
(Lab. Test Results)
ASTM D 4318

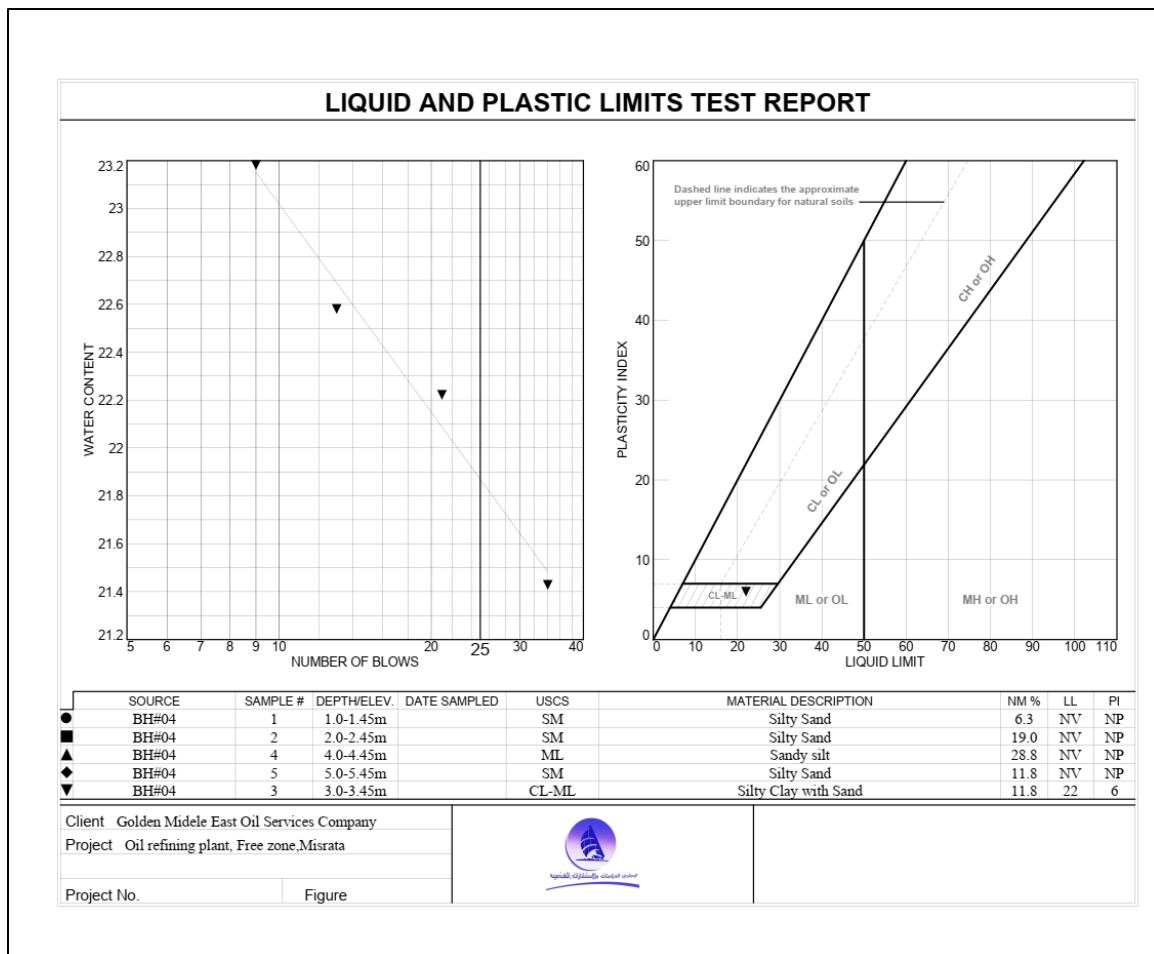
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	N° Job: 226 N° Revision: 0.0			
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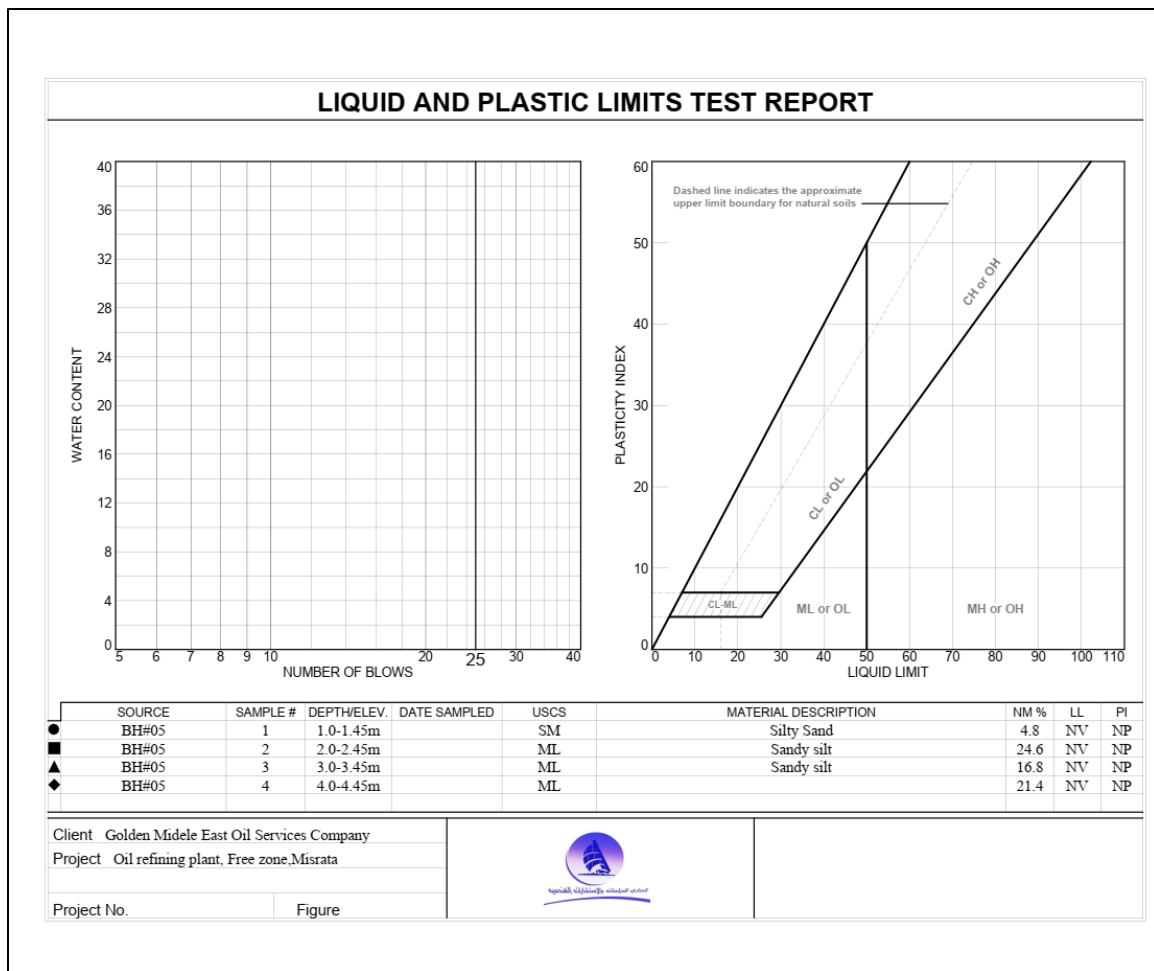
