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Influence of Hybrid Polymeric Fibers on Flexural Strength of M30 Grade Concrete

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Abstract: Plain unreinforced Concrete has good compressive strength but it tends to be brittle and is weak in tensile strength. Fiber reinforcement is useful in controlling cracks, enhancing toughness, providing post crack ductility, improving impact resistance and reducing flexural fatigue. Hybrid Fiber Reinforced Concrete (HFRC) is formed from a combination of fibersdiffering in material properties. The effect of hybridized fibers on flexural strength of M30 grade concrete is investigated in this paper. Control andhybrid fiber composites of three different combinations were cast using varying fiber proportions of steel and Polypropylene Fiber, steel and Glass Fiber and Steel and Nylon Fiber. Flexural strength tests were performed and results were analyzed to associate with above fiber combinations.
Keywords: HFRC, Fiber Reinforced Concrete, Polypropylene fiber, Glass Fiber, Nylon Fiber.

1. Introduction

Concrete is widely used for construction purposes due to its desirable properties like high stiffness, compressive strength and durability under normal environmental conditions. However plain concrete is brittle and has low flexural strength. Thus, fiber reinforcements are provided to overcome these shortcomings. Incorporation of fibers in concrete has been found to improve several of its properties; cracking resistance, ductility and fatigue resistance, impact and wear resistance. [1]This paper presents the experimental results of influence of various proportions of Hybrid Fiberson flexural strength of M30 Grade Concrete. The hybrid fibers used are composites of uniformly distributed steel fibers with Polypropylene fibers, steel fibers with Glass fibers and steel fibers with Nylon fibers. The structural improvement is obtained by steel fiber whereas resistance to plastic shrinkage cracking is obtained by polymeric micro fibers.[2] The addition of polypropylene fibers to plain concrete increases its compressive strength from 4% to 17%. [3] The percentage increase of flexural and split tensile strength of various grades of glass fiber concrete mixes compared with 28 days is observed from 10 to 20%. [4] The specimens have been tested with various proportions of Ground Granulated Blast Furnace Slag (GGBS), which is used as a cement replacement material being economical and resistant to alkali aggregate reactions.The ACI report indicates that the presence of GGBS in the mix improves workability and makes the mix more cohesive. [5]The rate of gain of modulus at early ages for slag cements increases far more with an increase in temperature than an equivalent Portland cement concrete. [6]

2. Experimental program

2.1 Concrete Mix Constituents

2.1.1 Cement

Ordinary Portland Cement of 53 grade was used. The cement used has been tested for various proportions as per IS: 4031-1998 and found to be conforming to various specifications of IS: 12269-1987. The specific gravity was 3.15.

2.1.2 Course Aggregate

The crushed aggregates used were of maximum size 20mm and minimum size 12mm. The specific gravity was 2.74.

2.1.3 Fine Aggregate

River bed sand was used as fine aggregate. The specific gravity was 2.63 and fineness modulus was 2.86 respectively.

2.1.4 Ground Granulated Blast Furnace Slag

Blast furnace slag is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.Fineness in terms of specific surface area was found using Blain's Air permeability apparatus as 3800cm^2/gm.

2.1.5 Water

Fresh, clean and potable water was used for mixing and curing the concrete as per IS: 456-2000.

2.1.6 Chemical Admixture

Polycarboxylic ether based superplasticizer (CONXL-PCE 8860) was used, it is a high range water reducing admixture (upto 40%), lead to 1 to 4 hours slump retention, conforms to ASTM C494 and complies with IS: 9103-1999.

2.1.7 Steel Fibers

End hook steel fibers (NOVOCON HE0630) with length 12 mm, filament diameter 0.6 mm and density 7850 kg/m^3 having the aspect ratio of 50 were used.

2.1.8 Polypropylene Fibers

Polypropylene Fibers of length 38 mm, diameter 0.1 mm, specific gravity 0.9 and aspect ratio of 380 were used.

