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Rehabilation and Reparing of Reinforced Concrete Structure

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ABSTRACT

Worldwide, there is a high need for strengthening and repairing damaged reinforced concrete buildings. Recent study shows that FRP composites are a viable alternative to established methods for strengthening and repairing concrete. FRP composites improve load carrying capacity, impact resistance, and inhibit fracture formation in structural members. FRPs have been extensively used as interior and external reinforcing materials for structural strengthening and rehabilitation. AFRP/CFRP/GFRP synthetic fibre reinforced polymers have been utilised for strengthening and retrofitting for 30 years. The current study's main goal is to investigate the behaviour of a flexural part reinforced and restored with various FRP materials wrapped in various patterns and layers. This study used E-Glass fibre as a structural reinforcement to boost the strength and stability of the various structural elements. The GFRP can be woven (Woven Roving Mat Fibre - WRM) or non-woven (Chopped Strand Mat Fibre - CSM) (Chopped Strand Mat Fibre- CSM). roving Reinforced concrete beam specimens with varied FRP wraps and RC jacketing were cast to determine the structural characteristics of flexural elements exposed to static loading. Beams were wrapped in woven roving mat in single and double layers at the bottom and sides to test various wrapping tactics and strengthen and repair beams.

INTRODUCTION

Failure and concrete faults can be repaired and rehabilitated using a variety of approaches. We'll go over some concrete restoration methods and materials in this section. When compared to steel and other construction materials, cement has various benefits over them. Although this isn't always the case, it does happen occasionally.(Chaalal et al., 2006). Cracks, concrete spreading, strengthening exposure, excessive deflections, and other symptoms of duress are examples of faults. Cracking and concrete splitting can occur as a result of reinforcing corrosion and a reduction in structural strength. In such cases, repairs to the affected regions are necessary, as is the replacement of the entire structure.

FAILURES CAUSES AND DEFECT IN CONCRETE STRUCTURES

Incorrect Designing With Concrete Causes Structural Failure

For a structure to meet current building safety and strength requirements, construction operations must follow all applicable regulations and guidelines. In general, the selection of materials necessary for a project should allow for the usage of code-approved materials. When preparing a concrete mixture, different negative elements such sulphide in soil or groundwater and freezing and thawing should be carefully examined.

Impact of Climate Change

In Indian settings, the lack of concrete durability due to the freezing and thawing action of frost is of little consequence. However, it's one of the most important factors for most people around the world. When concrete with moisture is subjected to a freezing and thawing cycle, the damage is the most severe. (Sharma, et al., 2015). Despite its impermeability, cement paste requires tremendous pressure to transfer water, even over short distances. Concrete of typical strength only requires pressures that approach the paste's tensile strength to move by around 0.2mm. It's possible to protect concrete from freezing and thawing damage by injecting a little amount of air into the cement paste, with the spacing between the bubbles being no more than 0.4mm apart. In order to receive the extra water, the air bubbles must be half empty. As the concrete cures, the bubbles will be the first to absorb moisture since they are the coarsest part of the pore system Only the amount of entrained air may be detected in wet concrete when AEA is employed. Depending on the maximum aggregate size, between 4 and 8 percent of air is needed. Even without the addition of AEA, air is sucked into the mix during mixing. Stabilization of desired air bubble shape is achieved by AEA. (Attari et al., 2012)

(UA & Neale, KW 2007). Adding silica flume will also help, although there's no solid research to support this claim just yet.

Corrosion

In RCC, steel reinforcement complements concrete's weakness in tension (tensile stress), but it also reduces the concrete's durability and long-term usefulness because of its susceptibility to corrosion. Because concrete deterioration is caused by the corrosion of embedded steel, repairs and rehabilitation of concrete structures have recently become a worldwide activity on par with construction itself. When Reinforced Concrete Construction (RCC) first became popular in the early 20th century, it replaced nearly all of the previously used construction materials, such as timber, (stone) masonry, and steel sections, etc. The R. C. structures had a life expectancy of about 100 years. This anticipation was dashed with the dawn of the twenty-first century when we saw older structures, perhaps 20 to 25 years old, showing significant deterioration and suffering. Increasingly, the long-term durability of concrete is being explored in the global development community. Several reasons can cause early difficulty in reinforced concrete structures, but corrosion of steel is the most common culprit. In all places throughout the world, corrosion appears to be an all-pervasive problem that is destroying all kinds of structures and has been dubbed "Cancer" for concrete.

