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## Comparative Study of Deep Beams with Different Reinforcement Materials Using ANSYS

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**Abstract-** The use of deep beam has become more prevalent in recent years. With large growth of construction work in many developing countries, deep beams design and its behavior prediction have great importance. Several large reinforced concrete girders in high rise buildings, foundation walls, water tanks, were found to have very wide cracks near the side face. In order to avoid this problem, side face reinforcement spacing is to be changed and deep beam with different reinforcement materials is to be studied. This analytical study was done using ANSYS. An FEA approach can be done in the modal to get precise stress and deformation values. Then the relationship between side face reinforcement spacing and deformation was found out.

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**Keywords:** Deep beam, FEA, ANSYS

### I. INTRODUCTION

RC deep beam are very useful members in buildings, bridges and infrastructures. Deep beams are the beam with a depth comparable with their span length. According to IS-456 (2000) clause 29, a simply supported beam is classified as deep when the ratio of its effective span  $L$  to overall depth  $D$  is less than 2. In Continuous deep beam the  $L/D$  ratio is less than 2.5. The effective span is defined as the center to center distance between the supports or 1.15 times the clear span whichever is less.

Side face reinforcement or skin reinforcement is provided in a beam having depth 750mm or more. Skin reinforcement is provided on the sides of deep beams to reduce the formation of crack. Side face reinforcement spacing is the most important factor in deep beams. Otherwise the crack will increase and lead to corrosion reducing the beam strength. To avoid these problems, new reinforcement materials are adopted. Corrosion resistance, high strength, high modulus of elasticity and price of the reinforcement are the most important factors in the case of reinforcement material.

### II. OBJECTIVES

- To study the relationship between side face reinforcement spacing and deformation.
- To identify the better reinforcement material.
- To compare the results with other reinforcement material.

### III. SCOPE

The scope is to study the deep beam implementation economical by providing different side face reinforcement spacing. By studying relationship between stress and deformation occurring corresponding to spacing, better spacing can be suggested and can be made economical than that of conventional ones. Then find the better reinforcement material.

### IV. METHODOLOGY

- Modeling in CATIA and importing geometry to ANSYS
- Selection of suitable material properties
- Selection of suitable elements from ANSYS element library
- Meshing
- Solving the problems using appropriate loads and boundary conditions
- Observation and conclusion

### V. FINITE ELEMENT ANALYSIS

#### A. Details of model

3 deep beams having dimensions 380 mm x 2100 mm x 4000mm are considered. Finite element analysis was carried out in simply supported beams with different side face reinforcement spacing. Materials used were M20 grade concrete and Fe415 steel. Reinforcements were provided as per IS Code 456. 8 mm diameter bars were provided in side

face with different side face reinforcement spacing such as 120mm, 170mm, 220mm. Six 16mm diameter bars were provided in the tension side. Deep beams were modeled using CATIA V6. This Analysis was carried out using ANSYS.

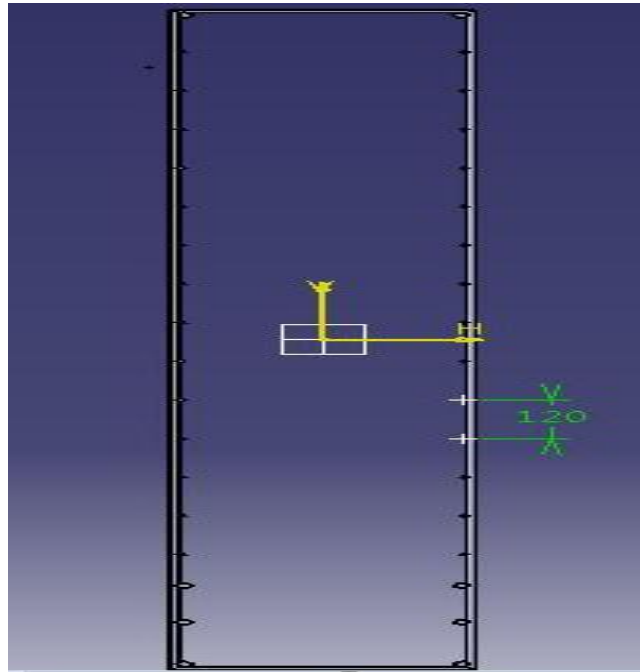


Fig 1: Cross section of deep beam

### *B. Material Properties*

The materials used in this work are steel, bamboo and carbon rod. These materials have different properties. The properties of materials are,

