Geoengineering Properties of calcareous and Quartzite sand collected from West Alexandria coastal line and Abo Rawash Quarry area.

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ABSTRACT:

This article represents a comparative study between the calcareous sand which covering the Mediterranean coastal line and quartizitic sand from Abo Rawash quarry area. The geological and geotechnical characteristics of calcareous and quartizitic sand materials have been studied. The laboratory tests are including physical, chemical mechanical properties. The mechanical properties include direct shear test, compaction parameters (by modified proctor and California Bearing Ratio) and unconfined compressive strength of sand cement mortar cubes. The chemical analyses include Insoluble residue, CL and SO3 percentages. The tested samples grain size gradation revealed that the both samples of calcareous sand and quartizitic sand are classified as poorly graded sand (Sp). The coastal line calcareous sand samples have 99% of carbonate materials content and Abo Rawash quartz sand has only 2% of carbonate materials. The calcareous sand has a peak friction angle of about 28° to 32.6° and cohesion 0.06 kg/cm^2 while the quartizitic sand has a peak friction angle about 38° and cohesion 0.08kg/cm^2. The average values of the CBR of calcareous sand samples and quartizitic sand, compacted at optimum moisture content are 5.88 and 17.35%, respectively

Key Words: calcareous sand, quartzite sand, Petrographic description and shear - compaction parameters

1 - INTRODUCTION

Long strip of thick calcareous sand covering the Mediterranean coastal line between Alexandria and Alamine cities. The encountered calcareous sand is derived from the oolitic limestone ridges of Quaternary age. These ridges nearly parallel to the coastal line and recorded in some researches as 4 ridges (El- Asmar, 2000).The thick deposits of calcareous sand as well as the parent bedrock of oolitic limestone represent the main foundation bedrock of coastal line resort villages .representative samples have been collected from this calcareous sand strip through open pit of 2m depth. The first group (sample 1) collected 500 m south of the coastal line and the second group (sample 2) collected from the beach. The collected samples geographic location is between latitude 30°13′ and 31°10′ N and Longitude 28°14′ and 29°15′ E. A third group of quartzite sand (sample3) have been collected from Abo Rawash sand quarry area to obtain a guide comparative study between calcareous sand and quartzite sand.

This article represents a comparative study of geological and geotechnical parameters based on laboratory testing and microscopic analysis. Also it will focus on the engineering problems related to use the calcareous sand in building construction row materials. The geographic location (Google earth Land Sat image locations) of the collected site samples are shown in Figure 1.

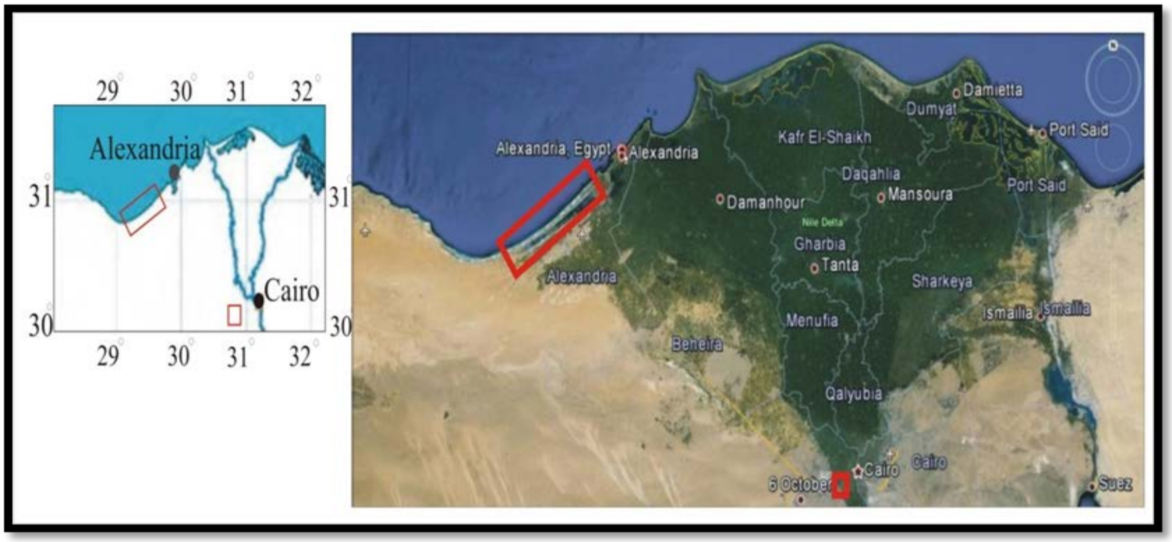

Figure 1: Location map of collected samples, calcareous sand from north coastal line east Alexandria and quartz sand from Abo Rawash south west Cairo .

