International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Modeling and Analytical Approach for Cotton/Epoxy Composite Laminates

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ABSTRACT

Composites are becoming anessential part of today's material because they offer advantagessuch as low weight, corrosion resistance, high fatigue strength; faster assembly etc. composites aregenerating curiosity and interest all over the worlds.The objective of this research is to provide the simulation methodology for natural fiber composites to predict the tensile strength using FEA tool: ANSYS APDL. For this purpose, cotton fiber as a reinforcement and epoxy resin as a matrix is selected for the analysis of composites due to theavailability of its experimental data. The model is proposed for the composite laminates with 3 layers, 5 layers and 7 layers of fiber and resin. The models are prepared as per the specimen size of ASTM D3039 standard. The failure of the composite laminates is considered for the analysis of composite as per the matrix failure criteria. The comparison of the strength is carried out for the 3 layer, 5 layer, and 7 layer laminates and signifies outcome as increase the volume fraction of fiber, the tensile strength of the composites is increasing.The proposed modeling and analytical approach may be preferred for the prediction of the tensile strength of the composite laminates.

KEYWORDS

Cotton/Epoxy Composite, Modeling of composite laminates, Analysis of composite laminates, Comparison.

INTRODUCTION

The composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents[1].These high-performance composites consist of different constituents which are subjected to structural loads, or any type of loading, different deformations occur in different constituents leading to large differences of deformations and stresses between these constituents, which are known as residual deformations and stresses. Figure 1 shows the classification of composites [2].

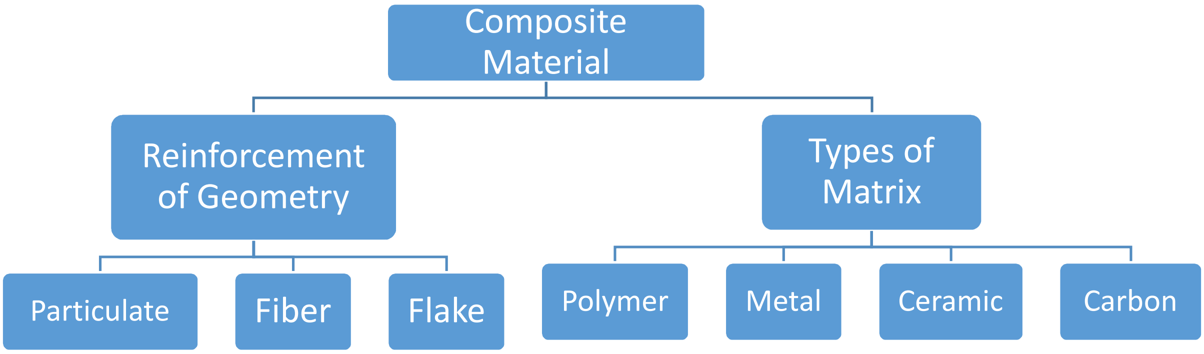

Figure 1. Classification of Composites [2].

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LITERATURE REVIEW

ANSYS is general purpose finite element analysis (FEA) software package which is engineering simulation software (computer- aided engineering, or CAE) that utilizes Finite element Analysis. It is a numerical method in which a complex system is divided into very small pieces. The software uses equations that generate the behavior of these elements and solves them all [3].

Piyush Gohil et al. (2011) discovered that the attempts made for jute and other repeatedly used natural fiber, provides data but there is a paucityof experimental data for other seldom natural fiber like cotton, banana, pineapple leaf, and other. So, in present study natural fiber is selected as the scope of the study. Piyush Gohil et al. (2011) also studied Cotton-Epoxy Composites: development & mechanical characterization and provided the experimental evaluation as per table 1. Hence, the cotton fiber reinforced composites is selected for the analysis of composites due to theavailability of experimental data.

Table 1. Properties of material [3].

