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Finite element analysis of mild steel - rubber sandwich composite material

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Abstract. Composites are widely used in many industrial applications including civil engineering, automotive, marine, aviation, etc. Major applications of composites are its strength to weight ratio. The sandwich composites are multilayered materials made by bonding stiffness, high strength skin facings to low density core material. The main benefits of using the sandwich concept in structural components are the high stiffness and low weight ratios. These structures can carry in-plane and out-of-plane loads and exhibit good stability under compression, keeping excellent strength to weight and stiffness to weight characteristics. In the present paper, the properties of mild steel - rubber sandwich specimens with varying core thickness were evaluated using a three point bending test in ANSYS and the results were correlated and analyzed.

1. INTRODUCTION

Among wide variety of composite structure available, sandwich laminates play an important role in industries as the cost of fabrication can be reduced by using sandwich structures. A typical such material which find a lot of application recently is mild steel sandwiched between rubber layers forming fiber metal laminates (FML).It is observed to have excellent qualities such as overall reduced weight, corrosion resistance and environment friendliness. The fiber/metal composite technology combines the advantages of metallic materials and fiber reinforced matrix systems. Metals are isotropic because they have a high bearing strength and impact resistance and are easy to repair. Full composites have an excellent fatigue characteristic and have high strength and stiffness. The fatigue and corrosion characteristics of metals and the low bearing strength, impact resistance and reparability of composites have overcome by the combination of metal and fibers. These material systems are created by bonding composite laminate plies to metal plies.

The concept is usually applied to aluminium with agamid and glass fibres also it is applied to other constituents. Several articles have shown that, FMLs possess both the wonderful impact resistance characteristics of metals and the attractive mechanical properties of fiber reinforced composite materials. In fields such as aerospace, construction, consumer products, transportation and sporting goodsFibre reinforced composite materials have gained a widespread popularity over conventional materials. For structural applications where high strength-to-weight and stiffness-to-weight ratios are required the fibre-reinforced composite materials are ideal. By altering lay-up and fibre orientations composite material can be tailored to meet the particular requirements of stiffness and strength .The ability to manufacture a composite material as per its job is one of the most significant advantages of composite material over an ordinary material. Due to the high strength to low weight ratio, resistance in fatigue and low damping factor, composite materials have wide range of applications in car and aircraft industries. Research in the design of mechanical, aerospace and civil structure and development of composite materials has grown tremendously in few decades. The problem of selecting a suitable material has been studied for a long time. One of its applications concerns the selection of the optimal distribution of fibre orientations in composite structures and the identification of the optimal stacking sequence. In most aerospace applications, the candidate materials are restricted to the conventional angles with plies oriented at 0°, 45°, -45° and 90°. This is by nature a discrete optimization problem. However, the specific parameterizations discussed here allow working with a continuous formulation, and reliable optimization methods developed for problems involving continuous variables can therefore be applied.

1.1 Application Areas of Sandwich Structures

In aerospace applications various honeycomb cored sandwich structures were used for space shuttle constructions also they are used for both military and commercial aircrafts. The U.S. Navy and the Royal Swedish Navy has used honeycomb sandwich bulkhead to reduce the weight of the ship and to withstand underwater explosions for more than 20 years. Moreover, locomotives are designed in order to resist the pressure waves occurring during the crossing of two high-speed trains in tunnels. More recently, sandwich constructions are commonly used in civil engineering projects such as bridge decks, wall and roof claddings for buildings because of their low cost and thermal performance. Also, railcars for rapid transit trains, busses, sailboats, racing boats, racing cars, snow skis, water skis and canoes are all employing sandwich constructions

1.2 Objectives

- Modeling of sandwiched composite material using ANSYS.
- Simulation and analysis of sandwich composite material. With different core thickness.
- Static analysis for varying core thickness of sandwich composite material.
- Model analysis.

2. LITERATURE REVIEW

Integrating different varieties of ceramics, fibers, metals and polymer forms is used in composite materials and many people around the world have worked on it

Johnson and Sims [1] have done research on design and mechanical properties of sandwich materials. Since this material have a low density core, it is used widely in panel applications where the loads are flexural. Sandwich materials are used for production of cars and vans body panels, sheet shells etc which includes steel/plastic laminates, integral skinned plastic forms and glass fibre reinforced polyester skins with foamed plastic cores. A method for designing optimum sandwich structures for least weight or cost is given in their work and also design formulae for the flexural stiffness and strength of such sandwich materials are reviewed. Mechanical property data are shown on various sandwich materials of potential interest for vehicle panel applications. It is then shown how use of the least weight design gives a means of improving the flexural properties of existing sandwich constructions.

