Structural Analysis of Kevlar-49 Fiber Reinforcement Composite Material using FEM

Mudike Karthik Yadav[1]
[1]*Research scholar*
Mechanical engineering
Kakatiya Institute of Technology and science, Warangal, India.

B. Ravi Kumar[2]
[2]*Assistant professor*
Mechanical engineering
Kakatiya Institute of Technology and science, Warangal, India.

D. Sharon Stephen[3]
[3]*Research scholar*
Mechanical engineering
Kakatiya Institute of Technology and science, Warangal, India

G. Vikas[4]
[4]*Research scholar*
Mechanical engineering
Kakatiya Institute of Technology and science, Warangal, India.

J. Swetha[5]
[5]*Research scholar*
Mechanical engineering
Kakatiya Institute of Technology and science, Warangal, India.

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Abstract - *In the process of manufacturing automobiles, it is necessary to have insight on the weight reduction of the vehicle's components so as to increase the performance. Considering this aspect, the usage of composite materials comes into light. It is observed that the relative values of strength and stiffness of composite materials when compared to most metals and non-metals are extremely high with a relatively small increase in weight. The components which demand maximum strength and stiffness respective to weight seek the application of composite materials. Finite Element method is a computational analysis method that provides the user to perform diverse analysis in an easy manner. This project is an attempt to understand the nature of composite materials under the application of load. The structural analysis of the Kevlar-49 fiber reinforcement and epoxy composite material is done using ANSYS ACP software.*

Key Words: Weight reduction, Stack ups, Composites, Kevlar fiber-49 reinforcement, epoxy, ANSYS ACP, FEM.

1.INTRODUCTION

The focus on composite materials brightened when in the 1930's. "Composite materials" also referred to as "composition materials" or briefly "composites," as the most frequently used term, display materials consisting of two or more components. The discovery on composite materials has been evolving since the idea that two or more materials when used together as one performs better than either of the single materials combined. The two different components display considerably diverse physical and/or chemical characteristics. Merging the two or more basic materials creates a new material with features different from the single constituents. The manufacturing of machine parts using plastics reinforced from glass fibers was made possible the study on composite materials is done in the search of materials that out performs the usual materials composite materials allows us to design a material specific to a required task. The composite material is usually constituted of fibers, lamina, flakes, particles and matrices. Polymer matrix composites have developed to the fastest emergent and most extensively used composites, compared with well-established materials like metals.

1.1 Kevlar-29 Fiber Reinforcement

Kevlar-49 fiber composites are usually strong composites materials compared to others glass and carbon composite materials. It is a synthetic material belongs to aramids group, The chemical compound of Kevlar fiber is poly-para-phenylene terephthalamide, Kevlar is mainly used in bullet proof materials, has it's been well known for its high tensile strength to weight ratio which is more than carbon fiber and glass fiber.

1.2 Basic properties of Kevlar-49 fiber

Fiber Diameter (μm)	12
Density (kg/m^3)	1467.0
Longitudinal Modulus (GPa)	151.7
Transverse Modulus (GPa)	4.14
Longitudinal Shear Modulus (GPa)	2.90
Longitudinal Poisson's Ratio	0.35
Longitudinal Tensile Strength (MPa)	2757.9
Longitudinal Compressive Strength (MPa)	517.1

** As provided by the manufacturer, Dupont Inc. USA*

2. LITERATURE REVIEW

This report provides a brief overview of the FEM analysis of the composite materials. A special module designed for the composite materials ANSYS ACP (PRE & POST) is used to analyses the structure of the composite materials. In this report we analyzed the deformation of the kevalr-49 fiber UD and epoxy composite materials under an application of pressure. Eight categories of orientation stack up are analyzed with different fabric thicknesses. Composite materials have a large scope of design, testing and analysis. Since they are used in many industries including the beverage, food processing, automobile, aerospace, ship and dock industries, Composite materials have become the center of research for materials. Many studies have been done based on the design of the components using the composite materials. These components include the shafts, wheel rims, compressors etc. Since the scope of the composites is not just being comprised of the shape but also the fabric thickness, stack up orientation, matrix type etc., we have performed analysis on the basic fabric thickness and stack up orientations. There are various orientation and stack up methods that can be analyzed in the composite materials. In this project we have considered 5 layers of different thicknesses in each plank with various orientations, to find out which gives the least deformation for the applied pressure. These days, primarily, the finite element method is used to do the design and analysis of composite materials. Ansys ACP is a computational analysis method

