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Experimental Study on usage of Class-E Glass Fiber in the Cement Concrete

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Abstract- **Glass fiber reinforced concrete is a material made of a cementitious matrix composed of cement, sand, water and admixtures in which short length glass fibres are dispersed. It has been widely used in the construction industry for non structural elements, like façade panels, piping and channels. GFRC offers many advantages such as being lightweight, fire resistant, good appearance and strength. Moreover, concrete suffers from low tensile strength, limited ductility and little resistance to cracking. In order to improve these properties and an attempt has been made to study the effect of addition of glass fibers in concrete.**

In the present investigation, the compressive strength, Split tensile strength, Flexural Strength and workability of concrete containing varying proportions of glass fiber and 10mm of coarse aggregate is studied. The result of parameter is compared to those of standard M20 grade concrete. The addition of glass fiber decreases the workability of concrete, so we added admixtures to the concrete. Class –E fiber is to be used in our project at different percentages varying from 0% to 1.5% with the concrete mix. In this project, trial test for concrete with glass fiber and without glass fiber is conducted to indicate the differences in compressive strength, flexural strength and split tensile strength by using specimen of various sizes.

Key Words: Compressive Strength, Glass Fiber Reinforced Concrete, Class-E Glass Fiber, Split Tensile Strength, Admixtures.

1. INTRODUCTION

1.1 General:

Fiber glass is a fiber reinforced polymer made of a plastic matrix reinforced by fine fiber of glass fiber glass is a lightweight, extremely strong and robust material. Glass Fiber Reinforced Polymer (GFRP) reinforcement is been used in concrete structure, and this material has many advantages over conventional steel reinforcement. It has a high strength-to-weight ratio. Its bulk strength and weight properties also very favourable when compare to metals and it can be easily formed using moulding process.

1.2 Objectives:

- The main objective of our paper is to determine the strength of the concrete by the addition of glass fibers with various proportions.

1.3 Scope:

- The addition of glass fibers on the concrete gives desire strength than the conventional concrete mixes. So, it is used for concreting purpose.
- It has good insulating property so we can use this concrete in under water constructions.

2. TYPES OF GLASS FIBER:

2.1 A-Glass Fiber: With regard to its composition, it is close to window glass. Soda lime glass with high alkali content between 10-15%. Very poor mechanical properties but high resistance to chemical attacks.

2.2 C-Glass Fiber:

This kind of glass shows better resistance to chemical impact. Mainly used in the form of surface tissue in the outer layer laminates used in chemical and water pipes and tanks.

2.3 D-Glass Fiber:

Improved die electric glass developed for high performance electronic applications.

2.4 E-Glass Fiber:

Lower alkali content (<1%) and stronger. Good tensile and compressive strength and stiffness, good electrical properties and relatively low cost, but impact resistance relatively poor.

2.5 AE-Glass Fiber:

Alkali resistant glass.

2.6 R,S (or) T-Glass Fiber:

Having higher tensile strength and modulus than E-Glass, with better wet strength retention.

3. Properties of E-Glass Fiber:

3.1 Chemical Compositon :

E-Glass is a low alkali glass

Composition	Percentage
SiO_2	54%
Al_2O_3	14%
CaO+MgO	22%
$Na_2O + K_2O$	Less than 2%

3.2 Physical Properties of E-Glass Fiber:

- Good electrical insulation
- High strength
- High stiffness
- Relatively low density
- Non-flammable
- Resistant to heat
- Good chemical resistance
- Relatively insensitive to moisture

- Able to maintain strength properties over wide range of conditions
- Low cost

4. MANUFACTURING OF E-GLASS FIBER:

E-Glass fibers are generally produced using melt spinning techniques. These involve melting the glass composition into a platinum crown which has small holes for the molten glass to flow.

Continues fibers can be drawn out through the hole and wound onto spindles, while sort fibers may be produced by spinning the crown, which forces molten glass out through the holes centrifugally. Fibers cut to length using mechanical means or air jets.

Fiber dimension and to some extent properties can be controlled by the process variables such as melt temperature (Hence viscosity) and drawing/spinning rate. The temperature window that can be used to produce the melt of suitable viscosity is quite large, making this composition suitable for fiber forming.

As fibers are being produced, they are normally treated with sizing and coupling agents. These reduce the effects of fiber-fiber abreaction which can significantly degrade the mechanical strength of the individual fibers other treatment may also be used to promote wetting and adherence of the matrix material to the fiber.

