AN EXPERIMENTAL STUDY OF COMAPRISON OF STRENGTH OF GLASS FIBRE REINFORCED AND CONVENTIONAL CONCRETE OF M-30 GRADE

Apurva Gaur[1] Ranoo Sharma[2] Shraddha Srivasatava[3] Gautam Singh[4] Vivek Kumar[5]

[1]Undergraduate , Civil Engineering Department, Buddha Institute of Technology (India)
[2]Assistant Professor, Civil Engineering Department, Buddha Institute of Technology (India)
[3,4,5]Undergraduate , Civil Engineering Department, Buddha Institute of Technology (India)

ABSTRACT

Glass-Fibre reinforced concrete (GRC) is a material made of cementatious matrix composed of cement, sand, water and admixtures, in which short length glass fibre are dispersed. GFRC has been widely used in construction industry for non-structural elements, like facade panels, piping and channels. GRC offers many advantages such as being light weight, fire resistance, good appearance and strength. In this study trial tests for concrete with glass fibre and without glass fibre are conducted to indicate the difference in compressive strength and flexural strength by using cubes of varying sizes. 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. It is a recent advancement in the construction technology since it is light in weight therefore, bringing economy in the construction. Steel is replaced by the glass fibre helps in avoiding structural deterioration and corrosion in reinforced concrete structures. Keeping in mind about the global environmental conditions many alternatives are searched to increase the strength, durability, shrinkage characteristics and serviceability of concrete. Hence, here Glass Fibre is added and tests have been performed with varying percentage of 1% and 2% of cement by adding as an admixture.

Keywords— Glass Fibre, Light Weight, Economic, Eco-Friendly, Compressive strength, Flexural strength, Serviceability.

INTRODUCTION

The construction industry is revolutionizing in two major ways. One way is the development of construction techniques, such as using automated tools in construction. The other is the advancement in high-performance construction materials, such as the introduction of high strength concrete. Among these

high-performance materials, fibre reinforced concrete (FRC) is gradually gaining acceptance from civil engineers. In recent years, research and development of fibres and matrix materials and fabrication process related to construction industry have grown rapidly. Their advantages over other construction materials are their high tensile strength to weight ratio, ability to be molded into various shapes and potential resistance to environmental conditions, resulting in potentially low maintenance cost. These properties make FRC composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which can apply to various types of structure, for example offshore platforms, buildings and bridges.

Concrete is the most versatile construction material of use next to water. The simplest reason for its extensive use in the construction of almost all civil engineering works is that the properties can be controlled within a wide range by using appropriate ingredients and by special mechanical, physical land chemical processing techniques. Concrete is the most widely used construction material having several desirable properties like high compressive strength, stiffness and durability under usual environmental conditions. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. This shortcoming is offset by providing steel bars at appropriate locations at the time of casting the members to take up the tensile stresses and sometimes the compressive stresses if required Normally reinforcement consists of continuous deformed steel bars or pre-stressing tendons. The advantage of reinforcing and pre-stressing technology utilizing steel reinforcement as high tensile steel wires have helped in overcoming the in capacity of concrete in tension but the durability and resistance to cracking is not improved. These properties can be improved by the use of fibres in the concrete. It has been revealed that concrete reinforced with a permissible amount of fibre acquires better performance in compression, flexure, toughness and energy absorption, in which the degree of improvement relies on the types of fibres used. Experiment shave been carried out by several investigators using fibres of glass, carbon, asbestos, polypropylene etc. More over fibres also helps in restricting the growth of micro-cracks at the mortar-aggregate interface thus transforming an inherently brittle matrix i.e. cement concrete with its low tensile and impact resistances, into a strong composite with superior crack resistance, improved ductility and distinctive post cracking behaviour prior to failure.

