

Optimization of Total Deformation in Different Honey Comb Structures using FEM

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Abstract: A sandwich structure consists of two strong face sheets separated by a lightweight core made of materials such as foam, cellular, or honeycomb structures. These structures are designed to achieve high stiffness-to-weight and strength-to-weight ratios while minimizing material usage. Different core geometries, including circular, rectangular, triangular, ribbon, sisal, and honeycomb shapes, influence the stress, deformation, and overall performance of the structure. Among them, the hexagonal honeycomb core is the most effective due to its low weight, high axial stiffness, and excellent structural efficiency. As a result, honeycomb sandwich structures are widely used in aerospace, automotive, railway and transportation industries where lightweight and high-strength materials are required.

Key Words: FEM Honeycomb, design analysis

1. INTRODUCTION

In the construction of sandwich structure there are three principal parts which are two face sheets having core. During industry age, the sandwich structure with various shapes such as circular, rectangular, triangular and honeycomb had significant change in stiffness and weight ratio. There is also provision of internal sheet in between core area. Sandwich structure manufactured with thin sheets of metal with different types of core foam, cellular and hexagonal type structure. The invention of the honeycomb sandwich, due to its low weight and increased axial stiffness, is one of the most lauded structural engineering breakthroughs in the industry, with applications in transportation, cars, aircraft, and railroads, among others. Sandwich Panels or Sandwich Structures are a subset of structural composites that are optimized for material savings and excellent stiffness-to-weight and strength-to-weight ratios. The core material is lightweight and engineered to give adequate shear strength to sustain transverse shear loads while also providing sufficient shear stiffness to prevent the panel from buckling.

LITERATURE REVIEW

Advanced core topologies for ballistic and dynamic protection have also received increasing attention. Walkowiak et al. (2026) performed comparative numerical analyses on sandwich panels with auxetic and non-auxetic lattice/prismatic cores under ballistic loading. Their results indicated that optimized auxetic core geometries can reduce rear-face deflection by up to 90% and increase plastic energy dissipation significantly compared with conventional monolithic and honeycomb configurations.

In the context of impact resistance and energy absorption, Balan and Raj (2025) examined sandwich polymer composites subjected to projectile and shock-wave loading. Their work introduced reinforced mesh-integrated sandwich cores and revealed that the incorporation of steel and glass fiber mesh significantly improved impact energy absorption while minimizing structural deformation. The authors emphasized that core geometry and interfacial bonding quality play a decisive role in determining impact performance.

Hamza et al. (2024) experimentally and numerically investigated the effect of honeycomb core geometric parameters on the static and dynamic performance of aluminum sandwich plates. Their findings demonstrated that increasing the core height significantly enhances natural frequency and stiffness while reducing transient deformation. The study also reported that cell size and wall thickness substantially influence damping ratio and maximum bending response.

Thomas et al. [1] 2019 observed the detailing of honeycomb structure regarding their cell size m length of nodes used in structure and configuration of cell. This review enhances the view of different material shape and emphasis on honeycomb node size and cell structure.

J. S. Kumar et al. [2] 2017 did his research on the parameters like size of cell and the thickness of the total wall used on design, researcher also concludes the parameter with cell size is most important in design of panel as well as wall thickness is least important. Akiwate et al. [3] 2017 research about core height and the skin of sandwich panel.

2. RESEARCH METHODOLOGY

Honeycomb structures are used to provide a basic sense of the dimensions of honeycomb cells and the area used for modeling. Ansys Work bench was used to create the design. Because of its light weight and great axial flexibility, the honeycomb structure is favoured over most conventional structural methods and materials.

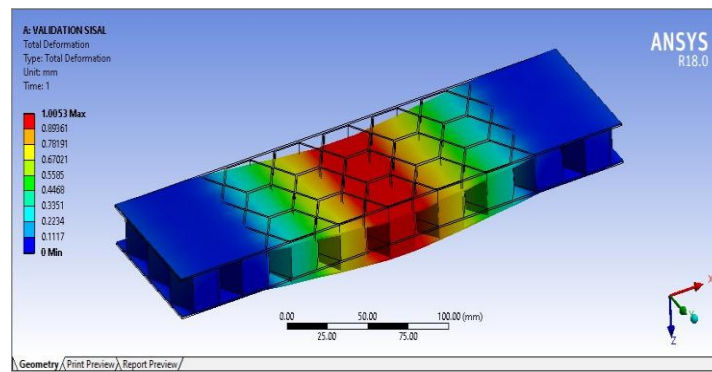


Fig -1 :Validation of base paper model of honey comb structure with total deformation values

Figure 1 shows the validation of base paper model for honey comb structure and it shows the deformation values of the structure and the maximum value of the honey comb structure is 1.0053 mm at the centre of the structure, at the both end of the validation structure with sisal material it become 0.11 mm which shows the suitable variation as per the base paper.

