RESEARCH ARTICLE OPEN ACCESS

Analysing The Composite Structure Of Riverted ,Hybrid And Bonded Joints

B.MEGANATHAN & E.S.ESAKKI RAJ
ASST PROFESSOR/MECHANICAL ENGINEERING
VELAMMAL INSTITUTE OF TECHNOLOGY

ABSTRACT
Composite materials have been widely used as structural elements in aircraft structures due to their superior properties. Aircraft structure is a huge assembly of skins, spars, frames etc. The structure consists of an assembly of sub-structures properly arranged and connected to form a load transmission path. Such load transmission path is achieved using joints. Joints constitute the weakest zones in the structure. Failure may occur due to various reasons such as stress concentrations, excessive deflections etc. or a combination of these. Therefore, to utilize the full potential of composite materials, the strength and stress distribution in the joints has to be understood so that suitable configuration can be chosen for various applications.

I. INTRODUCTION

Over the past three decades, application of composite materials are continuously increasing from traditional application areas such as military aircraft, commercial aircraft to various engineering fields including automobiles, robotic arms and even architecture. Due to its superior properties, composites have been one of the materials used for repairing the existing structures. In such applications and also for joining various composite parts together, they are fastened together either using adhesives or mechanical fasteners. Nowadays, a novel method called hybrid joint is also being employed, where a combination of both adhesive and mechanical fasteners is used.

1.1 OBJECTIVE

To investigate the stress distribution and Tensile Strength of various configuration of single lap joint. A parametric study of hybrid joint by varying the three dimensional parameters of the joint will be carried out. Modeling and analysis of 3-D models of the Bonded, Riveted and Hybrid joints were carried out using ANSYS 11 FEA software and also Tensile Strength of these joints were carried out using Universal Testing Machine(UTM)

1.2 **IMPORTANCE** OF THE WORK

Analysis using FEA tool is necessary to standardize the experimental procedures and testing sequence.

II. LITERATURE REVIEW

Any number papers can easily be found for mechanically fastened joints and adhesive bonded joints whereas for hybrid joints, there are only a limited number of papers available. Some of them are briefly discussed below.

1. Hart-Smith conducted a theoretical investigation of combined bonded/bolted stepped lap joints between titanium and Carbon Fiber Reinforced Plastic (CFRP). While no significant strength benefits were found in comparison to perfectly bonded joints, the combined bolted-bonded joint was found to be beneficial for repairing damaged bonded joints and limiting damage propagation. Under room temperature and ambient humidity conditions, 98% of the applied load was predicted to be transferred by the adhesive.
2. Chan and Vedhagiri investigated the use of bolted, bonded and combined bonded-bolted joints used in repair. A single strap joint with CFRP adherends was considered with two bolts used in the overlap region. The study primarily considered stress distributions in the laminates and limited consideration was given to load transfer through the joint. The structural response of various configurations of single lap joint, namely, bonded, bolted and bonded-bolted joints, was analyzed by three-dimensional finite element method. For the case of hybrid joints, it was found that the bolts do not take an active role in load transfer before the initiation of the failure. However, the bolts in the hybrid joint actually reduce the in-plane axial stress near the edge of overlap.
3. Gordon Kelly investigated the load distribution in hybrid joints numerically through the use of finite element analysis. A three dimensional finite element model was developed including the effects of bolt-hole and nonlinear material behavior and large deformation. From the study, it was found that load transferred by the bolt increases with increasing adherent thickness and adhesive thickness and decreases with increasing overlap length, pitch distance and adhesive modulus.

4. Fu and Mallick investigated the static and fatigue strength of hybrid joints in a Structural Reaction Injection Moulded (SRIM) composite materials. The authors performed an experimental investigation on a single lap joint considering the effect of different washer designs. It was concluded that the performance of the hybrid joints was dependent upon the washer design which affected the distribution of the bolt clamping force. The hybrid joints were shown to have higher static strength and longer fatigue life than adhesive bonded joints for the studied material system.

5. Jin-Hwe Kweon, Jae-Woo Jung and others conducted tests to evaluate the strength of carbon composite to aluminum double lap joints with two different adhesive materials, film and paste types. The three types of joints-bonded, bolted and hybrid-were considered. It was found that the strength of hybrid joints with film type adhesive is dominated by the strength of the adhesive itself. On the contrary, the strength of the joints with paste type adhesive was mainly affected by the bolt joint. In general, it was found that hybrid joining is effective when the mechanical fastening is stronger than the bonding. On the contrary, when the strength of the bolted joint is lower than the strength of the bonded joint, the bolt joining contributes little to the hybrid joint strength.

