EXPERIMENTAL STUDY ON THE COMPRESSIVE STRENGTH OF GLASS FIBRE CONCRETE

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Abstract

Glass Fibre Reinforced Concrete is recent introduction in the field of concrete technology. The present day world is witnessing the construction of very challenging and difficult Civil Engineering Structures. Concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Concrete the most widely used construction material has several desirable properties like high compressive strength, stiffness, durability under usual environmental factors. At the same time concrete is brittle and weak in tension. Efforts are being made in the field of concrete technology to develop high performance concretes by using fibres and other ad- mixtures in concrete up to certain proportions. To improve the concrete properties, the system was named alkali resist- ance glass fibre reinforced concrete in the present view the alkali resistance glass fibre has been used. In the present experimental investigation the alkali resistance Glass Fibres has been used to study the effect on compressive strength on M30 grades of concrete.

GFRC can be used wherever a light, strong, weather resistant, attractive, fire resistant, impermeable material is re- quired. It has remarkable physical and mechanical assets. GFRC properties are dependent on the quality of materials and accuracy of production method. Despite its wide range applications in architecture the chief goal is to show and introduce important structural purposes, for instance: anti rust characteristics of GFRC made it a good replacement for water and sewer pipes and tanks, a thin protective layer of GFRC on concrete beams and columns can increase their durability in fire as well as low temperatures and generally it is a good replacement for susceptible materials in difficult environments.

INTRODUCTION

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from a cylindrical water storage tank to be rectangular beam or column in a high-rise building Conventional concrete is composed of aggregates (sand, gravel...), cement, water and ad- mixtures where it is necessary. Concrete with a uniform structure, good plasticity and the ability of deformation by form, sound and thermal insulation and the capability of quality development by admixtures, is getting more and more popular in structural industries every day. Consid- ering all the concrete benefits, we cannot deny its weak- nesses. The first fundamental problem of concrete is low tensile strength which is approximately 10%-15% of its compressive strength nevertheless this crucial problem can be solved by the reinforcement.

In addition, reinforcement must be calculated to prevent brittle failure in order to have plastic behavior; the maxi- mum standards must be respected to prevent corrosion of reinforcement

Fibre reinforced concrete

Fiber reinforced concrete is relatively new constructional material developed through extensive research and devel- opment work during the last three decades. The fibers are randomly oriented, discrete, discontinuous elements made from steel, glass or organic polymers (Synthetic Fibers). The fibers are introduced in the matrix as ‘micro reinforcement’ so as to improve the tensile strength by delaying the growth of cracks, and to increase the tough- ness by transmitting stress across a cracked section so that much larger deformation is possible beyond the peak stress. The prime objective of usual natural fibers such as straw in brick making has always been to alter and improve the properties of the brittle matrix. When two dif- ferent kinds of materials with contrasting properties of strength and elasticity are combined together, they realize a great portion of the theoretical strength of the stronger component, and these combined materials are called two- phase materials.

Types of Fibres

Fibres are classified into two categories namely hard in- trusion and soft intrusion. Fibres having a higher elastic modulus than the cement matrix can be termed as hard intrusion and fibers having a lower elastic modulus are called as soft intrusion.

Steel Fibres Glass
Fibre Synthetic
Fibres

Carbon Fibres
Acrylic Fibres
Aramid Fibres
Nylon Fibres
Polyester Fibre
Polyethylene Fibre
Polypropylene Fibres
Natural Fibres
Unprocessed Natural Fibres
Processed Natural Fibres

Development of fibre reinforced concrete

Reinforcement, which could be moulded into shaped dur- ing the casting of concrete, or even included in the origi- nal mix, has long been the aim of many researches. The quest for new material as substitute for the existing ma- terial or finding a new or better use of known materials is very much accelerated but the socio-economic neces- sities. It is well-established fact that generally a material in fibrous form has much higher strength than in bulk form. Composite materials are being developed are used increasingly as they have advantaged in combining the merits of individual components and obviating their indi- vidual shortcomings as much as possible. Based on these concepts, a great amount of effort is currently put into research on use of thin, high strength fibre of steel, glass, plastic etc, in concrete mix.

