

FLEXURAL BEHAVIOUR OF HYBRID FIBER REINFORCED CONCRETE BEAM BY PARTIALY REPLACING FINE AGGREGATE WITH GLASS POWDER

Submitted in partial fulfilment of the requirements for
the award of Masters in Engineering degree in
Structural Engineering

by

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DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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DEPARTMENT OF CIVIL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **C.M.BERSIL ANTONY ROMARIO (Reg.No.41380004)** who carried out the project entitled **"FLEXURAL BEHAVIOUR OF HYBRID FIBER REINFORCED CONCRETE BEAM BY PARTIALY REPLACING FINE AGGREGATE WITH GLASS POWDER"** under my supervision from January 2023 to May 2023

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DECLARATION

I, C.M.BERSIL ANTONY ROMARIO (Reg.No.41380004) hereby declare that the Project Report entitled **“FLEXURAL BEHAVIOUR OF HYBRID FIBER REINFORCED CONCRETE BEAM BY PARTIAL REPLACING FINE AGGREGATE WITH GLASS POWDER”** done by us under the guidance of **Mrs.B.Priyadharshini M.E**, at Sathyabama Institute of Science And Technology, Chennai is submitted in partial fulfillment of the requirements for the award of Masters in Engineering degree in Structural Engineering

DATE: 05-05-2023

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SIGNATURE OF THE CANDIDATE

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ABSTRACT

This paper has highlighted an evaluation of the study experimentally investigated like mechanical performance of hybrid fiber reinforced concrete (HFRC) with glass powder. Fiber like basalt fiber (BF) and polyvinyl alcohol (PVA) fiber. Basalt fibers of two geometrical length 6mm and 12mm having been proposed to increase the concrete's mechanical characteristics, I need to make a number of standard concrete cubes, cylinders, and beams and test them for strength and other characteristics before producing concrete specimens made of glass powder. replacing fine aggregate of 15% with poly vinyl alcohol fiber proportion of 0.1%, 0.2% and 0.3% and Basalt fibre content ranges from 0.1% to 0.3% The strength of the cast specimens is evaluated. I'm going to contrast the behaviour of glass powder concrete with regular concrete using the test data. Investigations have also looked into using glass trash as fine aggregates while making concrete. Studies from the past indicate that glass powder improves the concrete's mechanical performance.

Keywords: Glass powder (GP), Basalt fiber (BF), Polyvinyl alcohol fiber (PVA), Hybrid fiber reinforced concrete (HFRC), Fiber reinforced concrete (FRC)

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LIST OF ABBREVIATION

ASR	Alkali silica reaction
ASTM	American society for testing and materials
BF	Basalt fiber
BFRC	Basalt fiber bars and fiber reinforced concrete
BFRP	Basalt based fiber reinforced polymer
CAD	Computer aided design
CG	Coarse glass
CRI	Crack resistance index
EDX	Energy Dispersive X-ray
FA	Fly ash
FEA	Finite element analysis
FG	Fine glass
FI	Flexibility index
FRC	Fiber reinforced concrete
GF	Glass fiber
GP	Glass powder

GUI	Graphical user interface
HFC	Hybrid reinforced concrete
OPC	Ordinary Portland cement
PVA	Polyvinyl alcohol
SEM	Scanning electron microscopy
SENB	Single edged notched beams
SF	Silica fume
UPV	Ultrasonic pulse velocity
UHPC	Ultra high performance concrete
WG	Waste glass
WGP	Waste glass powder

CHAPTER 1

INTRODUCTION

1.1 GENERAL

As a composite material, concrete is formed of cement, water, coarse aggregate and fine aggregates and sometimes additional materials like admixtures or fibers. it is a versatile and a popular building material because of its strength, durability and ability to be shaped and molded into various forms

The basic components of concrete are cement, water and aggregates cement is a binding agent that reacts with water to assemble a paste that hardens overtime along with binds the combined aggregates. water is added to the cement to create a workable paste, aggregates are added to mix to provide bulk and strength to the concrete. coarse aggregates such as gravel or crushed stone, are used to provide structural support, while fine aggregates Fillers, like sand, are employed. the voids among the coarse aggregate and helps the cement paste bind to the aggregates

The qualities of concrete, including its sturdiness and durability and workability can be modified by adding various materials like admixtures, fibers, or pigments to the mix the concrete is given admixtures mix to enhance its attributes, such as setting time, workability and strength. fibers such as steel, synthetic or natural fibers may be included in the mixture. increasing the concrete strength in tensile, toughness and resistance to breaking. pigments can be added to the mix to give the concrete a specific colour or texture

1.1.1 Fiber Reinforced Concrete (FRC)

Fiber-reinforced concrete (FRC) is a type of concrete that incorporates fibrous material to increase its structural integrity. It has uniformly distributed, distinct short fibers that are oriented at random. Natural fibres, synthetic fibres, glass and steel fibres be all types of fibers. Fibre reinforced concrete comes in a variety of concretes, fibre materials, geometries, distributions, orientations, and densities. takes on different characteristics within these various fibers.

Fiber reinforced concrete (FRC) is a variety of concrete such incorporates fibers as reinforcements. The fibers used can be made from various materials such as steel, glass, synthetic fibers, natural fibers or a combination of these. Concrete's mechanical qualities, such as strength, are improved through fibre addition., toughness, along with ductility.

Fiber reinforced concrete is frequently utilised in structural applications, such as buildings and bridge constructions, where high performance and durability are required. The fiber in concrete with fiber reinforcement helps to distribute the stress within the concrete matrix, thereby reducing cracking and increasing the resistance to impact and fatigue. Additionally, fiber-reinforced concrete can be used in non-structural applications such as precast concrete products, decorative concrete and shotcrete but can be taken into account for a variety of building materials (such as foundations, beams, and pliers).

Volume fraction (V_f) is a unit of measurement used to express how much fibres are added to a concrete mixture in relation to the sum of the composite's volumes material (concrete as well fibers V_f typically ranges from 0.1 to 3%. Dividing the fiber's length (l) by its diameter (d) yields the aspect ratio (l/d). When calculating the aspect ratio an comparable diameter of fibers with noncircular cross sections is utilised. Two categories of fibers can be distinguished: fibers with moduli less than those of the concrete matrix. Examples include Polypropylene, nylon, and cellulose fibers that are

stronger than cement in terms of modulus. Glass, steel, asbestos fibers, etc. are some examples.

While type 2 fibers have a greater modulus than cement and offer a greater strength performance for the concrete, type 1 fibers are said to improve the strain performance of the material. More fibers are incorporated a more homogeneous, isotropic substance into the concrete mixtures. Consequently, the fragile nature of concrete is changed to a malleable condition. This enhances the behaviour of the concrete's ductility under large loads.

1.1.2 Hybrid reinforced concrete (HFC)

Hybrid reinforced concrete (HFC) is such a type of concrete that incorporates two or more types of reinforcing materials to enhance its mechanical properties. The combination of different reinforcing materials is intended to take advantage of their unique properties to produce a concrete that is stronger, more durable and more resistance to cracking

Hybrid reinforced concrete (HFC) is frequently utilised in infrastructure projects like building bridges and tunnels where toughness and durability are essential. it can also be used in the construction of buildings, where it can also be used in the construction of buildings, where it can provide additional seismic resistance and protect against damage from natural disasters.

1.1.3 Glass

Glass is a hard, brittle and transparent material created by rapidly cooling a melted combination of silica (silicon dioxide), soda (sodium carbonate), and lime (calcium oxide) after it has been heated to a high temperature. glass is used in a variety of applications. There are different types of glass each with its unique properties and uses, such as tempered glass, laminated glass, borosilicate glass, leaded glass. glasses can be coloured or frosted to achieve specific effects. The best material for recycling is glass.

Table 1.1 Components and percentage of glass

Components	Percentage (%)
Silica (SiO ₂)	70.4
Alumina (Al ₂ O ₃)	1.9
Iron oxide (Fe ₂ O ₃)	1.2
Magnesium Oxide (MgO)	10.3
Sodium Oxide (Na ₂ O)	14.0
Potassium Oxide (K ₂ O)	0.4

Utilising recovered glass helps reduce energy use, and growing recycling awareness accelerates efforts to utilize waste glass in a variety of industries. Among its major addition for the construction industry, wherever leftover glass be used to make concrete. Glass utilisation in architectural concrete still need development. Crushed and screened waste glass provides a robust, secure, and cost-effective substitute for sand in concrete, according to many studies.

Recycling glass refers to the conversion of used glass into new materials. Cullet is glass that has been broken or imploded and is prepared for remelting. Cullet comes in two varieties: interior and exterior. Interior cullet be made up of flawed products that are discovered and deemed defective by quality control procedure throughout the transitional stages of product modifications (such variations in thickness and colour) and production offcuts in the course of an industrial process of making glass. Glass scrap Those have been gathered or processed again with the

intention of reclaim is known as exterior cullet. Waste is referred to as either pre- or post-consumer external cullet is acceptable. When referring to end-of-waste exterior cullet will always be meant when the word "cullet" is used..

1.1.4 Using glass as a pozzolan

Glass can be used as a pozzolan in the process of making concrete. pozzolan are the substance that are used into concrete to increase strength and durability. when glass is ground into a fine powder, It can be used to partially replace the cement in concrete. The powder of glass reacts with calcium hydroxide in the cement to form calcium silicate hydrate, which is a main component of concrete

Using glass as a pozzolan in concrete has several benefits. it reduces the amount of cement needed in the mix of concrete, which can help reduce the carbon footprint of construction industry, it can improve the durability of the concrete by reducing the amount of calcium hydroxide that is available to react with external elements such as water and carbondioxide, that can cause degradation overtime, using glass as a pozzolan can reduce waste by recycling glass

Concrete containing smaller glass particles performs more favourably mechanically and durably than concrete containing larger glass particles, which is an important factor in the pozzolanic performance of the glass powder.

1.1.5 Fine aggregate as glass

The most common man-made construction material is concrete, and demand for it is rising daily. By using river sand as fine aggregate, natural resources are depleted, the water table is lowered, bridge piers drop, and the riverbed is eroded. Fine by lowering aggregate content and minimising the negative effects of river dredging, the concrete manufacturing industry will become more sustainable. In a certain percentage and size range, waste glass can be used in place of fine aggregate. Due to an increasing demand

for glass products, there has been a gradual rise in the amount of waste glass created in recent years. The majority of glass debris has been and is still being placed in landfills.

Glass could be used as a fine aggregate in production of concrete, when the glass is crushed into small particles, it can be replaced for a portion of the sand in the fine aggregate of concrete

Using glass as a concrete with fine aggregate will reduce the quantity of sand required in the concrete mix it can help to reduce the environmental impact of sand mining, it can improve the thermal insulation of the concrete. one of the main challenge is to obtaining a consistent and reliable source of glass particles, since properties of the glass can vary depending on its source and processing methods. the utilize the glass as a fine aggregate may require some modifications to the design mix of concrete to ensure that the concrete has the desired characters, by its strength as well as workability, it has the potential to be a sustainable and effective to improve the performance of concrete and reduce waste

1.1.6 Glass recycled for construction

Alternative markets for recycled glass waste include the construction industry (used for the construction of road pavement, as an aggregate in asphalt, pipe bedding material, drainage or filler aggregate), the production of cement and concrete (using recycled glass waste as aggregate), as a partial replacement for cement, and as a partial replacement for cement. and aggregate in the same blend or source material for making cement

1. Aggregates: Crushed Glass can serve as an alternative to traditional construction aggregates such as sand and gravel. It is applicable to concrete and asphalt mixes as well as in drainage systems and road base

2. Insulation: Using recycled glass processed into a material known as foam glass, which has insulating properties. this material can be utilized as insulation in walls, roofs and floors
3. Glazing: Glass cullet, which is crushed and graded glass is a raw resource that may be utilized for new glass products. this can include glazing for windows and doors as well as glass tiles as mosaics
4. Landscaping: Crushed glass can be used in landscaping applications, such as in the construction of the pathways, retaining walls and decorative features
5. Countertops: Recycled glass can be incorporated into other architectural features, providing a unique and eco-friendly

By first finding a use for glass that is more valuable than landfill space and then through lowering the adverse effects of the building industry, the opportunity presented a proposed remedy is to include glass fibre into concrete. that employs Using the concepts of the circular economy, new business possibilities will be generated..

1. One benefit of incorporating concrete with glass would be to recycle the 8 million tonnes of post-consumer glass that are currently land filled annually.
2. Lower the 90 million tonnes yearly cement demand, which results in 90 million tonnes CO₂ emissions from cement production.
3. Reduce exposure to potentially harmful substances, such as heavy harmful concrete element, particularly when remodeling and demolishing a building.

1.2 OBJECTIVES

1. To investigate the mechanical strength of the concrete by the substitution of glass powder along with hybrid fiber
2. To analyze the effects of glass powder as a substitute for fine aggregate in part with poly vinyl alcohol fiber (PVA) and basalt fiber
3. To investigate and compare the behaviour of the conventional concrete beam and glass powder with polyvinyl alcohol fiber and basalt fiber concrete beam
4. To investigate the use of basalt fibre as a concrete reinforcing material through different experimental projects
5. To compare the analyzed results with experimental results

1.3 SCOPE

The scope of the present investigation includes:

1. By partially substituting the fine aggregate with glass powder and hybrid fiber, the flexural strength of the beam is assessed.
2. To create a mathematical model for forecasting the flexural strength of glass-powder concrete.
3. To compare the experimental work with the analytical model to determine the impact of glass powder.

