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FEM ANALYSIS OF RCC RING BEAM IN AN INTZE TANK REINFORCED BY FRP USING ANSYS 14.5

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ABSTRACT
The mechanical behavior of composite concrete structures is difficult to analyze by an analytical model, as it becomes increasingly complex to consider the nonlinear behavior of the composite material. FE analysis is an efficient solution to overcome the problems. Repair and Rehabilitation engineering is a specialized field, which calls for skills and abilities beyond design and construction engineering. The systematic approach to deteriorate structure is necessary and there should be balance between technology management and economics. The first task when a structure shows sign of cracking, spalling or any other sign is to determine whether the damage is structural or non-structural. In this study test specimen of an Beam Section from Intze Tank Middle Section sized 1000mm x 600mm having overall length 14m of grade M-30 and Loading condition for Beam Section is 600 KN which is analysed in both conditions such as unreinforced means without FRP wrapping which is base model and reinforced means wrapped by FRP with different length is taken for Finite Element Method analysis for the investigation of deformation and stresses. Ansys software is used for finite element modelling. In this study unreinforced beam and beam reinforced with CFRP are compared on the basis of deformation and stresses. The analytical concrete Beam Section model was generated using FEM software program ANSYS 14.5. In ANSYS 14.5 software concrete Beam Section this is subjected to loading through vertical loading which is 600KN.

KEYWORDS: FEM, RCC Beam, FRP, ANSYS 14.5, Reinforced Concrete etc.

1. INTRODUCTION
Concrete creation is normally expected to present trouble free carrier all through its intended layout lifestyles. But, these expectancies aren't realized in many constructions due to structural deficiency, fabric deterioration, unanticipated over loadings or bodily damage. Untimely material deterioration can stand up from some of reasons, the most common being while the construction specifications are violated or while the ability is uncovered to harsher carrier surroundings than the ones anticipated throughout the making plans and design levels. Bodily damage can also arise from fire, explosion – as well as from restraints, both internal and outside, in opposition to structural motion. Except in extreme cases, maximum of the structures require healing to fulfil its purposeful necessities by way of suitable repair strategies.

In general, the properties of Fibre Reinforced Polymer are controlled by the type of fibres used for strengthening. The following types of fibres are generally adopted for structural applications:
i. Carbon Fibre
ii. Glass Fibre

Different fibre types have different properties. Application of carbon fibre brings about very good improvement in strength but the failure is usually explosive in nature. Application of glass fibre leads to reasonable improvement in strength and failure is more ductile. The properties of typical fibres are presented in Table 1 Different fibres types shown in Figs. 1 and 2.

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Table 1 Properties of Fibres used in FRP (Source ACI 440.2R)

Sl. No.	Types of Fiber	Tensile Strength (GPa)	Ultimate Tensile Strain	Elastic Modulus (GPa)
1	Carbon	2050-3790	0.012	220-240
2	Glass	1860-2680	0.045	69-72

Figure 1 Carbon Fibre

Figure 2 Glass Fibre

In the past, research works have been carried out by researchers with regard to the effect of FRP wrappings for a particular type of wrapping and loading conditions. Not much work has been carried out in a single work to find the effectiveness of CFRP and GFRP wrapping for different span of beams in a Water Tank. Such a research shall lead to valuable findings and comparative values. This research work is significant on account of the investigation on Stress Strain behaviour on reinforced concrete beams strengthened with different GFRP and CFRP configurations. This study is indented to evaluate the effect of Glass Fibre Reinforced Polymer (GFRP) and Carbon Fibre Reinforced Polymer (CFRP) laminates on the performance of RC ring beams under static loading.

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2. LITERATURE REVIEW

Shiohara et al. 2010 re-examined twenty reinforced concrete interior beam-to-column joint failed in joint shear. The data indicated that joint shear stress had increased in the most specimens, even after apparent joint shear failure starts, while beam moment decreases due to decrease of flexural resistance which is caused by reduction of distance between stress resultants in beam at column face. The cause of the deterioration of story shear is identified to be a degrading of moment resistance of joint, originated from a finite upper limit of anchorage capacity of beam reinforcements through the joint core. To reflect the fact, Hitoshi introduced a new mathematical model and proposed a new approach for the design of beam-to-column joint in seismic zone based on the prediction of the model.

Xiaobing et al. (2013) the experiment was carried out to study the mechanical behavior of square FRP-strengthened concrete columns subjected to concentric and eccentric compression loading. Basing on the study, a numerical analysis model was developed and verified against the test results of square concentrically loaded plain concrete columns and square eccentrically loaded RC Columns. An analytical formula for the increase of maximum compression load for FRP strengthened columns with respect to non strengthened columns was developed and verified by the test results of the square and rectangular RC columns. It was found that the increase of the maximum compression load of the strengthened concrete columns increase linearly with increased amount of FRP sheets used decreased linearly with increased load eccentricity and exponentially with increased concrete compression strength with respect to non-strengthened columns. This implies that FRP wrapping might be most suitable for low strength concrete members.

Mukharjee et al. (2002) the experiment was carried out to investigate the behaviour of RCC joint with and without adequate shear reinforcement in the joint region. The joints were strengthened by different types of FRPs in different configurations before and after failure and their behaviour was compared with the control specimen. The specimens with adequate shear reinforcement and strengthened with FRPs exhibited higher dissipation of energy and ultimate deformation than controlled specimens. The main cause for the superior performance of the FRP strengthened is the confinement of concrete by FRP wraps. The damaged specimen were strengthened by FRP wraps and exhibited better performances in terms of ultimate load carrying capacity, displacement under ultimate load and energy dissipation energy. Non-ductile joints strengthened by FRP also exhibited better performance and their performance depends on the number of layers of FRP wrapping. But the displacement at yield increased to a much lesser extent than the load.

