A STUDY ON STRENGTH CHARACTERISTICS OF GLASS FIBRE REINFORCED HIGH PERFORMANCE-CONCRETE

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Abstract - *Plain concrete possess very low tensile strength, limited ductility and little resistance to cracking. Fibres when added in certain percentage in the concrete improve the strain properties, crack resistance, ductility, flexure strength and toughness of plain concrete. Majority of studies and research in fibre reinforced concrete has been devoted to steel fibers. But in recent times, glass fibers have become available, which are free from corrosion problem which is associated with steel fibers. In order to prevent the damage of concrete exposed to a marine environment and in hydraulic structures, the measures adopted include: reducing the water-cement ratio by using super plasticizers; employing Portland Pozzolana cement; use of glass fibre preventing corrosion and holding the composite together against freezing and thawing. The present study is an experimental investigation conducted on concrete composites of M30 and M40 grades, using glass fibres and Portland Pozzolana cement, best suited for marine and hydraulic structures. Cem-fill anti crack, high dispersion, alkali resistance glass fiber have been employed in percentages varying as 0.03, 0.06, and 0.1 percentage by volume of concrete. The strength and durability properties of this composite, at 7 days and 28 days curing, in terms of properties like compressive strength, flexure strength and split tensile strength were studied*

Key Words: Glass Fibre, Pozzolana cement, Strength properties, marine environment

1.INTRODUCTION

Fiber Reinforced Concrete is a composite material consisting of a matrix containing a random distribution or dispersion of small fibres, having a high tensile strength. Due to the presence of these uniformly dispersed fibres, the cracking strength of concrete is increased and the fibres acting as crack arresters. Fibers when added in certain percentage in the concrete improve the strain properties well as crack resistance, ductility, as flexure strength and toughness. Alkali resistant glass fibre prevents corrosion and helps improve concrete properties. Like increase tensile strength, improve resistance to impact, increase shear strength, better water resisting properties. Glass fibers weight is much lighter than when steel is used in concrete. Good freeze-thaw resistance helps protect varying climatic conditions at marine environments in very cold countries. Conventional concrete has the trait known as "brittle failure" because it has a semi-crystalline structure, which tends to shatter on impact. This is especially dangerous when subjected to explosive force because ballistic debris is created which can create significant collateral damage. This is not the case with GRFC, as it does not experience brittle failure. The glass fiber tends to hold the material together because the fibers are dispersed randomly and lay in all directions within the material matrix. GFRC has a dramatically reduced ballistic debris profile. In this study , it is decided to experiment find out the strength and durability of the Glass Fibre Reinforced Concrete made using Portland Pozzolana Cement for assessing its suitability for Marine and Hydraulic Constructions. Deshmukh et.al.has studied in his paper 'Effect of Glass Fibres on Ordinary Portland cement Concrete'(2012) [1] that the glass fiber of 0 %, 0.03%, 0.06% and 0.1 % by volume fraction of concrete were used and the results have shown improvement in mechanical and durability properties with the addition of glass fibers. It is observed that compression, flexural and split tensile increased with increase in percentage of glass fiber. Neel Shah stated in his paper 'Tensile Strength of High Performance Concrete Using Supplementary Cementing Material and Glass Fiber'(2013) [2] that the concrete without any fibres will develop the cracks due to plastic shrinkage, drying shrinkage. This paper outlines the experimental investigation of Splitting Tensile Strength for HPC mixes of grade M25 and M30 by replacing 0, 30, 40, and 50 percentage of the mass of cement with Fly Ash and 0.1, 0.2 percentage of Glass Fibre and using a super plasticizer. It is observed that 0.2% glass fibre in different grade of concrete give better performance in strength aspect at the age of 7,28 and 56 days. As compared to the plain concrete of M25 grade split¬ting tensile strength reduced about 6%, 10% and 14% respectively 30%, 40% and 50% of fly ash with 0.2% glass fibre at 56 days. It is also observed that split tensile strength decrease with the high replacements of fly ash with cement in concrete. Philipp Löber conducted experiment titled 'Structural Glass Fiber Reinforced Concrete for Slabs on Ground'(2014) [3] focussing on the design of a glass fiber reinforced concrete for structural components and the study of the suitability of this concrete in slabs on ground. Materials used include superplasticiser "Muraplast FK 43" and AR-macro glass fibers. The flexural bearing capacity of glass fiber reinforced fine concrete or mortar is determined on thin plate stripes in four-point bending tests. They found out a 40% increase of fiber content results in a 59% increase of flexural strengths. The influence of mixing time on the residual tensile strength decreases with increasing fiber content, but plays an important role in the production of load-bearing parts consisting of glass fiber reinforced concrete. Joanna Julia Sokołowska experimented in his study "Effect of acidic environments on cement concrete degradation'(2014) [4] assessed of the chemical resistance of five concretes containing different binders, including common normal and high early strength cements and mix of Portland cement and siliceous fly ash, treated with hydrochloric acid. Specimens exposed to acid aggression showed significant mass loss and mechanical properties decrease. It was statistically confirmed that aggressive environment parameters have a significant effect on the chemical resistance of tested concretes. Rama Mohan Rao.P conducted experimental study on 'Effect of Glass Fibres fly ash based Concrete'(2010) [5] in which fly ash was used to replace ordinary Portland cement at various levels of 0%, 25% and 40% by mass of binder content. The E glass fibres of 0.1%, 0.2% and 0.3% by volume fraction of concrete were used. The addition of glass fibres into the fly ash concrete mixtures marginally improves the compressive strength at 28 days. The percentage of fly ash increases, the performance of the concrete decreases. There is an increase from 8.5% to 16% in split tensile strength. The flexural strength of 25% FA replacement with addition of glass fibre shows comparable with plain concrete. The volume fraction of glass fibre 0.3% gives better strength values on par with control mix..

