ANALYSIS OF COMPOSITE MATERIALS BY USING FEM MODEL

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Abstract

The composite material is fabricated using glass fibers namely E-Glass 300, E-Glass 450, Combined titched and woven drawings having different orientations. The material is fabricated by hand lay method. Stress, strain, density, young's modulus, impact strength and flexural strength properties are studied in an isophthalic resin as a matrix reinforced with glass fibers for different orientation of fibers. A comparison on mechanical properties has been derived between all the different fibers having different orientations. In this project, the effects of orientation angle on the fiber at the natural frequency of symmetric composite beamare investigated analytically and numerically. This presents a powerful method for evaluating the constitutive properties of composite materials through a mixed numerical-experimental identification procedure based on both the extracted mode shapes and the corresponding natural frequencies of the materials. The analytical results are compared with the numerical results which clearly show that the results are very close to each other. From this suitable material which withstands in above discussed aspects has been found.

1. Introduction

1.1 Composite Materials

Rapid technological advances in engineering brought the scientists and engineers to a point, where they became limited by the capabilities of traditional materials. With the limits of the technology pushed, the materials failed to answer the requirements of the designers or manufactures. Researches in materials technology are constantly looking for solutions to provide stronger, durable materials which will answer the needs of their fellow engineers.

A composite is a structural material which consists of combining two or more constituents. The constituents. The constituents are combined at a macroscopic level and are not soluble in each other. The advantage of composite materials is that, if well designated, they usually exhibit the best qualities that neither constituent possess. Some of the properties that can be improved by forming composite materials are

- Strength - Fatigue life.
- Stiffness - Temperature dependent behavior.
- Corrosion resistance - Thermal insulation.
- Wear resistance - Thermal conductivity.
- Attractiveness - Acoustical insulation.
- Less weight

1.2. Fibers

Fibers are the principal constituents in a fiber-reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure. Proper selection of the type, amount and orientation of fibers is very important, because it in influences the following characteristics of a composite laminate.

- Specific gravity.
- Tensile strength and modulus.
- Compressive strength and modulus.
- Fatigue strength and fatigue failure mechanisms.
- Electric and thermal conductivities.

Reinforcing fibers that provide the means of creating composite materials of high strength and stiffness, combined with low density, it is worthwhile examining in a little more details the nature of these fibers and their origins.
The various types of fibers currently in use are discussed in what follows:

- Glass fibers
- Carbon fibers
- Boron fibers
- silicon carbide fibers

1.2.1 Glass fiber

Glass fibers with polymeric matrices have been widely used in various commercial products such as piping, tanks, boats and sporting goods. Glass is by far the most widely used fiber, because of the combination of low cost, corrosion resistance and in many cases efficient manufacturing potential. It has relatively low stiffness, high elongation and moderate strength and weight and generally lower cost relative to other composites.

1.2.2 Carbon fiber

Carbon fibers, more than all other fibrous reinforcements, have provided the basis for development of PMCs as advanced structural engineering materials. Carbon fibers are commercially available with a variety of tensile module ranging from 207Gpa on the low side to 1035 Gpa on the high side.

1.2.3 Boron Fiber

Boron fiber used as reinforcement for polymeric and metallic materials is available in many forms, several diameters and substrates or carbon. The diameter of boron fibers is among the largest of all the advanced fibers, typically0.002-0.008inch (0.05-0.2mm).

1.2.4 Silicon Carbide fiber

Silicon Carbide (SiC) fibers are used primarily in high temperature metal and ceramic matrix composites because of their excellent oxidation resistance and high temperature strength retentions. Sic whisker reinforced metals are very small, typically 8-20µ in (20-51nm) in diameter and about 0.0012 in (0.03mm) long.

2. Experimental Details and Procedure

2.1 Fabrication of composite materials

2.1.1 Selection of Materials

- E-glass with orientation of 40 degree and having mas of 450gm per sq.m.
- E-glass with orientation of 60 degree and having mas of 300gm per sq.m.
- Woven drawings with aorientation of 90degree and having mas of 510gm per sq.m.
- Combined titched drawing with orientation of 60*40*90degree and having mas of 610gm per sq.m.

2.1.2 Materials used for fabrication

- Glass fiber
- Isophthalic resin
- Polyvinyl alcohol

- Catalyst

2.1.3Properties

- Molecular formula $C_6H_4(C_2H_4O)_2$
- Density - 1.19-1.31g/cm^3
- Melting point - 230ºC

2.2Preparation of material

The material is prepared by selecting the corresponding fibers with specified orientations with the required cross sections. Isophthalic resin is embedded uniformly on the matrix, which blends glass fiber with each other and hardens of material. Polyvinyl alcohol which is the releasing agent is applied on the surface.

