Evaluation of Sand Quarries Exposed along Eastern Nile Valley Bank, Qena Region, Egypt

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Abstract— Mineralogical, geochemical and geotechnical investigations were carried out on the succession of of Quaternary sands extending on the eastern side of the Nile valley around Qena region to evaluate their suitability to be used as quarries. The studied sands are belonging to Pleistocene prenile deposits, termed Qena Sand Formation. To fulfill this objective, thirty samples of the investigated Quaternary sands were collected from different localities representing four sand quarries distributed along the study area. Mineralogical and geochemical analyses were performed on some selected samples. A soluble sulfates and chlorides percentage of the study sand has been measured. Physical and geotechnical parameters such as granulometric analysis, water content, organic matter content, plasticity, free swelling, California bearing ratio, and loss percentage of the studied sands has been examined. The results indicated that the investigated sands are suitable to quarrying. The studied sands can be utilized in highways constructions, asphalt mixtures, and cement concretes. The loss percentage of the studied sands varies from 15.40 to 44.86 %.

Index Terms— Loss percentage of Sand, Quaternary Sand, Granulometric analysis, Dissolved Sulfates and Chloride.

1 Introduction

The widespread sand quarries along the Eastern side of Nile valley can be considered as extremely significant sources of construction materials at Qena governorate that fill the needs of urban settlements and sustainable development of new cities (new Qena city). Among several geotechnical tests, the loss percentage of the sand deposits is very critical factor for evaluation of characteristics and economic significance of the sand sediments.

1.1 Previous Works

Some studies of sedimentology and mineralogy were carried out by [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], and [17]. Studies of Structure and tectonic investigations has been done by [18] [19], [20], [21], [22], [23], and [24]. Natural Geohazards investigation was studied by [25]. Some geotechnical measurements also has been done by [26], [27], [28] [29], [30], [31], [32], [33] and [34].

1.2 Location of the Studied Area

The study area is located in the eastern side of Nile valley at Qena governorate. It extends from Qus town (at the South) to Dishna town (at the North).

The area is located between latitudes 25° 47¯ and 26° 17¯ N and longitudes 32° 26¯ and 32° 53¯E. Four quarry faces at several localities has been chosen along the eastern bank of the Nile valley for evaluation of the sediments sampled in the studied localities (Quaternary sand) (Table 1 and Figure 1 and 2).

TABLE 1
LONGITUDES AND LATITUDES OF THE STUDY QUARRIES

East	North	Quarry
Coordinate system (WGS 1984)		
32°26'24.84"	26°12'1.85"	Dishna
32°38'16.11"	26°13'1.23"	Almakhadma
32°53'18.29"	25°58'52.99"	Qift
32°54'8.77"	25°53'7.41"	Qus

1.3 Scope of the current Study

The current study transacted with an investigation of the geotechnical attitude of Quaternary sand which outcropped over the studied localities of the study area for evaluation of their proportion to be used as sand quarries. The fundamental framework of the study is an assessment of the study localities of sand to use in several engineering applications particularly highway constructions, cement concretes, and asphalt mixtures.

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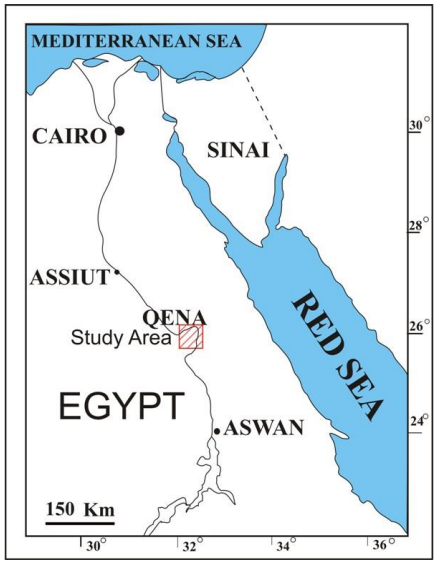

Fig. 1. Location map of the studied area.

Fig. 2. Satellite map shows the allocation of the studied sand quarries

1.4 Geological Setting

The studied sand includes a wide range of deposits which differ in textures and mineralogical composition, reflecting the environmental sedimentary characteristics of the Qua-ternary sediments. The allocation of the studied localities of sand is illustrated with a total description in a geological map (Figure 3). Quaternary deposits, at Qena region, include the Prenile sediments (Qena sand and Kom Ombo gravel) and Bank sediments (Nile silt). Prenile sediments appear as a thick and readily conspicuous unit made up at most of sand which likely have been deposited by adequate river possessing E-W direction [18]. These sediments are subdivided into 2 units termed Qena sand (lower part) and Kom Ombo gravel (upper part) [11]. The quaternary sand at the studied area is classified as Prenile Qena Sand.

