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POLYPROPYLENE FIBERS POTENTIALS IN THE IRAQI CEMENTITIOUS CONCRETE CONSTRUCTIONS

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ABSTRACT

An experimental study is achieved to investigate the polypropylene fibers potentials on the mechanical performance of concrete constructions. It is found that an addition of 1% and 2% of polypropylene fibers to concrete mixes produces a reduction of concrete slump 20% and 28% respectively comparing with conventional mix (0% of polymer) and an increasing in compressive strength of (13.1 % and 19% after 7days), (8.5% and 14.3% after 28days), and (12.25% and 17.2% after 90days) respectively. There is also an increasing in flexural strength of (11.1 % and 18.3% after 7days), (13% and 24% after 28days), and (13.8% and 20.7% after 90days) respectively as well as an increasing in splitting tensile strength of (7 % and 11.6% after 7days), (12.5% and 17.8% after 28days), and (19% and 22.4% after 90days) respectively. It can also be observed that at the age of 90days the addition of the polypropylene enhances the tensile mechanical performance of the concrete members due to the strengthening effect of polypropylene fiber reinforcement to concrete paste.

Keywords FRC: Fiber Reinforced Concrete IOS: Iraqi Organization Specifications

INTRODUCTION

Fiber Reinforced Concrete (FRC) is one of the fastest growing segments in the concrete industry as more and more engineers, architects, owners, specifies and concrete contractors are turning to the use of fibers to supply their reinforcing needs in their concrete applications.

Polymers fibers nowadays become a fortuitous production in various types of manufacture over the worldwide. These materials are accompanied with many favorable characteristics such its light weight, availability, durability, and acceptable mechanical performance. Polymers fibers are first used as admixture to concrete in 1965 and subsequently improved to be a fibrillated material for production of fiber reinforced concrete.

Sabina et al. (2009) studied the performance of waste plastic polymer in the bituminous concrete mixes, they indicate that waste polymer modifier is stable up to 200 c^0. It is observed that 60/70 penetration grade paving bitumen and aggregate satisfy specified limits. Saenz et al. (1999) and Castan˜o et al. (2000) indicate that concrete offers many advantages in the application in ceramic industry due to its improved mechanical characteristics, low permeability and higher resistance against chemical and mechanical attacks. Although concrete behaviour is governed significantly by its compressive strength, the tensile strength is still important for appearance and durability of concrete. Therefore polymer fibers are generally introduced to enhance its flexural tensile strength, crack arresting system and post cracking ductile behaviour of basic matrix.

Dodson (1989) Concrete modification study by employing polymer materials has been carried out for about 40 years ago. In general, the reinforcement of brittle building materials with fibers has been known from ancient period such as putting straw or hay into the mud for housing walls or reinforcing mortar using animal hair. Many materials like jute, bamboo, coconut, rice husk, cane bagasse, and sawdust as well as synthetic materials such as polyvinyl

alcohol, polypropylene, polyethylene, polyamides etc. have also been used for reinforcing the concrete (Sheldon et al., 1982; Ramaswamy et al., 1984; Jindal, 1986; Jindal, 1990; Colling, 1981; Hananth,).

Ken & Trevor (2010) studied the effect of fire on concrete parts spalling (Concrete spalling can be defined as the breaking off of layers or pieces of concrete from the surface of a structural element when exposed to the high and rapidly increasing temperatures experienced in fires Malhotra (1984) and explain the polymer microfibers benefits and the mechanism of how these fibers reduces concrete spalling (Halard & Michael 2012). Among the new types of high performance concretes are self-compacting concrete (SCC) and ultra-high strength concrete (UHPC). While most of the properties of SCC are roughly similar to normal concrete NC - this holds by far not true for UHPC. Not only the mechanical properties but also the durability sustainability of UHPC deviates significantly from normal concrete .They also indicated that (UHPC) could be successfully produced by adding 0.3-0.6 of polypropylene fibers to conventional mixes. Wang & Balard (2006) indicated that with the addition of fibers, the flexural behavior is improved with an increase of ductility index by approximately 40% as compared to the plain concrete beams. Crack widths of FRP/FRC were found to be smaller than those of FRP/plain concrete system and the values predicted by the ACI 440 equations. Furthermore, the compressive failure strains of concrete in FRP/FRC beams exceed the strain of 0.0040 mm/mm. In this research, it is desired to evaluate the effect of polypropylene fibers on the concrete constructions made of Iraqi Portland Cement.

