EXPERIMENTAL STUDY ON HYBRID FIBRE IN CONCRETE

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Abstract - *The purpose of this study is to improve the ductility of concrete by incorporating hybrid steel and polypropylene fibres. The changes in mechanical properties and also bulk density and workability of concrete due to the addition of hybrid steel and polypropylene fibres have been studied. The properties were investigated include bulk density and workability of fresh concrete as well as compressive strength, flexural tensile strength, splitting tensile strength, and toughness of hardened concrete. Fifteen concrete mixtures with different volume fractions of steel and polypropylene fibres were tested. An increase in compressive and flexural strength due to the addition of steel fibres was observed. Polypropylene fibres, on the other hand, caused a minor change in mechanical properties of hardened concrete especially in the mixtures made with both steel and polypropylene fibres. Nowadays, it is well established that the incorporation of fibres improves the engineering performance of structural and nonstructural concrete, including better crack resistance, ductility, and toughness, as well as enhanced tensile strength, resistance to fatigue, impact, blast loading, and abrasion. Flexural strength and tensile strength are also enhanced. However, such improvement can only be reached when using the appropriate type and amount of fibres.*

***Key Words*: *Hybrid fibre, Workability, Compressive strength, Tensile strength, Flexural strength*.**

1. INTRODUCTION

India has taken a major initiative in developing the infrastructures such as express highways, power projects, and industrial structures, etc., to meet the requirements of globalization. In the construction of buildings and other structures, concrete plays the rightful role and a large quantum of concrete is being utilized.

In addition to the concrete, to increase their strength along with concrete we are using fibres to arrest cracks. There are several types of fibres such as steel, synthetic and natural fibres. Now, we are using Steel fibre (SF) and Polypropylene fibre (PF) in concrete to increase the strength and to improve the mechanical properties of concrete.

1.1 Steel Fibre

It is now well established that one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and ultimate, particularly under flexural loading; and the fibres can hold the matrix together even after extensive cracking. The net result of all these is to impart to the fibre composite pronounced post–cracking ductility which is unheard of in ordinary concrete.

1.2 Synthetic Fibre

Synthetic fibres are manufactured from manmade materials that can withstand the long-term alkaline environment of concrete. Now, Synthetic fibres are used in concrete to enhance the mechanical properties of concrete. These include fibres such as polypropylene, glass, nylon, carbon, aramid, polyethylene, acrylic, and polyester fibres.

The most important property of polypropylene is its versatility. The polypropylene fibres have good ductility, fineness, and dispersion so they can restrain the plastic cracks.

2. Literature Review

C.X. Qian, P et al., investigated the "Development of hybrid polypropylene-steel fibre-reinforced concrete". This research first investigates the optimization of fibre size, fibre content, and fly ash content in hybrid polypropylene-steel fibre concrete with low fibre content based on general mechanical properties. The research results show that certain content of fine particles such as fly ash is necessary to evenly disperse fibres. The different sizes of steel fibres contributed to different mechanical properties, at least to a different degree. Additions of a small fibre type had a significant influence on the compressive strength, but the splitting tensile strength was only slightly affected. A large fibre type gave rise to opposite mechanical effects, which were further fortified by optimization of the aspect ratio. There is a synergy effect in the hybrid fibres system. The fracture properties and the dynamic properties will be further investigated for the hybrid fibres concrete with good general mechanical properties.

P.S. Song, J.C. Wu, S. Hwang, B.C. Sheu investigated the "Statistical analysis of impact strength and strength reliability of steel–polypropylene hybrid fibre-reinforced concrete". This paper statistically investigates the first-crack strength, failure strength, and strength reliability of steel–polypropylene hybrid fibre-reinforced concrete in comparison with the steel fibre-reinforced concrete. The former strengths were measured using the drop weight test in a batch of 48 discs. The hybrid fibre-reinforced concrete showed smaller variation in the two strengths, although a larger scatter in the percentage increase was observed in the number of post-first-crack blows, compared to those of the steel fibre reinforced concrete. The Kolmogorov–Smirnov test indicates that the two fibre-reinforced concretes hardly followed the normal distributions on the two strengths and the percentage increase. Dunnet's calculations indicate that the hybrid fibre-reinforced concrete provides a less significant improvement on the two strengths and the percentage increase than the steel fibre-reinforced concrete. The Kaplan–Meier analysis indicates that the hybrid fibre-reinforced concrete improves a little higher reliability of the first-crack and failure strengths than the steel fibre-reinforced concrete. A bi-role failure strength regression model is recommended for the two concretes.