1.4 NEED FOR THE PROJECT

1. To assess the effectiveness of basalt fibre and polyvinyl alcohol fibre as partial replacements for fine aggregate in concrete beams.

2. To know the effectiveness of glass powder in strength improvement
3. To examine the impacts of waste glass on characteristics of concrete containing recycled glass
4. To examine the impact of compressive durability of concrete to improve serviceability
5. To improve the long period deflection of the concrete

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURES

HeydarDehghanpour.et.al (2022) said that Fracture energy, non-destructive testing, some physical and mechanical tests and micro-structural investigations were conducted on 18-month Ultra High Performance Concretes (UHPCs) reinforced with 0.7 V%, 1.3 V%, and 2.0 V% PVA fiber, glass fiber (GF), and steel fiber (SF). To evaluate the fracture energy, dissipated energy, flexural strength, crack resistance index (CRI), and flexibility index (FI) of UHPCs, a fracture test was conducted on Single Edge Notched Beams (SENB). Resonance frequency measurements using the ASTM C215 standard on the SENB samples were used to determine the dynamic modulus of elasticity and damping ratios of the UHPCs. Additionally, ultrasonic pulse velocity (UPV), electrical resistivity, static modulus of elasticity, compressive strength, The cylindrical samples also underwent testing for density, Leeb hardness, and Schmidt hammer. The interaction between the matrix and various fibers was investigated using Energy Dispersive X-Ray (EDX) and Field Emission Scanning Electron Microscopy (FE-SEM) techniques.

K.I.M. Ibrahim (2021) said that the Waste glass (WG) causes serious environmental issues, in part because WG Rivers are inconsistent. Concrete manufacturing has used a number of strategies to achieve this goal in response to growing environmental difficulties to reduce solid wastes and reuse them as much as feasible. This study's main objective is to investigate the suitability and impact of using waste glass powder (WGP) as a partial replacement for cement weight in three different types of concrete. Ordinary concrete, concrete containing silica fume (SF), and concrete with fly ash

(FA) are these three crucial varieties. 0%, 5%, 10%, 15%, and 20% were the WGP replacement percentages based on cement weight. Both both the hardened and fresh stages of concrete, some mechanical and other properties have been studied.

Giuseppe Vairo.et.al (2019) said that physico-chemical and mechanical properties of basalt products, as well as good process ability features and cost-effectiveness of the corresponding production technologies. Basalt fibres in particular make it possible to create composite materials that are seriously competitive with those made using conventional glass or carbon fibres. A number of structural applications in civil engineering may benefit from basalt-based fiber-reinforced materials, according to recent experimental programmes and analytical techniques. Different composite materials have been developed depending on the fibre treatment and arrangement, as well as the matrix type (polymeric or cementitious). For instance, basalt-based fiber-reinforced polymers (BFRP) and cementitious matrices (BFRCM) can be used to strengthen and retrofit existing structures (concrete and masonry), and new design concepts can be utilised by making use of basalt-based rebars and fiber-reinforced concrete (BFRCThis article seeks to provide a thorough analysis of the state of the art regarding basalt fibres, basalt-based composite materials, and their applications in the field of civil engineering by tracing the key lines of evidence and highlighting relevant perspectives and unresolved issues.

G.Di Bella.et.al (2015) said that the basalt ones represent the most interesting for their properties. The aim of this review is to illustrate the results of research on this topical subject. The mechanical, thermal, and chemical properties of basalt fibre were covered in the introduction. A description of its primary manufacturing technology has also been provided. The impact of using this mineral fibre as reinforcement for various matrices, including metal, concrete, and polymers (both thermoplastic and thermoset). Furthermore, an overview on the application of this fiber in biodegradable matrix composites and in hybrid composites has been

provided. Finally, the studies on the industrial applications of basalt fiber reinforced composites have been reviewed.

Shilpa Raju, Dr. P. R. Kumar (2014) said waste glass is one material that exhibits pozzolanic qualities when ground to an extremely fine powder and can be utilised as a partial substitute for cement in concrete. This study makes an effort to determine the strength of concrete that uses waste glass powder as a partial replacement for cement. A 5% to 40% increment of 5% glass powder substitution of cement has been researched. At ages 7, 28, and 90 days, its compressive and flexural strengths were assessed, and the results were compared to those of regular concrete. Results indicated a 20% cement substitution.

Leonard D.Tijing.et.al (2014) said that the Vacuum assisted resin transfer moulding was used to create hybrid composites. Using a three-point bending test, the fracture was discovered. surfaces were examined by scanning electron microscopy. The The current findings indicated that the flexural strength and modulus of hybrid composite laminates were strongly dependent on the sequence of fiber reinforcement. All the stacking sequences showed a positive hybridization effect. the compressive side of the interply hybrid composite containing carbon fibre exhibited higher flexural strength and modulus than when basalt fabric was placed at the compressive side. Here, basalt and carbon fibre layers are stacked in the right order. was found to improve the balance of the mechanical properties of the hybrid composite laminate.

GerryLee, chi.et.al (2013) has said that On the characteristics of dry-mixed concrete blocks, the impacts of replacement percentages and particle size distribution of recycled fine glass (FG) aggregates were examined. A consistent total aggregate/cement ratio of 4% was used for all the combinations, and fine aggregate made up 50% of the total aggregate. Four distinct FG particle sizes (un-sieved, 2.36 mm, 1.18 mm, and 600 m) were used to replace sand in a total of 17 concrete block mixes, including a

control (0% of glass) mix. The percentages of replacement were 25, 50, 75, and 100%. Properties such packing density, hardened density, and water absorption were examined, as well as how air and water curing affected compressive strength at 7 and 28 days. The findings indicate that when the fine aggregate's fineness modulus decreased, the water consumption of the mix increased. In comparison to the control concrete block, all blocks containing FG exhibited higher water absorption and lower hardened density. This was particularly obvious for FG with particle sizes less than 600 m. With the use of coarser FG, slight losses in compressive strength were seen, but significant increases occurred when the particle size of FG was decreased to less than 600 m. This suggests that pozzolanic reactivity in finer FG was appreciable

Bhandari.P.S , Tajne. K.M (2013) Said that the need to add value to wastes and the opening towards the use of sand replacement materials, both in mortars and concretes, with the purpose of promoting increased sustainability of building materials, were the motivation for this project, which tries to create mortars with crushed glass aggregate. This work presents an experimental parametric research for making mortar blocks from fine and coarse glass trash. Investigated are the mechanical characteristics of mortar blocks with varying replacement amounts of fine glass (FG) and coarse glass (CG) with fine aggregate (FA). The test results show that the replacement of Fine aggregate by Fine Glass at level of 20% by weight has a significant effect on the compressive strength of the mortar blocks as compared with the control sample because of pozzolanic nature of FG. The findings point to this waste's pozzolanic reactivity and present opportunities for its application in mortars.

Ahmed shayan (2013) said that Glass can have harmful alkali-silica reaction (ASR) issues because it is unstable in the alkaline environment of concrete. By processing it into a fine glass powder (GLP) for use as a pozzolanic material in concrete, this feature has been taken advantage of. In

laboratory tests, it can reduce the alkali reactivity of both naturally reactive aggregates and coarser glass particles.

T.U.Ganiron and N.Ucolganiron (2013) said that In order to help the industry contribute to the preservation of the environment, to encourage the government to find solutions regarding the disposal of waste materials to landfills, and to impart new knowledge to the contractors and developers on how to improve the construction industry methods and services, concrete mixture with recycled bottles as an alternative fine aggregates for mass housing projects that will meet the American Society for Testing and Materials (ASTM) requirements has been developed. Comparing concrete containing recycled bottles in the same amounts to regular concrete. The results of the experiments were observed in the lab, where exact data was meticulously collected.

V.Jappes.et.al (2012) said that This paper describes unsaturated polyester composites with and without basalt fibre reinforcement that have been treated with acid and alkali. This investigation's goal was to find out how surface alterations like NaOH and H₂SO₄ affected various mechanical attributes like tensile, shear, and impact strengths. A computer-assisted universal testing machine was used to calculate variations in mechanical parameters such as the tensile strength, the inter-laminar shear strength, and the impact strength of different specimens. and a device for measuring Izod Impact. The fracture surface of the composites under a scanning electron microscope (SEM) revealed surface changes to the fibre and increased fiber-matrix adhesion. The investigation's findings demonstrate that basalt fibre reinforced composites have better mechanical qualities than glass fibre reinforced composites. The use of basalt fibre as a reinforcing ingredient in polymer composites is confirmed by this research.

AminNoushini.et.al said that The current work has looked into the impact of uncoated polyvinyl alcohol (PVA) fibre addition on the dynamic properties of fibre reinforced concrete (FRC). PVA fibre with two different

geometric lengths (6 mm and 12 mm), each with a different aspect ratio of 428 or 857.

S.Baxter.et.al said that an aggregate in concrete is problematic because of the strong alkali-silica reaction (ASR) between the cement paste and the glass aggregate. The use of broken waste glass as aggregate for concrete goods was studied in a research study at Columbia University. ASR in concrete with glass aggregate was studied from a fundamental perspective. Waste glass was demonstrated to produce mortar bar expansions in the ASTM C 1260 test of less than 0.1%, which is lower than that of reference bars, when ground to U.S. standard sieve size No. 50 or less in the absence of glass. Additionally, green glass has the potential to be a cheap ASR suppressant and does not exhibit any expansion at all.

D. Diogo Serpa.et.al said that Analysing the effects of aggregate size (fine, coarse, or both) and glass content (5, 10, and 20% of the total volume of aggregates) on the mechanical performance of concrete built with various amounts of glass. Utilising glass aggregates as an environmentally friendly substitute for simply throwing it away reduces the need for natural resource consumption and landfill space. The aggregates' density and abrasion were investigated. Workability and density tests were conducted on new concrete. It was discovered that adding glass aggregates increased the hardened concrete's compressive, splitting, tensile, and flexural strength as well as elastic modulus and abrasion wear.

L.Barbieri.et.al. said that By combining and sintering "negative cost" elements from one aluminium foundry and municipal solid waste incinerators (MSWIs), glass matrix composites have been created. To create the glass matrix, the bottom ashes from two MSWIs were used, and as a second step, solid wastes from the aluminium alloy industry were put to use. Without using any additives, the bottom ashes were heated to 1400°C and vitrified.

S.P. Gautam.et.al. Said that the use of recycled glass promotes energy conservation. The utilisation of discarded glass in various forms in numerous fields is being examined more quickly due to the growing awareness of glass recycling. One of its major contributions was to the construction industry, where leftover glass was used to make concrete. Glass utilisation in architectural concrete still need development. The utilisation of waste glass as coarse and fine aggregates for concrete's aesthetic as well as ASR (Alkali-Silica-Reaction) alleviation purposes was further investigated in laboratory trials. According to the study, used glass can efficiently substitute fine aggregate (up to 40%) without significantly affecting strength.

Chi Sun Poon and Jian-Xin Lu said that the influences of waste glass in cullet and powder forms on workability, compressive and flexural strengths, fire resistance of the AAC mortar were investigated. The experimental findings demonstrated that the workability improved dramatically with lowering aggregates-to-binder ratios and gradually rose as the level of natural sand replacement by glass cullet was raised. According to the data on mechanical properties, the compressive strength decreased as the glass cullet content rose. However, 50% glass cullet replacement was the ideal level for flexural strength. A decrease in strength was seen when glass powder was utilised in place of fly ash and slag due to its low reactivity. However, the addition of glass cullet could increase the AAC's resistance to exposure to high temperatures of 800 °C in terms of fire resistance. Because of the mechanical and fire characteristics, using scrap glass as AAC material proved possible.

Sayisetti Rajaiah.et.al said that Glass can produce harmful alkali-silica reaction issues since it is unstable in the alkaline environment of concrete. By processing it into a fine glass powder (GLP) for use as a pozzolanic material in concrete, this feature has been taken advantage of. In this investigation, glass powder that is high in silica is used to partially replace the cement. In order to test the strength and other properties of ordinary concrete, we have planned to make a number of cubes, cylinders, and beams in these shapes. We will next prepare concrete specimens using glass powder in various amounts, such as 5, 10, and 15%.

