

Finite Element Modeling of Hybrid Fibre Reinforced Concrete Beam with Elastomeric Bearing Pads

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Abstract - The main obstacle to finite element analysis of reinforced concrete structures is the difficulty in characterizing the material properties. Hybrid Fibre means if two or more types of fibres are rationally combined in a common matrix to produce a composite that drives benefits from each of the individual's fibres and exhibits a synergetic response. Here steel fibres and polyolefin fibres are used in hybrid form. A three-dimensional nonlinear finite element analysis is conducted to investigate the general behavior of composite beam with and without elastomeric bearing pads using finite element method packaging software named ANSYS. The analytical program aimed at raising the strength of the beams using fibres and elastomeric bearing pads. The result showed that the deflection decreases by using elastomeric bearing pads and with increase of percentage of hybrid fibre. Also analyze the behavior of Hybrid beams without steel reinforcement and understanding how the load and deflection will be controlled without steel reinforcement. In case of Hybrid fibre reinforced concrete beam without reinforcement with elastomeric bearing pads the load will be borne by the fibers used and deflection can control by using elastomeric material.

Key Words: Flexural behaviour, Hybrid fibre reinforced concrete beam, Elastomeric bearing Pads, ANSYS

1. INTRODUCTION

Reinforced concrete structures are largely employed in engineering practice in a variety of situations and applications. Traditional empirical methods remain adequate for ordinary design of reinforced concrete members, the wide dissemination of computers and the development of the finite element method have provided means for analysis of much more complex systems in a much more realistic way. Much effort has been spent in search of a realistic model to predict the behavior of reinforced concrete structures. Fibres have been used as reinforcement since ancient times, historically horsehair was used in mortar and straw in mud bricks.

In the early 1900s, asbestos fibres were used in concrete, there was a need to find a replacement for the asbestos used in the concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass, and synthetic fibres such as polypropylene fibres were used in concrete, and research in to new fibre reinforced concretes continues today. Hybrid

Fibre Reinforced Concrete (HFRC) can be used in any kind of construction because of its unique Properties and also as it very easy to obtain high range of strength values. Elastomeric bearings have low initial cost, low maintenance and also can withstand wide movements. Elastomeric bearings may use thin steel laminate reinforcement between the elastomeric layers to provide for greater strength, a steel sole plate to allow attachment to steel superstructures, and may use a steel masonry plate.

1.1 Objectives

The objectives of the work can be summarized as follows:

- To study the theoretical analysis of beams by using nonlinear three dimensional finite element program, ANSYS 16.1
- The analytical program aimed at raising the strength of the beams using Fibres and elastomeric bearings
- To investigate the flexural behavior of composite beams with and without elastomeric bearings under different load and dimension case.
- To study the validity of the used methods of analysis by comparing their results with the experimental ones.
- Analyze the behavior of Hybrid beams without steel reinforcement

2. ANSYS MODELING

The basic concept of FEM modeling is the subdivision of the mathematical model into disjoint (non-overlapping) components of simple geometry. The response of each element is expressed in terms of a finite number of degrees of freedom characterized as the value of an unknown function, or functions or at a set of nodal points. The response of the mathematical model is then considered to be the discrete model obtained by connecting or assembling the collection of all elements.

2.1 Descriptions of the Model

The program system ANSYS offers a variety of material models for different materials and purposes. The most important material models in ANSYS for RCC structure are concrete and reinforcement. We use Workbench 16.1 has been used to model,

- Conventional Concrete beam with and without elastomeric bearing pads
- Hybrid fibre reinforced concrete beam with and without elastomeric bearing pads
- Hybrid fibre reinforced concrete beam without steel reinforcement
- Hybrid fibre reinforced concrete beam without steel reinforcement and with elastomeric bearing pads

A beam with dimensions shown in Table 1 has been used to model the above cases

Table -1: Specification of beam

Length of beam	3000mm
Depth of beam	450mm
Width of beam	300mm
Steel bars	8mm,10mm
Stirrups	6mm dia @ 200mm
Clear cover	25mm

Properties of materials used

The grade of concrete in beams is M30 and Fe 415 grade of steel is used.

