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Fem Analysis of Structural Response of Sandwich Beam

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Abstract **- Sandwich plate 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 behavior. This study examines the behavior of sandwich plate driven by the varying core thickness and different core stiffness. 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 aluminum while the core is made up of foam family. The stress and deformation fields are analyzed. The core thickness and core material stiffness was varied keeping the skin thickness constant and the behavior of the sandwich beam is studied under static and dynamic conditions.**

Keywords **- Hills road, road construction, Trans Arunachal highway (NH-13), problem and solution.**

I. INTRODUCTION

Research efforts continuously are looking for new, better and efficient construction materials. The main goal of these researches is to improve the structural efficiency, performance and durability. New materials typically bring new challenges to designer who utilizes these new materials. In the past decades various sandwich panels have been implemented in aerospace, marine, architectural and transportation industry. Light-weight, excellent corrosion characteristics and rapid installation capabilities created tremendous opportunities for these sandwich panels in industry. Sandwich panel normally consists of a low-density core material sandwiched between two high modulus face skins to produce a lightweight panel with exceptional stiffness. Face skins act like flanges of an I-beam.

These faces are typically bonded to a core to achieve the composite action and to transfer the forces between sandwich panel components. Sandwich panels have been successfully used for many years in the aviation and aerospace industries, as well as in marine, and mechanical and civil engineering applications. This is due to the attendant high stiffness and high strength to weight ratios of sandwich systems [1]. The use of the sandwich constructions in the aerospace structures can be traced back to Second World War when British De Havilland Mosquito bomber had utilized the sandwich constructions [5]. In the early use, the sandwich structure was very simple in construction, with simple cloth, fabric or thin metal facings were used and soft wood were used as the core. The conventional sandwich construction comprises a relatively thick core of low-density material which separates top and bottom faceplates (or faces or facings) which are relatively thin but stiff. The materials that have been used in sandwich construction have been many and varied but in quite recent times interest in sandwich construction has increased with the introduction of new materials for use in the facings (e.g. fiber- reinforced composite laminated material) and in the core (e.g. solid foams) [2].

II. METHODOLOGY

A study of composite sandwich plate of configuration, thickness of the skin = 0.02m, width of beam= 0.2m, length of beam= 1m with load acting on beam= 5000 N and core material thickness will be varied from 0.01m to 0.03m under point load are considered for study. The sandwich panel consists of Aluminum 3003-H14 plate at top and bottom face sheet and four types of foam H100, H250, AirexR63.50 and Herex C70.200 are investigated. The core thickness is varied keeping the skin thickness constant and the behavior of the sandwich beam is studied under static and dynamic conditions. Finite element method (FEM) is used to analyses 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 stress, strain, and deformation are analyses. The core thickness is varied keeping the skin thickness constant and the behavior of the sandwich beam is studied under static and dynamic conditions.

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III. FINITE ELEMENT MODELLING OF SANDWICH BEAM

1. Sandwich Beam Geometry

The sandwich beam consists of two face sheets made of metal. The thickness of each face is a. Soft core of d thickness is sandwiched between those face sheets. The core material is made of foam which is soft compared to the face sheets. The length of beam is designated by l. Figure 1 illustrates the sandwich beam geometry whereas the dimensions of the sandwich beam are shown in Table 1.

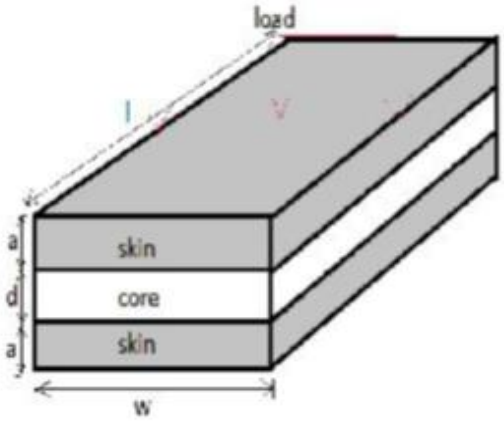

Fig.1. Geometry of Beam.

Table I: Dimensions of Beam.

Thickness of skin, a	0.02 m
Width of beam, w	0.2 m
Load acting on beam, P	5000 N
Length of beam, l	1 m

2. Study Parameters

The main parameters that have influence on the performance of the sandwich plate are, the core thickness and the core material stiffness.

