

Finite Element Analysis of Cantilever Beam with Multiple Circular Hole and V-Notch of Different Materials

Nomesh Kumar Sahu¹, LokeshSingh², SushilKumar Maurya³

^{1,2} GD Rungta College of Engg and Technology, Bhilai, India

³ Modern Institute of Technology & Research Centre, Alwar, India

¹nomeshsahu.93@gmail.com, ²lokeshsingh25@gmail.com, ³mauryasushil86@gmail.com

Abstract- This study investigates the deflection in a cantilever beam of uniform rectangular cross section made of linear elastic material that is homogeneous and isotropic. In this study, the effects of multi hole and V- notch location on the homogenous cantilever beams with three different materials have been investigated. In this paper we are working for analysis of deflection due to notches and hole in structure which is beam or rod with rectangular cross section. We are performing this experiment with three different material which are steel, aluminium and titanium. V-notches and hole at three different locations 15, 30 and 45mm. This experiment is performed by finite element analysis software here we are using Lisa Fea software for analysis.

Keywords- cantilever beam, material, maximum deflection, notches, finite element analysis.

I. INTRODUCTION

We sometimes see that a beam have more than one hole or notch for any specific reason and due to this notches strength of beam will reduces. As the no. of notches increases the beam will become weaker. So it becomes necessary to check the strength of beam.

Failure of structure is caused by either natural defects or defects due to design of structure. Design of structure may be type of material used in structure, dimension used for beam column and frame of other type etc. type of notches or hole also provided in structural for some reason. Here we will analyse beam with three holes to beam with three V-notches.

II. LITERATURE REVIEW

Many numerical and experimental studies have been done on effect of notches on beam. [1] Samalet. al. studied the deflection and stress distribution in a long, slender cantilever beam of uniform rectangular cross section made of linear elastic material properties that are homogeneous and isotropic. [2]Pasinliet. al. was investigated the effects of hole dimension, shape and position, and beam thickness on the lateral buckling behaviour of woven fabric laminated composite cantilever beams, having two square or two circular holes,. Firstly, the theoretical, experimental and numerical critical buckling loads of the beams without holes were found and compared with each other. [3] Erklig et.al. studied the effects of different cutouts on the lateral buckling behaviour of composite beams made of polymer matrix composites. Cut-outs like circular, rectangular, square, elliptical and triangular are generally used in composites. This paper includes two parts; first part is an experimental part and second is a numerical part. In the experimental part, samples with square, circular and without cutouts are used and critical

lateral buckling loads are determined experimentally. In the second part, finite element analysis is performed to predict the effects of different cutouts, location and size of cutouts on the lateral buckling behaviour of the beam.

III. METHODOLOGY

In this chapter we will discuss about how to perform analytical work. It included how to make an object from node, creation of nodes, creation of element, meshing, apply load and constraint etc. In this project we use isotropic metallic material for rectangular cross-section beam. Here notch used is of two type circular hole and V notch. Homogeneous material is used in this project. Software used for this analytical experiment is LISA FEA.
Dimension of beam - $60 \times 12 \times 10 \text{ mm}^3$

Step.1 Selection Of Material - We select three material steel, titanium and aluminium and its property are given below.

Table.1- property of material

Material	Young's modulus (E) N/mm ²	Poisson's ratio (μ)	Density(ρ) Kg/mm ³
Steel	206×10^3	0.30	7.84×10^{-6}
Aluminium	67×10^3	0.34	2.7×10^{-6}
Titanium	105×10^3	0.34	4.548×10^{-6}

Step.2 Create A Node - Create a node by specifying its X, Y & Z co-ordinate



Fig 1- Creation of nodes by coordinate point

Step.3 Create An Element - Create an element either by selecting the nodes using the mouse or entering a list of node numbers. Follow the number sequence to form element.

