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Flexural Behaviour of Polypropylene Fiber Reinforced Concrete with Natural and Artificial Sand

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Abstract--This paper presents the experimental result of flexural strength of Polypropylene fiber in concrete with natural and artificial sand. The Polypropylene fibers of aspect ratios 20, 25 and 30, with different volume fractions 0.0, 0.25, 0.5, 0.75 and 1.0% by weight of cement were used for reinforcing the concrete. Concrete mix was prepared with 100% natural sand as a normal mix and mix with optimum percentage of natural sand (35%) & artificial sand (65%) was used. For the purpose of experimentation concrete mixes were designed for M20, M30 and M40 grades. Due to incorporation of fibers, considerable improvement in flexural strength was observed.

Keyword--Artificial sand, Natural sand, Polypropylene fiber, flexural strength.

I. INTRODUCTION

Concrete is a backbone of infrastructural development of the world. Concrete has a capacity to enhance its property with the help of other suitable ingredients. Aggregate shares maximum volume in concrete. Due to scarcity of natural sand, artificial sand is one of the suitable substitute ingredients. The partial replacement of natural sand with 65% of artificial sand has given better results.

Recently micro fibers such as man-made and natural fiber have been incorporated into the concrete. Use of natural fiber in concrete proceeds advent of conventional reinforced concrete in historical context. Polypropylene fibre is versatile thermoplastic material which is produced by polymerizing monomer units of polypropylene molecule into very long polymer molecules or chains in the presence of catalyst under carefully controlled heat and pressure, can be used for arresting micro cracks and to enhance the properties of concrete.

II. LITERATURE REVIEW

Priyanka *et. al.*[1] study shows the effect of partial replacement of natural sand by manufactured sand on the compressive strength of cement mortar of proportion 1:2, 1:3 and 1:6 with water cement ratio as 0.5 and 0.55. The results are compared with reference mix of 0% replacement of natural sand by manufactured sand. The compressive strength of cement mortar with 50% replacement of natural sand by manufactured sand reveals higher strength as compared to reference mix. The overall strength of mortar linearly increases for 0%, 50% replacement of natural sand by manufactured sand as compared with reference mix. Manufactured sand has a potential to provide alternative to natural sand and helps in maintaining the environment as well as economical balance.

Vinayak R. *et. al.*[2] study shows the replacement of natural sand by 60% artificial sand results in producing the concrete of satisfactory workability and strength properties. It is also possible to minimize the area of surface cracks of concrete, thus achieving the durable concrete. However, for more than 60% replacement of natural sand by artificial sand causes reduction in compressive strength of concrete mixes with increase in the area of cracks. The replacement of natural sand with artificial sand will help in conserving the natural resources of sand and maintain the ecological balance of the nature. Prakash Rao *et. al.*[3] investigated the concrete with stone crusher dust which is

available abundantly from crusher unit at low cost, the test conducted pertain to concrete with reverse sand of strength 28.1 mpa and that with granite stone crusher dust of strength 32.8 mpa. Test on strength of concrete and on flexural behaviour of RC beam under 2 point loading sustained about 6 percent more load.

Singh S.P. *et. al*.[4] (2010) has evaluated the strength and flexure toughness of Hybrid Fibre Reinforced Concrete (HyFRC) containing different combinations of steel and polypropylene fibres. The specimens incorporated steel and polypropylene fibres in the mix proportions of 100-0%, 75-25%, 50-50%, 25-75% and 0-100% by volume at a total volume fraction of 1.0%. The results indicate that concrete containing a fibre combination of 75% steel fibres + 25% polypropylene fibres can be adjudged as the most appropriate combination to be employed in HyFRC for compressive strength, flexural strength and flexural toughness. A maximum increase in compressive strength of the order of 18% over plain concrete was observed in case of concrete containing 75% steel fibres + 25% polypropylene fibres. In case of static flexural strength tests, a maximum increase in flexural strength of the order of 80%, centre point deflection corresponding to peak load of the order of 84% was observed for HyFRC with 75% steel fibres + 25% polypropylene fibres. The results obtained in this investigation indicate that, in terms of flexural toughness, concrete with fibre combination of 75% steel fibres + 25% polypropylene fibres gives the best performance.