2.1.9 Glass Fibers

The glass fibers used were of Cem-fil-anti-crack with modulus of elasticity 72Gpa, length 12 mm, filament diameter – 14 microns, specific gravity 2.68 and the aspect ratio of 855.

2.1.10 Nylon Fibers

Nylon 6 fibers with length 45 mm, filament diameter 0.3 mm and density 1130 kg/m^3 having the aspect ratio of 200 were used.

2.2 Test Specimens

2.2.1 Concrete Mix Proportion

Water: Cement: Fine aggregate: Coarse aggregate - 0.42:1:1:2

2.2.2 Casting Details

Cylindrical concrete blocks having the dimensions- 100 x 100 x500 mm were casted. The materials were weighed based on calculations obtained for the mix proportion 0.42:1:1:2. Cement, fine aggregate, coarse aggregate and reinforcement steel were taken and mixed for the lower half of the concrete slab. The interior surface of the mold was cleaned, grease was applied and then prepared mix was placed in the mold in layers and each layer was compacted. Then cement, fine aggregate, coarse aggregate, slag and Polypropylene/Glass/Nylon fibers were taken and mixed for the upper half of the concrete slab. The prepared mix was placed in the mold in layers and each layer was compacted. Then the prepared concrete slab along with the mold was kept on the vibrating table for compacting. After that the assembly was kept to dry for 24 hours .After 24 hours the mold was opened and the concrete block was ponded for curing. The flexural strength readings were taken on day 7 and day 28.

2.2.3 Testing the specimens

Flexural testing was conducted using a 100kN capacity electrically operated flexural testing machine at a displacement rate of 0.05 mm/sec. The modulus of rupture is calculated using the formula. $\sigma = 3PL/2bd^2$, where, P = load in N applied to the specimen, L= length of the support span in mm, b = width in mm of the specimen, d = depth in mm of the specimen.

3. Experimental Results and Discussion

The test results of variation of flexural strength of concrete with varying proportions of steel and polypropylene hybrid fiber reinforcement and replacement of cement by GGBS, at 7^{th} and28^{th} days are represented in Table-1 and graphically represented in Figure-1. It is noted that the flexural strength of concrete is increased by60-70% in this case. The variation of flexural strength of concrete with varying proportions of steel and Glass hybrid fiber reinforcement and replacement of cement by GGBS, at 7^{th} and 28^{th} days is represented in Table-2 and graphically represented in Figure-2. It is noted that the flexural strength of concrete is increased by 35-45% in this case. The variation of flexural strength of concrete with varying proportions of steel and Nylon hybrid fiber reinforcement and replacement of cement by GGBS, at 7^{th} and 28^{th} days is represented in Table-3 and graphically represented in Figure-3. It is noted that the flexural strength of concrete is increased by 25-35% in this case.

The variation of flexural strength of plain concrete with GGBS dosage is represented in Figure-4. The 7^{th} day flexural strength values are observed to decrease by 5-7% and 28^{th} day flexural strength values decrease by 2-7%, for 20% increase in slag dosage.

It is evident from the results that maximum increase in flexural strength in obtained with steel-polypropylene hybrid fiber.

Table 1: Flexural test results for Steel and PP fiber reinforcement

GGBS Dosage (%)	Steel and PP fiber (%)	7^{th} day Strength (MPa)	28^{th} day Strength (MPa)
10	0	2.50	3.85
	0.1	4.15	6.08
	0.2	4.21	6.20
	0.3	4.35	6.47
30	0	2.36	3.58
	0.1	3.90	5.90
	0.2	4.00	6.02
	0.3	4.06	6.12
50	0	2.20	3.50
	0.1	3.61	5.39
	0.2	3.78	5.70
	0.3	3.82	5.68

