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Experimental Study on Behavior of High Early Strength Fiber Reiforced Concrete using Polyester and Glass Fibers

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***Abstract*- In current scenario of civil engineering many applications of High early strength fiber reinforced concrete spread throughout the world ranging from pavements to the industrial buildings and water retaining structures. Many research works are still under progress in the field of high early strength to obtain high strength of concrete within the short time without any cracks formation with high workability. The demand for high early strength in a very short duration has come up. There have been demands like, 40 MPa of M60 concrete in 3 days, 50% of target strength in 24 hours, 12 MPa in 12 hours,12 MPa in 10 hours.**

The main aim of this study is to provide an extensive database and a summary of a comprehensive experimental investigation on the mechanical properties of high early strength fiber reinforced concrete (HESFRC) using different combinations of polyster fibers and glass fibers and to achieve a minimum target compressive strength of 50% of strength in 24 hours.

In this study, four batches of concrete for M50 grade were cast. Basic one is controlled concrete (without fibers) with 20% of silica fume and the remaining three with different volume fractions of 0.5%, 1%, and 1.5% fibers .The above volume fractions are further divided in to combination of two different fibers of polyester and Glass of combination 25:75, 50:50, 75:25 respectively for glass and polyester fibers. Concrete specimens (cubes, cylinders and prisms) were cast, cured and tested for 1, 3,7days and 28days strength to determine the behavior such as compressive, Split tensile and flexural strength. From the results obtained it is concluded that target compressive strength of 50% of strength in 24 hours is obtained in control mix and with other combination of mixes. The optimum combination of volume fraction is 75:25 of polyester and glass fiber respectively provides maximum strength at in 24 hours.

Key Words: High early strength fiber reinforced concrete, polyester fiber, glass fiber, silica fume, fly ash, flexural strength, compressive strength, split tensile strength, Super plasticizer.

1. INTRODUCTION:

Concrete is the most important material in all countries and its consumption is increasing day to day. In general terms, high performance concrete (HPC) may be defined as any concrete that provides enhanced performance characteristics for a given application. Concretes that provide substantially improved resistance to environmental influences, high durability under service conditions, extraordinary properties at early ages, or substantially enhanced mechanical properties, are potential HPCs. High performance concrete can be made by using mineral admixtures (e.g micro silica, metakaolin, fly ash, blast furnace slag etc.) The strength and durability properties of HPC with silica fume and metakaolin replacing cement is found to be enhanced relative to conventional concrete. Report of ACI committee 363 in 1979 defined high-strength concrete as having compressive strength more than 41 MPa.Generally HESFRC is defined as concrete which achieve a minimum target compressive strength of 50% of strength in 24 hours.

Fiber reinforced harden has flatter favorite since of its hole arresting gear, tall enthusiasm absorption properties, pliable manner besides notify-cracking tensile brawn. The properties of Fiber Reinforced Combine hinge over the effective shift of burden among the form plus the fibers which in bout generally lean on the stripe of fiber, fiber geometry, fiber capacity, orientation also dispensation of fibers, besides extent further carve of sum. The crystal fiber which is originally wearied in association along concrete was discovered to be effected by salty stipulation of fasten. Consequently in the introduce inquest, crystal fiber has been wearied to hurdle the enigma of alkali-crystal backlash. With the advance of artificial fiber, macro synthetic fiber could be a correct solution for enhanced operation, such as- subsidize light weight concrete structure, high corrosion resistance; better residual flexural strength, smaller crack width and improved function in impact, abrasion along with more of a leveled surface than modern steel fiber reinforced concrete

In this study, mechanical behavior of high early strength fiber reinforced concrete reinforced with three different percentages (0.5%, 1%, and 1.5%) of macro synthetic fibers and glass fibers where plain concrete as a control specimen was investigated for compressive strength, split tensile strength and flexural strength in 24 hours.

2. MATERIAL PROPERTIES:

2.1 Cement: Ordinary Portland cement, 53 grade confirms to IS: 12269-1987

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2.2 Fine aggregate: Locally available river sand confirms to zone II Grading of IS: 383-1970

2.3 Coarse aggregate: Locally available crushed blue granite stone confirming to graded aggregate of nominal size 12 mm as per IS 383-1970

2.4 Silica fume: Obtained from ELKEM India (P) Ltd., Navi Mumbai confirming to ASTMC 1240 as mineral addmiture in dry densifiedform.