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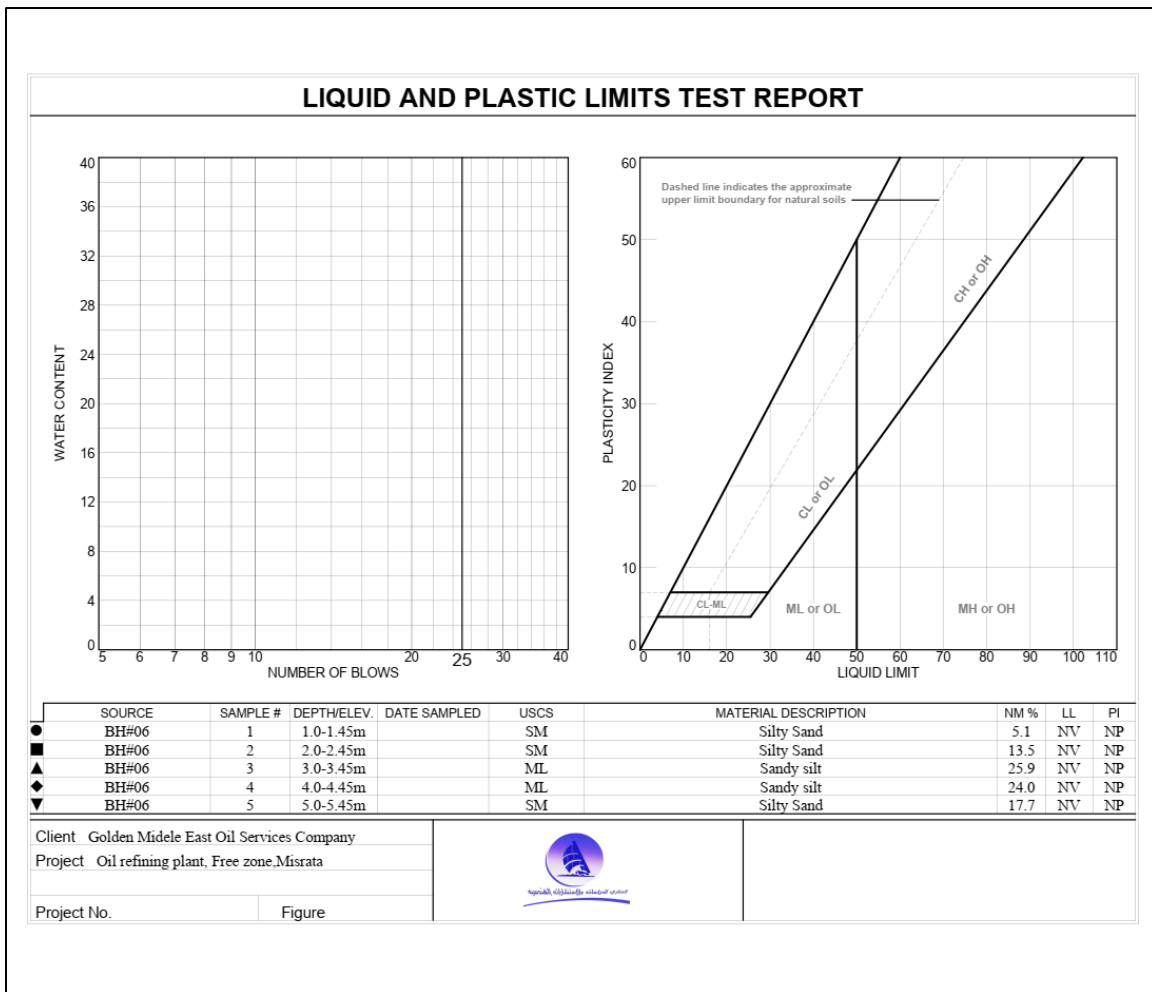
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	N° Job: 226 N° Revision: 0.0			
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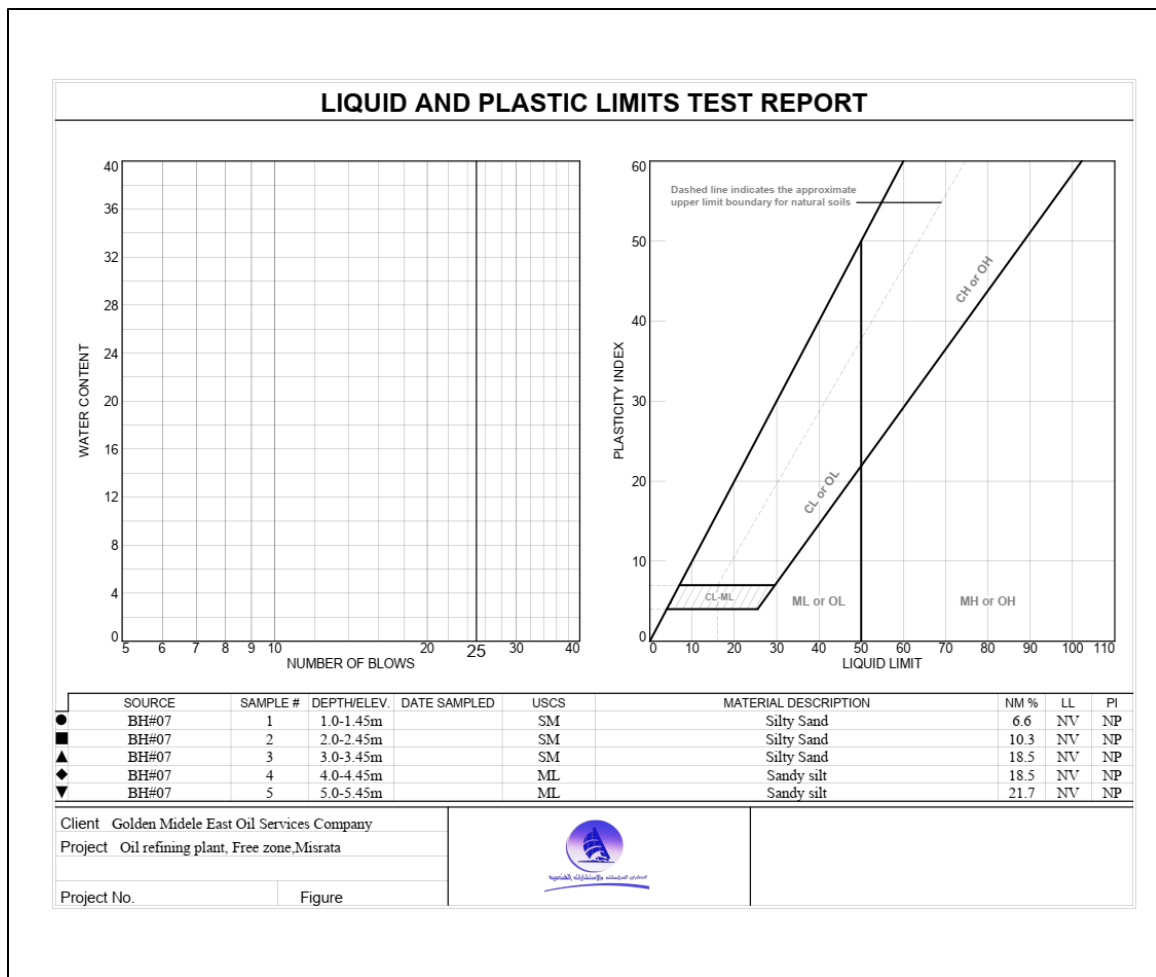