Moradi and Esfahani (2016) Using steel fiber reinforced concrete (SFRC) causes significant improvement in the behavior of deep beams with openings. This paper proposed a method for designing SFRC deep beams with opening, which was derived from previous studies on the behavior modeling of SFRC beams under tension and design principles of strut and tie method. To evaluate the proposed method, four large-scale specimens were used, which included two SFRC and two reinforced concrete deep beams with opening. Results of the test series illustrated the applicability of the proposed method.

3. OBJECTIVE OF THE PRESENT WORK

The objective of present study is to evaluate the effectiveness of the use of FRP laminates as external reinforcement to reinforced concrete frames with Ring Beam section in an Intze Tank subjected to stress and Deformation. The following FRP configurations are examined:-

- First analysis is going to be done on unreinforced sections of Intze tank ring beam which is compared to reinforced sections with FRP laminates.
- Wrapping is done in different patterns at Intze tank ring beam.
- After the analysis of above two researcher supposed to use different type of FRP laminates as well.
- Researcher will validate the retrofitting method by using FRP laminates in software package ANSYS 14.5.
- Researcher will also give the best FRP laminate properties for reduction in stress and deformation for the different loading conditions as per given objective 2 and objective 3.

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4. METHODOLOGY

In this study test specimen of an **Beam Section** from Intze Tank **Middle Section** sized **1000mm x 600mm** having overall **length 14m** of **grade M-30** and Loading condition for **Beam Section** is **600 KN** which is analysed in both conditions such as unreinforced means without FRP wrapping which is base model and reinforced means wrapped by FRP with different length is taken for Finite Element Method analysis for the investigation of deformation and stresses.

Warping lengths of Fiber Reinforced Polymer for both Unreinforced and Carbon Fiber Reinforced Polymer is varying which is given below in table 3.1.

Table 2 warping lengths of FRP laminates

Test Name	FRP		Warping Length L (m)
B1	Without FRP	Without FRP	NIL
B2	CFRP	GFRP	2
B3	CFRP	GFRP	6
B4	CFRP	GFRP	10
B5	CFRP	GFRP	14

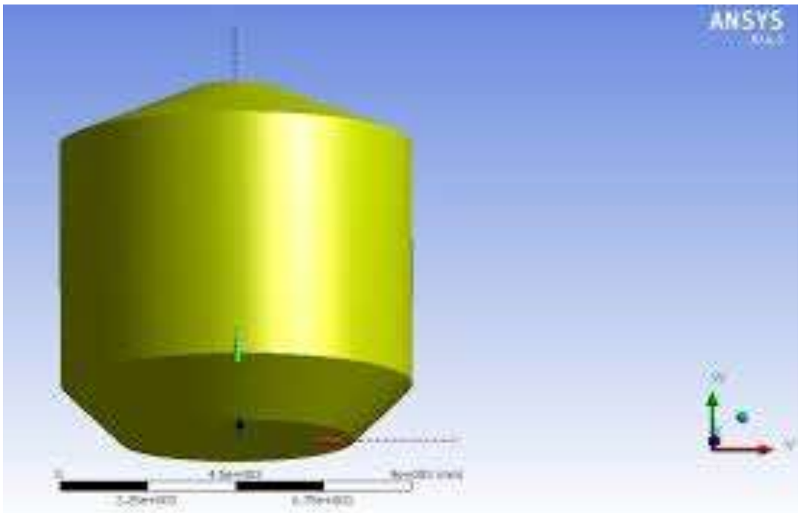

Figure 3 CAD Model of Intze Tank

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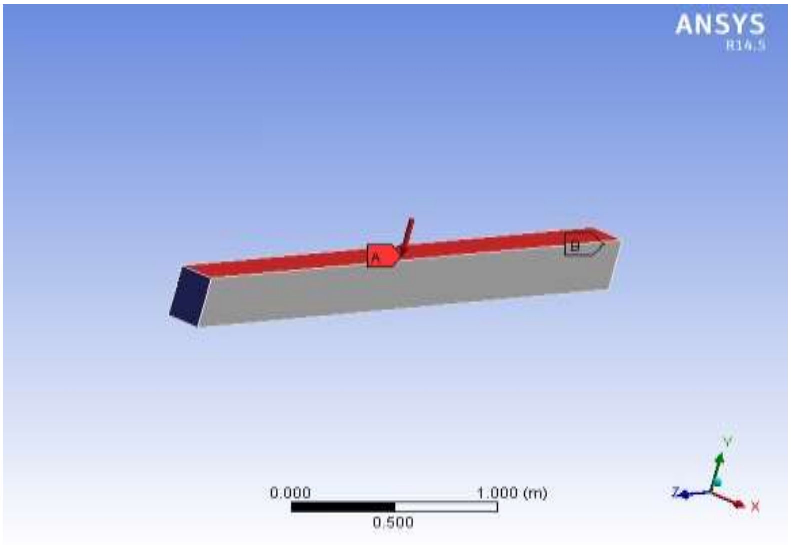

