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THE EFFECT OF PLASTICIZER ADDITIVE AND POLYPROPYLENE FIBER IN DIFFERENT RATIO ON ABRASION, WATER ABSORPTION AND DENSITY OF HARDENED CONCRETE

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Abstract

In this study; the effect of polypropylene fibre additive and plasticizer additive in different ratios on vertical abrasion, water absorption and density of hardened concrete was analyzed. Water-cement ratio was stabilized in all mixtures. Water-cement ratio is 0.52. Hyper-plasticizer chemical additive was used in the mixtures. Additive ratios in mixtures are 0.6%, 0.8%, 0.9% and 1.1% of cement weight. 25 series of samples were obtained together with non-fibrous control sample. Vertical abrasion, water absorption and density tests were done 28 days of samples. Each experiment was done at least on two samples and averages of experiment results were obtained. Vertical abrasion test was done on 70x70x115 mm samples with F80 alumina emery powder. As a result of the experiment, abrasion width on samples was measured. Abrasion width of C12, D6, D12 and E12 were lower than control mixture. In other words these mixtures exhibited less abrasion compared to control mixture. Abrasion width of other mixtures was higher than control sample. 70x70x115 mm samples were used as well in water absorption experiment. While water absorption value of control sample was 3.43%, water absorption values of polypropylene fibre reinforced concrete vary between 2.76% and 4.63%. It was observed that polypropylene fibre additive generally increases water absorption value of concrete. However, water absorption value was lower than control samples in every D added mixture. Cubic (15x15x15 cm) and cylinder (15x30 cm) samples were used for density experiment. Density of cubic samples varies between 2.39 and 2.42, density of cylinder samples varies between 2.39 and 2.43. Polypropylene fibres and chemical additive ratio have but little effect on density of concrete.

Keywords: Polypropylene fibres, abrasion, water absorption, hyper-plasticizer, density.

1. INTRODUCTION

Polypropylene fibers have recently widely been used in the building materials. Many studies have been performed regarding usage of polypropylene fibers in concrete and mortars [1-7]. In the study in which polypropylene fibers additives of 0.45 kg/m^3, 0.90 kg/m^{3}and 1.80 kg/m^3 by weight were used, water absorption and water permeability values increased and wet shrinkage values decreased as well with fly ash and polypropylene fibre additives. They reported that freeze-thaw resistance of polypropylene fibre reinforced concretes lightly increased compared to non-fibrous concrete [8]. They reported that unit weights of concretes, reinforced with polypropylene fibre and fly ash in the ratio of 0.05%, 0.1% and 0.20% by volume, decrease even a little, workability decreases, workability increases with addition of fly ash. The

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abrasion losses and water absorption values of the concrete, reinforced with fibre in the ratio of 0.2 % by volume, increased [9]. 900 g/m^3 polypropylene fiber additive by weight increased concrete abrasion resistance from 0.2860% to 0.3966 [10]. 910 g/m^3 polypropylene fiber additive by weight increased concrete abrasion resistance by 21.24 % [11]. The abrasion losses of 0.18% was obtained in the concrete, reinforced with 425% polypropylene fibre by volume. It didn't have much effect on unit weight [12]. Water absorption and water permeability values of concrete, reinforced with 0.45 kg/m^3, 0.90 kg/m^3 and 1.80 kg/m^3 polypropylene fibre by weight, increased with fly ash and polypropylene fibre additives and wet shrinkage values of those decreased [13]. Industrial wastes and polypropylene fibre additive of 0.2 % by volume increased capillary absorption value and water absorption value by weight of concrete [14]. Water absorption values of concrete, reinforced with polypropylene fibre of 2 % by volume, and that of concrete, in different water-cement ratios and reinforced with different plasticizer additives, decreased. Abrasion resistance value released as 0.8 in additive inclusion of 2%, and 1.97 in additive inclusion of 1% by volume [15]. Vertical abrasion, water absorption and density tests of concretes with hyperplasticizer and polypropylene fibre additives in different ratios were done in this study. The effect of polypropylene fibre additive and admixtures ratio on abrasion, water absorption and density of hardened concrete was analyzed.

