Free Vibration Analysis of FRP base Composite Sandwich Beam using FEA & Experimental approach

Rupali R. Chavan[1] Prof P. S. Talmale[2]
[1]ME Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]Late G. N. Sapkal college of Engineering, Nasik, Maharashtra, India

Abstract— A composite beam consists of laminate consisting of more than one lamina bonded together through their thickness. Composite materials have interesting properties such as high strength to weight ratio, ease of fabrication, good electrical and thermal properties compared to metals. The equation of motion for the viscoelastic sandwich beam is studied. Different specimens have been modelled by varying the core layers and face layers and studied under the fixed-fixed and cantilever boundary conditions for modal analysis. A finite element model has been developed for the three layer viscoelastic sandwich beam. The sandwich beam is modelled using linear displacement field at face layer and non-linear displacement field at core layer. The Natural frequencies are obtained for various models using different core materials and boundary conditions. The results obtained are compared with the earlier existing and experimental results.

Key words: Damping, Finite Element Method, Sandwich Beam, Viscoelastic, Vibration Analysis

I. 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. 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 behaviour of sandwich structures with viscoelastic material and fibre reinforced polymer (FRP) face sheets compared to metallic face sheets.

A. *Material properties of Sandwich Structure*

The material choice in sandwich structures depends upon the need of employment such as high strength, high temperature resistivity, surface finish etc. In recent times the number of available cores has increased enormously due to the introduction of more competitive cellular plastics. Combining options of face sheet materials with different core materials give the new ideas to be integrated with a wide range of applications. It is the obligation of the designer to have reliable information about the strength and stiffness of the materials used in the design for efficient analysis and design of sandwich structures. The best practice is to devote to tests for obtaining adequate material properties. The ample number of material choices may appear as an additional complexity, but is really one the main features of using sandwich structures. The materials best suited for a particular application may be utilized and some drawbacks can be overcome by geometrical sizing. The elementary objective of the designer is to achieve an efficient design that will utilize each material component to perform the function with good efficiency. It is the need of the designer to have reliable information about the stiffness and strength of the materials used in the design for efficient design and analysis of sandwich structures. The suitable practice is to devote to test for obtaining adequate material properties. The enormous number of material choices may appear as additional complexity, but is really one the main features of using the sandwich structures. The beat suited materials for a particular application may be used and some drawbacks can be overcome by geometrical correction. The basic objective of the designer is to make a good design that will utilize the each material component to perform the function with good efficiency.

B. *Core Material*

The function of the cores is to give support for the thin skin layers so that they do not deform outwardly or inwardly, and to keep them in relative position to each other. The main requirements of the core are generally the shear and compressive modulus and strength. The main objective of any designer in choice of core material is that it would not fail under the any applied load and there should not be any deformation of core in thickness wise, thus requiring a high modulus of elasticity perpendicular to face layers. The core layer is exposed to shear so that global deformations and core shear stresses are developed by the shear strains in the core. The thickness of core and core material are two main parameters that decide the most of the properties of the sandwich structure.

The core layer consists of some typical features as given below,

1) Lower density
2) Damping of vibration and noise
3) Shear strength and shear modulus
4) Stiffness perpendicular to the top and bottom faces
5) Thermal insulation

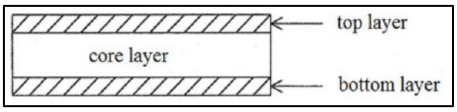


Fig. 1: Sandwich beam model

C. Face Material

The bottom and top layers of conventional sandwich structure are called as face layers or face sheets (as layers are in sheet form). From any structural materials that are available in the form of thin sheets can be used as a face material. The top and bottom layers face materials carry the compressive and tensile stresses in the sandwich. The flexural rigidity is often very small and it can be ignored. Fiber glass-reinforced plastics are common and acceptable to choose as face materials.

The face layer consists of some typical features as given below

- High impact resistance
- High compressive and tensile strength
- Wear resistance
- Resistance to different conditions (chemical, heat, etc.)
- High stiffness giving high flexural rigidity
- Good surface finish.