#### 1. Steel as reinforcement material

Steel is a remarkable reinforcement material as it combines high strength, modulus of elasticity, homogeneity and a relatively low price. The main drawback in using ordinary steel is its expansive corrosion behavior. Steel is highly recyclable and is therefore recycled to a large extent in practice.

#### 2. Bamboo as reinforcement material

Bamboo is a renewable and versatile resource, characterized by high strength and low weight, and is easily worked using simple tools. The analysis of the replacement of steel with bamboo as reinforcement shows that reinforcement with bamboo is quite cheaper than that of steel reinforcement. The positive attributes of bamboo is its environment-friendly nature.

#### 3. Carbon rod as reinforcement material

The use of fibre reinforced composite rods as reinforcement of concrete elements seems to be an effective solution to overcome durability problems of traditional steel reinforced concrete structures. The advantages of fibre reinforced composite materials over steel include the excellent corrosion resistance, mechanical properties similar to steel, high strength-to-weight ratio and excellent fatigue resistance, among others.

### *C. Results and Discussion*

The stress and deformation of beam having different reinforcement material with different side face reinforcement are shown below.

#### 1. Case 1- 120mm side face reinforcement spacing

##### *a) Steel as reinforcement material*

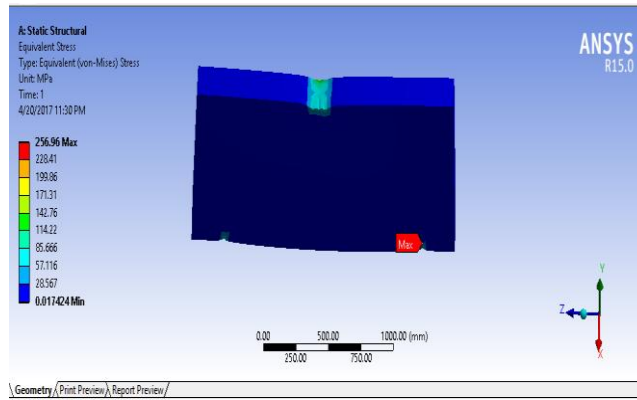


Fig 2: Equivalent stress distribution of steel as reinforcement material

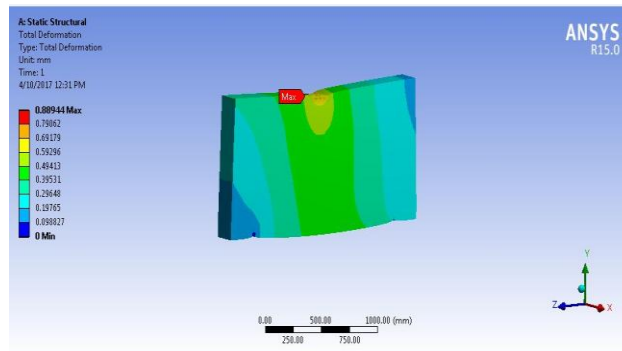


Fig 3: Total deformation of steel as reinforcement material

*b) Bamboo as reinforcement material*

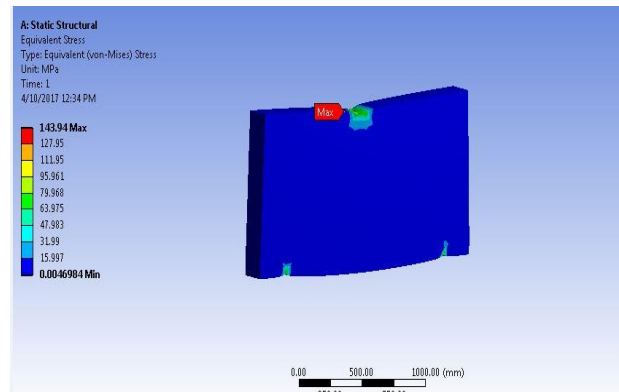


Fig 4: Equivalent stress distribution of bamboo as reinforcement material

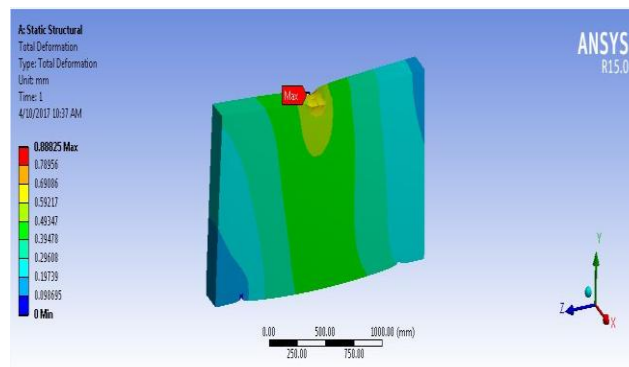


Fig 5: Total deformation of bamboo as reinforcement material

c) Carbon rod as reinforcement material

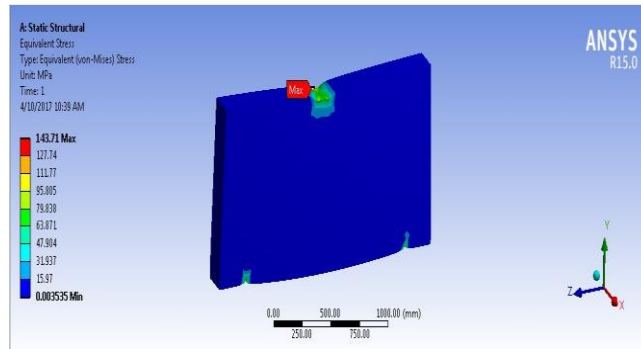


Fig 6: Equivalent stress distribution of carbon rod as reinforcement material

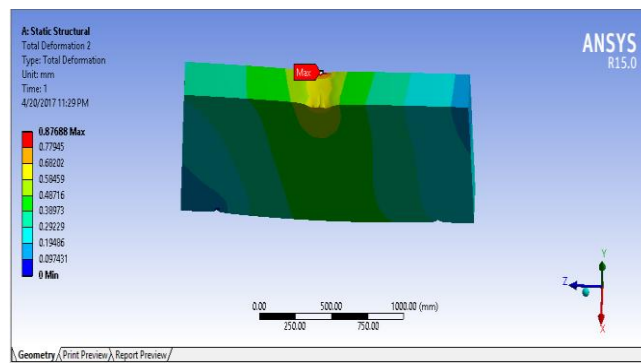


Fig 7: Total deformation of carbon rod as reinforcement material

Table 1: Comparison of reinforcement material with 120mm side face reinforcement spacing

Material	Steel	Bamboo	Carbon rod
Stress (MPa)	256.96	143.94	143.71
Deformation (mm)	0.889	0.889	0.876