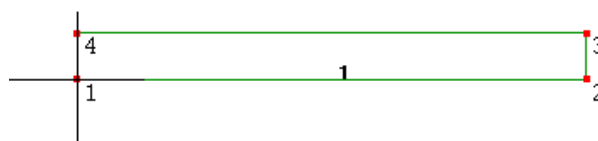


Fig 2- Creation of element by nodes

Step.4 Meshing - Meshing is done either by a combination of nodes and elements or by using ready-made template patterns. It is of two types that is 2D and 3D mesh.

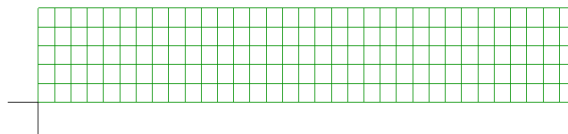


Fig 3 – Meshing of element



Step.5 Extrude - In this process any surface is given its width. Once a 2D plane mesh has been created it can be extruded, revolved or lofted to create a 3D model.

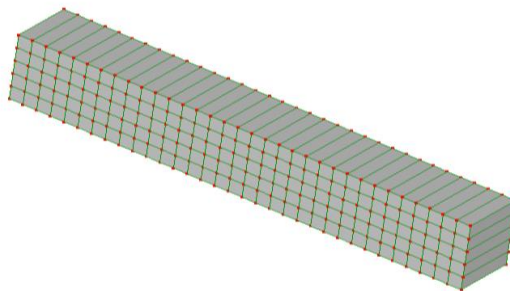


Fig 4- Extrusion of element



Step.6 Create A Hole - Hole is created using tool given in software and in this tool side of square and radius of circle need to be given.

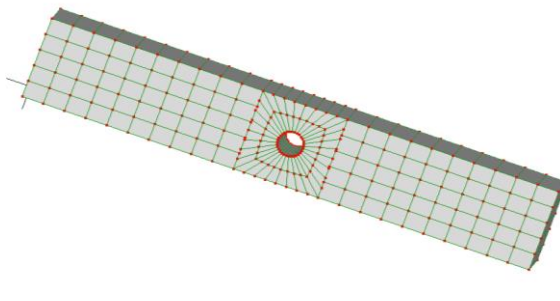


Fig 5 – Circular Hole In Beam



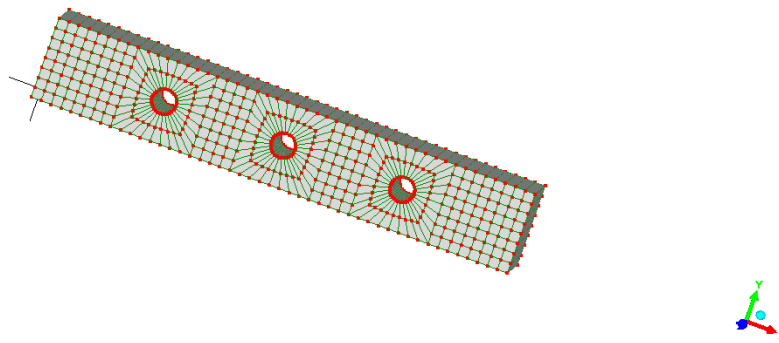


Fig 6-Beam with circular notch at three points simultaneously

Step.7 Create A "V" Notch - Putting coordinate point of V notch in step 2 and then element is created. This element is then meshed. By extruding this 2D element following results are obtained.

