Experimental Study on Behavior of Fiber Reinforced Concrete using Polyester and Glass Fibers

Prof. S.Anandaraj[1], Prof.K.Letcham[2],
[1,2] Assistant Professor,
Department of Civil Engineering,
KPR Institute of Engineering and Technology,
Coimbatore, Tamilnadu, India.

Dr. P.Vincent@Venkatesan[3]
[3] Senior Professor,
Department of Civil Engineering,
Mepco Schlenk Engineering College,
Sivakasi, Tamilnadu, India.

Dr. Jessy Rooby[4]
[4]Professor,
Department of Civil Engineering,
Hindustan University,
Chennai, PIN 603 103, Tamilnadu, India

Abstract **- Normally Concrete is firm in compression but anemic in tension and shear. To eliminate those problems the introduction of fibers was brought in as an alternative and also to improve the ductile property of concrete. The purpose of this study is to find the behavior of concrete reinforced with hybrid macro fibers. By adding macro fibers in the concrete, cracks during plastic and hardening stage are reduced. By adding the macro fibers, tensile strength and small amount of compressive strength are increased. In this study, four batches of concrete were cast. Basic one is controlled concrete (without fibers) and the remaining three with different volume fractions of 0.5%, 1%, and 1.5% .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 polyester and Glass fibers. Concrete specimens (cubes, cylinders and prisms) were cast, cured and tested. The various parameters such as compression, Split tensile and flexural strength are determined. From the above results it is concluded that the optimum combination of volume fraction is 25:75 of polyester and glass fiber respectively.**

Key Words: Microfiber reinforced concrete, polyester fiber, glass fiber, flexural strength, compressive strength, split tensile strength.

I. INTRODUCTION

Concrete based materials have been implemented in structural members since prehistoric times. Day by day the importance of concrete has developed and the limitations of concrete have been slowly but surely eliminated which increases the life of concrete allowing a higher achievement. However, concrete is firm in compression but anemic in tension. To overcome this failing in concrete, steel reinforcement is utilized to carry the tensile forces and prevent any cracking the concrete so that it remnant largely in compression under load. [1]

Glass Fibre reinforced concrete (GFRC) is defined as concrete made with cement containing Fine and coarse aggregate and discrete fiber. The initiation of Glass fibers was an alternative to developing concrete in view of improving its tensile and flexural strengths. GFRC is being increasingly used to improve tensile strength, energy absorbing capacity and better fatigue strength. Generally, for structural applications, Glass fibers plays an major role supplementary to reinforcing bars. Glass fibers can arrest cracking and improve tensile strength as a result of fatigue, impact, and shrinkage, or thermal stresses.

With the advancement of synthetic fiber, macro-fibers (fiber's diameter is larger than 0.1mm is defined as macro-fiber [5]) have been used generally in civil engineering. Due to some limitations of steel fiber, macro synthetic fiber could be a better solution for augment performance, such as- ease light weight concrete structure, high corrosion resistance; better enduring (post-cracking) flexural strength, smaller crack width and improved performance in impact, abrasion along with more of a leveled surface than classic steel fiber reinforced concrete [1]. Synthetic macro fibers are a new type reinforcement material in reinforced concrete.

In this study, mechanical behavior of concrete reinforced with three different percentages with different combinations of polyester and glass, where plain concrete as a control specimen was investigated. In this investigation, several laboratory works were performed for instance, casting and testing of cubes for compression and tension, Beams for shear and prisms for the determination of stress-strain relationships and finally making comparison and discussion on the test results[1]

II. FIBERS USED IN THIS PROJECT:

- Polyester fibers
- Glass fibers.