Previous studies on hybrid joints have considered fixed joint geometries and material systems. Limited consideration has been given to the prediction of load distribution in the joints. This study was focused on the analysis of stress distribution in three prominent joining methods namely, bonded, bolted and hybrid joints. FEA is used to study the stress distribution in the members involved under various design conditions.

2.1 UNIVERSAL TESTING MACHINE

The most common testing machines are universal testers, which test materials in tension, compression, or bending. Their primary function is to create the stress strain curve described in the following section in this chapter. Testing machines are either electromechanical or hydraulic. The principal difference is the method by which the load is applied. Electromechanical machines are based on a variable-speed electric motor; a gear reduction system; and one, two, or four screws that move the crosshead up or down A microprocessor-based closed-loop servo system can be implemented to accurately control the speed of the crosshead.

Hydraulic testing machines are based on either a single or dual-acting piston that moves the crosshead up or down. However, most static hydraulic testing machines have a single acting piston or ram

2.2 INTRODUCTION TO TENSILE TESTING

Tensile tests are performed for several reasons. The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a materia

2.2.1Tensile Specimens and Testing Machines

Consider the typical tensile specimen shown in Fig.. It has enlarged ends or shoulders for gripping. The important part of the specimen is the gage section. The cross-sectional area of the gage section is reduced relative to that of the remainder of the specimen so that deformation and failure will be localized in this region.

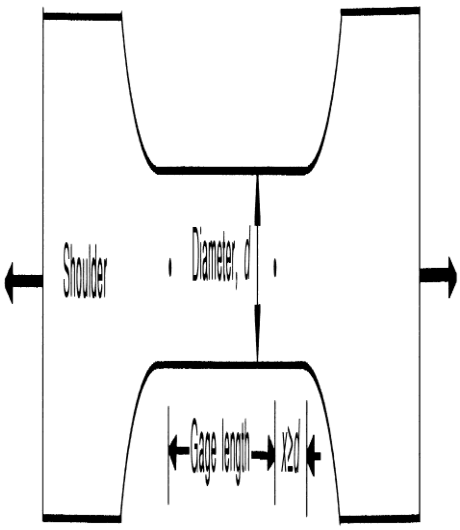


Fig. 2.1. Testing Specimen

The gage length is the region over which measurements are made and is centered within the reduced section. The distances between the ends of the gage section and the shoulders should be great enough so that the larger ends do not constrain deformation within the gage section, and the gage length should be great relative to its diameter. Otherwise, the stress state will be more complex than simple tension. The end may be screwed into a threaded grip, or it may be pinned; butt ends may be used, or the grip section may be held between wedges. The most important concern in the selection of a gripping method is to ensure that the specimen can be held at the maximum load without slippage or failure in the grip section. Bending should be minimized.

III. COMPOSITE JOINTS

Ideally, it is always preferred to make monolithic structures, that is, structures without joints. This ideal can never be realized for many reasons like size limitations imposed by materials or the manufacturing process, need for disassembly of structure for transportation and access for inspection and repair etc. Basically, there are two types of load-carrying joints available: mechanically fastened joints and adhesively bonded joints. Nowadays, a novel method called hybrid joint is also being used in certain applications.

A short description of the three types of joints used in the present work namely, bonded, riveted and hybrid joints is given below.

In general, there are numerous advantages of adhesive bonded joints over the traditional mechanical fastened joints. These advantages include large bond area for load transfer, low stress concentration, smooth external surfaces at the joint, less sensitivity to cyclic loading, time and cost saving, high strength to weight ratio, electrical and thermal insulation, conductivity, corrosion and fatigue resistance, crack retardation, damping characteristic and so on.

1. They require surface preparation.
2. Joint integrity is difficult to confirm by inspection. Thus ensuring a quality of bonding has been a challenging task

3.2 RIVETED JOINT

Riveted joints can be used quite successfully on laminates up to about 3mm thick and also where a tight fit, called interference fit, is necessary.

In addition to material and configurationally parameters, the behavior of riveted joints is also influenced by rivet parameters such as rivet size, clamping force, hole size and tolerance. Of these parameters, the clamping force, that is, the force exerted in the through – thickness direction by the closing of the fastener, is of critical importance.

IV. MANUFACTURING

4.1 LAMINATE PREPARATION

- The laminate size is 300mm × 250mm x 25 mm
- No. of layer is 5.

