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The Effect of Emboss Fiber (Modified Polypropylene Fiber) on the Behavior of Concrete used in Concrete Pavements

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ABSTRACT: Concrete pavements are widely used by pavement engineers due to their advantages over flexible pavements such as longer lifetime, good performance and durability, etc. However, concrete pavements represent some drawbacks such as shrinkage that increases the tensile stress in concrete, which may lead to cracking, warping, etc. Drying shrinkage is the most important type of shrinkage in concrete pavements. Polypropylene fibers can be used to control or reduce the width of cracking by bridging both sides of the crack. In this study, the effect of Emboss fiber on the behavior of concrete pavement was investigated. Slump, compressive strength, third-point flexural strength, electrical resistance, skid resistance, free shrinkage and restrained shrinkage by ring test were performed. Two water-cement ratios of 0.35 & 0.4 were used for mix design and the percentage of polypropylene fiber used in mixtures was 0.44% by concrete volume. The results showed that the use of Emboss Fiber reduced the workability of concrete. Also, these reinforcements had different effects on compressive and flexural strength and electrical resistance depending on the homogeneity of Emboss fiber reinforced concrete. Furthermore, toughness indices and energy absorption of concrete were significantly increased by using Emboss fiber reinforced concrete. In addition, using fiber indicated a slight reduction in the amount of free and restrained shrinkage and occurrence of first-crack. Polypropylene fibers had a key role in controlling crack width by bridging both sides of the crack. Finally, no certain relationship was observed between using SRA and changing the skid resistance of concrete pavement

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1- Introduction

Concrete pavements are widely used due to their pros over flexible pavements, such as longer lifetime, good performance and durability, etc. [1]. However, there are some drawbacks like drying shrinkage, which is defined as the contracting of a hardened concrete mixture due to the loss of capillary water [2]. Also, shrinkage may lead concrete pavement to cracking, warping & curling and cause a reduction on performance and lifetime [3, 4].

Fibers are one of the materials that use for controlling shrinkage cracks width by bridging between both sides of crack walls [5, 6]. The effect of using polypropylene fiber on the behavior of concrete was investigated by Ramezanianpour et al. [5]. The results showed that using fiber led to reduce the value of compressive, flexural & tensile strength of concrete because of the increasing porosity of concrete. Mo et al. [7] remarked that using polypropylene fiber had a contradictory effect on compressive strength but improved ductility of concrete. Also, Wang et al. [8] investigated the effect of polypropylene fibers on the behavior of high-performance concrete and reported that using fibers improves the mechanical properties of concrete. Gong et al. [9] represented that drying & autogenous shrinkage of concrete decreases by using polypropylene fiber as a reinforcement. Badogiannis et al. [10] reported that using fiber reduces and delays concrete shrinkage.

Controlling the shrinkage phenomenon on the concrete pavement has some advantages such as increasing concrete slabs length and rate of implementation. Different effects of fibers on the mechanical and durability properties of concrete were an important challenge in using this material as a reinforcement. In this study, the effect of Emboss fiber on the behavior of concrete used in concrete pavements was investigated

2- Materials and Methods

Type II Portland cement produced by Tehran cement factory was used in this study with a density of 3130 kg/m3. Furthermore, 3 types of aggregates were used in this study: gravel 9.5-19 mm, gravel 6-12 mm and sand 0-6 mm. The proportion of each type of aggregates were 20%, 25% and 55% of total weight, respectively. Also, the properties of Emboss Fiber and superplasticizer are shown in Table 1.

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Table 1. Properties of Emboss fiber & Superplasticizer

name	density (gr/cm^3)	nature
Emboss Fiber	0.91	Polypropylene
superplasticizer	1.05	Polycarboxylate, non-ionic

Table 2. Concrete mix Composition (per cubic meter)

Name	OPC 0.35	Fiber 0.35	OPC 0.4	Fiber 0.4
W/C	0.35	0.35	0.4	0.4
Cement (kg)	400	400	400	400
Gravel 9.5-19 (kg)	375.6	375.6	365.3	365.3
Gravel 6-12 (kg)	469.5	469.5	456.6	456.6
Sand 0-6 (kg)	1032.8	1032.8	1004.6	1004.6
Water (kg)	140	140	160	160
Superplasticizer (kg)	2	3	1.6	1.6
Emboss Fiber (kg)	0	4	0	4
Density (kg/m^3)	2372	2363	2344	2334
Slump (mm)	63	68	60	52

The mix composition was obtained based on the national method for concrete mix design [11] with two W/C of 0.35 & 0.4 and the amount of cement was 400kg/m3. In addition, the percentage of Emboss fiber was 0.44 by volume of concrete. Table 2 displays four concrete mix composition investigated in this study.

1. Also, slump, compressive strength, flexural strength with center point loading, electrical resistance, skid resistance, free shrinkage and restrained shrinkage were performed as an experimental program.

3- Results and discussion

Results of slump flow for each mix composition were represented in table 2. It shows that decreasing W/C or using Emboss Fiber effectively reduced workability of concrete.

Results of compressive and flexural strengths were shown in Figure 1. As it can be seen, W/C has a reverse effect on the mechanical properties of concrete. It might be due to the reduction of matrix and non-react water and increase aggregate after decreasing the water-cement ratio.

Using Emboss fiber had a different effect on the mechanical properties of concrete in different W/C, because using fiber increases concrete heterogeneity that effect on mechanical properties [5]. Furthermore, using Emboss fiber increased the amount of dissipated energy and ductility of concrete.

Figure 2 represents the results of electrical and skid resistance. It was observed that electrical resistance and mechanical properties had similar behavior in fiber reinforced concrete mixes. Also, there is no certain relationship between skid resistance results and types of concrete at constant W/C. In addition, electrical & skid resistance of concrete improved at lower W/C.

