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Variation of stresses at different nodal points in a isotropic beam using ANSYS

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ABSTRACT: *Compression and tension phenomena are being developed in the analysis of beams using different approaches. Different approaches sometimes result in vary close variations with each other. The simulation software ANSYS uses the finite element concept to visualize the stress and its variation and comparison at different nodes. This paper illustrates the conditions where the bending stresses getting minimized and maximized as the changes in nodal distance. It shows that the neutral axis has the least bending stresses where the outmost fibers give the maximum. And also the theoretical calculations comply with the finite element results up to certain conditions.*

KEYWORDS: *Finite element, ANSYS, bending stress, meshing.*

I. INTRODUCTION:

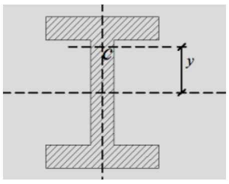
A part of a structure like beams have been using in the modeling of structural finite element analysis [1]. Finite Element Analysis aims to mathematically model a physical body that cannot be solved with satisfied result by other means. And FEA is an effective method of determining the static performance of structures for three reasons which are saving in design time, cost effective in construction and increase the safety of the structure[2]. A member subjected to bending moment and shear force undergoes certain deformations. The material of the member will offer resistance or stresses against these deformations[3]. Using FEA, the mathematical modeling of the body is done by splitting the body into small and smaller parts whose performance and response can be modeled simply finite elements. FEA analysis, and the most reliable, is still the static structural analysis limited to:-

- elastic, homogeneous, isotropic materials & linear material properties
- small deflections: geometry changes can be ignored
- all material well below yield: no plastic deformation

The ANSYS 15.0 meshing application is a separate ANSYS Workbench application[4]. The Meshing application is data-integrated with ANSYS Workbench, meaning that although the interface remains separate, the data from the application communicates with the native ANSYS Workbench data. Here construction geometry is used to insert a path which means of creating a path between nodes of a meshed model. And this practice will give linearized stress in axial direction.

The theoretical flexure formula shows that

Figure 2.1



$\boldsymbol{\sigma} = \frac{\boldsymbol{M}\,\boldsymbol{y}}{\boldsymbol{I}}$ where σ is the bending stress in a particular cross section(i.e. Figure 2.1), M is the moment developed due to applied loads, y is the distance from the neutral axis to the upper(compressive) fiber or lower(tensile) fiber and I is the moment of inertia in xx direction[5][3].

The calculations are done considering a uniform rectangular cross-sectional beam of linear elastic isotropic homogeneous materials. The beam is assumed to be mass less, inextensible having developed no strains [6].

II. BEAM ANALYSIS IN ANSYS:

Typical section is shown in Fig. 2.1 which is to be used here.
Material = Structural steel, Modulus of Elasticity= 29 x 10^3 ksi. Poisson's ratio: 0.3

Fig. 2.2

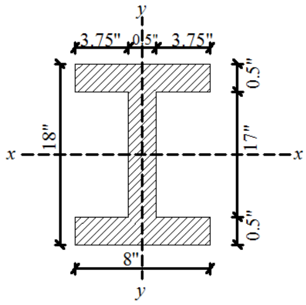


TABLE: 2.1

Flange width	8 in	Web thickness	0.5 in
Flange thickness	0.5 in	Total height	18 in
Length of the beam	180 in		
Nonlinear Effects	Yes		

TABLE: 2.2

FEA by ANSYS		
Nodes	252673	
Elements	54720	

Now beam has been defined with four axial(cross sectional) linear paths to show its range of bending stresses. The table below shows the details:

TABLE: 2.3

Object Name	Axial at 90 in	Axial at 60 in	Axial at 30 in	Axial at 10 in
State	Fully Defined			
Definition				
Path Type	Two Points			
Path Coordinate System	Global Coordinate System			
Number of Sampling Points	47.			
Suppressed	No			
Start				
Coordinate System	Global Coordinate System			
Start X Coordinate	0. in			0 in
Start Y Coordinate	18. in			
Start Z Coordinate	90. in	60. in	30. in	10. in
Location	Defined			
End				
Coordinate System	Global Coordinate System			
End X Coordinate	0. in			0 in
End Y Coordinate	0 in			
End Z Coordinate	90. in	60. in	30. in	10. in
Location	Defined			

III. CONFIGURATION WITH ANSYS:

A. Location of linear paths:

In the starting of analysis the following Fig. 3.1.1, 3.1.2, 3.1.3 and 3.1.4 show that the location of axially linear path for stress analysis which complying the table 2.3.

