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Evaluation of Performance of Shear Deficient Curved Beams Strengthened by Different Methods

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Abstract: The study on experimental investigation and nonlinear finite element simulations of shear deficient and Glass Fiber Reinforced Plastic (GFRP) strengthened reinforced concrete beams are done. The responses, in terms of load-deflection behaviour, failure loads and crack patterns, obtained from numerical simulations are validated with that of the experimental investigations. The validated numerical models are then used for studying the efficacy and effectiveness of various strengthening schemes using epoxy impregnated GFRP fabric where the number of layers, orientation and distribution of fibers are considered as parameters. In this study investigations are done in curved beams. Modelling and analysis of curved beams is done in ANSYS 16.1 software.
Keywords: Glass Fibre Reinforced Polymer

I. INTRODUCTION

Failure of a civil structure refers to the loss of structural integrity due to loss of the load-carrying capacity. In a well-designed system, a localized failure should not cause immediate or even progressive collapse of the entire structure for any kind of loading. Various factors affect the deterioration of a structural member. Apart from structural deterioration due to aging, errors made during design and construction phase, and increased load, all contribute to the deficient behaviour of structures. In recent years, lot of research was focused on strengthening of under designed and deficient RC structures. Different types of beams are used in building structures. Nowadays curved beams are commonly used as a structural component in building structures for improving aesthetic appearance. Curved beams include normal curved beam (curve in plan) and arch beam (curve in elevation).

II. LITERTURE REVIEW

Literature survey includes a brief review of the past and recent study performed by researchers. A brief review of previous studies focused on strengthening of shear deficient reinforced concrete beams are studied.

A. Radhikesh Prasad Nanda1 et al. (2018) conducted a study on RC Beam strengthening by Glass Fiber Reinforced Polymer. In this study the experimental investigation of Glass Fiber Reinforced Polymer (GFRP) strengthened reinforced concrete beams. The behaviour of control and GFRP strengthened beams under static loading is studied [9].
B. Nawal Kishor Banjara et al. (2017) conducted a study on experimental and numerical investigations on the performance evaluation of shear deficient and GFRP strengthened reinforced concrete beams. In this study The present study is focused on the experimental investigation and nonlinear finite element simulations of shear deficient and Glass Fiber Reinforced Plastic (GFRP) strengthened reinforced concrete beams [7].
C. Qudeer Hussain et al. (2017) conducted a study on shear strengthening of RC deep beams with Sprayed Fiber Reinforced Polymer Composites (SFRP): Part 2 Finite Element Analysis. This paper presents the finite element analysis conducted on SFRP strengthened Reinforced Concrete (RC) deep beams is done. The analysis variables included SFRP material (glass and carbon), SFRP thickness (3 mm and 5 mm), SFRP configuration and strength of concrete [8].

III. METHODOLOGY

Literature survey is conducted on shear deficient concrete beams under various loading conditions. From various researches structural behaviour and other parametric behaviour of shear deficient beams are studied. For the validation of project work the experimental results of normal control shear deficient straight beams from the journal [7] is used. The result obtained in terms of maximum deformation corresponding to the loading which is compared with the result obtained in ANSYS software and the percentage of variation is also calculated. Modelling is done using ANSYS. ANSYS is an American Computer-aided engineering software which stands for Analysis of Systems. In this work, shear deficient beams with 20% shear deficiency are strengthened by GFRP with variable angular orientations which are modelled using Finite Element Software ANSYS and also partial replacement

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using UHPFRC and UHPC are done. M40 grade concrete and standard steel are used for the study. Static structural analysis will be carried out for the analysis of project work. Shear deficient concrete column with steel reinforcement is modelled and the resultant deformations are compared. Curved beam with 20% shear deficiency are modelled and strengthened using GFRP. GFRP is wrapped at shear area of the beam sections in both one and two layer. The GFRP is wrapped at different angle sections in shear deficient beams. This GFRP strengthened beams are compared with the normal control curved beam. Partial replaced beams using UHFRC and UHFC are also compared with conventional beams. The parameters taken for the study are deformation and load.

