

Structural Analysis of Isotropic and Orthotropic Beams and Plates in First Order Shear Deformation Theory

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ABSTRACT: In the classical theory of plates (CPT), it is assumed that plane sections initially normal to the mid surface before deformation remain plane and normal to that surface after deformation. This is the result of neglecting transverse shear strains. However, non-negligible shear deformations occur in thick and moderately thick plates and the theory gives inaccurate results for laminated plates. So, it is obvious that transverse shear deformations have to be taken into account in the analysis. One of the well known plate theories is the Reissner and Mindlin model which is a first order shear deformation theory (FSDT) and takes the displacement field as linear variations of midplane displacements. In this theory, the relation between the resultant shear forces and the shear strains is affected by the shear correction factors.

In this thesis, finite element analysis is performed to analyze the response of isotropic and orthotropic beams and plates. The assumed field displacements equations are represented by a first order shear deformation theory. Structural analysis is performed for different materials Aluminum, Steel, Carbon Fiber and Glass Epoxy. Analysis is performed to compute the natural tic deformations and stresses for plates and beams with different boundary conditions, one end fixed and two ends fixed. The analysis is also performed on plate using shell element for composite materials. Theoretical calculations for beam are done to determine displacement, stress and strain. Modeling is done in Pro/Engineer and Analysis is done in Ansys.

KEY WORDS: Reissner , mindlin, beams and plates

I. INTRODUCTION

The theory of beams shows remarkably well the power of the approximate methods called "strength of materials methods." These methods depend on the use of statics, superposition and simplifying assumptions that turn out to be very close to the truth. They give approximate, not exact, results that are usually more than adequate for engineering work. Calculus and a little differential equations are all the mathematics required for this approach, not the partial differential equations or tensor analysis that are typical tools in elasticity.

Strength of materials methods can be used for beams of arbitrary cross sections, for beams whose shape varies along the length, for loads applied in any direction at any point, distributed or concentrated. Many of these applications are discussed in the first reference, which shows the versatility of the method. The results obtained are fully adequate for engineering design. On the other hand, an accurate and rigorous quantitative solution in these varied cases would be extremely difficult and usually impossible.

An introduction to many of the concepts that will be needed here will be found in [Elasticity](#), including the meaning of shear and bending moments, and shear and moment diagrams.

II. LITERATURE REVIEW

The first order shear deformation theory For symmetrically laminated composite plates On elastic foundation
by S. Seren Akavci, Huseyin R. Yerli and Ali Dogan