II. LITERATURE REVIEW

Manish Kumar et.al. [1] Had studied the sandwich beam. This study examines the behavior of sandwich beams driven by the viscoelastic rubber core. Finite element method (FEM) is used to analyze the overall transient responses, harmonic responses and the static responses of the sandwich systems subject to a concentrated point load at the mid span of the beam. The simple software had developed for calculating the data. The software are validated by compare data using the software package ANSYS.

Prathamesh et.al. [2] Studied the dynamic characteristics of a beam with four cracks. A finite element model has been developed for the three layer composite beam .A systematic approach has been made in the present investigation to develop model and simulate for evaluation of natural frequencies and mode shapes of fixed-fixed and cantilever beam.

N. Jacques et.al. [3] Studied the geometrically nonlinear vibrations of sandwich beams with viscoelastic materials. For this purpose, a zigzag model is used to show the displacement field by using a new finite element formulation. An efficient solution procedure based on the harmonic balance method is also developed. The viscoelastic behavior is handled by using hereditary integrals and their relationships with complex module. Considering the various problems of nonlinear vibrations of sandwich beams, demonstrate its abilities.

V.N. Burlayenkoet.al. [4] Studied the finite element vibration analysis of plates has become one of the classical problems over the past several decades. Different finite element plate models based on classical, standard and improved shear deformable plate theories, three-dimensional elasticity equations or their combinations have been developed.

M. Meunier, et.al. [5] Presented new analytical model that accurately predicts the forced response of fiber reinforced plastic (FRP) sandwich plate s subjected to transverse applied loads. It is based on Reddy„s refined high order shear deformation theory and offers the feasibility of accounting for the viscoelastic properties of the constitutive materials without restriction to the steady state motion.

Dvir Elmalich, et.al. [6] Studies the variation on the behavior of FRP strengthened walls with delaminated regions by the effect of the inter-laminar contact. The paper shoes an analytical approach that unifies the displacement and stress fields of sub-regions where the delaminated faces are in contact with ones where the layers are free of contact.

P. Bangarubabu, et.al. [7] studied the effectiveness of the sandwich structures; the effects of distributed viscoelastic layer treatment on the loss factors are studied. The dynamics of bare beam with free and constrained viscoelastic layers are investigated. The viscoelastic layer is bonded uniformly on the beam. Frequency dependent young's modulus and loss factors are considered in the model of viscoelastic material. From the experiments it is observed that beams with constrained viscoelastic layer provide higher loss factors than free layer. The dynamics of sandwich beams is modeled using hexahedral element (3-D element). The predicted Eigen frequencies obtained from the model are compared with the experimental results in cantilever boundary condition using free and constraint layers. Modal strain energy approach is used to predict loss factors. Results show that higher loss factor is obtained using constrained viscoelastic layers.

M. R. Doddamani, et.al. [8] Studied the dynamic analysis of jute-epoxy sandwiches with fly ash reinforced functionally gradient (FG) flexible, compliant rubber core is presented. By using conventional casting technique FG samples are prepared. Presence of gradation is quantified by weight method. He study the influence of fly ash weight fraction, jute orientation and core to total thickness (C/H) of sandwich on damping ratio (DR) and natural frequency (NF).

Dr. P. S. Senthil Kumar [9] studied the damping characteristics of Hybrid polymer composite, which can be used in many applications and in engineering structures. The study aims to characterize the mechanical and damping properties of prepare a glass-epoxy composite with addition of carbon (600mesh) fillers with different weight fractions. By using Hand lay-up and vacuum bag molding technique, the carbon filler are reinforcement and fabricated. By using free and forced vibration test with different amplitudes the damping characteristics were evaluated. The result indicates that with increase in weight percentage of carbon reinforcement content the damping characteristics improved. Further it was found that glass fiber –epoxy matrix with 5% carbon particles better damping properties which can be used for structural application.

