PERFORMANCE OF POLYESTER AND POLYPROPYLENE FIBRES IN CONCRETE

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Abstract— This study investigates the effect of the polypropylene and polyester fibres on the properties of concrete. The hybrid fibres were used at five different fibre fractions of 0%, 0.1%, 0.2%, 0.3% and 0.4% by weight of cement and in addition to this micro silica was used as cement replacement material of 0%, 5%, 10%, and15% by weight of cement. The compressive and splitting tensile strengths of the concrete mixes were examined. Results of the experimental study indicate that polypropylene and polyester fibres improved the properties of concrete at each volume fraction considered in this study. Among different combinations of hybrid fibres and micro silica concrete mixtures, the best performance was attained by a mixture that contained 10% of micro silica and 0.1% fibre content.

Index Terms— High Strength Concrete,Workability,Compressive strength, split tensile strength , polyster fibres, polypropylene fibres,Mechanical Properties of Concrete.

1 INTRODUCTION

CONCRETE is the most widely used construction material, because of the several well-known advantages it offers, such as low cost, general availability, and wide applicability. However, the Ordinary Portland Cement (OPC) has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Fly ash, ground granulated blast furnace slag, rice husk ash, high reactive metakaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. Additionally it is well understood that the use of supplementary cemtitious materials as part of binders is required for production of good strength concretes.

Concrete is quasi-brittle material, and its brittleness increases with its strength and poor resistance to crack opening and propagation are the main disadvantages of conventional concrete. Fibres are incorporated into cementations concretes to overcome this weakness, producing materials with increased tensile strength, ductility, toughness.[1,2]. The test results of D.S.Sidhu[3] illustrated that silica fume content of 15% gives optimum results. Bhanja and Sengupta[4] were worked on modified water cement ratio law for silica fume concrete. They were proposed the modified relationships to evaluate the strength of silica fume concrete. Experimental results of M.Mazloom et al. [5] demonstrated that as the proportion of silica increased, the workability of concrete of silica increased the workability of concrete decreased but its short term mechanical properties such as 28th day compressive strength increased. Test results of Rafat Siddique et al.[6], Damyanti and Modhera[7],illustrated that the polyester fibres can be potentially used in concrete production to increase me-

ISSN 2229-5518

chanical properties. Recently,Sang et al. [8] investigated on the strength potential of nylon – polypropylene fibre reinforced concrete at a fibre content of 0.6 Kg/m3 and found that the mechanical properties of the nylon fibre concrete improved by over those of the polypropelene fibre concrete. The nylon fibres registered a higher tensile strength and possibly due to its better distribution in concrete. From the above recent past literature it is noticed that no studies were conducted with the help of combination of two fibres. Hence in the present investigation the effect of polyester and polypropylene was examined for cement concrete by conducting the cube compressive and split tensile strength

2. TEST PROGRAM AND PROCEDURE

To evaluate the workability and strength characteristics in terms of compressive and split tensile strengths, a total of 20 mixes were tried with different percentages of micro silica (0%,5%, 10%,and 15%) and different percentages of polyester fibre and polypropylene fibre (0%,0.1%, 0.2%, 0.3% & 0.4%). For each percentage of fibre, polyester and polypropylene dosage is equally distributed (for example if the dosage of fibres is 0.1, this indicates as 0.05% polyester and 0.05% polypropylene). Fresh concrete properties evaluated by slump cone test and mechanical properties were evaluated through compressive and split tensile strength tests. The experiments were carried out at 7 days, 14 days and 28 days of curing age, and for all tests, three specimens were tested for each curing age.

2.1 Materials and mixing procedure

Ordinary Portland cement 53 grade was used in the present study. The specific gravity of cement was about 3.14. Micro silica was used in the present study was procured from Astra chemicals, Chennai. The chemical and physical properties of micro silica are given in Table 1. Coarse aggregate with 70% passing 20 mm and retained on 12.5 mm sieve and 30%

ISSN 2229-5518

Fig.1 (a): Polyester Fig.1 (b) Polypropylene fibre

TABLE 1
PHYSICAL AND CHEMICAL PROPERTIES OF MICRO SILICA

S.No	physical properties		Chemical properties	
1	Particle size	0.1 microns	Silica	99.89%
2	Adour	Odorless	Alumina	0.04%
3	Colour	Premium white colour powder	Ferric oxide	0.04%
4	Specific gravity	2.63	Calcium oxide	0.00%
5	Bulk density	480-720 kg/m^3	Potassium oxide	0.00%
6	Surface area	13,000-30,000 m^2/kg	Sodium oxide	0.00%

