Egypt. J. Chem. **Vol. 64,** No. 3 pp. 1553 - 1562 (2021)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Effect of Granite Weathered Granules Additives as Aggregates In Cement Concrete

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Abstract

Granitic weathering products were obtained from South Sinai. These aggregates were assessed to be used in the manufacturing of cement concrete. Chemical and mineralogical compositions and physical parameters of the selected samples were carried out. The composition of the main phase is quartz, albite, and microcline, while river sand shows only quartz as one phase.

Four batches were designed with two different grain size divisions between the fines to medium granules. Two batches were designed with aggregates of granite weathering products only for all sizes. The other two batches were designed with coarse and medium granite aggregates and a fine of river sand. Some technological characteristics of the four batches in terms of bulk density, expansion, and compressive strength were detected. It is deduced that the replacement of the fine granite weathering products fraction with the river sand in two ratios (10 & 20%) yields higher amounts of the technological properties. The maximum compressive strength results recorded are 101.53% and 180.92%, in the batch nos. 4 and 3, respectively. The batch contains 20% of the river sand; fine fraction is denser and higher expansion and crushing strength values. SEM and EDX of the batches nos. 2 and 3 support the technological properties and the phase composition of the main component of granite and river sand granules as well as the composition of the main oxides of the OPC common in the market and elucidated that the river-sand as fine granules has better technological characteristics than the granite fine granules.

Keywords: Granite-weathering, Concrete. Technological properties.

1. Introduction

Concretes are the main famous building substance usually used in construction purposes. It can be shaped, fashioned, and applied for most constructors, including buildings of pavements, culverts, bridges, retaining walls, and other structures.

Concrete is a mixture of aggregates, cement, and water, which are chemically inert materials. Aggregates include various sizes of gravels, which constitute the bulk of the concrete and causing its strength. The fine aggregate particles fill the vacant spaces between the coarse and medium grains, while cement (OPC) fills the finest spaces, bonded the aggregates together. Thereby, the concretes their high strength and density as well as impermeability [1].

As the concrete is mixed, it will be in a plastic or semi-fluid phase, then moulded into various shapes. After two hours, the concrete begins to stiffen and a significant increase in strength happened during the first week and continues to harden with time. The compressive strength of the concrete increases and reached nearly 95 percent of its strength after a period of 28 days.

The aggregates are the essential factor in the concrete strength. Using varying size aggregates yields more dense and strong concrete. The composition of fine aggregate normally includes sand with different sizes ranging from 0.3 to 5 mm, while the coarse aggregate pertains to 40 mm. Aggregate is acquired from different sources of rocks forming grains. Natural aggregate can be obtained from river beds, gravel pits, lakes and dunes use without any mechanical treatment. This aggregate consists of round and polished as well as angular particles.

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Receive Date: 02 November 2020, Revise Date: 24 November 2020, Accept Date: 25 November 2020
DOI: 10.21608/EJCHEM.2020.48575.2994

Aggregate must be neither porous nor brittle. Aggregate could be produced by crushing, massive rock, such as basalt, quartzite, granite, limestone, and porphyry to be sharp-edged and angular. It is necessary to wash the aggregates if it contains impurities of clay or variable materials, as these negatively influence the strength of the obtained concrete. Impurities of clays cause a high level of shrinkage and prevent the concrete-steel adhesion in reinforced concrete. Dust and fine crushing residues lower the mechanical strength and chemical resistance.

The best batch is that consolidates with the minimum voids, with cement and fine particles. Theoretically, a mixture of 1:2:4 (cement: sand: gravel) will give a dense concrete. In practice, when dense and plastic concrete is required by a mixture of 1:2:3 is applied mainly because of the difference in the percentage of empty spaces. Water/cement ratios in the range between 0.4 and 0.6 provide high workability without affecting the quality of the concrete. The mixing time varies, usually, 1.5 to 3 minutes is sufficient to acquire a good mixture. Mixing more than 3 minutes will not improve the quality of the mixture. Also, smooth coarse aggregates decrease the strength of concrete by 10% than the roughened aggregates. They were also suggested that a fine coating of impurities such as silt on the aggregate surface could hinder the development of a good bond and thus affects the strength of concrete produced with the aggregates [1-5].

