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GLASS FIBER REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH FLYASH

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ABSTRACT

Concrete is one of the most widely used construction material in today's world. Cement being one of the essential constituent of the concrete. Environmental issues are also playing a vital role in today's world, the production of cement one of the major constituent of concrete leads to release the of significant amount of carbon dioxide a greenhouse gas contributing 7% of greenhouse gas emission to the earth atmosphere, beside deforestation and burning of fossil fuels. Safe disposal of glass waste generated in day to day life due to limited life span and after use it is either stock piled or sent to land fill is also a challenging task. There is now a significant world-wide interest to solve the environmental problem caused by industrial waste and other material by including such material in the manufacture of concrete. Effort have been made in concrete industry to use waste glass in concrete production not only provide significant environmental benefits but also enhances performances of concrete when used at optimum amounts. Effort have been made in the concrete industry to use fly ash & waste glass as partial replacement of cement, fine & coarse aggregates.

Recently the research has shown that the waste glass can be effectively used in concrete as several alternative for the constituent of concrete under proper fraction and grade. Waste glass when ground to a very fine powder show pozzolanic properties as it contains high SiO_2 and therefore to some extent can replaced cement in concrete and contributes strength development.

In this study, glass fibers in different volume fraction with 20%, 30% and 40% replacement of cement by fly ash has been to study the effect on compressive strength, split tensile strength, of concrete and compared it to the conventional concrete. The overall test result shows glass fiber could be utilized in concrete. The result indicate that the maximum strength of concrete occurs at around 20% glass powder. Beyond 20% glass fiber the strength of concrete reduces and is lower than that of the control.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Cementious materials in the form of mortars or concretes are used as construction material since they are cheap, durable and have adequate compressive strength and stiffness for structural use. Due to its very low tensile strength and low ductility it cannot be used directly for structures. Concrete is probably the most widely used man made construction material in the world. Also any type and shape of the component of the structural member can be fabricated when the concrete is green either in factory or at the place of casting.

Fibers prevent micro cracks from widening. Addition of fibers makes components ductile and tough. Conventional concrete cracks easily. When concrete is reinforced with random dispersed fibers, we get favorable behavior for repeated loads. Advanced cement based materials and improved concrete construction techniques provide opportunities for the design of structures to resist severe load resulting from earthquakes, impact, fatigue, and blast environments.

In case of structure of odd shapes it is very difficult to ascertain the proper placement of reinforcements however, this problem does not arise in case of fiber reinforced concrete and also the progress of work can be achieved at much faster rate.

FRC is very ductile and particularly well suited for structures which required to exhibit:

- Shrinkage control of concrete (fissuration):

- High thermal resistance
- Resistance to impact, blast and shock loads and high fatigue
- Resistance to seismic hazards.
- The degree of improvement
- Very high flexural, shear and tensile strength

-Any specific property exhibited by SFRC depends on a number of factors that include:

- Fiber shapes, its aspect ratio (length to diameter ratio) and bond characteristics.
- Type of fiber used (Natural, metal, Synthetic, Glass etc.)
- Concrete mix and its age
- Steel fiber content

The Glass Fiber Reinforced Concrete (SFRC) has been used in various applications throughout the world. The principal advantages of SFRC versus plain or mesh/bar reinforced concretes are:

- Increased tensile strength and tensile strain capacity thus allowing increased Contraction/construction joint spacing
- Cost savings of 10% - 30% over conventional concrete flooring systems.
- Reinforcement throughout the section in all directions versus one plane of reinforcement (sometimes in the sub-grade) in only two directions.
- Increased ultimate flexural strength of the concrete composite and thus thinner sections.

Increased flexural fatigue endurance and again thinner slabs.

- Increased flexural toughness or the ability to absorb energy.
- Increased impact resistance and thus reduced chipping and joint sapling.
- Increased shear strength and thus the ability to transfer loads across joints in thin Sections.

The Steel Fiber Reinforced Concrete can be used to achieve high-strength, durability and economy in the various fields of civil engineering projects such as:

(a) Overlays

Roads, Airfields, Runways, Container, Movement and Storage Yards, Industrial Floors and Bridges.

(b) Pre-cast Concrete Products

Manhole covers and Frames, Pipes, Break-Water Units, Building Floor and Walling Components, Acoustic Barriers, Krebs, Impact Barriers, Blast Resistant Panels, Vaults, Coffins etc.

(c) Hydraulic and Marine Structures

Dams, Spillways, Aprons, Boats and Barges, Sea Protection Works.

(d) Defense and Military Structures

Aircraft Hangers, Missile and Weaponry Storage Structures, Blast Resistant Structure, Ammunition Production and Storage Depots, Underground Shelters etc.

(e) Shotcreting Applications

Tunnel Linings, Domes, Mine Linings, Rock-Slope Stabilization, Repaint and Restoration Distresses Concrete Structures etc.

(f) Special Structures

Machine Foundations, Currency Vaults and Strong Rooms, Impact and Fiber-Protective Shells and Lost Forms, Column-Beam Joints in Seismic-Resistant Structures, End Zones of Prestressed Concrete Elements, High Volume Steel Fiber Reinforce Concrete structures made out of SIFCON and CRC (Slurry Infiltrated Fiber Concrete and Compact Reinforced Concrete)

Some studies have shown that suitable admixtures have improved the workability of fiber reinforced concrete up to an extent.

The most significant effect of incorporating fibers to delay and control the tensile cracking of this composite material. The fiber and the matrix share the tensile load until the matrix cracks and then almost the full force gets transferred to the fiber. The fibers provided a ductile member in a brittle matrix and the resulting composite has ductile properties. This is a predominant features of fiber-reinforced concrete (FRC).The effect of fibers in a cementations material is principally to cause relief of tensile stress at the crack tip and prevent unstable crack.

The improvements in ductility and energy absorption capacity resulting from the increase in fiber volume fraction are comparable to those improvements due to the effect of confining steel of conventional concrete by transverse steel. Since confinement by transverse steel produces improvements of the same nature as fiber reinforcement in the compressive behavior of concrete for a certain reinforcement index of each fiber type, there exists a confinement condition which results in comparable compressive stress-strain relationship of fiber-reinforced concrete.

Some applications in India and abroad:

Fiber reinforced concrete is in use since many years in India, but the structural applications are very much limited. However, its application is picking up in the recent days. Following are some of the major projects where large quantities of steel fibers have been used. (See Appendix –B for detailed application.)

1. A Balcony At Hotel Taj Heritage Was Replaced By GRC Original In RCC Same Old Finish (100 Years Old) Was Replaced With Same Style.

2. The fibers have also been used for Yachimata CC Bridge, Tokyo Rainbow Bridge, Japan.

3. More than 400 tonnes of Shaktiman Steel Fibers have been used recently in the Construction of a road overlay for a project at Mathura (UP).

1.2 RESEARCH PROBLEM

Reuse of glass waste in concrete based application in India is not widely developed, while its application in concrete based product can support the challenge that faces the solid waste management and the greening the environment. Like all the other municipal waste generated, glass waste has many negative impact on the environment, health, society and the economy. The quantity of waste glass has slowly increases over the year due to growing need and usage of glass product. Over last decade the concern of global environmental impact is forcing the civil engineers to introduce the product in the construction industry such as to replace or add them as suitable alternatives in the industry. Therefore the reuse of waste enhances the reduction of the total amount of landfill waste, contribute to the reduction of renewable and nonrenewable resources, enhances the reduction of carrying of raw material, thereby lowering green gas emission and is a source of income generation and job creation when reused as cement replacement.