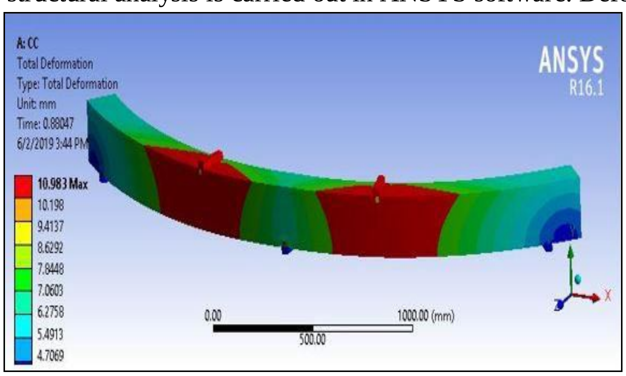
IV. ANALYSIS OF SHEAR DEFICIENT CURVED BEAMS STRENGTHENED USING GFRP WRAPPING

A. Geometric Modelling of Beam

Modelling of six curved concrete beam were done in this analysis. GFRP and steel reinforcement is done by using element types of solid 186, shell 181 and link 180 respectively. One conventional curved beam and five GFRP strengthened curved beams are modelled in ANSYS Software to compare their performance. All the beams are modelled in size 1800×200×150 mm. The materials here used are concrete in the beam body and steel as reinforcement bar. One conventional shear deficient curved beam and five shear deficient strengthened curved beams are modelled in ANSYS software. It is important to correctly select the mesh size and layout in finite element analysis. A good mesh means accurate results with better convergence but also has time consideration. A very fine mesh model will always provide accurate results but will require excessive computer time. In this analysis, suitable numbers of elements were carefully chosen for the concrete model and reinforcement model based on convergence studies in order to obtain accurate results without excessive use of computer time. Curved beams are modelled using regular rectangular mesh. The mesh size provided is 15mm.

B. Analysis

Static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads. Static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.



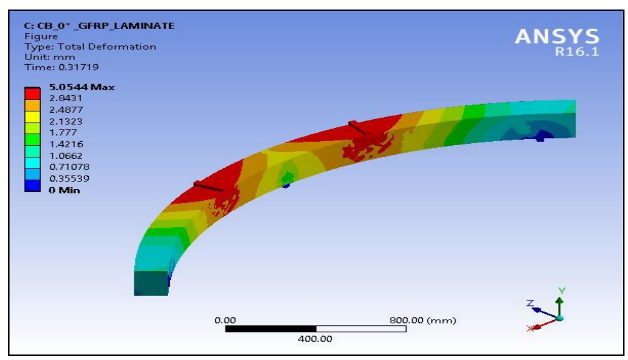
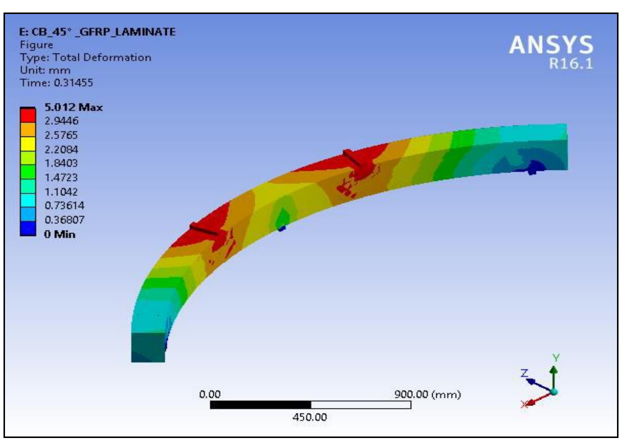


Fig. 1 Deformation diagram of conventional normal curved beam Fig. 2 Deformation diagram of GFRP (00) strengthened normal curved beam



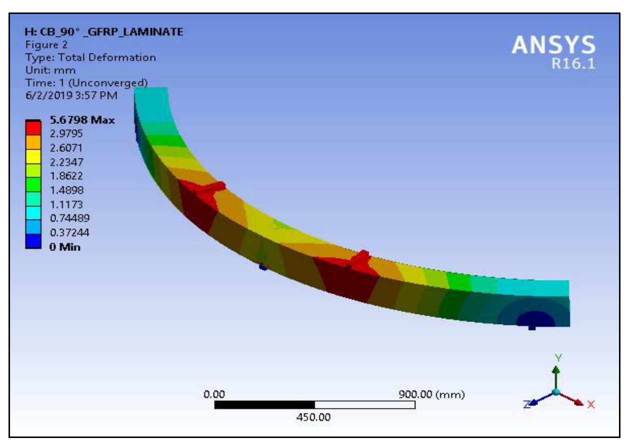
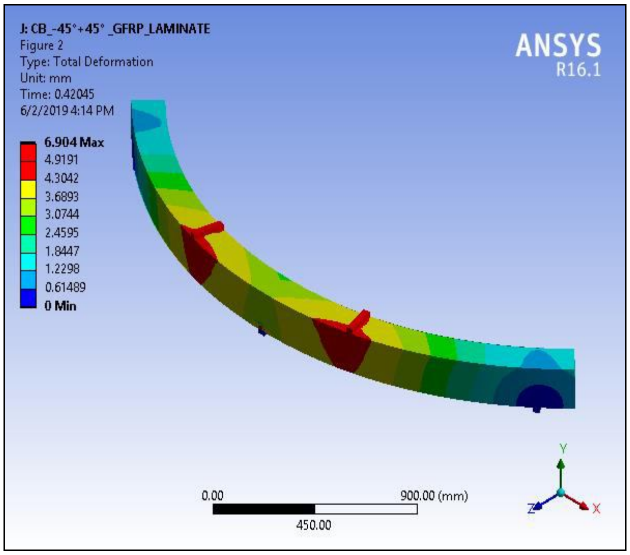


