Static Analysis of Single Lap Joint of Composite Materials

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Abstract— Mechanically fastened joints are critical parts in composite aircraft structures. The composite structural members are highly used in the following applications such as aerospace, automobiles, marine, architecture etc., In the past decades, adhesive bonding is a practical joint method for joining composite materials which provide low shear and tensile strength .To improve the tensile strength, the joint is made with material joint. Glass Fiber/Chopped strands mat and Bi-Directional fly / Epoxy composite is fabricated by hand lay-up method. The tensile properties of the material joint are obtained and compared with that of bolted joint. The experimental results shows that the material joint has superior tensile properties than the bolted joint and the Bi-Directional fly composite exhibits superior tensile strength than the chopped strands mat. Finite element analysis also done and compared with the experimental results and found to be similar.

Key words: Chopped strands mat, Bi-Directional fly, Hand lay-up, Epoxy, Material joint

I. INTRODUCTION

A composite materials is defined as a material system which consists of a mixture or a combination of two or more distinctly materials which are insoluble in each other and differ in form or chemical composition. Thus, a composite material is labeled as any material consisting of two or more phases. Many combinations of materials may, therefore, be termed as composite materials, such as concrete, reinforced rubbers, conventional multiphase alloys, fibre reinforced plastics, and fibre reinforced metals and similar fibre impregnated materials. Two-phase composite materials are classified into two broad categories: particulate composites and fibre reinforced composites. Particulate composites are those in which particles having various shapes and sizes are dispersed within a matrix in a rondom fashion. These composites are treated as quasi-homogeneous and quasi-isotropic. Examples of this composite are mica flakes reinforced with glass, aluminium particles in polyurethane rubber, lead particles in copper alloys and silicon carbon particles in aluminium. Particulate composites are used for electrical application, welding, machine parts and other purpose. Fibre reinforced composite materials consists of fibres of significant strength and stiffness embedded in a matrix with distinct boundaries between them. Both fibres and matrix maintain their physical and chemical identities, yet their combination performs a function which cannot be done by constituent acting singly. Fibres of fibre reinforced composites (FRC) may be short or continuous. It appears obvious that FRP having continuous fibres is indeed more efficient.

II. MATERIALS AND FABRICATIONS

SPECIFICATION	JOINT BY MATERIAL	JOINT BY BOLT
LENGTH (L)	200mm	200mm
WIDTH(w)	60mm	60mm
THICKNESS(t)	5mm	5mm
BOLT DIAMETER		D = 15mm d = 10mm
LOCATION OF BOLT		h = 30mm e = 50mm

Table 2 Dimensions of the specimens.

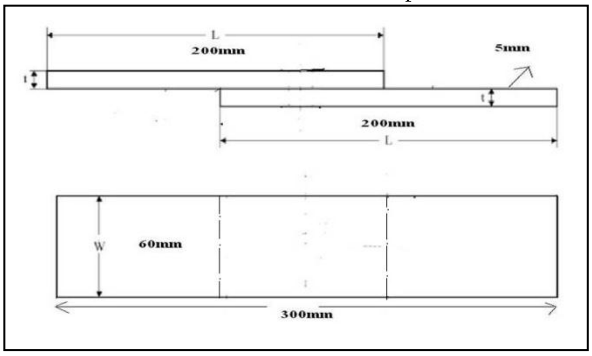

Fig 4: Basic single-lap joint by material

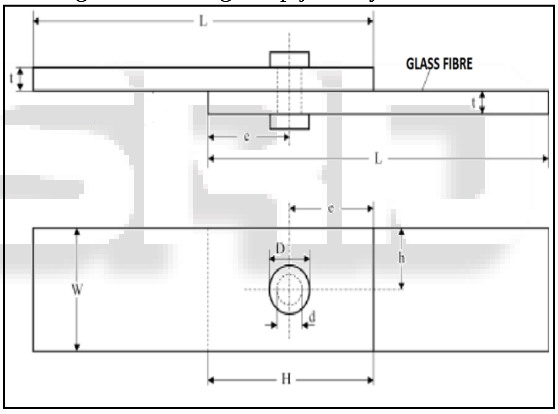

Fig 5: Basic single-lap joint by bolt

Fig 7: chopped strand mat lap joint

Fig 8 : Bi-Directional fly lap joint

III. EXPERIMENTAL AND ANALYTICAL ANALYSIS

A. *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 chopped strand mat under tension, compression and in-plane shear loading conditions are summarized. It is necessary to determine of basic properties of the chopped strand mat for use as basic input data for the model. A chopped strand mat under static loading was fully characterized to prepare complete set of input data. The experimental determination of the mechanical properties of chopped strand mat under static loading conditions has always been a key issue in the research on composite materials. With the rise of huge variety of composites, 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.