1.3 AIM

The aim of research was to investigate the use of glass waste as a partial replacement of cement in concrete and find out their effect on the economy and strength of concrete.

1.4 SPECIFIC OBJECTIVES

The specific objectives were:

i. Determine the optimum waste glass content to be added as partial replacement of cement.
ii. To determine an optimum mix proportion of cement, fine ground glass waste, sand, course aggregate and water cement ratio for a given grade of concrete.
iii. To determine the mechanical and chemical properties of the optimized concrete.
iv. To economically compare conventional concrete with the concrete modified glass waste.
v. Review the merits of using powdered waste glass as supplementary cementitious material, replacing a portion of the cement powder used.
vi. Study the influence of waste glass on hardened and fresh properties of concrete mixes.
vii. Utilization of industrial waste in a useful manner in cement production and diverting a waste material from landfills.
viii. Protect the environment by the use of industrial waste in concrete in order to improve the environmental impact on concrete industry by reducing the greenhouse effect gases produced.
ix. Review the merits of using powdered waste glass as supplementary cementitious material, replacing a portion of the cement powder used.

1.5 SCOPE OF THE RESEARCH

The cement industry is facing challenges such as cost increases in energy supply, requirements to reduce CO_2 emissions and the supply of raw material in sufficient qualities. The scope of this research aim to identify the pozzolanic reaction when waste glass is utilized as partial replacement of cement. The usage of waste glass to replace cement could reduce the cost of concrete and also the consumption of cement; there by directly reduce the CO_2 emission which is related to the production of cement. Also this reduce the cost of making concrete since a waste material in used. Glass powder can be also used as a binder with partial replacement of cement which take some part of reaction at the time of hydration; also it act as filler material. Due its silica content, ground glass is considered a pozzolanic materials and as such can exhibit the properties similar to other pozzolanic materials. The scope was also limited to experimental investigation.

1.6 TERMINOLOGY

Cement Concrete

A homogeneous mixture of cement, sand, gravel and water is very strong in carrying compressive forces and hence is going increasing importance as a building material is going increasing importance as a building material throughout the world. It is weak in resisting tensile forces.

Proportioning Of Concrete

The process of selection of relative proportions of cement, sand, coarse aggregate, water so as to obtain a concrete of desired quality.

Concrete Mix Design

Mix design is process of suitable ingredients of concrete and determine their relative quantities with the object of producing an economical concrete having certain minimum properties that is workability, strength, and durability.

Characteristic Strength

It is the value of the strength of the material below which is not more than 5% of the test results are expect to fall.

Workability

Workability is the key property of concrete especially freshly mixed concrete or mortar. It is used to describe the ease of difficulty with which the concrete is handled, transported and placed between the forms with minimum loss of homogeneity. It is also as the amount of internal work necessary to produce full compaction.

Standard Deviation

It is defined as the value of deviation of given value from the mean calculated from the actual test results.

Durability

Durability is defined as the concrete to with stand the environmental condition to which it is exposed. It is necessary to emphasize the durability in design and construction of concrete structures.

Target Strength

In order that not more than specified proportion & of the test result are likely to fall below the characteristics strength, the concrete mix has to be designed for a somewhat higher compressive strength. This strength is called target strength.

Aggregate & Cement Ratio

It is ratio of aggregate to cement. The various factor involved selecting the aggregate /cement ratio of a mix are the desired workability, size, shape, texture and overall grading of the aggregates.

1.7 SUPPLEMENTARY CEMENTITIOUS MATERIALS

Supplementary cementitious materials are those which react in the pore solution of hydrating cement either hydraulically of pozzolanically, to create a product which contributes to the properties of hardened concrete.These can include natural pozzolans (clays, zeolites, diatomite) (Urhan, 1987), hydraulic materials other than Portland cement, and manufactured materials that can participate in a pozzolanic reaction (Cheriaf, Cavalcante Rocha, & Pera, 1999; Escalante-Garcia, Gorokhovsky, Mendoza, & Fuentes 2003; Filipponi, Pomi, & Sirini, 2003; Pacewska, Bukowska, Wilinska, & Swat, 2002; Paya, Monzo, & Borrachero, 1999; Sun, Fang, Chen, & Lui, 2000). Traditionally, the most widely used supplementary cementitious material derived from a waste source are fly ask, grounded granulated blast furnace slag, and silica fume. In 2001, 11% of fly ash, 90% of grounded granulated blast furnace slag, and 185% of silica fume produced in Canada were used in the concrete industry as supplementary cementitious materials. In the case of silica fume and grounded granulated blast furnace slag, they were imported from other countries in order to meet the construction demand in Canada (Bouzoubaa & Fournier, 2005). By replacing a percentage of the cement powder used in concrete with one of these materials, at least three benefits are realized; engineering, economic, and ecological. Engineering benefits include the optimization of certain properties of the fresh or hardened concrete, such as increasing through the use of SF. Economic benefits include, for example, the relatively lower cost of fly ash when compared to cement powder. Ecological benefits consider the decrease in CO_2 released and raw materials consumed as a result of less cement manufactured, and the use of materials otherwise bound for landfill (Malhotra & Mehra, 1996).

CHAPTER 2

LITERATURE REVIEW

Sekhar, et al. Fibers impart energy absorption, toughness and impact resistance properties to FRC material, and these characteristics in turn improve the fracture and fatigue properties of FRC. This system was named alkali resistance glass fiber reinforced concrete. In the present experimental investigation the alkali resistance Glass fibers has been used to find out workability , resistance of concrete due to acids , sulphates and Rapid chloride permeability tests of M 30 , M40 and M 50 grade of glass fiber reinforced concrete and ordinary concrete at the 28 and 90 days with varying percentages of glass fibers.

R. Satheesh Raja, et al. This paper describes the mechanical behavior of fly ash impregnated E-glass fiber reinforced polymer composite (GFRP). Initially the proportion of fiber and resin were optimized from the analysis of the mechanical properties of the GFRP. It is observed that the 30 wt% of E-glass in the GFRP without filler material yields better results. Then, based on the optimized value of resin content, the varying percentage of E-glass and fly ash was added to fabricate the hybrid composites. Results obtained in this study were mathematically evaluated using Mixture Design Method. Predictions show that 10 wt% addition of fly ash with fiber improves the mechanical properties of the composites.

Cengiz Duran, et al. Reports on a comprehensive study on the properties of concrete containing fly ash and steel fibers. Properties studied include unit weight and workability of fresh concrete, and compressive strength, flexural tensile strength, splitting tensile strength, elasticity modulus, sorptivity coefficient, drying shrinkage and freeze–thaw resistance of hardened concrete. Fly ash content used was 0%, 15% and 30% in mass basis, and fiber volume fraction was 0%, 0.25%, 0.5%, 1.0% and 1.5% in volume basis. The laboratory results showed that steel fiber addition, either into Portland cement concrete or fly ash concrete, improve the tensile strength properties, dryingshrinkage and freeze– thaw resistance. However, it reduced workability and increase sorptivity coefficient.

