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Effects of Barite Sand Addition on Glass Fiber Reinforced Concrete Mechanical Behavior

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Abstract

Glass fiber reinforced concrete (GFRC) is a cementitious composite reinforced by the addition of alkali-resistant glass fibers. GFRC is widely used for various types of precast products in civil engineering industries. GRFC mixes generally include silica sand to produce precast concrete elements; however, silica sand was replaced with barite sand at the ratios of 5%, 10 % and 15 % of wt. in order to reveal its applicability and potential for different engineering purposes. The flexural strength and the freeze-thaw(F&T) resistance of the composites were studied. The experimental results showed that the replacement of silica sand with barite sand up to 15 % of wt. enhances the mechanical properties of the composites in respect to flexural strength and F&T resistance properties.

Keywords: Glass fiber, silica sand, barite sand, silica sand replacement, glass fiber reinforced concrete.

1. Introduction

Fiber addition into the matrix significantly enhances the mechanical properties of the concretes. Engineering properties of the concrete such as flexural strength, toughness, abrasion resistance and impact can be increased with the addition of various types of fibers according to the results of many literature studies [1-3]. Various types of fibers such as basalt, carbon, aramid and glass have been commonly used for reinforcing cementitious matrixes [4, 5].

Some academics reported that glass fiber addition increase the flexural and splitting tensile strength of the composites up to 20 %. Flexural toughness and shear toughness properties can also be increased by inclusion of a certain amount of fibers as per the results of the studies [6,7].

Barite mineral is commonly used as aggregates for producing heavyweight concrete. Barite aggregate added concrete mixes are generally selected to minimize the effect of radiations such as gamma rays. The addition of this mineral in small quantities can enhance the concrete behavior against the radiation waves compared to the conventional concrete mixes [8,9]. Some researches results showed that addition of barite mineral can not enhance the mechanical properties of the ordinary concrete [10, 11].

Barite mineral is more sensitive to abrasion compared to the other types of aggregates. In addition, due to massive usage of barite minerals for the radiation shielding purposes, it becomes difficult to find coarse graded barite aggregates [12].

In this study, the aim was to investigate the potential usage of barite aggregates as silica sand replacement materials in GFRC applications.

2. Materials and Experimental Details

CEM I type white cement complying the TS EN 197-1 standard was used as a binding material. Some physical and chemical properties of the white cement can be found in Table 1.

Table 1. The chemical and physical properties of CEM I 52.5 R cement

Chemical Properties (%)		Physical Properties	
SiO_2	21.6	Specific weight (t/m^3)	3.06
Al_2O_3	4.05	Specific surface (cm^2/g)	4600
Fe_2O_3	0.26	Whiteness (%)	85.5
CaO	65.7	Initial Setting time (min.)	100
MgO	1.30	Final Setting time (min.)	130
Na_2O	0.30	Water for standard consistency (%)	30
K_2O	0.35	Volume constancy (mm)	1
SO_3	3.30	0.045 Sieve Residue (%)	1
Free CaO	1.6	0.090 Sieve Residue (%)	0.1
Chloride (Cl)	0.01	Compressive Strength at 2 days (MPa)	37
Insoluble	0.18	Compressive Strength at 7 days (MPa)	50
Loss on Ignition	3.20	Compressive Strength at 28 days (MPa)	60

Silica sand and barite mineral were selected as aggregates. Particle size distribution of silica sand is given in Fig. 1. And chemical and mineralogical properties of the aggregates can be found in Table 2.

