AN EXPERIMENTAL INVESTIGATION OF GLASS FIBRE ON BOTTOM ASH BASED CONCRETE

Submitted as Partial fulfilment of the requirements for the award of the Degree of Master of Technology in Structural Engineering

PROJECT PHASE - II

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ABSTRACT

Bottom ash is a hazardous by-product from coal based thermal power plants. Glass fibre increases the flexural strength and strain capacity of the concrete. In this project, bottom ash can is replaced with fine aggregates. The study was conducted to evaluate the strength characteristics of glass fibre and bottom ash on concrete. The concrete mix design was done for M30 grade concrete. Mix was prepared for different combinations (0%, 25%, 35%, 50% and 100%) replacement of sand by bottom ash with (0.3% of glass fibre).The specimen such as cubes of 150 x 150 x 150 mm in size and cylinder of 150 x 300 mm in size, beam of 1000 x 100 x 200 mm in size are casted and evaluate the properties such as compressive strength, split tensile strength & flexural strength has been analyzed and it has been compared with control mix for the duration of 7 and 28 days.

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Symbols	Abbreviations
GFRC	Glass Fiber Reinforced Concrete
BA	Bottom Ash
KN	Kilo Newton
L	Length
m^2	Square meter
m^3	Cubic meter
mm^3	Cubic millimeter
ml	Milliliter
mm	Millimeter
Mpa	Mega Pascal
N/mm^2	Newton per Square millimeter
w/c	Water Cement Ratio
W	Weight
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 General

Concrete is an artificial material which has wider applications in the construction industry. The basic ingredients of concrete are cement, sand, coarse aggregate and water. Plain cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Recent trends in concrete technology are to improve the workability, strength and resistance to smaller cracks in the concrete.

Addition of small closely spaced and uniformly dispersed fibres to concrete, acts as crack arresters and substantially improves the static and dynamic properties of plain concrete. The fibres of short length and small diameters can be used in high strength concrete to convert its brittle nature to a ductile one. The fibres used can be of steel, polypropylene, nylon, glass or carbon. Each of the above mentioned fibre has its own characteristic properties and limitations.

The coarser material, which falls into furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers and is known as Bottom Ash. This paper presents the experimental investigations carried out to study the effect of use of bottom ash as a replacement of fine aggregate**.**

1.2 Glass Fibre

On a specific strength (i.e. strength to weight) basis, glass fibre is one of the strongest and most commonly used structural materials. Some Lab tested fibres have shown strength up to 6896 MPa and commercial grades range from 3448 – 4830 MPa. The continuous glass filaments are manufacture by two basic process i.e. by marble melt process and direct melt process respectively. To minimise abrasion related degradation of glass fibres, surface treatments (sizing's) are applied prior to gathering of fibres in to strands. Commonly glass fibres are round and straight and have diameters ranging from G (9-10.2 μm) to T (22.9 – 24.1 μm) are used. The glass fibres are available in different forms like continuous form, woven roving, surfacing mats, three dimensional and multidimensional (such as 5-D, 7-D, 11-D) etc. There are several glass fibre types with different chemical compositions providing the specific physical/chemical properties. E-glass (calcium aluminoborosilicate composition) is best for general purpose structural use. S-glass (magnesium aluminosilicate composition) is a special glass with higher tensile strength and modulus, good heat resistance, strong resistance to acids. C-glass has good chemical stability in chemical corrosive environments. T-glass fibre exhibits improved performance over E-glass such as 36% increase in tensile strength, 16% increase in tensile modulus, increased heat resistance, improved impact, electrical, thermal and chemical resistance properties. R-glass (magnesium-lime-aluminosilicate) has higher tensile strength and modulus compared to E-glass and gives higher resistance to fatigue, aging temperature and corrosion.

1.3 Bottom Ash

Energy is the main backbone of modern civilization of the world over, and the electric power from thermal power stations is a major source of energy, in the form of electricity. In India, over 70% of electricity generated in India, is by combustion of fossil fuels, out of which nearly 61% is produced by coal-fired plants. This results in the production of roughly 100 ton of ash. Most of the ash has to be disposed off either dry, or wet to an open area available near the plant or by grounding both the fly ash and bottom ash and mixing it with water and pumping into artificial lagoon or dumping yards. This causes the pollution in water bodies and loss of Productive land.

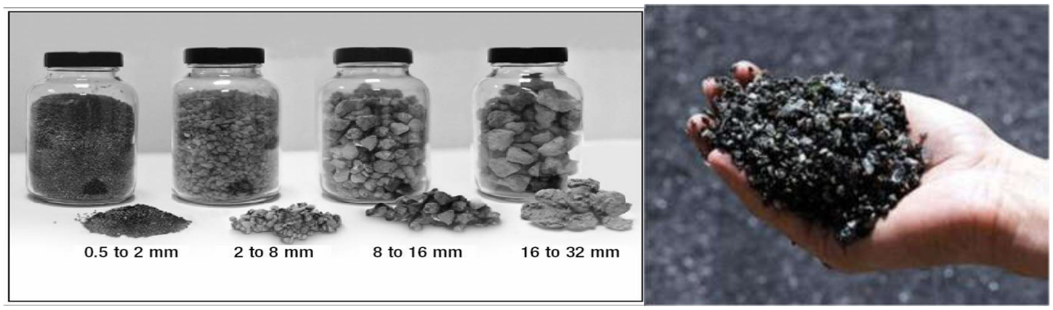

Fig. 1.1 Bottom Ash

1.4 Need for Study

The continuous reduction of natural resources and the environmental hazards posed by the disposal of coal ash has reached alarming proportion such that the use of coal ash in concrete manufacture is a necessity than a desire. The use of coal ash in normal strength concrete is a new dimension in concrete mix design and if applied on large scale would revolutionize the construction industry, by economizing the construction cost and decreasing the ash content.