2. Case 2- 170mm side face reinforcement spacing

a) Steel as reinforcement material

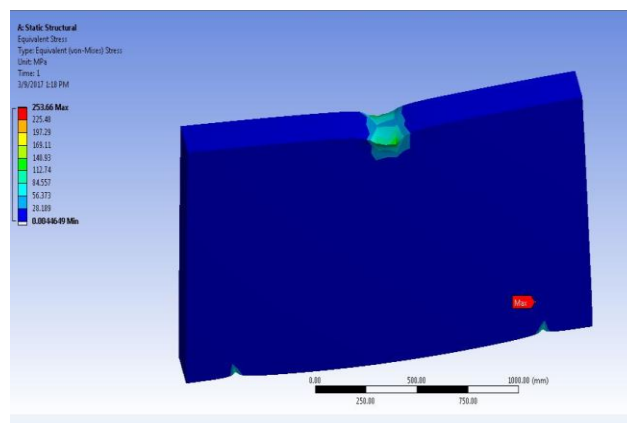


Fig 8: Equivalent stress distribution of steel as reinforcement material

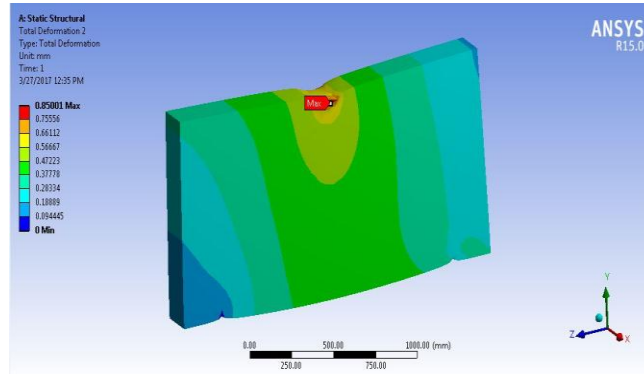


Fig 9: Total deformation of steel as reinforcement material

b) *Bamboo as reinforcement material*

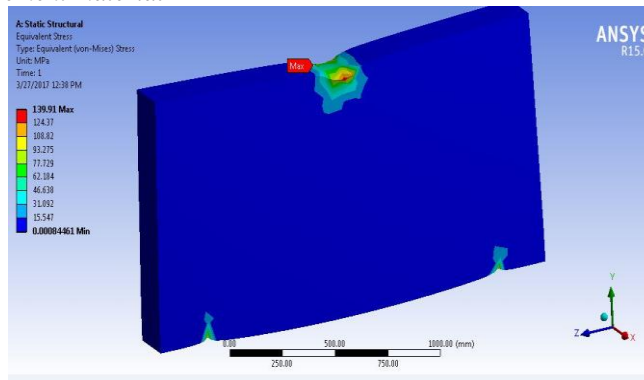


Fig 10: Equivalent stress distribution of bamboo as reinforcement material

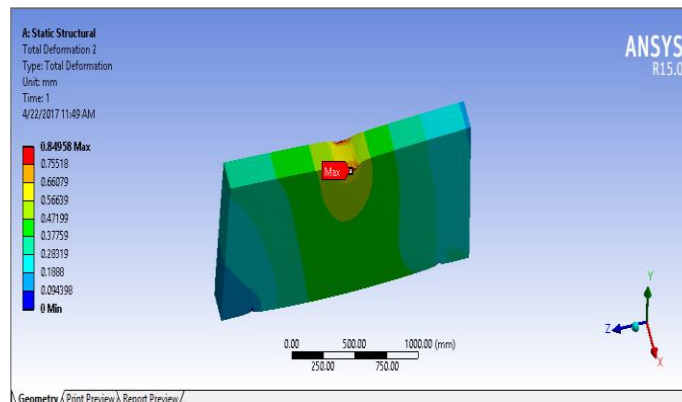


Fig 11: Total deformation of bamboo as reinforcement material

c) *Carbon rod as reinforcement material*

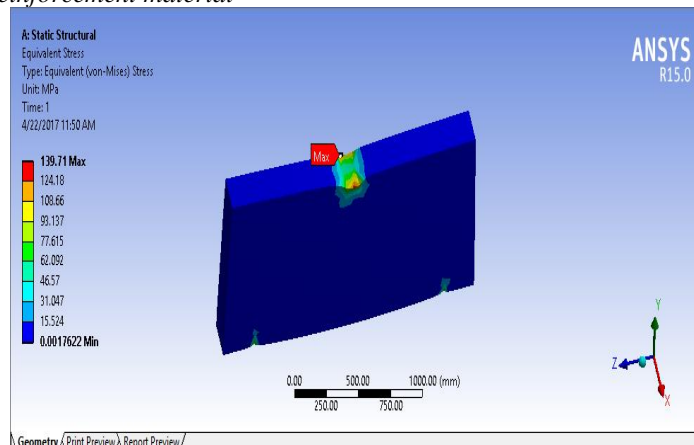


Fig 12: Equivalent stress distribution of carbon rod as reinforcement material

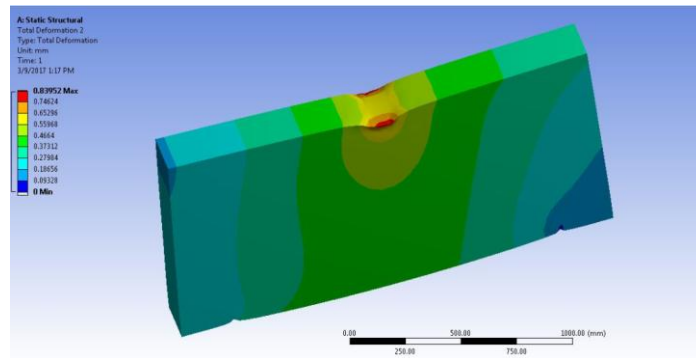


Fig 13: Total deformation of carbon rod as reinforcement material

Table 2: Comparison of reinforcement material with 170mm side face reinforcement spacing

Material	Steel	Bamboo	Carbon rod
Stress (MPa)	253.66	139.91	139.71
Deformation (mm)	0.850	0.849	0.839