Vijay Baheti, et al. The mechanical activation of fly ash was carried out using ball milling to promote adhesion with epoxy.The 5 h of wet pulverization was found to result into particle size of less than 500 nm. The obtained nanoparticles were incorporated into epoxy to prepare three layered laminated composite of glass fabrics. The results revealed substantial improvement in mechanical properties of nanocomposites as compared to neat and unmilled fly ash composites. Moreover, the storage modulus exhibited 85.71, 38.09, 104.76 and 80.95% increment over neat composites for 1, 3, 5 and 10 wt% of activated fly ash at200 C.

Satish, et al. Based on the laboratory experiment on fiber reinforced concrete (FRC), cube and cylinders specimens have been designed with steel fiber reinforced concrete (SFRC) containing fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 53.85, 50 aspect ratio and alkali resistant glass fibers containing 0% and 0.25% by weight of cement of 12mm cut length were used without admixture. Comparing the result of FRC with plain M20 grade concrete, this paper validated the positive effect of different fibers with percentage increase in compression and splitting improvement of specimen at 7 and 28 days, analyzed the sensitivity of addition of fibers to concrete with different strength.

Yogesh Iyer Murthy The experimental work dealt with the use of glass fiber in concrete which was obtained from the glass industry as a waste product. It was found that the compressive strength of concrete did not increase much but the flexural strength showed almost 30% increase in strength. The slump value found to be decreased with increase in fiber content. It was found that the use of fiber glass in concrete not only improved the properties of concrete but also small cost cutting.

KRENCHEL (1974) Studied the effect of randomly distributed glass fibres on the flexural strength, compressive strength, tensile strength and young's modulus of elasticity of the material. He concluded that as the fibercontent increases, the strength increases showing optimum strength at 0.75% reinforcement by weight.

MUZHIR S.M, NAVI S.Q.A, QADEER ASLAM AND ISRAIL MOHD. (1996) Present study on FRC as an alternative to timber for door, window frames and beams as the environmentalists are aware about the afforestation. In view of keeping ecology in balance, the FRC can be used as a good alternative to building material.

Topçu and Canbaz (2007) Demonstrated through experiments that the addition of fibers provide better performance for concrete, while fly ash in the mixture may adjust the workability and strength losses caused by fibers, and improve strength gain. The result s are based on experimental invest igatio ns in which concr ete was produced with three different replacement ratios of fly ash and three different types of steel and polypropylene fibers.

KENJI AND NAAMN (1990) Concluded that for the test period and the exposure condition used in their study, no cracking was detected on surface of steel fiber reinforced concrete specimen subjected to corrosion. Severe corrosion exposure of steel fiber reinforced concrete can lead to significant reduction in minimum dia of fiber thus leads to decrease in peak strength in tension and bending, as well as dramatic reduction in toughness. Observation of fractured surfaces of steel fiber reinforced concrete specimen tested in tension and bending indicate specimen tested in tension and bending indicate that the effect of corrosion on .pa minimum fiber diameter gradually changes the type of failure from typical fiber pullout to fiber breakage before pull out.

CHAPTER 3

METHODOLOGY

3.1 FLOW CHART

The replacement of cement with fly ash in glass fiber reinforced concrete reduces the environmental pollution and improves the mechanical and durability properties of concrete. In the Paper, glass fibers in different volume fractions with 20% ,30%, & 40% replacement of cement by fly ash has been used to study the effect on compressive strength, split ensile strength, of concrete. For each mix standard sizes of cubes, cylinders as per Indian Standards were cast and tested for compressive strength and split tensile strength at age of 7 & 28 days.

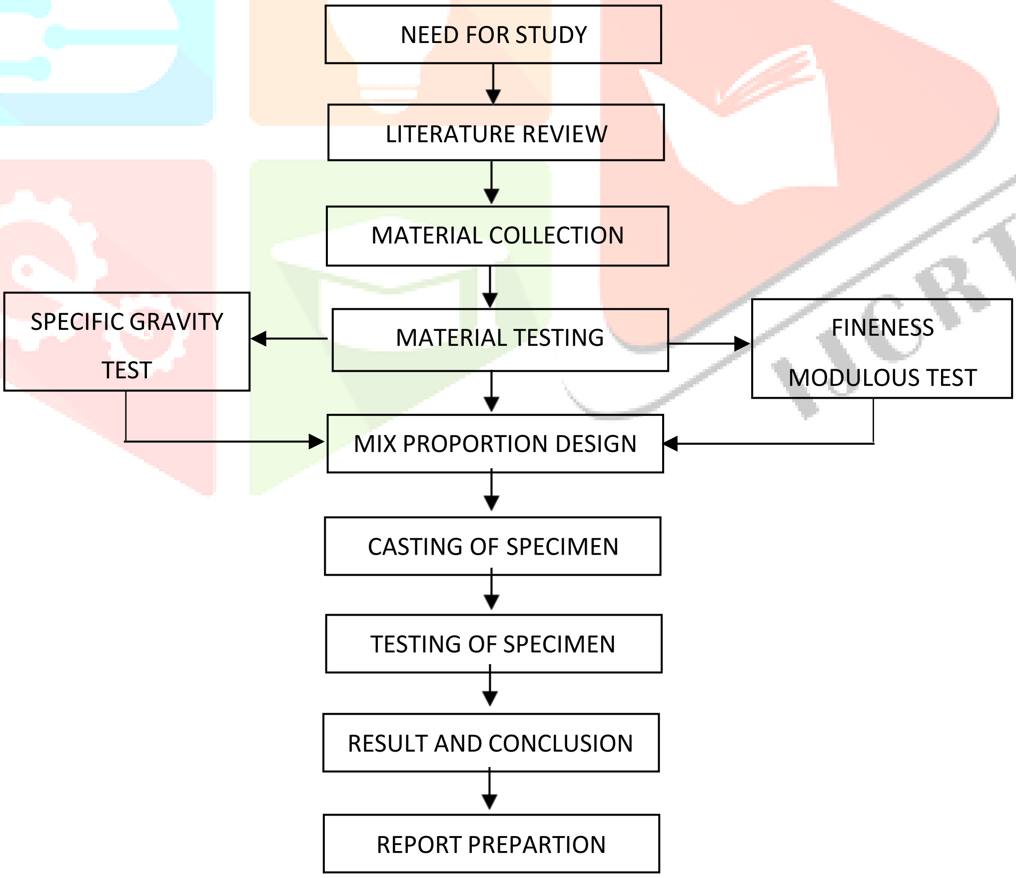

FIG 3.1 EXPERIMENTAL METHODOLOGY

3.2 MATERIAL

The raw materials of casting are cement, coarse aggregate, fine aggregate, water fly ash has been collected and the aggregate are cleared and preserved.

3.2.1 CEMENT

Cement acts as a binding agent for materials. Cement as applied in Civil Engineering Industry is produced by calcination at high temperature. It is a mixture of calcareous, siliceous, aluminous substances and crushing the clinkers to a fine powder. Cement is the most expensive materials in concrete and it is available in different forms. When cement is mixed with water, a chemical reaction takes places as a result of which the cement paste sets and hardens to a stone mass. Depending upon the chemical compositions, setting and hardening properties, cement can be broadly divided into various categories.