2 Materials and Methods

2.1 Materials

Thirty samples of the study sand have been collected from four quarry faces allocated along the Eastern bank of the Nile valley at Qena governorate. The weight of every sample was up to one kilogram. The studied sand is Wadi deposits and belongs to Quaternary age (Pleistocene). The length of the studied quarry faces is 100 m. The thickness of the quarry faces are changing from 16 to 23 m (Figure 4a,4b). The gravel layer occurs on the surface for all of the studied quarries sands

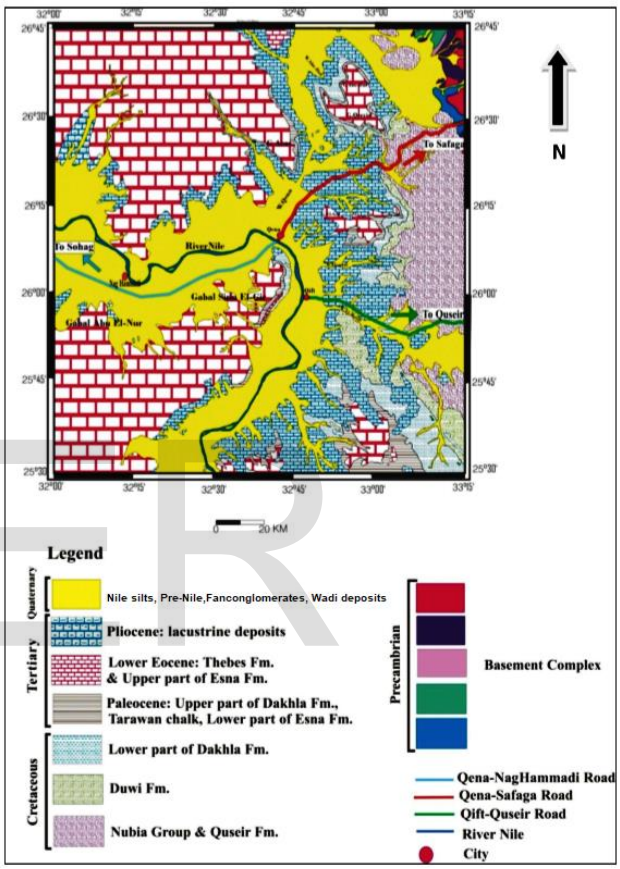

Fig 3. Geological map of the study area modified after [30]..