3. Case 2- 170mm side face reinforcement spacing  
 a) *Steel as reinforcement material*

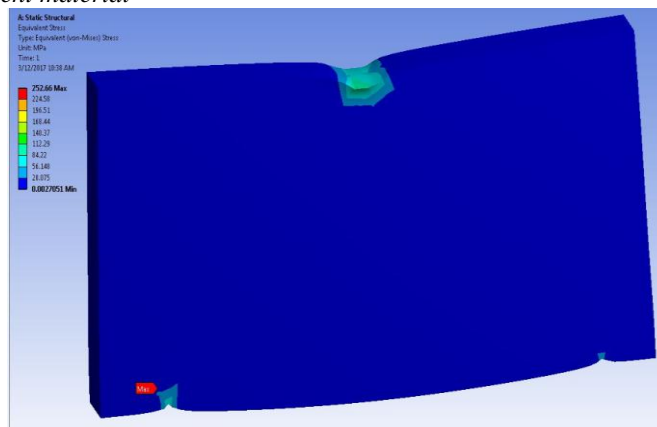


Fig 14: Equivalent stress distribution of steel as reinforcement material

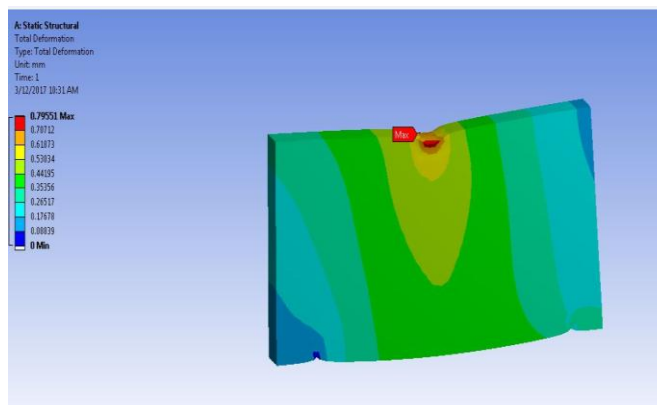


Fig 15: Total deformation of steel as reinforcement material

b) *Bamboo as reinforcement material*

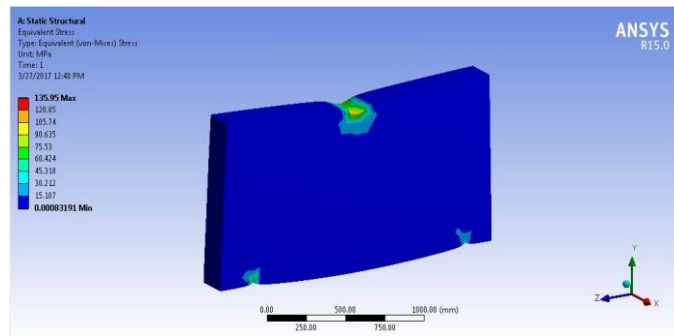


Fig 16: Equivalent stress distribution of bamboo as reinforcement material

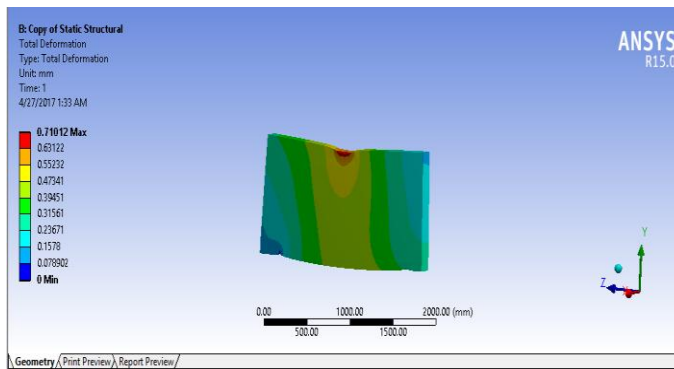


Fig 17: Total deformation of bamboo as reinforcement material

b) *Carbon rod as reinforcement material*

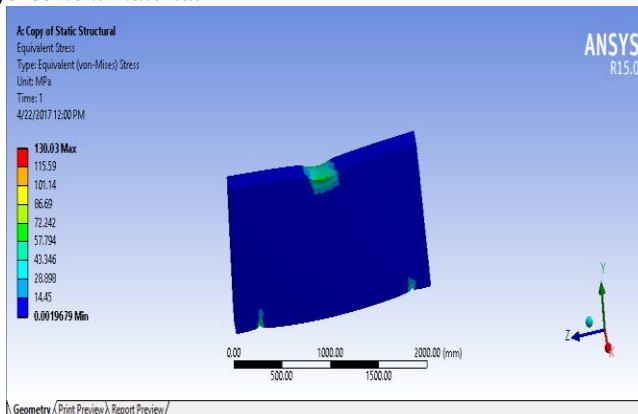


Fig 18: Equivalent stress distribution of carbon rod as reinforcement material

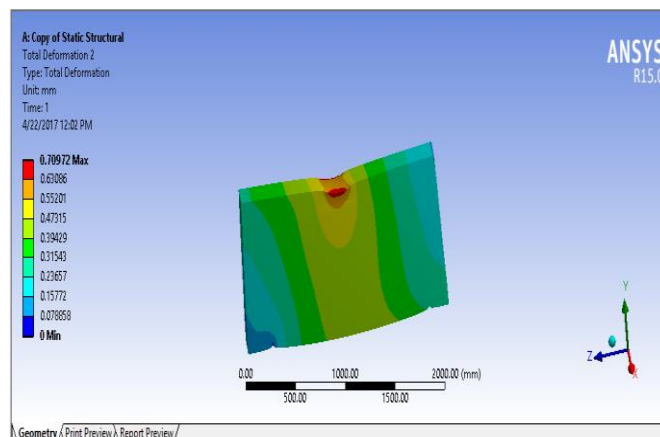


Fig 19: Total deformation of carbon rod as reinforcement material

Table 3: Comparison of reinforcement material with 220mm side face reinforcement spacing

Material	Steel	Bamboo	Carbon rod
Stress (MPa)	252.66	135.95	130.03
Deformation (mm)	0.795	0.710	0.709

## VI. CONCLUSIONS

Finite Element Analysis has been used to understand the behavior of deep beams with different reinforcement material such as steel, bamboo, carbon rod etc. Then stress and deformation were tabulated. The best reinforcement material and spacing were selected. Following are the observations from this study,

- Change of spacing of side face reinforcement doesn't show much variation in stress and deformation values.
- 220mm spacing shows less stress and deformation.
- The deformation of carbon rod and bamboo are low as compared to those of steel.
- Carbon rods are better compared to other reinforcement materials.

## VII. FUTURE SCOPE

- Investigation on the use of other reinforcement material.
- Experimental study on deep beam with different reinforcement material.
- Vibration analysis of deep beam with different reinforcement material.

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