STUDY ON VIBRATION ANALYSIS OF SANDWICH CANTILEVER BEAM USING FINITE ELEMENT ANSYS SOFTWARE

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Abstract - *The three layer viscoelastic sandwich beam with combination of metal as well as non metal, has been developed by a finite element model. The sandwich beam is modeled using non-linear displacement field at core layer and linear displacement field at face layer. Different specimens have been modeled by varying the face and core layers and studied under the cantilever boundary conditions for modal analysis using FEA .*

Key Words: **ANSYS, Core Layers, Damping, Modal Analysis, Sandwich Beam**

1.INTRODUCTION

Damping has a very high importance in structures and systems subjected to dynamic loading. Passive damping treatment is one of the methods to control the noise and vibration in structures. The airborne and structure borne noise and vibration occur more frequently in systems. The traditional passive control methods that include use of absorbers, barriers, mufflers, silencers, etc. are for airborne noise. The unwanted vibrations decreased with constant excitation frequency, modification of system's stiffness or mass as vibrations as these parameters amend the resonant frequencies But in most cases, the isolation or dissipation of vibrations is done by using isolators or damping materials. Viscoelastic materials (damping material) exhibits both viscous fluid and elastic solid material characteristics. Constrained layer and unconstrained layer or free layer treatment are the two types of treatment of viscoelastic material. In a sandwich structure generally the bending loads are carried by the force couple formed by the face sheets and the shear loads are carried by the lightweight core material. Depending on the functional requirements, sandwich structure utilizes the constrained layer treatment method to obtain the best properties out from all layers. Sandwich beams which are the answer to many structural problems demanding self control and flexible characteristics involving mechanical and thermal stresses. many structural problems claiming self control and flexible characteristics consisting mechanical and thermal stresses for that sandwich beam is the best solution. The technological involvement of this categories of beams are vast, as they are vital in remote operations, expensive space operations subjected to extreme thermo-mechanical loadings, aerospace skins, protective shields, components in reactor vessels, machine tools, and medical applications. The beams have characteristics such as thermo-electro-mechanical coupling, functionality, intelligence, and gradation at micro and nano scales. The main task for us are nothing but credibility and fairness of these systems .It covers the whole spectrum of electro-thermo mechanical conditions by customized it with varying operating conditions such as across a wide range of temperature, magnetic & electric fields, pressure and mechanical load and integration of both or many. The objective of this study is to understand the dynamic behavior of sandwich structures with viscoelastic material and fiber reinforced polymer (FRP) face sheets compared to metallic face sheets.

1.1 MODELLING OF SANDWICH BEAM

The sandwich beam model figured out here reasoned on the following considerations,

1.Top and bottom layers are assumed as ordinary beams with axial and bending resistance.

2.The core layer upholds contemptible longitudinal stress but considers the non linear displacement fields in x and z directions.

3. There is no slippage between these three layers which are assumed to be perfectly bonded.

4. Transverse displacements of top and bottom layers similars transverse displacement of core at interfaces.

The top and bottom layers are isotropic and linear elastic material with thickness h_1 and h_3, also viscoelastic material as a core layer has thickness h_2 together form the sandwich beam and this viscoelastic core layer under harmonic loading exhibits complex modulus in the form of $\mathrm{Ec} = \mathrm{E}^{'}(1 + \mathrm{i}\eta)$ where η is the loss factor. The viscoelastic sandwich beam model is shown below.

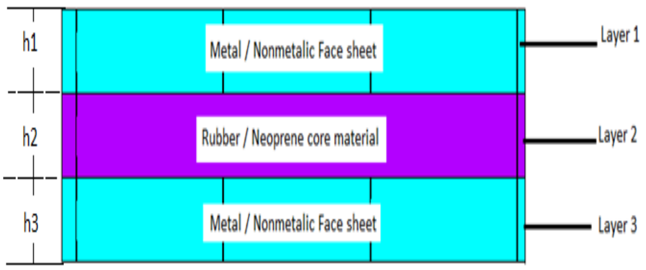


Figure1. Sandwich Beam model

2. DESIGN CONSIDERATIONS

Structural loads throughout its design life as well as structural integrity in the in-service environments are sustained by using a sandwich structure. It should fulfill the following requirements:

- The tensile, compressive, and shear stresses produced by applied loads are withstand by using the face sheets which should have sufficient stiffness.
- The shear stresses produced by applied loads withstand by using the core which should have sufficient stiffness.
- Overall buckling of the sandwich structure under loads prevent by using the core which should have sufficient shear modulus.
- The wrinkling of the face sheets under applied loads prevent by using the Stiffness of the core and compressive strength of the face sheets.
- Inter-cell buckling of the face sheets under design loads prevent by using the core cells which should be small enough.
- Crushing due to applied loads acting normal to the face sheets or by compressive stresses produced by flexure prevent by using the core which should have sufficient compressive strength.
- The excessive deflections under applied loads prevent by using the sandwich structure which should have sufficient flexural and shear rigidities.
- The structural integrity during in-service environments should be maintain by Sandwich materials (face sheet, core and adhesive).

