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Evalution of the Different Foundation Beds at Barwa Area by Using Geophysical and Geotechnical Studies.

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ABSTRACT

This research involves the geotechnical properties of different foundation beds of Barwa area. The study area is characterized by very gentle topography and lack of sharp relief and is covered by Miocene, Oligocene and Eocene deposits which are mainly composed of sands and gravels intercalated with clay lenses. The investigation results of sands at foundation levels reveal that the average value of effective diameter is 1.59, uniformity coefficient is 25.98, coefficient of curvature is 1.88, friction angle average is 36°.

The investigation results of clays at foundation levels reveal that the average value of moistuer content ranges from 12.5 to19.58%, liquid limit ranges from 21.19 to 69.22%, plastic limit ranges from 16.81 to 27.93%, shrinkage limit ranges from 7.11 to 11.45%, plasticity index ranges from 10.78 to 46.63%, liquidity index ranges from -0.44 to 0.01%, consistency index ranges from 1.21 to 1.44% and free swelling ranges from 125 to 155%. The results of chemical analysis for soil samples reveal that the average value of p^H is 8.15%, sulfates is 0.1328% and chlorides is 0.11281%. According to Egyptian code (2001), more than 50% of the studied samples are non aggressive soil.

There are three main geoelectric layers of different lithologies and thickness; besides the surface layer.

- The surface layer has a wide range of it's resistivity values ranging between 23 and 319 Ohm-m. This layer is composed of sand with gravels with clayey sand.
- The first layer has a resistivity value > 500 Ohm-m and thickness varying from 3 m to 7 m. This layer is composed of sand with gravel.
- The second layer has a relatively low resistivity value < 15 Ohm-m and its Thickness varying from 7m to 12m. This layer is composed of sandy clay.
- The third layer has a resistivity value ranging from 15 to 100 Ohm-m and its thickness varying from 16m to 26m.This layer is composed of fine sand to sandy gravel.

The velocity waves (V_p) of the first layer range between 380 to 1150 m/Sec. In the second layer the velocity waves (V_p) range between 560 and 3650 m/Sec. The average of poison ratio for the first layer is ranging between 0.235 and 0.327 and from 0.235 to 0.237 in the second layer.

Keywords: Soil, effective diameter, Uniformity coefficient, coefficient of curvature.

Introduction

The present study deals with geotechnical and geophysical studies to get information about the foundations bed and determine the risk zone of the urbanized. Barwa is considered as a new City project. Our study area is new Cairo City extensions and named "Barwa" and having an area of approximately 8.5 Sq.Km. The study area is defined by the following Co-Ordinates. Longitudes 31°33′05" and 31°35′45" E and Latitudes 29°59′40" and 30°01′40" N. It bounded between Cairo Suez Desert Road from the north, El-Qattamiya-Ain El-Sokhna Road from the south, Ring Road

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from the west and Regional Eastern Road from the east (Fig.1). The research work involved a number of field disturbed soil samples were collected and analyzed for various index and engineering parameters. The laboratory experiments which were carried out on these samples are: grain size analysis (54 samples), direct shear test (20 samples), chemical analysis (32 samples), atterberg limits (8 samples) and free swell testing (8 samples). The soil of the study area was classified on the basis of their engineering behavior according to unified soil classification systems (USCS) and classification proposed by international association of engineering geologists **(IAEG, 1981).**

Experimental Work:

Samples were selected thoroughly to cover the different soil types and features present in each area to assist in defining the specifications of the region and propose the best solution or how to treat with its defects program is designed to serve the aim of this research. The laboratory tests were selected to obtain the required physical and mechanical properties of soils to evaluate the different foundation beds for new Cairo City extensions (Barwa).The laboratory experiments which were carried out on soils are: grain size analysis (54 samples), direct shear test (20 samples), chemical analysis (32 samples), atterberg limits (8 samples) and free swell testing (8 samples).

In this study the direct shear test is used to estimate the shear strength parameters.

The chemical analysis, in its simplest sense, is mainly used to determine the degree of aggressive of soils. By determine the organic, sulphate and chloride salts content. The water extraction method can be used for the sulphate, chloride, and p^H values.

Filed Work:

a. Geoelectric Survey:

It includes two types of field survey in the study area, the geoelectric survey and topographic survey. Atotal of 24 Shlumberger vertical electric soundings have been conducted at the study area.

b. Shallow Seismic Survey:

The In-line offset reversed layout was applied in shooting each spread. Along each spreads a total of 23 geophones were laid out with 5 m distance between each two successive geophones. The shot points were so arranged that 2 offset shots, for normal and reverse shooting, were displaced a distance of 5 m from the first geophone. A sledge hammer (10 kg) was used as an impulse energy source for producing the compressional wave (P-wave) at each shot point.

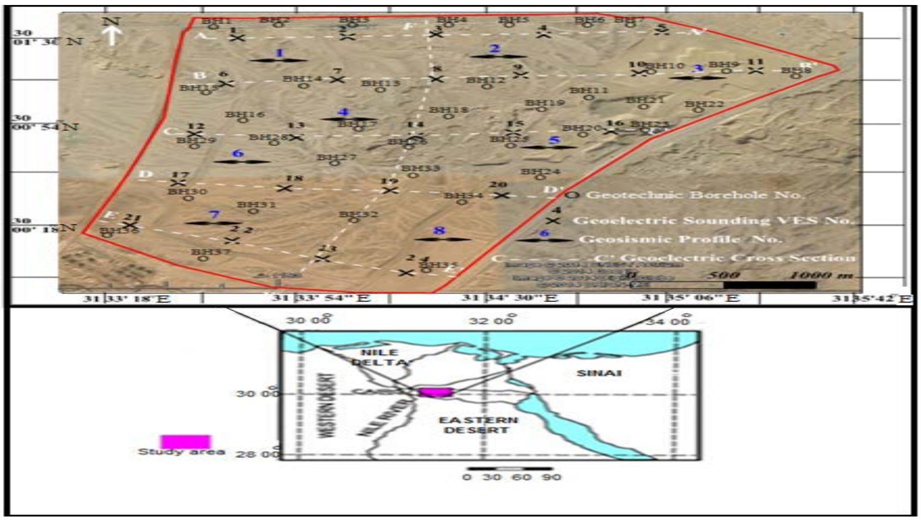

Fig. 1: Location Map of the Study Area**.**

Geologic Setting:

The geology of the study area was studied by many authors such as ***Abd El-All et al.(1982)***. In addition to many other works. The study area is essentially built of sedimentary rocks in addition to some patches of basaltic flows in several localities ranging in age from Middle Eocene to Upper Miocene.

Oligocene Age:

The Oligocene sediments are represented mainly by the Cairo Facies (Gebel Ahmer Formation). Basaltic flows are recorded at the top of the Oligocene sediments in this Facies(Fig.2).Oligocene sediments are lacking in the Helwan area south of the study area ***(Swedan 1991)***.

Miocene Age:

The Miocene sediments cover a large area of the Cairo-Suez district and form less conspicuous topographic features than the Eocene rocks. They are found in

sporadic patches all over the greater Cairo area. According to ***Abu Khadrah (1968) and Hussein (1980)*** divided the Miocene sediments in the Cairo-Suez district into two units: Marine Miocene and non marine Miocene.

A: -Marine Miocene (Hommath Formation):

This unit overlies Oligocene sands and gravels in some areas and basaltic flows in others, it underlies non marine Miocene sands and gravels. The thickness in the area east of Cairo (60 m) in Gebel Anqabiya.

The marine Miocene section occurs as patchy, isolated outcrops along the Cairo-Suez road, but eastward it covers bigger areas, these outcrops are controlled by a system of faults trending east west. Theyare made up of sparsely fossiliferous calcareous sandstone and arenaceous limestone ***Swedan(1991)***.

B: - Non-Marine Miocene (Hagul Formation):

This unit covers most of the northeastern part of the study area. It is also exposed along both sides of the Cairo-Suez Road, with an average thickness of 40 m at Gebel El-Nassuri Gebel El-Anqabiya area. It is usually composed of white to grayish white, coarse grained quartz sands, crossbedded in parts and unstratified in others. The sand section is intercalated by gravels beds composed of well rounded flint pabbles associated with fossil wood.

Pliocene Age:

At Gebel El-Nassuri, El-Anqabiya, El-Hamza and Um Qamer, on the top of non marine Miocene found Pliocene sediments represented by crossbedded sands with some clay and conglomerate capped by a thin bed (0.56 m) white hard, very dense limestone.

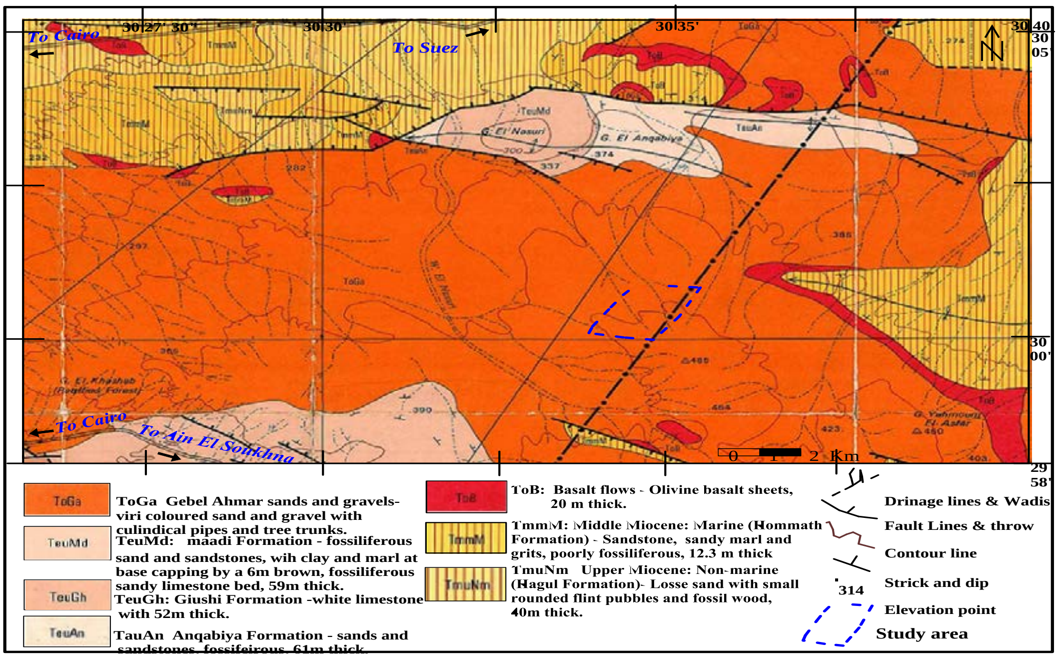

Fig. 2: Geological Map of the Area under Study and Its Vicinities(After EGSMA,1983).

Geotechnical Studies:

The foundationbeds of the new Cairo City extensions(Barwa)are the soil which are mainly composed of sands and gravels intercalated with clay lenses. The laboratory tests on sands are sieve analysis, direct shear test and chemical analysis but the laboratory tests of clays are the initial water content, atterberg limits and free swell test.

