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RESEARCH ARTICLE

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PREDICTIVE IMPACT BEHAVIOR ON FIBERGLASS REINFORCED LAMINATES WITH THE DIFFERENT COMPOSITE CORE STRUCTURE

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ABSTRACT

Fiber reinforced composites have become increasingly important over the past few years and are now the first choice for fabricating structures where low weight in combination with high strength and stiffness are required. Fiber Reinforced Plastics (FRP) composites are in greatest commercial use. They have been extensively used in aerospace, automotive, marine and construction industries due to their inherent advantages over conventional metals. Failure modes of such laminated structures are also different than those of conventional metallic materials. Impact is one such great design limitation criteria involved in designing new composite products.

In this paper to characterize the damage occurred on fiberglass laminates subjected to mass impact. The effect of adding a protective layer of rubber to the laminates is also investigated. Composite FEA structures will be generated for FEA study. Impact test will be conducted on various models with the variation of core structure/layer orientation, to find impact behavior on fiberglass reinforced laminates and impact test will be conducted by adding rubber layer to the optimum core structure.

Key Words: Impact, fiberglass reinforced laminates, Unidirectional Fabrics, fiberglass laminates, FEA, optimum, core structure, layer orientation.

1. INTRODUCTION

In its most basic form a composite material is one, which is composed of at least two elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the 'matrix'), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. This reinforcement is usually in fibre form. In addition, the manufacturing process used to combinefibre with resin leads to varying amounts of imperfections and air inclusions. Typically,with a common hand lay-up process as widely used in the boat-building industry, alimit for Fibre Volume Fraction is approximately 30-40%. With the higher quality, more sophisticatedand precise processes used in the aerospace industry, Fibre Volume Fraction's approaching 70% canbe successfully obtained.the geometry of the fibres in a composite is alsoimportant since fibres have theirhighest mechanical properties along their lengths, rather than across their widths.This leads to the highly anisotropic properties of composites, where, unlike metals,the mechanical properties of the composite are likely to be very different when testedin different directions. This means that it is very important when considering the use ofcomposites to understand at the design stage, both the magnitude and the directionof the applied loads.

2. OBJECTIVE

Impact behavior on fiberglass reinforced laminates with the variation of composite core structure the investigation is carried on the effect of adding a protective layer of rubber to the laminates. Impact test will be conducted on various models with the variation of core structure orientation to find impact behavior on fiber glass reinforced laminates. This paper also involves optimum core structure in which impact test will be conducted by adding rubber layer.

3. Methodology

(***a)Modal Analysis***

A modal analysis is typically used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It can also serve as a starting point for another, more detailed, dynamic analysis, such as a harmonic response or full transient dynamic analysis. Modal analyses, while being one of the most basic dynamic analysis types available in ANSYS, can also be more computationally time consuming than a typical static analysis. A reduced solver, utilizing automatically or manually selected master degrees of freedom is used to drastically reduce the problem size and solution time.

(b)Harmonic AnalysisUsed extensively by companies who produce rotating machinery, ANSYS Harmonic analysis is used to predict the sustained dynamic behavior of structures to consistent cyclic loading. A harmonic analysis can be used to verify whether or not a machine design will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.

4. MODELING AND SILMULATION

4.1. Impact analysis of composite laminates with FRP 0^0-90^0-0^0

Meshed model:

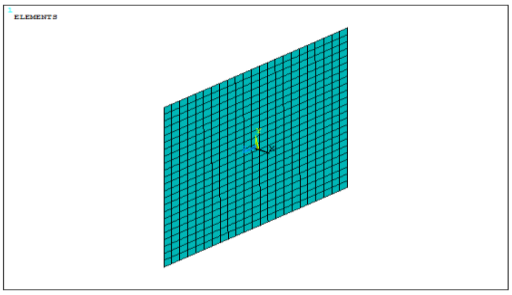
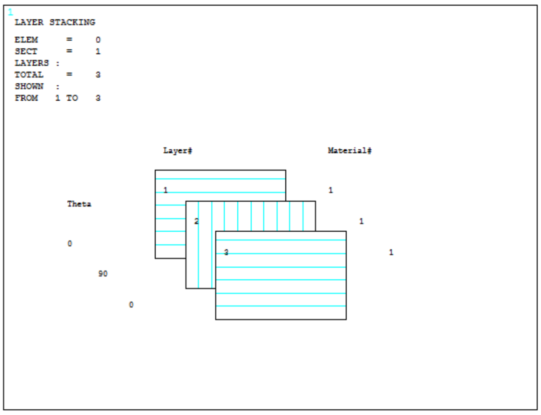


Figure. 4.1: Meshed model

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers



.**Figure: 4.2 Layers used for reinforcement**.

Displacement:

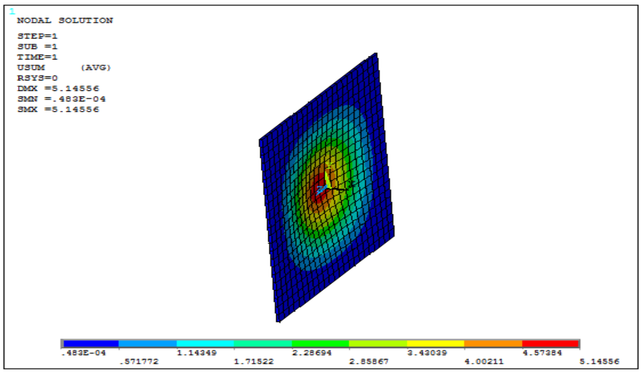


Figure: 4.3.The displacement values due to impact loads

Max displacement= 5.1455

Stress:

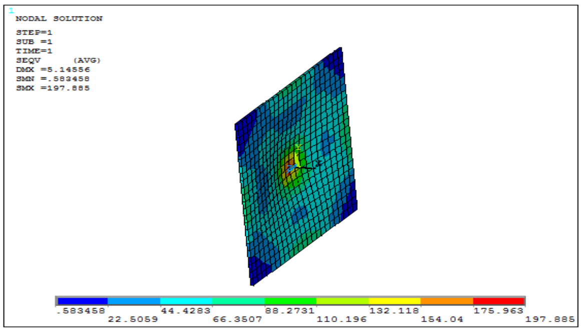


Figure: 4.4.The stress value with the help of color bar

Color bar is used to determine the value ranges on object. Stress considers all directional and principal stresses. Max stress=197.885 N/m^2

