International Journal of Mining Science and Technology 24 (2014) 467–470

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

A study of some Egyptian carbonate rocks for the building construction industry

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ARTICLE INFO

Article history:
Received 5 September 2013
Received in revised form 10 November 2013
Accepted 15 February 2014
Available online 5 June 2014

Keywords:
Carbonate rocks
Building construction
Raw materials
Aggregates

ABSTRACT

A number of geotechnical analyses were carried out on selected carbonate rock samples from eight sites located in Egypt. This analysis was to assess the suitability of these rocks for building construction aggregate. The analyses included properties of uniaxial compressive strength, tensile strength, porosity, water absorption, and dynamic fragmentation. The success of building construction depends to a large extent on the availability of raw materials at affordable prices. Raw materials commonly used in the building industry include sands, gravels, clays and clay-derived products. Despite the widespread occurrence of carbonate rocks throughout Egypt, the low premium placed on their direct application in the building sector may be explained in two ways: firstly, the lack of awareness of the potential uses of carbonate rocks in the building construction industry (beyond the production of asbestos, ceiling boards, roof sheets and Portland cement); and secondly, the aesthetic application of carbonate rocks in the building construction depends mainly on their physical attributes, a knowledge of which is generally restricted to within the confines of research laboratories and industries. Thus this paper addresses the physical and mechanical characteristics of some Egyptian carbonate rocks, evaluating them for their suitability as building construction aggregates.

1. Introduction

In the past some work has been carried out on the evaluation of Egyptian carbonate rocks for construction purposes include geotechnical analyses of limestone specimens from north to south Egypt. The first comprehensive work was performed by Tame and Edet, on the suitability of Egyptian limestone for cement manufacture [1–5]. The mechanical properties of middle Eocene limestone of Minia formation along the Nile valley were studied; the strength increased as porosity decreased, with slightly porous fine grained limestone being of intermediate strength, while semi porous coarse grained limestone was brittle and very weak [6–7]. Upper cretaceous carbonate rock ranged from strong and very brittle with lower modulus ratio on average in the Abu Roush area, to rock that was slightly porous to semi porous, and weak with a medium modulus ratio. Carbonate rocks of manfauolt formation in the Asyut area were studied, which found that the characteristics of the investigated samples by volume weight average equals to 2.33 mg/cm^3, average porosity is 12.1%, and the compressive strength varies between 199 and 352 kg/cm^2 [8–10].

2. Study area

The four hundred and five samples used in this study were obtained from different sites in Egypt, Aswan, Qena, Sohag, Asyut, Minia, Helwan, Suez, and Sinai. Lower Paleozoic rocks are exposed in various regions of Egypt (southern central Sinai, northern Eastern Desert and southwestern Western Desert), in addition to occurring in the subsurface such as the northern Western Desert and the Gulf of Suez. Lower Paleozoic rocks in Egypt including surface and subsurface rock units of formational status were discussed by Said (see Fig. 1) [11]. These localities cover two major sedimentary basins in Egypt; the southern samples were collected from Misr Cement Company and Aswan quarries. The deposits are composed of intercalations of calcareous sandstone, nodular marly limestone, massive limestone, and calcareous hard ground and gypsum layers of the Gebel el-Gir Formation, which were reported. Carbonate rocks belonging to the Eocene and the upper Cretaceous dominate the top portion of the sediment section, while the lower portion is mainly clastics, and belongs to the Mesozoic and

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http://dx.doi.org/10.1016/j.ijmst.2014.05.008
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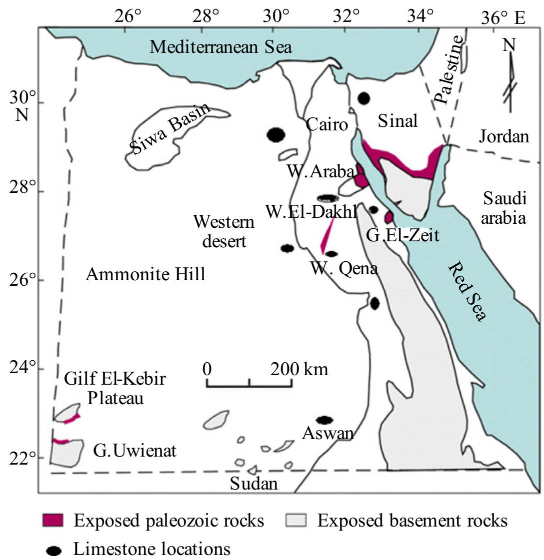

Fig. 1. Geological map of the studied area.