Sr. No.	Constitute	Elastic modulus (GPa)	Poisson's Ratio(υ)
1	Cotton Fiber	8.20	0.3
2	Epoxy Resin	2.85	0.3

Many researchers have analytically and experimentally investigated the mechanical properties (tensile, flexural, toughness, fatigue etc.) of FRP composites [4-6] and other used finite element analysis to predict the behavior of FRP and their mechanical properties [7-10]. Houshyar et al. (2009) &Ghassemieh and Nassehi (2001) developed a micromechanical model to understand the behavior of fiber and particulate reinforced polymeric composites. [11, 12]. This model was used to simulate stress distribution and to identify the maximum stress concentrations locations. The interfacial stresses evaluated by themodel were compared with the well-known shear lag and modified shear lag models. Horsta et al. (1998)developed a finite element model to predict the interfacial tensile and shear stress and validated experimentally and perfect bonding between fiber and matrix was considered [13]. Caporale et al. (2006)examined the behavior of unidirectional fiber-reinforced composites with imperfect interfacial bonding with the aid of finite element method [14]. However, a few efforts were made to relate the experimental results of mechanical properties of FRP with the finite element analysis results while considering the isotropic behavior of composites [15]. The main advantage of using finite element analysis is to generate the quantitative data about the failure morphology of the composites and to understand the deviation of results from the experimental results. Hence, in present work, an attempt is carriedout for the prediction of the tensile strength of thecomposite material by finite element analysis using FEA Tool: ANSYS APDL and deliversthe simulation methodology for natural fiber composites laminates.

MODELING APPROACH

The modeling is proposed for the analysis of composite laminates by considering the 3layers, 5layers and 7 layers of fiber and resin. The modeling of 3layers, 5layers, and 7 layers are shown in figure 2, figure 3 and figure 4 respectively.The modeling is carried out in Autodesk fusion 360 software. Here, 3 layers, 5 layers, and 7 layers are selected to vary the volume fraction of fiber among the composite laminates. The layers of laminates are restricted for up to 7 layers because with increasing fiber layer 3 to 4, the composite layers are to be 9 layers.For the 9 layers of composite laminates, the volume fraction of fiber reaches to 0.44 which is practically difficult to achieve during the fabrication of composites. The interphase is not properly generated between fiber and matrix for this case. The coding and layer details are shown in Table 2.

Table 2. Coding and layer details for the modeling.

Sr. No.	Laminate Layers	Fiber Layers	Resin layers	Code
1	3	1	2	RFR
2	5	2	3	RFRFR
3	7	3	4	RFRFRFR

The modeling is carried with the size of 250 mm*15 mm*4 mmas per the ASTM D3039. During the modeling of composites volume fraction of fiber, volume of fiber, matrixare proposed forRFR, RFRFR and RFRFRFR as described below.

The volume of composite is proposed for RFR, RFRFR and RFRFRFR as per the equation 1,

$$V_c = L*W*H \qquad \text{Eq. (1)}$$

The volume of fiber is proposed for RFR as per the equation2,

$$V_f = \frac{V_c}{3} \qquad \text{Eq. (2)}$$

The volume of fiber is proposed for RFRFR as per the equation 3,

$$V_f = \frac{V_c}{5} \qquad \text{Eq. (3)}$$

The volume of fiber is proposed for RFRFRFR as per the equation 4,

$$V_f = \frac{V_c}{7} \qquad \text{Eq. (4)}$$

The volume fraction of fiber is proposed as per the equation 5,

$$v_f = \frac{V_f}{V_c} \qquad \text{Eq. (5)}$$

The volume of matrix is proposed as per the equation 6,

$$V_m = V_c - V_f \qquad \text{Eq. (6)}$$

The calculated values of volume fraction of fiber, volume of fiber, matrix and composites are shown in table 3.

Table 3. Volume fraction of fiber, volume of fiber, matrix and composites details for the modeling of composite laminates.