The river sand consumption is very high due to the increase in using concrete owing to infrastructural growth. , while, the waste granite obtained by the industry has heaped up over years result in problems of pollution. The aim of the present work is to develop a concrete using the granite wastes, industrial waste as an alteration substance for the fine aggregates [6].

Replacement of river sand, fine aggregates by fine granites, the compressive strength has increased by 22% with the use of 35% [7]. Fine aggregates of granite slurry waste produced a cohesive mix and decrease the workability of granite slurry concrete and increases in compressive strength when the replacement of cement by granite slurry waste was up to 5% [8]. The Split tensile strength also increases with the replacement of 5% of granite polishing power with natural aggregates [9-11].

In the construction industry, marble and granite are used for different architectural purposes like flooring and cladding, etc., due to their appearances, strength, and resistance to fire. The waste granite and marble industry composed of a fine powder, granules as well as sludge that represent one of the environmental problems around the world. In Egypt, the fine waste generated from granite processing is estimated by over 30% of the volume of the massive block [12-13].

Using of the powder of the granite can minimize the cost of construction, which is available at free of cost. Also, environmental Pollution can be decreased by reducing the production of cement and also the health hazards by using the granite powder as a partial replacement to Cement. The acute shortage of river sand, huge shortcomings on quality of river sand, high cost, greater impact on road damages, and environmental effects. The Construction Industry shall start using industrial sand to the fullest extent as an alternative to the natural River sand [14-21].

The scope of the present research is studying the assessment and utilization of granite weathered aggregates for the cement concrete. Also, investigates their physical parameters in term of their bulk density, apparent porosity, and water absorption of the raw placer deposits. The technological characteristics of the concrete after 28 days of the curing time were performed. The compressive strength as an indication of the mechanical characteristics was also measured. The chemical and mineral composition of the raw as well as the microstructure and microanalysis of the concrete were carried out. Also, study the effect of replacement the fine fraction of the concrete with river sand on the technological characteristics of the concrete expressed in bulk density, expansion, and compressive strength.

2. Material and methods

2.1 Aggregates.

The aggregates were obtained from Wadi Lethi area (Figure 1), which is located in the eastern part of southern Sinai about 20 Km from Sharm El Sheikh-Dahab Asphaltic road, between longitudes 33° 05' E-33° 20' E and latitudes 27° 50' N -28° 05' N. [22-23] studied the area and mentioned in the occurrence of various granitic types. Weathered granites (stream sediments) were collected aggregates with different sizes.

Aggregates were classified into three categories as coarse, medium, and fine aggregates. The coarse variety is more than 4 mm, medium 4-2 mm, and fine less than 2 mm. River sand common in the market of the building materials is used in some batches as a replacement to the fine aggregates of stream sediments. The chemical analysis of each category was obtained using XRF techniques and illustrated in Table 1. The Mineralogical composition of the stream sediments, as well as river sand, was obtained using the XRD technique to detect the phase composition of them (Figure 2). Physical parameters in terms of bulk density and apparent porosity were also determined using water displacement methods [24] as illustrated in Table 2. The percentages of the cement and water were applied following the standard specification [25]. The concretes were cast into cubic moulds with 5 × 5 × 5 cm3 dimensions, then de-molded after 24 h and cured in ~ 100% humidity chamber for 28 days. The prepared cubes were tested for crushing strength and bulk density following ASTM C20 2010 [23-24]. Ordinary Portland cement available in the local market was used. Water used for drinking is available for the concrete mix with 0.4% of water/cement ratio as illustrated in Table 3.

Four batches were designed as listed in Table 3. Two of them are composed of aggregates of granite and different percentage of medium and fine of the same aggregates. While the other two batches are the same percentage with sand as fine aggregate instead of placer deposits. The bulk density and shrinkage as well as the crushing strength of the concrete cubes were estimated and displayed in Table 4.

The phase composition **and** the microanalysis with the microstructure of the selected batches were detected using XRD and SEM attached with EDX, respectively.

