

# Geotechnical Characteristics Of Quaternary Deposits South East Aswan City, Egypt.

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**Abstract** —This study describes geotechnical properties of the soil south east Aswan city. Laboratory tests were carried out to assess the physical and mechanical properties of the soils. Different types of soils were discovered by drilling six boreholes all over the studied zones including friable clays, laminated clay with remains of calcareous materials, clayey sand and well graded sand with gravel. The particle size distribution classified sand samples as clayey sand (SC) and well graded sand (SW). The investigated soil samples had slightly different specific gravity values ranged from 1.87 to 2.2 g/cm<sup>3</sup>. The unconfined compressive strength showed promising values in range of 1.86 - 22.1Mpa. Shear characteristics of the fine grained soils (friable clay) possessed the lowest peak friction angle (17°) while the medium to coarse grained sands had the highest peak friction angle (25°). Clayey samples displayed moderate swelling pressure, in the vicinity of 16kg/cm<sup>2</sup>, pointing to possibility of some problems during and after construction processes. The extracted water from soil under investigation exhibited not aggressive manner.

**Keywords**—Geotechnical Properties, Unconfined Compressive Strength, Swelling Pressure (Oedometer), Shear Strength and chemical analysis.

## 1 - INTRODUCTION

Land reclamation projects in desert regions become an important national target for establishment of new communities. One of these innovative communities placed nearby the eastern bank of the Nile River in Aswan city, which considered one of the most important touristic site in Egypt. The studied area lies between longitudes 32° 51' and 33° 15' E and latitudes 24° 00' and 24° 15' N (Fig. 1). The present study dealt with investigation of the geotechnical properties of Quaternary sediments representing the foundation bed for engineering constructions together with evaluating their corresponding geotechnical behavior.

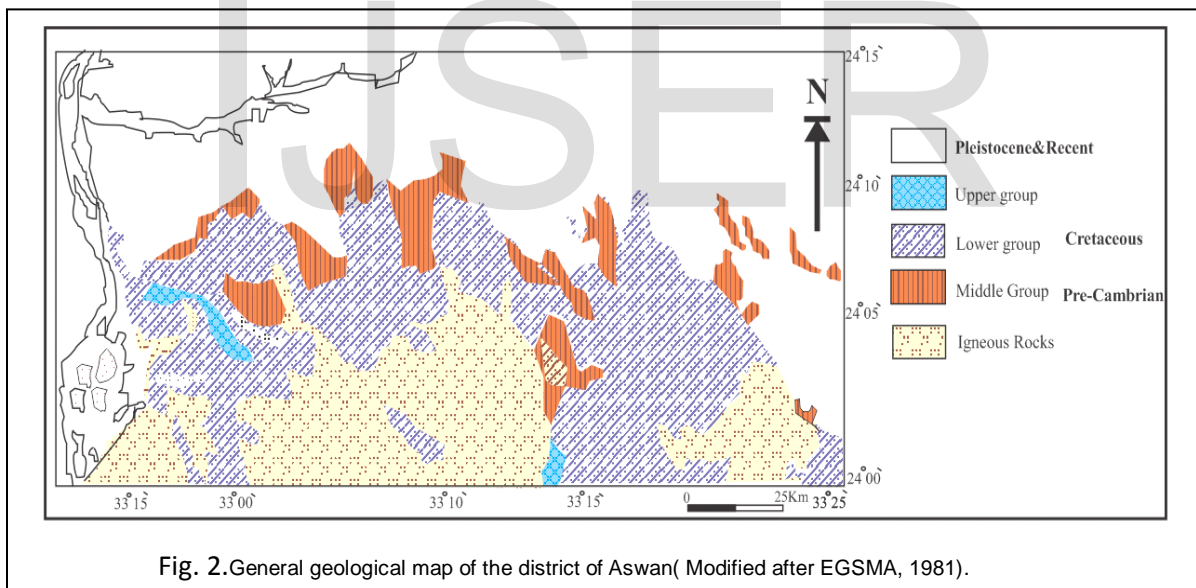
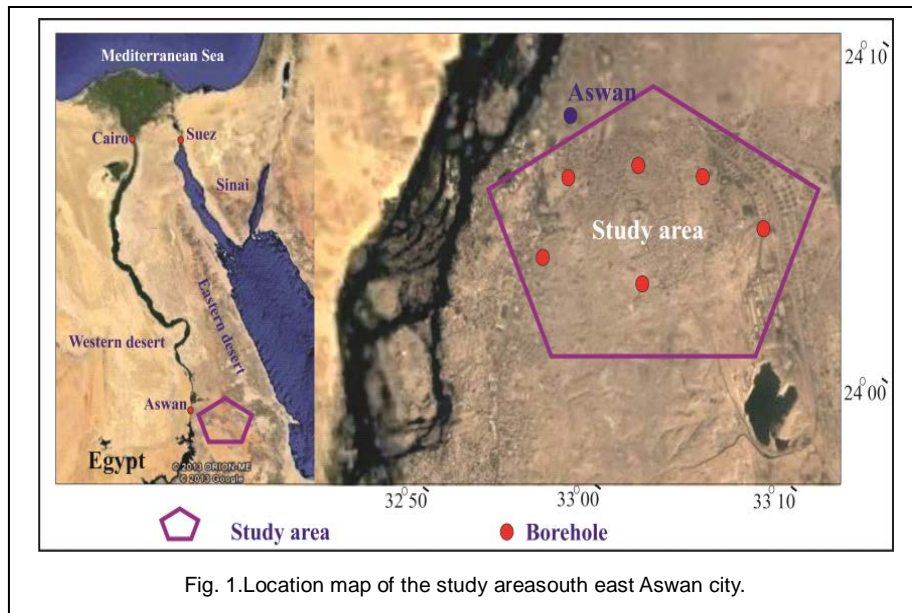
## 2 –GEOLOGIC SETTING