5. LITERATURE REVIEW:

5.1 Suredra.p shah, james I, Daniel and darmawan ludirdja in "toughness of glass Fibre Reinforced Concert Panels Subject to Accelerated Aging" PCI Journal /Sep to Oct 1987. Pg.98,99.

This literature explains the GFRCcompositesfabricated with commonly used alkali resistant glass fiber and composites fabricated with E-glass fiber in combination with a polymer latex modified matrix show a reduction in flexural strength toughness when exposed to a accelerated aging environment.

5.2 Yogesh Iyer Murthy, Apoorv Sharda and Gourav Jain in "Performance of Glass Fiber Reinforced Concrete" International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue 6, June 2012, Page No. +247.

This literature explains the compressive strength of concrete did not increase much, the flexural strength almost 30% increases in strength compare to the beam with 0% fiber. The slump value decreased with increase in fiber content. The use of fiber glass in concrete, not only improves the properties of concrete and can do a small cost cutting, but also provides an easy out let of the efficient disposal of this environmental hazard.

6. MATERIAL INVESTIGATION

6.1 Cement

6.1.1 Initial Setting Time

The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top is taken as initial setting time.

Result: The initial setting time of cement is 35min 45seconds.

6.1.2 Final Setting Time of Cement:

It is the replacement of needle by a circular attachment. The cement shall be considered as finally set when, upon, lowering the attachment gently cover the surface of the test block, the centre needle makes an impression, while the circular cutting edge of the attachment fails to do so.

Result: The final setting time of cement is 85min 30sec (1hr.25min.30sec)

6.2 Tests for Coarse Aggregate

6.2.1 Specific Gravity Test

Specific gravity of aggregates is made use of in design calculations of concrete mixes. With specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also requied in calculating the compacting factor in connection with the workability measurements. Similarly, specific gravity of aggregate is required to be considered when we deal with light weight and heavy weight concrete.

Formula:

$$\text{Specific Gravity} = \frac{w2-w1}{(w2-w1)-(w3-w4)}$$

Result: The specific gravity Coarse Aggregate is 2.7

6.2.2 Impact Test:

With respect to coarse aggregates, toughness is usually considered the resistance of the material to failure by impact. Several attempts to develop a method of test for aggregates impact value has been made.

Formula:

$$\text{Aggregate impact value} = \frac{\text{Wt of Aggregate Passing 2.36mm sieve}}{\text{Weight of Aggregate}} \times 100$$

Result: Aggregate impact value = 16.13%

6.2.3 Crushing Value Test:

Aggregate crushing value gives a relative measurement of the resistance of a aggregate sample to crushing under gradually applied compressive load. Generally, this test is made on single sized aggregate passing 12.5mm and retained on 10mm sieve. The aggregate is placed in a cylindrical mould and a load of 40 ton is applied through a plunger. The material crushed to finer than 2.36mm is separated and expressed as a percentage of original weight taken in the mould. This percentage is referred as aggregate crushing value.

Formula:

$$\text{Aggregate Crushing Value} = \frac{Wt\ of\ aggregate\ passing\ 2.36mm\ sieve}{\text{Wt of Aggregate}} \text{x}100$$

Result: Aggregate Crushing value = 19.37%

6.2.4 Water Absorption Test:

Porosity and absorption of aggregate will affect the water/cement ratio and hence the workability of concrete. The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when immersed in water for 24hrs. The ratio of the increase in weight to the weight of the dry sample expressed as percentage is known as absorption of aggregate.

Formula:

$$\text{Water Absorption} = \frac{w4-w5}{w5}\ X\ 100$$

Result: Water Absorption = 0.6%

6.3 TESTS FOR FINE AGGREGATE

6.3.1Specific Gravity Test:

The specific gravity of each constituent is known then its weight can convert into solid volume and hence a theoretical yield of material per unit volume can be calculated. It is also required in calculating the compacting factor in connection with the workability measurements.

Formula:

$$\text{Specific Gravity} = \frac{w2-w1}{(w2-w1)-(w3-w4)}$$

Result: Specific Gravity = 2.5

6.3.2 Sieve Analysis Test:

This is the name give to the operation of dividing the sample of aggregate into various fractions each consisting of the same size. This sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation.