The protective oxide film on the reinforcing steel's surface is removed when the low pH front comes close to it, allowing corrosion to occur if oxygen and moisture are present, both of which are required for the corrosion reactions to occur.

Failures Identification and Concrete Structures Defects

Diagnoses that accurately pinpoint the source, nature, and extent of damage as well as any resulting structural deterioration are critical, as an incorrect diagnosis can lead to poor material selection or restoration techniques that result in the treated zone failing once more. Once the essential repairs have been made, the structure's operability may be required as well. Concrete cracks can appear for a variety of reasons, but if the fractures are particularly deep, the structure becomes dangerous to occupy. The water and air bleed from the base concrete to the higher surface causes a void to form. Preventing delamination can be accomplished by the use of post-processing techniques like blistering. Finishing the project should be started as soon as feasible after the bleeding has stopped. (Dejke, V. et al., 2001)

Repair And The Need For Concrete Structure Rehabilitation

Many structures of reinforced concrete (RC) are decaying, often early, and have to take corrective action to restore their safety and/or serviceability. Structural repairs and rehabilitation are the reconstruction and renovation processes of an establishment or its structural elements. This includes diagnosing the origin of distress, removing damaged materials and sources of distress and choosing and using appropriate materials for restoration that prolong the life of your construction. (Zhongwei Guan 2013)

Any of the following may be necessary for structural repairs:
The structure's defective design
Improper performance and poor performance
Extreme weather conditions and environment
High level of chemical assault
Structural ageing

Various Ways For Repairs And Rehailitation Of Concrete Structure

A repair strategy will be chosen based on a variety of factors, such as the extent and kind of damage, the structure's function and value, the availability of appropriate materials and repair facilities,. Compression, tensing, twisting, and flexing are all methods of manipulating buttons. Every failure is possible, depending on the type of loads the concrete is subjected to. Some concrete structure repair and rehabilitation approaches include the following: Blistering and elamination are both examples of blistering. A concrete slab is isolated from its subsurface by a thin layer of concrete. Delamination occurs when the cement on top is hardened before the cement on the bottom is. (Ferhat et al., 2013. It generates a void because of the water and air bleed from the base concrete to the upper surface. Finishing processes like blistering can help avoid delamination. Begin finishing after the bleeding process if as all possible.(Udhayakumar, 2007)

Resin Based Repair of Concrete

Epoxy, polyester, acrylic, and polythene are common resins. When using resins for repairs, it is critical to have a thorough grasp of their structural performance over time and in severe environments, especially. The materials are generally used to repair and restore qualities such as strong strength (i.e. thin sections), excellent adherence (i.e. small patches), faster curing (i.e. time savings) and a high chemical strength. (Zhang, et al., 2005)

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Concrete Repair By Epoxy Resin
Once the resin & hardener are mixed, the chemical reaction starts. Most combos are of 30 to 60 minutes pot life. They create great resistance and adhesives and, besides having strong waterproofing, are resistant to many chemicals. The coil vessel comprises mainly of an inlet and outflow vessel for resin mix, pressure gauge, compressed air connection with a pressure grouting regulator (10 – 15 kg/cm2 to withstand pressing). In the grouting vessel, a pre-mixed resin + hardener is injected through the dump in the crack. The grouting is transported in the next bucket when cracks are filled.(Xiang Kai &Wang Guo-hui, 2013)

Bonding Old To New Concrete
Epoxy resin is utilised successfully to connect old and new concrete with an unique Polyamide Härter Combination.

The method involves — Lose and damaged cement emoval by mechanical means or by water jet The drying surface is A suitable epoxy resin (special grade unmodified solvent with a stiff nylon brush) is applied.