Mohammad Alem iArdakani et al. [2] For advanced aerospace structural applications, fiber metal laminates (FMLs) are used due to their high specific mechanical properties especially fatigue resistance.The most important factor in manufacturing of these laminates is the adhesive bonding between aluminum and FRP layers. Several glass-fiber reinforced aluminum (GLARE) laminates with different bonding adhesion were manufactured in this study.He also conducted Drop weight impact tests based on ASTM D7136 standard to study the effects of interfacial adhesive bonding on impact behavior of these laminates. It was observed that the damage size is greater in laminates with poor interfacial adhesion compared to that of laminates with strong adhesion between aluminum and glass layers. In addition, FMLs of with good adhesion bonding show better resistance under low velocity impact and their corresponding contact forces are about 25% higher than that of specimens with a weak bonding. Moreover, maximum central deflections in laminates with strong bonding are about 30% lower than that of FMLs with poor adhesion.

KeeJoo Kim et al. [3] The main objective of this study was to develop basic techniques in order to apply aluminum sandwich sheets for an automotive hood part. Two aluminum skins tone polypropylene core is being adhered to make the aluminum sandwich sheet. Though it has the same bending stiffness as a steel sheet, it is 65% lighter than the steel sheet and 30% lighter than an aluminum alloy sheet. Therefore, it is exclusively a good substitutive materials for a steel body to improve the fuel efficiency. Through aluminum sandwich sheet, however, it has relatively lower formability than that of the steel sheet for automotive application. In this study, we developed application techniques of the aluminum sandwich sheet for automotive hood. The various formability evaluations were carried out in order to secure the fundamental data for the measurement of sheet metal forming and the establishment of optimum application conditions of the sandwich sheet. It was found from these results, that the sandwich sheet could reduce the weight and maintain the flexural rigidity simultaneously comparing to the steel sheet.

Morisada et al. [4] were successfully achieved to disperse multi-walled carbon nanotubes (MWCNTs) into a magnesium alloy (AZ31) using friction stir processing (FSP). The FSP with MWCNTs increases the micro hardness of the composites. The maximum micro hardness of these composites was 78 Hv, which is almost twice that of the AZ31 substrate (41 Hv).

3. METHODOLOGY

Methodology for Finite element analysis of mild steel - rubber sandwich composite material

- Modeling of sandwiched composite material using ANSYS.
- Simulation and analysis of sandwich composite material. With different core thickness.
- Static analysis for varying core thickness of sandwich composite material.
- Model analysis.

3.1 Material properties

Table -1 Material property

PARAMETER	FACE SHEET	CORE
Material	Mild Steel	Rubber
Young's Modulus	210GPa	0.2GPa
Poisson's Ratio	0.303	0.48
Density	8050kg/m3	1100kg/m3

3.2 Dimensions of the beam

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

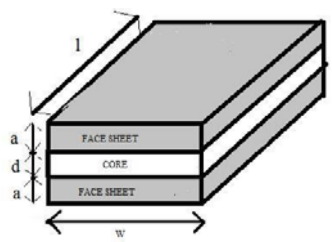

Fig.3.1: Dimensions of Beam

a=0.02m…… thickness of the face sheets
w=0.2m…….width of the beam
P=5000N…… load acting on the beam
l=1m………...length of the beam
Dimension of core thickness (d)

Table-2 Thickness of the selected cores

Condition	Thickness(m)
1	0.001
2	0.015
3	0.02
4	0.025
5	0.03

4. RESULTS AND DISCUSSIONS

Results of the sandwiched composites are as shown below.

