Finite Element Analysis of Fiber Reinforced Composite Material

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***Abstract*— In engineering, Design, and Optimization forms are essential issues to set up economical designing frameworks. Contrasted with isotropic materials, it is important to manage more convoluted scientific model that address the material anisotropy for Fiber-Matrix composites. The plan procedure of composites for the exertion required or the advantage wanted must be orderly, which incorporates inventive ways to deal with integrate elective arrangements. In such manner, the primary objective of all such endeavour is important to reach limiting the exertion required or to expand the coveted advantage for improvement of Mechanical properties by substituting and Alternating Fiber, Matrix and their Orientation.**

***Keywords*— Optimization, Isotropic materials, Fiber-Matrix composites, Mechanical properties, Orientation**

I. INTRODUCTION

Nowadays, composite materials are used in various industries like automotive, aerospace, marine and sporting goods. We can predict that they can also replace or substitute the conventional materials**.** A composite material is a material produced using at least two constituent materials with essentially unique physical or compound properties that consolidated and create a material with qualities not the same as the individual part. These constituent materials work synergistically to create a composite material that has enhanced properties when contrasted and the individual constituent materials. Composite materials are referred to those composite materials created and utilized in the aviation ventures. They more often than not comprise of elite filaments as fortifying stages and polymers or metals as lattices. Composite material is made essentially out of a framework, i.e. a constant stage, or, in other words, a support (fortification is an auxiliary stage), or, in other words, broken stage.

II. TYPES OF COMPOSITION IN COMPOSITES

Composite material includes something like artificially extraordinary materials (heterogeneity): a fortification, and a grid that ties the support and is isolated from it by a sharp interface.

A. Matrix

The matrix combines the individual particles of reinforcement, ensuring them against impacts and keeps their infringement. The essential capacity of the network is to transmit the outer load onto the fortified stage. For the network, a great bond quality with the fortifying stage material (i.e. ideal wettability without concoction communication at the interface of the lattice and fortification) is required. Among different prerequisites for the network, a low weight is regularly included. In correlation with the fortification stage, a grid has for the most part bring down quality and more noteworthy versatility.

B. Reinforcement

The reinforcement phase transmits the bulk of the external loads. It is expected to have high strength and a modulus of elasticity E (E is about one order higher than that of the matrix), as well as a small deformation at a fracture with a high proportion of elastic deformation. Regarding the tensile behaviour of the composite it is given by the shape, concentration and orientation *of* reinforcement.

The shape of reinforcement particles can be considered approximately as a sphere (the powder form of reinforcement) or as a cylinder (fibers). Their size and distribution then determine the texture of the composite

The concentration is a density of the reinforcing phase, expressed in terms of volume or the quantity of weight. It is one of the most important parameters that affect the properties of the material.

The orientation of the reinforcing phase affects the isotropy of the system. If the reinforcing particles have the shape and dimensions in all directions about the same (for example powders), the composite behaves basically as an isotropic material, therefore its properties are the same in all directions. On the contrary systems reinforced with cylindrical reinforcement (fibres) show an anisotropy of properties.

III. METALLIC FIBRES

Metal fibers are among the cheapest, but they are relatively heavy. They are used to reinforce the metal matrices. Due to their specific weight (density) they are not too preferred. The main role in the preparation of the composite metal-metal is played by the compatibility of the fibers and the matrix.

For support of metal reinforcement for temperatures up to 300°C strands of carbon steel are utilized. For the support of metal lattices for a high temperature, strands made of warmth safe metal are utilized, for instance tungsten or molybdenum. In particular, these are the most normally utilized filaments:

- Steel - often strengthening aluminium alloys
- Tungsten - for strengthening heat resistant materials, but they are very heavy.
- Boric - very light, yet rigid and solid; their production is relatively difficult; typical representative - Boric fibers: where a layer of boron is applied on a thin tungsten wire by a chemical deposition of BCl3 vapour and its surface is protected against oxidation (or any boron diffusion into the matrix) by a thin layer of Sic.
- Recently, extensive research into the fibers of the metallic glasses has been carried out.

