

# GEOTECHNICAL STUDY AT 15 MAY CITY, CAIRO, EGYPT

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## ***ABSTRACT***

*The present study deals with the Geotechnical Investigation to get information a foundation and determine Soil and Rocks characteristics.*

*From the In-situ geotechnical test and laboratory analysis were classified Rock Quality % to Poor*

*And increasing the results at northern, northwestern and southeastern parts of the area ,while the decreasing of values at southwestern side.*

*The Rocks Classification according to unconfined compressive Strength ( $Q_u$ ) are medium weak to depth between 1 to 4 meter while are medium weak to medium hard at depth of 8 meters to 12 meters.*

*The Soil classification according U.S.C.S. in A-line Chart between inorganic silts and very fine sands, with slight plasticity to inorganic clays of low to medium plasticity ,silty clays , lean clays.*

*The chemical analysis used to determine the degree of aggressive for Soil , ranging between non-aggressive and moderately aggressive.*

*The main Geotechnical problem based on the history of geology for the area and the present geotechnical study is that the main formation of the area is limestone, with some cavity, cracks and lenses of clay, probably occurring on engineering constructions especially with seepage of water.*

***Keywords:*** *Rock Quality; Unconfined Compressive Strength; Atterberg Limits; Aggressive of Soil.*

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## 1-INTRODUCTION

15th May City is a suburb of eastern Helwan, Egypt, and is part of Greater Cairo. It was established in 1978, and is located south of the Nile Delta and east of central Helwan city. It was constructed to solve the problem of insufficient accommodation.

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The present work is geotechnical engineering data studying the engineering properties of rocks of the study area.

The area under investigation is located at south of the Nile Delta which covers an area about 607.3 km<sup>2</sup> and lies between longitudes 31° 49' 13.5" and 31° 24' 03" East and latitudes 29° 49' 40.5" and 29° 50' 55" North (Fig.I.1).

15th May City's climate is characterized by desert climatic. During the year, there is virtually no rainfall in 15th May City. The average annual temperature is 22.1 °C in 15th May City. In a year, the average rainfall is 17 mm.

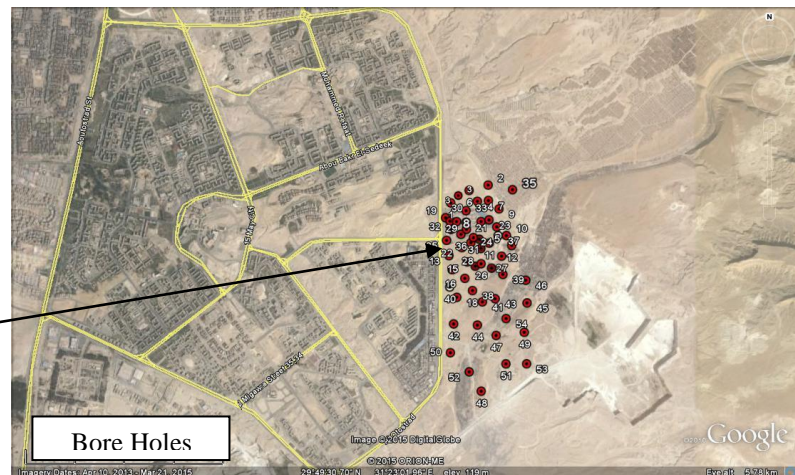
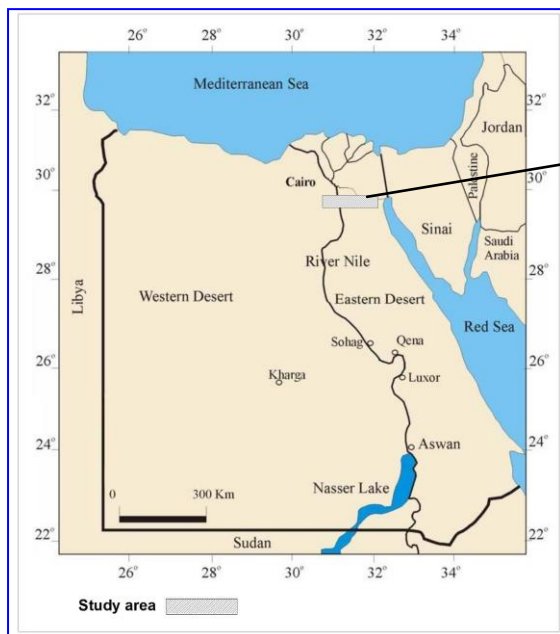