Figure 4 Support Condition and loading point of beam section

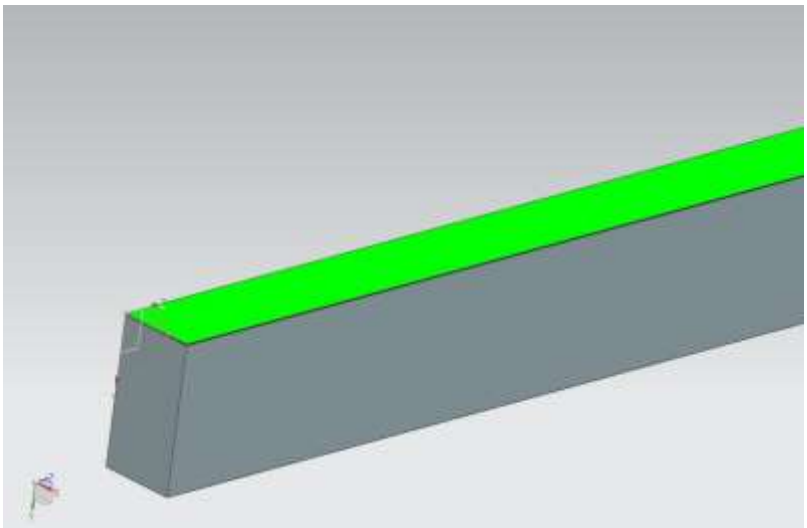

Figure 5 Warping Pattern of FRP laminates on the Beam section 14m

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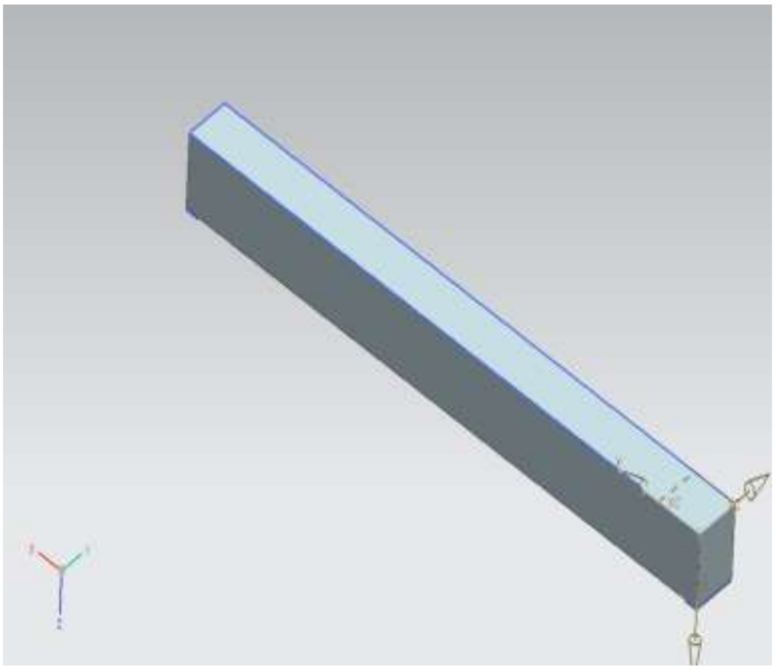

Figure 6 Base Model of beam section without FRP sheet

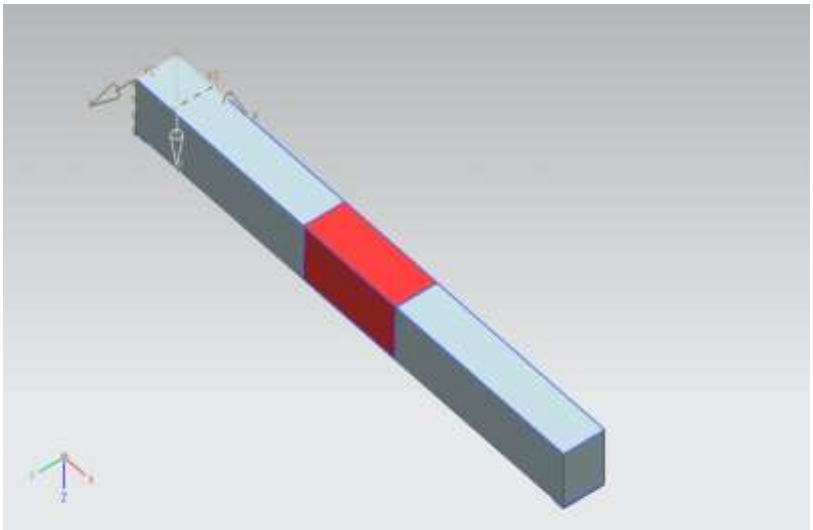

Figure 7 Base Model of beam section with FRP (length 2m) sheet

4.1 Basic Analysis Procedure in ANSYS
The three basic procedures are involved in ANSYS software for solving any problem & these are following;

- Pre-processing
- Solution
- Post processing

4.2 Preprocessing
It consists of following steps-

- CAD modeling.
- Meshing

- Boundary condition
- Loading condition

4.3 Solution

Solve a set of liner or nonlinear algebraic equations simultaneously to obtain nodal results, such as displacement values at different nodes or temperature value at different nodes in a transfer problem.

4.4 Post Processing

At this point, you may be interested in values of von-mises stresses, elastic strain and deflections.
A finite-element computer program, ANSYS has been used to analyse the present problem. ANSYS is general finite-element software for numerically solving a wide variety of structural engineering problems. The ANSYS element library consists of more than 100 different types of element.

Beam system have been analysed using general purpose finite element software ANSYS to investigate deflection pattern and stress pattern.

