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Strength Studies on Glass Fiber Reinforced Concrete Members by Partial Replacement of Natural Sand by Manufactured Sand Subjected to Acidic Attack

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Abstract - *Concrete is the most broadly used in the construction field. It consists of a mixture of well graded fine and coarse aggregates and binding material such as cement, water and admixtures. In comparison to other constructing materials like steel and polymers, concrete is substantially extra brittle and exhibits a low tensile strength. According to fracture toughness values, concrete is at least 100 times less crack proof than steel in service thus concrete cracks prior, and this cracking creates clean way for deleterious agents ensuring in advance saturation, freeze than harm, scaling discoloration and metallic corrosion. In this study 25mm cut glass fibers are used (1%) and manufactured sand is used as partial to full substitute of natural sand to overcome the lack of good quality river sand and to prepare economic concrete mixes and tested for different strength tests of concrete. A total of 7 mixes of M30 grade of concrete were prepared by varying the percentage of M sand with a fixed percentage of glass fibers. The study work focused on the strength and durability characteristics of GFRC. All the specimens were tested for compressive, split tensile and flexural strength in the laboratory and results were reported. M30 grade of concrete is achieved and addition of glass fiber with 100% M sand gave the highest compressive and tensile strength and improved flexural strength to some extent.*

Key Words: **Glass Fiber, GFRC, Compressive Strength, Tensile Strength, Flexural Strength, Acidic Attack.**

1. INTRODUCTION

Concrete is a completely robust and flexible construction material. It includes cement, fine aggregate and coarse aggregate combined with water. The Cement paste or gel binds the fine aggregate and coarse aggregate. Cement paste starts chemical reaction with the water, after the chemical reaction hardening process continues for long time, and the whole mix binds together. The preliminary reaction of hardening commonly happens within some hours. Few weeks requires for concrete to achieve maximum strength and hardness. It can preserve to complete harden to reach good strength for many years. Concrete made the usage of OPC has unique benefits and locate it irresistible and strong enough in maintaining compressive strain however likely in hold tension forces and as a result had a bent to get brittle. The fundamental fault in concrete is that it begins to expand crack quick and those cracks are decreasing the power of concrete and causing fracture, failure, and less durability assets. This drawback towards tension can successfully overcome through the usage of steel reinforcement and to a point by means of the use of addition of green quantity of fibers inside the concrete.

2. MATERIALS USED

The OPC 43 grade cement of Ultra Tech Company has been used in the present experimental work. In this project fine aggregate is replaced for different mixes as 20%, 40%, 60%, 80%, and 100%. Specific gravity of the fine aggregate used in the project is 2.50.The M sand used in the present work is laid to zone-II. Specific gravity of M-sand is 2.57. In this project M sand is replaced for different mixes as 20%, 40%, 60%, 80%, 100%. Coarse aggregate used in the present work is angular dust free type, 20mm and down size course aggregates are used. Specific gravity of the coarse aggregate used in the project is 2.82. Water used for the preparation of wet concrete, preparation of hydrochloric acid solution and for curing of specimens is normal tap water. Glass fiber is of length 25mm. This fiber used in the experiment is 1% for all the mix proportion.

3. Methodology

The mix proportioning procedure for the concrete was done according to IS 10262: 2009. The proportioning is carried out to achieve specified characteristics at specified age, Workability of fresh concrete and durability requirements. Concrete grade M 30 was proportioned according to the procedure as mentioned in the code.

4. Mix Proportion

The basic mix proportion for M 30 grade of concrete is cement, fine aggregate, coarse aggregate and water and also in this experimental work 1% of glass fiber by weight of cement is adopted for mix M 2 to M 7 and M sand is replaced by natural sand by various percentages such as 20%, 40%, 60%, 80%, 100%. Total 7 mixes were studied. Water cement ratio of 0.45 for M 30 concrete was maintained for all the mixes. Details of these mixes are presented in table 1.

Table -1: Details of Material quantity for Mix Design

Mix Design	Material Quantities (Kg/m³)						
	Cement	Coarse Aggregate	Fine Aggregate	M-Sand(in % of fine aggregate)		Water in liters	Glass fiber (1% of cement) in gms
M1	427	1234	594	0	0%	192	0
M2	427	1230	588	0	0%	192	4.27
M3	427	1230	470	121	20%	192	4.27
M4	427	1230	353	242	40%	192	4.27
M5	427	1230	235	363	60%	192	4.27
M6	427	1230	118	483	80%	192	4.27
M7	427	1230	0	604	100 %	192	4.27

Table -2: Mix Proportion

W/C Ratio	Cement kg/m³	Fine Aggregate kg/m³	Coarse Aggregate kg/m³
0.45	427	593.6	1233.6
	1	1.39	2.88