Sr. No.	Composite laminates	Volume of fiber V_f (mm^3)	Volume of matrix V_m (mm^3)	Volume of composite V_c (mm^3)	Volume fraction of fiber (v_f)
1	RFR	4987.50	10012.50	15000	0.33
2	RFRFR	6000	9000	15000	0.40
3	RFRFRFR	6412.50	8587.50	15000	0.42

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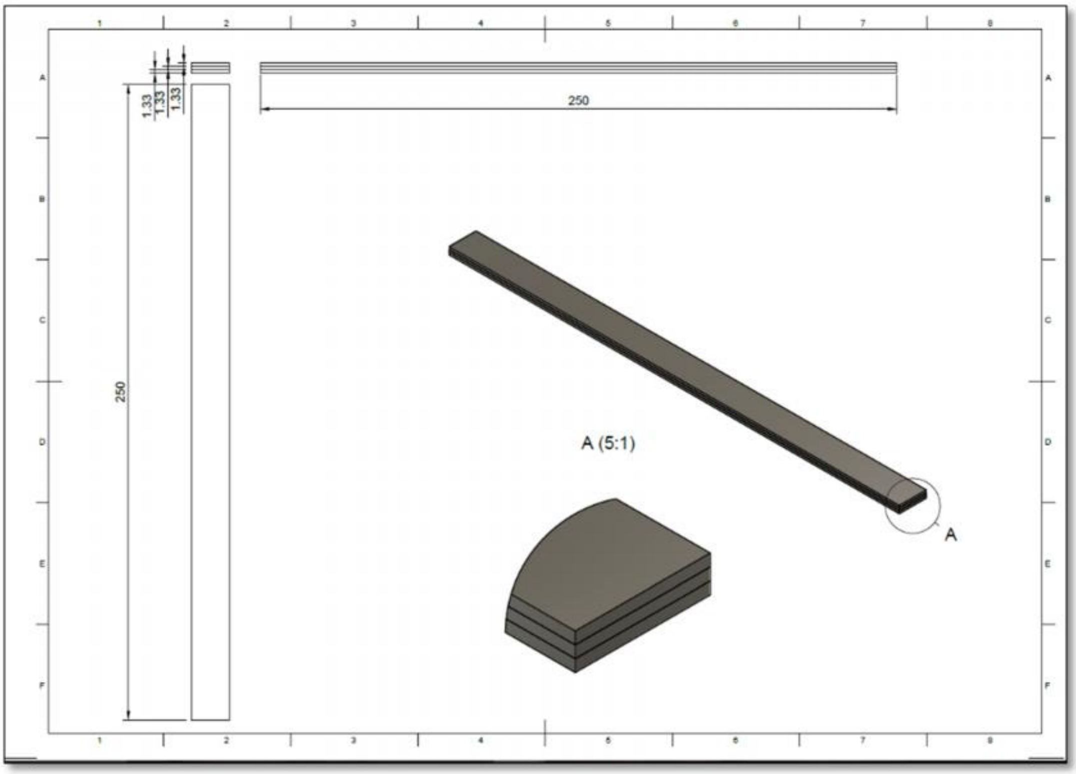

Figure 2. Modeling of composite laminates with 3 layers arrangement.