3. RESULT AND DISCUSSION

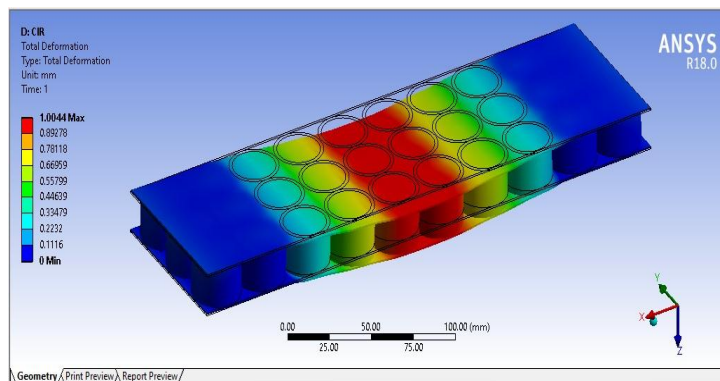


Fig-2: Total Deformation of Circular Sandwich Structure

Figure 2 shows the total deformation of circular sandwich structure with centre load distribution. The maximum value at the centre of the structure is 1.044 mm and gradually distribution towards the end of the structure value with 0.11 mm. The distribution also shows the values 0.7811 mm, 0.55789 mm and 0.232 mm.

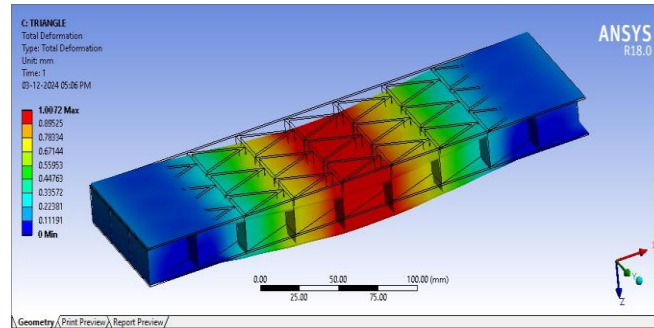


Fig-3:Total Deformation of Triangular Sandwich Structure

Figure 3 shows the total deformation of triangular sandwich structure with center load distribution. The maximum value at the centre of the structure is 1.072 mm and gradually distribution towards the end of the structure value with 0.1191 mm. The distribution also shows the values 0.67 mm, 0.55 mm and 0.44 mm.

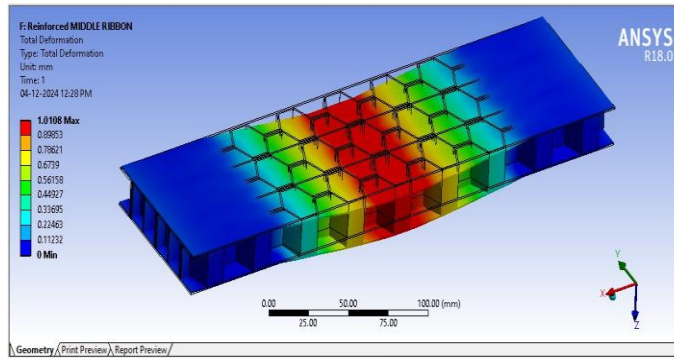


Fig-4: Total Deformation of Reinforced Ribbon Type (Hexagonal with Extended Fin)

Figure 4 shows the total deformation of reinforced ribbon type with extended fin structure. Structure with the value of 1.0108mm maximum deformation at the centre of the beam structure and gradually distributed to the ends, where the values varies 0.67 mm to 0.33mm and at the end of the structure there is lowest deflection 0.11mm. Hexagonal type structure with extended fin gives maximum support and best distribution of the load towards all combination.

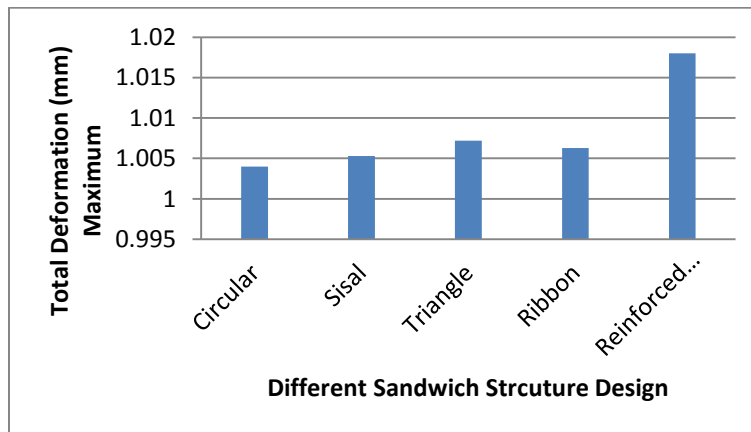


Fig- 5 : Graph of Maximum Deformation as per different proposed Sandwich design

To begin with, based on the two main performance measures, the stress and deformation, the Circular geometry got the best placement several times. It recorded the lowest measured stress (499.9 MPa) and also the lowest cumulative deformation (1.004 mm). This concomitant decrease in both stress and overall movement is of great importance in engineering language, as it suggests a wider load path with little concentration effects and a relatively stiff response with relatively small elastic strains. When converted into graphs, i.e. bar charts sorted by performance or radar plots that overlay various measures, the Circular would visually reduce to the optimal area in case of the headline criteria, proving it to be the top candidate.

