International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 04 | Apr 2019 www.irjet.net p-ISSN: 2395-0072

Shear Stress Distribution in Beams

R. Keerthana[1], P. Sathiya Bama[2]

[1]M.E Project Student, Dr.Mahalingam College of Engineering and Technology, Pollachi-642003
[2]Assistant Professor, Dept. of Civil Engineering, Dr.Mahalingam College of Engineering and Technology, Pollachi-642003, Tamil Nadu, India

---

Abstract - *All materials fail under a certain loading conditions; it might be in tension, compression, torsion, bending and shear or may be combination of loads. Any type of loads can induce two types of stress. The stresses are normal stress and shear stress. In this work, mainly focused on shear stress distribution in rectangular beams by varying depth/breadth ratio. When shear load is applied, the impact of the shearing stress throughout the rectangular cross-section of the beam occurs. It can be resolved by estimating the shearing stress at the particular height from the neutral axis. The distribution of shearing stress on the cross-section of the beam represents a parabolic curve where the maximum shearing stress occurs at the neutral axis of the beam. The analysis of beam is done by using ANSYS software. The analysis of beam is done up to the depth/breadth ratio of 10 and interpretation of results has done.*

***Key Words*: shear stress, shear load, depth/breadth ratio**

1. INTRODUCTION

1.1 General

Any force which tries to shear-off the member is called shear force. Shear force is an unbalanced force, parallel to the cross-section. To resist the shear force, the element will develop the resisting stresses, which is known as shear stress. When a beam is subjected to a transverse loading, a normal and a shearing stresses result in the beam. The influence of shearing stress in the beam does not disturb the influence of the bending stress.

The shearing stress in beam is defined as the stress that occurs due to the internal shearing of the beam that results from shear force subjected to the beam. It is denoted by the symbol τ and is expressed in the unit N/mm^2.The equation of shearing stress is

$$\tau = \frac{V}{bd}$$

Where, V is shear force

b is width of the section

d is depth of the section

The shear stress distribution will vary based on the sections such as rectangular section, triangular section, circular section, I section, and T section.

1.2 Shear stress distribution of different sections

The following shows the shear stress distribution of various sections.

1.2.1 Shear stress distribution for rectangular section

Consider a rectangular beam section whose depth of section is d, width of section is b.

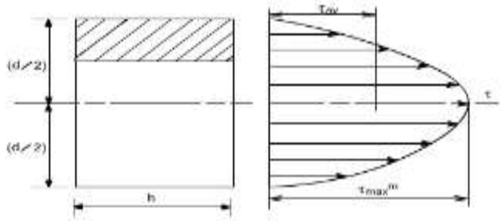

Fig-1.1 Shear stress distribution of rectangular section

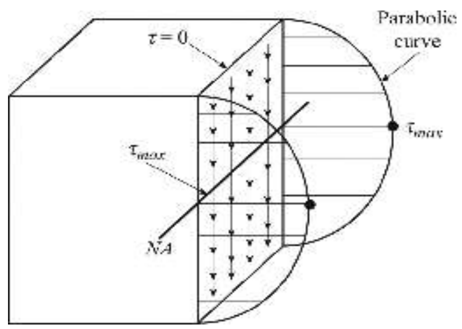

Fig-1.2 Rectangular cross-section of beam

Shear stress is distributed parabolically across the rectangular section. Shear stress is maximum at neutral axis and will be zero at the extreme ends. The vertical shear stress creates horizontal shear stress. Shear stress is distributed clockwise or anticlockwise throughout height, so shear stress variation will be shown in only on one side. In a rectangular beam, when shear load is applied, the impact of the shearing stress throughout the rectangular cross-section of the beam occurs. It can be resolved by estimating the shearing stress on the cross-section of the beam represents a parabolic curve where the maximum shearing stress occurs at the neutral axis of the beam. The equation for maximum shear stress in rectangular section is

$$\tau_{Max} = 1.5\frac{V}{bd}$$

1.2.2 Shear stress distribution for I section

In I section, the web bears the most of the shear stress and according to the bending theory it is said that flange will bear most of the bending stress.