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	N° Job: 226 N° Revision: 0.0			
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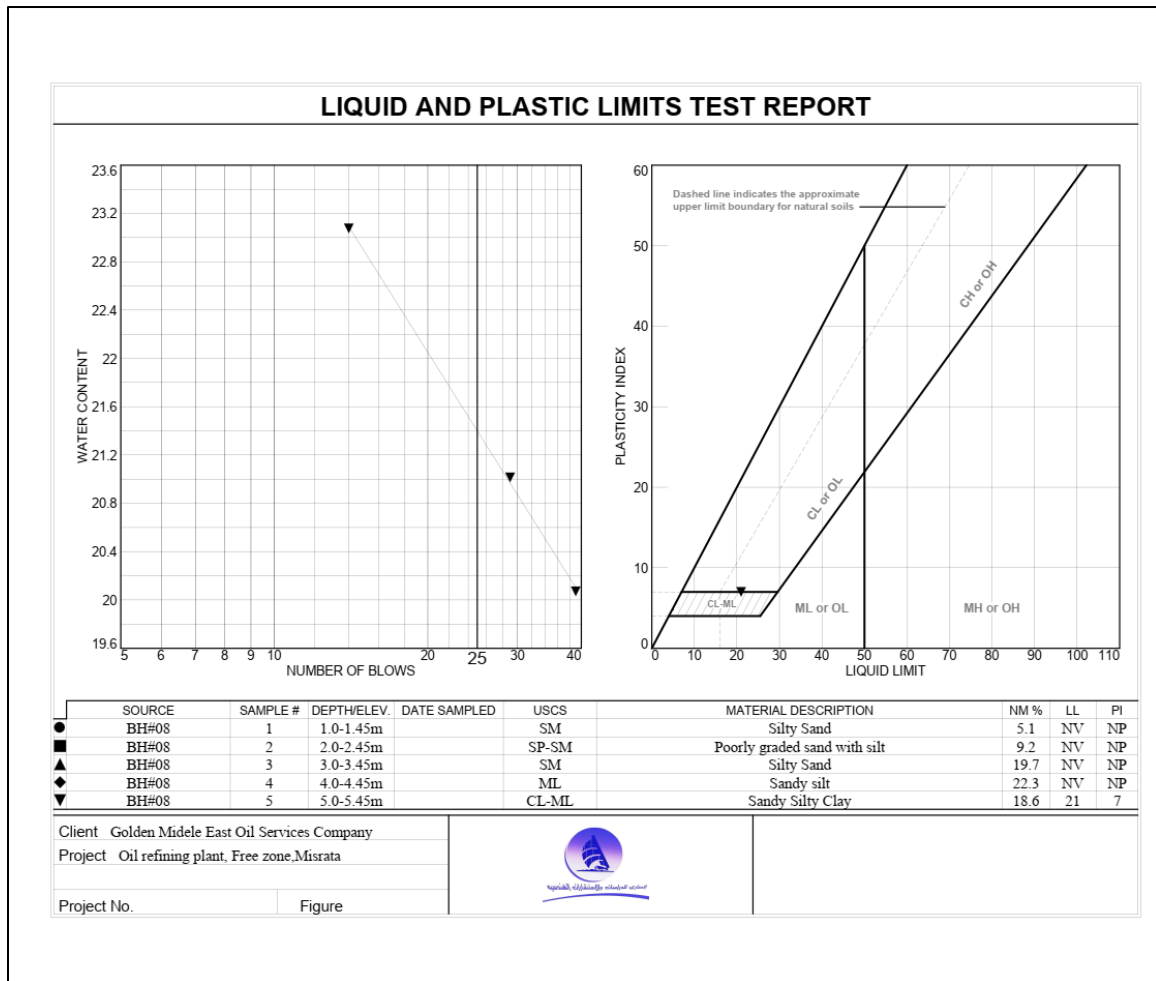
	Project: The construction of oil refining factory, Misratah.			
	N° Job: 226 N° Revision: 0.0			
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	Project: The construction of oil refining factory, Misratah.			
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APPENDIX 'D'