ChunxiangQian, Piet Striven "Fracture properties of concrete reinforced with steel polypropylene hybrid fibres". This research discusses polypropylene fibres and three sizes of steel fibres reinforced concrete. The total fibre content ranges from0% to 0.95% by volume of concrete. A four-point bending test is adopted on the notched prisms with the size of 100 _ 100 _ 500 mm3to investigate the effect of hybrid fibres on crack arresting. The research results show that there is a positive synergy effect between large steel fibres and polypropylene fibres on the load-bearing capacity and fracture toughness in the small displacement range. But this synergy effect disappears in the large displacement range. The large and strong steel fibre is better than soft polypropylene fibre and small steel fibre in the aspect of energy absorption capacity in the large displacement range. The static service limitation for the hybrid fibres concrete, with ``a wide peak'' or ``multi-peaks'' load±CMOD patterns, should be carefully selected. The ultimate loadbearing capacity and the crack width or CMOD at this load level should be jointly considered in this case. The KIC and fracture toughness of a proper hybrid fibre system can be higher than that of a mono-fibre system.

Wei Sun, Huisu Chen, XinLuo, HongpinQian investigated "The effect of hybrid fibres and expansive agent on the shrinkage and permeability of high-performance concrete" In this paper, high-performance concrete (HPC) incorporated with an expansive agent and hybrid fibres, i.e., steel fibres, polyvinyl alcohol fibre (PVA fibre), and polypropylene fibre (PP fibre), was produced. The properties measured included shrinkage and water permeation of the concrete. The effect of hybrid fibres and/or expansive agents on the shrinkage and water permeation properties was investigated. Test results indicated that the hybrid fibres of different types and sizes could reduce the size and amount of crack source at different scales; hybrid fibres combined with an expansive agent provided better enhancement for shrinkage resistance and impermeability of HPC than mono - incorporation of hybrid fibres or expansive agent; the improvement of the shrinkage resistance and the impermeability of the concrete resulted from the combined use of an expansive agent and hybrid fibres, which was dependent on the amount of expansive agent, types and sizes of hybrid fibres, the total volume fraction of fibres, proportions of hybrid fibres, and so on. The relevant mechanisms were also discussed based on the analysis of the test results of the pore structure of the concrete.

Nicolas Ali Libre, Mohammad Shekarchi, MehrdadMahoutian, ParvizSoroushian investigated the "Mechanical properties of hybrid fibre-reinforced lightweight aggregate concrete made with natural pumice". The purpose of this study is to improve the ductility of pumice lightweight aggregate concrete by incorporating hybrid steel and polypropylene fibres. The changes in mechanical properties and also bulk density and workability of pumice lightweight aggregate concrete due to the addition of hybrid steel and polypropylene fibres have been studied. The properties were investigated include bulk density and workability of fresh concrete as well as compressive strength, flexural tensile strength, splitting tensile strength, and toughness of hardened concrete. Nine concrete mixtures with different volume fractions of steel and polypropylene fibres were tested. A large increase in compressive and flexural ductility and energy absorption capacity due to the addition of steel fibres was observed. Polypropylene fibres, on the other hand, caused a minor change in mechanical properties of hardened concrete especially in the mixtures made with both steel and polypropylene fibres. These observations provide insight into the benefits of different fibre reinforcement systems to the mechanical performance of pumice lightweight aggregate concrete which is considered to be brittle. These results guide the design of concrete materials with reduced density and enhanced ductility for different applications, including the construction of high-rise, earthquake-resistant buildings.

3. Objective

The objective of this project is as follows:

- Casting the concrete specimens by using various percentages of different fibres.
- Testing the concrete specimens with the addition of a different percentage of fibre and investigation are made on Hybrid Fibres.
- Enhances the mechanical properties by adding steel fibre.

- Enhances the bridging of smaller micro-cracks by addition of synthetic fibre such as polypropylene
- Increases the mechanical properties, namely compressive strength, split tensile strength.