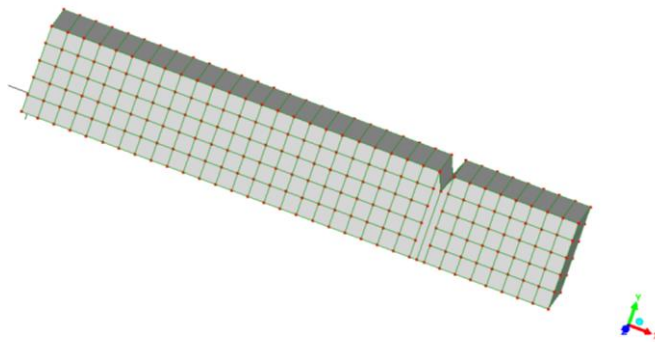


Fig 7 -V notch in beam

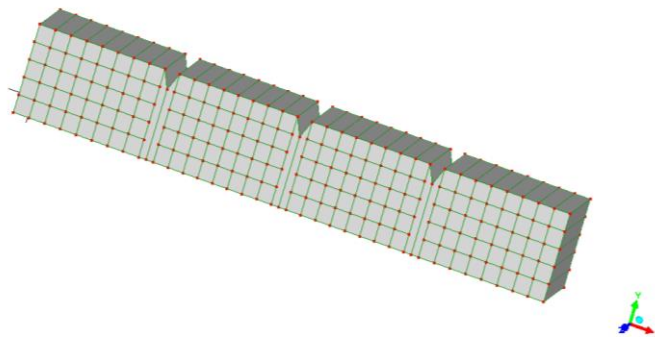


Fig 8 -Extrusion of beam with V notch at three points simultaneously

Step.8 Apply Load And Constraint - A fixed support constrains all the face's nodes against displacement in any direction. A force applied to nodes is divided equally between the nodes. A force can be applied to a named selection containing nodes or faces.

Let us force is applied to right side of the beam.

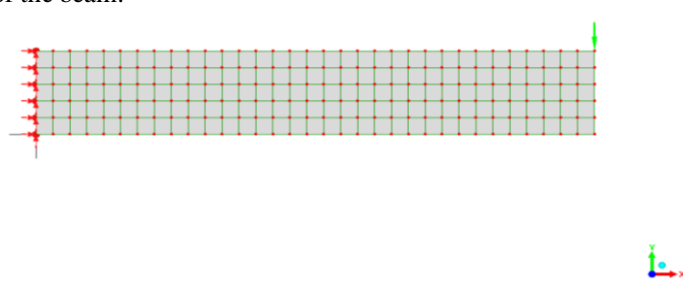


Fig 9- Constraint and load is applied on beam

Step.9 Solve - After applied force and constraint Click “=” to solve the model. Select any item below Solution to display a field value as a colour coded contour plot. The results are listed in the outline tree below Solution

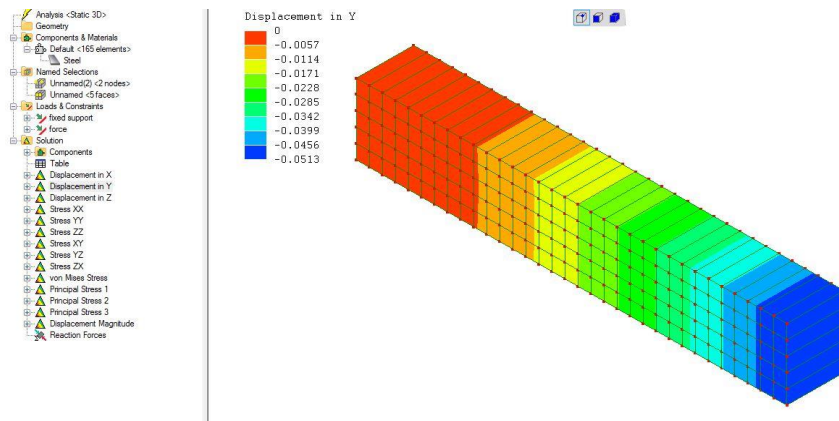


Fig 10- Results are listed below solution

IV. RESULTS AND DISCUSSION

In this section, Maximum stress and displacement for different material in the elastic beam are determined with the help of LISA Fea software. The results are displayed with the help of figures, Tables and Bar graphs. The effects of load with and without hole and notch in beam are analysed. Thus a number of experiments performed by three materials with different notch position it is also compare by beam with no notch.

Consider beam without notch made up of steel, the dimension of beam is $60 \times 10 \times 8 \text{ mm}^3$

Here we are considering the displacement in Y direction of upper right corner node for analysis.

