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Paper Authors
G.Ravi, T.Malyadri, N.Veerendrababu

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A STUDY ON INFLUENCE OF DISPERSED AND SHORT INTEGRAL GLASS FIBER ON THE MECHANICAL BEHAVIOUR OF TEXTILE REINFORCED CONCRETE

G.Ravi*, T.Malyadri **N.Veerendrababu

*PG Scholar ,Srinivasa Institute of Engineering & Technology,Cheyyeru

** Assistant Professor , ,Srinivasa Institute of Engineering & Technology,Cheyyeru

*** Assistant Professor&HOD , Srinivasa Institute of Engineering & Technology,Cheyyeru

ABSTRACT: Concrete is one of the oldest and most common construction materials in the world mainly due to its low cost and availability. Concrete has attained the status of a major building material in all the branches of modern construction. It is difficult to point out another material of construction which is as variable as concrete. Concrete is the best material of choice where strength, durability, impermeability, fire resistance and absorption resistance are required. The main objective of this study is to investigate and compare the compressive, flexural and splitting tensile strength of glass fiber concrete with plain M30 grade concrete. Glass fiber is a material made from extremely fine fibers of glass, which is a natural material that is found in volcanic rocks originated from frozen lava. It is used as a fire proof textile in the aerospace and automotiveindustries. In general fibers are used in concrete to improve its structural integrity. Now a days, among all fibers, Glass fiber is gaining more importance due to its exceptional properties which include resistance to corrosion and low thermal conductivity. It also improves tensile strength, flexural strength and toughness of concrete. It can be used to extend the life of important concrete structures such as nuclear power plants, highways and bridges. The variable factors considered in this study were M30 grade of concrete cubes, cylinders and beams are prepared by using cubes of size (150 x 150 x 150) mm and cylinders of size 150 mm (dia) x 300 mm (depth) and beams of size (500 x 100 x100) mm that were casted and cured in portable water for a period of 28 days. The specimens were then tested for split tensile strength, flexural strength and compression strength of the conventional concrete without using glass fiber and concrete with using Glass fiber material at 7,14,28 days.
Keywords: Concrete, Glass fiber, Compressive strength, flexural strength, Split tensile strength.

1. INTRODUCTION

1.1 CONCRETE:

Concrete is a composite material consists of mainly water, coarse aggregate, fine aggregates and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily molded into desired shape can be formed by mixing these ingredients in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on large-scale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire. The colosseum in Rome was built largely of concrete and the dome of the pantheon is the World's largest unreinforced concrete structure. After the collapse of Roman Empire in the mid-18th century, the technology was re-pioneered as the usage of concrete has become rare. Today, the widely used man made material is concrete in terms of tonnage.

1.2 PROPERTIES OF CONCRETE:

Generally, the Concrete is a material having high compressive strength than to tensile strength. As it has lower tensile stress it is generally reinforced with some materials that are strong in tension like steel. The elastic behavior of concrete at low stress levels is relatively constant but at higher stress levels start decreasing as matrix cracking develops. Concrete has a low coefficient of thermal expansion and its maturity leads to shrinkage. Due to the shrinkage and tension, all concrete structures crack to some extent. Concrete prone to creep when it is subjected to long-duration forces. For the applications various tests be performed to ensure the properties of concrete correspond to the specifications. Different strengths of concrete are attained by different mixes of concrete ingredients, which are measured in psi or Mpa. Different strengths of concrete are used for different purposes of constructions. If the concrete must be light weight a very low-strength concrete may be used. The Lightweight concrete is achieved by the addition of lightweight aggregates, air or foam, the side effect is that the strength of concrete will get reduced. The concrete with 3000-psi to 4000-psi is often used for routine works. Although the concrete with 5000-psi is more expensive option is commercially available as a more durable one. For larger civil projects the concrete with 5000-psi is often used. The concrete strength above 5000 psi was often used for specific building elements. For example, the high-rise concrete buildings composed of the lower floor columns may use 12,000 psi or more strength concrete, to keep the columns sizes small.

Bridges may use concrete of strength 10,000 psi in long beams to minimize the number of spans required. The other structural needs may occasionally require high strength concrete. The concrete of very high strength may be specified if the structure must be very rigid, even much stronger than required to bear the service loads. For these commercial reasons the concrete of strength as high as 19000-psi has been used.