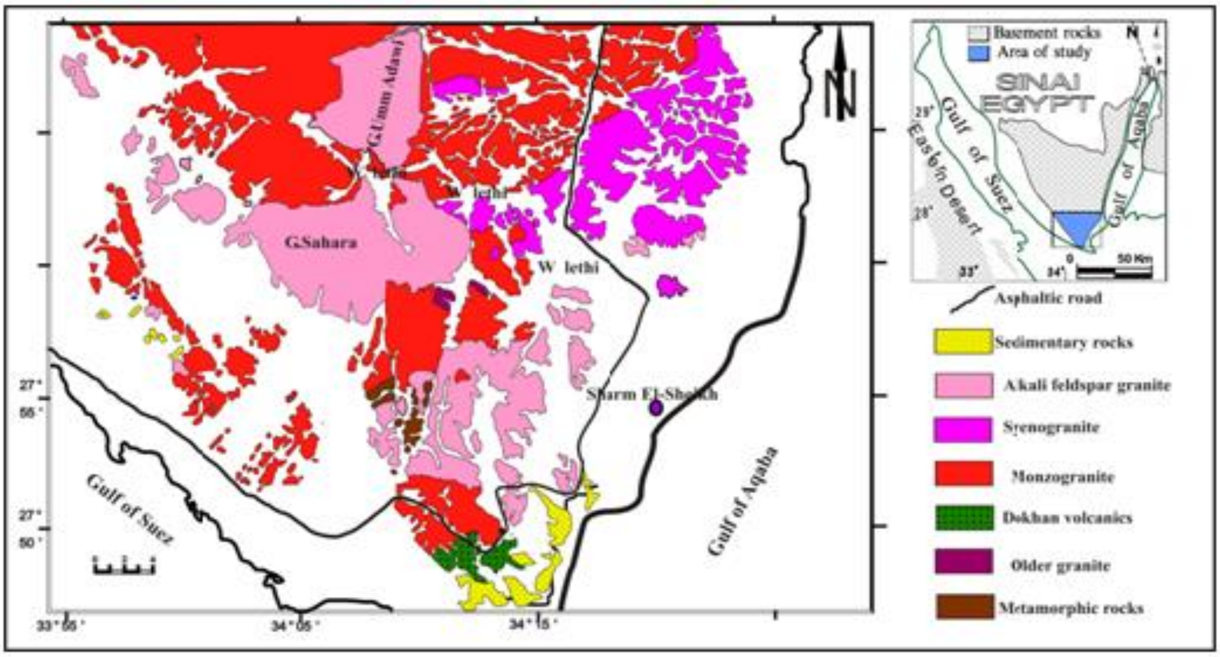
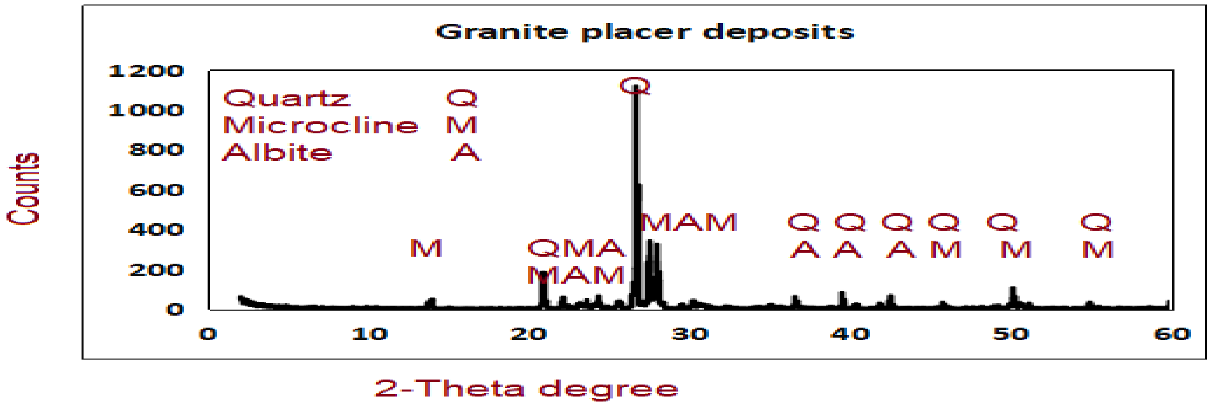


Figure 1



Mineral Name	Chemical Formula	Semi Quant [%]
Quartz, syn	Si O2	66
Microcline ordered	K (Al Si3 O8)	10
Albite, calcian, ordered	(Na , Ca) Al (Si , Al)3 O8	24