Research Significance

This research is aimed to investigate the effect of polypropylene fibers on the physical and mechanical properties of fresh and hard concrete mixes made of Iraqi Portland cement.

Materials under Viewing

Briefly, many materials are used in concrete mixes such as:-

I) Gravel with sulphuric Saline of 0.055% and gradation as in Table (1).
II) Sand with sulphuric saline of 0.348% and gradation shown in Table (2).

Table 1. Gravel Gradation

Grain Size, mm	*Finer %*	*Iraqi Specifications, No.45, (1984)*
37.5	100	100
19.5	96	95-100
9.5	48	30-60
4.75	2	0-10

Table 2. Sand Gradation

Grain Size, mm	*Finer %*	*Iraqi Specifications, No.45, (1984)*
10	100	100
4.75	96	90-100
2.36	87	85-100
1.18	76	75-100
0.6	64	60-79
0.3	14	12-40
0.15	2	0-10

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III) Super-plasticizer characterization is shown in Table (3):-

Table 3. Super-plasticizer characterization (sp33)

Item	*Description*
Color	Brown
Density	1.19 gm/cm^3
Water Absorption percentage	2.5-3 if W/C > 0.5 1-1.5 if W/C < 0.5

IV) Cement with physiochemical properties shown in Table (4)

V) Polypropylene fibers characteristics are as shown in Table (5) and Fig.(1)

Table 4. Physiochemical Composition of Portland cement

Chemical Analysis (According to IOS No.5/1984)		
Oxide	% by weight	Allowable Limits
CaO	64.04	---
SiO_2	20.90	---
Al_2O_3	5.68	---
Fe_2O_3	3.2	---
MgO	1.76	≤4%
So_3	2.74	≤2.5% if C_3A <5% ≤2.8% if C_3A >5%
Free Lime	0.84	---
Loss on Ignition	1.3	≤4%
Insoluble Residue	0.82	≤1.5%
L.S.F.	0.91	0.66-1.02
C_3S%	46.99	---
C_2S%	24.47	---
C_3A%	9.64	---
C_4AF%	9.74	---
Physical Analysis (According to IOS No.5/1984)		
Setting Time, min,		
Initial	140	≥45min
Final	230	≤600min
Fineness(Blaine), m^2/kg	280	≥230
Soundness (Auto Clave), %	-	≤0.8
Compressive Strength, Mpa at:-		
3days	22	≥15
7days	34	≥23

Table 5. Polypropylene Characterization

Item	*Description*
Color	White
Fiber Length	12mm
Fiber Diameter	18 μm
Density	0.91 gm/cm^3
Chemical Composition	100% poly-propylene

Mixes Proportions & Concrete Samples Preparation

1- Mixes with proportion of 1: 1.5: 3 cement: sand: gravel respectively with addition of 1% super-plasticizer and 0.45 W/C ratio are prepared.

2- Six samples for each age (7, 28, 90 days) are prepared for the specified tests; they are compressive (cubes), splitting tensile (cylinders), and flexural strength (beams) tests. This means that 54 samples are prepared.

3- The previous prepared samples in (2) are repeated again for three times with different polypropylene content; 0%, 1%, and 2%. This means that total number of samples is 162.

Table (6) includes the dimensions of the concrete samples.

Table 6. Concrete Sample Dimension

Sample	*Length, cm*	*Width, cm*	*Height, cm*
Cube	15	15	15
Cylinder	15cm in Diameter		**15**
Beam	15	15	520cm in Length

Fresh Concrete Tests

The prepared mixes are tested initially in fresh state to investigate the behavior of concrete under the effect of different content percentage by weight of the Polypropylene. The slump test results for different polypropylene content is shown in Fig.(2).