B. *Determination of the Tensile Properties*

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 chopped strand mat 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.

Fig 9: Tensile test in Universal Testing Machine

C. *Analysis Procedure*

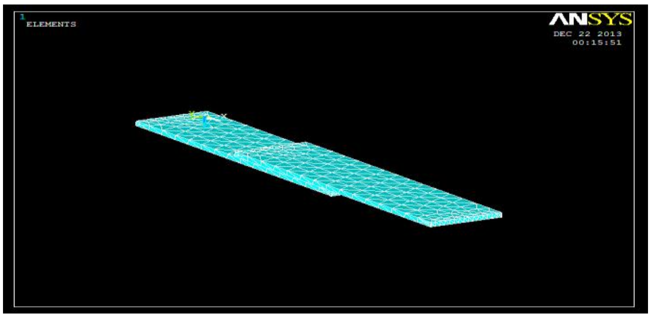

Fig 10: Mesh view of material lap joint.

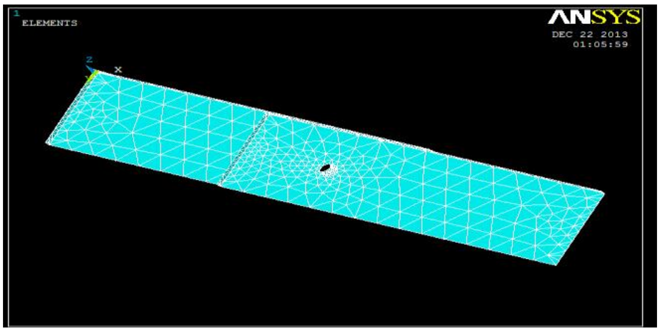

Fig 11: Mesh view of bolted lap joint.

IV. RESULTS AND DISCUSSIONS

A. *Experimental Results*

In the following subsections, the experimental results of loaded composite laminates are presented. The general behavior 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.

LAP JOINT	BREAKING LOAD	TENSILE STRENGTH
Joint by material	16.5 KN	27.50N/mm²
Joint by bolt	10.1 KN	16.83 N/mm²

Table 3: Experimental results of chopped strands mat lap joint.

LAP JOINT	BREAKING LOAD	TENSILE STRENGTH
Joint by material	26.6 KN	44.34N/mm²
Joint by bolt	12.2 KN	20.34 N/mm²

Table 4: Experimental results of Bi-directional fly lap joint.

These are the breaking load and tensile strength of lap joints obtained in experimental test by universal testing machine. It shows the material joint have more tensile strength than bolted joint. The results are shows in the Table 3 & 4.

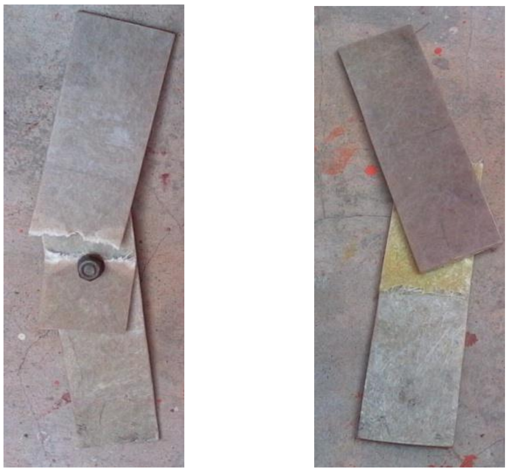

Fig 12: Failure in Lap Joint.

The lap joint by bolt had a shear failure near the bolt and the material joint had a shear in overlap region of where the joint is take place. Also by the experimental test the values shows bi-directional fly joint gives more tensile strength than the chopped strand mat.

B. Analytical Results

The analytical results are carried out by using ANSYS the Fig 13 & 14 shows the tensile results of chopped strand mat.