Commonly used process for the manufactured of composite materials are rolling, forging, Extrusion. Here we are going to use rolling process with hand roller for the uniform distribution of the resin over the matrix. The resin and catalyst mixture is applied on the surface. The process is to be repeated until we have achieved required thickness. Material should be allowed for curling.

2.3 Experimental Setup

The gauge length is that length which is under study or observation when the experiment on the specimen is performed. The gauge length of a specimen bears a constant standardized ratio to cross sectional dimension for certain reasons.

The specimen is placed in the machine between the grips and an extensometer required can automatically record the change in gauge length during test. If an extensometer is not fitted, the machine itself can record the displacement between its crosshead sections which the specimen is held. However, this method not only records the change in length of specimen but also all other extending elastic components of the testing machine and its drive system including any slipping of the specimen in the grips.

3. Results and Discussions

3.1 Tensile Test

The specimen is prepared by sing Glass fiber and Isophthalic resin with different orientation of the fiber and the following tensile test are performed.

Table 3.1.1 Young's Modules along horizontal direction of fiber

SL.NO	Types of fibre	Stress KN/mm^2	strain	Density g/cc
1	E-GLASS 300	0.086	0.0579	1.497
2	E-GLASS 450	0.145	0.0567	1.459
3	Combined Titched	0.0225	0.0676	1.025
4	Woven drawings	0.121`	0.0697	1.692

Table 3.1.2Young's Modules along transverse direction of fiber

SL.NO	Types of fibre	Stress KN/mm^2	strain	Density g/cc
1	E-GLASS 300	0.043	0.0565	1.497
2	E-GLASS 450	0.049	0.0549	1.459
3	Combined Titched	0.041	0.0549	1.024
4	Woven drawings	0.058	0.0543	1.692

The specimen is prepared by using Glass fiber and Isophthalic resin with different orientation of fiber and the following tensile test are performed and the Mechanical properties of fiber materials is shown in table 3.

Table 3.1.3 Mechanical properties of fiber materials

Materials	Yong's modules E_1 (Horizontal direction) N/mm^2	Yong's modules E_2 (Transversal direction)) N/mm^2
E-GLASS 300	1485.3	761.06
E-GLASS 450	2557.3	892.5
Combined Titched	3332.8	746.81
Woven drawings	1736.01	1086.1

3.2 Impact Test (Charpy Test)

3.2.1 E-Glass 450

Property :Charpy impact strength (Notch)

Standard : ASTM D 6110

Unit : Joule

Energy loss due to friction = 2J

Energy required to break the specimen = 25J

Total energy = 25-2 = 23J

3.2.2 Combined Titched

Property :Charpy impact strength (Notch)

Standard : ASTM D 6110

Unit : Joule

Energy loss due to friction = 2J

Energy required to break the specimen = 33J

Total energy = 33-2 = 31J

3.2.3 Woven Drawings

Property :Charpy impact strength (Notch)

Standard : ASTM D 6110

Unit : Joule

Energy loss due to friction = 2J

Energy required to break the specimen = 27J

Total energy = 27-2 = 25J

Table 3.2.1. Impact strength of fiber materials

S.NO	Materials	Impact strength(J)
1	E-GLASS 450	23
2	Combined Titched	31
3	Woven drawings	25

3.3 Flexural Test

3.3.1 E-Glass 450

Flexural Strength = 1.5 *wl/bt^2 (N/m^2)

F=143867*10^{4}N/m^2

3.3.2 Combined Titched

Flexural Strength = 1.5 *wl/bt^2 (N/m^2)

F=2161363*10^{4}N/m^2

3.3.3Woven Drawings

Flexural Strength = 1.5 *wl/bt2 (N/m^2)

F=219989*10^{4}N/m^2

Table 3.3.1. Flexural Strength of Fiber Materials

SL.NO	MATERIAL	FLEXURAL STRENGTH (Kg/cm^2)
1	E-GLASS 450	1438.67
2	COMBINED TITCHED	2613.63
3	WOVEN DRAWINGS	2199.89

Table3.3.2 Comparison Between Mechanical Properties of Fiber Materials

MATERIAL	IMPACT STRENGTHIN JOULES	FLEXURAL STRENGTH (Kg/cm^2)	E_1 (N/mm^2)	E_2 (N/mm^2)
WOVEN DRAWINGS	26	2199.89	1736.01	1086.1
COMBINED TITCHED	31	2613.63	3332.8	746.81
E-GLASS 450	33	1438.67	2557.3	892.5

3.4 Finite Element Analysis

Finite element analysis is used to determine the natural frequencies and modes shapes of a structure. The natural frequencies and mode steps are important parameters in the design of structure for dynamic loading conditions. The FEA requires three steps

