

RETROFITTING OF BEAMS USING FIBER REINFORCED POLYMER

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in Civil 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 "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ABISHEAAK MADHAVAN K.(REG. No.38200002)** and **AKASH V.R (REG. No.38200004)** who carried out the project entitled "**RETROFITTING OF BEAMS USING FIBER REINFORCED POLYMER**" under my supervision from November 2021 to April 2022

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Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We, **ABISHEAAK MADHAVAN K. and AKASH V.R.** hereby declare that the Project Report entitled "**RETROFITTING OF BEAMS USING FIBER REINFORCED POLYMER**" done by us under the guidance of **Dr. R. Nirmala** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

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ABSTRACT

Existing structures are being retrofitted to increase their earthquake and ground motion resistance. Due to degradation caused by a variety of reasons such as corrosion, a lack of detailing, and beam-column joint bonding failure, many old reinforced concrete structures around the world are in desperate need of rehabilitation, repair, or replacement.

The construction industry has accepted fibre reinforced polymer (FRP) composite as a possible replacement for repairing and strengthening RCC structures. This paper presents an experimental evaluation of reinforced concrete beams retrofitted with various types of fibers on the outside.

The goal of this research was to look at how beams performed after being retrofitted with various natural and synthetic fibres, such as glass fibres and steel wire mesh.

Experimental studies were carried out to explore the behaviour of beams that were engineered to fail in either flexural or shear failure. Four-point bending was used to load the beams until cracks appeared. After that, the beams were unloaded and reinforced with GFRP. The beams were finally loaded to their breaking point.

The analyses were used to generate load-deflection relationships, failure modes, and fracture patterns, which were then compared to experimental data. The models were then used to evaluate the effects of various factors on retrofitted beam behaviour, as well as the use of GFRP in RCC Beams to achieve the maximum increase in load capacity.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Concrete is the most frequently utilised man-made manufacturing material on the planet. It is made by combining cementitious materials, water, aggregate, and admixtures in the proper amounts. Cement mortar has proven to be both expensive and scarce. To compensate for the scarcity of natural resources and to seek new ways to protect the environment, sustainable construction involves the use of non-traditional and revolutionary materials as well as recycling waste materials. This experiment was carried out to see if Bagasse ash could be used as a cement replacement material in outside beam-column joints, similar to Ordinary Portland Cement. Bagasse ash, a waste product of bagasse burning, has pozzolanic properties and is likely utilised as a cement alternative.

During the course of their service lives, reinforced concrete structures should be modified and improved on a regular basis. Adjustments in their use, new layout standards, deterioration due to corrosion within the steel as a result of exposure to a harsh environment, and chance events such as earthquakes are the main contributors. Due to problems with reinforced concrete, structures deteriorate. Natural disasters such as earthquakes have repeatedly demonstrated how vulnerable modern systems are to seismic impact, making efforts such as retrofitting and rehabilitation of degraded infrastructure critical in seismically active locations.

As a result, upgrading and strengthening old concrete structures has become one of engineering science's most pressing concerns. Engineers are frequently confronted with challenges relating to retrofitting and strengthening old structures. Engineering obstacles include an increase in commission hundreds, changes in the structure's usage, style and/or construction flaws, deterioration issues, changes in style code requirements, and seismic retrofits, to name a few.

There are two viable options in such situations: Retrofitting or replacement is a term used to describe the process of replacing or retrofit Full structure replacement has a number of disadvantages, including increased material and labour costs, a greater environmental effect, and inconvenience due to disruptions in the structure's operation, such as traffic concerns. When possible, retrofitting a structure to repair or modify it is usually the best option.

The performance of the beam determines the structural integrity of any building. the associate applicable style for beams in structures is required to satisfy the wants of strength and malleability to stop any sudden failure. underneath seismal action, the beam zone is taken into account the foremost sensitive zone that undergoes different shear stresses in numerous directions. Adding pulp ash to the concrete mixture improves the flexural and shear capability, ductility, toughness, and energy absorption capability.

1.2 OBJECTIVE

The aim of the present study are

- To determine the qualities of the materials used in the retrofit of a reinforced concrete beam with GFRP.
- Investigate the behaviour of reinforced concrete beams upgraded with GFRP using a four-point bending test.
- Using the ABAQUS application, create finite element models to simulate the behaviour of beams.
- To compare the load-deflection relationships of retrofitted reinforced concrete beams with and without GFRP wrapping

CHAPTER 2

LITERATURE REVIEW

Sayed et. al., (1999) Fiber Reinforced Polymer (FRP) Laminates Are Used to Strengthen Reinforced Concrete Beams The behavior of concrete beams reinforced with several types of polymer FRP laminates is described in this paper. The experimental programme comprised strengthening and testing 14 rectangular cross-section beams with simple supports, each of which was initially loaded over its cracking load. Before being subjected to the ultimate test, the damaged beams were reinforced using FRP laminates.

Sing-ping Chiew et. al. (2007) The flexural behaviour of RCC beams augmented with GFRP was investigated experimentally and computationally, with the conclusion that by glueing GFRP laminates to the tension face of flexural RC beams, both strength and stiffness can be increased.

Pannirselvam et. al (2008) American Journal of Engineering and Applied Sciences, "Strength Modelling of Reinforced Concrete Beam with Externally Bonded Fibre Reinforcement Polymer Reinforcement This study examines the structural behaviour of a reinforced concrete beam with externally bonded FRP. In each kind, three different steel ratios were used, as well as two different GFRP types and two different GFRP thicknesses.

