Effect on Strength and Durability of Synthetic fiber-reinforced concrete with use of fly ash and silica fume

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ABSTRACT

With the growing interest in the use of synthetic fiber-reinforced concrete in the construction industry, attempts to clarify its performance have become important. The characteristics of various synthetic fibers and the behavior of concrete reinforced with each of these fibers are discussed here. The current research concerns about the effect of strength and durability of synthetic fiber-reinforced concrete with use of fly ash and silica fume based which are considered to be promising for the development of cementious composite material. In this research various proportions of fly ash & silica fume would be used in mass basis to study effect on it with the used of synthetic fiber. And also Synthetic Fiber such as Recron 3s Polyester & Polypropylene in different proportion are used to determine the compressive strength, tensile strength, flexural strength & durability.

Keyword: - *Synthetic fiber Reinforced Concrete, fly ash, silica fume, Polyester Fiber, Polypropylene Fiber*

1. INTRODUCTION

Concrete is a widely used material around planet. Large quantities of different types of concrete are used due to its structural advantages and strength. The enhanced properties of the concrete in freshly prepared and hardened states, durability and its environmental impact are very remarkable topics for analysis. One methodology to extend some manufacturing properties of concrete is that the use of fibers as an additional material within the concrete mixture

1.1 Fiber Reinforced Concrete

Fiber Reinforced Concrete is a composite material consisting of fibrous material which increases its structural integrity. It includes mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce the bleeding of water.

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1.2 Synthetic Fiber Reinforced Concrete

Synthetic fibers have become more attractive in recent years as reinforcements for cementitious materials. They can provide effective, relatively inexpensive reinforcement for concrete and are alternatives to asbestos, steel and glass fibers. If the fibers were further optimized, the same fiber-reinforced concrete property improvement could be achieved at a lower expense or greater improvements could be obtained without increasing the reinforcement cost. Fiber types that have been incorporated into cement matrices include polypropylene (PE), polypropylene (PP), acrylics (PAN), poly(viny1 alcohol) (PVA), polyamides (PA), aramid, polyester (PES) and carbon

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2. EXPERIMETAL RESEARCH AND INVESTIGATIONS

For Any kind of research work, study or research we need to define method first, before the work is carried out. It should be divide following two phase of investigation Initial phase & Final phase. In First phase or initial phase of investigation Finalization of mix design will be carried out. Before Finalization of concrete mix design, setting time of cement, sieve analysis of aggregates, specific gravity of the aggregate, water absorption and fineness modulus are required. Mix design should be carried out as per IS-10262-2009.

2.1 Materials & Its Properties

1. Cement: Ordinary Portland Cement 53 Grade (Brand :Ultra tech) conforming to IS 12269-2013 to be used
2. Coarse Aggregate: Materials that are large to be retained on 4.7 mm sieve size are called coarse aggregates, and its maximum size can be up to 63 mm. coarse aggregates are generally manufactured by blasting in stone quarries or by breaking them by hand or by crushers.
3. Fine Aggregates: Fine aggregates are the structural filler that occupies most of the volume of the concrete mix formulas. Depending on composition, shape, size and other properties of fine aggregate you can have a significant impact on the output.
4. Water: Water Conforming to IS 3025 1994 for chemical compositions to be used.
5. Fly Ash: Class-F fly ash of STALLIN ENERGY PVT. LTD. is used
6. Silica Fumes: Silica fumes of STALLIN ENERGY PVT. LTD is used
7. Polyester and Polypropylene Fibers: Recron• 3s Fibers are Engineered Micro Fibers with a unique "Triangular" Cross-section, can used as a Secondary Reinforcement in Concrete

Sr. No.	Properties	Units	POLYESTER	POLYPROPYLENE	Remarks
1.	Shape		Triangular	Triangular	
2.	Cut Length	mm	3 / 4.8 / 6 / 12 / 18 / 24	3 / 4.8 / 6 / 12 / 18 / 24	+/- 1mm Project specific customized lengths can be produced on request
3.	Effective Diameter	microns	20-40	25-40	
4.	Specific Gravity		1.34-1.39	0.90-0.91	
5.	Melting Point	Deg. C	250-265	160-165	
6.	Tensile Strength	Gpd	4-6 *	4-6 *	*Estimated tensile strength in Mpa 4-6 *Polyester 480-730 Polypropylene 320-490
7.	Elongation	%	20-60	60-90	Initial Modulus
8	Young's Modulus	Mpa	> 5000	> 4000	Tests done as per AC
9.	Alkaline Stability		Very Good	Very Good	32 standards

Fig -1: Chemical & Physical properties of Recron 3s Fibers

2.2 Mix Designing & Proportioning.

Proper Mix Design is Essential for good quality concrete. The mix design for concrete are to carried out as per IS 10262 and IS 456 for various mixes with replacement to Cement by Fly ash & silica fumes in weight proportions. Further Various proportions of polyester & polypropylene fibers were added .

