EXPERIMENTAL STUDY OF GLASS FIBER REINFORCED CONCRETE BEAMS IN FLEXURE

A PROJECT REPORT

Submitted by

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(71206413014)

in partial fulfillment for the award of the degree

of

MASTER OF ENGINEERING

in

STRUCTURAL ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE

ANNA UNIVERSITY:: CHENNAI 600 025

JUNE 2008

ANNA UNIVERSITY :: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report titled **"EXPERIMENTAL STUDY OF GLASS FIBRE REINFORCED CONCRETE BEAMS IN FLEXURE"** is the bonafide work of **P.PRASATH, Reg No: 71206413014,** who carried out the research work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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DEDICATED TO MY LOVABLE PARENTS

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ACKNOWLEDGEMENT

First and foremost I submit my thanks to **The Almighty,** through whom all things are possible. This work was not by my might nor by power, but by **His Spirit**. This work is not possible without the gifts, **God** has given to me.

I take pride and immense pleasure in expressing my deep sense of gratitude indebtedness to my guide **Dr.J.Premalatha,** Professor of Civil Engineering Department for her innovative ideas continued conduce, untiring efforts and encouragements which enabled the successful completion of thesis work.

I deem great pride in expressing heartfelt gratitude to **Dr.S.L.Narasimhan,** H.O.D, Department of Civil Engineering for allowing me to do this project and the facilities extended throughout the project.

I express my profound gratefulness to **Dr.Joseph.V.Thanikal,** Principal for providing the necessary facilities for the successful completion of thesis work.

I also sincerely thank the faculty members, non-teaching staff of Civil Engineering Department.

Last but not the least; I thank my **PARENTS** for their moral support.

ABSTRACT

ABSTRACT

The use of glass fibre reinforced concrete has been steadily increasing for the past few decades. A significant research has been conducted in glass fibre reinforced concrete. The major areas of application include pavement bridge decks, airfield, manhole covers and so on. An attempt has been in my thesis to study the various mechanical properties of glass fibre reinforced concrete. The results presented in my thesis provide a comparison of plain concrete and glass fibre reinforced concrete.

The materials used are ordinary Portland cement, sand, fly ash and coarse aggregate. The fibre used in this study is AR glass fibre. In this thesis, 4 numbers of proto type glass fibre reinforced concrete beams were casted with various % of glass fibre and fly ash replacement with cement. The specimens were tested for 7 and 28 days strength and their behavior are studied under compression, tension and flexure as per the method recommended by Indian standards. Behavior of R.C.C beams with different percentages of Glass fibre content under flexure are discussed in this thesis

LIST OF FIGURES

LIST OF SYMBOLS

LIST OF SYMBOLS

GFRC -Glass fibre reinforced concrete

Fck -Characteristic compressive strength of concrete

t -Risk factor.

s -Standard deviation.

w/c -water cement ratio.

F_a -Fine aggragate.

C_a -Coarse aggregate.

S_c -Specific gravity of cement.

S_{fa} -Specific gravity of fine aggregate.

S_{ca} -Specific gravity of coarse aggregate.

p -Load in N/mm^2.

l -Length of the cylinder (depth).

b -Breadth of the beam.

d -Depth of the beam.

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1GLASSFIBRE

Glass fibres are formed from different types of glass. Their characteristics and properties are determined by mixing various ingredients. These ingredients are then melted in a high temperature furnace. The molten glass in then fed in to the fabrication equipment. The strands or silvers from the fibre forming stage can be wound on a tube by a high speed winder to give continuous filament stable fibre is cut from strands to specific lengths referred as chopped strands.

Glass fibres are generally classified by the fibre diameter, the chop length. The moisture content and the chemical contents of fibres are further characterized by their physical and chemical properties, which are governed primarily by the glass composition. There are several glass fibres types with different chemical composition.

1.2TYPES OF GLASS FIBRES

- A-glass fibre
- C-glass fibre
- S-glass fibre
- E-glass fibre
- AR-glass fibre

A - GLASS FIBRE

A glass fibre is typical window glass for comparison purpose and it is no used in fibre manufacturing

C - GLASS FIBRE

This is a soda lime borosilicate composition that is, used for its chemical stability in corrosive environment Therefore it is used often in composites the contact or contain chemical materials.

S-GLASS FIBRE

This type of glass has magnesium alumino silicate composition which demonstrates high strength and its therefore used in applica4ns where high strength is required more stringent quality control procedures are necessary with S glass.

E-GLASS FIBRE

This is a family of glasses with calcium alumino borosilicate composition and a maximum alkali content of 2%. E glasses are generally used as a general-purpose fibre when high strength and high electrical resistively is required. It gives good compressive strength and cost is also very cheap.

AR-GLASS FIBRE

AR glasses are alkali resistance glass, which is used to strengthening cement. Its zirconium oxide gives it excellent resistance to the alkaline compounds generated during drying. The reinforcement of cement with AR glass filament gives improved modulus at break with good durability.

The glass composition itself makes the glass fibres alkali-resistant. The coating applied to the glass filament adds properties and functions of the glass in the final application. But the glass composition when melting in the glass furnace includes all the key components which makes the glass alkali- resistant.

AR glass fibres have a density that is similar to that half concrete. This ensures niform mixing in the matrix. Also this ensures low rebound losses especially relevant in lastering applications

The fibres also have an elastics modulus which is significantly higher than concrete. This enables the fibres to provide an effective reinforcement during the hardened stage of concrete.

1.3 GLASS FIBRE REINFORCED CONCRETE (GRC)

GRC is a material that is currently making a significant contribution to the economics, technology and aesthetics of the construction industry worldwide. This environmentally friendly composite, with its low consumption of energy and natural raw materials, is being formed into a wide variety of products and has become the product of choice among architects, engineers, designers and users for its flexibility to meet performance, appearance and cost parameters.

As manufacturing process has evolved, so have the fibres. Large range of fibres have been developed to satisfy .the needs of the markets, and to provide optimum processing efficiency and performance in the chosen manufacturing methods. In addition to the manufacturing processes, guidelines and techniques for moulding, achieving different surface finishes and enhanced mechanical properties have also been developed.

The sheer versatility of GRC challenges the imagination and extends the limits of what has been previously possible with a cementitious material. Crack prevention is a widely accepted fact that traditional concrete mixes are prone to plastic shrinkage during the setting phase and this can lead to cracking These fibres made of Alkali-Resistant glass are also resistant to acids and other chemical and can be easily incorporated in the concrete mix.

1.4 SCOPE AND NEED FOR PRESENT STUDY

In my study, experimental work has been made to study the flexural behavior of glass fibre reinforced concrete beams. It is done with varying the percentage of glass fibre and fly ash is taken for the optimum content. The experimental work is done with the mix design procedure by combining Bureau of Indian Standards (BIS) and ACI code methods of mix design. Literature of previous works were studied and based on these the experimental investigation of glass fibre reinforced beams is done.