TABLE 2
PROPERTIES OF SYNTHETIC FIBRES

S.No	Properties	Polyester	Polypropylene
1	Shape	Triangular	Triangular
2	length(mm)	12	12
3	Diameter(microns)	30-35	34
4	Specific gravity	1.34	0.91
5	Melting point(Deg.c)	250-265	160-165
6	Tensile strength(Kg/cm2)	4000-6000	4000-6000
7	Alkali Resistance	Very good	Very good
8	Electrical conductivity	Low	Low
9	Thermal conductivity	Low	Low
10	Acid & salt resistance	Excellent	Excellent

passing 12.5 mm and retained on 10 mm sieve were used. The specific gravity of fine and coarse aggregate was 2.53 and 2.6 respectively. A new generation Conplast SP 430 DS supplied by FOSROC Chemicals Pvt Ltd was used as super plasticizer. Two types of fibres namely polyester and polypropylene fibres as shown in Figure1(a) and (b), has been used in this experimental program which are supplied by Reliance Industries Limited, India. The fibres properties are presented in Table 2. In the present experimental work the mix was designed for M50 grade as per IS – 10262 -2009.

3 EXPERIMENTAL PROGRAM

Among the 20 series of mixtures, one was the control mixture and the remaining were containing different percentages of micro silica (5%, 10%, and 15 %,) and different percentages of polyester fibre and polypropylene fibre (0.1%, 0.2%, 0.3&0.4%). The specimens were cast in steel moulds and were compacted on a vibration table. They were demoulded after approximately 24h and transferred to the curing tank until their testing dates. From the experimental work, the obtained results are presented in the discussion of test results. In the following sections the results are tabulated in tabular form. In the first column of the tables Mixture ID is mentioned. In the table it is noticed that MS indicate micro silica(5,10 and 15% denotes % of replacement of cement with silica fume) and F-0.1 indicates fibre and its content respectively.

4 RESULTS AND DISCUSSION:

4.1 Workability

Slump value of the fresh concrete was measured using slumpcone, time ranged from immediate after mixing, 30 min and 60 min, it is the convenient method and useful to control the quality of the concrete. The slump values of various mixes are listed in Table 3. It is observed that as micro silica and synthetic fibres content increases as the workability decreases. The reduction in slump may be due to fibre addition and micro silica. It can be observed that the mixes incorporating higher micro silica content tended to require higher demand of super plasticizer.

4.2 Compressive strength

Compressive strength is the most important property of the hardened concrete. The concrete cubes were cast, cured and tested accordance with the IS standard and the 7,14 and 28 days compressive strength results are listed in Table 4.From the results it is clear that Partial replacement of 10% cement by micro silica shows 7.98% greater than the controlled concrete mix. Addition of synthetic fibres (polyester fibres + polypropylene fibres) in concrete shows 8.87% greater than the controlled concrete mix. Partial replacement of 10% cement by ‗micro silica' and addition of synthetic fibres (polyester fibres + polypropylene fibres)content at 0.1% shows optimum results in comparison with other mixes in this study.

4.3 Split tensile strength:

The variation of splitting tensile strength of the different fibre-reinforced concretes at the ages 7,14,and 28 days are presented in Table 5. The results of fibre reinforced concrete shows that Partial replacement of 10% cement by ‗micro silica' shows 5.71% greater than the controlled concrete mix. Addition of ‗synthetic fibres (Polyester fibres + Polypropylene fibres) in concrete shows 22.29% greater than the controlled concrete mix. Partial replacement of 10% cement by ‗micro silica' and addition of ‗synthetic fibres (polyester fibres + polypropylene fibres)'content at 0.1% shows optimum results in comparison with other mixes in this study.

5 CONCLUSIONS

The following conclusions are drawn from the present ex-

ISSN 2229-5518

perimental investigations with respect to Micro silica, Synthetic fibres and Micro silica &synthetic fibres.

(a)Micro Silica

- The slump value decreases as the % of micro silica increases.
- Addition of micro silica increases the 28 days compressive strength but micro silica does not have significant influence on the splitting tensile strength of concrete.
- Cement replacement up to 10% with micro silica leads to increase in compressive strength and thereafter leads to decrease in the compressive strength.
- It was observed that the compressive strength of concrete is increased up to 7.98%.
- The optimum replacement level of micro silica is 10%

(b) Synthetic fibres

- Workability of concrete decreases with increase in fibre volume fraction.
- Notable increase in compressive strength is reported with addition of fibres.
- The problem of low tensile strength of concrete can be overcome by addition of fibres.
- Fibres have a strong impact in terms of minimizing crack width an density their positive role in this regard is proportional to their dosage in the mix.