Y. Mohammadi et.al. [10] Studied the free vibration analysis of sandwich plates with power-law FG face sheets. By considering the in-plane stresses of the core, the high-order sandwich plate theory is improved. The equations of motion are reduce from twenty three equations to eleven equations by using a new approach and then solve them. Both unsymmetrical and symmetric sandwich plates are considered in this analysis. Good agreement is found between theoretical predictions of the fundamental frequency parameters and the results obtained from other references for simply supported sandwich plates with functionally graded face sheets. The results also revealed that as the side-to-thickness ratio and the core-to-face sheet thickness ratio affect the fundamental frequency parameters significantly.

M Siva Prasad et.al. [11] Studied that Sandwich beams are composite systems used as light weight load bearing components having high stiffness-to-weight and Strength-to weight ratios. The use of thin, strong skin sheets adhered to thicker, lightweight core materials has allowed industry to build strong, stiff, light, and durable structures. Due to the use of viscoelastic polymer material, sandwich beams can exhibit time-dependent behavior. This study examines the behavior of sandwich beams from by the viscoelastic rubber core. Finite element (FE) method is used to analyze the overall transient responses, harmonic responses and the static responses of the sandwich systems subject to a concentrated point load at the mid span of the beam.

V.N. Burlayenko and T. Sadowski [12] studied that for analyzing of the dynamic response of sandwich plates with partially damaged face sheet-to-core interface a finite element model has been developed. Damaged detached at the interface is taken into account for simulation of sandwich plates,, vibrations for understanding the effect of intermittent dynamic contact between the fragments. By using the ABAQUS/Explicit code, Transient and forced dynamic responses of the sandwich plates damaged by debonding have been obtained. The influence of the local strongly nonlinear contact behavior on the global dynamics of the sandwich plates is examined.

Ebrahim Sadeghpour et.al.[13] Studied that the free vibration response of a de bonded curved sandwich beam by using a high order theory. The Rayleigh-Ritz method and the Lagrange's principle are employed to derive and solve the governing equations .Since the real contact condition at the de bonded region is nonlinear, two linear with contact and without contact‖ models are employed.

Sudhakar R et.al. [14] Studied that for the free vibration analysis of composite and sandwich arches a higher- order refined model with seven degrees of freedom per node is developed. As the cross-sectional warping is accurately modeled by this theory, it does not require any shear correction factor The strain field is modeled through cubic axial, cubic transverse shear and linear transverse normal strain components.

Shafi Ullah et.al.[15] studied the free and forced vibration tests for obtaining the vibration damping characteristic of Nano composites and carbon fiber reinforced polymer composites (CFRPs) containing multiwall carbon nanotubes (CNTs).By varying the Several vibration parameters ,characterize the damping behavior in different amplitudes, natural frequencies and vibration modes.

Y. Swathi et.al. [16] studied that , with 4 FRP layers, subjected to a) simply supported and clamped-clamped boundary conditions. The static and dynamic analysis is carried out on a sandwich beam, consisting of a viscoelastic core layer and 2-face layers, each. by varying the parameters of the core layer such as its geometry and damping coefficient ,the Static and dynamic response of the beam is studied. The problem is analyzed using 3- dimensional Finite Element Method and is modeled in ANSYS software. The damping coefficient is useful to control the dynamic response of the beam. It is observed that the thickness of the core layer influences both static and dynamic response. For selecting the materials and their arrangement for the safe design of sandwich structures this type of analysis is useful for obtaining the strength, stiffness and sufficient damping to control the harmonic response.

Kant and Swaminathan [17], who expanded the in-plane displacements as cubic functions of the thickness coordinate, assuming an incompressible core; the equation of equilibrium were obtained using the principle of minimum potential energy; closed-form solutions for particular cases were developed by solving the boundary value problem through the Navier‟s technique.