Fig 2.1:Silica Fume

Characteristics	Result(%by mass)	Specifications
SiO2	88.7	% min 85.0
Moisturecontent	0.7	% max 3.0
Carbon	0.9	% max 2.5
>45 micron	0.2	% max 10
Bulk density	670	500-700 Kg/m3

Table 2.1: Charactreistic of Silica Fume

2.5 Fly Ash: Type-II fly ash from Neyveli Lignite Corporation was used as cement replacement material. The properties fly ash are confirms to IS 3812 –1981of Indian Standard Specification for Fly Ash for use as Pozzolana and Admixture

Fig 2.2 Fly Ash

2.6.Super plasticizer: GLENIUM ACE 30 is an admixture of a new generation based on second-generation polycarboxylic ether polymer with high early strength attained. It is free of chloride & low alkali and compatible with all types of cements

2.7 Water: Potable water is used.

2.8. Polyester fibers: Polyester fibres are available in monofilament form belong to the thermoplastic polyester area. They are temperature sensitive and above normal service temperatures their Properties may be differed. Polyester fibres are hydrophobic.

2.9.Glass fibers : Glass fiber has high tensile strength (2 – 4 GPa) and elastic modulus (70 – 80 GPa) but has brittle stress-strain characteristics (2,5 – 4,8% elongation at break) and low creep at room temperature

Fiber material	Length (mm)	Diameter (mm)	Aspect ratio
Polyester	12	0.04	300
Glass fibers	12	0.05	240

Table 2.2 properties of Fibers

Fig 2.1 Glass Fibers

Fig. 2.2 Polyester Fibers

3. OBJECTIVE OF THIS STUDY:

- To study the behavior of high early strength concrete by adding 2 different fibers of polyester and Glass fibers of 0.5%, 1.0% & 1.5% with each combination of 25:75, 50:50, 75:25 respectively for Glass fibers and polyster fiber for M 50 grade cocrete.
- To find the optimum mix for M50 which gives high early strength in 24 hour with different percentage of fibers with different combinations and to compare the results with controlled mix of concrete.

3. CASTING AND TESTING:

The prescribed quantities of materials are weighed and place over the plat form. Initially the cement and fine aggregate are mixed well organized in the dry state until they are completely blended. Then the coarse aggregate, glass fibres are mixed to dry mix of cement and fine aggregate and they are blended thoroughly until the coarse aggregate and fibres uniformly dispersed all over the batch. Super plasticizer is mixed in water and added to uniformly distributed mass until plastic concrete of homogenous colour is accomplish. This plastic concrete is placed in the cube, cylinder and prism moulds. After this the filled moulds are planted over the vibrator for compaction. Later these moulds are kept for 24 hours, After 24 hours the

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specimens are re-moulded and immediately tested for 1 day strength for compression, split tensile strength and for flexural strength and other specimens are cured for 3, 7 and 28 days. After 3, 7 and 28 days the casted specimens are taken form the curing pond and kept under shade for surface dry and testing should be done.

5. MIX DESIGN:

Concrete mix has been design based on ACI committee recommendation has been used for M50 design. The proportions and quantities of various materials for the concrete mix have been tabulated below.

	Cement	F.A	C.A	Water	Superplaticier
ByRatio	1	1.47	1.67	0.35	1.2
By weight	422kg/m³	621Kg/m³	706Kg/m³	147.6Litre	5.064Kg/cum

Table. 1 Proportion of mix design for M50 concrete

6. EXPERIMENTAL WORKS:

6.1 Compressive Strength Test

The strength of concrete is restrained by the proportioning of cement, coarse and fine aggregates, Water, and various admixtures [1]. The scale of the water to cement is the key factor for determining concrete strength as shown [1]. When the water-cement ratio is low, the Compressive strength is more. A certain minimum amount of water is necessary for the proper chemical action in the crystallization of concrete; excess water increases the workability but minimizes strength. An amount of the workability is achieved by a slump test. Actual strength of concrete in place in the structure is also greatly damaged by quality control for placement and analysis. The tenacity of concrete is express in the US by *f' c* which is the compressive strength of test cylinder 6 inches in diameter by 12 inches high measured on the1,3,7 & 28th day after they are made.