CHAPTER 2

METHODOLOGY

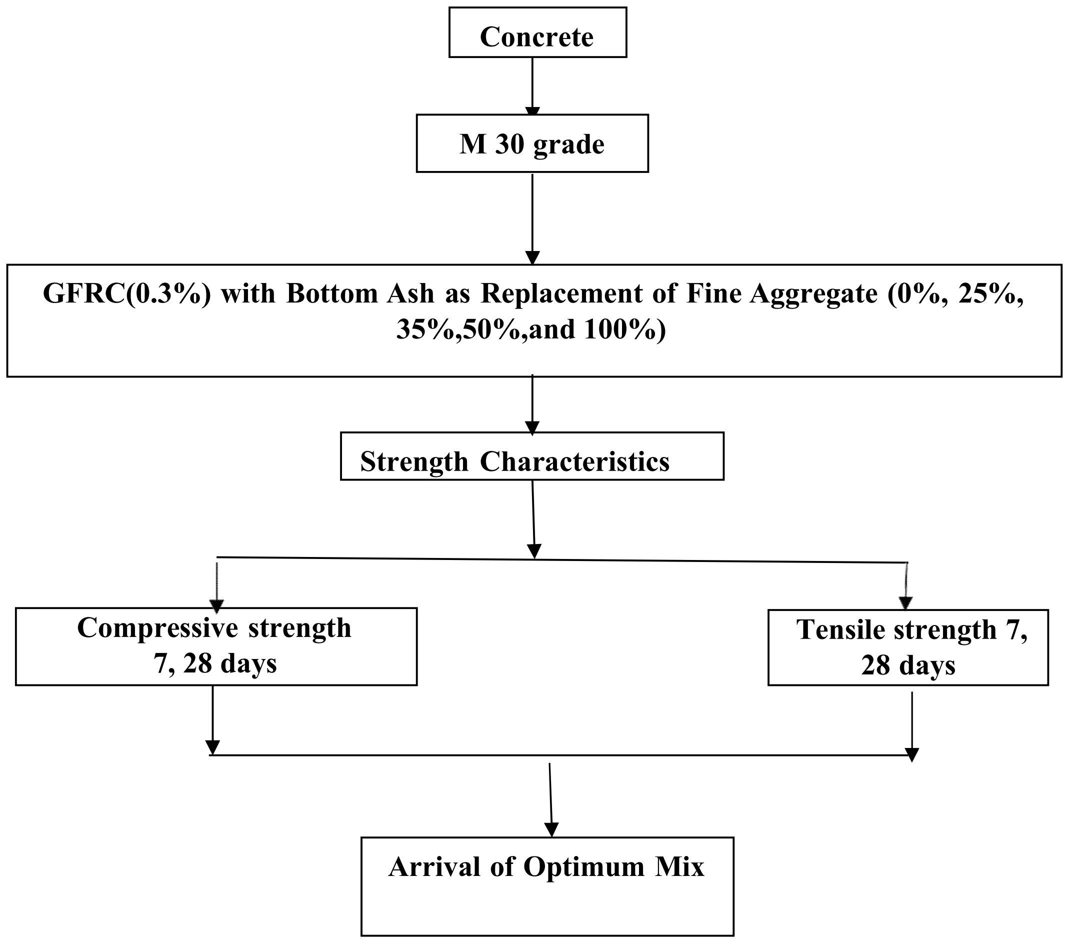

Fig 2.1METHODOLOGY

CHAPTER 3

LITERATURE REVIEW

In this chapter, earlier research work in the usage of fibres to improve the strength of glass fibre reinforced concrete is discussed.

Maslehuddin et. al.,(1989) have conducted experimental investigations were carried out by replacing sand by equal weight of flyash, with sand replacement levels of 0, 20 and 30 % and w/c ratio of 0.35, 0.40, 0.45and 0.50, keeping cement content constant at 350 kg/m3 in all mixes. Compressive Strength gain and corrosion resistance was higher for sand replaced with flyash mixtures. Also, the corrosion rate of reinforcing steel bars in concrete was lowest in 30% replacement level.

A study on the potential of using bottom ash as pozzolanic material was done by **Tarun R et. al.,(1989).** The quality was improved by grinding until the particle size retained on sieve 325 mm was less than 5% by weight. The results showed that pastes of cement with replacement by original or ground bottom ash, between 10-30% resulted in longer initial setting time, depending onthe fineness of the ashes, compared to setting time of the cement paste. Original bottom ash mortar had higher water requirement than that of the cement mortar and ground bottom ash mortar had lesser water requirement than that of the cement mortar. Bottom ash could be used as a pozzolanic material if it was ground having retention on 325-micron sieve less than 5%.

The municipal solid waste bottom ash (MSWBA) was used as alternative aggregate for the production of building concrete presenting a characteristic strength at 28 days of 25 Mpa by **Maslehuddin et. al.,(1989).**

Wu Yao, et. al., (2003) compared concretes containing different types of hybrid fibers at the same volume fraction (0.5%) in terms of compressive, splitting tensile, and flexural properties. Three types of hybrid composites were constructed using fiber combinations of polypropylene (PP) and carbon, carbon and steel, and steel and PP fibers. Test results showed that the fibers, when used in a hybrid form, could result in superior composite performance compared to their individual fiber-reinforced concretes. Among the three types of hybrids, the carbon–steel combination gave concrete of the highest strength and flexural toughness because of the similar modulus and the synergistic interaction between the two reinforcing fibers.

An attempt was made to develop 'Light Weight Concrete' in which flyash and bottom ash were used as partial replacement of cement and fine aggregate **Siddique et. al.,(2003).** The effects of furnace bottom ash on workability, compressive strength, and permeability, depth of carbonation and chloride penetration of concrete were investigated by Siddique et. al.,(2003) The natural sand was replaced with furnace bottom ash by 30, 50, 70 and 100 % by mass at fixed free w/c ratio of 0.45 and 0.55 and cement content of 382 kg/m3. The results showed increase in the workability of concrete, and decreased compressive strength, at fixed cement content and w/c ratio. No adverse influence on the long-term strength was observed. Air permeability, sorptivity and carbonation rate for bottom ash concrete was higher as compared to control concrete. However the chloride transport coefficient decreased with the increase of the replacement level up to 50%, beyond which it increased. A lightweight concrete using flyash (FA), furnace bottom ash (FBA) and Lytage (LG) as a replacement of OPC, natural sand and coarse aggregate respectively was manufactured.

Yeol Choi et. al., (2005) have studied splitting tensile strength and compressive strength of GFRC and PFRC at 7, 28 and 90 days. Test results indicate that the addition of glass and polypropylene fibers to concrete increased the splitting tensile strength of concrete by approximately 20–50%, and the splitting tensile strength of GFRC and PFRC ranged from 9% to 13% of its compressive strength. Based on this investigation, a simple 0.5 power relationship between the splitting tensile strength and the compressive strength was derived for estimating the tensile strength of GFRC and PFRC.

Ilker Bekir Topcu et. al., (2007)have done experimental investigation to study the effects of replacement of cement (by weight) with three percentages of fly ash and effects of addition of steel and polypropylene fiber. Current day knowledge of concrete technology focuses attention primarily on the use of different materials in the production of concrete, industrial wastes in particular. The use of fly ash in concrete today is an important subject and is growing in importance day by day. Using fly ash in concrete may both provide economical advantages and better properties in the production of concrete. Besides, concretes produced with three different replacement ratios of fly ash and three different types of steel and polypropylene fibers were compared to those without fibers used in concrete with FA. According to the results of the study, addition of fibers provide better performance for the concrete, while fly ash in the mixture may adjust the workability and strength losses caused by fibers, and improve strength gain.

Sivakumar. A, et. al., (2009) have conducted experimental investigation carried out on high strength concrete reinforced with hybrid fibres (combination of hooked steel and a non-metallic fibre) up to a volume fraction of 0.5%. The mechanical properties, namely, compressive strength, split tensile strength, flexural strength and flexural toughness were studied for concrete prepared using different hybrid fibre combinations – steel–polypropylene, steel–polyester and steel–glass. The flexural properties were studied using four point bending tests on beam specimens as per Japanese Concrete Institute (JCI) recommendations. Fibre addition was seen to enhance the pre-peak as well as post-peak region of the load–deflection curve, causing an increase in flexural strength and toughness, respectively. Addition of steel fibres generally contributed towards the energy absorbing mechanism (bridging action) whereas, the non-metallic fibres resulted in delaying the formation of micro-cracks. Compared to other hybrid fibre reinforced concretes, the flexural toughness of steel–polypropylene hybrid fibre concretes was comparable to steel fibre concrete. Increased fibre availability in the hybrid fibre systems (due to the lower densities of non-metallic fibres), in addition to the ability of non-metallic fibres to bridge smaller micro cracks, are suggested as the reasons for the enhancement in mechanical properties.

Aggarwal et al (2010) discussed that the replacement of fine aggregates with bottom ash can easily be equated to the strength development of normal concrete at various ages.

Rama Mohan Rao.P et. al., (2015) have done experimental investigation of different volume Fractions of glass fibres with 25% and 40% replacement of cement by flyash and studied the compressive, split tensile strength and flexural strength at age of 7 days, 28 days of the concrete. Test results indicate that strength of concrete decreases with increase in the percentage of flyash and there is an increase of about 8.5% to 16% in split Tensile Strength. The volume Fraction of glass Fibre, 0.3% gives better strength values compared to control mix.

CHAPTER 4

FIBRES

4.1 Fibre Types

The most common fibre types used in composite industry are

- Glass fibres.
- Carbon and organic (Kevlar) fibres.
- Boron fibres.
- Metallic fibres.

4.1.1 Glass Fibres

Glass fibres exhibit the typical glass properties of hardness, corrosion resistance, and inertness. They are flexible, lightweight, and inexpensive. These properties make glass fibres the most common type of fibre used in low cost industry applications. Because glass has an amorphous structure, its properties are the same along the fibre and across the fibre. Glass fibres are useful because of their high ratio of surface area to weight. The high strength of glass fibres is attributed to the low number and size of defects on the surface of the fibre. Tensile strength of glass fibres reduces at elevated temperature but can be considered constant for the range of temperature at which polymer matrices can be exposed (up to 275^{o}C depending on the matrix type).