2. MATERIALS AND METHODS

2.1. Materials

Only CEM I / 42.5 R type cement was used as a binding agent. Admixture with hyper plasticizer was used. Amount of admixture was also increased with increasing of fiber in the mixtures. Thus, fluency of fresh concrete was preserved. The additive ratios in the mixtures were, 0.6%, 0.8%, 0.9% and 1.1% of weight of cement. Sand of 0-4 mm and crushed stone with dimensions of 7-15 mm and 15-22,4 mm were used as aggregate. The grain size curve of aggregates used in the mixtures is given in figure 1. 8 kinds of fibres including A,B,C,D,E,F,G and H were used as polypropylene fibers (Figure 2). Technical characteristics of polypropylene fibers are given in Table 1. Slenderness is the ratio of fiber length to the shortest edge of fibre.

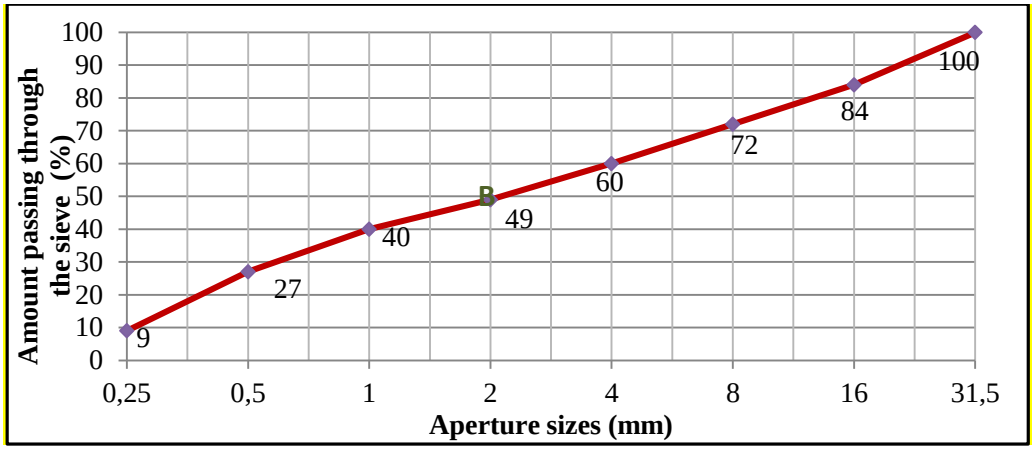


Figure 1. The grain size curve of aggregates used in the mixtures

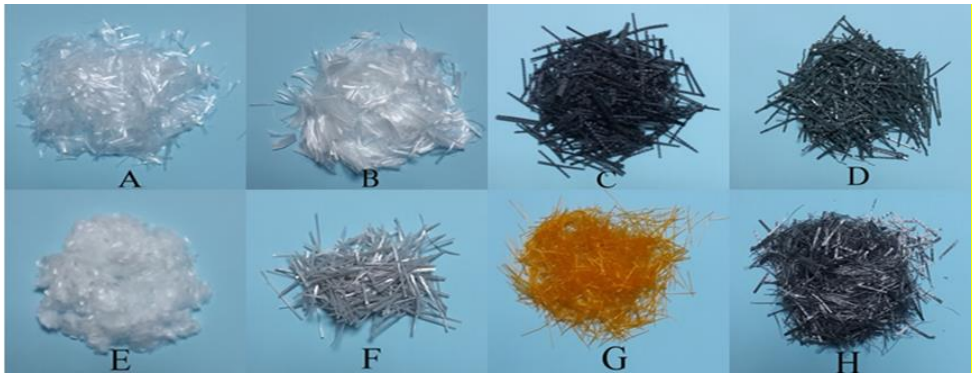


Figure 2. Polypropylene fibers

Table 1. Properties of polypropylene fibers

Fiber	Tensile Strength (MPa)	Unit Weight (g/cm^3)	Melting Point (˚C)	Modulus of Elasticity (MPa)	Water Absorption (%)
A	450-600	0.91	160-590	3500	0.01/0.02
B	400-500	0.91	160-590	3500	0.01/0.02
C	400-800	1.36	253	11300	0.04
D	400-800	1.36	253	11300	0.04
E	600-700	0.91	150-160	3500	0.01/0.02
F	620	0.90	160-590	9500	-
G	400-800	1.36	250	11237	0.4
H	600	0.90	230	3800	0.01/0.02