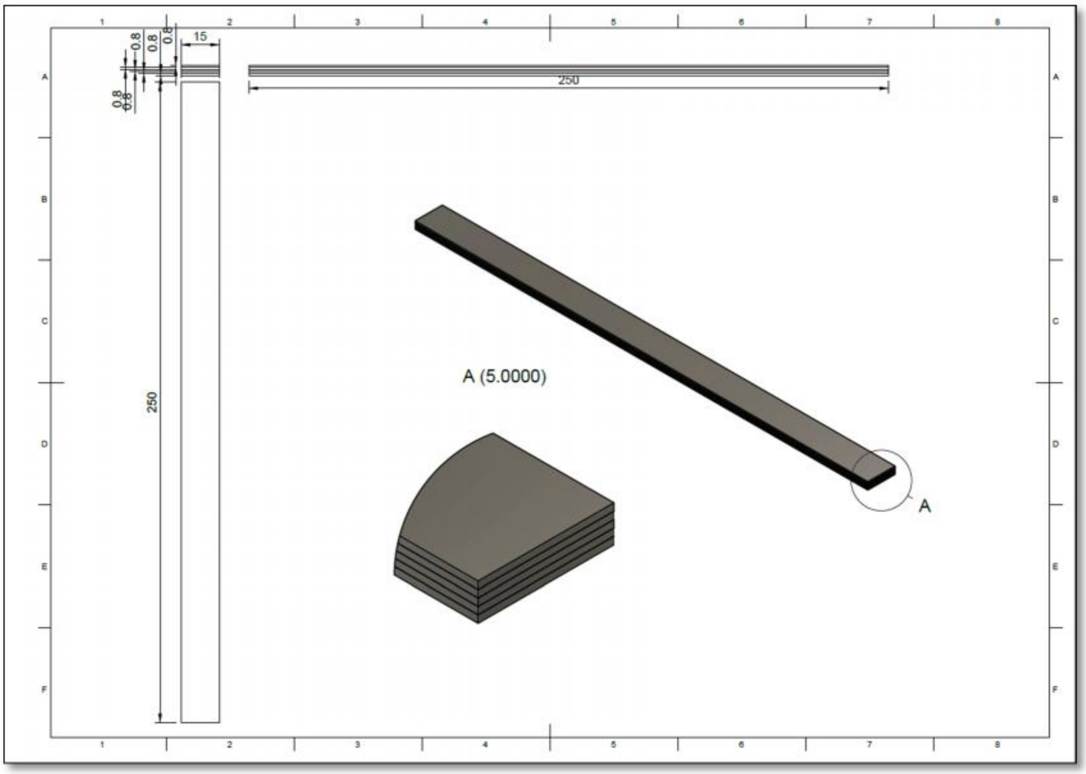

Figure 3. Modeling of composite laminates with 5 layers arrangement.

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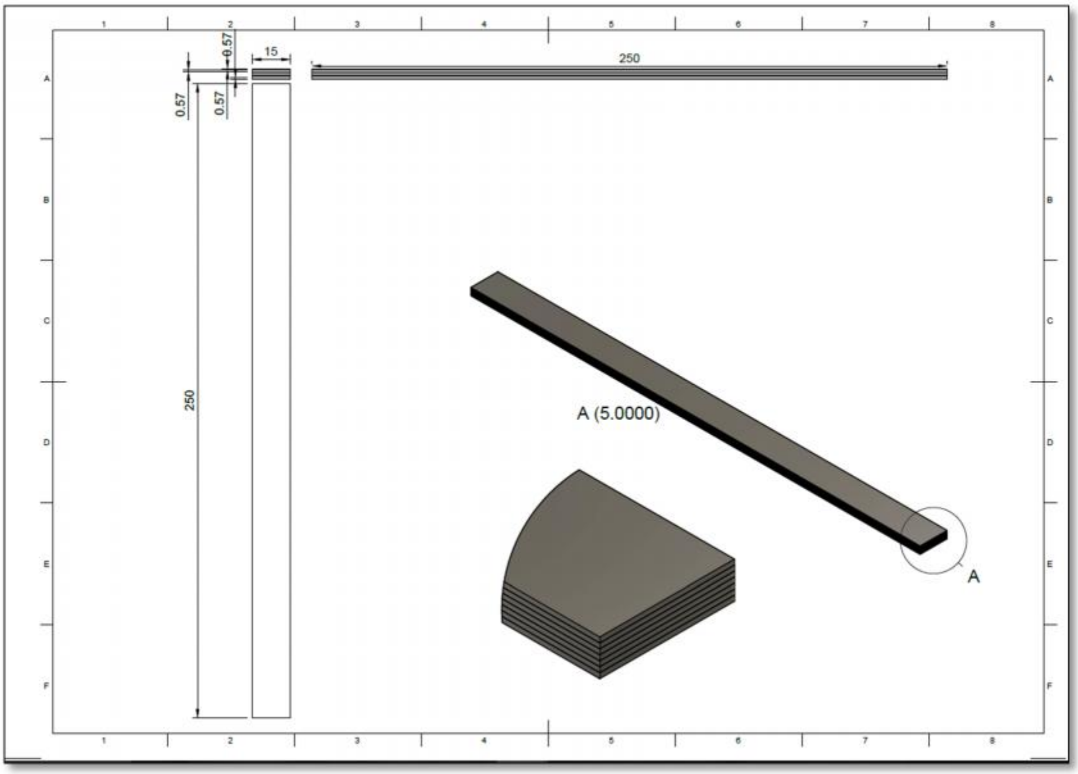

Figure 4. Modeling of composite laminates with 7 layers arrangement.