Fig.(1) Location Map of study area

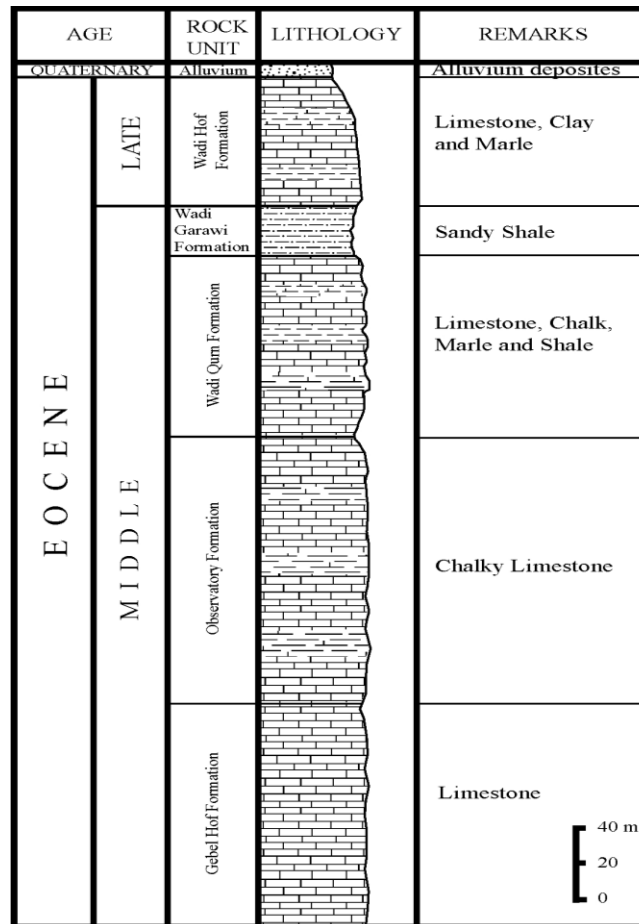


Fig.(2) Stratigraphy column of the study area (after Said 1990)

### .2.1. Litho-Stratigraphy

The litho-stratigraphy of the study area could be divided as follow (Abdallah and Abdel Hady, 1968, Conoco, 1987, Hermina and lindenberg, 1989, Said, 1990 and Swedan. A. H, 1991): show fig,(2)

**A) Tertiary volcanic**, which belongs to Precambrian rocks and consists mainly of basaltic dykes sills and flows.

**B) Eocene Rocks**, comprises the following from the older to younger:

**1- Mokattam group**: which predominantly consisting of Wadi Ryan Formation and shallow marine, dense medium bedded limestone with local chert and few Nummulites with Giushi Formation above and Gabal Hof Formation which rich in Numm.gizehensis below.

Wadi Ryan Formation: Consists mainly Shallow marine limestone with Nummulites gizehensis repeateadly intercalated by shale and sandy shale.

Giushi Formation: This is made up of white to grayish-white, massive compact limestone, highly fossiliferous with Nummulites aff pulchellus, Nummulites contortus-striatus, Echinolampas fraasi, Echinolampas africanus and various pelecypods, gastropods and corals. The Formation is exposed at Gabal El-Gushy occupying the middle part of the Mokattam scarp.

It weathers into a plateau surface forming a step in the main Mokattam scarp above which the Maadi clastics retreat farther east. Its maximum thickness about 52.3 m was measured at quarry in the El-Basatine area.

**Gabal Hof Formation:** The beds of Gabal Hof Formation are exposed in the main scarp of Gabal Hof which extend northward to Gabal Tourah. These beds are Helwan. The maximum thickness was measured at Wadi Abu El-Rakham in the Gabal Hof area is about 120m. Farag and Ismail, (1959) subdivided the Formation into two units in its type locality at Wadi Abu El-Rakham as follow; Nummulites gizehensis beds exposed in the upper part of Gabal Hof Formation and limestone poorly fossiliferous forming the lower part of Gabal Hof Formation.

**2- Maadi Formation:** which composed of a series of brown and yellowish-brown to earthy-brown beds and is divided as follows; Hard brown sandy limestone with Anisaster gibbtrulus and Echinolampas crameri, Alternating yellow sand, grey shales and marls with Carolia placunoides and sandy limestone and marls with Turritella angulata and Nummulites contortus-striatus.

**3- Qasr El-Sagha Formation:** made up of littoral marine to continental clastic sequence with Oyster beds, Carolia Placunoides and intercalation of silt and claystones. In lower parts Nummulites striatus and fossiliferous calcarenite.

**C) Oligocene Rocks,** represented by Gabal El-Ahmar Formation which consists of continental vividly coloured sand, quartzite and gravel.

**D) Miocene Rocks,** which consist of from the top to bottom as follow: Hagoul Formation (Upper Miocene), Hommath Formation (Middle Miocene) and Sadat Formation (Lower Miocene). Hagoul Formation consists of fluvial sandstone and arenaceous carbonate, deposited in the regressive sea of the late Miocene. Hommath Formation consists of Sadat Formation consists of Oyster banks and algal, coralline limestone.

