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Fabrication and Analysis of Single lap joint Glass Fiber Reinforced Polymer Composite Materials

R.Mohammad Giyahudeen

Assistant Professor, Mechanical Department, Maha Barathi Engineering College, Chinnasalem

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***ABSTRACT -** Composite materials have made way to various fields, including aerospace structures, underwater vehicles, automobiles and robot systems. Due to the high strength to weight ratio of composites, they serve as a suitable alternative to metals, therefore making the need for a reliable database of structural design more important. Most of the modern civilian and military aircraft use composite materials for their primary structural components (in addition to metals). One of the key areas in composite structural design involves the tensile strength of joints. In the present work, the lap joint is fabricated from Uni directional ply and Bidirectional ply of GFRP (Glass fiber reinforced polymer) along with 10% Silicon Carbide powder specimens are subjected to tensile test. The effect of fibers and Silicon Carbide on the tensile strength of lap joint is investigated both experimentally, numerically and FEA analyzed using conventional software ANSYS. The result of each GFRP is compared.*

***Keywords*— Single Lap Joint, Silicon carbide, GFRP, Static analysis**

1. INTRODUCTION

Composite are made up of individual materials referred to as constituent materials. There are two categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. Joint efficiency has been a major concern in using laminated composite materials. Relative inefficiency and low joint strength have limited widespread application of composite. The need for durable and strong composite joint is even urgent for primary structural members made of laminates. Because of the anisotropic and heterogeneous Nature, the joint problem in composite is more difficult to analyse than the case with isotropic materials.

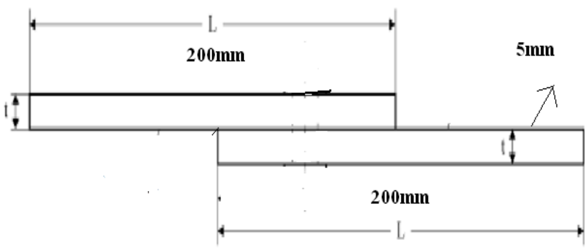
1.1 Material Selection and Laminate Manufacture

The fiber-reinforced composite material used in this study was produced at IZOREEL firm. Other reason of the selection these lay-ups are to observe variety of failure modes. All laminates balanced about the mid-plane both to prevent thermal distortion during manufacture and to eliminate bending and twisting when under tension. All laminates were made from E glass fibre and epoxy resin using press-mould technique. For matrix material, epoxy LY556 and hardener HY951 were mixed in the mass ratio of 100:80. The resin and hardener mix was applied to the fibres. Fibres were coated with this mix. Then 10 % of Silicon carbide mixed with it. Subsequent plies were placed one upon another as required orientations. A hand roller was used to compact plies and remove entrapped air that could later lead to voids or layer separations. The mould and lay-up were covered with a release fabric. Once the matrix and fibres are combined, it is necessary to apply the proper temperature and pressure for specific periods of time to produce the fibre reinforced structure. For this purpose, resin-impregnated fibers were placed in the mould for curing. The press generates the temperature and pressure required for curing. In all cases, the mould was closed to stops giving nominal thickness. The glass fibre and epoxy were cured at 120 C under a pressure of 9 MPa and this temperature was held constant for 4 hours for the first period. Afterwards, the temperature was decreased to 100 0C and held constant for 2 hours for the second period. After the second period, the laminates were cooled to room temperature, removed from press and trimmed to size.

1.2 Mechanical Properties

In this study, glass/epoxy material is used with the material properties measured at Department of Metallurgical and Materials Engineering; certain experiments were performed to measure the mechanical properties. By assuming in-plane assumption, the number of experiments required to characterize the material parameters are reduced.

Length	200mm
Width	60mm
Thickness	5mm



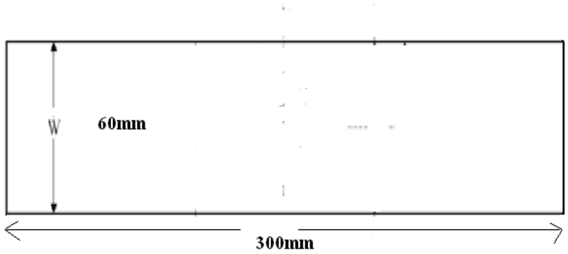


Fig 1.1 Single lap joint

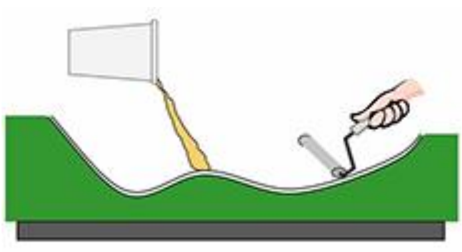


Fig 1.2 GFRP Process

2. EXPERIMENTAL, ANALYTICAL AND NUMERICAL ANALYSIS

2.1 Experimental Evaluation

In this chapter, the glass/epoxy material is fully characterized experimentally and the results are presented. The results of static experiments for measuring the stiffness and strength of a Uni directional and Bi directional composite composite under tension, compression and in-plane shear loading conditions are summarized. It is necessary to determine of basic properties of the Uni directional and Bi directional composite composite for use as basic input data for the model. A Uni directional and Bi directional composite composite under static loading was fully characterized to

