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Effect of Punching on Polypropylene Fiber Tapes for Reinforcing Concrete

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Abstract: Application of different fibers such as carbon, steel, glass and polypropylene in concrete increase ductility under various loads including; bending, tensile and impact. The main role of adding fibers is when fibers bridge cracks. Using steel reinforcing bars or prestressing traditionally is used to overcome the low tensile strength and low strain capacity of fractured unreinforced concrete. Fibers of various types can also be used to improve the mechanical properties of concrete including higher bonding strength between fibers and concrete, higher resulting toughness and higher post crack strength of fiber reinforced concrete. However, although the bonding strength of each fiber with concrete is finite but it can be improved by surface treatment of fiber like punching whose effect was studied. In this paper, polypropylene fibers are selected in three forms; simple tape fibers,semi punch tape fibers,and full punch tape fibers and their usage in concrete was studied on such as; splitting tensile strength according to (ASTM C496) and compressive strength according to (ASTM C39) and also slump test according to (ASTM C143). The result of slump test indicated that these fibers were ineffective on workability of concrete and also result of compressive strength (3, 7 days) indicated reduction in comparison with plain concrete but sample with semi punch polypropylene fibers increased compressive strength of 4.25% in comparison with plain concrete (28 days).Finally simple polypropylene fibers in concrete increased splitting tensile strength of 10.21% in comparison with plain concrete (28 days).

Key words: Polypropylene fibers · Fiber reinforced concrete · Mechanical anchorage · Splitting tensile strength · Compressive strength

INTRODUCTION

Fibers have been used since Biblical times to strengthen brittle matrices for example straw and horse-hair was mixed with clay to form bricks and floors. Concrete is inherently brittle material with a relatively low tensile strength. Reinforcement with randomly distributed short fibers presents an effective approach to the stabilization of the crack system and improves the ductility and tensile strength of concrete [1].

Another approach is to replace the steel bars with fibers to produce a fiber reinforced concrete and this is termed as FRC[1] [2] .

FRC is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC thousands of small fibers are dispersed and distributed randomly in the concrete during mixing and thus improves concrete properties in all directions. Fiber helps to improve the post peak ductility performance, pre-crack tensile strength, fatigue Strength, impact strength and eliminate temperature and shrinkage cracks. Portland cement concrete is considered to be a relatively brittle material that when is non- reinforced, it fails under tensile stresses. Steel reinforcing has been used to overcome this problem. As a composite system, the reinforcing steel is assumed to carry all tensile loads. The problem with employing

[1]Fiber reinforced concrete

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steel in concrete is that over time steel corrodes due to the ingress of chloride ions. A better and permanent solution may be replacing the steel with a reinforcement that is less environmentally sensitive.More recently micro fiber, such as those used in traditional composite materials have been introduced into the concrete mixture to increase its toughness, or ability to resist crack growth [3].

The use of polypropylene fibers has successfully increased the toughness of concrete. Although Polypropylene fibers are characterized by low elastic modulus and poor physiochemical bonding with cement past, it is quite apparent that the load carrying ability of a structure under flexural loading is considerably increased [4].

Researchers have reported that PF[2] can improve the flexural ductility [5], compressive strength [6], toughness [5], split tensile strength [7], spalling resistance [8], modulus of rupture [6] and long term durability of concrete [9]. Additionally, PF reduces concrete's plastic shrinkage [10, 11], improves permeability and is able to release the vapor pressure of concrete to reduce the spalling distress especially at high temperatures due to the melted PF in the concrete pores [12, 13].

In additional, polypropylene fibers reduce or relieve internal forces by blocking microscopic crack from forming within the concrete [14].

Advantage of Using Polypropylene Fibers: A polypropylene fiber has some special characteristics such as high strength, ductility and durability, abundant resource, low cost and easily physical and chemical reformation [15].

Polypropylene is inert in high PH cementitious environment and easy to disperse [16].

Improvement Polypropylene Fibers: Since polypropylene shows poor adhesion with cementitious matrix due to their hydrophobic and smooth surfaces [17, 18]. Hence, various researches have been implemented to modify the surface structure of polypropylene fibers in order to improve their performance in composite applications. Some surface processing attempts of polypropylene such as wet chemical treatment [19], flame treatment [20], mechanical micro-pitting [21] and cold plasma treatment [22], wet chemical treatment methods such as acid or any other solution etching may cause excessive etching which simultaneously results in mechanical performance loss of material. The magnitude of etching is hard to measure and etching chemical should be washed out with high amounts of cleaning solutions. Disposal of these wastes may also cause environmental problems [23]. On the other hand, mechanical micro- pitting may cause cross-section loss and hard to apply on short fibers with small diameters [21]. Flame or heat treatment usually results into more brittle structure [24].

In this study the effect of anchorage was investigated on tape fibers in which punching were used as a kind of anchorage for fibers. Three types of tape fibers were produced and used in concrete and their performance in compressive strength and splitting tensile strength as well as fibers effect was studied on slump.

MATERIALS AND METHODS

Experimental Studies: The concrete matrix consisted of Portland cement type II (produced by kordestan cement factory), pea gravel (produced by metosak factory)with water absorption of 2.35% and breakage of 4%, gravel (produced by metosak factory)with water absorption of 1.8 % breakage 1%,sand with fineness modulus of 4.21and the maximum of 12.7mm, water and polypropylene fibers.

Polypropylene Fibers: Fiber used in this work was produced by polypropylene sheets that were made of recycled geraniol. With cutting polypropylene sheets (500*700mm) the tape fibers were produced with thickness of 0.6 mm, length of 50mm and width of 3 mm. Mechanical anchorages for using in concrete were created in those tapes which are named as follows.

