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COMPARATIVE STUDY ON GLASS FIBER REINFORCED CONCRETE WITH CONVENTIONAL CONCRETE

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ABSTRACT

Glass-fiber reinforced concrete (GRC) is a material made of a cementitious matrix composed of cement, sand, water and admixtures, in which short length glass fibers are dispersed. It has been widely used in the construction industry for non-structural elements, like façade panels, piping and channels. GRC offers many advantages, such as being lightweight, fire resistance, good appearance and strength.

In this study trial tests for concrete with glass fiber and without glass fiber are conducted to indicate the differences in compressive strength by using cubes, tensile strength by using cylinders, flexure strength by using rectangular beams. Various applications of GFRC shown in the study, the experimental test results, techno-economic comparison with other types, as well as the financial calculations presented, indicate the tremendous potential of GFRC as an alternative construction material. Glass Fiber Reinforced Concrete (GFRC) or (GRC) is a type of fiber reinforced concrete. Glass fiber concrete are mainly used in exterior building façade 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. GFRC is a form of concrete that uses fine sand, cement, water, coarse aggregate and admixture is glass fibers. Many mix designs are freely available on various websites, but all share similarities in ingredient proportions. The concrete during mixing. Glass fibers are produced in a process in which molten glass is drawn in the form of filaments, through the bottom of a heated platinum tank or bushing.

Key words: Glass fiber, cementitious, GRC, Construction.

CHAPTER 1
INTRODUCTION

Use of GFRC:

Glass Fiber Reinforced Concrete (GFRC) or (GRC) is a type of fiber reinforced concrete. Glass fiber concretes are mainly used in exterior building panels and as architectural precast concrete. This material is very good in making shapes on the front of any building and it is less than steel. Earlier research work in the usage of fibers to improve the strength of reinforced Concrete, resistance to fire, reduce the bleeding and arrest the cracks.

GFRC is a form of concrete that uses fine sand, cement, polymer (usually an acrylic polymer), water, other admixtures and alkali-resistant glass fibers. Many mix designs are freely available on various websites, but all share similarities in ingredient proportions Glass fiber reinforced cementations composites have been developed mainly for the production of thin sheet components, with a paste or mortar matrix. And 5% fiber content. Other applications have been considered, either by making reinforcing bars with continuous glass fibers joined together and impregnated with plastics, or by making similar short, rigid units, impregnated with epoxy, to be dispersed in the concrete during mixing. Glass fibers are produced in a process in which molten glass is drawn in the form of filaments, through the bottom of a heated platinum tank or bushing.

CHAPTER 2
LITERATURE REVIEW

2.1 LITERATURE SURVEY:

1. M. Chaitanya Nava Kumar, et al (2021), reported that the world is developing rapidly due to the construction of buildings for commercial and residential. Due to the usage of concrete it leads to the shortage of the natural resources. Silica fume is added as admixture to partial replacement of cement with different percentages of 0, 5, 7.5 and 12.5. AR glass fibers are used to increase the mechanical properties of concrete. The test results were obtained with reference to compressive and split tensile strength at 28days. A constant percentage of 0.03% of glass fibers is added to the concrete.
2. Smita Singh et al (2018), in this study they investigated that the effect of alkali resistance glass fibers in addition of 0.5% and 0.1% on compressive strength of M20 grades of concrete. Total 27 samples were prepared under this study to determine the compressive strength of different proportions of glass fibers in concrete. The results found
for 0%, 0.5% and 1% glass fibers in concrete about 18.59 MPa, 20.81 MPa and 21.5 MPa after 7 days, 19.6 MPa, 22.22 MPa, 22.7 MPa after 14 days and 20.59 MPa, 24.4 MPa and 25.3 MPa respectively.
3. Samprati Mishra (2017), concluded that it has been observed that with addition of Glass Fiber with plain concrete increases the strength properties. Maximum compressive strength is attained in addition of 0.20%of Glass Fiber with M40 grade of concrete.

CHAPTER 3
OBJECTIVES OF THE PROJECT:

1. Study the mix design aspects of the GRC.
2. Understand the various applications involving GRC.
3. Perform laboratory tests that are related to compressive, tensile, flexure by use of glass fiber in the concrete pour.