Paleozoic (Nubian sandstone complex). The geological setting was adopted by Said to describe the equivalent lower Eocene sequence in the Nile valley, Egypt [12,13].

3. Study method

A total of four hundred and five carbonate rock samples from different deposits were subjected to the index property and strength characterization tests that were reported, and were conducted to ISRM standards [14–17]. The size of the cylindrical specimens used for the tests ranged from 23.58 to 54.45 mm in length and 15.70–16.70 mm in diameter. The index properties (specific gravity, density porosity and water absorption) were determined in accordance with the methods outlined by Edet [18]. The strength results were corrected according to a standard size specimen with a diameter of 48 or 54 mm and a length to diameter ratio between 2 and 3 using the Turk and Dearman correction, as illustrated in the following Eq. (1).

$$\delta_{50}/\delta_m = D0.18/(1.754 + 0.535(D/L)) \quad (1)$$

where δ_{50} is the uniaxial compressive strength of a 50 mm diameter rock; δ_m the Uniaxial compressive strength of a rock specimen having a different diameter; D the diameter of specimen; and L the length of specimen.

4. Results and discussion

4.1. Specific gravity, density, porosity and water absorption values

Using the data from Table 1, the mean specific gravity of the carbonate rocks ranges between 2.23 for the Qenamarly limestone and 2.76 for the Oolitic limestone of Sinai. Similarly, the mean dry densities (Table 1) do not show large significant variations. The range of dry densities is between 2.43 mg/m^3 for the Asyut marly limestone and 2.64 mg/m^3 for the marly limestone deposit at Qena. The variations in specific weight are attributed to differences in age, fossil content and fabric of the carbonate rocks. The mean values of absolute porosities are presented in Table 2, and show the highest value of 10.2% for Helwan deposit (marlylimestone) in comparison to the lowest value (5.4%) from Asyut deposit. The water absorption values of these carbonate rocks range between 0.92% (sandy limestone, Asyut), and 5.8% (marly limestone, Helwan).

4.2. Uniaxial compressive strength, tensile strength and Young's modulus value

The highest value of 105.66 N/mm^2 was obtained by the Asyut specimen and the lowest 33.25 N/mm^2 belongs to the Helwan carbonate rock sample (Helwan in Table 2, and in Fig. 2). Specimens from all localities were saturated and subjected to unconfined compression tests. All samples showed a reduction in strength, as

Table 1
Mean values of some physical properties for studied area.

Location	Specific gravity (*G*)	Density (*P*)		Water absorption	Age
		Dry (mg/m^3)	Saturated (mg/m^3)		
Aswan	2.56	2.54	2.71	4.20	Eocene
Qena	2.23	2.45	2.64	1.58	Paleocene
Sohag	2.50	2.64	2.76	4.85	Pliocene
Asyut	2.45	2.43	2.68	0.92	Pleistocee
Minia	2.65	2.50	2.69	1.60	Holocene
Helwan	2.41	2.52	2.70	5.80	Pliocene
Suez	2.67	2.62	2.79	2.25	Miocene
Sinai	2.76	2.47	2.59	5.52	Holocene

Table 2
Mean uniaxial compressive strength and Young modulus value.

Location	UCS (N/mm^2)		Tensile strength (N/mm^2)		Porosity (%)	Density (mg/m^3)	Coefficient of dynamic fragmentation (%)
	Dry	Saturated	Dray	Saturated			
Aswan	46.55	22.10	4.21	1.55	8.90	2.54	17.85
Qena	74.62	36.72	5.26	2.52	7.60	2.45	19.25
Sohag	40.36	12.90	4.01	1.05	9.35	2.64	21.25
Asyut	105.66	93.44	8.35	6.98	5.40	2.43	25.70
Minia	68.50	28.25	5.32	2.38	7.85	2.50	21.35
Helwan	33.25	31.40	2.86	1.89	10.20	2.52	24.35
Suez	55.36	38.21	8.74	1.77	8.01	2.62	21.10
Sinai	38.05	22.20	3.20	1.65	9.80	2.47	20.50