3. Core Thickness

A sandwich beam whose core thickness is varied is modeled using ANSYS. The specifications of the beam are shown in table 2.

Table II: Variation of core thickness.

Condition	Thickness, cm
1	1.0
2	1.5
3	2.0
4	2.5
5	3.0

4. Core Material

In the current research, different materials are used. Their modulus of elasticity is varying from 37.5 MPa through 138.6 MPa, 180 MPa, and 402.6 MPa as shown in Table 3.

Table III: Material properties.

Material	Source	Young's modulus (MPa)	Poisson's ratio	Shear modulus (MPa)	Shear strength (MPa)
Face sheet : Aluminum 3003-H14	Boyer and Gall 1991	69000	0.33	25000	120
Core A : Airex R63.50	Rao, 2002	37.5	0.335	14.05	0.45
Core B: H100	Kuang, 2001	138.6	0.35	47.574	1.2
Core C: Herex C70.200	Rao, 2002	180	0.37	65.69	1.6
Core D: H250	Kuang, 2001	402.6	0.35	117.2	4.5

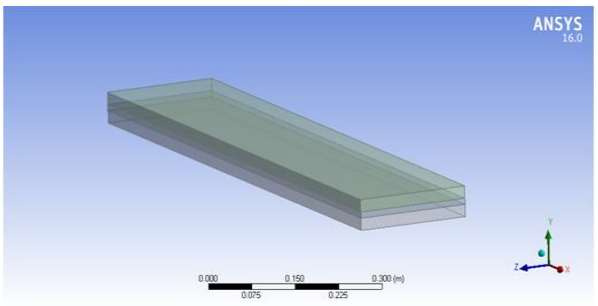

Fig.2. FEM model of sandwich beam.

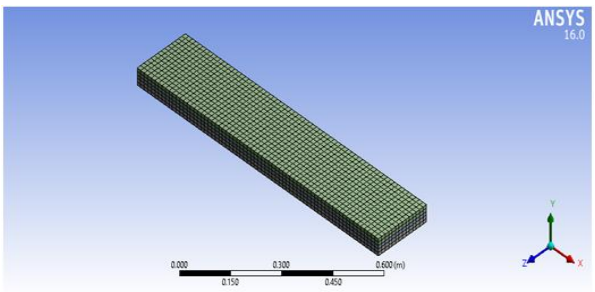

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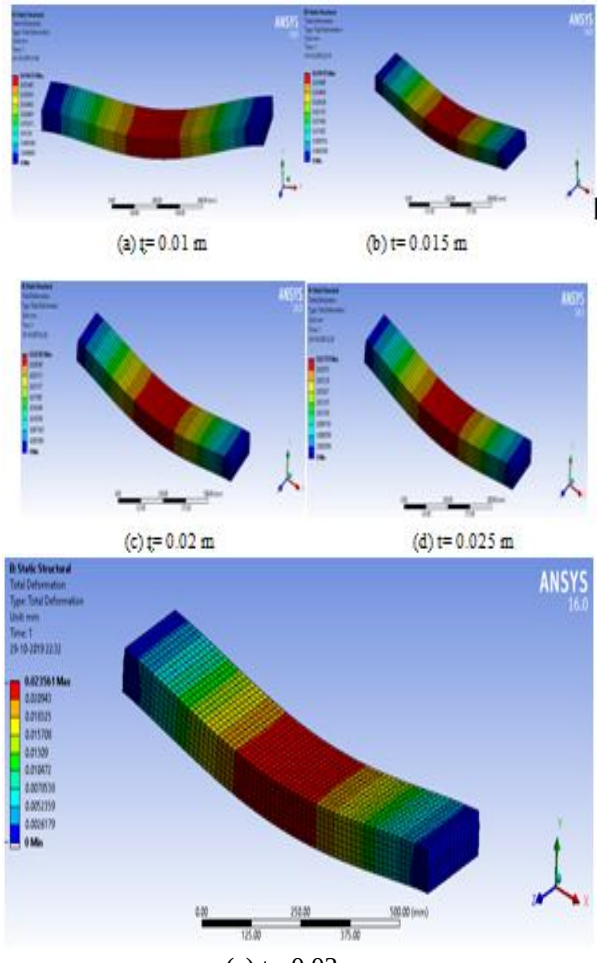
Fig.3. Mesh model of sandwich beam.