Fiber	Length (mm)	Width (mm)	Thickness (mm)	Slenderness	Shape
A	12	0.48	0.30	25	Circular
B	19	0.48	0.30	37.5	Circular
C	30	1.20	0.30	100	Fibrous
D	30	1.20	0.45	25	Double Hook
E	30	0.48	0.30	62.5	Circular
F	40	0.433	0.433	0.92	Plain
G	18	0.3	0.50	36	Circular
H	20	0.6/1.3	0.18/0.22	33/46	Plain

2.2. Mixture Ratios

Experimental studies were carried out on 25 series of concrete mixtures. One of these mixtures was a control mixture and the others were mixtures with polypropylene fibers. Fiber ratios in the mixture are 600, 1200 and 1800 g/m^3. The polypropylene fibers were indicated by A,B,C,D,E,F,G,H. For example; A6 indicates containing an additive of 600 g/m^3 of fiber A, B12 indicates containing an additive of 1200 g/m^3 of fiber B, C18 indicates containing an additive of1800 g/m^3 of fiber C. The control mixture was indicated with CNL. Water-cement ratio (W/C=0.52) was stabilized in all mixtures. The mixture ratios are given in Table 2.

Table 2. Ratios and amounts of materials used within the source concretes.

Ingredients		CNL	Mixtures with Fiber, g/m^3		
			600	**1200**	**1800**
Sand (0-4 mm)	(kg/m^3)	1127	1127	1127	1127
Crushed Stone (7-15 mm)	(kg/m^3)	451	451	451	451
Crushed Stone (16-22,4 mm)	(kg/m^3)	301	301	301	301
Water	(kg/m^3)	156	156	156	156
Cement	(kg/m^3)	300	300	300	300
Polypropylene Fiber	g/m³	-	600	1200	1800
Admixture	%	0,6	0,8	0,9	1,1
Water-cement ratio	**W/C**	**0.52**	**0,52**	**0,52**	**0,52**
Unit weight	**(kg/m^3)**	**2335**	**2335**	**2335**	**2335**

3. RESULTS AND DISCUSSION

3.1 Fresh Concrete Properties

The slump value of the control sample was measured as 170 mm. The slump values of the mixtures were measured in the range of 150-190 mm. The compression factors of the mixtures were measured in the range of 0.89-0.99. Fiber additive decreased workability and increased plasticizer additive need. It was observed that fiber additives, being added into mixtures, decrease workability of fresh concrete. Fiber aggregation and segregation weren't observed in the mixtures with fiber additive of 600 and 1200 g/m^3. However, when the amount of fiber in the mixture exceeded the value of 1800 g/m^3, aggregation and segregation were observed (Table 3). Therefore, the amount of fiber didn't exceed the value of 1800 g/m^3

Table 3. Fresh concrete properties

Mixtures	Slump (cm)	Compression Factor	Mixtures	Slump (cm)	Compression Factor
CNL	**17**	**0.97**	**K**	**17**	**0.97**
A/6	17	0.97	E/6	17	0.96
A/12	18	0.93	E/12	16	0.95
A/18	16	0.91	E/18	15	0.94
B/6	16	0.94	F/6	15	0.96
B/12	17	0.89	F/12	17	0.96
B/18	15	0.89	F/18	17	0.94
C/6	16	0.99	G/6	16	0.95
C/12	19	0.93	G/12	17	0.95
C/18	17	0.93	G/18	18	0.94
D/6	17	0.93	H/6	18	0.95
D/12	17	0.94	H/12	19	0.96
D/18	17	0.95	H/18	19	0.96

3.2. Vertical abrasion Test

Test was done, abrading the samples, 70x70x115 mm in size, prepared in accordance with the EN 1338 standard, with F80 aluminum oxide abrasive powder in 75 min/cyclic at vertical abrasion device (Figure 3). The abrasion depths were measured from three points on the abraded surface and the average depth of abrasion was calculated (Figure 4).