2- Geologic setting of sand samples:

Calcareous sand: The northwest coastal plain of Egypt comprises a sequence of carbonate ridges. A comprehensive review on earlier works is found in (Shukri et al, 1956 and Butzer, 1960) Studied the geomorphology of these ridges and proposed that, at least eight transgressions above sea level took place during Pleistocene. The origin of these oolitic ridges are windblown material derived from the Tertiary limestone of the western desert, which later have been reworked by agitating water movements of beach waves (Hilmy, 1951) .

Coastal line calcareous sand is mainly made up of loose sands eroded from the underneath oolitic limestone ridges. The coastal dunes are found close to the beach, they are composed of loose white oolitic carbonate sands washed from degradation of oolitic coastal ridges, the coastal ridge is an elevated land from slopes gently landward and steeper seaward this ridge is composed of white cross bedded, friable oolitic limestone, locally this ridge is covered by snow white carbonate sand.

Accordingly three formations are identified, these are from younger to older, the Alexandria oolitic limestone Formation of Late Pleistocene to Holocene age, the Burg El-Arab fossiliferous limestone Formation, and El-Hammam bioclastic limestone Formation of Middle to late Pleistocene age.

Quartzite sand: the quartzite sand is mainly composed of quartz mineral with some silt and clay materials. It is mainly has a continental origin during the Oligocene age. The latter is overlain by loose sands and gravel. Five Kilometers from the study area at Qaret El Hadadean, basaltic lava sheets are 28 m thick and are overlain by sands, overlying the basalts as of Early Miocene age. Oligocene sands and gravels unconformably overlie the Cretaceous rocks at Gebel

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Abu Roash and El Midawara area (South of Gebel Abu Roash). Marine Oligocene belongs to the Daba formation (Norton, 1967).The quartz sand samples were collected from Abo Rawash quarries area north-east of 6th October City.

3- Petrographic description of tested samples.

Microscopic study was carried out on five samples. **McBride classification (1963)** was used to classify the rock types of the sandstones and **Folk's classification (1962)** was used to classify the carbonate types.

Lithologically the sands along the northern coast called calcareous sand composed of quartz grains and carbonate grains consist of ooids and intraclasts. Microscopically, it is composed predominantly, more than 50 percent of detrital sand size medium to coarse grains of quartz and classified as (lith- arenite) (**Fig. 5 a and b)**.

The sands collected from Abo Rawash area is classified as (quartz arenite). Microscopically this sand material is composed mainly of quartz, medium to coarse grains, unequigranular, subangular to subrounded as shown in (**Fig. 5 c and d**).

The carbonates along the Northern Coast that represented as ridges along the northern coast classified as oolitic limestone (oosparite). It is composed of coarse- grained ooids and intraclasts where the cement is mostly sparite (**Fig. 5 e**).