Jun et al. [18] introduced a dynamic finite element method for free vibration analysis of generally laminated composite beams on the basis of first-order shear deformation theory. The influences of Poisson effect, couplings among extensional, bending and torsional deformations, shear deformation and rotary inertia are incorporated in the formulation. The dynamic stiffness matrix is formulated based on the exact solutions of the differential equations of motion governing the free vibration of generally laminated composite beam.

Barbosa et.al [19] focused on the passive damping systems as viscoelastic materials in the laminated places. Golla Hugles Method (GHM) has been used in characterizing the viscoelastic materials and GHM based finite element model has been presented and validated with the various numerical and classic formulation comparisons.

Bekuit et al. [20] for the dynamic and static analysis they considered the quasi-two dimensional finite element formulation. The model is of three layers and consists of the both longitudinal and transverse displacement field. These formulations were independent of flexibility of the core layer.

Grewel et al. [21] have modeled a sandwich beam using the linear and nonlinear displacement at its core layer by using the finite element method. Parametric studies were carried to find out the effect of core layer thickness on the natural frequencies and the loss factor for the sandwich beam structure and they considered the partial treatment of the structure to obtain the more damping for the fixed free and fixed -fixed boundary conditions.

Yadav [22] discussed about the vibration damping in the four layered sandwich beam. He used the method of equilibrium forces and beam theory for deriving the equation of motion for the vibration analysis. They conducted the analysis with the mass and rubber spring mounted on a sandwich beam structure for the simply supported boundary conditions.

Sandwich beams which are the answer to many structural problems demanding self-control and flexible characteristics involving mechanical and thermal stresses. The technological implications of this class of beams are immense, as they are especially useful 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, to name only a few. As the advent of steel changed the last century, similarly these beams which will revolutionize the 21st century.

III. Finite Element Analysis

Today the finite element Analysis (FEA) is considered as one of the well-established and convenient technique for the computer solution of complex problems in different fields of engineering, from other side, FEM can be examined as a powerful tool for the approximate solution of differential equations describing different physical processes. The Finite Element Analysis (FEA) is a numerical method for solving problems of engineering and mathematical physics. Useful for problems with complicated geometries, loadings, and material properties where analytical solutions cannot be obtained. The process of representing a physical domain with finite elements is referred to as meshing, and the resulting set of elements is known as the finite element mesh. As most of the commonly used element geometries have straight sides, it is generally impossible to include the entire physical domain in the element mesh if the domain includes curved boundaries. ANSYS is a general purpose finite element analysis tool with a group of engineering simulation programs capable of modelling structures under different loading conditions. It can solve problems of relatively simple structural analysis to the most complicated linear to nonlinear analyses. In this analytical framework, ANSYS is used for evaluating the frequencies, displacements and mode shapes of the model of a cracked plate to investigate the theoretical predictions. The required inputs for the ANSYS finite element analysis consists of model geometry, material properties, loading and boundary conditions.

A. *Modal Analysis*

Same set of command is used for modal analysis that used in any other type of finite element analysis. Likewise, choose similar option from the graphical user interface (GUI) to build and solve models. Modal analysis determines the vibration characteristics (natural frequencies and mode shapes) of a structure or machine components. Experimental modal analysis of a system, deals with determination of natural frequencies, damping ratios, and mode shapes through the vibration testing. In the case of forced vibration, the analysis includes the study of acceleration, velocity and displacement responses of the systems. Modal analysis is the identification of vibration characteristics of elastic structures. It consists of describing a system by its modal parameters; natural frequencies, natural damping and natural modes. This method can also be used to predict the vibration behavior of a machinery element that has to be modified for any reason including the one of modifying the vibration properties themselves by reducing the amplitude of vibration at a given frequency or by shifting the resonance frequency of a given mode. Another application for modal testing is that of force determination. Given a theoretical model and measured vibration on a real structure, it is possible to determine the forces that act upon the real structure. Nevertheless this method is very sensitive to modeling inaccuracies and little errors can have huge consequences. Accurate Modal Analysis requires understanding of the theoretical basis of vibration, accurate measurement of vibration, careful and detailed data analysis.