Fig. 3 Deformation diagram of GFRP (450) strengthened normal curved beam Fig. 4 Deformation diagram of GFRP (900) strengthened normal curved beam



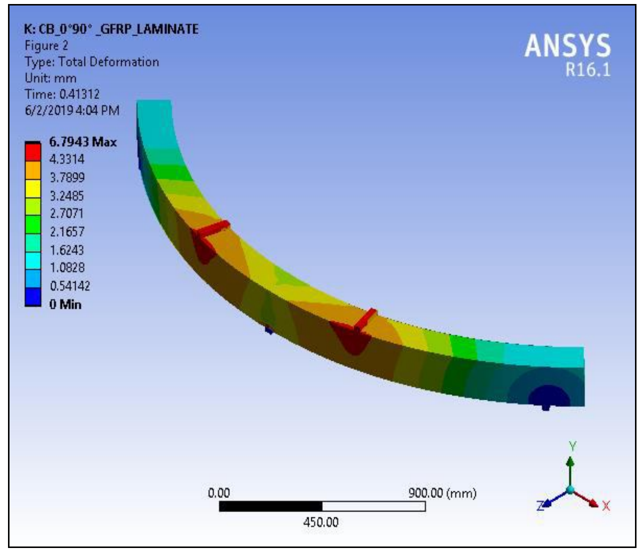


Fig. 5 Deformation diagram of GFRP (-450 and +450) normal curved beam   Fig. 6 Deformation diagram of GFRP (00 and 900) strengthened normal curved beam

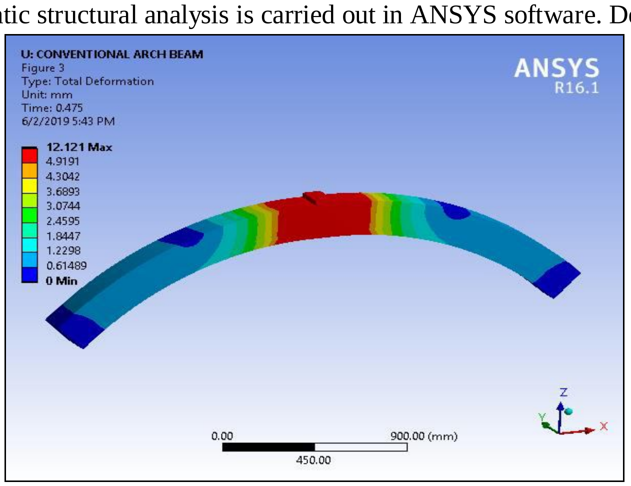
V. ANALYSIS OF ARCH BEAMS STRENGTHENED USING GFRP WRAPPING

A. Geometric Modelling of Beam

Modelling of six arch concrete beam were done in this analysis. GFRP and steel reinforcement is done by using element types of solid 186, shell 181 and link 180 respectively. One conventional arch beam and five GFRP strengthened arch beams are modelled in ANSYS Software to compare their performance. All the beams are modelled in size 1800×200×150 mm. The materials here used are concrete in the beam body and steel as reinforcement bar. One conventional shear deficient arch beam and five shear deficient strengthened arch beams are modelled in ANSYS software. It is important to correctly select the mesh size and layout in finite element analysis. A good mesh means accurate results with better convergence but also has time consideration. A very fine mesh model will always provide accurate results but will require excessive computer time. In this analysis, suitable numbers of elements were carefully chosen for the concrete model and reinforcement model based on convergence studies in order to obtain accurate results without excessive use of computer time. Arch beams are modelled using regular rectangular mesh. The mesh size provided is 15mm.

B. Analysis

Static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads. Static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.