- Simple tape (ST)
- Semi punch tape (SPT)
- Full Punch tape (FPT)

Table 1: concrete mix proportions

Fibers Wt %	Gravel Wt %	Sand Wt %	Cement Kg	Water to cement ratio
0.13	50	50	400	0.38

Table 2: characteristics of ST, SPT, FPT polypropylene fibers

	Strain at yield (mm)	Elongation at break (mm)	Tensile strength (Mpa)	Initial modulus (Mpa)
ST	0.036	0.325	20.422	1236.95
SPT	0.027	0.027	15.493	1.047
FPT	0.022	0.027	10.966	0.865

[2]Polypropylene fiber

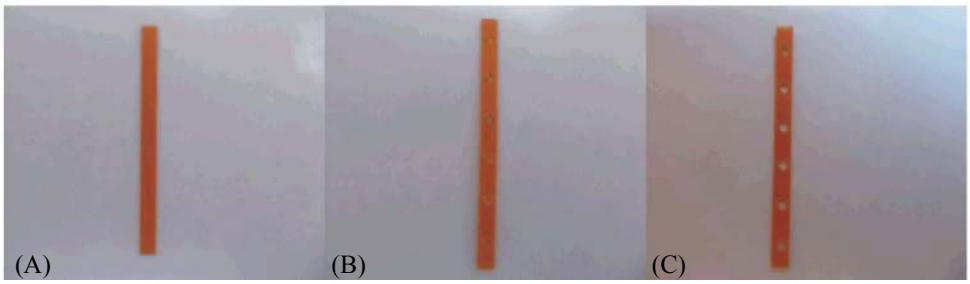

Fig. 1: Polypropylene fibers ST (a) SPT (b) FPT (c)

RESULTS AND DISCUSSION

Results of compressive strength and splitting tensile strength tests are presented in Table 3. Including plain sample s_1 and sample inclusive fiber STs_2, sample inclusive fibers SPT s_3 and also FPT fibers termed s_4.

Compressive Strength: Reduction of compressive strength of concrete (with low, medium and high strength) can explain that the presence of high number of fibers in $1m^3$ fiber concrete create breakage of bond between cement and aggregates and this inclusion represents a large surface area of material breaking the cement and aggregates bonding to cause loss of compressive strength [25].

In this work there are almost 20500 polypropylene fibers (in $1m^3$ oncrete) whose presence is breakage bond between cement and aggregates followed by loss of compressive strength of concrete.

Splitting Tensile Strength: When tensile stress occurs in concrete, then this stress transfers directly from to fibers. With regard to results of tensile strength one can say that existence of ST fibers leads to increased splitting tensile strength since these fibers enhances tensile strength of concrete considerably. In fact, ST fibers had more tensile strength and elongation at break than two other fibers that decreased tensile strength of fiber mixed concrete.

In fact punching on fibers caused reducing of their tensile strength and also elongation at break. In splitting tensile test, when tensile stress was transferred to fibers and to the points of full punch and semi punch as the weak points for fibers and as points of stress concentration. Hence, the fibers rupture from those points in matrix [15, 26].

Polypropylene fiber usage has no effect on increasing of slump of concrete since presence of fibers in concrete caused decrease of slump of concrete. Slump of all samples (s_1 -s_4) was 30mm.

Table 3: results of compressive and tensile splitting strength tests

	Compressive Strength Mpa			Tensile Strength KPa
	3days	7days	28days	28days
S1	15.94	25.37	38.06	3642
S2	12.89	22.84	36.71	4014
S3	15.90	19.92	39.65	3242
S4	10.58	15.83	28.24	2757

Table 4: Tensile strength of fibers and concrete include fibers

Splitting tensile strength concrete include fibers KPa		Tensile strength of fibers KPa	
S_2	4014	ST	20422
S_3	3242	SPT	15493
S_4	2757	PT	10966

Study of Tensile Strength of Polypropylene Tape Fibers and Concrete to Include These Fibers: Regarding the results in Table 4 we conclude that by creating semi punches in tapes tensile strength of fibers was reduced 24.13%in comparison with simple tape fibers. Whereas when these fibers were used in concrete then splitting tensile strength of concrete in comparison with plain concrete was reduced 10.98% and in comparison with s_2 splitting tensile strength reduction was about 19.23%.

In full punch tape fibers tensile strength of fiber in comparison with simple tape fiber was reduced 46.30%and with application of these fiber in concrete loss of splitting tensile strength of concrete was 24.29% in comparison with plain concrete and also for s_2 was 31.31%.Therefore, when SPT and FPT fibers were introduced in composite then loss of splitting tensile strength was less than when these fibers were investigated individually out of composite.Hence, this point should be taken into consideration.

CONCLUSION

Effects of polypropylene fiber tapes were investigated up on their usage in concrete. These fiber tapes were either simple, semi-punch and full punched

types. Results indicate that inclusion of simple tape fibers in concrete cause an improvement of its tensile strength which in fact is the weak point of concrete. The other two types of fibers have the opposite effects. On the other hand, all three kinds of tapes reduce the compressive strength of concrete which can be neglected since there are so many other ways to improve this strong characteristic of concrete. Fiber also enhanced the workability of concrete which can lead to eliminating the necessity of using plasticizer and super plasticizer.

Finally, we conclude that recommendation for using polypropylene fiber tapes in form of simple type fibers in concrete when they are produced from of polypropylene sheets made of recycled geraniol seems to be cost effective and feasible if a mass production can be planned for them.

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