Formula:

Uniformity Coefficient = D_{60}/D_{10}

Coefficient of Curvature = $(D_{30})^2/D_{60}XD_{10}$

Percentage of weight retained = [(Wt. of soil retained)/(Total weight of soil taken)]X100

Cumulative Percentage Weight Retained = Percentage Weight Retained on sieve + Percentage Weight Retained in all above layer of Sieve

Percentage Mixing = 100 – Cumulative Percentage Weight Retained

Fineness Modulus = Sum of cumulative percentage – weight retained up to 0.15mm

Table1: Sieve Analysis

S.No	Sieve opening in mm	Weight of sieve +soil(g)	Weight of seive(g)	Wt. of soil retained(g)	% Retained (%)	Cumulative % of retained (%)	% of finer (%)
1	4.75	456.6	423.4	31.2	3.12	3.12	96.88
2	2.36	424.1	388.8	35.3	3.53	6.65	93.35
3	1.18	523.9	369.4	154.5	15.45	22.21	77.79
4	600µ	592.5	355.5	237.0	23.70	45.08	54.92
5	425 µ	581.3	380.3	201	20.1	65.90	34.10
6	300 µ	535.5	358.8	176.4	17.64	83.54	16.46
7	150 µ	495.9	340.3	155.6	15.56	99.10	0.9
8	75 µ	327.9	319.1	8.8	0.88	99.98	0.02
9	Pan	423.7	423.5	0.2	0.02	100.0	0

Result:

Uniformity Coefficient = 2.80

Coefficient of Curvature = 1.29

Fineness Modulus = 1.99

Percentage of Gravel (>4.75mm) = 3.12%

Percentage of Sand (4.75mm – 0.75mm) = 96.86%

Percentage of Silt + Clay (<0.075mm) = 0.22

Sand Zone = III

6.3.3 Water Absorption Test:

Porosity and absorption of aggregate will affect the water/cement ratio and hence the workability of concrete. The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when immersed in water for 24hrs. The ratio of the increase in weight to the weight of the dry sample expressed as percentage is known as absorption of aggregate.

$$\text{Water Absorption} = \frac{w4-w5}{w5}\ X\ 100$$

Result:

Water Absorption = 2.02%

6.3.4 Moisture Content Test:

Determination of moisture content in aggregate is of vital importance in the control of the quality of concrete particularly with respect to workability and strength. The aggregate will absorb a certain quantity of water depending on its porosity. The water content can be expressed in terms of the weight of the aggregate when absolutely dry, surface dry or when wet.Water content means the free water, or that held on the surface of aggregate or the total water content which includes the absorbed water plus the free water, or the water held in the interior portion of aggregate particals.

Formula:

Moisture Content in Fine Aggregate = $\frac{Sand\ Weight - Dry\ Sand}{Dry\ Sand}\ X\ 100$

Result:

Moisture Content in Fine Aggregate =1.27%

Table2: Mix Design

Water(litre)	Cement(kg)	Fine Aggregate(kg)	Coarse Aggregate(kg)
25	50	70	125
0.5	1	1.4	2.5

7. WORKABILITY TEST

7.1 Compacting Factor Test

The compacting factor test is one of the most efficient tests for measuring the workability of the concrete. The test works on the principle of determining the degree of compaction achieved by standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted.

Formula:

Compaction factor = (Weight of partially compacted concrete)/(weight of fully compacted concrete)

Result: Compaction Factor = 0.8542

7.2 SLUMP CONE TEST

Slump cone test in the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or dry concrete. It does not measure all factor contributing to workability, nor is it always representative of the pliability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Repeated batches of the same mix, brought to the same slump, will have the same water content and water cement ratio: Provided the weight of aggregate, cement and admixtures are uniform and aggregate grading is within acceptable limits.

Table3: Slump Value

Percentage of Water by wt of cement	Slump(mm)	Nature Of Slump
40%	No slump	Dry
50%	30mm	True slump
55%	55mm	Shear Slump
60%	80mm	Collapse

Result: True Slump Value = 30mm
Water = 50% of Cement Weight.

8. PREPARATION AND CASTING OF SPECIMEN:

Preparation was started with the collected materials. First we started with conventional concrete mix of M20 grade with 10mm coarse aggregate, fine aggregate and 53 grade cement. We mixed with mixture machine and casted the conventional concrete mix in 98 specimens with 3 Cubes,3 cylinder and 3 prism. After 24hrs we removed the mould and placed the cube, cylinder and prism for curing for different intervals like 7 days, 14days and 28days. After curing process the specimen are taken for testing, for cube compressive strength is tested, for cylinders split tensile strength is tested and for prisms flexural strength is tested and those reading are noted.