1.3 USING FIBERS AS CONCRETE ADMIXTURES

Admixtures are the materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties such as workability, curing temperature range, set time or color. Addition of fiber to concrete 3makes it tough and fatigue resistant such type of admixture is used extensively in important engineering projects. Addition of fiber to concrete is a convenient and practical method of improving several properties of the materials for example toughness, impact resistance and flexural strength. It also assists in changing the flow characteristics of the material. The use of new materials and modern techniques is important in construction activities. Proper use of different kinds of materials and the latest technology becomes imperative to improve quality and cut costs. The life and durability of structure alsoincreases.

1.4 GLASS FIBERCONCRETE

In the 1940's, potential of glass as a construction material was realized and improvement continued with the addition of zirconium dioxide in 1960's for harsh alkali conditions. To enhance durability of materials, new generation of glass fibres directed to improvement process. In this way, glass fibre reinforced concrete (GFRC) was started to produce for the satisfaction of different demands. Scientific studies and tests on the GFRC have shown that the physical and mechanical properties of the GFRC change depending on the quality of the materials and the accuracy of the production methods. GFRC can be used wherever a light, strong, fire resistant, weather resistant, attractive, impermeable material is needed. As technology advances, it is possibly expected to build the whole building and complex freeform with low cost. In recent years, the effect of glass fibres in hybrid mixtures has been investigated for high-performance concrete (HPC), an emerging technology termed, which has become popular in the construction industry.

1.5 PROPERTIES OF GLASSFIBER

High tensile strength: Glass has greater tensile strength than steel wire of the same diameter, at a lower weight.

Dimensional stability: Glass fibre is not sensitive to variations in temperature and hygrometry. It has a low coefficient of linear expansion

High heat resistance: Glass fabrics retain 50% of room temperature tensile strength at 370°C, 25% at 480°C, a softening point of 845°C and a melting point of 1,135°C.

Good thermal conductivity: Glass fibres are great thermal insulators because of their high ratio of surface area to weight. This property makes it highly useful in the building industry.

Great fire resistance: Since glass fibre is a mineral material, it is naturally incombustible. It does not propagate or support a flame. It does not emit smoke or toxic products when exposed to heat.

Good chemical resistance: Glass fibre is highly resistant to the attack by most chemicals. Outstanding electrical properties: Glass fibre has a high dielectric strength and low dielectric constant. It is a great electrical insulator even at low thickness.

Dielectric permeability: This property of glass fibre makes it suitable for electromagnetic windows.

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Compatibility with organic matrices: Glass fibre can vary in sizes and has the ability to combine with many synthetic resins and certain mineral matrices like cement.
Great durability: Glass fibre is not prone to sunlight, fungi or bacteria.
Non-rotting: Glass fibre does not rotand remains unaffected by the action of rodents and insects.
Highly economical: It is a cost-efficient choice compared to similar materials.

2. LITERATUREREVIEW

Md.Abid Alam et al. (2015) experimented on glass fiber reinforced concrete to study the properties of the concrete, for experiment Cem-Fil Anti-Crack, Hd 12mm, Alkali Resistant glass fiber were used for the work. The specific gravity of the fiber is 2.68 mm and the length 12 mm. For the experimentation, M20 and M30 Grade concrete is used under the proportioning procedure mentioned under IS 10262-2009. For M20 grade of concrete 0.50 W/C Ratio is used and for M30 Grade of Concrete 0.42, W/C Ratio is used. Fibre is added in an increment of 0.02% from 0% to 0.06%. (0%, 0.02%, 0.04%, 0.06%). And according to the test result concrete attain higher strength that the target strength. An M20 grade of concrete attains 41.28 Mpa of Compressive Strength and 5.76Mpa of Tensile Strength when 0.06% of fiber is added in concrete. And M30 grade of concrete attain 62.29Mpa of Compressive strength and 7.17Mpa of Tensile Strength. Almost concrete attain 1 times of the target strength of the concrete.