Bhuvaneshwari et. al (2015), Jordan Journal of Civil Engineering, "Strengthening of Shear Deficient Reinforced Concrete Beams Retrofitted with Cement-based Composites Experimentally and statistically, the strength and stiffness of damaged reinforced concrete beams with insufficient reinforcements were investigated to see if retrofitting might restore their strength and

stiffness. Glass fibre strips are wrapped with cement-based composite binders during retrofitting.

Gopi Krishna et. al (2015), "Externally Bonded CFRP Retrofitting of Reinforced Concrete Beams" The behaviour of retrofitted reinforced concrete beams with externally bonded CFRP using various types of resins (Epoxy orthophthalic resin, Iso resin) after initial load is investigated in this work. The static load responses of all the beams were examined using the two-point load approach in terms of flexural strength, crack observation, and CFRP fabric-concrete compositeness.

Rosemol K George et. al (2014) Anumol Raju and Liji Anna Mathew (2013) "Retrofitting RC Beams with FRP" This study presents an experimental assessment of retrofitted beams with various types of fibres externally. The goal of this research is to look at how beams react after being retrofitted with a variety of natural and synthetic fibres such as steel, polypropylene, coir, and cotton.

Siddika et al (2019) FRP composite retrofitting approaches for RC beams. The performance of repaired and retrofitted beams made of FRP fails below the FRP's ultimate stress limit.

Aravind, et. al (2013) - Carbon or glass fibre reinforced polymers were retrofitted with RC beams using epoxy resins. One for the B1C-90 type.

Xie and Hu (2013) (RC) structures in a coastal environment is a difficult engineering task. Retrofitting RC components with carbon fibre reinforced polymer is required (CFRP).

Barbato (2009) Externally bonded fibre reinforced polymer flexurally strengthens reinforced concrete (RC) beams. The proposed FE, dubbed FRP-FB-beam, takes into account distributed plasticity.

Sheikh (2002) The use of FRP for retrofitting beams, slabs, walls, and beams and columns was investigated in this article to see if employing external FRP reinforcement had any benefits.

Kim and Shin (2011). To see if the structural behavior of reinforced concrete (RC) beams modified with revolutionary hybrid fiber reinforced polymer (hybrid FRPs) varies.

Nayak et al 2018 Reinforced concrete (RC) beams that have been externally rebuilt using glass fibre reinforced polymer One beam was left unwrapped, while the other nine were wrapped in a variety of patterns.

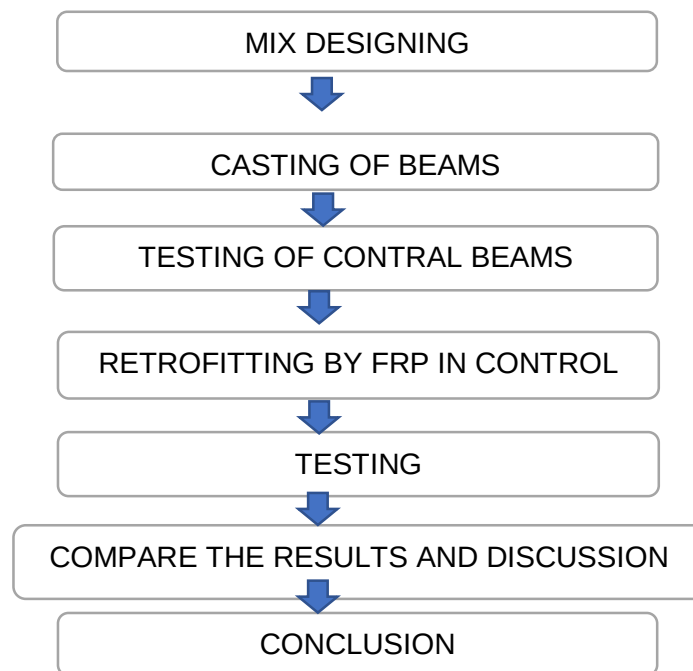
CHAPTER 3

METHODOLOGY AND PROPERTIES OF MATERIALS

3.1 GENERAL

Ordinary Portland Cement (OPC), Aggregates, and Water were used in the study and are described in the following sections.

3.2 METHODOLOGY



3.3 CEMENT

Ordinary Portland cement (OPC) is the most often used type of cement. It's an important part of concrete, mortar, and plaster. It's made up of atomic number 20, silicon, and atomic number 13 oxides in various proportions. Portland cement and similar materials are formed by combining clay with sedimentary rock (a calcium source) and then grinding the resulting clinkers with a sulphate source (most normally gypsum). The strength of

regular Portland cement is classified into three grades: 33, 43, and 53, based on the strength of the cement after twenty-eight days. We've been accustomed to The cement used in the study was regular Portland cement with a grade of 43.



Fig. 3.1: Picture of cement

3.4 COARSE AGGREGATE

Among other coarse particle materials used in construction, building aggregate includes sand, gravel, crushed stone, slag, recycled concrete, and geosynthetic aggregates. The most commonly mined mineral on the earth is aggregates. Aggregates are a component of concrete and asphalt concrete, among other materials. the mixture serves as a reinforcement for the overall composite material's strength. When compared to damp soils, values are higher due to the relatively high hydraulic conduction. Because the most coarse mixture size utilised is twenty millimetres, the smallest coarse mixture size used is twelve millimetres.

Sand, gravel, crushed stone, slag, recycled concrete, and geo-manufactured aggregates are all included in the construction aggregate category. Among other coarse particle materials used in construction; the mixture serves as a reinforcement for Aggregates are widely used in emptying applications such as foundation and French drains, septic drain fields, wall drains, and road facet edge drains because of the overall composite material's strength due to its relatively high hydraulic conduction worth compared to most soils. Buildings, streets, and trains all use aggregates as a foundation material.