A. Glass Fibers:

In the form first used, glass fibers were found to be alkali reactive and products in which they were used deteriorated rapidly. Alkali-resistant glass containing 16%

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zirconia was successfully formulated in the 1960's and by 1971 was in commercial production in the UK. Other sources of alkali-resistant glass were developed during the 1970's and 1980's in other parts of the world, with higher zirconia contents. Alkali-resistant glass fiber is used in the manufacture of glass-reinforced cement (GRC) products, which have a wide range of applications. Glass fiber is available in continuous or chopped lengths. Fiber lengths of up to 35 mm are used in spray applications and 25-mm lengths are used in premix applications[2].

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. Claims have been made that up to 5% glass fiber by volume has been used successfully in sand-cement mortar without balling[2].

Fig 1. Glass fibers

Glass-fiber products exposed to outdoor environment have shown a loss of strength and ductility. The reasons for this are not clear and it is speculated that alkali attack or fiber embrittlement are possible causes. Because of the lack of data on long-term durability, GRC has been confined to non-structural uses where it has wide applications. It is suitable for use in direct spray techniques and premix processes and has been used as a replacement for asbestos fiber in flat sheet, pipes and a variety of precast products. GRC products are used extensively in agriculture; for architectural cladding and components; and for small containers.

B. Advantages of Glass Fibers:

- ✓ Post cracking behavior.
- ✓ It increases tensile strength and small amount of compressive strength.
- ✓ It arrests the micro and macro cracks.

C. Polyester Fibers:

Polyester fibers are available in monofilament form and belong to the thermoplastic polyester group. They are temperature sensitive and above normal service temperatures their Properties may be altered. Polyester fibers are somewhat hydrophobic. Polyester fibers have been used at low contents (0,1% by volume) to control plastic-shrinkage cracking in concrete.

Fig 2. Polyester fibers

There are some important properties of polyester fibers are,

- ✓ The equivalent diameter of polyester fiber is 20μm
- ✓ The relative density is 1.34 to 1.39
- ✓ The tensile strength of polyester fibers is 230 to 1100 Mpa
- ✓ The elastic modulus of polyester fibers is 17Gpa
- ✓ The ultimate elongation of polyester fibers is 12 to 150%
- ✓ The ignition temperature of polyester fibers is 600°C
- ✓ The Melt, oxidation or decomposition of polyester fibers is 260°C

D. Advantages Of Polyester Fibers:

- ✓ Reduces crack during plastic and hardening stage.
- ✓ Reduces water seepages and protects steel in concrete from corroding and walls from dampening.
- ✓ Rebound loss reduced by 50-70%.
- ✓ Time taken for plastering is reduced and work is completed faster.
- ✓ Increases abrasion resistance by over 40% thereby increasing life of concrete surface.
- ✓ Impact strength is increased by 20 to 40%.
- ✓ Reduces the crack width since it act as a bridge.

E. Applications Of Polyester Fibers:

- ✓ RCC&PCC like lintel, beam, column, flooring and all plastering.
- ✓ Foundation, tanks, manhole cover and tiles.
- ✓ Plastering.
- ✓ Roads and pavements.
- ✓ Hollow blocks and precast.

III. OBJECTIVES OF THIS WORK:

- ➢ To study the behaviour of concrete by adding 2 different fibres of polyester and Glass of 0.5%, 1.0% & 1.5% with each combination of 25:75, 50:50, 75:75 respectively for polyester and Glass fibres.
- ➢ To determine the behavior such as compressive strength, split tensile strength, flexural strength.
- ➢ To determine the optimum combination of fibers with above %.
- ➢ From the optimum combination, Beams are to be cast with 0.5%, 1% and 1.5% of fibers and to determine the flexural strength.

IV. MIX DESIGN:

Concrete mix has been design based on Indian standard Recommended Guidelines IS: 10262-1982.The proportions and quantities of various materials for the concrete mix have been tabulated below.