Allowable bearing capacity of soil (ABC)

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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	11	145.03	132.24	124.86	194.87	31.9
	2.45	3	38.34	34.96	33.01	51.51	27.6
	3.90	2	21.07	19.22	18.14	28.32	26.8
	4.45	3	34.19	31.18	29.44	45.94	27.8
	5.45	8	105.74	96.42	91.04	142.09	32.6
	8.95	37	481.26	438.84	414.33	646.68	42.5
	10.0	35	463.28	422.45	398.86	622.52	42.5
	1.45	11	145.03	132.24	124.86	194.87	25.2
End of boring							
BH-02	0.0	←Existing ground level					
	1.45	10	130.52	119.02	112.37	175.39	31.4
	2.45	4	51.12	46.61	44.01	68.69	28.3
	3.45	3	32.97	30.06	28.38	44.30	27.6
	4.45	3	45.59	41.57	39.25	61.26	28.6
	5.45	4	52.87	48.21	45.52	71.04	29.4
End of boring							
BH-03	0.0	←Existing ground level					
	1.45	9	116.02	105.80	99.89	155.90	30.8
	2.45	4	51.12	46.61	44.01	68.69	28.3
	3.45	3	32.97	30.06	28.38	44.30	27.6
	4.45	3	45.59	41.57	39.25	61.26	28.6
	5.45	2	31.72	28.93	27.31	42.63	27.8
End of boring							

