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INFLUENCE OF FIBER LAYER HYBRIDIZATION ON FLEXURAL BEHAVIOR OF HYBRID COMPOSITES USING FEM/ANSYS

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ABSTRACT

In the present investigation flexural behavior of hybrid composites were studied using validated finite element analysis. Influence of synthetic (glass) fiber volume fraction in a total constant fiber volume and their orders of layup on flexural behavior was the main focus of study. The behavior of these modified panels was compared with the behavior of NFRP composites. From the present study it was observed that hybridization of glass (synthetic) fibers in natural fibers reinforced in composite improves the overall mechanical behavior in general and flexural behavior in particular. Number of synthetic fiber layers i.e. synthetic fiber volume and their layup positions influences more on stress distribution. From the present study it is evident that layup of synthetic fiber layers near to the external load or reactions have better influence on stress distribution than the other layup order.

Keywords: Hybrid Composites Flexural Behavior Fiber Hybridization Layup Order And FEM/ANSYS.

I. INTRODUCTION

Composite materials are generally tailored using two different materials i.e. continuous phase (matrix) and discontinuous phase (reinforcement) to achieve the desired properties. GFRP composites are quite popular in many technical industries such as aviation, automobile and military etc [1]. Now a day natural fibers obtained from plants and natural resources for composites are gaining popularity due to some advantages i.e. they are less denser, recyclable and biodegradable[2]. However totally reinforced natural fiber plastic composites are not applicable for particular regions. To make them applicable, a little volume fraction of synthetic fibers will be added to natural fibers. The process of mixing two different fibers to a composite is known as hybridization. Many researchers around the globe have carried out the extensive research to study the physical properties and behaviour under external load. K. Alagarraja et al [3] have made an attempt to predict the mechanical behaviour of glass/sisal fibers reinforced epoxy resin composites also examine the surface defects such as surface cracks, interfacial properties, micro cracking etc. Madhu kiran J et al [4] have studied the flexural behaviour of multi-natural fiber i.e. pineapple and banana reinforced epoxy resin composites with various weight fractions. In their research findings they observed an increase in flexural strength with the increase in fiber content. Subbiah Jeeva.G et al [5] have studied the tensile behaviour of various types of natural fibers such banana, coconut and sisal epoxy composites by adding an additive metallic powder i.e. titanium oxide with fibers. They concluded that use of metallic powder improves tensile strength of the composites. Harikrishna M et al [6] have studied the mechanical behaviour of multi-fiber hybrid i.e glass/jute/banana fibers reinforced composites. The authors have noticed some superior properties compared to synthetic/natural fiber composites. According to authors the fabricated glass-banana-jute hybrid composites shows improved properties and comment that these composites can be used as substitute for synthetic fiber reinforced composites. Md Fayaz K et al [8] have reviewed the overall research/development taken place from past one decade in the field of composite materials. The authors have insight the various topics such as methods of fabrication, properties, testing etc. innovated during past one decade. They have made various reviews and given references of topics of interest. From the above literature review it was observed limited research has carried out on the method of layup of synthetic fibers with natural fibers in hybrid fiber reinforcement composite. In view of above fact the present area of investigation is mainly concern with the studies on influence of synthetic fiber volume and its layup position using finite element analysis. The most powerful analysis software i.e. ANSYS code is effectively used for the present investigation. The various synthetic layers layup positions

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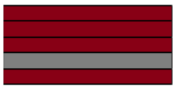
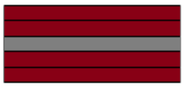
chosen for study are as shown in table-1.

Type-1(HFRC-1) No of GL=01 No of NF=04 Layer position Bottom most=1 Topmost=5

Table 1: Models of hybrid composites with different layer order

Model	Model-1	Model-2	Model-3
Layer position (From bottom to top)	2nd	3rd	4th
Composite section (20% glass fiber volume)			

II. VALIDATION OF FINITE ELEMENT ANALYSIS FOR FLEXURAL BEHAVIOR OF HOMOGENEOUS MATERIALS

This section is exclusively deals with validation of finite element modeling in order to check the efficiency of the numerical tool which is extensively used for present investigation. To carry out the validation process, 3-point bending problem of isotropic and homogeneous material i.e. steel panel was considered. The numerical analysis was performed using ANSYS software which is a quite versatile general purpose program provides an engineering solution to all realistic problems. However the user must confirm the numerical procedure comprising of finite elements, discretization and boundary conditions etc. In this method of solution more accurate post processing results can be obtained by carefully preprocessing the input data of the problem. To carry out the validation process a homogeneous steel beam model of dimensions 150mmx20mmx5mm was considered. For descritization of model 8-noded shell 281 elements were chosen. Simply supported with equal overhang on both sides and a mid-span load of 1000N were considered as boundary conditions. The complete geometric details of the problem and the required engineering analysis data is given in figure-1 and table- 2.