CHAPTER 3

METHODOLOGY

3.1 METHODOLOGY

Methodology is a systematic approach to conduct research, Methodology describes the complete procedure from surveying of literatures to comparison of results of conventional mix and mixes with partial replacement of glass powder as fine aggregate with varied proportional of hybrid fibres

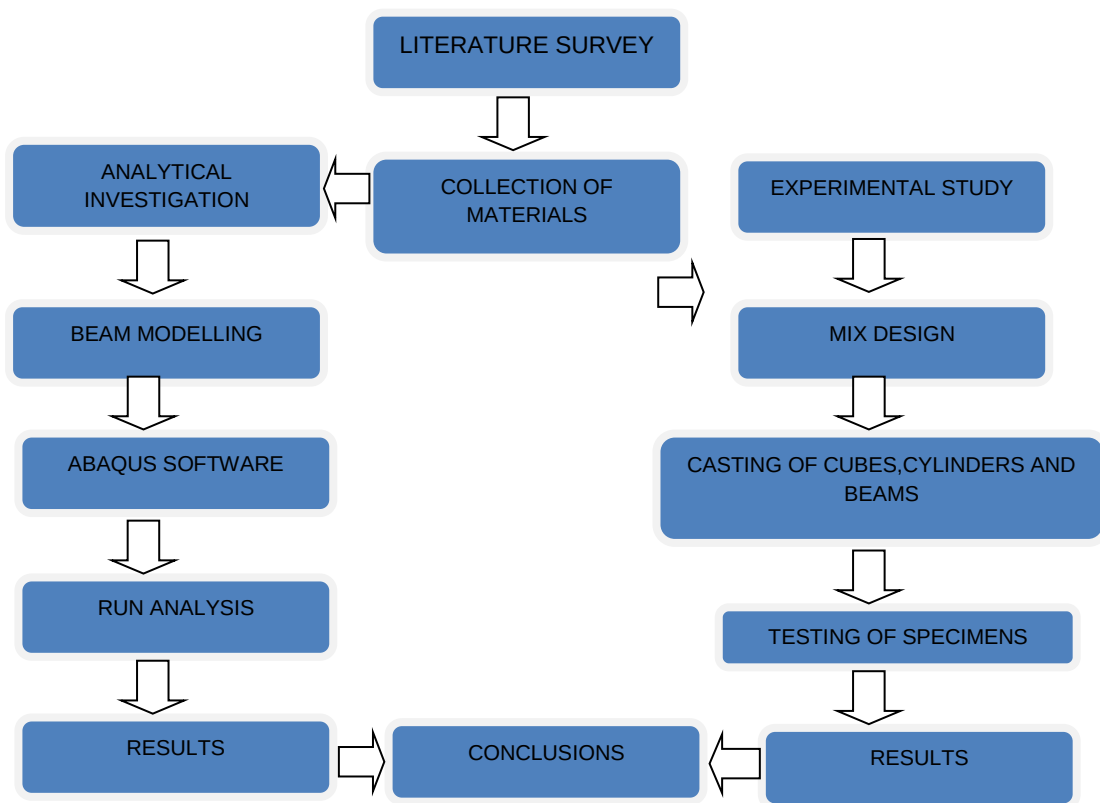


Fig.3.1 Flowchart of methodology

3.2 MATERIALS USED

3.2.1 Cement: (Ordinary Portland Cement Of Grade 53)

Cement is a fine powder composed mainly of calcium silicate and other minerals. It is used as a binding material in concrete, mortar, and other construction applications. When mixed with water, cement forms a paste that hardens and binds material together.

In this study I have used ordinary Portland cement (OPC) 53 grade cement. When initial higher strength is the criterion, 53 Grade OPC cement is used in RCC and pre-stressed concrete of higher classes, cement grouts, quick plugging mortars, etc.



Fig.3.1 Cement OPC grade 53

Ordinary Portland cement (OPC) 53 grade is a type of cement that conforms to the Indian standards specifications IS12269-1987. It is a high strength cement that is commonly used in construction applications that require a high level strength, such as in the construction of high-rise buildings, bridges and heavy-duty industrial structures. According to the Bureau of Indian Standards (BIS), the cement's grade number indicates the cement's minimum compressive strength, which is anticipated to be reached in 28 days. For 53 grade OPC cement, the cement must have a minimum compressive strength of 53 MPa, or 53 kilograms per centimetre square, by the end of the 28th day. OPC is coloured grey.

Table 3.1 Chemical constituents of ordinary portland cement (OPC)

COMPONENTS	PERCENTAGES (%)
Lime (CaO)	60 to 68%
Silica (SiO ₂)	17 to 26%
Alumina (Al ₂ O ₃)	3 to 9%
Iron oxide (Fe ₂ O ₃)	0.5 to 7%
Magnesia (MgO)	0.1 to 5%
Sulphur trioxide (SO ₃)	1 to 4%
Soda and or Potash (Na ₂ O+K ₂ O)	0.5 to 1.5%

3.2.2 Fine aggregate (M-Sand)

M-sand or manufactured sand, is a type of fine aggregate used in construction, typically made of crushed rock and gravel. It is a substitute for natural river sand, which is becoming scarce due to excessive mining and environmental concerns. The particle size of M-sand is generally between 0.15mm to 4.75mm, making it suitable for use in concrete and other construction applications. It is also free from impurities such as silt and clay, which can affect the properties of concrete. The particle size of coarse aggregate is greater than 4.75 mm, whereas that of fine aggregate is smaller. The most typical coarse aggregate size for concrete production is 20 mm.

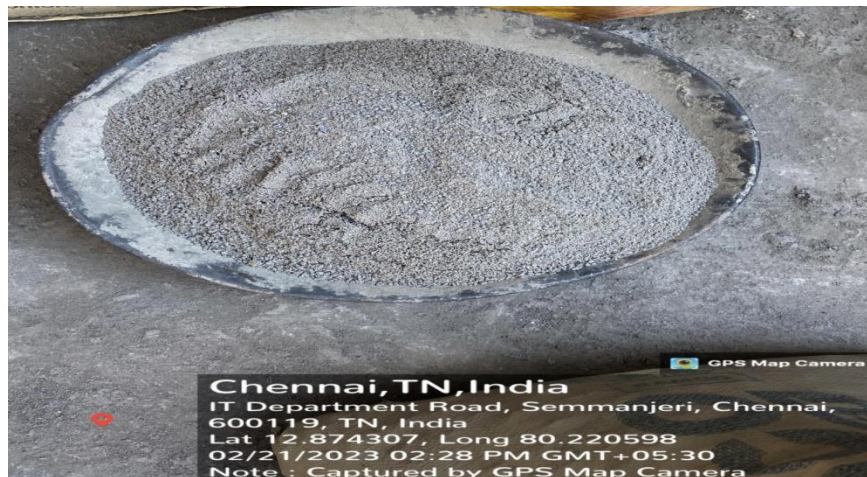


Fig.3.2 Fine aggregate (M-sand)

Table 3.2 Types of fine aggregates

Coarse sand	2.0mm-0.5mm
Medium sand	0.5mm-0.25mm
Fine sand	0.25mm-0.06
Silt	0.06mm-0.002
clay	< 0.002

3.2.3 Coarse aggregate

Coarse aggregates are defined as having a size more than 4.75 mm. Concrete is made from coarse aggregates, which are granular and uneven materials like sand, gravel, or crushed stone. Coarse is typically found in nature and can be obtained by blasting quarries or crushing them manually or with crushers. Before using them to make concrete, they must be thoroughly cleaned. Their strength and angularity have a variety of effects on the concrete

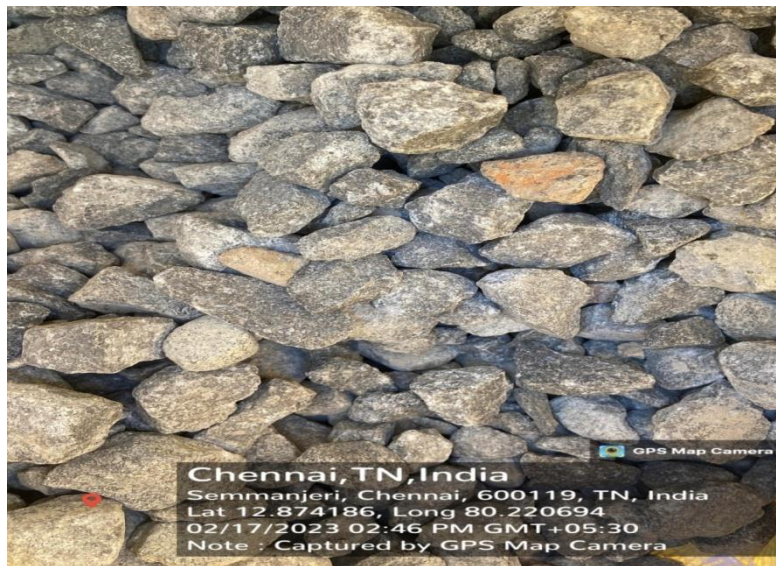


Fig.3.3 Coarse aggregate (20mm)

3.2.3.1 Size of coarse aggregates

Materials with a maximum size of 63mm that are large enough to be retained on a 4.75mm sieve size typically make up coarse aggregates. The amount of water required for the concrete mix, as well as the strength and workability of the concrete, are all influenced by the size of the coarse particles. It also aids in calculating the quantity of fine aggregate required to make a batch of concrete. The bondable surface area of cement, sand, and water decreases with size; less water and fine aggregate are used in concrete mixtures as a result.

3.2.4 Water

Water is an essential component in the production and the use of concrete, as it is needed to hydrate the cement and create a strong, durable material. However, water can also have negative effects on concrete if it is not used properly or if it penetrates the surface of the concrete

Excessive water in the concrete mix can result in a weaker, more porous material that is more susceptible to cracking, shrinking, and other forms of damage. This is because too much water can interfere with the chemical reaction between the cement and water that creates the hardening process.

Water can also cause damage to existing concrete structures if it penetrates the surface and reaches the reinforcing steel. This can lead to corrosion of the steel, Which can weaken the structure and potentially lead to collapse.

To prevent these issues, it is important to use the correct amount of water in the concrete mix and to take steps to prevent water from penetrating the surface of the concrete. This can include using sealers or coatings, providing proper drainage around the structure, and avoiding exposure to excessive moisture.

3.2.5 Glass powder

Glass powder is a finely ground powder made from glass that has been broken down into small particles. It is typically produced by grinding waste glass or by crushing glass bottles and other glass objects into a fine powder. Glass powder has several properties that make it useful in various applications. it is inert, non-toxic, and does not release any harmful gases or fume, making it a durable material.

Glass powder is commonly used in construction materials such as concrete, where it can be added as a partial replacement for cement or

sand. The addition of glass powder can improve the strength, durability and workability of concrete. The use of glass powder in concrete can also reduces the environmental impact of the concrete production by reducing the amount of CO₂ emissions associated with cement manufacturing

Glass powder can also be used in combination with other admixtures, such as fly ash, silica, fume, and slag to improve the mechanical properties of concrete. These admixtures can improve the workability of the mixture, reduce its water content, and improve its strength and durability.

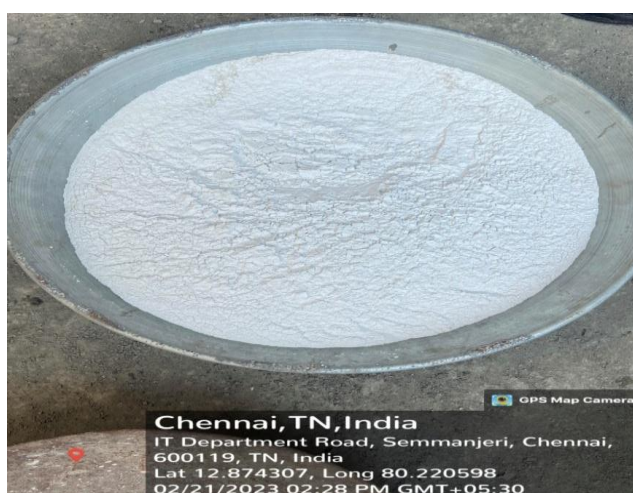


Fig.3.4 Glass powder

Table 3.3 components and percentages of glass powder

Components	Percentages (%)
Silica (SiO ₂)	76.39
Alumina (Al ₂ O ₃)	2.19
Calcium (CaO)	6.05
Magnesium as (MgO)	1.18
Sodium (Na ₂ O)	8.86
Potassium (K ₂ O)	2.84
Loss on ignition (@550°)	0.24

3.2.6 Polyvinyl alcohol fiber (PVA)

Polyvinyl Alcohol Fiber (PVA) is a water-soluble synthetic polymer that is widely used in various industrial and commercial applications. It is a thermoplastic polymer that can be easily dissolved in water and forms a clear, colourless, and odourless solution. Polyvinyl alcohol fiber (PVA) is produced by the polymerization of vinyl acetate monomer, which is then hydrolyzed to form polyvinyl alcohol fiber PVA. The degree of hydrolysis, the Polyvinyl alcohol fiber PVA is more water-soluble

Polyvinyl alcohol fiber (PVA) has desirable properties, including high tensile strength, flexibility, and film forming ability. It is used in the textile industry as sizing agent, in papermaking as a binder and coating, in adhesives and sealants, and as a component in emulsions and suspensions, in the medical field, Polyvinyl alcohol fiber PVA is used as a coating for medical devices and wound dressing, It is also used in contact lenses and artificial tears as a lubricant .Some forms of polyvinyl alcohol fiber (PVA) may contain residual traces of vinyl acetate monomer



Fig.3.5 Poly vinyl alcohol fiber

Table 3.4 properties of poly vinyl alcohol fiber

Properties	Values
Tensile strength	1600 Mpa
Elongation of break	7%
Diameter	0.4 mm
Length of fiber	12 mm
Aspect ratio	857
Young modulus	40 Gpa

3.2.7 Basalt fiber (BF)

Basalt fiber is a type of fiber derived from the basalt rock. basalt is a volcanic rock that is formed from the solidification of lava and it is found in abundance in many parts of the world. The process of producing basalt fibers involves melting the basalt rock at a high temperature and drawing the molten material into thin fibers

Basalt fibers are known for their excellent mechanical properties, including high tensile strength, good resistance to impact and fatigue and high modulus of elasticity. They also resistant to alkalis, acids, and high temperatures.

