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Study of tensile and flexure strength of lightweight concrete containing high silica and steel fibers

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ABSTRACT

Weight reduction of building is one of the items that has focused the attention of researchers. Use of lightweight material, causes reduction in dead weight and therefore lowers, earthquake forces applied to structure. With regard to weakness of concrete in tension researchers have paid special attention to improvement of these weaknesses and the different fibers are used for this purpose. Also the fibers in concrete can compensate part of the weakness of concrete in brittle. Different types of fibers are used in concrete such as steel fiber, glass fiber, poly propylene fiber and etc which improve some properties of concrete. In this paper steel fiber and high silica fiber with different percentages are used for making concrete specimens containing lightweight scoria and pumice aggregates so that those were subjected to tensile and flexural strengths after curing. Results show that use of 0.9% steel fiber led to highest tensile and flexural strengths.
KEYWORDS: lightweight concrete, high silica fiber, steel fiber, tensile, flexure

1. INTRODUCTION

Nowadays, one of the best scientific, practical and economic solutions to reduce the risks of earthquakes is lightening in the construction industry[1]. The use of light- weight concrete causes to reduce dead- weight of the building, to decrease structural dimension and consequently leads to cost efficiency of the plan. Due to the increasing use of other materials in the concrete to improve concrete quality, studies on the fibers have become more extensive in recent years. Nowadays, the use of fibers has received special attention due to their positive effect on the concrete properties [2]. The use of fibers for concrete reinforcement has begun since the early1960s. Initially, only the direct steel fibers were used which led to a significant increase inductility as well as resistance to failure. Initially, one of the major problems in the use of fiber was the problem of aggregation and fiber conglobation and the performance decline of concrete in High levels of usage. By modification of the mixed plan, by inventing fibers with more mechanical adherence (hook- fiber), and consequently due to the possibility of reducing the amount of required fiber and extending the use of lubricants and super lubricants in the concrete, these problems are largely solved[3].

This study is performed to study and determine the mechanical properties of light weight concrete containing Scoria and pumice in combination with high silica and steel fibers.

2. Experimental studies

2.1 Material sand their properties

Scoria used in this study has a specific weight of1665kg/m^3, 9.5 mm in diameter and half-hour water absorption is 11%. Also, the Pumice used in the study has a specific weight of 1340 kg/m^3, and its half-hour water absorption is 14%. Their grading is according to the ASTM C330 Standard. At all the mixed plans, 75% Scoria and 25% Pumice are used. The river-type sand is used, which its specific weight in the saturations point with dry surface, and its absorption are 2510 kg/m^3 and 3% respectively. Its grading is according to the ASTM C330 Standard.

The water used in this study is drinking water of Fooman city, Iran. Super-carboxylate-based lubricantP10-3R,by the density of 1100 kg/m^3, is used in all mixed plans to achieve desired lubricant, which its dosage is from 1to 1.6% of the cement content.

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Portland cements type 2 with density of 3150 kg/m^3 is used to generate all the mixed plans. AlsoMicro silica Pozzolan is used, which its dose at all the mixed plans is 10 % of cement weight and its density is 2120 kg/m^3.

The fibers used in this study are steel fibers with the specific weight equal to 7850 kg/m^3, they are hook – type with the length of 50 mm and high silica fibers with the specific weight equal to 2630 kg/m^3, and its length is 12 mm, which is tested as a new fiber in this study.

Fig. 1. High- silica fibers

Fig. 2. Steel fibers

2.2 Test description

Table 1. Concrete mixed design

No of design	cement	Micro silica	water	Water to cement ratio	Super-lubricant	sand	High-silica fibers	Steel fibers	Scoria	Pumice
(control)1	450	50	160	0.32	5	770	-	-	452	122
2	450	50	160	0.32	5	770	-	23.5	448	121
3	450	50	160	0.32	5	770	-	47.1	445	120
4	450	50	160	0.32	5	770	-	70.6	441	119
5	450	50	160	0.32	5.5	770	5.26	23.5	446	120
6	450	50	160	0.32	5.5	770	5.26	47.1	442	119
7	450	50	160	0.32	5.5	770	5.26	70.6	438	118
8	450	50	160	0.32	6.5	770	10.52	23.5	442	119
9	450	50	160	0.32	6.5	770	10.52	47.1	438	118
10	450	50	160	0.32	6.5	770	10.52	70.6	435	117
11	450	50	160	0.32	8	770	15.78	23.5	438	118
12	450	50	160	0.32	8	770	15.78	47.1	434	117