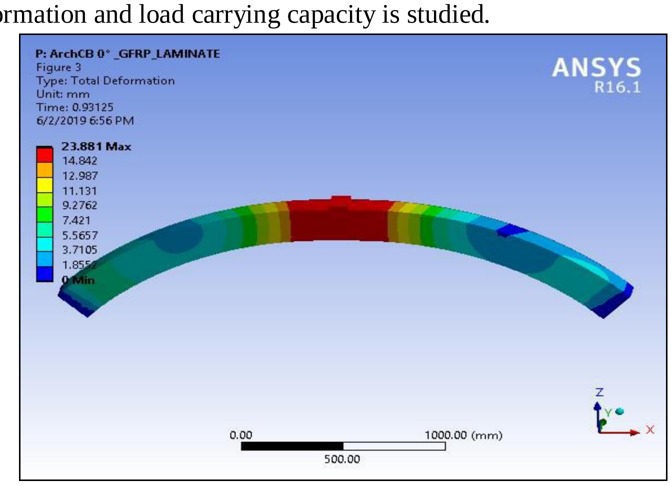


Fig. 1 Deformation diagram of conventional normal arch beam   Fig. 2 Deformation diagram of GFRP (00) strengthened normal arch beam

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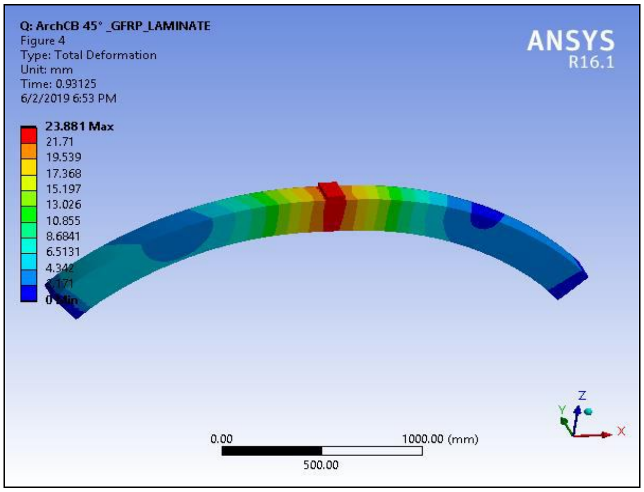


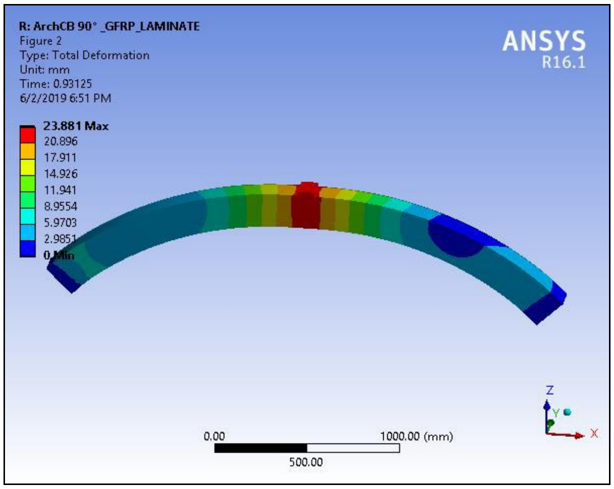
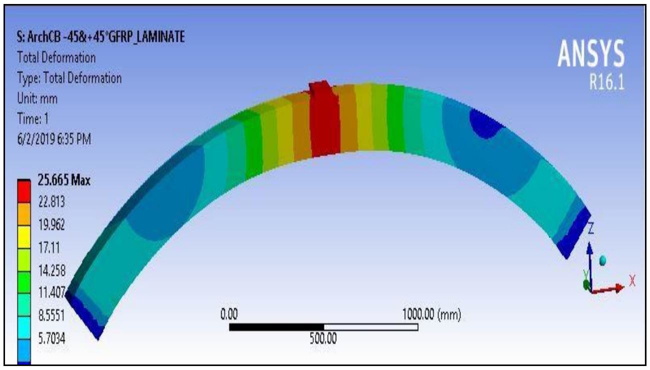