Poisson’s Ratio of concrete = 0.15

Young’s modulus of steel = $2 \times 10^5 \text{N/mm}^2$

Yield strength of steel = 415N/mm^2

Poisson’s Ratio of steel = 0.3

Here steel fibres and polyolefin fibres are used in hybrid form. The properties of fibre used are shown in Table 2

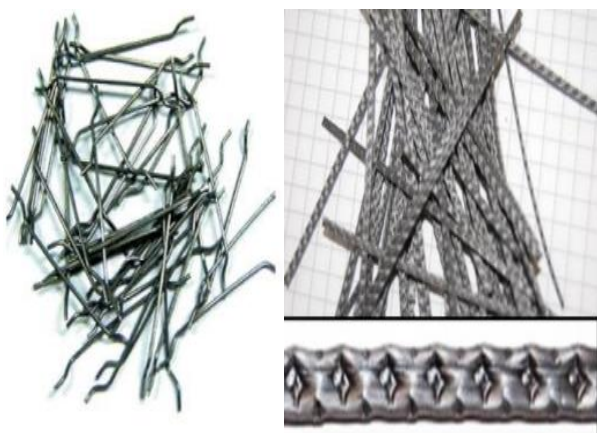


Fig -1: Hooked end steel fibers and polyolefin fibres

Table -2: Properties of Fibers used

Fiber Properties	Fiber Details	
	Polyolefin	Steel
Length (mm)	48	38
Shape	Straight	Hooked at ends
Size/Diameter	1.22×0.732mm	0.5mm
Aspect Ratio	39.34	60
Density (kg / m ³)	920	7850
Young’s Modulus	6GPa	210GPa
Tensile strength	550MPa	530MPa

2.2 Elastomeric bearing pads

Elastomeric bearings are generally made of rubber (vulcanised) blocks reinforced with steel plates. Elastomeric bearings may use thin steel laminate reinforcement between the elastomer layers to provide for greater strength, a steel sole plate to allow attachment to steel superstructures, and may use a steel masonry plate. Elastomeric bearings perform well during seismic events because of their relatively large plan dimensions and low height, and the natural dampening effect of the elastomer material. They are designed and sized to meet the needs of your structure, these bearings are rigid enough to transmit the necessary loads and flexible enough to permit the rotation and movement required by the structure.

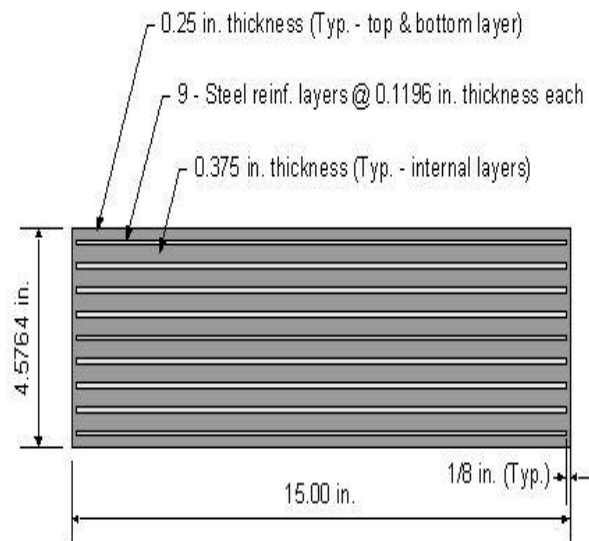


Fig -2: Elastomeric bearing pad

Table -3: Properties of Elastomeric bearing pads

Description	Details
Thickness of one elastomer layer	0.8cm
Thickness of one steel reinforcement layer	0.3cm
Shear modulus	0.68MPa
Elastomer moment of inertia I	1600cm ⁴
Shape factor S	12.3

