Experimental Investigation on Glass Fiber Reinforced Concrete

Mohammed Mukaram[1], Mohammed Khaja Moin Uddin[2], Mir Musaddiq Ali[3], Mir Firasath Ali[4]

[1, 2, 3]B.E Students, Dept. of Civil Engineering, ISL Engineering College, Hyderabad
[4]Assistant Professor, Dept. of Civil Engineering, ISL Engineering College, Hyderabad

---***---

Abstract - *Concrete is a widely used building material because of its special properties, such as high compressive strength and durability. The use of cement in the construction field has increased as urbanization has expanded. Many studies are currently underway in the era of urbanization to use western concrete material in construction to minimize construction costs. With the speed of urbanization increasing, more concrete strength in less time is needed. Glass fiber is one of the most effective materials for adding strength to concrete as an admixture. Today's construction industry demands higher-quality, thinner concrete with high strength. Glass fiber is a material made from extremely fine glass fibers. Glass fiber has exceptional mechanical properties, including high strength, flexibility, stiffness, heat resistance, and chemical resistance. Glass Fiber has mechanical properties similar to polymers and carbon fiber, but it is much less expensive and noticeably less brittle than other fibers. As a result, it is widely used in a variety of applications around the world. The focus of the research is on the strength characteristics of GFRC. According to IS 10262-2009, the concrete was engineered using M25 grade concrete, con plast as a super plasticizer, and a water cement ratio of 0.40. The performance of Cement Concrete with different percentages of Glass Fiber added, such as 0%, 0.5 %, 1%, and 1.5 %. In comparison to Control Concrete, the strength properties of Glass Fiber Reinforced Concrete is investigated.*

***Key Words*: Fiber reinforced concrete, Glass Fibers, compressive, flexural and split tensile strength.**

1. INTRODUCTION

Concrete is a composite material that primarily consists of water, aggregate, and cement. To achieve the desired physical properties of the finished material, additives and reinforcements (such as rebar) are frequently included in the mixture. When these ingredients are combined, they form a fluid mass that can be easily shaped. The cement hardens into a matrix that binds the other ingredients together to form a long-lasting stone-like material with many applications. After water, concrete is the most commonly used material on the planet. Concrete has been used to build landmark monuments for hundreds of years.
Because of the flexibility and durability of concrete, most of these structures have withstood the ravages of war as well as the harshness of the climate. Thanks to advances in materials science, particularly material characterization techniques, concrete technology has advanced rapidly, particularly since the 1950s. Concrete is now studied from an interdisciplinary perspective, with chemistry and materials science taking equal precedence over civil engineering. Another factor that has aided this progress is the development of concrete additives.

The compressive strength of concrete is high, but the tensile strength is low. Various efforts have been made to increase concrete's flexural strength. Additives and additive mixtures come in a variety of forms. The addition of glass fibers adds concrete tension resistance.

1.1 Glass Fiber Reinforced Concrete

GRC (glass-fiber reinforced concrete) is a material made up of a cementation matrix made up of cement, sand, water, and admixtures, with short length glass fibers scattered throughout. Non-structural elements such as façade panels, piping, and channels have been widely used in the construction industry. GRC has a number of advantages, including light weight, fire resistance, a pleasing appearance, and strength. Trial tests for concrete with and without glass fiber are carried out in this study using cubes of different sizes to show the differences in compressive and flexural strength.

Fig -1: Sample glass fibers

1.2 Research Objective

Because plain concrete is brittle by nature, the need to transform it into a ductile material is critical. The use of fibers as a randomly dispersed reinforcement is an alternative solution; the presence of fiber improves tensile, flexural, and ductility, as well as being much more effective at regulating cracking at the aggregate–matrix interface, but it reduces workability. The addition of a superplasticizer will improve the workability of the material.

2. LITERATURE REVIEW

•**AyeshkumarPitroda -**The additionof glass fiber into the concrete mixture possibly enhances the compressive strength at 28 days. The 0.1% expansion of glass fiber into the concrete shows better outcome in mechanical properties and solidness. It utilizes less cement than comparable cement and also often utilizes critical amounts of reused materials (as a pozzolan),GFC qualifies as economical.

•**Vinay Kumar Singh:** At the point when the primary crack happens in the matrix, the solid fiber get the heap. That help is more stronger than the matrix, so the following crack must happen somewhere else. Additional crack includes just new breaks, promptly captured, instead of making first crack proliferate.Disappointment creates as a progressive, as - plastic yielding. The addition of fibers into the concrete mixer improves the compressive strengthat 28 days yetthere is 60% increment in flexural strengthwith the addition of 0.7% fiber in concrete.