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BH-04	0.0	←Existing ground level					
	1.45	8	101.52	92.57	87.40	136.41	30.2
	2.45	3	38.34	34.96	33.01	51.51	27.6
	3.45	2	21.98	20.04	18.92	29.53	26.8
	4.45	4	56.98	51.96	49.06	76.57	29.4
	5.45	3	42.30	38.57	36.42	56.84	28.6
End of boring							
BH-05	0.0	←Existing ground level					
	1.45	8	101.52	92.57	87.40	136.41	30.2
	2.45	4	51.12	46.61	44.01	68.69	28.3
	3.45	3	32.97	30.06	28.38	44.30	27.6
	4.45	3	34.19	31.18	29.44	45.94	27.8
End of boring							
BH-06	0.0	←Existing ground level					
	1.45	8	101.52	92.57	87.40	136.41	30.2
	2.45	5	63.89	58.26	55.01	85.86	29.0
	3.45	3	43.96	40.08	37.84	59.07	28.3
	4.45	2	22.79	20.79	19.62	30.63	27.0
	5.45	2	21.15	19.28	18.21	28.42	27.0
End of boring							
BH-07	0.0	←Existing ground level					
	1.45	8	101.52	92.57	87.40	136.41	30.2
	2.45	5	63.89	58.26	55.01	85.86	29.0
	3.45	2	21.07	19.22	18.14	28.32	26.8
	4.45	3	45.59	41.57	39.25	61.26	28.6
	5.45	3	42.30	38.57	36.42	56.84	28.6
End of boring							
BH-08	0.0	←Existing ground level					
	1.0-1.45	9	116.02	105.80	99.89	155.90	30.8

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BH-08	2.45	6	76.67	69.92	66.01	103.03	29.6
	3.90	2	21.07	19.22	18.14	28.32	26.8
	4.45	3	45.59	41.57	39.25	61.26	28.6

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).

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APPENDIX 'E'

Photos of drilling and Samples

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Photo No. 1: Borehole#01 (Misurata free zone, Misurata city). Date:06/03/22



Photo No. 2: Borehole#02 (Misurata free zone, Misurata city). Date:06/03/22

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Photo No. 3: Borehole#03 (Misurata free zone, Misurata city). Date:06/03/22



Photo No. 4: Borehole#04 (Misurata free zone, Misurata city). Date:06/03/22

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Photo No. 5: Borehole#05 (Misurata free zone, Misurata city). Date:06/03/22



Photo No. 6: Borehole#06 (Misurata free zone, Misurata city). Date:06/03/22

	Project: The construction of oil refining factory, Misratah.			
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Photo No. 7: Borehole#07 (Misurata free zone, Misurata city). Date:06/03/22



Photo No. 8: Borehole#08 (Misurata free zone, Misurata city). Date:06/03/22

	Project: The construction of oil refining factory, Misratah.			
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Photo No 9: samples series along depth, BH#01 (Misurata free zone, Misurata city).



