International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-06, Issue-05, Aug 2020

Flexural strength FE analysis of hexagonal honeycomb structure using 3D printing

Ms. P. Pagare, PG Student, Mechanical Engineering Dept. of PDV Vikhe Patil College, Ahmednagar, Maharashtra, India. pagareprachi0@gmail.com

Prof. P. Narwade, Professor, Mechanical engineering Dept. of PDV Vikhe Patil College, Ahmednagar, Maharashtra, India. narwadeprashant@gmail.com

Abstract- The three-dimensional (3D) printing innovation has experienced fast advancement over the most recent couple of years and it is presently conceivable to print building structures. 3D printed combined statement demonstrating (FDM) material parts have particular anisotropic mechanical properties dependent on their as-fabricated print direction. The quality of material printed opposite to the testimony layers can be as low as half of qualities for infusion shaped parts because of not exactly ideal interlayer combination, restricting their utilization for basic applications. The focus of this project work is to present a study of the mechanical behavior of 3D printed honeycomb structures beam using 3 D printing material base material. Design of honeycomb structure with variable thickness of 1 and 2 mm to determine force reaction, stress and deformation. Flexural tests are to be conducted to determine the mechanical properties and failure characteristics of 3 D printing material materials. Based on the experimental results, a stress-strain relationship and a failure criterion based on the maximum stress criterion for 3 D printing material materials are proposed for the structures of 3D printed material. Finally a Finite element Analysis were conducted for a 3D printed honeycomb shell structure, which gives the summary that the printing direction has a significant influence on the load capacity of bearing of the honeycomb structure.

Keywords—FEA, Honeycomb Panel , polyacetal, 3d, bending, UTM

I. INTRODUCTION

Additive manufacturing (AM) was first evolved in the 1980's as sound system lithography (SL). The innovative work of this procedure was planned for disentangling the prototyping procedure by decreasing time and cost related with customary techniques. FDM has become the most famous and generally utilized AM strategy with half of the machines available being of this sort. As the advancement of FDM proceeded, the nature of parts created improved with the innovation developing into a last assembling technique. The layer savvy printing process takes into consideration the assembling of utilitarian and multifaceted parts at a moderately ease[1]. Nonetheless, parts created by this technique experience the ill effects of anisotropic properties constraining their utilization for specific applications. It likewise requires a client who is knowledgeable in the innovation and the printing strategies so as to upgrade the print parameters dependent on the proposed application. Added substance producing alludes to a gathering of procedures wherein material is stored layer by layer to develop a 3-Dimensional (3D) segment or model. This varies from ordinary subtractive strategies, for example, processing and machining, which start with a strong billet and evacuate material to make a last segment. There exists an assortment of added substance producing strategies, of which the most widely recognized incorporate Fused Deposition Modeling (FDM), Powdered Laser Sintering (PLS) and Electron Beam Sintering (EBS). PLS and EBS include utilizing a laser and an electron pillar individually to meld metal powder in bunches of even layers, developing the model vertically, while FDM melts and stores material layer by layer through a spout. Notwithstanding, the utilization of 3D printing and added substance fabricating in industry has developed also, as new strategies and research bring about upgrades in the nature of prints[4]. The key favorable circumstances of 3D printing and the explanation it has such a significant task to carry out in the assembling segment is on the grounds that it tends to be utilized to make segments which ordinary assembling can't make. This incorporates complex shapes which are either excessively troublesome or costly to plant or machine, for example, structures with inward depressions or those which don't permit access to regions which need machining. It is perfect for lean creation, where parts are possibly delivered when required with the goal that no stock is kept. Also, squander is low as just the material required for the part is utilized during make.