Fig. 3.1.1: Bending stress, Axial at 90 in

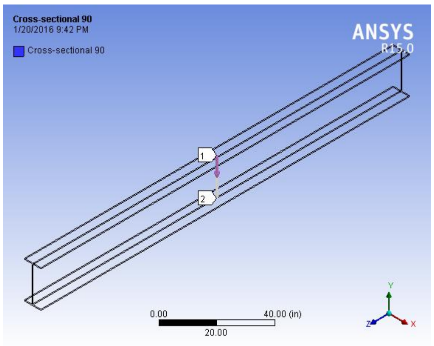


Fig. 3.1.2: Bending stress, Axial at 60 in

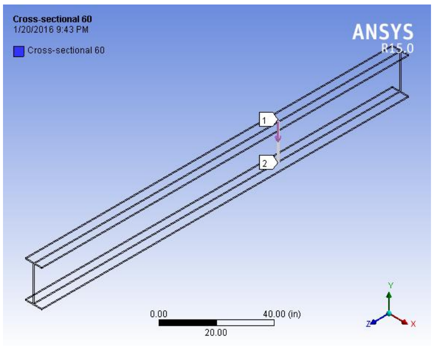


Figure 3.1.3: Bending stress, Axial at 30 in

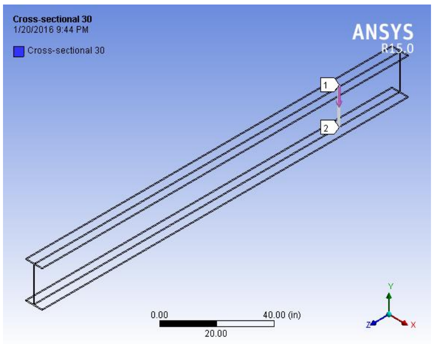
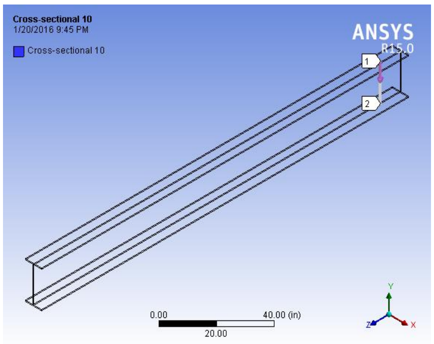


Figure 3.1.4: Bending stress, Axial at 10 in



***B*: Bending stresses:**

Using the flexure formula to find out the bending stresses, here four locations are considered. First one is at 90 in., 2nd one is 60 in., 3rd one is 30 in. and 4th one is at 10 in. from the right face as shown in Fig. 3.2.1

Fig. 3.2.1 Location of stresses

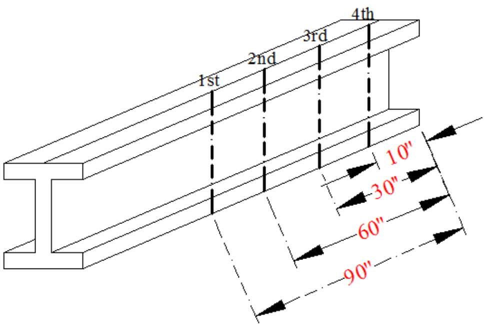


Fig. 3.2.2 to Fig. 3.2.5 shows the changes in stresses along the centroidal vertical axis in ANSYS. Here it is shown that as it moves far from the centre span, the stress varies. And more interesting thing is that the maximum stress is developed at the outer fibre in either compressive or tensile zone. But when it moves from centre either towards right or left, the bending stress decreases. And this is of course comply with the theoretical concept that the bending moment also decreases.

The table 3.1 below shows some points where comparison of stresses have been done by hand calculation and ANSYS. And the visual output have been made in Fig. 3.2.6 to Fig. 3.2.9. These Figures confirm that the stresses those developed by ANSYS, also comply with the theoretical calculation.