**E) Pliocene Rocks,** represented by Kom el-Shelul Formation which overlain by Pliocene deposits (north of Faiyum possibly younger). This Formation is represented by about 24m of marl and shale at the base with abundant Ostrea cucullata, Pecten benedictus, Chlamys sp and Claypeaster aegyptiacus overlain by unfossiliferous sandstone. On the eastern side of the Nile, south of Helwan, marine Pliocene sediments are represented by about 2.5 m of yellowish-brown, gritty calcareous sandstone with Pecten sp and Clamys sp. At the foot of Gabal El-Mokattam scarp and in the El-Dwiqa area, small patchy outcrops of sands and conglomeritic sandstone with some reworked Eocene boulders represented non marine Pliocene and these sediments extend to the edge of the Fayum depression.

**F) Quaternary sediments,** which consists mainly of Nile silt, wadi deposits, pre-nile deposits and protonile deposits.

## 2.4.2 Structural setting

The Structural pattern of Greater Cairo area is mainly controlled by faults and folds.

### A) Faults

The area is generally affected by two main fault system, the N 55° W and the nearly E-W systems. The first of these is the Erytherian trend is the main fault system. It affected the Eocene limestone plateau in the eastern part of the area as well as the older structures at Abu Rowash. The second on the Tehyan trend which affects mainly the Oligocene and Miocene sediments occupying the northeastern and western parts of the area. It also affects the central part of the eastern limestone plateau between Gabal Hof and Gabal El-Mokattam on the north. A third is less important fault system has N 15 °

E trend (Aqaba system) affects mainly the southwestern part of the area. All the faults are normal. Close by these fault planes beds dip at high angels (up to 50°) because of drag elsewhere, general dip are 2° or less (Swedan. A. H, 1991).

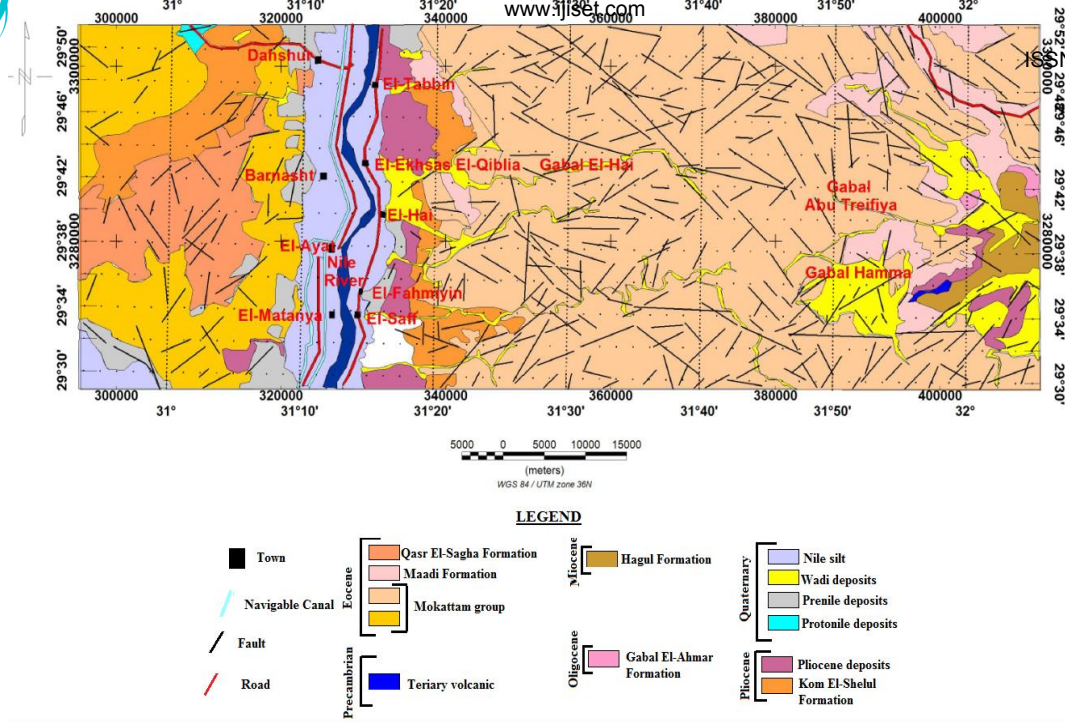


Fig.(3) Geological of the study area after (Conco 1987)

### B) Folds

In the northeastern part of the area two main systems of folds play an important role in the areal distribution of rock units. The first one is the east-west fold system seen at Gabal El-Nasuri-El-Anqabiya area. The second is seen north and south of Gabal Yahmoun El-Asmar and near the Maadi-Kattamiya road, where fold axes trend northwest-southeast and these two fold system trend affect Eocene and younger strata. An older system of fold is recorded in the Abu Rowash area, where Upper Cretaceous rocks are warped into the famous El-Hassana dome, northwest of Cairo (Swedan. A. H, 1991).