1.5 OBJECTIVE OF PRESENT STUDY

- The main objective is to study the flexural behavior of glass fibre reinforced concrete beams and to compare it with the plain cement concrete beams.
- To study the compressive strength and split tensile strength of glass fibre reinforced concrete beams by conducting experiments in the structural technology center.
- Optimum percentage of glass fibre content for the concrete will be arrived based on the experimental results

LITERATURE REVIEW

CHAPTER 2
LITERATURE REVIEW

1. **Ir. Richard Sumners (2002)** this paper discusses the different types of GRC.Several examples are illustrated as to where it has been used and how it has been produced. Latest developments in the durability problems of GRC are also discussed.

2. **Al-Hadeed, T.(2003)** "Deflection of gfrp beams" in this paper the test results of six RC beams with glass FRP (GFRP) reinforcement are analyzed and used to establish experimental moment-curvature relationships that take into account tension stiffening. Flexural deflection behavior is then examined against deflections derived from these relationships and cracked-section analysis. Other aspects of structural behavior are also discussed.

3. **HUANG Yue-lin, WU Jong-hwei (2004)** "Strengthening reinforced concrete beams using prestressed glass fibre". T- and □-shaped R. C. beams were tested in this study. T-shaped beams are considered under-strengthened beams because they always fail on the strengthened face (tension face) before or after strengthening. □-shaped beams are considered over-strengthened beams because they change the failure position from the tension face to the compression face after strengthening.

4.Dott.Ing.Giuseppe - "Structural Applications of Glass-fibre Reinforced Concrete Components (STRUCTA-GRC)"- The present project is aimed to the development of innovative, light-weight composite components, able to withstand to structural loads, to be used in the building construction sector instead of conventional, heavy pre cast concrete structures. By using theoretical models and experimental tests, it is demonstrated that grid supported GRC components, obtained by means of suitable compositions and production procedures, are slightly affected by the ageing drawback and show a long-term ductile behavior; in this way it would be possible to guarantee the required performances during all the life of the component.

5. Marta Kosior- Kazberuk, Malgorzata Lelusz: "Strength development of concrete with fly ash addition". The test result shows that all mixes containing fly ash were able to develop a higher flexural strength than the control mixes. High volume fly-ash concrete with good overall performance regarding workability, bleeding, setting time, temperature rise and mechanical properties.

6. Hamid Abbasi "A model for predicting the properties of the constituents of a glass fibre rebar reinforced concrete beam at elevated temperatures simulating a fire test". This paper develops a series of expressions to predict the apparent strength and stiffness of composite rebars and the concrete matrix at elevated temperatures typical of those experienced in a standard fire test. Two methods of predicting the thermal distribution through the concrete beam at any time in a fire are compared: a semi empirical method based on experimental data and a finite element method using commercial software. The semi empirical method is found to provide the most accurate prediction and this is then used to generate expressions for the reduction in compression strength of the concrete. Expressions from earlier work, which predict the reduction in strength and stiffness of rebar with temperate are then used in combination with the calculated temperature profiles to generate equations predicting the reduction in strength and stiffness with time of the rebar encased in the concrete.

7. Mohammad Razavi Noun "Tensile and Flexural Behaviour of Fibre Reinforced Cementitious Composites". An experimental study about the effect of fibres on the mechanical behavior of fibre reinforced cementlilous samples in tension end flexure is reported, cementitious samples contain varying amounts of E-glass, Doler 10 and Dotanit 11 fibres. Results shows that flexural and tensile strengths as well as toughness and ductility of fibre reinforced cement Increased considerably with respect to that of cement alone. While the properties enhanced with time for PAN reinforced samples, properties of glass reinforced cementitious samples degraded with time. An empirical model is used to represent the test data.

MATERIALS USED

CHAPTER 3
MATERIALS USED

3.1 E - GLASS FIBRE AND AR- GLASS FIBRE

3.1.2 E.GLASS FIBRE

This is a family of glasses with calcium alumino borosilicate composition and a maximum alkali content of 2%. E glasses are generally used as a general-purpose fibre when high strength and high electrical resistively is required. It gives good compressive strength and cost is also very cheap.

3.1.3 PROPERTIES OF E-GLASS FIBRE

1	Density	2.60 g/cm^3
2	Tensile strength	3400MPa
3	Tensile modulus	73000Mpa
4	Moisture content	<1%
5	Flammability	846°C
6	Youngs modulus	72Gpa
7	Specific gravity	2.6
8	Strain failure	4.5%

Table3.1 properties of E-glass fibre

COMPOSITION OF E-GLASS FIBRE

1	SiO_2	73%
2	Al_2O_3	1%
3	Fe_2O_3	0.1%
4	MgO	4%
5	CaO	8%
6	Na_2O_3	13%
7	K_2O	0.5%

Table3.2 Composition of E-Glass Fibre

AR-GLASS FIBRE

Back in the laid 70s and early 80s E-glass were promoted for use 55in concrete as reinforcement. It was quickly learned that E glass fibres were not chemically stable in concrete. Especially the alkalies in the cement attacked the E glass and within a very short period in time the fibers would break down. The next glass product made available to the cement concrete industry was the first generation, of AR-galss fibres or Alkali Resistant fibres. The AR-glass fibres of this geneultion were coated with Zirconia to protect the glass from alkali attack.

The Building Research Establishment in the UK first developed Cem -FIL Alkali Resistant Glass Fibres more than 30 years ago.

This product worked but not to the total satisfaction of looking for long term chemical stability. This need to develop long term chemical stability spawned the current generation of AR-glass fibres where the Zirconia is an integral ingredient of the fibre. Up to 16% by weight of the fibre is Zirconia; numerous research programs have been conducted to determine the stability of this generation AR-glass fibre product. [illegible] tests have proven that even at a calculated age of 28 years this new eneration of AR- glass fibres are chemically stable and retain the physical test properties een when compared to the test results when the fibres were initially cast in the concrete.

PROPERTIES OF AR GLASSFIBRE

Specific gravity	-	2.68
Youngs modulus	-	73 Gpa
Tensile strength	-	I .7Gpa
Fire performance	-	Incombustabile.

3.2 AGGREGATES

The maximum size of the coarse aggregate is restricted to 20mm, to avoid appreciable reduction in strength of the concrete. Fibre, also acts as aggregate. The inter-particle friction between fibers and aggregate controls time orientation and distribution of the fibers and consequently that improves the cohesiveness of the mix can significantly improve the mix.