General requirement of fibre reinforced concrete

The most exploitable form of the fibre composites will be in the use of short discontinuous fibers in either two-dimensional planner orientation as in thin section like shells, folded plate, etc, or in the random three directions as in thick sections like beams etc. Generally, econom- ic consideration will dictate the choice and volume per- centage of the fibres to be used. The basic requirement of fibres for improving the properties of concrete is high tensile strength elastic modulus, adequate extensibility, a good bond at the interface and good chemical stability. The fibres should be capable of withstanding the stresses for a long period i.e, they should be durable. The tensile strength of fibers may not be critical, if the composite fails by the fiber pullout, but if the fibres yield on fracture, then their strength plays an important role in determin- ing the strength capability of the composite.

Role of fibres

The role of fibres is especially to arrest any advancing crack by applying pinching force at the crack tips, thus delaying their propagation across the matrix. The ul- timate cracking strain of the composite is increased to many times greater than that of the unreinforced matrix. Unlike the conventional bars, the discrete fibres are dis- persed uniformly throughout the matrix hence they can be more beneficial in arresting the growth of any advanc- ing crack.

Introduction to glass fibre reinforced concrete (GFRC)

Glass fibre is a material consisting of numerous extremely fine fibres of glass. Glass fibre is commonly used as an insulating material. It is also used as a reinforcing agent for many polymer products to form a very strong and light fibre reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as “fibre glass”. Fiberglass is a light weight, extremely strong, and robust material. Although strength properties are some- what lower than carbon fibre and it is less expensive. Its

bulk strength and weight properties are also very favora- ble when compared to metals, and it can be easily formed using moulding processes.

Normal or E-glass is affected in the presence of alkalin- ity where as alkali-resistant glass fibre by trade name “CEM-FIL” has been developed and used. Cem-Fil alkali resistant (AR) glass fibres have been in use for 40 years in more than 100 countries worldwide to create some of the world’s most stunning architecture while offering strong and durable performance in widely varying cement and mortar based applications, including flooring, renders, top screeds, tunnels, utility poles, etc. Cem-FIL AR glass fibres are unique as a concrete reinforcement. Cem-Fil fibres have the same specific gravity as the aggregates, so assured fibre dispersion is easier to achieve than with other fibres.

CEM-FIL glass fibre

The CEM-FIL glass fibres contribute to crack control, per- meability and flexibility. This improves the durability of concrete.

Control of cracking

CEM-FIL glass fibres prevents the shrinkage cracks de- veloped during curing making the structure / plaster / component inherently stronger. Further when the loads imposed on concrete suddenly cause cracks and propa- gate rapidly. Addition of CEM-FIL glass fibres in concrete and plaster prevents / arrests such cracks.

Need for the present work

The advent of high strength concrete has helped construc- tion activity in many ways for example to build high rise buildings by reducing column sizes and increasing avail- able space and to put the concrete into service at much earlier age etc. concrete the most widely used structural material in the world is prone to cracking for a variety of reasons. These reasons may be attributed to structural or environmental factors, but most of the cracks are formed due to inherent weakness of the material to resist tensile forces, when it shrinks and it is restrained, it will crack. The randomly oriented fibres assist in controlling the propagation of micro-cracks present in the matrix, first by improving the overall cracking resistance of the matrix and later by bridging across even smaller cracks formed after the application of load on to the member, thereby preventing their widening into major cracks. Thus proper introduction of fibres in concrete improves both mechani- cal properties and durability.

Scope of present work

1. Review and research of glass fibres
2. Construct the concrete specimen by twenty seven cubes by partial replacement of cement by fibre with different percentages (0.8%, 1.2%, 1.5%) by weight of cement.
3. Investigation and laboratory testing on concrete cube.

4. Analysis the results and recommendation for further research work.

Summary

In this chapter, theoretical study on ordinary Portland ce- ment, Glass Fibre Reinforced Concrete and materials and classification. Also the scope and objective of the present study are discussed. Based on the objective of the pre- sent study, research papers were collected and studied. The review of research papers is discussed in the next chapter.