Many authors (e.g., Issawi, 1968, El Shazly et al., 1974) have deliberated the geology of such area. These studies indicated that the study area consisted of thick sedimentary section of Nubian Sandstone Formation of Upper Cretaceous age being overlaid by the Precambrian basement rocks (EGSMA, 1981 and Hume, W.F. 1964) (Fig. 2). This section consisted of ferruginous sandstone, sandstone and clays and ancient gravels, sands, river sands and Nile mud of Pleistocene and Recent ages. Clays existed as beds and lenses of widely varying dimensions within the sandstone beds.

## 3–MATERIALS AND METHODS

Determination of soil parameters of the area under investigation was performed by field and laboratory work. The field work represented soil sampling in the study area from (6) boreholes while the laboratory work focused on the measurements of various parameters using various types of analyses. The methodological approach used for the investigation and analysis of the geotechnical properties of the soils includes grain size and specific gravity analysis, unconfined compressive strength, shear strength, free swelling test, swelling oedometer test besides chemical analysis for soil - water extracts along the study area.

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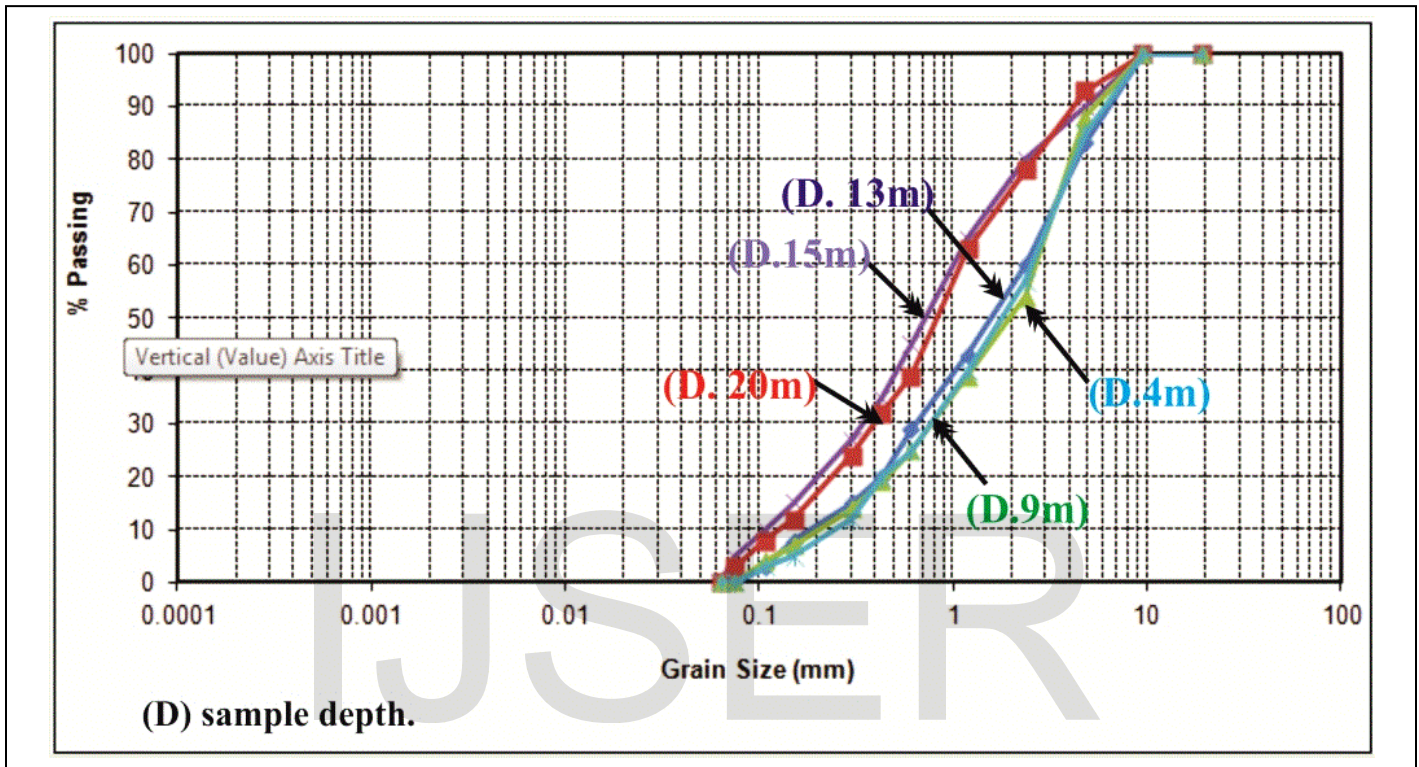
## 4 – RESULTS AND DISCUSSION

### 4.1 THE SOIL PROFILE

The present study demonstrates the geotechnical properties of the Quaternary sediments, which are located at shallow depths south east Aswan city. Six boreholes were drilled attending soils composed of friable clays, laminated clay with remains of calcareous materials and well graded sand with gravel.