Fig. 3.2.2: Changes in stresses, Axial 90

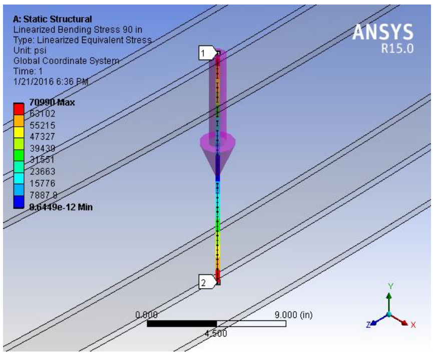


Fig. 3.2.3: Changes in stresses, Axial 60

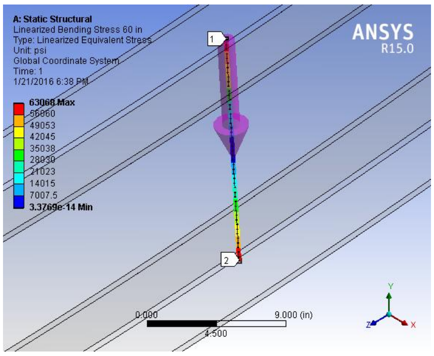


Fig. 3.2.4: Changes in stresses, Axial 30

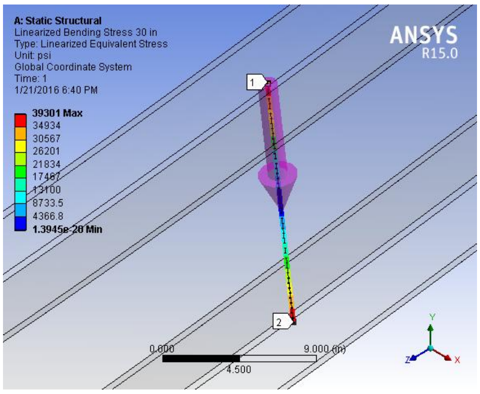


Fig. 3.2.5: Changes in stresses, Axial 10

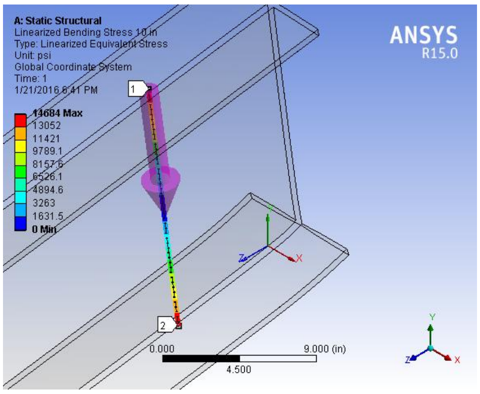


TABLE: 3.1

Distance from upper or lower fibre [in]	At 90 in		At 60 in		At 30 in		At 10 in	
	Theoretical [psi]	***ANSYS [psi]***	Theoretical [psi]	***ANSYS [psi]***	Theoretical [psi]	***ANSYS [psi]***	Theoretical [psi]	***ANSYS [psi]***
0	71350.80	70990	63422.93	63068	39639.33	39301	14974.86	14684
1.5	59459.00	59158	52852.44	52556	33032.77	32751	12479.05	12236
2.25	53513.10	53243	47567.20	47301	29729.49	29476	11231.14	11013
3	47567.20	47327	42281.95	42045	26426.22	26201	9983.24	9789.1
3.75	41621.30	41411	36996.71	36790	23122.94	22925	8735.33	8565.5
4.5	35675.40	35495	31711.46	31534	19819.66	19650	7487.43	7341.9
5.25	29729.50	29579	26426.22	26278	16516.38	16375	6239.52	6118.2
6	23783.60	23663	21140.98	21023	13213.11	13100	4991.62	4894.6
6.75	17837.70	17748	15855.73	15767	9909.83	9825.2	3743.71	3670.9
7.5	11891.80	11832	10570.49	10511	6606.55	6550.1	2495.81	2447.3
8.25	5945.90	5915.8	5285.24	5255.6	3303.27	3275.1	1247.90	1223.6
9	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.0

