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Non Linear Finite Element Method of Analysis of Reinforced Concrete Deep Beam

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ABSTRACT: *This paper describes analysis of deep beams subjected to two point loading with three different L/D ratios (1.5, 1.6, 1.71) using Non-linear Finite element method (ANSYS 9.0 software) in order to investigate the stress and strain distribution pattern at mid-section of the beam. In ANSYS 9.0 software, SOLID 65 and LINK 8 element represent concrete and reinforcing steel bars. Non-linear material properties were defined for both elements .Using ANSYS software Flexural Strains and Stresses were determined at mid-section of the beam and shear stresses near the support of the beam. Also the failure crack-patterns were obtained. Variation of flexural stresses and strains, shear stresses were plotted. It was found that the smaller the span/depth ratio, the more pronounced is the deviation of strain pattern at mid-section of the beam.*

Keywords: *Deep Beam, Non-Linear Finite element method, ANSYS 9.0. L/D (Span to depth).*

I. INTRODUCTION

Deep beam can be defined as a beam having a ratio of span to depth of about 2 or less. The deep beams were usually observed in case of transfer girder, pile cap, raft beam, wall of rectangular tank, hopper, shear wall [5]. Because of their proportions deep beams are likely to have strength controlled by shear rather than flexure .In 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. Continuous beams are considered as deep when the ratio L/D is less than 2.5. The effective span is defined as the centre-to-centre distance between the supports or 1.15 times the clear span whichever is less.

II. ANALYSIS USING ANSYS SOFTWARE

The finite element analysis calibration study included modeling a concrete beam with the dimensions and properties [1]. To create the finite element model in ANSYS 9.0 there are multiple tasks that have to be completed for the model to run properly. Models can be created using command prompt line input or the Graphical User Interface. For this model, the graphical user interface was utilized to create the model. This section describes the different tasks and entries to be used to create the finite element calibration model.

2.1. Element Types

The element type for this model is shown in Table 1.

Table1. Element Types for Working Model

Material Type Element	ANSYS
Concrete	Solid65
Steel Reinforcement	Link8

A Solid65 element was used to model the concrete [2]. This element has eight nodes with three degrees of freedom at each node translations in the nodal x, y, and z directions. The element is capable of plastic deformation, cracking in three orthogonal directions, and crushing. A schematic of the element was shown in Fig.1.

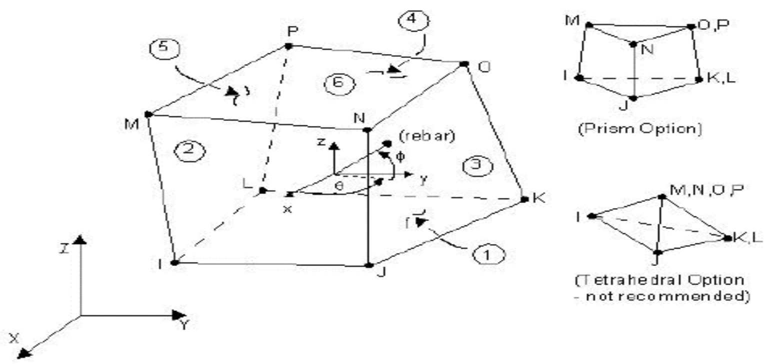

Figure1. Solid 65 elements

A Link8 element was used to model steel reinforcement [2]. This element is a 3D spar element and it has two nodes with three degrees of freedom translations in the nodal x, y, and z directions. This element is capable of plastic deformation and element was shown in the Fig.2.