ANALYTICAL APPROACH

The methodology flow for the analysis is shown in figure 5. The ANSYS 15 is used for the analysis.

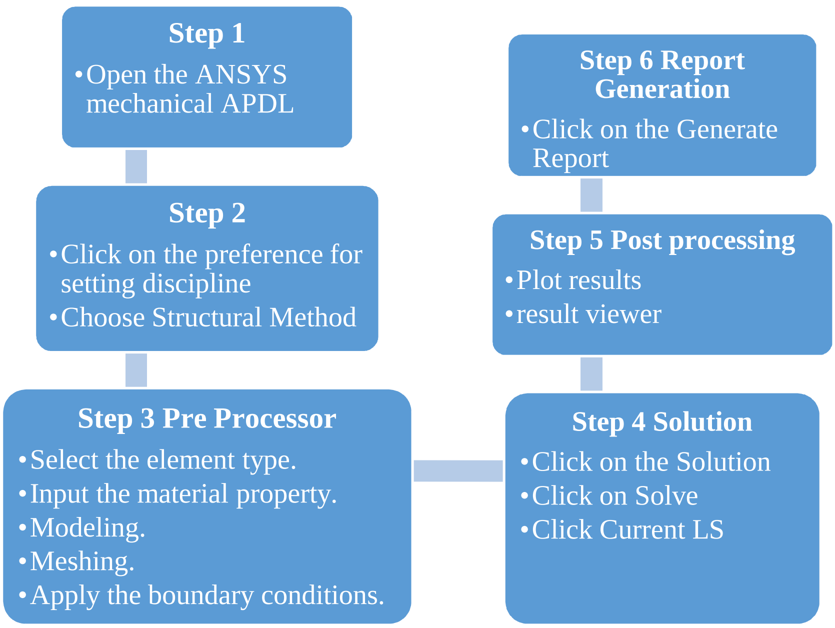

Figure 5. Analytical flow methodology.

The experimental elastic modulus of fiber was taken 8.20 GPa and epoxy resin was take as 2.81 GPa as per the literature as shown in table 1 for providing the material property during analysis. The poisons ratio was taken as 0.3. The fine tetra meshing is carried out during the analysis. The snapshot of it is shown in figure 6.

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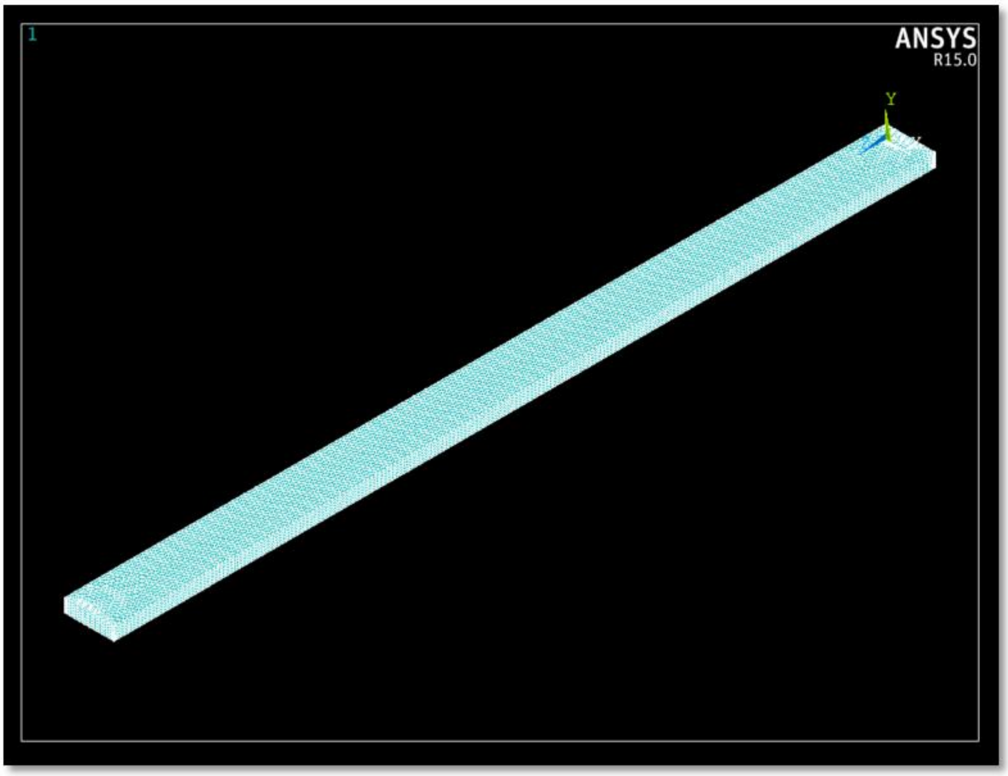