Strain:

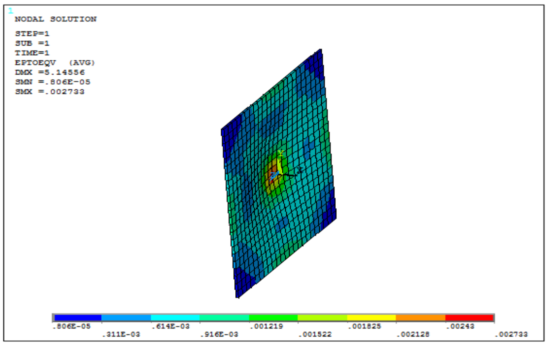


Figure: 4.5: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object strain considers all directional and principal strain. Max strain=0.002733.

4.2 Impact analysis of composite laminates with FRP 0^0-45^0-0^0

Meshed model:

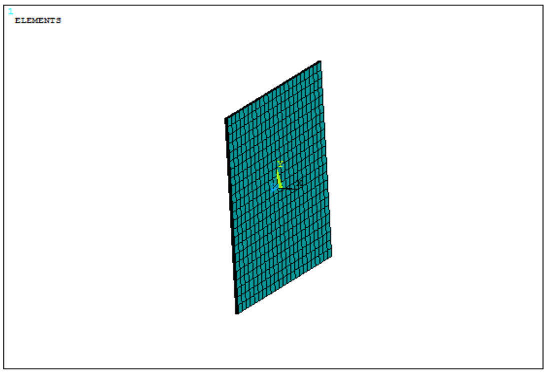


Figure: 4.6: The meshed modal.

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

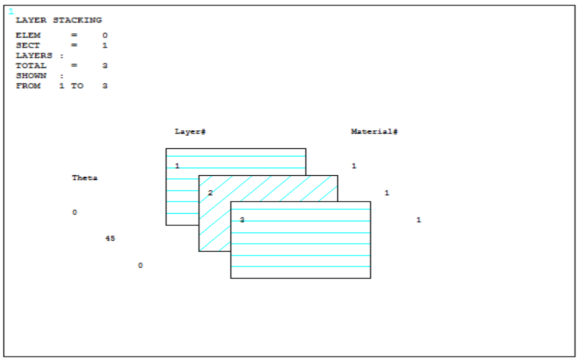


Figure: 4.7: The layers used for reinforcement.

Displacement:

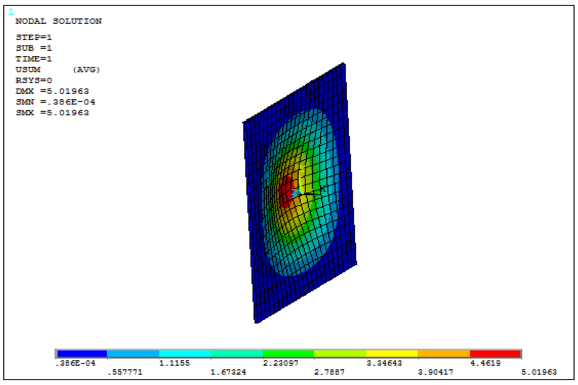


Figure: 4.8.The displacement values due to impact loads

Max displacement= 5.01963.

Stress:

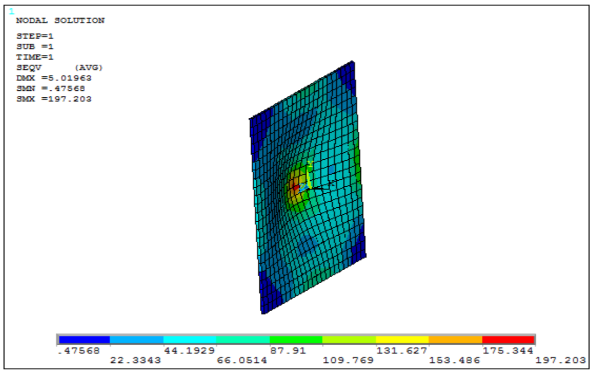


Figure.4.9: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object. stress considers all directional and principal stresses. Max stress=197.203 N/m^2.

Strain:

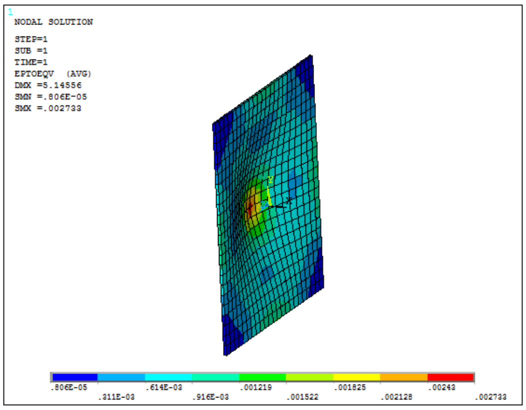


Figure: 4.10 The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max strain=0.002733.

4.3 Impact analysis of composite laminates with FRP 45^0-90^0-45^0

Meshed model:

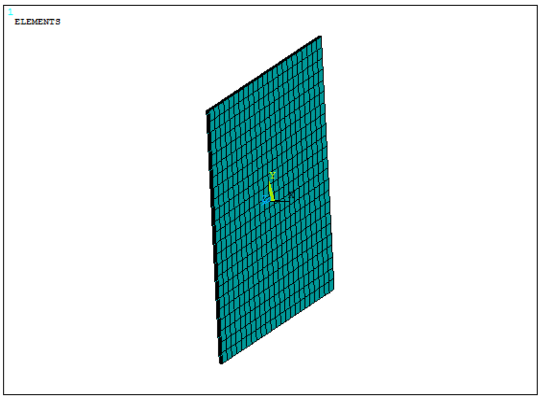


Figure: 4.11: The meshed modal.