S.No	% of fiber added	1 days (N/mm²)	3 days (N/mm²)	7days (N/mm²)	28 days (N/mm²)
1	-	25.54	31.36	36.62	54.67
2	0.5%	26.11	30.84	38.4	55.85
3	1.0%	29.73	35.45	40.42	57.41
4	1.5%	28.34	34.45	39.78	56.53

Table.6.1.1 Compressive Strength Test Results (50 - 50)

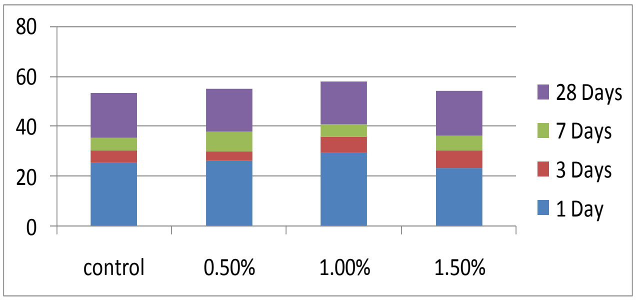
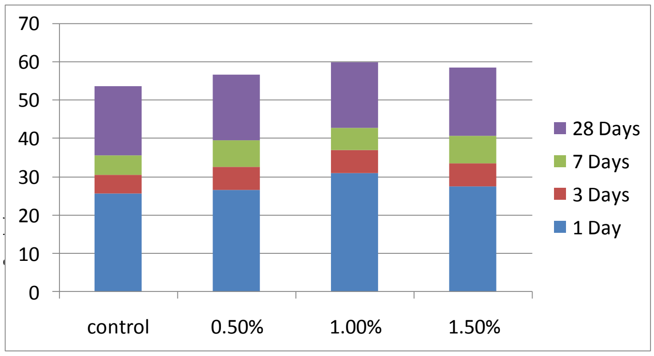


Fig 6.1.1 Variation of compressive strength at various ages

S.No	% of fiber added	1 days (N/mm²)	3 days (N/mm²)	7days (N/mm²)	28 days (N/mm²)
1	-	25.55	31.30	36.64	54.62
2	0.5%	26.6	32.54	39.41	56.74
3	1.0%	30.85	36.73	42.80	59.24
4	1.5%	27.55	33.16	39.52	57.36

Table.6.1.2 Compressive Strength Test Results (25 - 75)



S.No	% of fiber added	1 days (N/mm²)	3 days (N/mm²)	7days (N/mm²)	28 days (N/mm²)
1	-	25.55	31.30	36.64	54.62
2	0.5%	27.02	34.25	40.25	57.35
3	1.0%	31.25	37.54	43.24	64.24
4	1.5%	27.14	33.16	39.24	59.14

Table.6.1.3 Compressive Strength Test Results (75- 25)

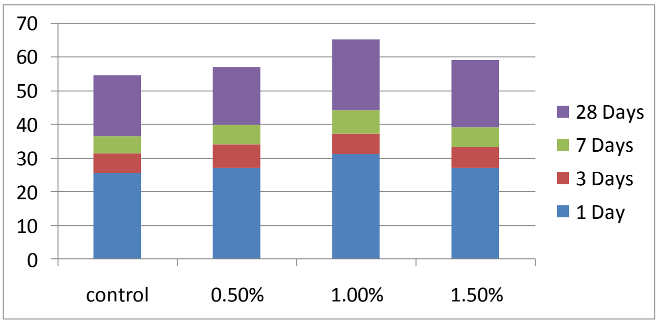


Fig 6.1.3 Variation of compressive strength at various ages

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6.2SPLIT TENSILE STRENGTH TEST

The split tensile strength of concrete cylinder was determined based on IS: 5816-1999. The load shall be applied nominal rate with in the range 1.2 N/(mm^2/min) to 2.4 N/(mm^2/min).

Split tensile strength $= \frac{2P}{\pi LD}$ N/mm^2

Table.6.2.1 Split tensile strength test results (25 - 75)

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.23	3.28	5.18
2	0.5%	2.62	3.74	5.71
3	1.0%	2.95	3.94	5.91
4	1.5%	2.79	3.81	5.84

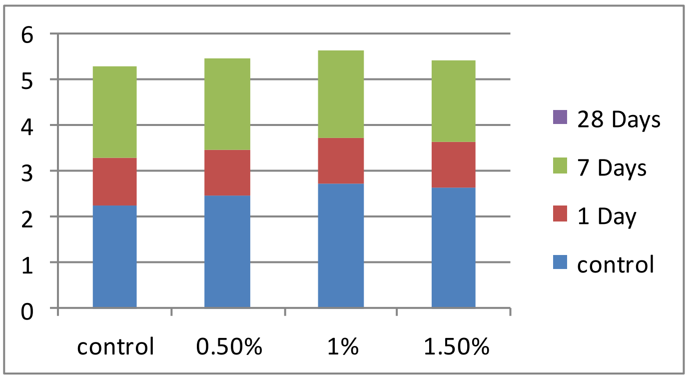

Fig6.2.1 variations of split tensile strength in 1,3,7 and 28 days(25- 75)