FINE AGGREGATE

River sand, passing through IS Sieve of size 1.18mm was used for this study. The particle size distribution of fine aggregate was determined from sieve analysis arid the experimental results are carried out to find the properties of fine aggregate. IS sieve ranging from 10mm to 150 micron were used to conduct the sieve analysis and fineness modulus was found out.

ROPERTIES OF FINE AGGREGATE

- Zone III
- Fineness modulus - 2.83
- Specific gravity - 2.61

COARSE AGGREGATE

Crushed granite coarse aggregate of maximum size 20mm is used. The experiments are carried out to find the properties of coarse aggregate. The entire tests are carried out as per IS: 2386~198314. Time properties of coarse aggregate are given below.

PROPERTIES OF COARSE AGGREGATE

- Angular
- Fineness modulus - 2.68
- Specific gravity - 2.6

3.3 CEMENT

Cement is the most important ingredient in concrete. One of the important criteria for the selection of cement is its ability to produce improved microstructure in concrete. As now day imagism grade cements are used in site works, i tried to get the strength for at present practicing concrete, so i used Birla super grade cement

PROPERTIES OF CEMENT

- Specific gravity - 3.14
- Initial setting time - 32 minutes
- Standard consistency - 30%

.4 WATER

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement, calcium-silicate-hydrate (C S-H) gel. Portable water available in college premises is used for mixing and curing.

3.5 FLYASH

Flyash is the best known and one of the most commonly used "pozzolans". Class F flyash is available in the large quantities and is produced when either anthracite, bituminous or sub- bituminous, or lignite coal is burned. Class F is generally low in lime, usually under 5 per cent and contains a greater combination of silica, alumina and iron (greater than 70 per cent) than class C flyash. Flyash (Class-F) was obtained from Mettur Thermal Power Plant (MTTP).

MIX DESIGN

CHAPTER 4

MIX DESIGN

4.1 INTRODUCTION

The determination of relative quantity. of materials like cement, fine aggregate, coarse aggregates and water is called the mix design of concrete.. Proportion is for concrete should be selected to make the most economical use of available materials to produce concrete of required quality.

Many methods have been recommended for mix proportioning of concrete all over time world. Among those methods, INDIAN STANDARD method was selected. The design of mix used for the present work by is method is given below

4.2CONCRETE MIX DESIGN (GRADE M25)

(a) DESIGN STIPULATION:-

i) Characteristic compressive Strength required	=	25 MPa
In the field at 28 days	=	20mm
ii) Maximum size of Aggregates	=	0.85C.F.
Iii) Degree of Workability	=	Fair
IV) Degree of Quality control	=	Moderate
v) Types of Exposure		

) **DATA FOR Testing**

i) Specific gravity of cement	=	3.15
ii) Compressive strength of cement at 7 days	=	satisfies the IS
iii) 1. Specific gravity of coarse aggregate	=	2.64
2. Specific gravity of fine aggregate	=	2.60
iv) Water absorption		
1. Coarse Aggregate	=	0.5%
2. Fine Aggregate	=	1%
v) Free (surface) Moisture		
1. Coarse Aggregate	=	Nil
2. Fine Aggregate	=	2%

i) TARGET MEAN STRENGH OF CONCRETE

The target mean strength for specified characteristic cube strength is 25+1.65x4 = 31.6 MPa

ii) SELECTION OF WATER CEMENT – RATIO

The water-cement ratio required for the target mean strength of 31.6MPa is 0.35. This is lower than the maximum value of 0.40% for 'Moderate' exposure. Adopt W/C of 0.5.

) SELECTION OF WATER AND SAND CONTENT

For 20 mm maximum size aggregate, sand conforming to grading Zone II, water content per cubic metre of concrete is equal to 180 kg and sand content as percentage of total aggregate by absolute volume is 35%.

For change in value of water-cement ratio, compacting factor, and sand belonging to Zone III, following adjustment is required

CHANGE IN CONDITION	PERCENT ADJUSTMENT REQUIRED	
	WATER CONTENT	SAND IN TOTAL AGGREGATE
For decrease in water-cement ratio by (0.6-0.5) that is 0.1	0	-2.0
For increase in compacting factor (0.8-0.85), that is 0.05	+1.5	0
TOTAL	+1.5	-2.0

Table4.1 percentage adjustment required

Therefore, required sand content as percentage of total aggregate by absolute volume = 35-2=33%

Required water content = 180 + 186*1.5/100 = 188.8 litre/cu.m.

iii) DETERMINATION OF CEMENT CONTENT

Water-cement ratio = 0.5

Water = 188.8 litre

Cement = 188.8 / 0.5 = 377.6 kg/m^3

This cement content is adequate for 'moderate' exposure condition.

iv) DETERMINATION OF COARSE AND FINE AGGREGATE CONTENTS

From Table 11.23, for the specified maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2 per cent. Taking this into account and applying equations on

$$V = \{(W + C/S_e + (1/p)\,(f_a/Sf_a)\} \times (1/1000)$$

$$C_A = \{((1-P)/P)) \times f_a \times (S_{ca} / S_{fa})\}$$

Where,

V = absolute volume of fresh concrete, which is equal to gross volume (m^3) minus the volume of entrapped air,

W = Mass of Water (Kg) per m^3 of concrete

C = Mass of Cement (Kg) per m^3 of concrete

S_e = Specific gravity of cement

P = Ratio of FA to total aggregate by absolute volume

C_a, F_a = total mass of CA and FA (Kg) per m^3 of concrete respectively and

S_{fa}, S_{ca} = specific gravity of saturated, surface dry fine aggregates and coarse aggregates respectively.

$$0.98 = \{188.8 + (377.6/3.15) + (1/0.33 \times (f_a / 2.6))\} \times (1/1000)$$

$$F_a = 576 \text{ kg/m}^3$$

$$C_a = ((1 - 0.33) / 0.33)) \times 576 \times (2.64 / 2.6)$$

$$= 1187.45 \text{ Kg / m}^3$$

The mix proportion then becomes:

WATER	CEMENT	F.A	C.A
188.8kg	377.6kg	576kg	1187.45kg
0.5 :	1	: 1.525:	3.143

4.3 ACTUAL QUANTITIES REQUIRED FOR THE MIX CEMENT

vii) WATER

1. For w/c ratio of 0.5, quantity = 17.5 litres of water.
   a. Extra quantity of water to be added for absorption in case of CA, at 1 percent mass. = 11.87 litres.
2. Quantity of water to be deducted for moisture present in sand, at 2 percent by mass. = 11.52 litres.
3. Actual quantity of water required to be added =188.8+11.87-11.52 = 189.15 liters

Actual quantity of sand required = 576+11.52 =587.52 kg

Actual quantity of coarse aggregate required = 1187.45-11.87=1175.58 kg

ix) ACTUAL QUANTITY OF COARSE AGGREGATE

1. Fraction I (60% of 20 MM) = 705.35Kg
2. Fraction II (40% of 12.5 MM) = 470.23Kg

PROPORTION BY WEIGHT

WATER	CEMENT	F.A	20MM C.A	12.5 MM C.A
189.15kg	377.6kg	587.52kg	705.35kg	470.23kg

PROPORTION BY RATIO

0.5 : 1 : 1.56 : 1.87 : 1

EXPERIMENTAL INVESTIGATION

CHAPTER 5

EXPERIMENTAL INVESTIGATION

5.1 GENERAL

The experiment was conducted to find the difference in increased compressive strength, split tensile strength and flexural strength; when glass fibers are added .to plain cement concrete. The tests were conducted at 7^{th} day & 28^{th} day. For that i followed all time procedures as per IS code specifications and tested.