IV. RESULTS AND DISCUSSIONS

1. Effect of core thickness

Deformation is a degree to which a structural element is displaced under a load. It is able to an angle or a distance. It is directly related to the slope of a deflected shape of the member below that load. Deformation contours obtained from ANSYS, FE are shown in Fig.4.



(e) t= 0.03 m

Fig.4. Deformation contour of sandwich beam with varying core thickness.

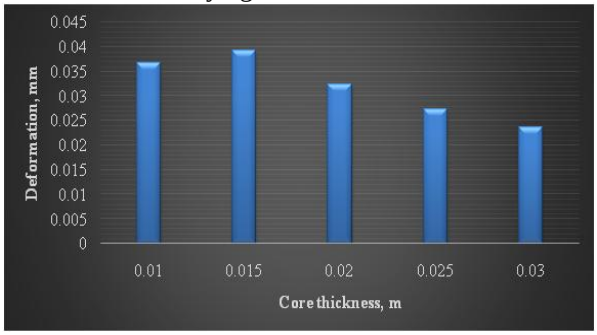
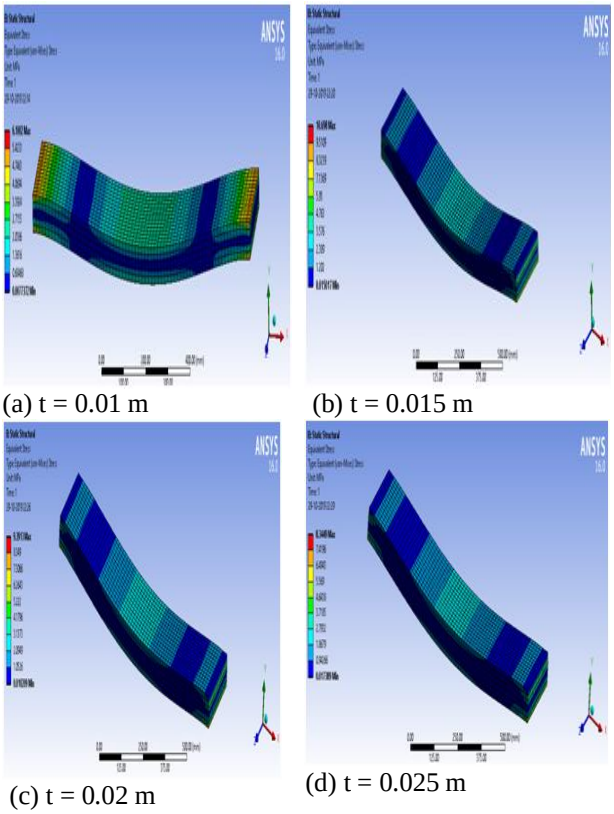


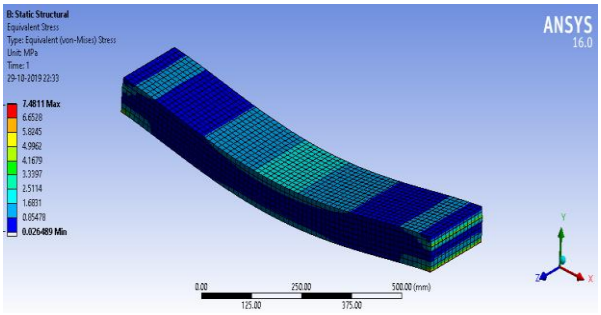
Fig.5. Variation of deformation of sandwich beam with varying core thickness.

Figure 5 shows the effect of core thickness on static deflection of sandwich beam. It can be observed that the value of the static deflection has decreased after core thickness from 0.015 to 0.03 m. It is concluded that as the core thickness increases the static deflection decreases. This can be attributed to the increase of the area moment of inertia of the beam. This is contradictory to Prasad et al. (2014) and Salams et. al. (2013) which showed that the core thickness has a significant effect on the deformation. For static analysis, figure 6 shows the contour of stress in sandwich beam with Core A: Airex R63.50. It is concluded from below figures that the use of core materials with lower core thickness has minimum stress value.