LITERATURE REVIEW

The applications of Glass Fibre Reinforced Concrete are getting wider day by day. This research is going on in many countries and some reviews are as follows:

Shah and Naaman (1976) carried out an investigation to determine the tensile, flexural and compressive strengths of concrete specimens reinforced with different lengths and volumes of steel and glass fibres. The tensile or flex- ural strengths of reinforced specimen was at most two to three times that of plain concrete while the corresponding strains or deflections were as much as ten times that of plain concrete. The stresses and strain at first cracking were not significantly different from those of plain con- crete. Extensive micro cracking were observed on the sur- face of failed flexural specimens indicating a significant contribution of the matrix even after the first cracking. For steel fibre reinforced specimens, the peak loads and deformations appear to be linearly related to the fibre pa- rameter: Vf L/D. after failure, steel fibres pulled out while most of the glass fibres broke.

Swamy and Stravrides (1979) carried out an investiga- tion to determine the influence of fibre reinforcement on restrain shrinkage and cracking of concrete. A ring type of restrain shrinkage test is reported to demonstrate the abil- ity of short, discrete fibres such as polypropylene, glass, and steel to control cracking and resist tensile stresses arising from restrained shrinkage. Three series of free and restrained shrinkage tests are reported with different ma- trices, types of fibres, and fibre contents. It is shown that the presence of fibres exercises a clear but small restraint to free shrinkage, and reduces drying shrinkage by up to 20 per cent. When shrinkage is restrained, fibre rein- forcement delays the formation of the first crack, prevents sudden failure observed with unreinforced matrices, en- ables the composite to suffer multiple cracking without failure, and reduces crack widths substantially. The fibre reinforced specimens were able to resist 50 to 100 percent more tensile stresses, and continued to resist theshrink- age stresses even after 8 to 12 months.

Applications of GFRC worldwide

Cladding

Much earlier, in the late 1970’s, GFRC panels were used on exterior wall of prefabricated timber frame houses con- structed to meet the shortage of dwellings in Scotland.

Road and rail sound walls

Throughout the world, new highways and mass tran- sit rail systems compete for space in already developed urban areas. The result is that major traffic routes are found closer to commercial and residential areas and it becomes necessary to suppress noise pollution to the surroundings. GFRC noise barriers are being increasingly used since they are light in weight and offer simplicity and speed of erection without requiring the use of heavy lifting machinery.

Ducts and Channels

For drainage and transporting liquids represent another application for GFRC. A commercially available high vol- ume, rain-water drainage channel used in parking lots, road and highway applications. These channels are de- signed for optimum flow capacity and are available in dif- ferent cross-sectional sizes with lengths ranging up to 2 meters (6.6 feet). Further, these channels are lightweight, easy to install in long sections with reduced excavation, maintenance free, and require fewer silt traps or man- holes due to their superior hydraulic performance. The channels are produced by vibration casting an AR fibers mix into a two-part mold.

EXPERIMENTAL PROGRESS

General

The experimental program was carried out to evaluate the mechanical properties i.e, compressive strength and split tensile strength with replacing glass fibre. The program involves casting and testing of total specimens. The speci- mens of standard cubes of 150mmx150mmx150mm and cylinders of 150mmx300mm are casted with and without glass fibre. In first batch the specimens were cast with 0% fibre content and remaining four batches were cast by using fibre varying with 0.8%, 1.2%, 1.5% by the weight of the cement.

Study of materials

The materials that are used for the current project are

1) Cement
2) Fine aggregate
3) Coarse aggregate
4) Glass fibre
5) Water
6) Admixture

Cement

Cement is defined as the product manufactured by burn- ing and crushing to powder an intimate and well-propor- tioned mixture of calcareous and argillaceous materials. The cement, which is generally used for preparing con- crete, is the Ordinary Portland Cement. But for special purposes other qualities of cement such as Low Heat Ce- ment, Rapid Hardening Cement, High Alumina Cement, White Cement, Blast Furnace Slag Cement, Sulphate Re- sisting Cement, etc. are also used.

