Analysis of Reinforced Concrete Beam using Ansys: A Review

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Abstract- *The main intention of this survey study is to collect different investigation studies published by different researchers for finite element investigation of reinforced concrete beam employing Ansys through various techniques. There are so many techniques for Analysis of Reinforced Concrete beam analysis and can be classified as analytical and Numerical techniques. FE investigation is a mathematical one widely applied to the concrete structures depends on the employ of the nonlinear performance of materials. FEA offered a tool which will be capable of simulate and forecast the answers of toughened and prestressed concrete component. The employ of FEA has increased because of succeeding information and capability of computer package and hardware. Any efforts for engineering researches could be done conveniently and quick using such multipurpose FE analysis packages. Some repeatedly used methods are discover failure as basic criteria and through FEM analysis of the structure the damage of the structure are detected. Application of Finite element method and ANSYS software are observed frequently by different authors to detect loading behaviour of reinforced concrete beam by different element types.*

Keywords- Finite Element Method, RC Beam, Ansys Software

I. INTRODUCTION

Beams of various materials like aluminum, iron, steel, and fiber reinforced combination of substances are broadly employed in structural development in civil and further engineering actions. Experimental analysis is widely found out to study individual component members and the concrete strength below different loading circumstances. This method offered the actual behavior of the structure. But it is lengthy and costly. 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 loading 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. This technique reacts well to non linear study as every element possesses various stress-strain actions. The reaction of every part is explained in conditions of a finite digit of degrees of freedom differentiated as the rate of an unidentified role at a place of nodal points. Non-linear investigation is a methodology that stimulates the precise actions of the material to estimate strength in inelastic vary and to recognize the potential of high load taking capability of the elements during redistribution, tensile and shear strength. Nonlinear activities of concrete beams are difficult because of different parameters. Non-linearity is also geometric or material non-linearity. A structure might have either one or second of them. Material non-linearity included non-linear stress strain connection of material and therefore modulus of elasticity is not a unique data. The dimensions of the model is replaced through loading in slender components for instance columns and moreover in deformable bodies. That case, geometric nonlinearity is encountered.

Many efforts have been developed by the past scholars to forecast the actions by ANSYS. The precision and junction of the explanation based on factors for example mesh size, constitutive functions of concrete, meeting criterion and tolerance standards etc. therefore in the current analysis an effort is prepared to execute nonlinear finite element investigation to investigate the reinforced concrete beam.

II. MATERIALS AND METHODS

A. Failure Criteria for Concrete:

The model developed using ANSYS is competent of forecasts breakdown for concrete materials. Each crack and breaking point failure approaches are based on. The 2 input strength factors that is ultimate single axial tensile and compressive force are required to classify a failure plane for the concrete. As a result, a condition for breaking point of the concrete because of a multiaxial tension state was analysed by

William and Warnke"s (1975) constructive prototype for multiaxial stresses. Bangash (1989) planned that in a very concrete part, cracking happens once the main tensile pressure in any way lies exterior the crushing surface. When cracking, the elastically modulus of the concrete part is redy to zero in the direction parallel to the principal tensile stress direction. Crushing happens once all major stresses are compressive and lie exterior the failure surface, then, the expandable modulus is locate to zero in every paths and the element in effectively disappears.

B. Finite Element Modeling:

Experimental RC beam specimen was analyzed by with ANSYS that is associate with engineering simulation commercially used software package providing a complete group that extents the complete variety of physics, offering right to use to almost several field of engineering replication that a design method needs. The software package use it's tools to place a virtual product through a rigorous testing procedure like testing a beam below totally different loading circumstances before it turns into a considerable object. ANSYS will perform advanced engineering analyses quickly, safely and much by kind of contact algorithms, time based mostly loading options and nonlinear material models. During this study it familiar with carry out distinct modelling of RC beam to investigate it below static loading conditions.

C. Reinforced Concrete:

For Modelling of concrete the ANSYS used an element defined as Solid65 that is non linear model of brittle material similar to concrete. It was an eight node solid iso parametric element with '3' D.O.F. at every node.

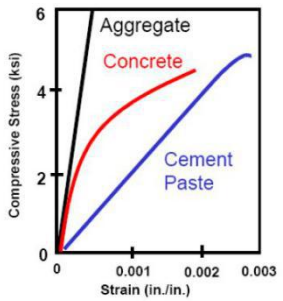
D. Steel Reinforcement:

when the Designing of steel ANSYS presented an element named as Link180 There having two methods to utilize it first was smeared and the second is discrete, discrete was measured to be extra convergent since it subtracts the area of steel from total concrete which was the actual circumstances wherever as in smeared the steel was entrenched in the concrete and performed as single element that was not the real case.