Aggregates, in other words, are utilised to build a stable foundation or a road/rail infrastructure.



Fig:3.2 Picture of coarse aggregate

3.5 FINE AGGREGATE

Fine aggregate is defined as inert or chemically inactive material that passes through a four.75 mm IS filter with fewer than 5% coarser particles. they'll be classified as follows:

i. Natural sand is a fine aggregate created when rocks deposited by streams or glaciers naturally disintegrate.

ii. Crushed stone sand is a fine aggregate made from exhausted stone that has been crushed.

iii. Crushed gravel sand is a fine aggregate made from natural gravel that has been crushed.

The fine aggregates' job is to fill in the spaces between the coarse particles. As a result, the ultimate mass's uniformity is reduced yet its strength is greatly increased. The natural stream is frequently used in conjunction with other elements. Finely crushed stone is also utilised as a fine mixture in regions where natural sand is not economically available.



Fig:3.3 Picture of fine aggregate

3.6 Water

For each mixture function, potable water was used in the experiments. It's the main component that When mixed with cement, it creates a paste that keeps the mixture together. Through a process called as association, water causes concrete to harden. T The association is a chemical event in which the core components of cement-type compounds bind with water molecules to generate hydrates or association products.

Water plays a critical part in the construction of 'ideal' concrete because the magnitude relationship between water and cement is the most vital factor. Excessive water diminishes the strength of concrete, whereas insufficient water makes it impossible to construct. For this study, a zero.4 water cement magnitude relation was used.

3.7 TESTS ON MATERIALS

3.7.1 Consistency Test on Cement

The purpose of this test is to determine the consistency of a specific cement sample. This test is carried out with the use of a Vicat equipment and a Vicat plunger. After 30 seconds, the settling of the plunger in mm is

measured using around 500 g of cement mixed with water. The offered sample must have a 32 percent consistency.

3.7.2 Setting Time Test on Cement

The purpose of this test is to establish the initial and ultimate setting times of a cement sample. Vicat apparatus and a Vicat needle are used in this test. A total of 500g of cement is utilised, together with the amount of water required to maintain a consistent consistency. The specimen is placed in a damp environment for 30 minutes, after which the needle is freed and the needle's settling is measured. The initial setup took 72 minutes, while the final setup took 5 hours and 30 minutes.

3.7.3 Specific Gravity Test on Cement

This test is used to measure the specific gravity of cement. It is accomplished with the use of a pycnometer. A pycnometer is a bottle with a capacity of ten to one hundred cubic centimeters and a ground-glass stopper fitted with a measuring device, as well as a facet inlet tube with a defined line and a -glass cap. Remove the stopper and cap from the pycnometer, weigh it properly, and record the load W . Fill the pycnometer with the sample, keep it at the same temperature, and close the stopper to prevent bubble formation. Raise the temperature gradually until the appropriate temperature is reached. Remove the section of the sample that is higher than the mark from the facet tube and close it. Completely wipe the skin surface, weigh correctly, and record the load W_1 . Use a constant pycnometer holding H_2O to perform a constant process. At the desired temperature, take note of the load W_2 . Cement has a specific gravity of 2.89.

3.7.4 Aggregate Impact Value Test

The purpose of this test is to determine whether the total impact is worth mistreating the impact testing machine. The examination sample is

made up of a 20mm combination. Give twenty-five light blows with the rounded end of the tamping rod to compact the fabric. Add two more layers in the same manner, until the cylinder is completely filled. Make a note of the surplus aggregates. validate the aggregates' Infobahn weight to the nearest gramme (W). Stop the impact machine without wedging or packing the extent plate, block, or floor, ensuring that it is firm and the hammer guide columns are vertical.

Fill the cup halfway with the sample and tamp it down with twenty-five light strokes of the tamping rod. Raise the hammer till the lower face is 380 millimetres above the surface of the combined sample in the cup, then let it fall freely on it.. Provide fifteen of these blows with a one-second break between them. Remove the crushed mixture from the cup and filter it through a pair of 36 millimetre IS sieves for one minute, or until no more significant quantity passes. Weigh the fraction that passes through the sieve to a precision of one gramme. Weigh the fraction that is kept in the sieve as well. The reason why the combined effect is worthwhile. Because of the conjunction Impact worth, the mean of two observations, rounded to the closest integer, is rumoured.

3.7.5 Sieve Analysis of Fine Aggregate.

The sieve analysis test is used to characterize coarse grain soil by obtaining a distribution of grain size larger than 75 microns. For roughly 5 minutes, the aggregate is sieved in a sieve shaker. The test was carried out on 20mm aggregate and river sand that was procured for our project. We may deduce that the sand is from Zone II, which means it is fine by nature and has good workability. As a result, we'll use a reasonable amount of river sand and 20mm aggregate to prepare the concrete.

CHAPTER 4

EXPERIMENTAL INVESTIGATION

4.1 CASTING OF BEAM

A beam is a structural member that can withstand loads applied to its axis from the side. Its primary means of deflection is bending. The loads applied to the beam at its support points cause reaction forces. All of the forces acting on the beam create internal stresses, strains, and deflections, resulting in periodic shear forces and bending moments. The method of support, profile (cross-sectional shape), length, and material of beams identify them.