2. EXPERIMENTAL PROGRAMME

2.1 Materials Used

2.1.1 Portland pozzolana Cement

The cement used in the experimentation was Portland pozzolana cement, which satisfies the requirements of IS: 1489-1991 specifications. The physical properties of tested cement are given in Table No.1

Table.1. Physical properties of Pozzolona cement

Sl.No.	Properties	Value
1	Fineness	1.9
2	Specific Gravity	2.9
3	Normal Consistency	32%
4	Setting time Initial Final	 20 min 203 min
5	Soundnesss test Le-Chat Expansion	1mm

2.1.2 Fine Aggregates

Manufactured sand purchased from the supplier was used as fine aggregate. The sand used confirmed to grading zone -11 as per IS: 383-1970 specification. Sieve analysis of fine aggregate are given in Table No.2.

Table2: Sieve Analysis of Fine Aggregate (IS: 383-1970)

IS Sieve Size	Weight Retained (g)	Cumulative Weight Retained (g)	Cumulative % Weight Retained	Cumulative % Passing	Grading Zone 11
4.75	0.035	0.035	3.5	96.5	90-100
2.36	0.170	0.205	20.5	79.5	75-100
1.18	0.190	0.395	39.5	60.5	55-90
600µ	0.120	0.515	51.5	48.5	35-59
300µ	0.150	0.665	66.5	33.5	8-30
150µ	0.130	0.795	79.5	20.5	0-20
Pan	0.205	1.00	100	0	-

2.1.3 Coarse Aggregate

The crushed stone aggregate by local quarry purchased from the supplier. The coarse aggregates used in the experimentation were 20 mm and down size aggregate and tested as per IS: 383-1970 and 2386 – 1963(I, II and III) specifications. Sieve analysis of coarse aggregate are given in table No.3 and physical and mechanical properties of tested coarse aggregate are given in Table.No.4

Table3: Sieve Analysis of Coarse Aggregate (IS 383 -1970)

IS Sieve Size	Weight Retained (g)	Cumulative Wt. Retained(g)	Cumulative % Weight Retained	Cumulative % Passing	IS Specification
20	0.023	0.023	1.15	98.88	85-100
10	1.946	1.969	98.45	1.55	0-20
4.75	0.031	2	100	0	0-5
Pan	0	0	0	0	-

Table4. Physical and Mechanical Properties of Coarse Aggregate (IS: 2386 -1963)

Properties	Results	Permissible limit
Impact value	10.1%	Should not be more than 30% used for concrete
Crushing value	17.84%	Should not be more than 30% for surface coarse and 45% other than wearing coarse
Specific gravity	2.64	2.6-2.8

2.1.4 Glass Fibres

The glass fiber used is alkali-resistance glass fiber which has a cut length of 12mm and a diameter of 14 microns. The three main ingredients used to make glass are silicon dioxide (SiO2), lime (calcium oxide or CaO) and aluminum oxide (Al2O3). Changing the mix of those components and other minerals will result in significantly different glasses. E-glass (with good electrical insulation properties, hence the name) is a commonly used glass on the market.