### **3- Geotechnical Study**

#### **1.3 Physical and Engineering Properties of Rocks :**

Rock is involved in many civil engineering projects. Rock properties inherently are a part of the exploration, design, construction and in service (post construction) phases of such projects.

The rock is classified into two groups; intact rock and rock mass.

- a. Intact rock is the term applied to rock containing no discontinuities such as joints and bedding.
- b. Rock mass is a mass of rock interrupted by discontinuities, with each constituent discrete block having intact rock properties.

The problem for the engineer is further complicated by the lateral and vertical variations that occur within a rock mass as a result of differing environmental conditions either at the time of rock formation or at some later time. Anisotropy in rock, therefore, is the rule rather than the exception. This anisotropy usually is recognized and described by geologists at a scale that may not be sufficiently detailed for engineering purposes.

The experimental testing in the study area are Rock Quality, unconfined compression, atterberg limits, absorption, dry density and chemical component.

### 1.3.1 Rock Quality Designation (R.Q.D)

Rock Quality Designation (R.Q.D) ;is a modification of core recovery, in the only the intact pieces of core that are more than ten centimeters long are added together in calculating length recovered. An (R.Q.D) of 100% indicates 100% core recovery with all pieces equal to or greater than 10 cm in length. Thus it does not imply an unjointed rock mass (*Deere et al., 1967*). The R.Q.D described as very poor, poor, fair, good and excellent. From the average of R.Q.D is 25.3, 32.3,41.6

Depth (m)	1 to 4	4 to 8	8 to 12
Average (R.Q.D)	25.3	32.3	41.6

Table. 1 Shows average the results, while detail results represents in vertical legend in distribution map

Table. 2:Rock classification according to Rock Quality Designation (R.Q.D)

R.Q.D. %	Rock quality
< 25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

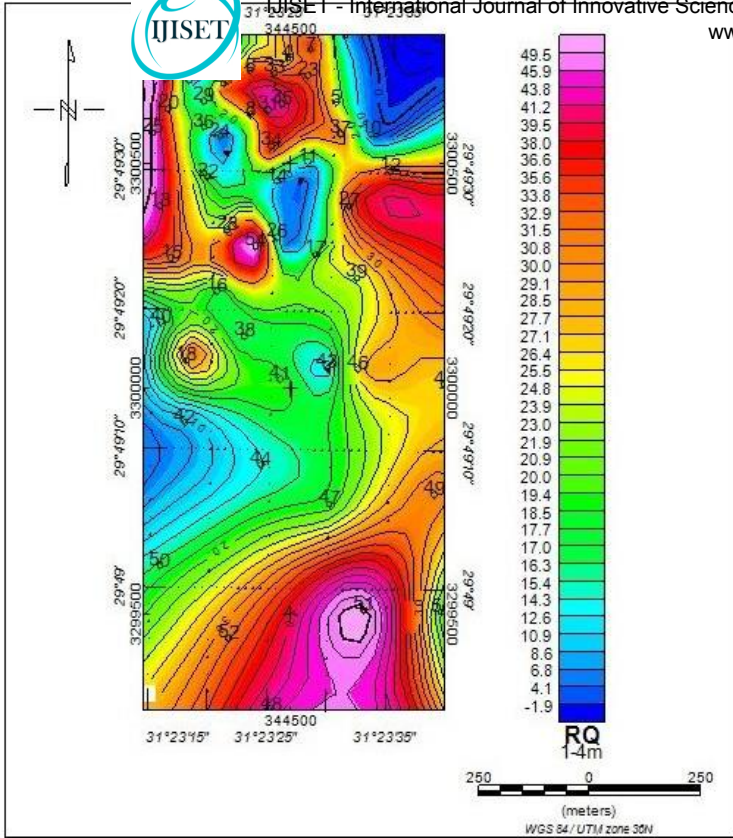


Fig.(4-1)Rock quality areal distribution map. depth from 1 meter to depth 4 metres

