

Strength Analysis of RC Beam by using ANSYS: A Review

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Abstract: - The utilization of outwardly wrapped fiber reinforced polymer (FRP) sheets, strips or steel plates is a present and suitable method for increasing strength of reinforced concrete (RC) beams. Various authors have been concluded on reinforced concrete beams with strengthened with the utilization of fiber reinforced polymer composite. greater part of researches explained on shear strengthening compared with flexural strengthening, while several optimizations the effect of openings on shear and flexural separately with several loading situations. By wrapping Carbon Fiber Reinforced Polymer (CFRP) sheets, retrofitting of concrete structures provide a more economical and precisely superior substitute to the traditional techniques in many situations because it offers high strength, low weight, corrosion resistance, high fatigue resistance, easy and rapid installation and smallest modification in structural geometry. This study examined the effect of polymers on beam by reading many articles on strengthening of reinforced concrete beams with and without fiber reinforcement polymers.

Keywords: RC beam, CFRP, Strengthening, FRP, concrete.

I. INTRODUCTION

Composite materials are ready through two or more ingredient materials with many physical and chemical functions that when combined construct a material with characteristics completely different from the individual elements. Most ordinarily used material is Fiber strengthened polymer (FRP). The utilization of FRP as outer reinforcement has received a lot consideration from structural researchers. Its laminates have put on quality as outer strengthening for the strengthening of reinforced concrete structures. Externally bonded FRP laminates and materials will be used to augment the flexural strength of reinforced concrete beams. Externally wrapped fiber reinforced polymers (FRP) is a structural strengthening method in reaction to the high want for repair and strengthening of reinforced concrete structures. The FRP reinforcement has revealed to be appropriate to the strengthening of structural components or restoring of damaged structures of, like columns, beams, slabs, etc. Presently, FRP materials are broadly used to augment the flexural and shear capability of RCC members. Finite element research is also employing to evaluate these type structural components. FEA is a process worked for the estimation of structures, supplying a precise computation of the component's response subjected to various structural loads. The employ of FEA has been the preferred method to analyze the actions of concrete as it is much faster than the

investigational way and is cost effective. With the arrangement of complicated arithmetical tools for study similar to the finite element technique it has turns into probable to mold the complex actions of Concrete beams by FEM techniques. Finite element technique is a mathematical analysis process which separates the structural component into lesser parts and after that simulates static load in circumstances to calculate the response of concrete. The employing of this method is rising as a result of huge progression of engineering and computer knowledge.

II. FINITE ELEMENT FORMULATION

Finite Element Analysis

The stress examination in the areas of civil, mechanical and aerospace engineering, naval architecture, and nuclear engineering is invariably complicated, and for several of the issues, it's extraordinarily troublesome and tedious to get analytic solutions. In these situations, engineers' generally alternative to numerical methods to simplify the problems. An analytic solution is a mathematical modeling that analyses the value of the field variable at any place in the body. For problems concerning complex boundary circumstances, it is complicated and in many times intractable to generate analytical solutions that satisfies the leading degree of difference or give the acute importance to the governing functional. The three mathematical methods that give estimated solutions are practical approximation, limited difference method and finite element process.

Finite Element Method

Finite part technique is a vital and powerful tool for resolution structural issues not solely with in the marine field however conjointly within the style of most industrial merchandise and even in non-structural fields. FEM is used to a good style of issues in linear and nonlinear solid mechanics, dynamics, and submarines structural stability issues, in accordance with the event of engineering. The standard technique in resolution stress associated deformation issues is an analytical one victimization theories of beams, columns and plates, etc. thus its function is constrained to simplest structures and hundreds. Within the finite part technique, the answer region is use in account as engineered of several small, interconnected sub regions referred to as finite components. Since it's terribly tough to search out the precise response of difficult structure

below specified loading conditions, the structure is approximated as composed of different divisions within the finite part model.

Types of FRP

Various kinds of FRP materials are there in the marketplace base on the content used to build them. These are CFRP, GFRP and AFRP. They have more strength and more stress compared to ordinary steel. *CFRP (Carbon Fiber Reinforced Polymer)*

They include fibers of carbon as an exterior mediator and their crystal structure is microscopic which makes its very strong reinforcing material. Fibers utilize to build them are very fewer in diameter 0.005 to 0.01mm. Figure 1 shows the CFRP. They can be further classified into various groups base on the elastic modulus, stress and elongation. CFRP have been utilized in different industries like automotive, aerospace and building structures. They also been using in other applications because of their low weight and stiffness.



Figure 1. Carbon fiber reinforced polymer (CFRP)

GFRP (Glass Fibre Reinforced Polymer)

They have been used in the industries because of their light weight. They could be made of polyester, epoxy and phenolic. They have high impact strength, environmental damage and resistance tolerance. A GFRP has been explain in figure 2.