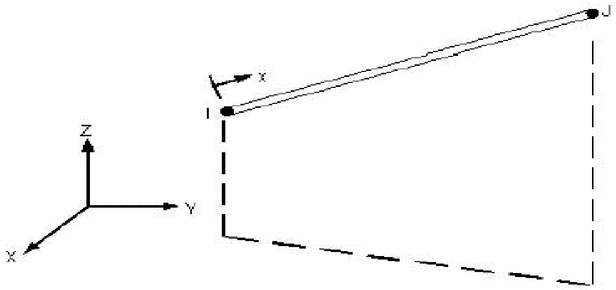

Figure 2. Link 8 element

2.2. Real Constants

Real Constant Set 1 was used for the Solid65 element [2]. It requires real constants for rebar assuming a smeared model. Values can be entered for Material Number, Volume Ratio, and Orientation Angles. The material number refers to the type of material for the reinforcement. The volume ratio refers to the ratio of steel to concrete in the element. The reinforcement has uniaxial stiffness and the directional orientations were defined by the user. In the present study the beam was modeled using discrete reinforcement. Therefore, a value of zero was entered for all real constants, which turned the smeared reinforcement capability of the Solid65 element of Real Constant Sets 2 and 3 were defined for the Link8 element. Values for cross-sectional area and initial strain were entered. Cross-sectional area in set 2 refers to the reinforcement of two numbers of 10mm diameter bars. Cross-sectional area in set 3 refers to the 8 mm diameter two legged stirrups. A value of zero was entered for the initial strain because there is no initial stress in the reinforcement. The real constants were given in Table 2.

Table 2. Real Constants

Real Constants Set	**Element Type**		**Real constants for Rebar 1**	**Real constants for Rebar 2**	**Real constants for Rebar 3**
1	Solid 65	Material no. V.R	0	0	0
2	LINK 8	Area (mm2) Initial strain	78.5 0	- 0	- 0
3	LINK 8	Area (mm2) Initial strain	50.24 0	- 0	- 0

2.3. Modeling

The beam was modeled as volume [2]. The model was 700 mm long with a cross section of 150 mm X 350 mm. The Finite Element beam model was shown in Fig.3. The dimensions for the concrete volume were shown in Table.3.

Table 3. Dimensions for Concrete

ANSYS	Concrete(mm)
X1,X2,X-coordinates	0, 700
Y1,Y2,Y-coordinates	0, 350
Z1,Z2,Z-coordinates	0, 150

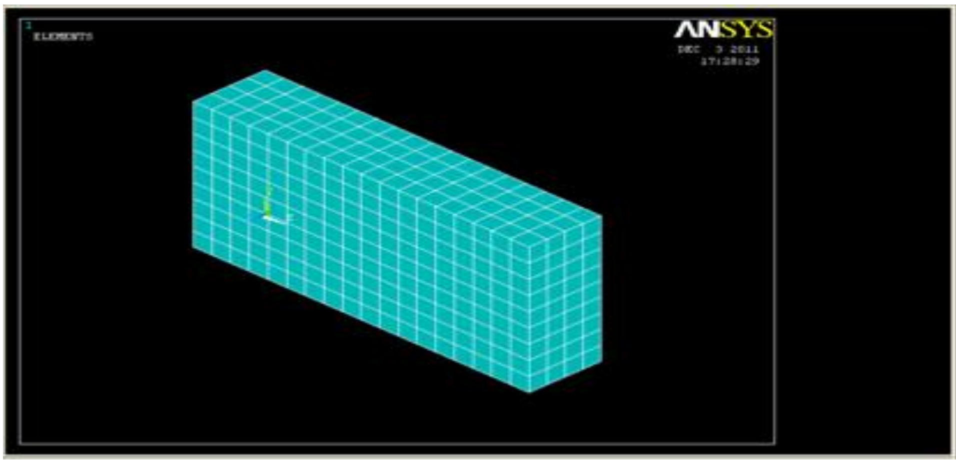

Figure 3. Finite element model & mesh of beam

2.4. Meshing

To obtain good results from the Solid65 element, the use of a rectangular mesh was recommended [2]. Therefore, the mesh was set up such that square or rectangular elements were created. The meshing of the reinforcement was a special case compared to the volumes. No mesh of the reinforcement was needed because individual elements were created in the modeling through the nodes created by the mesh of the concrete volume. The meshing and reinforcement configuration of the beam were shown in Fig.3 and Fig.4.