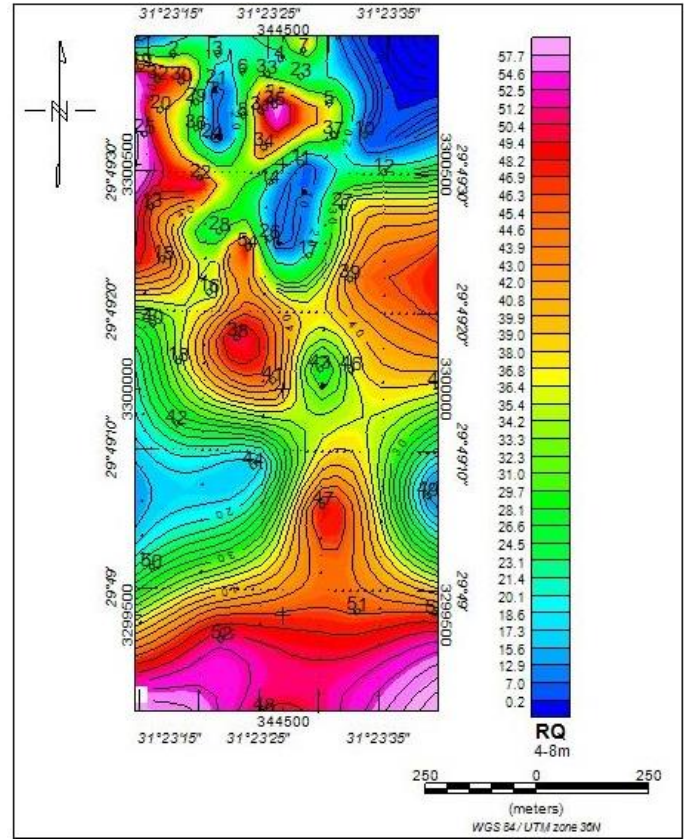


Fig.(4-2) Rock quality areal distribution map .depth from 4 meter to depth 8 metres

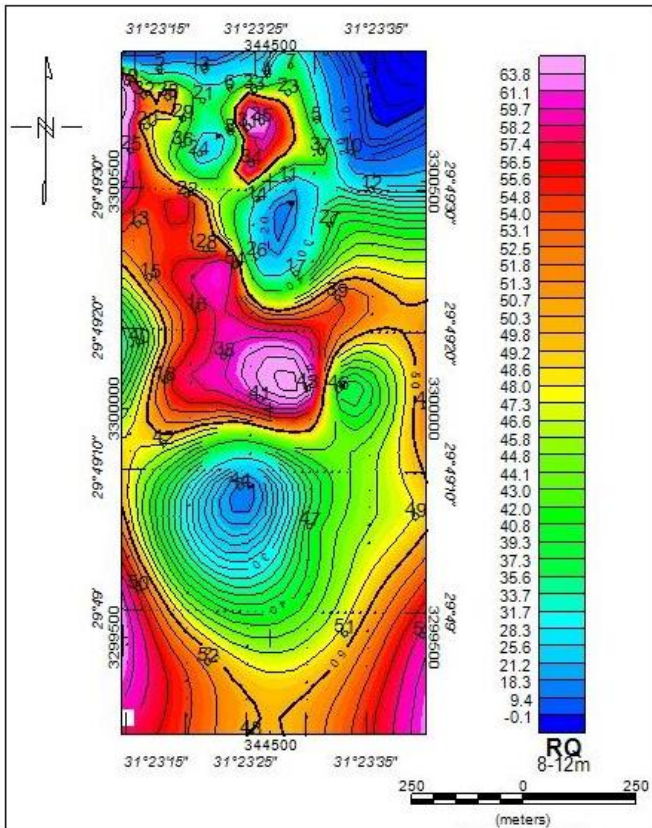


Fig.(4-3)Rock quality areal distribution map ,depth from 8 meters to depth 12

### 1.3.2. Unconfined Compressive Strength ( $q_u$ ):

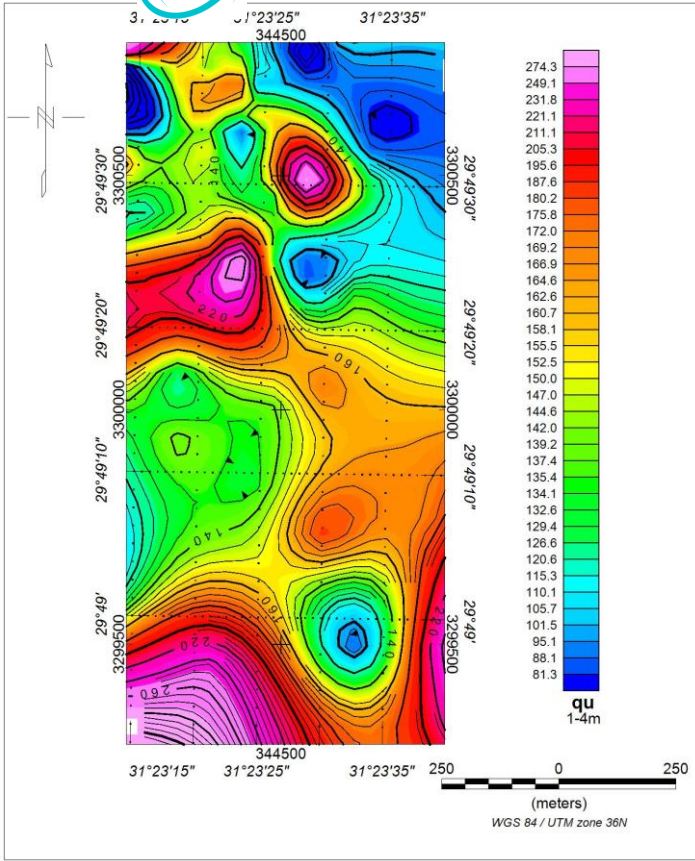
Unconfined (or uniaxial) compressive strength, is normally determined by statically loading a cylinder, cube, square, of rock to failure, the load being applied across the upper and lower faces of the sample. The results obtained are in part a function of the length breadth ratio of the sample and of the rate of loading. The simplicity of the test is somewhat deceptive (Hawkes and Mellor, 1970). . *The Rocks Classification according to unconfined compressive Strength ( $Q_u$ ) are medium weak to depth between 1 to 4 meter while are medium weak to medium hard at depth of 8 meters to 12 meters.*