Figure 2. Glass fiber reinforced polymer (GFRP)

AFRP (Aramid Fiber Reinforced Polymer)

Aramid is a synonym of “aromatic polyamide”. They are quality heat resistant material and have been utilizing in military camps and aerospace industries. Molecules of these fibers are joined with strong hydrogen bonds shown in figure 3 that help in mechanical heat transfer. They are to thin than

human hair and are sensitive to temperature and UV a ray which makes them unsuitable in structure applications. A typical AFRP has been seen in figure 4.

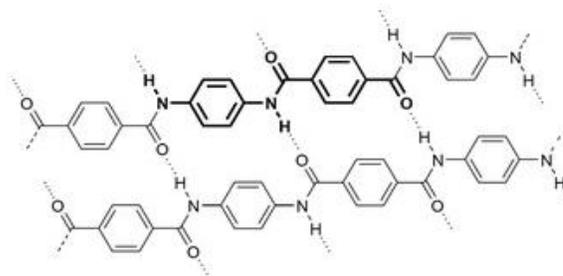


Figure 3: Hydrogen bond connections



Figure 4: Aramid fiber reinforced polymer (AFRP)

III. LITERATURE SURVEY

V. S. Pawar et. al. (2016) they analyzed three models of RC beams modeled In Ansys software to find out the effect of percentages of steel reinforced in flexural behavior as under, balanced and over RC elements. Nonlinear FEM analysis is applied to examine RC beams up to failure with FEM software ANSYS. RC models designed to the four points bending are modeled considering the frequent use in the laboratory. FE models of RC models, Designed in ANSYS 15 employing the concrete component have precisely found the nonlinear flexural response of these systems up to failure.

Pradeep singh et. al. (2016) they investigated the FEM analysis of RC beam using Ansys and find out the effect of different Fibre reinforced polymer. The FRP material used the same as an exterior strengthening extensively to compact with the strength necessities connected to flexure and shear in structural arrangement. Concrete beam designed in Ansys then FRP material laminated above it and calculated the effect of tension and different loading conditions.

N. F. Heny et. al. (2016) they studied about finite element modeling of FRP- coated concrete employing modified concrete broken plasticity design. A parametric analysis was found out to estimate the sensivity of the stress-strain and lateral strain-axial strain performances to dissimilar input materials parameters. Modifications were initiated to the concrete broken plasticity model used for Fe modeling of FRP coated concrete columns under monotonically functional axial compression. Then consequences of the customized concrete broken plasticity model were compared with investigational

outcomes of FRP wrapped circular and rectangular concrete specimen. FE results generated with the planned model were in extremely superior bond with the test data.

A. S. Harihar et. al. (2016) they studied about the nonlinear FE Analysis that has been found to simulate the performances of RC beams strengthened using CFRP sheets. FE models were designed depends on investigational tests performed by the authors in a preceding investigation. Four point bending analysis is carried out for the RC beam. FE software ANSYS 14.0 is used for modeling and analysis by conducting non-linear static examination. They investigated the flexural performances of RC elements strengthened by CFRP sheets. From the investigation outcomes and calculated strength values. As predicted the flexural potency and rigidity of the strengthened beams improved compared to the control samples. The reinforcement provided increases the strength also increases by the increase in many layers of CFRP sheet the strength and hardness also increases.

V. B. Dawari et. al. (2014) they analyzed the nonlinear Concrete design for FE examination of RC Beams. They investigate on non-linear flexural parameter of RC beams. Non-linear FE examination of concrete elements under flexural loading is explained in this Study. FE modeling of RC elements is found by discrete reinforcement modeling method. The capability of the design to detain the vital crack areas, loads and deflections for different loadings in RC beam has been demonstrate. Comparison is analyzed between the experimental outcomes and FE analyses concerning primary crack formation and the ultimate load competency of beams.

P. Prandaman et. al. (2014) they studied about the FE investigation of beam retrofitted with special FRP composite sheets found by the ANSYS software. Three RC elements with special FRP combined sheet sample were designed by Pro-E software. The first RC beam coated by CFRP material, other with GFRP sheet material and third with KFRP sheet. The performances of the above three retrofitted beams were compared with the controlled specimen and then results shows when RC beam is wrapped with CFRP, GFRP and KFRP then deflection of composite beam reduces as compared to the RC beam specimen. They explained that the strength of the RC beam is increased by retrofitting with FRP.