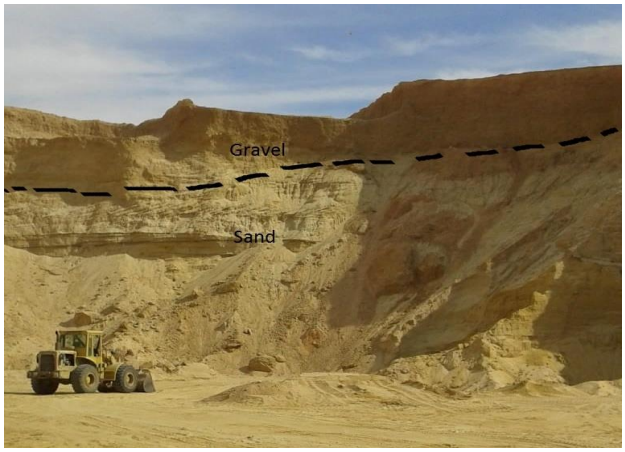

Fig.4a. Field photo of the sand quarry face at Almakhadma

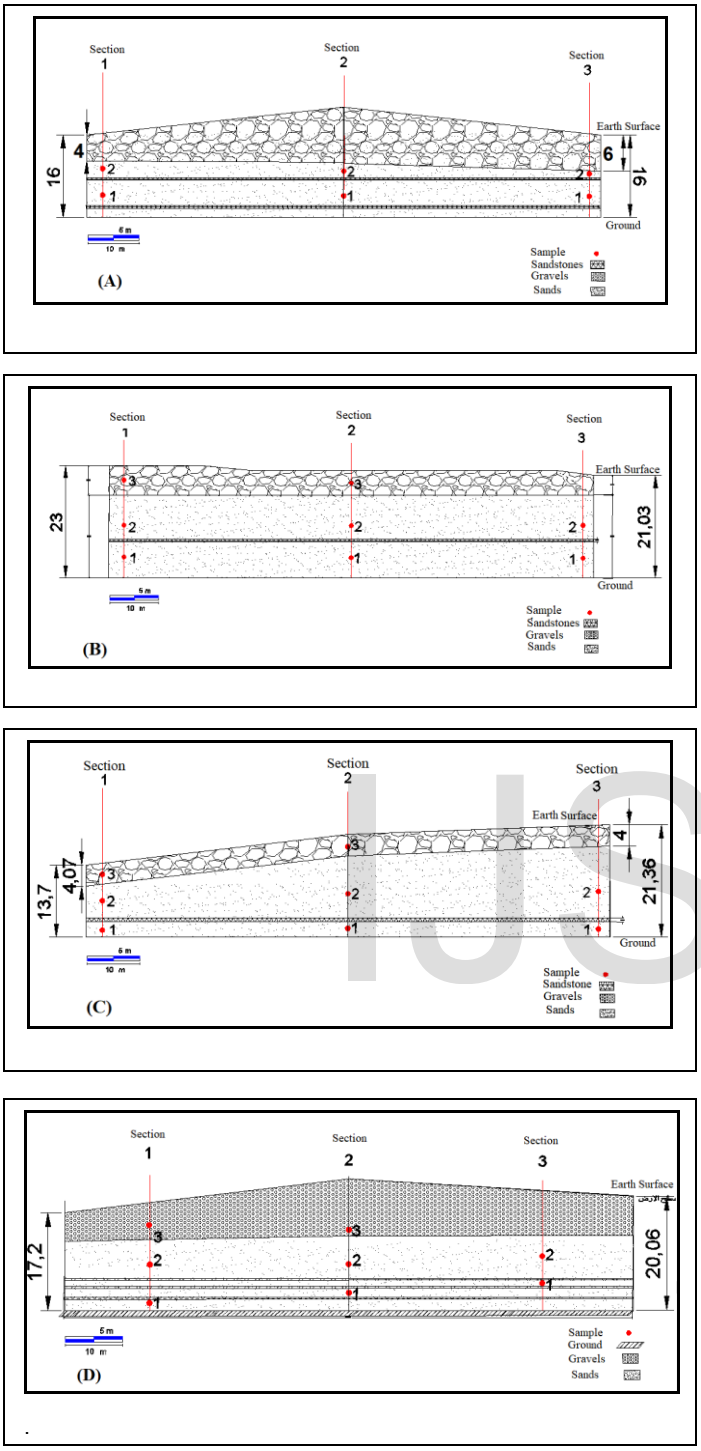

Fig. 4b Four cross sections at the studied sands quarries faces.

2.2 Methods

Geochemical and mineralogical analyses, X-ray fluores-cence (XRF) and X-ray diffraction (XRD) of the studied sand has been achieved. Dissolved sulfates [35] and chlorides [36] were checked and analyzed. Physical and geotechnical properties which including water content [37], Granulometric Analyses [38], organic content [39], plasticity [40], free swelling [41], and proportion of loss [42] have been carried out. Total station Sokkia CX7 without prism used to measure the thickness of each layer at the investigated sand quarries faces, which helps to calculate the loss percent of the studied sand quarries as showed in tables 5, 6, 7, and 8.

3 Results

3.1 Mineralogical and Geochemical Results

The average geochemical results indicated that the studied Dishna town, Almakhadma village, Qift town, and Qus town sand was essentially composed of SiO2 (48.76 to 94.65 %) and Al2O3 (2.63 to 6.90 %). The studied Dishna and Almakhadma sand were mainly contain relatively higher percent of calcium ranging from 16.73 to 18.73 %. The sample of Dishna and Almakhadma sand was contained higher chlorides (190.77 to 235.66 ppm) and sulfates (110.34 to 125.44 ppm). The results showed also that the sample of Qift and Qus sand was contained lower chlorides (69.88 to 73.81 ppm) and sulfates (46.33 to 50.55 ppm). The results of mineralogy illustrated that the study sand was mainly composed of quartz, calcite, orthoclase, and plagioclase (albite) (Table 2 & 3).

TABLE 2

AVERAGE OF MINERAL COMPOSITION OF THE STUDIED LOCALITIES

Samples	Minerals Compositions			
Dishna	Quartz	Calcite	Albite	-
Almakhadma	Quartz	Calcite	Albite	Illite
Qift	Quartz	Orthoclase	Albite	Kaolinite
Qus	Quartz	Orthoclase	Albite	Gypsum

3.2 Physical and Geotechnical Results

3.2.1 Physical and Geotechnical Results

The obtained results illustrated that the amount of water content of the investigated sand samples ranges from 0.13 to 0.41 g/cm3. The organic content results of the examined samples vary from 4.00 to 7.00 % (Table 4).