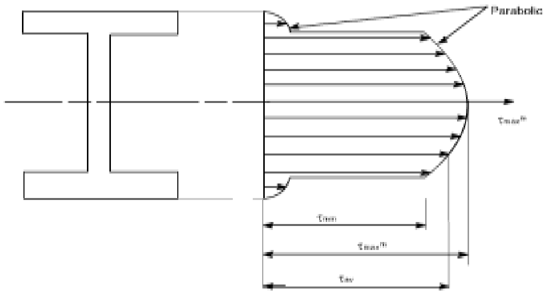

Fig-1.3 Shear stress distribution of I section

The equation for maximum shear stress in I section is

$$\tau_{Max} = \frac{V}{Ib} \text{ X } \frac{B}{8}(D^2 - d^2) + \frac{b}{2} \text{ X } \frac{d^2}{2}$$

1.2.3 Shear stress distribution for T section

T section is not symmetrical over neutral axis, shear stress distribution also will not be symmetrical. The method of finding shear stress distribution in t section is similar to that of I section.

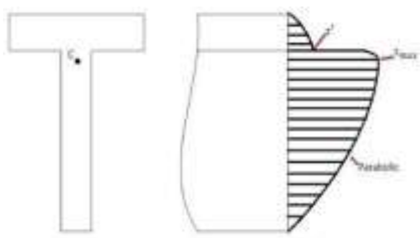

Fig 1.4 Shear stress distribution of T section

1.2.4 Shear stress distribution for Triangular section

The maximum shear stress is at a distance h/2 from the base of the triangle, which is also at a distance of h/6 from the centroidal axis. The maximum shear stress distribution in triangular section is

$$\tau_{Max} = \frac{3V}{bh}$$

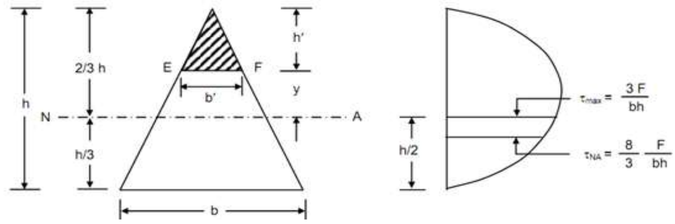

Fig 1.5 Shear stress distribution of Triangle section

1.2.5 Shear stress distribution for Circular section

In circular section, the shear stress distribution is parabolic. The maximum shear stress is at the neutral axis and the end of the section has zero stress. The average shear stress in a beam of circular

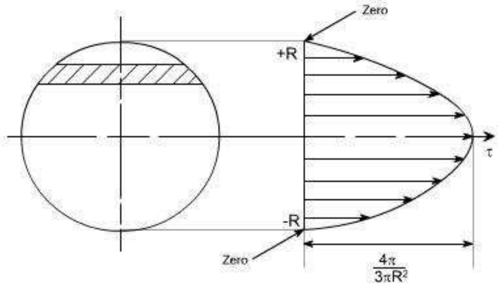

Fig 1.6 Shear stress distribution of I section

The maximum shear stress distribution in circular section is

$$\tau_{Max} = \frac{4V}{3A}$$

1.3 Factors affecting shear strength of concrete

1.3.1 Size of beam

As the depth of the beam increases, the shear stress at failure decreases. For rectangular section beam, the shear stress distribution is parabolic and maximum shear stress is at neutral axis of the section. The maximum shear stress will be 1.5times the average shear stress.

For circular section beam, the shear stress distribution has a parabolic variation. The shear stress is maximum when y=0, at the neutral axis. The maximum shear stress will be 4/3times of average shear stress.

For I section, the shear stress distribution is parabolic in the flange and web. From the shear stress diagram for this section, the most of the shear stress is taken by web only. This is very important in the design.

For triangular section, the shear stress has a parabolic variation. The maximum shear stress will be 8/3times of average shear stress.

1.3.2 Shear span to effective depth

Its effect is pronounced when span to depth ratio is less than two and has no effect when it is greater than six.

1.3.3 Tensile strength of concrete

The inclined cracking load in shear is a function of the tensile strength concrete.

1.3.4 Longitudinal reinforcement

The shear strength of the RC beams is found to drop significantly if the longitudinal reinforcement ratio decreases below 1.2 to 1.5%.

1.3.5 Axial force

Axial tension decreases the inclined cracking load and the shear strength of concrete, whereas axial compression does just the opposite.

1.3.6 Light weight aggregate concrete

Light weight aggregate concrete reduces tensile strength than concrete with normal aggregates.

1.3.7 Size of coarse aggregates

Increasing the size of coarse aggregates increases the roughness of the crack surfaces, thus allowing the higher shear stresses to be transferred across the cracks.

