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Compressive strength and water absorption of concrete containing scoria and high silica and poly propylene fibers

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ABSTRACT

Today, due to benefits resulting from weight reduction of building including dead weight; insulation against sound and heat; less use of materials such as cement and steel bars in addition to lowering earthquake forces lead to economical design. Use of fibers not only compensate tensile weakness of concrete but also improves some mechanical characteristics and prevent concrete crack propagation. In present study, concrete specimens containing scoria with use of High-silica (Hs) fibers of 0.1 , 0.2 and 0.3 percentages combined with 0.1 and 0.2% poly propylene (PP) fibers were made and tested for compressive strength and water absorption. Results show that an increase of Hs fiber with 0.1% and 0.2% PP have increased both 7 and 28 days strengths. Highest and lowest 7 and 28 days compressive strength have respectively been gained with 0.3% Hs – 0.1% PP and 0.1 Hs – 0.2 PP. Moreover, least water absorption rate for 30 min and 24 hours were respectively resulted in specimens of 0.2% Hs – 0.1%PP and for 0.2%Hs – 0.2% PP.

KEYWORDS: lightweight concrete, Scoria, High silica fiber, poly propylene fiber, Compressive strength, Water absorption.

1. INTRODUCTION

One of the important problems in designing and implementing the buildings is the high dead weight of them. Reduction of deadweight and the use of concretes with lower specific weight and higher compressive strength in concrete structures have always received a lot of attention by the design engineers. This is important because earthquake forces on structures are consistent with the structure weight and weight reduction of the structure is the most important factor in the reduction of earthquake effect[1]. It is obvious that the use of light materials, leads directly to lower the load of the structure and consequently the weight reduction of all the components of the structure, and finally it causes to cost efficiency of the design. Since, light concrete is brittle and fragile as like as regular concrete, different types of fibers are used in this kind of fibers to overcome this problem. Also, reinforced the concrete with fiber instead of bar, not only decreases the weight of concrete, but also removes damages resulted from steel Corrosion. Also, fibers can improve mechanical properties of the concrete and they can prevent from propagation of cracks in concrete. Different types of fibers which are used in the concrete are as follows: steel fibers, glass fibers, poly propylene fibers…

Steel fibers can be generated with various forms: straight, hook form, rack form to improve the concrete behavior. Generally, the presence of steel fibers causes to strengthen the concrete strength. Its important property is high flexural strength and strength against fraction. It means that when the fraction starts, fibers play their role in fixing the fraction and limiting the size of fraction. And they prevent from extending fraction even with increasing loading. This property is a good solution to reduce fragility of the pure concrete. Also, steel fibers increase shear strength. The most important effect which is provided by adding steel fibers in the concrete is flexibility of the concrete and more capability in energy absorption. Steel fibers can be used to build tunnels, dams, power plants, concrete pavement, roads, bridge deck, railway sleepers, commercial and industrial flooring, airport runways, Slope stabilization and other special events instead of the mesh[2].

Glass fibers are most known amplifiers used in the composites industry. There are various types of glass fibers commercially. Chemical compounds of these fibers are different from each other and each of them is appropriate for

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a specific application. Glass fibers have appropriate strength and hardness; they maintain their mechanical property at high temperatures, they have appropriate strength against humidity and corrosion and it is relatively cheap[2].

Poly propylene is a thermoplastic that is obtained from the polymerization of propylene and it is recyclable. Poly propylene was generated in laboratory scale in early 1950, and then they were generated commercially at the end of this decade. Tensile strength, low density, discoloration, hardness, resistance to acid, base and solvents are some properties of poly propylene. Low cost of its generation compared to other thermoplastics made a specific position for poly propylene in the industry. Polypropylene is one of the most widely used plastic and nowadays it has a lot of application in different industries. Some of the most important advantages of poly propylene are as follows: reduction of fractions and preventing from extending fractions, reduction of permeability and increase of the durability of concrete. Polypropylene fibers with long maintenance are not affected by rust and corrosion, and they do not occupy space in the workshop. They are mixed in the concrete very easily. Concrete reinforced with Polypropylene fibers have very higher compressive strength compared with concrete reinforced by amateur[3]

High silica fibers include 96% silica, and they are generated in the piece-formandinlengthsof3, 6, 12, 18, 24and50. One of the characteristics of this fiber is that it is heat insulators and nonconductor. It is also stable against heat, corrosion and chemicals. The fibers are non-toxic and harmless and are compatible with the environment[4].

In this study, we considered and determined compressive strength and water absorption containing light weight scoria and high silica as well as poly propylene fiber.