5.2 CASTING

For this experiment totally 45 specimens where cast and tested to get the results of compressive strength, split tensile strength and flexural strength at 7^{th} & 28^{th} day. Cubes casted to find compressive strength for PCC and glass fiber. Similarly cylinders for split tensile strength .Beams of were casted and they were tested for flexural behavior.

For each and every type 3 specimens were casted to get the average strength. Cube and Cylinder were tested for 7^{th} & 28^{th} day and beam was tested for 28th day.

The properties of the material, which are used for investigation, are presented in this section all the experiments tat are adopted to determine characteristics of the material are carried out as per Indian Standards.

5.3 MOULD DETAIL

The internal Dimensions of the mould are

a) Cube size => 150mm x 150mm x 150mm

b) Cylinder size => 300mm leng, 150mm Dia

c) Beam size =>100mm x 150mm x 2000mm

Metal moulds, preferably steel or cast iron, thick enough to prevent distortion is required. They are made in such a manner as to facilitate the removal or the moulded specimen without damage and are so machined that, when it is assembled ready for use, the dimensions and internal faces are required to be accurate within the following limits.

The height of the mould arid the distance between the opposite faces is of the specified size ± 0.2mm. Time angle between adjacent internal faces: and between internal faces arid top arid bottom planes of tine mould is required to be 90 ± 0.5. The interior faces of time mould are plane surfaces with a permissible variation of 0.03mm. Each mould is provided with a metal base plate having a plane surface. Time base plate is of such dimensions as to support time mould during the filling without leakage arid it is preferable attached to the mould by springs or screws. The parts of time mould, when assembled, are positively and rigidly held together, and suitable methods of ensuring this, both during the filling and on subsequent handing of time filled mould, are required to be provided

5.4 PREPARATION OF TEST SPECIMEN

In assembling the mould for use, the joints between the' sections of the mould are thinly coated with mould oil and a similar coating of mould oil is applied between time contact surface of the bottom of the mould and the base plate mm order to ensure that no water escapes during time filling. The interior surface of the assembled mould is also required to be thinly coated with mould oil to prevent adhesion of concrete

The cylindrical mould is required to be of metal which shall be not less than 3mm thick. Each mould is capable of being, opened longitudinally to facilitate removal of time specimen and is provided with means of keeping it closed while in use. Care should be taken so that the ends are not departed from a plane surface, perpendicular to the axis of the mould, by more that 0.05mm. Where assembled ready for use the mean internal diameter of the mould should be 15.C cm ± 0.2mm and in no direction the internal diameter is less than 14.95 cm or more than 15.05cm. The height maintained is 30.0cm ± 0.1mm. Each mould is provided with a metal base plate and with a capping plate of glass or other suitable material. The bas~ plate and the capping plate are required to be at least 6.5mm thick and such that they do not depart from a plane surface by more that 0.02mm. The base plate supports the mould during filling without leakage and is rigidly attached to the mould. The mould and base plate are coated with a thin film of mould oil before use in order to prevent adhesion of concrete.A steel bar 16mm in diameter, 0.6 m long and bullet pointed at the lower end serves as e tamping bar.

5.5 GEOMETRY OF TEST SPECIMEN:

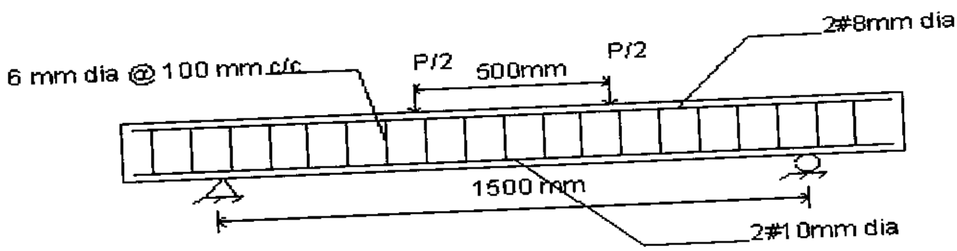

Fig 5.1 dimensions of test specimen

TESTING

CHAPTER 6

TESTING

6.1TESTING PROCEDURE

Testing of hardened concrete play an important role in controlling arid confirming time quality of cement concrete works. Systematic testing of raw materials, fresh concrete arid hardened concrete are inseparable part of any quality control programme for concrete, which helps to achieve higher efficiency of the materials used and greater assurance of the performance of the concrete with regard to both strength amid durability. Time test methods should be simple, direct amid convenient to apply.

One of time purposes of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. As the hardening of the concrete takes time, one will not come to know, the actual strength of concrete for some time. This is an inherent disadvantage in conventional test. But, if strength of concrete is to be known at an early period, accelerated strength test can be carried out to predict 28 days strength. But mostly when correct materials are used and careful steps are taken at every stage of the work, concrete normally the required strength. Tests are made by casting cubes or cylinder from the representative concrete. It is to be remembered that standard compression test specimens give a measure of the potential strength of the concrete and not of time strength of the concrete is structure. Knowledge of the strength of concrete in structure can not be directly obtained from tests on separately made specimens.

All the beams were tested for flexure under a loading frame of capacity 30 tonne. These beams were tested on a span of 1500mm with simply supported conditions under two point loading. The companion cube specimens were also tested in the compression testing machine of capacity 2000kN. Deflections were measured under the loading point and at the mid span using Linear Variable Differential Transducers

(LVDTs). The crack patterns were also recorded at every load increment. All the beams were tested up to failure.

6.2 THE DIFFERENT TYPES OF TESTS CONDUCTED ARE:

i. Compression Test
ii. Splitting Tension Test
iii. Flexural Strength Test

i). COMPRESSION TEST:

Compression test is the, most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

The compression test is carried out on specimens cubical or cylindrical in shape. The compression strength of concrete is determined using parts of a beam tested in flexure. The end parts of beam are left intact after failure in flexure and, because the beam is usually of square cross section, this part of the beam could be used to find out the compressive strength.