II. LITERATURE REVIEW

AMM Nazmul ahsan et al. [1] In this research it presents a novel grain-based division approach appropriate for bended freestyle formed slim divider objects. The grain geometry is upgraded for most extreme consistency in their surface curvature and flow to lessen their manufacture unpredictability, bolster volume and creation time. When

 DOI : 10.35291/2454-9150.2020.0561

the grains are produced, they are ideally arranged on the base plane to decrease the deviation brought about by the surface bend. The grain is at that point decorated with variational hexagonal honeycomb cells to catch useful variety. The proposed approach is executed on two freestyle formed custom articles head protector and hand cast, and tried on industrially accessible printers for creation. Gathering time is to a great extent subject to the quantity of grains. With better get together and basic soundness for example methodical grain to grain opening and connector can be utilized to facilitate the gathering procedure. It is observed that the thickness of cross section design remains steady inside each grain and shifts between grains. The proposed particular structure and assembling strategy will likewise be reasonable for appropriated assembling or network-based assembling coordinated effort for bigger parts.

Simon R. G. Bates et al. [2] in this paper it presents fiber creation (FFF) 3D printing of thermoplastic polyurethanes (TPUs) an exceptional capacity to make tailorable, adaptable cell structures which can be planned and advanced for explicit energy engrossing applications. By using industrially accessible thermoplastic polyurethane as a parent material it was conceivable to frame structures which could be more than once packed without crack, and by enhancing our printing strategy all noticeable void age was expelled in the examples broke down. Upon rehashed pressure of all TPU honeycombs, emotional cyclic mellowing conduct happened, with up to a 25% decrease in energy ingestion saw from the first to the second compressive cycle (εmax=0.7). Further examinations concerning the conduct of the TPU parent material, which incorporate cyclic relaxing, will be led just as high strain rate and effect investigation of the honeycomb structures. The FFF 3D printing process utilized in this investigation is reasonable, quick and has allowed the creators to produce the primary 3D printed cell structures fit for withstanding rehashed pressure cycling to densification. With further advancement, this printing procedure and the utilization of TPUs holds magnificent potential for making elite, custom fitted energy engrossing structures for extraordinary conditions.

Yiran Man et al. [3] in this research it presents the load bearing board produced with various topological structures, for example, vertical lattice, slanted square matrix, and honeycomb framework was printed by direct ink composing innovation utilizing a similar crude material of kaolin mud and α-Al_2O_3 powder. +e three sorts of tests were sintered at 1450°C × 3 h. +e impact of printed structures on mechanical property of load bearing board tests was examined. It is concluded that mechanical properties of each test are full scale anisotropic. +e consequences of approval inferred that when considering just structure the investigation of the chilly modulus of burst demonstrated that honeycomb matrix upheld structure displayed the most elevated quality opposite way and vertical upheld structure displayed the most noteworthy quality equal way. It could be gathered that under the opposite load appropriation worry in the example with vertical supporting structure was progressively nonuniform and the stress focus was progressively obvious by FEM. Thought about with other load bearing sheets, 3D printed load bearing board with honeycomb matrix upheld utilizing kaolin as crude materials was over half decreased in weight, and mechanical properties were sufficient for ordinary use.

F. N. Habib et al. [4], in this article it presents to examine the in-plane static compressive pounding conduct and energy assimilation limit of 3D printed polymeric honeycomb structures of various unit cell thicknesses. Uniaxial semi static pressure tests were performed on hexagonal honeycomb structures of differing divider thicknesses imprinted in Nylon 12 by combined affidavit demonstrating 3D printing. This examination has explored the compressive conduct of FDM printed Nylon 12 honeycomb structures of various unit cell thicknesses in two in-plane bearings. It was seen that the proportion of cell divider thickness to cell divider length (t/l) of honeycombs decides their compressive conduct and energy assimilation trademark. As (t/l) builds the honeycomb's compressive modulus, level pressure and energy assimilation limit increments while the densification strain (compressibility) diminishes. The most extreme energy ingestion productivity of all structures in both X1 also, X2 bearings is about comparative (half). It was finished up that FDM and 3D printing can be utilized to create polymeric honeycombs with wanted measurements also, high energy assimilation effectiveness for specific applications. 3D printing gives geometrical opportunity in plan and the honeycombs created by this methodology carry on in an anticipated manner.