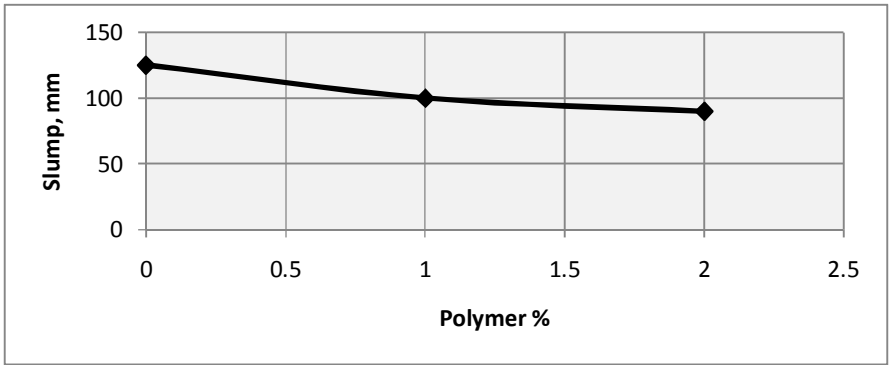

Fig.1. Slump Values Versus Polypropylene Percentage

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HARDENED CONCRETE STATE TESTS

Compressive Strength Test

A compressive strength is carried out on 54 samples for the ages (7, 28, and 90days) and different Polypropylene percentages (0%, 1%, and 2%) and the results are indicated in Figs 3, and 4.

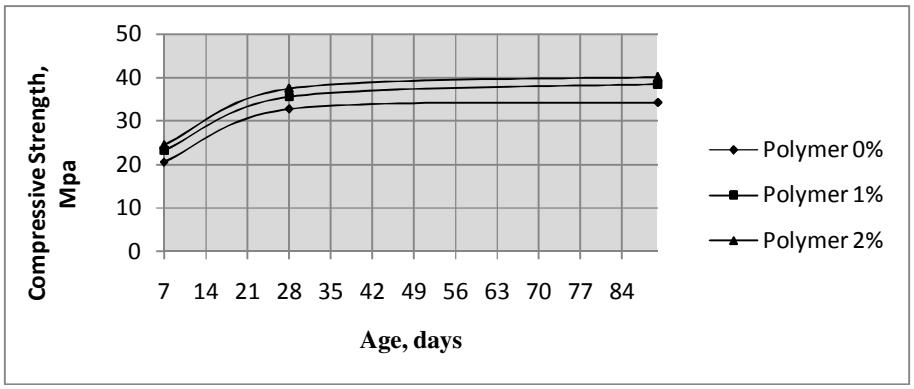

Fig.3 Compressive Strength Versus Age for Different Polypropylene Content

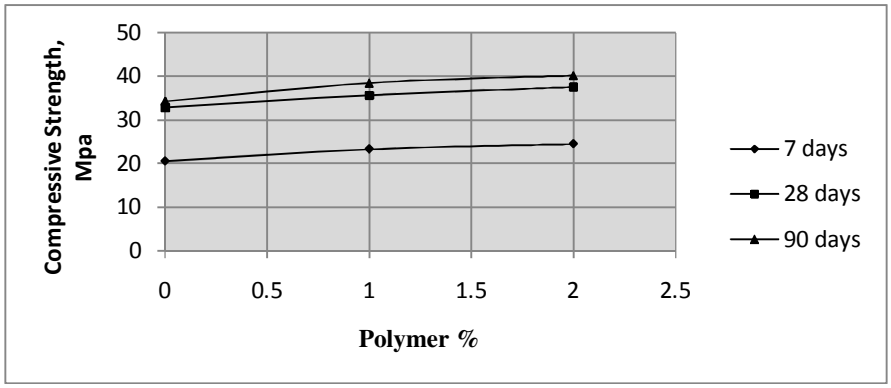

Fig.4 Compressive Strength Versus Polypropylene Content for Different Ages

Splitting Tensile Strength

The splitting tensile strength are achieved on the specified 54 cylindrical samples and the results are represented in Fig. 5