(a) t = 0.01 m (b) t = 0.015 m

(c) t = 0.02 m (d) t = 0.025 m



(e) t = 0.03 m

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Fig.6. Stress contour in sandwich beam with varying core thickness.

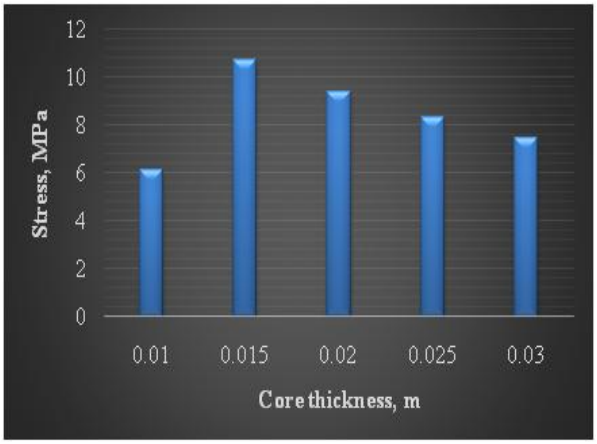

Fig.7. Variation of stress in sandwich beam with varying core thickness.

From this study, the stress is decreasing with that of the core thickness. It is the same as in case of the deflection 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. This is contradictory to Prasad et al. (2014) and Akour & Maaitah (2012).

2. Modal Analysis

Six mode shapes are considered and modal analysis was done for every thickness value and it is shown below.

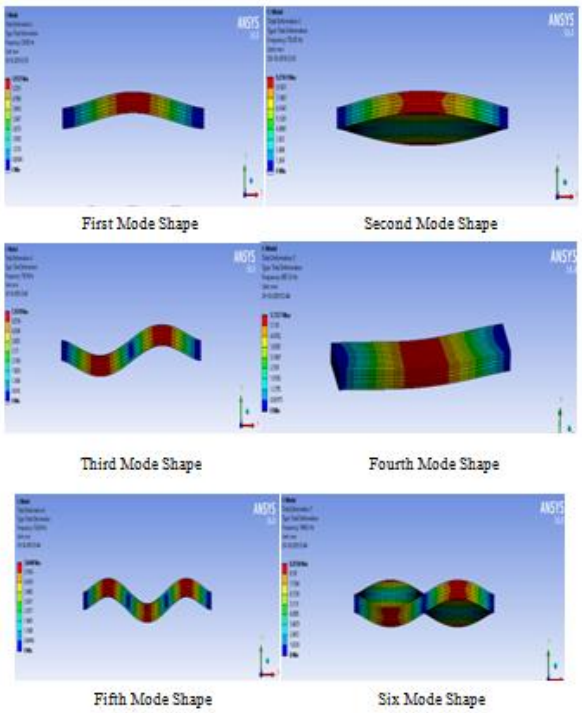

Fig.6. Frequency at different mode shape with varying core thickness.

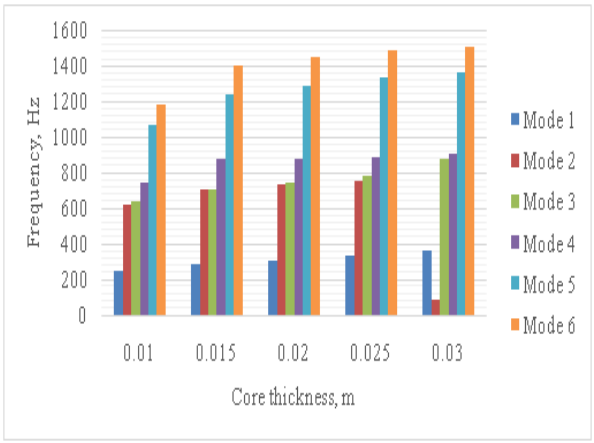

Fig.7. Variation of frequency at different mode shape with varying core thickness.

The harmonic analysis is done for all the thicknessvalues and the graphs have been plotted. It is foundthat the amplitude of the beam increases up to a certain frequency with core thickness. Hence it is concluded that core thickness significantly impact the frequency. Six mode shapes are considered and modal analysis was done for every core material and it is shown below.

