PERFORMANCE ENHANCEMENT OF PLAIN CEMENT CONCRETE BEAMS USING FIBER-REINFORCED POLYMER (FRP) COMPOSITES

[1]Sruthi,[2]Srujana,[3]Krishna Prasad
[123]Student
Department of Civil Engineering

ABSTRACT

Plain cement concrete (PCC) beams, while strong in compression, exhibit low tensile strength and are prone to cracking and structural failure under flexural loads. To address these limitations, the incorporation of Fiber-Reinforced Polymer (FRP) composites has emerged as a promising solution for enhancing the mechanical performance of concrete structural elements. This study investigates the effect of externally bonded FRP composites on the flexural behavior, load-bearing capacity, and failure characteristics of PCC beams. Various types of FRP materials, including glass and carbon fibers, are applied to concrete beam specimens, and their performance is evaluated through experimental testing under static loading conditions. The results reveal significant improvements in the ultimate load capacity, ductility, and energy absorption of FRP-strengthened beams compared to unreinforced specimens. The study also discusses the modes of failure observed and highlights the effectiveness of FRP retrofitting in delaying crack propagation and improving overall structural performance. These findings demonstrate the potential of FRP composites as an efficient and durable reinforcement method for upgrading existing concrete infrastructure.

I. INTRODUCTION

1.1 GENERAL

Concrete is one of the most widely used construction materials due to its availability, compressive strength, and durability. However, plain cement concrete (PCC) suffers from inherent weaknesses in tension and flexure, making it susceptible to cracking and brittle failure under bending loads. This limitation has prompted the need for reinforcement strategies to improve the structural behavior of concrete members, especially beams, which are critical load-bearing elements in buildings and infrastructure.

Traditional reinforcement with steel bars addresses tensile weaknesses to a certain extent, but issues such as corrosion, long-term durability, and maintenance costs remain challenges in aggressive environmental conditions. In response to these concerns, Fiber-Reinforced Polymer (FRP) composites have gained attention as a modern alternative for strengthening and retrofitting concrete structures. FRPs offer several advantages over conventional reinforcement materials, including high tensile strength, lightweight nature, corrosion resistance, and ease of application.

In recent decades, the use of externally bonded FRP sheets or laminates has emerged as a practical and efficient method for upgrading the performance of existing concrete elements. These materials can be applied to structural components without significantly altering their geometry or weight, making them particularly suitable for retrofitting projects. The effectiveness of FRPs in enhancing load-bearing capacity, flexural strength, crack resistance, and energy absorption has been well-documented in various research studies and practical applications.

This study focuses on evaluating the mechanical performance of PCC beams strengthened with different types of FRP composites, such as Glass Fiber-Reinforced Polymer (GFRP) and Carbon Fiber-Reinforced Polymer (CFRP). Through experimental testing, the research aims to investigate the flexural behavior, failure modes, and overall structural improvement achieved using FRP reinforcements. The insights gained from this study can contribute to the development of reliable, cost-effective, and durable solutions for strengthening aging or underperforming concrete structures.

The paper is organized as follows: Section II reviews relevant literature on FRP applications in structural engineering. Section III describes the materials, methods, and experimental setup used in this study. Section IV presents the results and analysis of beam performance under loading. Finally, Section V discusses the conclusions and suggests future research directions.

1.2 STRENGTHENING USING FRP COMPOSITES

A few years ago, the construction industry started to use FRP for structural reinforcement, mainly in combination with other building materials such as wood, steel, and cement. FRPs have a few more developed characteristics, such as a high strength-to-weight ratio, a high firmness-to-weight ratio, plan flexibility, non-destructiveness, high weakness strength, and ease of usage. Only a few experts have focused on the use of FRP sheets or plates connected to cement footers. Fortification using glue-fortified fiber-supported polymers has shown to be a viable approach for a variety of large-scale designs such as sections, shafts, pieces, and dividers. FRP materials are increasingly being used for exterior support of current large designs since they are non-destructive, non-attractive, and resistant to various synthetic chemicals. The use of remotely fortified glass fiber-supported polymers (GFRP) to enhance the flexural, shear, and torsional limits of RC radiates has been shown in previous research. The adaptable glass fibre sheets have been revealed to be profoundly appealing for reinforcing RC radiates because to their adaptable nature and ease of care and application, along with high elasticity weight proportion and solidity.