Figure 2

3. Results and discussion

Table 1 illustrates the chemical analyses of the aggregates used for making the concretes. **Hence**, the various sizes of the stream sediments, SiO_2 is the main content with lesser amounts of Al_2O_3, Na_2O, K_2O, Fe_2O_3, and TiO_2. SiO_2 ranges from 70-75% and Al_2O_3 (12.8-14.5%), Na_2O, and K_2O as 4.2 to 4.8% for both of them. Fe_2O_3 contents of 2.0 to 2.40%, while TiO_2 average is 0.2%. Other oxides are traces and also recorded. The major oxide composition of river sand is SiO_2 as 91.40% with lesser amounts of Al_2O_3 and $Fe2O_3$ as 3.30 and 1.39%, respectively. Other impurity oxides were detected in lesser contents.

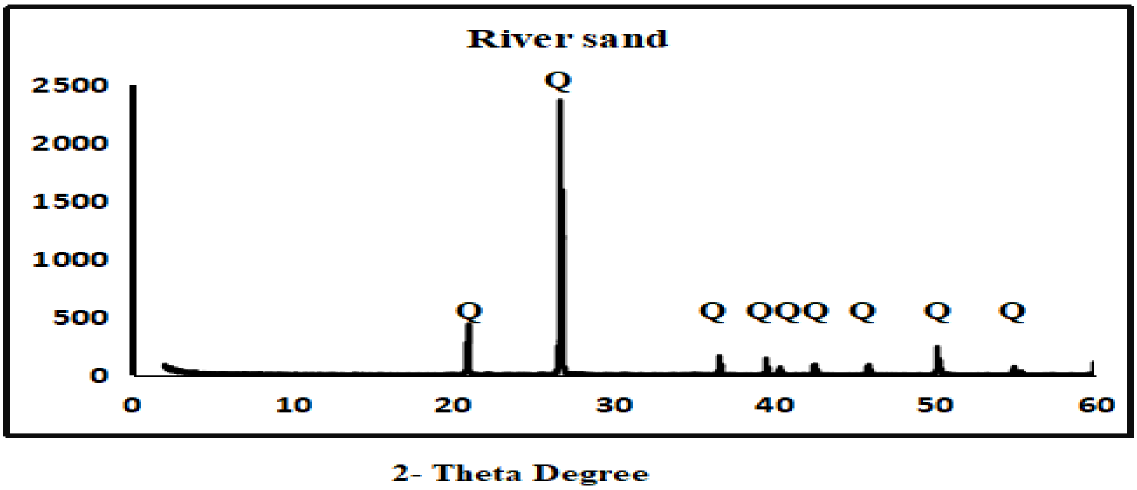
The mineralogical composition of the weathering products and sand is exhibited in figures 2&3. It is confirmed that quartz is the main mineral in the weathering products with percent to 66% with subordinate amounts of Albite (24%) and microcline feldspar (10%), Figure 2. Quartz is the monophase recorded in the river sand sample as displayed in Figure 3.

Table 2 explains the bulk density, apparent porosity, and water adsorption of the raw placer aggregates carried out using water displacement methods [26] as 2.55 g/cm3, 5.68%, and 2.23, respectively. The composition of the designed batch of the concrete was displayed in Table 3. The four batches are composed of coarse, medium as well as fine aggregates, cement, and water in a proper ratio. Batches nos. 1 & 2 composed of the three fractions of weathering product aggregates without river sand, while batches nos. 3 and 4 contain river sand instead of the fine fraction of stream sediments, **F**igure 4.

Technological characteristics of the four batches after curing for 28 days exhibited in Table 4. It ensures that the batches contain river sand have a bulk density higher than that contain fine granite weathering products as 2.17 & 1.87 as well as 1.75 & 1.79 g/cm3, respectively. While the linear expansion also increases by increasing the river sand in the fine fraction. Compressive strength tested for 28 days exhibited the following values of the four batches 62.91, 72.17, 180.92, and 101.53 kg/cm^2.

From the above results, we can conclude that by increasing the fine fraction of the concrete, density, expansion and compressive strength increase. With replacement, the fine fraction of the weathering products with the river sand the density, expansion, and compressive strength increased. The maximum compressive strength of the batches was recorded in batch no. 3 with the highest content of river sand, fine sand fraction as 180.92 kg/cm2, which composed of 50% coarse fraction and 30% medium fraction and 20% of river sand as a fine fraction.