Figure 6. Details of meshing (3D)

SagarChokshi (2011) tested the epoxy resin and provided the epoxy resin failure at 0.9 mm [16]. So, in thepresentstudy, the deformation of composites is taken as per matrix failure criteria as 0.9 mm in the analysis of composites during analysis of composite.

RESULT AND DISCUSSION

The snapshot of the analytical results are shown in figure 7, Figure 8 & Figure 9. The results are also shown in table 4. The comparison of tensile strength for RFR, RFRFR and RFRFRFR composite laminates is carried out as shown in figure 10.

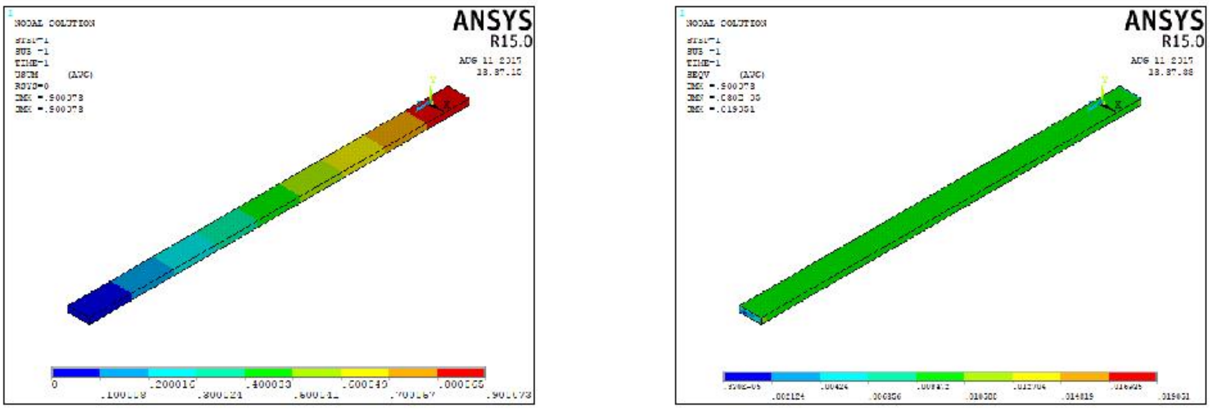

Figure7. Layered RFR (Resin-Fiber-Resin)