Table 1: Proportion of mix design for M25 concrete

	Cement	Fine Aggregate	Coarse Aggregate	Water
By Ratio	1	1.21	2.87	0.45
By weight	425kg/m³	512Kg/m³	1218Kg/m³	191.61Litre

IV. EXPERIMENTAL WORKS:

A. Compressive Strength Test

The strength of concrete is controlled by the proportioning of cement, coarse and fine aggregates, Water, and various admixtures. The ratio of the water to cement is the chief factor for determining concrete strength as shown. The lower the water-cement ratio, the higher is the Compressive strength. A certain minimum amount of water is necessary for the proper chemical action in the hardening of concrete; extra water increases the workability (how easily the concrete will flow) but reduces strength. A measure of the workability is obtained by a slump test. Actual strength of concrete in place in the structure is also greatly affected by quality control procedures for placement and inspection. The strength of concrete is denoted in the United States by *f' c* which is the compressive strength of test cylinder 6 in. in diameter by 12 in. high measured on the 28th day after they are made.

Table.2 Compressive Strength Test Results (25% - 75%)

S.No	% of fiber added	7days strength (N/mm2)	28days strength (N/mm2)
1	CC	16.85	27.25
2	0.5%	17.02	28.68
3	1.0%	17.98	31.84
4	1.5%	19.33	33.16

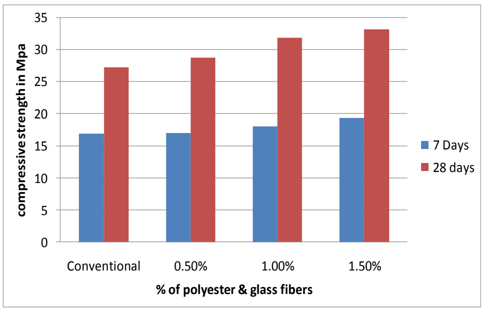

Fig 3 Variation of compressive strength at various ages

Table.3 Compressive Strength Test Results (50% - 50%)

S.No	% of fiber added	7days strength (N/mm^2)	28days strength (N/mm^2)
1	CC	16.85	27.25
2	0.5%	16.52	27.84
3	1.0%	17.03	29.52
4	1.5%	18.14	31.97

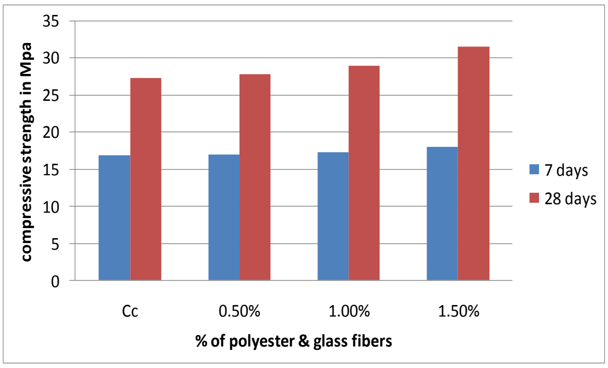

Fig 4 Variation of compressive strength at various ages

Table.4 Compressive Strength Test Results (75% - 25%)

S.No	% of fiber added	7days strength (N/mm^2)	28days strength (N/mm^2)
1	CC	16.85	27.25
2	0.5%	16.92	27.76
3	1.0%	17.24	28.91
4	1.5%	17.98	31.53

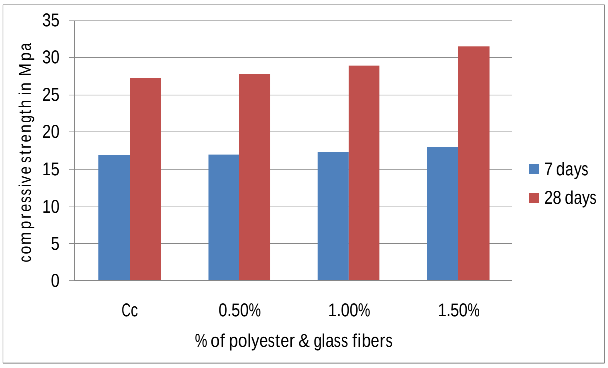

Fig 4 Variation of compressive strength at various ages

B. Split 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).

Table.5. Split tensile strength test results (25% 75%)