Ordinary Portland cement (OPC)

OPC is most important type of cement. The OPC was classified into three grades namely (i) 33 grade (IS:269-1989) (ii), 43 grade (IS:8112-1989), (iii) 53 grade (IS:12269-1987).If the 28 days compressive strength is not less 33n/mm^2(Mpa), it is called 33 grade cement, if the strength is not less than 43 MPa, it is called 43 grade cement and if the strength is not less than 53 MPa, it is called 53 grade cement. IS:10262-1982 has classified OPC grade wise from A to F depending upon the 28 days compressive strength.

Oxide	Percentage Content
CaO	60 – 67
SiO_2	17 - 25
Al_2O_3	3 - 8
Fe_2O_2	0.5- 6.0
MgO	0.1 -0.4
Alkalies	0.1 - 1.3
SO_3	1.0 - 3.0

TABLE 3.1 Chemical Composition of Cement

3.2.2 FINE AGGREGATES

The material we have used as fine aggregate in this project is locally available river sand obtained from Yamuna river bed near Badarpur conforming to Grading zone II of IS: 387-1970. Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens. River sand (0.4.75mm is suitable for all concrete preparations and is used across all segments such as independent houses, builders RMC Plants, Concrete Batching Plants and Infrastructure Concrete works.

3.2.3 COARSE AGGREGATES

The material whose particles are of size as are retained on I.S. Sieve No. 480 (4.75mm) is termed as coarse aggregate. The size of coarse aggregate depends upon the nature of work. The coarse aggregate used in this experimental investigation are of 20mm, 10mm and 6mm sizes, crushed angular in shape. The aggregates are free from dust before used in the concrete.

3.2.4 WATER

The water used was portable water that is clean and may not impair the strength or durability of the concrete and that is free of detrimental amounts of chlorides, acids, alkalis, salts, sugar and other organics or chemical substances that may adversely affect the concrete. Casting and curing of specimens were done with the portable water that is available in the college premises. Water to be used in the concrete work should have following properties:

- It should be free from injurious amount of soils it should be free from injurious amount of acids, alkalis or other organic or inorganic impurities.
- It should be free from iron, vegetable matter or any other types of substances, which are likely to have adverse effect on concrete or reinforcement.
- It should be fit for drinking purposes. The function of water in concrete it acts as lubricant.

- It acts as a chemically with cement to form the binding paste for coarse aggregate and reinforcement.

3.2.5 GLASS FIBER

Glass is defined as a hard, brittle, translucent and commonly transparent substance, white or colored, made by fusing together sand or silica with lime, potash, soda or lead oxide. Class E fiber was used. Fiberglass is an immensely versatile material due to its light, inherent strength, weather resistant finish, and variety of surface texture.

Oxides	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O
Percentage	70	1.9	1.2	10.3	14	0.4

TABLE 3.2 Chemical Composition of Glass

Use extreme care when handing this dry powder pigment to prevent breathing the dust particles. Make sure you wear a respiratory mask when working with this powder. Glass is a solid material with non-crystalline structure. It tends to break in elongated and sharp form. Usually, glass material is non-toxic, because it is in a solid form. The major risk comes, therefore, by physical contacts with cullet. Physical contacts with cullet can cause permanent damages to the eye and severe irritations to the skin. Throughout the experiments damages to the eye and severe irritations to the skin, throughout the experiments, some basic precautions, such as the use of glasses, cuff, gloves, security shoes and helmet were followed. **Note that**: For this research, no admixtures were used due to the fact that a reduction of the cost of the concrete with glass wastes was a major concern. It was expected that the cost should be less than that of conventional concrete in order to promote their re-use in masonry and concrete applications.

3.2.6 Fly Ash

Fly ash is a fine, glass powder recovered from the gases of coal fired plants during the production of electricity by electrostatic precipitators. These micron-sized earth elements consist of silica, alumina and iron. When combines with lime and water the fly ash forms a cementitious compound with properties similar to that of Portland cement.

S. No	Country	Production MT	Utilization MT
1	India	130	41
2	China	100	45
3	USA	75	65
4	UK	15	50
5	Germany	40	85
6	Australia	10	85
7	Canada	6	75
8	France	3	85
9	Denmark	2	100
10	Italy	2	100

TABLE 3.3 Generation and Utilization in Different Countries

3.3 Preliminary Test

The preliminary test of materials are specific gravity of cement, fine aggregate, coarse aggregate, fineness of cement, consistency of cement, initial setting time of cement, sieve analysis for sand, impact test and crushing test on coarse aggregate. All the preliminary tests have been conducted.

3.4 Mix Design

The mix design is in accordance with Indian mix design method.

3.5 BATCHING, MIXING, CASTING AND CURING

A careful procedure is adopted in the batching, mixing and casting operations. The coarse aggregates and fine aggregates were weighed first with an accuracy. The concrete mixture is prepared by mixing machine on a watertight platform. None clean and oiled moulds for each category were then placed on the vibrating table respectively and filled in three layers. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould. The specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. After that these were demoulded with care so that no edges were broken and were placed in the curing tank at the ambient temperature for curing. The ambient temperature for curing was 27 $\pm$ 20C.

3.6 TESTING OF SAMPLE

The steel mould of size 150x150x150mm is well tightened and oiled thoroughly. The fresh mixed concrete is placed and well compacted through mechanical vibrators and after 24 hours they were allowed for curing in a period of 7, 28 days and they were tested. After the curing period the specimen is taken out from the curing tank and wipes it clean. The dimensions of the specimens and the weight of the specimens were noted down with accuracy. Then the specimen is placed between the loading the surface of the Compression Testing Machine and the load is applied till the specimen falls. The ultimate load at the time of failure is noted down. The load was applied at the rate of 140 kg/cm^2 min till the cube breaks.

CHAPTER 4

PRELIMINARY INVESTIGATION

4.1 OBJECT OF TESTING

The main objective of testing was to known the behavior of concrete along with the replacement of cement in concrete. The main parameters studies were Compressive strength. The materials used for casting concrete samples along with tested results are described.

4.2 PRELIMINARY TEST OF MATERIALS

4.2.1 Cement

The type of cement used was 43 grade Ordinary Portland Cement.

4.2.2 Specific Gravity

The density bottle was used to determine the specific gravity of cement. The bottle was cleaned and dried. The weight of empty bottle with brass cap and washer W_1 was taken. The bottle was filled by 200 to 400g of dry cement and weighed as W_2. The bottle was filled with kerosene and stirred thoroughly for removing the entrapped air which was weighed as W_3. It was emptied, cleaned well, filled with kerosene and weighed as W_4.

$$\text{Specific gravity of cement (G)} = \frac{W2-W1}{(W2-W1)-(W3-W4)}.$$

Where

W1= Weight of empty density bottle with brass cap and washer in gm

W2= Mass of the density bottle & cement in gm.

W3=Mass of the density bottle, cement & kerosene in gm.

W4= Mass of the density bottle filled with kerosene in gm.

4.2.3 Fineness (by Sieve Analysis)

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface are for hydration and hence faster development of strength. 100 grams of cement was taken on a standard IS Siever No. 9 (90 microns). The air-set lumps in the sample were broken with fingers. The sample was continuously sieved giving circular and vertical motion for 15 minutes. The residue left on the sieve was weighed.