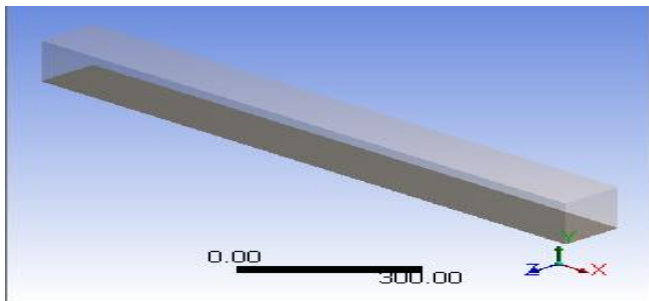


Fig3: Modeling of a concrete beam with Elastomeric bearing pad

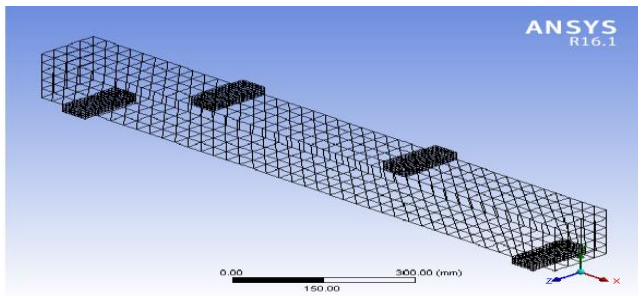


Fig 4: Meshed view of the Hybrid fibre reinforced concrete beam without reinforcement

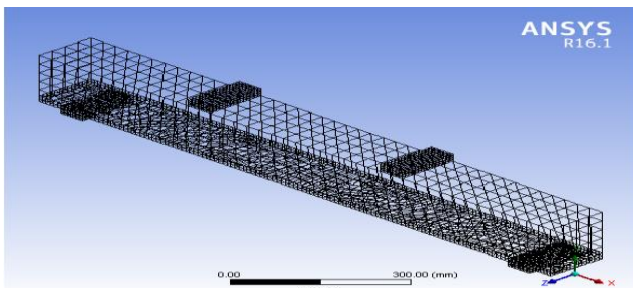


Fig5: Meshed view of the Hybrid fibre reinforced concrete beam without reinforcement and with elastomeric bearing pads

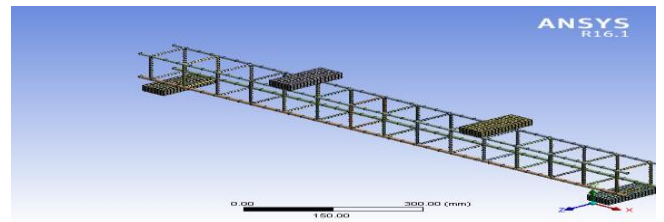


Fig6: Meshed view of the Stirrup inside the Hybrid concrete beam

3. ANALYSIS

Numerical analysis is performed using the ANSYS finite element program to predict the deflection of Hybrid fibre reinforced concrete beam. Analyzing the specimen under Two point loading and nonlinear analysis was carried out for all the specimens. The deformed shape of various beam models are given below.

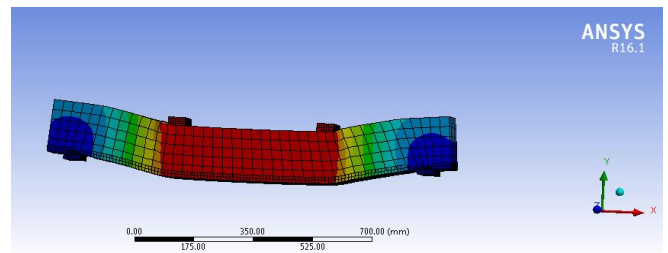


Fig7: Total deformation of Hybrid fibre reinforced concrete beam with elastomeric bearing pads