IV. FINITE ELEMENT MODELLING AND LOAD ANALYSIS

In this research paper, a plate of dimension 150*80*5 (all in mm) is taken and then it was imported to ansys workbench V19.2 . After that, we assign structural steel to the rectangular plate and then necessary boundary conditions were applied to the plate. The results were analysed and maximum and minimum normal stress to the face of the rectangular plate was noted. Afterward, we took composite material which was a combination of epoxy carbon and structural steel which gives good mechanical properties compared to homogeneous structural steel. The results obtained were compared with the rectangular plate of structural steel. This plate was undergone meshing in Ansys V19.2.

Case 1:-

Material – structural Steel
Element size – 150*80*5
Mass – 0.471 kg
Applied load – 30 MPa
Number of node – 3593
Element types – rectangular box
Number of elements- 480

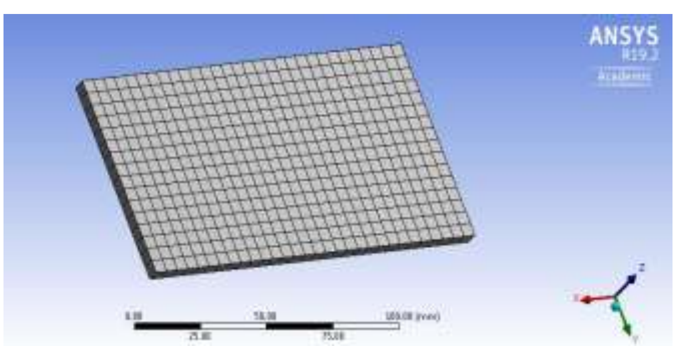

Figure 1: Initial condition of plate after meshing

After applying the boundary condition (in this case fixed from both sides) and applying normal stress and pressure on the top face of plate the following results were obtained which are shown in figures 2 and 3.

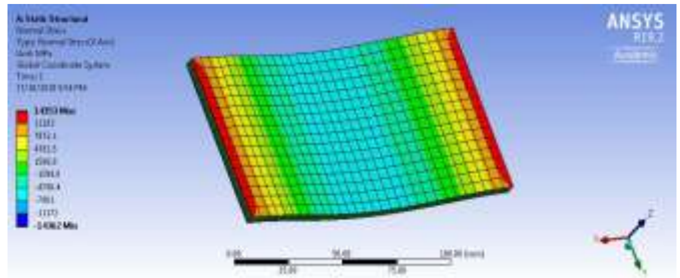

Figure 2: Normal stress on structural steel plate

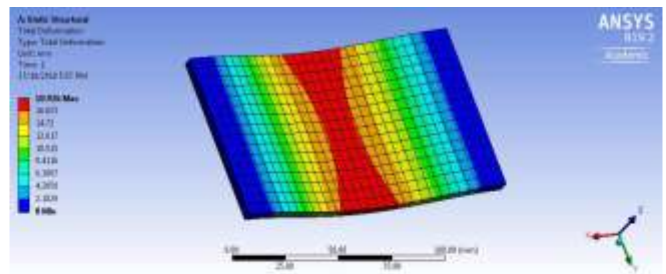

Figure 3: Total Deformation of structural steel plate

Case 2:-

Material – composite material (structural steel & Epoxy carbon UD prepreg)
Element size – 150*80*5
Mass – 0.471 kg
Applied load – 30 MPa
Number of nodes – 18690
Element types – rectangular box
Number of element – 15000
Number of modelling plate – 5

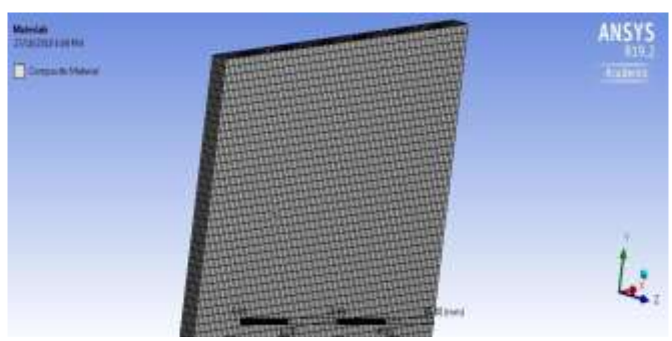

Figure 4: Initial condition of Composite material plate after meshing

After applied boundary condition and analysis of composite plate the result obtained for normal stress of 1st, 3rd, 5th layer , whole composite plate and total deformation are as figure 5,6,7,8 and 9.