3.2.2 Plasticity

The percent of the plasticity index for the tested sand illustrated in Table 4. Obtained results were changing from 2.00 to 6.00 % .

3.2.3 Granulometric Analyses

The result analyses illustrated that study sand was classified in the categories of sand size (90 to 98 %), gravel size (0 to 10 %), and silt size (0 to 10%), as displayed in Figure 5 (grain size distribution curves A, B, C, and D). On the basis of unified soil classification system (USCS), samples of the studied localities were classified as SP, poorly graded sand. In the AASHTO system (American association of state highway and transportation official), the soil is classified into seven major groups: A-1 through A-7

On the basis of this classification system, samples of the studied localities were classified as A1-b (group one).

TABLE 3

AVERAGE OF GEOCHEMICAL RESULTS OF THE STUDIED SAMPLES AT DIFFERENT LOCALITIES

Average	Dissolved (ppm)		Chemical Oxides (%)								
	CL	S	SiO_2	Al_2O_3	K_2O	CaO	Fe_2O_3	Na_2O	Cl	SO_3	L.O.I
Dishna	190.77	110.34	48.76	6.90	1.26	18.73	2.63	1.42	0.62	5.65	11.65
Almakhadma	235.66	125.44	49.75	5.93	1.16	16.73	2.33	1.72	0.72	6.45	12.85
Qift	69.88	46.33	94.65	2.63	0.63	0.05	0.34	0.07	0.20	0.03	1.24
Qus	73.81	50.55	93.67	3.65	0.53	0.04	0.35	0.06	0.30	0.04	1.84

L.O.I = LOSS ON IGNITION

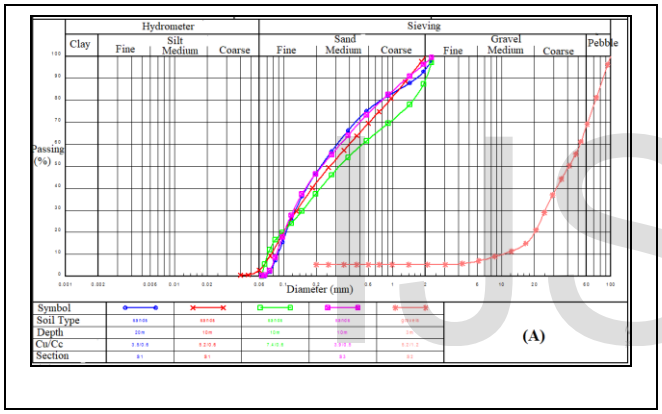

Fig. 5. Four (A, B, C, and D) grain size distribution curves of the study sands.

3.2.4 Free Swelling

Free swelling percentages of the investigated sand samples vary from 5.00 to 35.00 % (Table 4).

3.2 Proportion of the Loss of the Sands

Based on the Egyptian standard specification (ESS), the Loss Percentage of the Sand is equivalent to the percentage grain size which greater than 4.75 mm in addition to the percentage of the grain size lower than 0.073 mm.

After investigation of the studied sand quarry faces and the Granulometric Analysis, the obtained results indicated that the Proportion of the Loss of the Sands at the investigated localities changing from 23.54 to 44.86 %.

TABLE 4
GEOTECHNICAL AND PHYSICAL PROPERTIES OF THE STUDIED SANDS SAMPLES

Location / Properties	Dishna Quarry			AlMakhadma Quarry			Qift Quarry			Qus Quarry		
	S1 (1)	S2 (2)	S3 (1)	S1 (2)	S2 (1)	S3 (2)	S1 (1)	S2 (2)	S3 (1)	S1 (2)	S2 (1)	S3 (2)
Water Content	0.15	0,17	0,13	0.30	0.23	0.19	0.41	0.36	0.25	0.33	0.31	0.30
Organic Content	-	-	-	05	07	04	06	04	05	-	-	-
Plasticity index	02	02	04	06	05	06	06	04	05	02	03	02
Free Swelling (%)	12	11	07	33	27	35	29	30	33	05	10	15
Proportion of Loss (%)	44.86			24.50			23.54			42.22		
USCS Classification	SP			SP			SP			SP		
AASHTO Classification	A1-b			A1-b			A1-b			A1-b		

TABLE 5
LOSS PERCENTAGE OF DISHNA SAND QUARRY

Total Proportion of Loss (%)	Total Face Area (m^2)	Area of Loss for Each Layer (m^2)	Proportion of Loss for Each Layer (%)	Area of Each Layer in the Face (m^2)	Layer
100 *1875.00/841.24 **44.86** =	1852.85	735.00	100.00	735.00	Upper Gravels Layer
		6.24	0.60	1040.00	Sands Layer
		100.00	100.00	100.00	Clay Layer
		841.24			Loss of Face Area