•**J. D. Chaitanyakumar:** The addition ofthese Fibers into concrete can significantly expand the compressive for sanitation, beautifying non recoverable shape work and different items. It is material made from extremely fine fibers of glass. Fiber glass is a lightweight, greatly strong, and robust material. Despite the fact that Its mass strength and weight properties are also very favorable when compared to metal, and it very well may be effortless shaped utilizing forming forms.Glass is themost established, and most commonplace, execution Fiber.

•**Chandramouli K. and Srinivasa Rao P.:** Glass Fibers improve the strength of the material by expanding the power required for distortion and enhance the sturdiness by expanding the vitality required for break proliferation. The benefit of pre-stressing on innovation using steel reinforcement as high tensile steel wires have helped in defeating the insufficiency of concrete in pressure but the ductility size of compressive strength. This might be credited to the reality Fibers suppress the confinement of miniaturized into full micro cracks and therefore the obvious tensile strength of the network increases. It was seen that the expansion of glass Fibers, the compaction factor of 0.93 to 0.97 was kept up for all evaluations of cement.

•**M. H. Rahman, et al (b) (2016)** This research paper states that chemical composition of clear and colored glass are very much similar and they could be considered as pazzolanic materials and the results of the study depicts that there is 2% increase in the strength by using 20% replacement of cement by glass powder and it has also stated that for every six ton usage of glass powder reduces up to one ton of CO2 production which is very eco friendly as well as there will be 14% of reduction of cost it also results to be economical.

3. MATERIALS AND METODOLOGY

The materials used in the preparation of Concrete are:
1. Cement
2. Fine aggregate i.e., Natural Sand
3. Coarse aggregate
4. Water
5. Glass Fibers

To produce good quality of concrete we need good quality ingredients which satisfy the Standards. Hence tests on different ingredients mentioned above are conducted as per IS standards which are presented below. Properties are represented in the form of Tables for every material used in the production of Concrete.

Cement

Portland Pozzolana Cement of 43 grade of AMBUJA brand confirming to I.S is used in the present work. The cement is tested for its various properties as per IS: 4031 – 1988 and found to be confirming to the requirements as per IS: 1489-1999 Part-1. In order to avoid the possible variation in the properties of cement from various batches all the specimens are prepared from the same batch of cement. The results of tests concluded on cement are as follows.
Cement - Portland Pozzolana Cement
Brand Name - Birla gold cement
Specific Gravity - 3.1

Fine Aggregate – Natural Sand:

Sand which is passed on 4.75mm sieve & retained on 150µ sieve are used

Physical Properties of Natural Sand

S.NO	PROPERTY	VALUE	REQUIREMENTS AS PER IS 383
1	Fine Aggregate	Sand	As per Indian Standards
2	Specific Gravity	2.65	2.6-2.8
3	Water Absorption	0.25%	Should not be > 1% for construction
4	Density	1450 gm/cc	Within the Code Provisions
5	Fineness Modulus	2.74	2.6-2.9

Table -1: properties of natural sand

Coarse Aggregate:

The Coarse aggregate is free from clay matter, silt and organic impurities etc. the coarse aggregate is also tested for specific gravity and it is 2.82, fineness modulus of coarse aggregate is 4.07. Aggregate of normal size 20 mm downgraded 60% passed on 20.0 mm sieve and remaining 40% is taken from the sieve 10.0 mm (passing) and 4.75

mm (retained) is mostly used in the experimental works, which is acceptable according to IS: 383– 1970

Properties of Coarse Aggregate

S .no	Property	Value	Requirements as Per IS 383
1	Coarse Aggregate	Machine crushed granite	Within the Code Provisions
2	Specific Gravity	2.75	2.6 to2.8
3	Water Absorption	0.33%	Should not be >1%
4	Fineness Modulus	7.78	6.5-8.5
5	Shape Tests a)Elongatio		as per IS 2386part 1, the flakiness

Table -2: properties of coarse aggregates

Water:

About 38% of cement At Normal Room Temperature = 550ml.

Glass Fiber

The Glass fiber used should be high-quality Alkaline–Resistant glass fiber which is designed to reinforce cements and other alkaline matrix.