*Table (3 ) Shows average the results, while detail results represents in vertical legend in distribution maps.*

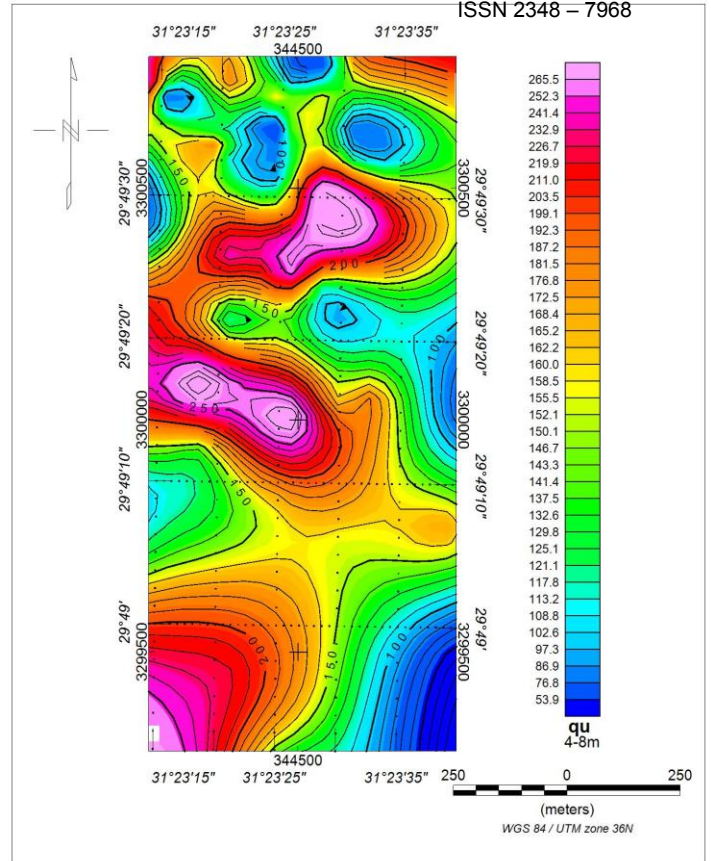
Depth (m)	1 to 4	4 to 8	8 to 12
Average $q_u$	147.7	153.6	174.5

Table4.Rock classification according to Unconfined Compressive Strength ( $q_u$ ) in Egyptian Code.

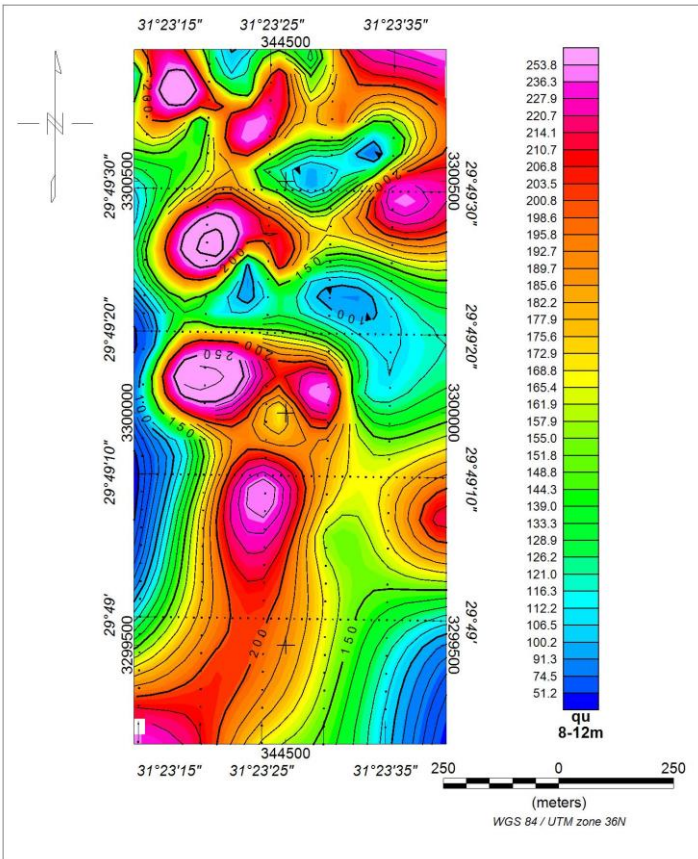
$q_u$ (Kg/cm <sup>2</sup> )	Rock type
>2000	Extremely hard
2000-1000	Very hard
1000-500	Hard
500-125	Medium hard
125-50	Medium weak
50-12.5	Weak
$\leq 12.5$	Very weak