Grain Size Analysis:

The quantitative data that an engineer needs depend upon the mechanical properties such as stiffness and strength, and these must be determined from mechanical tests. Coarse grained soils have good bearing capacities and good drainage qualities, and their strength volume change characteristics are notsignificantly affected by change in moisture conditions. Fine grained soils have less load bearing capacities compared with coarsegrained. The results of the mechanical analysis are tabulated in table (1) and the data are represented in cumulative curves (Fig. 3) for samplesNo. 1.1, 1.2, 2.1and 2.2 .

Table 1: Sieve Analysis of the Studied Samples.

Sieve opening (mm) / Sample No.	Finer (Passing) weight (%)							Statistical parameters				
	4 - 2	2 -1	1 - 0.5	0.5 - 0.25	0.25 - 0.125	0.125 - 0.063	0.063 - 0.032	D_{10}	D_{30}	D_{60}	C_U	C_C
1.1	84.22	81.30	65.32	38.22	28.87	24.27	19.67	0.020	0.260	0.750	9.370	1.120
1.2	84.33	75.11	59.51	27.46	14.14	9.17	6.12	0.163	0.450	0.961	5.890	1.293
2.1	82.46	62.14	44.10	24.48	15.92	11.90	8.84	0.095	0.501	1.900	20.00	1.391
2.2	81.66	67.74	50.83	28.00	14.56	9.08	5.85	0.165	0.451	1.459	8.842	0.845
3.1	25.48	8.60	3.36	1.40	1.06	0.80	0.60	2.110	5.055	8.100	3.839	1.495
3.2	75.64	65.54	51.25	27.90	17.35	12.64	8.84	0.092	0.450	1.500	16.30	1.467
4.1	96.00	91.59	78.39	37.69	16.68	10.66	7.66	0.135	0.360	0.609	4.511	1.576
5.1	94.05	78.14	52.04	24.65	13.44	9.00	6.71	0.163	0.499	1.100	6.748	1.389
5.2	81.12	69.24	46.56	25.24	15.34	9.76	6.49	0.158	0.499	1.515	9.589	1.040
6.1	100	98.00	89.40	55.71	28.65	13.54	7.09	0.100	0.255	0.465	4.650	1.398
6.2	93.51	84.24	61.13	27.00	15.55	10.86	8.43	0.125	0.450	0.844	6.752	1.919

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7.1	96.67	89.88	68.02	26.99	11.62	6.62	4.85	0.201	0.440	0.741	3.687	1.300
8.1	100	94.28	76.19	38.38	16.25	8.27	5.17	0.168	0.350	0.611	3.637	1.193
8.2	64.51	42.54	21.14	7.64	4.22	3.22	2.44	0.480	1.300	4.000	8.333	0.880
9.1	100	99.34	97.34	50.91	23.46	11.72	7.63	0.110	0.390	0.495	4.500	2.793
9.2	100	97.34	82.05	48.50	25.80	13.11	9.99	0.075	0.270	0.515	6.867	1.887
10.1	95.81	89.08	67.84	40.21	16.50	8.02	5.36	0.170	0.340	0.695	4.088	0.978
10.2	99.12	98.10	82.32	42.82	22.73	13.66	8.46	0.090	0.300	0.590	6.556	1.695
11.1	100	97.66	83.00	30.46	12.80	8.38	5.42	0.190	0.418	0.610	3.211	1.508
11.2	95.59	91.38	52.62	21.46	12.40	8.19	5.30	0.194	0.508	1.000	5.155	1.330
12.1	97.47	92.72	80.02	46.36	23.12	11.71	7.09	0.120	0.296	0.585	4.875	1.248
12.2	98.27	93.52	72.21	20.45	11.24	6.02	4.66	0.220	0.490	0.700	3.182	1.559
13.1	71.12	67.09	56.28	18.59	9.14	5.37	4.80	0.255	0.508	1.100	4.314	0.920
13.2	96.69	90.13	69.65	18.11	10.72	7.68	6.74	0.225	0.500	0.715	3.178	1.554
14.1	96.42	94.55	86.39	55.67	32.58	13.13	10.08	0.075	0.240	0.475	6.333	1.617
15.1	100	96.67	91.48	49.65	24.70	10.99	7.84	0.125	0.290	0.500	4.000	1.346
16.1	81.52	79.49	76.68	49.62	22.07	12.91	8.45	0.090	0.297	0.560	6.222	1.750
16.2	91.94	85.99	55.52	15.84	10.75	8.29	6.61	0.200	0.445	0.985	4.925	1.005
17.1	91.16	89.97	86.40	68.50	32.04	14.39	9.27	0.080	0.240	0.390	4.875	1.846
17.2	40.14	28.39	20.49	14.21	9.79	6.84	4.43	0.255	2.180	12.55	49.23	1.484
18.1	98.46	95.01	81.50	33.55	15.97	9.84	6.98	0.150	0.359	0.610	4.067	1.705
18.2	90.35	87.58	80.81	52.30	19.00	9.00	6.17	0.159	0.300	0.502	3.157	1.128
19.1	95.11	90.69	74.12	29.23	11.83	4.87	2.00	0.210	0.425	0.690	3.286	1.247
19.2	88.39	83.76	78.38	48.00	22.46	9.34	5.55	0.158	0.296	0.566	3.582	0.980
20.1	93.14	91.52	89.96	76.92	35.18	15.88	9.86	0.076	0.189	0.350	4.605	1.343
20.2	100	99.60	98.28	67.84	42.58	14.76	7.29	0.098	0.200	0.365	3.724	1.118
21.1	87.00	77.62	62.92	38.82	19.00	10.50	7.38	0.147	0.328	0.790	5.374	0.926
21.2	97.90	96.34	91.28	36.54	18.99	9.47	5.64	0.154	0.360	0.589	3.825	1.429
22.1	21.37	11.66	7.36	4.78	2.43	1.06	0.80	1.500	5.995	12.15	8.101	1.972
22.2	93.35	92.70	87.17	41.51	17.14	8.70	5.60	0.160	0.330	0.580	3.625	1.173
23.1	98.88	94.88	73.49	28.14	16.55	8.57	6.95	0.160	0.227	0.695	4.344	0.463
24.1	98.46	95.53	77.31	39.79	17.79	8.16	5.24	0.163	0.339	0.605	3.712	1.165
24.2	100	96.12	76.93	23.65	13.16	7.97	6.23	0.190	0.460	0.790	4.158	1.410
25.1	100	95.07	79.61	32.15	10.98	5.38	3.12	0.225	0.400	0.615	2.733	1.156
25.2	98.29	96.35	88.79	41.49	14.89	8.95	6.18	0.160	0.338	0.559	3.494	1.277
26.1	95.79	86.01	55.79	30.88	15.73	8.38	5.62	0.165	0.410	0.945	5.727	1.078
26.2	99.10	96.05	78.19	33.48	13.99	6.99	4.01	0.198	0.398	0.618	3.121	1.295
27.1	94.74	88.82	67.60	28.86	12.86	7.38	5.22	0.191	0.426	0.710	3.717	1.338
27.2	98.44	93.04	73.05	37.83	17.74	10.46	6.97	0.141	0.340	0.650	4.610	1.261
28.1	13.23	5.05	3.70	2.08	1.91	1.72	1.67	3.111	6.000	9.455	3.039	1.224
28.2	96.56	94.26	87.63	35.45	19.04	10.11	8.25	0.150	0.360	0.599	3.993	1.442
29.1	82.51	77.73	58.74	21.41	13.58	7.63	6.17	0.192	0.500	0.900	4.688	1.447