9. Compressive Strength Test:

Table4: compressive Strength of Nominal Concrete

S.No	Days of curing	Compressive strength (N/mm^2)	Average (N/mm^2)
1	7	22.3	21.57
2		21.0	
3		21.4	
1	14	27.5	26.2
2		24.3	
3		26.8	
1	28	29.6	28.6
2		28.2	
3		28	

Table5: Compressive Strength of Glass Fiber Concrete

S.No	Percentage of Glass Fiber	Days of curing	Compressive strength (N/mm^2)	Average (N/mm^2)
1	0.5	7	28.4	23.5
2			21.0	
3			21.1	
1	0.5	14	28.6	28.53
2			27.4	
3			29.59	
1	0.5	28	31.7	30.46
2			30.18	
3			29.59	
1	1	7	31.0	28.83
2			26.9	
3			28.6	
1	1	14	30.01	31.1
2			33.2	
3			30.0	
1	1	28	34.6	34.1
2			32.5	
3			35.2	
1	1.5	7	22.0	20.47
2			19.1	
3			20.3	
1	1.5	14	31.6	29.57
2			28.91	
3			28.2	
1	1.5	28	30.0	31.53
2			32.49	
3			32.1	

10. SPLIT TENSILE STRENGTH TEST:

Table6: Split Tensile Strength of Nominal Concrete

S.No	Days of curing	Split Tensile strength (N/mm^2)	Average (N/mm^2)
1	7	2.16	2.09
2		1.99	
3		2.12	
1	14	2.1	2.32
2		2.46	
3		2.4	
1	28	2.8	2.9
2		3.1	
3		2.8	

Table7: Split Tensile Strength of Glass Fiber Concrete:

S.No	Percentage of Glass Fiber	Days of curing	Split Tensile strength (N/mm^2)	Average (N/mm^2)
1	0.5	7	2.1	2.37
2			2.69	
3			2.32	
1	0.5	14	2.66	2.63
2			2.73	
3			2.5	
1	0.5	28	3.1	3.14
2			3.19	
3			3.14	
1	1	7	2.82	2.68
2			2.58	
3			2.65	
1	1	14	2.8	3.0
2			3.1	
3			3.12	
1	1	28	3.46	3.36
2			3.36	
3			3.26	
1	1.5	7	2.23	2.32
2			2.39	
3			2.33	
1	1.5	14	2.16	2.59
2			2.71	
3			2.9	
1	1.5	28	3.1	3.2
2			3.6	
3			2.9	

11. FLEXURAL STRENGTH TEST:

Table8: Flexural Strength of Nominal Concrete

S.No	Days of curing	Flexural strength (N/mm^2)	Average (N/mm^2)
1	7	5.2	5.41
2		6.2	
3		4.84	
1	14	6.4	6.2
2		6.28	
3		5.86	
1	28	7.4	7.32
2		7.36	
3		7.2	

Table9: Flexural Strength of Glass Fiber Concrete

S.No	Percentage of Glass Fiber	Days of curing	Flexural strength (N/mm^2)	Average (N/mm^2)
1	0.5	7	5.7	5.8
2			5.9	
3			5.8	
1	0.5	14	7.3	6.9
2			6.8	
3			6.6	
1	0.5	28	7.4	7.89
2			8.2	
3			8.07	
1	1	7	6.8	6.4
2			6.2	
3			6.2	
1	1	14	7.4	7.13
2			6.8	
3			7.19	
1	1	28	8	8.13
2			8.08	
3			8.31	
1	1.5	7	6.2	6.2
2			6	
3			6.4	
1	1.5	14	7.6	6.8
2			6	
3			6.8	
1	1.5	28	7.3	7.3
2			7.21	
3			7.39	

12. CONCLUSION:

- The addition of glass fibers into the concrete mixture marginally improves the compressive strength at 28 days.
- It is observed from the experimental results and its analysis, that the compressive strength of concrete, splitting tensile strength of concrete and flexural strength of concrete increases with addition of percentage of glass fibers.
- The addition of 1% Glass fibers into the concrete shows better result than the other proportions.

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