4. Testing of Fresh Concrete

4.1 Slump Test

The slump test is the most commonly used method of measuring the consistency of concrete which can be employed. It is used conveniently as a control test and indicates the uniformity of concrete from batch to batch.

Fibre Percentage	Slump Value (mm)
0.1%	92
0.2%	93
0.3%	96
0.4%	94
0.5%	90
0.6%	86

Table – 4.1: Slump Value

4.2 Testing of Specimens

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete work. Systematic testing of raw materials, fresh concrete, and hardened concrete are an inseparable part of any quality program for concrete, which helps to achieve higher efficiency of the material used and greater assurance of the performance of the concrete about both strength and durability. Compressive strength, Split Tensile Strength, and Flexural Strength tests were determined.

5. Results and Discussion

5.1 Introduction

The specimens were cast and allowed to cure for 7 and 28 days and were tested. The details of specimen type and the type of test conducted are shown in Table 5.1

Type of Test	Test specimen	Size (in mm)	No. of Specimens
Compressive Strength	Cube	150 x 150	45
Split tensile strength	Cylinder	150 x 300	45
Flexural strength	Prism	100 x 100 x 500	45

Table 5.1: Details of Test Specimens and Types of Mechanical test.

5.2 Compressive Strength

5.2.1 Polypropylene Fibre

S. No.	Addition of fibre in %	COMPRESSIVE STRENGTH (N/mm^2)	
		7th day	28th day
1	0%	25.73	28.89
2	0.1%	26.23	29.38
3	0.2%	26.98	29.91
4	**0.3%**	**27.67**	**30.66**
5	0.4%	26.58	29.88
6	0.5%	25.78	28.22
7	0.6%	24.89	27.45

Table 5.2.1: Compressive Strength of Polypropylene Fibre.

5.2.2 Steel Fibre

S. No.	Addition of fibre in %	COMPRESSIVE STRENGTH (N/mm^2)	
		7th day	28th day
1	0%	25.73	28.89
2	0.2%	26.32	30.22
3	0.4%	26.95	31.55
4	**0.6%**	**27.40**	**32.08**
5	0.8%	26.85	31.45

Table 5.2.2: Compressive Strength of Steel Fibre.

5.2.3 Hybrid Fibre

S. No.	Volume Fraction (v_f) in %	Addition of fibre in % (Polypropylene fibre)	Addition of fibre in % (Steel fibre)	Compressive strength (N/mm^2)	
				7th day	28th day
1	0	0	0	25.73	28.89
2	0.8	0.2	0.6	30.04	45.42
3	**0.9**	**0.3**	**0.6**	**31.66**	**46.44**
4	1.0	0.4	0.6	29.42	45.24

Table 5.2.3: Compressive Strength of Hybrid Fibre.

5.3 Split Tensile Strength

5.3.1 Polypropylene Fibre

S. No.	Addition of fibre in %	SPLIT TENSILE STRENGTH (N/mm^2)	
		7th day	28th day
1	0%	1.55	2.78
2	0.1%	1.65	2.98
3	0.2%	1.78	3.15
4	**0.3%**	**1.84**	**3.45**
5	0.4%	1.75	3.15
6	0.5%	1.60	2.95
7	0.6%	1.43	2.76

Table 5.3.1: Split Tensile Strength of Polypropylene Fibre.

5.3.2 Steel Fibre

S. No.	Addition of fibre in %	SPLIT TENSILE STRENGTH (N/mm^2)	
		7th day	28th day
1	0%	1.55	2.78
2	0.2%	1.63	2.85
3	0.4%	1.76	2.90
4	**0.6%**	**1.98**	**3.15**
5	0.8%	1.65	2.87

Table 5.3.2: Split Tensile Strength of Steel Fibre.

5.3.3 Hybrid Fibre

S. No.	Volume Fraction (v_f) in %	Addition of fibre in % (Polypropylene fibre)	Addition of fibre in % (Steel fibre)	Split tensile strength (N/mm^2)	
				7th day	28th day
1	0	0	0	1.55	2.78
2	0.8	0.2	0.6	2.84	3.52
3	**0.9**	**0.3**	**0.6**	**3.12**	**3.64**
4	1.0	0.4	0.6	2.99	3.46

Table 5.3.3: Split Tensile Strength of Hybrid Fibre.