If the epoxy coating is free, the fresh concrete should be spread.

Epoxy resins are used in construction, not as a fundamental source of energy. Because these resins are so expensive, it's critical to use them wisely Epoxy and other synthetic resins will find new uses in the future.

Polymer Concrete Composites
Most flaws in normal construction concrete can be fixed by applying a surface coating or impregnating the structure with polymer concrete composites. Structural applications of polymer-concrete composites date back to 1950, but the materials themselves are new. Most other materials can't stand up to their chemical and acid resistance, and they're exceedingly strong. Polymer impregnated (PIC) polymer concrete composites include PIC, PC, polymer cement, and modified concretes (PCC or PMC). This type of concrete, known as polymer-impregnated concrete (PIC), has pores that may be filled with monomers like styrene to make it watertight and chemically resistant. A polymeric ingredient (latex and pre-polymer) is added to PCCs and PMCs during the mixing process, along with the standard cement composite. (Illen, et al., 2012)

Sealants
Crack sealing in concrete buildings may be accomplished with a variety of commercial sealants. Structural integrity and serviceability may be ensured by using joint sealants. Toxic liquids, gases, and other undesired contaminants can degrade the quality of concrete if they are transported there (Panigrahi et al., 2014) Initially, the fissures are expanded along the face and pointed with screened material when the damaged surface is restored.

Surface Concrete Treatment

To guard against mild conditions of attack, applications of sodium silicate and silicon fluoride are used. Insect and borer protection is provided by bitumen and charcoal tar. Durability of concrete has also been improved by the use of plastic, rubber latex fibre, and PVC coatings.

Steel Fiber Rainforced Concrete
The inclusion of small steel fibres in concrete diameter improved a number of concrete properties, including its tensile, impact, and wear resistance. repairing and rehabilitating concrete structures with steel fibre reinforced concrete is one

usage (SFRC). Using guiniting or shotcrete procedures, so that the SFRC can be installed on the sides and bottom of the structure.

Repair And Rehabilitation Materials Other Than Concrete

Certain buildings may be repaired using a wide range of materials. New chemical grouts have been developed for foundation repair to ensure soil compaction and steel reinforcement protection. The machine foundations and underground structures were repaired with superplastized fiber-reinforced concrete. In order to cover concrete surfaces or bars that will endure harsh conditions, specialised latex or bitumen-sized paints have been developed. (Yasmeen et al., 2010)

LITRATURE REVIEW

This chapter provides an in-depth look at the work being done to strengthen and rehabilitation old concrete structure, including study of basic beam rehabilitation and their qualities, as well as modification strategies for boosting their performance, are all discussed in the literature study (Fei Yan et al., 2016)

(Ashutosh Sharma et al., 2015) Non-destructive tests utilising ultrasonic waves were performed to track the progression of corrosion in FRP sheet-bonded reinforced concrete cylinder reinforcement. GFRP and CFRP sheets were used to repair these concrete cylinders after they were exposed to a chloride environment for a short time. (Hawileh et al., 2014) investigated the load carrying capacity of shear-deficient RC beams with externally bonded CFRP sheets. Flexural longitudinal reinforcement was found to improve the shear strength of RC beams by a significant margin. For the experiment, thirteen beams were divided into three groups by the shear span's absence of transverse reinforcement and by the longitudinal steel reinforcement ratio used in each group.

(Panigrahi et al., 2014)Epoxy-bonded di-directional GFRP fabrics were used to examine RC T-beams. It was tested under four-point bending by casting 12 beams and employing mechanically-anchored bonded GFRP sheets to strengthen them in shear. Due to the fact that it eliminates de-bonding and efficiently utilises GFRP sheets, the results demonstrated that this technology is effective and significantly increased the shear capacity.