Two selected batches record the highest parameters of the technological properties were studied using SEM and EDX. Figure 5 shows the microstructure and micro-analysis of the concrete batch no. 2. Batch no. 2 shows coarse, medium, and fine granite grains gray in colour cemented together with OPC cement. Some pores also were detected as illustrated in Figure 4. EDX explains the composition of the granite grains as expressed in the percentage of oxides SiO2, Al2O3, Na2O, and K2O, while cement paste referred to the main oxides of CaO, SiO2, Al2O3, and Fe2O3. Point no 1. Clear the cement coating between the granules, while points nos 2&3 are cement around the coarse grains, medium, and fine grains of granite between the edges of the coarse and medium grains. While point no. 4 confirms the Ettringite phase with cotton-like microstructure as irregular white grains showed in Figure 6 exhibits the microstructure of the batch no. 4 which recorded the maximum technological properties, it is clear that the homogeneity state of the coarse, medium, and fine grains with cement batch with very good compaction and low pores. Point nos. 1-3 show coarse and medium granules of granite as well as fine river sand pasted with cement as their major oxides recorded. While point no. 4 displays the Ettringite phase in its cottons like micro-structures as white irregular grains within Cement and granules. The microstructure of the two batches supports the technological properties and the phase composition of the main component of granite and river sand granules as well as the main oxide composition of the OPC common in the market.