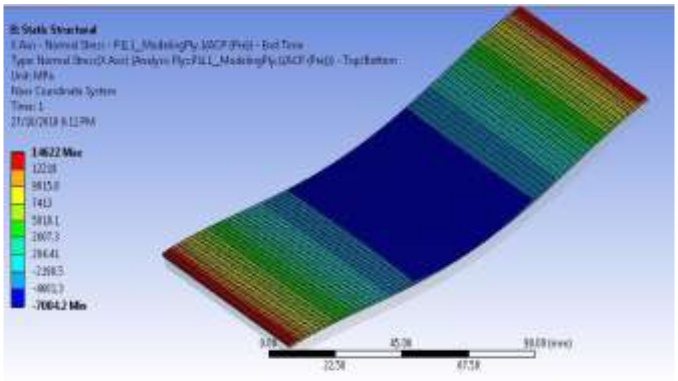

Figure 5: Normal stress for top layer of composite material plate

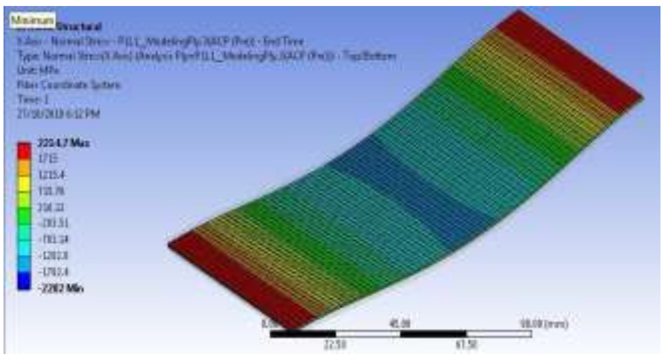

Figure 6: Normal stress for middle layer of composite material plate

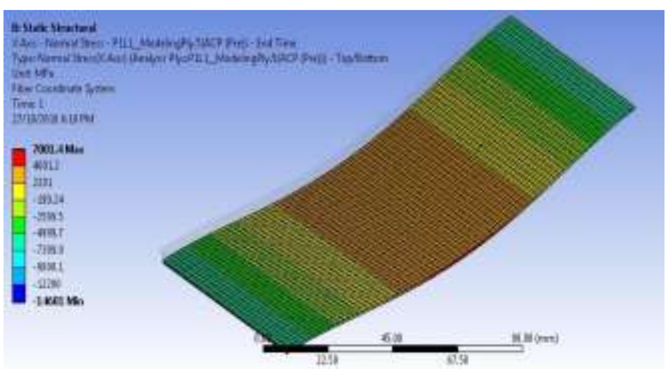

Figure 7: Normal stress for bottom layer of composite material plate

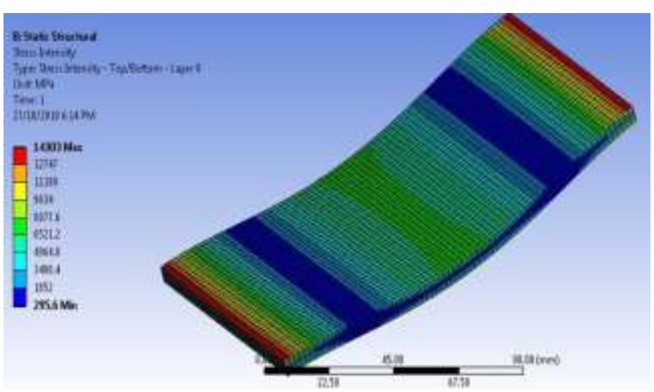

Figure 8: Normal stress for whole composite material plate

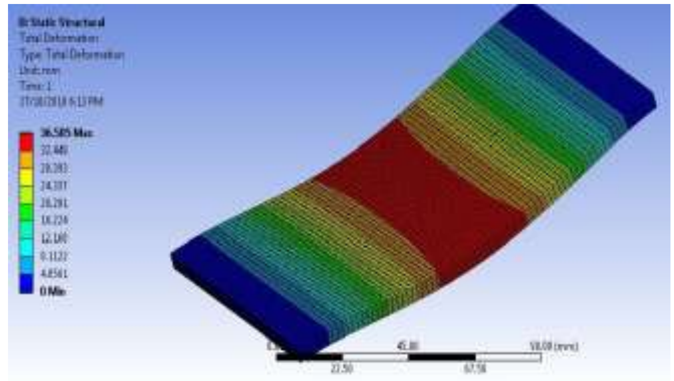

Figure 9: Total deformation of composite material plate

Case 3:-

Material – composite material (structural steel & epoxy E-glass UD)
Element size – 150*80*5
Mass – 0.471 kg
Applied load – 30 Mpa
Number of nodes – 18690
Element types – rectangular box
Number of element – 15000
Number of modelling plate – 5

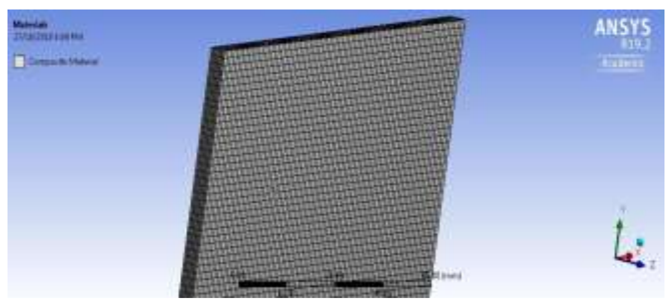

Figure 10: Initial condition of composite material plate after meshing

After applied boundary condition and applying load at centre of composite material plate the result obtained of normal stress and total deformation are as shown in figure 11 and 12.

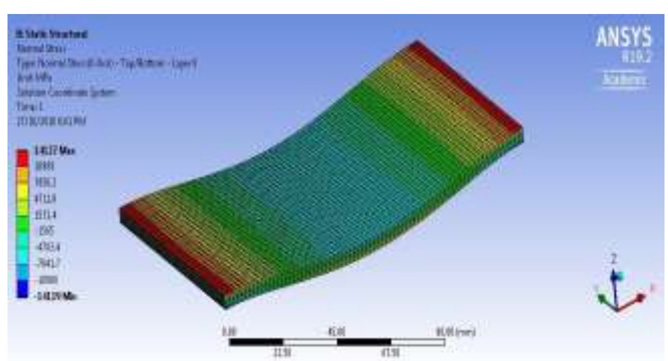