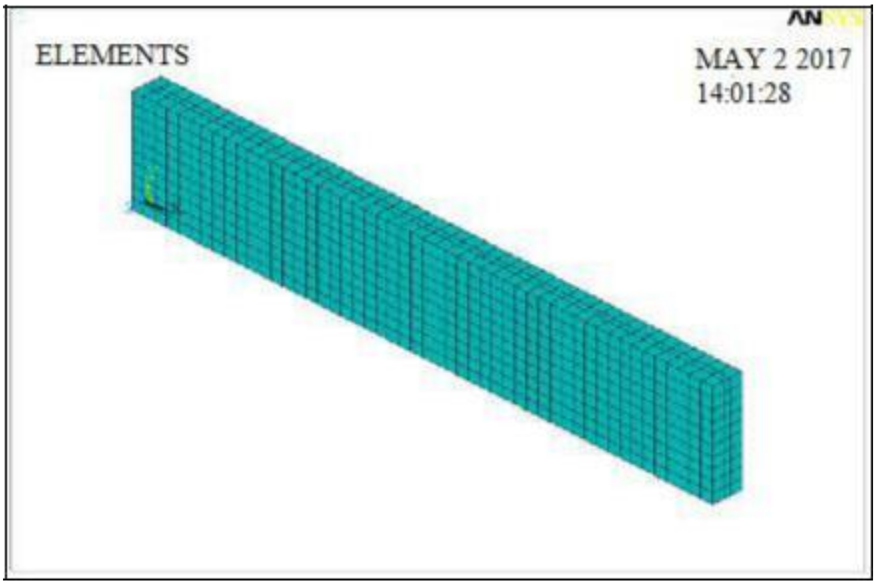

Fig.4.1: Modeled Sandwich Beam

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4.1 Static Analysis

I. For core thickness 0.01m

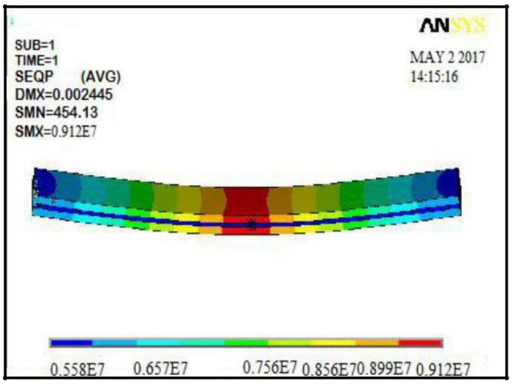


Fig.4.2: Von Misses Stress for 0.01m thick

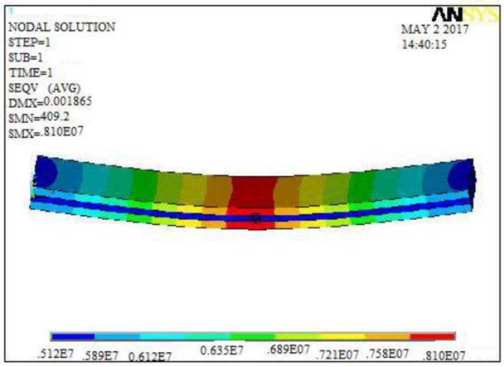
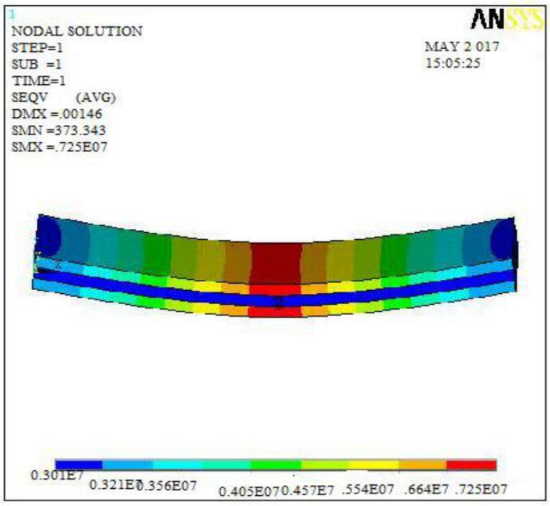