III. LOADING

Static Loading

Concrete can be explained as compound material that is created by binding aggregates as one with a cementitious paste. Whereas the independent reaction of a cement mixture and aggregate mixture to an under load is linear as explain in Figure, it are often seen that response of the composite concrete is extremely nonlinear. Different have proposed that this may be certified to presence of a weak bond or surface transition zone between the material mixture and also the paste matrix (Mehta, 1996). The effect of unreinforced material to mechanical loading should primary described to totally comprehend how reinforced elements react. Instantly under loading conditions, concrete usually is consideration to make a few small-cracking (Shah and Slate, 1965; Attiogbe and Darwin, 1987; Li et al., 1991), while it is regularly considered to be unimportant because small change is noticed in the load-displacement reaction. The load-movement response remains fairly linear until the load level reaches approximately 40% to 50% of the maximum strength. At present the stress-strain reaction turns into less linear as an augment in micro-cracking develops consequential in reduce of the elastic modulus of the objects. While load point moves toward to the top, the slope of the load-displacement curve is once again reduced as the cracks begin to coalesce and localize in one region of the specimen. This localized area will eventually become the place of a visible crack. Depending on how the sample element is loaded the crack could effect in sudden failure or continues to develop and grow after the peak load is reached resulting in large visible cracking. Once the peak load is reached the sample element starts to reveal strain-softening working consequential in a steady reduce in load bearing ability with rising strain as explained in Figure (Jansen and Shah, 1995).



Stress strain response of behaviour of concrete (1 ksi = 6.89 MPa).
Adapted from T. Subramani et. Al. 2014

IV. LITERATURE SURVEY

Researches of different researchers on Analysis of reinforced concrete beam using Ansys.

B. H. Osman ET. Al. [2016] they identified numerical analysis using ANSYS software program was done by modeling 27 reinforced concrete beams with and without

CFRP sheets. The beam proportions, concrete strength, strengthening configuration of the CFRP sheets, and FRP thickness were considered as the major restrictions of the numerical investigation. The finite element elements are proficient to precisely forecast the load capacities for the simulated RC beams make stronger in shear with CFRP composites. The outcomes achieved using ANSYS finite element are comparatively the same to the experimental ones, presentation reasonable contract with deviation not more than 5% in all the specimens. The FE sturucture were capable to precisely forecast the load bearing capacities for the simulated RC beams strengthen in shear with FRP composites. This shows the force of the enhanced FE models and reliability of the ANSYS FE simulation [1].

Pradeep singh ET. al. [2016] identified simulation of concrete reinforced beams use of ANSYS FEM software package. Results of varied FRP also will be calculated. The FRP as an exterior strengthening is worked extensively with the strength requirements connected to flexure and shear in structural arrangements. Examination of the conferred scholar effort has been findout in the existing investigation. Primary the plain concrete beam will be modeled in ANSYS after that the FRP substance will be coated over it. Result of tension and various loading circumstances investigates in this Research [2].

G.M. Chen ET. al. [2015] Analysed a dynamic explanation approach for overcoming convergence complexities in simulating the bonding crashs in FRP-strength Concrete beams, that has been with sucess applied within the FE study of several kinds of breaking failures in FRP-strengthen RC beams and FRP-to-concrete joints . A primary challenge for these simulations is with the aim of general explanation techniques for instance the Newton–Raphson process and the curve-length technique frequently not succeed to join. This investigation examines the data's of using a dynamic analysis method in such FE simulations, wherein debonding breaking is cared for as a dynamic trouble and resolved by a suitable time integration process. Numerical values are obtainable to explain that an proper dynamic approach efficiently overcomes the convergence difficulty and offered precise predictions of test consequences [3].

Jayalin. D. et. al. [2015] discussed about Finite Element sturucture has been designed by use of Ansys 15 to analyze concrete beams with gaps. The gaps in beams are developed for function channels and pipes. The cracks usually occur because of the stress concentration about the gaps. They studied about beams strengthened by Carbon Fibre toughened Polymer and Glass Fibre toughened Polymer Concrete plates. '13' beams were designed; one beam is the base toughened concrete beam with no any gap. '6' beams with gaps developed with CFRP fibers and six beams with gap retrofitted with GFRP were too investigated. as of the research, the load deflection correlation, crack pattern and crack at ultimate load were achieved and comparison was completed for CFRP and GFRP beams. Since the load deflection correlation, it was obtained that the action of beams developed with CFRP was enhanced that of the beams designed with GFRP [4].