Ezeokonkwo, J. C*et. al*.[5] have examined the use of polypropylene fibres to improve the compressive strength of sandcrete blocks. This involved the reinforcement of sandcrete blocks with twisted polypropylene fibres of length 50mm, 75mm and 100mm respectively at 5 different volume fractions of 1 per cent, 2 per cent, 3 per cent, 4 per cent and 5 per cent, and 5 different water/cement ratios of 0.4, 0.5, 0.6, 0.7 and 0.8. Analyses of the results showed that, addition of fibre increased the compressive strength from 2.236 per cent to 35.783 per cent and it is dependent on the length, volume fraction of fibre and water/cement ratio.

Patel Priti A*et. al*.[6](2012,) hasexplored properties such as compressive strength, flexural strength, split tensile strength and shear strength of polypropylene fibre reinforced concrete. Triangular shaped polypropylene fibre of 12 mm length and having density 1400 kg/m^3, with fibre volume fractions 0%, 0.5%, 1%, 1.5% and 2 % were used in the experiments. The compressive strength of material increases from 8% to 16% for PFRC with increasing fibre content. The splitting tensile strength due to polypropylene fibre addition enhanced from 5% to 23%. The flexural strength increased with increasing fibre content. The maximum increase in flexural strength of PFRC was 36%.

Vairagade Vikrant S.*et. al*.[7] (2012,) have studied the compressive strength, flexural strength and tensile strength of fibrillated polypropylene fiber reinforced concrete (PFRC) containing fibers of 0%, 0.25% and 0.4% volume fraction of fibrillated polypropylene fibers of 15mm, 20mm and 24mm length. It was observed that the compressive strength for M20 grade of concrete from three different cut length fibers at same volume fraction shows nearly same results with minor increase. By addition of 0.4%, 24 mm cut length fibrillated Polypropylene fibers showed maximum compressive strength. With same volume fraction, change in length of fiber result nearly minor effect on compressive strength of fiber reinforced concrete. For longer length fibers, the split tensile strength was higher. Used of 24 mm long fiber with same volume of fraction had given maximum split tensile strength over fiber 15 mm and 20 mm cut length.

RamujeeKolli.*et. al*.[8] (2013) have made concrete samples with fine polypropylene monofilaments (Recron 3s) fibers of 12mm length, the amounts varies from 0%,0.5%,1%, 1.5% and 2.0%, to determine the compressive strength and splitting tensile strengths after 28 days of curing period. It was observed that the cube compressive strength increased up to 1.5% fiber content there after strength was decreased at 2.0% fiber content.

Parveen*et. al*.[9](2013) have presented the effect of variation of polypropylene fibers ranging from 0.1% to 0.4% along with 0.8% steel fibers on the behaviour of fibrous concrete. The mechanical properties of the concrete such as compressive and tensile strength have been

investigated. The result shows that addition of polypropylene fiber has a little effect on the compressive strength, but there was significant increase in the tensile strength with increase in fiber volume fraction. Hybrid (steel + polypropylene) fiber showed about 5.7% increase in compressive strength for 0.2% polypropylene fiber, an increase of 47% of split tensile strength and 50% of flexural strength for 0.3% polypropylene fiber.

Hadipramana Josef *et. al.*[10] (2013) has examined contribution of PF on strength of foamed concrete. Mechanical test were performed to measure effect of PF on improving compressive and splitting tensile strength. Results indicate that PF significantly improving compressive and splitting tensile strength. Behaviour of PF where drawn into foamed concrete similarly with normal concrete. The fibrillation and interfacial bonding between PF and matrix has been occurred and reduced the micro crack of matrix and prevented propagation crack growth. Maharashtra Engineering Research Institute, Nashik*et. al.*[11] Oct. 2007 Technical Report on Study of Plast Fiber, Fibrillated polypropylene fiber used as a secondary reinforcement material for concrete and mortor& observed that enhancement in compressive strength is observed up to 16% at 28 days with higher aspect ratio i.e.24 mm and direct tensile strength improved significantly while using fibers. More ever with higher aspect ratio and higher doses of fiber enhancement of strength is observed up to 28%. Rajendra P. Mogre.*et. al.*study shows that there is feasibility of replacement of natural sand by artificial sand . the feasibility range is from 60 % to 80%. It was seen from above research there was improvement in the strength of concrete. It was also commented that there is need to find optimum percentage replacement [12,13,14] authors extended their research and observed that optimum replacement was 65%. It was also observed that maximum percentage increased in strength was found for M20 grade and gradually reduced for M40 grade of concrete [15].Author also developed regression model for split tensile strength during incremental replacement of natural and artificial sand in concrete. It was observed that developed mathematical model was significant to represent the relationship and also helpful to predict the value of split tensile strength of the concrete[16,17] .