Fig. 4.1 Showing the Fibres used

4.1.2 Carbon Fibres

A carbon fibre composite refers to a composite in which at least one of the fillers is carbon fibres, either short or continuous, unidirectional or multidirectional, woven or nonwoven. The matrix is usually a polymer, a metal, a carbon, a ceramic, or a combination of different materials. Except for sandwich composites, the matrix is three-dimensionally continuous, whereas the filler can be three-dimensionally discontinuous or continuous. The properties of carbon fibres depend on the raw material and manufacturing process. The fibres begin as an organic fibre, rayon, polyacrylonitrile or pitch which is called the precursor. The precursor is then stretched, oxidized, carbonized andGraphitized. There are many ways to produce these fibres, but the relative amount of exposure at temperatures from 2500-3000°C results in greater or less graphitization of the fibre. Higher degrees of graphitization usually result in a stiffer fibre (higher modulus) with greater electrical and thermal conductivity values.

4.1.3 Boron Fibres

Boron fibres are produced by a chemical vapour deposition process. Boron can be deposited on a tungsten wire core, and on a glass or graphite filament core. The fibres thus produced have nominal diameters ranging from 0.1-0.2 mm. They are characterized by low density, high tensile strength and high modulus of elasticity. They are extremely stiff, e.g., five times stiffer than glass fibres. This stiffness makes boron filaments difficult to weave, braid, or twist, but they can be formed into resin impregnated tapes for hand lay-up and filament winding processes. The high cost of boron filaments has limited their use to experimental aircraft and aero-space applications.

4.1.4 Metallic Fibres

Steel fibres are one of the commonly used metallic fibres. The diameter varies from 0.25 to 0.75 mm. It improves the flexural impact and fatigue strength of concrete. It has been extensively used in overlays of roads, airfield pavements and bridge decks. But it is likely to get rusted and loose some of its strength.

4.1.5 Aramid Fibres

The best known organic fibres are Aramid fibres. Aramid fibres have high energy absorption during failure, which makes them ideal for impact and ballistic protection. Because of their low density, they offer high tensile strength-to-weight ratio, and high modulus-to-weight ratio, which makes them attractive for aircraft and body armour. Aramid composites have relatively poor shear and compression properties. Careful design is required for their use in structural applications that involve bending or compression.

4.2 Role of Fibers

- Crack control.
- Reduction of water permeability.
- Reduction of Rebound Loss.
- Increase in flexibility.

4.2.1 Crack Control

The fibers are used for preventing micro shrinkage cracks developed during curing. Due to imposed load on concrete, crack will propagate. Addition of fibers to concrete and plaster prevent/arrest cracks caused by volume change (expansion and contraction) fiber of 1 kg has millions of fibers which support mortar/concrete in all directions.

4.2.2 Reduction of Water Permeability

A structure free from micro cracks prevents entering and migrating of water or moisture throughout the concrete. This in turn helps to prevent the corrosion of steel.

4.2.3 Reduction of Rebound Loss

The fiber reduces rebound ‘splattering of concrete’ and shotcretes. This reduces wastage of mortar.

4.2.4 Increase in Flexibility

The modulus of elasticity is high with respect to the modulus of elasticity of concrete or mortar binder. The fiber helps to increase flexural strength.

4.3 Effect of Fibers on the Properties of Concrete

- Workability.
- Reduce bleeding.
- Plastic cracking.
- Impact resistance.
- Durability.

4.3.1 Workability

The inclusion of fibers imparts stability to fresh concrete which will be apparent in a reduced slump test measurement. However, at normally recommended dosage rates the placing and compaction characteristic of the concrete are usually still satisfactory without adjustment of the water content.

4.3.2 Reduce Bleeding

Tests on concrete with polypropylene fibers have shown that the amount of bleeding is considerably reduced and this helps to reduce and this help to reduce the risk of plastic cracking. The effect on early age tensile strength initial hardening is a major contributory factor.

4.3.3 Plastic Cracking

The principle effect of fibers is on plastic and limiting those cracks that can occur early in the hardening process. Fibers can also enhance the resistance to spalling at rises and joints.

4.3.4 Impact Resistance

Impact and fatigue resistance are both related to flexural toughness and improved by the inclusion of fiber.

4.3.5 Durability

Durability will, in most cases, be improved as a result of the fibers on the early age behavior of the concrete, namely by reducing bleeding and plastic cracking. Minimized bleeding improves the hydration of the cement close to the surface thereby providing better long-term resistance to carbonation, abrasing, and other aggressive agencies. The fibers can be used with air-entraining agents without any adverse effect on the air void system.

4.4 Glass Fiber Types

- Chopped strand mat
- Direct roving
- Spray rovings
- Assembled rovings

CHAPTER 5

MATERIAL PROPERTIES

5.1 Cement

Lot of factors impact on the strength of concrete, but strength of cement is the most important and direct factor. The experiment uses the quality – guaranteed local cement. The use of 53 grades OPC is preferred as it was seen from the past records of cements available in market.

The mechanical properties of the used cement as determined by laboratory tests showed its suitability for concrete works. The mechanical properties of the cement used in this investigation are given below.

Table 5.1 Chemical Composition of Cement

Chemical composition	**Percentage**
SiO_2	21.88
Al_2O_3	4.37
Fl_2O_3	2.84
CaO	62.62
MgO	3.94
SO_3	2.76
LOi	0.73
Na_2O	0.55

Table 5.2 Physical Properties of Cement

Name of the tests	Tested value	Value As per IS : 12269 – 1987
Standard consistency test	33%	-
Initial setting time	30mins	>30mins
Strength test	54.08N/mm^2	53 N/mm^2
Fineness test	6%	<10%
Soundness test	2mm	<10mm
Specific gravity	3.1	3.25

Fig5.1 Standard Consistency Test

Fig5.2 Vicat Apparatus to find initial setting time

5.2 Fine Aggregate

The sand used for the experimental programme was locally procured and conformed to Indian standard specifications IS 383-1970. The sand was first sieved through 4.75mm sieve to remove any particles greater than 4.75mm and then washed to remove the dust. Properties of fine aggregate used in the experimental work are tabulated below. The aggregate was sieved through a set of sieves as shown in figure. The fine aggregate belonged to grading zone III.

5.2.1 Properties of Fine Aggregate

Specific Gravity : 2.64

Fineness modulus : 3.05

Water absorption : 0.25%

5.2.2 Fineness Modulus of Fine Aggregate

Table 5.3 Fineness Modulus of Fine Aggregate

Sl. no	I.S sieve size (mm)	Weight of materials Retained (Kg)	Cumulative weight of material retained (Kg)	Cumulative % retained	Cumulative % of Passing
1	4.75	0.0167	0.0167	003.34	96.66
2	2.36	0.0772	0.0939	018.78	81.22
3	1.18	0.0580	0.1919	038.38	61.62
4	0.6	0.0635	0.2554	051.08	48.92
5	0.30	0.1674	0.4678	093.56	6.44
6	0.15	0.0122	0.4800	100.00	4.00
7	PAN	0.0200	0.5000	-	-

Fineness Modulus of Fine Aggregate = $\sum f/100$

= 3.05

5.2.3 Specific Gravity of Fine Aggregate

Description		Weight of Sample
Weight of empty pycnometer (w_1)	=	616gm
Weight of pycnometer + fine aggregate (w_2)	=	1379gm
Weight of pycnometer + F.A + water(w_3)	=	1932gm
Weight of pycnometer + water (w_4)	=	1458gm

Specific gravity of fine aggregate = $\frac{\text{Dry weight of fine aggregate}}{\text{Weight of equal volume of water}}$

$$= \frac{W_2 - W_1}{(W_4-W_1) - (W_3-W_2)}$$

$$= \frac{763}{289}$$

The value obtained for Specific gravity of fine aggregate is 2.64

Fig5.3 Weighing of Pyconometer

5.3 Coarse Aggregate

The material which is retained on BIS test sieve no. 480 is termed as a coarse aggregate. The broken stone is generally used as a coarse aggregate. The Coarse Aggregate is the strongest and least porous component of concrete.