Beams are commonly used to describe structural components in buildings and technology, but any structure that is designed to hold lateral loads, Beam structures are found in a variety of applications, including automotive car chassis, craft parts, machine frames, and various mechanical or structural systems.

Beams used to be square timbers, but now they might be composed of metal, stone, or a combination of wood and metal, such as a flitch beam. Beam beams are commonly used to transmit vertical gravity forces, but they can also be utilised to transport horizontal loads of pounds (for example, loads caused by an earthquake or wind, or in tension to resist rafter thrust as a tie or compression as a collar beam). Hundreds of pounds of force are carried from a beam to columns, walls, or girders, which subsequently transfer the force to nearby structural compression elements. Joists could rest on beams in a lightweight frame system.

In the woodworking industry, a beam is sometimes referred to as a plate, such as a sill plate or a plate, or as a beam, such as a summer beam or a dragon beam. Because of the loads placed on them, beams are subjected to compressive, tensile, and shear stresses on the interior. At the highest point of the beam, the first length is slightly reduced to circle a smaller radius arc, resulting in compression, while at the extremely low point of the beam, the same original beam length is slightly stretched to encompass a larger radius arc, resulting in tension.

The neutral axis is defined by the equal beginning length of the centre of the beam, which is normally halfway between the highest and lowest points due to the radial arc of bending. Shear stress is applied to the beam above the supports. There are some ferroconcrete beams in which the concrete is completely crushed and the tensile forces are carried by steel tendons. Under loading conditions, prestressed concrete beams are designed to deliver compression over predicted tension. The beam is solid above the high-strength steel tendons, which are strained. The tendons are gradually loosened after the concrete has hardened, and the beam is immediately placed beneath eccentric axial loads. The beam's immediate carrying capacity is increased as a result of the eccentric loading, which creates an indoor moment. On highway bridges, they're quite common.

The Euler–Bernoulli beam equation is the basic tool for structural study of beams. The "virtual work method" and the "slope deflection technique" are two mathematical methods for calculating beam deflection. Because the beam is in direct contact with a brittle material like glass, engineers are interested in determinative deflections. Deflections of beams are sometimes reduced for aesthetic purposes. Although technically sound, a noticeably droopy beam is unsightly and should be avoided. Deflection is reduced with a stiffer beam (high modulus of physical property and high moment of area).



Fig:4.1 8mm reinforcement



Fig:4.2 Concrete MIX mould



Fig:4.3 Frame for RCC beam

4.2 RETROFITTING MATERIALS

The adjustment is known as seismic retrofitting. Existing structures can be used to generate a significant amount of resistance to earthquake-induced seismic activity, ground motion, and soil failure. Seismic retrofitting is becoming more significant as we gain a better knowledge of seismic stress on structures and as we learn from recent large earthquakes close to cities. Before the late 1960s for wealthy countries (the United States, Japan, and so on) and the late 1970s for various other parts of the world, there were no modern seismic codes (Turkey, China, and so on), [1] several structures were built with insufficient particularization and reinforcement for seismic protection. As a result of the impending drawback, a variety of analysis work has been carried out. The New Zealand Society for Earthquake Engineering (NZSEE) and the ASCE-SEI 41[2] give advanced technical recommendations for seismic assessment, retrofit, and rehabilitation around the world. [3] These requirements need be

updated on a regular basis; for example The crispness of welded steel frames was diminished by the 1994 Northridge earthquake.

Tropical cyclones, tornadoes, and severe thunderstorm winds are examples of natural hazards that could benefit from the retrofit solutions detailed here. While the current seismic retrofitting trend focuses mostly on structural modifications to minimize the seismic risk of existing structures, it is equally vital to mitigate the risk and loss associated with non-structural components. It's also important to remember that while proper initial design and future renovations can frequently significantly improve seismic performance, there is no such thing as an earthquake-proof construction.

4.3 GLASS FIBER REINFORCED POLYMER [GFRP]

Optical fibre reinforced Plastic (GFRP) was first created in the mid-1930s and has since become a standard in the construction industry. The benefits of the Beaux-Arts were revealed in 1967, when the attempted destruction of Disneyland's "House of the Future," formerly intended primarily for component development. The futurist house, built in 1956-7, was totally composed of covering material, and it was supposed to be demolished in 1967 once it was no longer thought essential. The wrecking ball mysteriously deflected off the structure, suggesting that GFRP's potential had been recognised and it had begun to thrive.. By 1994, the construction industry had used roughly 600 million pounds of composite materials. Today, Stromberg Beaux-Arts provides a wide range of GFRP solutions to satisfy your structural and aesthetic requirements. Stromberg's style and drafting teams work directly with you, the client, to capture your vision on paper. Our sculptors carve a model to your requirements once all of the drawings have been approved. Mildew is then created using a variety of materials such as covering material, steel, wood, or rubber, depending on the detail. A carefully formulated mixture of polyester or synthetic resin, as well as alkali-resistant glass fibres, is sprayed into the mildew. Almost every shape or type can be shaped.

Stromberg's design and drafting teams collaborate with you, the customer, to bring your idea to life on paper. The optical fibre can be arbitrarily organised, planate into a sheet (known as a shredded strand mat), or plain-woven into a

material. The plastic matrix could be made from a thermosetting compound (epoxy, polyester organic compound, vinyl ester) or a thermoplastic compound (epoxy, polyester organic compound, vinyl ester). Depending on the covering material used, the glass fibres are made from a variety of glass designs. All of these glasses comprise oxide or salt, with various proportions of metal oxides, magnesium, and atomic number 5 in most cases. Glass fibres must be made with extremely low levels of flaws if they are to be used in covering materials.