Fig.4.3: Von Misses Stress for 0.015m thick



I. Fig.4.4: Von Misses Stress for 0.02 m thick

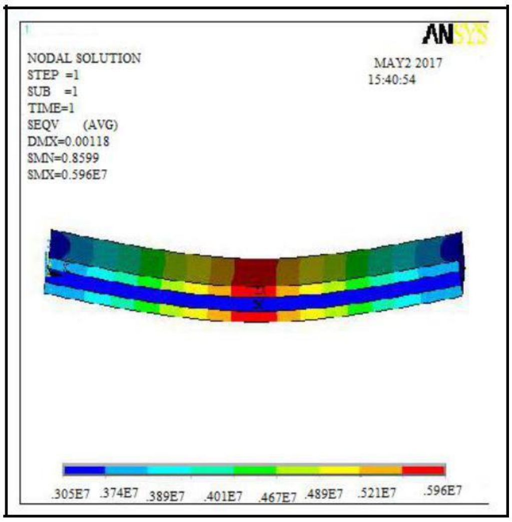


Fig.4.5 For core thickness 0.025m

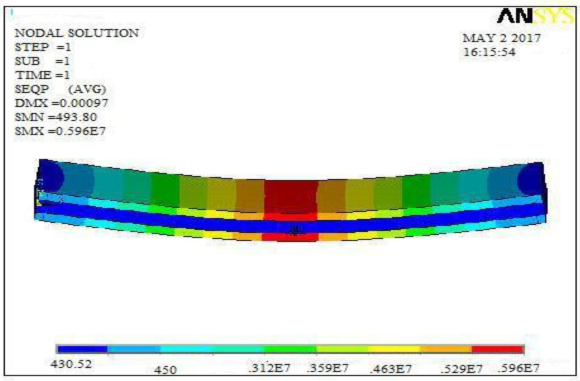


Fig.4.6: Von Misses Stress for 0.03 m thick

Table 3. 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

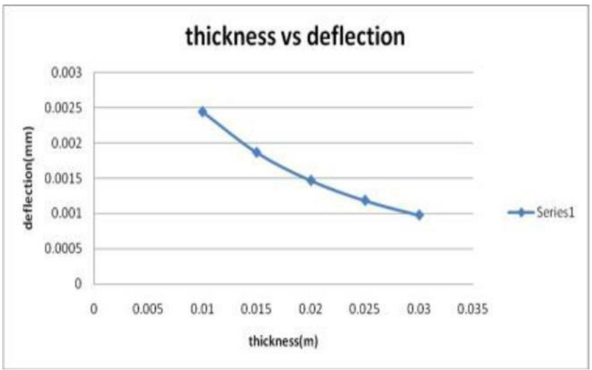


Fig.4.7: Graph between deflection and core thickness

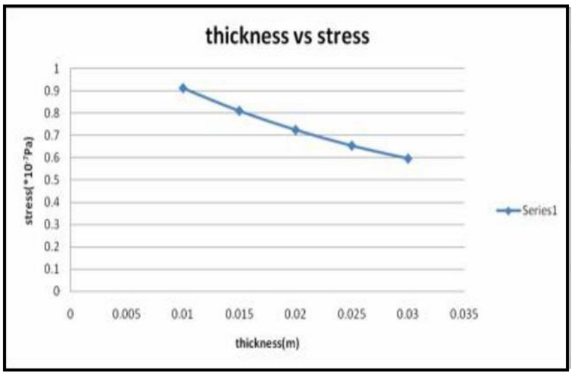


Fig.4.8: Graph between Von Misses stress and Core Thickness

From this, we can conclude that as the core thickness increases the deflection decreases. Stress also has the same concept. If the skin thickness is constant, this decrease will continue in the same fashion. The optimum value can be determined only if there is any change in the skin thickness.

4.2 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

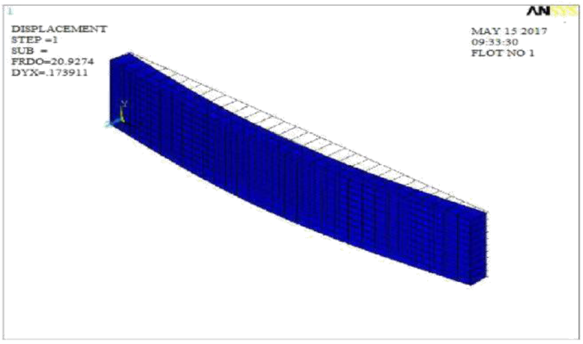


Fig.4.9: First Mode Shape

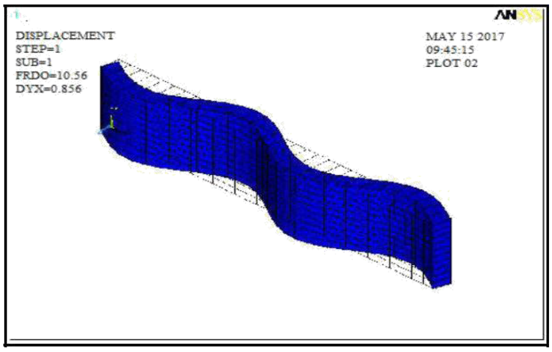


Fig.4.10: Fifth Mode Shape

Modal Frequencies

Table 4.Mode shape with varying core thickness

Mode shape	0.01m	0.015m	0.02m	0.025m	0.03m
1	39.987	45.41	50.88	56.54	61.429
2	158.54	179.35	199.8	219.76	239.1
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

CONCLUSIONS AND FUTURE SCOPE

Conclusions:

The following conclusions are drawn from the present work:

- Analyzed 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.

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Future Scope:

Analysis can be carried out on different materials with different stacking sequences, boundary conditions and varying core and skin thickness. Further analysis can be done for prediction of delimitation stress. Also, relations can be find out by varying face sheet thickness along with that of the core thickness.

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