B. *Observations and FEA Analysis*

Different types of sandwich beam specimens were made for investigation which consists of:

1) Specimen 1: Aluminium – Rubber- Aluminium
2) Specimen 2: Aluminium- Neoprene – Aluminium
3) Specimen 3: Steel- Rubber- Steel
4) Specimen 4: Steel-Neoprene-Steel
5) Specimen 5: FRP-Rubber-FRP
6) Specimen 6: FRP-Neoprene-FRP

Plate dimension considered for the sandwich beam for the analysis as 500 x 50 x 4.5 mm.

The Material Properties of Sandwich Beam for Face and Core Layers as follows.

Type of material	Young's Modulus E (GPa)	Shear Modulus G (GPa)	Density Kg/ m^3	Poisson's Ratio
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 1: Material Properties of Sandwich Beam for Face and Core Layers

1) *Steps of Modal Analysis*

The steps involved in model analysis are,

a) Modelling

Modeling includes the making of model geometry or to import the geometry from another software package in the working environment. This step in analysis is to create the geometric model and to generate a finite element mesh for the given geometry. There are two methods used to create finite element model one is solid modeling and other is direct generation. Use solid modeling, which automatically mesh the geometry with nodes and elements.

b) Model meshing

This step includes the job name and analysis title and then defines the element types, element real constant, material properties, and the model geometry.

c) Loadings

In this step, define analysis types and options, apply load, and satisfy load step options to get the finite element solution for the natural frequency.

d) Expansion of the modes

Specify the number of mode that, you have to expand. If frequency range is selected, only modes within that range mode results are appeared.

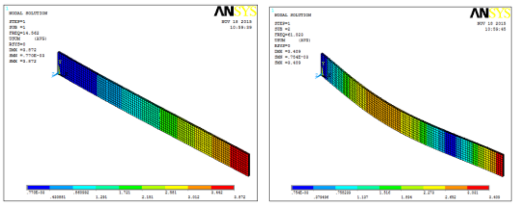
e) Results

Results from modal analysis are written to the structural results file. Results consist of natural frequency, mode shapes relative stress and force distribution. Those results wish to see, database must contain the same modal for which the solution was calculated.

The FEA analysis is done on the ANSYS software and following results were obtain as follows,

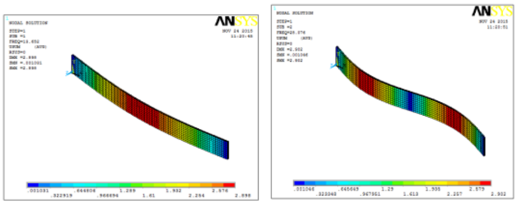
– For Cantilever Beam Boundary Condition.

1) AL-Ru-AL



Mode I Mode II

2) AL-Ne-AL



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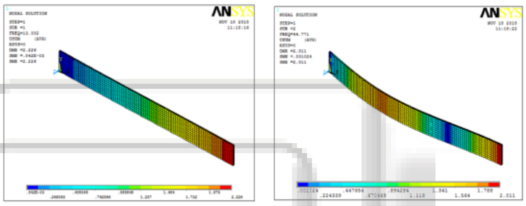
3) St-Ru-St



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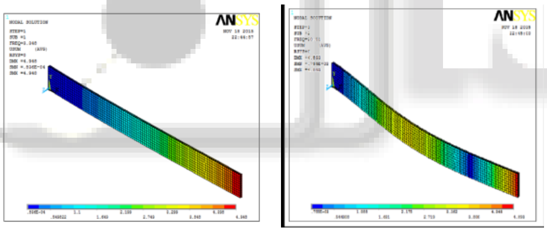
4) St-Ne-St



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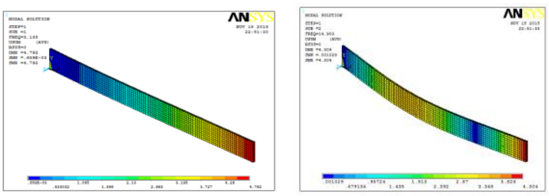
5) FRP-Ru-FRP