III. MATERIALS

A. Cement

Ordinary Portland cement of 53 grades confirming to IS 12269-1987 was used. The physical properties are Specific gravity 3.12, soundness 1.20 mm, Initial setting time 167 minutes, Final setting time 255 minutes, Normal Consistency 31%, Fineness m^3/kg 320 and 28 days compressive strengths 58.25 MPa.

B. Fine Aggregate

Natural sand obtained from the river and available in the local market was used. The artificial sand obtained from the local crusher was used. The physical properties of natural and artificial sand are Specific Gravity for natural sand is 2.6 and for Artificial sand is 2.90, Fineness Modulus for natural sand is 2.78 and for Artificial sand is 2.97 and Bulk Density kn/m_3 for natural sand is 15.60 and for Artificial sand is 17.62.

C. Coarse Aggregate

Locally available rock stone aggregate of nominal size 10 mm and 20 mm mixed aggregate are used. The physical properties of these coarse aggregates are Specific gravity as 2.96, Density kn/m_3 as 16.10 and Fineness Modules (20 and 10) mm as 7.35.

D. Polypropylene Fiber

The polypropylene fiber used for this study is from Bajaj Group of Nagpur who has been manufacturing fabrics and polymer compounds with wide range of application including construction industry Tashi India Ltd. Nagpur, a marketing arm of Bajaj group introduced new products as “PLAST FIBERS” .

The Plast Polypropylene fiber used for experimentation are supplied by Tashi India Ltd. Nagpur Properties are as follows:

Form- Fabricate Stabilized, Water Absorption-Nil, Specific gravity-0.91, Denier-1050, Dispersion-Excellent, Tensile strength- 0.67 kN/Sq.mm, Melting point- 7165^0C and Cut Length- 20mm, 25mm, 30mm.

IV. EXPERIMENTATION

The physical Characteristics of material used that is cement natural sand, artificial sand and course aggregate are tested initially and polypropylene fiber are used as supplied by Tash India Ltd. Nagpur with 0%,0.25%,0.5% and 1% of weight of cement and different aspect ratio of 20 , 25 & 30. The exact amount of concrete ingredients (Table-1) and polypropylene fiber were weighed and mixed thoroughly with proper sequence to avoid balling action by using super plasticizer in laboratory concrete mixer till the consistent mix was achieved. The standard prism of 100x100x500 mm was used. Three prism by using 0% artificial sand & 100% natural sand (F1) and 65% artificial & 35% natural sand (F2) with polypropylenefiber were casted for testing. The average strength was calculated as per acceptance criteria using IS 456 – 2000 is followed and the average values are illustrated in table 2 and as shown in Fig. 1-3.

Table 1 : Quantity of Material

Sr. No.	Material	Grade of Concrete		
		M20	M30	M40
1	Cement, kg/m^3	315	380	445
2	Fine aggregate, kg/m^3	615	592	560
3	Coarse Aggregate (10 mm and 20mm), kg/m^3	1300	1259	1200
4	Aggregate cement ratio	6.07	4.87	3.95
5	Water, liter /m^3	156	175	180

V. CONCLUSION

The conclusion based on experimental results are as below :

1. The Flexural Strength is increased upto 24.90% for 100% Natural sand & 0% Artificial sand and 29.93% for 65% Artificial sand & 35% Natural sand.
2. The percentage increase in Flexural Strength is maximum for 0.75% of volume fraction and 25mm cut length.
3. The percentage increase in Flexural Strength is maximum for M30 grade of concrete.