Basalt fibers are used as a reinforcement material in various composite applications, including construction, automotive and aerospace industries. Basalt fibers can be used to produce different products such as basalt fiber reinforced polymer (BFRP) bars, Basalt fiber reinforced concrete (BFRC) and basalt fiber mats. In construction BFRC is used to increase the strength and durability of structures like bridges, tunnels and buildings. In automotive and aerospace applications, basalt fibers are used to produce lightweight composite materials that offer high mechanical properties and durability.



Fig.3.6 Basalt fiber

Table 3.5 Properties of basalt fiber

Properties	Values
Density	2.70 kg/dm ³
Moisture content of basaltic rock	0.1 %
Melting point	1350 C
Diameter	13 μ m
Length	6-18 mm
Sizing type	silane
Moisture content	$\leq$ 0.30%
Sizing content	$\leq$ 0.50%

CHAPTER 4

ANALYTICAL INVESTIGATION

4.1 GENERAL

Analytical investigation refers to the process of examining and evaluating data or information using analytical methods.

The goal of analytical investigations is typically to gain a deeper understanding of a particular phenomenon. In this research analytical investigations may be used to analyze experimental data and develop the model to explain observed phenomena

4.1.1 Finite element analysis (FEA)

The behavior of complex structures and systems can be studied computationally using finite element analysis (FEA). To simulate how a structure will react to different loading and boundary conditions, it is frequently used in engineering and scientific domains. A complex structure or system is divided into smaller, more manageable pieces known as finite elements using this technique. The behaviour and interactions between the finite elements are then determined through independent mathematical analysis of each finite element.

The process of performing FEA involves several steps:

1. Model creation: A computer-aided design (CAD) model of the structure or system is created using software such as solid works or AutoCAD
2. Mesh generation: The model is divided into smaller, simpler parts called finite elements. These elements are typically triangles or rectangles in two dimensions and tetrahedrons or hexahedrons in three dimensions.

3. Material properties and loads: The properties of the materials used in the model, such as elasticity and density, are assigned to each finite element. Loads such as forces, pressures and temperatures are also assigned to the model.
4. Equation formulation: Mathematical equations are formulated for each finite element based on the material properties, loads, and boundary conditions.
5. Solution: The equations are solved using numerical methods to determine the behavior of each finite element and the overall behavior of the structure or system
6. Post-processing: The results of the analysis are presented in graphical and numerical forms to help interpret the behavior of the structure or system. this step may involve the use of visualization tools such as animations or contour plots.

4.2 ABAQUS SOFTWARE

ABAQUS is a powerful finite element analysis (FEA) software suite developed by Dassault systemes. it is used by engineers and researchers in various fields, including mechanical, aerospace, civil and biomedical engineering.

Abaqus software is used to simulate and analyze the behavior of structures and materials under different loading conditions. abaqus allows users to create 3D models of structures or parts, apply loads and constraints and simulate how they will behave under different conditions. the abaqus software provides a wide range of material models, including linear and non-linear, isotropic and anisotropic and elastic and visco elastic, to accurately model the behavior of real materials. abaqus software has a graphical user interface (GUI) for pre-processing and post-processing as well as a scripting interface for automation and customization. it is also used in academic research for simulating complex phenomena and analyzing experimental data

Some of the key features of ABAQUS include:

1. Nonlinear analysis capabilities: ABAQUS can handle nonlinear material behavior, geometric nonlinearity and contact interactions.
2. Multiphysics simulation: ABAQUS can perform coupled simulations involving multiple physical phenomena such as structural, thermal and fluid.
3. Material modeling: ABAQUS includes a wide range of material models for simulating various types of materials such as metals, polymers and composites.
4. Element types: ABAQUS provides a wide range of element types for modeling various types of structural and fluid behavior.
5. Customization and automation: ABAQUS provides a scripting interface for automating simulation processes and customizing simulations.

4.2.1 Details of specimens analysed by ABAQUS

Four beams of length 1500mm and cross sectional dimensions of 230mmx230mm with varying mix proportion of hybrid fibers as basalt fiber and polyvinyl alcohol fiber with glass powder reinforced with reinforced bars of Fe550 of 10mm diameter were studied using the ABAQUS software. fig 4.1 shows the cross sectional dimensions of the beam specimens

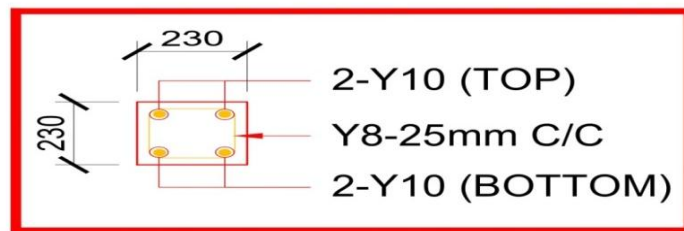


Fig.4.1 cross sectional dimensions of beam specimens

Pre-processing or modeling: In the Finite Element Analysis (FEA) simulation process utilising the ABAQUS software, preprocessing is a crucial step. Creating and defining the model's shape, allocating materials, and specifying boundary conditions and loads are all part of the preprocessing phase. You can define and generate the model using the graphical user interface (GUI) provided by ABAQUS, or you can utilise Python scripting.

Post-processing: An integral part of every Finite Element Analysis (FEA) simulation is post-processing. Post-processing in ABAQUS entails visualising and evaluating the simulation's outcomes. For the purpose of post-processing the simulation results, ABAQUS offers a variety of tools and methods

4.2.2 Analysis of hybrid reinforced beams

Modeling: The first step in the analysis is to create a 3D model of the beam with reinforced bar of diameter 10mm in the ABAQUS software. The model should include all the necessary dimensions, materials properties and boundary conditions. The model of the beam created in ABAQUS is shown in fig.4.2.

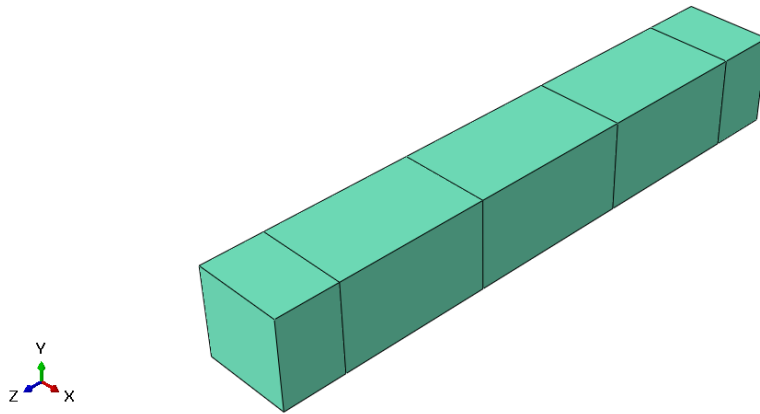


Fig.4.2 model of the beam specimens

Meshing in ABAQUS software

Meshing is a crucial step in FEA that entails breaking a complicated geometry down into smaller, more manageable pieces called "meshes" to aid in numerical analysis. The built-in Mesh module in ABAQUS is used for meshing, and it offers a variety of tools for creating and changing meshes.

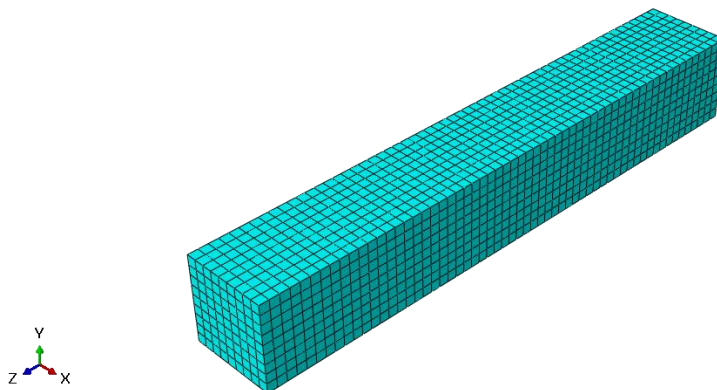


Fig 4.3 Meshed beam model in ABAQUS software

These procedures should be followed in ABAQUS to mesh a part:

- In ABAQUS, you may create a part geometry from scratch or import one from another programme.
- Describe the part's material characteristics, such as its Young's modulus and Poisson's ratio.
- By specifying the mesh size, element type, and meshing settings, you may create a meshing strategy.
- Utilise the ABAQUS Mesh module to create the mesh.
- Utilise the ABAQUS Mesh Quality module to examine the mesh's quality. The precision and stability of the analysis might be impacted by the mesh's quality.

Material properties in ABAQUS: After meshing, the next step is to define the material properties of the hybrid concrete beam reinforced with Fe550 bars. this includes specifying the young's modulus, poisson's ratio and other material properties that are relevant to the beam's behavior under loading conditions. Material characteristics are crucial input parameters that define the behavior of materials under various loading and environmental situations in ABAQUS

The properties of the materials which were provided as input for analysis is mentioned in table 4.1

Table 4.1 Material properties

Test mix	Modulus of elasticity	Poisson's ratio	Yield strength
M40 Concrete mix	30992	0.2	-
0.1%PVA 0.3%BF 15% GP	27890	0.2	-
0.2% PVA 0.3% BF 15% GP	28842	0.2	-
0.3% PVA 0.3% BF 15% GP	29107	0.2	-
Steel	21000	0.3	550Mpa

Reinforcing steel bar properties: The next step is to define the properties of the reinforced bars used in the beam. this includes specifying the young's modulus, poisson's ratio and other material properties that are relevant to the reinforced bars behavior under loading conditions .the 3D model of reinforced steel bars is shown in fig4.4.

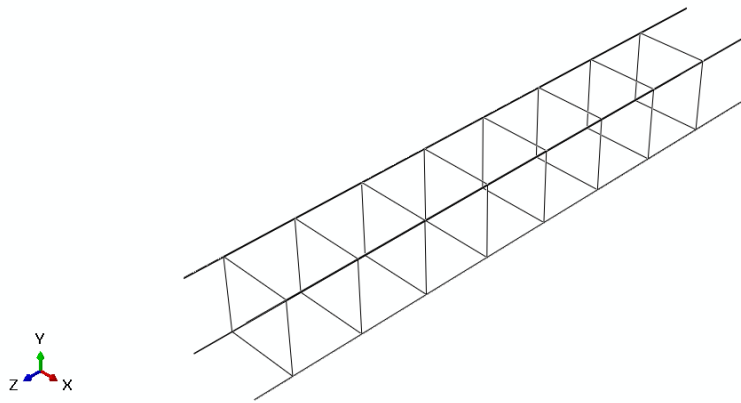


Fig.4.4 3D model reinforcing bars

Boundary conditions: The next step is to apply the boundary conditions to the beam reinforced with Fe550D reinforced steel bars. this includes fixing one end of the beam and applying the load to the other end. The boundary conditions are consistent with the actual conditions under which the beam will be used.

Solving: once the boundary conditions are applied, the ABAQUS software solves the equations governing the behavior of the beam reinforced with Fe550D reinforced steel bars under loading conditions. this involves solving a large system of equations using numerical techniques.

Deflection of the structure

The amount of structural deformation caused by an applied load is known as deflection. Using the Finite Element Analysis (FEA) method, you can simulate and examine the deflection behavior of a structure in ABAQUS.