Fiberglass is a durable and lightweight material that may be found in a wide range of items. It's not as strong or rigid as carbon fibre composites, but it's less brittle and costs less. It has a higher bulk strength and weight than many metals and can be formed into complicated shapes quickly. Crafts, boats, autos, tub tubs and enclosures, swimming pools, hot tubs, septic tanks, water tanks, roofs, pipelines, cladding, casting, surfboards, and external door skins all employ covering material.

Glass-reinforced plastic (GRP), glass-fiber-reinforced plastic (GFRP), and GFK (from German: Glasfaserverstärkter Kunststoff) are all frequent names for the covering material area unit. The composite is sometimes known as "fibreglass strengthened plastic" since optical fibre is usually referred to as "fibreglass". In this literature, the word "glass fibre" might refer to the full optical fibre reinforced material rather than just the optical fibre.



Fig:4.4 Polyester and reinforced glass fiber

4.4 STEEL MESH

Steel wire has unique qualities that make it ideal for coating. IRON wire mesh is created by twisting two adjacent wires at least four times to generate a strong honeycomb mesh structure. As a result, it has a lot of strength and sturdiness. Regardless of whether an area is stopped, the entire IRON mesh structure will not be destroyed. The thermal growth constants of the coating layer, the plaster layer, and the reinforcing metal layer are all different. As a result, IRON wire (durable twisted plain-woven mesh - no stiff mesh) is far more suitable for coating than welded wire mesh or swollen metal when subjected to extreme temperature changes. Once applied, it efficiently protects the plaster layer from drying out and breaking.

Its polygonal design prevents internal tensions from forming. IRON wire is easy to attach on semicircular and angular surfaces because to its flexible construction. Its many edges are twisted mesh, which improves corrosion resistance and eliminates the risk of injury at work. IRON wire is ideal for

reinforcement coating in construction, reinforcement waterproofing, floor levelling, and facade work because to its unique physical and mechanical features

Plaster IRON wire is available in a variety of materials, mesh sizes, and wire diameters. Galvanized low carbon wire and toughened wire are used.

Mesh size (distance between polygon faces) ranges from thirteen to fifty millimetres.

The wire mesh has a diameter ranging from 0.06 to 2.0mm. Delivered in rolls with widths ranging from one metre to two metres and lengths of 50, 100, and 200 metres. The price per square metre of plain-woven mesh is determined by the wire diameter and kind (uncoated steel or galvanized).

Wire mesh has become a well-known phrase for people in the design and engineering fields that frequently employ various types of wire products for their or their projects. Mesh's cheap, practical, and safe value has been overlooked by many in these industries..



Fig:4.5 Iron mesh

CHAPTER 5

RESULTS AND DISCUSSION

5.1 MIX DESIGN M30 CONCRETE CALCULATIONS

a) Targeted strength:

$$F'_{ck} = f_{ck} + (1.65 \times s)$$

$$S = 5 \text{ N/mm}^2$$

$$\begin{aligned} F'_{ck} &= 30 + (1.65 \times 5) \\ &= 38.25 \text{ N/mm}^2 \end{aligned}$$

b) Selection of w/c ratio:

For severe exposure condition (RCC)

Min. water cement ratio - 0.45

Min. grade – M30

W/C raio = 0.45

c) Calculation of water content:

max. water content for 186kg for 50mm slump

3% of water for every 25mm slump change

100mm slump we use so add 6% with it

$$= 186 + [(6/100) \times 186]$$

$$= 197\text{kg}$$

d) Calculate cement content:

$$\text{W/c ratio} = \text{water content/ cement content}$$

$$= 230.5 / 0.45 = 512.22$$

e) Aggregate proportion between coarse and fine aggregate:

$$20\text{mm aggregate} = 0.6$$

$$\text{w/c ratio} = 0.45$$

If ± 0.05 change in w/c ratio change proportion to ± 0.01

$$0.5 - 0.45 = 0.05 \text{ so add } 0.01 \Rightarrow 0.6 + 0.01 = 0.61$$

Pumpable concrete reduce 10% vol. of coarse aggregate

$$\text{Vol. of coarse} = 0.9 \times 0.61 = 0.55$$

$$\text{Vol. of fine} = 1 - 0.55 = 0.45$$

f) Mix design calculation:

$$\text{i) Vol. of cement} = 1 \text{ m}^3$$

$$\text{ii) Vol. of cement} = \text{mass} / \text{specific gravity} \times 1/100$$

$$= 0.14 \text{ m}^3$$

$$\text{iii) Vol. of water} = \text{m/sp.g} \times 1/1000$$

$$= 0.2 \text{ m}^3$$

$$\text{iv) Vol. of all in aggregate} = [i - (ii + iii)]$$

$$= 0.66 \text{ m}^3$$

$$\text{v) m of coarse aggregate} = \text{iv} \times \text{vol. of proportion of coarse aggregate} \times \text{sp.g} \times 1000$$

$$= 994.62 \text{ kg}$$

$$\text{vi) m of fine aggregate} = \text{iv} \times \text{vol. of proportion of fine aggregate} \times \text{sp.g} \times 1000$$

$$= 814\text{kg}$$

FINAL OUTPUT:

$$\text{Cement} = 438 \text{ kg/m}^3$$

$$\text{Water} = 197 \text{ kg/m}^3$$

$$\text{Coarse Aggregate} = 994.62 \text{ kg/m}^3$$

$$\text{Fine aggregate} = 814 \text{ kg/m}^3$$

$$\text{W/c ratio} = 0$$

5.2 COMPRESSIVE STRENGTH OF RC CONCRETE

Table 5.1 Compressive result

Days	Specimen 1(KN)	Specimen 2(KN)
7 th days	350	350
14 th days	483	490
28 th days	540	530