4.2.4 Consistency

The objective of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency. 500 grams of cement was taken and made into a paste with a weighed quantity of water (% by weight of cement) for the first trial. The paste was prepared in a standard manner and filled into the vicat mould plunger, 10mm diameter, 50mm long and was attached and brought down to touch the surface of the paste in the test block and released allowing it to sink into the paste by its own weight. The depth of penetration of the plunger was noted. Similarly trials were conducted with higher water cement ratios till such time the plunger penetrates for a depth of 33-35mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35mm from the top is known as the percentage of water required to produce a cement paste of standard consistency.

4.2.5 Initial Setting Time

The needle of the Vicat apparatus was lowed gently and brought in contact with the Surface of the test block and quickly released. It was allowed to penetrate into the test block. In the beginning the needle completely pierced through the test block. But after sometime when the paste starts losing its plasticity, the needle penetrated only to a depth of 33-35mm from the top. The period elapsing between the time when waster is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top was taken as the initial setting time.

4.2.2 Coarse Aggregate

20mm down size aggregate was used.

4.2.2.1 Specific Gravity

A pycnometer was used to find out the specific gravity of coarse aggregate. The empty dry pycnometer was weighed and taken as W_1. Then the pycnometer is filled with 2/3 of coarse aggregate and it was weighed as W_2. The pycnometer was filled up to the top of the bottle with water and weighed it as W^4.

$$\text{Specific gravity of Coarse Aggregate (G)} = \frac{W2-W1}{(W2-W1)-(W3-W4)}.$$

Where

W1= Mass of empty pycnometer in gm.

W2= Mass of pycnometer & coarse aggregate in gm.

W3=Mass of the pycnometer, coarse aggregate & water in gm.

W4= Mass of the pycnometer filled with water in gm.

4.2.2.2 Bulk Density

Bulk density is the weight of a material in a material in a given volume. It is expressed in Kg/m3.A cylindrical measure of nominal diameter 250mm and height 300mm was used. The cylinder has the capacity of 1.5 liters with the thickness of 4mm. The Cylindrical measure was filled about 1/3 each time with thoroughly mixed aggregate and tampered with 25 strokes. The measure was carefully struck off level using

tamping rod as straight edge. The net weight of aggregate in the measure was determined. Bulk density was calculated as follows:

$$\text{Bulk density} = \frac{\text{Net weight of coarse aggregate in Kg}}{\text{volume}}$$

4.2.2.3 Surface Moisture

100g of coarse aggregate was taken and their weight was determined, say W_1. The sample was then kept in the oven for 24 hours. It was then taken out and the dry weight is determined, says W_2. The difference between W_1 and W_2 gives the surface moisture of the sample.

4.2.2.4 Water Absorption

100g of nominal coarse aggregate was taken and their weight was determined, say W_1. The sample was then immersed in water for 24 hours. It was then taken out, drained and its weight was determined, says W_2. The difference between W_1 and W_2 gives the water absorption of the sample.

4.2.2.5 Aggregate Impact Test

Procedure: - This test is for aggregate in concrete that undergoes impact as in runway in airports. Fill the measure about one third full with aggregate and using the tapping rod the aggregate with 25 strokes. Repeat the procedure twice for the remaining two-third portion adding each time one third of the volume and tamping it. Note down the weight of the sample. Transfer the sample to the cylinder in three layer of one third volume and tamp it as usual. Place the cylinder in its position in the impact testing machine firmly allow the load to fall 15 times at 1 blow per sec. at constant rate. Take the sample out of the cylinder carefully. Sieve the sample in 2.36 mm sieve, weigh the portion passing through it. The percentage fine is the aggregate impact test value. Repeat the procedure for two more samples. Then take the average of aggregate impact value. It should not be more than 45% for aggregate for concrete for ordinary use and not more than 30% for aggregate for concrete for runway and pavements.

4.2.2.6 Crushing Test

Aggregate crushing value gives a relative measure of the resistance of an aggregate sample against crushing under gradually applied compressive load.

Procedure: Aggregate passed through 12.5 mm IS sieve and retained on 10mm IS sieve is filled in the three layers is given in 25 blows, Using bullet end of the tamping rod in the cylindrical measure. Then transform the sample of the aggregate in three layers in aggregate crushing mould subjected each layer to 25 blows by using the tamping road. Insert the plunger to rest horizontally on the surface of the aggregate. Place the entire set up between the plates of the compression testing machine. So that it reaches 40 in 10min at a uniform rate of loading. Release the load and take entire set up from the compression testing machine. Remove the aggregate from the cylinder and sieve it through IS sieve 2.36mm. Weight the fraction passing through the IS sieve 2.36 mm taking care to avoid the loss of fines. Repeat the procedure for two more samples. Then take the average of crushing value.

4.2.2.7 Fineness Modulus

The sample was brought to an air-dry condition by drying at room temperature. The required quantity of the sample was taken (3kg). Sieving was done for 10 minutes. The material retained on each sieve after shaking, represents the fraction of the aggregate coarser then the sieve considered and finer than the sieve above. The weight of aggregate retained in each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage retained (F) to 100.

4.2.3 Properties of Water

Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6.

4.3 PRELIMINARY TEST RESULTS

4.3.1 CEMENT

The cement has been tested for the physical properties as per IS: 8112 standards.

S.No.	Description of Test	Test Results Obtained
1	Cement used	OPC 43 grade
2	Specific gravity of cement	3.15
3	Finesse (Sieve Analysis)	95% passing (90mm)
4	Standard Consistency	33%

Table 4.1: Cement Properties

4.3.2 FINE AGGREGATE

Fine aggregate are those which can pass through 4.75 mm IS sieve, the residue of the sieve are not considered.

S.NO.	Description of Test	Test Results Obtained
1	Specific gravity of fine aggregate	2.64
2	Water absorption of fine aggregate	0.80%
3	Grading of fine aggregate	Zone-II

Table 4.2: Fine Aggregate Properties

4.3.3 COARSE AGGREGATE

The maximum particle size of coarse aggregates is 75 mm and minimum size is 4.75 mm.

S.No.	Description of Test	Test
1	Specific gravity of coarse aggregate	2.7
2	Water absorption of coarse aggregate	0.81%
3	Grading of coarse aggregate	2^{nd} grade
4	Aggregate Impact Value	26.33%
5	Crushing Value	22.56%

Table 4.3: Coarse Aggregate Properties

4.3.4 FLY ASH

The fly ash was procured from National Thermal Power (NTPC) in Gautambudhnagar (U.P.)

Fineness of test fly ash : 8.4%

Specific gravity of fly ash : 2.55

Chemical	SiO2	Al2O3	Fe2O3	Na2O	MgO	CaO	SO3
%	61.24	25	8.71	0.09	0.09	4.22	0.49

Table 4.4: Chemical Properties of Fly Ash

4.3.5 GLASS FIBER

Class E fiber was used. Fiber glass is an immensely versatile material due to its light, inherent strength, weather resistant finish, and variety of surface texture.

4.4 EXPERIMENTAL SETUP

4.4.1 Test on Fresh Concrete.

After mix design it is very necessary to know the various properties of fresh concrete such as workability, compacting factor and Vee-bee's time factor, so various tests of concrete is usually carried out. The various tests which are conducted for fresh concrete are slump test to known the workability, compacting factor text to determine the workability and Vee-Bee Consistometer test for consistency.