Nasr Z. Hassan et al. [2015] analysed transverse gaps are frequently offered during concrete beams to contain utility ducts and pipes. Finite element examination has been employed with the purpose of analyse this trouble. Fifty-seven beams analyzed employing finite element plan with ANSYS V12. The investigation consequences compared by fifteen investigational beams had been completed. reinforced of all beams with gaps found out to six types of special scheme about the opening employing fiber-toughened polymer . The concrete beams were modelled in 'ANSYS V12' Program below statically load. The breakdown loads, crack formation, strain improvement and type of failure and energy inclusion were investigated here in this research [5].

Kiran M. ET. al. [2014] they analyzed the performance of RC beam is analyzed by finite element technique. A organize beam is investigated employ a precise set of manage information and is then evaluated to the following models by changing the parameters. The parameters used to complete this study are varying depths, steel percentage, and steel cushion and shear reinforcement. It is experiential that by increasing the tension steel, the initial cracking behavior is not exaggerated. however it has additional impact in the post cracking segment of the beam. The ultimate competence of concrete could be ranged by varying the proportion of steel. By removing steel plate at support and loading point, stress concentration takes place. Also the beam without steel plate shows more cracks than the beam with steel plate. Hence for more accurate analysis, steel cushion has to be incorporated in modeling [6].

P. Parandaman ET. al. [2014] they studied the finite element study of beam designed with various fiber toughened polymer composite sheets employing ANSYS software. Three RC beams by special FRP composite plate samples were modeled employing Pro-E software. The primary RC beam wrapped through carbon fiber toughened polymer plate, the next with glass fiber toughened polymer plate and the third with Kevlar fiber toughened polymer plate. The actions of the over three developed beams were analysed with the controlled sample and the consequences are offered in this research. The load hauling competence of the concrete beam designed with various FRP is over the RC beam 10 samples. It could be

accomplished that the potency of the beam is enlarged by designed with fiber toughened polymers [7].

N. R. Joshuva et. al. [2014] studied about toughened and pre-tensioned beams are examined for their nonlinear performance with external loading employing the finite element technique of examination. ANSYS 12.0, an efficient finite element analysis software package, which is used for the investigation of the material elements. Load-deflection reactions, deviations of tensions in concrete material and steel and the crack formations at critical phases of loading are calculated. The mathematical forecasts are analysed to the data findout using the assumptions of structural examination. On comparing the performance of the concrete beam with that of the prestressed concrete beam, the advantage of prestressing was verified as the prestressed concrete beam was seen to show a higher service load range and advanced final load competence [8].

S. R. Viradiya et. al. [2014] the nonlinear Finite Element Analysis that has been noted to simulate the behaviour of failure modes of toughened Concrete beams tough in flexure by Fibre toughened chemical laminates. '2' concrete beams were developed in FEM software employing ANSYS. From the investigation the load changing relationships, crack pattern, first crack load and Ultimate load was establish and compared with the investigational consequences presented in Literature. The load deflection plan achieved from mathematical studies explain fine contract through the investigational plots. There was a variation in performance between the RC beams toughened by GFRP layers and with no GFRP layers. Consequently, designing of investigational beams could be adoptable in ANSYS. Substantiation of investigational consequences can also be completed employing ANSYS [9].

T. Subramani, [2014] they analysed crack recognition in concrete Beams employing ansys software. The modal considerations of an unspoiled beam are observed and balanced with the vibration performance of the beam subjected to controlled destructive. preferred rigidity limitations in the finite part prototype are familiar in such a method that the computed design amount equivalent the calculated quantities. A FEM method has been employed to arrangement a injure allocation in beams connected with rising stress outlines. modern scanning laser structure tools has been engaged for this intention. It can be establish that modal updating is certainly a potential tool to recreate the damage outlines [10].

Usama Ebead et. al. [2014] they analyzed Numerical designing of Shear toughened RC Beams Using different methods. The structural performance of shear toughened beams needs higher mathematical processes of those consequences are substantiated by credible experimental findings. The structures are improved to evaluate the shear and interfacial types of actions of beams toughen employing one of three special methods, namely, bonded mechanically permanent, and cross FRP methods. The both performance among the EB, MF, and hybrid EB or MF FRP and the concrete is based for employing interface parts for together perpendicular and inclined FRP strips. consequences are existing in provisions of the ultimate load-carrying competencies, load-deflection interaction, and both stress distributions [11].