Glass fibre–reinforced concrete (GFRC) is a type of concrete which basically consists of a cementitious matrix composed of cement, sand, coarse aggregate, water, polymer and admixtures, in which short length glass fibres are dispersed. In general, fibres are the principal load-carrying members, while the surrounding matrix keeps them in the desired location sand orientation, acting as a load transfer medium between the fibres and protecting them from environmental damage. In fact, the fibres provide reinforcement for the matrix and other useful functions in fibre-reinforced composite materials. Glass fibres can be incorporated into a matrix either in continuous or discontinuous (chopped) lengths. Glass fibres have large tensile strength and elastic modulus but have brittle stress strain characteristics and low creep at room temperature. Glass fibres are usually are usually round and straight with diameters from 0.005 mm to 0.015 mm. Different types of glass fibres are available in the market having different length, diameter and aspect ratio. In the present study alkali resistant glass fibres were used throughout the experiments. The study comprises of a comparative study of some of the properties of concrete for two different grades of concrete by varying the percentages of fibres. The aim of this study was to identify the improvement in strength characteristics of concrete with the addition of glass fibre. In the study, glass fibre is added to concrete and Plain Cement Concrete (PCC) is used as reference to study its effect on flexural, compressive and tensile strength properties and also drying shrinkage. Fibre is coated with oil so as to decrease the water absorption. Some of the advantages being observed are low-cost, low density, reasonable specific strength, good thermal insulation, reduced wear and ability to be recycled with minimal impact on environment (Majid Ali et al.,2011). Thus, in addition to the enhancement in the physical properties of concrete, it turns out to be a sustainable waste management technique.

STUDY AREA AND DATA COLLECTION

GFRC over Conventional Concrete-

Lighter weight- With GFRC, concrete can be cast in thinner sections and is therefore as much as 75% lighter than similar pieces cast with traditional concrete. An artificial rock made with GFRC will weigh a small fraction of what a real rock of similar proportions would weigh, allowing for lighter foundations and reduced shipping cost.

High strength- GFRC can have flexural strength as high as 4000 psi and it has a very high strength-to-weight ratio.

Reinforcement: Since GFRC is reinforced internally, there is no need for other kinds of reinforcement, which can be difficult to place into complex shapes.

Toughness- GFRC doesn't crack easily it can be cut without chipping.

Adaptability- Sprayed or poured into a mould, GFRC can adapt to nearly any complex shape, from rocks to fine ornamental details.

Sustainable- Because it uses less cement than equivalent concrete and also often uses significant quantities of recycled materials (as a pozzolona), GFRC qualifies as sustainable**.**

NEED FOR STUDY - GFRC derives its strength from a high dosage of AR glass fibre. While compressive strength of GFRC can be quite high, its very high flexural and tensile strengths that make it superior to ordinary concrete. Essentially the high dose of fibres carries the tensile loads and make it more flexible without cracking. GFRC is used to make large, light weight panels that are often used as facades. So there is a reduction in total cost of material used. So, due to its better structural properties and reduced cost with high strength we need to study its properties for further optimum use of it.

MATERIALS

1.Cement- OPC 43 grade of Cement was used and is conforming to IS 12269:2013. The physical properties are given as under -

- Specific Gravity= 3.16
- Normal Consistency =26%
- Fineness=8%

2. Coarse Aggregate- Crushed angular aggregate of maximum 20mm. The physical properties are given as under-

- Specific Gravity 2.6,
- Crushing Value 12.42%,

- Abrasion Value 14.5%,
- Impact Value 11.2%.

3. Fine Aggregate- Locally available river sand used. The physical properties are given as under-

- Specific Gravity 2.4
- Water Absorption 0.8%
- Bulking of sand 11.9%

4. Water- Fresh portable drinking water should be used for curing and casting of specimen.

5. Admixture- Con plast was used as a super plasticizer at the rate 1% & 2% by weight of Cement. This was in liquid form.

6. Glass Fibre- The Glass Fibre is of Cem-FIL with filament diameter14 microns, length 12mm, aspect ratio of 857.1, tensile strength 2500Mpa, elongation breaks 3.6%, modulus of
elasticity 70Gpa, density 2780 kg/m^3, white colour, and chopped strand fibre type and of type alkali resistant are used in this experimental study.