Results: The ABAQUS programme presents the findings in the form of stress, strain, and deformation charts when the solution is achieved. The findings may be used to estimate the hybrid reinforced beam's flexural strength, or its capacity to bear the loads. the results can be used to determine is the hybrid reinforced concrete beam with reinforcing bars will be able to withstand the loads it is expected to experience in real world conditions

Table 4.2 Flexural strength outcome of beam (Analytical)

Load (KN)	Conventional mix	0.1%PVA 0.3% BF 15% GP	0.2%PVA 0.3%BF 15%GP	0.3%PVA 0.3%BF 15%GP
	DEFLECTION (mm)			
0	0	0	0	0
10	0.067	0.022	0.028	0.049
20	0.135	0.067	0.088	0.118
30	0.225	0.115	0.134	0.204
40	0.324	0.169	0.2	0.251
50	0.42	0.214	0.271	0.298
60	0.516	0.258	0.323	0.352
70	0.601	0.299	0.415	0.444
80	0.673	0.326	0.471	0.48
90	0.734	0.358	0.521	0.55
100	0.759	0.388	0.552	0.614

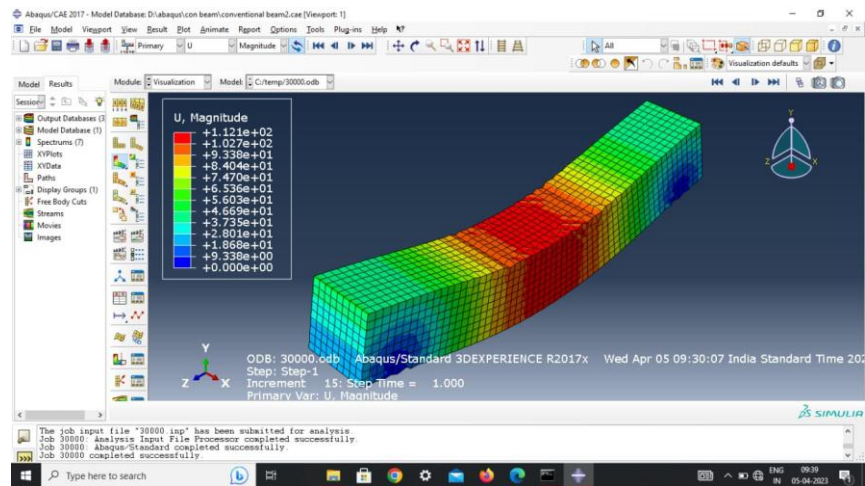


Fig.4.5 Deformation of the conventional beam

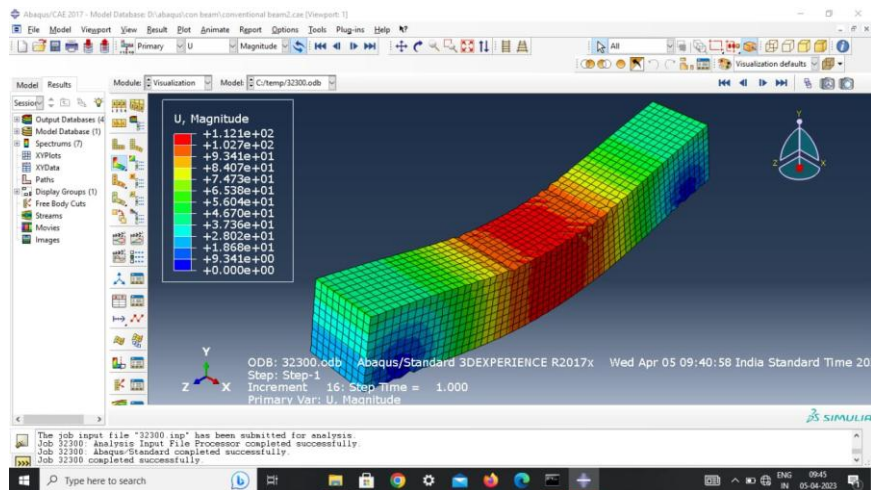


Fig 4.6 Deformation of the beam with 0.1% PVA, 0.3%BF and 15% of GP

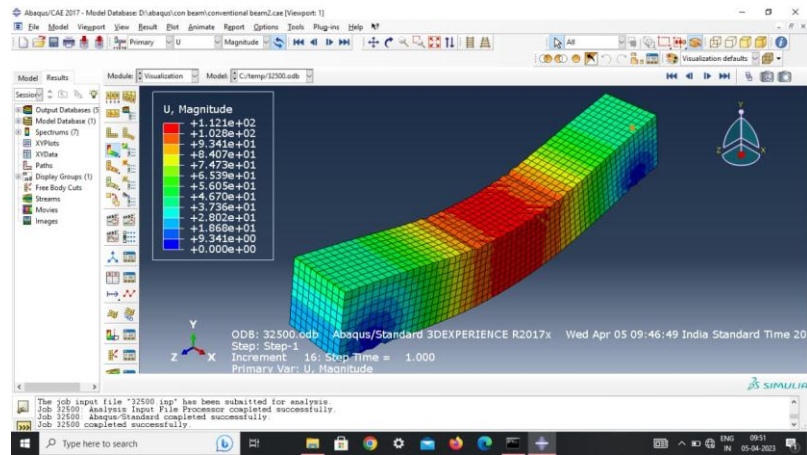


Fig 4.7 Deformation of the beam with 0.2% PVA, 0.3%BF and 15% of GP

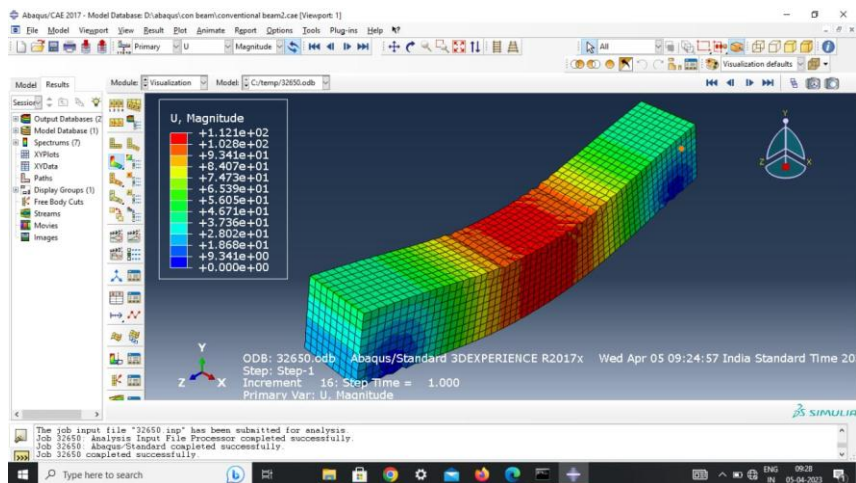


Fig 4.7 Deformation of the beam with 0.3% PVA, 0.3%BF and 15% of GP

CHAPTER 5

EXPERIMENTAL INVESTIGATION

5.1 General

The experimental work has been carried out for specimens of M40 concrete cubes, cylinders and beams which has been casted with different proportions of Polyvinyl alcohol fiber and basalt fiber with 15% of glass powder as a substitution of fine aggregate. some of the fundamental assessment has been carried out to find the properties used in the concrete, in this research the performance of the concrete is determined which contains the waste glass powder with polyvinyl alcohol fiber and basalt fiber by preparing concrete cubical specimens and cylindrical specimens and examined to obtain the compression strength and splitting tensile strength of the specimens.

5.2 TEST ON MATERIALS

5.2.1 Test cement

The following examination was done to estimate the properties of the materials used in the investigation.

Table 5.1 Test on ordinary portland cement (OPC53)

01	Standard consistency	32%
02	Specific gravity	3.15
	Setting time	
03	(i)Initial setting time	40 minutes
	(ii)Final setting time	510 minutes
04	Fineness	3%

5.2.2 Test on fine aggregate

Zone III M-sand that complied with Table 4 of IS 383-1970 was utilised. The fine aggregate was determined to have a specific gravity of 2.60. This table offers the findings of the sieve analysis of fine aggregate.



Fig 5.1 sieve analysis of fine aggregate

Table 5.2 Sieve analysis test on fine aggregates

S.No	Sieve size	Cumulative weight retained (gm)	Percentage retained	Cumulative percentage retained	Percentage passing
01	4.75	0	0	0	100
02	2.30	24	2.4	2.4	97.6
03	1.18	344	34.4	36.8	63.2
04	600 microns	150	15.0	51.8	48.2
05	300 microns	180	18.0	69.8	30.1
06	150 microns	230	23.0	92.8	7.2
07	75 microns	50	5.0	97.8	2.2
08	PAN	22	2.2	100	-

Table 5.3 specific gravity test on fine aggregate

SI NO	Determination	Grams (gm)
1	Weight of sample taken	2000
2	Weight of saturated and surface dry aggregate (C)	500
3	Weight of pycnometer+sample+water (A)	1826
4	Weight of pycnometer +water (B)	1514
5	Weight of oven dry sample (D)	496
6	Specific gravity= $\left[\frac{D}{C-(A-B)} \right] \times 100$	2.64

5.2.3 Test on coarse aggregate

Coarse aggregate of 20mm size of aggregate conforming to Table 2 of IS 383-1970 was used in this study. The coarse aggregate was determined to have a specific gravity of 2.70. This table offers the findings of the sieve analysis of coarse aggregate.

Table 5.4 Sieve analysis test on coarse aggregate

S.No	Sieve size	Cumulative weight retained (gm)	Percentage retained	Cumulative percentage retained	Percentage passing
01	80	0	-	-	100
02	40	0	-	-	100
03	20	850	85	85	15
04	10	148	14.8	99.8	0.2
05	4.75	2	0.2	100	0

Table 5.5 specific gravity test on coarse aggregate

SI NO	Determination	Grams (gm)
1	Weight of sample taken	1000
2	Weight of saturated and surface dry aggregate (C)	3388
3	Weight of pycnometer+sample+water (A)	2736
4	Weight of pycnometer +water (B)	990
5	Weight of oven dry sample (D)	941
6	Specific gravity= $\left[\frac{D}{C-(A-B)}\right] \times 100$	2.75

5.2.4 Test on glass powder

Glass powder used as a partly substitution of fine aggregate. Specific gravity of glass powder is 2.54

Table 5.6 specific gravity test on materials

Materials	Specific gravity
CEMENT	3.15
FINE AGGREGATE	2.64
COARSE AGGREGATE	2.75
GLASS POWDER	2.54

5.3 Mix design

Concrete mix design is the methodology of determining the suitable ratios of cement, sand and aggregates to attain the desired strength in structures. In other terms, a concrete mix can be expressed as Cement:Sand:Aggregates. The process of concrete mix design involves several steps, computations and laboratory testing to identify the appropriate mix proportions. In this research I have used M40 grade of concrete mix, M40 grade is used to create foundations and support beams on commercial construction projects. the advantage of concrete mix design is that it provides the correct proportions of materials, making the construction of concrete economical in achieving the required strength of structural components. The purpose of mix design is to produce a workable, long lasting concrete mix with the necessary strength.

Mix design involves several steps, including

1. Determining the required properties of the concrete, such as compressive strength, workability and durability
2. Selecting the appropriate type and quality of materials, such as cement, aggregates, and water, based on their properties and availability.
3. Determining the proportions of materials needed to produce the desired concrete mix
4. Adjusting the mix proportions to account for factors such as moisture content of aggregates, temperature and other environmental factors
5. Testing the concrete mix to verify that it meets the required properties and adjusting as necessary

Mix design for M40 grade as per IS 10262:2009 & IS 456:2000

1. Grade designation:M40
2. Type of cement: OPC 53 Grade
3. Maximum nominal size of aggregate:20mm
4. Minimum cement content:360kg/m³ (IS 456:2000)
5. Maximum cement content:420kg/m³
6. Maximum water-cement ratio:0.40 (table 5 of IS 456:2000)
7. Workability:100-120mm slump
8. Exposure condition: moderate
9. Degree of supervision: Good
10. Type of aggregate: crushed angular aggregates
11. Specific gravity of cement:3.15
12. Specific gravity of fine aggregate:2.64
13. Specific gravity of fine aggregate:2.75

Target strength f_{ck}'

$$F_{ck} = f_{ck} + 1.65 \times S$$

where

F_{ck} = Target mean compressive strength at 28 days

S-standard deviation (from table 2, IS 10262:2019)

$$F_{ck} = 40 + 1.65 \times 5$$

$$F_{ck} = 48.25 \text{ N/mm}^2$$

OR

$$F_{ck} = f_{ck} + X$$

$$F_{ck} = 40 + 6.5 \text{ (table 1, M40=6.5)}$$

$$F_{ck} = 40 + 6.5$$

$$F_{ck} = 46.5 \text{ N/mm}^2$$

$$\text{Greater } F_{ck} = 48.25 \text{ N/mm}^2$$

Water cement ratio

$$\text{Maximum water cement ratio} = 0.45$$

Adopt water cement ratio as 0.40

$$0.4 < 0.45$$

Hence ok

Table 5.7 Mix design of M40 grade

Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (lit)
394	744	1121	157.6
1	1.88	2084	0.4

Table 5.8 Materials required for the M40 mix for the casting specimens

MATERIALS	CUBE	CYLINDER	BEAM
CEMENT	63.84kg	100.23kg	125 kg
WATER	25.43lit	39lit	49.83 lit
GLASS POWDER	18.14kg	28.8kg	26.6kg
M-SAND	102.32kg	160.8kg	200.59kg
COARSE AGGREGATE	181.44kg	285.18kg	355.8kg
PVA FIBER	0.548kg	0.861kg	1.075kg
BASALT FIBER	0.548kg	0.861kg	1.6131kg

5.4 PREPARATION OF SPECIMENS

5.4.1 Size of the specimens

- Size of cube:150x150x150mm
- Size of cylinder:150x300mm
- Size of beam:1500x230x230mm

5.4.2 Casting of moulds

Casting of cement mixes typically involves the use of moulds to create objects or structures out of cement based mixtures. The process is similar to other casting processes in that a liquid material is poured into a mould and allowed to solidify, taking on the shape of the mould cavity.



Fig.5.2 Casting of moulds

The casting of cement mixes typically involves the following steps

1. Preparation of the mould: The mould is prepared by applying a release agent or coating to prevent the cement mixture from sticking to the mould
2. Mixing of the cement mixture: The cement mixture is prepared by mixing cement, sand, aggregates and water to form a workable mixture.
3. Pouring of the mixture: The cement mixture is poured into the mould and allowed to settle and consolidate
4. Curing: The cement mixture is allowed to cure, typically by being kept in a moist environment, to allow the cement to harden and develop the required strength.
5. Demoulding: Once the cement has hardened, the casting is removed from the mould and may be further processed, finished or cured

5.4.2 Cube specimen

The following steps are taken into consideration while casting the concrete cube specimens:

A concrete cube refers to a standard size cube-shaped sample of concrete used for testing purposes. The size of the cube is usually 6inchesx6inchesx6inches (15cmx15cmx15cm) and the mould must be equipped with a base plate and the cement used must be 420kg/m³. Mild steel ramming bars conforming to IS:10262-2019 with rounded ends must be used. The rod should be 16±0.5mm in diameter and 600±2mm in length. The begin the casting process, the mould plate must be detached and cleaned. Then reassembled to ensure all bolts are tight. A thin layer of oil is applied to all surface of the cubic mould. The face of the cubes must be parallel the concrete should be mixed and poured into the mould as quickly as possible

in a layer about 5 cm deep. After a spoonful of concrete has been poured, it should be moved along the top edge of the mould so that it is evenly distributed. Each layer must be compressed manually or by vibration. For manual compaction, each layer of the concrete is compacted with a rammer with a minimum of 35 strokes. Strokes must penetrate the base layer and wrap the bottom layer to full depth. If a void forms in the rammer shaft, it must be closed by tapping the edge of the mould.