Photo No 10: samples series along depth, BH#02 (Misurata free zone, Misurata city).

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Photo No 11: samples series along depth, BH#03 (Misurata free zone, Misurata city).

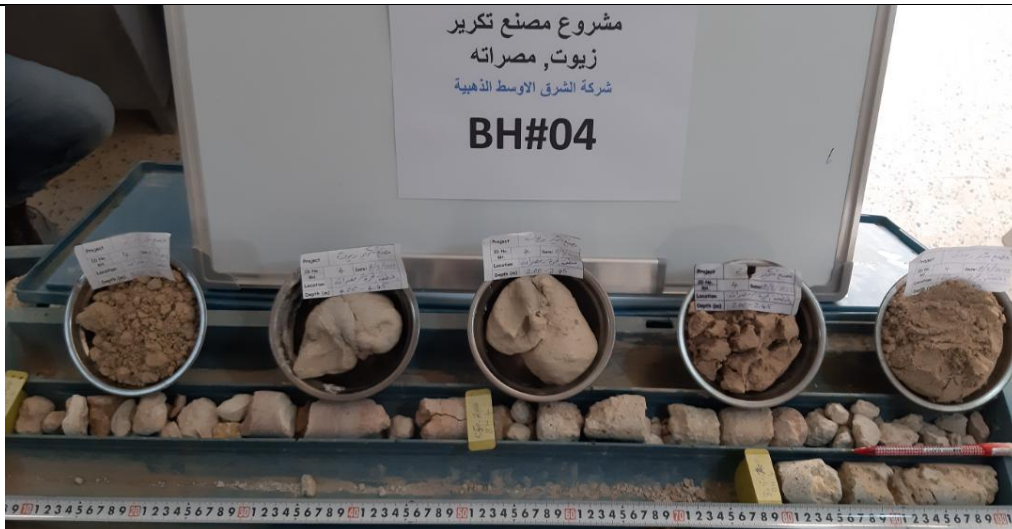


Photo No 12: samples series along depth, BH#04 (Misurata free zone, Misurata city).

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Photo No 13: samples series along depth, BH#05 (Misurata free zone, Misurata city).



Photo No 14: samples series along depth, BH#06 (Misurata free zone, Misurata city).