Table -1: Mix Proportions Details

Mixture	Fly Ash (kg/m3)	Silica Fume (kg/m3)	Cement (kg/m3)	Fiber (%)	Fine aggregate (kg/m3)	Coarse Aggregate (kg/m3)	Water (kg/m3)
25CM	0	0	376	0	696.28	1206.7	187.93
25PE00	113	38	225	0	696.28	1206.7	187.93
25PE01	113	38	225	0.1	696.28	1206.7	187.93
25PE02	113	38	225	0.2	696.28	1206.7	187.93
25PE03	113	38	225	0.3	696.28	1206.7	187.93
25PL00	113	38	225	0	696.28	1206.7	187.93
25PL01	113	38	225	0.1	696.28	1206.7	187.93
25PL02	113	38	225	0.2	696.28	1206.7	187.93
25PL03	113	38	225	0.3	696.28	1206.7	187.93
30CM	0	0	418	0	683.09	1191.35	187.77
30PE00	125	42	251	0	683.09	1191.35	187.77
30PE01	125	42	251	0.1	683.09	1191.35	187.77
30PE02	125	42	251	0.2	683.09	1191.35	187.77
30PE03	125	42	251	0.3	683.09	1191.35	187.77
30PL00	125	42	251	0	683.09	1191.35	187.77
30PL01	125	42	251	0.1	683.09	1191.35	187.77
30PL02	125	42	251	0.2	683.09	1191.35	187.77
30PL03	125	42	251	0.3	683.09	1191.35	187.77

2.3 Preparations and Casting of Specimen

Total of 18 mix proportions were to be made. Initially control mix (CM) for M25 & M30 as per IS were prepared. In mixtures 25PE & 30PE cement was partially replaced with fly ash (30%) and Silica Fume (10%). And subsequently, in these eight mixtures (25PE00, 25PE01, 25PE02, 25PE03,30PE00, 30PE01, 30PE02 and 30PE03) four percentages (0, 0.1, 0.2 and 0.3) of polyester fibers were added, and their designation is detailed in Table 2. The control mix without fly ash was proportioned as per Indian Standard Specifications IS: 10262-1982 to have a 28-day cube compressive strength of 25 & 30 MPa.

Similarly In mixtures 25PL & 30PL cement was partially replaced with fly ash (30%) and Silica Fume (10%). And subsequently, in these eight mixtures (25PL00, 25PL01, 25PL02, 25PL03, 30PL00, 30PL01, 30PL02 and 30PL03) four percentages (0, 0.1, 0.2 and 0.3) of polypropylene fibers were added, and their designation is detailed in Table 2. The control mix without fly ash was proportioned as per Indian Standard Specifications IS: 10262-1982 to have a 28-day cube compressive strength of 25 & 30 MPa.

3. RESULTS AND DISCUSSIONS

3.1 Workability Test (Slump Test)

Slump test is a laboratory or at site test used to measure the consistency of concrete. Slump test shows an indication of the uniformity of concrete in different batches. The shape of the concrete slumps shows the information on the workability and quality of concrete.
The workability of Concrete mix prepared with fly ash 30 % & silica fume 10 % decreases with the increase in synthetic fibers.

Table -2: Slump Test Details

Mix	**Material**			**Fiber**	**Slump**
Name	Concrete Grade	Silica Fume (%)	Fly Ash (%)	(%)	Slump value (mm)
25PE00	M25	10	30	0	105
25PE01				0.1	101
25PE02				0.2	96
25PE03				0.3	95
25PL00				0	105
25PL01				0.1	103
25PL02				0.2	99
25PL03				0.3	97
30PE00	M30	10	30	0	108
30PE01				0.1	103
30PE02				0.2	101
30PE03				0.3	98
30PL00				0	108
30PL01				0.1	104
30PL02				0.2	101
30PL03				0.3	97

3.2 Compressive Strength Test

Compressive strength results of Fly ash & silica fume containing concretes made with and without polyester fibers were determined at the ages of 7& 28. Results are given in Table 3 and also shown in Figs. 2.

From the results shown in table 3 it is clearly evident that there is decrease in compressive strength of 7 & 28 days when compared to normal concrete mix due to pozzolonic effect which becomes more significant with ages due to presence of high volume of fly ash.