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.23	3.28	5.18
2	0.5%	2.45	3.43	5.21
3	1.0%	2.74	3.75	5.62
4	1.5%	2.64	3.65	5.42

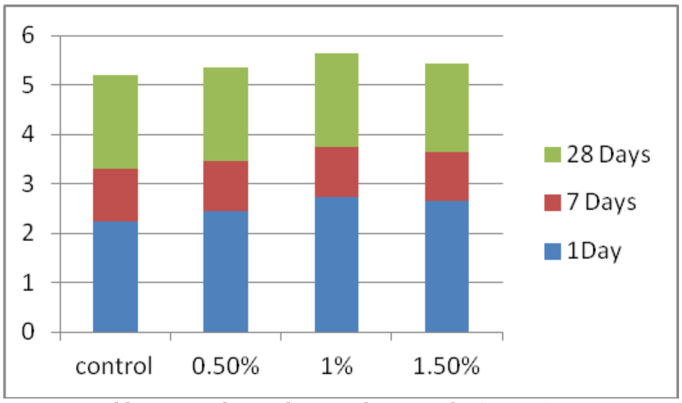

Table.6.2.2. Split tensile strength test results (50 - 50)

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.23	3.28	5.18
2	0.5%	2.84	4.02	5.94
3	1.0%	3.04	4.15	6.32
4	1.5%	2.84	3.94	5.73

Table6.2.3 split tensile strength test results (75-25)

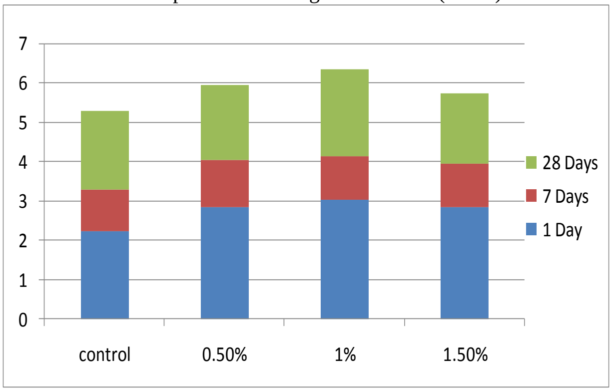

Fig 6.2.3 Variation of split tesile strength (75-25)

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.14	3.37	5.06
2	0.5%	3..662	4.881	7.322
3	1.0%	3.965	5.612	8.415
4	1.5%	3.531	5.452	8.182

6.3 FLEXURAL STRENGTH TEST

This test method is used to find the modulus of rupture of specimens prepared and cured. The strength determined will differ where there are divergence in specimen size, preparation, moisture condition, or curing. This test method covers denotation of the flexural strength of concrete specimens by the use of a simple beam with center-point loading. It is not an alternative to Test Method. The values stated in either SI units or inch-pound units are to be noticed separable as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used freely of the other. Linking values from the two systems may result in non-conformance with the standard.

Table6.3.1 Flexural strength test results (25-75)

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.14	3.37	5.06
2	0.5%	2.691	3.915	5.856
3	1.0%	3.248	4.521	6.732
4	1.5%	3.147	4.125	6.245

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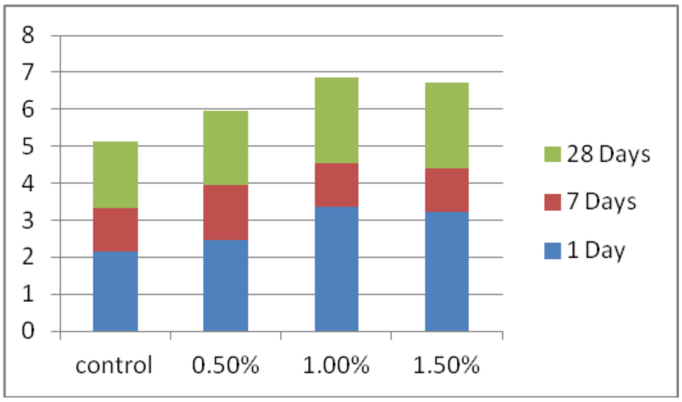

Fig 6.3.1 Variation of Flexural strength at 1, 7 and 28days

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.14	3.37	5.06
2	0.5%	3..662	4.881	7.322
3	1.0%	3.965	5.612	8.415
4	1.5%	3.531	5.452	8.182