1.4 Rectangular cross section of beam

Considering a rectangular cross section beam where, b is width of the rectangular suction, d is depth of the rectangular section, NA is neutral axis of the beam section, F is shear force , τ is shear stress, A is area of section CDEF where shear stress to be determined, $\bar{y}$ is distance of the C.G of area CDEF from neutral axis of beam, A is area of section CDEF where shear stress to be determined, I is moment of inertia of the given section about the neutral axis

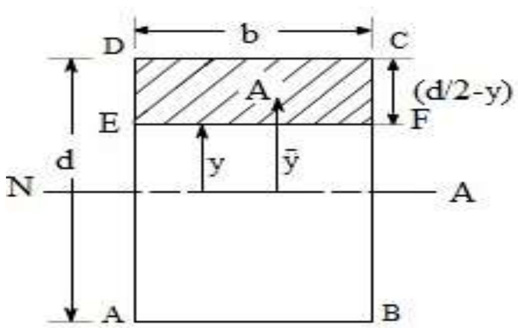

Fig 1.7 Rectangular cross section of beam

The maximum shear stress will occur at y=0 or at neutral axis and value of shear stress will be zero for the area at the extreme ends. The average shear stress or mean shear stress will be simply calculated by dividing shear force with area.

$\tau_{Max} = 1.5\, \tau_{Average}$

2. NUMERICAL INVESTIGATION

A simply supported beam was considered with the following parameters. The length of the beam is 1000mm, breadth of the beam is 100mm and depth of beam varying from 100mm to 1000mm.Uniformly distributed load of 100KN/m is applied on the beam. Using the above parameters the beam was modeled with ANSYS software. The shear stress acting in the cross section of the beam is analyzed with varying d/b ratio.

2.1.1 Dimension of beam 1

The following are the dimension of beam: Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 100mm

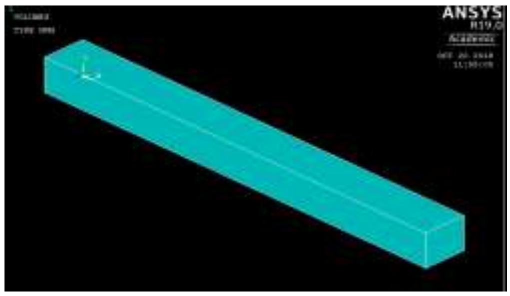

Fig-2.1 Dimension of beam

2.1.2 Material property

The poisson's ratio of concrete is 0.18 and young's modulus is 2E4 is provided.

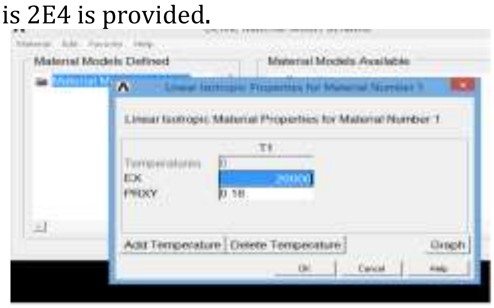

Fig -2.2 Material property for beam

2.1.3 Meshing of beam:

The meshing of beam is done. The number of element division provided for meshing is 10.

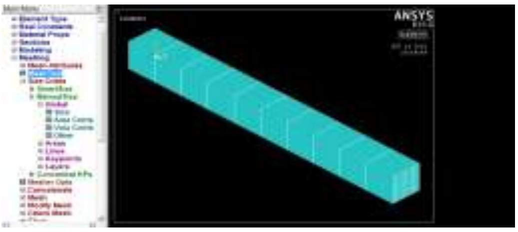

Fig-2.3 Meshing of beam

2.1.4 Boundary conditions:

The beam is simply supported. The boundary conditions are one end pinned and other end roller supported.

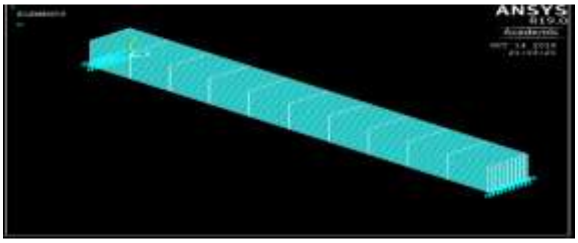

Fig 2.4 Boundary conditions for beam

2.1.5 Load acting on beam:

A uniformly distributed load of 100KN/m is applied on the beam.