In the last several years, the use of fibre supported polymers (FRPs) for the recovery of existing significant designs has grown rapidly. FRP has been proven to be effective in strengthening cement footers that are prone to flexure, shear, and twist. Regrettably, present Indian significant plan standards (IS Codes) prohibit any preparations for flexural, shear, or torsional strengthening of underneath people using FRP materials. Due to the lack of plan principles, groups were formed between the exploration community and industry to study and improve the use of FRP in the flexural, shear, and torsional repair of existing structures. FRP is a composite material made up mostly of high-strength carbon, aramid, or glass filaments embedded in a polymeric grid (e.g., thermosetting sap), with the strands serving as the primary load-carrying component.

This support may take the shape of prefabricated overlays or adjustable sheets, among other options. The coverings are pre-relieved tough plates or shells that are inserted by glueing them to the significant surface using thermosetting pitch. The sheets are either dry or pre-impregnated with tar (known as pre-preg) before being installed on a large surface and repaired. Wet lay-up is the term for this type of installation. High rigidity, lightweight, great solidity, high weariness strength, and amazing sturdiness are only a few of the physical and mechanical characteristics offered by FRP materials. FRP frameworks are easy to implement due to their lightweight and formability. These frameworks are a fantastic option for exterior support since they are non-destructive, non-attractive, and mostly resistant to synthetic chemicals. When compared to traditional reinforcing methods, the characteristics of FRP composites and their flexibility have resulted in significant cost savings and reduced office shutdown time (e.g., area broadening, outer post-tensioning, and fortified steel plates).

Reinforcing using remotely reinforced FRP sheets has been shown to be useful for a variety of RC underlying components. To provide additional flexural strength, FRP sheets may be attached to the strain side of main individuals (e.g., chunks or pillars). To provide additional shear strength, they may be attached to the web sides of joists and radiates or folded over portions. They may be folded over portions to increase significant control and, as a result, segment strength and flexibility. FRP sheets may be used to strengthen cement and brickwork separators to make them more likely to resist parallel loads, as well as circular constructions (such as tanks and pipes) to resist internal pressure and reduce consumption. Starting today, a small number of huge square metres of surface reinforced FRP sheets have been used in a variety of fortification operations all over the globe.

Objectives

- The primary goal is to investigate the use of fibre reinforced polymer to improve the strength of current as well as old and worn out structures, in order to either accomplish or extend the structure's anticipated life.
- To compare the strength values of a structure that have been decreased by fire activity to those of a normal structure.
- To draw a curve depicting the impact of fire reaching various depths of structural components.
- Calculate the % improvement in strength due to the use of FRP.

II. PROPOSED METHODOLOGY

The goal of the project is to determine the compressive and flexural strength of cubes, as well as the deflection of reinforced concrete beams. In this concrete blend model, the extents of components that will produce cement with the required appealing characteristics are chosen. The proportions of the M20 combination should be preferred in such a way that the resulting concrete is craved workability while new and can be set and compacted easily for the expected reason, the proportions of the M20 combination should be preferred in such a way that the resulting concrete is craved workability while new and can be set and compacted effortlessly for the expected reason, the proportions of the M20 combination should be preferred in such a way that the resulting concrete is craved workability while new and Consider the unique example control specimen and retrofitting specimen in ordinary Portland cement (OPC) with water, fine aggregate, coarse aggregate (20mm) and (12mm) and the beam. To improve the beam's quality, Fiber Reinforced Polymers (FRP) sheets or plates are utilised. Reinforced glass fibre fortified polymer (GFRP) guided test on 28 days to maximise the quality of retrofitting sample with unique resin characteristics such as epoxy resin, GP resin, and isophthalic resin. A total of twelve number beams were cast, with the specific test results being recorded. The beams were flexural strength tested after being upgraded with single layer GFRP utilising complete form wrapping. The flexural strength and deflection achieved by changing the load in various specimens were the characteristics to be considered in evaluating the execution of the beam.