Fig. 3 Deformation diagram of GFRP (450) strengthened normal arch beam

Fig. 4 Deformation diagram of GFRP (900) strengthened normal arch beam



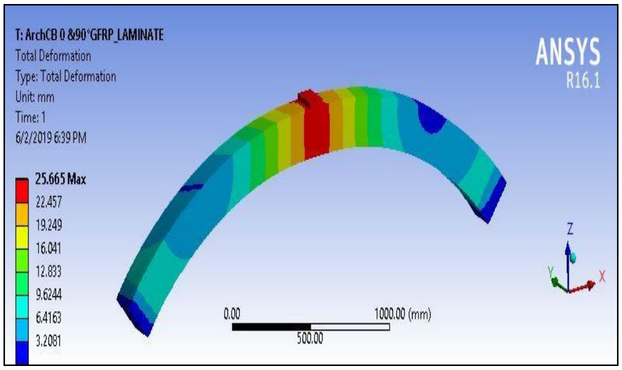


Fig.5 Deformation diagram of GFRP (-450 and +450) normal arch beam

Fig.6 Deformation diagram of GFRP($0^0$and 90^0) strengthened normal arch beam

VI. ANALYSIS OF NORMAL CURVED BEAMS STRENGTHENED BY PARTIAL REPLACEMENT USING UHPFRC AND UHPC

Modelling and analysis of normal curved shear deficient beams are strengthened by partial replacement using UHPFRC and UHPC. One conventional shear deficient curved beam and shear deficient strengthened curved beams are modelled in ANSYS Software. After modelling of beam component is done, the meshing is done as rectangular meshing of 15mm size. Here loading is applied in the form of displacement and the method is known as displacement convergence criteria. Static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.