S.Hemalatha et al. (2016) study experiment weredone with the Cem-FIL Fibre with the length of 12mm, which has resistance with alkali resistant. The fiber was added in concrete with an increment of 0.33% and added up to 2%. In this experiment ConPlast admixture (Super Plasticizer) is used at a rate of 1% to the weight of cement. In this work, M40 grade of concrete is used. The compressive strength of the concrete increases until 1% of glass fiber is added to the concrete after that strength decline gradually. The compressive strength of the concrete increased by (48.88Mpa) 1.22 time of the target means strength of the concrete. M40 Grade of concrete attains a flexural strength of 6.86 Mpa and Tensile strength of 7.96 Mpa when 1% of glass fiber is added to theconcrete.

J.D.Chaitanya Kumar et al. (2016) study where carried out using an M20 grade of concrete and glass fiber is added as 0.5%, 1%, 2%, 3%. And the specimens are cast for a compressive and tensile test of the concrete. In this experiment, concrete attains strength when 2% of the fiber is added to the concrete and when 3% fiber is added to the concrete the strength of concrete declines. When the fiber is added 2% the strength of the concrete attains 26.98Mpa of compressive strength, 2.94Mpa of Flexural Strength and 3.57Mpa of the Tensile strength of the concrete after 28 days of curing. In this experiment, the author mentioned that the workability of the concrete is increased and thus the glass fiber reduces the crack under differentloading

S.NO	Properties	Test results	IS: 169-1989
1.	Normal consistency	0.45	
2.	Initial setting time	29min	Minimum of 30min
3.	Final setting time	598min	Maximum of 600min
4.	Specific gravity	3.18	

Table-1 Properties of cement

S. No	Description Test	Result
1	Sand zone	Zone- II
2	Specific gravity	2.63
3	Free Moisture	0.01
4	Fineness modulus	3.19

Table 2: Properties of Fine Aggregate

S. No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.77
3	Fineness modulus	7.22
4	Water absorption	0.15%

Table 3: Properties of Coarse Aggregate

MIX DESIGN FOR M30 GRADECONCRETE:

[According to investigations done on FA, CA, cement]

DESIGN STIPULATIONSDATA:

Gradedesignation : M30
Typeof cement : OPC 53 grade
Maximum nominal sizeofaggregate : 20 mm
Maximumwater-cementratio :0.45
Degreeof supervision : Good
Typeofaggregate :Crushed angular

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Exposurecondition :moderate
Workability :100mm(slump)

TEST DATA FORMATERIALS:

1. Typeof cement : OPC 53 grade conforming to IS:
2. Specific gravityofcement: 3.1

3. Specific gravity of
a) Fineaggregates : 2.71
b) Coarseaggregates : 2.78
4. Water absorption of
a) Fineaggregates : 0.34%
b) Coarseaggregates : 0.6%

TARGET MEANSTRENGTH:
[According to IS 10262-2019, clause 4.2]
$f^{l}ck=fck+1.65(S.D)$ $f^{l}ck=35+1.65(5)$
[here S.D is standard deviation from table 2, clause 4.2.1.3]
$f^{l}ck= 43.25N/mm$
Standard Deviation S=5N/mm

SELECTION OF WATER CEMENTRATIO:
[According to IS 456-2000, table 5] (i)
W/C=0.45
(ii) W/C=0.45(from fig 1, IS 10262-2019)
W/C=0.45

SELECTION OF WATERCONTENT:
[According to IS 10262-2019, table 2]
From table 2 of IS 10262:2009, Maximum water = 197.16lit(for 100mm slump) for 20mm aggregate.
Required water content = 197.6liters

CALCULATION OF CEMENT CONTENT:
We have, W/C=0.45
Cement content=197.6/0.45
=438.13 kg/m^3
From table5 of IS 456-2000, the minimum cement content. For moderate exposure condition =280kg/m^3
450kg/m^3> 320kg/m^3
Hence ok.