5. Mixing Procedure

Estimated quantities of cement, fine aggregate and coarse aggregate are weighed as per the mix proportion obtained by mix design above 1: 1.39: 2.88 which indicates M30 concrete grade and w/c ratio is 0.45.First weighed coarse aggregate and fine aggregate of respective mix are thoroughly mixed and then cement is added dry mixed again. If the mix design contains addition of fiber and Partial replacing natural sand by manufactured sand then fiber is weighed as 1% of total estimated cement in the respective mix and M sand is replaced as percentage weight of natural sand and the weighed M sand and fiber are added to the dry mix of coarse and fine aggregate along with cement. All the design materials are thoroughly dry mixed and then the required quantity of water as per design is added and workable mix is prepared. This fresh concrete is filled in the respective moulds of cube, cylinder and beam in 3 layers and each layer is compacted by hand and after 3 layers vibrating machine is used for complete compaction of concrete and smooth finishing over the top surface is given and mark the designation of the specimen. After 24 hours of casting the moulds are demolded and the casted specimen are weighed and kept for curing process of 28days. As above procedure same number of specimen are casted for durability test so after 28days of curing durability specimens are surface dried and weighed and kept for acid attack for 62 days. Strength specimens after complete of curing period of 28 days are taken out of water & surface dried and weighed and tested for compressive, tensile and flexural strength.

6. EXPERIMENTAL METHODOLOGY

6.1 Compression Test

In this project work the cubes of size 150mmX150mmX150mm are used to find the compressive strength. The prepared specimens are tested on compressive testing machine of 2000kN capacity. The load applied on the specimen until specimen fails and failure load is noted. Compressive strength of cubes are calculated as,

$$F = P/A$$

Where,
F = Compressive strength (in MPa)
P = Load of failure (in N)
A= C/S area of cube (in mm^2)

6.2 Split Tensile Test

This test is conducted for evaluation of Concrete Tensile strength. Shape of the specimen is cylindrical and size 150mm diameter and 300mm height. It is conducted on Compressive Testing machine of 2000kN capacity as per IS 5816-1999. The specimens are tested after completion of curing period and failure loads are noted.
Split Tensile Strength is evaluated as

$$F = 2*P/\pi DL$$

Where,
F = Tensile strength of concrete (in MPa).
P = Failure load of specimen (in N).
L = length of the cylinder and (in mm)
D = diameter of the cylinder (in mm)

Flexural Strength Test

To evaluate the strength of beam specimens are prepared of size 150mmX150mmX700mm. This test is conducted on compressive testing machine and the load is act on the top surface of the beam using two point load method which is spaced at distance of 28cm as per IS 516-1959. Load will be applied on the prism up to the complete failure. Flexural Strength is calculated as,

$F = PL/bd^2$ If a is more than 200 mm or
$F = 3Pa/bd^2$ If a is less than 200mm

Where,

a = Distance b/w failure line and near support.
b = Width of prism (in mm).
d = measured depth of the prism was supported (in mm).
P = Applied failure load on the prism.

7. Results and Discussion

7.1 Compressive Strength Test Results

Table no 3 - Comparison of compressive strength With and Without Subjected to Acidic Attack

Mix Design	28 days Strength (N/mm²)	62 days Strength (N/mm²)
M1	39.41	33.19
M2	40.59	35.11
M3	42.07	40.59
M4	42.96	41.93
M5	44.44	42.37
M6	47.11	45.48
M7	48.44	46.67

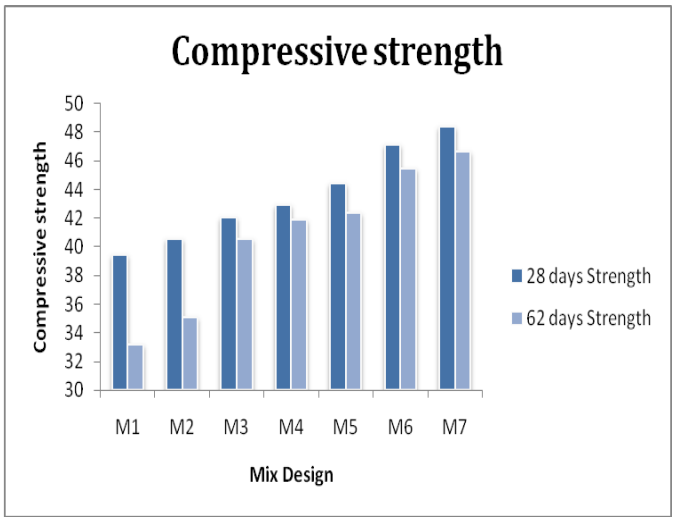

Fig. 1 : Graphical representation of Comparison of compressive strength with and without Acidic Attack.

- 28 days compressive strength of conventional concrete is greater than 62 days conventional concrete.
- The graph clearly representing the Mix from M2 to M7 which is containing glass fiber and natural sand is replaced by M sand showed the compressive strength of 28 days is more than the 62 days compressive strength.

