

Glass Fiber Reinforced Concrete with Partial Replacement of Cement with Flyash

K.Venu Rami Reddy, S.Vijayan

PG Student (Structural Engineering), Department of Civil Engineering, SRM University, Ramapuram, Chennai, India

Assistant Professor (O.G), Department of Civil Engineering, SRM University, Ramapuram, Chennai, India.

ABSTRACT: Concrete is a material which is weak in tension, and is often affected by cracking and scaling which are connected to plastic and hardened states and drying shrinkage. Generally concrete suffers from low tensile strength, limited ductility and little resistance to cracking. With increase in coal based thermal power projects there is increase in production of fly ash as a waste material and the disposal of this fly ash is hazardous if it is not disposed well. Glass fiber is a chemically inorganic fiber, obtained from molten glass of a specific composition. The replacement of cement with fly ash in glass fibre reinforced concrete reduces the environmental pollution and improves the mechanical and durability properties of concrete. In the paper, glass fibres in different volume fractions with 10% and 20% replacement of cement by fly ash has been used to study the effect on compressive strength, split tensile strength, flexural strength of concrete. For each mix standard sizes of cubes, cylinders and prisms as per Indian Standards were cast and tested for compressive strength and split tensile strength at age of 7 days.

KEYWORDS: Glassfiber, Concrete, Flyash, Crack Reduction, Compressive Strength, Tensile Strength

I. INTRODUCTION

Concrete is a composite material containing hydraulic cement, water, coarse aggregates and fine aggregates. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This hard material is a brittle material which is strong in compression but very weak in tension. So to increase the tensile strength of concrete a technique of introduction of fibers in concrete is being used. These fibers act as crack arrestors and prevent the propagation of the cracks. These fibers are uniformly distributed and randomly arranged. This concrete is called as fiber reinforced concrete. The main reasons for adding fibers to concrete is to improve the post-cracking response of the concrete, i.e., to improve its energy absorption capacity and ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material.

Studies conducted so far proved that the short and discrete, small fibers can improve the flexural load carrying capacities and impact resistance for non ferrous fibers.

Fiber reinforced concrete is concrete containing fibrous material which enhances its structural integrity. So we can define fiber reinforced concrete as a composite material of cement concrete or mortar and discontinuous discrete and uniformly dispersed fiber. Fiber is discrete material having some characteristic properties. The fiber material can be anything. But not all will be effective and economical. Some fibers that are most commonly used are steel, glass, carbon, and natural fibers.

Glass fiber is a recently introduced fiber in making fiber concrete. It has very high tensile strength of 1020 to 4080 Mpa. Glass fiber concretes are widely used in exterior building facade panels and as architectural precast concrete. This material is very good in making shapes on the front of any building and it is less dense than steel. Fly ash can be used in pervious concrete as a substitute for a portion of the cement. The advantage of using fly ash is obvious. Fly ash is a by-product of coal burning in power plants, its utilization saves the energy required to produce the cement.

The objectives of this study

- To study the behaviour of glass fiber reinforced concrete with fly ash as a replacement to cement.
- To study the mechanical properties of the cubes, cylinders, prisms and to arrive at optimum results.
- To study the compressive strength and split tensile.
- To compare the results optioned

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II. LITERATURE REVIEW

Sekhar, et al. [1] Fibers impart energy absorption, toughness and impact resistance properties to FRC material, and these characteristics in turn improve the fracture and fatigue properties of FRC. This system was named alkali resistance glass fiber reinforced concrete. In the present experimental investigation the alkali resistance Glass fibers has been used to find out workability , resistance of concrete due to acids , sulphates and Rapid chloride permeability tests of M 30 , M40 and M 50 grade of glass fiber reinforced concrete and ordinary concrete at the 28 and 90 days with varying percentages of glass fibers .

R. Satheesh Raja, et al. [2] This paper describes the mechanical behavior of fly ash impregnated E-glass fiber reinforced polymer composite (GFRP). Initially the proportion of fiber and resin were optimized from the analysis of the mechanical properties of the GFRP. It is observed that the 30 wt% of E-glass in the GFRP without filler material yields better results. Then, based on the optimized value of resin content, the varying percentage of E-glass and fly ash was added to fabricate the hybrid composites. Results obtained in this study were mathematically evaluated using Mixture Design Method. Predictions show that 10 wt% addition of fly ash with fiber improves the mechanical properties of the composites.