3. STRUCTURAL ANALYSIS

Engineering analysis relies heavily on numerical simulation-based methods, which are characterized by low costs, accurate, results and quick processes. Today, advanced numerical simulation techniques are being increasingly implemented, partly as a result of technological advancements. Numerical simulations are becoming significantly more advanced due to the flexibility of its implementation. In this paper, we present ACP Workbench 19.2, a unique tool for handling composite materials using advanced numerical methods. This software is able to create reinforcement and its different orientations in an effective manner. Assigning an orthotropic property to reinforcement is also a very easy process within ANSYS ACP. This will provide the reliability in the composite analysis results and guide to avoid experimentation. Lastly, the laminate with matrix will be more user-friendly.

3.2 Loads and Constraints

- Dimensions of the plank: 1000*500*t (in mm)
- Thickness of the plank: 3mm, 5mm
- Constraints: all sides of the plane are fixed
- Pressure: 100pa
- Type of composite: Kevlar-49 fiber UD and Epoxy
- No. of layers: 5

Orientation Stickups of 5 Layers	Angles of Each Layer in Degrees with X-axis
Category 1	0,0,0,0,0
Category 2	90,0,90,0,90
Category 3	90,90,90,90,0
Category 4	90,90,90,90,90
Category 5	0,30,45,60,0
Category 6	0,45,90,45,0
Category 7	0,30,60,30,0
Category 8	20,45,20,45,20

Table 3.2.1 Categories of orientation stack ups

*This orientation is applied for both models (3mm&5mm).