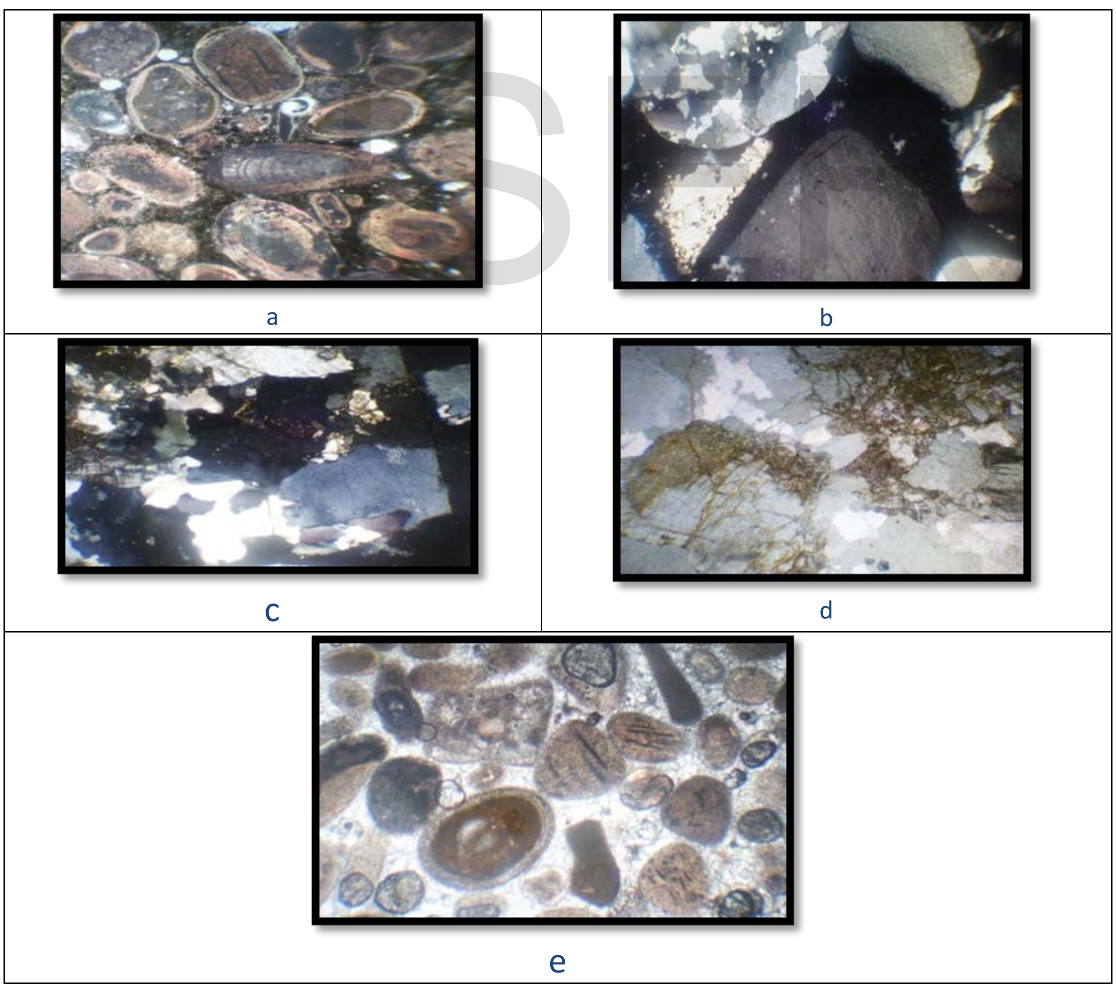


Figure 5: (a) Photomicrograph of the coarse- grained ooids and intraclasts in lith- arenite C.N. (b) Photomicrograph of the calcareous materials in Lith- Arenite C.N. (c) Photomicrograph showing quartz grains in quartz arenite C.N. (d) Photomicrograph of quartz grains in quartz arenite P.L and (e) Photomicrograph of the coarse- grained ooids and intraclasts in limestone (oosparite) C.N.

3- Laboratory testing program

The collected sand samples have been tested as per the international slandered ASTM to determine the gradation coefficients (Cu and Cc), shear parameters by direct shear test, compaction parameters by modified proctor and California Bearing Ratio (CBR) and unconfined compressive strength of sand cement mortar cubes (after setting time 7, 14 and 28 days) .The chemical analysis include Insoluble residue, CL and SO3 percentages. The microscopic studies include lithologic description of sand material, oolitic limestone parent rock and the Petrographic description of the sand cement compressive strength tested cubes.

4- Results and discussions:

4.1 Grain size analysis

Grain size distribution of the collected samples were performed according to [ASTM D-422], the uniformity coefficient value (C_u) 2.5 to 2.63 for calcareous sand and 2.74 for quartzitic sand. The Coefficient of curvature (Cc) was calculated from laboratory measurements and the value equals 1.08 for calcareous sand and 1.04 for quartzite sand, are considered to be of well graded (for values 1-3 the sample is well graded).