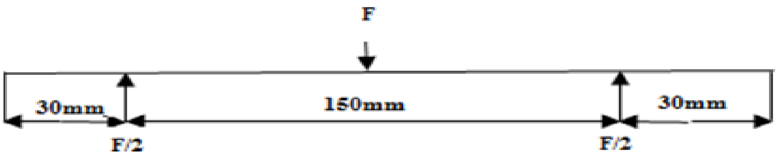


Figure 1: Line diagram of steel panel under three-point bending

Table-2: Geometric details of steel panel used for Flexural behavior

Material	Span (l)	Width(b)	Thickness(t)	Load(F)	Young's modulus	Poisson's ratio(ν)
Mild steel	**150mm**	**20mm**	**5mm**	**1000 N**	**2x10^5 MPa**	**0.34**

The geometric and finite element models of the steel panel were generated on GUI of ANSYS after carefully preprocessing the required data as shown in figure-3. ANSYS program was run successfully using static solver and the contours of post analysis results such as stress distribution and beam deflection etc. were obtained shown in figure 4.

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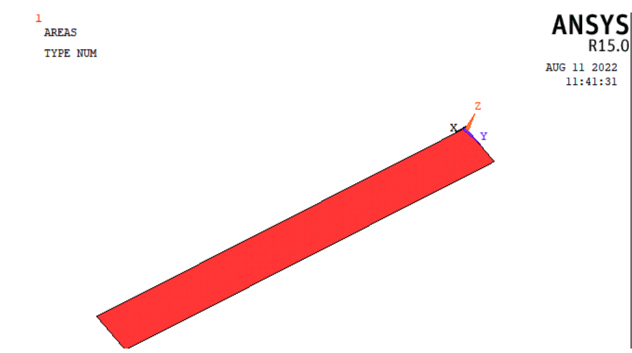

Figure 2(a): Geometric model of the steel plate

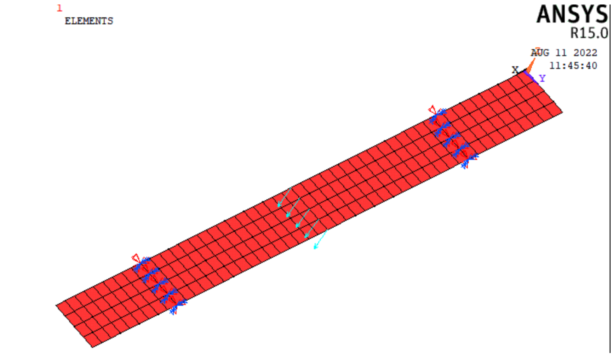

Figure 2(b): Finite element model of steel plate

Figure-2: Finite element modeling of steel plate

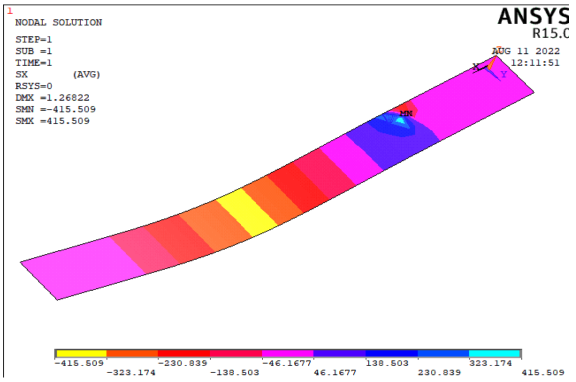

Figure 3(a): Bending stress distribution

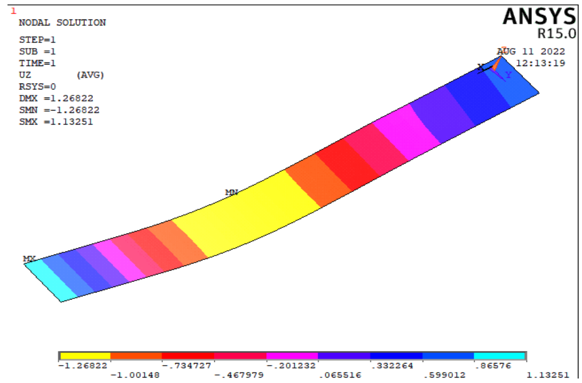

Figure 3(b): Deflection distribution

Figure 3: Post processing results of validation process

The outcome of finite element analysis and the analytical solution using simple bending theory (Bernoulli's theorem) are compared and % error was estimated as shown in table 3.