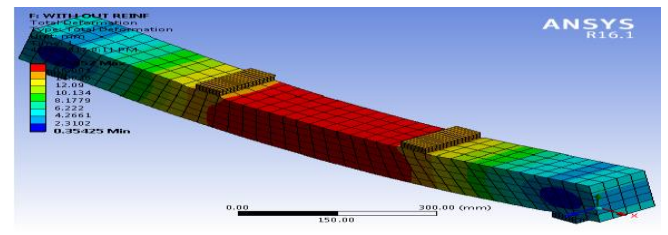


Fig 8: Total deformation of Hybrid fibre reinforced concrete beam without reinforcement

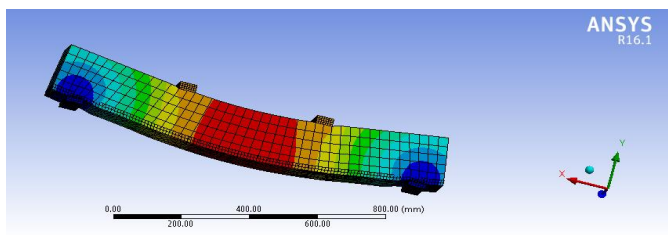


Fig9: Total deformation of Hybrid fibre reinforced concrete beam without steel reinforcement and with elastomeric bearing pads

4. RESULTS AND DISCUSSION

4.1 Load - Deflection curve

The Load - Deflection behaviour of different beam models are tabulated as shown in below. The recorded values of load and deflection were used to draw the load deflection plots and the deformation corresponding to each increment of load for all specimens was noted. The load deflection graph for all flexural specimen is also shown below.

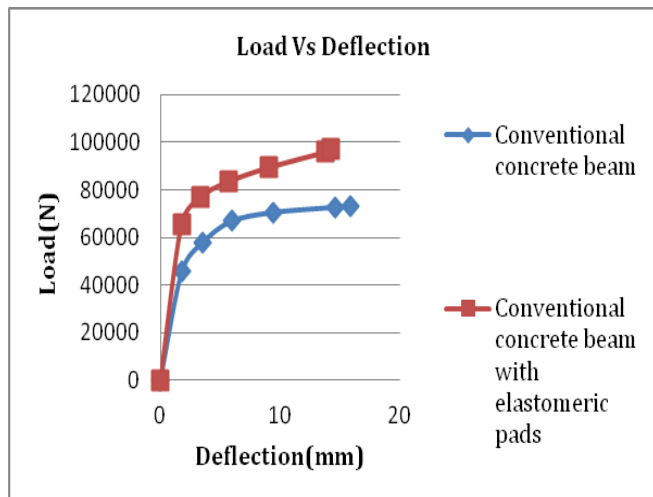


Chart 1: Load Deflection behavior of Conventional concrete beam with and without elastomeric bearing pads

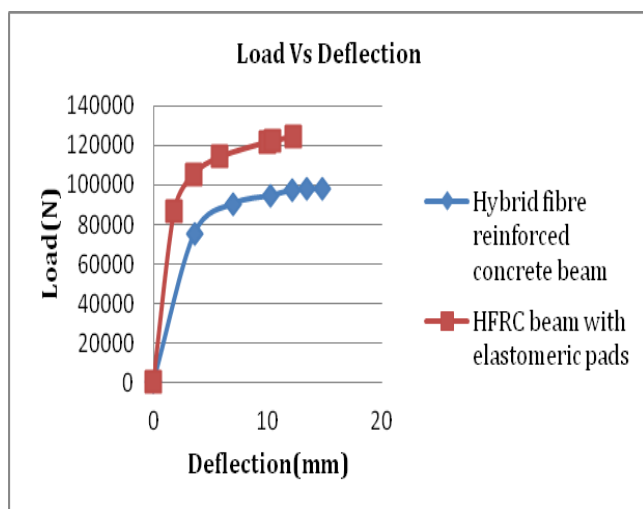


Chart 2: Load Deflection behavior of Hybrid fibre reinforced concrete beam with and without elastomeric bearing pads