T. Subramani et. al. (2014) they studied about crack detection in RC beam with Ansys software. FE models of 3.0 m in general RC beams, designed in ANSYS V8.0 with the concrete elements have precisely detained the nonlinear flexural performances of these systems up to failure. The element employs a smeared crack model to permit for concrete cracking with the option of designing the reinforcement in a distributed or discrete behavior. In this study the modal parameters of an undamaged beam are examined and compared with the vibration performances of the beam subjected to control damaging. Preferred stiffness factors in the FE model are managed in such a way that the computed design quantities equivalent the measured

quantities. FEM tool has been employed to cause a damage formation in beams associated with increasing stress patterns.

Sankar Jegadesh et. al. (2014) they studied about a non-linear finite element analysis procedure is adopted with the Softened Membrane Model (SMM) and Macgregor Model that incorporates the material qualities and performances of RCC member which can be applied to obtain the shear behavior. The FE package ANSYS with its 3D Modeling is used as a tool for the analysis of the RCC beams. The 3D concrete Solid 65 FE model is employed in this research to model the nonlinear performances of RC beams. The analysis is derived from the 5 factor plasticity crash surface because of Willam-Warnke. The load deflection bend investigation is done in ANSYS and the outcomes are compared with the available experimental results taken from the literature. The prediction of the ultimate load by the two different models throws light on the fact that SMM predicts conservative results when compared with the experimental and analytical data.

N. S. Badiger et. al. (2014) investigates bending analysis of RC beam. The outcomes of the design beam regarding mesh size, changeable depths, and apply of steel cushions for hold and loading points, effect of shear reinforcement on flexure proceedings, impact of tension reinforcement on actions of the beam are analyzed and discuss. Finite element software ANSYS 13.0 is used for designing and examination by performing non linear static investigation. A conventional beam is examined using a specific set of control data and is then compared to the succeeding models by varying the parameters. The parameters used to complete this study are varying depths, steel percentage, and steel pad and shear reinforcement.

M.P. karthik et. al. (2014) they studied about performances and shear performance of hybrid fibre RC beams. They investigate to explain shear cracking action of hybrid fibre RC beams, through the combination of scrim bled steel fibre and synthetic fiber like recycled polyethylene therephthalate and polypropylene during the amount part of 0.5%. The mechanical functions and shear performances were calculated for concrete prepared using various hybrid fiber combinations like ST-pp and ST-RPET. The investigational outcomes were explored with the nonlinear FE analysis using ANSYS 12 that has been evaluate to simulate the action of failure modes of Hy-FRC beams. The outcomes explain that the mixture of ST-PP is relatively similar with the experimental investigation.

M. S. safna et. al. (2014) conducted numerical analysis CFRP coated RC columns. A RC column model was calibrated to experimental data, and the ultimate load handling potential and load deflection curves were compared to the investigational outcomes. This study mainly explained with the numerical examination of CFRP coated RC beams. At this point CFRP coated RCC column is examined using finite element software, ANSYS. The nonlinear investigation is performed for concentric with eccentric loading of the RCC

column. The ultimate weight power of both wrapped and unwrapped RC column sample is evaluated by three dimensional models. The study assists to conclude the finest ply orientation from the six set of ply orientations calculated. The optimum ply direction plan obtained is 90/90/90/90. The work focused the appropriateness of CFRP coating for strengthening column.

N. K. Antony et. al. (2013) investigated the parametric analysis on the strength parameter of concrete beam by Ansys. They calculated about the evaluation of strength of a concrete beam forecasted using the models planned by IS code and Ansys software with the equivalent investigational shear force of the concrete beams. The limitations considered are shear extent to penetration ratio, proportion of steel and cube compressive force of concrete beam. The parametric examination on the shear strength of concrete beams is investigated by the samples planned by IS code and Ansys software. The consequences of the analysis give an insight to the range for the magnitude of the various parameters to be considered for the optimum action of several structural systems.

G. Vasudevan et. al. (2013) FE designing of RC beams and analyses beam using ANSYS 12.0 and the vital rate of the outcome are also compared with investigative data's planned using IS 456: 2000 codal provisions. Wide-range graphical presentation of the outcome for example deflected form of the beam, stress-strain difference along the length and depth of the beam and crack transmission is produced by generating a group files by the ANSYS parametric design. Relationship is prepared between the test outcomes, FE investigation and analytical ideals regarding first crack creation and the ultimate capacity of beams, so as to have a broad accepting on the action, which may decrease the physical destructive laboratory testing for the future researchers.

Vasudevan. G. et. al. (2011) parametric investigation on nonlinear FE study on flexural actions of RC beams using ANSYS. Outcome of the four point bending examination performed regarding concrete constitutive performances, mesh size, addition of steel cushion for the supports and loading points, effect of shear reinforcement on flexural action, convergence criteria, and effect of percentage of reinforcement are investigate. The conclusion of this examination will offer a wider stage for advance employing of ANSYS in the analysis of RC beams.