(Xiang Kai and colleagues. 2013) An investigation was carried out using carbon fibre reinforced polymer sheets enhanced by fire-damaged concrete (RC) to develop a method to calculate the flexibility of the beams. A method was developed to calculate the bending moment of a fire-damaged RC beam section reinforced with CFRP sheets on the outside

Research by (Haddad et al., 2013) looked at how shear-deficient reinforced concrete can be repaired using advanced composite materials. The experiment makes use of prototype beams that have undergone a significant amount of sulphate cyclic degradation. Fiber reinforced polymer (FRP) sheets or strips were used in various designs to repair these beams.

(Ferhat Aydin et al., 2013) To find out more about the hybrid concrete-GFRP beam, studied the characteristics of several GFRP profiles. GFRP box profiles were used to cast hybrid building elements and many flexural behaviour tests were conducted. He also looked at the effect of employing epoxy to glue sand particles to the inside surface of the GFRP profile on the concrete's ability to stick to it and vice versa. (LuisValarinho et al., 2013)It has been shown in an experimental study that annealed glass panes strengthened with fibre reinforced plastic pultruded laminates (GFRP) in continuous beams can effectively redistribute internal forces after cracking.

(Attari et al., 2012) In an experiment conducted the effectiveness of FRP fabric (Glass–Carbon)-based external strengthening systems for reinforced concrete beams was examined. It was decided to use a 4-point bending device to conduct a failure study on seven flexural reinforced concrete beams that had been cast and tested.

Siddiqui (2009)An experiment was conducted on reinforced concrete beams using FRP composites that were externally bonded. Beams were put through their paces in terms of flexural and shear strength tests. Both bonding at the tension face and bonding at the tension face with end anchorage have been adopted for flexural strengthening.

(Pannirselvam et al., 2009) examined the strength of beams covered in GFRP laminate. It was found that crack, yield, and ultimate loads had different deflection details that corresponded to their respective crack widths, as well as deflection and energy ductility ratios.

Compared to reference beams, it was found that the ultimate load bearing capacity was up by roughly 85.70 percent, the deflection ductility value was up by 64.48 percent, and the energy-ductility value was up by 118.90 percent as a result of the examination.

(Biswarup Saikiaet et al., 2006) examined the strength and serviceability of GFRP-reinforced beams constructed using limit state concepts. GFRP reinforced beams showed a block type rotation failure during the analysis, however control beams reinforced with steel rebars showed a flexural failure at the same time. For the purpose of analysing the strength of GFRP reinforced beams, an analytical model was developed. The analytical model's predictions are compared to the experimental data.

(Tarek H. Almusallam et al., 2006) Each category had unstrengthened and strengthened beams, for a total of 84 beam specimens. In order to evaluate the specimens' performance, researchers calculated their flexural capacity and load–deflection relationships before putting them in various situations. Despite being subjected to various climatic conditions for six, twelve, and twenty-four months, the tests showed that the flexural strength of the beams was unaffected by any of them.

(Sim et al., 2005) conducted studies on the reinforcement of RC beams utilising Russian-made basalt fibre sheets with 1000 MPa stress strengths. Single, double, and three layers of basalt fibre sheet were used to reinforce RC beams. According to the results of their research, a two-layer strengthening scheme outperformed a single layer and three layers in terms of results.

(Zhang and Hsu 2005) Beams without shear reinforcement were used in tests After 28 days of drying, the CFRP was used to wrap the beams in this photo. The results of the tests showed that the concrete beam's serviceability, ductility, and ultimate shear strength may all be greatly improved using the CFRP system.

(Brena et al., 2003).R.C. beams with CFRP flexure strengthening strips were put to the test, They ran a test to see if the FRP strips could be strengthened and also to see if they could fail owing to the de-bonding process. End anchorages were found to prevent failures from de-bonding and enhance the ductility of beams when used.Synthetic FRPs including carbon, aramid, and glass fibres are frequently used to reinforce degraded reinforced structures.

METHODOLOGY

Necessity For This Study

Because of the current degradation of the environment and the depletion of natural resources, it is imperative that existing structures be made to last longer. It's critical to repair structures that have been destroyed by human activity, poor design, natural disasters, and other factors. In order to extend the lifespan of damaged structures, rehabilitation strategies must be highly effective. As a result, after structures have been repaired and rehabilitated, it's critical to assess their performance. It's also important to look into the materials' strength qualities while designing a rehabilitation programme. When a building starts to fail, it needs to be reinforced. To keep the structure stable, all of its parts must be strengthened at the same time (Sundarraja& Rajamohan, 2008; Francesco Bencardino et al., 2002).