TEST FOR WORKABILITY BY SLUMP TEST

This method of test specifies the procedure to be adopted, either in the laboratory or during the progress of work in the field, for determining, by the slump test, the consistency of concrete where the nominal maximum size of the aggregate does not exceed 38mm. The workability or slump depends upon the water content and proportion of fine aggregate to coarse aggregate and aggregate to cement ratio. Slump test is a field test used to check consistency of concrete.

Apparatus Mould

The mould for the test specimen shall be in the form of the frustum of a cone having the following internal dimensions:

Dimensions	cm
Bottom diameter	20
Top diameter	10
Height	30

The mould shall be constructed of metal (brass or Aluminum shall not be used) of at least 1-6 mm thickness and the top and bottom shall be open and at right angles to the exits of the cone.

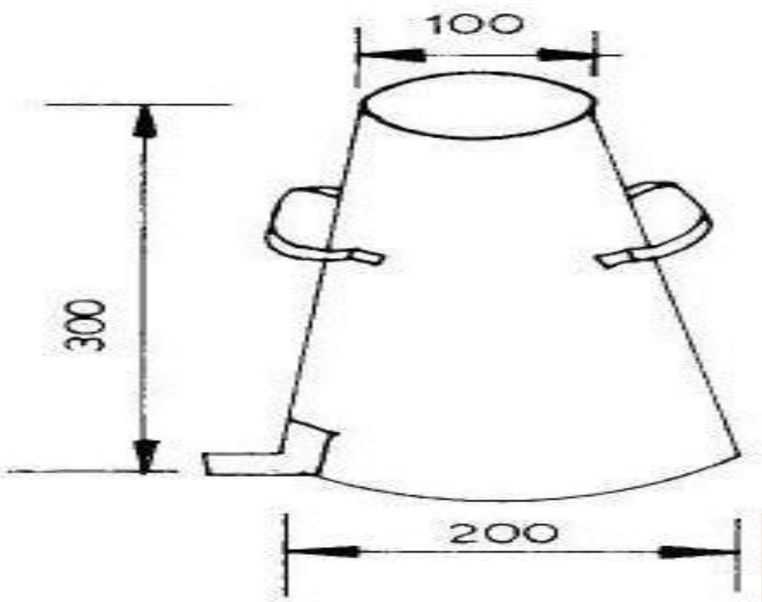

FIG 4.1 SLUMP CONE

Tamping rod

The tamping rod shall be of steel or other suitable material, 16mm in diameter O-6m long and rounded at one end.

Procedure:

The internal surface of the mould shall be thoroughly cleaned and freed from Superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth, horizontal, rigid and non-absorbent surface, such as a carefully leveled mental plate, the mould being firmly held in place while it is being field the end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross-section of the mould and for the second and subsequent layers shall penetrate the underlying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded, the concrete shall be struck off level with a trowel or the tamping rod, so that the mould is exactly filled. Any mortar which may have leaked out between the mould and the base plate shall be cleaned away.

The mould shall be removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of the specimen being tested. The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Slump:

The slump measured shall be recorded in terms of millimeters of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally gives incorrect result and if this occurs the test shall be repeated with another sample. If, in the repeat test also, the specimen should shear, the slump shall be measured and the fact that the specimen sheared, shall be recorded.

4.4.2 TESTS ON HARDENED CONCRETE

Harden stage is the stage which continues till the final setting but start the initial setting time i.e. the time duration which concrete loses its elasticity. Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. The purpose of testing hardened concrete is to confirming that the required strength of concrete is used at site. In case of design mix concrete, these tests are used for checking if the concrete has the required target strength for which it is designed. The tests that are chiefly adopted are compression test on cubes, split tensile strength on cylinders and flexural test on beams.

Compressive Strength:

The compressive strength of concrete is defined as the load which causes the failure of specimen, per unit area of cross section in uniaxial compressive under given rate of loading. The strength of concrete is expressed as N/mm^2. The concrete making properties of various ingredients of mix are usually measured in terms of the compressive strength. Compressive strength is also used as a qualitative measure for other properties of hardened concrete.

Compression test is the most common test conducted on hardened concrete because most of the desirable characteristics properties of concrete because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

Cube specimens of size 150mm x 150mm x 150mm

Testing Machine

The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in the following procedure. The permissible error shall be not greater than ± percent of the maximum load. The bearing surface of the platens, when new, shall not depart from a plane by more than 0.01 mm. The movable portion of the spherically seated compression platen shall be held on the spherical seat, but the design shall be such that the bearing face can be rotated freely and titled through small angles in any direction.

Age at Test

Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Ages of 13 weeks and one year are commended if tests at greater ages are required. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.

Number of Specimens

At least three specimens, preferably from different batches, shall be made for testing at each selected age.

Procedure

Specimens stores in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing.

The bearing surfaces of the testing machine shall be wiped clean any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the center of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/mm unit the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Calculation

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest kg per sq. cm.

CHAPTER 5

MIX DESIGN

5.1 GENERAL

The design concrete mix involves the determinate of the most rational proportion of ingredients of concrete to achieve a cone which is workable in its plastic state and will developed the rare qualities when hardened. A properly designed concrete mix should have minimum possible cement content without sacrificing the concrete quality in order to make it concrete mix.

5.2 METHOD OF MIX DESIGN

Indian standard method (IS: 456:2000)

5.2.1 ASSUMPTIONS:

The basic assumptions made in mix design are:-

The compressive strength of workable concrete is by and large, governed by the water cement ratio. The size, shape, and type and grading of aggregates; the amount of water added determines the workability of concrete.

5.3 MIX DESIGN IN ACCORDANCE WITH THE RECOMMENDED GUIDE LINES FOR CONCRETE MIX DESIGN.

5.3.1 DATA FOR MIX DESIGN

The following basis data are required to be specified for design of a concrete mix:

1. Characteristic compressive strength (i.e., below which only a specified proportion of test result are allowed to fall) of concrete at 28 days.
2. Degree of workability desired

3. Limitations of the water-cement ratio and the minimum cement content to ensure adequate durability.
4. Type and maximum size of aggregate to be used.
5. Standard deviation (s) of compressive strength of concrete

5.4 DATA FGOR MIX PROPOTIONING IN ACCORDANCE WITH IS: 10262-2009

1. Grade designation :M30
2. Type Of Cement :OPC 43 grade confirming IS:8112
3. Maximum Nominal Size Of Aggregates :20 mm
4. Minimum cement content :300kg/m^3
5. Workability 75
6. Exposure condition :SEVERE
7. Degree of supervision :GOOD
8. Types of aggregate :Crushed angular aggregate
9. Maximum cement content :450 Kg/m^3
10. Chemical admixture type :NIL

5.4.1 TESTED DATA FOR MATERIALS:

1. Cement used :OPC 43 Grade
2. Specific gravity : 3.15
3. Specific gravity of coarse aggregate : 2.6
4. Specific gravity of fine aggregate : 2.7
5. Fineness of test fly ash : 8.4%
6. Specific gravity of fly ash : 2.55
7. Water absorption of coarse aggregate : 0.6
8. Water absorption of fine aggregate : 0.9
9. Grading of coarse aggregate : Zone 2
10. Grading of fine aggregate : Zone 1

TARGET MEAN STRENGTH OF MIX DESIGN

$f_{ck} = fc_k + 1.65 S$

$f`_{ck}$ =target compressive strength at 28 days.

f_{ck} = Characteristic compressive strength of concrete at 28 days.