Further Increase in synthetic fibers increases the compressive strength significantly as shown in Figure 2. From the table it is clear that addition of polyester fiber & polypropylene fiber up to 0.2% increase the compressive strength significantly. Further increasing the fiber content to 0.3% the compressive strength shows no significant improvement. Hence optimum value of result obtained was with fiber content of 0.2%

Table -3: Compressive Strength for various concrete mixtures at 7& 28 days

Mix	**Material**			**Compressive strength (N/mm^2)**	
Name	Fly Ash (%)	Silica Fume (%)	Fiber (%)	7 Days	28 Days
25PE00	30	10	0	12.93	22.15
25PE01			0.1	16.15	25.90
25PE02			0.2	17.52	26.83
25PE03			0.3	17.55	26.85
25PL00			0	12.93	22.15
25PL01			0.1	16.55	25.79
25PL02			0.2	17.36	26.97
25PL03			0.3	17.38	26.95
30PE00	30	10	0	14.09	23.35
30PE01			0.1	18.50	27.90
30PE02			0.2	19.10	28.35
30PE03			0.3	19.12	28.38
30PL00			0	14.09	23.35
30PL01			0.1	18.63	27.56
30PL02			0.2	19.07	28.49
30PL03			0.3	19.13	28.52

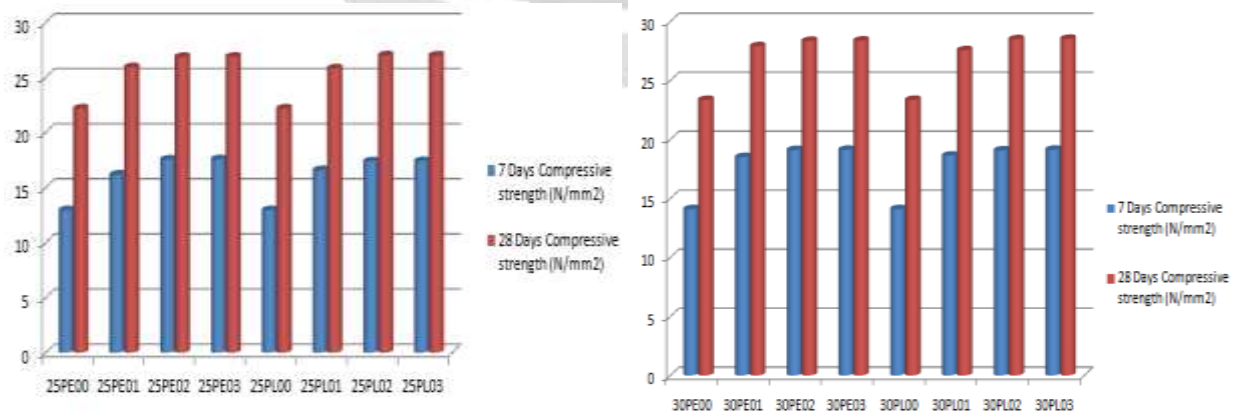

Fig -2: Compressive test results for various concrete Mixes

3.3 Flexural Strength Test

Flexural test evaluates the tensile strength of concrete indirectly. It tests ability of unreinforced concrete beam or slab to withstand failure in bending. From the test carried out it can be concluded that there is marginally increase in strength due to addition on synthetic fibers. The strength increased up to 11 % with the addition of fibers up to 0.2%. Further increase in fibers shows no increment in strength. Hence the optimum value can be taken as 0.2% for both fibers

Table -4: Flexural Strength for various concrete mixtures at 28 days

Mix	**Material**			**strength (N/mm^2)**
Name	Fly Ash (%)	Silica Fume (%)	Fiber (%)	28 Days
25PE00	30	10	0	3.21
25PE01			0.1	3.52
25PE02			0.2	3.58
25PE03			0.3	3.55
25PL00			0	3.21
25PL01			0.1	3.60
25PL02			0.2	3.64
25PL03			0.3	3.61
30PE00	30	10	0	3.94
30PE01			0.1	4.26
30PE02			0.2	4.39
30PE03			0.3	4.35
30PL00			0	3.94
30PL01			0.1	4.22
30PL02			0.2	4.41
30PL03			0.3	4.38