V. B. Dawari [2014] optimizes solution regarding non-linear flexural actions of concrete beams. Non-linear finite component examination of concrete beams below flexural loading is offered in this investigation. Finite element designing of concrete beams is found out employing separate strengthening modelling method. The potential of the design to capture the serious crack sections, loads and deflections for varied loadings in concrete beam has been illustrated. Comparison is created between the experimental results and finite element examination with regard to primary crack pattern and the final load capacity of beams. The analysis procedure employed in this paper and varied output plots created by FEA have offered a deeper approaching for future function of finite element tool considered for the investigation of beams. founded on the investigation found out on the RC beams by ANSYS, it is found that consequences are more responsive to mesh size, materials properties, load augmentation, etc [12].

Vasudevan et. al. [2013] they studied finite element investigation by separate reinforcement designing of '6' toughened concrete beams below four-point bending are existing in this research. Finite element designing of toughened beams is found out by ANSYS, and the critical datas of the consequences are also compared with investigative values considered using code limitations. broad-range graphical explain of the results for instance deflected form of the beam, stress-strain difference along the length and deepness of the beam and crack propagation is produced by creating a bunch file employing the ANSYS mathematical design language. evaluation is completed involving the test results, finite element investigation and investigative values regarding preliminary crack pattern and the ultimate ability of beams, so as to have a broad considerating on the performance, which might decrease the physical disparaging laboratory analysis for the future scholars [13].

W.Y. Gao et. al. [2013] Analysed a '3D' finite element model for the precise forecast of together the thermal and the mechanical actions of RC beams exposed to fire. In this FE structure, particular consideration is paid to the designing of mediatory bond-slip behavior between the strengthen steel and the concrete, an feature which has infrequently been measured by previous mathematical studies. Results achieved from this FE design are measured with existing test data to examine the accuracy of the model. This evaluation explains that the addition of the steel-to-concrete mediatory actions directs to extra precise forecasts of the deflection of RC beams exposed to fire. forecasts from this FE model also permit the difficult allocation and evolution of stresses in the reinforcing steel and the concrete to be examined in detail, leading to a improved considerate of the local reactions of RC beams presentation to fire [14].

Zhang ET. Al. [2013] identified the FEM investigation software, to make nonlinear investigation of toughened concrete beam. The design replicating the experiment method was established, the estimate consequences of ANSYS are contrast with the investigational results. The comparison explain that ANSYS examination outcomes are comparable to investigational consequences, which pointed to ANSYS study software could be employed to analyze the mechanical limitations of toughened concrete structures [15].

O. A. INGASON [2013] they analyzed cracking in toughened concrete beams is a normal process that occurs for a small portion of the ultimate load, already in the service state. The main aim of the investigation to enlarge a finite element model of a beam that is able to describe the interaction between the reinforced bars and the cracked concrete. Emphasis is given to the consideration of the two major length scales in concrete structure; a FE beam-type model considering great bond involving the constitutive materials developed in the Diana software tool. The results from the developed model were set up to communicate well to the fore mentioned techniques and the investigational curves. But, further parametric studies are proposed with the intend of get better the presentation of the design [16].

Shiyun Xiao ET. Al. [2012] identified Dynamic research of concrete beams at various loading values was carried out with the MTS electro-hydraulic servo system to study the results of loading rates on the mechanical actions of beams. The effects of loading rates on the cracking, ultimate and failure potency and movements, ductility and lost energy capability of concrete beams were studied. The conclusions shows with the increasing of load values, firstly, the cracks distributed more equably but their depth decreased. Secondly, the cracking, ultimate, failure strengths and displacements of beams increased with the loading rates. Finally, the ductility and dissolute power capability of concrete beams improved obviously with the growing loading rates [17].

R.S. Ravichandran et. al. [2012] conducted an experimental analysis performed to examine the value of Glass Fibre toughened Polymer laminates in enhancing the flexural capacity of high potency concrete beams. '8' beams were toughened with cut thread mat glass fibre toughened polymer and multi directional cloth glass fibre toughened polymer .The experiment parameters incorporated the strengthening ratio, GFRP covered material and their width. All the beam sample were correspond to bending test in a loading structure. Deflection and strain dimensions have been completed during suitable instrumentation. The consequences explain that the GFRP toughened beams reveal augmented potency, flexural rigidity and compound action until failure [18].