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

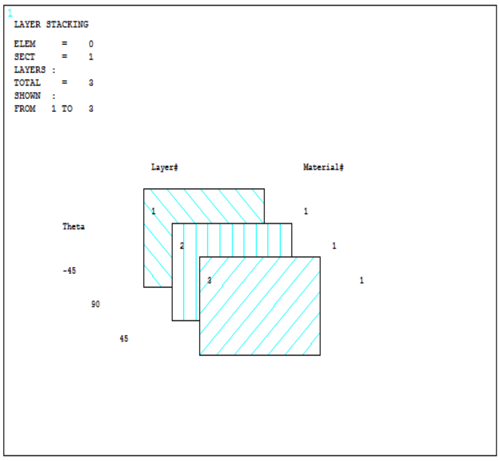


Figure: 4.12: The layers used for reinforcement.

Displacement:

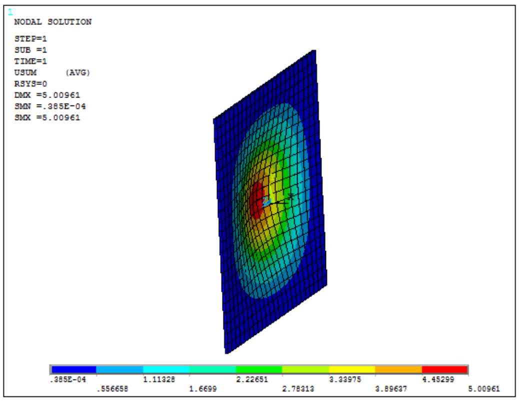


Figure: 4.13 The displacement values due to impact loads.

Max displacement= 5.00961.

Stress:

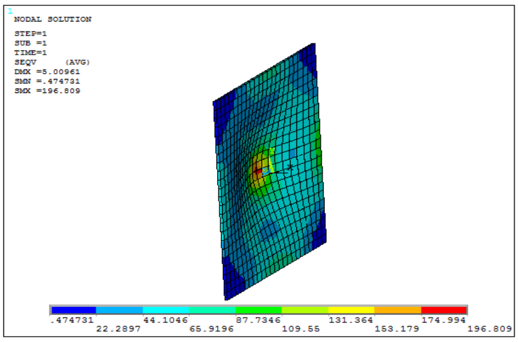


Figure: 4.14: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object. stress considers all directional and principal stresses. Max stress=196.809 N/m^2.

Strain:

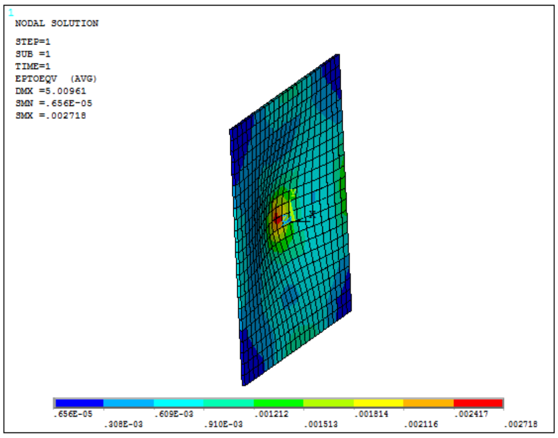


Figure: 4.15: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Von misses strain considers all directional and principal strain. Max strain=0.002718.

4.4 Impact analysis of composite laminates with FRP 90^0-45^0-90^0

Meshed model:

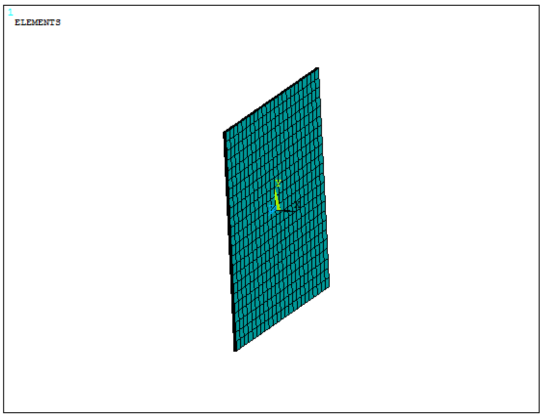


Figure: 4.16 : The meshed modal.

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

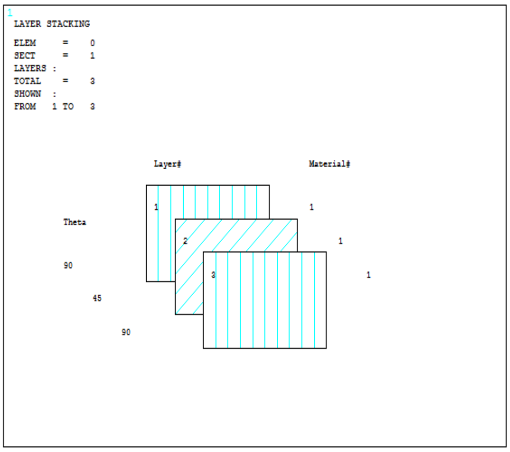


Figure. 4.17: The layers used for reinforcement.

Displacement:

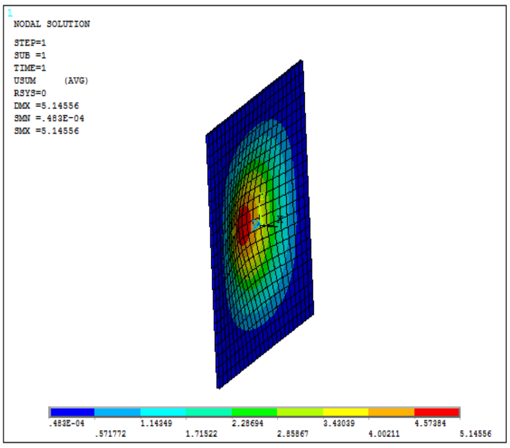


Figure.4.18: The displacement values due to impact loads.

Max displacement= 5.14556.