Table 3: Comparison of simple bending theory and FEM/ANSYS results

Simple bending theory		FEM/ANSYS		% error
Bending stress (σ_b)	**Deflection (y)**	**Bending stress (σ_b)**	**Deflection (y)**	**7.7%**
450MPa	**1.68mm**	**415MPa**	**1.26mm**	

From the above analysis it was observed that finite element method can provide solutions close to actual/analytical results upon carefully pre-processing the modeling data. The validated analysis tool i.e. FEM/ANSYS is extensively used for present investigation.

III. FLEXURAL BEHAVIOR OF HYBRID COMPOSITE

In the previous section, validation of finite element modeling for flexural behavior of homogeneous steel plate material was carried out successfully. In this section flexural behavior of hybrid composite were carried out using validated finite element analysis through the medium of general purpose program i.e. FEM/ANSYS. Major attention was given to study the influence of synthetic fiber layer (20% of total fiber volume) order or layup position on flexural behavior of hybrid composite. The various layup orders considered for study is as shown in Table-1.To maintain the uniformity in the analysis, some constant analysis data was used throughout the study as follows.

Type of composite: Hybrid of Glass-jute fiber reinforced plastic composites (HFRP-1)

Total no of fiber layers =05 (GF=01; JF=04)

No of Synthetic layers (Glass fiber) = 01 (20% of total fiber volume)

Dimensions of test specimen 250x20x6 mm^3

Span length=150mm

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Over hanging =50mm (on either side)

Mid span load=100N

Type of elements: 8 node shell 281

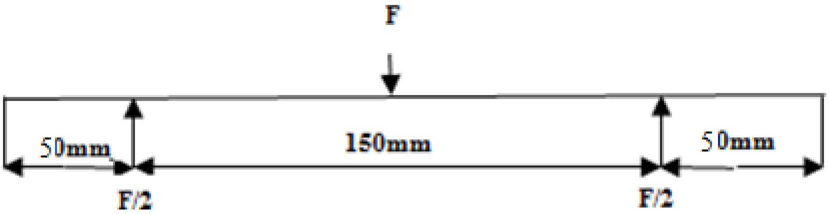

Figure -4: Line diagram of Hybrid composite beam under mid span load (F)

Prior to study the influence of fiber layer hybridization on flexural behavior of hybrid composites, flexural behavior of pure natural fiber reinforced composite (NFRC) were studied. Finite element analysis was performed on NFRP composite model of above specification and loading conditions following the above analysis data as discussed in previous section. The post processing results of analysis i.e. bending stress distribution in NFRP composite panel is obtained as shown in figure-6.

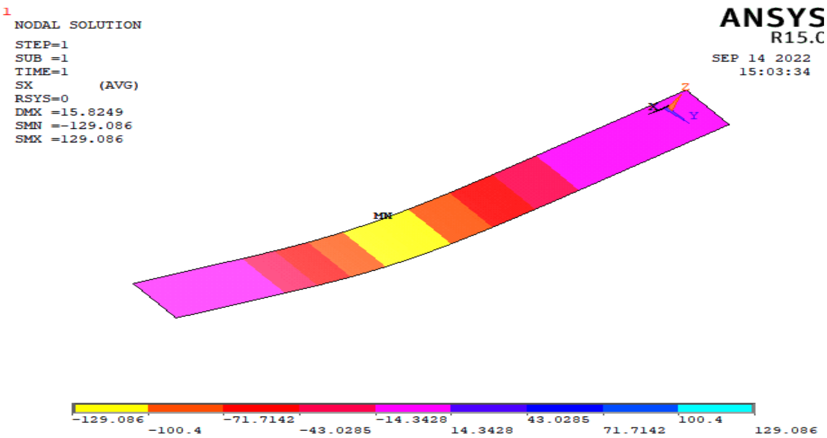

Figure -5: Bending stress distribution in NFRP composite (σ_b) =129MPa

Following similar procedure flexural behavior of chosen models of hybrid composites were studied. Finite element analysis was performed on all the models (as shown in table-1) under similar and identical test conditions. The post processing results of analysis is as given in fgure-7.