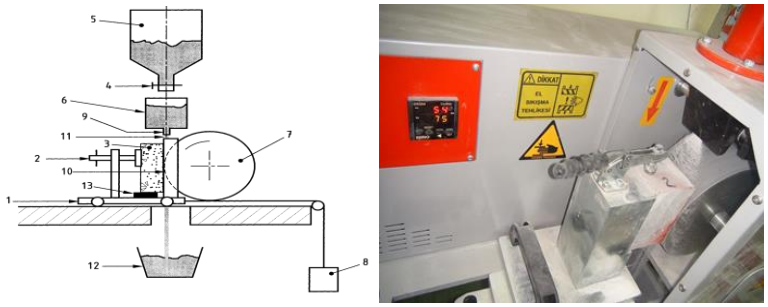


Figure 3. Vertical Abrasion Test Device

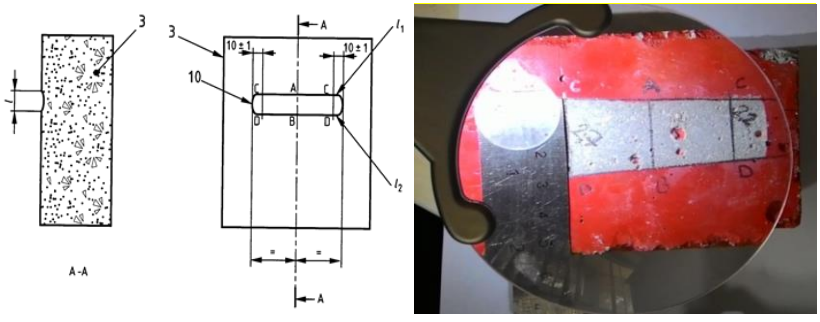


Figure 4. Measurement of Abrasion Depths

Abrasion widths on the samples were measured at the end of the test. Abrasion widths of C12, D6, D12 and E12samples were measured lower than those of control sample. In other words, these samples exhibited less abrasion compared to control samples. The abrasion widths of other samples were measured higher than those of control sample. The abrasion width of the control sample was measured as 21.5 mm. The abrasion widths

of the fibrous samples vary between 20 mm and 27.5 mm. The highest abrasion width was measured at the sample C6. The lowest abrasion width was measured at the sample D6 (Figure 5).