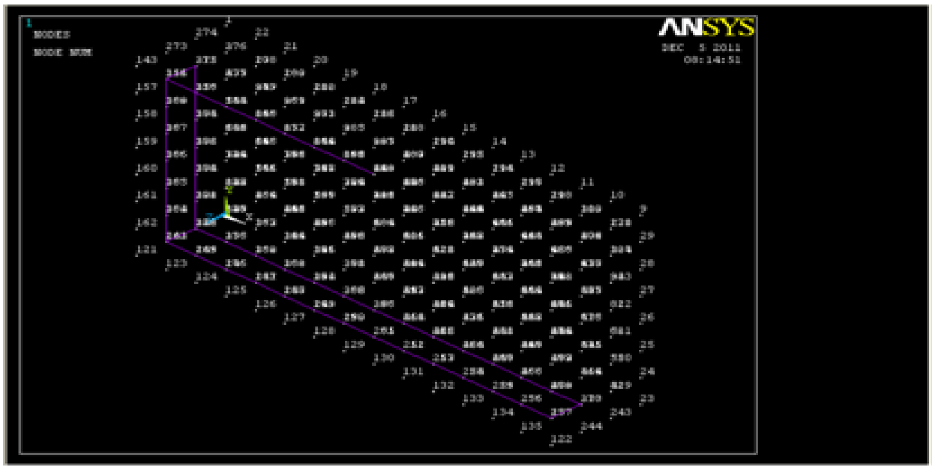

Figure 4. Reinforcement Configuration

2.5. Loads and Boundary Conditions

Displacement boundary conditions were needed to constraint the model to get a unique solution [2]. To ensure that the model acts the same way as the experimental beam boundary conditions need to be applied at points of symmetry, and where the supports and loading exist. The support was modeled as a hinged support at both ends. Nodes on the plate were given constraint in all directions, applied as constant values of zero. The loading and boundary conditions of the beam were shown in Fig.5.

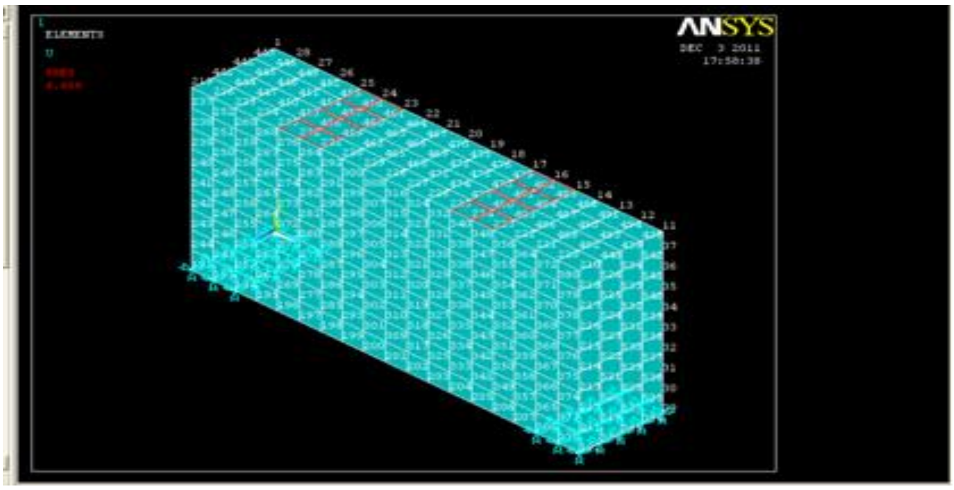

Figure 5. Loading and boundary conditions

III. RESULTS AND DISCUSSION

The variation of flexural stresses, strains at mid span and shear stresses near support were evaluated for various L/D ratios.

