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MECHANICAL TESTING AND FINITE ELEMENT ANALYSIS OF CFRP STRENGTHENED REINFORCRD CONCRETE BEAMS: A REVIW

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ABSTRACT

Nowadays Carbon Fiber Reinforced Polymers are widely being used to enhance the mechanical properties of Reinforced Cement Concrete. Previously many research works has been accomplished, where retrofitting is done by using Carbon Fiber Reinforced Polymer (CFRP). It has been already proved that use of CFRP can increase the compressive strength, flexural strength and other properties of concrete as compare to normal concrete. Researchers have also applied the check by comparing the results with the results of model providing same properties by Finite Element Analysis (ABAQUS OR ANSYS). In this paper a deep insight has been provided on the researches where mechanical properties of RCC is enhanced by using CFRP and results were compared with the Finite Element Analysis.

Keywords: *Finite Element Analysis, ABAQUS, Flexure strength, Repair and strengthening techniqu*

INTRODUCTION

The rehabilitation, maintenance and upgrading of structural elements, is reasonably one of the most essential problems in civil Engineering. The large number of structures build by using old code of design in past. Throughout the world the constructions which are completed till are not safe according to the update versions of codes. Since replacement and removal of such deficient structural members incurs much time and more money. Strengthening has the best way to repair or retrofit such type of elements and it is acceptable way to improve load carrying capacity, also improves their service lives. Infrastructure damage caused by premature deteriorations of structures and buildings hassled to the investigation of several process for strengthening. CFRP is a mixed and composite material of matrix and reinforcement to improve the strength matrix is a polymer resin (epoxy) to blind with the reinforcement and form a long chain. CFRP is high in strength and light weight. Approx five times more in strength and two times stiffer compare to steel. CFRP is high cost material than all other fibre materials (CFRP, GFRP & AFRP). Tensile strength, compressive strengths are very high and thermal expansion, density are less. CFRP is good electricity conductor and composites have high stiffness, strength and toughnes. It can also apply to increase shear capacity of RCC members through wrapping of fibres around the member section which is strengthening. It is also improve the section ductility, significantly improving the collapsing resistance under the hazardous loads. The use of composite materials is increasing all over the world for the repairing or replacement of reinforced concrete structures over the last few years and the use of FRP jackets or sheets to provide external confinement to reinforced concrete columns. The composite materials have appeared as advanced solutions by their stiffness and strength to weight ratios and by their non-corrodibility. less time and labor are required for installation. In the construction industry the application of FRP can reduce some of the no longer desired properties of high strength concrete such as its brittle (liable to break) behavior.

FINITE ELEMENT ANALYSIS

- FE Analysis can be done using FEM (finite element method) which is a numerical technique for simulation of the physical phenomenon here the physical phenomenon can be of any type.

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- To quantity (or) to understand any physical phenomena it was necessary for using mathematics.
- The physical phenomena include fluid behavior, flexural conduct, thermal behaviour, development of biological cells. In which most procedure were depicted by PD equation. Hence for computers in solving such PDE'S various numerical techniques were being developed since last few decades among those of a prominent one leading a very good position today was FEA.
- The differential equations not only can describe physical phenomena that have been occurred in engineering mechanics it can also describe of nature. But PDE'S are the equations that are complicated for solving to compute the structure related quantities such as strain, stresses for estimating behavior of the components that were investigated under the load was given.
- The importance of Finite element analysis just gives the solution approximately for a problem. it is a kind of numerical approach for getting the genuine outcomes of partial (PDE) equations.
- The described Finite Element Analysis is a method of numerical which is help to predict how assembly or a part behaves for the conditions that were given.

LITERATURE REVIEW

Dias, Barros, and Janwaen (2018)

This study is investigating the flexural behaviour of Rcc Beams by taking the NSM (Near Surface Mounting) technique strengthens with FRP laminates. 4 strengthened beams are tested and having cross section of 150 × 300 mm and lengths are 2600mm and 2400 mm. One beam is control and remaining beams are strengthened flexurally by using various % (percentage) of carbon laminates. Compression test is carried out on 150mm dia cylinders and 300mm dia from uniaxial tensile tests are Performed. Diamond cutter & LVDT's are used to measure the deflections. The Results are shows that CFRP laminates are very effective solution to increase cracking, whereas maximum loads and yielding of beams are failed in bending.