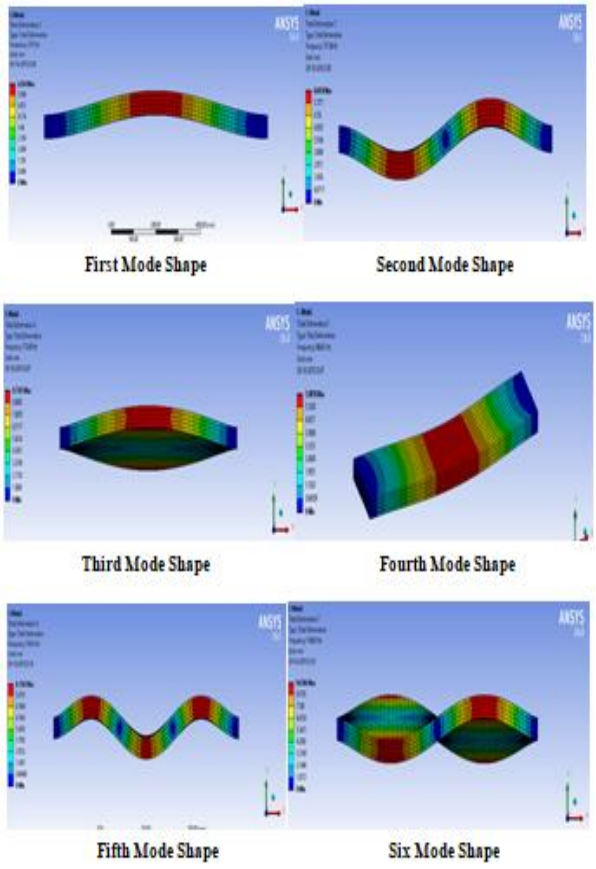

Fig.8. Frequency at different mode shape with different core material.

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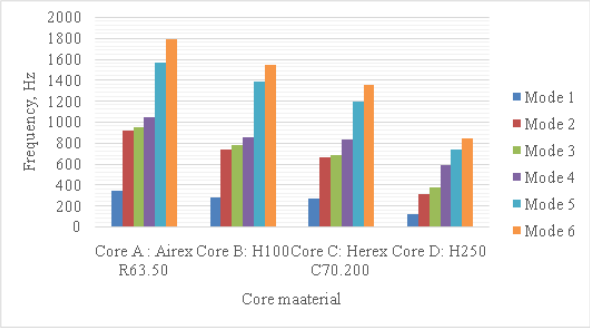

Fig. 9. Variation of frequency at different mode shape with different core material.

The harmonic analysis is done for different core material and the graphs have been plotted. It is found that the amplitude of the beam increases up to a certain frequency with core material stiffness. Hence it is concluded that core material stiffness significantly impact the frequency.

V. CONCLUSION

1. It can be observed that the value of the static deflection has decreased after varying core thickness from 0.015 to 0.03 m. It is concluded that as the core thickness increases, static deflection decreases. Maximum deformation was recorded is 0.039155 mm at core thickness 0.015m. This can be attributed to the increase of the area moment of inertia of the beam. This result is contradictory to Prasad et al. (2014) and Salams et. al. (2013) which showed that the core thickness has a significant effect on the deformation.
2. From this study, the stress is decreasing with that of the varying core thickness. It is the same trend as in case of the deflection. 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. Maximum stress intensity was recorded is 10.698 Mpa at core thickness 0.015m. This is contradictory to Prasad et al. (2014) and Akour & Maaitah (2012).
3. It is observed that the deflection has a maximum value at the mid of the beam equal to (0.036 mm). For sandwich beam with other cores the deflection has a maximum value at the mid of the beam respectively. Also, it is observed that, the value of the static deflection has increased from 0.036 mm to 0.25mm. It is concluded that the use of core materials with lower Young's modulus leads to increasing sandwich beam static deflection and vice versa. Maximum deformation was recorded is 0.25405 mm when core material is Core D: H250.
4. It is observed that the stress has a maximum value at the end point of the beam equal to 6.1002 Mpa. For sandwich beam with other cores the stress has also a maximum value at the end point of the beam respectively. Also, it is observed that, the value of the stress has increased from changing core material. It is concluded that the use of core materials with lower Young's modulus leads to increasing sandwich beam stresses and vice versa.
5. It is found that the amplitude of the beam decreases with core material stiffness. Hence it is concluded that core material stiffness significantly impact the frequency.

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