2. Experimental studies

2.1 Materials and their properties

The scoria used in this study is 9.5 mm and it has specific weight of 1665kg/m^3 and its half-hour water absorption is 11%. In addition, its grading is done according to the ASTM C330 and it is based on table 1. 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, which is shown in table1.

Table 1. Grading light weight Scoria and fine grained

Sieve size (mm)	scoria	Standard range of light weight	fine grained	Standard range of fine grained
12.5	100	100	-	-
9.5	82.62	80-100	100	100
4.75	7.18	5-40	99.8	95-100
2.36	2.21	0-20	98.5	80-100
1.18	1.88	0-10	78.3	50-85
0.6	-	-	55.4	25-60
0.3	-	-	5.7	5-30
0.15	-	-	1.2	0-10

Portland cements type 2 with density of 3150 kg/m^3 is used to generate all the mixed plans. Also Micro silica Pozzolan is used to fill the pores of the concrete and to increase its strength, which its dose at all the mixed plans is 10 % of cement weight and its density is 2120 kg/m^3. The super-lubricants are called strong water depressors, since they can reduce water in the concrete mix three or four times more than additive material of usual water depressors. Super- lubricants cause to water surface tension, and they significantly increase fluency of the set[5]. 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. The quality of water in the concrete is important because its Impurities may have effect on the cement formation and concrete strength, or they can cause to create spots on the concrete surface or even reinforcement corrosion[6].The water used in this study is drinking water of Fooman city.

The fibers used in study are silica and poly propylene fibers, which are tested for the first time in this study and in Iran, as a new fiber and in combination to generate concrete. Their specific weight is 2630 kg/m^3, and 900 kg/m^3 respectively, and also their length are 12 and 9 respectively.

Fig.1. High silica fiber

Fig. 2. Poly propylene fiber

Fig. 3. The used materials

2.2 Test description

Table2. The mixed concrete design (kg/m^3)

Number of design	cement	Micro silica	Water	Water to cement ratio	Super-lubricant	sand	High silica fiber	Poly-propylene fiber	scoria
Control (1)	450	50	160	0.32	5	770	-	-	604
2	450	50	160	0.32	5.5	770	2.63	0.9	600
3	450	50	160	0.32	6	770	5.26	0.9	597
4	450	50	160	0.32	6.5	770	7.89	0.9	595
5	450	50	160	0.32	5.5	770	2.63	1.8	598
6	450	50	160	0.32	6.5	770	5.26	1.8	595
7	450	50	160	0.32	7.5	770	7.89	1.8	592

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[7]. It should be noted that the by adding the percent of fibers the time of mixing is increased to distribute fibers in the concrete fully and uniformly. Cylindrical specimens equal to 10×10×10is used. 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. Then, the concrete was poured in the mold in several layers. Density is done in 3 layers and by 25 hitting to each layer through a standard bar with a diameter of 16mm. 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 7^{th} and 28^{th} days.

3. Compressive strength test results

Finally, after implementing compressive strength test, the results obtained consistent with the table 3.

Table3. The results of compressive strength of the samples (MPa)

Number of design	Description (%)	7- days compressive strength	28-days compressive strength
1	Control sample	25.5	34.5
2	0.1 poly propylene, 0.1 high silica	24.5	36
3	0.1 poly propylene, 0.2 high silica	27	39.5
4	0.1poly propylene, 0.3high silica	28	41.5
5	0.2 poly propylene, 0.1high silica	23	35
6	0.2 poly propylene, 0.2 high silica	24	36
7	0.2poly propylene, 0.3 high silica	27	37.5