The cube specimen is of the size 150 x 150 x 150 mm. If the largest nominal size of the aggregate does not exceed 20 mm, 100 mm size cubes may also be used as an alternative.

In my investigation i used 150mmx 150mm x 150mm size cube. The compressive strength of concrete was found out for ordinary PCC then for glass fibre mixed concrete. For 7th day and 28th day.

Fig 6.1 Test Setup of Various Specimens of GFRC

ii). SPLITTING TENSILE TEST

The test is carried; out by placing a cylindrical specimen horizontally between time loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along time vertical diameter.

When the load is applied along, an element on the vertical diameter of time cylinder is subjected to a vertical compressive stress of

$$\frac{2P}{PLD} \qquad \frac{D^2}{r\,(D-r)}$$

and a horizontal stress of

$$\frac{2P}{PLD}$$

Where

P is the compressive load on the cylinder

L is the length of cylinder

D is its diameter and r and (D-r) are the distance of the elements from time two loads respectively.

The main advantage of this method is that tine same type of specimen and time same testing machine as are used for time compression test can be employed for this test. That is why this test is gaining test is simple test to perform and gives more uniform results than other tension tests. Strength determined in time splitting t3st is believed to be closer to time true tensile strength of concrete, than the modulus of rupture. Splitting strength gives about 5 to 12% higher value than the direct tensile strength. In my investigation i used 300x150mm cylinder. The split tensile strength of concrete was found out for ordinary PCC then for AR glass fibre mixed concrete for 7^{th} day and 28^{th} day.

iii) FLEXURAL STRENGTH TEST

Concrete as we know is relatively strong in compression and weak in tension. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely developed in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.

A concrete road slab is called upon to resist tensile stresses from two principal sources wheel loads and volume change in the concrete. Wheel loads may cause high tensile stresses due to bending, when there is arm inadequate subgrade support. Volume changes, resulting from changes in temperature and moisture, may procedure tensile stresses due to volume changes alone may be high.

Flexural strength tests are carried out at the age of 28 days for the 100x100x500mm prism specimens using 5000kN capacity flexural strength testing machine by subjecting the specimen to two point loading to determine the flexural as per IS:516-1959. The flexural strength has been calculated using the formula,

$$F_R = PL/BD^2$$

Where,

F_R	-	Flexural Strength of the specimen in MPa
P	-	Maximum Load in N applied to the specimen
L	-	Span of the specimen in mm
B	-	Measured Width of the specimen in mm
D	-	Measured Depth of the specimen in mm

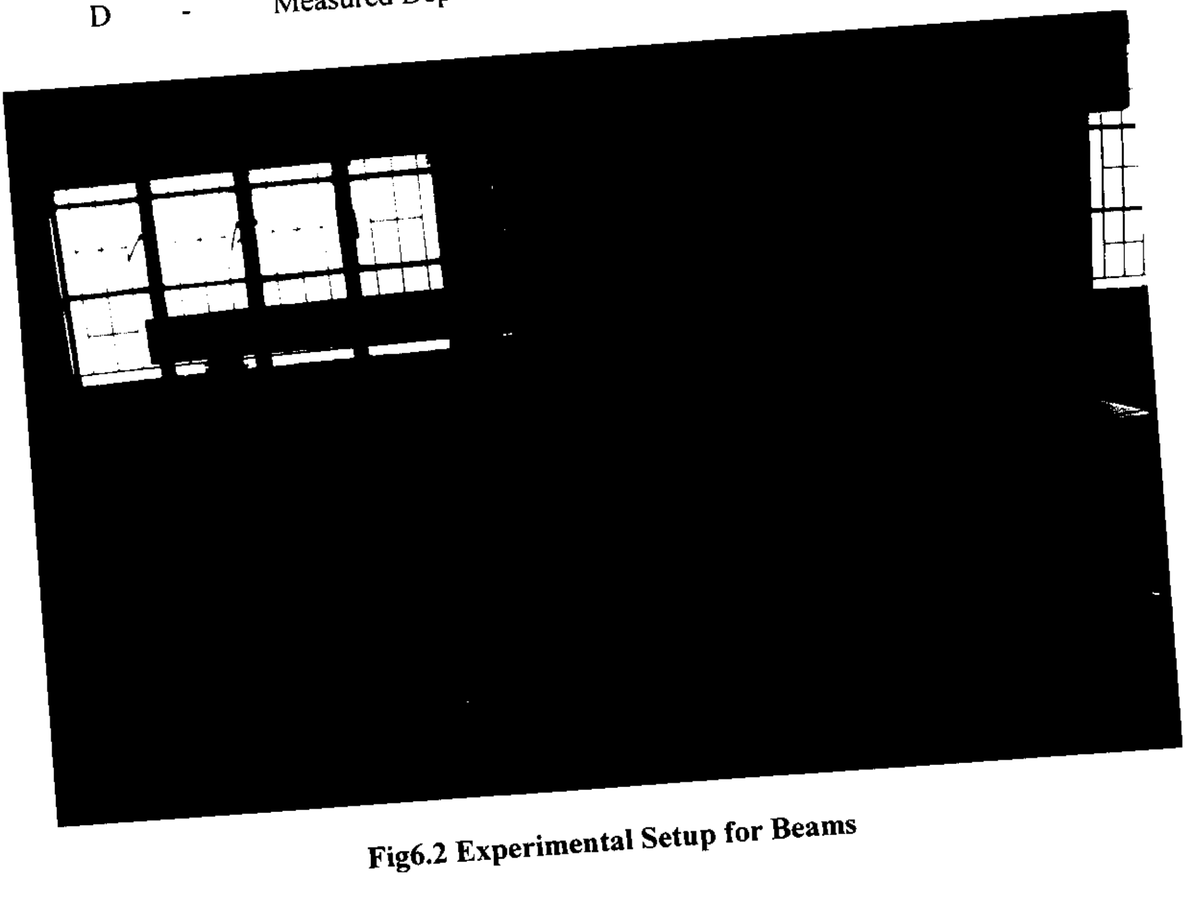

Fig6.2 Experimental Setup for Beams

RESULTS AND DISCUSSION

CHAPTER 7

RESULTS AND DISCUSSIONS

7.1 CUBE COMPRESSIVE STRENGTH

The cube compressive strength for 7 and 28 days with various percentages of glass fibre is done and the results are tabulated as follows

S.NO	%GLASS FIBRE	Failure load kN	Compressive strength MPa	% increase in compressive strength
1	O	385	18.25	0
2	1	486	21.6	15
3	2	535	23.77	23
4	2.5	548	24.35	25

Table 7.1 compressive strength for 7th day

S.NO	%GLASS FIBRE	Failure load kN	Compressive strength MPa	% increase in compressive strength
1	0	558	25.10	0
2	1	622	27.64	9
3	2	655	29.11	13
4	2.5	663	29.46	14

Table 7.2 compressive strength for 28th day

In compression test the specimens with 2.5% of glass fibre with 20% replacement of fly ash gave the maximum increase in compressive strength compared to other specimens. The mix with 2% percentage of glass fibre also had the same strength compared to the controlled specimens.