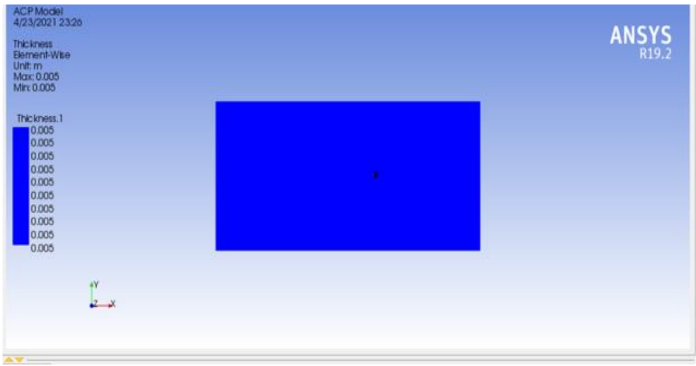

Fig 3.2.1 Plank of Thickness 5mm

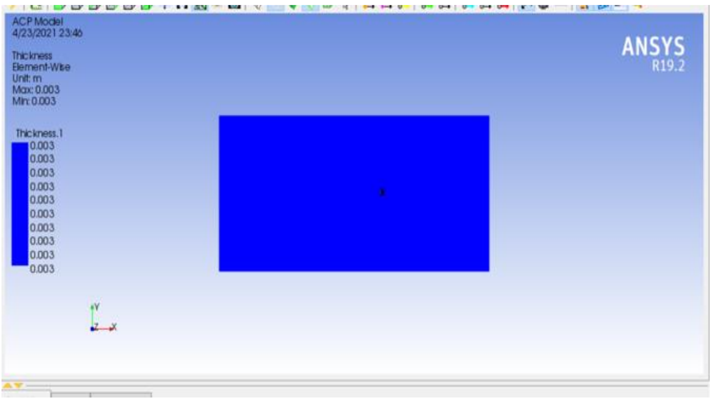

Fig 3.2.2 Plank of Thickness 3mm

4. RESULTS

4.1 Category 1 – (0,0,0,0,0)

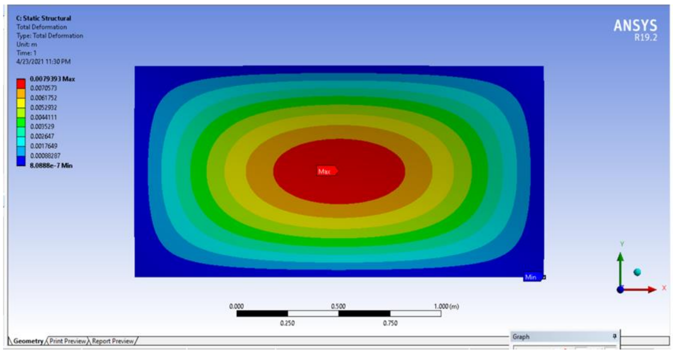

Fig 4.1.1 Deformation of 5mm thickness plank

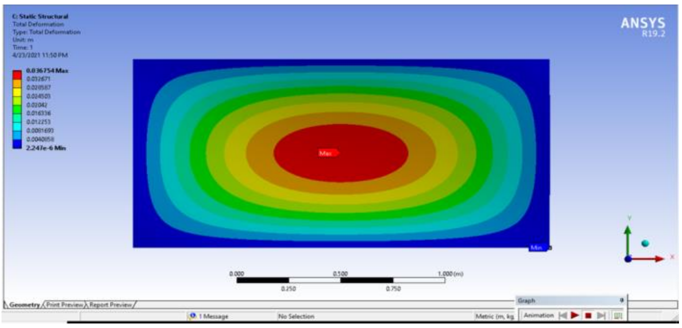

Fig 4.1.2 Deformation of 3mm thickness plank

4.2 Category 2 – (0,90,0,90,0)

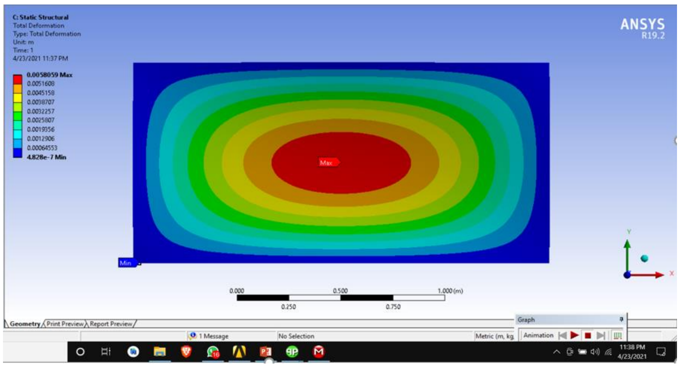

Fig 4.2.1 Deformation of 5mm thickness plank

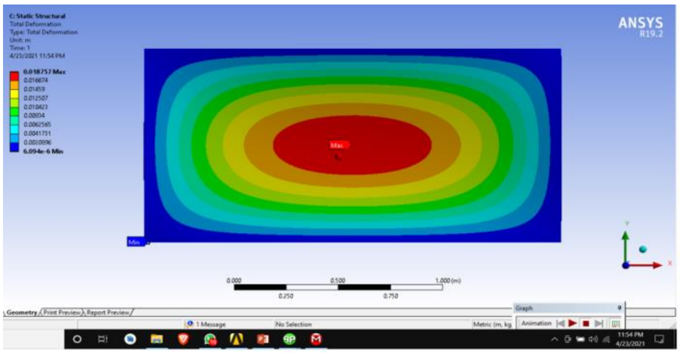

Fig 4.2.2 Deformation of 3mm thickness plank

4.3 Category 3 – (90,90,90,90,0)

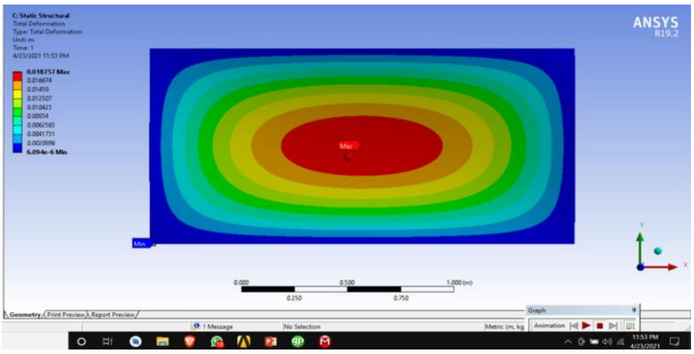

Fig 4.3.1 Deformation of 5mm thickness plank

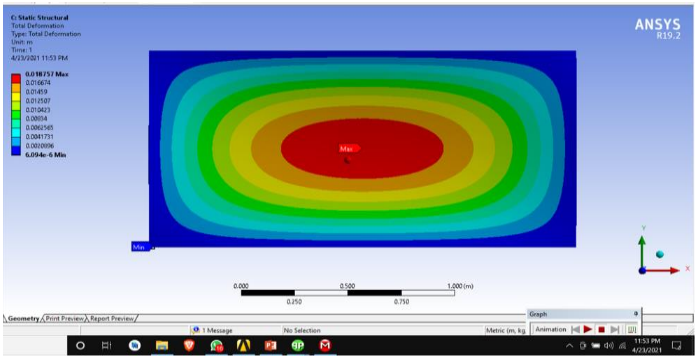

Fig 4.3.2 Deformation of 3mm thickness plank

4.4 Category 4 – (90,90,90,90,90)

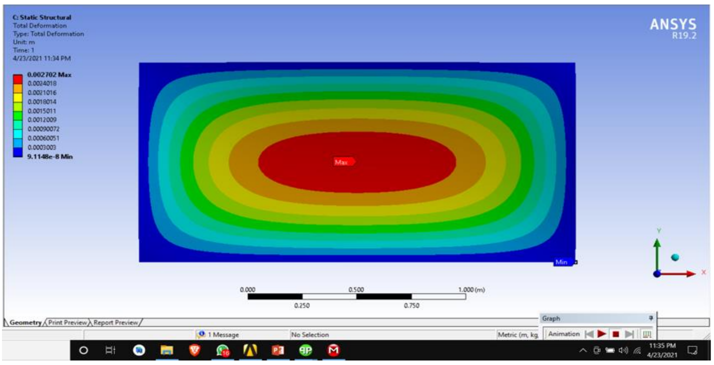