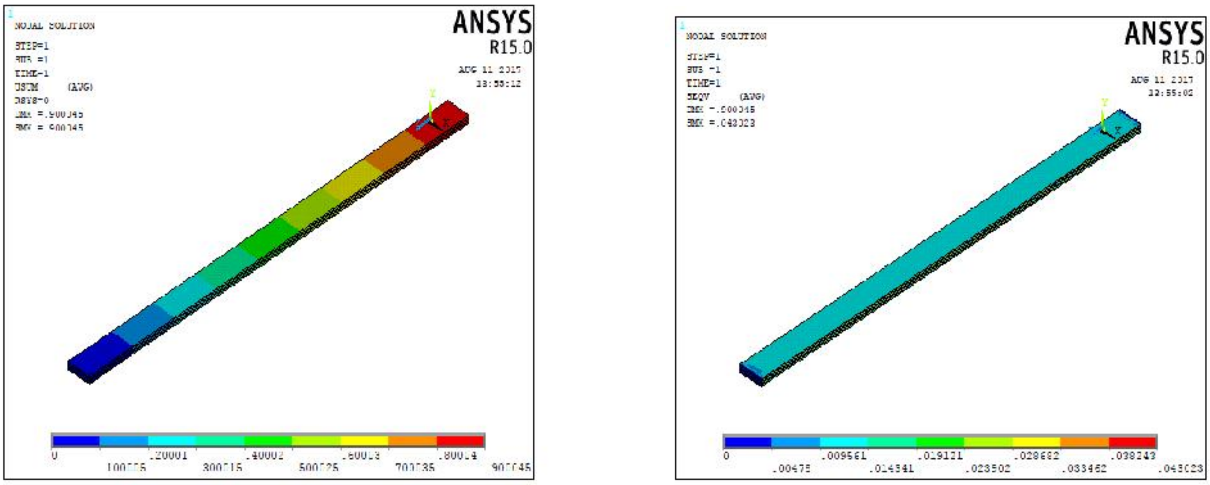

Figure8. Layered RFRFR (Resin-Fiber-Resin-Fiber-Resin)

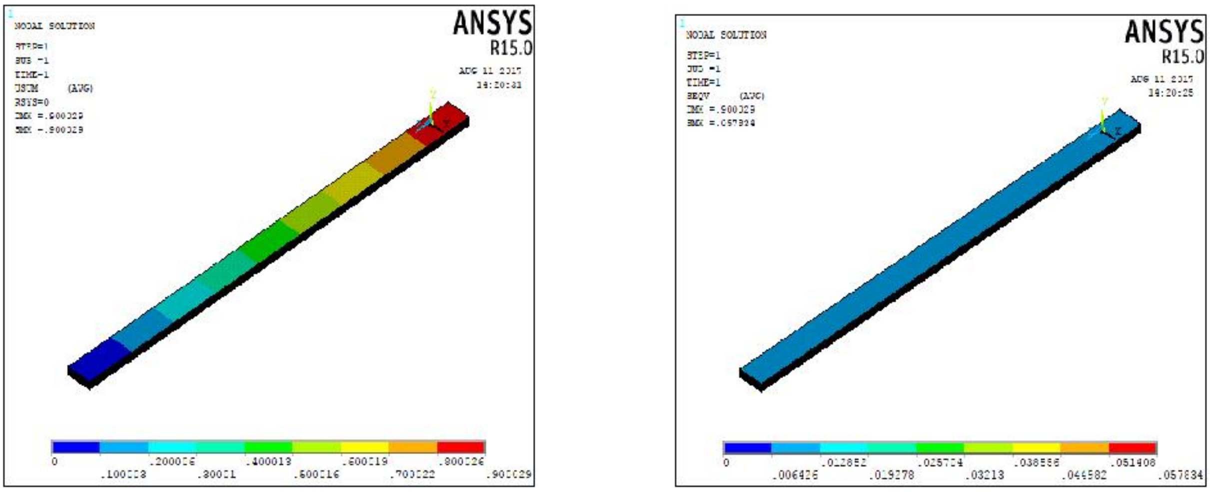

Figure9. Layered RFRFRFR (Resin-Fiber-Resin-Fiber-Resin-Fiber-Resin)

Table 4. Summary of Results

Sr. No.	Composite laminates	Volume fraction of fiber (V_f)	Tensile Strength (MPa)
1	RFR	0.33	19.05
2	RFRFR	0.40	43.02
3	RFRFRFR	0.42	57.82

Through the table 4, the volume fraction of fiber is measured for 3 layers, 5 layers and 7 layers are in the range of 0.33 to 0.42. It is observed that the tensile strength of fiber in the range of 19.05 to 57.82 MPa. Through the figure 10, it is observed that with an increase in volume fraction of fiber, the tensile strength of composite laminates increases.