III. MATERIALS

3.1 CONCRETE

Concrete is a building material made out of portland cement and water, as well as sand, gravel, crushed stone, or inert materials such expanded slag or vermiculite. Cement and water combine to create a mixture that hardens into a strong, stone-like mass via chemical reaction. Aggregates are the inert components, and for economy, just enough cement paste is required to cover all of the aggregate surfaces and fill all of the gaps. The concrete paste is flexible and may be moulded into any shape or troweled to create a smooth finish. Hardening starts quickly, although measures are taken, typically by covering, to prevent fast moisture loss, since water is required to complete the chemical reaction and enhance strength. However, too much water causes the concrete to become porous and fragile. The nature of the concrete is mainly determined by the quality of the paste produced by the cement and water. Designing the mixture refers to the proportioning of the components in concrete, and most structural work requires concrete with compressive strengths of 15 to 35 MPa. A rich combination for columns could be 1 volume of cement to 1 volume of sand and 3 volume of stone, whereas a lean mixture for foundations might be 1:3:6. Concrete may be constructed as a thick mass that resembles artificial rock, with chemicals added to make it waterproof, or it can be made porous and extremely permeable for filter bed applications. To generate minute bubbles for porosity or light weight, an air-entraining chemical may be applied. Concrete typically takes at least 7 days to fully harden. The hydration of the tricalcium aluminates and silicates causes the steady rise in strength. Originally, angular sand was recommended for use in concrete, but rounder grains are now preferable. The stone is typically shattered into sharp pieces. Concrete's weight varies depending on the kind and quantity of rock and sand used. The density of concrete including trap rock may be as high as 2,483 kg/m3. Steel bar, also known as rebar or mesh, is inserted in structural components to enhance the tensile and flexural strengths. Concrete is extensively utilised in precast units such as block, tile, sewage, and water pipe, as well as decorative goods, in addition to structural applications.

The study was carried out using Portland slag cement (PSC) of grade 43. Physical characteristics were examined in line with Indian Standard standards. Clean river sand, passing through a 4.75 mm sieve with a specific gravity of 2.68, was utilised as the fine aggregate in this study. According to Indian Standard standards, the fine aggregate grading zone was zone III. As coarse aggregate, machine crushed granite broken stone with an angular form was utilised. The coarse aggregate had a maximum size of 20 mm and a specific gravity of 2.73. Both mixing and curing of concrete were done using ordinary clean portable water that was devoid of suspended particles and chemical compounds.

The largest aggregate size utilised in concrete was 20 mm. To obtain a strength of 20 N/mm2, a nominal concrete mix of 1:1.5:3 by weight is utilised. The water cement ratio is set at 0.5. To measure the compressive strength of concrete, three cube specimens were cast and tested at the time of the beam test (at the age of 28 days). The concrete's average compressive strength was 31N/mm2.

3.1.1Cement

Cement is a powdered substance that may be formed into a paste by adding water and then moulded or poured into a solid mass. Cements refer to a variety of organic compounds used for attaching or fastening objects, although they are classed as adhesives, while the word cement refers to a building material. Portland cement is the most commonly utilised of the building cements. It's a bluish-gray powder produced by finely grinding clinker made by heating an intimate combination of calcareous and argillaceous minerals to high temperatures. A combination of high-calcium lime stone, sometimes known as cement rock, and clay or shale is used as the primary raw material. Some cements may also include blast-furnace slag, which is known as portland slag cement (PSC). Iron oxide is primarily responsible for the cement's colour. The colour would be white if there were no impurities, but neither the colour nor the specific gravity is a quality indicator. The study utilised Portland slag cement (PSC)–43 grade with a specific gravity of at least 1.0.