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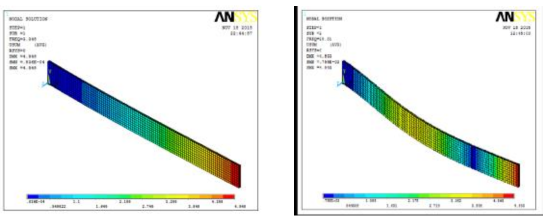
6) FRP-Ne-FRP

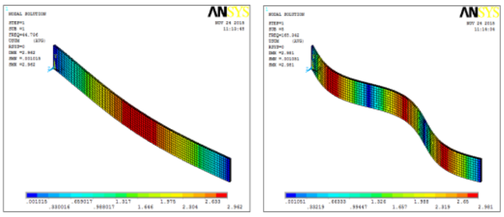


Mode I Mode II

Fig. 2: Frequency Response of Specimens for Cantilever Beam Boundary Condition.

– For Simply Supported Beam Boundary Condition.

1) AL-Ru-AL



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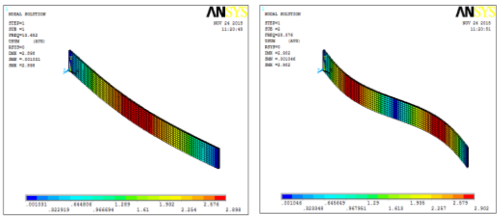
2) AL-Ne-AL



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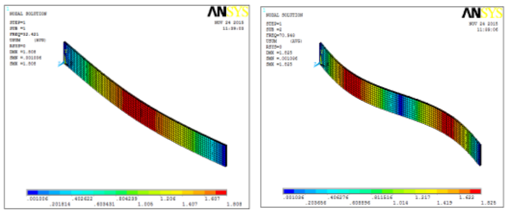
3) St-Ru-St



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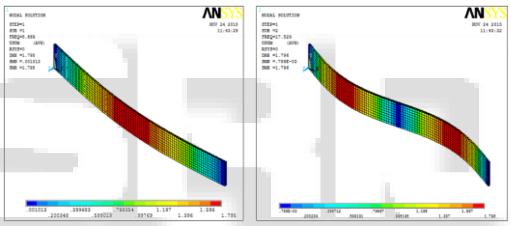
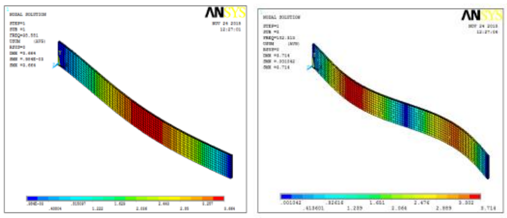
4) St-Ne-St



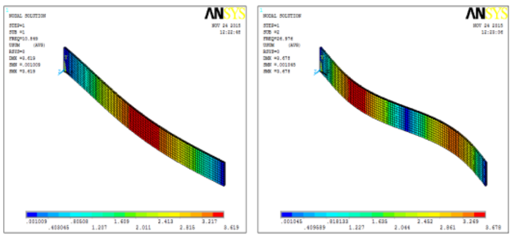
Mode I Mode II

5) FRP-Ru-FRP



Mode I Mode II

6) FRP-Ne-FRP



Mode I Mode II

Fig. 3: Frequency Response of Specimens for simply supported Beam Boundary Condition

The natural frequencies obtained by using the ANSYS software for different boundary condition like simply supported beam and cantilever beam boundary conditions are given in Tables 2 and 3.

