NUMERICAL STUDY ON STRESS ANALYSIS OF CURVED BEAMS

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ABSTRACT

The static analysis of naturally curved beams with closed thin walled cross section has many important applications in mechanical, civil and aeronautical engineering. Many of the curved beams subjected to bending moment find in real life applications. Due to bending moment, tensile stresses developed in one portion of the section and compressive stresses in other portion of cross section. The analytical computation to determine these stresses are more complex, therefore in this paper we attempted the determination of stresses and deflection of curved beams when it is subjected to bending moment with the help of ansys software. The result obtained from ansys software is validated with the simplified stress equations of curved beams developed by the other researchers.

Keywords: Beams, Stress and Deflection

1. INTRODUCTION & LITERATURE SURVEY

The determination of stress and displacement in a rectangular cross section curved beam will play very important role in many structural problems. Many researchers attempted previously with the help of simple beam theory adopted for straight beams. In 1968 Gaydon has discussed the problem of rectangular cross section curved beam with boundary loadings. His work was totally on analytical complex expression. Sarma et al (1975) simplified the expressions developed by previous authors some extent by adopting Eigen function for the solution of stress problems of curved beams. Dym, cl and Williams proposed stress and displacement expressions for curved arcs which are more suitable to write finite element equations in 2011. ERIK PERSSON utilized MATLAB/CALFEM software’s to determine stress and deflections of structures made up of curved beams. He also compared the results with the analytical expressions developed by previous authors to simplify the problem of stress analysis of curved beams of rectangular cross section; we developed ansys fea
modeling in this paper. This work helps researchers to determine stresses quickly as per their requirement of beam size and material.

The paper is organized in the following manner: section 2 describes the geometry of the beam and load condition on it. It also covers the finite element model of curved beam. Section 3 discusses the results obtained from the ansys simulation study made on the curved beam with different loading condition. Conclusions are finally drawn in the section 4.

2. GEOMETRY AND FEA MODELING OF CURVED BEAMS

The cross section selected for curved beam is a rectangle having width: 40m height: 20mm. The outer and the inner diameter of curved beam are respectively 310mm and 300mm. The material used for curve beam is carbon steel of young’s modulus $2 \times 10^5$ MPa and poison ratio 0.3. The geometry of curved beam in ansys software. The sequential steps used to form geometry of curved beam are given below:

Step: 1 we need to select create option
Step: 2 we need to select Areas
Step: 3 we have to select annulus circle
Step: 4 after selecting annulus circle we need to select rectangle
Step: 5 we will get the required curved beam

If we follow above steps the curved beam geometric model appears as shown in figure 2.1

![Figure 2.1: Semi circular arc before meshing](image)

The FEA model of the curved beam is worked out with the following sequential steps in ANSYS:

Step: 1 choose the element type solid quadnode82
Step: 2 real constants are default
Step: 3 apply material properties by giving young’s modulus and Poisson ratio
Step: 4 sectioning width: 40 depth: 20
Step: 5 follow the modeling steps given above
Step: 6: Adopt meshing mesh tool smart size

The fea model obtained with the above steps is shown in the figure 2.2
3. RESULTS AND DISCUSSIONS

In this section the numerical study on deflection and stresses developed in circular arc rings subjected to different loading is covered. There are eight different arcs of rings considered for the study. The rectangular cross section beam is selected with the dimension 40mm and 20 mm. Figure 3.1 shows the ansys numerical results on four different circular beams whose circular included angles are 180°, 360°, 90° and 270°. Here every circular plate was loaded with 5N force. It is found that semi circular beam experienced maximum stress value up to 100MPa while three fourth circled beams encountered less stress value 47MPa. Figure 3.2 shows the numerical results of stresses and deflections of the four circular beams that are taken for simulation study earlier example. Here the load taken on the model is 10N but here the numerical studies shows the maximum stress induced is in full circular beam.
Fig 3.2: stress and deflection values of various curved beams with load 10N.

Fig 3.3: stress and deflection values of various curved beams with load 15N.

Fig 3.4: stress and deflection values of various curved beams with load 20N.

Set of figures shown in figure 3.3 predicts the stress and deflection values of four different circular plates when they are subjected to the bending load of 15N. Here also the maximum stresses are induced in a plate where circular arc included angle is 360 degrees.

Similarly the simulation studies are run on all four circular beams with the load 20N and the obtained results are shown in figure 3.4. Here the maximum stresses are developed in full circle beam having the value 176MPa.

The simulation studies are also worked out by changing arc included angle from zero degrees to 270 degrees for different loads ranging from 5N to 20N. The results are included in the form of graphs shown in figure 3.5.

Figure 3.5: Variation of stresses with the change of included arc angle of beams.

The stress ratio are also calculated as the ratio between maximum stress to minimum stress on every curved beam when loads are changed from 5N to 20N. The results of the variation of the stresses are shown in the figure 3.6.

![Variation of stresses with different loads on four curved beams](image)

**Figure 3.6:** Variation of stresses with different loads on four curved beams

The variation of stress ratio with the arc included angle is shown in the figure 3.7. It is observed from this figure that the stress ratio in all loading conditions on various curved beams found to be more than two and less than three. It implies that the bending stresses increase to minimum twice of the nominal stresses induced in straight beam. It is also found that the maximum stress ratio is on semi-circular curved beam.

![Variation of stress ratio arc angles](image)

**Figure 3.7:** Variation of stress ratio arc angles
4. CONCLUSIONS

After realizing the difficulty for the estimation of stresses and deflections in curved beam by different authors, this paper finds numerical solutions to get stresses and deflections in a curved beam with the help of ansys software. The magnitude of curvature of the beam is described with arc angle and various ansys models are developed, by changing curved angles from $0^0$ to $90^0$ to $180^0$ to $270^0$. After the ansys analysis on curved beam following conclusions are made.1) The stress values found to be maximum when a circular arc being subjected to a bending load. 2) When analysis is carried out on semi circular beam subjected to similar load conditions as that of other circular beams, it is found that maximum stress values are developed than the other cases. 3) The stress factor that is the ratio of maximum stress to minimum stress also calculated for full circle, semi circle, quarter circle, three fourth circular beams. When loads fluctuates from 5N to 20N, it is found that the stress factor 4.1 which is high in the case of load condition 10 N. The procedure adopted in this paper for modelling various types of circular beam. It is helpful to test numerically the stress values of various shapes of curved beams.

ACKNOWLEDGEMENTS

The authors thank the Head of the Mechanical Engineering, Principal and Director Sreenidhi Institute of Science and Technology (SNIST) Hyderabad for their support and permission to carry out this research thesis work.

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