Mineral Name	Chemical Formula	SemiQuant [%]
Quartz, syn	Si O2	100

Figure 3

Figure 4

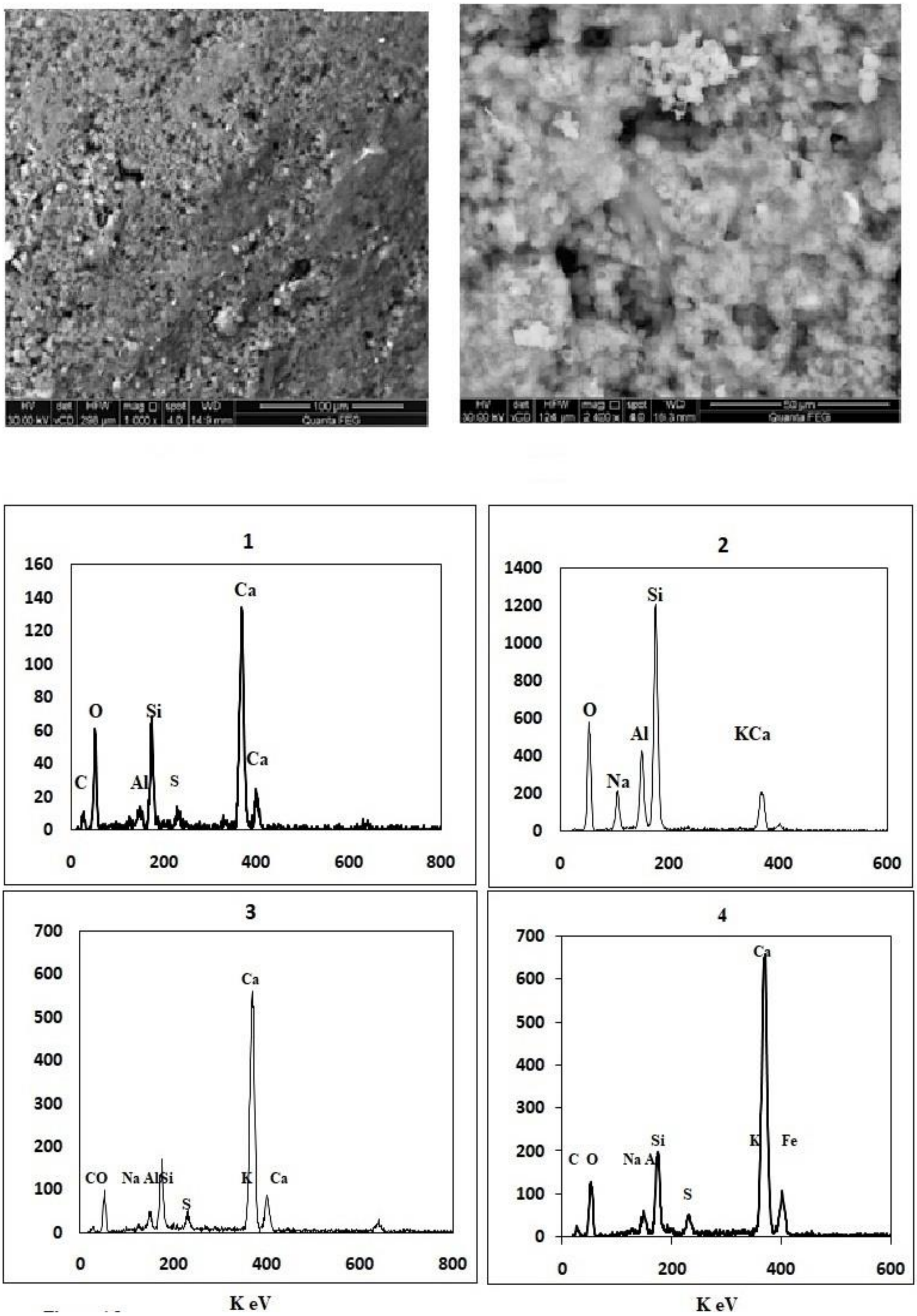

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Figure 5

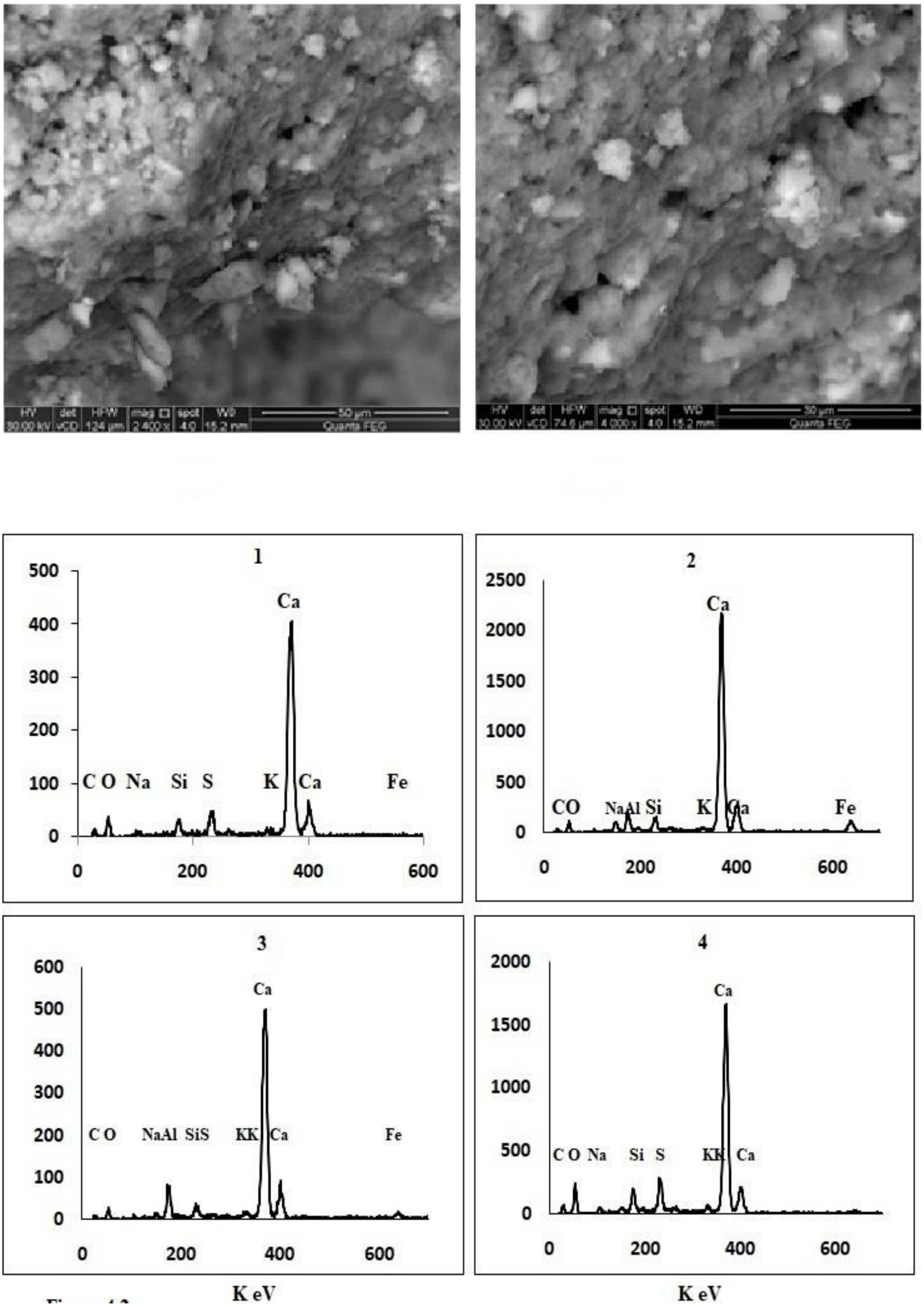
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Figure 6