Objective

The primary goal of this study is to discover an effective strategy for strengthening and repairing flexural components.

Beams Strengthening And Rehabilitation

In order to improve the structural element's load carrying capability, stiffness, ductility and stability the idea of strengthening and rehabilitation was developed. Structural changes, insufficient longitudinal main reinforcement, (Tara Sen HN 2013)

insufficient stirrups, and design or construction errors all call for strengthening of reinforced concrete beams. The goal of this research is to determine the flexural behaviour of reinforced concrete beams that have been strengthened and rehabilitated with woven roving and chopped strand wrapped fibre reinforced polymer composites.

Strengthening of Rc Beams

To optimise structural behaviour, the RC beams are wrapped in FRP and jacketed in concrete. In this chapter, the various strengthening methods used in the study are discussed in depth.

FRP Wrapping for Strengthening

The fiber-reinforced-plastic (FRP) covering strengthens the cast-in concrete beams. It's done with woven roving mat and chopped strand mat, two different forms of FRP materials. In order to determine the effect of wrapping a beam specimen in these mats, several designs and layers are used. Before covering the concrete with GFRP woven and chopped sheets, it had to be prepared. After roughening up the treated surface with coarse sand paper, it was thoroughly cleaned to eliminate any remaining dirt or debris. According to the manufacturer's recommendation, the epoxy and resin were combined in a plastic container at a ratio of 100:9 (Araldite AY 103-100 parts by weight and Hardener HY951-9) before being applied.(J A &Saqan E I, 2014)

Using External Jacketing To Increase Structural Integrity
Another approach of strengthening is to use an external jacket. Adding a second RC layer to the beam improved the flexural behaviour significantly. (Vani, 2017)

Concrete jacketing was used to increase the strength of the cast reinforced concrete beam test specimens. Adding reinforcement to the beam specimen is accomplished by lightly chopping the surface, after which it is filled in concrete on all sides by placing it in the mould. After a day, it is taken out of the mould and submerged in water for 28 days to cure before being tested.External jacketing with 2 Nos of 10mm diameter @ top and bottom and 6mm diameter stirrups spaced @ 175mm c/c strengthens and rehabilitates reinforced concrete beams cast with M20 grade concrete.

Provisions for Strengthening

RC Beam Rehabilitation
This research was done on the behaviour of a reinforced concrete beam after it had been fitted with FRP wrapping and a concrete jacket. The beam is subjected to an initial load derived from the control beam test in order to produce the damage condition necessary for rehabilitation. (Al-Sedyiri, 2013). Using a control beam that was tested all the way to its ultimate limit, the load at cracking value was determined for the retrofitting beam. A cracking point was found during the testing phase, and the relevant loads and deflections were recorded. This initial cracking stress served as a benchmark for inflicting damage on the beams so that their behaviour could be investigated after they'd been repaired. The middle third flexural loading was used to test these beams. Initially, beams were loaded all the way to the first crack, then the load was withdrawn fully and the beam was allowed to return to its original position. out. This was followed by rehabilitating beams with GFRP wrapping under a variety of schemes and external jacketing after they had been removed from the test set up.