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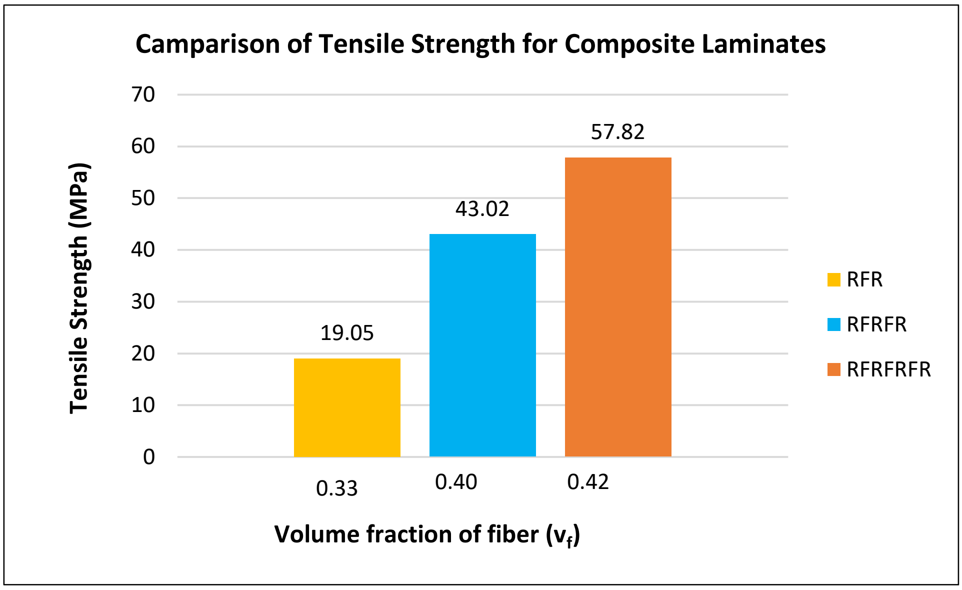

Figure 10. Comparison of tensile strength for composite laminates.

CONCLUSION

The paper concludes the following significance outcomes.

1. The tensile strength of the composite laminates increases, with increase in volume fraction fiber.

2. The modeling and analytical approach may be preferred for the prediction of thetensile strength of the composite laminates.

NOMENCLATURE

V_c = Volume of composite laminate

V_f = Volume of fiber

V_m = Volume of matrix

v_f = Volume fraction of fiber

L=Length of composite laminate

W= Width of composite laminate

H= Height of composite laminate

REFERENCES

[1] Kaw, A. K. 1997. Mechanics of Composites Materials.
[2] Gohil, P. 2011. Cotton-Epoxy Composites: Development and MechanicalCharacterization.
[3] Krishnamoorthy,K., Sasikumar, T. 2016. Analysis and Characterization of Tensile Property of the Composite Specimen using ANSYS.
[4] Ascione, F., Feo, L., Maceri, F. 2008. Composites Part B: Engineering. An experimental investigation on the bearing failure load of glass fibre/epoxy laminates.
[5] Shokrieh, M.M., Omidi, M.J. 2009. Composite Structures.
[6] Haider, A. Z., Zhao, X.L., Riadh, 2011. A.M. Procedia Engineering.
[7] Segurado, J., LLorca J. 2006. Mechanics of materials, Computational micromechanics of composites:The effect of particle spatial distribution.

[8] Zhang, Y. X., Yang, C.H. 2009. Composite Structures, Recent developments in finite element analysis for laminated composite plates.
[9] Kabir, M.R., Lutz, W., Zhu, K.,2009. Schmauder, S. Computational Materials Science,Fatigue modeling of short fiber reinforced composites with ductile matrix under cyclic loading.
[10] Goh, K. L, Aspden, R. M, Hukin, DWL. 2004. Composite Science and Technology.
[11] Houshyar, S., Shanks, R.A., Hodzic, A. 2009. Express Polymer Letters, Modelling of polypropylene fibre-matrix composites using finite element analysis.
[12] Ghassemieh, E., Nassehi, V. 2001. Polymer Composites, Prediction of failure and fracture mechanisms of polymeric composites using finite element analysis.
[13] Horsta, J. J., Salienkob, N. V.; Spoormaker, J. L. 1998. Composites Part A,
[14] Caporale, A., Luciano, R., Sacco, E. 2006. Computers and Structures, Micromechanical analysis of interfacial debonding in unidirectional fiber-reinforced composites.
[15] Naik, K.N. 1994. Woven Fabric Composites Introduction.
[16] Sagar Chokshi.2011. PG Thesis: Strength Prediction of Unidirectional Composites with Three Phase RVE Using APDL, CSPIT- CHARUSAT, Changa.