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Analysis of Sandwich Beam

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Abstract- Sandwich beams are composite systems having high stiffness-to-weight and Strength-to-weight ratios and are used as light weight load bearing components. 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 constituents, sandwich beams can exhibit time-dependent behaviour. This study examines the behaviour of sandwich beams driven 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.

In this study the skin, i.e. the top and bottom layers are made up of mild steel while the core is made up of rubber. The stress, strain, and deformation fields are analyzed. The core thickness is varied keeping the skin thickness constant and the behaviour of the sandwich beam is studied under static and dynamic conditions.

Keywords- Sandwich, viscoelastic, deformation fields

I. Introduction

Sandwich Beams are extensively used in the construction of aerospace, civil, marine, automotive and other high performance structures due to their high specific stiffness and strength, excellent fatigue resistance, long durability and many other superior properties compared to the conventional metallic materials. In general, these structures require high reliability assurance for which, the prediction of the maximum load that the structure can withstand.

A sandwich structured composite is a special class of composite materials that is fabricated by attaching two thin but stiff skins to a light weight but thick core. The core material is normally low strength material, but its higher thickness provided the sandwich composite with high bending stiffness with overall low density. Open and closes cell structured foams like polyvinylchloride, polyurethane, polyethylene or polystyrene foams, and honey combs are commonly used core materials. Open and closed cell metal foam can also be used as core materials. Laminates of glass or carbon fiber reinforced thermoplastics or mainly thermo set polymers (unsaturated polyesters, epoxies...) are widely used as skin materials. Sheet metal is also used as skin material in some cases. The core is bonded to the skins with an adhesive or with metals components by brazing together.

There are different types of sandwich structures. Metal composite material (MCM) is a type of sandwich formed from two thin skins of metal bonded to a plastic core in a continuous process under controlled pressure, heat, and tension. Recycled paper is also now being used over a closed-cell recycled craft honeycomb core, creating a lightweight, strong, and fully repulpable composite board. This material is being used for applications including point-of-purchase displays, bulkheads, recyclable office furniture, exhibition stands, and wall dividers. To fix different panels, among other solutions, a transition zone is normally used, which is a gradual reduction of the core height, until the two fiber skins are in touch. In this place, the fixation can be made by means of bolts, rivets, or adhesive.

The strength of the composite material is dependent largely on two factors:

1. The outer skins: If the sandwich is supported on both sides, and then stressed by means of a force in the middle of the beam, then the bending moment will introduce shear forces in the material. The shear forces result in the bottom skin in tension and the top skin in compression. The core material spaces these two skins apart. The thicker core material the stronger the composite. This principle works in much the same way as an I-beam does.

2. The interface between the core and the skin: Because the shear stresses in the composite material change rapidly between the core and the skin, the adhesive layer also sees some degree of shear force. If the adhesive bond between the two layers is too weak, the most probable result will be delamination.

Sandwich beams are composite systems having low weight and high strength and stiffness characteristics. Typical sandwich beams consist of two thin skin layers separated by a thick inner core. The use of thin, strong skin sheets adhered to thicker, lightweight core materials has allowed industry to build strong, stiff, light, and durable structures. When the skins and core are joined together, they function as a single structural component containing all the advantages of each component. Sandwich beams have high stiffness-to-weight and strength-to-weight ratios and are used as light weight load bearing components. Tensile and compressive stresses are mainly carried by the skins, while transverse shear stresses are predominantly experienced by the core. Typically, materials such as steel and aluminum sheets are used for the skins. The main function of the core is to increase the flexural rigidity of the sandwich beam, minimizing transverse deformation. Honeycombs, foams, and corrugated cores made of polymers or metals are typically used.

Sandwich structures can be widely used in sandwich panels; these kinds of panels can be in different types such as FRP sandwich panel, aluminum composite panel etc. FRP polyester reinforced composite honeycomb panel (sandwich panel) is made of polyester reinforced plastic, multi-axial high-strength glass fiber and PP honeycomb panel in special antiskid tread pattern mould through the process of constant temperature vacuum adsorption & agglutination and solidification.

Sandwich theory describes the behavior of a beam, plate or shell which consists of three layers - two face sheets and one core. The most commonly used sandwich theory is linear and is an extension of first order beam theory. Linear sandwich theory is of importance for the design and analysis of sandwich beams, which are of use in building construction, vehicle construction, airplane construction and refrigeration engineering.