The Maximum size of coarse aggregate used was 20 mm. The properties of coarse aggregate were Determined by conducting tests as per IS: 2386 (Part – III). The results are shown in test data of materials

5.3.1 Properties of Coarse Aggregate

Specific Gravity : 2.63

Fineness modulus : 7.28

Maximum size : 20mm

Water absorption : 1.86%

5.3.2 Fineness Modulus of Coarse Aggregate

Table 5.4 Fineness Modulus of Coarse Aggregate

Sl. No	Sieve size	Weight of materials Retained (Kg)	Cumulative weight of material retained (Kg)	Cumulative % retained	Cumulative % of Passing
1	80mm	-	0	100	0
2	40mm	-	0	100	0
3	20mm	2.186	72.883	27.117	72.883
4	10mm	0.674	22.483	4.634	95.366
5	4.75mm	0.139	4.633	0	99.99
6	PAN	0	0	-	-

Fineness modulus of Coarse Aggregate= ∑f/100

=7.28

Fig5.4 Sieve Shaker

5.3.3 Specific Gravity of Coarse Aggregate

Description		**Weight of Sample**
Weight of empty pycnometer (w_1)	=	625gm
Weight of pycnometer + coarse aggregate (w_2)	=	823gm
Weight of pycnometer + C.A + water(w_3)	=	1611gm
Weight of pycnometer + water (w_4)	=	1488gm

$$\text{Specific gravity of Coarse aggregate} = \frac{\text{Dry weight of Coarse aggregate}}{\text{Weight of equal volume of water}}$$

$$= \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= \frac{198}{75}$$

The value obtained for Specific gravity of Coarse aggregate is 2.63

5.4Glass Fibres

Glass fibre used was Chopped Strands of E-Glass Fibre

Table 5.5 Chemical Properties of Glass Fibre

Silica as SiO_2	76.39 %
Alumina as Al_2O_3	2.19 %
Calcium as Cao	6.05 %
Magnesium as Mgo	1.18 %
Sodium as Na_2O	8.86 %
Potassium as K_2O	2.84 %
Loss on Ignition(LOI)@550◦C	0.24 %

Table 5.6 Showing the Properties of the Fibres used

Length of Fibre (mm)	Diameter µm	Specific Gravity	Failure Strain%	Elasticity (GPa)	Tensile Strength (GPa)
6	12	2.60	3.0	80	2.5

5.5 Bottom Ash

5.5.1 Properties of Bottom Ash

Specific Gravity : 2.7

Maximum size : 0.5-2mm

Plasticity : None

Water absorption : 0.8-2%

5.5.2 Specific Gravity of Bottom Ash

Description	Weight of Sample
Weight of empty pycnometer (w_1)	= 625gm
Weight of pycnometer + bottom ash (w_2)	= 825gm
Weight of pycnometer + bottom ash + water(w_3)	= 1620gm
Weight of pycnometer + water (w_4)	= 1492gm

Specific gravity of bottom ash = Dry weight of bottom ash

Weight of equal volume of water

$$= \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= \frac{200}{72}$$

The value obtained for Specific gravity of bottom ash is 2.70

5.6 Water

Water used conforms IS 3025 (Part 22, 23), water to be used for mixing and curing should be free from injurious or deleterious material.Potable water is generally considered satisfaction. In the present investigation, available water within the campus is used for both mixing and curing purpose.

Portable tap water available in laboratory with pH value of 7.0±1 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well.

CHAPTER 6

MIX DESIGN

6.1 Indian Standard Method of Mix Design

The design of concrete mix will be based on the following factors, using physical properties of materials.

(a) Grade of concrete: This gives the characteristic strength requirements of concrete. Depending upon the level of quality control available at the site, the concrete mix has to be designed for a target mean strength which is higher than the characteristic strength.

(b) Type of cement: The type of cement is important mainly through its influence on the rate ofdevelopment of compressive strength of concrete as well as durability under aggressive environments ordinary Portland cement (OPC) and Portland Pozzolona cement (PPC) are permitted to use in reinforced concrete construction.

(c) Maximum nominal size of aggregate: It is found that larger the size of aggregate, smaller is the cement requirement for a particular water cement ratio. Aggregates having a maximum nominal size of 20mm or smaller are generally considered satisfactory.

(d) Minimum water cement ratio: The minimum w/c ratio for a specified strength depends on the type of cement.

(e) Workability: The workability of concrete for satisfactory placing and compaction is related to the size and shape of the section to be concreted.

6.2Mix Design for M30 Concrete by IS Method

Characteristic compressive strength for M30 grade is $30N/mm^2$

Target Strength for Mix Proportion:

f'_{ck} = f_{ck} + 1.65s

= 30 + 1.65 x 6

= 39.9 N/mm2

Selection of Water Content:

Max water content for 20mm aggregate = 186 litres

From table 2

= 186+ 0.6/100*186

= 187.116 lit

Calculation of Cement Content:

w/c ratio = 0.43

Cement ratio = 187.116/0.43

= 432.55 kg/m^3

Table 5; minimum cement content for several exposure condition =320kg/m3

432.55> 320 kg/m^3

Hence ok.

Determination of Fine Aggregate:

M-30 mix for fine aggregate

0.98 =[187.116+(432.55/3.14)+(fa/0.31*2.64)*(1/1000)]

Fa =536.55kg/m^3

Determination of Coarse Aggregate:

0.98 = [187.116+(432.55/3.14)+(Ca/(1-0.31)*2.64)*(1/1000)]

Ca = 1195.49kg/m^3

Mix:

Cement: Fine aggregate: Coarse aggregate: Water

1: 1.24: 2.76:0.43

Quantity per m^3

Cement = 432.55 kg/m^3

FA = 536.55 kg/m^3

CA = 1195.49 kg/m^3

W/c ratio = 187.12 lts

6.3 MixProportion

Table 6.1 Concrete Mix Proportion

Percentage replacement of FA with Bottom Ash	0%	25%	35%	50%	100%
Cement(kg/m^3)	432.55	432.55	432.55	432.55	432.55
FineAggregate (kg/m^3)	536.55	402.41	348.76	268.28	0
Coarse Aggregate(kg/m^3)	1195.49	1195.49	1195.49	1195.49	1195.49
BottomAsh(kg/m^3)	0	134.14	187.79	268.27	536.55
Glass Fibre(kg/m^3)	1.298	1.298	1.298	1.298	1.298
Water (lts)	187.12	187.12	187.12	187.12	187.12

CHAPTER 7

EXPERIMENTAL INVESTIGATIONS

7.1 General

For this experimental work cubes, cylinders and beams were casted in the laboratory. Cubes and cylinders were casted using concrete mixes with fine aggregates replaced by bottom ash of 0%,25%,35%,50% and 100% along with 0.3% glass fibre by weight of cement.

7.2 Testing of Specimens

7.2.1 Compression Test on Cubes

The cube specimen of the size 150 x 150 x 150 mm were tested after curing for period of 7 and 28 days for different combinations and results were compared with control specimens.

Fig 7.1 Compression Test

7.2.2 Split Tensile Strength on Cylinders

Cylinder Splitting Test: This is also sometimes referred as, “Brazillian Test”. This test developed in Brazil on 1943.Cylindrical test specimens have a length equal to twice the diameter. They are 150mm in diameter and 300mm long.

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.

Stress = $2P/\pi LD$ in N/mm^2

Where,

P - Load on the cylinder

L – Length of the cylinder

D – Diameter of the cylinder

Fig 7.2Split Tensile Test

7.2.3 Flexural Strength on Beams

It is measured by testing beams under 2 point loading (also called 4 point loading including the reactions). Beam Dimensions: 1. m length × 0.1 m breadth x 0.2 m depth.