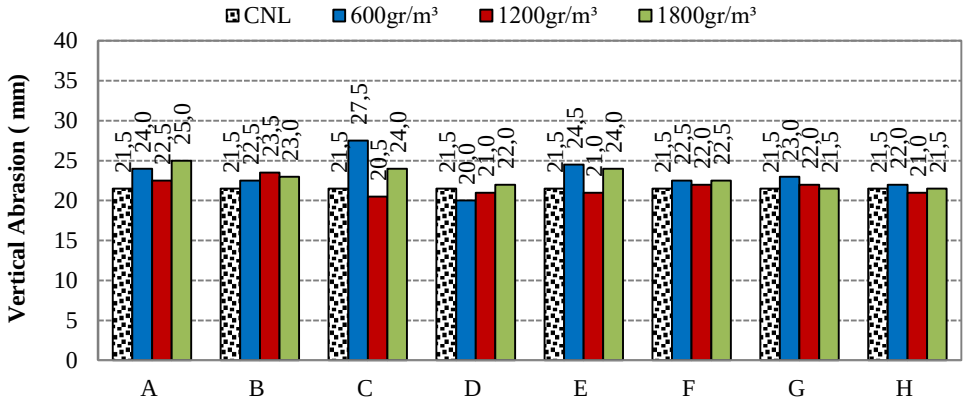


Figure 5. Vertical Abrasion Test Results

3.3. Water Absorption Test

The samples, weighing less than 5 kg, were prepared for total water absorption test. The samples dimensions were 70x70x115 mm. The samples prepared were maintained in the container filled with water until they reached to a constant mass (M_1) at temperature of 20±5 ^{0}C.The water layer was adjusted in such a way that it would be kept at least 20 mm over the samples. The samples were maintained in water at least for 3 days and weighed every 24 hours. The samples, getting out of water for weighing operation, were dried with a damp cloth, soaked and dewatered. Then weighing was conducted. When the mass difference between two successive weighing yields less than 0.1%, steady saturated mass was considered to be reached. The samples, considered to have reached to saturated mass, were placed to a drying oven so as to remain at least 15 mm distance between them, and they were dried until reaching to a constant dry mass (M_2) at temperature of 105±5 ^{0}C. The samples were maintained in the drying oven at least for 3 days and weighed every 24 hours. When the mass difference between two successive weighing yields less than 0.1%, constant mass was considered to be reached. The water absorption value (Wa) of each sample was calculated (Figure 6).

Fiber ratio and admixtures contained in the mixtures increased water absorption values of the samples. The water absorption value of the control sample was calculated as 3.43%. The water absorption values of the fiber mixtures vary between 2.79% and 4.63%.The lowest water absorption value was calculated in D12 mixture, the highest water absorption value was calculated in F12 mixture. The water absorption value increased in all fiber and admixture ratios of the mixtures with B, E and H fibers. It exhibited change depending on ratio of fiber and additive in other fibers.

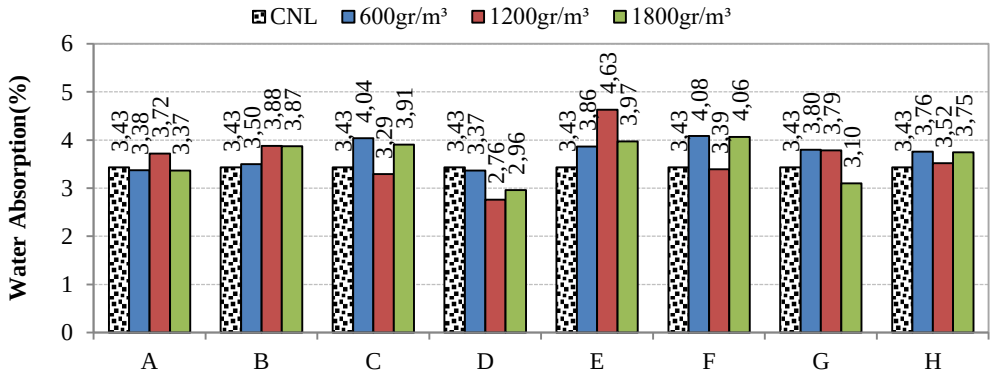


Figure 6. Water Absorption

3.4. Density Test

Density test of the hardened concrete was performed in accordance with EN 12390-7 standard. The cubical (15x15x15 cm) and cylindrical (15x30 cm) samples were used for the density test. Density of the cubical

samples varies between 2.39 and 2.42. The lowest density in the cubical samples was measured at F6 sample. The highest density in those was measured at E12 sample. Densities of cylindrical samples vary between 2.39 and 2.43. The lowest concrete density was measured at A18, B18 and E18 samples. Polypropylene fibers and admixtures didn't affect concrete density so much (Figure 7-8).