Cengiz Duran, et al.[3] reports on a comprehensive study on the properties of concrete containing fly ash and steel fibers. Properties studied include unit weight and workability of fresh concrete, and compressive strength, flexural tensile strength, splitting tensile strength, elasticity modulus, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete. Fly ash content used was 0%, 15% and 30% in mass basis, and fiber volume fraction was 0%, 0.25%, 0.5%, 1.0% and 1.5% in volume basis. The laboratory results showed that steel fiber addition, either into Portland cement concrete or fly ash concrete, improve the tensile strength properties, dryingshrinkage and freeze–thaw resistance. However, it reduced workability and increase sorptivity coefficient.

Vijay Baheti, et al.[4] et al.The mechanical activation of fly ash was carried out using ball milling to promote adhesion with epoxy.The 5 h of wet pulverization was found to result into particle size of less than 500 nm. The obtained nanoparticles were incorporated into epoxy to prepare three layered laminated composite of glass fabrics.The results revealed substantial improvement in mechanical properties of nanocomposites as compared to neat and unmilled fly ash composites. Moreover, the storage modulus exhibited 85.71, 38.09, 104.76 and 80.95% increment over neat composites for 1, 3, 5 and 10 wt% of activated fly ash at 200 C.

Satish, et al. [5] Based on the laboratory experiment on fiber reinforced concrete (FRC), cube and cylinders specimens have been designed with steel fiber reinforced concrete (SFRC) containing fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 53.85, 50 aspect ratio and alkali resistant glass fibers containing 0% and 0.25% by weight of cement of 12mm cut length were used without admixture. Comparing the result of FRC with plain M20 grade concrete, this paper validated the positive effect of different fibers with percentage increase in compression and splitting improvement of specimen at 7 and 28 days, analyzed the sensitivity of addition of fibers to concrete with different strength.

III. METHODOLOGY

The methodology adopted for this study is as follows. A detailed survey is carried out and the literatures can be seen in the references of the current paper. The replacement of cement with fly ash in glass fiber reinforced concrete reduces the environmental pollution and improves the mechanical and durability properties of concrete. In the paper, glass fibers in different volume fractions with 10% and 20% replacement of cement by fly ash has been used to study the effect on compressive strength, split tensile strength, flexural strength of concrete. For each mix standard sizes of cubes, cylinders and prisms as per Indian Standards were cast and tested for compressive strength and split tensile strength at age of 7 days.

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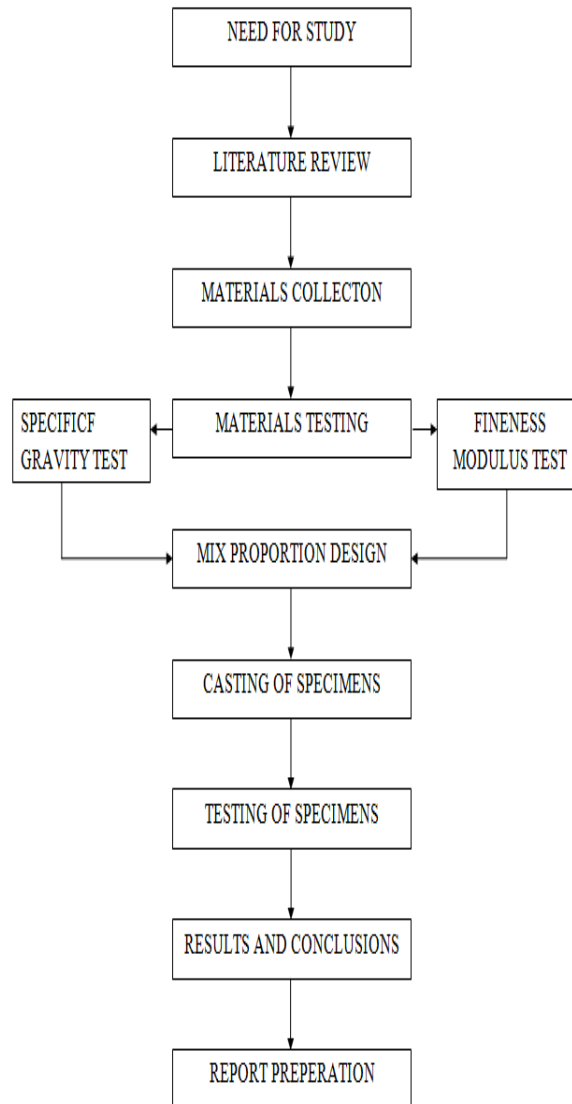