Kanygul Chynybekova et. al [5] In this article it focuses to make adaptable, stretchable, and lightweight delicate 3D printed questions by investigating their twisting reactions under pressure, pressure and flexure tests. The introduced look into thinks about delicate 3D printing, especially concentrating on the improvement of adaptable examples dependent on non-homogenous cross breed honeycombs for the inside of 3D printed articles to improve their adaptability and extra stretch ability including the lightweight inside. Through the examinations, we considered the effects of pressure, strain and flexure stacks on infill designs. It is observed that this investigation brings new developments into delicate 3D printing by giving these significant bits of knowledge into the plan procedure.

III. OBJECTIVES

- To investigate the effects of thicknesses and materials, manufacturing processes and length of span of honeycomb structure panel.
- To perform static structural analysis of 3D printed material with the help of ANSYS 19 software.
- To determine reaction force for application of load/displacement on honeycomb structure panel.
- Manufacturing of 3D printed honeycomb panel to perform three-point bend test.
- Validation of experimental results of three-point bending test with FEM simulation.

IV. METHODOLOGY

Step 1:- Initially research papers are gathered and studied to find out research gap for project then regarding parameters are studied and the objectives are decided. After going through these papers, we learnt about 3D printed honeycomb sandwich panel.

 DOI : 10.35291/2454-9150.2020.0561

ISSN : 2454-9150 Vol-06, Issue-05, Aug 2020

Step2:-The Research gap is studied to understand the limitations over other for project objectives.
Step 3: - After deciding the components, the 3 D Model and drafting will be done with the help of ANSYS software.
Step 4: - The components will be manufactured through 3d printing and three-point bend test will be performed.
Step 5: -The testing will be carried out and result and conclusion will be drawn.

V. APPLICATION OF PROJECT

Nowadays it is observed in 4-wheeler vehicle that front bumper are designed in either rectangular or circular shape with uniform cross section. But in present research to enhance the shock absorbing resistance design is modified in hexagonal structure with varying thickness of hexagonal shape. To understand and implicate the result for current design and future scope for new design implementation.