U.C : Uniformity Coefficient. E.D: Effective Diameter (D10). C.C : Curveture of Cofficient.

Parameters Obtained from Grain Size Distribution Curve:

1- Uniformity Coefficient U.C (measure of the particle size range) U.C is also called Hazen Coefficient

U.C = D60/D10 U.C < 5 --Very Uniform, U.C = 5 -- Medium Uniform, U.C >5 --No uniform

2- Coefficient of Gradation or Coefficient of Curvature C.C (Measure of the shape of the particle size curve)

C.C = $(D30)^2$ / D60 x D10 C.C from 1 to 3 --- well graded

From the table (1) the values of uniformity coefficient indicated that, the studied area is characterized by a range between well – graded and poorly graded soil.

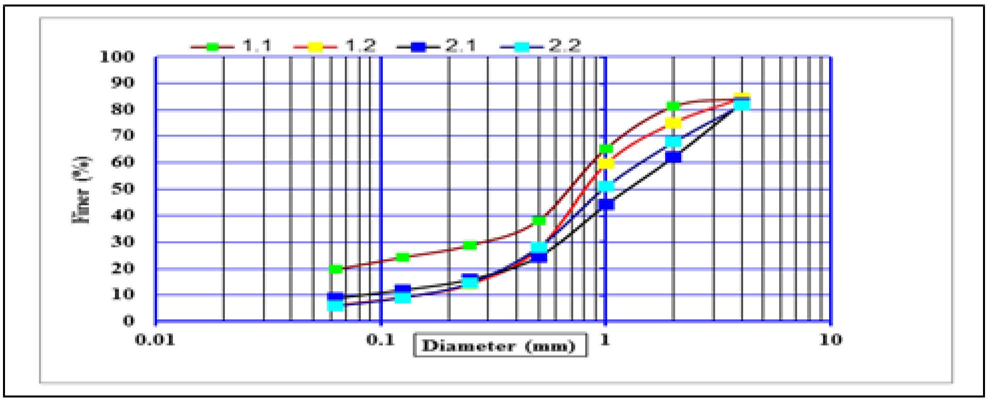

Fig. 3: Grain Size Distribution Curves of Samples No. 1.1, 1.2, 2.1and 2.2.

Direct Shear Test :

The importance of shear strength of soil becomes of primary importance in all stability problems such as bearing capacity of shallow foundation, stability of slopes, lateral earth pressure used to design of retaining wall and sheet pile walls.

The aim of this experiment is to estimate the shear strength parameters angle of internal friction (∅) and Cohesion (C).Consider an assemblage of soil particles confined between two plates of rough surfaces. Let a vertical stress (σ) and shear stress (τ), both per unit gross area, be applied to the assemblage. The behavior upon application of (τ) depends on the losseness or denseness to which the grain are originally packed friction angle average is 36°. The shear stress versus normal stress of some samples showed in Fig.(4).