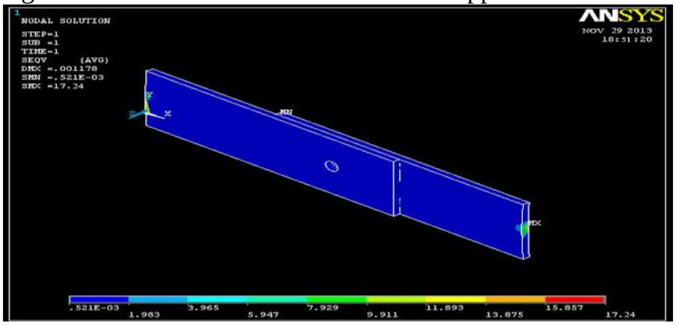

Fig 13: Tensile result of CSM bolt joint

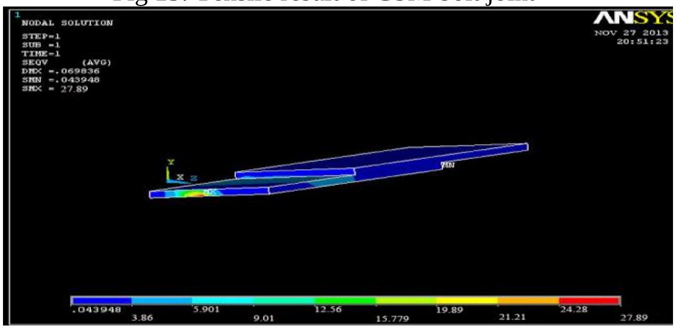

Fig 14: Tensile result of CSM material joint.

From the results of ANSYS the tensile strength of the chopped strand mat lap joint by bolt is 17.24N/mm^2 and lap joint by material 27.89N/mm^2.

The Fig 15 & 16 shows the tensile results of Bi-directional fly.

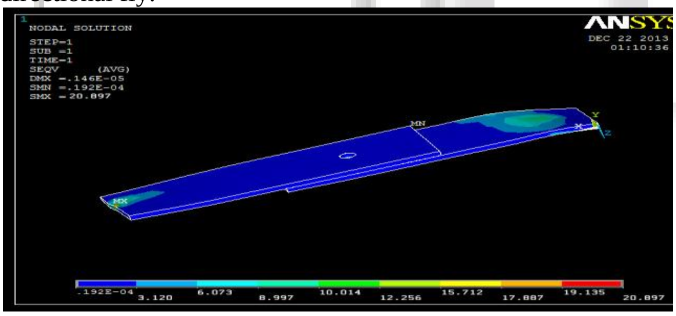

Fig 15: Tensile result of BDF bolt joint

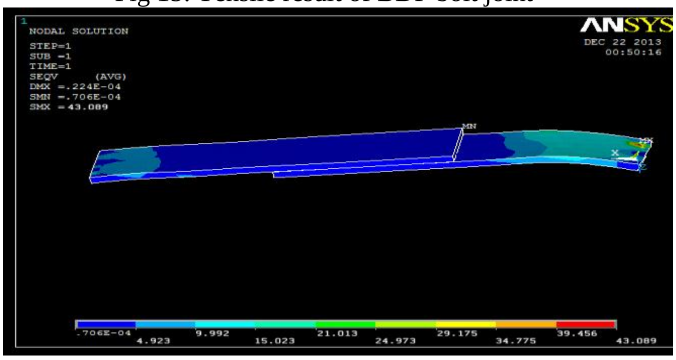

Fig 16: Tensile result of BDF material joint

From the results of ANSYS the tensile strength of the Bi-Directional fly lap joint by bolt is 20.89 N/mm^2 and lap joint by material 43.089N/mm^2. The analytical results are compared with the experimental results both are approximately equal each other. The comparison of results is shows in Table 5.

C. Final Results

MATERIAL TYPE	ANALYSIS RESULTS Tensile strength (N/mm^2)	EXPERIMENTAL RESULTS Tensile strength (N/mm^2)
CSM by material joint	27.89	27.50
CSM by bolt joint	17.24	16.83
BDF by maerial joint	43.089	44.34
BDF by bolt joint	20.89	20.34

Table 5 Comparison of the tensile strength of above two results.

V. CONCLUSION

Glass fibre Chopped strand mat/Bi-directional fly was fabricated by hand lay-up method. The composite material was fabricated according to the dimension. Material Lap joint has more tensile strength when compared with same dimensions of lap joint using bolt. The experimental and analytical results for glass fibre Chopped Strand Mat and Bi-directional fly epoxy composite are obtained. The Bi-Directional fly composite exhibits superior tensile strength than the chopped strands mat. The ANSYS results are in good agreement with experimental results.

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