Table 1 Chemical composition of the aggregates used in batches

Main Constituents (wt%)	(>4mm)	(4-2)mm)	(<2mm)	Sand
SiO_2	74.92	74.06	70.78	91.40
TiO_2	0.16	0.21	0.24	0.20
Al_2O_3	12.81	12.97	14.47	3.30
$Fe_2O_3^{tot.}$	1.97	1.98	2.40	1.39
MnO	0.04	0.04	0.05	0.02
MgO	0.32	0.53	0.58	0.33
CaO	0.35	0.71	0.88	0.45
Na_2O	4.39	4.22	4.73	0.63
K_2O	4.18	4.26	4.55	0.64
P_2O_5	0.09	0.13	0.16	0.06
SO_3	0.01	0.07	0.02	0.25
Cl	0.02	0.03	0.02	0.14
LOI	0.58	0.62	0.91	1.13
Total	99.84	99.83	99.79	99.94

Table 2 Bulk density, apparent porosity and water absorption of the stream sediments

Bulk density g/cm^3	apparent porosity %	water absorption
2.55	5.68	2.23

Table 3: Designed batch composition of the concrete

Batch no.	Cement ratio	Water/cement ratio	Granitic weathering products			Silica sand fraction
			Coarse >4mm	Medium 4-2mm	Fine <2mm	
1	15	0.5	50	40	10	-
2	15	0.5	50	30	20	-
3	15	0.5	50	30	-	20
4	15	0.5	50	40	-	10

Table 4 Technological properties of the four batches after 28 days curing time

Batch no.	Average Bulk density (g/cm^3)	Average Expansion ((%) mm)	Compressive Strength Kg/cm^2
Batch 1	1.75	5.6	62.91
Batch 2	1.79	8.8	72.17
Batch 3	2.17	9.6	180.92
Batch 4	1.87	9.4	101.53

4.Conclusions

Granitic weathering products were obtained from Wadi Lethi area, which is situated about 20 Km from Sharm El Sheikh- Dahab Asphaltic road, in the eastern part of South Sinai, between longitudes 33° 05' E- 33° 20' E and latitudes 27° 50' N -28° 05' N. These granules were assessed to be used as granules in cement concrete manufacture. So, chemical and mineral compositions as well as physical parameters were carried out for these samples. The main phase composition of the granite is quartz, albite, and microcline, while river sand shows only quartz as one phase. Four batches were designed with two different grain sizes like 50, 40, and 10%, as well as 50, 30, and 20% of coarse, medium, and fine, respectively.

Two batches were designed with coarse, medium, and fine granite weathering product aggregates. The other two batches were designed with coarse and medium granite weathering products, aggregates, and fine of river sand.

The technological characteristics of the four batches in terms of bulk density, expansion, and compressive strength were detected. It is deduced that the samples contain 20% of fine fractions are denser higher expanded and crushing strength.

Also, the replacement of the granite weathering products fine fraction with the river sand in two ratios (10 & 20%) yields higher results of density, expansion, and compressive strength. The maximum results recorded are 101.53 & 180.92%, in the batchs nos. 4 & 3, respectively.

SEM and EDX of the batches nos. 2 & 3 carried out supports the technological properties and the phase composition of the main component of granite and river sand granules as well as the main oxide composition of the OPC common in the market. It is deduced that the river sand as fine granules has better technological characteristics than the granite fine granules.

Acknowledgment

The financial support for this research was provided by the National Research Centre through internal project number 12010307.

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