Fig.1. Experimental methodology

IV. EXPERIMENTAL PROGRAMME

1. MATERIALS

A. CEMENT

The cement that was available in the local market was used in this study. The cement has been tested for physical properties as per IS: 8112 standards. The specific gravity OPC 53 grade cement were 3.14 respectively.

B. FINE AGGREGATE

River sand was available with local dealers has been screened and washed to remove all the organic and inorganic components that are likely to present in it. Sand has been sieved with 4.75mm to filter out large and unwanted organic wastes. Fineness modulus and Specific gravity of fine aggregate are 2.92 and 2.549 respectively.

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C.COARSE AGGREGATE

Crushed blue aggregate that are passing through 20mm and retained on 10 mm sieve have been used as coarse aggregate. Fineness modulus and Specific gravity of coarse aggregates are 6.33, 2.793 respectively.

D.FLY ASH

Fly ash is one of the naturally occurring products from coal combustion process. Specific gravity of fly ash is 2.13 and chemical oxide composition is shown in Table 1.

Table 1: Chemical oxide of fly ash

Chemical	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	Na ₂ O	MgO	CaO	SO ₃
%	61.24	25	8.71	0.09	0.09	4.22	0.49

E.GLASS FIBER

Class E Glass fibres were used. Fiber glass is an immensely versatile material due to its light weight, inherent strength, weather resistant finish and variety of surface textures.

2. CONCRETE MIX PROPORTIONS

M₃₀ grade of concrete was adopted with water cement ratio of 0.45. The mix was designed as per IS 10262 – 2009 [8] and IS 456 – 2000[9]. The mix ratio of M₃₀ is 1:1.69:2.8.

3. CASTING AND CURING

In this study, control mix was designed as per IS 10262:1982 to achieve a target compressive strength of 30 MPa. Fly ash was used to replace ordinary Portland cement at various levels of 10% and 20% by mass of binder content. The E glass fibers of 0.1%, 0.2% and 0.3% by volume fraction of concrete were used. The mix proportions of different mixes are shown in Table 2.

Table 2: Concrete Mix proportions

MIX ID	F10 G1	F10 G2	F10 G3	F20 G1	F20 G2	F20 G3
Noof Cubes	3	3	3	3	3	3
Noof Cylinder	3	3	3	3	3	3
FLY ASH (%)	10	10	10	20	20	20
CEMENT (kg)	8.67	8.67	8.67	7.56	7.56	7.56
FLYASH (kg)	1.47	1.47	1.47	2.16	2.16	2.16
GLASSFIBER	0.1	0.2	0.3	0.1	0.2	0.3
WATER (Lt)	4.86	4.86	4.86	4.86	4.86	4.86
FA (kg)	17.8	17.8	17.8	17.8	17.8	17.8
CA (kg)	30.7	30.7	30.7	30.7	30.7	30.7

V. RESULTS AND DISCUSSION

The compressive strength of concrete specimens was tested at 7 days. The values of compressive strength of mixes at 7 days are shown in the Table 3. The Split tensile strength of concrete was determined at 7 days in accordance with IS: 58161999. The values of split tensile strength are shown in the Table 3.