Fig. 3.2.6: Comparison of stresses, Axial 90

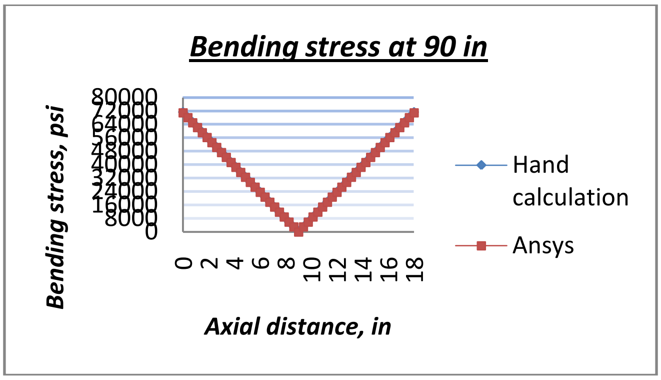


Fig. 3.2.7: Comparison of stresses, Axial 60

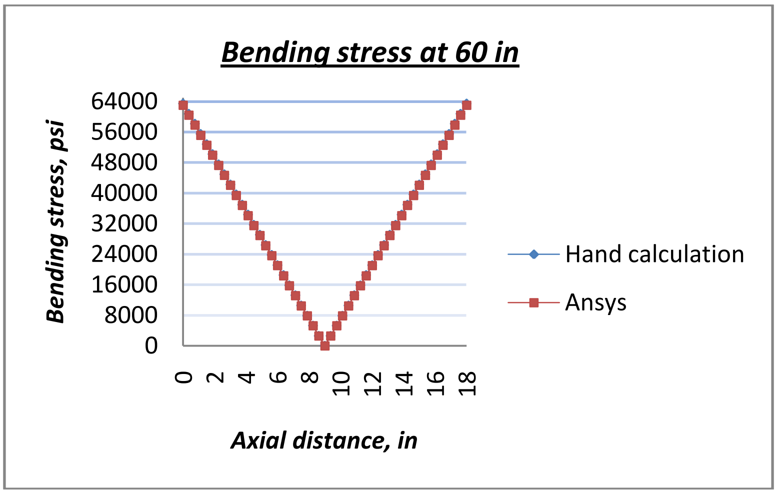


Fig. 3.2.8: Comparison of stresses, Axial 30

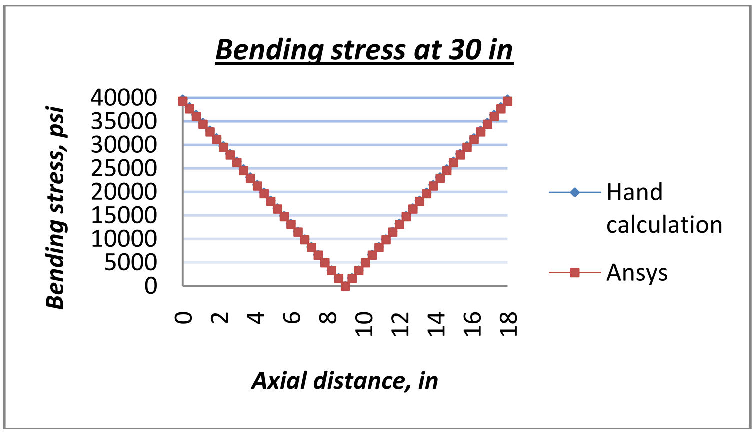
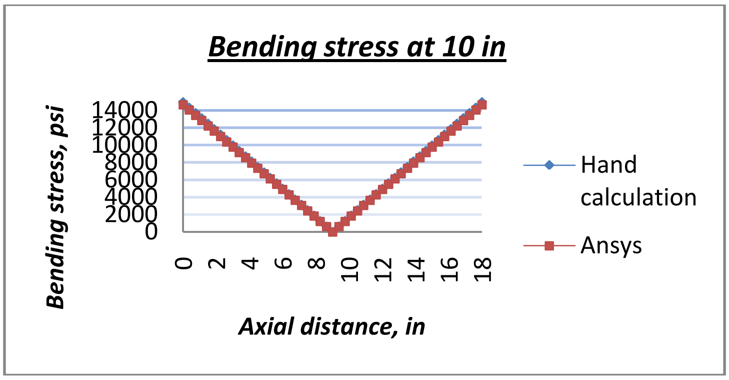


Fig. 3.2.9: Comparison of stresses, Axial 10



All figures show that the axial distance at 9 in has zero bending stress. And if any point below or above the neutral axis is considered, then it gives more stress and it increases linearly to outermost fibre.

IV. CONCLUSION:

The relation between bending stresses and bending moment has been expressed by flexural relation. That is the elastic deformations plus Hooke's law determine the manner of stress variation. Again the theoretical relation indicates that the flexure stress in any section varies directly with the distance of the section from the neutral axis. And this is also true for ANSYS. However this analysis allows to stand with the theoretical background of flexure formula when finite element analysis would considered.

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