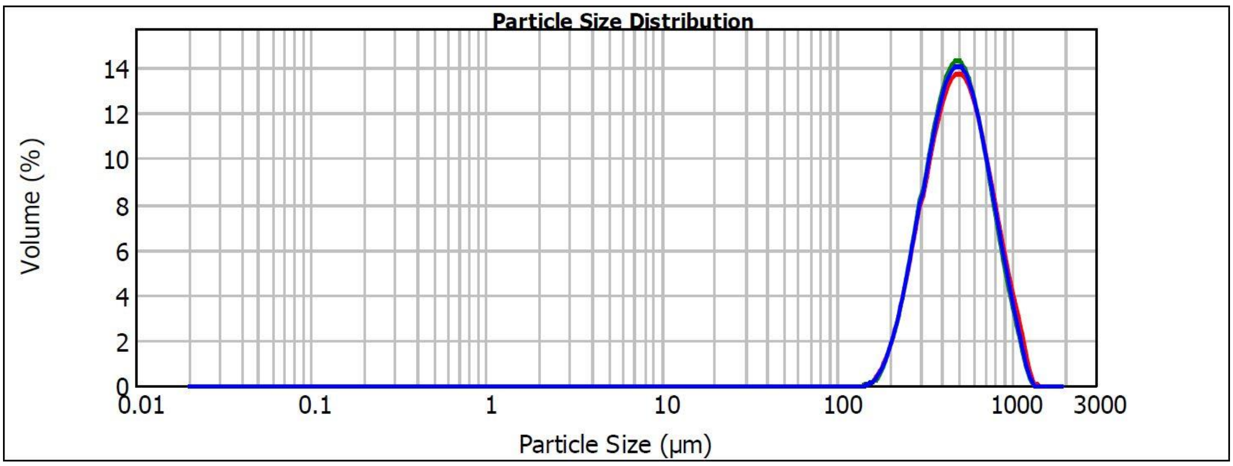

Fig.1. Silica sand particle size distribution

Table 2. Aggregates chemical and mineralogical properties

	Chemical and mineralogical composition						
	SiO_2	Fe_2O_3	MgO	CaO	K_2O	Na_2O	Al_2O_3
Silica sand	98.60	0.13	0.03	0.01	0.09	0.02	1.12
Barite	0.4	0.06	0.10	0.36	-	-	-

Polycarboxylate based plasticizer was used as the chemical agent. The water used during the experimental works was potable. Alkali resistant glass fibers were chosen as reinforcing fiber material, and mechanical and physical properties of the glass fiber are given in Table 3. Fiber ratio was kept constant as 3 % of wt. Mix proportions of the composite can be found in Table 4.

Table 3. Physical and mechanical properties of the alkali resistant glass fibers

Mechanical and physical properties of the glass fibers	
Ultimate strength, bending (MOR, MPa)	20-28
Elastic limit, bending (LOP, MPa)	7-11
Ultimate strength, tensile (MOR, MPa)	8-11
Elastic limit, tensile (LOP, MPa)	5-7
Compressive Strength (Mpa)	50-80
Elastic Modulus (GPa)	10-20
Dry density t/m^3	1.9-2.1

Table 4. Experimental sets

Mixture Code	Silica Sand(kg)	Barite Sand (kg)	Fiber ratio	White cement (kg)	W/C	Superplasticizer (kg)
R_1	50	0	3 %	50	0.34	0.50
M_1	47.5	2.5	3 %	50	0.34	0.52
M_2	45	5	3 %	50	0.34	0.55
M_3	42.5	7.5	3 %	50	0.34	0.58

The reference mix was composed of silica sand, white cement, glass fiber and superplasticizer. The specimens with the dimensions of 160 x 40 x 40 mm were made for the mechanical tests. Flexural strength tests were conducted with four-point bending test machine. All specimens were kept under the laboratory conditions for 24 hours. Flexural strength tests were conducted as per the requirements of TS EN 1170-4,5. F&T resistance of the specimens were determined in comply with the ASTM C 666 standard.

3. Results and Discussions

Flexural test results at 7, 15 and 28 days are given in Fig. 2. Flexural test results showed that strength values enhance with the increasing barite sand content.