A M. Ibrahim et. al. (2010) they examined to observe the outcomes of various factors on the overall actions of outwardly prestressed beams in conditions of the results of compressive concrete strength and effectual prestressing stress. That performance was slightly affected compared with investigational outcome. The undeviated exterior tendons mobilized lesser small flexural resistance and inelastic deflection than deviated tendons did. The augment in the beam ability in the beam subjected to loads at the third extent is larger than in the beam by a single load at the mid – span.

The conclusion of raising the effectual depth is that the ultimate load power is effectively increased.

M. Safari Gorji et al. (2008) they study on the performance of FRP-Strengthened RC connections. The main purpose of this analysis has been contrast on the strengthening of the connections to get better their structural actions. A FE investigation using ANSYS was developed to perform a parametric investigation. The FE sample takes into concern the nonlinear action of the constituent materials. To model the anchorage slip and anchorage extension of the reinforcement in the external relations, the nonlinear spring sample was employed. The investigation outcome designate that utilize of FRP laminates increases both the stiffness and load carrying capacity of the RC connections. By raising the length of laminates for strengthening the joint, trends of development the structural action of connections have been intensified. The strength of the flexural cracking is reduced due to the presence of FRP composites reinforcement.

I. Elyasian et. al. (2006) they investigated the FRP shear strengthening of RC beams numerically using ANSYS. In all numerical models examined in this study, the stresses in FRP laminates increased gradually until major cracks occurred after which concrete crushed locally and reinforcements yielded. At this stage FRP stress increased at a relatively large rate to rupture. The interaction of different cross-sectional parameters and the FRP were investigated and the trends explained in relevant graphs and tables. The results show that FRP shear strengthening is quite viable and by choosing the parameters carefully adequate ductility can be obtained in addition to reasonable strength gains. The model is used to examine the influence of fibre orientation, compressive strength of concrete, area of tensile and compressive reinforcements.

R. Santhakumar et. al. (2004) they analyzed the numerical investigation to create the action of retrofitted RC shear beams. The unretrofitted RC beam design selected as conventional beam and RC beams retrofitted by CFRP composites with $\pm 45^\circ$ and 90° fiber orientations. The cause of retrofitting on without crack and with crack beams was calculated also. The FE model accepted by ANSYS was used in this investigation. This numerical modeling assists to track the crack formation and propagation particularly in case of retrofitted beams within the crack formations cannot be seen by the investigational study because of wrapping of CFRP composites. This numerical analysis can be used to forecast the actions of retrofitted RC beams more accurately by transmission appropriate material properties.

H. Teh Hu et. al. (2004) they analyzed the nonlinear finite element analyses of rectangular RC beams strengthened by FRP. The control of fiber direction, beam span and reinforcement ratios on the ultimate power of the beams are investigated. It has been explained that the use of fiber-reinforced plastics can considerably augment the stiffnesses in addition to the ultimate strengths of RC beams. As well as,

with the similar fiber-reinforced plastics layer figures, the ultimate strengths of beams strengthened by fiber-reinforced plastics at the base of the design beams are much superior to those toughened by fiber-reinforced plastics on both sides of the beams.

A.R. Khaloo et. al. (2005) the flexural strengthening of RC beams by outside bonding of high-strength lightweight CFRP plates to tension face of the beam. Three collections of beams were investigated thoroughly and evaluated with presented investigational results. Outcome of the numerical investigation explained that, while addition of CFRP plates to the tension face of the beam increases the strength, it decreases the beam ductility. FE designing of 15 various beams in a parametric analysis indicates that steel area ratio, CFRP depth, CFRP ultimate strength and elastic modulus significantly influence the height of strengthening and ductility. The results of finite element analyses indicate that significant strengthening of RC beams can be obtained by bonding a relatively small amount of CFRP to the tension face of the beam. The analytical approach predicts the available experimental results satisfactorily.

IV. CONCLUSIONS

- Review study of FRP (fibre reinforced polymer) materials (CFRP, GFRP and AFRP) have been studied in the present paper.
- CFRP and GFRP have applications in structural industries while AFRP is mostly used in military applications.
- Layers of FRP material gives high load carrying capacity and good corrosion resistance to a structural beam.
- A FEM tool can be utilised to predict the behavior of a structural beam under the different loading condition.
- Total deflection of the structural beam with FRP laminates decreases. A further research for development of new technologies in composite construction such as Glass fibre polymer used to minimize the weight of concrete and increases the strength of the beam.
- It makes concrete more economical.
- The use of precast concrete and even the prestressed concrete component in certain composite structure applications may prove fruitful as it has potential due to the economy that can be achieved by these components in terms of time, labour and money.

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