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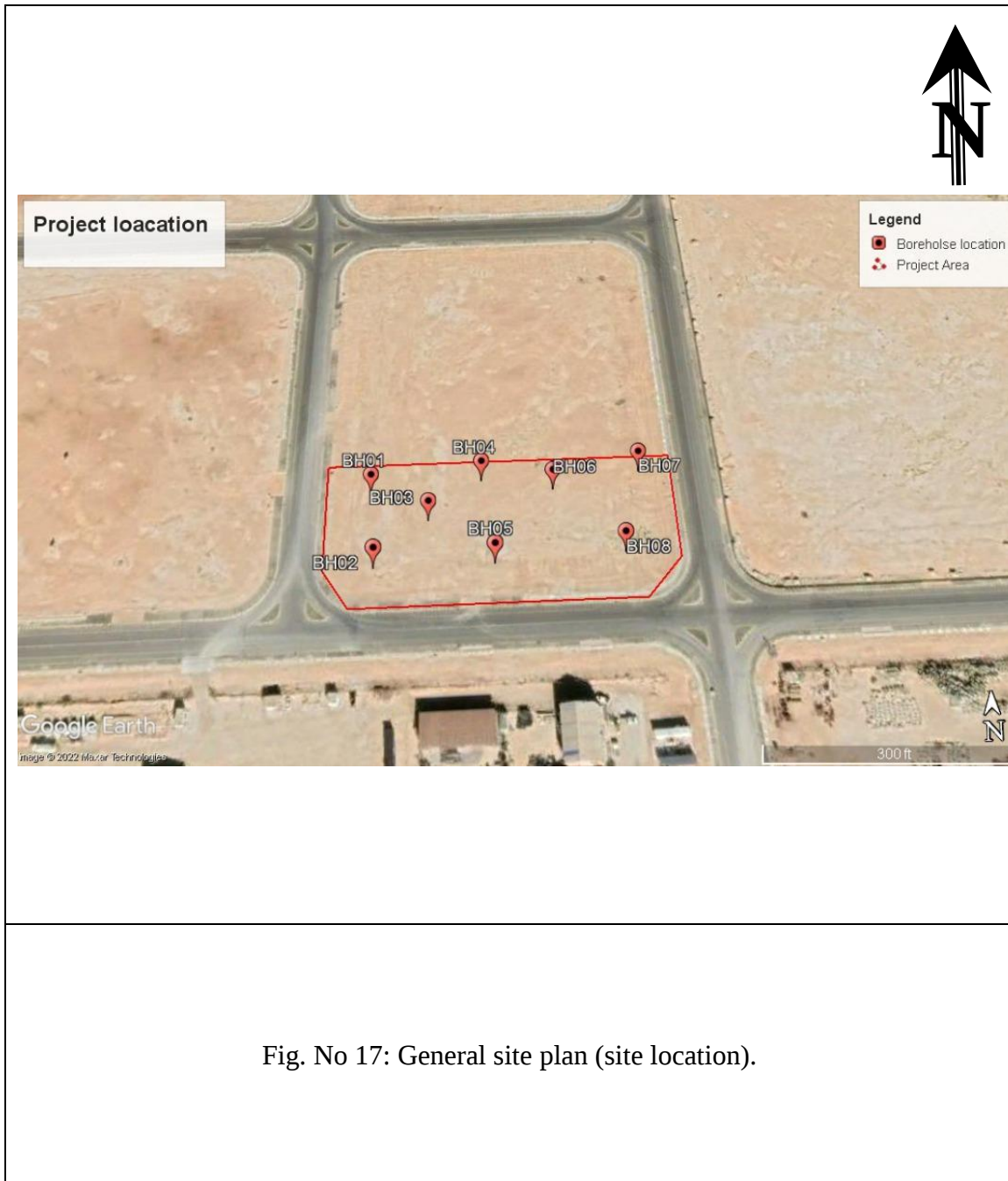


Photo No 15: samples series along depth, BH#07 (Misurata free zone, Misurata city).



Photo No 16: samples series along depth, BH#08 (Misurata free zone, Misurata city).

	Project: The construction of oil refining factory, Misratah.			
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APPENDIX 'F'

Requirement for concrete exposed to sulphate attack

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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		In ground-water		Minimum cement (1) content	Maximum water/cement (1) ratio
[-]	[%]	SO ₃ in 2:1 water : soil extract [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)	250	0.70
				Portland Blastfurnace Cement (PBFC)	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	330	0.50
				OPC or RHPC combined with minimum 70% or maximum 90% slag (5)	310	0.55
				OPC or RHPC combined with minimum 25% or maximum 40% pfa (6)	290	0.55
3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	Sulphate Resisting Portland cement (SRPC)	380	0.45
				OPC or RHPC combined with minimum 70% or maximum 90% slag	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 mortar 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 blastfurnace 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.

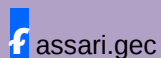
CONCRETE IN SULPHATE - BEARING SOILS AND GROUNDWATER
Building Research Establishment Digest No. 250, June 1981

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Rev.	Date	Description	Prepared	Verified	Approved
		Project: The construction of oil refining factory, (Misratah city).			
		Client: Golden Middle East Oil Services Co.			
		Location: Misurata free zone area, Misurata city -Libya			
00	06/3/22	Issue for approval	Eng. Abubaker	Eng. Ali	Eng. Ali