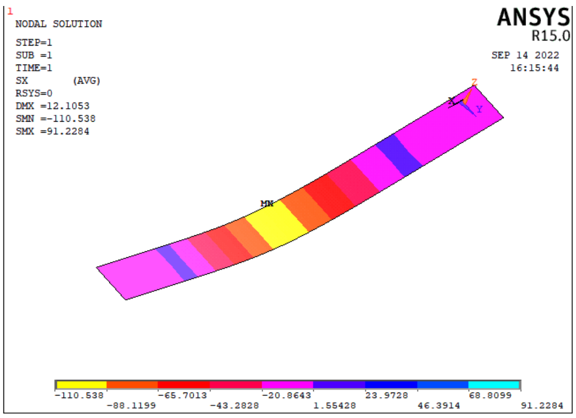

Figure -6(a): Model-1 (σ_b=110MPa)

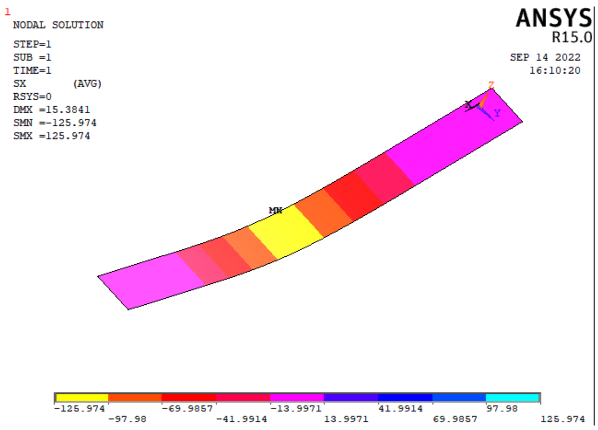

Figure-6(b): Model-2 (σ_b=125MPa)

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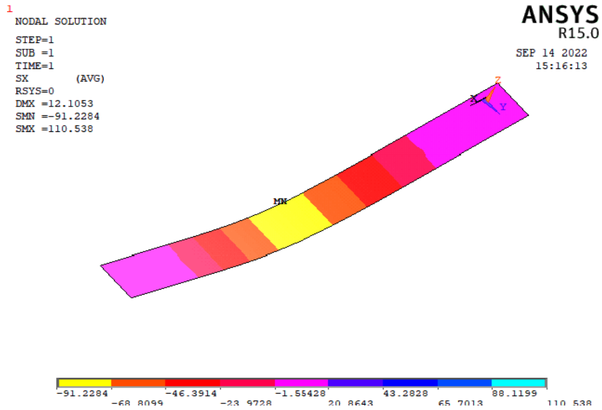
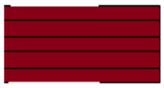
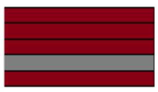
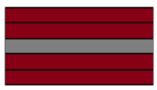


Figure-6(c): Model-3(σ_b=110MPa)

Figure 6: Bending stress distribution in Type-1(HFRP-1) composite (GF-01, NF=04)

The outcome of the bending analysis of single layer hybridization is tabulated in table 4.

Table 4: Comparison of bending behavior of NFRP &HFRP composites

NFRP composite  (Bending stress at mid span load of100N) =129MPa			
Model	**Model-1**	**Model-2**	**Model-3**
Layer position (From bottom)	**2^{nd}**	**3^{rd}**	**4rd**
Composite section			
Bending stress(σ_b)	**110MPa**	**125MPa**	**110MPa**

IV. RESULTS AND DISCUSSIONS

The demand and applicability of composite materials is increasing in all technical industries [9]. Researchers and technocrats around the globe are in search of new and advanced constituents for reinforcements used in composite materials. In opinion of researchers, the performance behavior of composite materials mainly relay on the composition of matrix and reinforcement [10]. For effective design and construction of composites, proper understanding of behavior of all their constituents under external loads is quite essential. This is mainly because, composite construction permits the tailored constituents i.e., reinforced materials, matrix materials, hardeners and method of manufacture due to which the derived /global properties get modified or can be altered. Furthermore, a variety of materials can be proposed for both reinforced and matrix materials to get the desired functional requirements and indispensible properties. Furthermore most of composite structures are subjected to loads causing lateral deflections. Thus for safe design of these structures study of flexural behavior is very essential. In view of above fact, the present investigation was mainly focused on the study of flexural behavior of hybrid composites made up of glass-jute fibers and epoxy resin using finite element analysis using Ansys code. The outcome of the investigation is as shown in figure-7.