The samples according to Unified Soil Classification as well graded sand (Sw), medium to coarse grains Fig. (2). This type of soil especially the coarse grained soils have good load bearing capacities and good drainage qualities, and their strength volume change characteristics are not segnifically affected by change in moisture conditions.

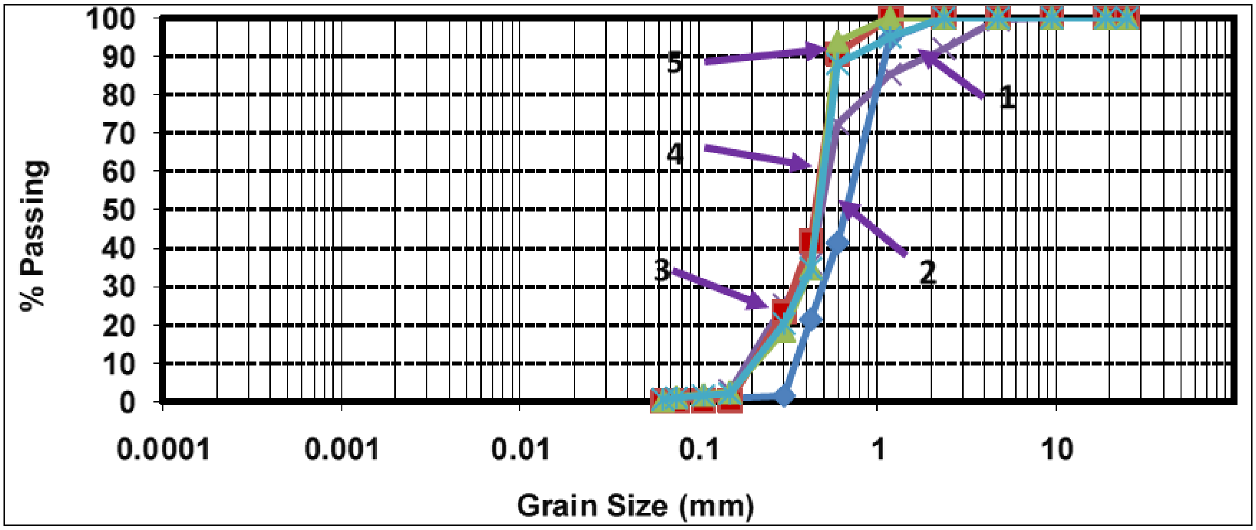


Figure 2: Grain size distribution curves of quartizitic sand (1), calcareous sand (2 and 3) and compacted crashed calcareous sand (4 and 5).

4.2 Specific Gravity Test Results

Calcareous sand and quartzite sand specific gravity (**Gs**) were performed as per (ASTM D 854-02) .The obtained results of sand soil samples had slightly different values of specific gravity as indicated in table (1). The specific gravity values of Abo Rawash quartz sand is 2.65 gm/cm³ and for calcareous sand samples were ranging from 2.73 gm/cm^3, to 2.83 gm/cm^3. The relatively high value of Gs for calcareous sand my attribute to the sand size materials is limestone rock parent not individual mineral grains as quartz sand of Abo Rawash.

Table 2: The laboratory measured parameters of specific gravity (Gs), void ratio (e) and unit weight (γ).

Parameters	Sample 1 Calcareous sand	Sample 2 Calcareous sand	Sample 3 quartz sand
Gs	2.73	2.83	2.65
e max	0.65	0.69	0.54
γmin	1.60	1.65	1.80
e min	1.25	1.35	0.79
γmax	1.90	1.97	2.2