Table1 : Specification of Beam

Materials For beam	1) Aluminium 2) Mild Steel 3) Rubber 4) Neoprene 5) FRP
Length of Beam	500mm
Thickness (t)	4.5mm. (Each Layer 1.5mm)
Width	50 mm

3.FINITE ELEMENT ANALYSIS

The natural frequency of the sandwich beam is found by the well known Finite Element (FEM) Software ANSYS. Modal analysis is carried out using the Block Lanczos method for finding the natural frequencies. The fixed free boundary condition was applied by constraining the nodal displacement in both x and z direction. First four modes are extracted to find out mode shape and natural frequency. ThFirst four mode natural frequencies are shown in Table 3.

Table 2 : Material properties of sandwich beam for face and core layers

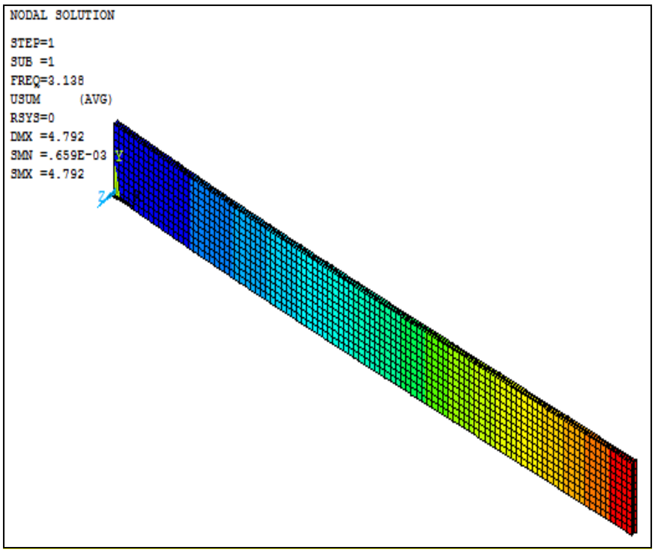
Types Of material	E (GPa)	G (GPa)	ρ (Kg/m³)	ν
Aluminium	70	27.3	2766	0.33
Steel	200	80	7850	0.3
FRP	2	0.5	1700	0.3
Rubber	0.00154	0.005	950	0.45
Neoprene	0.0008154	0.000273	960	0.49

Table 3: First Four Mode Natural Frequencies of Sandwich Cantilever Beam (By using ANSYS)

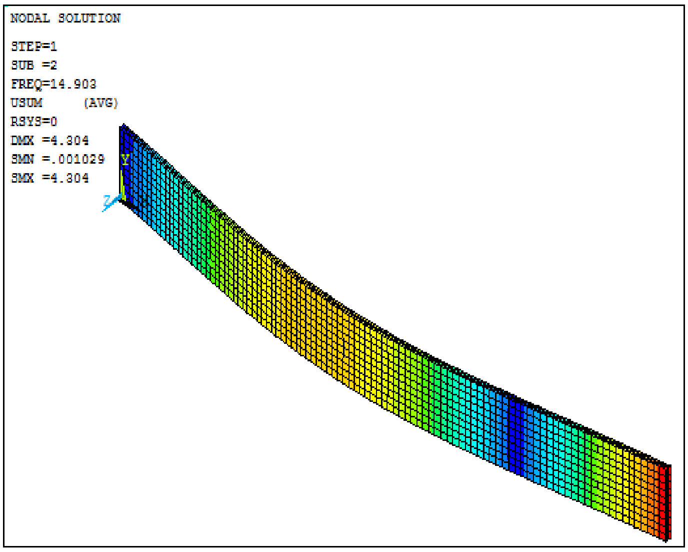
Sr. No.	Sandwich Pattern	Natural Frequency in Hz			
		Mode 1	Mode 2	Mode 3	Mode 4
1	Al-Al-Al	14.897	93.323	261.447	512.95
2	Al-Ru-Al	14.562	61.023	127.874	192.87
3	Al-Ne-Al	6.55	19.91	34.911	49.173
4	St-St-St	15.181	95.101	266.427	522.717
5	St-Ru-St	13.002	44.771	87.289	126.192
6	St-Ne-St	4.277	12.867	21.867	30.681
7	FRP-Ru-FRP	3.348	20.511	55.503	103.892
8	FRP-NE-FRP	3.138	14.903	32.776	51.229