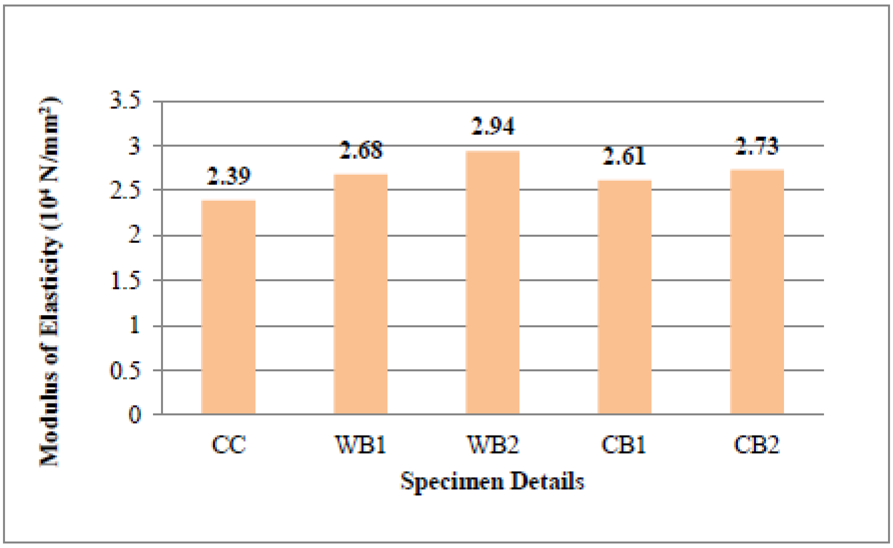
COMPANION SPECIMEN TEST RESULTS

Before examining the structural behaviour of RC beams externally coated in GFRP woven roving and chopped strand mat, the strength properties of concrete specimens wrapped in Woven roving and Chopped strand mat must be evaluated. Concrete strength parameters were studied in the laboratory utilising companion test specimens such as cubes, cylinders, or even prism specimens.

The compressive strength, split tensile strength, modulus of rupture, and modulus of elasticity of both types of FRP employed in this study were all measured on test specimens that were cast and wrapped in single and double layers, respectively.

These mechanical strength metrics were examined together with the impact wrapping had on the cylinder, cube, and prism specimens.

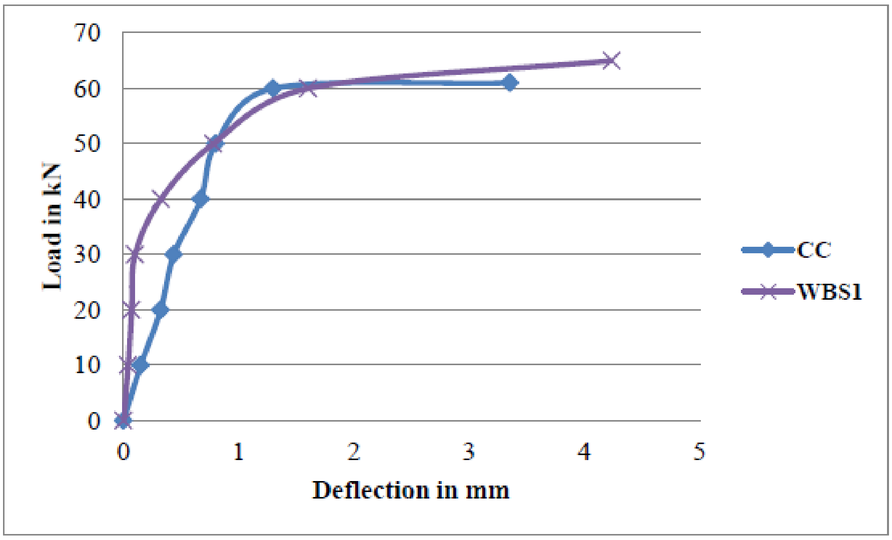
Roving mat in two layers has a higher modulus of elasticity of roughly 1.23 times that of the control prism, as shown by the above study on modulus of elasticity.



Modulus of Elasticity values

Assessment of Beams That Have Been Rahablitated With Frp

Static loading flexural behaviour of beams is thoroughly studied. It was computed and compared the load capacity, load - deflection curve, stiffness characteristics and ductility factor of the strengthened beam for several wrapping schemes to discover the best suited approach for strengthening RC beams.



Beam WBS1 Load-Deflection Curve

Compared to all beams, including the control specimen, the descending part of WB2's load-deflection curve has a less steep slope. All types of reinforced beams have a high load carrying capacity in the final stage. Although WBS1 was the strongest beam, it could only deflect 4.239mm at its highest point, while beams WB1 and WB2 both deflected 3.37mm and 4.232mm.