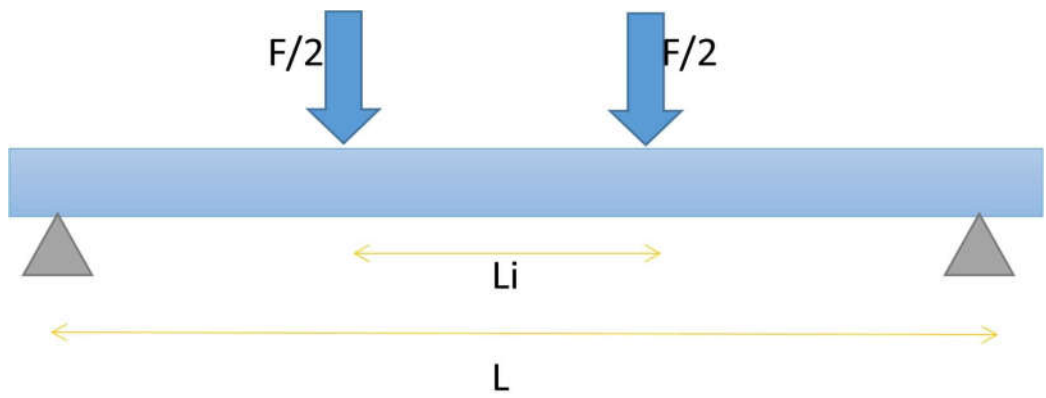

Fig 7.3 Beam under 2 Point Loading

$$\sigma = \frac{3F(L - L_i)}{2bd^2}$$

Where
F = the load applied to a sample of test length *L*, width *b*, and thickness *d*.

L= center to center distance of the supports.

Li= inner span.

Loading of control beam and BGC3 were carried out as shown respectively.

Comparisons of various test results are given in Table.3. The loads versus mid span deflection for both the beams were recorded, and their mean values were compared as shown similar response was observed for beam in both groups.

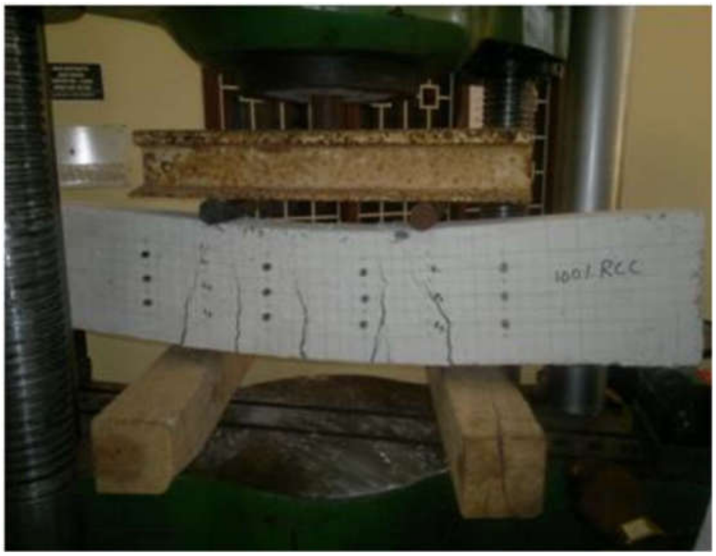

Fig 11. Flexural test on control beam

Flexural test on beam with BGC3 mix

7.2.4 Flexural cracks in control beam

Cracks formed in control beam were fewer in number but width was more, whereas in BGC3 numerous cracks with reduced crack width were formed which shows that the fibresarrested the widening of cracks. The beams after the test were as shown in Fig.12.

Flexural cracks in control beam and beam with BGC3 mix

7.2.5 Beam Reinforcement Details

All the beams were reinforced with 4 nos. of 10 mm diameter Fe 415 grade steel. Two numbers of 10 mm diameter bars at bottom and two numbers of 10mm diameter bars at top were used as main reinforcement.Shear reinforcement consists of 6mm diameter legged stirrups @ 100mm c/c throughout the length of the beam.

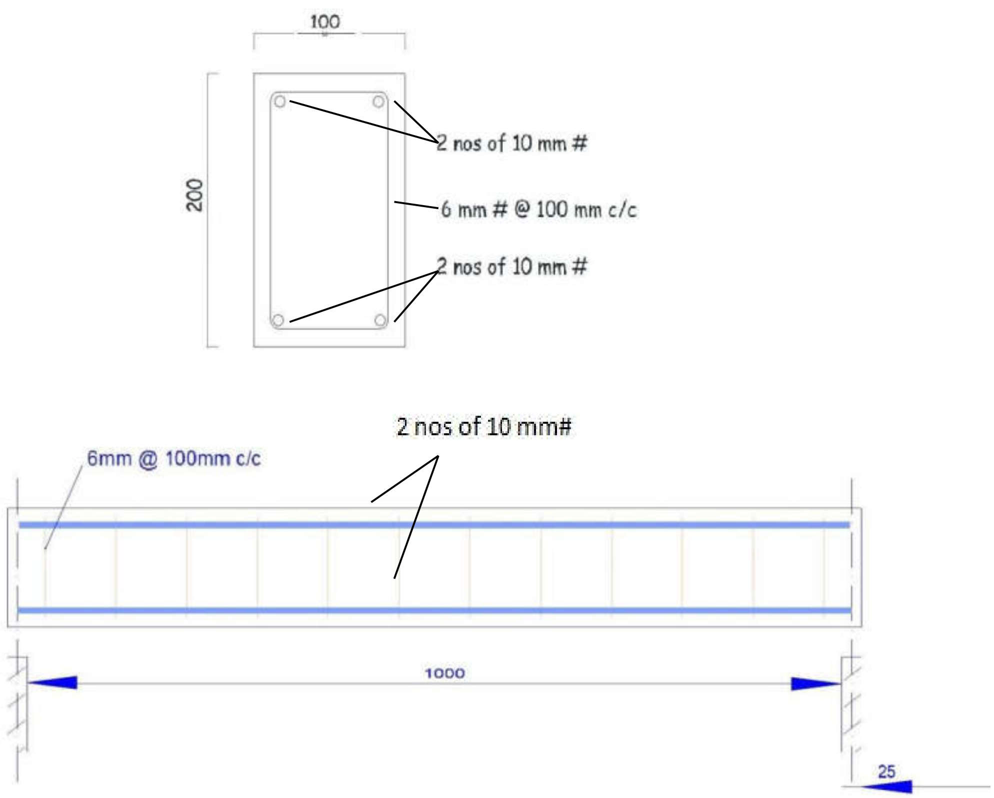

Fig 7.4Reinforcement Details for Beam

7.2.6 Testing of Beams

Flexural test on beams were carried out in universal testing machine of capacity 1000KN. The load was applied without shock and increased until failure occurs. The load-deformationpattern was plotted and maximum load applied to the specimens were recorded.

Fig 7.5Flexural Beam Test

7.3 Casting and Curing

The specimens are casted in a mould of the above specified sizes. The mould is arranged properly and placed over a smooth surface. The sides of the mould exposed to concrete were oiled well to prevent the side walls of the mould from absorbing water from concrete and to facilitate easy removal of the specimen. The reinforcement cages were placed in the moulds and cover between cage and form provided was 20 mm. Cement mortar block pieces were used as cover blocks. The concrete contents such as cement, sand and water were weighed accurately and mixed. The mixing was done till uniform mix was obtained. Then the steel fibres are placed into the mould .The concrete was infiltrated through the fibre bed immediately after mixing. The moulds are removed once the specimens attain their required strength. The specimens are then cured for a period of 7 to 28 days. The specimen after this curing period is taken out of the curing tank and let to dry in shade for a periods of 30 minutes before testing.