ESTIMATION OF COARSE AGGREGATEPROPORTION:
[According to IS 10262-2009, table 3]
Vol. of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (Zone -2) For water cement ratio 0.50=0.62, But our water content is 0.40 Volume of coarse aggregate is required to be increased to decrease the fine aggregate content, as w/c is lower by 0.10, the proportions of volume of coarse aggregate increased by 0.02.
Volume of coarse aggregate for the water cement ratio=0.64
Volume offineaggregate=0.62-0.01
=0.61

MIXCALCULATIONS:
The mix calculations for unit volume of concrete shall be as follows
Total volume = 1m^3
vol of cement = (mass of cement/ specific gravity of cement)×(1/1000)
= (438.13/3.18) × (1/1000)
= 0.137 m^3
vol. of water = (mass of water/ specific gravity of water) ×(1/1000)
= (197.16/1) × (1/1000)
=0.197 m^3
Volume of add mixtures = Nill
vol. of all in aggregates = [(a-b)-(c+d)]
= [(1-0.01)-(0.137+0.197)]
=0.656m
mass of CA = 0.656 × (vol. of CA) × (specific gravity of CA) ×1000
= 0.656 × 0.61 × 2.78 × 1000

=1130.24 kg
mass of FA = 0.656 × (vol of FA) × (specific gravity of FA) ×1000
= 0.656 × 0.39 × 2.71 × 1000
= 693.32 kg
Mix proportions fortrail(1m)
Cement = 438.13kg/m Water=197.16lit
Fine aggregate = 693.32kg Coarse aggregate =1130.24kg Water cement ratio = 0.45

Mix proportions byweight:Design mix of M30

C	:	FA	:	CA	:	W
438.13	:	693.32	:	1130.24	:	197.16
1	:	1.58	:	2.54	:	0.45

EXPERIMENTAL DETAILS
WORKABILITY:
The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. Workability is one of the

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physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.

DIFFERENT TEST METHODS FOR WORKABILITYMEASUREMENT:

Depending upon the water cement ratio in the concrete mix, the workability may be determined by the following three methods.

a. SlumpTest
b. Compaction FactorTest
c. Vee-bee consistometertest

TESTS TO BE CONDUCTED:

4.Compressive strength
5.split tensile strength
6.flexural strength.

RESULTS & DISCUSSION

Slump Conetest:

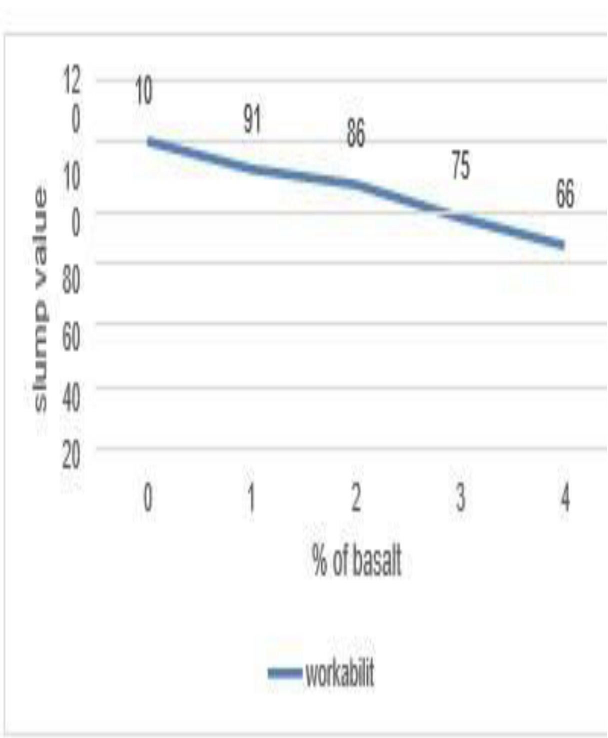

Figure 9: Comparison of workability for different mixes of M30 Grade

From the results it is observed that the workability is decreases with an increase of Glass fiber content over conventional M30 concrete grade.