Stress:

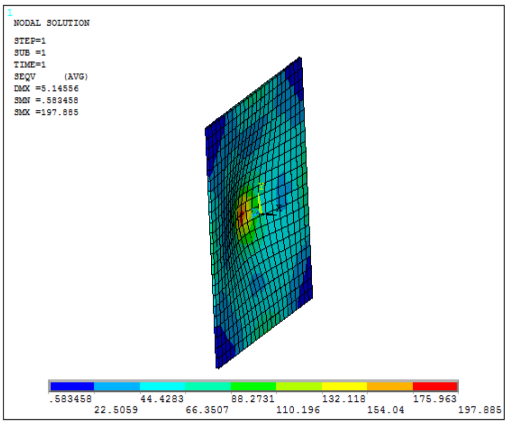


Figure .4.19: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object. Von misses stress considers all directional and principal stresses. Max stress=196.885 N/$m^{2.}$

Strain:

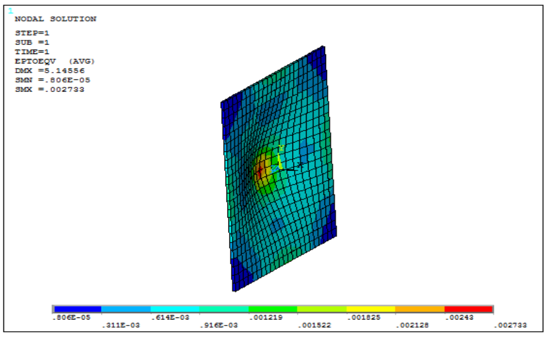


Figure .4.20: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Von misses strain considers all directional and principal strain. Max strain=0.002733.

4.5 Impact analysis of composite laminates with FRP 0^0-90^0-45^0-90^0-0^0

Meshed model:

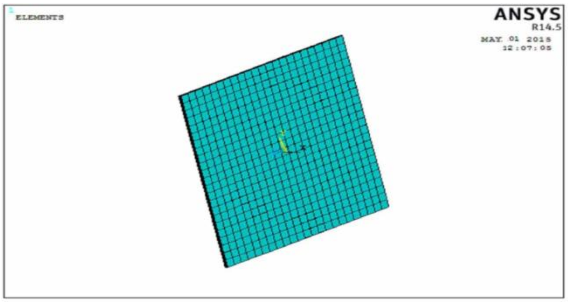


Fig: 4.21: The meshed modal

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

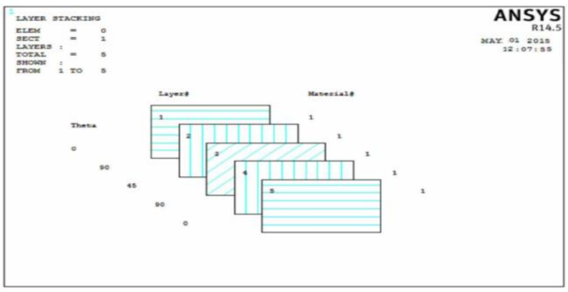


Figure .4.22 The layers used for reinforcement.

Displacement:

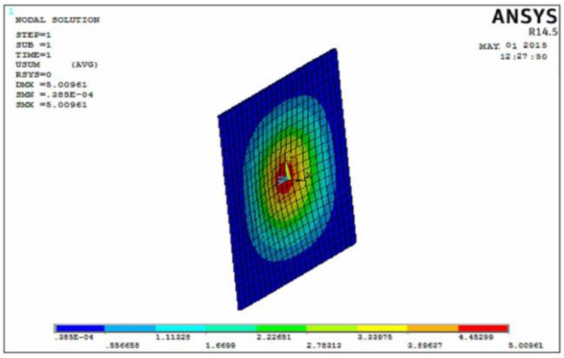


Figure .4.23: The displacement values due to impact loads

Max displacement= 5.00961.

Stress:

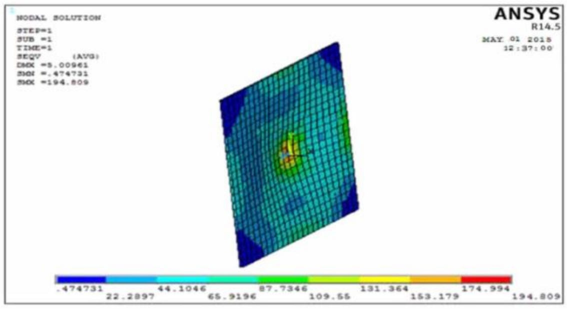


Figure .4.24: The stress value with the help of color bar

Color bar is used to determine the value ranges on object. Stress considers all directional and principal stresses. Max stress=194.809 N/$m^{2.}$

Strain:

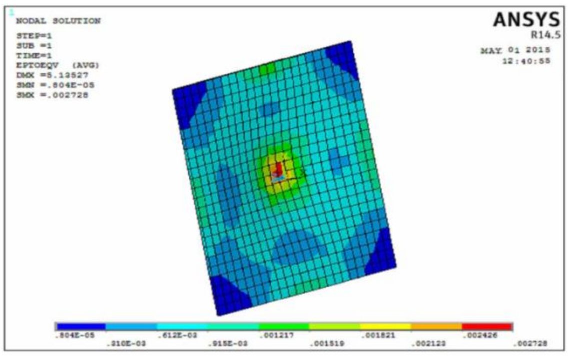


Figure .4.25: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max strain=0.002728.

4.6 Impact analysis of composite laminates with FRP 0^0-45^0-90^0-45^0-0^0

Meshed model:

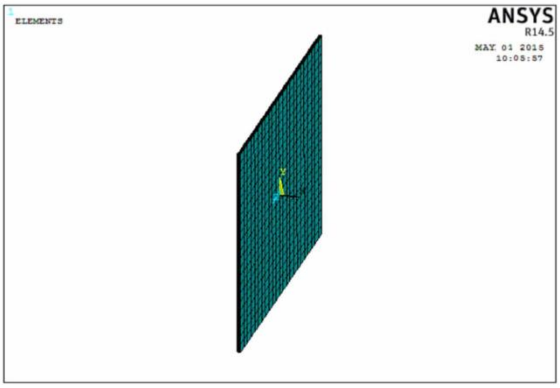


Figure: 4.26: The meshed modal

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh.Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

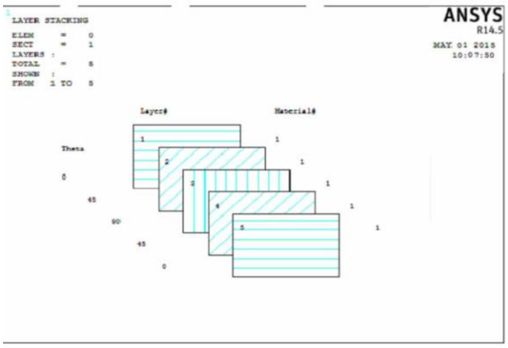


Figure .4.27: The layers used for reinforcement.