2.6. Variation of Flexural Strain

The variations of flexural strain were plotted at mid span of the beam for different L/D ratios. It was found that behaviour of flexural strain variation was non-linear. Also it was found that as the L/D ratio decreases the more pronounced was the deviation of strain pattern at mid-section of the beam. Fig.6.a to Fig.6.c were shown the variation of flexural strain at mid span for different L/D ratios.

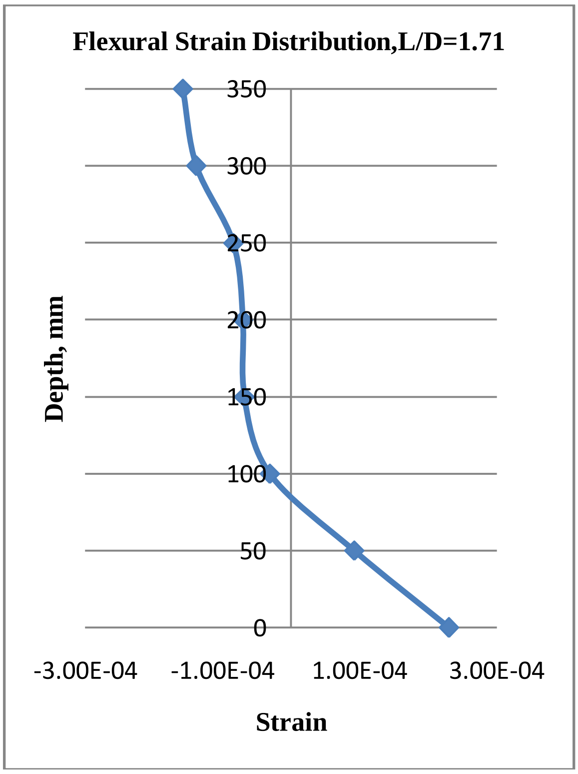

Figure 6.a. Flexural strain distribution for L/D = 1.71

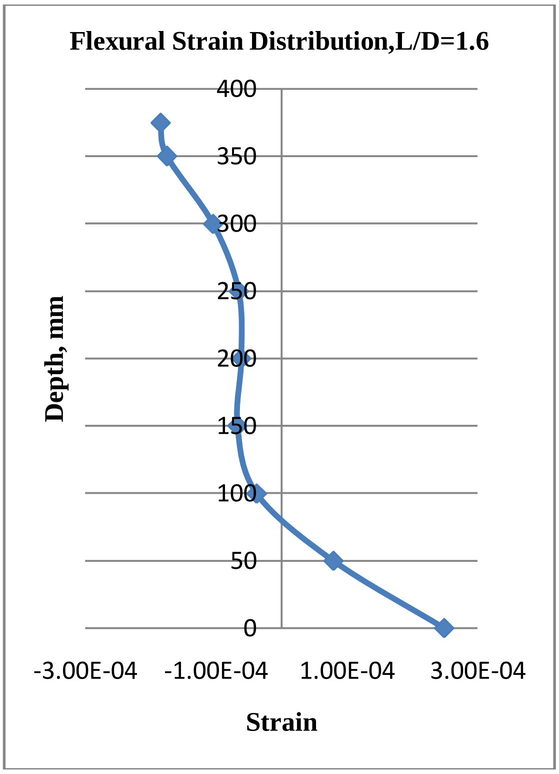

Figure 6.b. Flexural strain distribution for L/D = 1.6

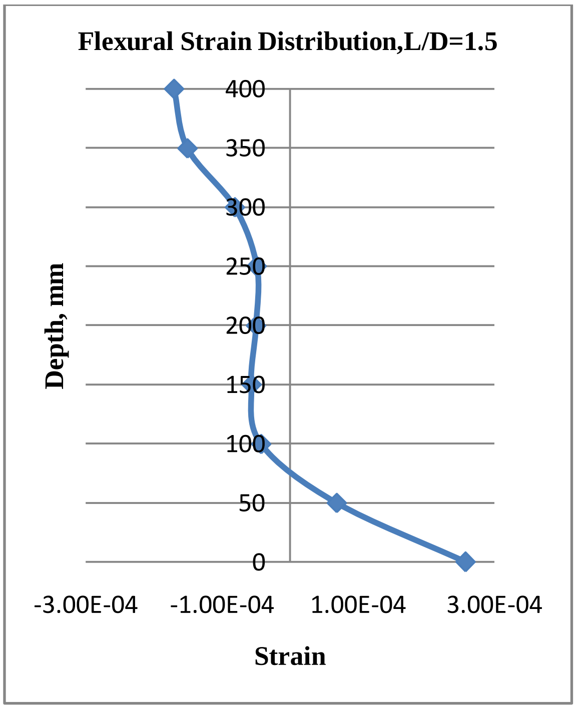

Figure 6.c. Flexural strain distribution for L/D = 1.5

2.7. Variation of Flexural stress

The variations of flexural stress were plotted at mid span of the beam for different L/D ratios. It was found that behaviour of flexural stress variation was non-linear. Fig.7.a to Fig.7.c were shown the variation of flexural stress at mid span for different L/D ratios.