Compressive strength:

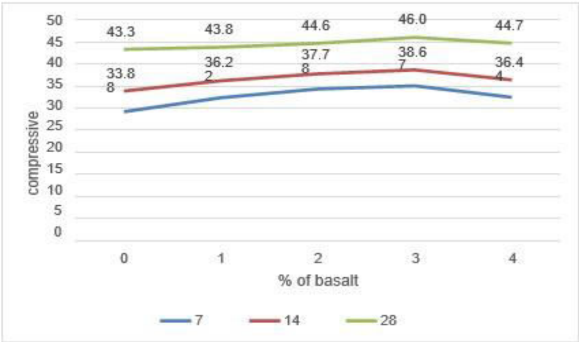

Figure 11: Graph of Compressive Strength comparison at 7, 14 and 28 days for M30 concrete

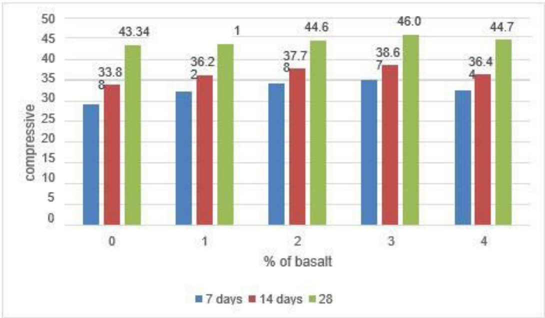

Figure 12: Compressive Strength comparison at 7, 14 and 28 days for M30 concrete

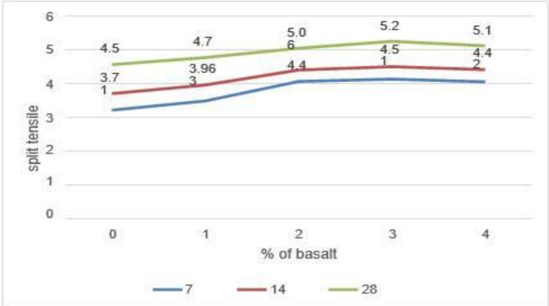

Figure 13: Graph of split tensile Strength comparison at 7, 14 and 28 days for M30 concrete

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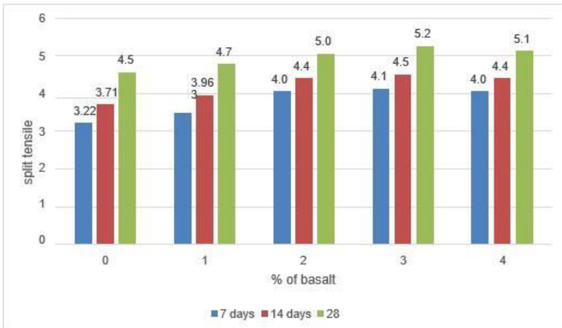

Figure 14: Split tensile Strength comparison at 7, 14 and 28 days for M30 concrete

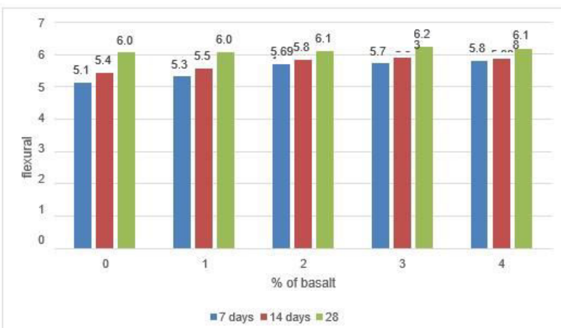

Figure 16: Flexural Strength comparison at 7, 14 and 28 days for M30 concrete

The split tensile strength of concrete varies as 8.5%, 15.9%, 22.6%, 20.6% for M1, M2, M3 and M4 compared with the conventional concrete after 7days of curing.
The split tensile strength of concrete varies as 4.9%, 13.7%, 17%, 16% for M1, M2, M3 and M4 compared with the conventional concrete after 14days of curing.
The split tensile strength of concrete varies as 11.7%, 23.5%, 36.6%, 31% for M1, M2, M3 and M4 compared with the conventional concrete after 28days of curing.

CONCLUSION

- **a.** Glass fiber concrete increases the compressive strength, flexural strength and tensile strength as compared with the conventional concrete.
- **b.** As the percentage of the Glass fiber in concrete increases workability of concrete decreases.
- **c.** From strength point of view, conventional concrete by using Glass fiber shows the positive results.
- **d.** It was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibers than Glass fiber concrete.
- **e.** Glass fiber increases the mechanical properties of concrete.
- f. Glass fibre was found to be amorphous in nature.
- g. It is possible to use Glass fiber in the field of reinforced cement and concrete.
- h. The addition of Glass fiber had a greater compressive and flexural strength at early stages.