2.2 MIX PROPORTION

Design of concrete mix needs not only the knowledge of material properties and properties of concrete in plastic condition, it also needs wider knowledge and experience of concreting. Even then the proportion of the materials of concrete found out at the laboratory requires modification and readjustments to suit the field conditions.

Table.5.Mix Proportion for M30 and M40

Grade	Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Water (l/m³)	w/c ratio
M30	382	638	1144	153	0.4
M40	395	633.9	1136	158	0.4

2.2.2 Casting of Concrete Specimen

Concrete was prepared by a mix proportions of M30 and M40 grade concrete. The different percentage of fibres like 0, 0.03, 0.06, and 0.1 were adopted in the experimental programme. Glass fibres were added in the mix by volume of concrete. The entire mix was homogeneously mixed with calculated amount of water and plasticizer. The compressive strength test specimens were of dimensions 150 × 150 × 150mm.The split tensile strength test specimens were of dimensions 150mm diameter × 300mm length. The flexural strength test specimens were of dimensions 100 × 100 × 500mm.These specimens were cast and tested after 7 days and 28 days of curing as per IS specification.

3. RESULTS AND DISCUSSIONS

3.1 Workability Test

In fresh state, concrete is first tested for slump and compaction factor and the results for various samples has been displayed in Table.2. It was observed that samples of M30 and M40 grade concrete with replacement of glass fibres have shown good slump values and compaction factor. The overall results of workability of Glass Fibre Reinforced Concrete with different percentage of Fibres is tabulated belwo.

Table.6. Workability of Glass Fibre Reinforced Concrete with Different Percentage of Fibres

Percentage of Fibres	M30 Concrete		M40 Concrete	
	Slump (mm)	Compaction factor	Slump (mm)	Compaction factor
0	70	0.8	80	0.84
0.03	60	0.89	100	0.87
0.06	75	0.9	90	0.9
0.1	80	0.9	95	0.89

3.2 Compressive Strength

Compressive strength tests were performed using compression testing machine on cube samples of M30 and M40 Grade concrete. Three samples per batch were tested with the average strength values reported in this paper. The 7-days and 28 days compressive strength of GFRC shows an increasing trend in compressive strength as percentage of glass fibre to volume of concrete increases. It can further be observed that the maximum compressive strength is obtained at M40 0.1% glass fibre for 28 days curing.

Table.7. Average Compressive Strength of M30 and M40

Sl.No.	% of Fibres	Average Compressive strength (N/mm²)			
		M30		M 40	
		7 Days	28 Days	7 Days	28 Days
1	0	42.2	48.89	43.85	49.48
2	0.03	45.18	49.08	45.47	52.49
3	0.06	51.11	52.59	52.05	53.37
4	0.1	51.70	56.74	52.59	57.66

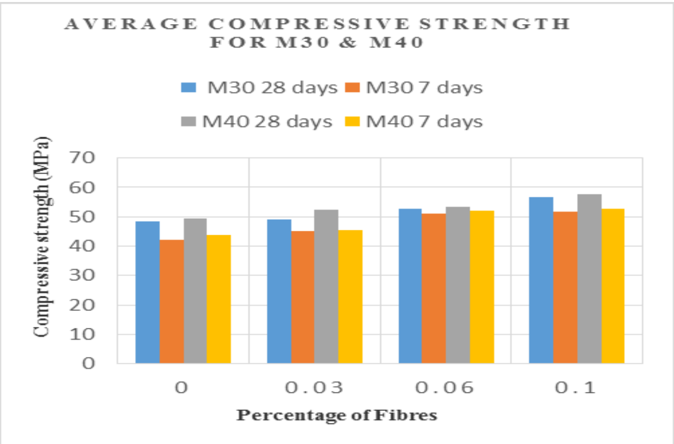

Fig.1. Average Compressive Strength for M30 & M40

3.3Flexural Strength:

The flexural strength of GFRC increases with increasing percentage of glass fibres. The percentage increase in flexural strength is maximum at 0.1% of glass fibre for both 7 days and 28 days curing of GFRC. The percentage increase in flexural strength of M30 7 days GFRC is 9.7% and M30 28 days GFRC is 16.6%. The percentage increase in flexural strength of M40 7 days GFRC is 12.5% and M40 28 days GFRC is 49.5%. Thus it can be observed that addition of glass fibre has significantly increased the flexural strength.