Figure 3 showed the effect of Emboss fiber on the behavior of free and restrained shrinkage (restrained shrinkage was tested on concrete with W/C=0.35). Using fiber improved concrete mixtures against free shrinkage (length change) and the ring's strain of restrained shrinkage. The reason is that cement paste was absorbed by fibers. Also, aggregates can better interlock together after using fiber in concrete mixtures [6, 12]. Furthermore, Emboss fiber decreased the crack width and number of cracks. It might be happened because fiber tries to control the width of the crack by bridging between both sides of crack walls [13].

Emboss fiber on the mechanical and durability properties of concrete used in concrete pavements. The results of this study can be summarized as follows:

- The use of Emboss fiber causes a reduction in slump flow and workability of concrete because of preventing aggregates and cement paste to move freely.

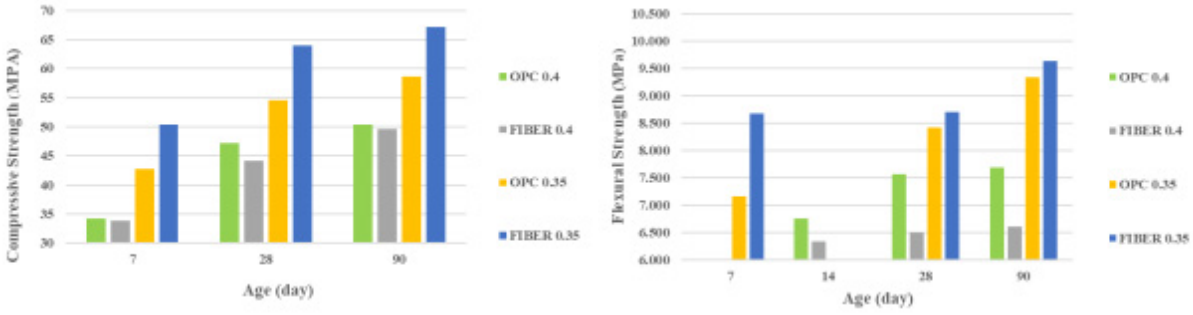

Fig. 1. Compressive (left) and Flexural (Right) Strength results

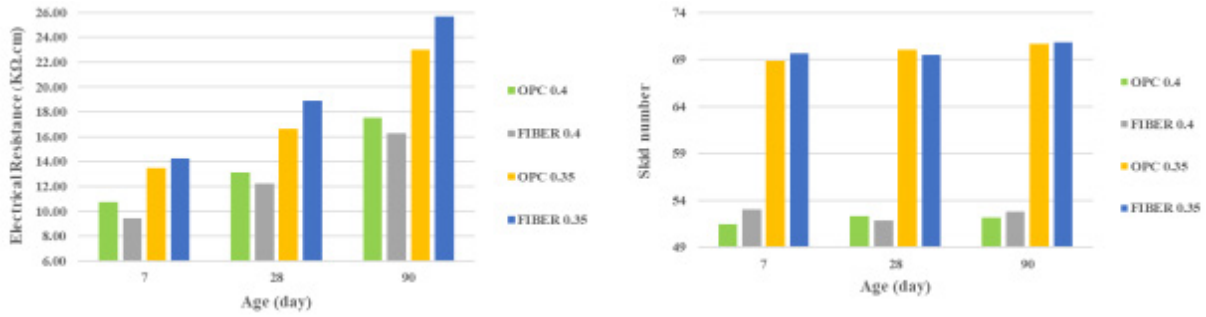

Fig. 2. electrical (left) and skid (Right) resistance results

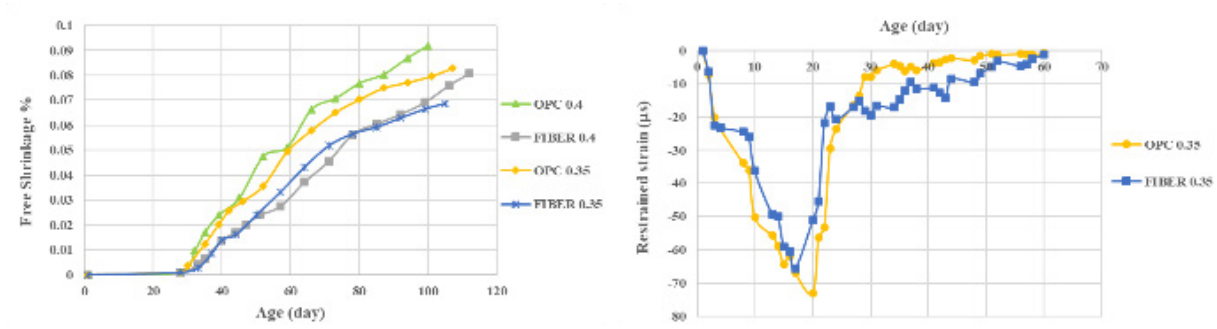

Fig. 3. Free (left) and restrained (Right) shrinkage

- This material had a different effect on the compressive and flexural strengths of concrete at each W/C. It happens because using fiber increases concrete heterogeneity that should be controlled. Furthermore, using Emboss fiber increased the ductility of concrete.

- Electrical resistance of concrete represented different behavior after using fiber in two mixtures with different W/C. It might be caused by the increasing heterogeneity of concrete.

- There was no certain effect between using Emboss fiber and variation of skid resistance.

- Free and restrained shrinkage had been reduced about 10 and 20 percent by using fiber, respectively. In addition, the crack width decreased about 35% which shows using fiber had a desirable effect on controlling shrinkage and its cracks. Fiber can act as a bridge between both sides of crack walls and prevent the growth of the crack.

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