S.No	% of fiber added	28days strength (N/mm^2)
1	CC	2.16
2	0.5%	2.31
3	1.0%	3.12
4	1.5%	3.77

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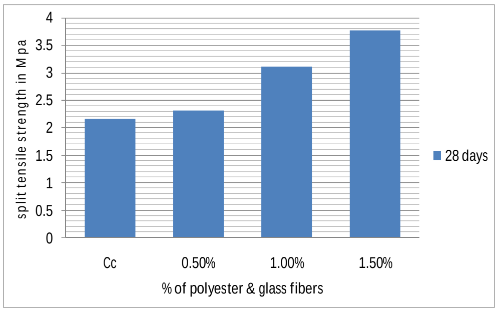

Fig .6 Variation of Split tensile strength at 28days

Table.6. Split tensile strength test results
(50% - 50%)

S.No	% of fiber added	28days strength (N/mm^2)
1	CC	2.16
2	0.5%	1.84
3	1.0%	2.68
4	1.5%	3.43

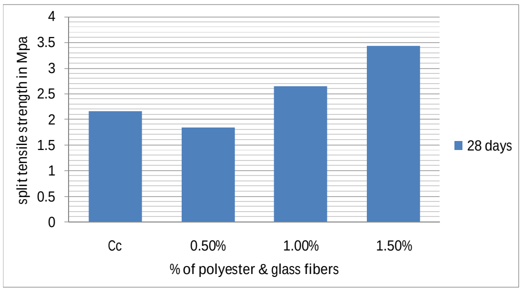

Fig .7 Variation of Split tensile strength at 28days

Table.7. Split tensile strength test results
(75% - 25%)

S.No	% of fiber added	28days strength (N/mm^2)
1	CC	2.16
2	0.5%	1.94
3	1.0%	2.38
4	1.5%	3.05

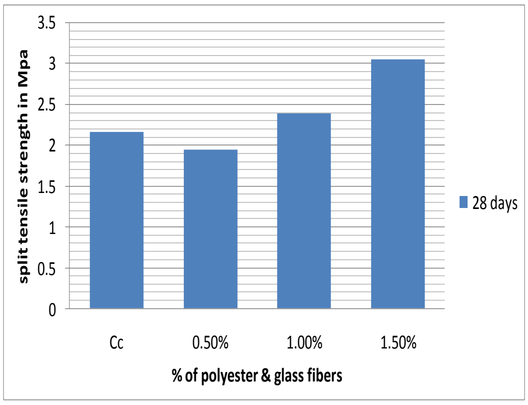

Fig .7 Variation of Split tensile strength
at 28days

C. *Flexural Strength Test*

This test method is used to determine the modulus of rupture of specimens prepared and cured. The strength determined will vary where there are differences in specimen size, preparation, moisture condition, or curing. This test method covers determination 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 regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

Table.8. Flexural strength test results
(25%   75%)

S.No	**% of fiber added**	**28days strength (N/mm^2)**
1	CC	4.95
2	0.5%	5.93
3	1.0%	6.78
4	1.5%	7.04

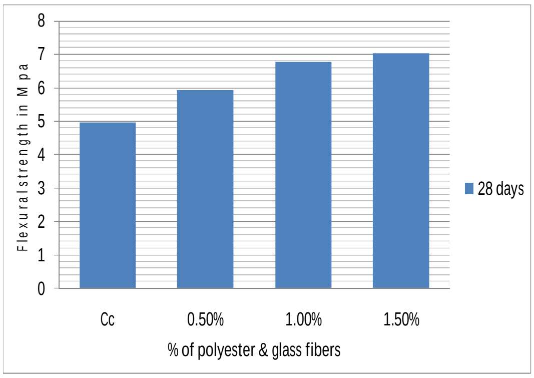

Fig 9 Variation of Flexural strength
at 28days

Table.9. Flexural strength test results (50% - 50%)