Prepare complete set of input data. The experimental determination of the mechanical properties of Uni directional and Bi directional composite composite under static loading conditions has always been a key issue in the research on composite materials. With the rise of huge variety of composite, the need for an efficient and reliable way of measuring these properties has become more important. The experiments, if conducted properly, generally reveal both strengths and stiffness characteristics of the material.

The stiffness characteristics are,
E1, E2: Longitudinal and transverse Young modulus
ν12: Poisson's ratio
G12: Shear modulus

Determination of the Tensile Properties of Uni directional and Bi directional composite

Tensile properties such as Young's modulus (E1), (E2); Poisson's ratio (ν12), (ν21); and lamina longitudinal tensile strengths (Xt) and transverse tensile strength (Yt) are measured by static tension testing longitudinal [00]6 and transverse [900]6 Uni directional and Bi directional composite composite specimens according to the ASTM D3039-76 standard test method. The tensile specimen is straight sided and has constant cross-section. The tensile test geometry to find the longitudinal tensile properties consists of six plies which are 200 mm wide and 60 mm height.

The tensile specimen is placed in the testing machine, taking care to align the longitudinal axis of the specimen and pulled at a cross-head speed of 0.5 mm/min. The specimens are loaded step by step up to failure under uni-axial tensile loading. A continuous record of load and deflection is obtained by a digital data acquisition system.

2.2 Numerical evaluation modelling of the problem

The geometry of the plate investigated in this study was shown in the mat is symmetric with respect to the z = 0 plane. Perfect bonding between each mat and frictionless contact are assumed. The composite plate is loaded with an in-plane load P for the bonded joint. It is desired to find the maximum failure load Pmax that can be applied before the joint fails and the mode of failure for each geometry. By increasing the load to a certain value, failure will start at a position near the edge. This load is first ply failure load. If after failure initiation the load is increased, failure will propagate in different directions. Finally at higher load damage will propagate to an extent that the plate cannot tolerate any additional load. This value is ultimate strength.

Tensile Strength =F/S*L
Where,
τ – Stress or strength in N/mm^2,
F – Load in N
L-length in mm

By using this formula the Tensile strength of composite is numerically calculated.

2.3 Basic Support of the Analysis

When modelling composite one of the key challenges is balancing the sophistication of the materials models against reasonable computational solution. In the first design phase, when many different solutions must be analysed in a short space of time. It is necessary to be able to complete the analysis of alone million element model with in one day. This is not currently possible using full composite materials characterizations.

The situation is even more severe when performing stochastic analyses or undertaking multi objective optimizations. Both typically required the running of 60-100 simulations to complete. If it is taking a day or more to run each analysis and then the whole process could easily take longer than three months.