Sr. No	Sandwich Pattern	Natural Frequency			
		Mode 1	Mode 2	Mode 3	Mode4
1	Al-Ru-Al	14.562	61.023	127.874	192.887
2	Al-Ne-Al	6.55	19.91	34.911	49.173
3	St-Ru-St	13.002	44.771	87.289	126.192
4	St-Ne-St	4.277	12.867	21.867	30.681
5	FRP-Ru-FRP	3.348	20.511	55.503	103.892
6	FRP-Ne-FRP	3.138	14.903	32.776	51.229

Table 2: First Four Mode Natural Frequencies for Sandwich Cantilever Beam (Finite Element Analysis by using ANSYS)

Sr. No	Sandwich Pattern	Natural Frequency			
		Mode 1	Mode 2	Mode 3	Mode4
1	Al-Ru-Al	43.336	102.346	166.89	230.4
2	Al-Ne-Al	12.252	25.596	40.932	55.31
3	St-Ru-St	31.021	68.463	108.27	146.8
4	St-Ne-St	7.269	15.049	24.905	33.84
5	FRP-Ru-FRP	37.181	99.833	174.92	252.5
6	FRP-NE-FRP	9.449	24.496	43.318	61.51

Table 3: First four mode natural frequencies for sandwich simply supported beam (finite element analysis by using ANSYS)

The results show that natural frequency for Al-Al-Al specimen is very high. By replacing the core material by viscoelastic material then the natural frequency decreases. The FRP-Ne-FRP specimen shows the lowest natural frequency for cantilever boundary conditions and St-Ne-St specimen also shows good damping characteristics except Mode I in cantilever beam condition.

IV. Experimental Analysis

Detailed FEA procedure is used in previous chapter for analysis. As FEA results are approximate and must be validated to confirm their abilities to predict the output, in this chapter the experimental procedure is followed to validate FEA result. Use of FFT analyzer is made for checking the ability of FEA models.

Fig. 4: Fixture used for experimental analysis

Figure 4 shows photograph of the fixture which is used, for impact hammer test along with specialized mounting to simulate the clamped end condition at the inner boundary. Analysis is done experimentally with the help of FFT analyzer, accelerometer and impact hammer. Natural frequencies are developed by hitting the plate with hammer; the response at a point of a plate is measured by using an accelerometer. FFT analyzer analyzed the output of accelerometer.

The experimental setup consists of a cantilever beam or simply supported Beam structure, transducers (accelerometer), a data-acquisition system and a computer with signal display and processing software. Different types of beam materials and its properties are listed in table 1. Different combinations of beam geometries for each of the beam material are used. Accelerometer is a sensing element (transducer) to measure the vibration response (i.e., acceleration, velocity and displacement). Data acquisition system takes vibration signal from the accelerometer, and encodes it in digital form. Computer acts as a data storage and analysis system. It takes encoded data from the data acquisition system and after processing (e.g., FFT), it displays on the computer screen by using analysis software. Fig. 5 shows an experimental setup of the cantilever beam. It includes a beam specimen of a particular geometry with a fixed end and at the free end an accelerometer is mounted to measure the free vibration response. The fixed end of beam is gripped with the help of clamp.

Fig. 5: Experimentation with the cantilever beam.

For getting precise free vibration cantilever beam data, it is very important to ensure that clamp is tightened properly; otherwise it may not give fixed end conditions in the free vibration data. 1) Accelerometer: It is a time-dependent vibration measuring device. Here, the shown accelerometer is a contacting type of transducer, which converts the acceleration of vibration into equivalent voltage signal, and sends it to data acquisition system. 2) Data acquisition system: It receives voltage signal from the accelerometer, and calibrate the data into equivalent accelerometer scale, and send it to computer where by using a vibration measurement software these data can be analyzed as time history (Displacement-Time) and in frequency domain (i.e., using FFT) 3) When the voltage signal from the accelerometer is sent to the data-acquisition system, it converts the signal to a mechanical vibration data (acceleration) and stores it to the computer.