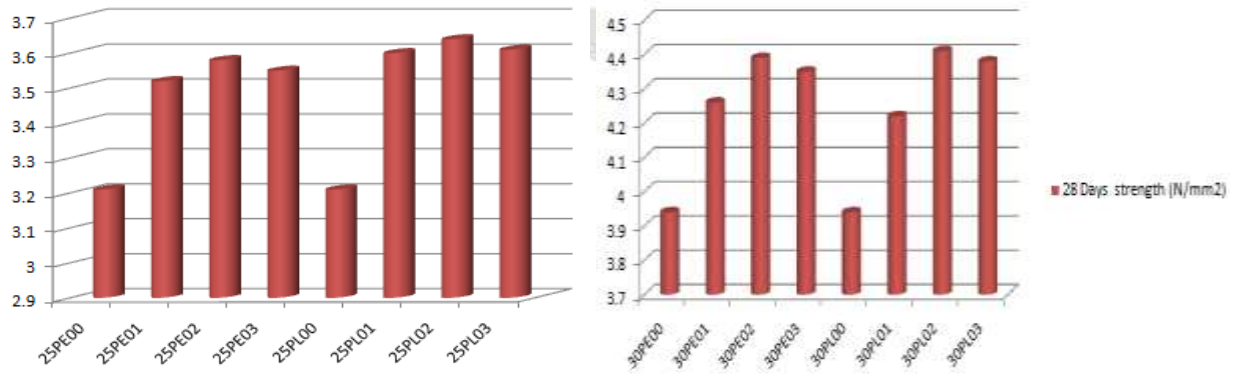

Fig -3: Flexure test results for various concrete Mixes

3.3 Split Tensile Strength Test

Various Specimen used for this test is of size 150 mm diameter and 300 mm height. Specimen is subjected to compression loads along two axial lines which are directly opposite .from the test carried out it can be concluded that there is marginally increase in strength due to addition on synthetic fibers. The strength increased up to 12 % with the addition of fibers up to 0.2%. Further increase in fibers shows no increment in strength. Hence the optimum value can be taken as 0.2% for both fibers

Table -5: Split Tensile Strength for various concrete mixtures at 28 days

Mix	**Material**			**strength (N/mm^2)**
Name	Fly Ash (%)	Silica Fume (%)	Fiber (%)	28 Days
25PE00	30	10	0	2.13
25PE01			0.1	2.32
25PE02			0.2	2.45
25PE03			0.3	2.42
25PL00			0	2.13
25PL01			0.1	2.36
25PL02			0.2	2.48
25PL03			0.3	2.44
30PE00	30	10	0	3.15
30PE01			0.1	3.37
30PE02			0.2	3.46
30PE03			0.3	3.42
30PL00			0	3.15
30PL01			0.1	3.42
30PL02			0.2	3.53
30PL03			0.3	3.49

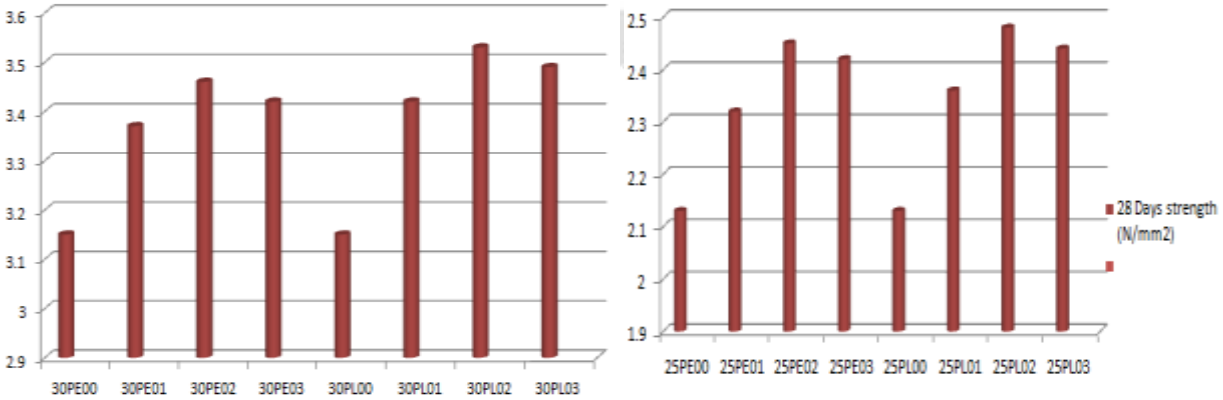

Fig -4: Split Tensie Strength test results for various concrete Mixes

4. CONCLUSIONS

- The workability of Concrete mix prepared with fly ash 30 % & silica fume 10 % decreases with the increase in synthetic fibers Further it is evident that there is decrease in 28 days compressive strength of Concrete mix prepared with fly ash 30 % & silica fume 10 % as compared to normal mix due to pozzolanic effect which becomes more significant with ages
- The compressive strength increases with the increase in synthetic fibers content upto 0.2 % further increase in fibers does not improve compressive strength significantly in both cases i.e. Polyester fibers & Polypropylene fibers the use of fly ash & silica fume can be carried out as cement replacement as it attains normal range at 180 days.
- Further there is increase in flexure & split tensile strength with the increase in synthetic fibers content upto 0.2 % further increase in fibers does not improve flexure & split tensile strength i.e. for polyester fiber & Polypropylene fibers Higher sulphate resistance were observed at every stage with increase in fiber content due to presence of silica fume & fly ash.
- The values show that at initial ages the addition of fly ash and Silica fumes affects the tensile strength. The adverse effect on initial ages is due to the slow heat of hydration and higher moisture content in the concrete. The later age specimens show that slowly it attains its strength and from 56 days it was identified that the concrete tends to behave in a normal way

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