$$\text{Compressive strength} = \text{load/area}$$

$$7^{\text{th}} \text{ day compressive strength} = 15 \text{ N/mm}^2$$

$$14^{\text{th}} \text{ day compressive strength} = 21.6 \text{ N/mm}^2$$

$$28^{\text{th}} \text{ day compressive strength} = 23.7 \text{ N/mm}^2$$

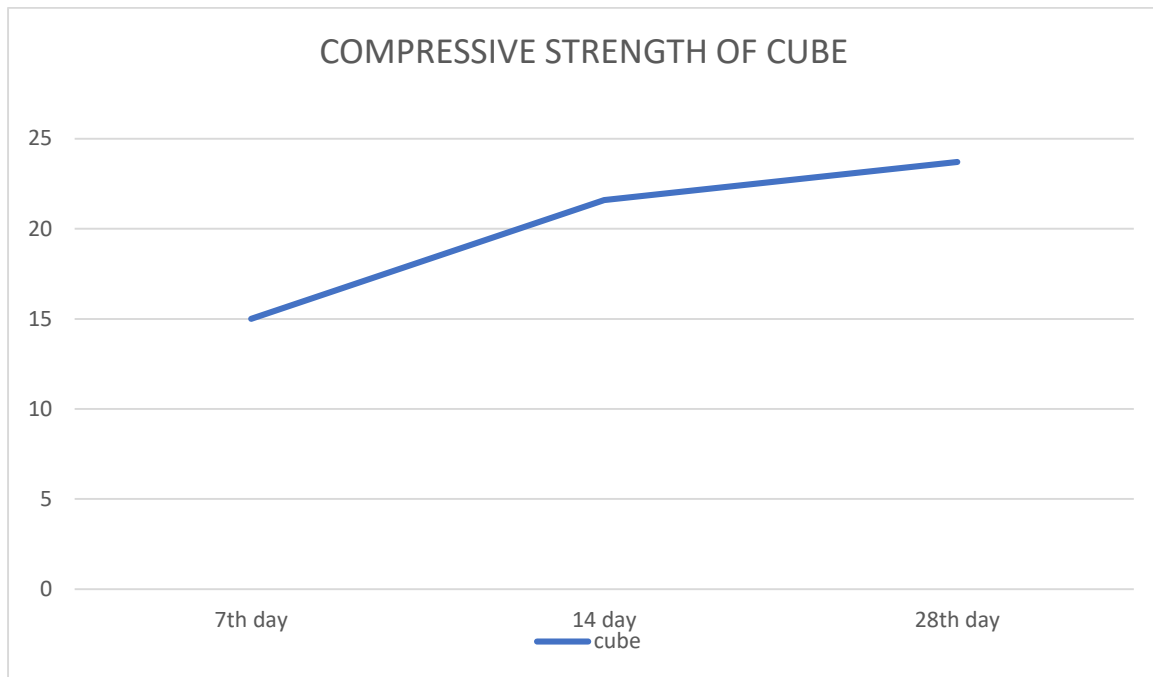


Fig:5.1 Graph of compressive test

5.3 SPLIT TENSILE STRENGTH OF THE CONCRETE

Table 5.2 Result of Split tensile test

Days	Specimen 1(KN)	Specimen 2(KN)
7 th DAYS	250	250
14 th DAYS	275	283
28 th DAYS	280	295