3.1.2. Fineaggregate

Fine aggregate, often known as sand, is a collection of mineral grains formed by the dissolution of rocks. It differs from gravel solely in terms of grain size or particle size, but not from clays that contain organic elements. Sands that have been sifted and separated from organic material by the action of water currents or winds over dry areas have typically consistent grain sizes. Typically, commercial sand is sourced from riverbeds or sand dunes that were created by wind activity. Sand makes up a large portion of the earth's surface, and the sands are typically quartz and other siliceous minerals. Silica sands, which are typically over 98 percent pure, are the most economically valuable. Beach sands are typically devoid of biological debris and contain smooth, spherical to ovaloid particles due to the abrasive impact of waves and tides. The white beach sands are mostly silica, but they may also include zircon, monazite, garnet, and other minerals, and they're utilised to extract different elements.

Sand is used in the production of mortar and concrete, as well as in polishing and sandblasting. In foundries, sands with a little amount of clay are used to make moulds. Filtering water is done using clear sands. The quality of the sands used for this purpose varies depending on where they are available. A silica sand used in concrete and cement testing is known as standard sand. In this experiment, fine aggregate collected from the Koel riverbed was utilised, which was free of any organic contaminants. The fine aggregate had a specific gravity of 2.68 after passing through a 4.75 mm screen. According to Indian Standard standards, the fine aggregate grading zone was zone III.

GLASS FIBER SHEET

These are fibres that are widely utilised in the naval and industrial sectors to create medium-high-performance composites. Their great strength is a distinguishing feature. Because glass fibres have a lower Young modulus of elasticity (70 GPa for E-glass) and have a poorer abrasion resistance than carbon or aramid fibres, they must be handled with extreme care. They also have a poor fatigue strength and are prone to creep. Fibers are subjected to sizing procedures that serve as coupling agents to improve the connection between fibres and matrix, as well as to protect the fibres from alkaline chemicals and moisture. These treatments help to improve the composite material's durability and fatigue performance (both static and dynamic). FRP composites based on fibreglass are often referred to as GFRP composites centred on carbon fibre are commonly referred to as GFRP composites, as shown in Figure 1. The resin is one of the most fundamental components that influences the composites' execution.

Fig.3.1.E-Glassfiber sheets

The thermoplastics and thermo sets are the two types of resins. At room temperature, a thermoplastic resin maintains its strength. When heated, it liquefies and hardens when cooled. Long-chain polymers do not cross-link artificially. The thermo set resin composites with this trademark are particularly appealing for structural applications. Unsaturated polyesters, epoxies, and vinyl esters are the most often recognised tars used in composites, while polyurethanes and phenolics are the least common.

3.1.4 Epoxies

Glycidyl ethers and amines are the most common types of epoxies used in composites. Material characteristics and cure rates may be tailored to suit the requirements of the job. Epoxies are mostly used in the marine, automotive, electrical, and apparatus industries. Epoxy resins' high density restricts its use to particular methods, such as shaping, fibre slowing, and hand lay-up. The right curing experts should be carefully selected since they will affect the kind of compound reaction, pot life, and final material characteristics. Despite the fact that epoxies may be expensive, they may be justified when better performance is required. The properties of unique polymeric resins, such as epoxy resin, general purpose (GP), and isophthalic resin, are listed in the table below.