Fig(5-1) Unconfined compressive strength areal distribution map ,depth from 1 meter to depth 4 meters



Fig(5-2) Unconfined compressive strength areal distribution map ,depth from 4 meters to depth 8 meters



Fig(5-3) Unconfined compressive strength areal distribution map ,depth from 8 meters to depth 12 meters

### 1.3.3. Atterberg limits:

Atterberg limits are an empirically developed but widely used procedure for establishing and describing the consistency of soil. Consistency is a term that is frequently used to describe the degree of firmness (e.g., soft, medium, firm, or hard). The consistency of cohesive soils is greatly affected by the water content of the soil. A gradual increase of the water content, for example may transform dry clay from perhaps a solid state to a semisolid state to a plastic state, and after further moisture increase, into a liquid state. The water contents at the corresponding junction points of these states are known as the shrinkage limit.

Table.5 shows the Results of Atterberg limits in Bore holes

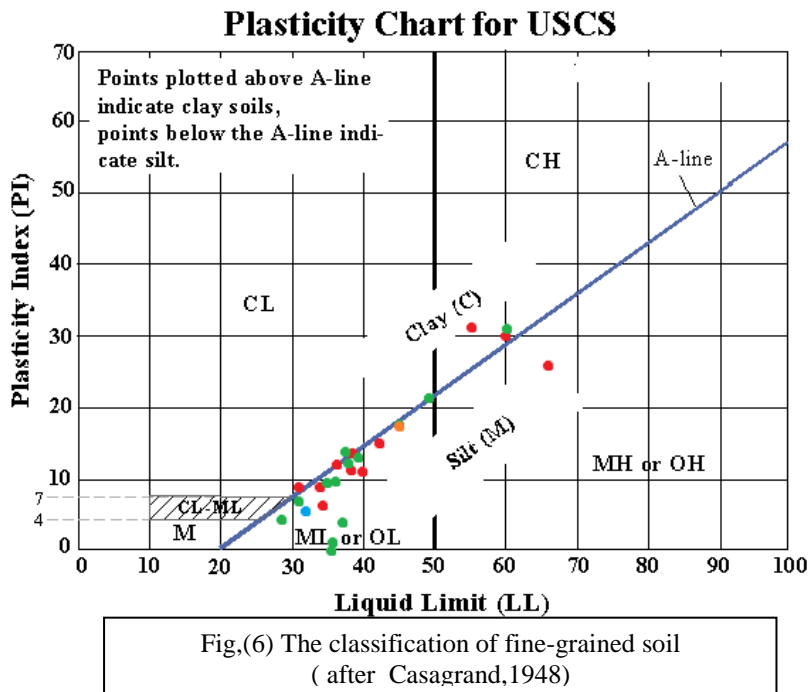
B.H.	Depth (meter)	L.L.	P.L.	P.I.	S.L.
3	9	55	24	21	31
4	7	64	38	20	26
5	6	36	24	20	12
6	6	30	22	24	8
7	4	37	24	20	13
8	5	40	29	21	11
11	5	33	24	21	9
15	8	32	26	21	6
17	3	60	30	19	30
18	5	38	26	19	12
19	3	41	27	11	14
21	5	38	26	19	12
23	5	50	28	20	22
24	4	35	34	18	1
25	2	32	25	21	7
26	3	34	25	20	9
29	5	38	25	20	13
31	7	60	29	20	31
35	3	28	24	20	4
37	2	36	26	20	10
38	2	38	24	21	14
46	7	45	28	20	17
48	6	45	28	18	17
54	6	32	26	20	6

### 1.3.4. Classification of Engineering Properties of Soils:

Engineering soils are subdivided into two main groups as a function of their predominant sizes and associated plasticity. The coarse grained soils are composed of sand size and larger particles.

The fine grained soils consist predominantly of silt and clay sized particles with differing degrees of plasticity measured by their atterberg limits rather than by sieving and hydrometer methods.

The unified soil classification system (USCS) is a textural plasticity classification scheme. Soils are divided into two major groups, coarse grained and fine grained soils, using the No. 200 sieve. Laboratory determination of liquid limit and plasticity indexes for a soil sample permits assignment of fine grained soils to the proper group by use of the plasticity chart or A line diagram. *Casagrand (1948)* the plasticity chart (Fig.88) shows that, the claystones of study area can be classified as inorganic clay of high and very high plastic soil.