Tensile strength = $2 \times \text{load} / \pi \times d \times l$

Tensile strength of 7th day = 3.54 N/mm^2

Tensile strength of 14th day= 4 N/mm^2

Tensile strength of 28th day= 4.17 N/mm^2

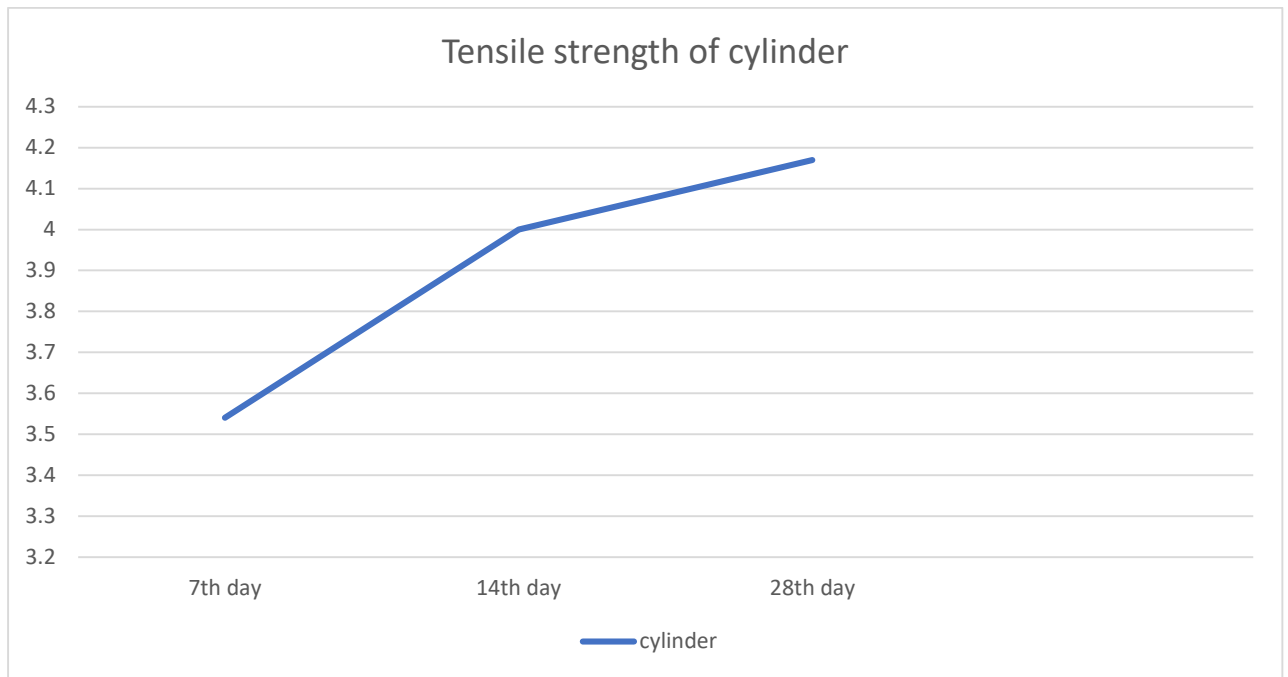


Fig.5.2 Graph of Split tensile test

5.4 FLEXURE TEST

Reinforced beam without GFRP

Table:5.3 Result of flexural test

Days	Specimen 1(KN)	Specimen 2(KN)	Specimen 3(KN)	Specimen 4(KN)
28 TH DAY	25	22.5	25	27

Flexural strength = FL/bd^2

Specimen 1 = $7.4N/mm^2$

Specimen 2 = $6.67N/mm^2$

Specimen 3 = $7.4N/mm^2$

Specimen 4 = $8.1N/mm^2$



Fig:5.3 Creack of beam



Fig:5.4 Beam test

Reinforced beam wrapped with GFRP

Table:5.4 Result of beam

Days	Specimen 1(KN)	Specimen 2(kn)
28 th Day	30.375	28.228

Flexural strength = FL/bd^2

Specimen 1 = 9 N/mm²

Specimen 2 = 8.364 N/mm²



Fig:5.5 Beam wrapped with glass



Fig:5.6 Beam wrapped with glass fiber



Fig:5.7 Beam wrapped with iron mesh

Reinforced beam with iron mesh

Table:5.5 Result reinforced beam with iron mesh

Days	Specimen 1(KN)	Specimen 2(KN)
28 th day	33.75	32.805

Flexural Strength = FL/bd^2

Specimen 1 = $10N/mm^2$

Specimen 2 = $9.72N/mm^2$

5.5 DEFLECTION

Table:5.6 Result of Nominal beam 1

PUMPING	LOAD (KN)	CENTER DEFLECTION(mm)
1	2.5	0.5
2	5	0.9
3	7.5	0.13
4	10	0.16
5	12.5	0.20
6	15	0.27
7	17.5	0.35
8	20	0.54
9	22.5	0.58

Table:5.7 Result of Nominal beam 2

PUMPING	LOAD (KN)	CENTER DEFLECTION(mm)
1	2.5	0.6
2	5	0.10
3	7.5	0.12
4	10	0.16
5	12.5	0.18
6	15	0.22
7	17.5	0.28
8	20	0.30
9	22.5	0.33
10	25	0.38

Table:5.8 Result of Nominal beam 3

PUMPING	LOAD (KN)	CENTER DEFLECTION(mm)
1	2.5	0.5
2	5	0.9
3	7.5	0.10
4	10	0.16
5	12.5	0.20
6	15	0.25
7	17.5	0.28
8	20	0.31
9	22.5	0.33
10	25	0.38

Table:5.9 Result of Nominal beam 4

PUMPING	LOAD(KN)	CENTER DEFLECTION(MM)
1	2.5	0.9
2	5	0.12
3	7.5	0.23
4	10	0.30
5	12.5	0.38
6	15	0.47
7	17.5	0.56
8	20	0.61
9	22.5	0.68
10	25	0.74
11	27.5	0.80

5.4.2 DEFECLTION OF RC BEAM WRAPPED WITH GFRP

Table:5.10 Defecltion of RC beam beam wrapped with gfrp1

PUMPING	LOAD(KN)	CENTER DEFLECTION(MM)
1	2.5	0.10
2	5	0.16
3	7.5	0.24
4	10	0.31
5	12.5	0.37
6	15	0.46
7	17.5	0.59
8	20	0.68
9	22.5	0.74
10	25	0.83
11	27.5	0.96
12	30	1.02

Table:5.11 Deflection of RC beam wrapped with gfrp beam2

PUMPING	LOAD(KN)	CENTER DEFLECTION(MM)
1	2.5	0.14
2	5	0.21
3	7.5	0.27
4	10	0.39
5	12.5	0.43
6	15	0.58
7	17.5	0.67
8	20	0.72
9	22.5	0.79
10	25	0.86
11	27.5	0.98

DEFLECTION OF BEAM WRAPPED WITH IRON MESH

Table:5.12 Deflection of RC beam wrapped with iron mesh

PUMPING	LOAD(KN)	CENTER DEFLECTION(MM)
1	2.5	0.18
2	5	0.29
3	7.5	0.36
4	10	0.42
5	12.5	0.51
6	15	0.58
7	17.5	0.67
8	20	0.73
9	22.5	0.79
10	25	0.86
11	27.5	0.98
12	30	1.07
13	32.5	1.12