7.2 Tensile Strength Test Results

Table no 4 - Comparison of split tensile strength with and without Subjected to Acidic Attack

Mix Design	28 days Strength (N/mm²)	62 days Strength (N/mm2)
M1	3.04	3.32
M2	3.44	3.91
M3	3.56	4.2
M4	3.72	4.36
M5	3.91	4.41
M6	4.32	4.64
M7	4.48	5.59

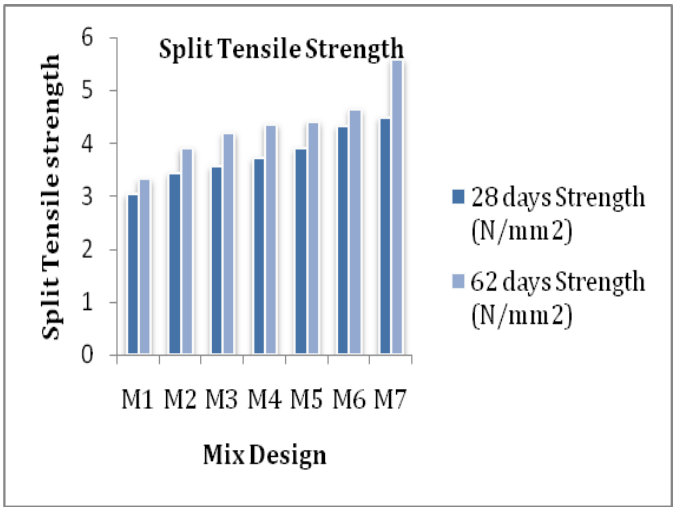

Fig. 2 : Graphical representation of Comparison split tensile strength with and without subjected to Acidic Attack.

- The above graph representing 62 days split tensile are higher than comparing to the 28 day compressive strength.
- The graph representing the 62 days split tensile strength of conventional concrete and concrete containing glass fiber is with partial replacement of M sand are not affected by acid attack and there is gradually increased comparing to 28 days split tensile strength.

7.3 Flexural Strength Test Results

Table no 5 Comparison of Flexural strength with and without Subjected to Acidic Attack

Mix Design	28 days Strength (N/mm2)	62 days Strength (N/mm2)
M1	5.19	7.04
M2	5.63	7.59
M3	6.22	8.52
M4	6.81	8.7
M5	7.26	9.26
M6	7.56	10.37
M7	8	10.56

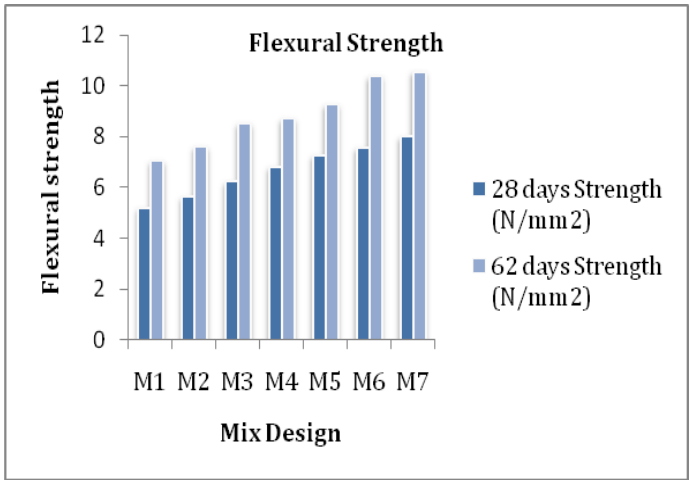

Fig.3: Graphical representation of Comparison Flexural strength with and without Subjected to Acidic Attack

- The results conclude that 62 days flexural strength is higher comparing to 28 days flexural strength.
- The concrete containing glass fiber and partial replacement of M sand is higher than conventional concrete and it is clearly observed that acid attack is not affected.

8. CONCLUSIONS

1. Addition of 1% glass fiber in concrete gives higher compressive, tensile and flexural strength of concrete.
2. Concrete specimens containing 1% glass fiber gives more strength than concrete without fiber (conventional concrete) when subjected to acidic attack.
3. Inclusion of 1% of glass fiber with various percentage of M sand (i.e. 20%, 40%, 60%, 80%, 100% as replacement to natural sand) showed gradual increment in compressive, tensile and flexural strength of 28days of concrete.
4. Glass fiber reinforced concrete with various percentage of M sand (i.e.20%, 40%, 60%, 80%, 100% as replacement to natural sand) gradual increment in compression, tensile and flexural strength even after 62 days acidic attack.
5. After 62 days of hydrochloric acid attack, glass fiber reinforced concrete with various percentage of M sand gave higher value of tensile strength and flexural strength than the tensile strength and flexural strength of 28days.
6. Compressive strength of conventional concrete as well as concrete containing glass fiber and M sand was affected by 62 days of hydrochloric acid attack and hence resulted in lower value compressive strength than 28 days compressive strength of concrete.
7. The combination of 1% glass fiber and use of 100% M sand instead of natural sand gave the maximum value of compressive strength, tensile strength, flexural strength of concrete.
8. From the above results it is concluded that, glass fiber acts as good resistance to hydrochloric acid attack on concrete.
9. From the result it is clear that, M sand used in the study can be used as 100% replacement to natural sand along with the inclusion of 1% glass fiber.

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