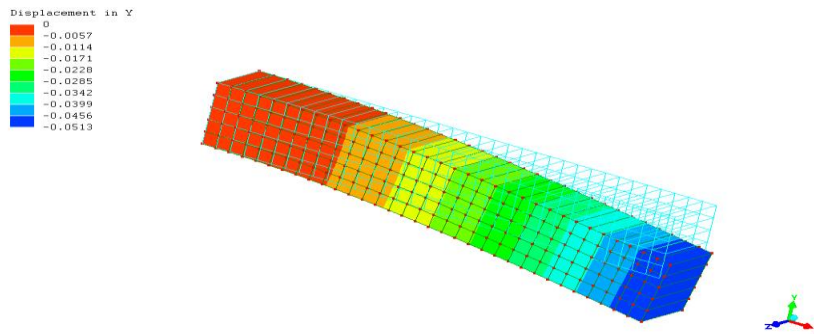


Fig 11 - Displacement of beam without hole

Location of notch and hole – notch and hole is located at three different points which are at a distance of 15mm 30mm and 45mm from fixed end.

Table.2 - Deflection (in mm) of node at corner (60,10,8) due to presence of notch

Material	Without notch	Combination of three notch with different location	Combination of three hole with different location
Steel	0.05129	0.06403	0.061785
Titanium	0.09958	0.1231	0.119002
Aluminium	0.15607	0.1915	0.188558

Table.3- Deflection (in mm) of node at corner (60,10,8) due to presence of notch

Material	Combination of three notch with different location	Combination of three hole with different location
Steel		

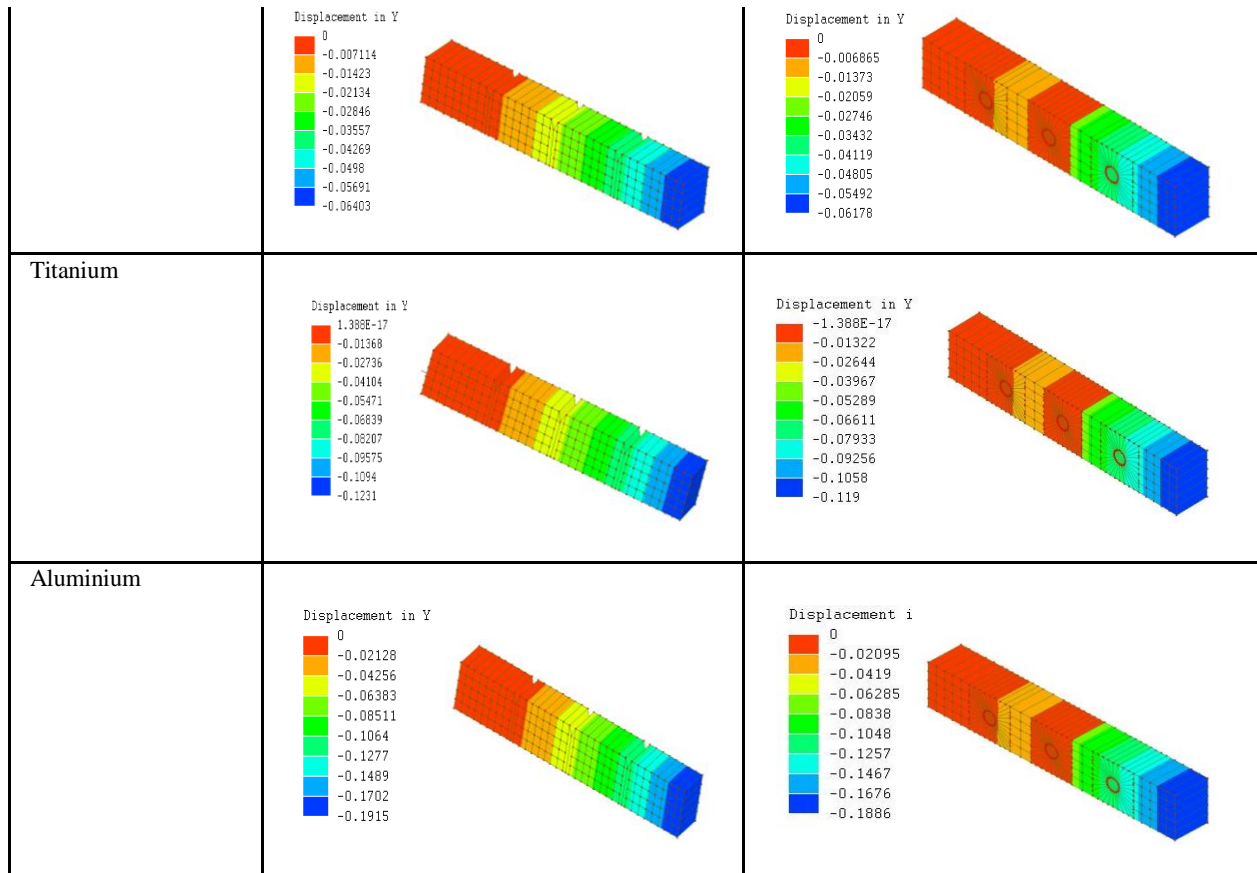
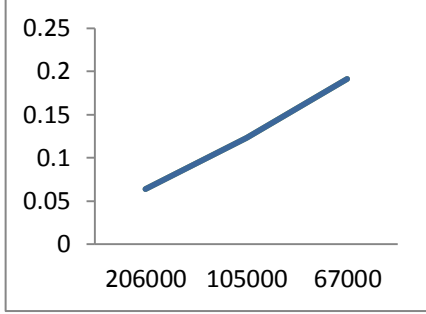
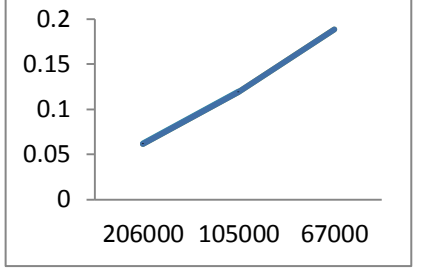