Fig 7.6 Concrete Mix

Fig 7.7 Specimen after Casting

Fig 7.8 Specimen in Curing Tank for Curing

CHAPTER 8

TEST RESULTS

8.1 Cube Compressive Strength

Table 8.1 Compressive Strength Resultsin N/mm^2 for 7 days

Glass Fibre (%)	Compression Strength in N/mm^2				
	0% BA	25% BA	35% BA	50% BA	100% BA
0%	31.72	29.25	23.85	20.98	9.2
0.3%	36.91	34.46	27.48	25.68	16.9

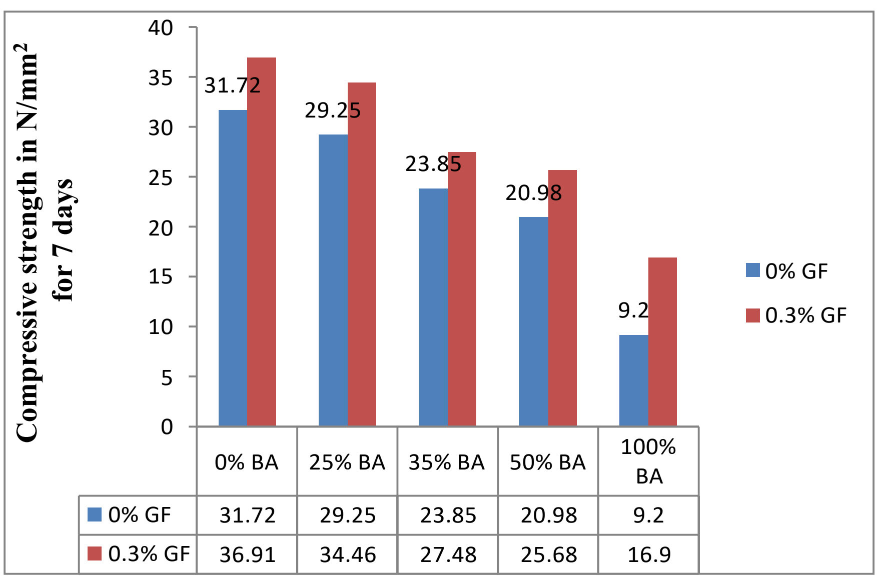

Fig 8.1 Compressive Strength Resultsin N/mm^2 for 7 days

Table 8.2 Compressive Strength Resultsin N/mm^2 for 28 days

Glass Fibre (%)	Compression Strength in N/mm^2				
	0% BA	25% BA	35% BA	50% BA	100% BA
0%	35.93	34.83	33.92	36.7	11.52
0.3%	40.24	38.32	37.22	36.9	25.4

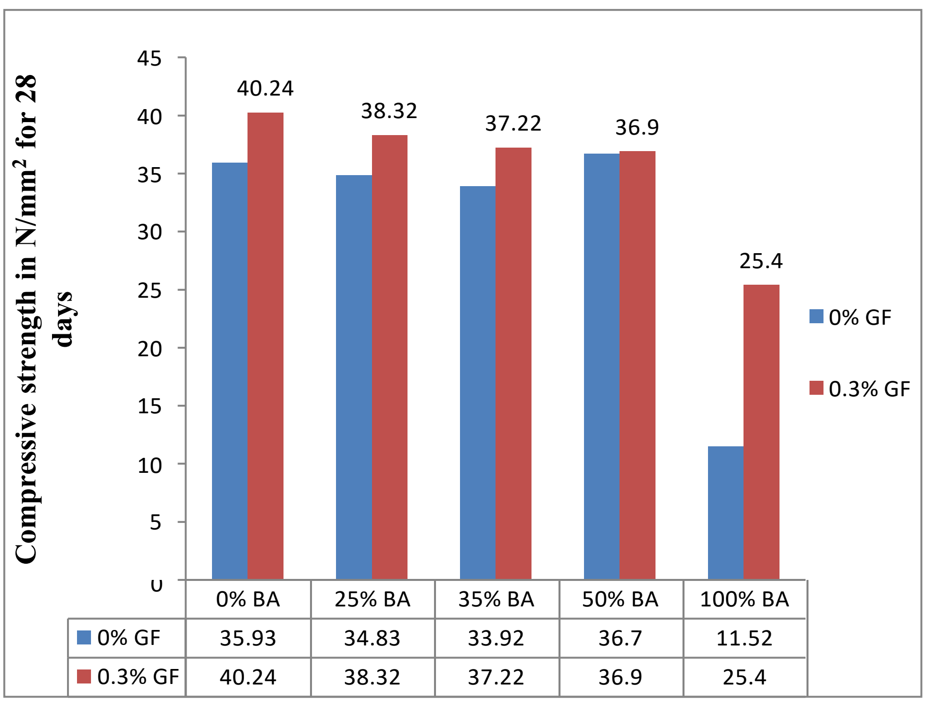

Fig 8.2 Compressive Strength Resultsin N/mm^2 for 28 days

8.2 Cylinder Split Tensile Strength

Table 8.3 Split TensileStrength Resultsin N/mm^2 for 7 days

Glass Fibre (%)	Split TensileStrength in N/mm^2				
	0% BA	25% BA	35% BA	50% BA	100% BA
0%	2.15	2.01	1.92	1.90	1.27
0.3%	2.53	2.48	2.32	2.24	1.61

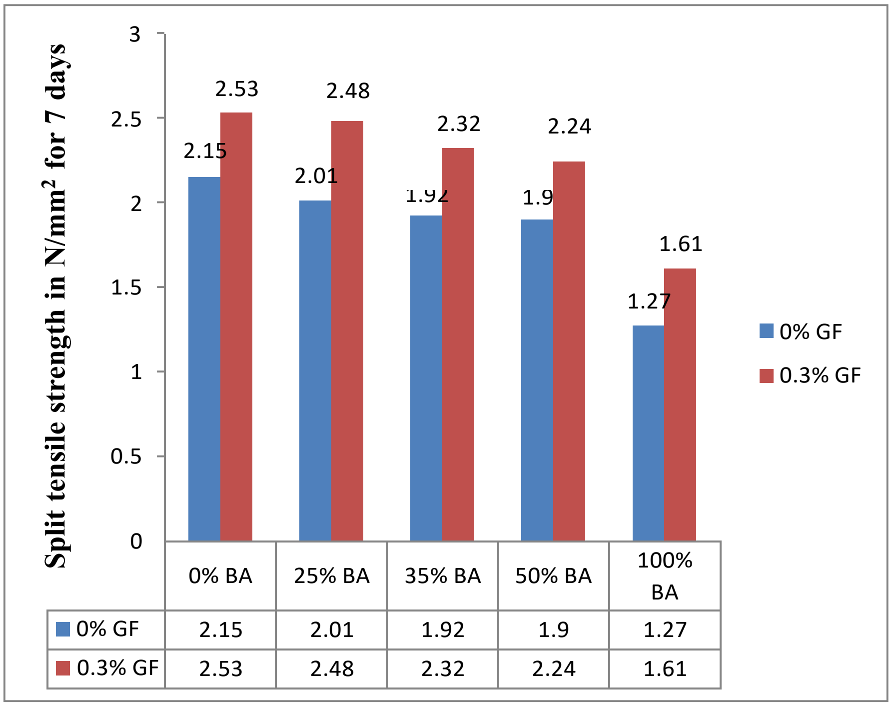

Fig. 8.3 Split TensileStrength Resultsin N/mm^2 for 7 days

Table 8.4 Split Tensile StrengthResultsin N/mm^2 for 28 days

Glass Fibre (%)	Split TensileStrength in N/mm^2				
	0% BA	25% BA	35% BA	50% BA	100% BA
0%	2.66	2.58	2.39	2.20	1.36
0.3%	3.23	3.07	2.90	2.65	2.11