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III. EXPERIMENTAL ANALYSIS

ANALYSIS OF LAMINATED PLATES - ONE END FIXED - STRUCTURAL ANALYSIS MATERIAL - ALUMINUM ALLOY

Material properties

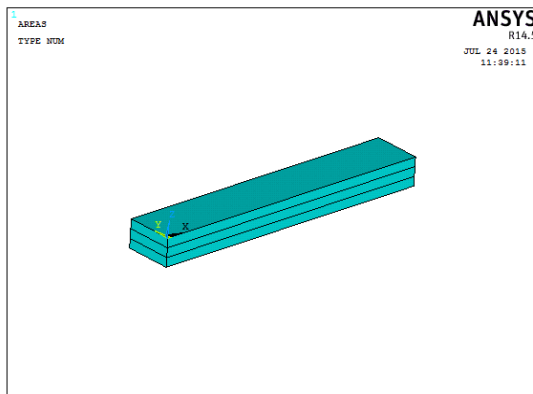
Young's Modulus - 717 GPa

Poisson's Ratio - 0.281

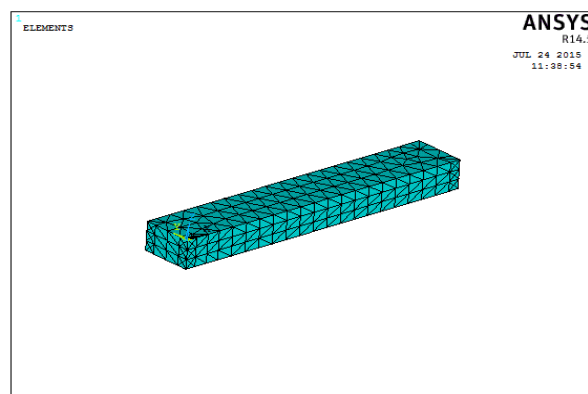
Density - 0.00000281Kg/mm³

Element Type - Solid 20 node 186

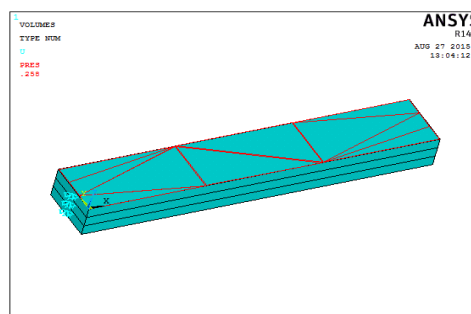
Imported Model



Meshed Model



Loads Pressure = Load / Area Load = 100N



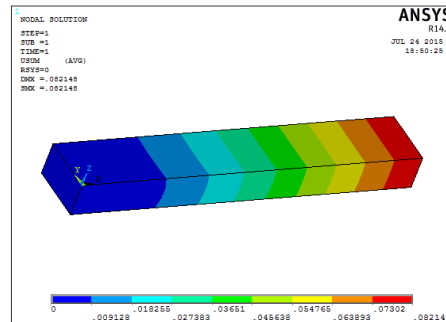
Solution – Solve – Current LS – ok

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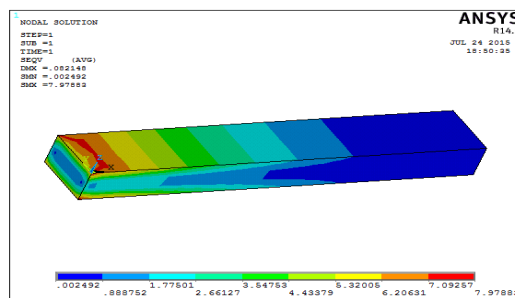
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General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – **Displacement Vector Sum**



The maximum displacement value was found out to be 0.082148mm.

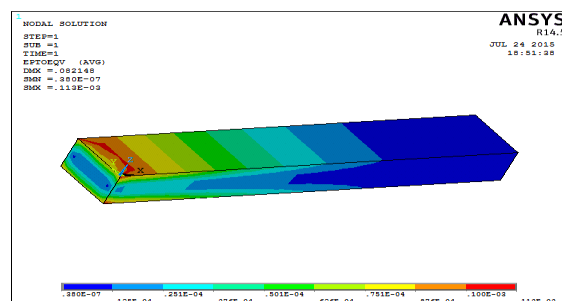
General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – **Von Mises Stress**



The stress value was found out to be 7.97883 N/mm^2

General Post Processor – Plot Results – Contour Plot – Nodal Solution – Strain –

Von Mises Strain



The maximum strain value was found out to be 0.00113

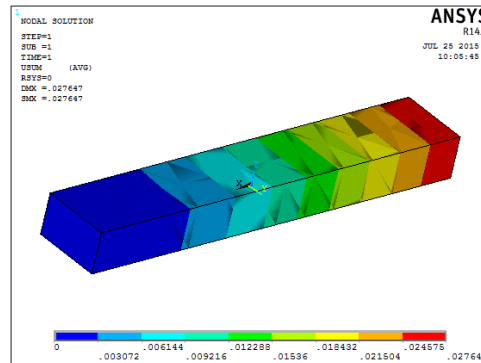
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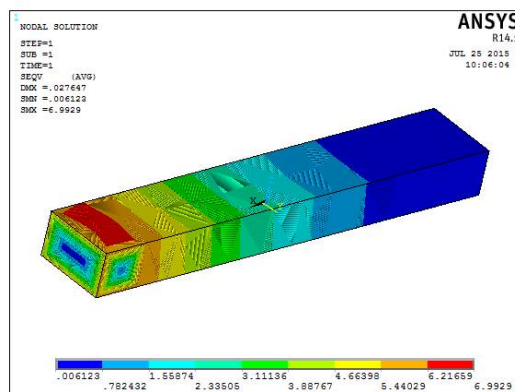
MATERIAL - STEEL

Displacement



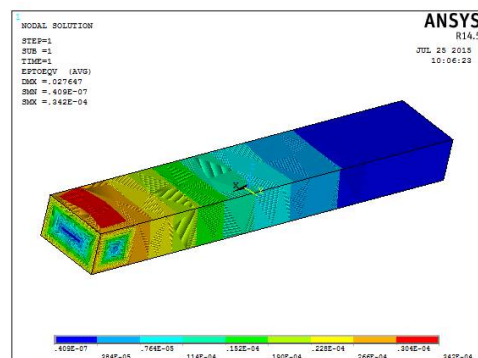
The maximum displacement value was found out to be 0.027647mm.