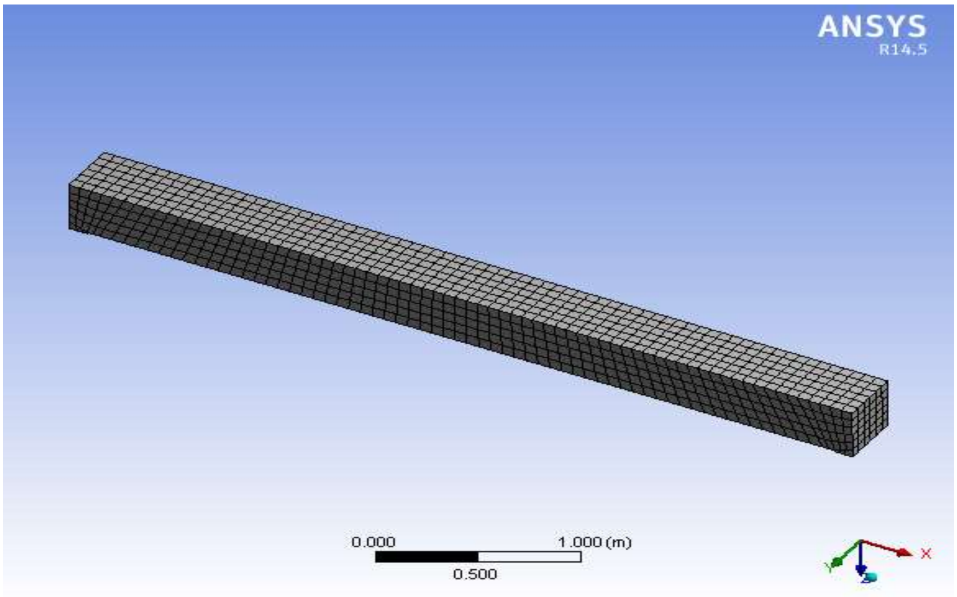

Figure 7 Mesh Model of Beam

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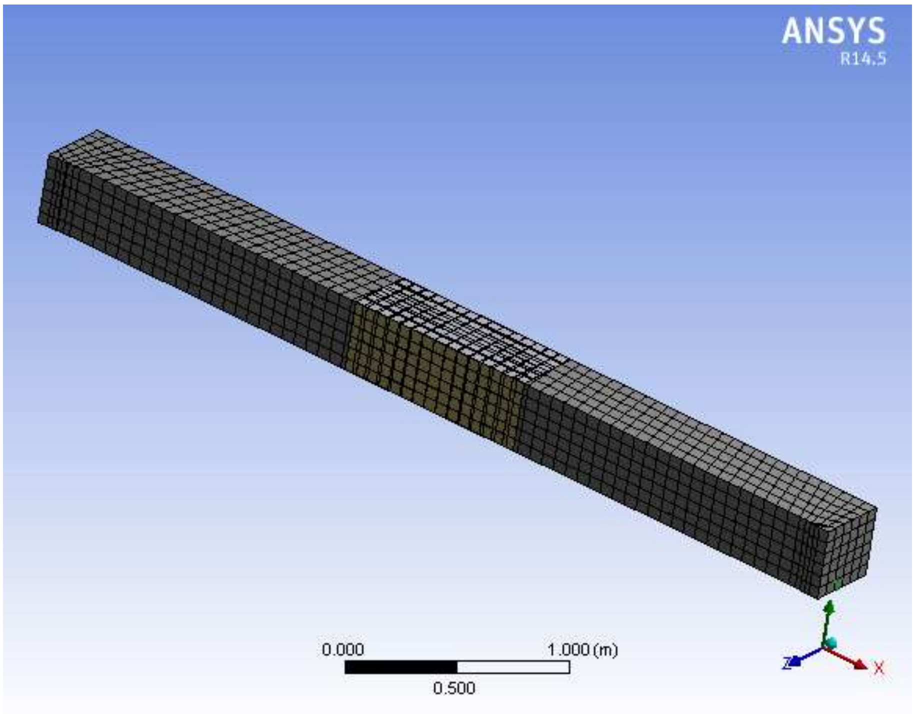