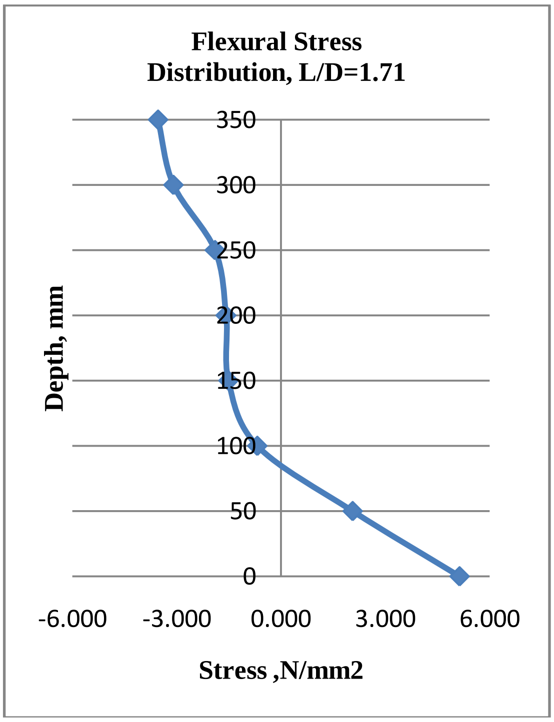

Figure 7.a. Flexural stress distribution for L/D=1.71

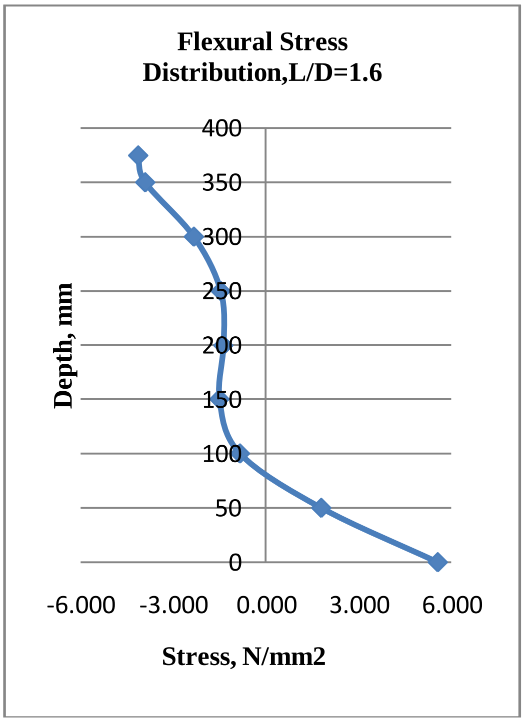

Figure 7.b. Flexural stress distribution for L/D=1.6

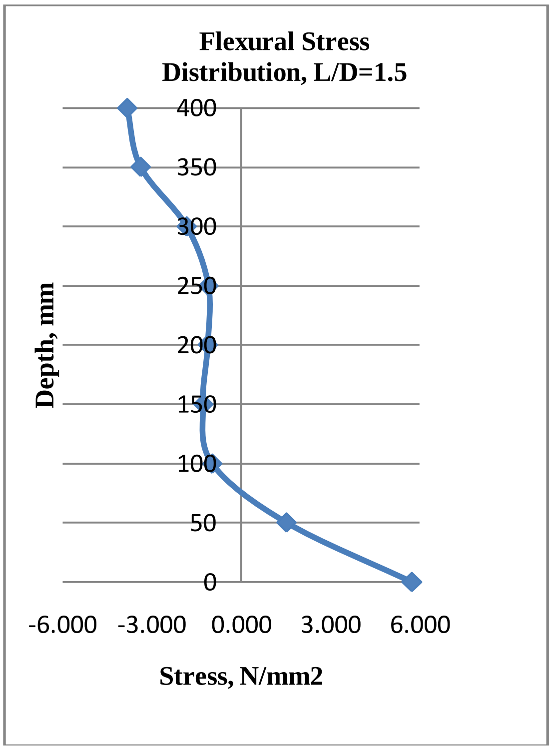

Figure 7.c. Flexural stress distribution for L/D=1.5

2.8. Variation of Shear Stress

Fig.8.a to Fig.8.c shows the shear stress near support of simply supported deep beam for different ratios of L/D. It was found that the smaller the span/depth ratio (i.e. less than2.0), the more pronounced was the deviation of the shear stress distribution.