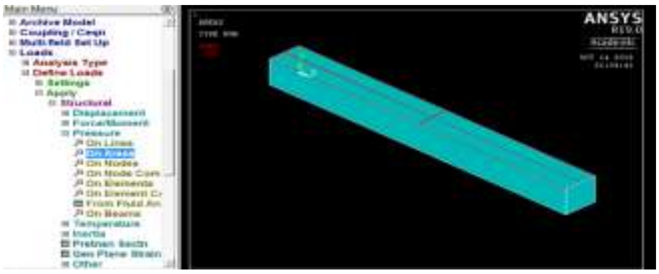

Fig-2.5 Load acting in beam

2.1.6 Solution

Preprocessing is done and to solve the beam solution run command is given. The solution is obtained for the given conditions for beam.

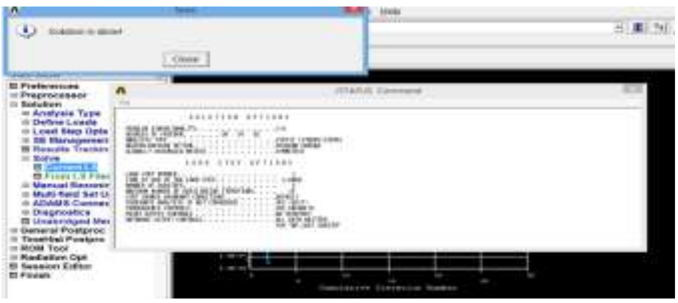

Fig-2.6 Solution obtained from ANSYS

2.1.7 Path of shear stress acting on beam

The shear stress path is plotted along y direction of beam

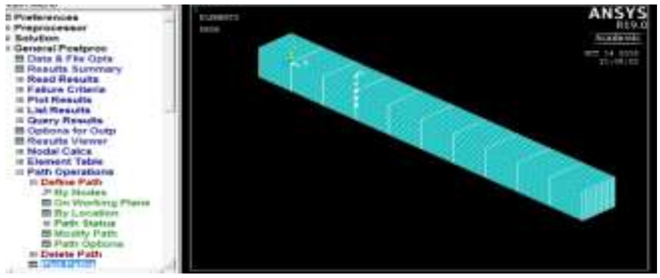

Fig-2.7 Path of shear stress on beam

2.1.8 Graph obtained:

The shear stress distribution graph is obtained for d/b= 1 at 250mm. The shear stress distribution is parabolic.

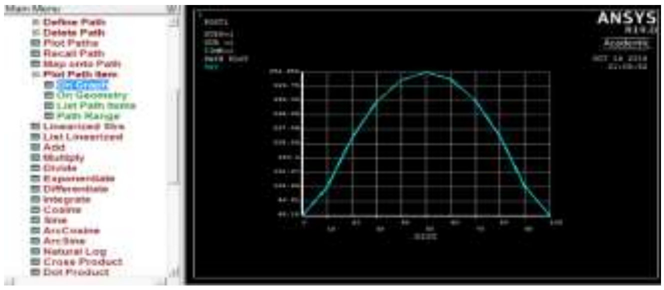

Fig-2.8 Graph for shear stress distribution

2.1.9 Shear stress distribution in beam at L/4, d/b ratio= 1

The depth of beam is 100mm, the shear stress at a length of 250mm and maximum shear stress at neutral axis is 375.15N/mm^2.

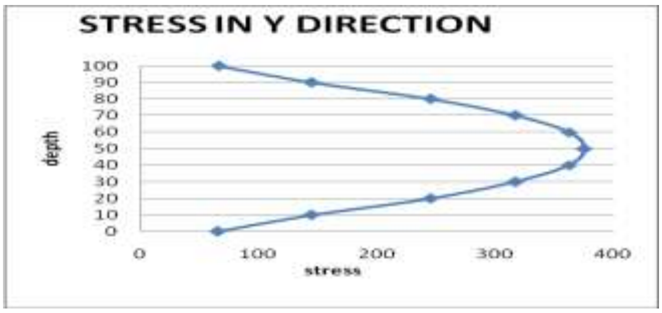

Chart-2.1 Shear stress distribution of beam at length of L/4, d/b ratio = 1

2.2 Dimension of beam 2

The following are the dimensions of beam 2:Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 200mm

2.2.1 Shear stress distribution in beam at L/4, d/b ratio=2

The depth of beam is 200mm, the shear stress at a length of 250mm and maximum shear stress at neutral axis is 185.12N/mm^2.