Figure 11: Normal stress on composite material plate

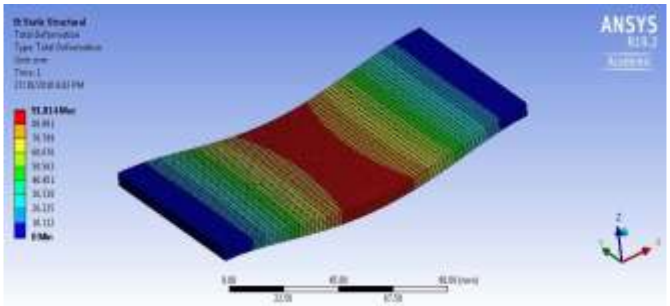

Figure 12: Total deformation on composite material plate

After the finite element modelling and load analysis , the results obtained are as shown in table :

Results

Sr .no.	Properties	Case1	Case2	Case3
1	Maximum stress	14353 MPa	14303 MPa	14127 MPa
2	Minimum stress	-14362 MPa	-295.5 MPa	-14119 MPa
3	Average stress	-4.7083 MPa	3277.8 MPa	-4.7511 MPa
4	Total deformation	18.926 mm	36.505 mm	91.014 mm
5	Average deformation	9.3211 mm	19.171 mm	46.319 mm

V. CONCLUSION

Here we take case 1 (structural steel) as reference and taking diverse sorts of blend of composite material like case 2 (Steel and epoxy carbon) and case 3 (steel and E-Glass). So by examining the table, we can say that case 2 has better magnitude of minimum stress compared to case 1 and 3 . Further the deformation in case 2 is more than case 1 but not than case 3 . So we can say that the composite material in case 2 can handle loads effectively without failure compared to case1 and case3.

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