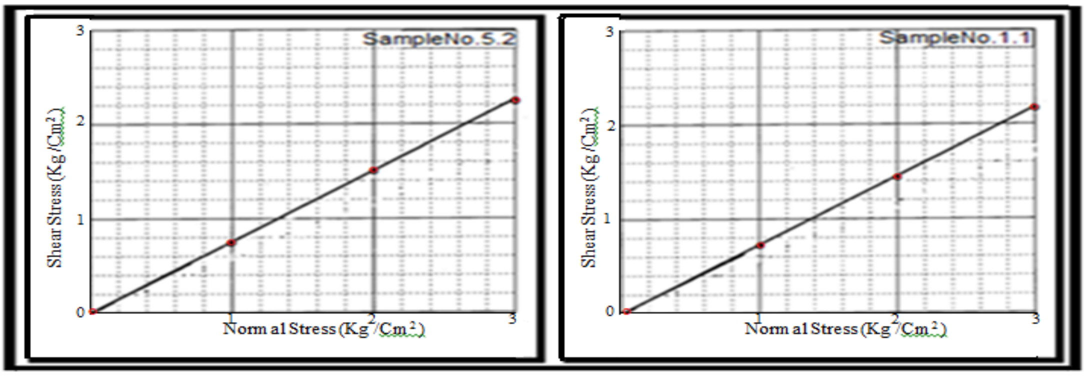

Fig.4: Shear Stress Versus Normal Stress of Samples No .(5.2 and 1.1).

Table 2: Friction Angle and Cohesion of the Studied Samples.

Sample No.	Normal stress (kg/cm2)	Peak shear stress (Kg/cm2)	Friction angle (∅)	Cohesion C (Kg)
1.1	1.00 2.00 3.00	0.76 1.42 2.18	35°	0.00
3.2	1.00 2.00 3.00	0.78 1.49 2.24	37°	0.00

5.2	1.00 2.00 3.00	0.86 1.46 2.21	37°	0.00
6.2	1.00 2.00 3.00	0.75 1.41 2.17	35°	0.00
7.1	1.00 2.00 3.00	0.89 1.49 2.22	37°	0.00
8.1	1.00 2.00 3.00	0.77 1.43 2.19	35°	0.00
9.2	1.00 2.00 3.00	0.75 1.42 2.17	35°	0.00
10.2	1.00 2.00 3.00	0.76 1.41 2.18	35°	0.00
15.2	1.00 2.00 3.00	0.88 1.48 2.21	36°	0.00
16.2	1.00 2.00 3.00	0.76 1.42 2.18	36°	0.00
17.2	1.00 2.00 3.00	0.78 1.44 2.20	36°	0.00
18.1	1.00 2.00 3.00	0.90 1.50 2.23	36°	0.00
19.2	1.00 2.00 3.00	0.75 1.44 2.17	36°	0.00
20.1	1.00 2.00 3.00	0.85 1.45 2.20	37°	0.00
23.1	1.00 2.00 3.00	0.87 1.47 2.22	37°	0.00
24.2	1.00 2.00 3.00	0.78 1.48 2.24	36°	0.00
25.2	1.00 2.00 3.00	0.87 1.47 2.23	37°	0.00
26.2	1.00 2.00 3.00	0.77 1.48 2.24	36°	0.00
28.2	1.00 2.00 3.00	0.74 1.41 2.17	35°	0.00
29.2	1.00 2.00 3.00	0.75 1.40 2.17	36°	0.00

Chemical Aanalysis:

The purpose of chemical analysis is to determine the degree of aggressive for soil and ground water samples, and to evaluate the ground water samples for drinking purposes. The results of chemical analysis are given in table (3). The values of p^H of the studied samples range from 6.1 (moderately aggressive) to 7.9 (non aggressive) with an average 7 (non aggressive). The values of sulphates range from 0.001% (non aggressive) to 0.88% (aggressive) with an average 0.491%

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(moderately aggressive). The values of cholorides are ranging from 25.89ppm (non aggressive) to 1380 ppm (aggressive) with an average 702.95ppm (moderately aggressive). According to Egyptian code (2001), more than 50% of the studied samples are non aggressive soil.

Table 3: Guiding Values of Determine Aggressive Degree of the Soil at Barwa Area.

Sample No.	E.C.	T.D.S.	SO_3%	P^H	C_1%
2.1	-	-	0.127	7.2	0.178
4.1	176	118	0.143	7.63	0.022
5.2	-	-	0.092	7.1	0.169
6.1	119	1311	0.11	7.62	0.075
7.1	-	-	0.056	7.3	0.233
9.1	117	176	0.188	7.34	0.047
10.1	-	-	0.18	7	0.113
11.2	-	-	0.142	7	0.069
12.2	-	2813	0.171	7.41	0.062
13.1	3020	-	0.20	7.1	0.027
14.1	-	-	0.11	7.2	0.071
15.1	-	81	0.068	9.3	0.044
16.2	285	185	0.092	7.39	0.038
17.2	-	-	0.094	7.1	0.060
19.2	-	200	0.126	9.3	0.237
20.1	-	-	0.134	7.2	0.209
21.1	286	186	0.11	7.39	0.071
22.1	-	-	0.144	7.1	0.053
23.1	1570	-	0.155	7.5	0.022
24.2	1550	210	0.168	7.2	0.155
25.2	3000	-	0.077	7	0.044
26.1	3150	-	0.044	7	0.013
28.1	-	-	0.147	7.2	0.024
29.1	-	-	0.154	7.5	0.029
30.1	1480	-	0.084	8.01	0.049
31.2	1010	-	0.195	7.2	0.013
32.1	3010	-	0.169	7.3	0.018
33.1	2020	-	0.077	7.2	0.044
34.1	1552	-	0.044	7.3	0.013
35.1	1520	-	0.147	7.1	0.024
36.1	430	280	0.035	7.26	0.211
37.2	-	-	0.123	7	0.018

Geotechical Properties of Fine Soile:

Moistuer Content:

The moisture content is defined as the ratio of the weight of water (Ww) present in a given soil mass to the dry weight of solid soil particles (Wd).