S = Standard deviation.

Target strength = 30 + 1.65× 5

(**Standard deviation=5, from IS 456: 2000, Table 8**)

$= 38.25 \text{ N/mm}^2$

SELECTION OF WATER CEMENT RATIO.

From table 5 of IS 456:2000, maximum w/c ratio is 0.45

SELECTION OF WATER CONTENT

From table 2 of IS 10262:2009, maximum water content

For 20 mm aggregate = 186 liter. (For 25-50 mm slump.)

Estimate water content for 75 mm slump

=186 + 186× 0.03 = 191.58 liter.

CALCULATION OF CEMENT

W/C ratio is 0.45

Cement content = 191.58/0.45 = 425.73 kg/m^3

PROPORTION OF VOLUME OF COURSE AGGREGATE & FINE AGGREGATE CONTENT

From table 3 of IS 10262:2009 Volume of course aggregate for 20 mm aggregate and fine aggregate (zone 1) is 0.6 .

Volume of fine aggregate =1-0.6

=0.40.

MIX CALCULATION

Volume of Concrete =1 m^3

Volume of cement = mass of cement/specific gravity of cement ×1/1000

= 425.73/3.15×1/1000.

=0.1351 m^3

Volume of water = 191.58/1×1/1000

=0.19158 m^3

Volume of all aggregate = 1-(0.1351+0.19158)

=0.6733 m^3

Mass of course aggregate =0.6733×2.6×0.6×1000

= 1050.34 kg/m^3

Mass of fine aggregate =0.6733×2.7×0.4×1000

= 727.16 kg/m^3

	Cement	Fine aggregate	Coarse aggregate	Water
QUANTITY (kg/m^3)	425.73	727.16	1050.34	191.58
Ratio	1	1.7	2.46	0.45

TABLE 5.1-Quantity of material

5.5 QTY. OF MATERIAL FOR DIFFERENT RATIO OF CONCRETE MIX

S.NO.	MIX CODE	FLY ASH%	GLASS %
1	M30	0%	0%
2	F20G1	20%	1%

3	F20G1.5	20%	1.50%
4	F20G2	20%	2%
5	F30G1	30%	1%
6	F30G1.5	30%	1.50%
7	F30G2	30%	2%
8	F40G1	40%	1%
9	F40G1.5	40%	1.50%
10	F40G2	40%	2%

TABLE 5.2 Concrete Mix Code And Ratio

TABLE 5.3 Mix Proportion

Mix Code	Cement (kg)	Glass Fiber (kg)	Fly ash (kg)	Fine Aggregate (kg)	Coarse Aggregat e (kg)	Water Content (lit.)
M30	425.73	0	0	727.16	1050.34	191.58
F20G1	340.59	3.4	85.14	727.16	1050.34	191.58
F20G1.5	340.59	5.10	85.14	727.16	1050.34	191.58
F20G2	340.59	6.81	85.14	727.16	1050.34	191.58
F30G1	298.02	2.98	127.7	727.16	1050.34	191.58
F30G1.5	298.02	4.47	127.7	727.16	1050.34	191.58
F30G2	298.02	5.96	127.7	727.16	1050.34	191.58
F40G1	255.44	2.55	170.2	727.16	1050.34	191.58
F40G1.5	255.44	3.83	170.2	727.16	1050.34	191.58
F40G2	255.44	5.10	170.2	727.16	1050.34	191.58

CHAPTER 6

RESULT AND DISCUSSION

6.1 RESULT OF CUBE COMPRESSION TEST

This test was conducted as per IS 516-1959. The cube of standard size 150x150x150 mm^3 were used to find the compressive strength of concrete. Specimen were placed in compression resting machine without eccentricity and a uniform rate of loading was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated. The result are tabulated in the table.

Cube compressive strength (f_{ck}) in MPa = P/A

Where,

P = cube compression load

A = Area of the cube on which load is applied

= 150x150 = 22500 mm^2

S.NO.	MIX CODE	FLY ASH%	GLASS %
1	M30	0%	0%
2	F20G1	20%	1%
3	F20G1.5	20%	1.50%
4	F20G2	20%	2%
5	F30G1	30%	1%
6	F30G1.5	30%	1.50%
7	F30G2	30%	2%
8	F40G1	40%	1%
9	F40G1.5	40%	1.50%
10	F40G2	40%	2%

Table 6.1 Concrete mix code

TABLE 6.2 COMPRESSIVE STRENGTH RESULT AT 7 DAYS

Mix CODE	Sample	Peak Load (KN)	Peak Stress (Mpa)	Average Compressive Strength
F20G1	1	518	23.08	22.62
	2	495.7	22.03	
	3	512.2	22.76	
F20G1.5	1	479.3	21.3	21.73
	2	500.2	22.23	
	3	487.5	21.66	
F20G2	1	510.5	22.3	23.36
	2	540.7	24.03	
	3	527.9	23.36	
F30G1	1	458	20.35	19.26
	2	440.2	19.56	
	3	402.6	17.89	
F30G1.5	1	451.5	20.06	20.37
	2	470.03	20.9	
	3	453.7	20.16	
F30G2	1	433.8	19.28	20.81
	2	480	21.33	
	3	491.6	21.84	
F40G1	1	250.6	11.13	11.37
	2	262.4	11.16	
	3	270.9	11.32	
F40G1.5	1	227.7	10.12	10.51
	2	242.5	10.77	
	3	240	10.66	
F40G2	1	230.9	10.26	10.51
	2	258.4	11.48	
	3	220.1		