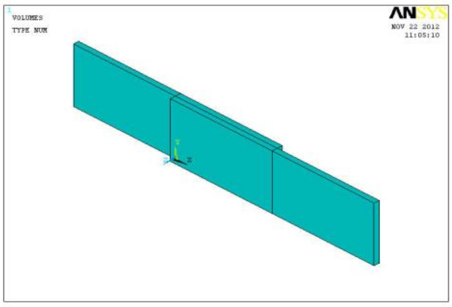


Fig.2.1 sample picture of Analysis of Uni directional ply

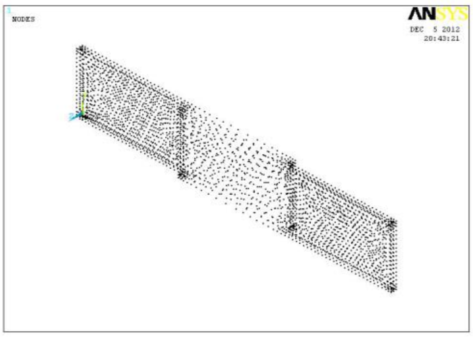


Fig. 2.2 Element nodes in single lap joint

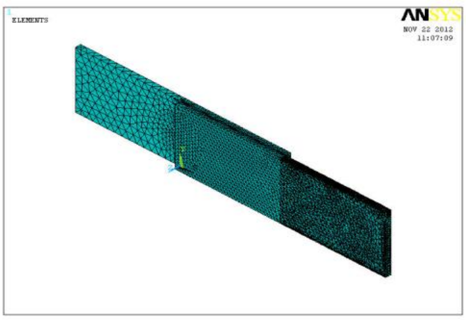


Fig.2.3 meshing the single composite lap joint

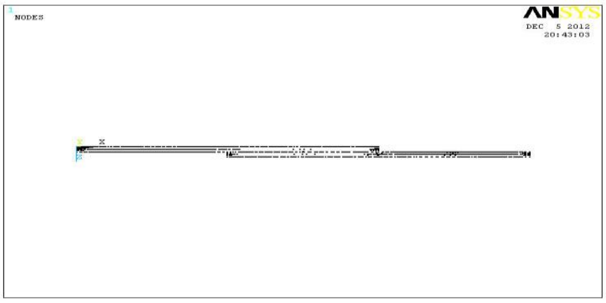


Fig.2.4 Two dimension single composite lap joint

MATERIAL TYPE	EXPERIMETALLY CALCULATED RESULTS	
	Tensile strength for Single Plate	Tensile strength for Joined Plate
UNI DIRECTIONAL PLY ALONG WITH 10% SIC	52.486	86.407
Bi DIRECTIONAL PLY ALONG WITH 10% SIC	74.733	122.71
BREAKING LOAD(CSM)	15.2kN	24.8kN
BREAKING LOAD(BDF)	19.8kN	30kN

Table.2.1 Tensile strength for experimentally calculated results

MATERIAL TYPE	NUMERICALLY CALCULATED RESULTS	
	Tensile strength for Single Plate	Tensile strength for Joined Plate
UNI DIRECTIONAL COMPOSITE	49.53	92.80
Bi DIRECTIONAL FLY	71.65	128.52

Table.2.2 Numerical calculated results for joint specimen

3. RESULTS AND DISCUSSIONS

3.1 Experimental results

No In the following subsections, the experimental results of loaded composite laminates are presented. The general behaviour of the all composite mentioned above was obtained from the load/displacement chart record from the testing machine. Because the appropriate value of joint strength depends upon the failure load, failure loads in deterministic sense were measured and were presented below.

3.2 Numerical Results

The numerical results are calculated by using the given below.

Tensile Strength =F/S*L

Where,

τ – stress or strength in N/mm²

F – Load in N

L-length in mm

Tensile strength = 24.8 x 10³/300 =92.80

By using this formula the Tensile strength of composite is numerically calculated.