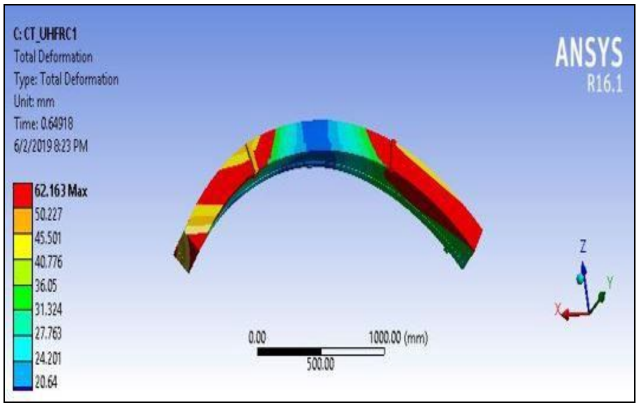


Fig.7 Deformation of beam partially replaced using UHPFRC

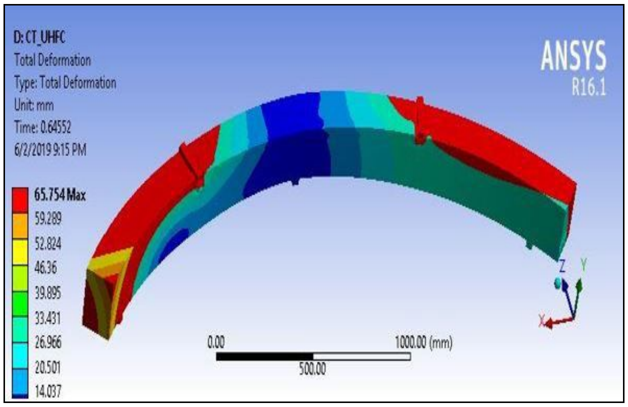


Fig. 8 Deformation of beam partially replaced using UHPC

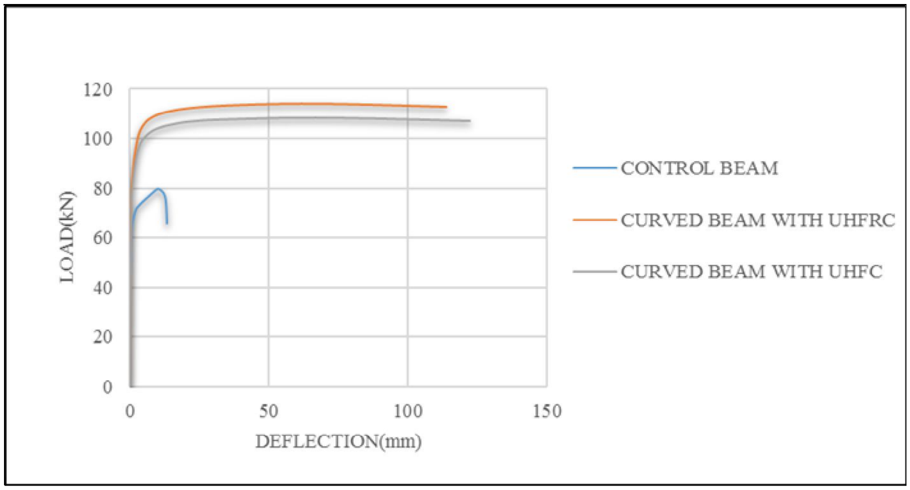


Fig. 9 Load deformation graph

VII. ANALYSIS OF NORMAL CURVED BEAMS STRENGTHENED BY PARTIAL REPLACEMENT USING UHPFRC AND UHPC

Modelling and analysis of normal curved shear deficient beams are strengthened by partial replacement using UHPFRC and UHPC. One conventional shear deficient curved beam and shear deficient strengthened curved beams are modelled in ANSYS Software. After modelling of beam component is done, the meshing is done as rectangular meshing of 15mm size. Here loading is applied in the form of displacement and the method is known as displacement convergence criteria. Static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.

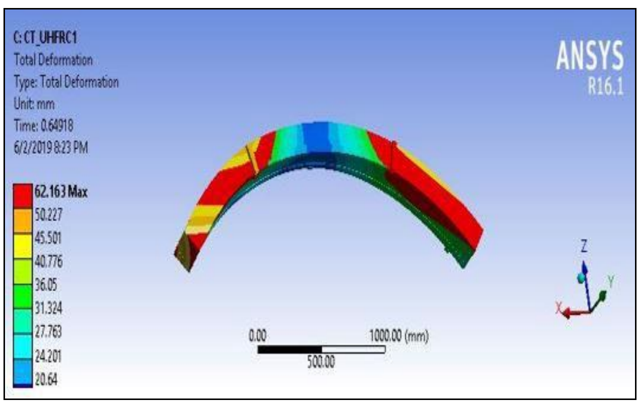


Fig. 7 Deformation of beam partially replaced using UHPFRC

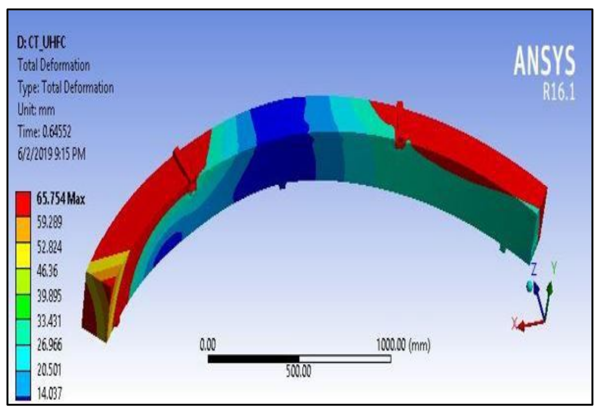


Fig. 8 Deformation of beam partially replaced using UHPC

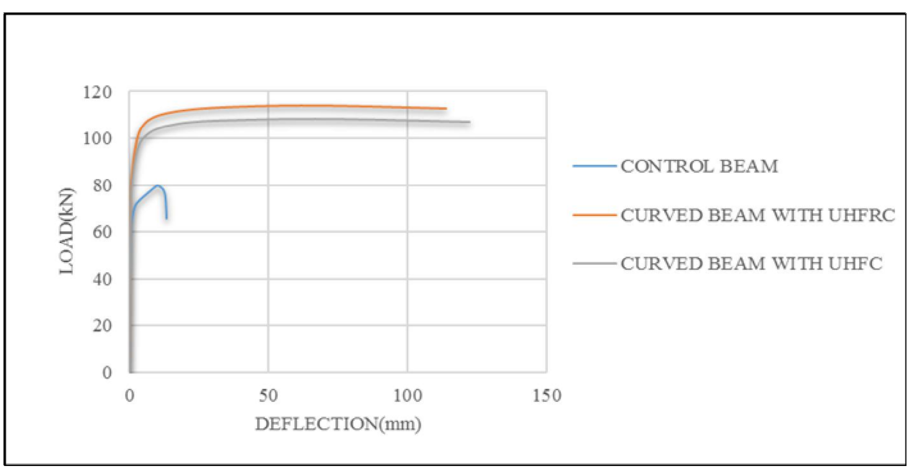


Fig. 9 Load deformation graph

VIII. ANALYSIS OF ARCH BEAMS STRENGTHENED BY PARTIAL REPLACEMENT USING UHPFRC AND UHPC

Modelling and analysis of arch shear deficient beams are strengthened by partial replacement using UHPFRC and UHPC. In order to compare conventional beam with partially replaced beams, beams which are partially replaced using UHPFRC and UHPC are modelled in ANSYS software. One conventional shear deficient curved beam and shear deficient strengthened curved beams are modelled in ANSYS Software. After modelling of beam component is done, the meshing is done as rectangular meshing of 15mm size. Here loading is applied in the form of displacement and the method is known as displacement convergence criteria. A displacement of 10 mm is given as load. Static structural analysis is carried out in ANSYS software. Deformation and load carrying capacity is studied.