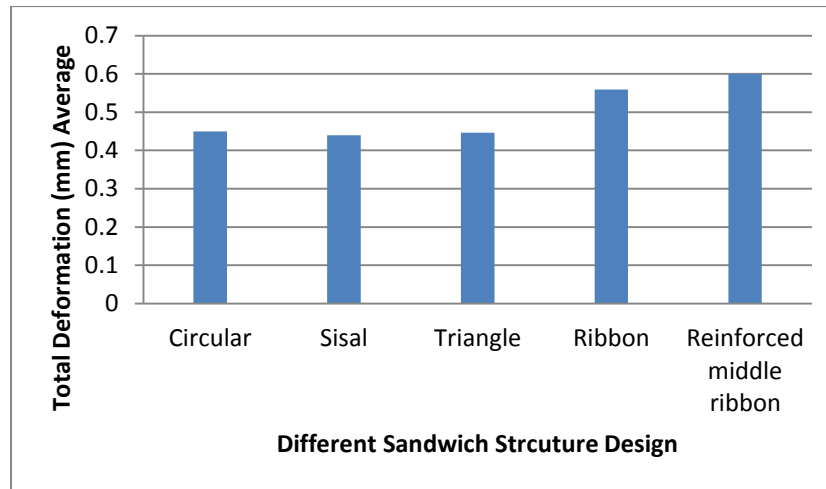


Fig 6 : Graph of Average Deformation as per different proposed Sandwich design

4. CONCLUSION

The other variants - Triangle, Ribbon, and Sisal - represent the intermediate categories: Triangle tends to a higher stress in the middle category but only moderately stressed deformation; Sisal tends to moderately stressed deformation and not so good deformation as Circular or Sisal; and Ribbon tends to a slightly lower stressed deformation than Triangle but not so good deformation as Circular or Sisal. Scatter and correlation plots indicate that there is a moderately strong positive correlation between stress and total deformation implying that variants which experience more stresses are also more likely to deform.

The hexagon shape of the reinforce ribbon was found to be the most useful of all shapes; the honeycomb structure hexagon was the lightest weight structure of all the cell shapes; this was attributed to the efficient system of packing of the hexagon shape, this saved costs due to the light weight structure, and the hexagon had the besttemporation of weight weight ratio of any cell geometry. The structure having a radius on its sides showed a considerable reduction in overall stress distribution (55.4%), compared to that of original structure, and the structure having fillets on its sides showed reduction in overall stress distribution which was not acceptable and hence would not be pursued in any further optimization.

REFERENCES

- [1] Hamza, N.A.A., AL-Fatlwe, F.M.K., & Talib, M.A., 2024. Experimental and numerical study of effecting core configurations on the static and dynamic behavior of honeycomb plate with aluminum material. *Defence Technology*, 39, pp.177–192.
- [2] Balan, G.S. & Raj, S.A., 2025. Impact load bearing and energy absorption in sandwich polymer composites: Projectile versus shock loadings. *Results in Engineering*, 25, 103815.
- [3] Li, X., Mao, H., Ichchou, M., Rumppler, R., & Göransson, P., 2025. A new wave-based structural identification framework for estimating material properties of honeycomb sandwich structural components. *Engineering Structures*, 322, 119042.

- [4] Walkowiak, M., Anders, D., & Reinicke, U., 2026. Comparative numerical studies of the mechanical efficiency of sandwich panels with different non-/auxetic prismatic and lattice cores subjected to ballistic loading. *Forces in Mechanics*, 22, 100354.
- [5] Thomas T, Tiwari G. Crushing behavior of honeycomb structure: a review, *International Journal of Crashworthiness*, 2019; 1-25.
- [6] Kumar JS, Kalaichelvan K. Taguchi-Grey Multi-Response Optimization on Structural Parameters of Honeycomb Core Sandwich Structure for Low Velocity Impact Test. *Silicon*, 2017; 10(3): 879-889. <https://doi.org/10.1007/s12633-016-9544-3>
- [7] Akiwate SB, Shinde VD. Experimental Investigation of Bending behaviour of Aluminum Alloy Honeycomb Sandwich Structure using Four Point Bending Tests, *International Journal for Innovative Research in Science & Technology*, 2017; 4(1):97-101.
- [8] Arbaoui J, Schmitt Y, Royer F. Effect of core thickness and intermediate layers on mechanical properties of polypropylene honeycomb multi-layer sandwich structures. *Archives of metallurgy and material*, 2014; 59(1): 11-16. <https://doi.org/10.2478/amm-2014-0002>
- [9] Vamja DG, Tejani GG. Experimental Test on Sandwich Panel Composite Material, *International Journal of Innovative Research in Science, Engineering and Technology*, 2013;2(7):3047-3054.
- [10] Rao KK, Rao KJ, Sarwade AG, Chandra MS. Strength Analysis on Honeycomb Sandwich Panels of different Materials, *International Journal of Engineering Research and Applications*, 2012; 2(3): 365-374.