2.3 Concrete mixing method

There are some steps for the mixing materials: at first, lightweight concretes are already saturated in the water for half an hour, then, after bringing out from the water they must be poured in a perforated container to separate the excess water from the surface, next, it must be poured to the concrete along with the sand, after that fibers, cement, micro silica, water and lubricant are added to the mixture[4]. It should be noted that the time of mixing must be increased to distribute fibers in the concrete fully and uniformly. Cylindrical specimens with a diameter of15 cm and a height of 30cm are used to implement tensile test and cubic specimens equal to 50×10×10 cm are used for bending test. In order to prevent from adhesion of concrete to the mould wall, internal walls of the mould are covered by a thin layer of oil. All the specimens are provided one day after concreting and molding in the water with 20±2 °C. Meanwhile, 3 specimens from each mixture were studied at the 28th days.

3. Tensile strength determination test

Breezily test was used to determine the tensile strength. In such a way that specimen was located in the desired place of the device, and two rebar at the side part and one rebar were placed at the highest part of the cylindrical sample. The lever of device was allowed to put force on the upper rebar. The results of this test are obtained according to the table 2.

Fig. 3. Apparatus for determining the tensile strength and the specimen below its jack

Table 2. The results of tensile strength of the samples

No	Descriptions (%)	Tensile strength of28 days	No	Descriptions (%)	Tensile strength of28 days
1	Control specimen	2.33	8	High silica, .4% +Steel.3%	2.64
2	Steel concrete .3%	2.74	9	High silica, .4%+ Steel.6%	2.8
3	Steel concrete .6%	2.77	10	High silica, .4%+steel .9%	2.46
4	Steel concrete .9%	2.86	11	High silica.6% +steel .3	2.78
5	High silica .2% + Steel concrete .3%	2.37	12	High silica.6% +steel .6%	2.21
6	High silica .2% + Steel concrete.6%	2.51	-	-	-
7	High silica .2% + Steel concrete .9%	2.80	-	-	-

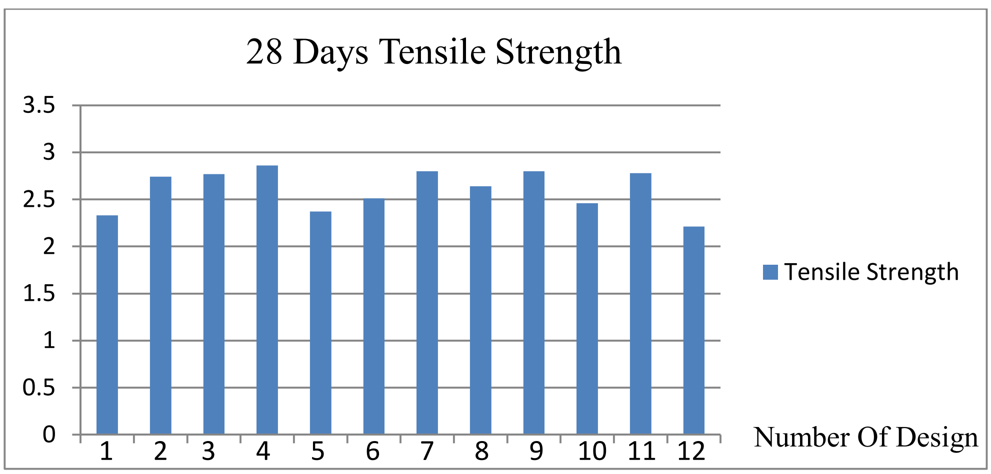

Diagram 1. Tensile strength

As it can be seen, the highest tensile strength is obtained in single .9 percents steel fibers, which the reason is, increase of adhesion between fibers and concrete matrix. This design has shown about 25 percents increase of tensile strength. The plans related to the.2 %high silica compound, and .9 %steel fiber (plan7), and .4% high silica and .6 %steel fiber (plan9) have the same tensile strength. If combined plans are selected, the selection of design7 will have more priority given the higher flexural strength of this design (that will be explained in the following sections). Also, choosing it would be more efficient because of the cost efficiency (at present, the price of high silica fiber is ten times more than steel fibers). The lowest tensile strength is related to the design12, which can be resulted from large volume of fibers and lack of appropriate efficiency. The tensile strength of this design even lower than control specimen.