Catia model for flexural strength of honeycomb structure

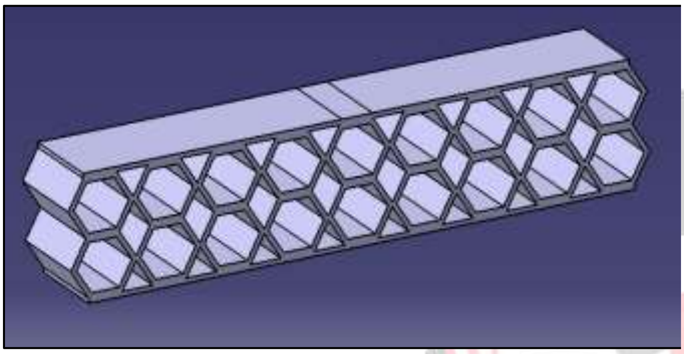


Fig.1. CATIA model of honeycomb panel with 1mm thickness

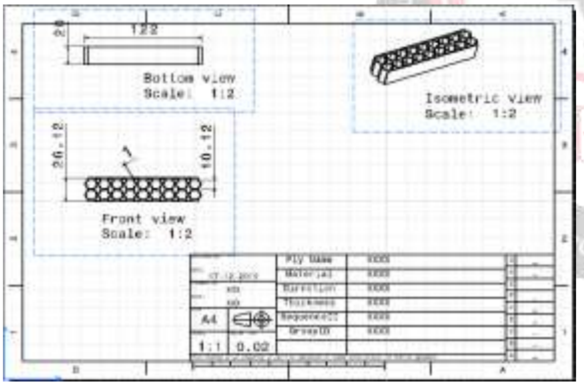


Fig. 2. Drafting of honeycomb panel with 1 mm thickness

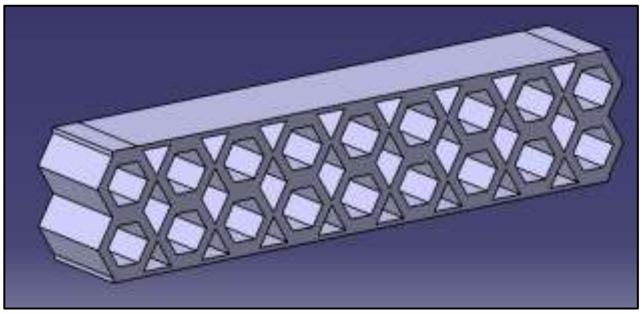


Fig.3. CATIA model of honeycomb panel with 2 mm thickness

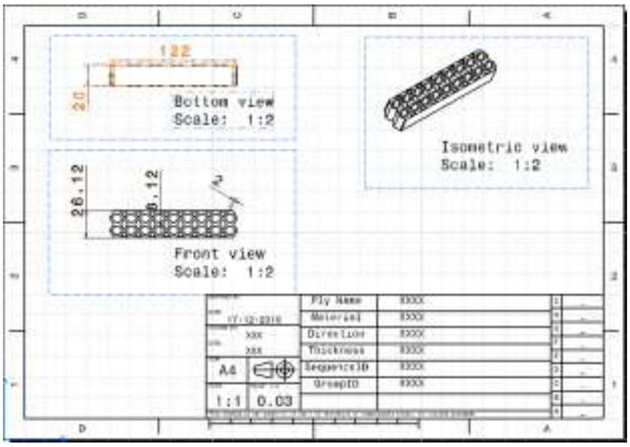


Fig.4. Drafting of honeycomb panel with 2 mm thickness

Table.1 Material Properties

Properties of Outline Row 4: POLYACETAL

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	1410	kg m^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poisson's Ratio	
6	Young's Modulus	3000	MPa
7	Poisson's Ratio	0.32	
8	Bulk Modulus	2777.8	MPa
9	Shear Modulus	1136.4	MPa

FE ANALYSIS:

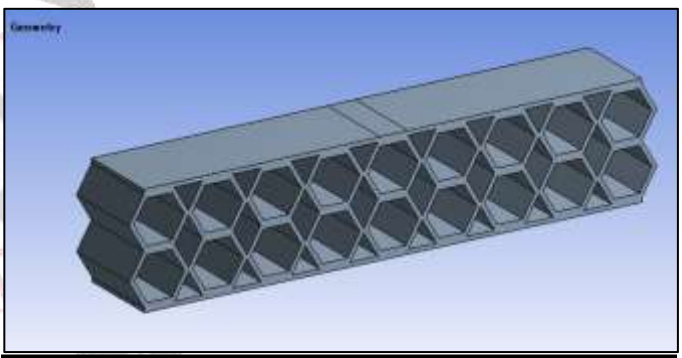
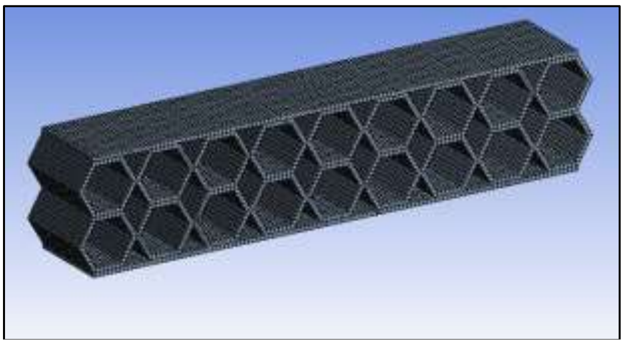


Fig.5. CATIA model imported in ANSYS

In ANSYS meshing is performed as similar to discretization process in FEA procedure in which it breaks whole components in small elements and nodes. So, in Finite element analysis boundary condition equation are solved at their elements and nodes. ANSYS Meshing is automated general-purpose, high-performance product. It produces the most appropriate mesh for effective, accurate, efficient Multiphysics solutions. A mesh technique is well suited for a specific analysis which is generated with a single mouse click for all components in a model.