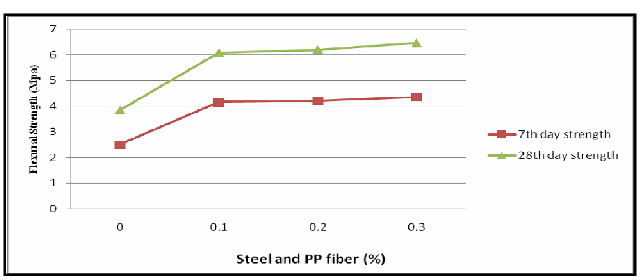

Figure 1: Variation in Flexural Strength of Concrete with Steel and PP Hybrid Fiber Dosage (at 10% GGBS Dosage)

Table 2: Flexural test results for Steel and Glass fiber reinforcement

GGBS Dosage (%)	Steel and Glass fiber (%)	7th day Strength (MPa)	28th day Strength (MPa)
10	0	2.50	3.85
	0.1	3.55	5.14
	0.2	3.62	5.41
	0.3	3.68	5.55
30	0	2.36	3.58
	0.1	3.31	4.98
	0.2	3.45	5.10
	0.3	3.54	5.29
50	0	2.20	3.50
	0.1	3.15	4.70
	0.2	3.21	4.69
	0.3	3.28	4.85

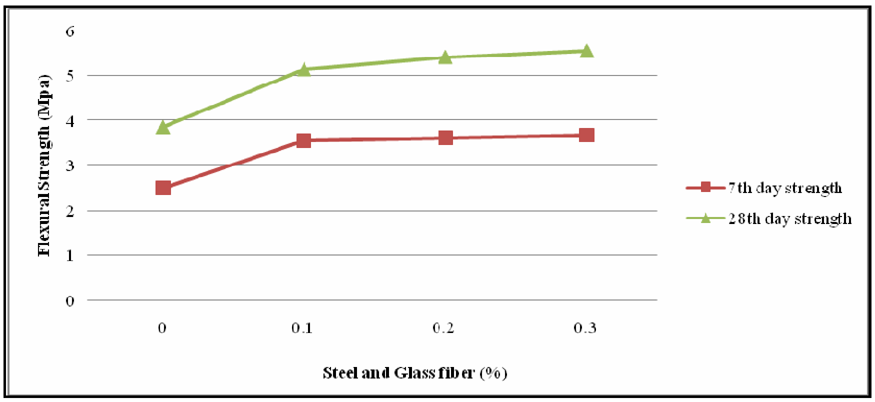

Figure 2: Variation in Flexural Strength of Concrete with Steel and Glass Hybrid Fiber Dosage (at 10% GGBS Dosage)

Table 3: Flexural test results for Steel and Nylon fiber reinforcement

GGBS Dosage (%)	Steel and Nylon fiber (%)	7th day Strength (MPa)	28th day Strength (MPa)
10	0	2.50	3.85
	0.1	3.28	4.90
	0.2	3.30	4.88
	0.3	3.32	4.95
30	0	2.36	3.58
	0.1	3.04	4.40
	0.2	3.14	4.65
	0.3	3.19	4.80
50	0	2.20	3.50
	0.1	2.90	4.38
	0.2	2.95	4.50
	0.3	3.01	4.68

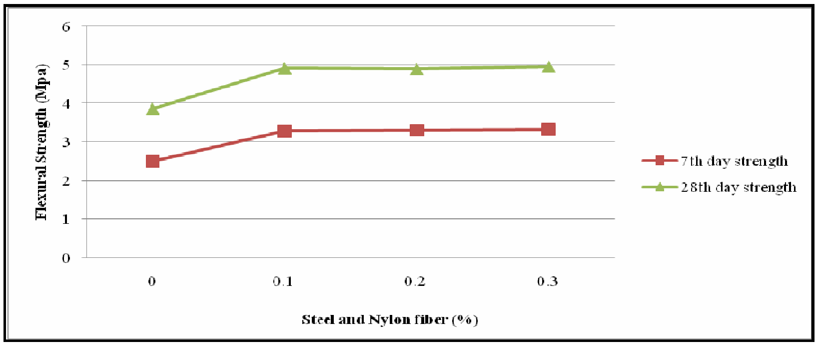

Figure 3: Variation in Flexural Strength of Concrete with Steel and Nylon Hybrid Fiber Dosage (at 10% GGBS Dosage)