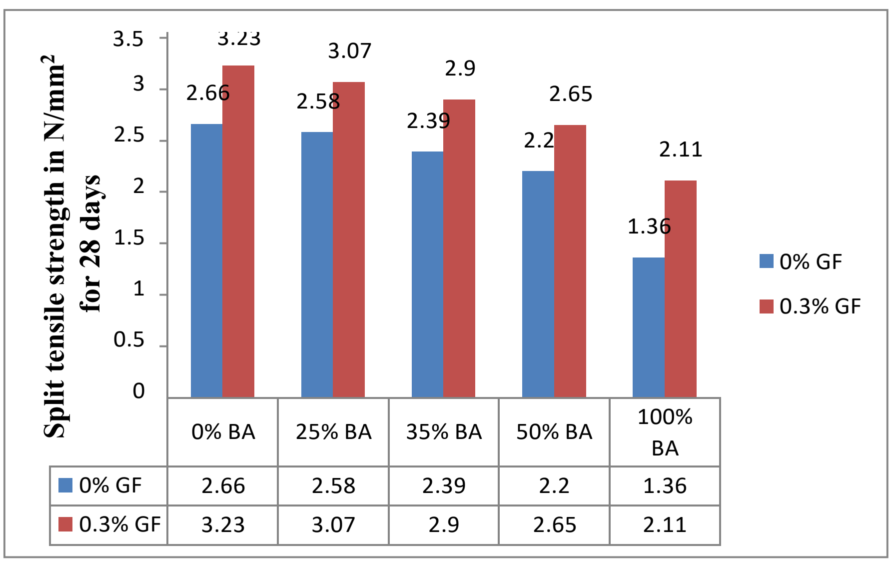

Fig. 8.4 Split Tensile StrengthResultsin N/mm^2 for 28 days

8.3 Beam Flexure Strength

Table 8.5 Comparison of Beam Test Results

	Peak Load (kN)	Flexural strength (N/mm²)	Young's modulus (N/mm²)	Max Bending Moment (kNm)	Maximum displacement (mm)
Conventional	68.60	18.00	20180	11.43	14.73
50 % Bottom ash + 0.3 % Glass fibre	72.25	18.96	20480	12.04	20.56