 DOI : 10.35291/2454-9150.2020.0561

ISSN : 2454-9150 Vol-06, Issue-05, Aug 2020

Statistics	
Nodes	35490
Elements	19780

Fig.6. Details of meshing

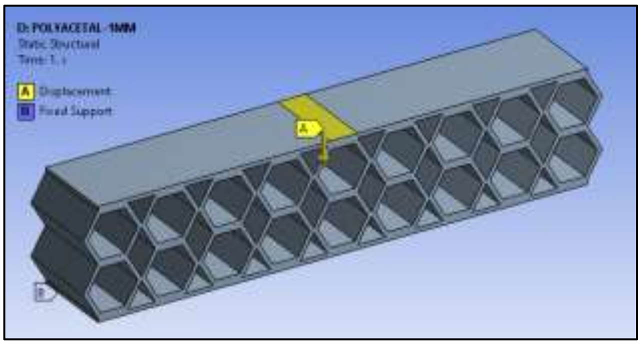


Fig.7. structural view of honeycomb panel

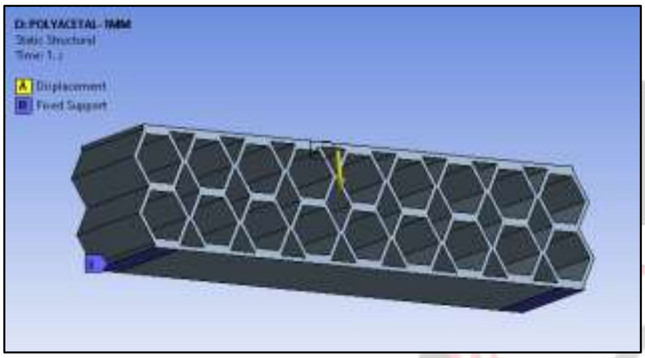


Fig.8. Boundary conditions

Fixed support is applied at base indicated in blue region and displacement of 10 mm is applied at top indicated in yellow color to determine reaction force, deformation and stress.

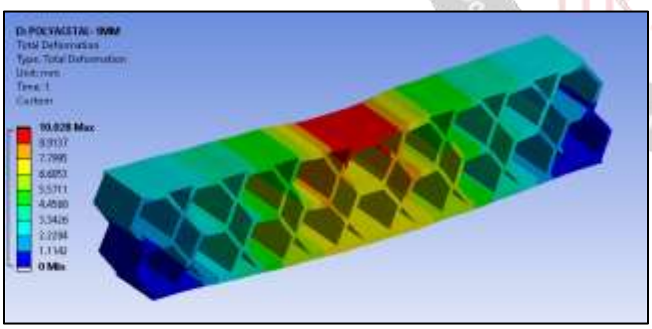


Fig.9. Deformation result

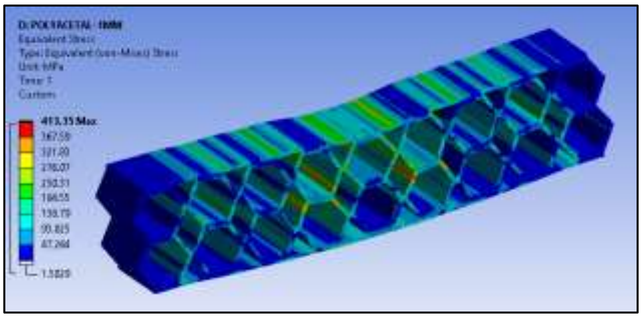


Fig.10. Equivalent stress result

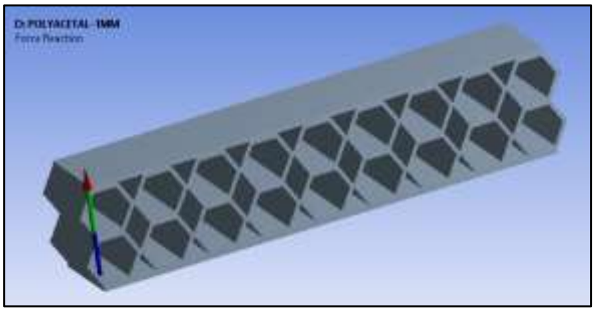


Fig.11. Force reaction result

Table.2. Force reaction result

Maximum Value Over Time	
X Axis	2.3826e-004 N
Y Axis	2326.6 N
Z Axis	1.6708e-008 N
Total	2326.6 N