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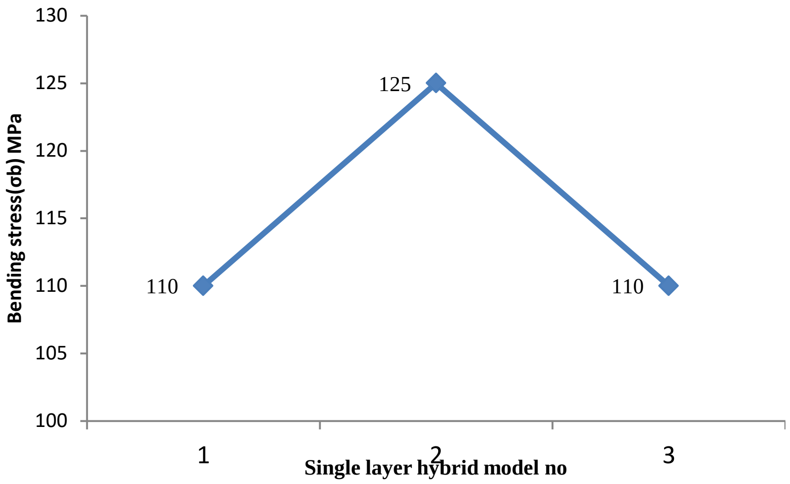

Figure 7: Bending stress n various hybrid models

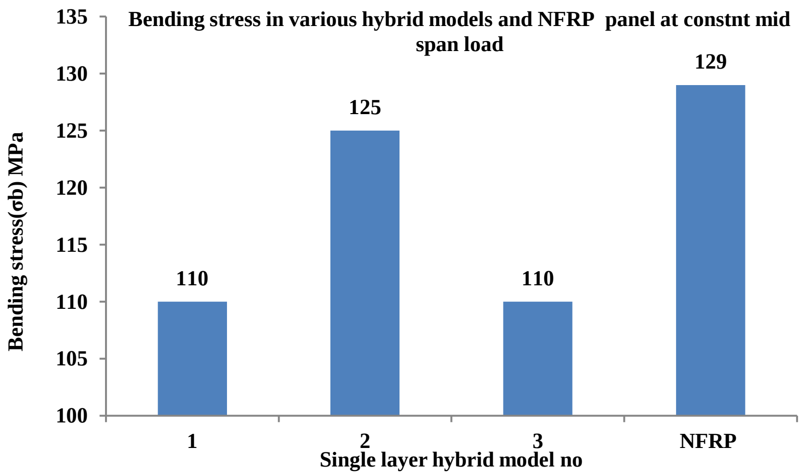

Figure 8: Comparison of bending stress in NFRP&HFRP composites

The behavior of hybrid panels was compared with the behavior of NFRP composites as given in figure-8. Furthermore the influence of synthetic (glass) fiber volume fraction and their layup orders on the functional behavior of composites was studied. From present investigation it was noted that bending stress induced in model 1&3 where the synthetic fibers are towards outer regions than at middle is less than with that of model-2 where the synthetic fiber is at the middle of the section. This indicates that layup of synthetic fiber near extreme regions i.e. away from neutral fiber improves the structural rigidity.

From the present study it is evident that hybridization of glass (synthetic) fibers with natural fibers reinforced composite improves the overall mechanical behavior in general and flexural behavior in particular. Number of synthetic fiber layers and their positions/layup influences more on stress distribution. From the present study it is evident that layup of synthetic fiber layers near to load or at the regions where the magnitude of stress is higher have better influence on stress distribution.

V. CONCLUSION

The validated finite element analysis was extensively used for the present investigation. From the present investigation it is obvious that hybridization of synthetic & natural fibers for composite construction with little volume fraction of synthetic fibers in it produces tremendous improvements in mechanical properties in general and flexural properties in particular. Number of synthetic fiber layers i.e. volume fraction of synthetic fibers and their positions/layup also influences on the stress distribution under external load. Layup of synthetic fiber layers near to applied loads and reactions reduces the stress intensity at constant applied load and hence life of composite panel can be improved.

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