Displacement:

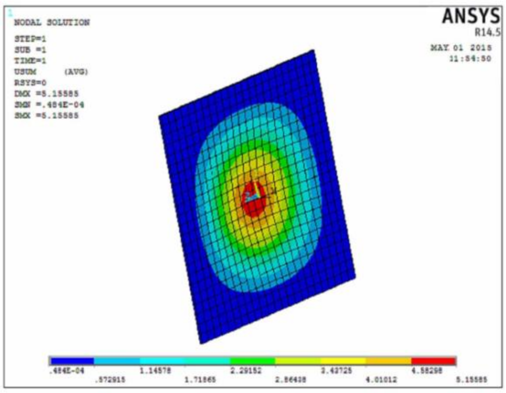


Figure .4.28: The displacement values due to impact loads

Max displacement= 5.15585

Stress:

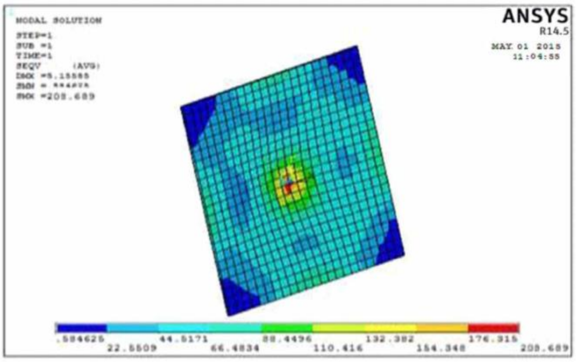


Figure .4.29: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object. Stress considers all directional and principal stresses. Max stress=208.689 N/m^2

Strain:

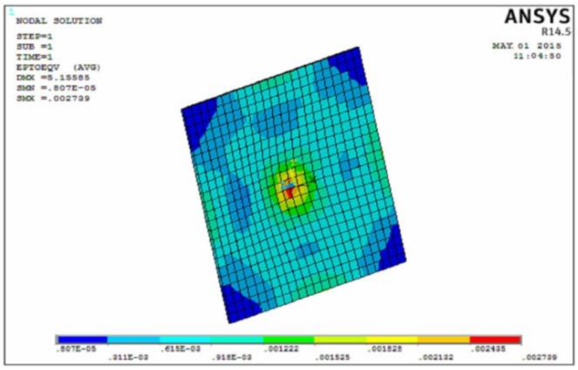


Figure .4.30: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max strain=0.002739

4.7 Impact analysis of composite laminates with FRP 0^0-90^0-0^0-90^0-0^0

Meshed model:

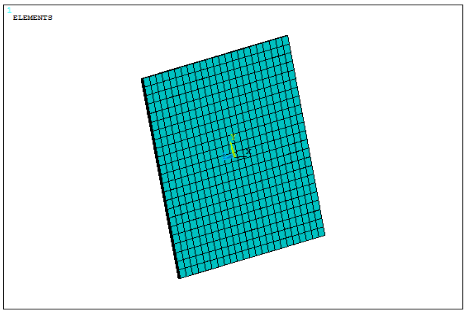


Figure.4.31: The meshed modal.

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Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

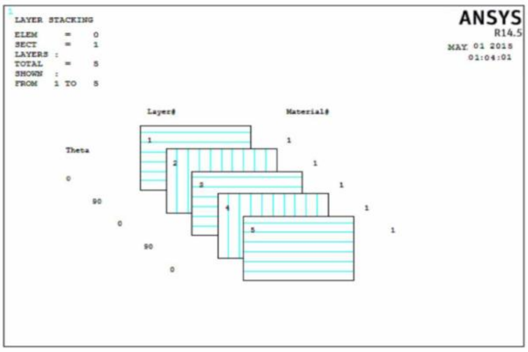


Figure.4.32: The layers used for reinforcement.

Displacement:

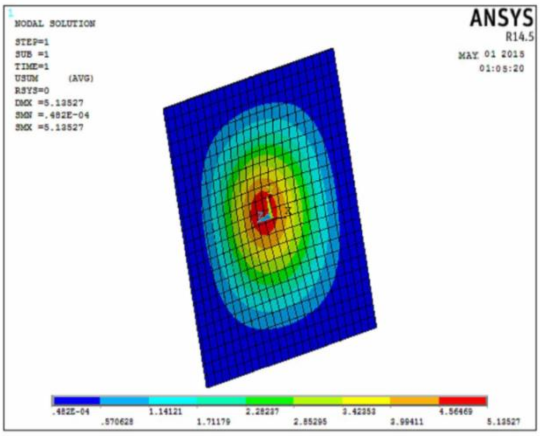


Figure .4.33: The displacement values due to impact load.

Max displacement= 5.13527

Stress:

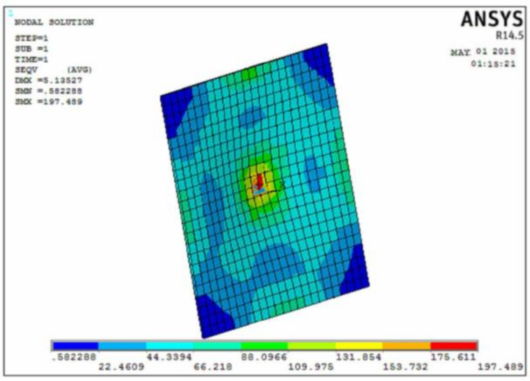


Figure .4.33: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object stress considers all directional and principal stresses. Max stress=197.489 N/m$^{2.}$

Strain:

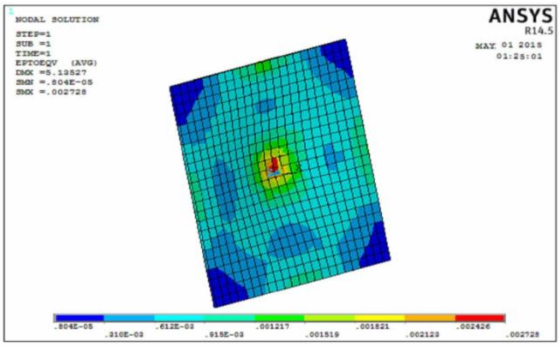


Figure .4.35: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max strain=0.002728.