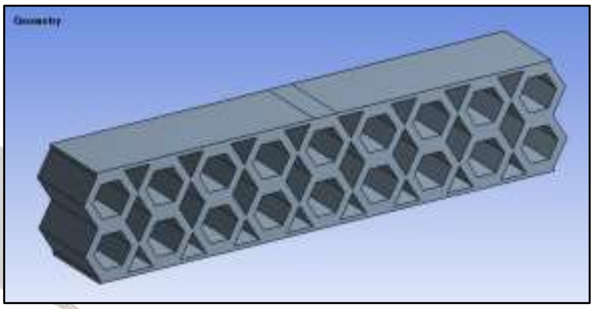
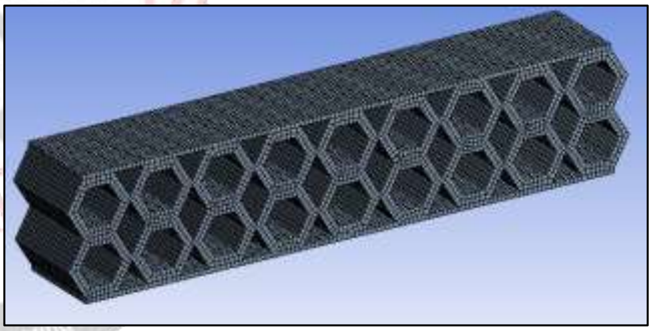


Fig.12. Honeycomb with 2 mm thickness imported in ANSYS



Statistics	
Nodes	47943
Elements	32720

Fig.13. Details of meshing

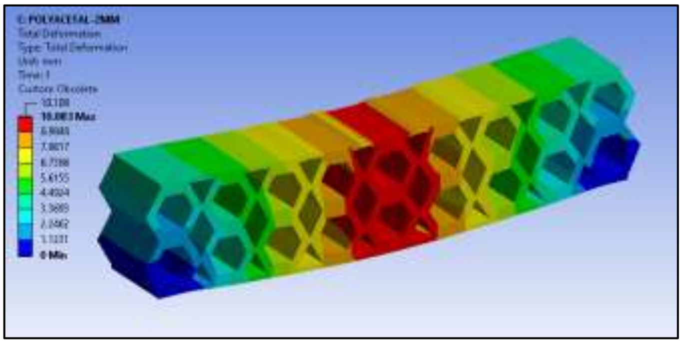


Fig.14. Total deformation results

 DOI : 10.35291/2454-9150.2020.0561

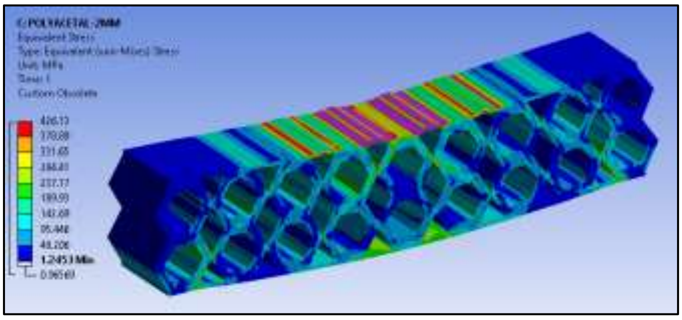


Fig.15. Equivalent stress result

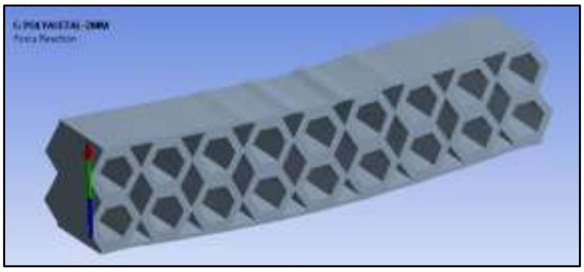


Fig.16. Force reaction result

Table.3. Force reaction result

Maximum Value Over Time	
X Axis	8.8538e-002 N
Y Axis	7523.6 N
Z Axis	5.2055e-009 N
Total	7523.6 N

VI. RESULT AND DISCUSSION

1. Reaction Force For Polyacetal Material With The Thickness of 1 mm= 2326.6N
2. Reaction Force For Polyacetal Material With The Thickness of 2 mm= 7523.6N

Table.4. result of analysis

Reaction force for 1mm of thickness	2326.6 N
Reaction force for 2mm of thickness	7523.6 N

From the result of analysis one can observe that higher the thickness higher the reaction force and also higher the load it can bear and with the introduction of honeycomb structure in the analysis the results obtained for the beam for the shock absorbing capacity are more than the without one.