Fig 4.4.1 Deformation of 5mm thickness plank

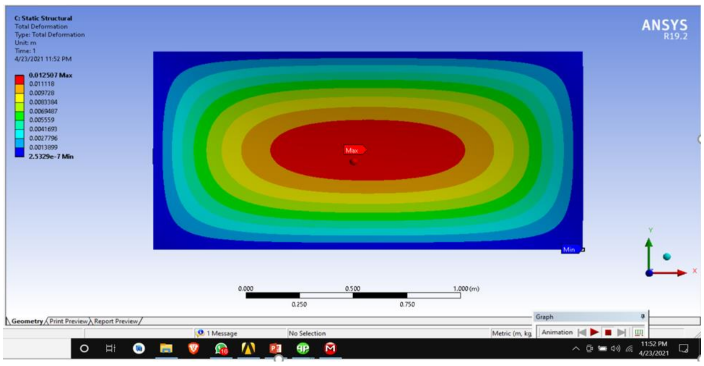

Fig 4.4.2 Deformation of 3mm thickness plank

4.5 Category 5 – (0,30,45,60,0)

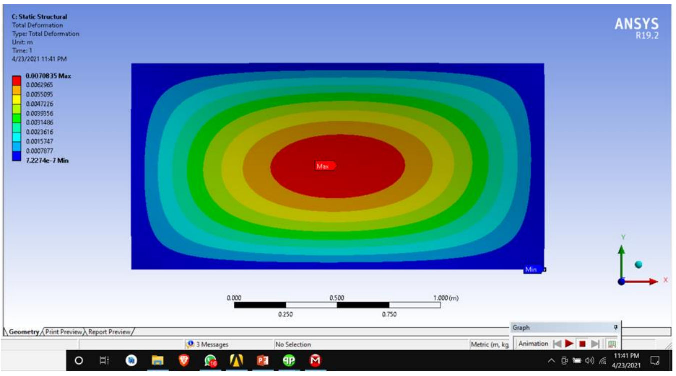

Fig 4.5.1 Deformation of 5mm thickness plank

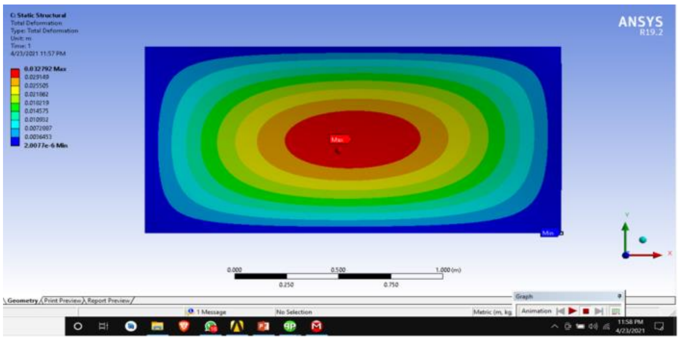

Fig 4.5.2 Deformation of 3mm thickness plank

4.6 Category 6 – (0,45,90,45,0)

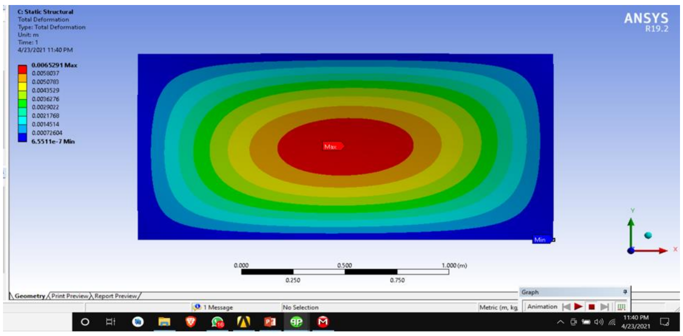

Fig 4.6.1 Deformation of 5mm thickness plank

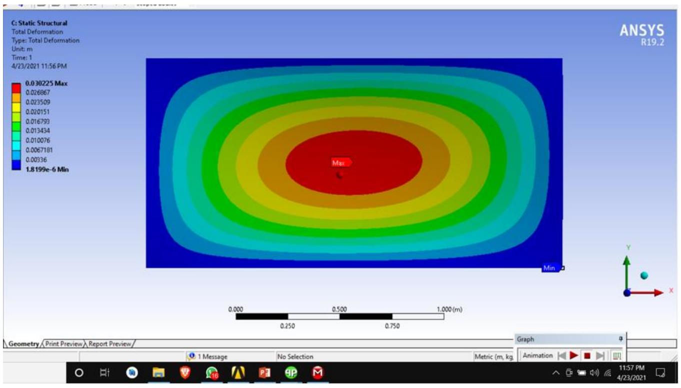

Fig 4.6.2 Deformation of 3mm thickness plank

4.7 Category 7 – (0,30,60,30,0)

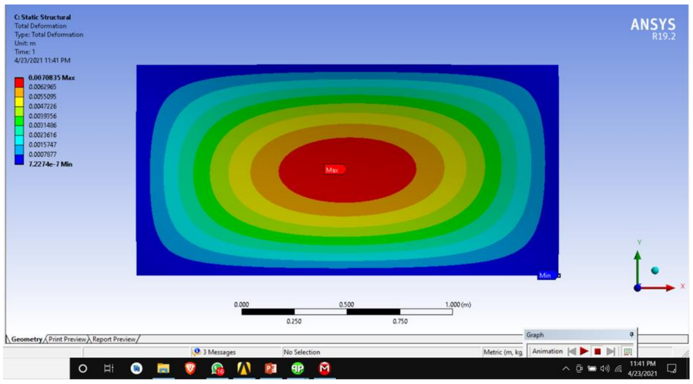

Fig 4.7.1 Deformation of 5mm thickness plank

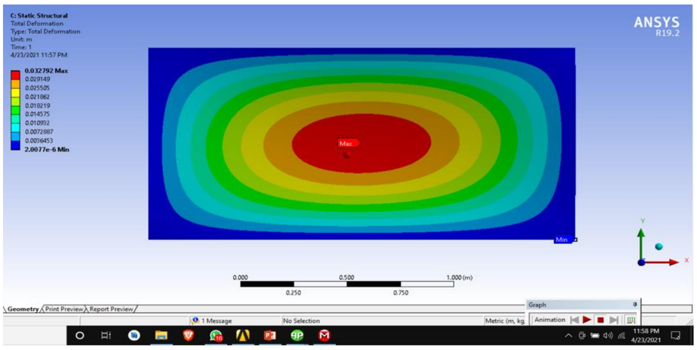

Fig 4.7.2 Deformation of 3mm thickness plank

4.8 Category 8 – (20,45,20,45,20)

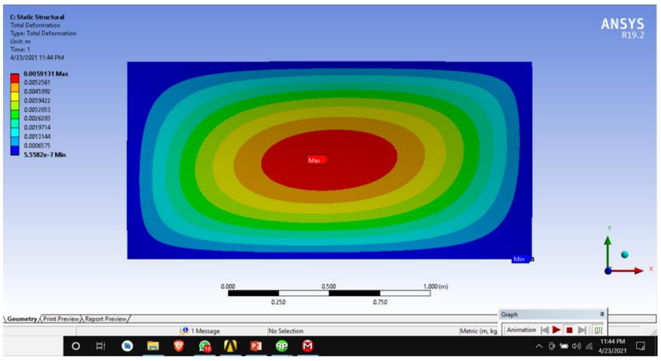