Ehab M. Lotfy [2011] analyzed the performance of concrete fiber polymer column FRP are obtainable. Nonlinear finite discertization investigation on 10-column samples was completed by employing ANSYS software. The nonlinear finite element examination program ANSYS is consume because of its abilities to forecast either the reply of reinforced concrete supports in the post-elastic variety or the eventual potency of a toughened concrete by FRP bars. A general set of limitations is examination consisting dissimilar chief reinforcement proportions, main reinforcement types (GFRP, Steel), the crossways reinforcement ratios, and the characteristic compressive potency of concrete. The analysis explained on the consequences of the investigated parameters on the deformation and ultimate resisting load [19].

R. S. LAVATE et. al. analyzed dynamic study of the composite material beam. In this investigation, longitudinal crossways Young Modulus, poison's ratio and shear modulus were found out by employing easy formulae. The longitudinal & transverse vibrations were obtained theoretically and analytically. Numerical study was performed by finite analysis software by using ANSYS 11. In this software, the test samples were designed in agreement to investigational tested samples. The limit circumstances were depended to the design. These outputs were transferred to the graphs. Inspection of the dynamic actions of the combination beam for several end circumstances is completed by both FEM and hypothetical investigation [20].

L. Dahmani et. al. [2010] they analysed '3D' nonlinear finite element design of toughened concrete beam. The common reason finite element package, ANSYS 8.0, is

engaged for the numerical researches. with SOLID65 solid elements, the compression devastating of material is make easy by plasticity algorithm whereas the cracking of concrete in strain region is accommodate by the nonlinear material structure. grimy reinforcement is employed and initiated as a proportion of steel entrenched in concrete. Assessment with hand considered consequences is offered for the concrete beam. Meeting of analytical results is explained. The potential of the design to confine the vital crack areas, loads and movements for several kinds of load in toughened concrete beam has been explained [21].

A. Büyükkaragöz [2010] analysed solution one beam strengthened by bonding with a prefabricated plate which has 80 mm thickness underneath and one control beam were produced. The specimens were tested in the laboratory and a single load was applied on the middle of the beam. The consequences of the research were compared with the outcomes achieved from the beam modelled with ANSYS finite discartization tool. When the consequences of the research were balanced with the designed computer program, it was shown that the outcomes of computer model gave similar outcomes to the real behavior [22].

V. CONCLUSION

In this study review, analyzed strength and find out failure of concrete beam by employing FEM Technique. A Concrete beam is analyzed employing a particular set of control value and is after that measured to the succeeding models by changing the parameters. The parameters used to complete this study are varying depths, steel percentage, and steel cushion and shear reinforcement. Both the experimental and theoretical methods are applied to predict and detect changes of RC beam during analysis. This survey will give an introduction to a new researcher in this field to different published papers at a single glance.

REFERENCES

[1] Bashir H. Osman, Erjun Wu, Bohai Ji, Suhaib S. Abdulhameed, "Effect of reinforcement ratios on shear behavior of concrete beams strengthened with CFRP sheets" HBRC Journal , 2016.

[2] Pradeep singh, Abhishek Mishra, Arpit Kulshreshtha, "Finite Element Analysis of Reinforced Concrete Beam Using Ansys" International Journal of Current Engineering and Scientific Research, ISSN(ONLINE): 2394-0697, VOLUME-3, ISSUE-1, 2016.

[3] G.M. Chen, J.G. Teng, J.F. Chen, Q.G. Xiao, "Finite element modeling of debonding failures in FRP-strengthened RC beams: A dynamic approach" ELSEVIER, 2015.

[4] Jayalin.D, Prince Arulraj.G, Karthika, "Analysis of Composite Beam Using Ansys" International Journal of Research in Engineering and Technology, eISSN: 2319-1163, 2015.

[5] Nasr Z. Hassan , Alaa G. Sherif, Amal H. Zamarawy, "Finite element analysis of reinforced concrete beams with opening strengthened using FRP" ELSEVIER, 2015.

[6] Kiran M. Malipatil, Neha S. Badiger, "Parametric Study on Reinforced Concrete Beam using ANSYS" Civil and Environmental Research, e-ISSN 2225-0514 ,Vol.6, No.8, 2014.