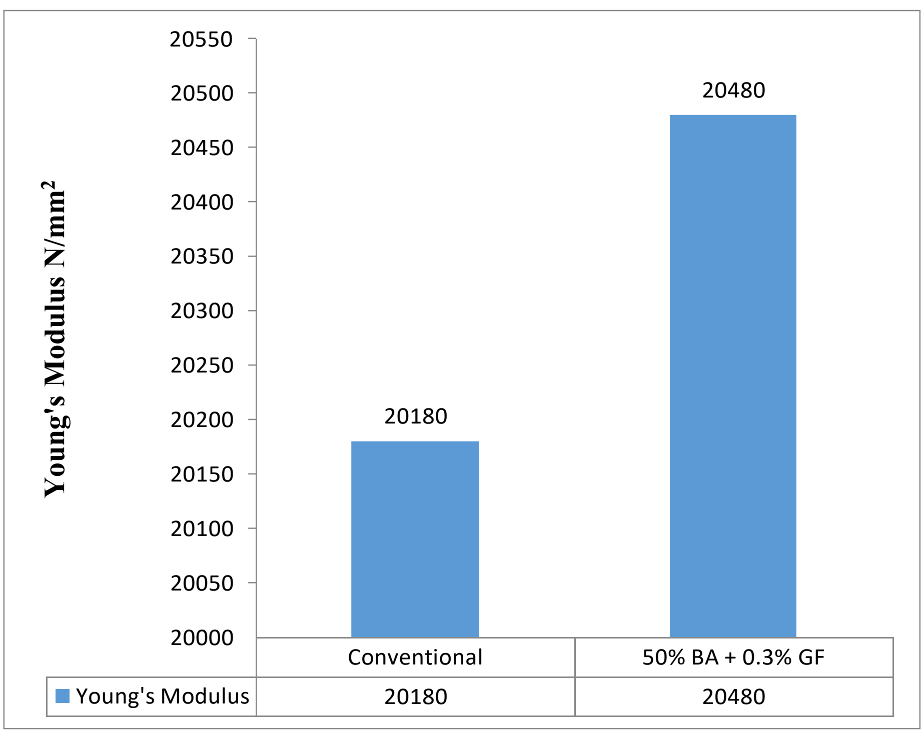

Fig. 8.5 Comparison of Young's Modulus of Beams

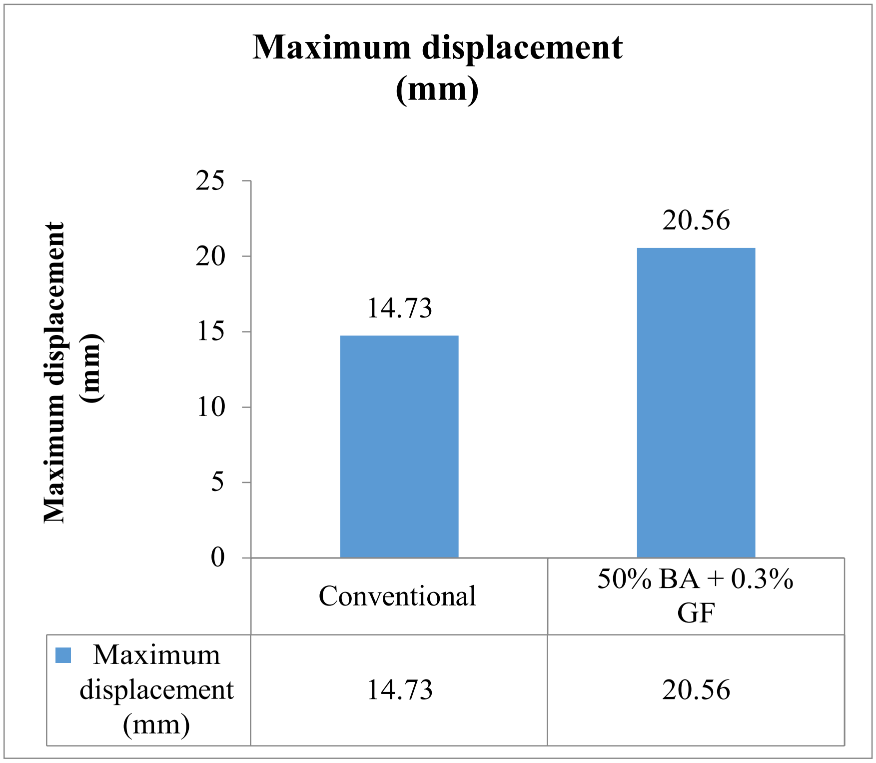

Fig. 8.6 Comparison of Maximum Displacement of Beams

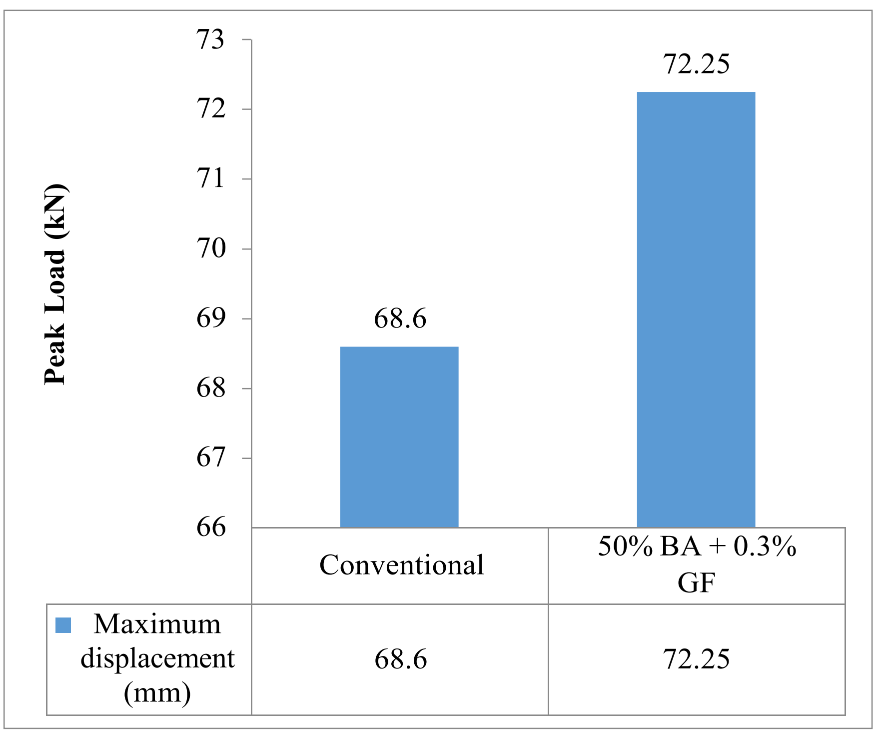

Fig. 8.7 Comparison of Peak Load of Beams

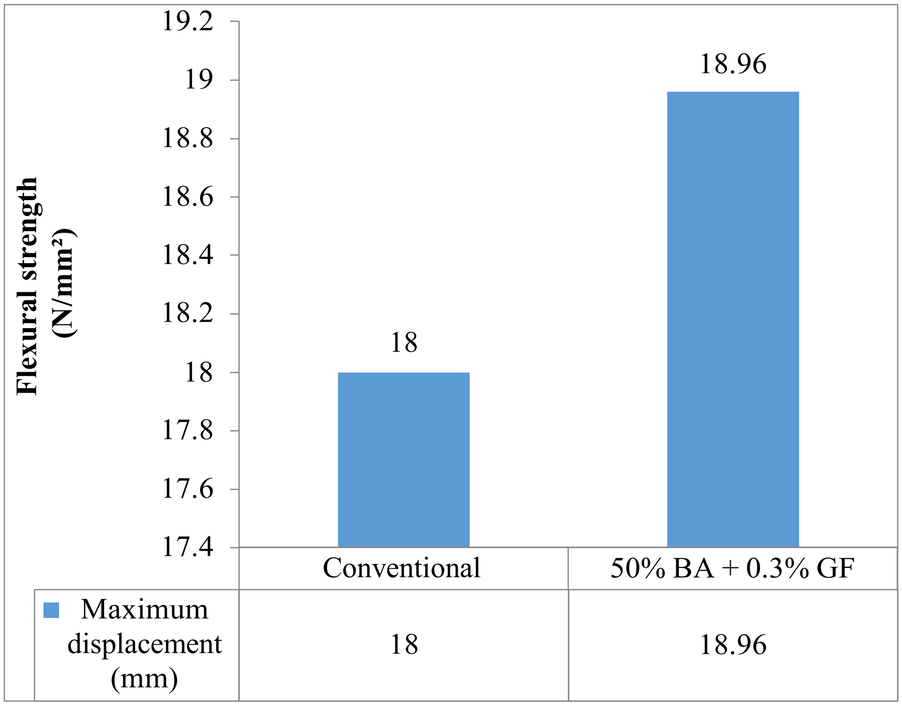

Fig.8.8 Comparison of Flexural strength of Beams

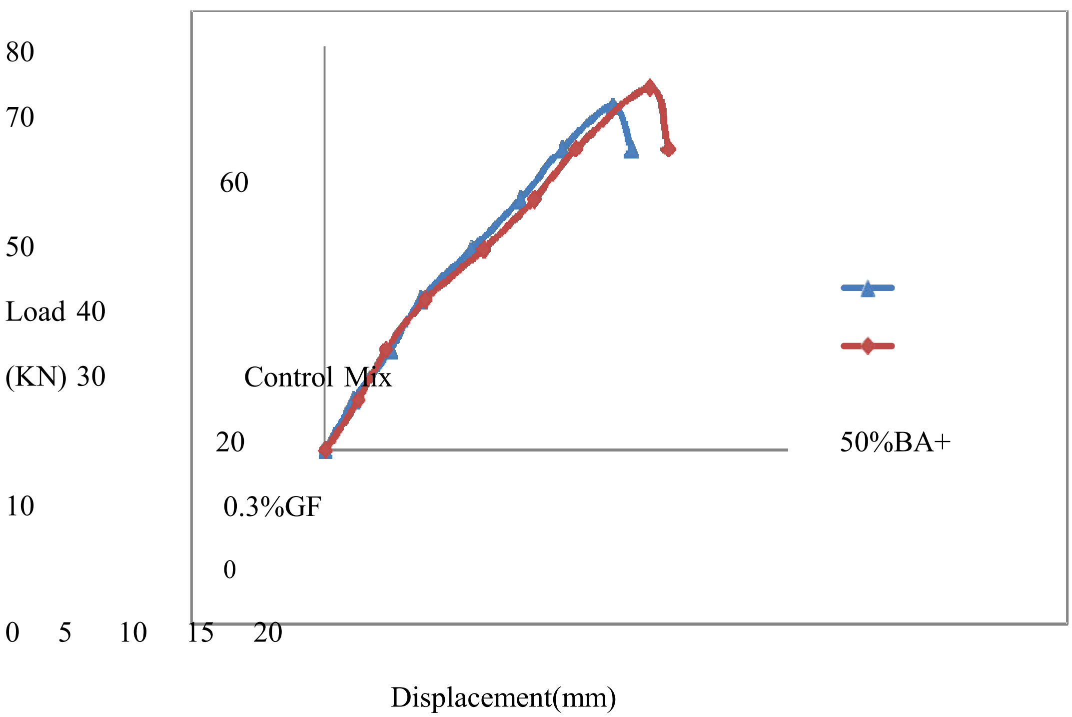

Fig. 8.9 Load Vs Displacement Curve

CHAPTER 9

CONCLUSION

9.1 Summary

In this project, bottom ash has been replaced with fine aggregates. The study was conducted to evaluate the strength characteristics of glass fibre and bottom ash on concrete. The concrete mix design was done for M30 grade concrete. Mix was prepared for different combinations (0%, 25%, 35%, 50%, and 100% replacement of sand by bottom ash) with (0.3% of glass fibre).The specimen such as cubes of 150 x 150 x 150 mm in size and cylinder of 150 x 300 mm in size are casted and evaluate the properties such as compressive strength, split tensile strength& flexural beam strength has been analysed and it has been compared with control mix for the duration of 7 and 28 days.

9.2 Conclusion

The following conclusions could be arrived from the study,

Effect on Bottom ash on the Compressive Strength

- The 7 day cube compressive strength results showed that the strength of concrete reduced with increase in bottom ash.
- But at 28 days the strength of concrete with 50% replacement of bottom ash was almost equal to that of the control mix.

Influence of glass fibre on the Compressive Strength

- Addition of 0.3% of glass fibre shows an increase in compressive for 0%, 25%, 35%, 50% and 100% replacement of bottom ash respectively.

Effect on Bottom ash on the Split Tensile Strength

- Increase in bottom ash shows a slight but noticeable increase in 7day split tensile strength.
- But at 28 days the strength gain when compared to the controlled mix was not good.

Effect of Glass fibreon the Split Tensile Strength

- Addition of glass fibre increases the tensile strength of the specimens.
- 50% bottom ash with 0.3% glass fibre showed the maximum 7 day and 28 day split tensile strength.

From the above it is clear that 50% replacement of bottom ash with 0.3% glass fibre is the most efficient mix.

Effect on the Flexural Strength

The following conclusions were derived based on the obtained results.

- On comparing the flexural strength of conventional concrete 50% Bottom Ash + 0.3% Glass Fibre proved to be the best.
- On comparing with the conventional beam 50% Bottom Ash + 0.3 % Glass Fibre showed better results with high flexural strength, high modulus of elasticity.
- However the 50% Bottom Ash + 0.3 % Glass Fibre specimen had the maximum displacement when compared to the Conventional beam.

Bottom ash is a hazardous material that is a serious threat to the environment. By using it as a replacement for Fine aggregate we can reduce land, water as well as air pollution and make the earth a better place to live in.

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