5.4 Flexural Strength

5.4.1 Hybrid Fibre

S. No.	Volume Fraction (v_f) in %	Addition of fibre in % (Polypropylene fibre)	Addition of fibre in % (Steel fibre)	Flexural strength (N/mm^2)	
				7th day	28th day
1	0	0	0	6.38	9.04
2	0.8	0.2	0.6	6.52	9.26
3	**0.9**	**0.3**	**0.6**	**6.68**	**9.52**
4	1.0	0.4	0.6	6.4	9.30

Table 5.4.1: Flexural Strength of Hybrid Fibre.

6. Conclusion

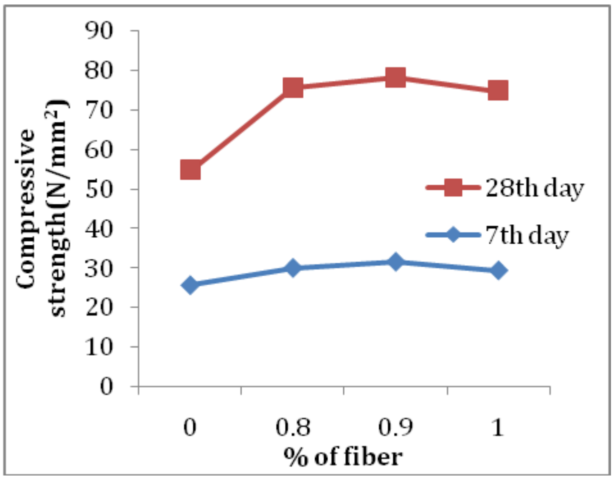

Figure 1: Compressive Strength

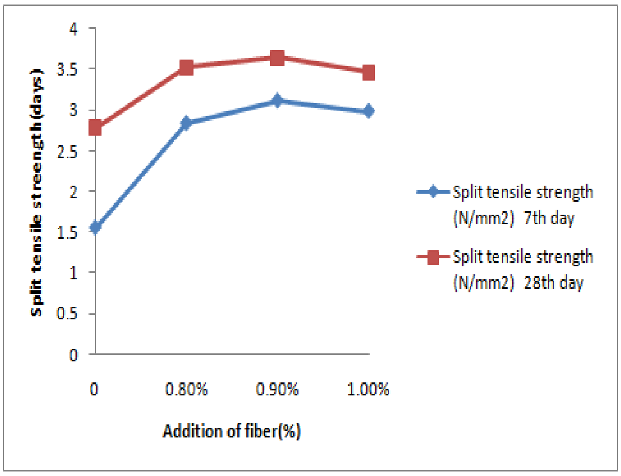

Figure 2: Split Tensile Strength

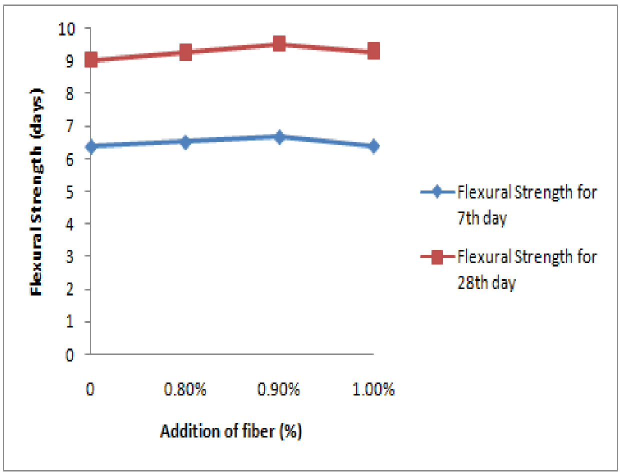

Figure 3: Flexural Strength

Thus we conclude that the addition of hybrid fibre in concrete improves the compressive strength, flexural strength, and split tensile strength.

- The test results of the compressive test show an increase of 1.60 times in strength greater than conventional concrete.
- Same as in split tensile strength, it shows an increase of 1.3 times in strength greater than conventional concrete in 28 days.
- The flexural strength test shows an increase of 1.0 time in strength greater than conventional concrete in 28 days.

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