4.3 Chemical analysis and Insoluble Reside:

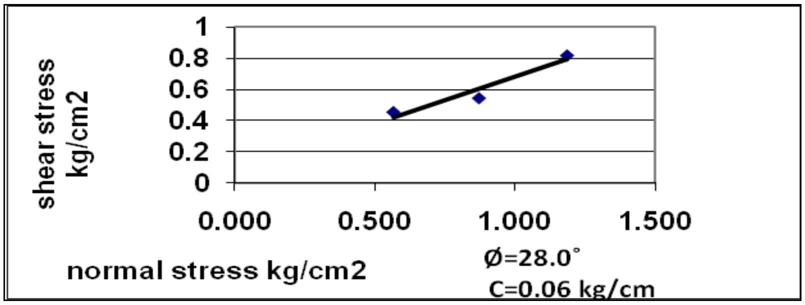
Chemical tests included determination of total dissolved salts (TDS), pH, Chloride ion (CL^-) concentration and Sulfate ion concentration (SO_3^-). CL and chloride ion concentration in Soil-water extracts sand samples as per **BS 1377**. The insoluble residue for both calcareous sand and quartz sand has been also conducted. The obtained test results are summarized in table (2). The near shore line collected samples of calcareous sand (sample 2) has high concentration of TDS, **CL^-** and (SO_3^-). The coastal line calcareous sand samples have 99% of carbonate materials content and Abo Rawash quartz sand has only 2% of carbonate materials. The sand samples of Abo Rawash and 500m away from coastal line calcareous sand have slightly aggressive condition if it compare with coastal line calcareous sand which is high aggressive soils.

Table 2: Chemical analysis and insoluble Residue of the calcareous and quartz sand samples.

Samples	TDS (ppm)	CL^- mg/l	SO_3^- mg/l	$Caco_3$
Calcareous sand	111	52	--	99.3%
	411	122	89	99%
quartz sand	150	61	--	2%

4.4 Shear characteristics of the soils

Direct shear tests were conducted to investigate the shear strength characteristics of the samples were performed as per (ASTM D- 3080); the calcareous sand had a peak friction angle of about 28° to 32.6° and cohesion 0.06 kg/cm^2 while the quartizitic sand had a peak friction angle about 38° and cohesion 0.08 kg/cm^2. This difference in peak friction angle is likely to be due to the percentage of calcareous materials in the sand. We can conclude that the strength of the quartz grains are higher the strength of the calcareous grains.



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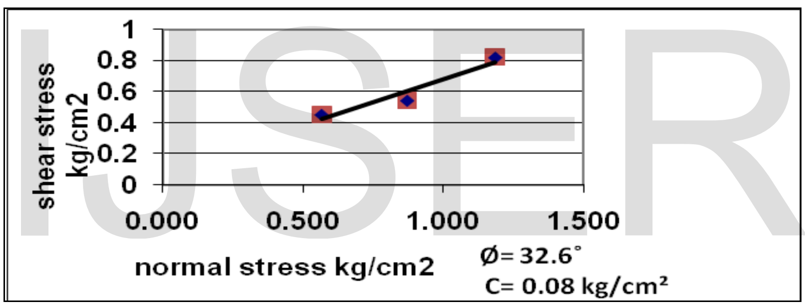

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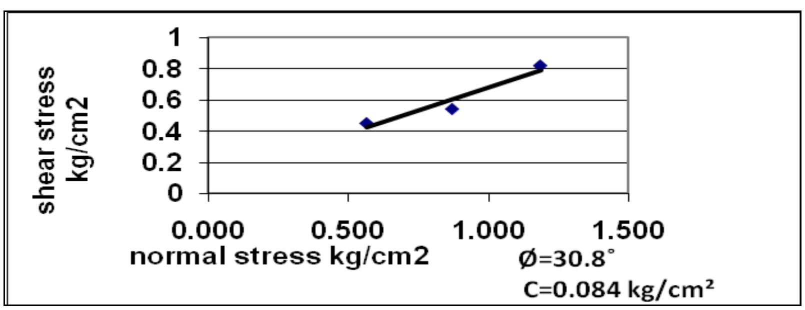

C

Figure 5: Direct shear test of calcareous sand samples (A and B) and quartzite Sand sample C.

4.5 Compaction test results:

Modified Proctor Test: The compaction test was performed for calcareous and quartzite sand according to [ASTM D698-12], generally the water acts as a lubricant between soil particles during the soil compaction process. Because of this, in the initial stages of compaction, the dry unit weight of compaction increases. However, another factor that will control the dry unit weight of compaction of a soil at given moisture content is the energy of compaction.

The compaction test results shown that the maximum dry density for calcareous sand 1.84 ton/m^3 and the optimum moisture content 10.37%, while the quartzite sand shown maximum dry density higher than calcareous sand 1.97 and the optimum moisture content 10.45% (Table 2).

Table 2: Proctor density of calcareous and quartizitic sand tested samples.