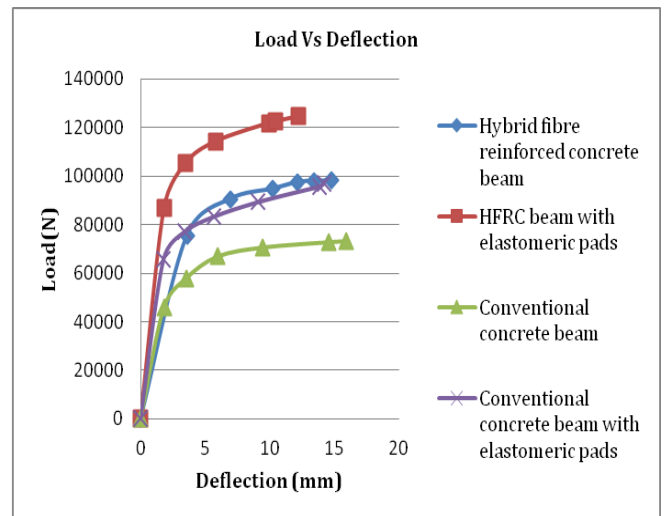


Chart 3: Load Deflection behavior of all the beams

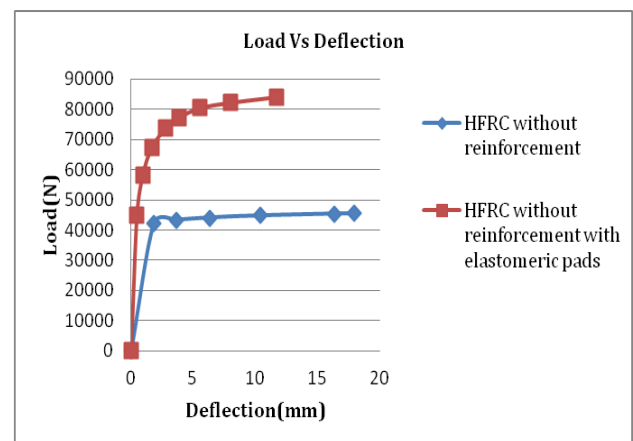


Chart 4: Beam without Reinforcement

The load-deflection curves obtained from Finite element analysis of all beams are presented.

- The result showed that the hybrid beam has more load carrying capacity than conventional beam and the flexural behavior is also more compared to conventional beam.
- The deflection of conventional concrete beam without elastomeric bearing pad is 15.915mm and with elastomeric bearing pad is 14.224mm
- The deflection of Hybrid fibre reinforced concrete beam without elastomeric bearing pad is 14.772mm and with elastomeric bearing pad is 12.239mm
- The deflection decreases by using elastomeric bearing pads and with increase of percentage of hybrid fibre. The deflection of conventional concrete beam with elastomeric bearing pads is 14.224mm and hybrid fibre reinforced concrete beam with elastomeric bearing pads is 12.239mm

- The flexural strength of fibre reinforced concrete with elastomeric bearing pads is higher than the conventional concrete with elastomeric bearing pads.
- In case of Hybrid fibre reinforced concrete beam without reinforcement with elastomeric bearing pads the deflection is 11.745 mm

5. CONCLUSIONS

A three-dimensional nonlinear finite element analysis is conducted to investigate the behavior of composite beam with and without elastomeric bearing pads. The Ultimate load of the Conventional and Hybrid fibre reinforced concrete beam obtained from the finite element analysis using ANSYS computer program (version 16.1) was compared with corresponding experimental data. From validation the analytical tests carried out for both beam indicated that the ultimate loads are in good agreement with the experimental results. In general, it can be noted that the finite element analyses agree well with the experimental result throughout the entire range of behavior. The deflection of beams with elastomeric bearing pad is less compared to those with elastomeric bearing pad. That is the ultimate load is increased with increase in fiber content and the deflection decreases by using elastomeric pads and with increase of percentage of hybrid fibre. In case of Hybrid fibre reinforced concrete beam without reinforcement with elastomeric bearing pads the load will be borne by the fibers used and deflection can control by using elastomeric material. The Hybrid fibre reinforced concrete can be used to resist seismic effects in structure, the floors additionally act as foundation slab that is bracing and carrying the entire building load.

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