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Table 3: Values of Compressive strength & Split tensile strength for 7 days

MIX	FLY ASH (%)	GLASS FIBER	COMPRESSIVE STRENGTH (N/mm ²)		SPLIT TENSILE STRENGTH (N/mm ²)	
F10G1	10	0.1	13.55	13.25	0.636	0.707
			12.88		0.778	
			13.33		0.707	
F10G2		0.2	15.33	15.77	1.274	1.155
			16.4		0.99	
			15.8		1.2	
F10G3		0.3	16.22	17.25	1.7	1.55
			18.66		1.41	
			16.88		1.55	
F20G1	20	0.1	12.44	12.96	0.84	0.75
			13.55		0.707	
			12.88		0.707	
F20G2		0.2	16	15.79	1.06	0.96
			15.55		0.92	
			15.55		0.92	
F20G3		0.3	15.11	14.66	1.274	1.201
			15.55		1.13	
			15.8		1.2	

1.Compression Behavior Of Specimens

The maximum compressive strength value is obtained when 10% of cement replaced with fly ash along with 0.3% glass fiber. Compressive Strength values gradually increased with increase of glass fiber percentage. Graphical representation of compression strength values for different percentages considered are shown in Fig 2.

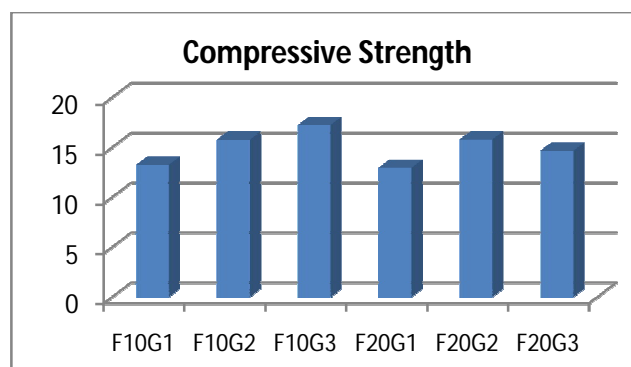


Fig.2. Compressive Strength values for 7 days

1. SPLIT TENSILE STRENGTH BEHAVIOR OF SPECIMENS

Split tensile strength of concrete increase gradually with percentage of glass fiber. And it decrees with increase in fly ash content. The maximum split tensile strength value is obtioned when 10% cement replace with fly ash along

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with 0.3% glass fiber . Graphical representation of split strength values for different percentages considered are shown in Fig 3.

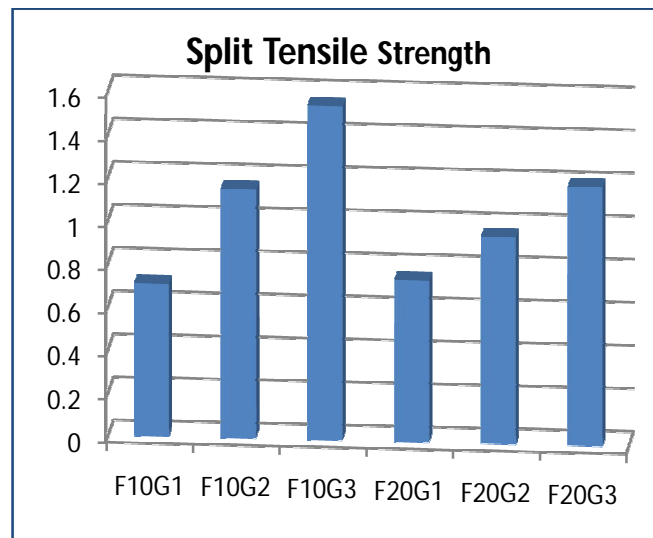


Fig.3. Split Tensile Strength values for 7 days

VI. CONCLUSION

In this paper we made an attempt to study the properties of glass fiber reinforced concrete with partial replacement of fly ash with cement. The maximum compressive strength value for 7 days is obtained when 10% cement replaced with fly ash along with 0.3% glass fiber. Compressive Strength increases with increase of glass fiber. And with increase of fly ash Compressive Strength decreases. However, 10% replacement of cement with fly ash along with 0.1%, 0.2% & 0.3% glass fiber showed increase in the compressive strength by increase in fiber percentage. The maximum split tensile strength value for 7 days is obtained when 10% cement replaced with fly ash along with 0.3% glass fiber . Due to addition of glass fiber split tensile strength increased and is optimum when 20% cement replaced with fly ash along with 0.1%, 0.2% glass fiber.

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