Table.4 - Graph and equation of displacement with respect to notch and hole

No.	Table	Graph	Equation						
V notch	<table border="1"> <thead> <tr> <th>Steel</th> <th>Titanium</th> <th>Aluminium</th> </tr> </thead> <tbody> <tr> <td>0.06403</td> <td>0.1231</td> <td>0.1915</td> </tr> </tbody> </table>	Steel	Titanium	Aluminium	0.06403	0.1231	0.1915		$y=0.063x$ -0.001
Steel	Titanium	Aluminium							
0.06403	0.1231	0.1915							
Circular hole	<table border="1"> <thead> <tr> <th>Steel</th> <th>Titanium</th> <th>Aluminium</th> </tr> </thead> <tbody> <tr> <td>0.06179</td> <td>0.1190</td> <td>0.188558</td> </tr> </tbody> </table>	Steel	Titanium	Aluminium	0.06179	0.1190	0.188558		$y=0.063x$ -0.003
Steel	Titanium	Aluminium							
0.06179	0.1190	0.188558							

From equation 1 and 2 it is clear that Equation is linear that means it follow straight line there are two parameter displacement and modulus of elasticity, if one parameter is known then another can be evaluate. It helps us to find the displacement of any particular material (if their modulus of elasticity is known).

V. CONCLUSION

In this experiment two notch are used one is V-notch and other is circular hole, by putting notch at three different location together from fixed end when load is applied on three different material the displacement of upper right node is obtained. By plotting graph between displacement and modulus of elasticity a straight line is obtained. Thus two straight lines is obtains from two different notch. By this equation if one parameter is known then another can be evaluate. It helps us to find the displacement of any particular material.

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