The selection of a particular type of cement to be used for manufacturing of concrete, depends upon the following factors :

a) The required strength of the concrete structure.
b) The type of structure.
c) The conditions under which the construction of struc- ture is to take place.

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Chemical composition of AR glass fibres, percent by weight

S.NO.	COMPONENT	GLASS FIBRE
1	**SiO_2**	61-62
2	**Na_2O**	14.6-15
3	**CaO**	_
4	**MgO**	_
5	**K_2O**	0-2
6	**Al_2O_3**	0-0.8
7	**Fe_2O_3**	-
8	**B_2O_3**	-
9	**ZrO_2**	16.7-20
10	**TiO_2**	0-0.1
11	**Li_2O**	0-1

Mechanical properties of AR glass fibre

s.no	property	glass fiber
1	Specific Gravity	2.70-2.74
2	Tensile Strength, MPa, Kg/mm^2	1700[173.35]
3	Modulus of Elasticity, GPa, Kg/mm^2	72[7342]
4	Strain at Break,%	2.0
5	Effect of Temperature(Cem-FIL® corporation)	Non-Combustible, Softening Point 860°C

Factors affecting properties of GFRC

The principal factors affecting properties of GFRC are

1. fiber content

2. water-cement ration or W/C

3. composite density

4. fiber orientation

5. fiber length

6. type of cure

7. Density and porosity are also functions of the degree of compaction

Methodology

- Composition of M20 concrete

1. Size of aggregate- 20 mm to 16 mm

2. Type of Cement- Ordinary Portland Cement (43 grade)

3. Mix Proportion- 1 : 1.5 : 3

4. Water Cement Ratio- 0.5

5. Specific gravity of Cement =3.15

6. Coarse aggregate =2.9

7. Fine aggregate =2.6

8. Water curing was done for 14 and 28 days.

9. Compressive strenght was tested on CTM

Observations

Compressive Strength of GFRC having different length of Glass Fibre

Test specimens

1.Test specimens consisting of 150×150×150 mm cubes for Compressive strength.

2. We made M20 grade concrete.

3. Composition of M20 grade 1:1.5:3.

Compressive Strength of Plain Concrete

Plain Concrete Sample Number	Load taken By Cube after 14 days	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	240	10.67	10.835
2	250	11	

Load taken By Cube after 28 days	Compressive Strength	Average Compressive Strength after 28 days
(kN)	(N/mm2)	(N/mm2)
440	19.55	19.78
450	20	

Compressive Strength of GFRC having different length of Glass Fibre

Compressive Strength of GFRC having different length of Glass Fibre	Load taken By Cube after 14 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	310	13.78	13.78
2	310	13.78	

Load taken By Cube after 28 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 28 days (N/mm2)
490	21.78	22.23

510	22.67

GFRC having 0.3% glass fibre having 1 inch length	Load taken By Cube after 14 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	350	15.56	15.78
2	360	16	

Load taken By Cube after 28 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 28 days (N/mm2)
510	22.67	23.12
530	23.56	

GFRC having 0.3% glass fibre having 1.5 inch length	Load taken By Cube after 14 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	350	15.56	16.23
2	380	16.89	

Load taken By Cube after 28 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 28 days (N/mm2)
560	24.89	24.23
530	23.56	

Compressive Strength of GFRC having different % of Glass Fiber

GFRC having .5 inch length and 0.3% glass fibre	Load taken By Cube after 14 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	310	13.78	13.78
2	310	13.78	

Load taken By Cube after 28 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 28 days (N/mm2)
490	21.78	22.23
510	22.67	

GFRC having .5 inch length and 0.6% glass fibre	Load taken By Cube after 14 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	350	15.56	15.78
2	360	16	

Load taken By Cube after 28 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 28 days (N/mm2)
580	25.78	26
590	26.22	

GFRC having .5 inch length and 1% glass fibre	Load taken By Cube after 14 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 14 days (N/mm2)
1	420	18.67	18.23
2	400	17.78	