CHAPTER 4
MATERIAL SURVEY

Materials used in glass fiber reinforced concrete:

- Fine aggregate
- Coarse aggregate
- Cement
- Glass fiber
- Water

CHAPTER 5
METHODOLOGY

PROCEDURE:

1. Machine mixing
2. Casting
3. curing

MIX DESIGN FOR M40 GRADE OF CONCRETE:

- Type of cement: OPC 53 grade
- Maximum nominal size of aggregate: 20 mm
- Minimum cement content: 340 kg/m³ (IS-456,table-5)
- Maximum water cement ratio: 0.45(IS-456,table-5)
- Workability: 100 -120mm (slump) (IS-456,cl.7.1)
- Exposure condition: Severe (IS-456,table-3)
- Degree of supervision: Good
- Type of coarse aggregate: Crushed angular aggregate
- Fine aggregate: zone-II
- Maximum cement content: 450 kg/m³
- Specific gravity of cement: 3.16
- Specific gravity of coarse aggregate: 2.73
- Admixture: Glass fiber

1) **Target Strength For Mix Proportion:**
Fck =fck+1.65S or fck +X, whichever is higher
From table 2, of IS 10262-2019, Standard deviation, S= 5N/mm²
From table 1, of IS 10262-2019, X=6.5N/mm² (factor based on grade of concrete)
Target strength = 40 + 1.65 x 5 = 48.25N/mm² or 40+6.5=46.5 N/mm²
Therefore, target strength=48.5N/mm²

2) **Water Cement Ratio:**
Exposure – very severe
From Table 3 & 5, IS: 456-2000
Water cement ratio = 0.45
It can be reduced since we use admixture
W/C ratio = 0.45-0.05=0.40
Therefore, water cement ratio = 0.40

3) **Water Content:**
From Table 4, IS 10262
20mm aggregate – 186kg (for 50mm slump)
100mm slump
For every 25mm- add 3% (IS-10262-cl.5.3)
186+6% of 186 = 197kg
For glass fiber reduce 20% (197-(20%of 197)) = 157.6kg
Therefore, water content = 157.6kg

4) **Calculation of Cement Content:**
Water cement ratio = water content/ cement content
Water content = 157.6kg
Water cement ratio = 0.4
Cement content = 157.6/0.4 = 394kg/m³ >340kg/m³
Therefore, cement content = 394kg/m³

5) **Aggregate proportion b/w C.A & F.A:**
IS – 10262, table – 5, cl.5.5.1
Zone – II-0.62 (w/c-0.5)
Every 0.05 decrease, increase 0.01 (w/c-0.4)
(0.5-0.4)/0.05 = 2
0.62+0.01+0.01 = 0.64
For pumpable concrete C.A can be reduced up to 10% (IS -10262, cl.5.5.2)

Volume of coarse aggregate = 0.64 – (10% of 0.64) = 0.576
Volume of fine aggregate = 1- 0.576 = 0.424

6) **Mix calculation per unit volume of concrete:**

a. Volume of concrete - 1 m^3

b. Volume of cement = mass of cement/mass density
= 394/ (3.16x1000)
= 0.125 m^3

c. Volume of water = mass of water/mass density
= 157.6/1x1000
= 0.1576 m^3

d. Volume of admixture = mass of admixture/ mass density
Assume, mass of admixture – 1.1% of cement
= ((1.1/100) x 394)/1.12 x 1000= 0.00386 m^3

e. Volume of all in aggregate =1 – (b + c + d)
= 1 – (0.125 + 0.158 + 0.00386) = 0.71 m^3

f. Mass of coarse aggregate
=Volume of all in aggregate x vol. of C.A x specific gravity of C.A
= 0.713x 0.576 x 2.73 x 1000 = 1121kg

g. Mass of fine aggregate
=Vol. of all in aggregate x vol. of F.A x specific gravity of F.A x 1000
= 0.713 x 0.424 x 2.46 x 1000 = 744kg

Table -5.1 Mix proportions for 1 cubic meter of M40 grade of concrete:

Mix proportion	**Water (kg/m^3)**	**Cement (kg/m^3)**	**Fine aggregate (kg/m^3)**	**Coarse aggregate (kg/m^3)**
By weight (kg)	157.6	394	744	1121