4. Flexural strength determination test

To determine the flexural strength values, three-point test was used in which the sample was placed on the bases of the device, and then the device puts force in the middle of the specimen. The amount of entered load is recorded at the time of failure. One of the effective parameters of this study is to put the specimen in the correct place and to regulate the speed of the device (that is, to choose the same speed for all the samples).

Fig. 4. Flexural specimen failure under the three-point test

Table3. The results of flexural strength of the specimens (Mpa)

No	Descriptions (%)	Flexural strength of28 days	No	Descriptions (%)	Flexural strength of28 days
1	Control specimen	5.16	8	High silica, .4% Steel +.3%	6.36
2	Steel concrete .3%	5.58	9	High silica, .4%+ Steel.6%	6.48
3	Steel concrete .6%	6.24	10	High silica, .4%+steel .9%	6.06
4	Steel concrete .9%	7.62	11	High silica.6% +steel .3	5.40
5	High silica .2% + Steel concrete .3%	6.30	12	High silica.6% +steel .6%	4.92
6	High silica .2% + Steel concrete.6%	6.36	-	-	-
7	High silica .2% + Steel concrete .9%	7.02	-	-	-

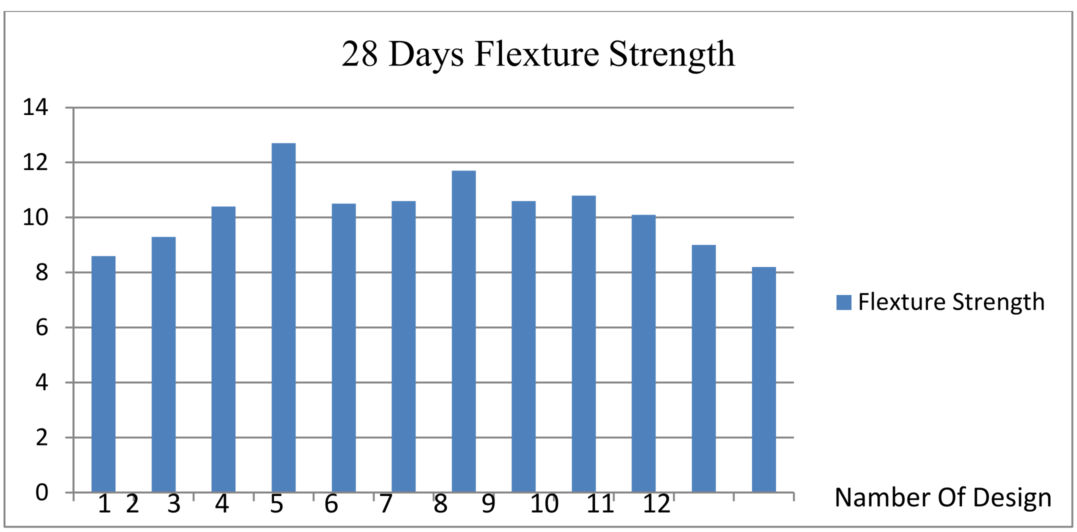

Diagram 2. Flexuralstrength

In the flexural diagram, .9 steel (design 4) fibers have the maximum strength which indicates appropriate connection between fibers and concrete matrix. In other words, this design has shown about 50 percents increased flexural strength compared to the control plan. After that, design7 (0.2 percents high silica and .9 percents steel fiber) has the highest flexural strength. The lowest flexural strength is related to the design12, which results from the large volume of fibers and lack of appropriate efficiency of the fibers. Tensile strength of this design even lower than control spacemen. It is also observed that similar to the tensile strength, high silica fibers, in combination with steel fibers, resulted in reduced flexural strength compared to the pure steel fibers.

5. Conclusion

1. Although the use of high silica and steel fibers individually leads to increased tensile and flexural strength [5, 6], based on the results of this study, combined use of leads to reduced tensile and flexural strength (proportional to their separate usage) in lightweight concrete. However, we see a higher strength than control sample.
2. The specific high weight of both two fibers led to the fact that adding more percent of these values proportional to water-cement ratio and the maximum amount of allowed lubricant is not possible.
3. The design related to the .9 steel fibers, received the highest tensile and flexural strength among the other plans. This design has shown about 50 % increase of tensile strength compared to control plan.
4. Each of these two fibers leads separately to increased tensile and flexural strength, but it is better to not use them in combination.

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