### 1.3.5. Absorption (ABS) and dry density ( $\gamma_d$ ) tests:

Absorption is the increase in the mass of rock due to water in the pores of the material, but not including water adhering to the outside surface of the particles. Absorption is expressed as a percentage of the dry mass. The rock is considered “dry” if it has been maintained in an environment for sufficient time to remove all visible water (The American Society, 2001).

$$\text{Absorption \%} = [(B-A)/A] * 100$$

Where:

B= mass of saturated surface dry test specimen in air g,

A= mass of oven dry test specimen in air g and C= buoyant mass of submerged test specimen in water g.

Table.6 average the result absorption values

Average ABS %		
From 1:4 meters	From 4:8 meters	From 8:12 meters
4.9	7.3	6.2

The terms density and is used interchangeably in soil mechanics. Though not critical, it is important that we know it. To find the formula for density.

Basic formula for density  $\rho = m/V$ . (where:  $m = W/g$ ).

Tables (6) showed the absorption values of bore holes through some depths in the study area and tables (7) showed dry density values of bore holes through some depths in the area.

Table.7 average the result absorption values

	Average Dry Density $\gamma_d$ (gm/cm <sup>3</sup> )		
Depth (m)	From 1 meter:4 meters	From 4:8 meters	From 8:12 meters
Average Dry Density $\gamma_d$ (gm/cm <sup>3</sup> )	2.38	2.32	2.317

### 1.3.6 Degree of Aggressive for Soil

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 pH values. These values are occasionally required to confirm the degree of aggressive for soil. According to the Egyptian code, table (8) determines the degree of aggressive for the soil and ground water and table (9) showed these values of some bore holes within the area.

Table.8: Determination of degree of aggressive for the soil and ground water according to Egyptian Code, 2001).

Highly agg.		Aggressive		Moderately agg.		Non aggressive		Degree of Aggressive
G.W	Soil	G.W	Soil	G.W	Soil	G.W	Soil	
> 5000 P.P.M	> 2% by weight	from 1000 to 5000 P.P.M	From 0.5 to 2% by weight	From 300 to 1000 P.P.M.	From 0.1-0.5% by weight	< 300 P.P.M	< 0.1% By weight	SO3
> 2000 P.P.M.		From 1000 to 2000 P.P.M.		From 300 to 1000 P.P.M.		Less tan 300 P.P.M.		C1
< 4.5		From 6-5		From 7-6		From 8-7		pH value

Chloride content ranged from (0.056 to 0.2), according to table (V-16) the description of chloride content are non aggressive for the soil, while pH values ranged from (7.1 to 7.6) which also descriptive by non aggressive for the soil. Sulphates Content divided in to two types the first one represented by moderately aggressive for the soil which founding at bore holes (1, 3, 31, 33 and 36), the second type represented by aggressive for the soil which founding at bore holes (10, 13, 15, 27 and 30).

Table.9: Chlorides Content, Sulphates Content and pH Values of some bore holes in the study area.

<b>Bore hole no</b>	<b>Depth of sample (meter)</b>	<b>NaCl</b>	<b>SO<sub>3</sub></b>	<b>pH Value</b>
1	3-4	0.15	0.32	7.1
3	3-4	0.09	0.23	7.6
10	2-3	0.12	0.63	7.4
13	2-3	0.11	0.51	7.2
15	2-3	0.17	0.73	7.4
27	2-3	0.063	0.81	7.3
30	2-3	0.056	0.74	7.1
31	2-3	0.16	0.14	7.4
33	3-4	0.2	0.16	7.6
36	2-3	0.11	0.18	7.4

## CONCLUSIONS AND RECOMMENDATION

*The main Geotechnical problem based on the history of geology for the area and the present geotechnical study is that the main formation of the area is limestone, with some cavity, cracks and lenses of clay, types these soil effect on the safety of foundations construction in case of foundation directly especially with seepage of water, in addition the Unconfined Compressive Strength ( $q_u$ ) is medium weak to medium hard .*

firstly after arrival drilling level required to a depth of overlying limestone layers fully in water and abundant water for 72 hours and removal of any surfaces arise as a result immersion and cleaned cracks that appear on the surface . the replacement in the site to reach the design level using clean sand that compaction layers thickness not exceeding 25 cm ever one layer and using a static vibrator weight 10 tons or suitable tool , being compaction field test and must achieve 95% of the density laboratory for testing by modified proctor ,the dry density soil replacement not less than  $1.75 \text{ t/m}^3$ , the casting ordinary concrete is needed to speed up after completion of the replacement and not leave to evaporation and the use of ordinary Portland cement about  $400 \text{ kg/cm}^3$  for reinforces concrete and  $250 \text{ kg/cm}^3$  for ordinary concrete, the thickness of cover concrete for reinforcing steel is 6 cm , isolate the external surfaces of reinforce concrete with oxidative bitumen . using modern spray tools to control the amount of water for irrigate the landscaping.

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