Historically, the first use of the concept of sandwich construction dates back to Sir William Fairbairn in England, 1849. The idea to combine two different materials to increase the strength of a structure was first used in the 1930s. In 1940, sandwich construction was used extensively in building the English Mosquito bomber during the War II. The Mosquito was implemented with a plywood sandwich construction. In the United States the core was originated. In the late 1940's, Hexcel Corporation was formed and it has played the most role in the development of sandwich construction. Sandwich beams are widely used in a variety of applications such as satellites, railroads and automobiles to name a few (Vinson, 2005).

Due to the use of polymer constituents, sandwich beams can exhibit time dependent behavior. Visco elasticity is the study of time-dependent materials showing a combined elastic solid and viscous fluid behavior when subjected to external mechanical loadings. The response of viscoelastic materials is determined not only by the current state of the load, but also by the history of the loading.

Sandwich beams are generally thick structures in which the thickness is not negligible as compared to other dimensions. Thus, shear deformation accounts for a significant amount of transverse deflection. In polymer foam cores, shear deformation often continues to increase under a constant load (stress). The strength of a sandwich beam is determined by the resistance of the skins or core to failures. Ideally, the skins should be designed to resist axial stresses, whereas the core should be designed for limited shear. Although the distribution of the shear stress through the thickness in sandwich beams is not uniform, for design purposes the shear stress through the core thickness is often assumed uniform.

Selection of materials in designing the structural and/or mechanical components play an important role and is fixed based on the strength, stiffness, cost and other mechanical properties such as hardness, toughness, wear resistance etc.. Materials selected in view of the above requirements may not have internal damping capacity. When the structures are subjected to harmonic loads of high frequencies, conventional damping techniques such as providing external dashpots, arranging dynamic vibration absorbers may not have control on the dynamic response of the structures resulting in failure at resonance frequencies.

Arrangement of soft core material that requires more energy to deform provides internal damping of structures known as sandwich treatment. Sandwich treatment will reduce the amplitude of oscillation depending upon the location, volume and mechanical properties of core layer in the structure. It is also important to study the effect of sandwich treatment on static response of the structure in order to confirm the safe design. When a sandwich structures with thin soft core is transversely loaded, the two faces tend to act as two independent beams, bending along their centroids, rather than along the neutral axis of the beam as a whole.

In this thesis static and dynamic analysis of sandwich beams with different core thickness under simply supported condition is studied. The results of the present model agree well with the analytical and experimental data reported in the literature. Parametric studies show that the variation of core thickness has a significant effect on the natural frequencies and mode shapes and maximum deflections.

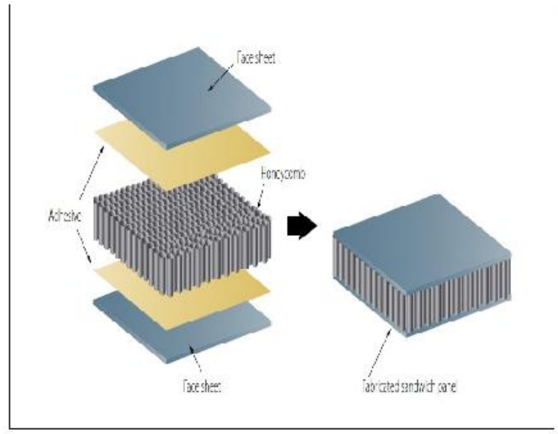

Fig-1 Sandwich Structure

II. Modelling of Sandwich beam

A sandwich beam whose core thickness is varied is modeled using ANSYS. The specifications of the beam are as follows:

DIMENSIONS OF THE BEAM

a=0.02m…… thickness of the skin

w=0.2m…….width of the beam

P=5000N…… load acting on the beam

l=1m………...length of the beam

Dimension of core varies.