[7] P. Parandaman, M. Jayaraman, "Finite Element Analysis of Reinforced Concrete Beam Retrofitted with Different Fiber Composites" Middle-East Journal of Scientific Research, ISSN 1990-9233, 2014.

[8] Nimiya Rose Joshuva, S. Saibabu, P. Eapen Sakaria, K. N. Lakshmikandhan, P. Sivakumar, "Finite Element Analysis of reinforced and Pre-Tensioned Concrete Beams" International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 4, Issue 10, October 2014.

[9] Shaishav R. Viradiya, Tarak P. Vora, " Comparative Study Of Experimental And Analytical Results Of Frp Strengthened Beams In Flexure" International Journal of Research in Engineering and Technology eISSN: 2319-1163, 2014.

[10] T. Subramani, R. Manivannan, M. Kavitha, "Crack Identification in Reinforced Concrete Beams Using Ansys Software" ISSN : 2248-9622, Vol. 4, Issue 6, June 2014.

[11] Usama Ebead, Huda Saeed, "Numerical Modeling of Shear Strengthened Reinforced Concrete Beams Using Different Systems" Journal of Composites for Construction, ISSN 1090-0268, 2014.

[12] V. B. Dawari, G. R. Vesmawala, " Application of Nonlinear Concrete Model for Finite Element Analysis of Reinforced Concrete Beams" International Journal of

Scientific & Engineering Research, ISSN 2229-5518 Volume 5, Issue 9, September-2014.

[13] G. Vasudevan, S. Kothandaraman, S. Azhagarsamy, "Study on Non-Linear Flexural Behavior of Reinforced Concrete Beams Using Ansys By Discrete Reinforcement Modeling" Springer, Vol. 45, No. 2, March, 2013.

[14] W.Y. GAO, Jian-Guo Dai, J.G. Teng a, G.M. Chen, "Finite element modeling of reinforced concrete beams exposed to fire" ELSEVIER, 2013.

[15] Xingzhong Zhang a, Leilei Liu b and Kedong Tang, "Nonlinear Analysis of Reinforced Concrete Beam by ANSYS" Vols. 438-439 (2013) pp 663-666.

[16] O. A. INGASON, "Coupled analysis of imperfectly bonded reinforcement in fracturing concrete" 2013.

[17] Shiyun Xiao, Wenbo Cao, Haohao Pan, "Experiment of Reinforce Concrete Beams at Different Loading Rates" 2012.

[18] R.S.Ravichandran, K. Suguna, P.N. Raghunath, "Flexural Behaviour of Composite High Strength Concrete – Fibre Reinforced Polymer Beams" IJCSET ,Vol 2, Issue 1, January 2012.

[19] Ehab M. Lotfy, "Nonlinear Analysis Of Reinforced Concrete Columns With Fiber Reinforced Polymer Bars" International Journal of Advanced Structural Engineering, Vol. 3, No. 2, Pages 133-151, December 2011.

[20] R. S. Lavate, A. T. Patil, A. M. Patil, N.V. Hargude, "Dynamic Response Analysis of Fiber Reinforced Composite Beam" IOSR Journal of Mechanical and Civil Engineering, ISSN: 2278-1684, PP: 38-47.

[21] L. Dahmani, A. Khennane,, S. Kaci, "Crack Identification In Reinforced Concrete Beams Using Ansys Software" Springer, Vol. 42, No. 2, 2010.

[22] A. Büyükkaragöz, "Finite element analysis of the beam strengthened with prefabricated reinforced concrete plate" Scientific Research and Essays ,Vol. 5, pp. 533-544, March, 2010.

[23] H.Y. Omran , P. Zangeneh , and R. EL-Hacha, "Finite Element Modelling Of Steel-Concrete Composite Beams Strengthened With Prestressed CFRP Plate" Internatiional Conference of International Institute, 2009.

[24] Ahmed Godat, Kenneth W. Neale, M.ASCE, Pierre Labossière, "Numerical Modeling of FRP Shear-Strengthened Reinforced Concrete Beams" Journal Of Composites For Construction, 2007.

[25] M. M. Hoque, "3D Nonlinear Mixed Finite-element Analysis of RC Beams and Plates with and without FRP Reinforcement" 2006.

[26] R.Santhakumar, E.Chandrasekaran, R.Dhanaraj, "Analysis of Retrofitted Reinforced Concrete Shear Beams using Carbon Fiber Composites" Electronic Journal of Structural Engineering, 2004.