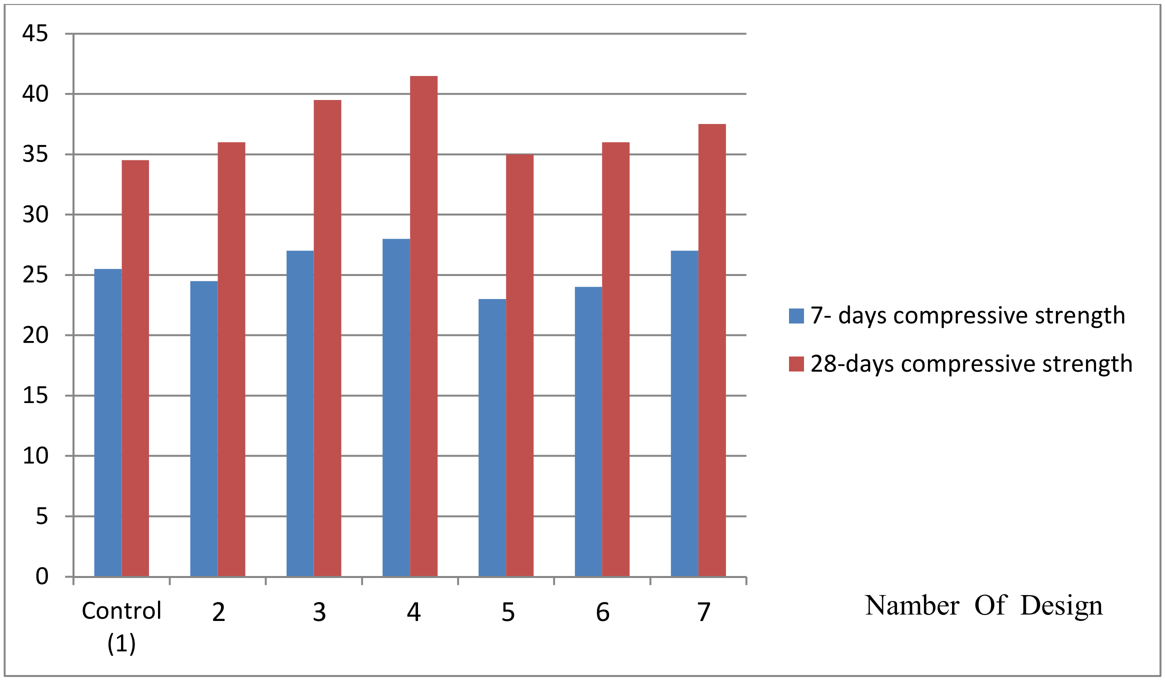

Diagram 1.Compressive strength

According to the diagram, it is revealed that by increasing High silica fiber (Hs), combined with 0.1 %pp as well as 0.2%, 7- days and 28-dayscompressive strengths are increased. However, as we know, adding pp fibers would decrease concrete compressive strength. Therefore, the strength which are created Hsfibers combined with 0.1 %pp are more than those strengths which are created in combination of Hs fibers with 0.2 %pp. Also, the highest and the lowest 7- days and 28-days compressive strengths are created 0.3 % (Hs) combined with 0.1% pp and in combination of 0.1% (Hs) with 0.2% pp (design 5).

In fiber specimens 0.1% (Hs) compound with 0.1 and 0.2 percentage pp (designs 2 and 5) and also 0.2% (Hs) combined with 0.2% pp (designs 6), 7-days and compressive strength is even lower than control sample. This reduction of strength in 0.1 Hs combined with 0.2 %pp is more significant. However, by passing time and during 28 days, their strength is more than control sample

4. Water absorption test and results

This test was done according to ASTM C642. In this way, in each test, average three cubic samples (10× 10×10) was introduced as the water absorption of it. The test was done on all the mixtures on the 28th days. According to the test, the maintenance condition of samples must be wet until the test day. At the time of test, samples bring out of the wet condition and they must dry at oven for at least 24 hours with 110°C. In addition, their weight will record as the dried sample weight. To calculate half hour water absorption, the samples must be placed at water for 30 minutes. At the end of this time, samples surface must be dried by the cloth and saturated weight must be recorded with dried surface of the sample. However, to calculate 24- hours' water absorption, the same action must be done after 24 hours. Half- hour and 24- hours percent of water absorption is obtained by the difference between samples weight in dry and wet conditions.

Table 4. The result of water absorption percents of the samples

Number of design	Description (%)	7- days water absorption percent	28-days water absorption percent
1	Control sample	4.07	6.12
2	0.1 poly propylene, 0.1 high silica	3.67	6.57
3	0.1 poly propylene, 0.2 high silica	3.13	5.27
4	0.1poly propylene, 0.3high silica	3.43	5.86
5	0.2 poly propylene, 0.1high silica	4.6	5.82
6	0.2 poly propylene, 0.2 high silica	4.4	5.1
7	0.2poly propylene, 0.3 high silica	4.1	5.9