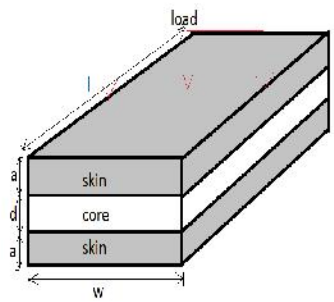

Fig-1.1 Dimensions of Beam

Table-1Variation of core thickness

Condition	Thickness(m)
1	0.01
2	0.015
3	0.02
4	0.025
5	0.03

Table -2 MATERIAL PROPERTIES

PARAMETER	SKIN	CORE
Material	Mild Steel	Rubber
Young's Modulus	210GPa	0.2GPa
Poisson's Ratio	0.303	0.48
Density	8050kg/m^3	1100kg/m^3

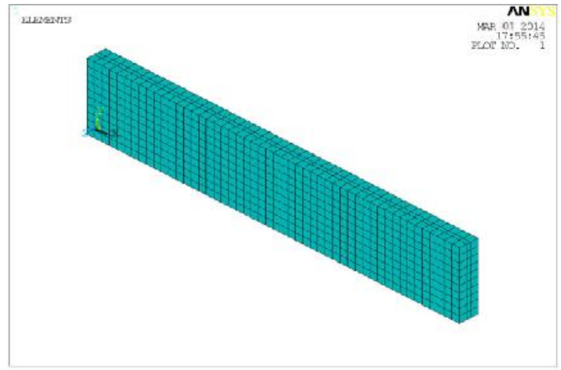

Fig-2 Modelled Beam

III.Static Analysis

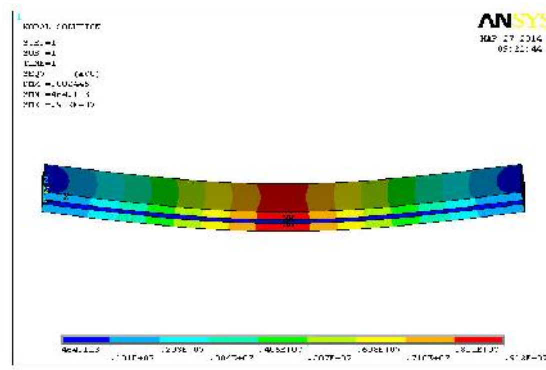

Fig-3 Von Misses Stress for 0.01m thick

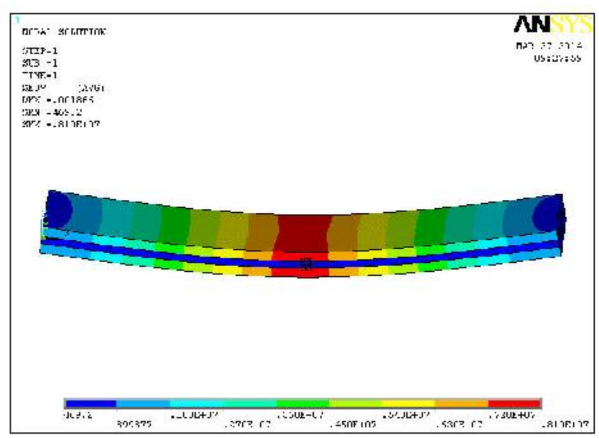

Fig-4 Von Misses Stress for 0.015m thick

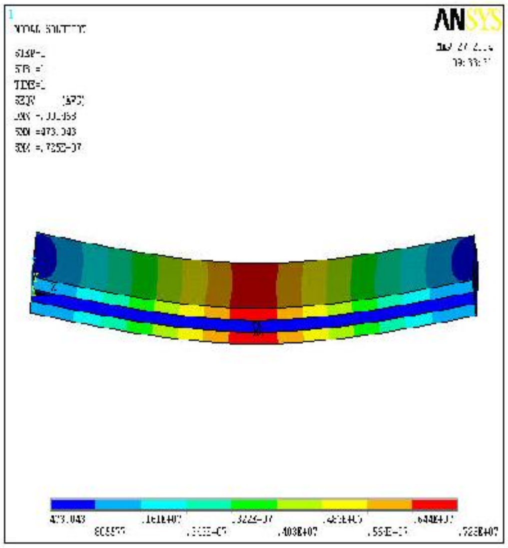

Fig-5 Von Misses Stress for 0.02 m thick

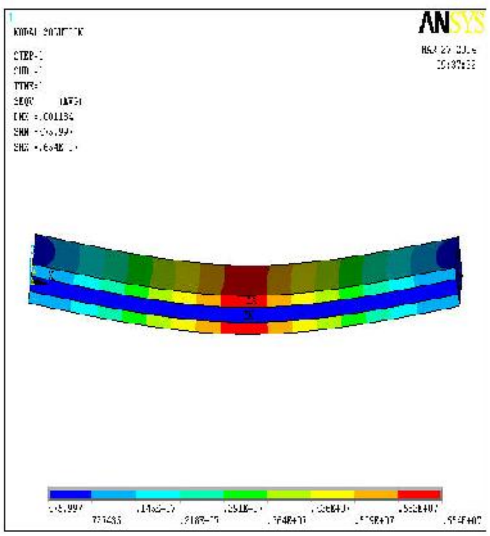

Fig-5 Von Misses Stress for 0.025 m thick

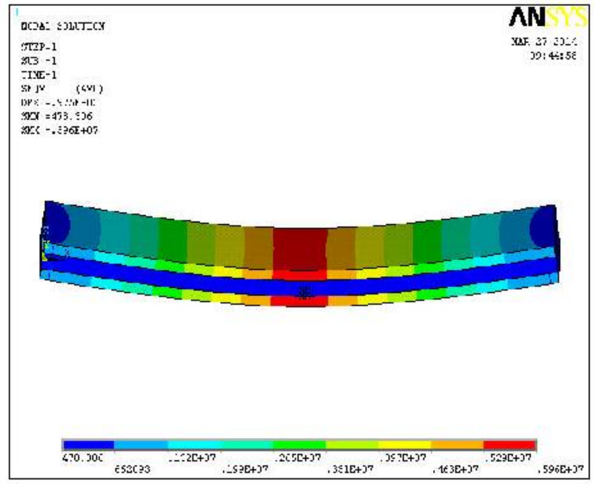