Figure 8 Mesh Model of Beam with FRP

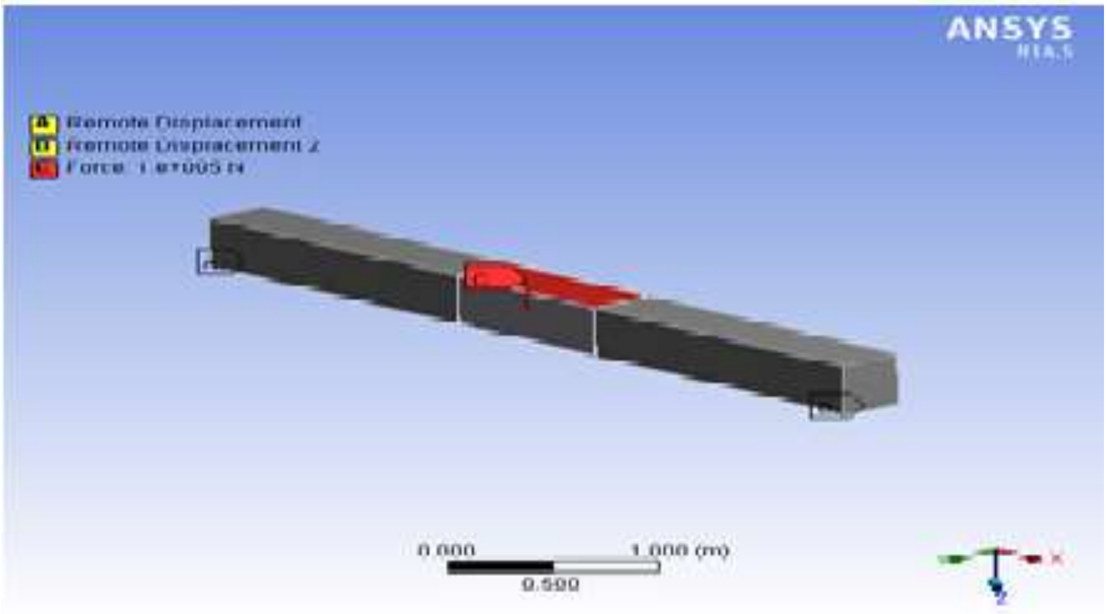

Figure 9 Support Condition and loading point of beam section

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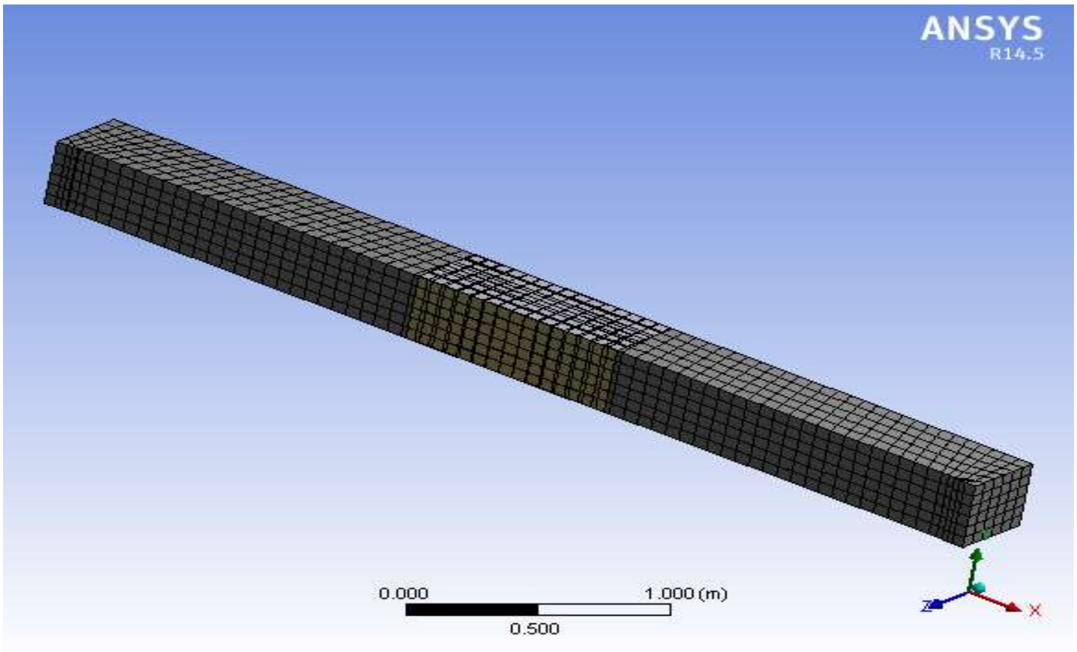

Figure 10 Warping Pattern of FRP laminates on the Beam section

4.5 Boundary Conditions

Various boundary conditions taken in the analysis are;

1. Static conditions with the loading.
2. Fix boundary conditions at the all degree of freedom of the beam system.
3. Plain strain condition exists within the beam system.