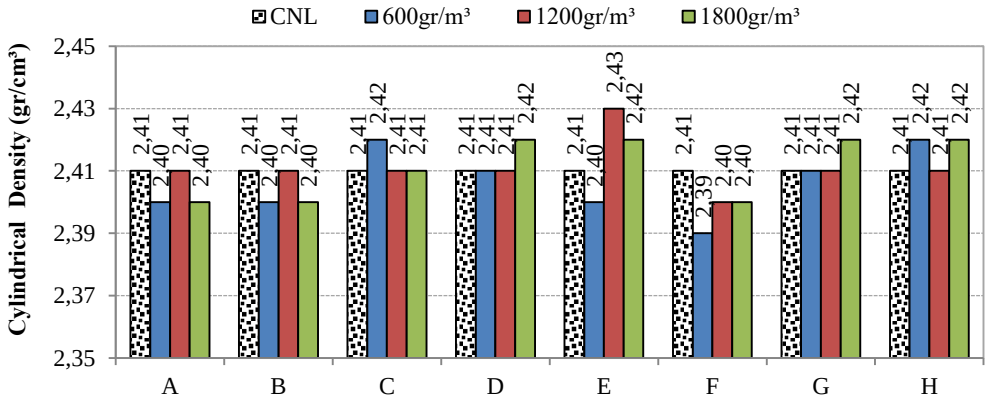


Figure 7. Density of Cylindrical Samples

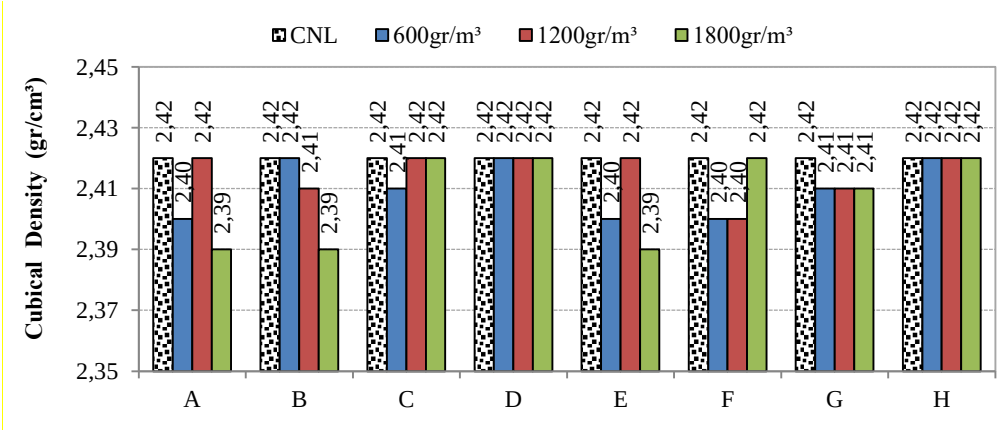


Figure 8. Density of Cubical Samples

4. CONCLUSIONS

It was seen that polypropylene fiber additive in mixture decreases workability of fresh concrete. Plasticizer additive increases with increasing of fiber additive as well. It was seen that segregation occurred especially when fiber additive of 1800 g/m^3 was exceeded and fibers formed aggregation in mixture. Therefore, fiber additive is recommended not to exceed value of 1800 g/m^3 for the performance of fresh concrete. The abrasion width of the control sample was measured as 21.5 mm. The abrasion widths of the fibrous samples vary between 20 mm and 27.5 mm. The highest abrasion width was measured at the sample C6. The lowest abrasion width was measured at the sample D. It can be said that amount of fiber additives and admixtures in mixtures haven't a positive effect on concrete abrasion.

Fiber ratio and admixture in mixtures increased water absorption values of the samples. This case can be explained with more easily penetration of water into gaps, formed by fibers in concrete. Water absorption value of the control sample was calculated as 3.43%. Water absorption values of fibrous mixture vary between 2.79% and 4.63%. Density of the cubical samples varies between 2.39 and 2.42. Density of cylindrical samples varies between 2.39 and 2.43. Polypropylene fibers and admixtures didn't affect concrete density so much. It has been concluded that cylindrical concrete density decreases with increasing of amount of A, B and E l fibers in mixture. In this case, increase of volume of fiber in mixture prevents full settlement of aggregate and cement phase and leads to formation of undesired gaps in concrete, which is determinant on decrease of concrete density.

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