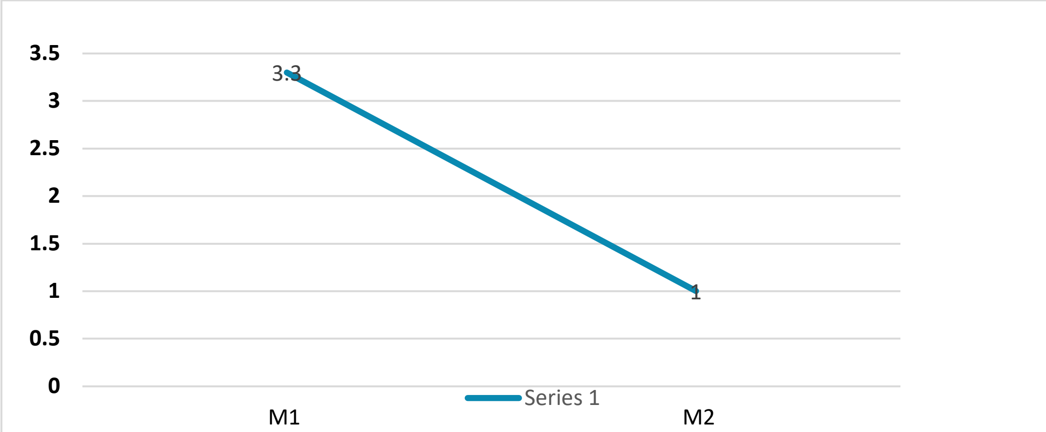
MIX RATIO:
CEMENT**:** F.A**:** C.A
1**:** 1.88**:** 2.84

<u>Mix calculations:</u>
MIX PROPORTION FOR DAY 1:
MIX 1 - NOMINAL MIX
9 Cubes, 9 Beams, 9 Cylinders
Total quantities required for 9 cubes, 9 beams, 9 cylinders are:
1. Quantity of cement=59.1kg
2. Quantity of fine aggregate=111.6kg
3. Quantity of coarse aggregate=168.15kg
4. Quantity of water =23.64liters

DAY 2: MIX 2(ADDING 5% GLASS FIBER)
MIX 2 –GFRC MIX
9 Cubes, 9 Beams, 9 Cylinders
Total quantities required for 9 cubes, 9 beams, 9 cylinders are:
1. Quantity of cement=59.1kg
2. Quantity of fine aggregate=111.6kg
3. Quantity of coarse aggregate=168.15kg
4. Quantity of water =23.64liter

TESTS: Various tests conducted on fresh concrete are

1. Slump cone test
2. Compaction factor test



TESTS: Various tests conducted on the hardened concrete are:

1. Compression strength test
2. Flexural strength test
3. Tensile strength test

CHAPTER 6
CALCULATIONS & RESULTS

<u>Table6.1 slump cone and compaction observations:</u>

MIX	Slump value (cm)	Partially compacted (kg)	Fully compacted (kg)	Compaction factor (W1/W2)
M1	3.3cm	14.44	16.07	0.898
M2	1cm	12.7	14.84	0.855