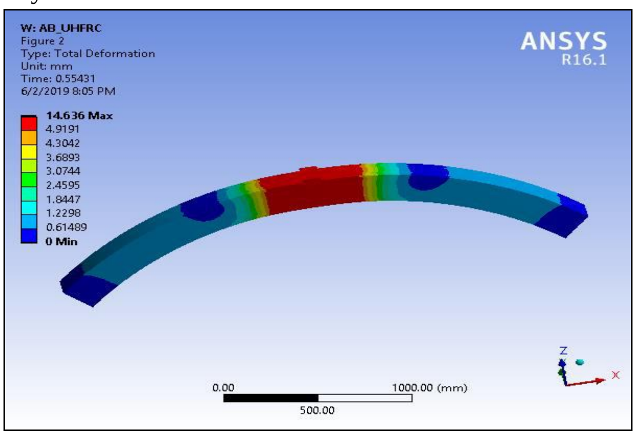


Fig. 7 Deformation of beam partially replaced with UHPFRC

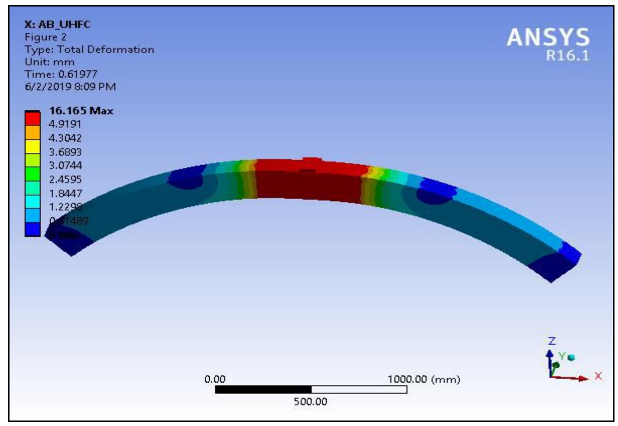


Fig. 8 Deformation of beam partially replaced with UHPC

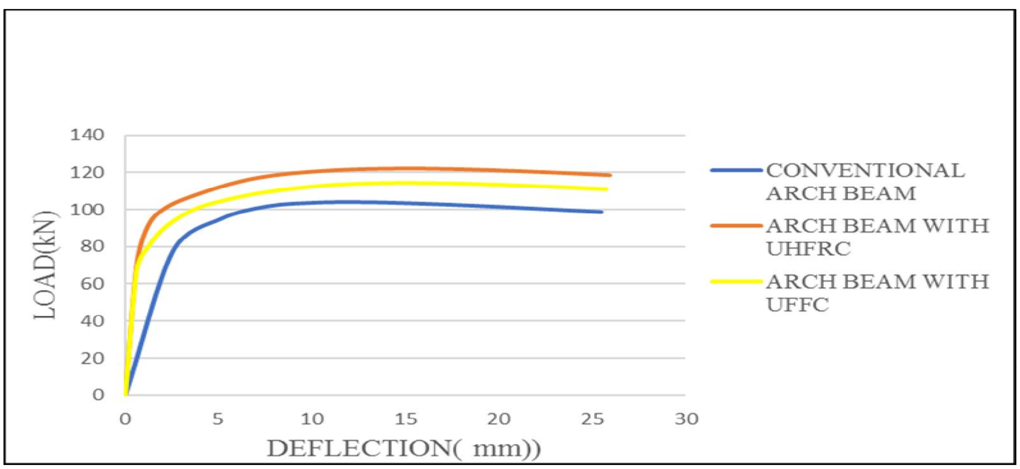


Fig. 9 Load deformation graph

IX. CONCLUSION AND FUTURE SCOPE

Nonlinear static analysis is performed to analyse the behaviour of shear deficient curved and arch beams strengthened by different methods. Curved beams are made shear deficient by increasing stirrup spacing. In this study 20% shear deficiency is selected i.e.; stirrup spacing is at 375mm. And this shear deficient beams are strengthened by different methods like wrapping using Glass Fibre Reinforced Polymer (GFRP) and partial replacement of concrete using Ultra High Performance Fibre Reinforced Concrete (UHPFRC) and Ultra High Performance Concrete (UHPC). Based on the studies, the schemes which provide optimum improvement in performance for strengthening of the shear deficient beams are identified. Nonlinear explicit dynamic analysis is performed to analyse the impact behaviour of best models. In this study, only curved beams are studied. So the same study can be conducted on different types of beams. Rather than wrapping and partial replacement, different types of strengthening techniques can be used. In this study, shear deficiency considered is 20%, so studies can be conducted on different shear deficiencies by increasing the stirrup spacing. The thesis work focused only on analysis of beams with a length of 1800mm. Therefore, analysis of beam with varying length can be studied.