TABLE:-1

Properties of Resin	Epoxy	GP	ISO
Glass transition temperature	120-130	80	80
Tensile strength	85N/mm2	55 N/mm2	55N/mm2
Tensile Modulus	10500 N/mm2	3450 N/mm2	3300 N/mm2
Elongation at break	0.8%	2.2 %	2.5-3.55 %
Flexural strength	112 N/mm2	80 N/mm2	125 N/mm2
Flexural Modulus	10000 N/mm2	3450 N/mm2	3400 N/mm2
Compressive	190 N/mm2		

IV. METHODLOGY

This chapter focuses on improving an analytical model for analysing and designing flexural beams reinforced with externally bonded glass fibre reinforced polymer composite sheets. The goal of this study is to correctly anticipate the flexural behaviour of reinforced concrete beams reinforced with glass fibre reinforced plastic sheet. Before the major experiment, several essential experiments on cement and fine aggregate are carried out to get preliminary project information.

4.1 Tests on Materials

The following are the many tests performed on the materials used in the project; various apparatus and equipment are used to test the quality and characteristics of the materials. These tests are carried out to determine the quality of the materials, and the findings aid in the mix design calculations. These fundamental tests must be carried out in order to get effective findings.

1. Gravity Specification
2. Relative Consistency
3. Analysis of Sieves
4. Cement Fineness
5. Absorption of water
6. Cement setting (first and final)

4.2. Specific Gravity

The ratio of a material's density to the density of a reference substance is known as specific gravity.

a)Specific Gravity of Cement

Specific gravity is defined as the ratio of a material's density to that of a reference substance, or the ratio of a substance's mass to that of a reference substance for the same volume, using water as the reference substance.

During the mix design calculation procedure, the material's specific gravity is utilised. For this test, a specific gravity bottle, a weight balance, kerosene, and cement were utilised as the equipment and supplies.

Because kerosene does not react with cement, it is used instead of water.

The following procedures are used to determine the cement's specific gravity:

1. W1 g is the weight of an empty specific gravity bottle.
2. A third of the capacity of a specific gravity container is filled with cement, and the weight of the bottle is recorded as W2 gms.
3. Fill the remaining 2/3 of the capacity of the specific gravity bottle with kerosene, and record the weight of the bottle as W3 gms.
4. Now carefully clean the specific gravity container and fill it solely with kerosene, noting the weight W4 gms.
5. Now solely use pure water to fill the specific gravity container, and record the weight W5 gms.

b) Sieve Analysis

The particle size distribution of coarse and fine aggregates may be determined via sieve analysis. The aggregates are sieved according to IS: 2386 (Part I) – 1963. We do this by passing aggregates through various sieves that have been standardised by the IS code, and then collecting different sized particles left behind from different sieves. The mechanical sieve shaker is used to conduct the sieve analysis in the laboratory. The primary goal of the test is to determine which zone the aggregate we're utilising belongs to. Taking a 1000g sample and analysing it using a sieve. The findings are shown in the tables below. The experiments were carried out on both fine and coarse material. Each aggregate's fineness modulus is computed, and the results are shown below the table. Before putting aggregates through sieves, make sure they're dry and devoid of any organic components. The existence of lumps in the aggregate should be eliminated by pressing with your fingertips. The following formula should be used to compute and report the results:

1. Retained sample weight
2% of the original weight was retained.
3. Percentage of total weight retained

TABLE :-2 Sieve analysis

Sieve size	Weight of aggregate (mm)	Weight Retained	% of weight Retained	Cumulative % Retained	Cumulative % of passing
4.75 mm	1000	25	2.5	2.5	97.5
2mm	1000	142	14.2	16.7	83.3
1mm	1000	187	18.7	35.4	64.6
600 µ	1000	247	24.7	60.1	39.9
300 µ	1000	277	27.7	87.8	12.2
150 µ	1000	91	9.1	96.9	3.1
75 µ	1000	29	2.9	99.8	0.2
pan	1000	2	0.2	100	0

4.3 Mix Design

Based on the quality of the materials used and their moisture content, concrete mix design recommends quantities of cement, fine aggregate, coarse aggregate, and water. The final mix proportions are recommended based on laboratory tests and mix design revisions. We can offer concrete with strength ranging from M10 to M100 and workability ranging from no slump to 150 mm slump value using mix design.