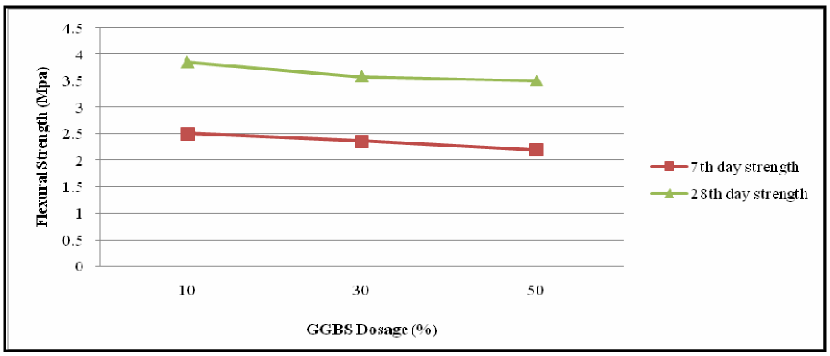

Figure 4: Variation in Flexural Strength of Plain Concrete with GGBS Dosage

4. Conclusions

Based on the experimental investigation the following conclusions are drawn:

- The 28th day flexural strength is increased by 60-70% on addition of steel-polypropylene hybrid fiber, as compared to that of plain concrete.
- The 28th day flexural strength is increased by 35-45% on addition of steel-glass hybrid fiber, as compared to that of plain concrete.
- The 28th day flexural strength is increased by 25-35% on addition of steel-nylon hybrid fiber, as compared to that of plain concrete.
- The 7th day flexural strength values are observed to decrease by 5-7% and 28th day flexural strength values decrease by 2-7%, for 20% increase in replacement of cement by GGBS in plain concrete.
- Steel-polypropylene hybrid fiber is most efficient for increasing the flexural strength of concrete among all the hybrid fibers tested in this study.
- Addition of fibers leads to reduction in bleeding, which in turn improves the homogeneity and integrity of concrete, thus reducing the risk of development of cracks.
- A gradual increase in early strength for flexural strength has been observed for hybridized concrete as compared to that of the plain concrete.
- The workability of concrete decreases with increase in fiber proportions.

References

1. Hashemi, S.H., Moghadam, I.M.,Influence of nano-silica and polypropylene fibers on bond strength of reinforcement and structural lightweight concrete (research note),*IJE TRANSACTIONS B: Applications* ,Vol. 27, No. 2 (February 2014) ,261-268
2. Beddar, M., Belgaraa, L., Ayadat, T., Optimizing of steel fiber reinforced concrete mix design, *IJE TRANSACTIONS B: Applications* ,Vol. 17, No. 1 (April 2004) 41-50

3. Anbuvelan, K., Khadar, M.M., Lakshmipathy, M., Sathyanarayanan, K.S.,Studies on properties of concretes containing polypropylene, steel and reengineered plastic shred fibre, *Indian Concrete Journal*, Vol.81, issue 4, (2007), 17-24.
4. Varma, A.U.,*Interational Journal of Engineering Research and Applications*, Vol. 3, Issue 5,(Sep-Oct 2013),1914-1918.
5. ACI226.1R-87, Ground Granulated Blast furnace Slag as a cementitious constituent in concrete, ACI Manual of concrete practice, part 1: Materials and general properties of concrete, 16pp (Detroit Michigan, 1994).
6. Neville, A.M., Properties of Concrete, 4th Edition (2003).
7. BIS (Bureau of Indian Standards) IS 12269-1987: Specification for 53grade Ordinary Portland cement. New Delhi, India.

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