3.3 Analysis Results

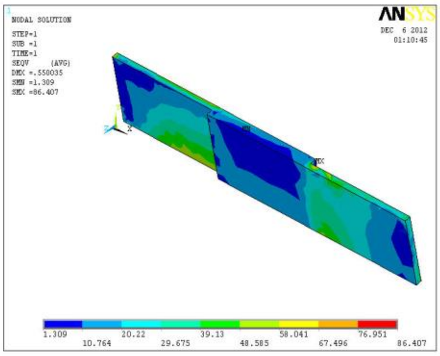


Fig.3.1 Ansys results of Uni directional ply composite

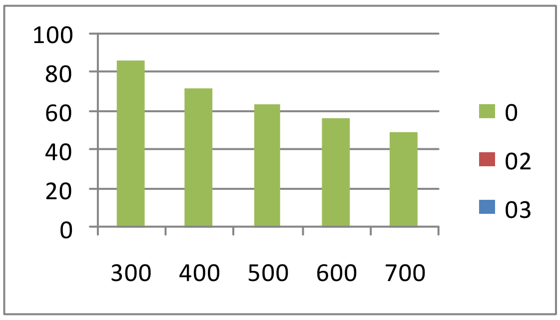


Chart.3.1 Graph for tensile strength to vary the length and width is constant

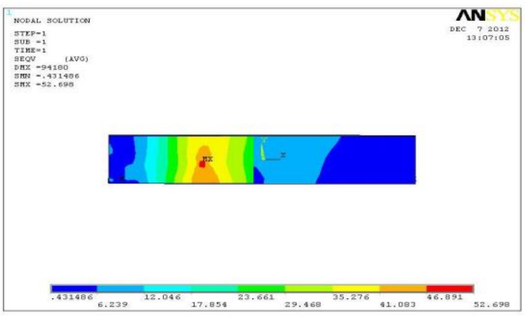


Fig.3.2 Single plate composite Uni directional composite

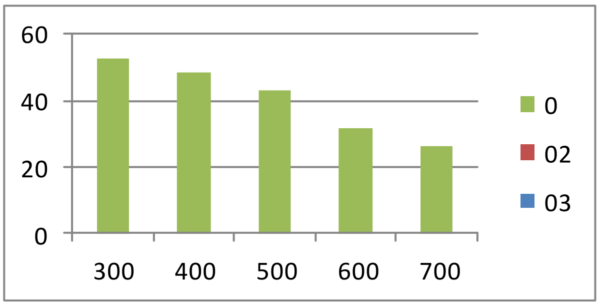


Chart.3.2 Graph for tensile strength to vary the length and width is constant

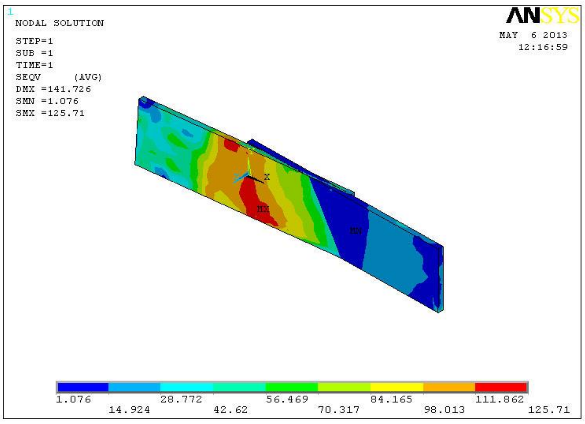


Fig.3.3 Single plate composite bi directional ply

Table.3.1 Ansys results of BDF mat

Material Type	Numerically calculated Tensile strength (N/mm²)	Analysis results Tensile strength (N/mm²)	Experimental results Tensile strength (N/mm²)
Uni directional composite	92.890	86.407	82.334
Bidirectional ply	128.52	125.71	122.71

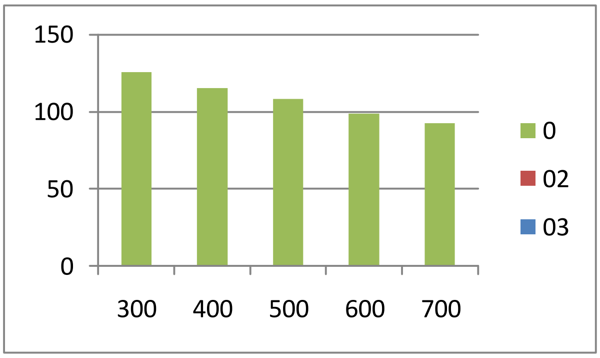


Chart.3.3 Graph for tensile strength to vary the length and width is constant

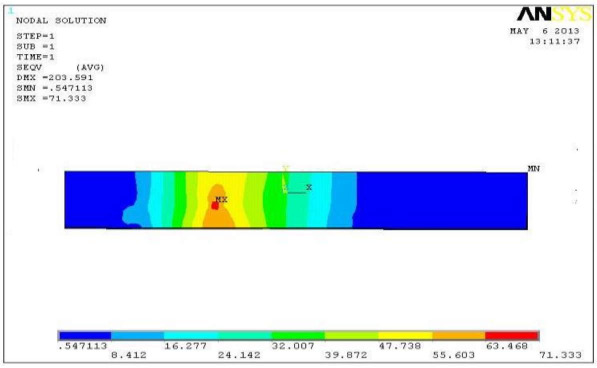


Fig.3.4 Single plate composite bi directional ply

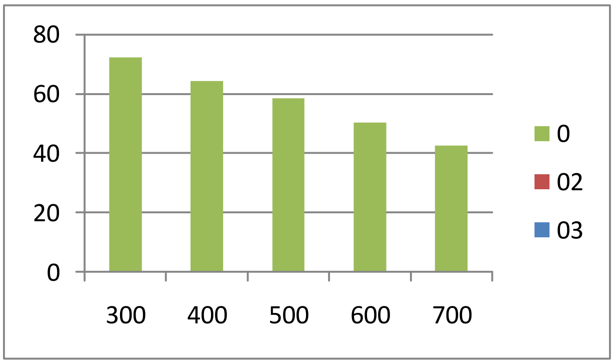


Chart.3.3 Graph for tensile strength to vary the length and width is constant

4. CONCLUSION

In this project Glass fibre (Uni directional and Bi directional composite composite) along with 10 %SiC was fabricated by hand lay-up method. The composite material was machined according to the dimension. In the bonded joining process composite gave the more tensile strength When compared with same dimensions of single plate .The Experimental and Analytical and numerical results for glass fibre (Uni directional Ply & Bi- Directional Ply) with 10%SiC epoxy composite are obtained. The ANSYS results are in good agreement with experimental and analytical results.

From this project it can be conclude that the tensile strength values of Bi-Directional fly (Tensile Strength - 122.71 N/mm^2) is more compared to the Uni directional (Tensile Strength-82.33 N/mm^2) lap joint material. Based on above compared values, Bi-Directional Ply with 10% siC is used for Aircraft and Automobile application.

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BIOGRAPHIES

R.Mohammad Giyahudeen
I Studied B.E Mechanical Engineering (Annamalai University), M.E Design (Sona Engineering College, Affiliated to Anna University)
13 years' experience in teaching professional and also have interested in research work.