Parameters	Sample 1	Sample 2	quartizitic sand
Maximum dry density (ton/m^3)	1.82	1.86	1.97
Optimum moisture content (%)	12.63	8.11	10.45

We concluded that at nearly the same optimum moisture content the silicatic sand had the maximum dry density higher than the calcareous sand Figure 6.The irregular shape of calcareous sand as shown in the compaction curves (Figure 6) may indicate on crushing of calcareous grains under the energy effort of compaction blows.

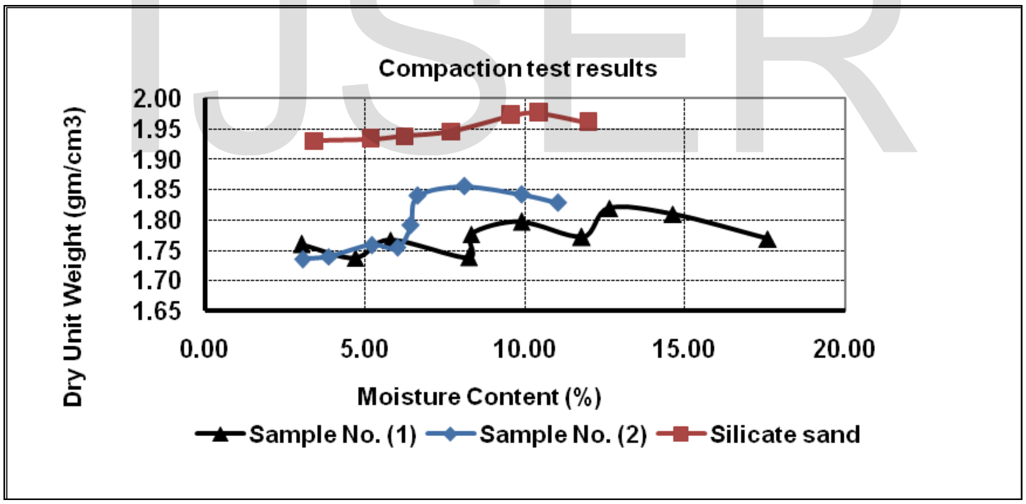

Figure 6: Modified Proctor Compaction Curves of calcareous and silicate sands.

Comparing the results of the relative density and the compaction test we conclude that the results of the calcareous almost the same in the two tests, but in the case of the results of the quartizitic sand we found that the relative density is more effective than the compaction.

4.6 California Bearing Ratio (CBR) tests:

This test used for determine the bearing capacity of a compacted soil under controlled moisture and density were performed as per (ASTM D 1883). The CBR test is run on three identically compacted samples. Each series of the CBR test is run for a given relative density and moisture content as determined from the modified proctor test Figure (6).The stress-penetration relation of the calcareous sand and quartzite sand is shown in figure 7. The average values of the CBR of calcareous sand samples and quartzite sand, compacted at optimum moisture content are 5.88 and 17.35%, respectively, Fig. (6). we can conclude that the strength of the quartz grain is higher the strength of the calcareous grain.

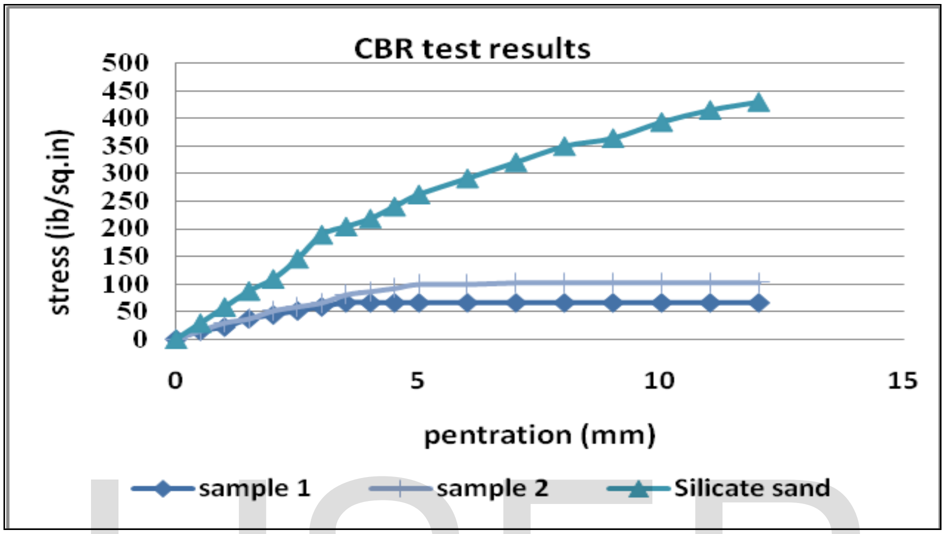

Figure 7: California Bearing Ratio test of the calcareous and silicate sands.