CONCLUSION

A flexural member was evaluated for different wrapping strategies such as Woven Roving Mat, Chopped Strand Mat, and Jacketing techniques under strengthening and rehabilitation conditions provided at various positions and different layers on the beam specimen, and their performance was studied under a two-point static loading condition. This research was made to assess the experimental and analytical investigation procedure. Important results have been reached as a result of these in-depth experimental research. Companion specimen research yielded the following findings:

The specimen with two layers of wrapping mat performs well under all test settings in all aspects. The cement bonding was not suddenly broken because of a failure of the adhesive. For example, a cube wrapped in two layers achieves 28.42 N/mm2 compression strength, a woven and chopped mat achieves 27.92 N/mm2, and the CC has a value of 23.68 N/mm2. A 20.02 percent increase in strength is achieved by using two layers, while a 17.91 percent gain is achieved by employing chopped woven mats in comparison to conventional cotton yarn.

The standard concrete cylinder has a split tensile strength of 2.86 N/mm2. The GFRP woven roving mat's strength rose by 19.23% and 42.66% when wrapped in single- and double-layer GFRP. While the specimens were wrapped in GFRP chopped woven mat as a single or double layer over the specimen, the strength values improved by 15.38 percent and 37.06 percent.

The flexural strength of Conventional Concrete was tested using a prism specimen, and the results were 3.40 N/mm2. Single and double layer GFRP wrapping of woven roving mat raises this prism's flexural strength to 8.82% and 20.59%, respectively, whilst chopped mat raises it to 8.24% and 12.94%, respectively, from the CC specimen. It is calculated that for the CC specimen, the Modulus of Elasticity is equal to 2.39x 104 N/mm2, whereas for other specimens, it is 2.68x 104 N/mm2; 2.94x 104 N/mm2; 2.61x 104 N/mm2; and 2.73x 104 N/mm2 respectively.

These values are higher than the control specimen by 12.13 percent, 23.01 percent, 9.21 percent, and 14.23 percent. The experimental study on strengthened beams came to the following conclusions:

Compared to CC, all types of reinforced beams have increased their weight carrying capacity. The best results are obtained when the FRP beams are wrapped in two layers of woven or chopped mat FRP at the bottom.

There was a maximum deflection of 4.232mm in Beam WB2 and 3.519mm in Beam CB2 when they were loaded to 85.00kN and 84.00kN, respectively. While the woven mat did not tear out while applying the load, both wrapping patterns had adequate bonding with the specimen and finally disperse the weight across the entire tension zone.

Beams reinforced with woven and chopped mat FRP had better load carrying capacity and deflection criteria than control specimens. There is a 4.90 percent increase in weight carrying capability for each additional beam. a shift in location Beam ductility is also high, indicating the beam has strong ductility behaviour under load action for WB2 and CB2 beams. The ductility of the GFRP-wrapped specimen is better than that of the traditional specimen.

Another way to boost load carrying capacity is by using an external jacket, but this procedure is more time consuming than wrapping. When the rehabilitated beam is wrapped in a woven fabric mat with a double layer (RWB2) and positioned at the bottom of the section, the flexural behaviour improves dramatically. The ultimate load capacity of this beam is 77.50kN, and the maximum allowable deflection is 3.89mm.

It has taken an ultimate load of 76.5kN and maximum deformation of 4.23mm in the same way as the RCBC2 beam has.

Scope of Future Study

The M20 concrete grade was used for this study's construction. This work will be done with high strength concrete in the future.

These mats were taken out of the repaired specimen because of their poor bonding. Woven mats and chopped GFRP mats were also used in this operation. Epoxies of higher quality can be used in the future to strengthen the bond strength between the damaged surface and the mat.

Shear mats had no effect on the test findings due to ribs that sprang from the concrete surface, hence only tension mats should be used in the future.

GFRP/CFRP mat wrapping may be studied to improve the shear strength of the beams.

Other structural elements such as columns and beam-column joints that are externally wrapped with GFRP/CFRP mats can be studied in the future.

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