Fig-6 Von Misses Stress for 0.03 m thick

Variation of Deflection and stress with thickness

Thickness (m)	Deformation	Stress(Pa)
0.01	0.0024	0.912e7
0.015	0.00186	0.810e7
0.02	0.00146	0.725e7
0.025	0.00118	0.654e7
0.03	0.00097	0.596e7

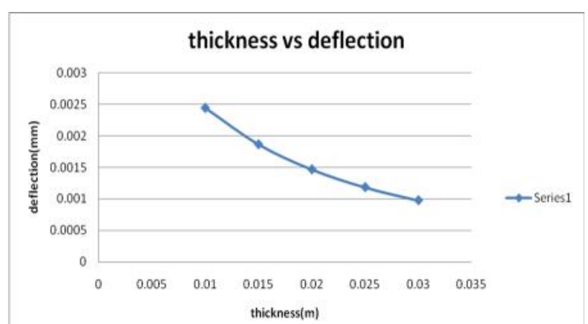

Fig-7: graph between deflection and core thickness

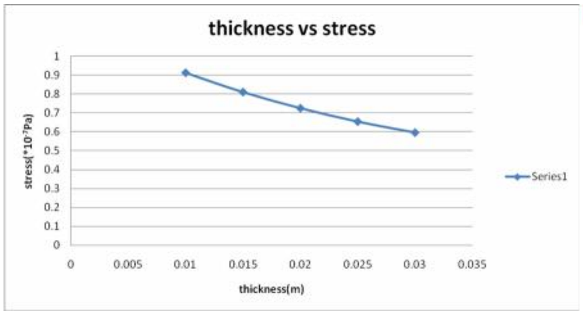

Fig-8 Graph between Vonmisses stress and Core Thickness

From this we can note that the deflection is decreasing with that of the core thickness. It is the same as in case of the stress also. This decrease will continue in the same fashion as the skin thickness is constant. When the value of the skin changes then an optimum value could be found out.

IV Modal Analysis

Six Mode shapes are considered and modal analysis is done for every thickness value.