Composition of AR Glass Fibre

S.no	Compound	Composition (Parts by Weight)
1.	SiO_2	50-60
2.	Al_2O_3	1-11
3.	ZrO_2	4-10
4.	ZnO	0.5-7
5.	Group I A Oxide	10-19
6.	Group II A Oxide	3-15

EXPERIMENTAL PROCEDURE

NOMINAL MIX DESIGN

IS 456: 2000 provides a more precise nominal mix proportions for different grades of concrete in terms of total mass of aggregates, proportions of fine to coarse aggregate and volume of water to be used per 50 kg (1 bag) of cement.

The concrete mix used in this project is M30. Mix proportion for M30. grade of concrete is 1:1.62:2.07 (cement: fine aggregate: coarse aggregate).

So, theoretically, for 1 cubic meters of M30 concrete, we need to have 0.155 cubic meters of cement.

For casting 1 cube, weight of quantities required:

- Weight of cement- 1.748kg
- Weight of fine aggregate- 2.832 kg
- Weight of coarse aggregate- 3.619 kg

- Total weight of 1 cube- 1.748+2.832+3.69 = 8.199 kg

STIPULATIONS FOR PROPORTIONING

- Grade designation: M30
- Type of cement: - OPC
- Max nominal size of aggregate: 20mm
- Min cement content: 320 kg/m^3
- Max water cement ratio: 0.40.
- Workability: 120mm (slump).
- Exposure condition: Mild (for reinforced concrete).
- Degree of supervision: Good.
- Type of aggregate: Crushed angular aggregate.
- Max cement content: 450 kg/m^3

Test Data for Materials

- Cement used: OPC
- Standard consistency of cement: 34%
- Initial setting time of cement: 34 min
- Final setting time of cement: 500 min
- Specific gravity of cement: 3.09 g/cc

1. Specific gravity of -

- Coarse aggregate: 2.84
- Fine aggregate: 2.64

2. Water absorption of-

- Coarse aggregate: 0.5%
- Fine aggregate: 1%

3.Free surface moisture of-

- Coarse aggregate: Nil
- Fine aggregate: Nil

4) Bulk density of

- Coarse aggregate: 1.37 kg/l
- Fine aggregate: 1.78 kg/l

5) Sieve analysis

- Coarse aggregate: Fineness modulus = 6.91
- Fine aggregate- Fineness modulus = 2.814 and conforming to grading zone II, Table 4 of IS 383.

Fig. Casting of Cube (Glass Fibre)

RESULTS AND DISSCUSION

- Compressive strength

a) Conventional Concrete Cube (M30 Grade)

S.no	Compressive Strength (N/mm^{2})	
	7 Days	28 Days
1.	15.71	20.07
2.	16	22.22
3.	19.22	25.37

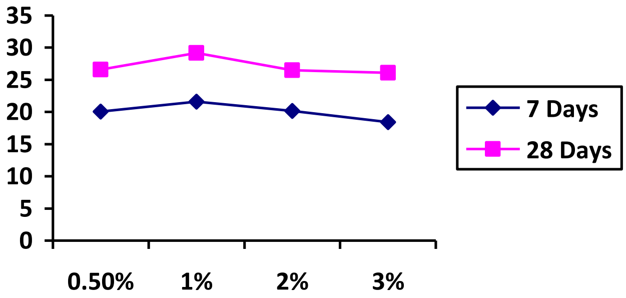
Effect of Compressive strength on Glass Fiber Concrete:

This figure represents the graph between the Compressive strength vs % of glass fibre. The glass fibre is added at the rate of 1% & 2%. Out of these the compressive strength is very high at 1% having for 7 days is 21.59 N/mm^2 and for 28 days is 29.18 N/mm^2.

Fig. Compressing of GFRC

ISBN : 978-93-87793-80-4

S.NO	M30 + Glass fibre	Compressive strength (N/mm²)	
		7 days	28 days
1.	0.5%	20.08	26.60
2.	1%	21.59	29.18
3.	2%	20.18	26.48
4.	3%	18.4	26.10



APPLICATIONS

1. In Architecture as Claddings
2. In Buildings as roofing, renovation etc.
3. In Engineering as bridges and tunnels, permanent framework etc.