5.4.3 Cylinder specimen

In order to properly evaluate the physical properties of concrete materials, it is necessary to manufacture and withstand test specimens according to established standards. Concrete cylinders are commonly used to evaluate the compressive and strength of concrete

1. Cylindrical mould: A 6inchx12inches (15cmx30cm) metal cylindrical mould is used to cast concrete specimens on site. Forms should be placed on a smooth, hard, flat surface before filling.
2. Punching bar: When using a formwork with a diameter of 150mm, concrete is poured evenly in 3 layers and each layer is evenly compacted 25 times with a steel bar with a diameter of 16mm and a length of 450mm-600mm with a hemispherical tip.
3. Casting process: The stroke must be evenly distributed over the cross section of the mould. The bottom layer must be putty throughout the depth. For each subsequent layer, the rod should penetrate the base layer approximately 25mm. Be sure to tap the edges of the mould to close them before adding the next layer of material.

5.4.4 Curing

Curing is an important process for developing the strength and durability of concrete and preventing cracks and other defects. This process involves maintaining the humidity and temperature of the concrete to ensure hydration. Proper curing is essential to obtain the desired concrete properties and characteristics. The curing process usually consists of three stages.

First stage: The first is initial curing, in which fresh concrete is covered with a moisture-retaining material such as wet burlap or plastic sheeting. this is done to prevent water loss and increase hydration. concrete should be stored in a shaded area and protected from direct sunlight, wind and temperature extremes

Second stage: The second stage is wet curing, in which the concrete is periodically sprayed with water or soaked in water after construction to maintain a moist environment for several days. this step will help to prevent the surface from drying out and cracking as well as further wetting and strength gains

Third stage: The third stage is sealing, where a hardener or membrane is applied to the concrete surface to retain moisture and speed up curing. This is particularly useful for large concrete surfaces such as sidewalks and floors where wet curing is not practical. the curing period depends on factors such as cement type, concrete thickness, ambient temperature and humidity and desired strength and durability.

In general, concrete should dry for a minimum of 7days,preferably 28days,to achieve maximum strength and durability. curing is also critical to the accuracy and reliability of concrete testing. concrete cubes, cylinders and beams requires proper curing to ensure accurate and reliable results. The concrete cubes are typically used for compressive strength

5.5 TESTING OF SPECIMENS

Three types of tests were conducted in this study, they are compressive strength test, splitting tensile strength test and flexural strength test. compressive strength test is performed for cube specimens, splitting tensile strength test is performed for cylindrical specimens and flexural strength test is performed for beam specimens. concrete cube specimens of dimensions Length=15cm,Breadth=15cm and Height =15cm were made by different fractions of polyvinyl alcohol fiber and basalt fiber with 15% of glass powder as a partial replacement of fine aggregate of 24 samples for 7 days and 24 samples for 28 days test as a total sample of 48 cube specimens were casted. Cylindrical specimen of dimensions 15cm diameter and 30cm height were made by different fractions of polyvinyl alcohol fiber and basalt fiber with 15% of glass powder as a partial replacement of fine aggregate of 24 samples for 7 days and 24 samples for 28 days test as a total sample of 48 cylindrical specimens were casted. Beam specimens of dimensions of length 1500mm,width of the beam is 230mm and the depth of the beam is 230mm.diameter of the main bar in the beam is 10mm



Fig.5.3 Compression and tensile strength testing machine

Samples and specimen details are mentioned below

The No.of.Cube specimens,Cylinder specimens and reinforced concrete Beams to be casted with each combinations

1. 0% of glass powder, 0% polyvinyl alcohol fiber (PVA) and 0% basalt fiber (conventional)
Cubes: 6 Nos
Cylinder: 6 Nos
Beam: 1 No
2. 15% Glass powder without polyvinyl alcohol fiber (PVA) and basalt fiber
Cubes: 6 Nos
Cylinder: 6 Nos
3. 15% Glass powder with 0.1% polyvinyl alcohol fiber (PVA) and 0.1% basalt fiber
Cubes: 6 Nos
Cylinder: 6 Nos
4. 15% Glass powder with 0.1% polyvinyl alcohol (PVA) and 0.3% basalt fiber
Cubes: 6 Nos
Cylinder: 6 Nos
Beam:1No
5. 15% Glass powder with 0.2% polyvinyl alcohol (PVA) and 0.1% basalt fiber
Cubes: 6 Nos
Cylinder: 6 Nos
6. 15% Glass powder with 0.2% polyvinyl alcohol (PVA) and 0.3% basalt fiber
Cubes: 6 Nos
Cylinder: 6 Nos
Beam:1 No

7. 15% Glass powder with 0.3% polyvinyl alcohol (PVA) and 0.1% basalt fiber
 Cubes: 6 Nos
 Cylinder: 6 Nos
8. 15% Glass powder with 0.3% polyvinyl alcohol (PVA) and 0.3% basalt fiber
 Cubes: 6 Nos
 Cylinder: 6 Nos
 Beam: 1 No

Table 5.9 Specimen designation of cube and cylindrical samples

SPECIMENS	GLASS POWDER (%)	PVA FIBER (%)	BASALT FIBER (%)
TEST MIX (A) CONVENTIONAL	0	0	0
TEST MIX (B) GLASSPOWDER	15	0	0
TEST MIX (C)	15	0.1	0.1
TEST MIX (D)	15	0.1	0.3
TEST MIX (E)	15	0.2	0.1
TEST MIX (F)	15	0.2	0.3
TEST MIX (G)	15	0.3	0.1
TEST MIX (H)	15	0.3	0.3

Table 5.10 Details of the test and specimens

SI NO	NAME OF THE TEST	DURATION OF CURING	NO OF SPECIMENS	TOTAL NO OF SPECIMENS
01	Compressive strength	7 days	24	48
		28 days	24	
02	Split tensile strength	7 days	24	48
		28 days	24	
03	Flexural strength	28 days	4	4



Fig.5.4 casted specimens

5.5.1 Compressive strength

The capacity of a material or structure to support loads on its surface without cracking or deflecting is known as compressive strength. When a material is compressed, its size tends to decrease, and when it is stretched, its size elongates. Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

The compressive strength was calculated in Mpa

$$F_c = P/A$$

Where F_c = compressive strength (N/mm²)

P = ultimate load (N)

A = loaded cube specimen (150mm x 150mm)

Specifically, 150mmx150mmx150mm cubes are utilised for this test.

TABLE 5.11 COMPRESSIVE STRENGTH OF THE CUBIC SPECIMEN FOR 7 DAYS

CUBIC SPECIMEN LABEL	DURATION OF CURING (DAYS)	STRENGTH (Mpa)			AVERAGE
		SAMPLE 1	SAMPLE 2	SAMPLE 3	
TEST MIX (A)	7	17.77	20	22.22	20
TEST MIX (B)	7	12.88	16.22	16.55	15.21
TEST MIX (C)	7	15.55	16.88	17.77	16.7
TEST MIX (D)	7	17.77	20	21.33	19.7
TEST MIX (E)	7	17.77	20	22.22	20
TEST MIX (F)	7	18.66	20.88	21.33	20.28
TEST MIX (G)	7	18.66	20	21.33	19.9
TEST MIX (H)	7	20	21.33	22.22	21.17

TABLE 5.12 COMPRESSIVE STRENGTH OF THE CUBIC SPECIMEN FOR 28 DAYS

CUBIC SPECIMEN LABEL	DURATION OF CURING (DAYS)	STRENGTH (Mpa)			AVERAGE
		SAMPLE 1	SAMPLE 2	SAMPLE 3	
TEST MIX (A)	28	39.1	39.5	40.2	39.6
TEST MIX (B)	28	30.2	32.0	33.3	31.83
TEST MIX (C)	28	31.5	33.5	34.6	33.2
TEST MIX (D)	28	34.6	38.55	38.55	37.2
TEST MIX (E)	28	34.6	35.1	38.2	35.96
TEST MIX (F)	28	36.8	38.5	38.5	37.6
TEST MIX (G)	28	35.5	36.8	37.7	36.66
TEST MIX (H)	28	38.7	40.8	40.96	40.1



Fig.5.5 compression testing on cube specimen

5.5.2 Splitting Tensile Strength Test

The capacity of concrete to withstand tensile stress or force is known as its tensile strength. The split cylinder test of the concrete technique is used to determine the tensile strength of concrete. The units of force per cross-sectional area (N/Sq mm or Mpa) are used to calculate the tensile strength of concrete.

The magnitude of tensile stress (T) acting uniformly to the line of action of applied loading is given by formula

$$T = 2P/DL$$

Where, T = Split Tensile Strength in MPa

P = Applied load,

D = Diameter of Concrete cylinder sample in mm.

L =Length of Concrete cylinder sample in mm.

TABLE 5.13 SPLITTING TENSILE STRENGTH OF THE CYLINDRICAL SPECIMEN FOR 7 DAYS

CYLINDRICAL SPECIMEN LABEL	DURATION OF CURING (DAYS)	STRENGTH (Mpa)			AVERAGE
		SAMPLE 1	SAMPLE 2	SAMPLE 3	
TEST MIX (A)	7	2.90	2.97	3.04	2.97
TEST MIX (B)	7	2.0	2.97	2.97	2.64
TEST MIX (C)	7	2.68	2.75	2.82	2.75
TEST MIX (D)	7	2.82	2.82	2.97	2.87
TEST MIX (E)	7	2.68	2.8	2.97	2.81
TEST MIX (F)	7	2.82	2.97	3.11	2.96
TEST MIX (G)	7	2.75	2.8	3.04	2.86
TEST MIX (H)	7	3.11	3.04	2.97	3.04



Fig.5.6 splitting tensile strength test on cylindrical specimen

TABLE 5.14 SPLITTING TENSILE STRENGTH OF THE CYLINDRICAL SPECIMEN FOR 28 DAYS

CYLINDRICAL SPECIMEN LABEL	DURATION OF CURING (DAYS)	STRENGTH (Mpa)			AVERAGE
		SAMPLE 1	SAMPLE 2	SAMPLE 3	
TEST MIX (A)	28	3.39	3.46	3.60	3.48
TEST MIX (B)	28	3.18	3.25	3.32	3.25
TEST MIX (C)	28	3.32	3.32	3.46	3.36
TEST MIX (D)	28	3.60	3.60	3.74	3.64
TEST MIX (E)	28	3.60	3.74	3.89	3.74
TEST MIX (F)	28	3.74	3.81	3.89	3.81
TEST MIX(G)	28	3.74	3.81	3.96	3.83
TEST MIX(H)	28	3.96	4.0	4.0	3.98

TABLE 5.15 SPECIMEN DESIGNATION OF THE BEAM SPECIMEN

BEAM SPECIMENS	GLASS POWDER (%)	PVA FIBER (%)	BASALT FIBER (%)
TEST MIX (A)	0	0	0
TEST MIX (D)	15	0.1	0.3
TEST MIX (F)	15	0.2	0.3
TEST MIX (H)	15	0.3	0.3

5.5.3 Four point flexural strength test

The four-point beam flexural test is a common technique for assessing bending or flexural strength. In this test, a beam supported at two places is loaded, and the deflection or deformation of the beam is measured. While the beam is supported at both ends, the load is applied at two points in the middle of the beam span. The resulting load versus deflection curve can reveal important details regarding the elasticity and strength of the material.

The load is steadily increased throughout the test until either the beam breaks or reaches its maximum load capacity. A displacement gauge is used to measure the beam's deflection at predetermined load intervals, and the load and deflection data are recorded. The relationship between the applied load and the consequent deformation of the beam is depicted by the load versus deflection curve.

The material's stiffness or rigidity is represented by the slope of the curve, while the maximum load capacity shows the material's maximum strength. The four point beam flexural test, a trusted method for assessing the flexural strength of materials, is frequently used in material testing. Four beams with dimensions of 230mm x 230mm and a length of 1500mm were cast with varied percentages of hybrid fibres, with glass powder serving as a fine aggregate in some cases. The load versus deflection values of four beams tested are provided in table.