The following are the mode shapes for the thickness value of 0.02m

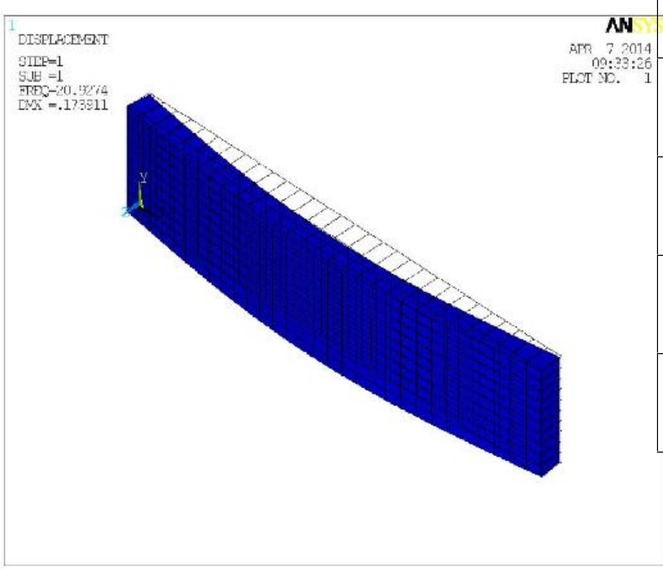

Fig-9: First Mode Shape

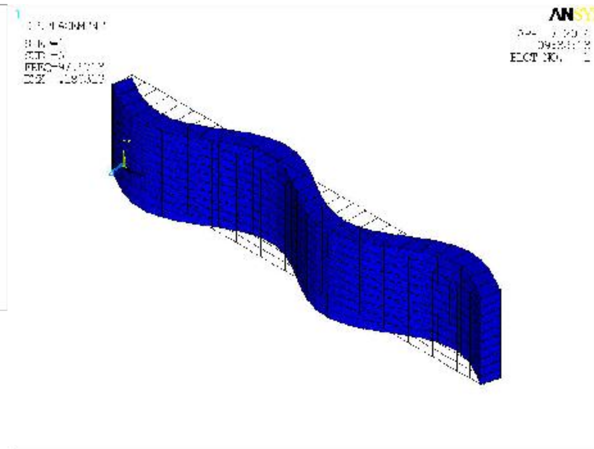

Fig-10: Fifth Mode Shape

Modal Frequencies

Mode shape	0.01m	0.015 m	0.02m	0.025 m	0.03m
1	39.987	45.41	50.88	56.54	61.429
2	158.54	179.35	199.8	219.76	239.15
3	240.85	262.75	260.6	258.62	256.62
4	264.98	267.70	292.96	316.54	338.42
5	351.21	394.96	437.12	477.38	515.58
6	494.89	548.86	598.90	594.21	589.62