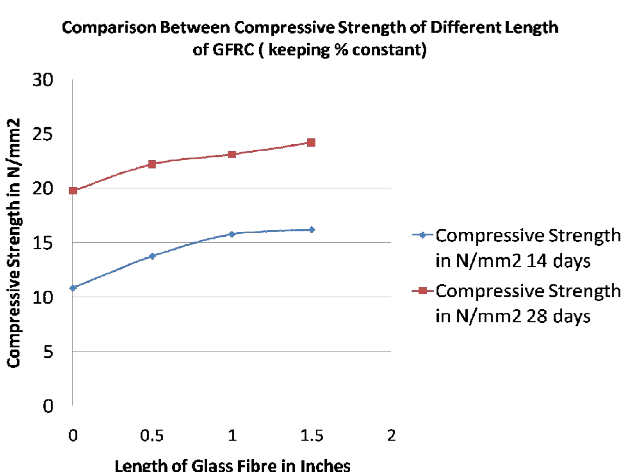
Load taken By Cube after 28 days (kN)	Compressive Strength (N/mm2)	Average Compressive Strength after 28 days (N/mm2)
600	26.67	26.89
610	27.11	

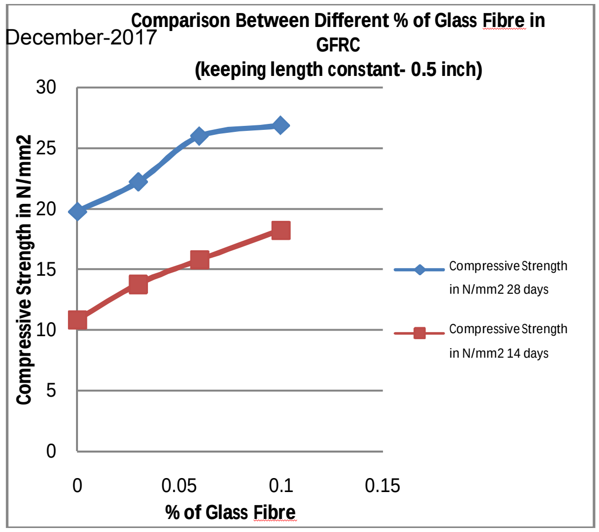
Compressive strength for M20 grade of concrete mix with different length of glass fibre.

Grade of concrete	NO. of days	Compressive Strength (N/mm2)			
M20		Ordinary concrete	With .5 inche GF lenght	With 1 inche GF lenght	With 1.5 inche GF length
	14	**10.83**	**13.78**	**15.78**	**16.23**
	28	**19.78**	**22.23**	**23.12**	**24.23**

Compressive strength for M20 grade of concrete mix with different % of glass fibre

Grade of concrete	NO. of days	Compressive Strength (N/mm2)			
M20		Ordinary concrete	With .03% GF	With .06% GF	With .1% GF
	14	**10.84**	**13.78**	**15.78**	**18.23**
	28	**19.78**	**22.22**	**26**	**26.89**





RESULT

Compressive strength ordinary concrete and varying percentage glass fibre concrete mixes

- Table gives 14 & 28 days compressive strength of concrete mixes with different % of glass fibre (0%,.03%,.06%,.1%) and their values are observed to be (10.84&19.78 , 13.78&22.22,15.78&26,18.23&26.89) N/mm2 respectively for M20 grade concrete.

- Table gives 14 & 28 days compressive strength of concrete mixes with same % of glass fibre (i.e. 0.03%) with varying length of fibre (.5,1,1.5) inch &their values are observed to be (13.78&22.23,15.78&23.12,16.23&24.23)N/mm2 Respectively for M20 concrete

CONCLUSION

- GFRC can be used wherever a light, strong, weather resistant, attractive, fire resistant, impermeable material is required .
- Steels are removed in the GFRC so that, no corrosion will occur and minimum cover is needed.
- GFRC industries suggest many new applications like: water storage tanks, septic tanks, coastal and marine structures, water and wastewater pipelines and etc.
- A reduction in bleeding is observed by addition of glass fibres in the concrete mixes.

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