Table.5.16 Load vs deflection of beam specimens (Experimental)

S.NO	LOAD (KN)	DEFLECTION (mm)			
		Conventional mix	0.1PVA 0.3BF 15%GP	0.2PVA 0.3BF 15%GP	0.3PVA 0.3BF 15%GP
1	0	0	0	0	0
2	10	0.3	0.15	0.22	0.29
3	20	0.72	0.32	0.45	0.69
4	30	1.21	0.54	0.81	0.95
5	40	1.49	0.89	0.97	1.19
6	50	1.79	1.04	1.15	1.3
7	60	1.99	1.21	1.32	1.74
8	70	2.26	1.39	1.54	2.01
9	80	2.55	1.51	1.75	2.24
10	90	2.74	1.74	1.97	2.51
11	100	3	1.99	2.12	2.64



Fig.5.7 Flexural test on beam specimen

5.5.4 Tensile modulus of concrete using compressometer:

A material's elasticity, or its propensity to deform and then reform after being subjected to an external force, is described by a quantity called Young's modulus. When a material's Young's modulus is high, it is stiff and challenging to deform, whereas when it is low, it is flexible and easy to deform.

The ratio of the stress placed on a body to the resulting strain, or Young's modulus, is a measure of a material's stiffness. The units of pressure or stress used to express it are usually pascals (Pa) or pounds per square inch (psi), and it is symbolised by the letter "E".

A cylindrical or prismatic test specimen is positioned between two compression platens and a compressive load is applied in a compressometer to calculate the Young's modulus. Strain gauges or other displacement sensors are used to monitor the specimen's deformation as a result of the load, which is normally applied at a consistent rate. Divide the load by the specimen's cross-sectional area to compute the compressive stress, and divide the deformation by the specimen's original length to determine the strain.

The Young's modulus can then be found by dividing the compressive stress by the strain. This gives a measurement of the compression-induced material resistance to deformation as well as the relationship between compressive stress and the resulting distortion. The Young's modulus value might vary depending on the type of material being tested as well as testing conditions like the rate of loading and temperature.



Fig.5.8 compressometer with the specimen

Table 5.17 young's modulus using compressometer for conventional concrete

S. NO	TEST MIX	FORCE APPLIED (KN)	STRESS (N/mm ²)	LENGTH (mm)	CHANGE IN LENGTH (mm)	STRAIN	TENSILE MODULUS
01	M40 MIX	25	1.41	300 mm	0.0133	4.4x10 ⁻⁵	31306
02		50	2.82	300 mm	0.027	9.1x10	30989
03		75	4.24	300 mm	0.043	1.4x10	30285
04		100	5.65	300 mm	0.055	1.8x10	31388
AVERAGE VALUE OF TENSILE MODULUS (YOUNG'S MODULUS)							30992

Table 5.18 young's modulus using compressometer for 0.1% PVA ,0.3% BF and 15% GP

S. NO	TEST MIX	FORCE APPLIED (KN)	STRESS (N/mm ²)	LENGTH (mm)	CHANGE IN LENGTH (mm)	STRAIN	TENSILE MODULUS
01	0.1%PVA	25	1.41	300 mm	0.01620	5.20	27115
02	0.3% BF	50	2.82	300 mm	0.0307	1.02	27647
03	15%GP	75	4.24	300 mm	0.0451	1.50	28266
04		100	5.65	300 mm	0.0595	1.98	28535
AVERAGE VALUE OF TENSILE MODULUS (YOUNG'S MODULUS)							27890

Table 5.19 young's modulus using compressometer for 0.2% PVA, 0.3% BF and 15% GP

S. NO	TEST MIX	FORCE APPLIED (KN)	STRESS (N/mm ²)	LENGTH (mm)	CHANGE IN LENGTH (mm)	STRAIN	TENSILE MODULUS
01	0.2%PV	25	1.41	300 mm	0.0147	4.9	28775
02	A	50	2.82	300 mm	0.0290	9.7	29042
03	0.3% BF	75	4.24	300 mm	0.0432	1.4	29444
04	15%GP	100	5.65	300 mm	0.0601	2.0	28109
AVERAGE VALUE OF TENSILE MODULUS (YOUNG'S MODULUS)							28842

Table 5.20 young's modulus using compressometer for 0.3% PVA, 0.3%BF and 15% GP

S. NO	TEST MIX	FORCE APPLIED (KN)	STRESS (N/mm ²)	LENGTH (mm)	CHANGE IN LENGTH (mm)	STRAIN	TENSILE MODULUS
01	0.3%P	25	1.41	300 mm	0.0151	5.03	28031
02	VA	50	2.82	300 mm	0.0311	1.03	27378
03	0.3%B	75	4.24	300 mm	0.0417	1.39	30481
04	F 15% GP	100	5.65	300 mm	0.0557	1.85	30540
AVERAGE VALUE OF TENSILE MODULUS (YOUNG'S MODULUS)							29107

CHAPTER 6

RESULTS AND DISCUSSIONS

6.1 INTRODUCTION

Numerous test have been conducted on hybrid fiber reinforced concrete cubical and cylindrical specimens for various test mix consists of basalt fiber and polyvinyl alcohol fiber is reviewed in this chapter and also the behavior of the hybrid fiber reinforced concrete beam specimen with respect to the various mix of hybrid fiber reinforced concrete and conventional concrete specimen is also discussed in this chapter

These include the concrete's compressive strength, split tensile strength, flexural strength with the addition of hybrid fiber with glass powder as a partial replacement of glass powder to establish the ideal volume fraction of percentage of hybrid fibers, and lastly taking into account the flexural behaviour of hybrid fibers beams with glass powder as a partial replacement of fine aggregate and control beams.

6.2 COMPRESSION STRENGTH OF HYBRID FIBERS REINFORCED CONCRETE

The mean compressive strength of hybrid fiber reinforced concrete with certain proportion of test mix on 7 days and 28 days test

CUBIC SPECIMEN LABEL	GLASS POWDER (%)	POLYVINYL ALCOHOL FIBER PVA (%)	BASALT FIBER (%)	STRENGTH (Mpa)	
				7 days	28 days
TEST MIX (A)	0	0	0	20	39.6
TEST MIX (B)	15	0	0	15.21	31.83
TEST MIX (C)	15	0.1	0.1	16.7	33.2
TEST MIX (D)	15	0.1	0.3	19.7	37.2
TEST MIX (E)	15	0.2	0.1	20	35.96
TEST MIX (F)	15	0.2	0.3	20.28	37.6
TEST MIX (G)	15	0.3	0.1	19.9	36.66
TEST MIX (H)	15	0.3	0.3	21.17	40.1

Table 6.1 Average compressive strength of 7 and 14 days test

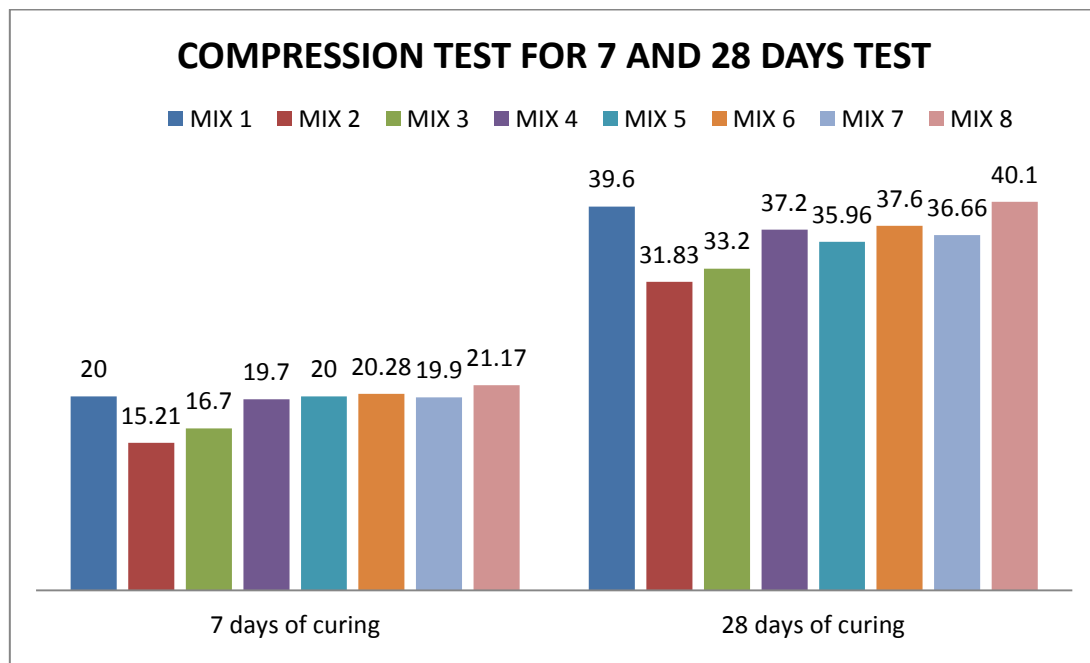


Fig.6.1 Compression test for 7 and 28 days test

The compressive strength results shows that the compressive strength generally increases with time, as expected, with higher values recorded after 28days compared to 7 days. The exact values of compressive strength will depend on various factors such as the type of materials, curing conditions and testing method used

The fig.6.1 clearly shows the compressive strength of the conventional mix and other seven mixes of 7 and 28 days of curing , By comparing the compressive strength of the conventional mix with other mixes, the mix 8 has the maximum compressive strength of 40.1Mpa and the mix 2 has the minimum compressive strength of 31.83 Mpa. While comparing the mix 1 with the conventional mix it shows decrease in the compressive strength ranges from 2.40 Mpa to 7.77 Mpa for other six mix proportions of 28 day testing of compressive strength.

As seen from above table, the compressive strength test for 28 days average compressive strength is maximum when 0.3% of polyvinyl alcohol fiber, 0.3% of basalt fiber and 15% of glass powder is used. The maximum compressive strength obtained from the compressive strength test for 28 days test is 43.89Mpa and compressive test on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 1.25% as compared to the conventional mix of M40 mix.

Table 6.2 Average split tensile strength for 7 and 28 days test

CYLINDRICAL SPECIMEN LABEL	GLASS POWDER (%)	POLYVINYL ALCOHOL FIBER PVA (%)	BASALT FIBER (%)	STRENGTH (Mpa)	
				7 days	28 days
TEST MIX (A)	0	0	0	2.97	3.48
TEST MIX (B)	15	0	0	2.64	3.25
TEST MIX (C)	15	0.1	0.1	2.75	3.36
TEST MIX (D)	15	0.1	0.3	2.87	3.64
TEST MIX (E)	15	0.2	0.1	2.81	3.74
TEST MIX (F)	15	0.2	0.3	2.96	3.81
TEST MIX (G)	15	0.3	0.1	2.86	3.83
TEST MIX (H)	15	0.3	0.3	3.04	3.98

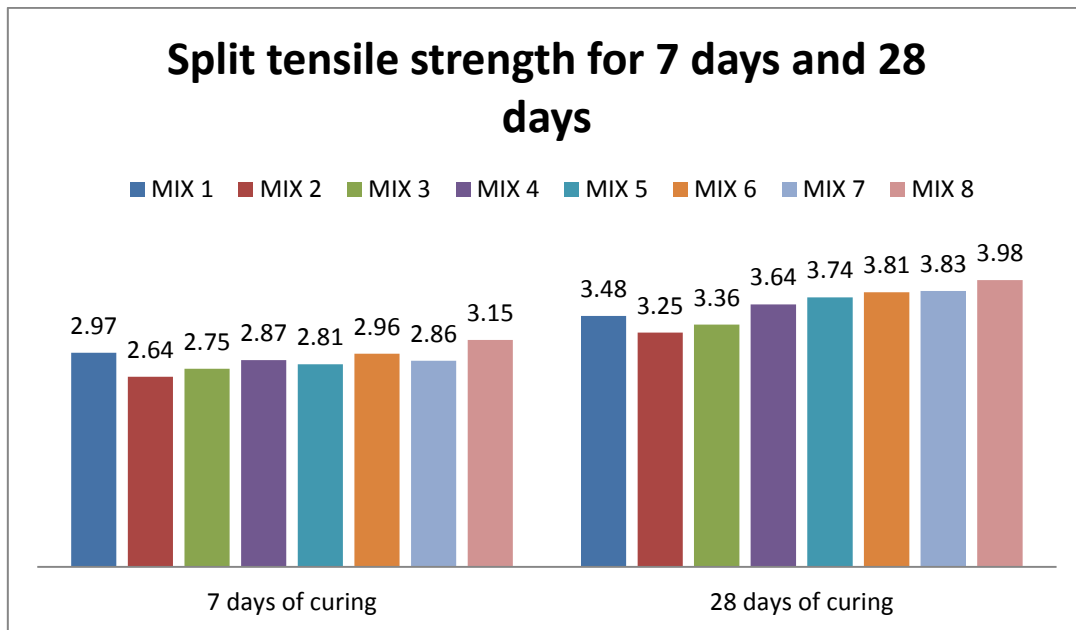


Fig.6.2 split tensile strength for 7 and 28 days test

6.3 TENSILE STRENGTH HYBRID FIBERS ON SPLIT TENSILE STRENGTH

The fig.6.2 clearly shows the split tensile strength of the conventional mix and other seven mixes of 7 and 28 days of curing. By comparing the compressive strength of the conventional mix with other mixes, the mix 8 has the maximum compressive strength of 3.98Mpa and the mix 2 has the minimum compressive strength of 3.25 Mpa. While comparing the mix 1 with the conventional mix it shows decrease in the split tensile strength ranges from 0.23 Mpa to 0.35 Mpa for other six mix proportions of 28 day testing of compressive strength.