Table 2: Flexural Strength for N.S. & A.S. with polypropylene fiber reinforced concrete

Sr. No	Grade of concrete	Length of fibre	Volume of fibre	Average Flexural Strength N/mm^2			
				28 Days (F1)	% increase (F1-I)	28 Days (F2)	% increase (F2-I)
1	M 20		0	3.3	0.00	3.77	0.00
		20	0.25	3.85	16.67	4.51	19.63
			0.5	4.02	21.82	4.61	22.28
			0.75	4.1	24.24	4.65	23.34
			1. 00	4.05	22.73	4.63	22.81
		25	0.25	3.9	18.18	4.6	22.02
			0.5	4.1	24.24	4.71	24.93
			0.75	4.12	24.85	4.72	25.20
			1. 00	4.05	22.73	4.71	24.93
		30	0.25	3.79	14.85	4.4	16.71
			0.5	3.95	19.70	4.57	21.22
			0.75	4	21.21	4.6	22.02
			1. 00	3.98	20.61	4.59	21.75
2	M 30		0	4.9	0.00	5.48	0.00
		20	0.25	5.6	14.29	6.7	22.26
			0.5	5.9	20.41	6.89	25.73
			0.75	5.98	22.04	6.98	27.37
			1. 00	5.95	21.43	6.94	26.64
		25	0.25	5.7	16.33	6.95	26.82
			0.5	6.08	24.08	7.1	29.56
			0.75	6.12	24.90	7.12	29.93
			1. 00	6.09	24.29	7.1	29.56
		30	0.25	5.21	6.33	6.45	17.70
			0.5	5.4	10.20	6.6	20.44
			0.75	5.5	12.24	6.65	21.35
			1. 00	5.45	11.22	6.63	20.99
3	M 40		0	5.75	0.00	6.41	0.00
		20	0.25	6.3	9.57	7.65	19.34
			0.5	6.58	14.43	7.71	20.28
			0.75	6.6	14.78	7.72	20.44
			1. 00	6.58	14.43	7.71	20.28
		25	0.25	6.35	10.43	7.69	19.97
			0.5	6.7	16.52	7.79	21.53
			0.75	6.72	16.87	7.82	22.00
			1. 00	6.7	16.52	7.81	21.84
		30	0.25	6.1	6.09	7.49	16.85
			0.5	6.35	10.43	7.6	18.56
			0.75	6.4	11.30	7.65	19.34
			1. 00	6.2	7.83	7.63	19.03