V Harmonic Analysis

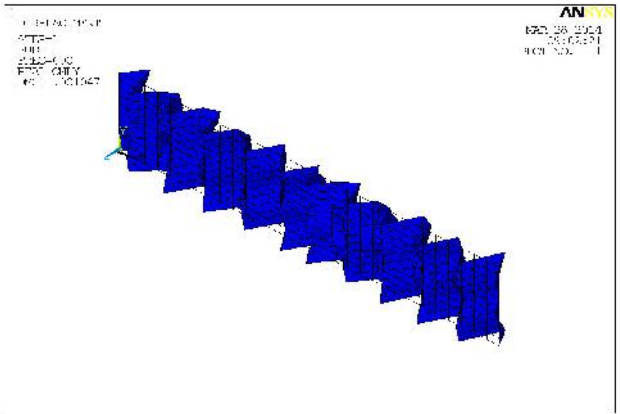

Fig-11 First mode frequency for beam with core thickness 0.01m

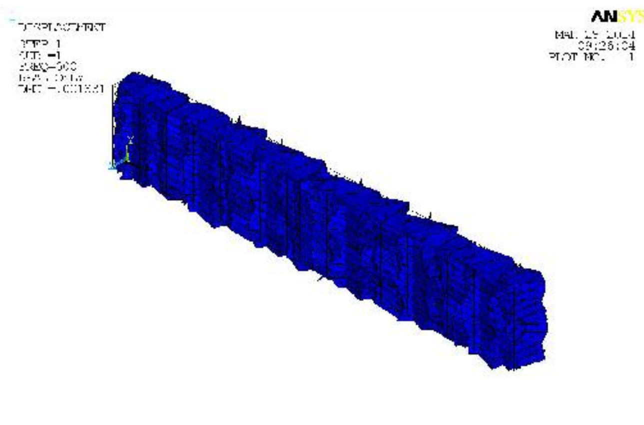

Fig-12 first mode frequency for beam with core thickness 0.025m

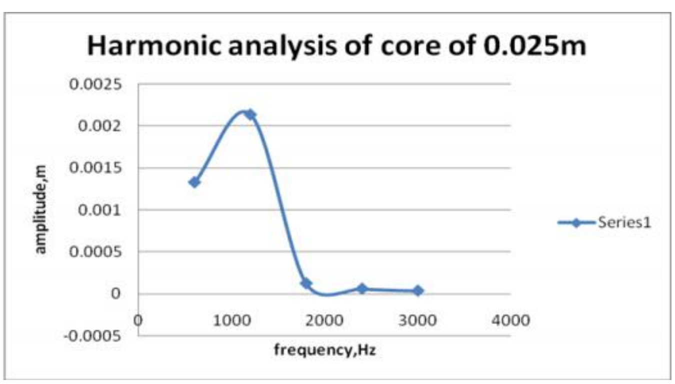

Fig-13 graph for harmonic analysis for core thickness 0.025m

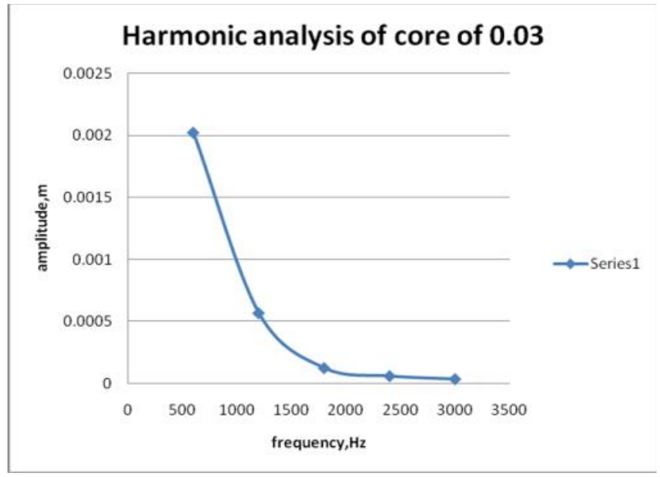

Fig-14 graph for harmonic analysis for core thickness 0.03m

The harmonic analysis is done for all the thickness values and the graphs have been plotted. It is found that the amplitude of the beam increases up to a certain frequency value and then decreases gradually. Hence we can calculate an optimal value where the amplitude may not reach very high and also the fundamental frequency could be found out.

VII CONCLUSIONS AND FUTURE SCOPE

Conclusions

The following conclusions are drawn from the present work:

- Analysed the sandwich beam and observed various parameters for varying thickness.
- It is observed from the results that the fundamental frequency increases as the core thickness increases which implies that the natural frequency also increases as the core thickness increases.
- By this analysis we can determine the frequency at which vibrations are maximum and avoid operating the system at that frequency and operate it at other frequencies.

Future Scope

Analysis can be carried out on different materials with different stacking sequences and boundary conditions and varying core and skin thickness. Further analysis can be done for prediction of delamination stress. The skin thickness can also be varied along with that of the core thickness and relations could be found out.

VIII REFERENCES

1. Project thesis of Roberts Tompkins submitted to TAMU University- Visco elastic analysis of Sandwich beam having Aluminum and Fiber reinforced polymer skins with polystyrene foam core-December 2009

2. Y. Swathi and Sd Abdul Kalam, “Sandwich Treatment in FRP beams: Static and Dynamic Response”. IJERT, vol1 9,2012,pp 2-5.

3. Noor AK and Burton WS, “Stress and free vibration analysis of multilayered composite panels” Compos Structures, vol11,1989,pp 183-204

4. Frostig Y, Baruch M, Vinley O and Sheinman I, “High order theory for sandwich beam behaviour with transversely flexible core”, J Eng Mech, vol 1 18, 1992, pp1026-1043.

5. Kant T and Swaminathan K, “Analytical solutions for the static analysis of laminated composite and sandwich plates based on a higher order refined theory”, Compos Structures, vol56, 2002, pp. 329-344.

6. Pandit MK, Sheikh AH and Singh BN, “ Analysis of laminated sandwich plates based on improved higher order zig zag theory”, J Sandwich Struct Mater, Vol 12 2010, pp.307-326.

7. K.Malekzadeh, M. R. Khalili and R.K. Mittal, “Local and Global Damped Vibrations of Plates with a viscoelastic soft flexible core: An improved high order approach” , Journal of sandwich structures and materials, vol7 2005,pp 431