Stress



The stress value was found out to be 6.9929N/mm²

Strain



The maximum strain value was found out to be 0.000342

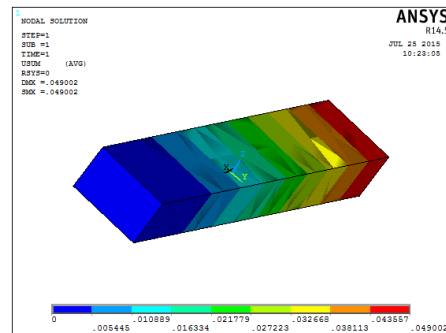
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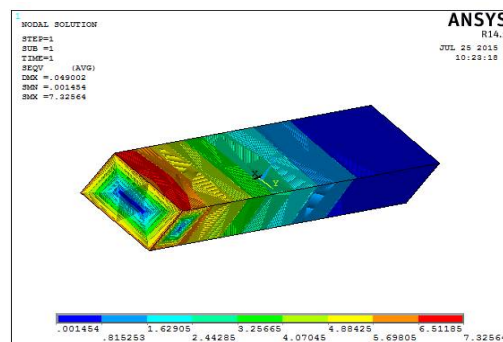
MATERIAL - CARBON FIBER

Displacement Vector Sum



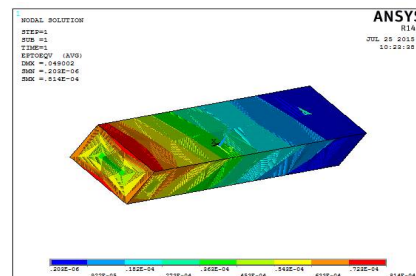
The maximum displacement value was found out to be 0.049002mm.

Stress



Maximum Stress value was found out to be 7.32564 N/mm²

Strain



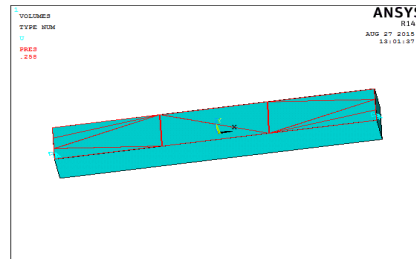
The maximum strain value was found out to be 0.000814

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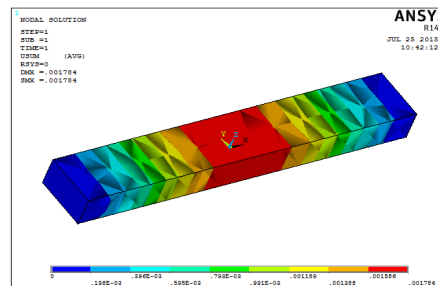
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TWO ENDS FIXEDSTRUCTURAL ANALYSIS MATERIAL – ALUMINUM Loads

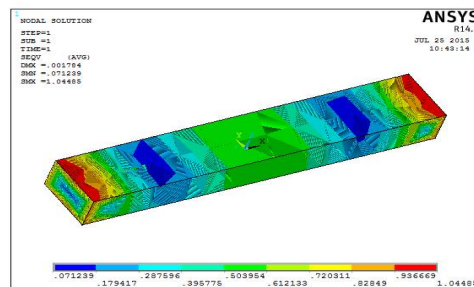


Displacement



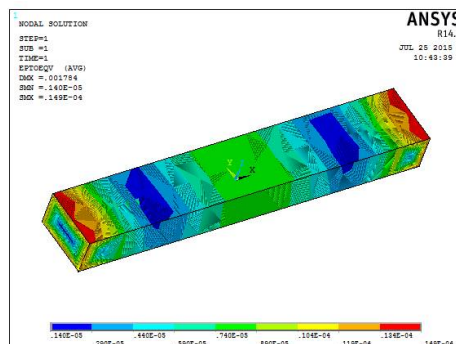
The maximum displacement value was found out to be 0.001784mm.