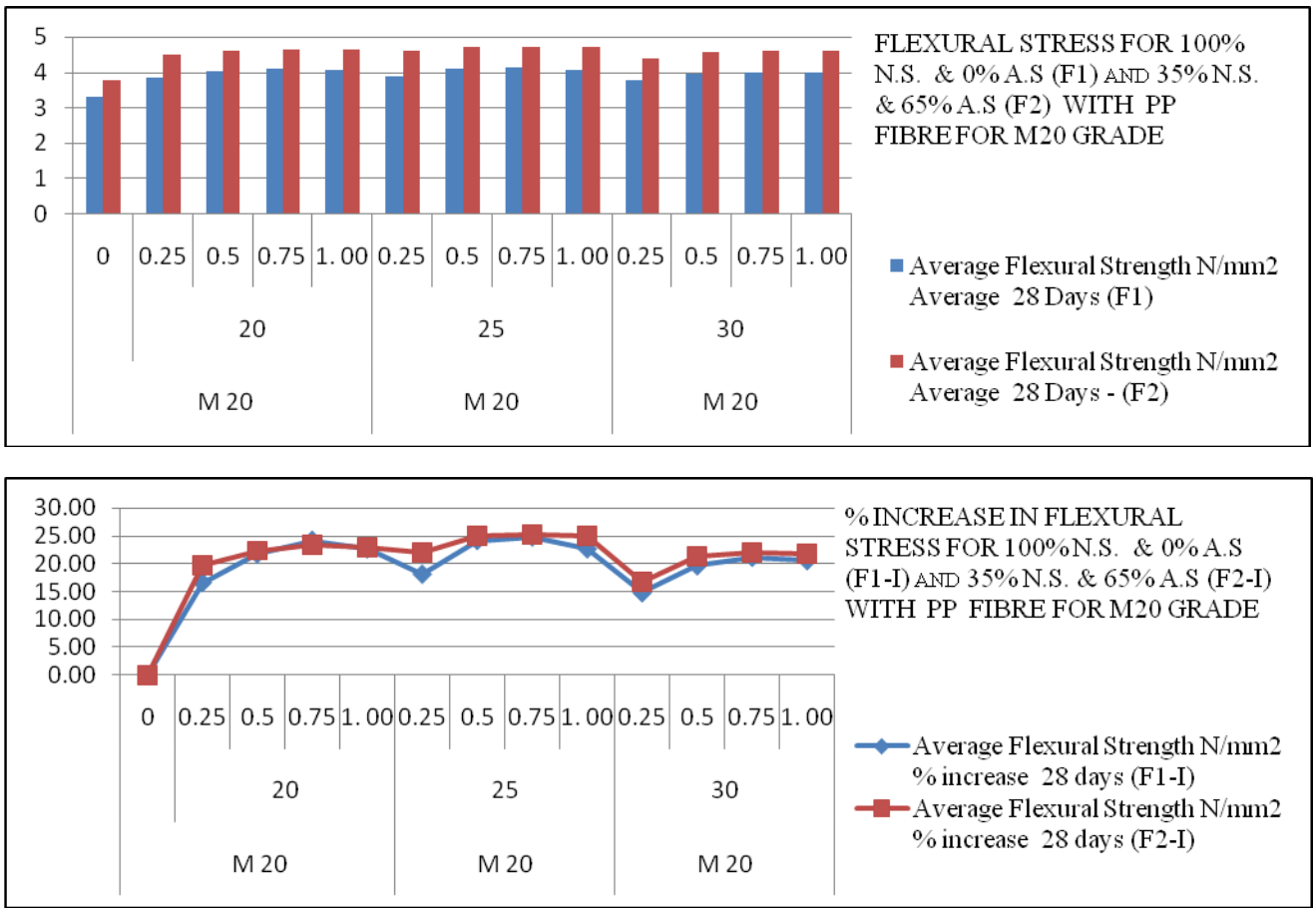

Figure 1. F.S. for 100% N.S. & 0% A.S. (F1) and 35% N.S.& 65% A.S (F2) with PP fiber for M20 grade

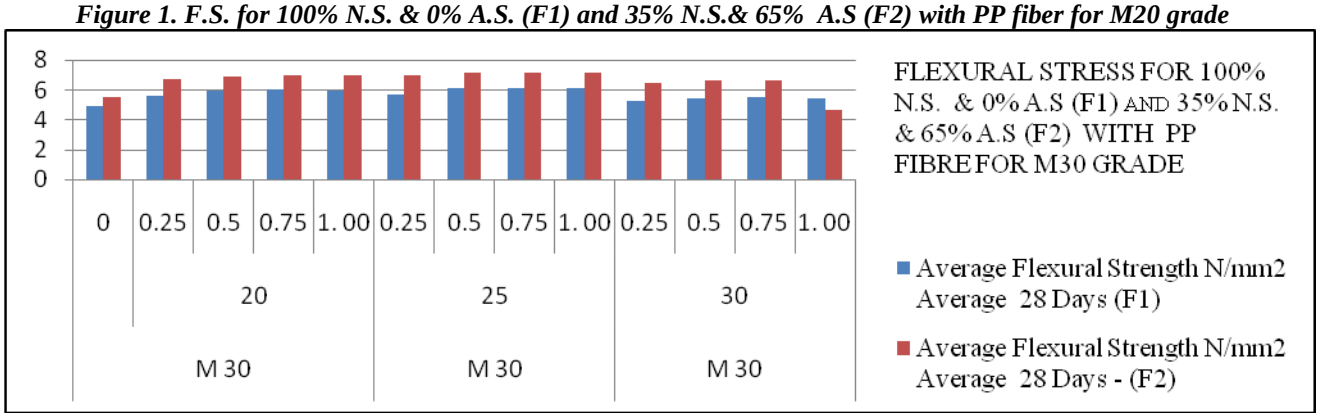

Figure 2. F.S. for 100% N.S. & 0% A.S. (F1) and 35% N.S. & 65% A.S (F2) with PP fiber for M30 grade