Fig 4.8.1 Deformation of 5mm thickness plank

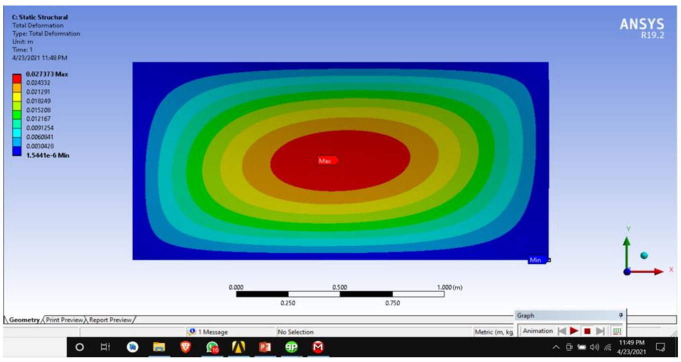

Fig 4.8.2 Deformation of 3mm thickness plank

4.9 Graph

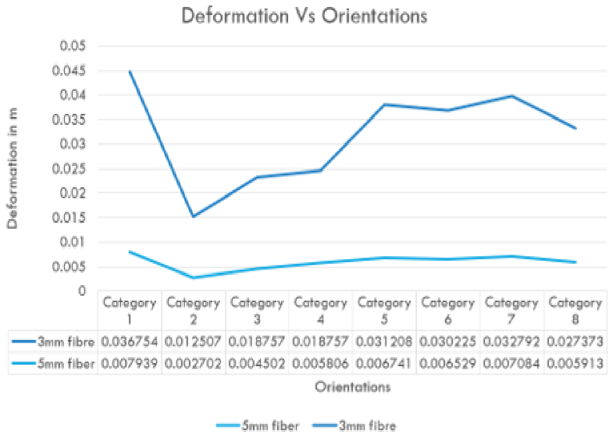

Fig 4.9.1 Deformation v_s orientation of final results

5. CONCLUSION

In this project we have observed the structural analysis of the Composite materials using the ANSYS ACP Module. We have performed analysis on the using different setup orientations for the deformation parameter. We have observed that, the planks of same number of layers with different thicknesses showed different results. The thickness of each layup in a plank and orientation of stack ups plays a vital role. We see less deformation where the layers are stacked up in a Category 2 - (90,90,90,90,90) orientation. Since, the subject of composites is vast, there is a large scope for the analysis in this area, we can perform the analysis on each aspect like the angle orientation, fabrics, ply thickness etc.

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BIOGRAPHIES

Mr. Mudike Karthik Yadav student of Mechanical Engineering from Kakatiya Institute of Technology and science, Warangal, India.

Sri B. Ravi Kumar Assistant professor of Mechanical Engineering department from Kakatiya Institute of Technology and science, Warangal, India.

Mr. Dandi Sharon Stephen student of Mechanical Engineering from Kakatiya Institute of Technology and science, Warangal, India.

Mr. Guttikonda Vikas student of Mechanical Engineering from Kakatiya Institute of Technology and science, Warangal, India.

Miss Swetha Janardhan student of Mechanical Engineering from Kakatiya Institute of Technology and science, Warangal, India.