TABLE 6
LOSS PERCENTAGE OF ALMAKHADMA SAND QUARRY

Total Proportion of Loss (%)	Total Face Area (m^2)	Area of Loss for Each Layer (m^2)	Proportion of Loss for Each Layer (%)	Area of Each Layer in the Face (m^2)	Layer
100 *2225.80/544.34 **24.50** =	1852.85	428.20	82.00	522.20	Upper Gravels Layer
		66.14	0.40	1653.60	Sands Layer
		50.00	100.00	50.00	Sandstone Layer
		544.34			Loss of Face Area

TABLE 7
LOSS PERCENTAGE OF QIFT SAND QUARRY

Total Proportion of Loss (%)	Total Face Area (m^2)	Area of Loss for Each Layer (m^2)	Proportion of Loss for Each Layer (%)	Area of Each Layer in the Face (m^2)	Layer
100 *1852.85/436.22 **23.54 =**	1852.85	356.28	89.00	400.31	Upper Gravels Layer
		4.94	0.34	1452.54	Sands Layer
		75.00	100.00	75.00	Sandstone Layer
		436.22			Loss of Face Area

TABLE 8
LOSS PERCENTAGE OF QUS SAND QUARRY

Total Proportion of Loss (%)	Total Face Area (m^2)	Area of Loss for Each Layer (m^2)	Proportion of Loss for Each Layer (%)	Area of Each Layer in the Face (m^2)	Layer
100 *2090.00/882.50 **42.22 =**	1852.85	799.00	100.00	799.00	Upper Gravels Layer
		8.50	0.70	1216.00	Sands Layer
		75.00	100.00	75.00	Sandstone Layer
		882.50			Loss of Face Area

TABLE 9
SPECIFICATION LIMITS OF SANDS UTILIZED IN VARIOUS APPLICATIONS [35] AND [36]

Parameter / Application	Dissolved Sulfates and Dissolved Chlorides (ppm)
Cement Concretes	Not More than 600 for Sulfate AASHTO, T290 Not More than 400 for Chlorides AASHTO, T291
Asphalt Mix.	-
Road Constructions (Base and Sub-base)	-

4 Discussions, Conclusions, and Recommendations

4.1 Discussions and Conclusions

The results of the geochemical analyses of the studied sands at Qus, Qift, Almakhadma, and Dishna quarries showed that they were mainly composed of SiO2 (48.76-94.65%), Cao (0.04-18.73%) and Al2O3 (2.63-6.90%), as well as small amounts of K2O, Na2O and Fe2O3. However, the sands at Dishna and Almakhadma quarries were mainly contain relatively high percent of CaO ranging between 16.73 and 18.73%. Dishna and Almakhadma sands exhibited higher contents of chlorides (190.77-235.66 ppm) and sulfates (110.34-125.44 ppm), whereas Qift and Qus sands showed lower amounts of chlorides (69.88-73.81 ppm) and sulfates (46.33-50.55 ppm). All the tested sand samples were not more than 600 for Sulfate and not more than 400 for Chlorides based on [35] and [36] respectively. The mine-ralogical composition of the studied sands was mainly composed of quartz, calcite, orthoclase, and albite. The granulometric analysis illustrates that the considered sands were composed of gravel (0-10%), sand (90-98%), and silt (0-10%), as illustrated in Figure 5 (A, B, C, and D). The investigated samples have been classified based on the unified soil classification system (USCS) as SP, poorly graded sand, and as A1-b (group one) (according to AASHTO).

The water amounts of the studied sand samples were varying from 0.13 to 0.41 g/cm3. The organic matter content results of the examined samples were changing between 4.00 to 7.00%. The values percent of the plasticity index of the tested sand were ranging between 2.0 and 6.0 %. Hence, the studied sands were classified as non-expansive.

After investigation of the studied sand quarry faces and the Granulometric Analysis, the obtained results indicated that the loss Percentage of the sand at the investigated localities changing from 23.54 to 44.86 %.

Generally, the sand deposits at the eastern side of the Nile valley in Qena governorate are in a huge amount and have a good quality and could be exploited in various engineering applications especially for cement concretes.

4.2 Recommendations

Mineralogical, geochemical and geotechnical evaluation of the sand quarries at the other side (western bank) of the Nile valley in Qena governorate is recommended. Comparison study between the sand quarries at both sides of western and eastern banks of the Nile valley is proposed.

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