Table:5.13 Deflection of RC beam wrapped with iron mesh 2

PUMPING	LOAD(KN)	CENTER DEFLECTION(MM)
1	2.5	0.12
2	5	0.23
3	7.5	0.31
4	10	0.38
5	12.5	0.47
6	15	0.52
7	17.5	0.65
8	20	0.72
9	22.5	0.80
10	25	0.89
11	27.5	0.96
12	30	1.11
13	32.5	1.18

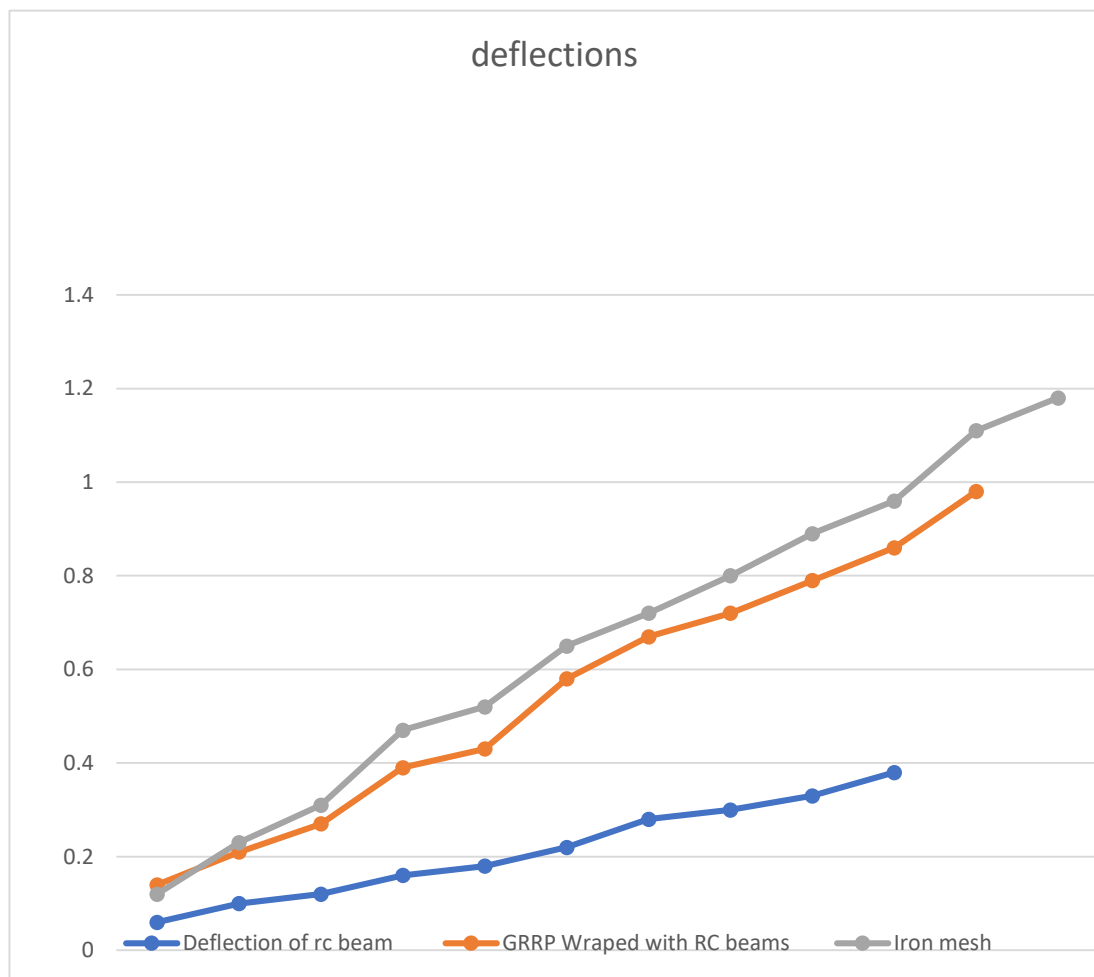


Fig:5.8 Graph of beam result

The maximum load was increased by using CFRP plates that were externally bonded. Furthermore, retrofitting causes the failure mode to transition to brittle. Early cracks in the strengthened beams appear at a higher load than in the un-strengthened control beam. Early cracks emerge earlier in the strengthened beams than in the control beam.

CHAPTER 6

CONCLUSION

This research looked at the flexural and shear performance of reinforced beams retrofitted with GFRP and Iron mesh following preloading. The following are the findings of this experiment:

- When GFRP and Iron mesh retrofitted beams are compared to control beams, the GFRP and Chicken mesh retrofitted beams have more stiffness.
- Using externally bonded CFRP plates, the maximum load was increased, and retrofitting changed the mode of failure from brittle to brittle. The modified beams have a narrower crack width than the control beams.
- This suggests that insufficient strengthening durations do not have the desired impact. The flexural behaviour of reinforced concrete beams that have been externally reinforced with carbon, glass, steel, coir, and polypropylene sheets is investigated in this experimental study. From the test results and calculated strength values, the following conclusions were drawn:
 - Because the beams are fully wrapped on all four sides, the deflections are kept to a minimum. stronger beams show early cracks at a higher load than the un-strengthened control beam.
 - External beam strengthening improved the flexural strength and ultimate load capacity of the beams.
 - When compared to a control beam, Glass Fibre sheets increased the ultimate load capacity of the beams by 62 percent.
 - When compared to a control beam, the ultimate load capacity of the iron mesh-enhanced beams is raised by 83 percent.

As can be seen from the examples above, Iron Mesh retrofitting is less expensive than GFRP. However, because iron mesh is prone to corroding, the retrofit's lifespan is reduced.

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