Properties of Glass Fibre

S. No.	CHARACTER	GLASS FIBERS
1	Number of fibres	212 million/kg
2	Aspect ratio	857:1
3	Typical addition rate	0.6 to 1.0 kg/m3 of concrete
4	Tensile strength	1700 Mpa
5	Modulus of elasticity	72 Gpa
6	Corrosion resistance	Excellent
7	Specific gravity	2.7
8	Density	26 KN/m3
9	Filament diameter	13-14 μ
1o	Filament length	9 mm

Table -3: properties of glass fibers

Mix Design

The selection of suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible is termed the concrete mix design. The mix design of the concrete has been carried out based on IS 10262 – 2009. In this Experimental study we are using M-25 grade concrete. The factors affecting the strength of concrete at a given age and cured at prescribed temperature is the degree of compaction.

Mix Design / Material Proportions (Codes) It was found that the cement concrete was dark in color and was cohesive. The amount of water in the mixture played an important role on the behavior of fresh concrete. When the mixing time was long mixture with high water content bleed and segregation of aggregates and the paste occurred. This phenomenon was usually followed by compressive strength of hardened concrete.

Fig -2: Batching of aggregates

The specimens of standard sizes and required shapes of different mix proportions were casted for 7, 14, 28, days and curing process is carried out after 24hrs from casting time.

Fig -3: Casted Specimens

4. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

4.1 Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Sl.no	Mix (days)	Fiber Content	Cube
			Compressive strength (N/mm^2)
1	7	0%	29.8
		0.5%	35.2
		1%	40.9
		1.5%	33.9
2	28	0%	33.5
		0.5%	38.5
		1%	45.6
		1.5%	36.1

Table -4.1: Compressive Strength values

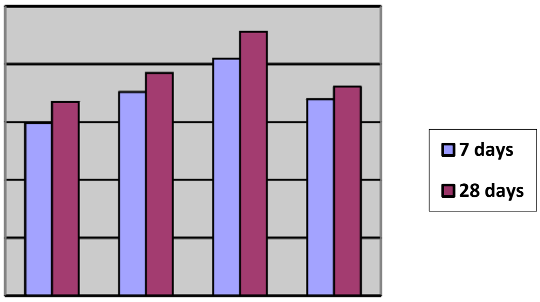

Chart -4.1: Compressive Strength

4.2 Split Tensile Strength

The split tensile test were conducted as per IS 5816:1999. The size of cylinder is 300mm length with 150mm diameter. The specimen were kept in water for curing for 7 days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

Sl.no	Mix (days)	Fiber Content	Cylinder
			Split Tensile strength (N/mm^2)
1	7	0%	1.41
		0.5%	2.83
		1%	2.62
		1.5%	2.43
2	28	0%	3.4
		0.5%	3.92
		1%	3.57
		1.5%	3.42

Table -4.2: Split Tensile Strength values

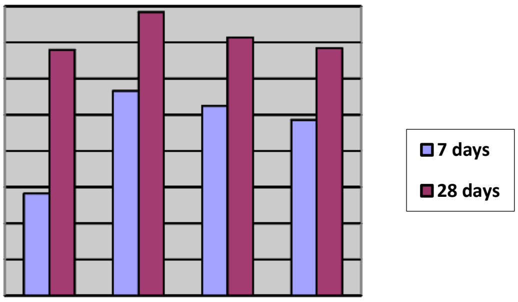

Chart -4.2: Split Tensile Strength

4.3 Flexural Strength

The Flexural test were conducted as per IS 516:1959. The size of beam is 100mm*100mm*500mm. The specimen were kept in water for curing for 28 days and on removal were tested in wet condition by wiping water and grit present on the surface. The test is carried out by placing a Beam specimen horizontally such that the load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints.

Sl.no	Mix (days)	Fiber Content	Beam
			Flexural strength (N/mm^2)
1	7	0%	2.40
		0.5%	2.46
		1%	2.65
		1.5%	2.51
2	28	0%	2.82
		0.5%	3.09
		1%	3.4
		1.5%	3.24

Table -4.3: Flexure Strength values

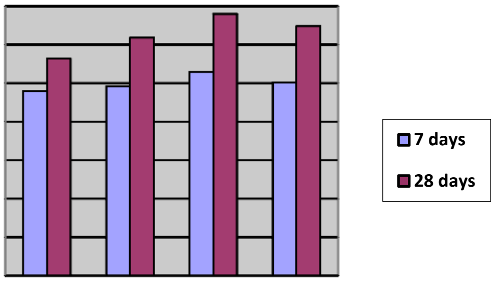

Chart -4.3: Flexural Strength

5. SUMMARY AND CONCLUSIONS

The primary aim of this research is to determine the effectiveness of using commercially available glass fibers as an additive in cementitious materials to enhance the mechanical properties of traditional concrete and increase the flexibility of concrete structures to avoid cracking and spalling.