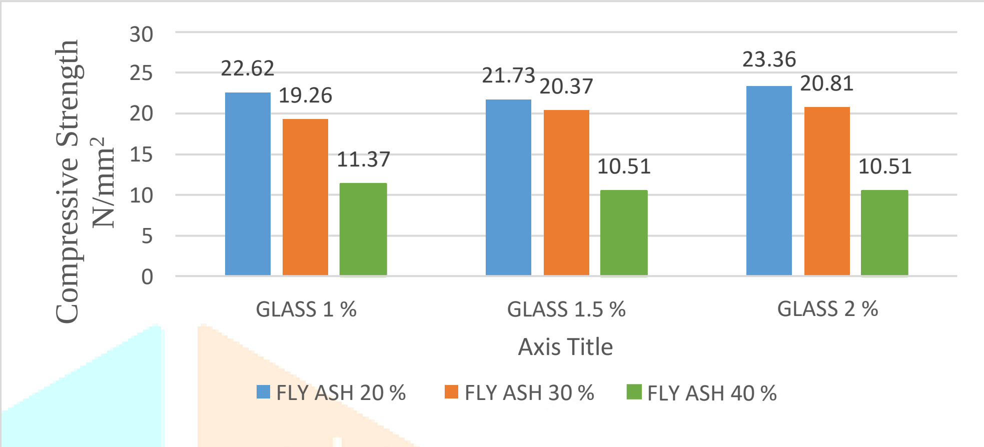

FIG 6.1 Compressive Strength at 7 Days

TABLE 6.3 Value of Compressive strength & Split tensile strength for 28 days

Mix CODE	Sample No	Peak Load	Peak Stress	Average Compressiv	SPLIT TENSILE STRENGTH(N/mm^2)	
F20G1	1	642.8	28.56	28.89	3.11	2.97
	2	649.1	28.84		2.67	
	3	669.5	29.72		2.98	
F20G1.5	1	638.5	28.37	28.84	2.89	2.97
	2	644	28.62		2.96	
	3	664.8	29.54		3.07	
F20G2	1	643.1	28.58	29.78	3.82	3.75
	2	676.7	30.04		3.53	
	3	668.7	29.72		3.92	
F30G1	1	560.6	24.91	24.56	1.28	1.38
	2	532.1	23.64		1.37	
	3	565.9	25.15		1.51	
F30G1.5	1	547.4	24.32	25.26	1.71	1.81
	2	576.1	25.6		1.83	
	3	582.5	25.88		1.90	
F30G2	1	581.04	25.82	25.89	1.57	2.03
	2	590.9	26.26		2.03	
	3	576.3	25.61		2.08	
F40G1	1	410.06	18.22	18.53	.84	.98
	2	439.2	19.52		1.02	
	3	401.7	17.85		1.08	
	1	400.3	17.79		1.27	
	2	460.1	20.44		1.28	

F40G1.5	3	470	20.88	19.7	1.44	1.33
F40G2	1	456.3	20.28	20.97	1.55	1.66
	2	462	20.53		1.65	
	3	497.5	22.11		1.80	

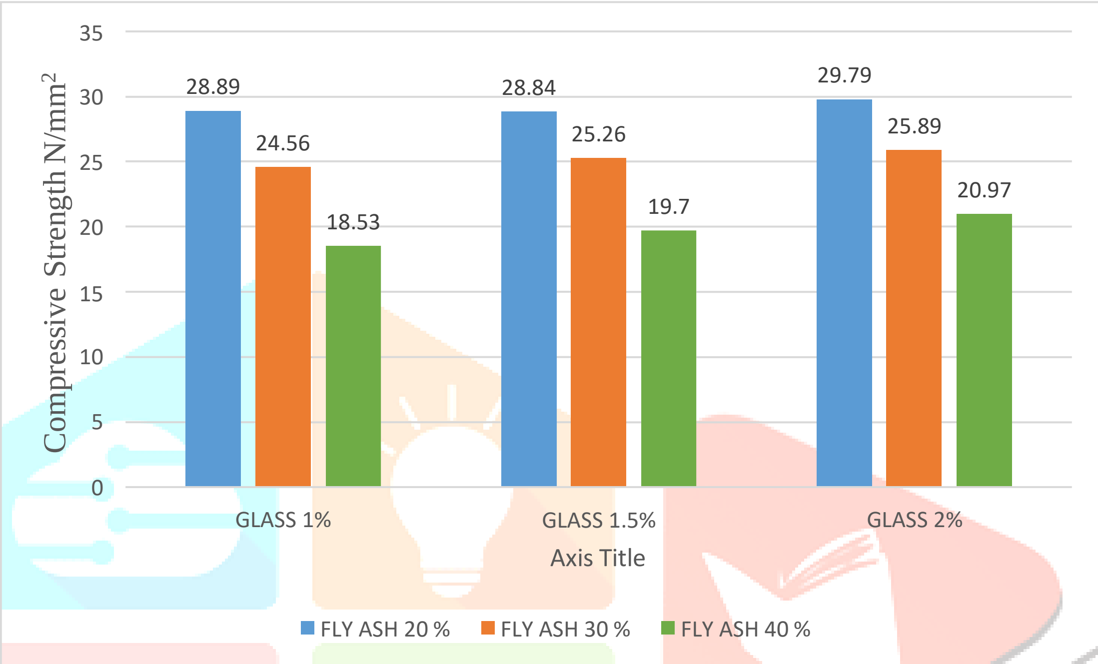

FIG 6.2 compressive strength value at 28 days

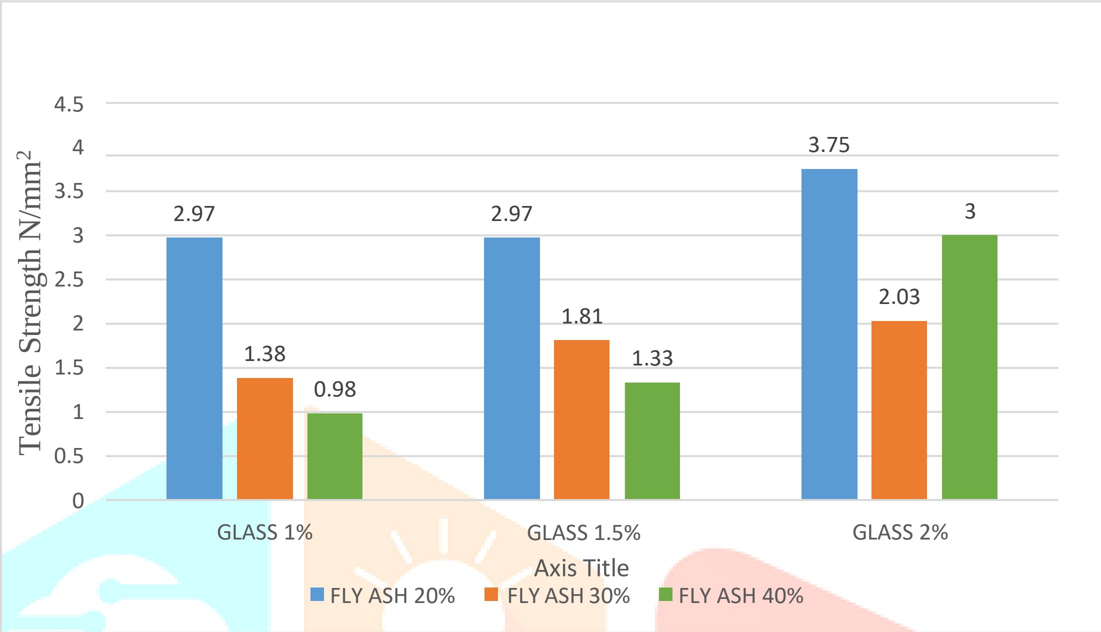

FIG 6.3 Tensile Strength Value at 28 Days

CHAPTER 7

CONCLUSION

Glass fiber withstand under any aggressive environment and climatic condition because of balanced combined physical and chemical properties. In this project strength of modified concrete is compared

In this paper, I made an attempt to study the properties of glass fiber reinforced concrete with partial replacement of fly ash with cement. The maximum compressive strength value for 28 days is obtained when 20% cement replaced with fly ash along with 2% glass fiber. Compressive Strength increases with the increase of glass fiber. And with an increase of fly ash Compressive Strength decreases. However, 20% replacement of cement with fly ash along with 1%, 1.5% & 2% glass fiber showed an increase in the compressive strength by increasing fiber percentage. The maximum split tensile strength value for 28 days is obtained when 20 % cement replaced with fly ash along with 2% glass fiber. Due to the addition of glass fiber split, tensile strength increased and is optimum when. 20% cement replaced with fly ash along with 2% glass fiber.

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