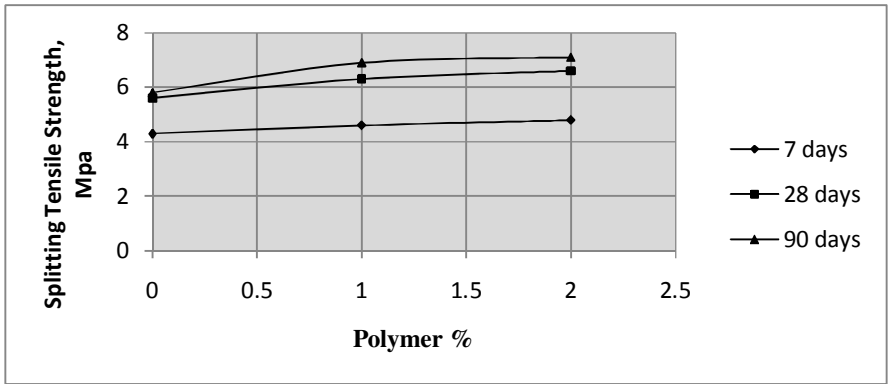

Fig.5 Splitting Tensile Strength Versus Polypropylene Content for Different Ages

Flexural Strength test

Flexural strength test has been carried on 54 cured samples for different ages and different polymer content percentage, and the test results are summarized in Fig.(6)

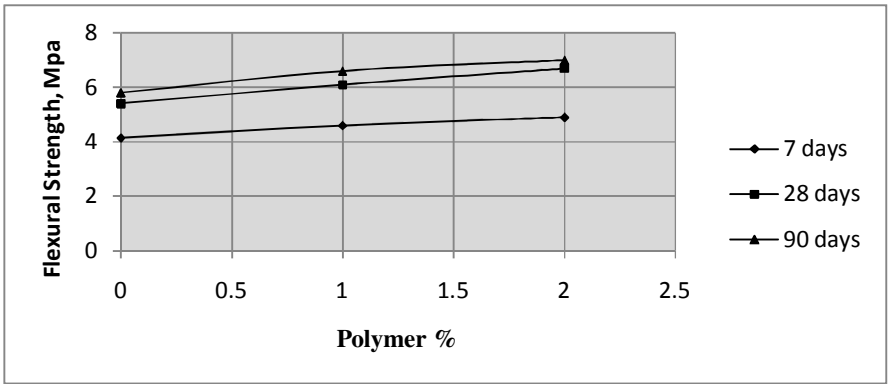

Fig. 6 Flexural Strength Versus Polypropylene Content for Different Ages

RESULTS DISCUSSION

An addition of 1% and 2% of Polypropylene fibers to the current concrete mixes produces the following changes:

1. A reduction of concrete slump 20% and 28% respectively comparing with conventional mix (0% of polymer). That means reduces the workability and molding of fresh concrete mixes.
2. An increasing in compressive strength of (13.1 % and 19% after 7days), (8.5% and 14.3% after 28days), (12.25% and 17.2% after 90days) respectively.
3. An increasing in flexural strength of (11.1 % and 18.3% after 7days), (13% and 24% after 28days), (13.8% and 20.7% after 90days) respectively.
4. An increasing in splitting tensile strength of (7 % and 11.6% after 7days), (12.5% and 17.8% after 28days), (19% and 22.4% after 90days) respectively.
5. Once, Its can be observed that at the age of 90days, the increasing percentage in splitting tensile strength is more than the increasing in flexural strength which in turn with an increasing more than the compressive strength. This reveals that Polypropylene fibers are relatively more active to increase tension strength than compressive strength.

CONCLUSIONS

The addition of Polypropylene fibers can lead to the followings conclusions:-

1- Reduction in the workability and mix slump.

2- It is more effective in the tension than compressive strength due to the adhesive and friction forces between concrete paste and Polypropylene fibers.

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