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Analytical Study on Non-Circular Concrete Beam Section Subjected to Torsion

Ramya. S[1], Rekha. M[2] and Swethaa. B[3]

[1]*Assistant Professor, Department of Civil Engineering, Sri Lakshmi Ammal Engineering College*
[2]*Assistant Professor, Department of Civil Engineering, Sri Lakshmi Ammal Engineering College*
[3]*Assistant Professor, Department of Civil Engineering, Sri Lakshmi Ammal Engineering College*
E-mail: [1]ramya.chml@gmail.com, [2]jasminerekha19@gmail.com, [3]swethaabaskaran@gmail.com

Abstract—*In this study, the analytical investigation on non-circular concrete beam section with equal lengths and grade of concrete but with varying cross sections is made. To determine the behaviour of non-circular concrete beam with respect to change in depth, three different cross sections measuring 500mm x 100mm x 100mm, 500mm x 100mm x 75mm, 500mm x 100mm x 50mm are modelled and analysed using STAAD. Pro. The normal stress characteristics of the various cross sections of non-circular concrete beams are studied.*

Introduction

Torsion is the twisting of an object due to the applied torque. In other words, torsion is the twisting or wrenching of a body by the exertion of forces tending to turn one end or part about a longitudinal axis while the other is held fast or turned in the opposite direction. This study investigates the effect of cross sections of rectangular concrete beams subjected to torsion. The grade of concrete is taken as M25 for all the cross sections.

Analysis of Rectangular Beam Sections

Sectional Dimensions

The concrete beams of suitable dimensions are considered.

The three different cross sections of beam considered for this investigation are as follows:

1. M25 grade of concrete beam of size 500mm x 100mm x 100mm.
2. M25 grade of concrete beam of size 500mm x 100mm x 75mm.
3. M25 grade of concrete beam of size 500mm x 100mm x 50mm.

Property of Materials

The properties of the materials to be used in the study are defines and are assigned to the modeled section. The values of the same are as shown in table 1.

Table I: Material Properties

Material Property	Value
Modulus of Elasticity E, N/mm^2	2 .17 x 10^4
Poisson's ratio, μ	0.17

Modeling of Concrete beams

The concrete beam of various depth to breadth ratio are modeled as follows by taking the x, y and z coordinates:

1) Size 500mm x 100mm x 100mm. : Ratio 1.00

2) Size 500mm x 100mm x 75mm. : Ratio 0.75

3) Size 500mm x 100mm x 50mm. : Ratio 0.50

The concrete beam is divided with 20 elements in x-x direction and 6 elements in y-y and z-z directions. The beam is fixed at one end and free at the another end. A unit torque applied at free end to induce torsion.

Analysis of Section

Analysis of Cross Section – I

The rectangular beam of section 500mm x 100mm x 100mm is modeled using STAAD.Pro and the torque is applied.

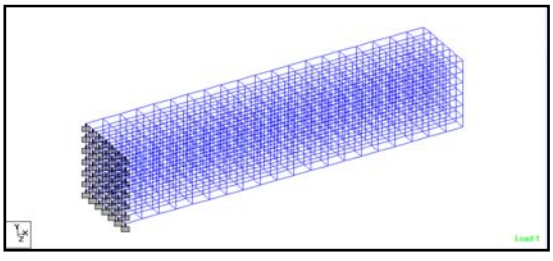

Figure 1 Concrete Beam of Size - 500mm x 100mm x 100mm

After modelling the beam, material properties and load conditions should be assigned. The post processing of beam has been carried out, the normal stress was analysed for x-x , y-y and z-z directions.

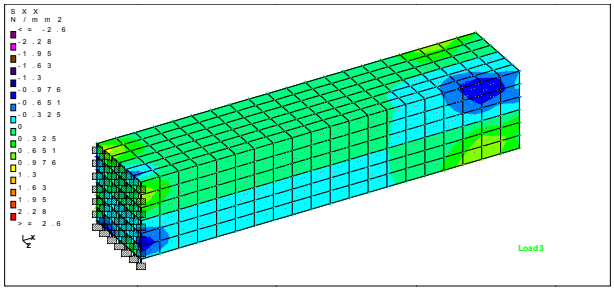

Figure 2 Normal Stress (S_{xx}) - 500mm x 100mm x 100mm

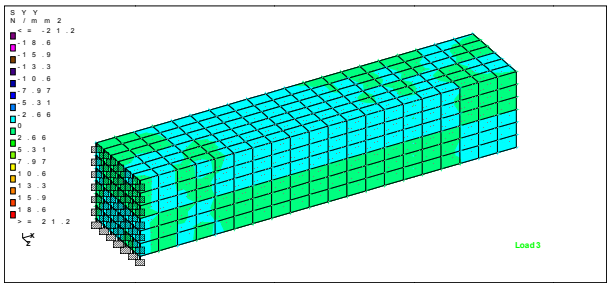

Figure 3 Normal Stress (S_{yy}) - 500mm x 100mm x 100mm

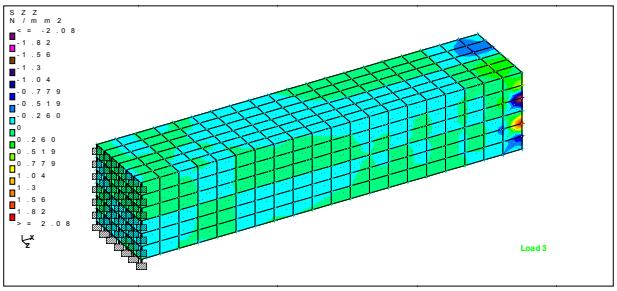

Figure 4 Normal Stress (S_{zz}) - 500mm x 100mm x 100mm

From the figure 2,3 and 4, the normal stress in x-x, y-y and z-z direction are unequal. The stresses in y-y direction was major and other direction was minor.