- Pre-processing
- Solving Matrix (solver)
- Post-Processing

3.4.1 Result of finite element analysis using ansys software

Fig 3.4.1 E-Glass 300

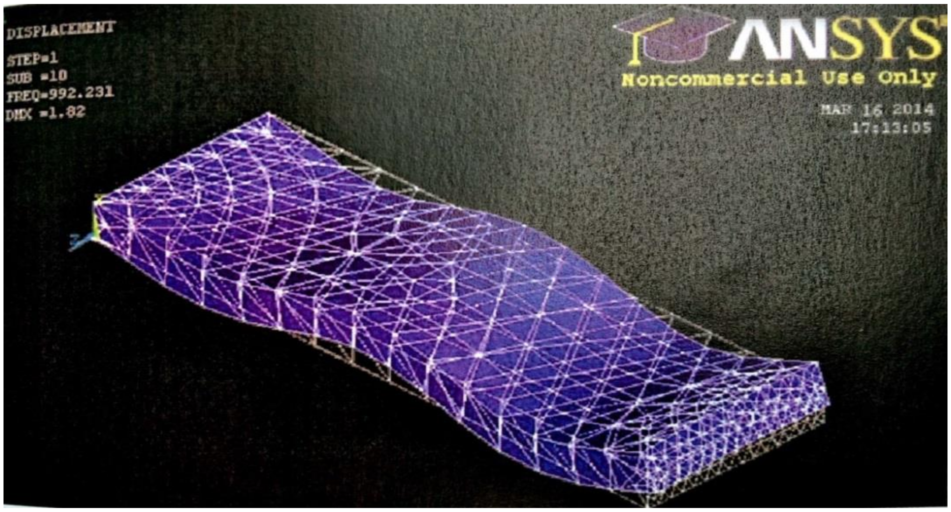

Fig 3.4.2.Extraction Frequency of E-Glass 300

Table 3.4.1 Frequency of E-Glass 300

SET	FREQUENCY (Hz)
1	32.051
2	89.532
3	198.45
4	208.33
5	422.47
6	461.66
7	544.40
8	635.17
9	943.71
10	992.23

Fig 3.4.3. E-Glass 450

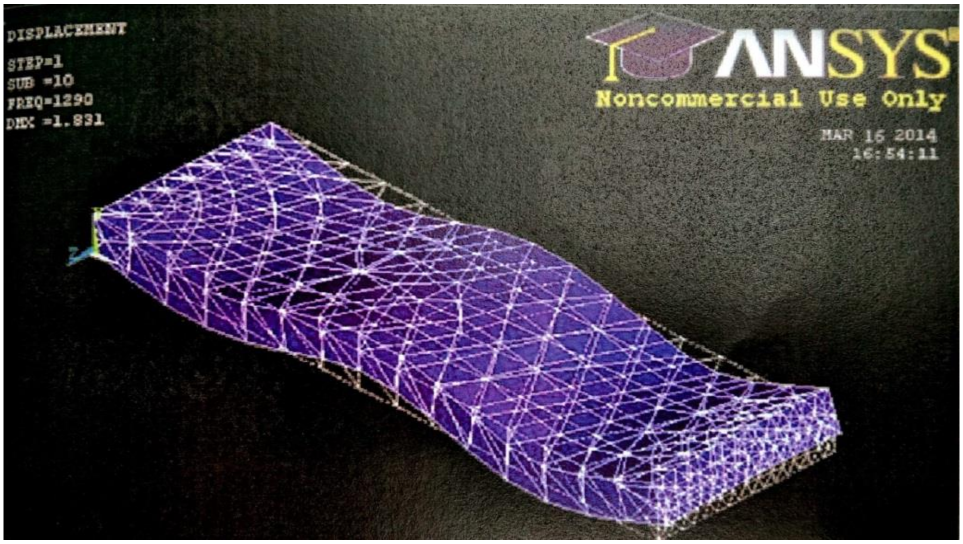

Fig 3.4.4. Extraction Frequency of E-Glass 450

Table 3.4.2 Frequency of E-Glass 450

SET	FREQUENCY (Hz)
1	41.835
2	116.15
3	258.64
4	268.73
5	546.31
6	598.57
7	707.88
8	819.31
9	1218.7
10	1289.9

Fig 3.4.5 Combined Titched

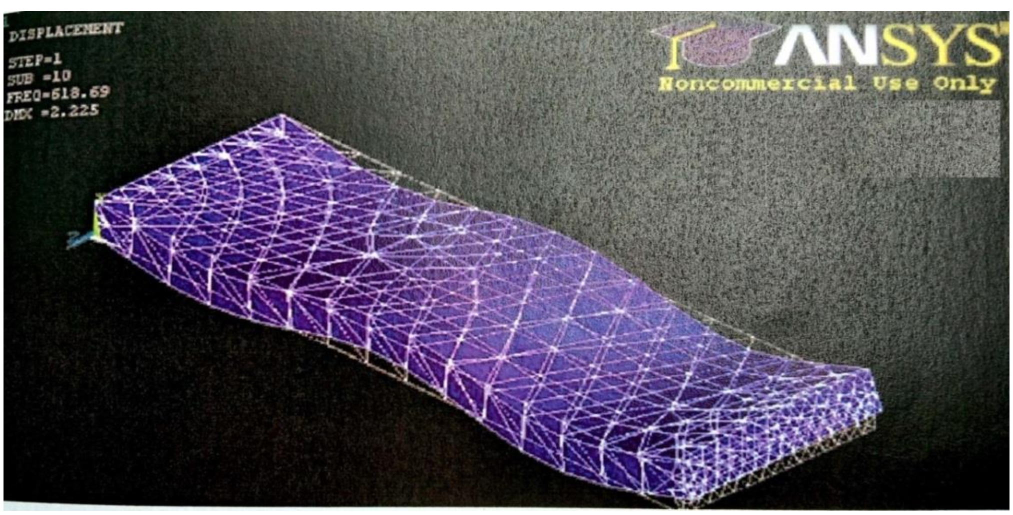

Fig 3.4.6 Extraction Frequency of combined Titched

Table 3.4.3 Frequency of Combined Titched

SET	FREQUENCY (Hz)
1	20.131
2	53.171
3	124.91
4	137.51
5	249.25
6	271.17
7	339.96
8	416.70
9	555.88
10	618.69

Fig 3.4.7. Woven drawings

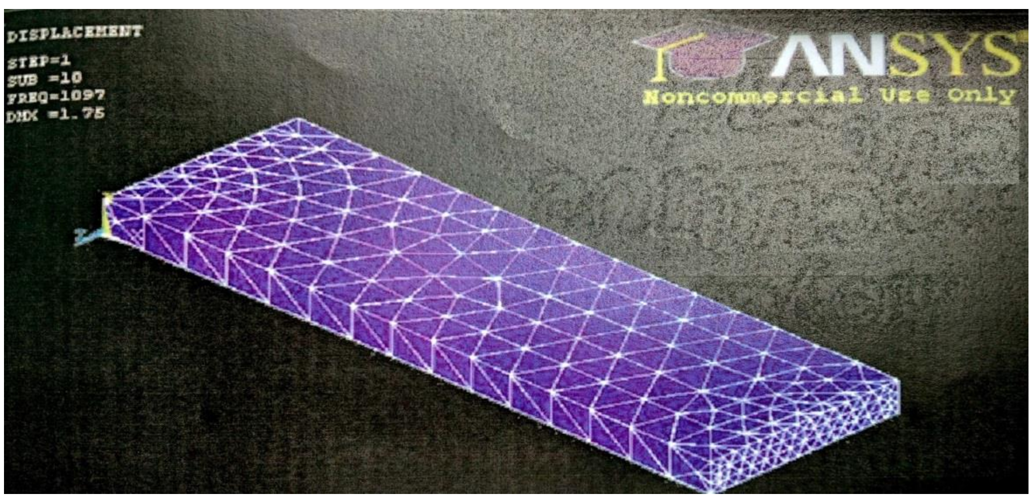

Fig 3.4.8 Extraction Frequency of woven drawings

Table 3.4.4 Frequency of Woven Drawings

SET	FREQUENCY (Hz)
1	35.497
2	98.962
3	219.70
4	230.32
5	465.57
6	510.61
7	601.91
8	703.25
9	1038.8
10	1097.0

Table3.4.5. Comparison between Frequencies of Fiber Materials

SL.NO	MATERIAL	FREQUENCY (Hz)
1	E-GLASS 300	992.23
2	E-GLASS 450	1289.9
3	COMBINED TITCHED	618.69
4	WOVEN DRAWINGS	1097.0

4. Conclusion

Successful fabrication of E-Glass 300, E-Glass 450, Combined titched and Woven drawings composite materials and tensile, impact and flexural tests were performed on these materials. From the results in the present work it was found that depending on the orientation of fibers, the materials are compared between them and high strength composite material can be found out. Direction of fiber has a huge impact on the properties of composite material.

Combined titched material has got the maximum flexural strength of 2613.63Kg/Cm^2 which is used to withstand point loads on it. The finite element analysis was performed on the entire specimen and frequencies were extracted. All the frequencies were compared and the material having the lower frequency will have less vibration relative to other materials. As a result, combined titched was found to have the lower frequency from the analysis because of the orientation of fibers and so it is the best material to withstand vibration.

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