CONCLUSION

These are the conclusions made by the experimental results:

- Analysis of results shows that there is an increase in compressive strength of conventional concrete cube by mixing alkali resistant glass fibres in it.
- Maximum compressive strength was obtained by mixing glass fibre as 1% by weight of the whole concrete mix, further increase gives slight deflection from the maximum strength.
- There was about 28.16% increase in compressive strength by mixing 1% by weight of glass fibres.
- Use of glass fibre is economic & appropriate method to obtain high strength concrete s panels obtained require less material and are of high strength.
- Thus, alkali resistant glass fibre can be successfully used in conventional concrete as are placement for reinforcement to obtain panels of less weight and dimension and high strength.

FUTURE SCOPE

GFRC is a composite material comprising a mixture of hydraulic cement, silica sand, alkali resistant (AR) glass fibres and water. The glass fibres effectively reinforce the mortar mix thereby improving its tensile and flexural characteristics. GFRC is a particularly attractive and durable cladding material. It can be moulded into a wide variety of complex shapes and profiles and is ideally suited to the popular fast-track. Approach of using lightweight, prefabricated cladding panels for the exteriors of modern buildings. The main advantage of GFRC panels over the corresponding precast concrete alternatives is the considerable saving in weight. This results in significant savings in the costs of transportation, handling and erection of the panels. If this weight advantage is considered at the design stage, it should be possible to effect substantial economies in the design of foundations and superstructures for high rise building constructions. Other notable advantages of GFRC cladding are its durability, chemical resistance, non-combustibility and good sound/heat insulation properties.

GFRC is used extensively in the architectural and civil engineering fields with the main products being:

- Cladding
- Permanent formwork
- Slates/Roof features
- Cornices
- Coping units
- Canopies
- Porticos
- Walkway roofs/Walls
- Sunscreens
- Artificial Rocks
- Drainage Channels
- Street Furniture
- Planters
- Arches
- Balustra Ding
- Box Beams
- Cable Trays
- Conservatory Walling
- Domed Roofs
- Door Surrounds
- Gutter units
- Sound barriers
- String course features.

REFRENCES

- *J.D.Chaitanya Kumar*, Experimental Studies on Glass Fibre Concrete (AJER), 2016.
- *Komalchawla*, studies of glass fiber reinforced concrete composites (IJSCER), 2013.
- *Eng. Pshtiwan N. Shakor*, Glass fibre Reinforced Concrete Use in Construction (IJTES), 2011.
- Practical Design Guide, International GRCA Technical Committee, Version 1.0.
- *C. Selin Ravikumar*, Glass Fibre Concrete: Investigation on Strength and Fire resistant properties, (IOSR-JMCE),2013
- “GRC for Architects and Engineers, GRC in Action UK”, GRCA International, 2003.
- Masuelli, M. A., “Fiber Reinforced Polymers–The Technology Applied for Concrete Repair”, Open Access E–Book, 2013.
- Afroughsabet, V., Biolzi L., Özbakkaloğlu, T., “High–Performance Fiber–Reinforced Concrete: A Review”, J. Mater. Sci., 2016, 51: 6517–6551.
- Masood, U., “Studies on Characteristics of Mixed Fiber Reinforced Concrete for Structural Applications”, Jawaharlal Nehru Technological University, Hyderabad, PhD Thesis, 2014.
- Ferreira, J. P. J. G., Branco, F. A. B., “The Use of Glass Fiber–Reinforced Concrete as a Structural Material”, Experimental Techniques, May–June,2007, pp. 64–73
- Bartos, P. J. M., “Review on the Performance of Glass Fiber Reinforced Concrete”, IOP Conf. Series: Materials Science and Engineering, Scotland, 2017, 246.
- Girard, J., “Introduction to GFRC (Glass Fiber Reinforced Concrete)”, The Concrete Countertop Institute, 2008.
- Bentur, A., Mindess. S., “Fiber Reinforced Cementitious Composites”, Second Edition, Taylor and Francis Group, London and New York, 2007.
- Zollo, R. F., “Fiber–Reinforced Concrete: An Overview after 30 Years of Development”, Cement and Concrete Composites, 1997, 19(2): 107–122
- “Design, Manufacture and Installation of Glass Reinforced Concrete (GRC)”, GRC Industry Group of National Precast Concrete Association, Australia, October 2006, pp. 29–32.