Some admixtures are also needed to improve concrete characteristics such as setting time, workability, and so on. In order to make the most use of these admixtures, they must be taken into account during the mix design calculations. Because an excessive amount of them may alter the characteristics of concrete and compromise its strength.

4.4 Casting of Moulds

This is where the project's experimentation begins. Everything we've done in the mix design calculation thus far has been theoretical. After calculating the mix ratio, the cubes are cast at this step. The casting in this experiment is done by hand mixing. The procedures to take while mixing concrete are as follows.

1. Gather or obtain all of the materials and tools needed to complete the task.
2. Materials must be gathered and weighed correctly using a weighing scale according to the mix design.
3. The coarse aggregate is first spread out on the ground.
4. On top of the coarse material, fine aggregate and coir fibre are placed.
5. The cement is then added, and everything is mixed together.
6. The necessary amount of water is then gently added to achieve a homogeneous mixture.
7. The insides of the moulds and slump cone equipment are then thoroughly lubricated.
8. The concrete is then put in three levels in the slump cone and compressed 25 times with a tamping rod at each layer.
9. Once you've obtained the slump.
10. Finally, the concrete is poured into the moulds and compressed using a tamping rod.
11. Once the mixture has been placed in the moulds, the top surface of the mould is levelled and a smooth finish is applied with a trowel.
12. After that, the moulds are set aside for 24 hours.

After 24 hours, the concrete cubes are demolded.

They're then put in the curing tank to cure

Fig-4.1

Preparation of samples

4.5 Compressive strength test

The compressive strength of concrete is one of the most important tests on concrete; it allows us to assess the strength of the material. With the assistance of this test, we can evaluate whether or not the concreting has been done correctly. Depending on the size of the aggregates used, cubes of 150mm x 150mm x 150mm or 100mm x 100mm x 100mm are available for cube testing.

This concrete is poured into the mould and carefully manipulated to remove any voids. They are demoulded and placed in water to cure after a 24-hour period. This specimen's top surface should be levelled and smoothed. This is accomplished by applying cement paste to the whole surface of the specimen and spreading it evenly. After 7 days and 28 days of curing, these specimens are examined using a compression testing equipment. The specimen should be loaded at a rate of 140 kg/cm2 per minute until it fails. The Compressive strength of concrete is calculated by dividing the load at the specimen's failure by the specimen's area. Concrete cubes' compressive strength is tested according to the methods outlined in IS:516 -1959.

The following steps are used to determine compression strength:

1. Specimens kept in water must be examined as soon as possible while they are still wet.
2. Remove any remaining particles from the top surface. If the specimens are dry, they must be maintained in water for 24 hours before being tested.
3. Before the specimen is tested, the weight and measurements of the specimen are recorded with an inaccuracy of 0.2mm.
4. Before inserting the specimen into the machine for testing. Any loose sand or other debris from the surfaces of the specimens that will be in contact with the compression platens must be removed from the bearing surfaces of the testing equipment.
5. In the case of cubes, the specimen should be positioned in the machine such that the weight is

given to the sides of the cubes as cast, rather than the top and bottom.

6. The specimen's axis should align with the spherically seated platen's centre of thrust.

7. As the spherically seated block is brought to bear on the specimen, gently rotate the moveable part by hand to produce a uniform section.