3.1 First Four Mode Shape of Sandwich Beam (FRP-Ne-FRP)

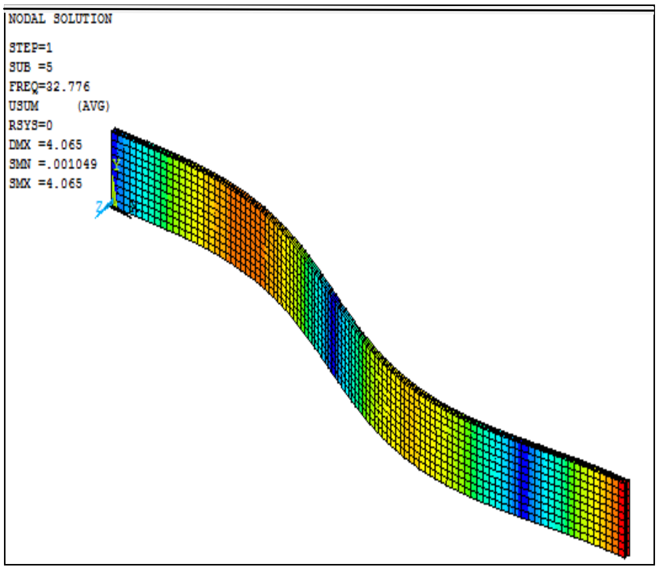
A)First Mode



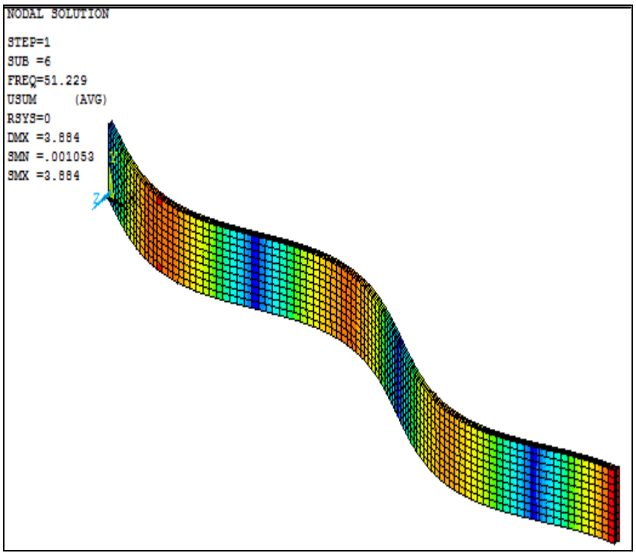
B)Second Mode



C) Third Mode



D) Forth Mode



4.RESULTS AND DISCUSSION

In these section current results for the present developed finite element model for the sandwich beam is shown. The material properties for sandwich beam are listed in Table 2. Following Six different types of sandwich beam test specimens were made for testing which consists of Aluminium – Rubber- Aluminium, Steel- Rubber- Steel, Aluminium- Neoprene – Aluminium, Steel-Neoprene-Steel, FRP-Neoprene-FRP, FRP-Rubber-FRP, Steel- Steel- Steel, and Aluminium – Aluminium – Aluminium. The comparison of first four natural frequency of sandwich cantilever beam is listed in Table 3. By comparing all results we observed that the combination FRP –NE- FRP has very low natural frequency than other combination The modal analysis using finite element method is carried out on the sandwich beams modeled to study the damping effect on the beams for cantilever boundary conditions. From the results one can say that damping characteristics for neoprene viscoelastic material has good result when compared with the rubber viscoelastic material.

5.CONCLUSION

With application of finite element method, the viscoelastic sandwich beam has been successfully modeled and testing is carried out. In this entire sandwich beam models face and core layer materials are different. The sandwich beams modeled here are carried out for modal analysis using finite element method to study the damping effect on the beams for cantilever boundary conditions. Damping characteristics of neoprene viscoelastic material has best results in comparison with the rubber viscoelastic material. For controlling the vibration of structures like beams, plates the viscoelastic constrained layer damping treatment plays a vital role.

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