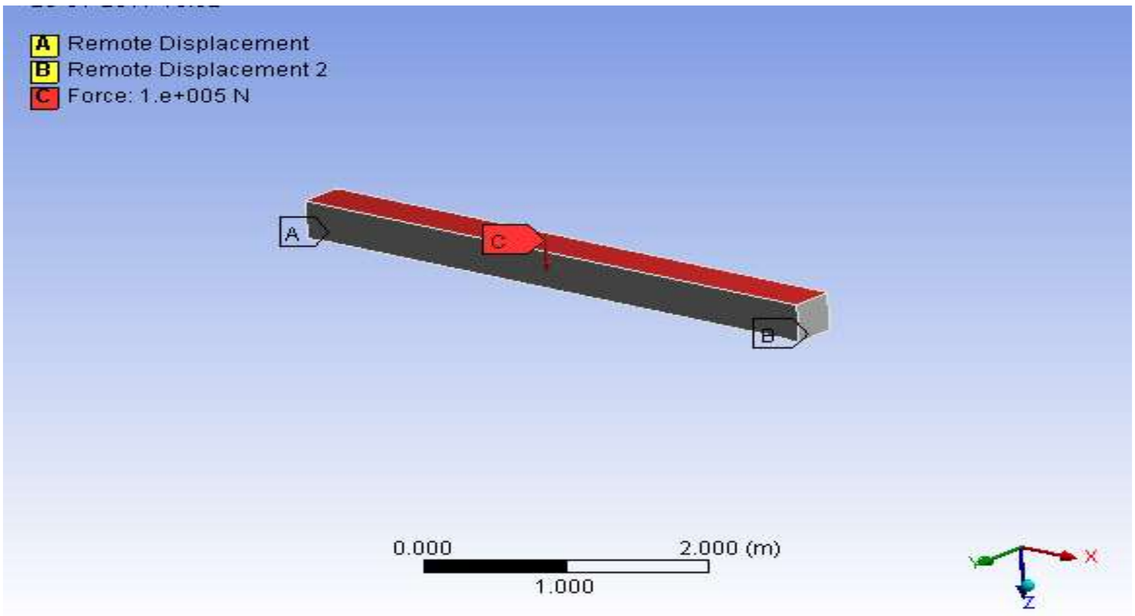

Figure 11 Boundary condition of beam section without FRP sheet

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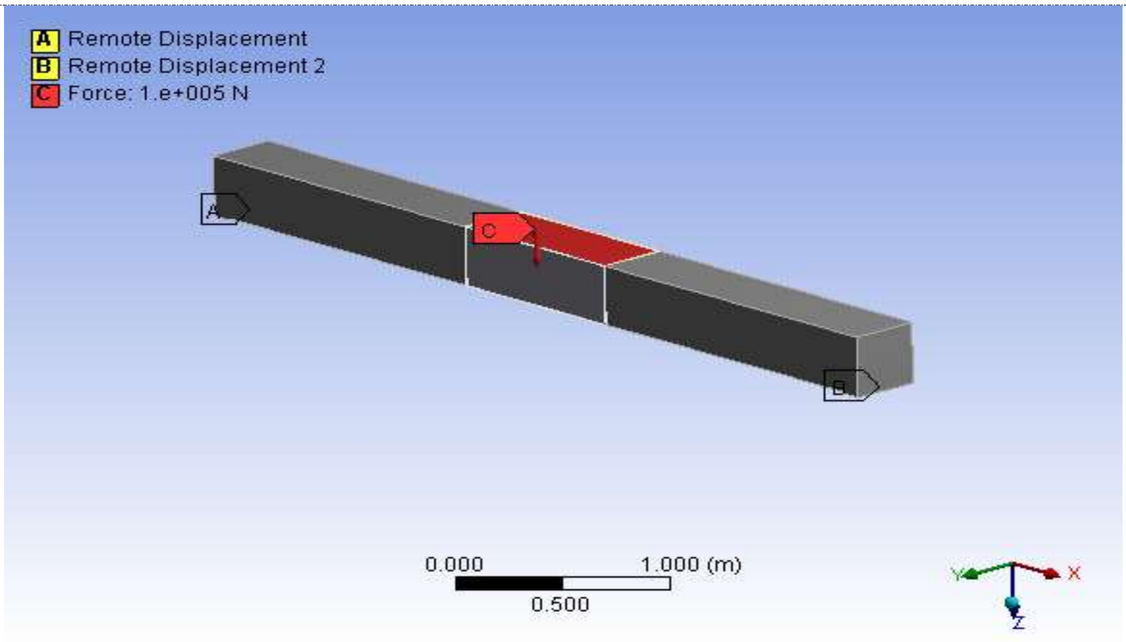

Figure 12 Boundary condition of beam section with FRP sheet

4.6 Obtain the Solution

Perform the linear static analysis by using plane strain element (and applying all the boundary conditions and loads then results were obtained through FEM analysis using ANSYS for beam system.