TABLE 3

SLUMP TEST RESULTS

MIXTURE ID	SLUMP	MIXTURE ID	SLUMP	MIXTURE ID	SLUMP	MIXTURE ID	SLUMP	MIXTURE ID	SLUMP
Plain	250	F-0.1 Plain	225	F-0.1 MS-5	170	F-0.1 MS-10	120	F-0.1 MS-15	40
MS-5	190	F-0.2plain	180	F-0.2 MS-5	115	F-0.2 MS-10	95	F-0.2 MS-15	35
MS-10	140	F-0.3 Plain	90	F-0.3 MS-5	55	F-0.3 MS-10	60	F-0.3 MS-15	10
MS-15	50	F-0.4 Plain	50	F-0.4 MS-5	30	F-0.4 MS-10	20	F-0.4 MS-15	0

TABLE 4

COMPRESSIVE STRENGTH

Mixture ID	Compressive strength (N/mm^2)			% of increase w.r.t. control mix	Mixture ID	Compressive strength (N/mm^2)			% of increase w.r.t.
	7 days	14 days	28 days			7 days	14 days	28 days	
Plain	38.04	44.8	54.75	0	F-0.3 MS-5	37.91	41.02	52.44	-4.41
MS-5	40.98	47.77	56.09	2.39	F-0.4 MS-5	36.58	40.48	49.42	-10.79
MS-10	42.08	49.24	59.5	7.98	F-0.1 MS-10	41.24	56.17	62.04	11.75
MS-15	41.06	46.84	57.87	5.39	F-0.2 MS-10	39.51	49.11	58.13	5.81
F-0.1Plain	44.71	54.75	60.08	8.87	F-0.3 MS-10	36.4	42.36	53.86	-1.65
F-0.2plain	44.04	52.71	57.46	4.72	F-0.4 MS-10	33.24	39.33	45.11	-21.37
F-0.3 Plain	40.09	48.93	51.02	-7.31	F-0.1 MS-15	37.73	46.04	57.91	5.46
F-0.4 Plain	34.93	42.36	50.22	-9.02	F-0.2 MS-15	36	42.17	53.24	-2.84
F-0.1MS-5	40.76	48.18	58.08	5.73	F-0.3 MS-15	33.73	39.82	49.15	-11.39
F-0.2MS-5	38.62	42.93	53.69	-1.97	F-0.4 MS-15	31.73	38.57	42.8	-27.92

TABLE 5

SPLIT TENSILE STRENGTH

Mixture ID	Split tensile strength (N/mm^2)			% of increase w.r.t. control mix	Mixture ID	Split tensile strength (N/mm^2)			% of increase w.r.t. control mix
	7 days	14 days	28 days			7 days	14 days	28 days	
Plain	3.62	4.63	4.95	-	F-0.3 MS-5	4.38	4.93	6.11	18.99
MS-5	3.71	4.86	5.15	3.88	F-0.4 MS-5	4.24	4.68	5.5	10
MS-10	4.23	4.65	5.25	5.71	F-0.1 MS-10	4.81	5.73	6.65	25.56
MS-15	4.16	5.01	5.18	4.44	F-0.2 MS-10	4.31	5.3	6.01	17.64
F-0.1Plain	5.02	6.07	6.37	22.29	F-0.3 MS-10	4.3	4.95	5.6	11.61
F-0.2plain	4.75	5.58	6.22	20.42	F-0.4 MS-10	3.87	4.64	5.12	3.32
F-0.3 Plain	4.56	5.47	5.98	17.22	F-0.1 MS-15	4.08	5.49	5.93	16.53
F-0.4 Plain	4.27	4.91	5.22	5.17	F-0.2 MS-15	3.84	5.23	5.57	11.13
F-0.1MS-5	4.7	5.27	6.45	23.26	F-0.3 MS-15	3.7	4.68	5.2	4.81
F-0.2MS-5	4.53	5.09	6.36	22.17	F-0.4 MS-15	3.35	4.4	4.92	-0.61

- The addition of synthetic fibres at 0.1% shows the optimum value.

(c) Micro silica & Synthetic fibres

- Workability of concrete decreases with increase in fibre and micro silica. However, higher workability can be achieved with the addition of HRWR admixtures.
- When micro silica is added to the fibrous mixtures, lead to an increased in compressive strength up to 11.75%, at the age of 28 days. This may be due to pozzolanic effect of micro silica and crack restriction effect of fibres.
- It is clear that fibre addition in concrete gives high tensile strength up to 25.56% which prevents cracks. As concrete is weak in tension, fibres in certain quantity gives high tensile strength.
- Adding micro silica to fibrous specimens improved the specimen strength more than adding micro silica by itself. These results shows that micro silica can strengthens the transition zone and reduces the crack initiation, and therefore, improves the failure strength of fibre concrete.
- The mixes with fibre content of 0.1% and micro silica of 10% showed optimum results in comparison with other mixes in this study.

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