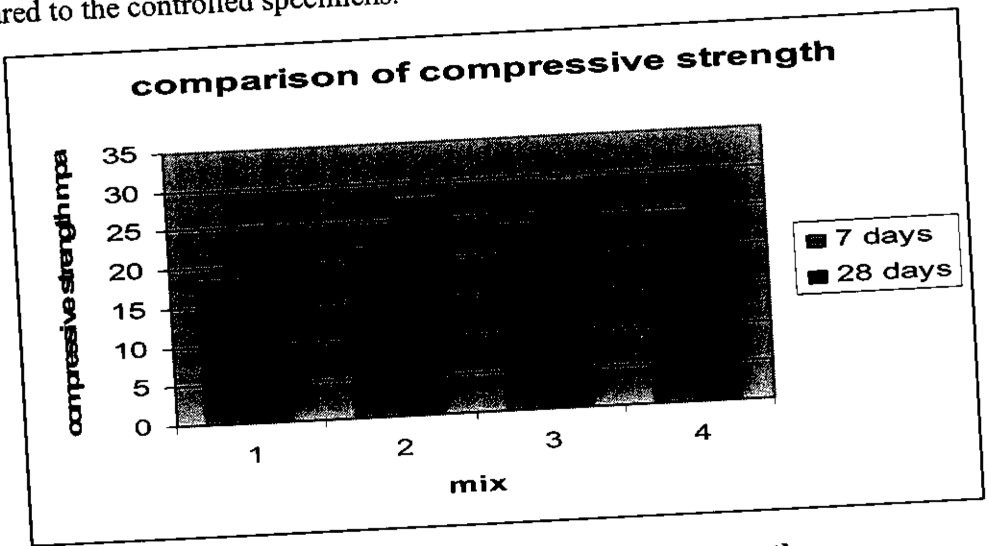

Fig 7.1 comparison of compressive strength

7.2 SPLITTING TENSILE STRENGTH

S.No	% GLASS FIBRE	Failure load kN	Tensile Strength MPa	% increase in tensile strength
1	0	190	1.34	0
2	1	255	1.80	27
3	2	325	2.30	43
4	2.5	335	2.37	45

Table 7.3 split tensile strength for 7th day

S.No	% GLASS FIBRE	Failure load kN	Tensile Strength MPa	% increase in tensile strength
1	0	213	1.48	0
2	1	272	1.94	23
3	2	353	2.39	38
4	2.5	365	2.58	44

Table 7.4 split tensile strength for 28th day

From the results the mix with 2.5% of glass fibre obtained the maximum split tensile strength. The split tensile strength for the controlled specimens has not shown much increase between 7th and 28th days. The mix designs with glass fibre have higher split tensile strength due to the binding action of glass fibre.

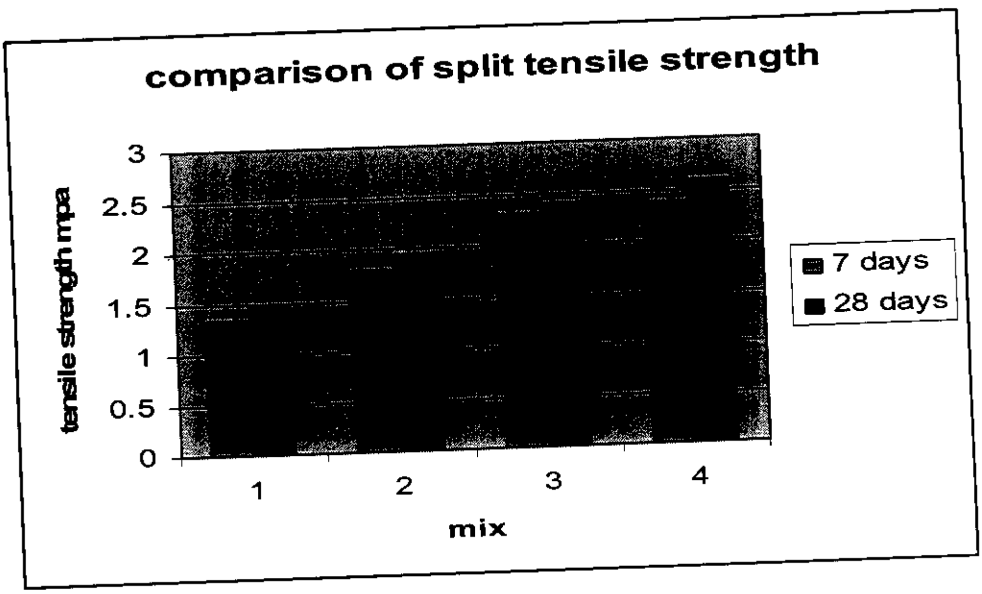

Fig 7.2 Comparison of Split Tensile Strength

7.3FLEXURAL TEST FOR GFRC BEAMS

Flexural strength for various percentages of glass fibre with fly ash for 28th day are tabulated below

s.no	% of Glass fibre	% of Flyash	First Crack point (kN)	Ultimate Load (kN)	Deflection (mm)
1	0	20	16.95	30.95	10.25
2	1	20	20.12	40.22	12.72
3	2	20	24.15	46.58	13.85
4	2.5	20	25.56	45.25	13.55

Table 7.5 flexural test for GFRC beams

The beam with 2.5% GFRC has the highest load carrying capacity of 45.25kN compared to conventional beam which has the ultimate load of 30.95kN. The first cracking point of the 2.5% GFRC beam has higher capacity of 25.56kN compared to the conventional beam having the first cracking point of 16.95kN. The cracks in the GFRC beams were minimum compared to conventional beam. The flexural behavior of GFRC beams with 2.5% glass fibre and 20% replacement level of fly ash has taken the ultimate load and the deflection of the beam is comparatively low to its ultimate load.