Chart-2.2 Shear stress distribution of beam at length of L/4, d/b ratio = 2

2.3 Dimension of beam 3

The following are the dimensions of beam 3: Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 300mm

2.3.1 Shear stress distribution in beam at L/4, d/b ratio=3

The depth of beam is 300mm, the shear stress at a length of 250mm and maximum shear stress at neutral axis is 125.65N/mm^2.

Chart-2.3 Shear stress distribution of beam at length of L/4, d/b ratio = 3

2.4 Dimension of beam 4

The following are the dimensions of beam 4:Length of beam = 1000mm,Width of beam = 100mm, Depth of beam = 400mm

2.4.1 Shear stress distribution in beam at L/4, d/b ratio=4

The depth of beam is 400mm, the shear stress at a length of 250mm and maximum shear stress at neutral axis is 93.75N/mm^2.

Chart-2.4 Shear stress distribution of beam at length of L/4, d/b ratio = 4

2. 5 Dimension of beam 5

The following are the dimensions of beam 5: Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 500mm

2.5.1 Shear stress distribution in beam at L/4, d/b ratio=5

The depth of beam is 500mm, the shear stress at a length of 250mm and maximum shear stress is 97.35 N/mm^2 at depth of 200mm.

Chart-2.5 Shear stress distribution of beam at length of L/4, d/b ratio = 5

2.6 Dimension of beam 6

The following are the dimensions of beam 6:Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 600mm

2.6.1 Shear stress distribution in beam at L/4, d/b ratio=6

The depth of beam is 600mm, the shear stress at a length of 250mm and maximum shear stress is 56.17 N/mm^2 at depth of 225mm.

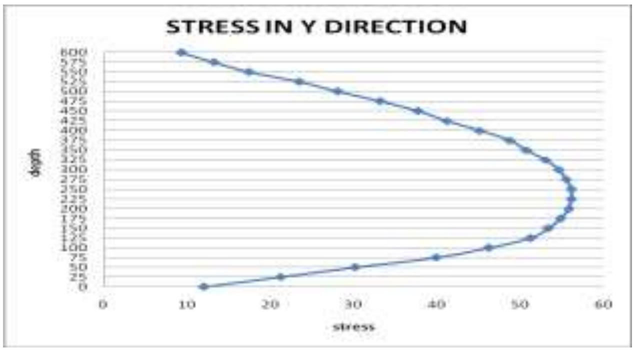

Chart-2.6 Shear stress distribution of beam at length of L/4, d/b ratio = 6

2.7 Dimension of beam 7

The following are the dimensions of beam 7:Length of beam = 1000mm, Width of beam = 100mm,Depth of beam = 700mm

2.7.1 Shear stress distribution in beam at L/4, d/b ratio=7

The depth of beam is 700mm, the shear stress at a length of 250mm and maximum shear stress is 49.88N/mm^2 at depth of 250mm.

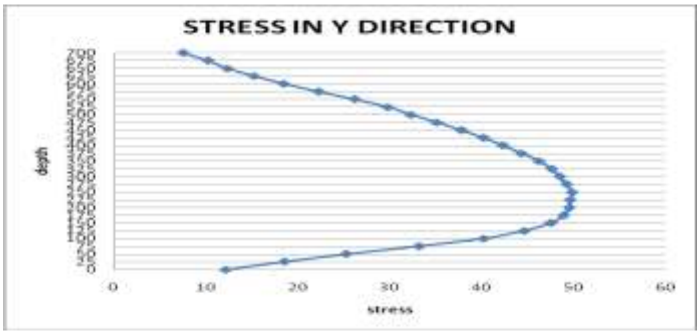

Chart-2.7 Shear stress distribution of beam at length of L/4, d/b ratio = 7

2.8 Dimension of beam 8

The following are the dimensions of beam 8: Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 800mm

2.8.1 Shear stress distribution in beam at L/4, d/b ratio=8

The depth of beam is 800mm, the shear stress at a length of 250mm and maximum shear stress is 45.97N/mm^2 at depth of 250mm.

Chart-2.8 Shear stress distribution of beam at length of L/4, d/b ratio = 8

2.9 Dimension of beam 9

The following are the dimensions of beam 9:Length of beam = 1000mm,Width of beam = 100mm,Depth of beam = 900mm

2.9.1 Shear stress distribution in beam at L/4, d/b ratio=9

The depth of beam is 900mm, the shear stress at a length of 250mm and maximum shear stress is 44.54 N/mm^2 at depth of 200mm.