As a consequence of the experiments and their findings, the following conclusions were drawn.

The experimental trials showed that adding glass fibers to concrete enhanced the strength properties of the concrete.

Glass fiber improves tensile strength by preventing micro cracks from being macro cracks. The use of glass fiber in concrete gives it strength and durability.

The conventional mix & M25 achieves a compressive strength of 33.5 N/mm2, Split tensile strength values of 3.4 N/mm2 and Flexural strength of 2.82 N/mm2 for 28 days of curing.

Compressive, flexural and split tensile strength of Glass Fiber Reinforced Concrete are maximum at 1% fiber content.

The compressive strength obtained at 1% fiber content is 45.6 N/mm2 which is 36% higher than the reference concrete strength with 0% fiber content.

The maximum split tensile strength attained at 0.5% fiber content is 3.92 N/mm2.

The maximum flexural strength obtained at 1% fiber content is 3.4 N/mm2, which is 20% higher than the reference concrete strength with 0% fiber content.

It was observed that cracking resistance of the concrete specimens improved to a greater extent and the specimens were intact with each other even after the failure of specimen under loading thus making it a non brittle failure.

ACKNOWLEDGEMENT

We are thankful to **Dr. Mohammed Masood,** Principal, ISLEC, for his encouragement throughout the project. We would also like to express our heartfelt thanks to **Ms. K. Nanchari,** Head of Civil Engineering Department, ISLEC for her help and unending cooperation with us during completion of this work.

REFERENCES

Asst.Prof. B. Radha Kiranmaye, Asst.Prof D. Tarangini, Asst.Prof K.V Ramana Reddy (2018), "Effect of glass fiber on properties of pervious concrete", Vol.09, Issue -4.

G. M. Sadiqul Islam, M. H. Rahman, Nayem Khazi (2017), "Waste glass powder as partial replacement of cement for sustainable concrete practice", International Journal of Sustainable Built Environment, 6.37-44.

Harish. B. A, Hanumesh. B. M, Siddesh. T. M, Siddhalingesh. B. K (2016), "An Experimental Investigation on Partial Replacement of Cement by Glass Powder in Concrete", International Research Journal of Engineering and Technology, Vol.03, Issue10.

Hosana. S, Snega. S, Prasitha. T (2019), "Analysis of Glass Powder as a partial replacement of cement in concrete ", International Journal of Research in engineering and Technology, Vol. 07, Issue-11.

Jose Marcos Ortega, Viviana Letelier, Carlos Solas, Marina Miro, Glacomo Moriconi, Miguel Angel Climent, Isidro Sanchez (2018)," Influence of Waste Glass Powder Addition on the Pore Structure and Service

Asst. Prof. Mithun Sawant, Daksha Dande, Shivani Sabde, Rutuja Bhalsing, Praful Yadav, Nilesh Ranjan, (2017), "Pervious Concrete with glass fiber", International Journal of Research in Advent Technology, Vol.5, No.-5.

M R V S G Guptha, P Uma, K Santosh (2018), "Performance Evaluation on Pervious Concrete by Partial Replacement of Glass Powder", International Journal of Technical Innovation in Modern Engineering and Science, Vol. 4, Issue-12.

Ali, M. F., Ali, S. H., Ahmed, M. T., Patel, S. K., & Ali, M. W. (2008). Study on Strength Parameters of Concrete by adding Banana Fibers.

Sukamal Kanta Gosh, Ananya Chaudary, Rohan Datta, D. K. Bera, "A Review on Performance of Pervious Concrete Using Waste Materials", International Journal of Research in Engineering and Technology, Vol. 04, Special Issue-13.

BIOGRAPHIES

Mir Firasath Ali, Assistant Professor, Department of Civil Engineering, ISLEC, Hyderabad, India

Mohammed Mukaram, Student, Department of Civil Engineering, ISLEC, Hyderabad, India

Mohammed khaja Moin Uddin, Student, Department of Civil Engineering, ISLEC, Hyderabad, India

Mir Musaddiq Ali, Student, Department of Civil Engineering, ISLEC, Hyderabad, India