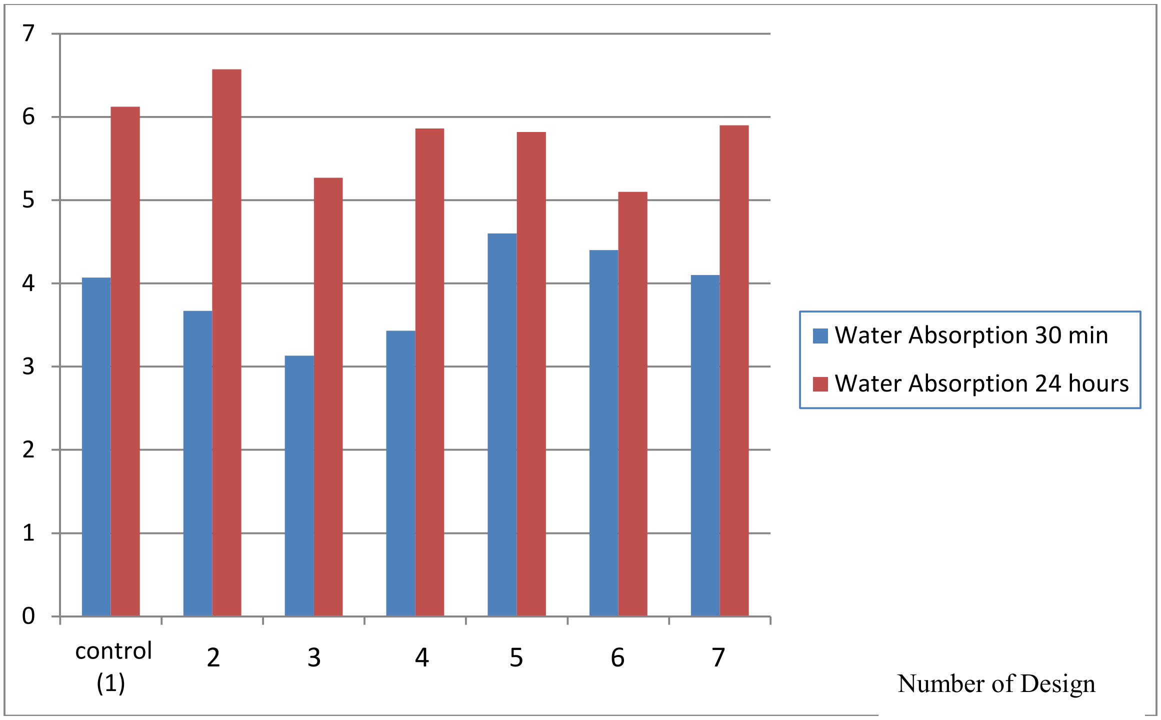

Diagram 2. Water absorption percent

The lowest amount of half- hour and 24-hours water absorption is obtained in combination of 0.2 (Hs) with 0.1 pp (design 2) and in combination of 0.2 (Hs) with0.2 % pp (design 6) (it can be said that when permeability has the higher priority, combined condition of fibers is more appropriate with (Hs) 0.2 with 0.1 and 0.2 pp. The highest amount of half- hour and 24-hours water absorption is obtained in high silica 0.1% compound with 0.2pp (design 5) and also in high silica compound 0.1 % with 0.1pp (design 2).

5. Conclusion

1. By increasing high silica fiber in combination with 0.1 pp and also 0.2%, 7- days and 28-days compressive strength is increased. However, as we know, adding pp fibers leads to reduction of compressive strength. Therefore the strength obtained by high silica compound with 0.1 pp is more than that strength obtained by high silica compound with 0.2 pp.
2. The highest and the lowest 7-days and 28-days compressive strength is obtained from 0.3 high silica compound with 0.1 pp and 0.1 high silica compound with 0.2 pp.
3. In 0.1 high silica compound (Hs)with 0.1 and 0.2 percentage combined with 0.1 and 0.2 pp and in 0.2 percentage combined with 0.2% , 7-days and compressive strength is even lower than control sample. This reduction of strength in 0.1 Hs combined with 0.2 %pp is more significant. However, by passing time and during 28 days, their strength is more than control sample.
4. The lowest amount of half- hour and 24-hours water absorption is obtained in in .2% high silica compound with 0.1 pp and also in 0.2 high silica compound with 0.2 pp (it can be said that where permeability have more priority, combined state of 0.2 high silica is more appropriate with 0.1 and 0.2% pp)
5. The highest amount of half- hour and 24-hours water absorption is obtained in 1% high silica compound with 0.2pp and also in 1% high silica compound with 0.1pp
6. Since, adding the amount of fibers in concrete fiber has led to reduction of the concrete efficiency, super lubricants must be used to overcome this problem.
7. Given that sample failure occurs in aggregates, weakness of lightweight concrete can be resulted from its aggregated weakness. However the evidence which was seen in the sample failure time, shows that the more the amount of fiber is in the surface unit, it prevents from extending the fraction and ductility of the under studied samples would improve. And it prevents significantly from the failure of the company.

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