4.8 Impact analysis of composite laminates with FRP with rubber 0^0-90^0-45^0-90^0-0^0

Meshed model:

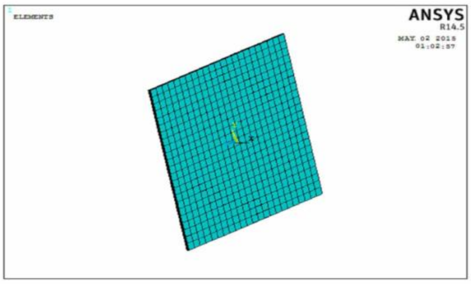


Figure.4.36:The meshed modal.

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

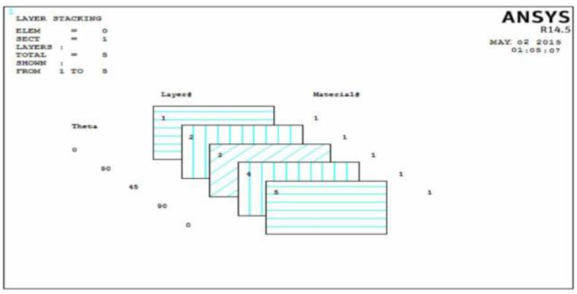


Figure.4.37: The layers used for reinforcement.

Displacement:

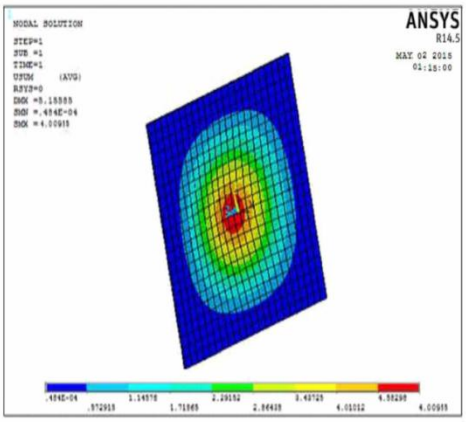


Figure.4.38: The displacement values due to impact loads

Max displacement= 4.009.

Stress:

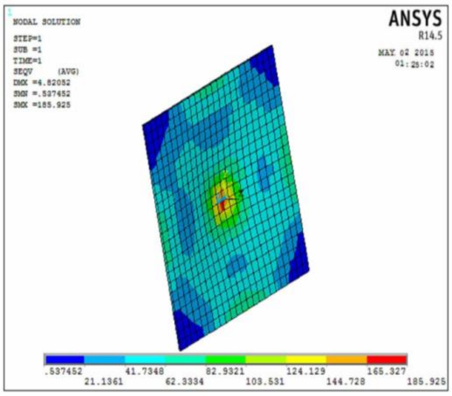


Figure .4.39: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object. Stress considers all directional and principal stresses. Max stress=185.925 N/m^2

Strain:

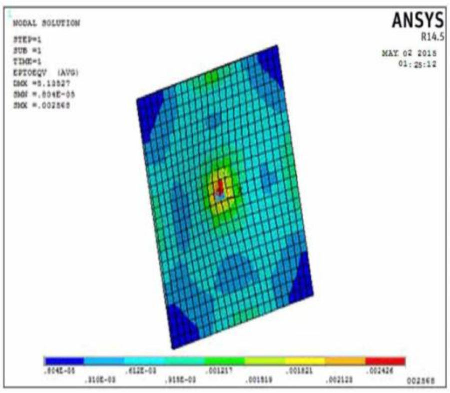


Figure .4.40: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max strain=0.00259.

4.9 Impact analyses of composite laminates with FRP rubber 0^0-45^0-90^0-45^0-0^0

Meshed model:

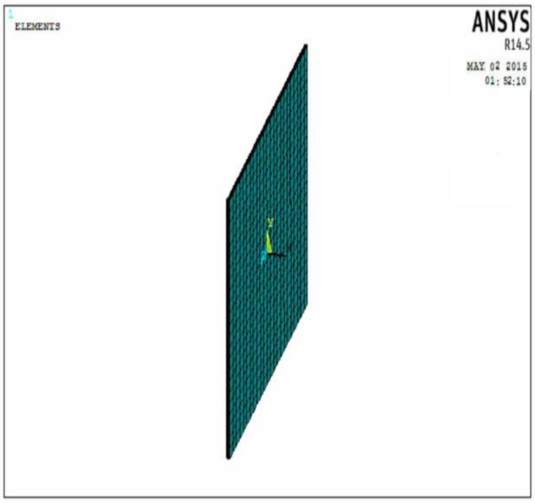


Figure.4.41: The meshed modal.