### 4.2 GRAIN SIZE ANALYSIS

Particle size distribution of the collected samples was performed according to ASTM D- 422. The uniformity coefficients ( $C_u$ ) for sands decreased with increasing depth (Table 1), being ranged from 7.2 to 13.5. By further depth increment, more coarser grains enriched by plenty of gravels were appeared linked with significant depression of sand (Fig. 3 and Table 1). According to Unified Soil Classification (ASTM D- 2487-98), these soils classified as Clayey sand (SC) that mainly composed of sands with clay and well graded sand (SW) that seemingly contain sands blended by gravels.



### 4.3 SPECIFIC GRAVITY TEST RESULTS

TABLE 1  
 GRAIN SIZE DISTRIBUTION PARAMETERS.

Depth (m)	Test no.	Fines (%)	Sand (%)	Gravel (%)	Soil Description	Uniformity Coefficient
4	1	13	81.4	5.2	Clayey sand (SC)	5.5
9	2	3.2	80.7	15.0	Well Graded sand (SW)	13.5
13	3	2.2	72.3	25.5	Well Graded sand (SW)	7.5
15	4	2.3	69.7	28	Well Graded sand (SW)	7.4
20	5	2.1	67.4	30.2	Well Graded sand (SW)	7.2

The results showed that the investigated samples of the soils had slightly different values of specific gravity [ASTM D-854]. Specific gravity values of the studied samples were ranging from 1.87 to 2.2 g/cm<sup>3</sup>, Table (2).

### 4.5 SHEAR CHARACTERISTICS OF THE SAMPLES

Direct shear tests were conducted to investigate the shear strengths of the soils [ASTM D- 3080]; It was found that the fine grained soils (clayey sand) possesses the lowest peak friction angle  $17^\circ$ , whereas the medium-to-coarse grained sands exhibits the highest peak friction angle  $25^\circ$  (Fig. 4). This difference in peak friction angle is likely to be due to the grading and the proportion of swelling clay minerals. Also, peak strength and frictional clay angle decay associated by increment in clay mineral swelling as well reduction in grain size, Table 2.