4.7 Unconfined Compressive Strength Test Results:

As shown in Fig. (8) The unconfined compressive strength of the quartzite sand is higher the compressive strength of the calcareous sand were performed as per (ASTM C- 109). The compressive strength of the quartazitic sand is directly proportional with the time. The maximum compressive strength of the quartzite sand was obtained after 28 days and equal to 420kg/cm2. The compressive strength of the calcareous sand is lower than the quartazitic sand. The compressive strength of the early stage is high than the elder stage because of the free lime in the samples, where the free lime in the elder stage with water makes gill action and decrease the compressive strength. The maximum compressive strength of the calcareous sand was obtained after 14 days and equal to 185kg/cm2.

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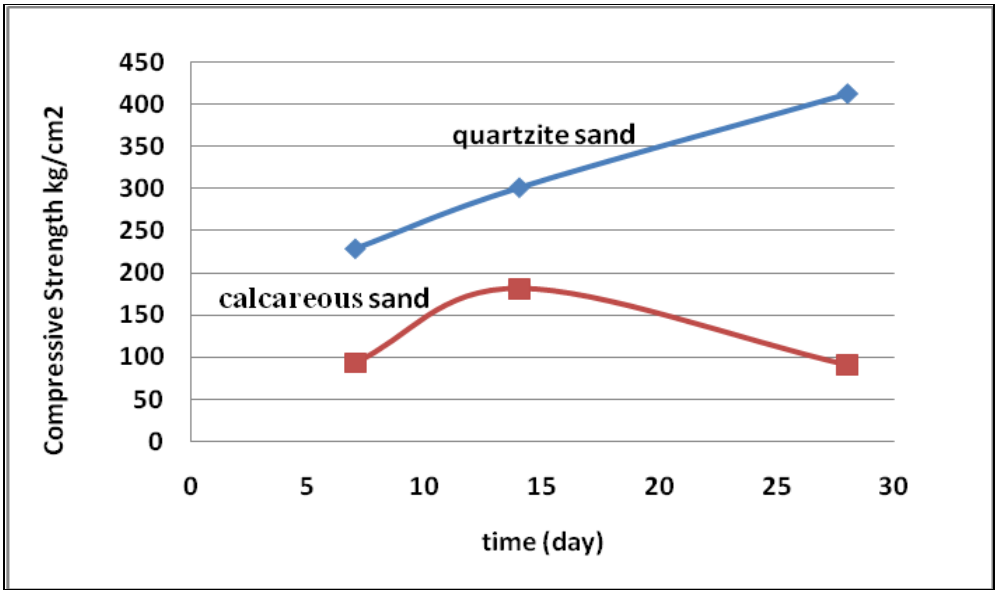

Figure 8: Unconfined compressive strength of sand-cement mortar cubes for calcareous and quartzite sands.

6- Conclusions:

The geological and geotechnical characteristics of the calcareous and quartzite sand have been studied. The basic engineering parameters of direct shear test, compaction, California Bearing Ratio (CBR), unconfined compressive strength of sand cement mortar cubes, the chemical analysis include Insoluble residue, CL and SO3 percentages and the microscopic studies were obtained through the field and laboratory studies.

Lithologically the sands along the northern coast called calcareous sand composed of quartz grains and carbonate grains consist of ooids and intraclasts. Microscopically the calcareous san can be classified as lith- arenite. The sands collected from Abo Rawash area is classified as (quartz arenite). The carbonates along the Northern Coast that represented as ridges along the northern coast classified as oolitic limestone (oosparite).

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In general we conclude that the uses of the quartizitic sand as a row building materials is better than the uses of the calcareous sand due to its chemical and mechanical stability.

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