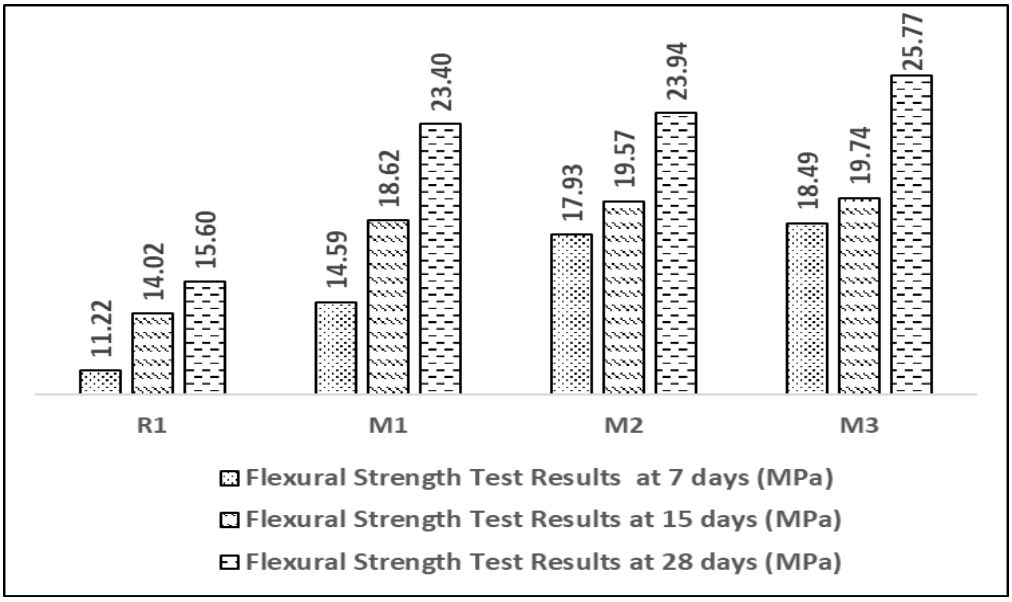

Fig.2. Flexural strength test results

Maximum flexural strength value was recorded as 25.77 MPa at 28 days and it was belonged the mixture M_3. Silica sand replacement with the barite sand at the ratios of 15 % of wt. significantly increased the strength values of the specimens.

The strength test results and strength losses of the composites can be found in Fig. 3. Barite added mixes have lower strength loss values compared to the reference mix. The minimum strength loss value after F&T cycles was obtained as 22.27 % belonged to the M_3 mix. Decrease in strength losses may be attributed to the increased durability of the mixes with the increasing barite content.

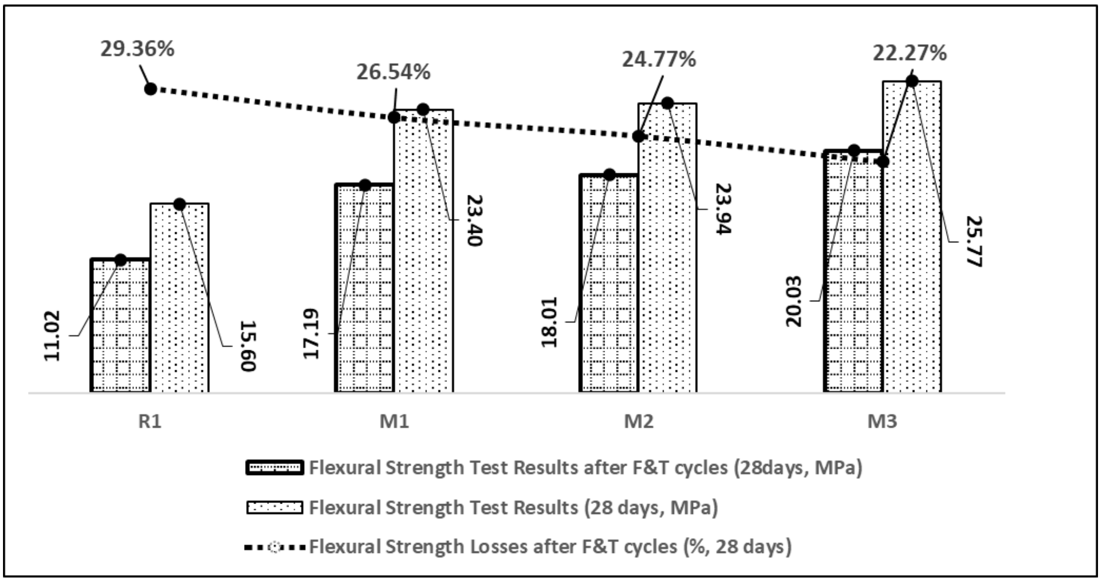

Fig.3. Flexural strength losses after F-T cycles

4. Conclusions

The effects of barite addition to glass fiber reinforced concrete were studied within the scope of this experimental research. A good synergy between the barite aggregate addition and conventional GFRC composition was obtained with the light of the results of the tests. The main findings can be summarized as follows:

- The increase in barite aggregate content in GFRC composites increases the flexural strength values.
- In replacement of 15 % of wt. silica sand with barite aggregates showed the best performances both for the flexural strength and F&T test results.
- Barite aggregates can be used in GFRC mixes for specific purposes such as radiation protection.
- As the amount of barite increased in GFRC, the durability property was also increased according to the F&T test results. Strength losses of the composites can be limited against the F&T effects with the addition of barite aggregates.
- Future studies should be conducted on possible aging effects.

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