S.No	% of fiber added	28days strength (N/mm^2)
1	CC	4.95
2	0.5%	5.69
3	1.0%	6.32
4	1.5%	6.65

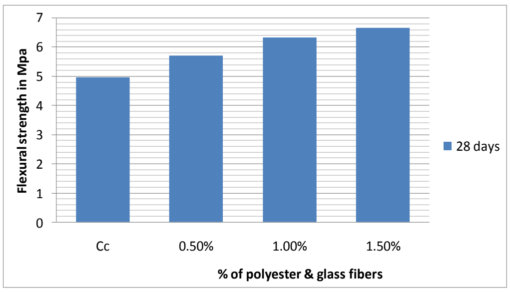

Fig 10 Variation of Flexural strength at 28days

Table.10. Flexural strength test results
(75% - 25%)

S.No	% of fiber added	28days strength (N/mm^2)
1	CC	4.95
2	0.5%	5.23
3	1.0%	5.98
4	1.5%	6.14

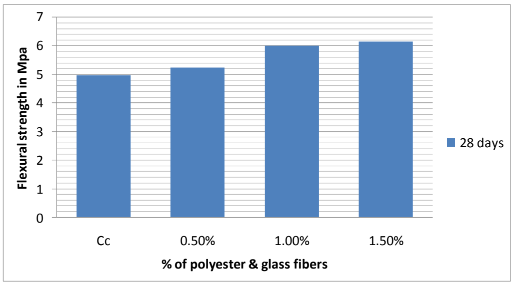

Fig 11 Variation of Flexural strength at 28days

CONCLUSION:

i) For 0.5% of fibers:

- ✓ 25:75 of polyester and glass fibers the compressive strength is increased 5.2% compared to control mix, the split tensile strength is increased 6.9% compared to control mix, the flexural strength is increased by 19.79% compared to control mix
- ✓ 75:25 of polyester and glass fibers the compressive strength is increased 2 % compared to control mix, the split tensile strength is decreased by 10% compared to control mix, the flexural strength is increased by 6% compared to control mix
- ✓ 50:50 of polyester and glass fibers the compressive strength is increased 2% compared to control mix, the split tensile strength is increased 15.2 % compared to control mix, the flexural strength is increased by 16.16% compared to control mix.

ii)For 1% of fibers :

- ✓ 25:75 of polyester and glass fibers the compressive strength is increased -14% compared to control mix, the split tensile strength is increased44.4% compared to control mix, the flexural strength is increased by 36.9% compared to control mix
- ✓ 75:25 of polyester and glass fibers the compressive strength is increased 6 % compared to control mix, the split tensile strength is increased10.2 % compared to control mix, the flexural strength is increased by 20.8% compared to control mix
- ✓ 50:50 of polyester and glass fibers the compressive strength is increased 7 % compared to control mix, the split tensile strength is increased 24% compared to control mix, the flexural strength is increased by 28.2% compared to control mix

iii) For 1.5% of fibers:

- ✓ 25:75 of polyester and glass fibers the compressive strength is increased 22 % compared to control mix, the split tensile strength is increased 74.5% compared to control mix, the flexural strength is increased by 42.2% compared to control mix
- ✓ 75:25 of polyester and glass fibers the compressive strength is increased 14.6% compared to control mix, the split tensile strength is increased 41.2% compared to control mix, the flexural strength is increased by 24.04% compared to control mix
- ✓ 50:50 of polyester and glass fibers the compressive strength is increased 14 % compared to control mix, the split tensile strength is increased 58% compared to control mix, the flexural strength is increased by % compared to control mix

iv) From the above results it is concluded that the optimum combination of volume fraction is 25:75 of polyester and glass fiber respectively. In all the mixes 25:75 combinations of polyester and glass fibres show optimum strength than other combinations.

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