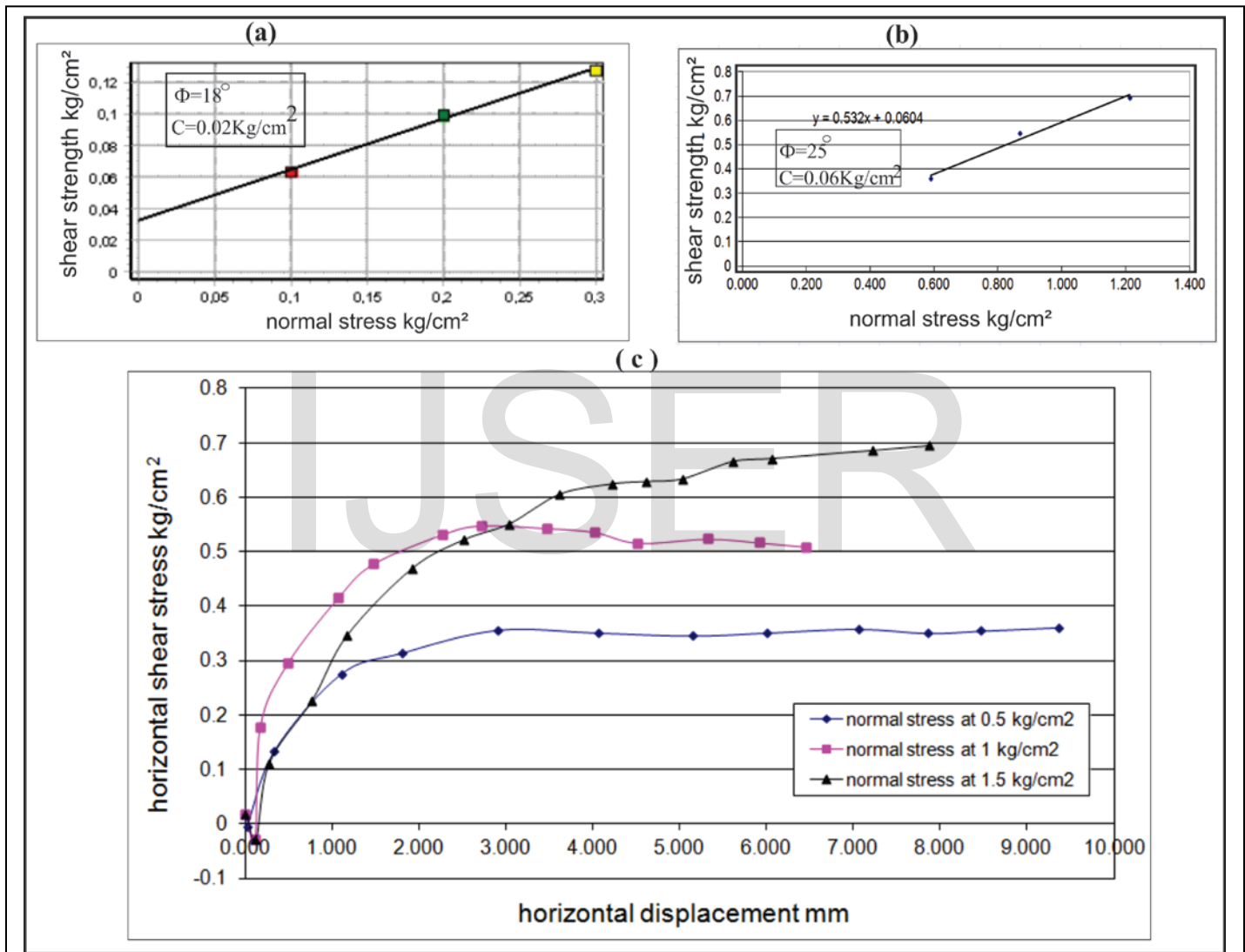


Fig. 4. Stress- Shear strength behavior of the clay (a) and sand (b) and (c).