Load kN	Deflection mm
0	0
5	1.55
10	2.53
15	4.85
20	6.23
25	8.31
30	10.25

Table7.6 load vs deflection of RC beam

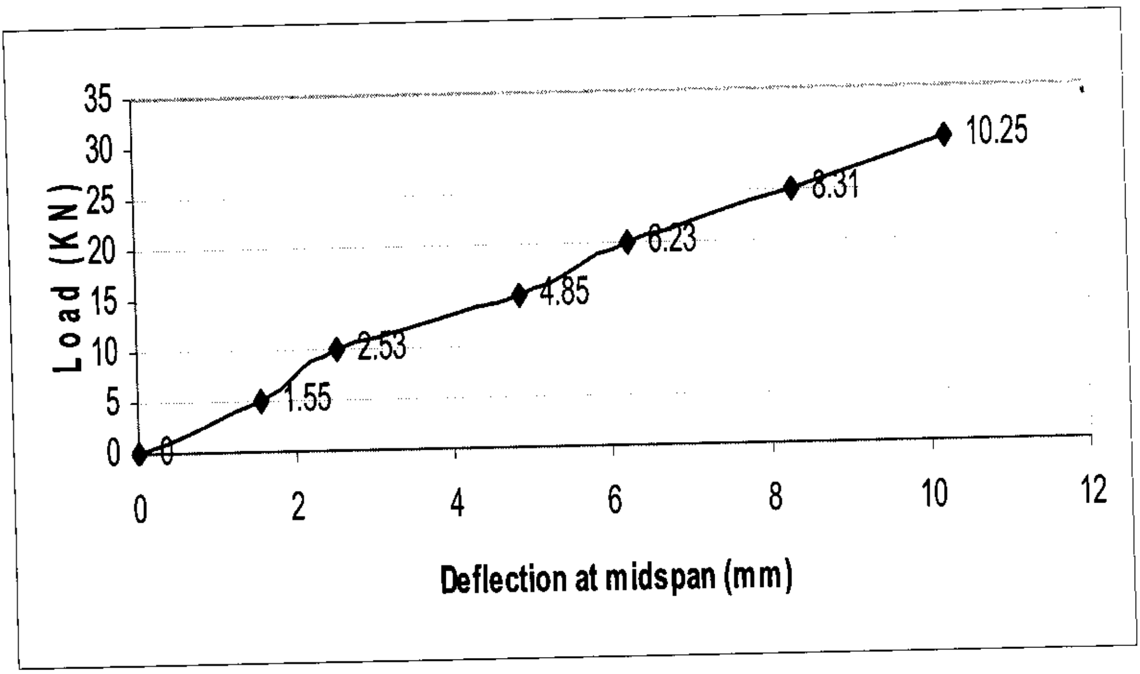

Fig7.3 Load Vs Displacement for RCC Beam

Load kN	Deflection mm
0	0
5	1.23
10	2.55
15	4.15
20	6.32
25	7.12
30	8.25
35	10.33
40	12.72

Table7.7 load vs deflection of GFRC beam

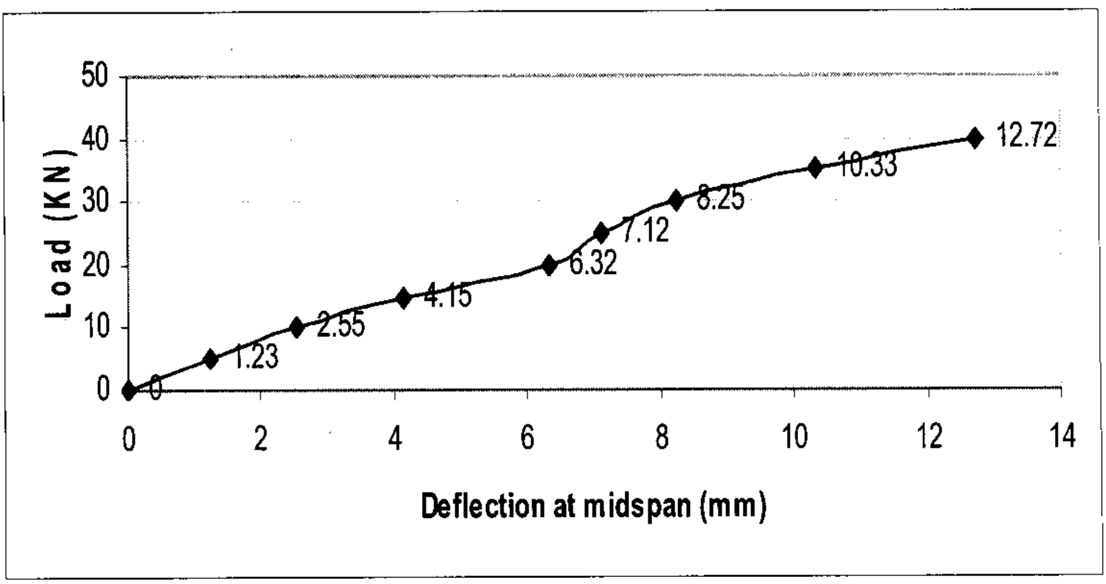

Fig7.4 Load Vs Displacement for GFRC Beam 1

Load kN	Deflection mm
0	0
5	1.5
10	2.12
15	5.12
20	6.50
25	7.23
30	8.45
35	10.34
40	11.55
45	12.63
50	13.85

Table7.8 load vs deflection of GFRC beam

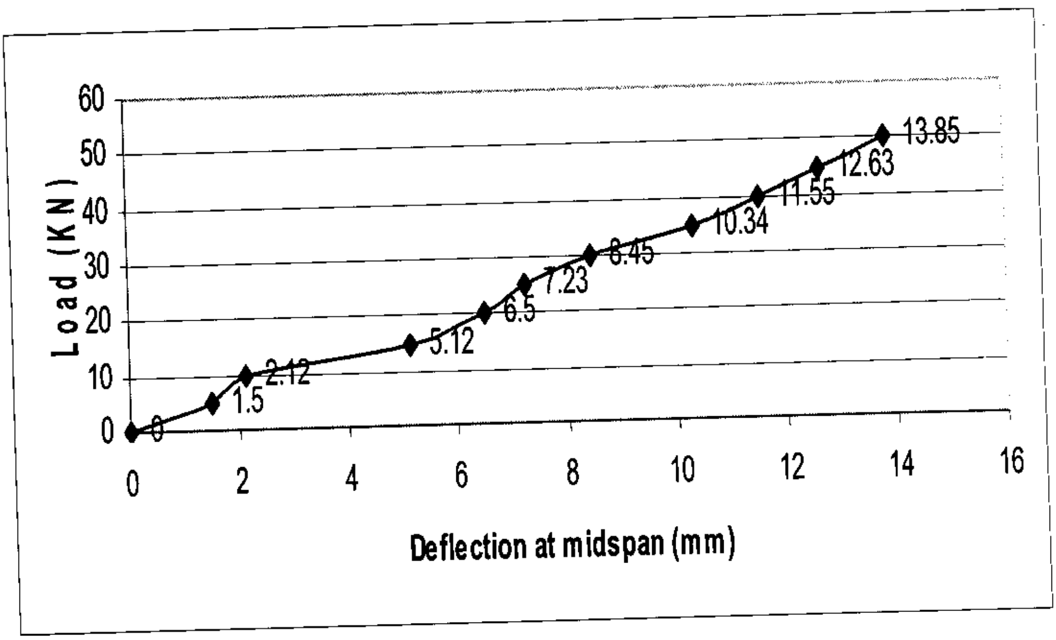

Fig7.5 Load Vs Displacement for GFRC Beam 2

Load kN	Deflection mm
0	0
5	1.15
10	2.85
15	4.85
20	5.25
25	6.61
30	7.12
35	9.21
40	11.21
45	13.55