From the above graph, the split tensile strength test for 28 days have been determined. we can see that, when the concrete with 0.3% of basalt fiber, 0.3% polyvinyl alcohol fiber with the partial replacement of 15% glass powder has increased. The maximum split tensile strength obtained for 28 days test is 3.98Mpa. The split tensile strength on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 13.4% as compared to the conventional mix of M40.

6.4 FLEXURAL STRENGTH EXPERIMENTAL METHOD

The load versus deflection values of beams casted with the conventional and steel fiber reinforced concrete for different fiber proportion mix. the load vs deflection curve is drawn for all four beams which is shown in fig.6.3 we can observe that beams reinforced with 0.1% of polyvinyl alcohol fiber 0.3% of basalt fiber and 15% of glass powder has 50% lower deflection compared to the conventional beam specimen, similarly beams with mix proportion 0.2% of polyvinyl alcohol fiber,0.3% of basalt fiber with 15% glass powder has deflection reduced by 34.4% and for 0.3% of polyvinyl alcohol fiber,0.3 basalt fiber and 15% of glass powder has deflection reduced by 12.77% compared to conventional specimen of beam

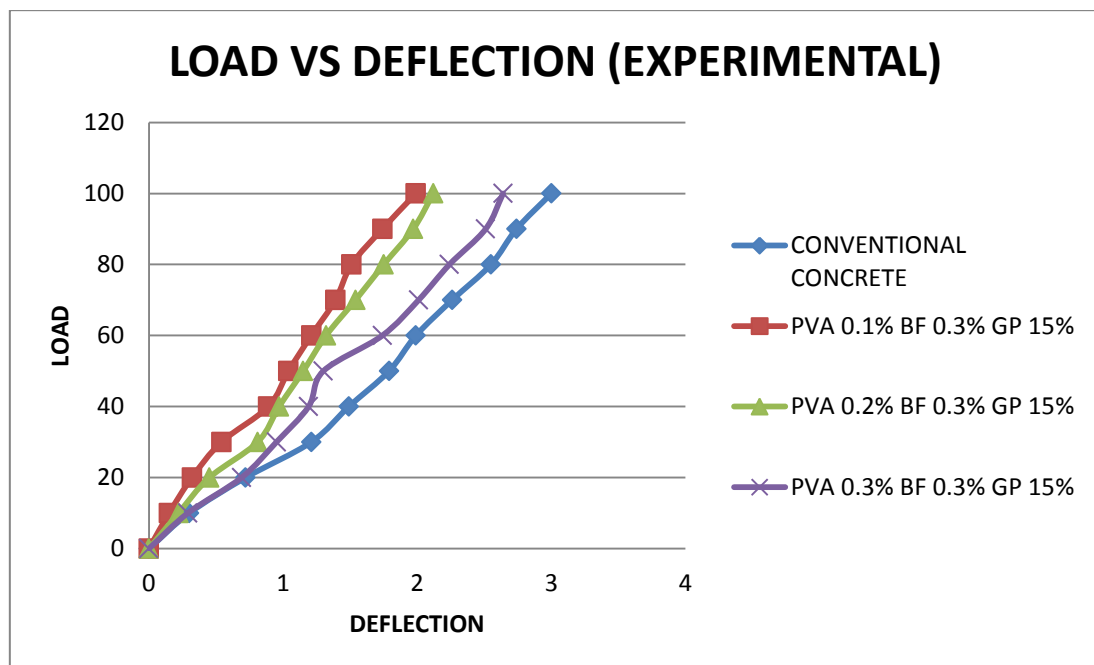


Fig.6.3 Load vs deflection (experimental)

6.5 FLEXURAL STRENGTH ANALYTICAL METHOD (ABAQUS SOFTWARE)

The load versus deflection values of beams casted with the conventional and hybrid fiber reinforced concrete for different fiber proportion mix. the load vs deflection curve is drawn for all four beams which is shown in fig .6.4 we can observe that beams reinforced with 0.1% of polyvinyl alcohol fiber 0.3% of basalt fiber and 15% of glass powder has 64.7% lower deflection compared to the conventional beam specimen, similarly beams with mix proportion 0.2% of polyvinyl alcohol fiber,0.3% of basalt fiber with 15% glass powder has deflection reduced by 31.6% and for 0.3% of polyvinyl alcohol fiber,0.3 basalt fiber and 15% of glass powder has deflection reduced by 21.1% compared to conventional specimen of beam

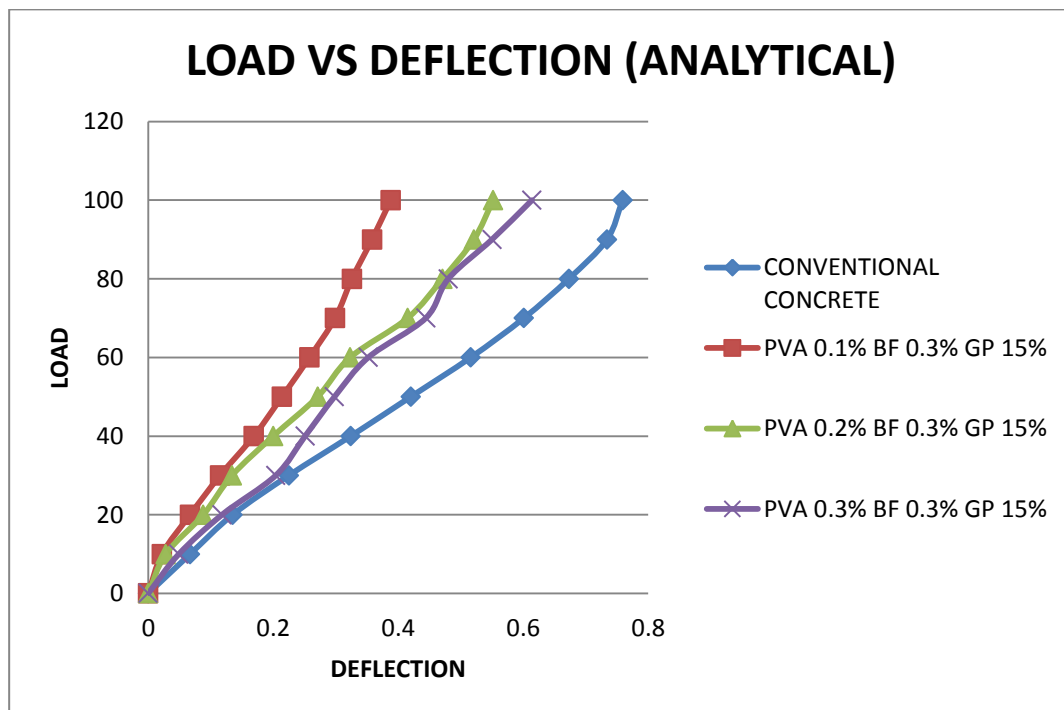


Fig 6.4 load vs deflection (analytical)

6.6 COMPARISON OF FLEXURAL BEHAVIOUR BY ANALYTICAL AND EXPERIMENTAL

The deflection values of four different beam models with varying mix proportions were compared by both analytical and experimental results, the ABAQUS software is used to create the model of the beams, and the properties of the materials were obtained from the experimental investigations of conventional and hybrid reinforced concrete beam specimens. The deflection images can be obtained after the deflection of the beam when the load is applied on the beam.

The results were plotted in a graph with deflection (mm) in X-axis and corresponding load (KN) in Y-axis and compared. The experimental deflection values were slightly higher than the analytical deflection. The conventional concrete beam will have slightly higher deflection values compared to other specimens.

The conventional concrete beam has slightly higher deflection values when compared with other beam specimens.

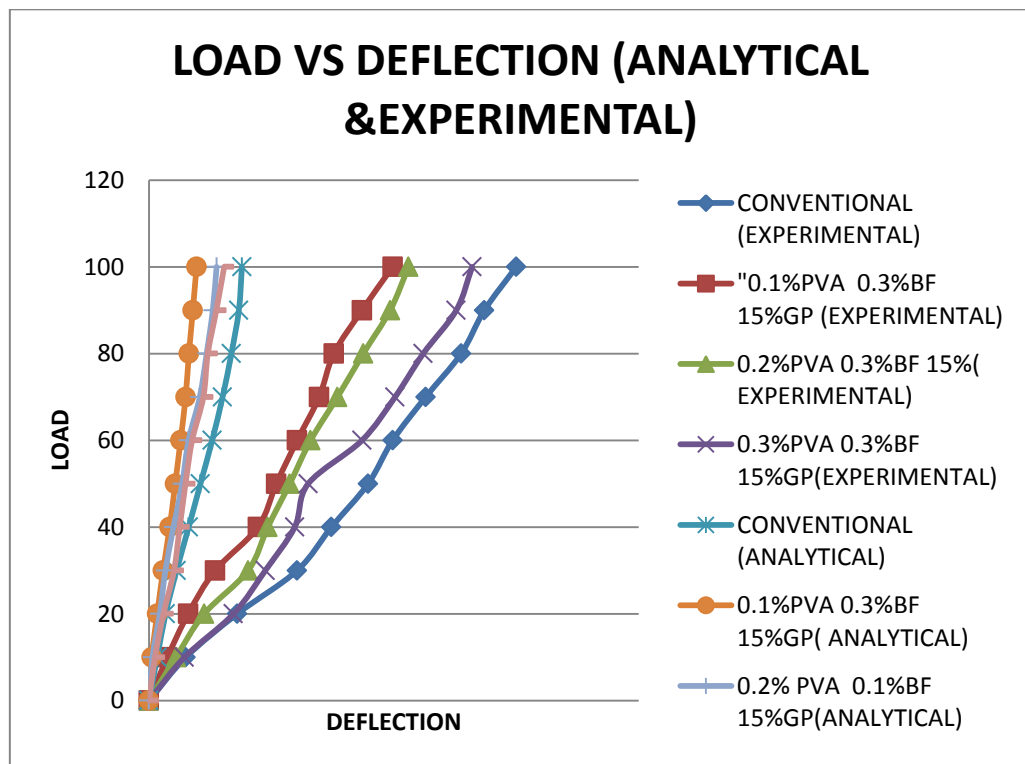


Fig 6.5 Load vs deflection (analytical and experimental)

CHAPTER 7

SUMMARY AND CONCLUSION

7.1 SUMMARY

- The various literature reviewed related to the partial replacement of glass powder as a fine aggregate in the construction industry
- Various literature reviewed related to the
- After conducting the literature survey, the objective, scope and need for this project are formulated
- Mix design was prepared for both conventional concrete grade of M40 and hybrid fiber reinforced concrete
- The physical properties of the materials used in the research was analysed
- The compressive strength and split tensile strength of hybrid fiber with partial replacement of fine aggregate with glass powder
- The process of selection of materials for the partial replacement of fine aggregate and the fibers utilized in the concrete specimen
- The flexural behaviour of hybrid fiber reinforced concrete beam with partial replacement of fine aggregate with glass powder were studied by both analytical and experimental method
- The results from both experimental test and analytical test done by the ABAQUS software will be compared and concluded

7.2 CONCLUSION

- The chapter describes a study that compared the properties of polyvinyl alcohol fiber, basalt fiber and the glass powder as a partial substitute for fine aggregate. The study examined the properties, compressive strength, tensile strength and flexural behaviour
- The study also concluded that replacing of 15% of glass powder resulted in a 21.8% decreased when compared to conventional concrete of grade M40
- The compressive strength test for 28 days average compressive strength is maximum when 0.3% of polyvinyl alcohol fiber, 0.3% of basalt fiber and 15% of glass powder is used. The maximum compressive strength obtained from the compressive strength test for 28 days test is 43.89Mpa and compressive test on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 1.25% as compared to the conventional mix of M40.
- The split tensile strength test for 28 days have been determined .we can see that, when the concrete with 0.3% of basalt fiber, 0.3% polyvinyl alcohol fiber with the partial replacement of 15% glass powder has increased. The maximum split tensile strength obtained for 28 days test is 3.98Mpa. The split tensile strength on 28 days test shows that concrete of 0.3% of poly vinyl alcohol fiber (PVA) and 0.3% basalt fiber with 15% of glass powder as a partial replacement of fine aggregate has been significantly increased by 13.4% as compared to the conventional mix of M40.

- In analytical of flexural behaviour, beams reinforced with 0.1% of polyvinyl alcohol fiber 0.3% of basalt fiber and 15% of glass powder has 64.7% lower deflection compared to the conventional beam specimen, similarly beams with mix proportion 0.2% of polyvinyl alcohol fiber,0.3% of basalt fiber with 15% glass powder has deflection reduced by 31.6% and for 0.3% of polyvinyl alcohol fiber,0.3 basalt fiber and 15% of glass powder has deflection reduced by 21.1% compared to conventional specimen of beam.
- In experimental analysis of flexural behaviour,beams reinforced with 0.1% of polyvinyl alcohol fiber 0.3% of basalt fiber and 15% of glass powder has 50% lower deflection compared to the conventional beam specimen, similarly beams with mix proportion 0.2% of polyvinyl alcohol fiber,0.3% of basalt fiber with 15% glass powder has deflection reduced by 34.4% and for 0.3% of polyvinyl alcohol fiber,0.3 basalt fiber and 15% of glass powder has deflection reduced by 12.77% compared to conventional specimen of beam.
- Further, the study suggested that the strength development in conventional concrete of grade M40 may be a reason for its superior performance in testing process while compared to the other mix proportions.