Jawdhari and Harik (2018)

To examine the RC beams clung to FEM is created. Two methods of failure were identifies, one is halfway crack initiated de-holding and concrete cover detachment. The RC beams are reinforced with various rodpanel setup fixed, for example, continous, over lapped and over lapped with anchorage jetty. In this trial different structures are made, for example, ultimate load, failure load, load mid range deflection history and so on these are researched by FE model. author is reasoned that the FE model furnished great relationship with tests and saw in different examination. CCS disappointment was reenacted by using the ductile pressure disappointment criteria. The contrast among anticipated and absorbed failure load shifted b/w 2.8% and 6.8 %. Author prescribes that field uses of CFRP to put fiber wraps at the board closures and finger joint area to stresses

Yang et al. (2018)

Investigating the flexure performance of a series RC beams are externally bonded (EB) with CFRP grid reinforced ECC matrix and 15 concrete beams are used among them only three beams are in control and the other remaining beams are strengthened with CFRP to prevent the end de-bonding failure provision of end anchorage is required.

Rajai Z Al-Rousan (2018)

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The conduct of the anchored CFRP concrete was examined with various dosage of MDSSF (macro dis-continuous structural synthetic fiber). In that 72 plain concrete beams were casted and tested. Researched parameters are samples of DSSF, scale of CFRP strips (sheets) and with anchored and without anchoring sheets. The behaviour of PC beams is tremendous sheet the attainability of utilizing full scale symmetric fibers and anchored sheets are improving. Because of the strength of CFRP sheets in the extension of the cracks, the cracking width diminished the expansion of Carbon FRP sheet and though the cracks length diminished with the increment of the Carbon FRP sheets length.

Benjamin kromoser (2018)

Accomplishing concrete components with thin walls and negligible wt. joining two elite materials i.e.; ultra-superior concrete as the matric and CFRP as reinforcement. The tested beams with 3 distinct sorts of inserts and 3 unique setups of the material CFRP support filling in as auxiliary and shear fortification. Beams with 3 sort of inserts and up to 3 distinctive layouts designs were moved compressive force effectively. The reasonableness of concrete inserts for carbon UTTPC beams exposed to high shear forces.

Bedon and Louter (2019)

The employments of hybrid and composite arrangements of auxiliary application speak to a typical methodology for the advancement of safe standards. The characteristic properties of rodss can generally to a great extent influence the general perceptions. Unpublished trial tests are quickly outlined first for a lot of 1 meter range LG specimens. Backing for starter exchange of the analyzed structure idea is likewise described from straightforward systematic results.

Chen et al. (2018)

The concrete used with treated steel RHS and SHS tubes exposed to inplane bending. Ultimate quality failure model flexural, solidness malleability and strains of test specimens are accounted. Reinforcing impact of CFRP was increased with the expansion of bita values. Flexural quality and stiffness of concrete filled steel of RHS and SHS were expanded with expansion of interface strength ratios between stainless steel cylinder and concrete up to 0.6.The ultimate strength are expanded with the increment of tubes proportion of stainlesssteel for concrete mixed with hardened steel RHS and SHS tubes with indistinguishable breadth and profundity of hardened steel tubes

Nguyen-Minh et al. (2018).

On the unbounded ligaments and the flexur conduct of UPCTbeams impact of carbon sheets and carbon U wrapped sheets are researched and measured in this investigation with the FRP bondpc beams repaired, ligaments and encompassing concrete keep up the integrity and along these lines the strain similarity conditions on ligaments, concrete& CFRP reinforcement is fulfilled. The flexural limit of the UPC beams (up to 37%) this upgrade would in general decrese of cfrp sheet proportion is expanded. Crack load is up to 26%, cracking widths are likewise fundamentally decreased up to one and half times and three and half times at the ultimate state and serviceability individually.

Zhang, Yu, and Chen (2017)

This study is on flexural strengthened RC beams with the help of NSM technique on CFRP strips. This design is the technique of Hong Kong guidelines. In this review he concluded that NSM method is enhancing the more properties than the EB method in flexurally strengthened RC beams. failure mode is de-bonding cohesion failure in NSM FRM to concrete by using the proper adhesive we get good results. He mentioned that the results must be needed.