The results of this test of the studied samples are given in table (4). The values range between 12.50 to 19.58%, average 16.04%.

Atterberg Limits and Consistency of Fine Soil:

Atterberg limits are empirically developed but widely used procedures for establishing and describing the consistency of soil. The engineering properties (uses) of fine grained soils are, generally, related to these index properties. The more plastic a soil means the more compressible, higher shrinkage-swell potential and the lower is its permeability will be **(Abramson *et al*., 1996).** Plastic index is important in classifying fine-grained soils and is fundamental to the Casagrande plasticity chart.

Liquid Limit (L.L):

The liquid limit is the water content at the point of transition of the clay sample from a liquid state to the plastic state.

The results of the liquid limit of studied samples are given in table (18) results of the liquid limit range between 21.19 to 69.22% (average 45.2%).

Plastic Limit (P.L):

The plastic limit is determined by rolling a small soil sample into threads and finding the water content at which threads approximately 3 mm in diameter will just start to crumble. The plastic limit depends on the type and amount of clay fraction in soil. The results of the plastic limit of studied samples are given in table(4). The values of the plastic limit range between 16.81 to 27.93% (average 44.74%).

Shrinkage Limit (S.L):

According to ***(Arora, 1988)*** the shrinkage limit is the water content below which no appreciable change in volume is observed**.** The results of this test are given in table (4). The values of this limit range between 7.11 to 11.45% (average 9.28). The shrinkage and its counterpart swelling of a cohesive soil are greatly influenced by the mutual arrangement of its constituent particles, i.e., its structure. For disturbed clay paste, low shrinkage limit values indicate a flocculated structure.

Plasticity Index (P.I):

The plasticity index is defined as the numerical difference between the liquid limit and the plastic limit. The values of the plasticity index are given in table (5). The value range from 10.78 (high plastic) to 46.63 (high plastic) average 28.70 (high plastic).

Liquidity Index (L.I):

It is the ratio of the difference between natural water content and plastic limit to the plasticity index.

The values of this liquidity index are given in table (5) and range between -0.44 to 0.01 an average (-0.215). The liquidity index of studied samples according to ***(Whitlow, 1983)***, is semi plastic or solid.

Table 4: Atterberg Limits and Free Swell Test of the Studied Samples.

Sample No.	Liquid Limit (L.L.)	Plastic Limit (P.L.)	Shrinkage Limit (S.L.)	Moisture Content %	Free Swell %
36.2	30.79	17.65	9.10	-	-
36.3	57.72	26.01	11.20	-	-
36.4	67.19	27.93	11.32	19.58	145
36.5	27.59	16.81	7.11	-	-
37.1	69.22	27.12	11.22	-	125
37.2	74.42	27.79	11.45	-	140
37.3	68.32	27.01	11.21	17.56	145
37.4	55.43	25.75	11.01	12.50	155

Table 5: Plasticity Index,Iquidity Index and Consistency Index of the Studied Samples:

Sample No.	Plasticity Index % (P.I.)	Liquidity Index % (L.I.)	Consistency Index% (C.I.)
36.2	13.14	-	-
36.3	31.71	-	-
36.4	39.26	0.01	1.21
36.5	10.78	-	-
37.1	42.10	-	-
37.2	46.63	-	-
37.3	41.31	-0.22	1.22
37.4	29.68	-0.44	1.44

Consistency Index (C.I):

The consistency is defined as the resistance of the soil to deformation ***(Arora, 1988).*** The values of this index are given in table(5).Results of the consistency index range between 1.21 to 1.44%. (average 1.32%). The studied samples consistency can be considered extremely stiff.

Free Swell Test:

The free swell tests consists of placing a known volume of dry soil in water and noting the swelled volume after the material settles, without any surcharge to the bottom of a graduated cylinder. The difference between the final and initial volume, expressed as a percentage of initial volume is the free swell value. According to **Bell (1983)**, soils having free swell value as high as 100% can cause considerable damage to lightly loaded structures, and soils having free swell value below 50% seldom exhibit appreciable volume change even under very light loadings. The values of the free swelling of the studied samples are given in Table (4) and range between 125 to 155 %. All samples have free swell of greater 50%. Hence, considerable attention should be given in foundation design even for light structures on such soils because their value shows expansiveness property.

Classification of Engineering Properties of Soil:

The classification of coarse grained soils (sand and sand with gravel) according to USCS (unified soil classification system) is showed in table (1). Some samples of coarse grained soil contain more than 12% of finer fractions or contain from 5% to 12% of finer fractions. The fine grained soils of the studied sample are classified by using plasticity chart according to **Casagrand's (1948),** (Fig.5) shows the claystone of study area can be classified as inorganic clay of high and very high plastic soil.

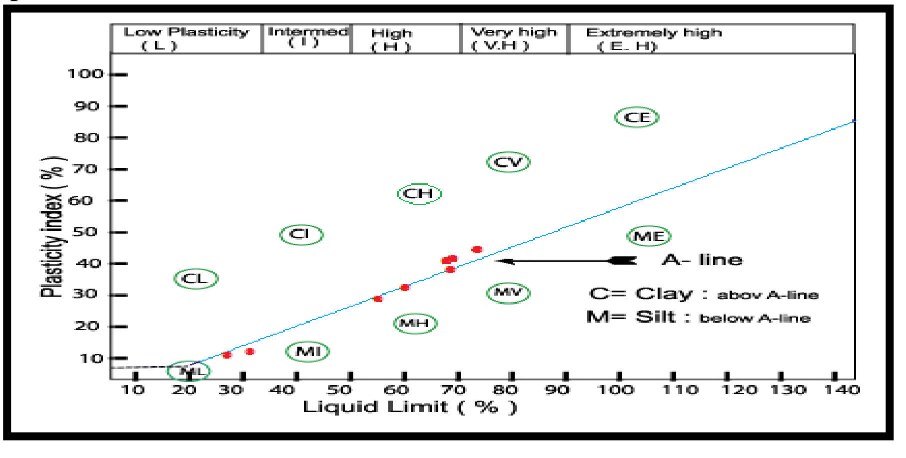

Fig. 5: Classification of Fine – Grained Soil ***(After Casagrand, 1948).***

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Geophysical Studies:

Geoelectric surveys are extensively used in civil engineering for determination of the depth of bedrock, weathered zone thickness, groundwater occurrences and clay extension, etc…

The electric parameters (resistivity and thickness of the different geoelectric layers) obtained from the interpretation of each VES sounding are given in Table (6).

Geoeletric Cross Sections:

Six geoelectric cross-sections have been illustrated along five profiles within the study area. These sections contain 24 VES'es to show the horizontal and vertical variations within the area of investigation.

For example:

Cross section F-F':

This geoelectric cross section (in the N-S direction) runs for about 4 km from VES No. 3 at the north, 8, 14, 19 to VES No. 23 at the south (Fig. 6). Three geoectric horizons can be distinguished along the cross section, beside the surface layer.

- The surface geoelectric layer shows resistivity values ranging from 29 to 319 Ohm.m. This layer has its maximum thickness 1.9 m under the sounding number 14. This layer is composed of sand with gravels and clayey sand.
- The first geoelectric layer has a relatively high resistivity values > 5oo Ohm.m and thickness of 15 m under VES No. 8. This layer is composed of sand with gravel. This layer is detected under VES No. 23.
- The second geoelectric layer has low resistivity values <15 Ohm.m and thickness reaching to 21 m under VES No. 19 and 11 m under VES No. 23. This layer is sandy clay.
- The third geoelectric layer is detected at VES No. 8. It has resistivity values ranging from 15 to 66 Ohm.m and thickness of 6 m, but under VES No. 8 it has a thickness of 9.5 m. This layer is composed mainly of fine sand to sandy gravel.

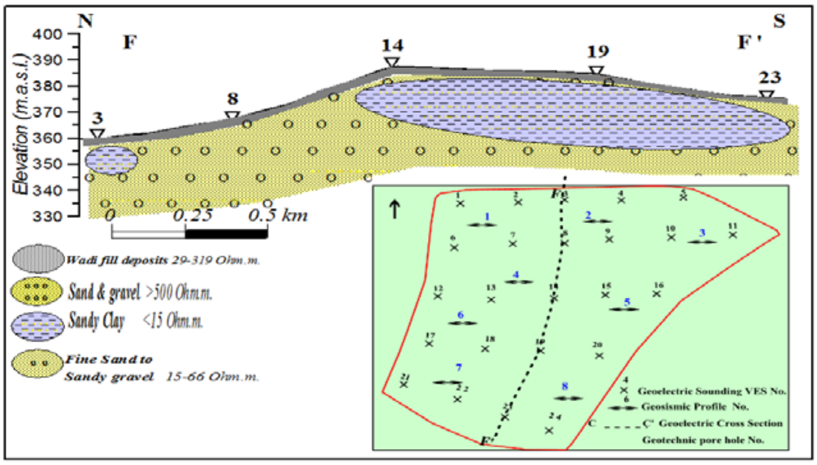

Fig. 6: Geoelectric Cross Section F F'.

Table 6: Interpreted Results of the Geoelectric Soundings (Resistivity (R) and Corresponding Thickness (H) of Different Geoelectric Layers).

Layer / VES No.	I		II		III		IV
	R_1	H_1	R_2	H_2	R_3	H_3	R_4
1	1	0.2	57	4.5	31	11.5	133
2	22	0.3	65	1.8	15.9	322	1233
3	66	0.2	127	2.5	77	6.5	342
4	12	2	5	5.8	32	16,9	135
5	56	0.2	117	4.5	61	11.5	133
6	5	2	77	4.5	21	21.5	129
7	21	0.2	67	2.5	31	5.5	133
8	11	2	117	9	323	23.5	121
9	23	2	122	22.5	92		
10	3	0.2	13	3.5	9	11.3	91
11	66	0.2	127	2.5	77	6.5	342
12	56	0.2	117	4.5	61	11.5	133
13	15	0.2	47	4.5	87	9.8	133
14	23	2	133	21.5	95		
15	56	0.2	117	4.5	61	11.5	132
16	92	0.2	232	8.5	42	12.5	132
17	23	2	132	21.5	95		
18	14	2	131	21.1	89		
19	35	2	132	3.5	95	16.3	53
20	25	2.1	132	21.3	97		
21	27	0.2	97	4.5	161	11.5	433
22	29	2	122	23.3	85		
23	46	1.8	119	4.2	61	12.3	107
24	51	0.2	117	4.4	51	11.5	133

Delineation of Clay Unit and Surface Layer in The Study Area:

The recognized clay layers in the study area, specially those layers which have shallow depth, must be taken into consecration for engineering purposes.