The stiffness also increases with the higher thickness

VII. CONCLUSION

The goal of the research work was to introduce honeycomb structure in the beam or any application as an alternative for the existing automobile bumper and to observe the effects of hexagonal honeycomb structure to reduce the risk of injuries to the occupant or pedetrician. In present research honeycomb panel structure with 1mm and 2 mm thick is analyzed to determine stiffness, stress and deformation. It is observed from existing result that honeycomb with 2 mm thickness have greater reaction force, for beam. Which gives higher strength, more absorbing capacity compared to 1 mm thickness of honeycomb structure. So from work it has been analyses through the Ansys that by introducing honeycomb structure in the application it can bear more force or load and with the increase of thickness it can bear more strength and the shock absorbing capacity also get increases due to honeycomb structure.

VIII. FUTURE SCOPE

The following recommendations can be made for future scope work in this thesis

1. Improvement can be done in design of honeycomb structure beam, changes in material used by varying their flexural strength and orientations of layer used in the laminate.

2.in present research face sheet and foam are joined together rigidly, but still better results can be obtained if the it gives more details of adhesive material properties while modeling the sandwich beam.

3. A multiple -cored sandwich beam can be redesigned with various foam bonded together by material of adhesive.

IX. ACKNOWLEDGMENT

The authors acknowledge the research paper guide, HOD of department and the principal of the Vikhe patil college of engineering for the support provided during the work of the research.

REFERENCES

[1] AMM Nazmul, bashir khoda, Honeycomb pattern on thin wall object with grain based 3d printing, Procedia Manufacturing 12 (2017).

[2] Bates , S . R . G., Farrow, I. R., & Trask, R. S. (2016). 3D printed polyurethane honeycombs for repeated tailored energy absorption. Materials and Design, 112, 172-183. https://doi.org/10.1016/j.matdes.2016.08.062

[3] Yiran Man, Xudong Luo, Zhipeng Xie, and Dianli Qu, Influence of 3D Printed Topological Structure on Lightweight

Mullite Load Bearing Board in Thermal Environment, Hindawi, Advances in Materials Science and Engineering, Volume 2020, Article ID 8340685, 8 pages, https://doi.org/10.1155/2020/8340685

[4] F. N. Habib, P. Iovenitti, S. H. Masood & M. Nikzad (2017): In-plane energy absorption evaluation of 3D printed polymeric honeycombs, Virtual and Physical Prototyping, DOI:10.1080/17452759.2017.1291354

[5] Kanygul Chynybekova and Soo-Mi Choi, Flexible Patterns for Soft 3D Printed Fabrications, Symmetry 2019, 11, 1398; doi:10.3390/sym11111398, Symmetry 2019, 11, 1398

[6] Simon R.G. Bates, Ian R. Farrow, Richard S. Trask , Compressive behaviour of 3D printed thermoplastic polyurethane honeycombs with graded densities. Jmade (2018), https://doi.org/10.1016/j.matdes.2018.11.019

[7] M.H. Norhidayah, A. Hambali, ,Y. Mohd Yuhazri, M. Zolkarnain, Taufik,and H.Y. Saifuddin "A Review of Current Development in Natural Fiber Composites in Automotive Applications", Applied Mechanics and Materials Vol. 564 (2014) pp 3-7 Online available since 2014/Jun/06 at © (2014) Trans Tech Publications, Switzerland

[8] Oliver Döbrich, Thomas Gereke, ChokriCherif "Modelling the mechanical properties of textile-reinforced composites with a near micro-scale approach" [9] "Modelling of textile composites with fibre strength variability" by M.Y. Matveev, A.C. Long, I.A. Jones, Composites Science and Technology 105 (2014) 44–50

 DOI : 10.35291/2454-9150.2020.0561