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

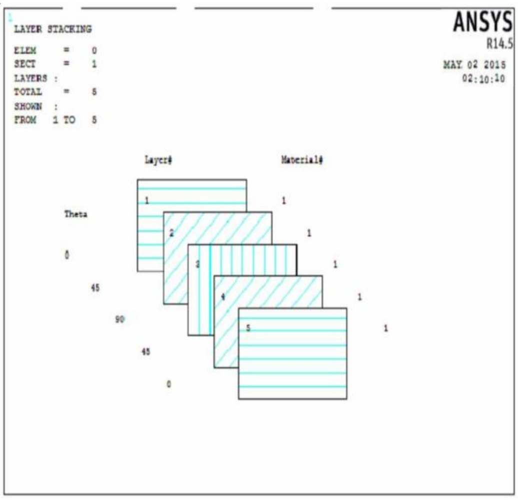


Figure.4.42: The layers used for reinforcement

Displacement

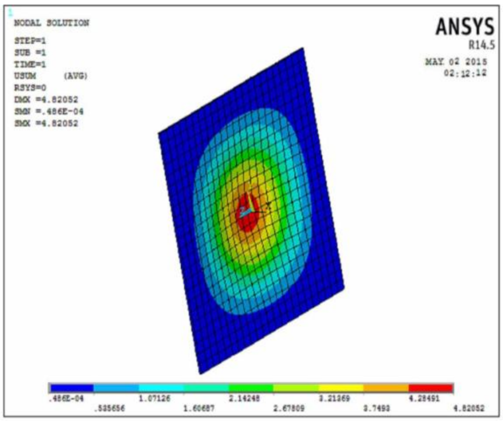


Figure .4.43: The displacement values due to impact loads

Max displacement= 4..820

Stress:

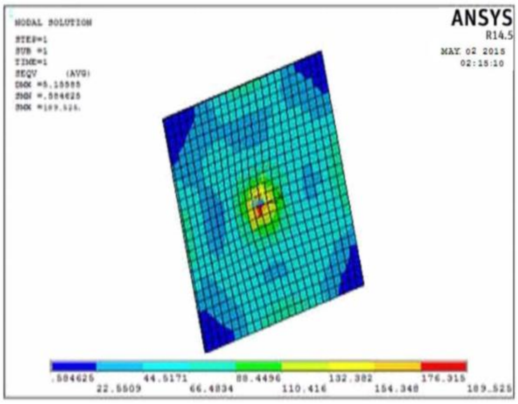


Figure. 4.44: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object. Stress considers all directional and principal stresses. Max stress=189.525 N/m$^{2.}$

Strain:

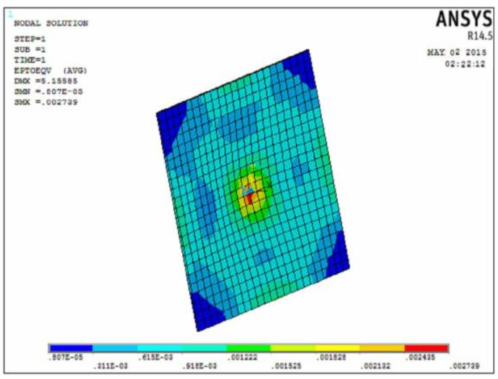


Figure. 4.45: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max.strain=0.002729.

4.10 Impact analysis of composite laminates with FRP rubber 0-90-0-90-0

Meshed model:

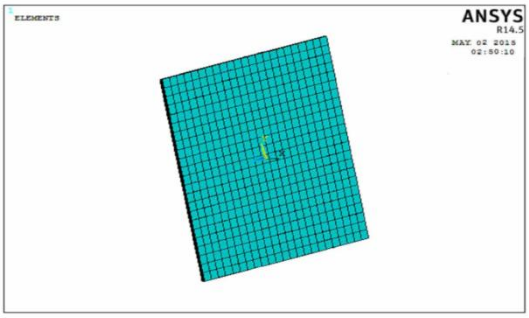


Figure .4.46: The meshed modal.

Default solid Brick element was used to mesh the components. The shown mesh method was called Tetra Hydra Mesh. Meshing is used to deconstruct complex problem into number of small problems based on finite element method.

Layers:

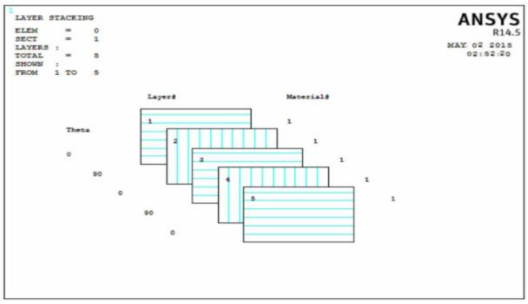


Figure. 4.47: The layers used for reinforcement.

Displacement:

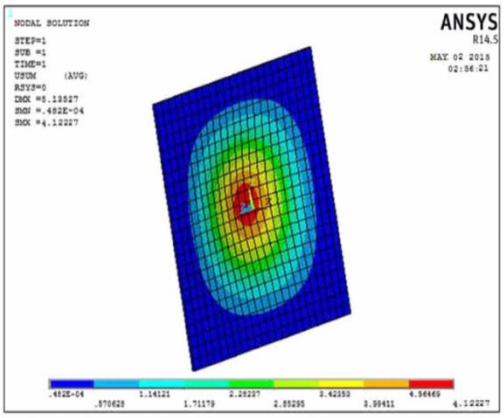


Figure .4.48: The displacement values due to impact loads

Max displacement= 4.12227.

Stress:

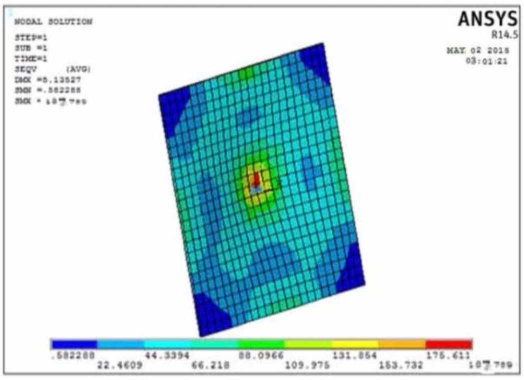


Figure.4.49: The stress value with the help of color bar.

Color bar is used to determine the value ranges on object stress considers all directional and principal stresses. Max stress=187.789 N /m^2

Strain:

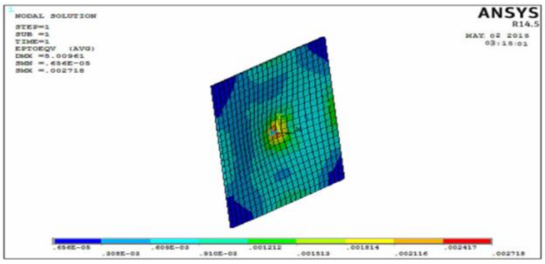
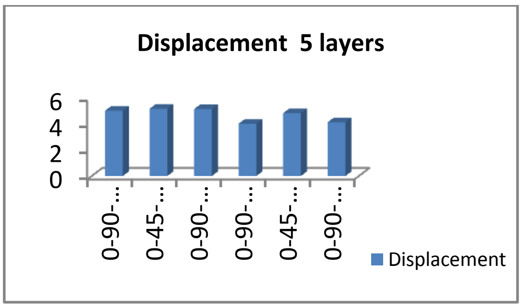


Figure .4.50: The strain value with the help of color bar.

