Rehabilitation and Repairing 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. This FRP wrapping strengthens the structural integrity of the structure by acting as an outside strengthening layer to the structural elements. 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.

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.

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. These factors, like as soil conditions, are met when materials are suitably selected and match code specifications. (Abdel et al., 2007)

One of the most common causes of structural weakness and safety issues, as well as eventual failure, is the failure to properly select the material. When preparing a concrete mixture, different negative elements such sulphide in soil or groundwater and freezing and thawing should be carefully examined.

Incorrect Design of Concrete Structures Calculation and Detailing

When considering designs for undesired events and expensive structural improvements, extreme caution is required. Therefore, a comprehensive inspection to check that the sizes, thicknesses, and reinforcing distances and sizes of reinforced concrete are enough to handle the most important load combinations is recommended. The examination must include structural stability as well as usability and robustness.

Wrong Techniques of Construction and Insufficient Quality Considered Supervision and Control

Failures caused by concrete's resistance to movement, abrasion, moisture and temperature changes, freezing and thawing and overloading can be attributed to environmental or mechanical factors. The use of substandard construction methods and materials combined with shoddy workmanship, subpar craftsmanship, and shoddy materials will lead to poor structural performance and, eventually, failure of concrete structures. Table 1 outlines common construction issues and their relationship to structural failure. (ACI Committee 440 2007)

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). When the temperature drops below 0 degrees Celsius, the water in the cement paste's capillary pores freezes solid. Because the gel pores are so small, water inside of them freezes even in the middle of winter. Excess water in the capillaries must be moved since it grows by 9 percent when frozen. 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.

With a higher dose of AEA, more air is entrained, but the impact is not linear and with most agents, higher doses plateau out.. More air is entrained in mixes with a higher slump. Very stiff mixes are difficult to entrain air into, and their particle size and type have a significant impact on how much air is actually entrained. Air entrainment experiments have indicated that sand is the most important cause.

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 ConcreteConstruction (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 buried steel should be adequately protected by good concrete, according to idealists. (Biswarup Saikia, et al., , 2006)

LITRATURE REVIEW

This chapter provides an in-depth look at the work being done to strengthen andrehabilitation 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)

(Tara and Reddy, 2013) Using jute as reinforcement in concrete, tested the strength of the structure compared to that of CFRP and GFRP. Various failure modes, flexural strengthening effects on ultimate load and load deflection, ductility studies of RC beams externally bonded with JFRP, CFRP and GFRP for both complete wrapping and strip-wrapping methods, etc, are all included in this report Overall, with full wrapping technique (62.5%, 150%, and 125% for JFRP), and 25.5%, 50%, and 37.5% for strip wrapping technique, respectively, the RC beams' ultimate flexural strength was increased by RC beams by a factor of three. A high deformability index for jute textile FRP demonstrated the material's enormous potential as a structural reinforcer.

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. A series of tests was performed on the repaired beams to determine their shear strength capacity as well as their stiffness and deflection. The findings of these tests were compared to those of controls as well as damaged beams that had been exposed to sulfuric acid.

(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. Its production with excellent physical and mechanical qualities, he found, had a
favourable impact on the study's overall results. Hybrid beams' flexural and fracture toughness ratings improved dramatically, according to the research.

(Luis Valarinho 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. The study also included several other test such as material characterization tests, tensile tests, and flexural tests, as well as tests to determine the effect of the adhesive used. Thetype of adhesive used to link GFRP to glass has a considerable impact on the ultimate load and post-cracking performance of multi-span beams.

(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. They also said that this basalt fibre sheet strengthening could be a good alternative to conventional FRP strengthening systems because of its moderate structural strength and great fire resistance. As we all know, shear failure can strike at any time and without warning, thus it's always better if the beam breaks in flexure rather than shear. In these circumstances, FRP's externallybonded reinforcement comes in handy.

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).

Scope of the Study

To determine the best strategies for reinforcing and rehabilitating the flexural part, scientists are conducting this inquiry. As part of our research, we're trying to figure out the ultimate load carrying capability of reinforced concrete beams that have been strengthened and rehabilitated with a variety of FRP materials and a procedure known as external jacketing, they were compared to data from a control sample.

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

Until a uniform colour was achieved, the blending process was repeated. For the beam, pre-woven and chopped GFRP sheets were used. Over the epoxy resin, a GFRP woven sheet was put. Next, the epoxy resin was applied equally to the concrete surface. Aroller was used to remove the extra resin off the sheet. It was done to get rid of any trapped air between the epoxy resin film and the work surface. The operation with the steel roller was repeated after another layer of epoxy resin had been applied. To establish proper contact between the epoxy/concrete and epoxy/GFRP woven sheets, theair that had been trapped between them was evacuated. The procedure was carried outin a temperature-neutral environment. Before testing, reinforced concrete beams needed at least 48 hours to dry completely. (Tokgoz, 2011)

CONCLUSION

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 matas 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 thefollowing 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.
- The specimen's energy absorption is enhanced by the GFRP wrapping method as well. In comparison to other specimens, Beam WB2 absorbs a significant amount of energy. That woven roving mat-wrapped beam offers good deformation and elongation properties without tearing out of. When compared to woven roving mat, the chopped GFRP mat tore and didn't hold up as well.
- 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 inthe same way as the RCBC2 beam has.

  This study's findings suggest that FRP wrapping techniques are superior to external jacketing for strengthening and rehabilitation of reinforced concrete beams because theyare more cost-effective. The external jacketing modifies the structure's size (increases the structure's size), which is bizarre from an aesthetic standpoint.

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