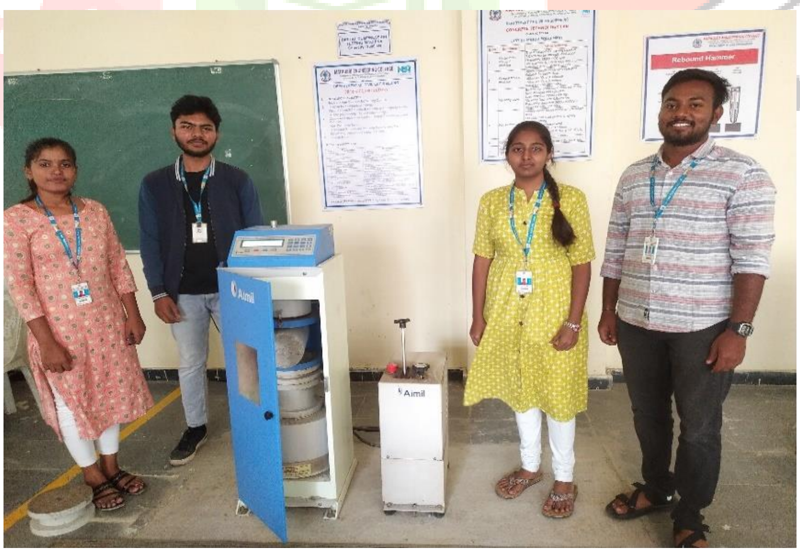


Fig 6.1 Slump cone test

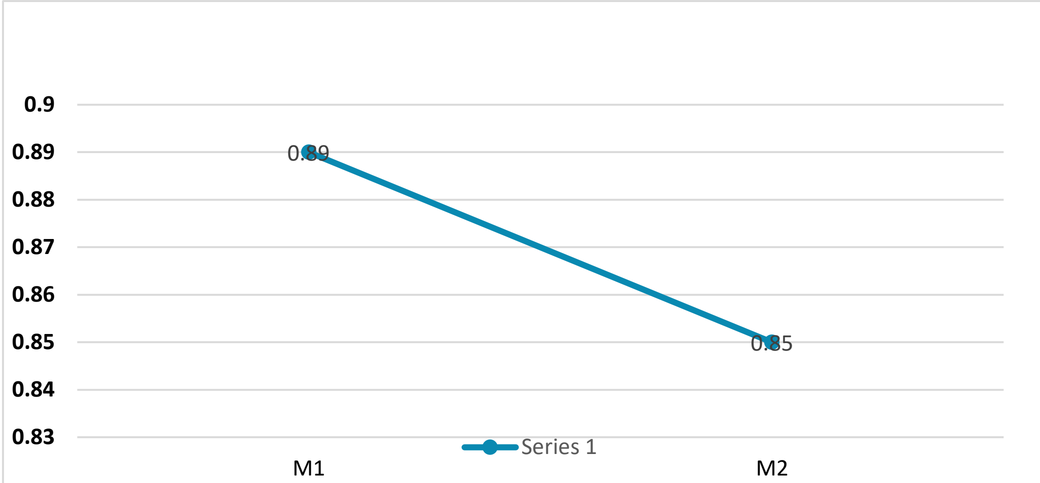


Fig 6.2 Compaction factor test

6.2 COMPRESSIVE STRENGTH TEST:

Table 6.2 Compressive strength for 7 days:

% of glass fiber	No. of cubes	Load (KN)	Compressive strength(N/mm^2)	Average strength (N/mm^2)
	Cube 1	508.0	22.57	
0%	Cube 2	516.8	22.96	22.41
	Cube 3	488.8	21.72	
	Cube 1	494.3	21.96	
5%	Cube 2	520.1	23.11	22.6
	Cube 3	511.5	22.73	

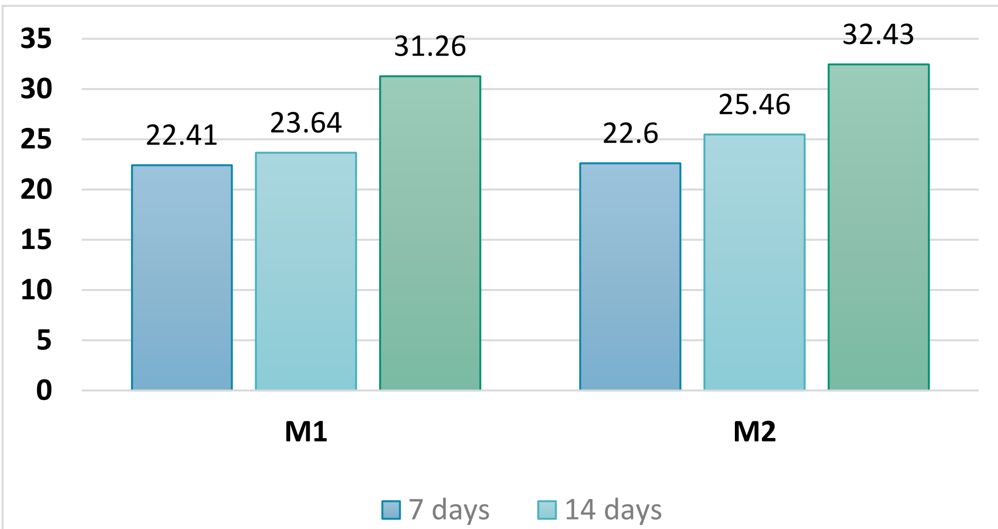
Table 6.3 Compressive strength for 14 days:

% of glass fiber	No. of cubes	Load (KN)	Compressive strength(N/mm^2)	Average strength (N/mm^2)
	Cube 1	578.9	25.72	
0%	Cube 2	540.3	24.17	23.64
	Cube 3	473.6	21.04	
	Cube 1	573.3	25.49	
5%	Cube 2	570	25.33	25.46
	Cube 3	575.6	25.58	

Table 6.4 Compressive strength for 28 days:

% of glass fiber	**No. of cubes**	**Load (KN)**	**Compressive strength(N/mm²)**	**Average strength (N/mm²)**
	Cube 1	705.5	31.35	
0%	Cube 2	676.4	30.06	31.26
	Cube 3	728.8	32.39	
	Cube 1	730.1	32.45	
5%	Cube 2	729	32.4	32.43
	Cube 3	729.56	32.42	

6.3 Analysis of compressive strength



6.3 SPLIT TENSILE STRENGTH TEST:

Table 6.5 Split tensile strength for 7 days:

% of glass fiber	**No. of cylinders**	**Load (KN)**	**Tensile strength(N/mm²)**	**Average strength (N/mm²)**
	Cylinder 1	97	5.48	
0%	Cylinder 2	125.8	7	6.53
	Cylinder 3	126.4	7.12	
	Cylinder 1	127.6	7.22	
5%	Cylinder 2	130.2	7.3	7.26
	Cylinder 3	129.3	7.28	

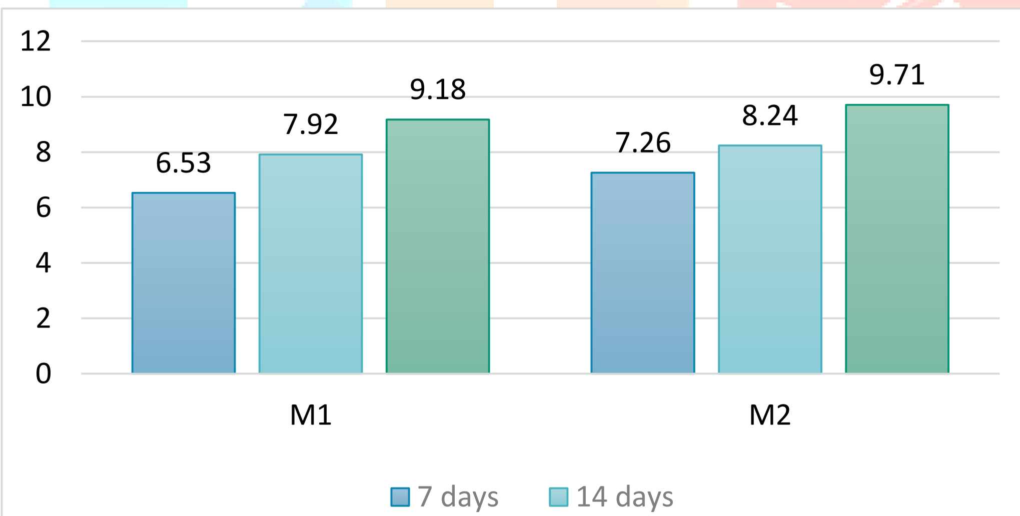
Table 6.6 Split tensile strength for 14days:

% of glass fiber	No. of cylinders	Load (KN)	Tensile strength(N/mm^2)	Average strength (N/mm^2)
	Cylinder 1	115.8	6.55	
0%	Cylinder 2	147.9	8.37	7.92
	Cylinder 3	152.6	8.85	
	Cylinder 1	142.2	8.04	
5%	Cylinder 2	145	8.23	8.24
	Cylinder 3	148.9	8.45	

Table 6.7 Split tensile strength for 28days:

% of glass fiber	No. of cylinders	Load (KN)	Tensile strength(N/mm^2)	Average strength (N/mm^2)
	Cylinder 1	162.8	9.21	
0%	Cylinder 2	161.9	9.01	9.18
	Cylinder 3	163.6	9.32	
	Cylinder 1	171.1	9.68	
5%	Cylinder 2	173.6	9.76	9.71
	Cylinder 3	172.4	9.71	

6.4 Analysis of split tensile strength



6.4 FLEXURE STRENGTH TEST:

Table 6.8 Flexure strength test for 7days:

% of glass fiber	No. Of Beams	Load (KN)	Flexure strength (N/mm^2)	Average strength (N/mm^2)
	Beam 1	12	1.2	
0%	Beam 2	10	1	1.03
	Beam 3	9	0.9	
	Beam 1	13	1.3	
5%	Beam 2	9	0.9	1.13
	Beam 3	12	1.2	

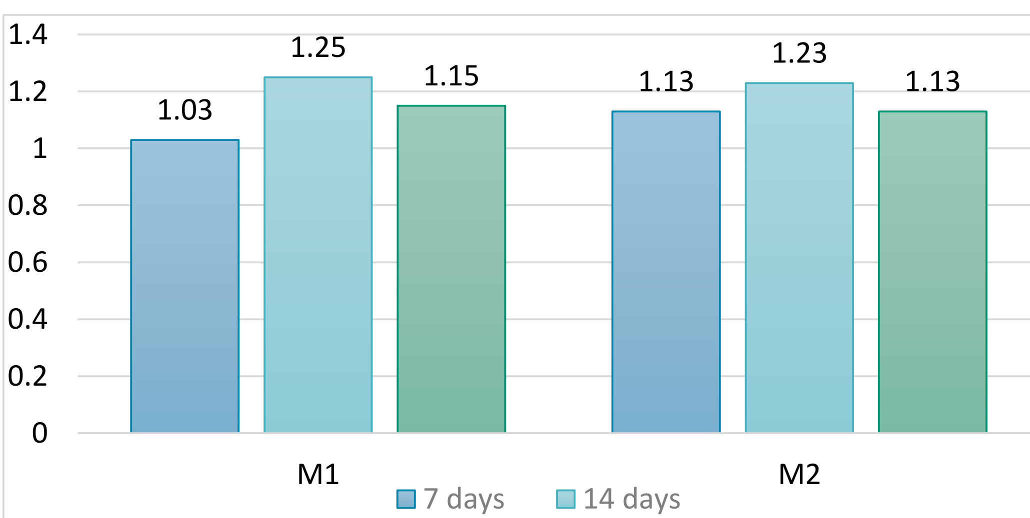
Table 6.9 Flexure strength test for 14days:

% of glass fiber	No. Of Beams	Load (KN)	Flexure strength (N/mm^2)	Average strength (N/mm^2)
	Beam 1	13	1.3	
0%	Beam 2	13.5	1.35	1.25
	Beam 3	11	1.1	
	Beam 1	10	1	
5%	Beam 2	12	1.2	1.23
	Beam 3	15	1.5	

Table 6.10 Flexure strength test for 28days:

% of glass fiber	No. Of Beams	Load (KN)	Flexure strength(N/mm^2)	Average strength (N/mm^2)
	Beam 1	15	1.5	
0%	Beam 2	7	0.7	1.15
	Beam 3	12.5	1.25	
	Beam 1	13	1.3	
5%	Beam 2	10	1	1.13
	Beam 3	11	1.1	

6.5 Analysis of flexure strength



CHAPTER 7
CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION:

On the basis of results obtained, following conclusions can be drawn:

1. The compressive strength of concrete is increased by 1.17% with the addition of 5% glass fiber.
2. The split tensile strength of concrete is increased by 0.53% with the addition of 5% glass fiber.
3. The flexure strength of concrete is decreased by 0.02% with the addition of 5% glass fiber.
4. Glass fiber reinforced concrete has more strength compared to conventional concrete. It also increases the durability of concrete and reduces crack growth. So it is better to use glass fiber reinforced concrete.

7.2 FUTURE SCOPE:

1. Excess addition of glass fibers reduces the flexure strength.
2. Workability of concrete decreases with the addition of glass fibers.

CHAPTER 8
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