The following profiles for examples:

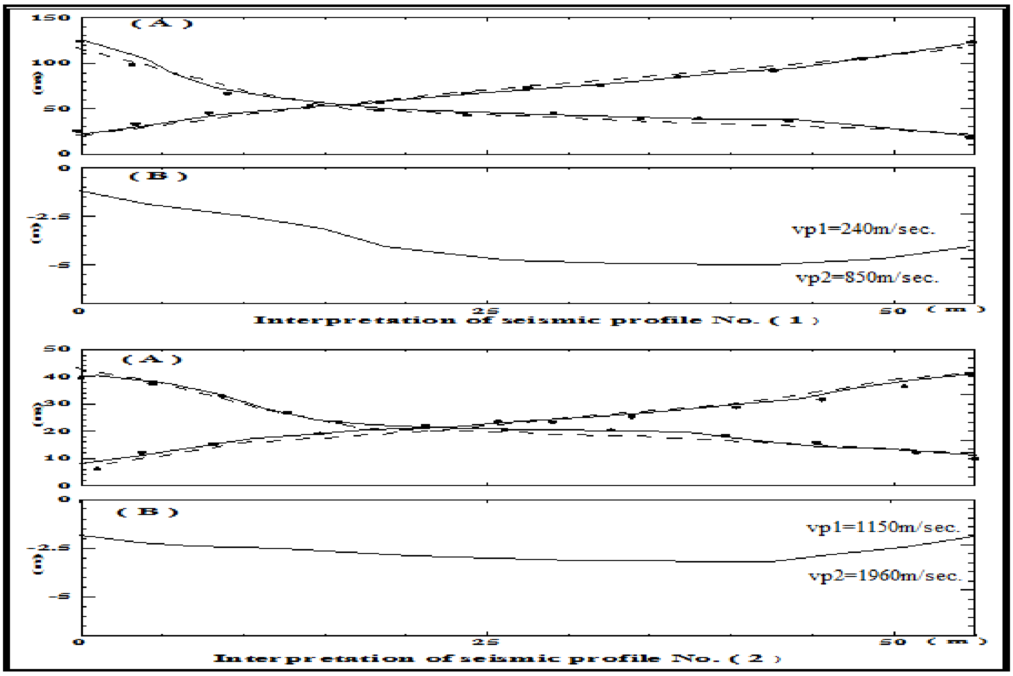

Fig. 7: Time – Distance Curve (A) and Depth-Distance Curve (B)of Profiles 1 & 2 of Compressional Waves V_p .

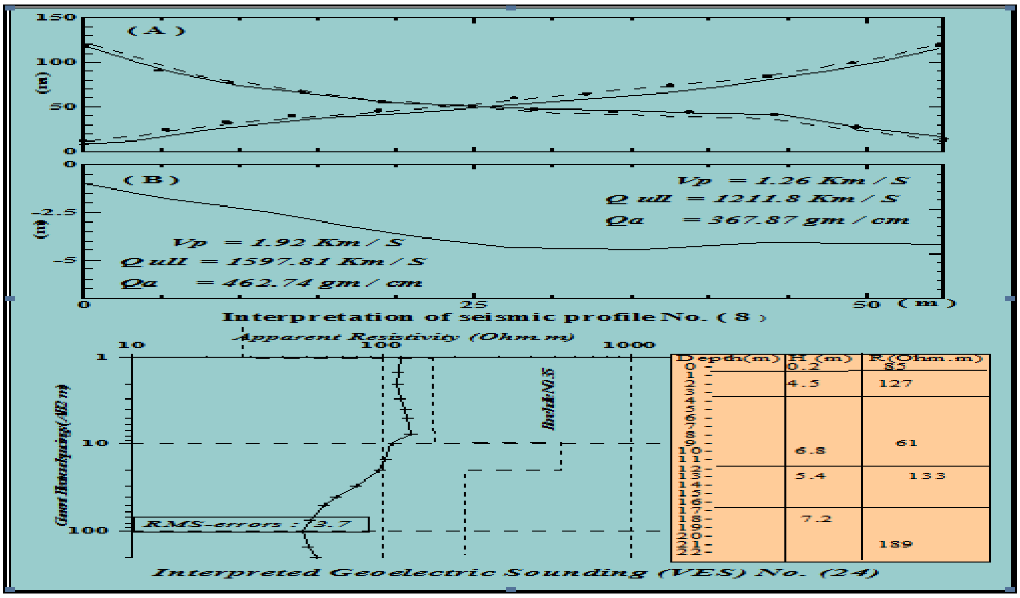

Fig. 8: Interpreted Seismic Profile, VES Curve and Borehole Description of Site No. (8).

Conclusions:

Sedimentological studies of Barwa area dealt with grain-size analysis. The results of grain size analysis proved that, the studied area is characterized by a range between well –graded and poorly graded soil. The distribution curves are generally of fine to coarse skewed and leptokurtic to mesokurtic.

The Atterberg limit shows that, the claystones of Barwa area have high liquid limit compared to their relatively low plastic limit. This indicates that the high range of plasticity of samples. The clay is swelling and may befurther supported by the low values of shrinkage limit and high free swelling.

Recommendations:

The soil of New Cairo City extensions (Barwa) from the foundation point of view is divided into three types: sandy soil, gravel soil (Sand with gravel) and clay soil (claylenses).

The first and second types are suitable for direct foundation above them. These two types are classified as coarse grained soils. Which have good load bearing capacities and good drainage qualities, and their strength and volume change characteristics are not significantly affected by changes in moisture conditions. So, it is recommended here to build a lot of buildings.

The third type is not allowed to direct foundation because of its high swelling property, which has a dangerous effect on the buildings that are found there. If it is necessary to use this type of soil for building, this soil should be replaced by a soil of clean sand taken from another spots to be distributed under the foundation. This replacement layer should not be less than 1.5m thick. It is also recommend to create green and open play grounds on this type of soil. If it is needed to build on it, villas and small housings can be constructed.

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