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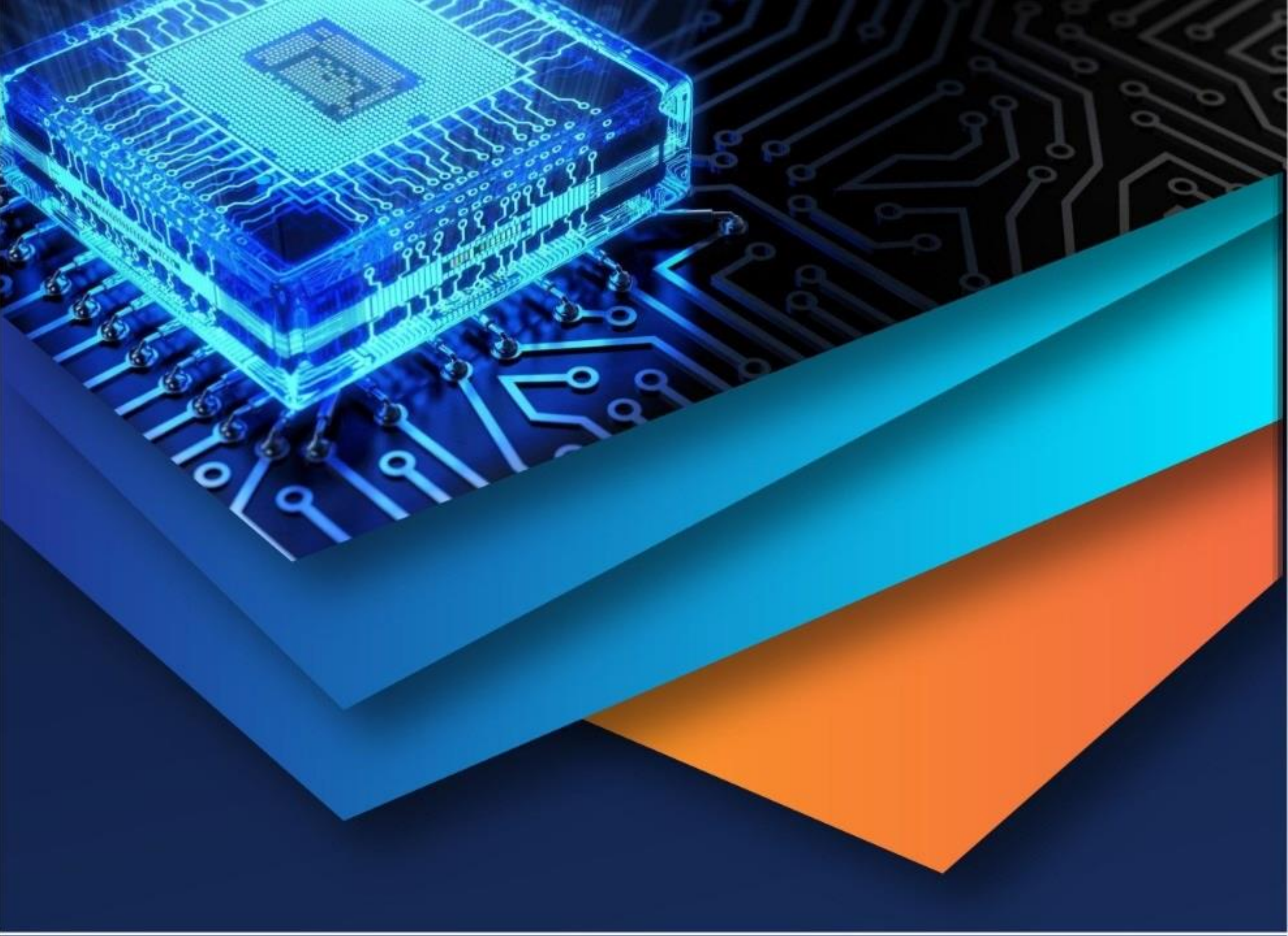

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