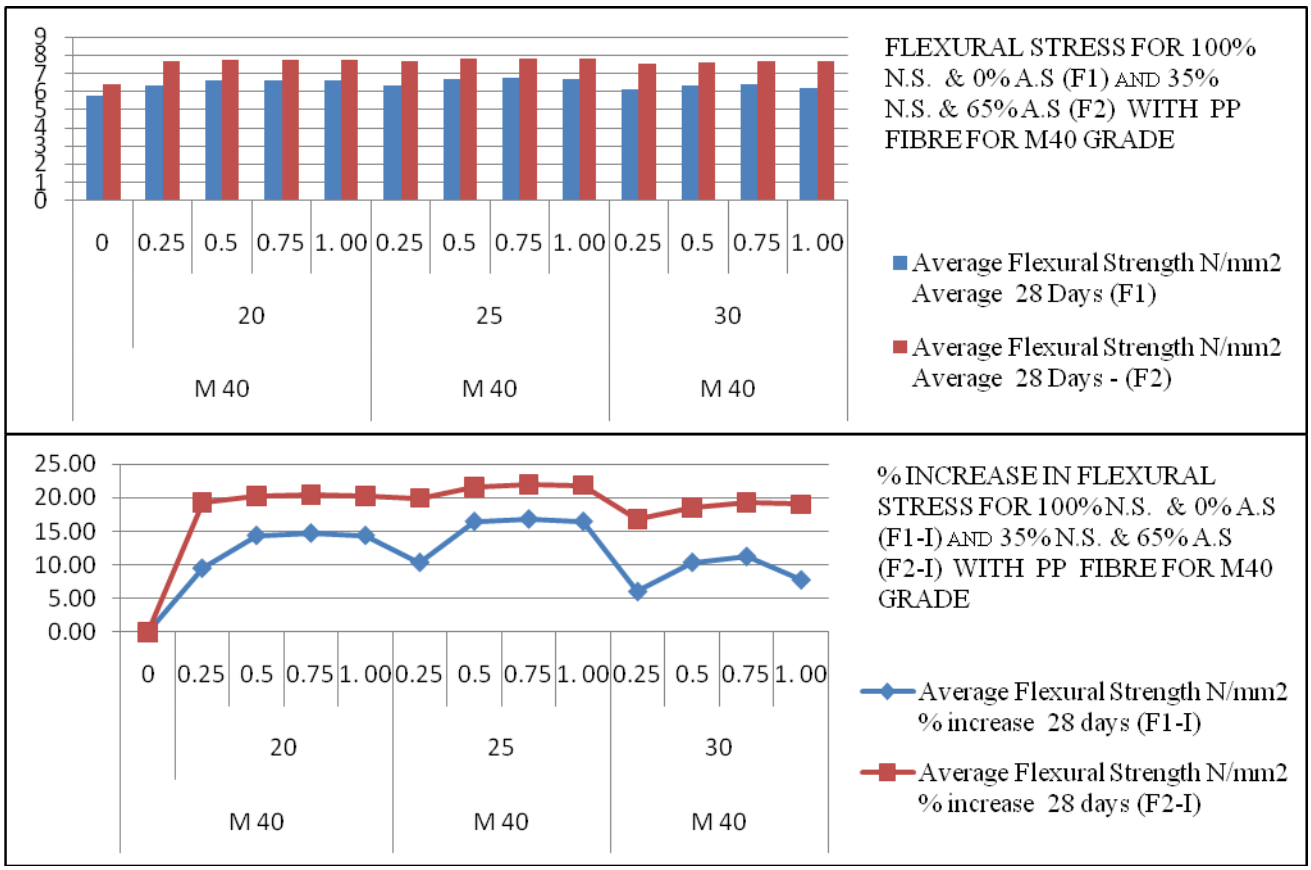

Figure 3. F.S. for 100% N.S. & 0% A.S. (F1) and 35% N.S. & 65% A.S (F2) with PP fiber for M40 grade

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