Stress



The stress value was found out to be 1.04485 N/mm²

Strain



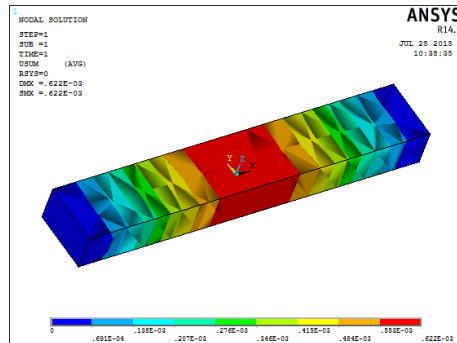
The maximum strain value was found out to be 0.000149

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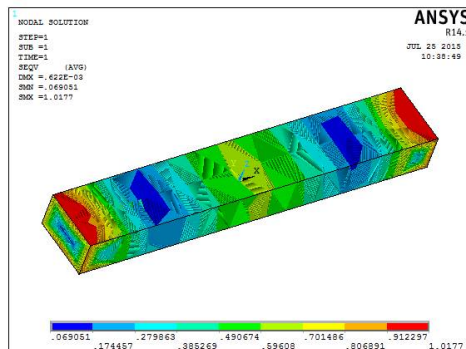
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MATERIAL - STEEL Displacement



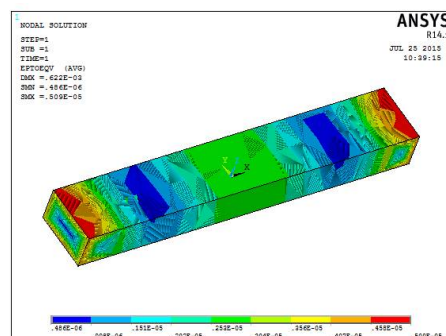
The maximum displacement value was found out to be 0.00622mm

Stress



The stress value was found out to be 1.0177N/mm²

Strain



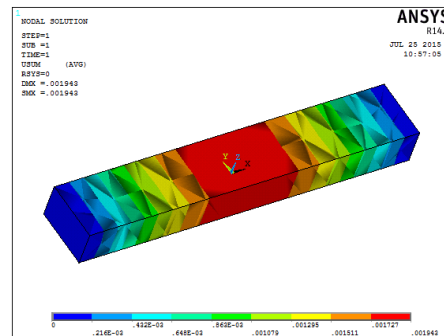
The maximum strain value was found out to be 0.0000509

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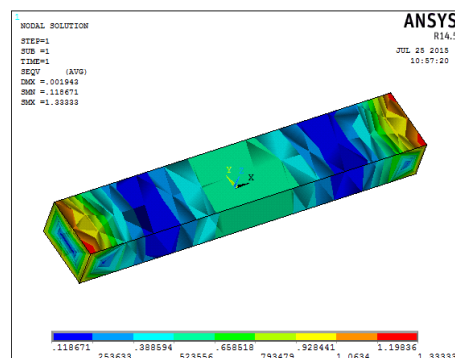
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MATERIAL - CARBON FIBER
Displacement



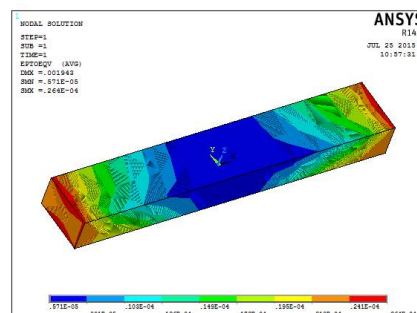
The maximum displacement value was found out to be 0.001943mm

Stress



The Maximum Stress value was found out to be 1.33333N/mm²

Strain



The maximum strain value was found out to be 0.000264

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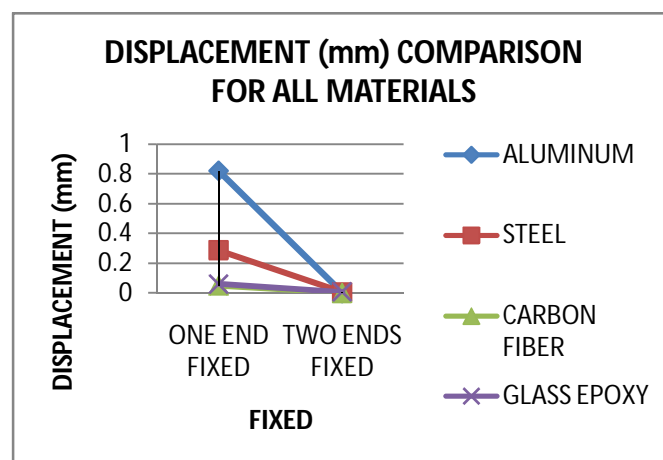
IV. RESULTS TABLE