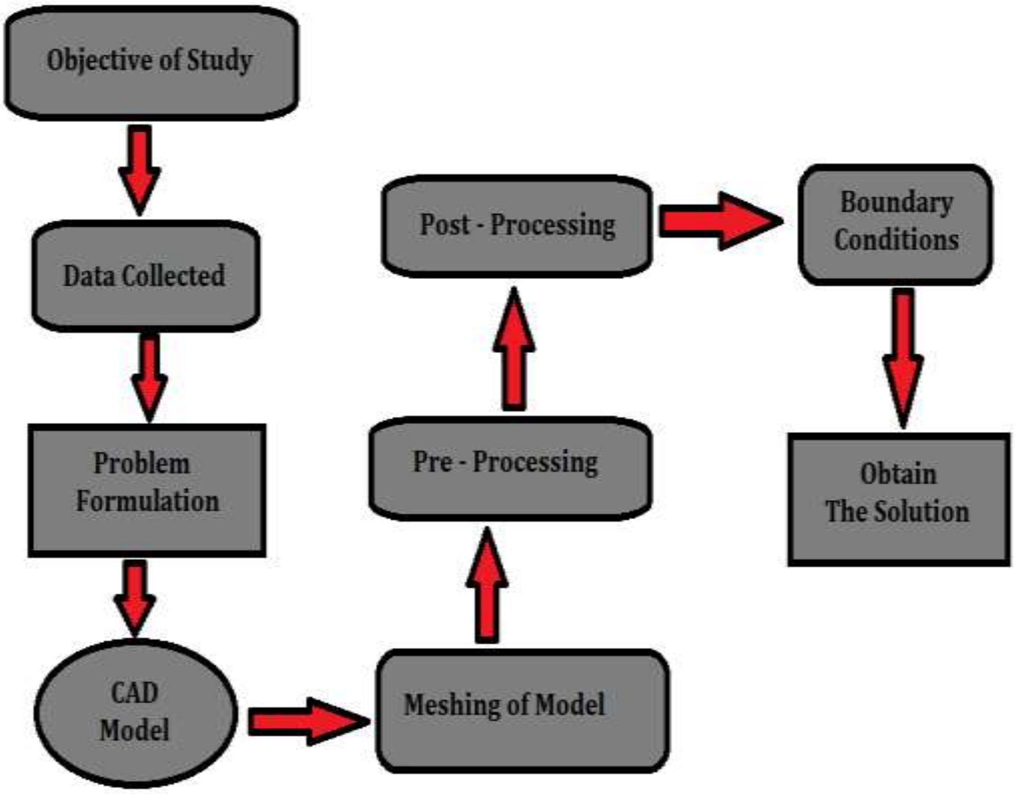

Figure 13 Flow Chart of Methodology

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5. RESULTS

5.1 Deformation Results

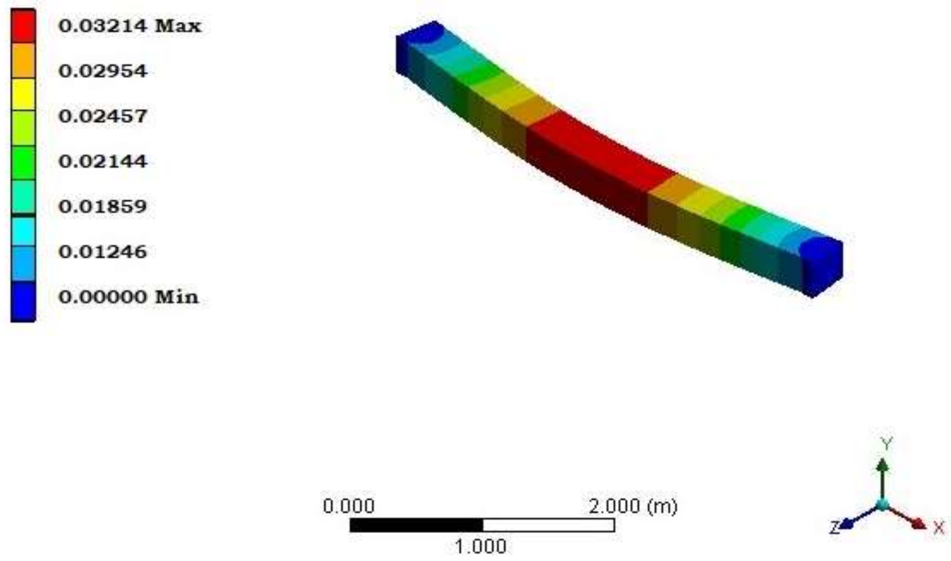

Figure 14 Deformation of Base Model Beam Section

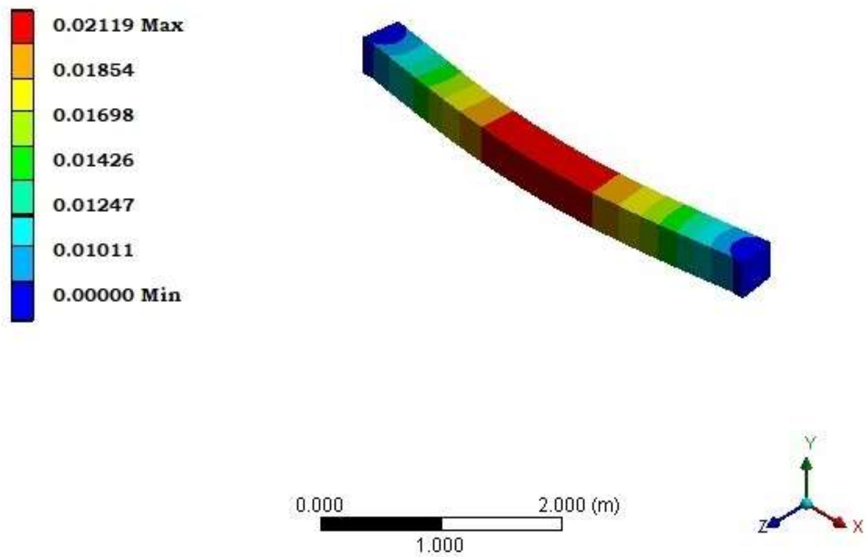

Figure 15 Deformation of CFRP L=14000

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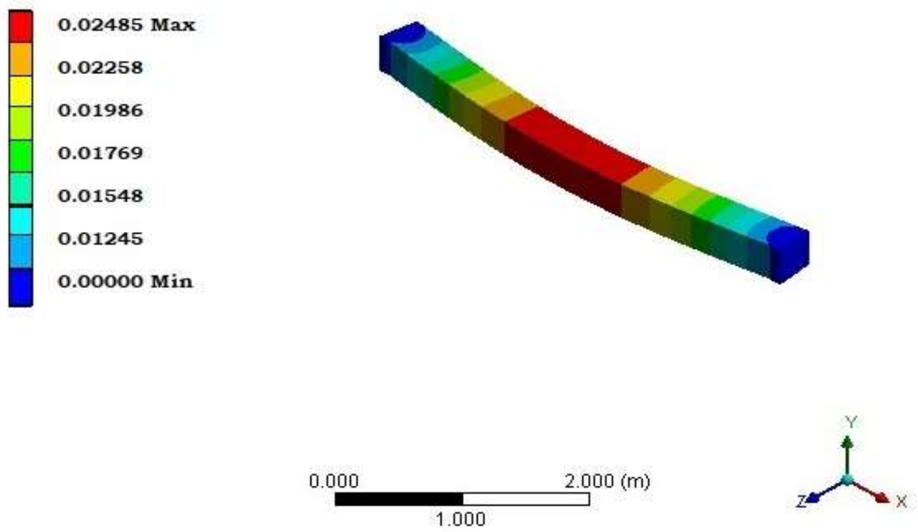