Table 6.3.2 Flexural strength test results (75-25)

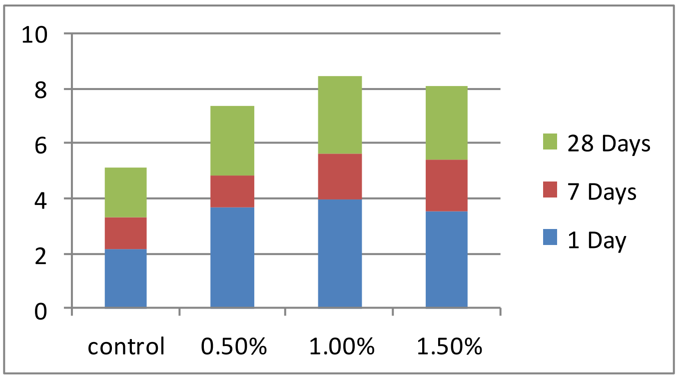

Fig 6.3.2 Variation of Flexural strength at 1, 7 and 28days

S.No	% of fiber added	1day (N/mm^2)	7 days (N/mm^2)	28days (N/mm^2)
1	CC	2.14	3.37	5.06
2	0.5%	2.451	3.974	5.961
3	1.0%	3.351	4.521	6.860
4	1.5%	3.210	4.485	6.750

Table.6.3.3. Flexural strength test results (50- 50)

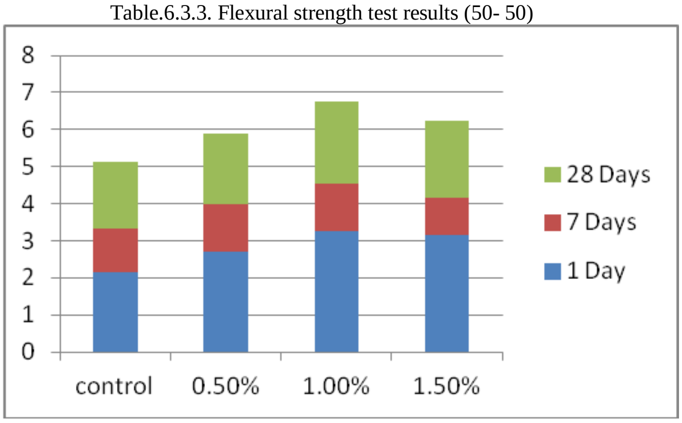

Fig 6.3.3 Variation of Flexural strength at 1, 7 and 28days

7. CONCLUSION AND RESULTS:

The primary objective of HESFRC mixes to achieve a 50% of target compressive strength at 1 day is satisfies by the control mix as well as all mixes containing glass and polyester fibers.

- ✓ The compressive strength values at 1 day from 150X150X150mm cubes for 0.5% of fibers are increased by 3 to 12.5% at 1 day comparing to control mix.
- ✓ In 0.5% the combinations of 75-25 glass and polyester fibers are increased by 10%.By using 1% of fibers the 1 day strength is noted to be increased by 15% to 23%.The combination of 75-25 is increased by 22.5%,the other combination of 25-75 and 50-50 is increased to 16% and 21%It is generally noted that by using 1.5% of fibers causes a significant decreases in compressive strength at 1 day about 10% in all combinations of fibers coparing to 1% combinations.

The split tensile strength values at 1 day from 150X300mm cylinder for 0.5% of fibers are increased upto10% at 1 day

- ✓ In 0.5% the combinations of 75-25 glass and polyester fibers are increased by 27.35%.By using 1% of fibers, the 1 day strength is noted to be increased upto 36.32%. The other combination of 25-75 and 50-50 is increased 22 to 30%. It is generally noted that by using 1.5% of fibers causes a significant decreases in split tensile strength at 1 day.

The flexural strength values for different combination of fibers are noted.

- ✓ For 0.5% of fibers 75-25 combination has increase upto 2 times. For 25-75 and 50-50 combination of fibers are increased by 15% to 25%
- ✓ For 1% of fibers 75-25 combination has increase upto 2.3 times. For 25-75 and 50-50 combination of fibers are increased by 50% to 57%.
- ✓ For 1.5% of fibers flexural strength has get considerable decreases in strength.
- ✓ The optimum mix obtained for 50% of compressive strength at 1 day, was the mix containing 1% of fibers with 75-25 combination of glass and polyester fibers.
- ✓ In all the mixes 75-25 combination of glass and polyester fibers show high early strength at 24 hours than other combinations.

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