PLATES - ONE END FIXED

Material	Displacement (mm)	Stress (N/mm ²)	Strain
ALUMINUM	0.82148	7.97883	0.00113
STEEL	0.28675	7.93554	0.000392
CARBON FIBER	0.051201	8.60947	0.000943

PLATES - TWO END FIXED

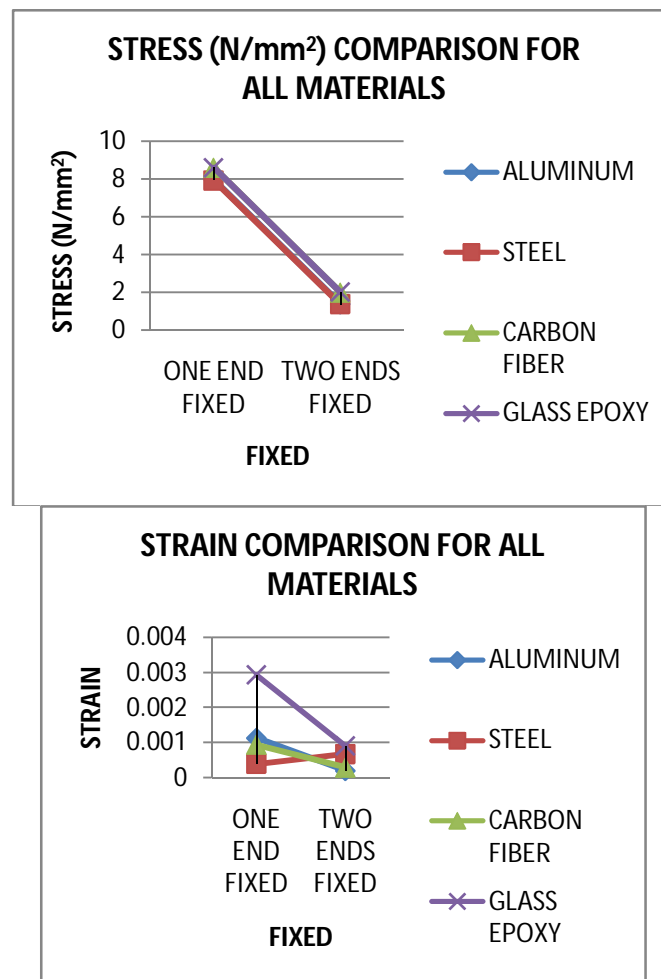
Material	Displacement (mm)	Stress (N/mm ²)	Strain
ALUMINUM	0.001885	1.37339	0.000194
STEEL	0.00658	1.36355	0.0000674
CARBON FIBER	0.002136	1.99894	0.000290



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V. CONCLUSION

In this thesis, finite element analysis is performed to analyze the response of isotropic and orthotropic beams and plates. The assumed field displacements equations are represented by a first order shear deformation theory. Structural analysis is performed for different materials Aluminum, Steel, Carbon Fiber and Glass Epoxy. Analysis is performed to compute the deformations and stresses for plates and beams with different boundary conditions, one end fixed and two ends fixed. The analysis is also performed on plate using shell element for composite materials. Modeling is done in Pro/Engineer and Analysis is done in Ansys. By observing the analysis results, the following conclusions can be made:

- For plates, the displacements are less for orthotropic materials Carbon Fiber and Glass Epoxy than isotropic materials Steel and Aluminum. The stresses are more for Carbon Fiber and Glass Epoxy than Steel and Aluminum. By comparing the results between one end fixed and two ends fixed, the displacements and stresses are more for two ends fixed than one end fixed.
- For plates with shell element, the displacements and stresses are more for two ends fixed.
- For beams, the displacements are less for orthotropic materials Carbon Fiber and Glass Epoxy than isotropic materials Steel and Aluminum. The stresses are more for Carbon Fiber and Glass Epoxy than Steel and Aluminum. By comparing the results between one end fixed and two ends fixed, the displacements and stresses are less for two ends fixed than one end fixed.

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Theoretical calculations for beam are done to determine displacement, stress and strain. When compared the results between theoretical and analytical results, the theoretical and analytical values are almost equal or vary by a small percentage. The analytical results are less than that of theoretical results for displacement and are more for stresses.

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