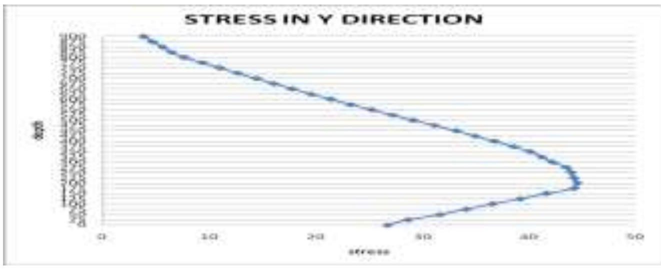

Chart-2.9 Shear stress distribution of beam at length of L/4, d/b ratio = 9

2.10 Dimension of beam 10

The following are the dimensions of beam 10. Length of beam = 1000mm, Width of beam = 100mm, Depth of beam = 1000mm

2.10.3 Shear stress distribution in beam at L/4, d/b ratio=10

The depth of beam is 1000mm, the shear stress at a length of 250mm and maximum shear stress is 44.25N/mm^2 at depth of 200mm.

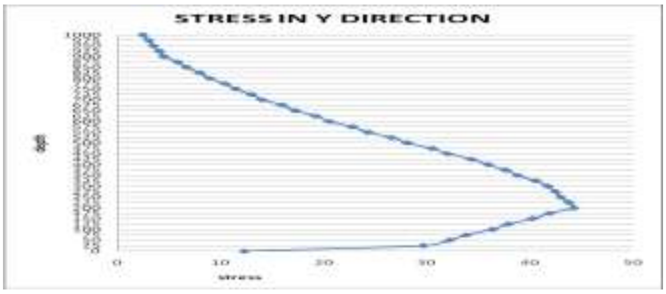

Chart-2.10 Shear stress distribution of beam at length of L/4, d/b ratio = 10

3. CONCLUSION AND FUTURE WORK

This project is specifically concerned about investigation of a rectangular beam which is modeled and analyzed for different d/b ratios by finite element analysis using ANSYS software.

The results obtained from ANSYS, Mechanical APDL 19.0, there is variation in shape of the graphs in Y direction for varying d/b ratio of 1 to 10. The very low values of d/b theories are conservative and for very high d/b ratio, it occurs on unsafe side which is evident from variation in change of conventional shape of graph.

The d/b ratio upto 4 (within all practical ranges), the theory holds good. The d/b>4, incase of beam with abnormal size, shear stress graph in Y direction varies and d/b does have some influence. Incase of these beams, due to the high ratio of d/b, beam action itself is modified. For predicting the accuracy in variation of shear stress, the beam depth must be increased and analysis must be done.

REFERENCE

1. Abd El Rahman Megahid , Mohamed M. Rashwan "Effect of shear span to depth ratio on the statical behaviour of HSCB subjected to transverse loading" Journal of Engineering Sciences,2016.
2. M.Ahmadi "Analysis of Rehabilitation effect on the improvement capacity reinforced concrete beams with FEM" the 2nd International Conference on Rehabilitation and Maintenance in Civil Engineering, 2013.
3. Amer M. Ibrahim, Wissam D. Salman "Finite element analysis of reinforced concrete beams with CFRP in flexural" Diyala Journal of Engineering Sciences, 2009.
4. Biao Hua, Yu-Fei Wub "Effect of shear span-to-depth ratio on shear strength components of RC beams" Engineering Structures,2018.
5. Darmansyah Tjitradi, Eliatun Eliatun, Syahril Taufik "3D ANSYS Numerical Modeling of Reinforced Concrete Beam Behavior under Different Collapsed Mechanisms" International Journal of Mechanics and Applications, 2017.
6. Minh Tung Tran "Influence Factors for the Shear Strength of Exterior and Interior Reinforced Concrete Beam-Column Joints" Procedia Engineering, 2016.
7. Neha S. Badiger "Study of Behaviour of Reinforced Concrete Beam Using ANSYS" 3rd World Congress on Civil, Structural and Environmental Engineering, 2018.
8. Prof. S. S. Patil, A. N. Shaikh, Prof. Dr. B. R. Niranjan "Experimental and Analytical Study on Reinforced Concrete Deep Beam" International Research Journal of Engineering and Technology, 2016.
9. Patel, S.K.Dubey, K.K.Pathak "Analysis of infilled beams using method of initial functions and comparison with FEM" Engineering Science and Technology, an International Journal, 2014.
10. Tamon UEDA "Behaviour in shear of reinforced concrete beams under fatigue loading" Hokkaido University Collection of Scholarly and Academic Papers, 2016.