8. Gradually apply a load to the cube at a rate of about 140 Kg/cm2/min until the specimen breaks.

9. Make a note of the maximum load and any unique characteristics in the kind of failure.

10. Concrete cube average compressive strength=(load/area)

Fig-4.2. Specimen loaded into testing machine

V. RESULTS AND DISCUSSION

The load at which the flexural fracture first developed and the ultimate load at which the specimen fails are both recorded during the flexural strength test of control beams. These beams are classified as part of the SET I of beams. In SET II, three beams will be preloaded until flexural cracking occurs, and then retrofitted with GFRP sheets made from ISO resin. This resin is applied to the beams with a brush and will cure in 10 seconds, therefore the sheet should be wrapped around the beam as quickly as possible before the resin dries. Additionally, pressure should be given to the glass fibre layer in order for it to securely adhere to the beams' surface. The modified beams should be evaluated in a flexural strength testing machine once they have been properly placed. The ultimate load and deflection of the failure beam are meticulously recorded. In SET II, three beams will be preloaded until they develop a flexural fracture, then retrofitted with GFRP sheets and Epoxy resin. This resin is applied to the beams with a brush and will cure in 10 seconds, therefore the sheet should be wrapped around the beam as quickly as possible before the resin dries. Additionally, pressure should be given to the glass fibre layer in order for it to securely adhere to the beams' surface. The modified beams should be evaluated in a flexural strength testing machine once they have been properly placed. When recording the ultimate load and deflection data, extreme caution is required.

In SET III, three beams will be preloaded until they develop a flexural fracture, then retrofitted with GFRP sheets and Epoxy resin. This resin is applied to the beams with a brush and will cure in 10 seconds, therefore the sheet should be wrapped around the beam as quickly as possible before the resin dries. Additionally, pressure should be given to the glass fibre layer in order for it to securely adhere to the beams' surface. The modified beams should be evaluated in a flexural strength testing machine once they have been properly placed. When recording the ultimate load and deflection data, extreme caution is required.

Three beams will be pressured till flexural fracture and then retrofitted with GFRP sheets using GP resin in SET IV. This resin is applied to the beams with a brush and will cure in 10 seconds, therefore the sheet should be wrapped around the beam as quickly as possible before the resin dries. Additionally, pressure should be given to the glass fibre layer in order for it to securely adhere to the beams' surface. The modified beams should be evaluated in a flexural strength testing machine once they have been properly placed. When recording the ultimate load and deflection data, extreme caution is required.

Analysis of Compressive strength for different specimens

Thefollowingtables2and3illustratethecompressivestrengthofcementconcretecubeestimatedbytakingintoaccounttheareaofthespecimenandbysuitablymodifyingtheload. The strengths of control specimens like (C1,C2,C3) and wrapped specimens like (W1,W2,andW3) are tested and assessed.

Table:-3CompressivestrengthforControlSpecimen

l.No	Specimens	Area of specimens	Weight of mould (Kg)	Load at failure (kN)	Compressive strength (N/mm^2)	Average Compressive strength(N/mm^2)
	C1	22500	8.49	550	24.44	24.48
	C2		8.62	539	23.9	
	C3		8.57	565	25.11	

Display the compressive strength of the control specimens in Table 2. In reality, the compression test of cubes is the most comprehensive examination of hardened concrete, partly because the bulk of concrete's famous distinguishing characteristics are qualitatively related to its compressive strength. Six test cubes

(C1, C2, C3, C4, C5, and C6) must be cast for the compression test. The average of the three specimens' test strengths is used to calculate the sample's test strength (C1, C2, and C3). 3cubes also wraps with a variety of resins. 150mm concrete, 150mm concrete, 150mm concrete, 150mm concrete, 150mm concrete, 150mm concrete, 150 Concrete of the M20 grade is used to make the cubes. The area of the control specimen is set to 22500, and the weight of all control specimens is adjusted. The load observed to reduce down the compressive strength in CC1 when the load started is 560 and the strength is 24.48kN/mm2. The strength is found to take are treat in each control specimen where the weight is changed, and the divergences between the C1 strength and the C2 and C3 strength are 0.26 percent and 1.26 percent, respectively.