### 4.6 SWELLING CHARACTERISTICS OF THE SAMPLES UNDER INVESTIGATION

#### 4.6.1 FREE SWELLING TEST

This test considered as a qualitative indicator for expansive soils. Free swell test was performed by putting 10cm<sup>3</sup> of dry soil into 100cm<sup>3</sup> of distilled water into a gradual cylinder. After 24 hours the volumes of settled and swelled soil were recorded

(Egyptian code, 2001). It is worth mentioning that these soils develop moderate swelling percentage, being ranged between 50 - 62%, pointing most probable to various problematic situations during or after constructing processes.

#### 4.6.2 SWELLING PRESSURE (OEDOMETER) TEST RESULTS

TABLE 2  
 GEOTECHNICAL PROPERTIES OF THE SOILS ALONG THE STUDY AREA.

Soil Type	Specific Gravity, (g/cm <sup>3</sup> )	Uniaxial Compressive Strength, (Mpa)	Effective friction angle, $\Phi$ (°)	Shear Strength, (Mpa)	Effective Cohesion, C (Mpa)	Swelling Percent (%)	Swelling Pressure Oedometer, (Kg/cm <sup>2</sup> )
Friable Clay	2.2	1.86	17	5.2	3.3	62	10
Clayey Sand	2.1	22.1	22	6.7	3.5	59	11
Laminated Clay	1.8	12.7	20	7	4.2	60	16
Medium to coarse grained sands	1.9	15.0	25	8	5.3	-	-

Swelling pressure test using oedometer instrument, in accordance to Egyptian code, 2001, indicate that friable clay, laminated clay and clayey sand exhibit pronounced swelling pressure ranged in between 10 – 16 kg/cm<sup>2</sup>, while swelling pressure for medium-to-coarse sandstone was vanished, Table 2.

#### 4.7 CHEMICAL ANALYSIS FOR SOIL-WATER EXTRACTS

The total dissolved salts (TDS), pH, chloride (Cl<sup>-</sup>) and sulfate (SO<sub>4</sub><sup>-2</sup>) ions concentrations, and conductivity were detected. The samples were immediately preserved after being subjected to ice tanks. The collected water samples were sent to the laboratories to be chemically analyzed. Samples were analyzed at the laboratory according to the standard analytical procedures (Anonymous, 1985). chloride ion (Cl<sup>-</sup>) concentration in soil-water extracts soil samples as per BS 1377. The results were

TABLE3  
 CHEMICAL ANALYSIS FOR SOIL-WATER EXTRACTS ALONG THE STUDY AREA.

TDS (ppm)	Cl <sup>-</sup> (mg/l)	SO <sub>4</sub> <sup>-</sup> (mg/l)	pH	Conductivity (μ S)
1000	350	20	7.4	20
1200	370	18	7.5	22
1100	290	21	7.4	20
1000	320	22	7.3	24
1000	340	20	7.4	25
950	350	19	7.4	22



conducted as shown in Table (3) according to Russian code 10178-76 and 22266-76 1987. Based on previous results, water extracts soil samples along the studied area were non aggressive indicating presence of neutral soil of pH ~7 with much lower conductivity values associated by poor total dissolved salts (TDS) besides reduced concentrations for chloride and sulphate ions.

## 5 CONCLUSION AND RECOMMENDATIONS

Analysis and interpretations of the laboratory results as well the field observations led to the following findings:

- The soil composed of friable clays, laminated clay with remains of calcareous materials and well graded sand with gravels. Further increasing in soil depths showed more coarser grains with growing percentages of gravels and decreasing ratios of fines.
- The investigated soil samples had slightly different specific gravities, ranged from 1.87 - 2.2 g/cm<sup>3</sup>, attributing probably to their corresponding mineral composition.
- The friable and laminated clays were inapplicable to bear huge constructions. Thus, it is noticeable to elicit those clays. On the other hand, clayey sand samples and medium-to-coarse grained sands exhibited medium to high strength posing them to tolerate grand constructions and inhabitanancies.
- The fine grained soils (friable clay) performed the lowest peak frictional angle 17°, whereas the medium -to-coarse grained sandstone developed advanced peak frictional angle 25°. Such difference in peak frictional angle is likely to regard to the grading and the proportion of swelling clay minerals. Moreover, the peak strength and the friction angle of the clays showed marked reduction with elevation in swelling clay minerals and diminishing in grain size.
- The clayey soils along the study area enveloping friable and laminated clays, and clayey sand possessed medium swelling sensitivity.
- The water extracts soil samples along the study area were non aggressive.

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