Figure 15 Deformation of GFRP L=14000

5.2 Stress Results

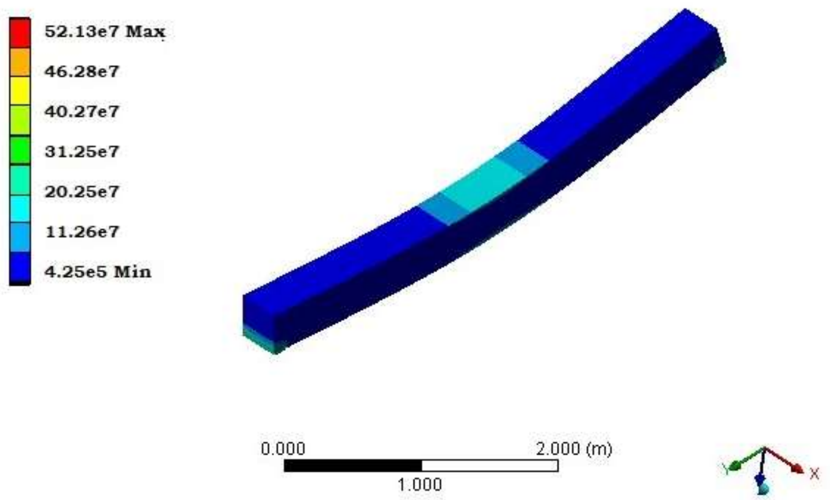

Figure16 Stress of Beam Section BASE MODEL

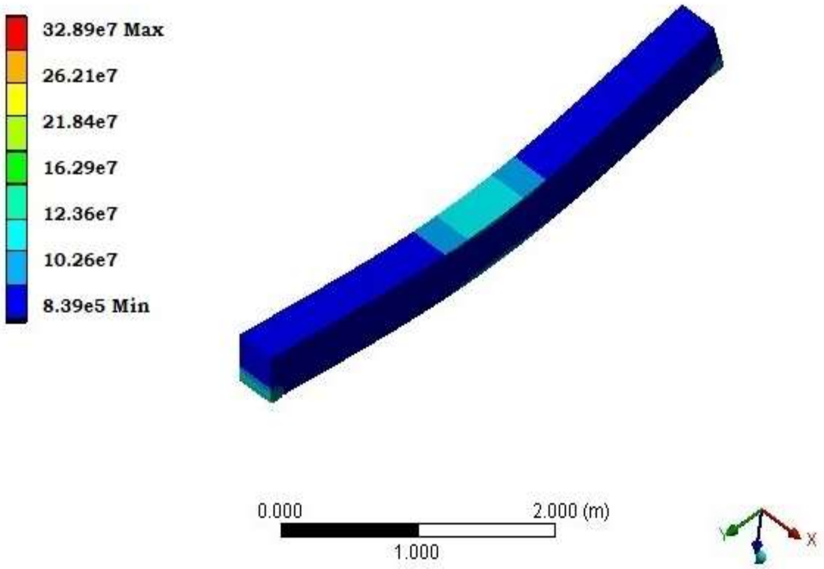

Figure 17 Stress of CFRP L=14000mm

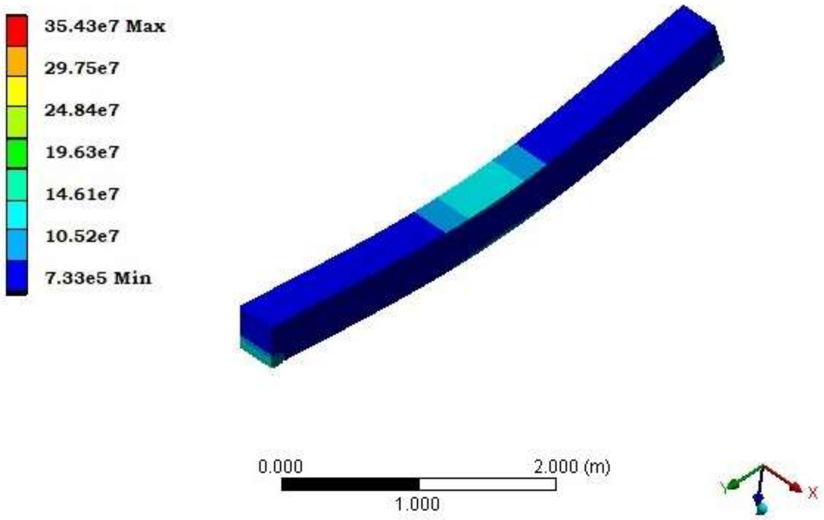

Figure 18 Stress of GFRP L=14000mm

6. CONCLUSION

The analytical concrete Beam Section model was generated using FEM software program ANSYS. In ANSYS software concrete Beam Section this is subjected to loading through vertical loading which is 600KN.
Following conclusions can be drawn from current study:

- There is 34% reduction in deformation for length of 14000mm CFRP laminate as compare to Without FRP concrete.
- There is 36.91% reduction in stresses for length of 14000mm CFRP laminate as compare to Without FRP concrete.
- There is 22.9% reduction in deformation for length of 14000mm GFRP laminate as compare to Without FRP concrete.
- There is 32.05% reduction in stresses for length of 14000mm GFRP laminate as compare to Without FRP concrete.

- CFRP provided more strength to the structure Beam and effective than GFRP reinforced and Without FRP concrete material in reduction of deformation and stresses.

Based on results obtained from the present investigation, the following conclusions can be made on the behaviour of beam section reinforced by different FRP materials:

- Strength of concrete can be increased by using FRP reinforced beam system.
- A load deflection response was measured when FRP reinforcement was provided. The stiffer response was observed at a relatively more reduction in deflection is observed with CFRP sheet as compare to GFRP and Without FRP concrete.
- A load and stress response was measured when FRP reinforcement was provided and a response was observed that, relatively more reduction in stress is also considered in CFRP sheet as compare to GFRP and Without FRP concrete

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