Table.8. Average Flexural Strength for M30 & M40

Sl.No.	% of Fibres	Average flexural strength (N/mm²)			
		M30		M40	
		7 Days	28 Days	7 Days	28 Days
1	0	5.33	5.33	5.33	6.0
2	0.03	5.48	6.13	5.73	6.13
3	0.06	5.61	6.23	5.80	6.86
4	0.1	5.85	7	6.0	7.97

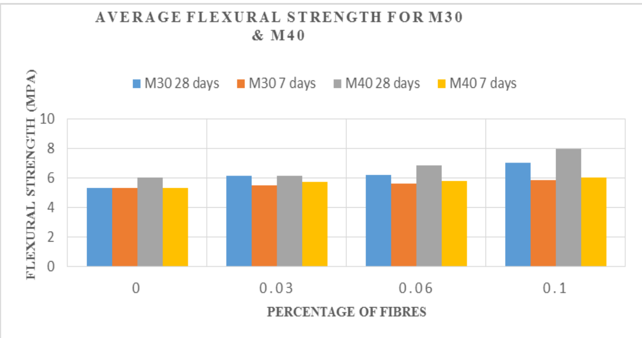

Fig.2. Average Flexural Strength for M30 & M40

3.4 Split-tensile strength:

The split tensile strength of GFRC increases with increasing percentage of glass fibres. The percentage increase in tensile strength is maximum at 0.1% of glass fibre for both 7 days and 28 days curing of GFRC. The percentage increase in tensile strength of M30 7 days GFRC is 25.9% and M30 28 days GFRC is 12.4%. The percentage increase in tensile strength of M40 7 days GFRC is 18% and M40 28 days GFRC is 22%. Thus it can be observed that addition of glass fibres has significantly increased the tensile strength in both 7 days and 28 days curing.

Table. 9. Average Split Tensile strength for M30 & M40

Sl.No.	% of Fibres	Average Split Tensile strength (N/mm²)			
		M 30		M40	
		7 Days	28 Days	7 Days	28 Days
1	0	2.43	3.06	2.82	3.47
2	0.03	2.83	3.33	3.13	3.92
3	0.06	3.02	3.35	3.30	4.19
4	0.1	3.06	3.44	3.33	4.23

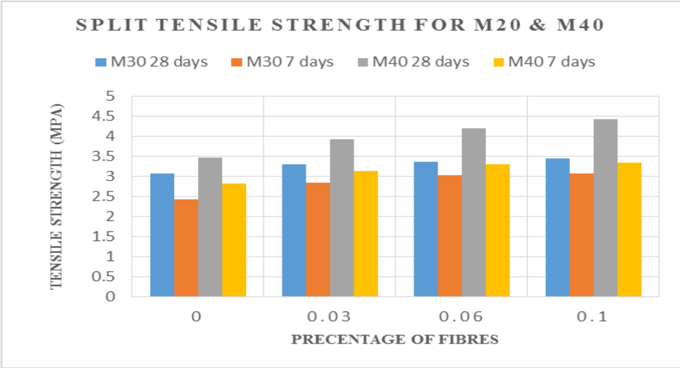

Fig. 3.Average Split Tensile Strength for M30 & M40

4. CONCLUSION:

1. In this study, it is concluded that the variety of Glass Fibre Concrete made with Portland Pozzolana Cement is an excellent choice for marine and hydraulic structure constructions, as compressive strength, flexural strength and tensile strength increases with increase in percentage of glass fibre with respect to volume of concrete. Also since, the deterioration found for chloride resistance is found to be very less.
2. As this composite increases tensile strength it may reduce the area of steel reinforcement required, minimizing the deterioration in marine environment's and hydraulic structures, if any, due to corrosion of steel reinforcements.
3. As tensile and compressive strength increases with increase in percentage of glass fibre with respect to volume of concrete, marine and hydraulic structural elements can be provided with extra concrete cover supported by glass fiber, which makes it hard for elements that cause deterioration to reach the surface of steel reinforcements, preventing corrosion and increasing the life of concrete in these environments.

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