Analysis of Cross Section – II

The rectangular beam of 500mm x 100mm x 75mm was modelled using STAAD. Pro. The discrimination of beam is done and support conditions are assigned.

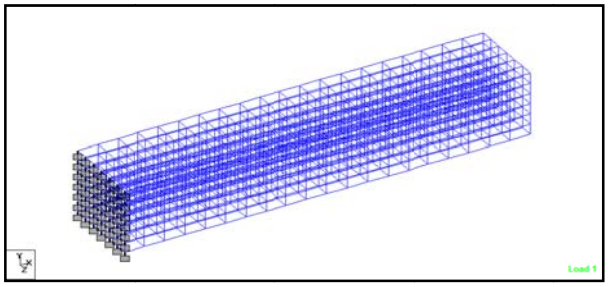

Figure 5 Concrete Beam of Size - 500mm x 100mm x 75mm

The Preprocessing can be done with same poperties. The normal stress value can be obtained by postprocessing the beam.

Analysis of Cross Section –III

(Concrete Beam of Size – 500mm x 100mm x 50mm)

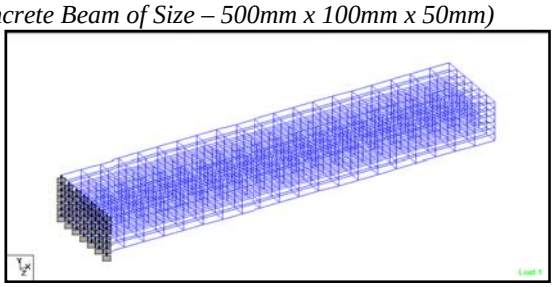

Figure 6 Concrete Beam of Size - 500mm x 100mm x 50mm

Results and Discussion

Normal stress at X – Direction (S_{XX})

Normal stress in x-x direction was minor stress and it is seen to increase with increase in depth. The variation in stress to the depth to breadth ratio is plotted in the following graph.

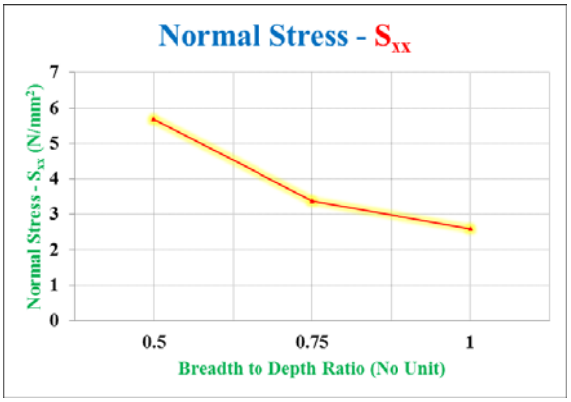

Figure 7 Normal Stress at x - direction (S_{xx})

Normal stress at Y – Direction (S_{YY})

Normal stress in y – direction is identified to be major and it increases with increase in depth. The variation in stress of different ratio is seen to vary linearly.

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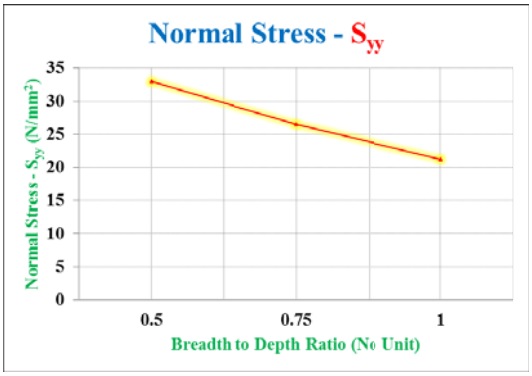

Figure 8 Normal Stress at y – direction(S_{yy})

Normal stress at Z – Direction (S_{ZZ})

The normal stress in z direction is minor stress and the variation is as showed in the figure 9.

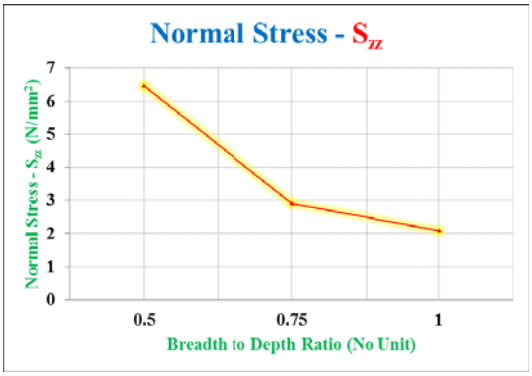

Figure 9 Normal Stress at z - direction (S_{zz})

Conclusions

From the analysis of concrete beams of various depths, the following equations and results are obtained:

- From figure 7, the equation S_{xx} = -1.54x + 6.966 is obtained for Normal Stress in x – direction.
- From figure 8, the equation S_{yy} = -5.9x + 38.7 is obtained for Normal Stress in y – direction.
- From figure 9, the equation S_{zz} = -2.19x + 8.2 is obtained for Normal Stress in z – direction.
- The Normal Stresses S_{xx}, S_{yy} and S_{zz} increases by decreasing the beam depth ratio.

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