Table7.9 load vs deflection of GFRC beam

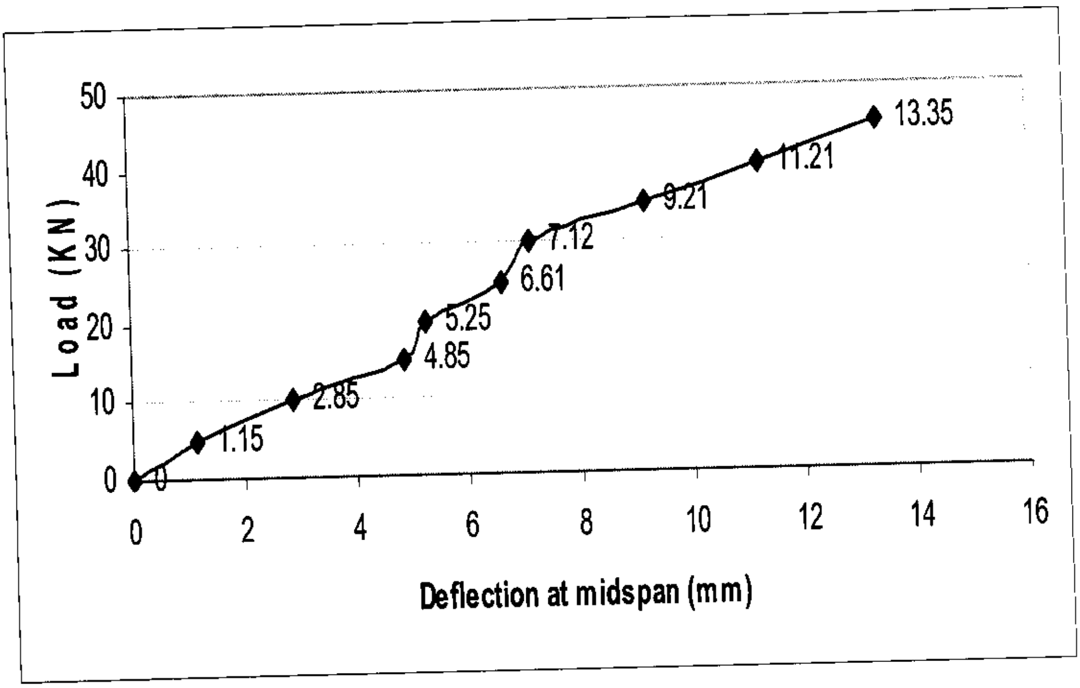

Fig7.6 Load Vs Displacement for GFRC Beam 3

CONCLUSION

CHAPTER 8
CONCLUSION

- Compared with steel fibres, the smaller diameter of glass fibres ensures better and more uniform dispersion, efficient load transfer, and their greater surface area provide better ability to bridge cracks.

- Compared with polypropylene fibres, the bond between glass fibres and the matrix is far superior, giving increased reinforcing efficiency and limiting fibre pull-out.

- Glass fibres have sufficient resilience and compliance that they can aligned randomly in the mix, and are therefore able to bride micro-cracks before they can reach a critical size, giving a substantial increase in durability

- Compared with conventional beam the GFRC beams have a higher value first cracking point and the cracks in GFRC beams are minimum.

- For M25 grade of concrete with 2.5% of glass fibre the compressive strength increases up to 25% with 20% replacement of fly ash.

- For M25 grade of concrete with 2.5% of glass fibre the tensile strength increases up to 44% with 20% replacement of fly ash.

- The load at the first crack was increased up to 33% for the G.F.R.C beam with 2.5% glass fibre and 20% replacement of fly ash.

- From my thesis I conclude by saying 2.5% addition of glass fibre with concrete is optimum.

PHOTOGRAPHS

CHAPTER 9

PHOTOGRAPHS

Fig 9.2 AR glass fibre

Fig 9.2 Compression Test

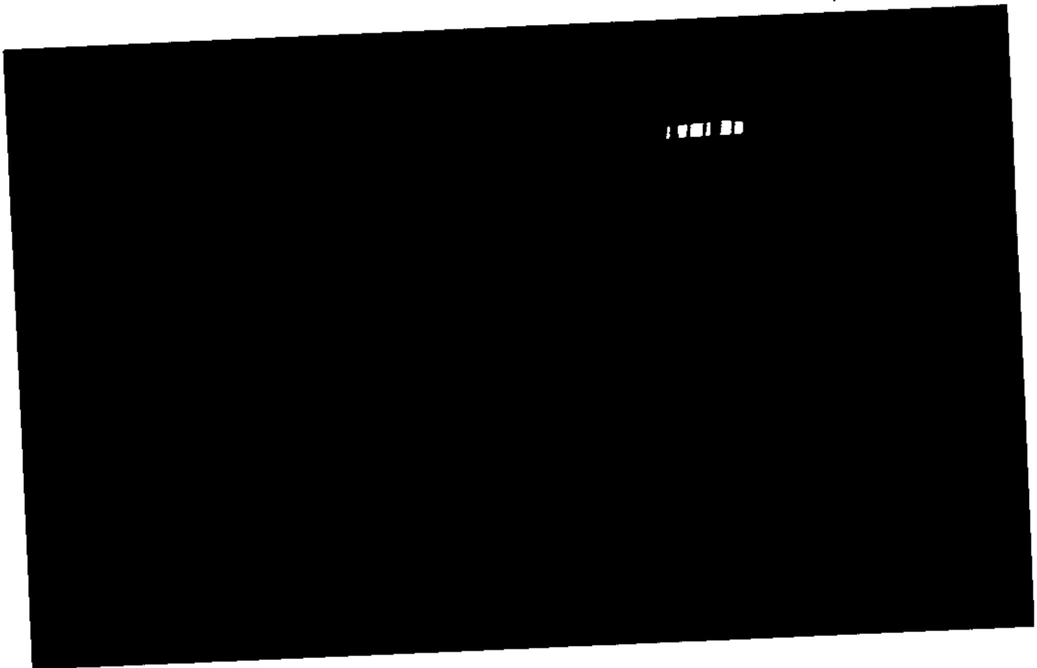

Fig 9.3 Crack Pattern of GFRC Beam

Fig 9.4 split tensile strength test

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REFERENCES

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