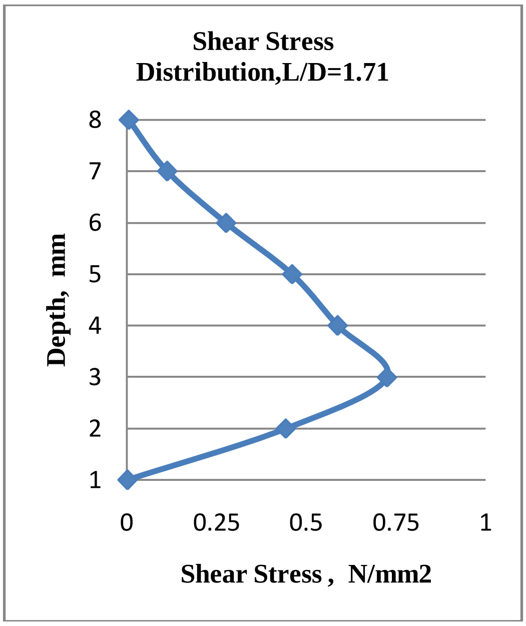

Figure 8.a. Shear stress distribution for L/D=1.71

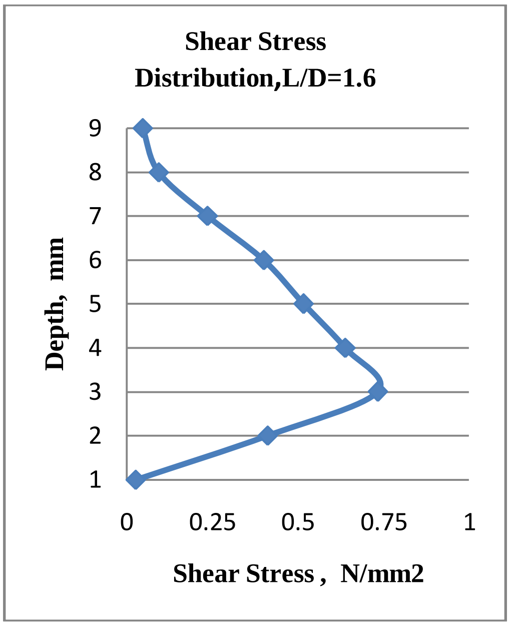

Figure 8.b. Shear stress distribution for L/D=1.6

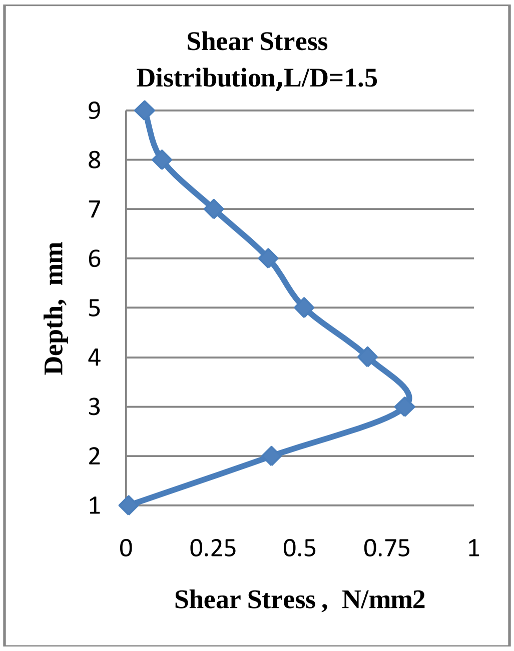

Figure 8.c. Shear stress distribution for L/D=1.5

IV. Conclusions

Deep beams having different L/D ratios were analyzed by using non-linear finite element method (by ANSYS 9.0) subjected to two points loading. Some prominent conclusions were summarized here.

1. From the flexural stress and strain graphs it was observed that smaller the span/depth ratio (i.e. less than or equal to 2.0), the more pronounced is the deviation of the stress-strain pattern i.e. the variation is not linear as in case of shallow beams.
2. Flexural stress and strain variation graphs indicate that the definition of simply supported deep beam as per IS 456:2000 i.e. when L/D ratio is less than or equal to 2.0 is reasonably accurate.
3. From the flexural strain and stress graphs it was observed that as L/D ratio of the beam decreases the neutral axis shifted towards soffit of the beam.
4. From the shear stress variation graph it was observed that as span/depth ratio decreases the shear stress increases.

REFERENCES

Journal Papers:

[1] Anand Parande, P. Dhayalan, M. S. Karthikeyan, K. Kumar and N. Palaniswamy, Assessment of Structural Behavior of Non-corroded and Corroded RCC Beams Using Finite Element Method, Sensors & Transducers Journal, Vol. 96, Issue 9, pp.121-136(2008).

[2] Mohammed Sh. Mahmood and Amer M. Ibrahim, Finite Element Modeling of Reinforced Concrete Beams Strengthened with FRP Laminates, European Journal of Scientific Research ISSN 1450-216X Vol.30 No.4 (2009), pp.526-541.

[3] Muhammad Abdur Rashid And Ahsanul Kabir, Behaviour Of Reinforced Concrete Deep Beam Under Uniform Loading, Journal Of Civil Engineering, The Institution Of Engineers, Bangladesh, Vol CE 24,No-2,1996.

Books:

[4] F. K. Kong Reinforced Concrete Deep Beams, (Van Nostrand Reinhold, New York 2011).

[5] Varghese and Krishnamoorthy, Strength and Behavior of Deep Reinforced Concrete Beams. (Asoke K. Ghose, Prentice-Hall of India private Ltd. , 2006).

[6] S. Ramamrutham, Design of Reinforced concrete structures.(Dhanpat Rai publishing company,2011).

[7] S S. Bhavikatti, Finite Element Analysis, (New Age International (P) Ltd., Publishers, 2010).

[8] R.D.Cook, D.S.Makus and M.F.Plesha, Concept and Applications of Finite Element Analysis, (John Wiley and Sons, 1989).