Color bar is used to determine the value ranges on object. Strain considers all directional and principal strain. Max strain=0.002718

Result tables:

5 layers:



	0-90-45-90-0 layer Orientation	0-45-90-45-0 layer Orientation	0-90-0-90-0 layer Orientation	0-90-45-90-0 with rubber	0-45-90-45-0 with rubber	0-90-0-90-0 with rubber
Stress	194.809	208.689	197.489	185.925	189.525	187.789
Displacement	5.009	5.155	5.135	4.009	4.820	4.122
Strain	0.002718	0.002739	0.002728	0.002592	0.002729	0.002718

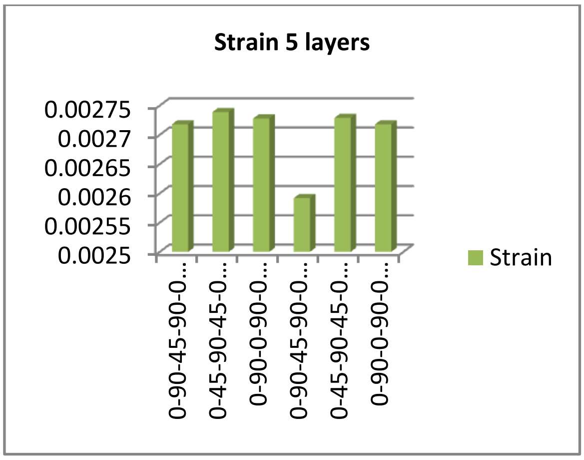


Figure .4.51: Strain Vs Layer

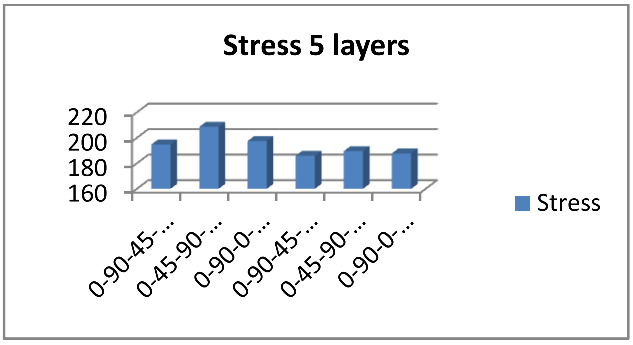


Figure .4.52: Stress Vs Layer

3 Layers:

	0-90-0 layer Orientation	0-45-0 layer Orientation	45-90-45 layer Orientation	90-45-90 layer Orientation
Stress	197.885	197.203	196.809	197.885
Displacement	5.145	5.01963	5.00961	5.145
Strain	0.002733	0.002724	0.002718	0.002733

Figure .4.53: Displacement Vs Layer

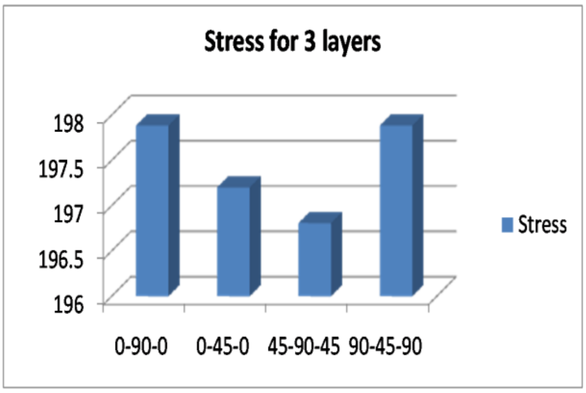


Figure .4.54: Stress Vs Layer

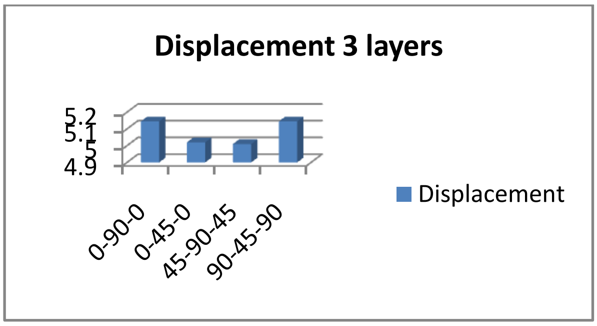


Figure .4.55: Displacement Vs Layer

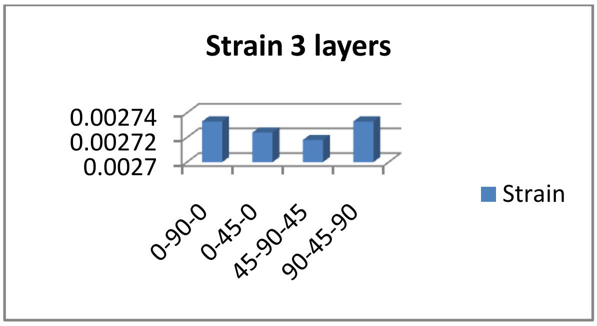


Figure .4.56: Strain Vs Layer

CONCLUSION

In this project work impact analysis on FRP Laminates is done to determine the effect of layer orientation and rubber layer combination. In the first step data analization is done to understand the problem and rectification methodology. In the next step analysis is done on FRP Laminates by varying layer orientations on layered matrix.

In the next step analysis is done on FRP Laminates using rubber layer in middle. As per the results FRP Laminates with 0-90-45-90-0 with rubber as middle layer is giving maximum impact loading capacity. If rubber layer is used as middle layer impact loading capacity will be increased by 6%.of color bar. Color bar is used to determine the value ranges on object.

Strain considers all directional and principal strain. Max strain=0.002592.

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