A. Experimental Procedure

1) Choose a beam of a particular material (steel-rubber-steel, aluminum-neoprene-aluminium or other) with dimensions (L, w, t) and transducer.
2) Clamp one end of the beam while other end is free for the cantilever beam condition and for simply support beam condition clamp one end of the beam while other end is just rest on support.
3) Place an accelerometer (with magnetic base) at the free end of the cantilever beam and at the middle point along the length for simply support beam, to measure the free vibration response (acceleration).
4) Give an initial deflection to the cantilever beam or SSB and allow it to oscillate its own. To get the higher frequency it is suggested to give initial displacement at an arbitrary position apart from the free end of the beam (e.g. at the mid span).
5) This could be done by bending the beam from its static equilibrium position by applying a small static force at the free end of the beam for cantilever condition and at middle of total length of beam in case of SSB and suddenly releasing it, so that the beam oscillates its own without any external force during the oscillation.
6) The free oscillation could also be started by giving a small tap at the free end of the beam or middle of beam.
7) Record the data obtained from the chosen transducer in the form of graph (variation of the vibration response with time).
8) Repeat the procedure for 5 to 10 times to check the repeatability of the experimentation. 9. Repeat the whole experiment for different specimen and different condition. 10. Record the whole set of data in a data base.

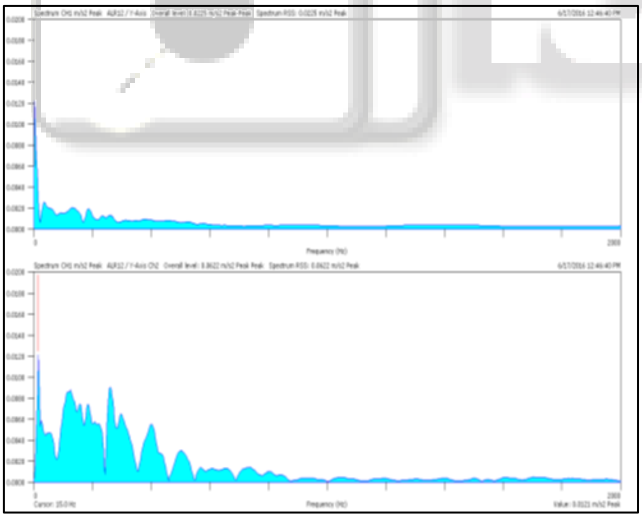


Fig. 6: Sample experimental results on FFT analyser.

Sr. No	Sandwich Pattern	Natural Frequency			
		Mode 1	Mode 2	Mode 3	Mode4
1	Al-Ru-Al	15.0	60.0	125.0	363.0
2	Al-Ne-Al	7.5	22.50	32.50	47.50
3	St-Ru-St	13.8	50	92.50	127.5
4	St-Ne-St	5.0	15.0	27.50	35.50
5	FRP-Ru-FRP	5.0	22.50	57.50	105.0
6	FRP-Ne-FRP	3.50	15.50	35.50	52.5

Table 4: First four mode Natural Frequencies for Sandwich Cantilever Beam (by Experiment with Fft Analyzer)

Sr. No	Sandwich Pattern	Natural Frequency			
		Mode 1	Mode 2	Mode 3	Mode4
1	Al-Ru-Al	15.0	102.50	172.50	232.50
2	Al-Ne-Al	12.50	32.50	47.50	57.50
3	St-Ru-St	32.50	72.50	110.50	152.50
4	St-Ne-St	10.0	17.50	22.50	35.00
5	FRP-Ru-FRP	30.0	102.50	175.00	255.00
6	FRP-NE-FRP	12.50	27.50	45.00	65.00

Table 5: First four Mode Natural Frequencies for Sandwich Simply Supported Beam (By Experiment with Fft Analyzer)

V. CONCLUSION

The natural frequencies for different specimen with different boundary condition are calculated by different analysis. The theoretical analysis carried out by using Euler's beam theory. 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 beam boundary conditions as well as simply supported beam boundary condition. Along with that experiment is carried out with help of two channels FFT Analyzer. By comparing the all results, 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. Also by considering fundamental mode (MODE I) result shows that FRP-Ne-FRP specimen having the best damping characteristics as compare to other specimen and St-Ne-St Specimen also shows good damping characteristics for other mode except mode I.

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