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Jadooe, Al-Mahaidi, and Abdouka (2017)

In this study the anchor is investigated the effect of Near Surface Mounting of CFRP laminates repair of damaged(heat) Rc Concrete beams by testing the 8 RC beams were two are normal beams and the remaining 6 are tested under the ISO- 834 study fix curve at 600 and 700 degree C for two hours .The FEM were able to predict the behavior experiment. The experiment shown that all the strengthened beams shown high flexure strength compared with other damaged beams. The beams which are strengthened by NSM technique of Carbon FRP laminates using epoxy shown higher bearing capacity. The beams are regained the ultimate load carrying capacity up to 134% and 121% strengthened with NSM CFRP. The numerical study presented using a range of model based on ATENAGID and shown good capacity between experimental results.

Adel, Hamed, and El-kashif (2018)

This study is investigated the preloading effect of five RC concrete beams which are having with the same dimension and reinforcement details and the types of strengthening are used Jacketing and CFRP sheets along with the deflections & reinforcement strains has been also recorded . Results shows that increasing strength with the RC jacketing at preload level as on key role is increasing the flexure load and the deformation of Reinforced Concrete continuous columns while in case of strength, ductility and dissipated energy. It is concluded that there is no effect on the flexural capacity on continuous RC concrete beams if Carbon laminates are mixed as strengthened method.

(Subhani et al. 2017)

The author is to increasing the load carrying capacity Laminated veneer lumber (LVL) is used which is used in construction material available in Australia and few other countries. To enhancing the flexural capacity CFRP is applied on the tension side of LVL beams. In this study two analytical models are used, in that one is elastic-plastic behaviour and another one is non-linear behaviour. Total 98 number of beams are casted for testing in that 3 are control beams, three are strengthened using CFRP strips and remaining three are strengthened with CFRP wrapping (U wrapping).

Firmo et al. (2017)

In this study numerical simulations on fire behaviour of RC concrete beams are flexurally strengthened with Corbon FRP strips and by using EBR&NSM techniques the physical & mechanical properties of materials are taken in to the consideration. 3D model was tested through finite elemental analysis by using the ABAQUS software.

Dharsini et al. (2014)

This study is for bonding effects behavior of Epoxy CFRP. The CFRP and epoxy interfere region is weak region in the matrix. 2D micro finite element model is along with epoxy ABAQUS software is used to understand the behavior of matrix and their stiffness and strength and tensile stresses also analyzed. The anchor observed that when the tensile load applied single, the stress are high at top and bottom fibers and same stresses extended to interfere. Thus the main effect is where the applied combined loading application was effect interface region. Tensile stress at top and bottom fiber is initiating the damage.

Chellapandian, Prakash, and Sharma (2019)

Enhancing the mechanical properties of FRP under flexural strength. 8 square beams were casted and strengthened with NSM EB and hybrid strengthening (combination of both NSM and EB). A micro based nonlinear 3 dimensional FE model is developed to investigate RC beams. Results shown that load carrying capacity of hybrid

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strengthened beams are high compare to other techniques and significant residual capacity of higher displacement. Energy absorption capacity is high in hybrid FRP. Micro plane based FEM study is able to study the flexure behavior of concrete beams with Carbon fiber and without different CFRP strengthen behavior.

Ariyachandra et al. (2017)

To upgrading the flexural execution of (CFRP), the point to point test program is led to quality strengthened concrete beams to ensure delayed activity b/w CFRP laminate/concrete. The aggregate of twenty eight little scale Carbon fiber strengthened and control concrete beams were tried and by utilizing three point loading test. Untimely finished debonding is the most basic sort of failure wherein the CFRP concrete composite beams displays a few kinds of failure models in which happens at the interfaced of bond line or inside concrete spread area. As the load deflection bend can be partitioned in to two bits, the main segment almost a straight line and the second bit with level conduct and with little decrease on quality. The major flexural crack load conveyed by carbon fiber sheets and just as extent of the two segments depends on parameters.

Bocciarelli et al. (2018)

This study is based on numerical as well as analytical techniques to the impact of few parameters of the Carbon FRP strain distribution. Analytical estimate of axial load in reinforcement should count for the interfacial behaviour b/w composite and steel substrate. Numerical model is on de-bonding of CFRP reinforcement investigated in commercial finite element code Abaqus.

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