Table:-4 CompressivestrengthforwrappedSpecimen

l.No		T rials	A rea of specimen (mm²)	L oad failure	Comp ressive streng th	Aver age compressive strength N/mm²
	W1(ISO)	1	2 2500	8 40	37.3	31.8 7
				8 60	31.2	
				6 10	27.11	
	W2(GP)	2		7 40	32.8	32.4 3
				7 60	33.7	
				6 95	30.8	
	W3(Epoxy)	3		7 10	31.55	29.4 7
				6 70	29.77	
				6 10	27.11	

Table 3 shows the compressive strength of wrapped specimens for which tests are carried out on different Glass fibre reinforced polymer specimens. W1 specimens are wrapped in isophthalic resin-bonded glass fibre reinforced polymer, while W2 and W3 specimens are wrapped with GPresin-bonded GFRP. When W cube is changed in each specimen, the load based on compressive strength increases.

Table:-5 Flexuralstrengthanddeflectionfordifferentspecimens

Test results	1	I 2	B 3	GP Resin R 1	R 2	R 3
Initial crack load	3	3 2.5	3 1	3 1.5	3 5.2	3 3
Ultim ate load(kN)	7	3 6	3 5	4 4	4 7	4 5
Deflec tion (mm)	.432	0 .417	0 .449	0 .573	0 .521	0 .545
Ultim ate moment (kN-m)	.7	3 .2	2 .9	3 .83	3 .62	3 .9
Flexur al strength (N/mm²)	6.8	1 8.5	1 9.2	2 2.3	2 3.6	2 4

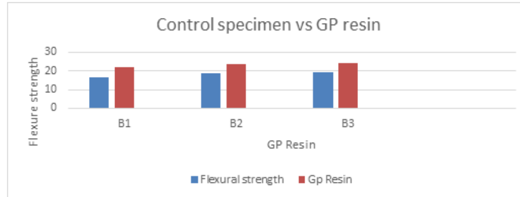
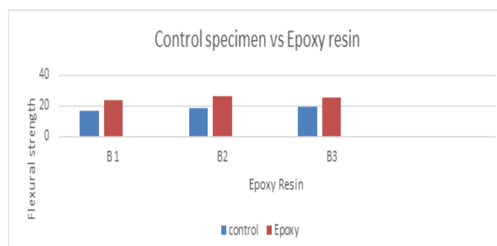


TABLE-6

Te st results	B 1	B 2	B 3	Epoxy Resin R 4	R 5	R 6
In itial crack load	3 3	3 2.5	3 1	4 0	3 3.5	3 0
Ul timate load(kN)	3 7	3 6	3 5	5 1	4 3	5 0
D eflection (mm)	0 .432	0 .417	0 .449	0 .562	0 .583	0 .625
Ul timate moment (kN-m)	2 .7	3 .2	2 .9	4 .15	4 .32	4 .18
Fl exural strength (N/mm²)	1 6.8	1 8.5	1 9.2	2 3.5	2 6	2 5.6



VI. CONCLUSION

The application of Fiber-Reinforced Polymer (FRP) composites has proven to be an effective technique for enhancing the structural performance of plain cement concrete beams. Through this study, it was observed that externally bonded FRP materials, such as Glass Fiber-Reinforced Polymer (GFRP) and Carbon Fiber-Reinforced Polymer (CFRP), significantly improve the flexural strength, load-bearing capacity, and crack resistance of concrete elements. The experimental results demonstrated a marked increase in the ultimate load and ductility of FRP-strengthened beams when compared to unreinforced specimens.

Additionally, the use of FRP composites delayed the onset of cracking and altered the failure mode from brittle to more ductile behavior, which is desirable for structural safety. The lightweight and non-corrosive properties of FRP also make it a durable and practical solution for retrofitting and strengthening aging or damaged concrete structures.

In conclusion, FRP composites offer a reliable, efficient, and cost-effective approach to improving the performance of concrete beams in both new construction and rehabilitation projects. Future research could focus on optimizing fiber orientation, investigating long-term durability under environmental exposure, and developing hybrid reinforcement techniques that combine FRP with traditional methods for even greater structural efficiency.

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