4.2 RESIN

Resin is to transfer stress between the reinforcement fibers, act as a glue to hold the fiber together.Commonly used resins are:

- Epoxy, polyester and vinyl ester
- Epoxy LY556 is selected.

4.3 TYPES OF HARDENER

- HY951 – at room temperature.
- HT927 – temperature ranging from 80˚C – 130˚C
- HT974 – temperature ranging from 70˚C – 80˚C
- HZ978 – temperature ranging from above 100˚C

4.4 PREPARATION OF EPOXY AND HARDENER

- Epoxy LY556 and it mixed with Hardener HY951.
- Ratio of mixing epoxy and hardener is 10:1

4.5 SPECIMEN PREPARATION FOR GLASS FIBER

- The mould should be well cleaned and dry.
- Release agent is applied.
- The epoxy mixture is uniformly applied.
- First woven mat is laid into the molded.

V. TETING OF SPECIMEN

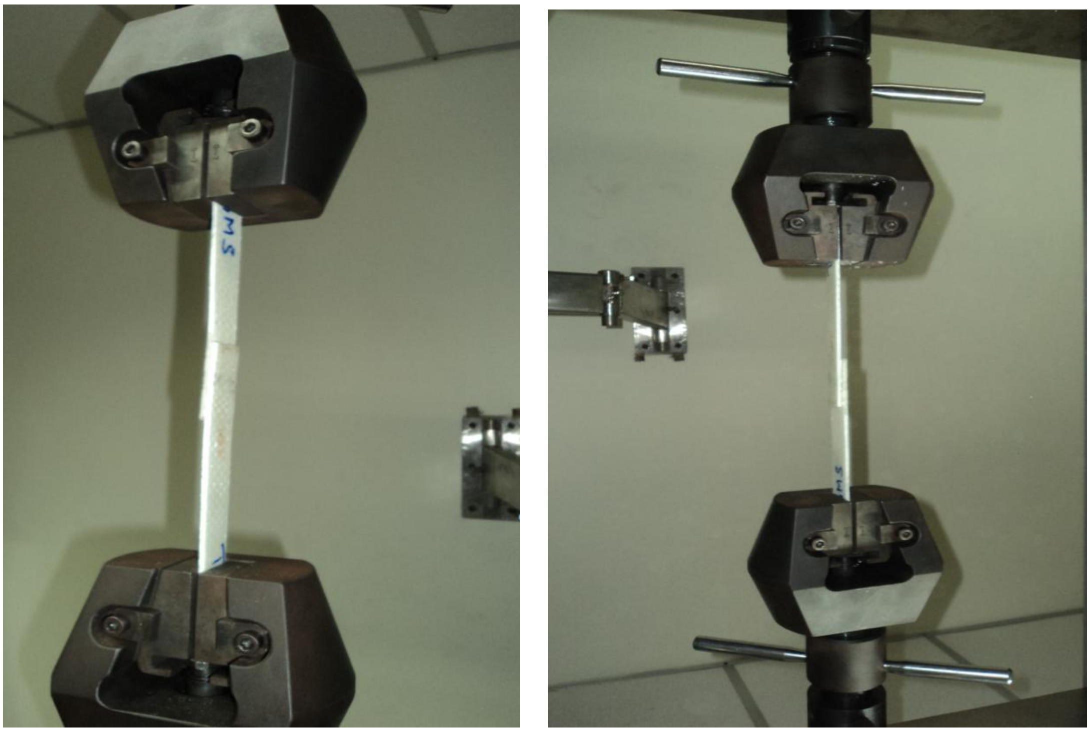


Fig 5.1 to Fig. 5.4 Testing of Bonded Joint (Before & After)

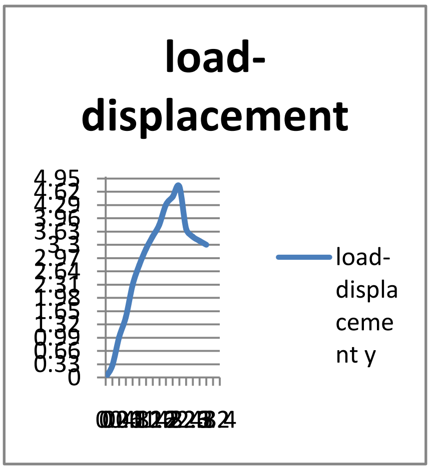
Fig. 5.5 to Fig. 5.7 Testing of Riveted Joint (Before & After)

ISSN : 2248-9622, Vol. 5, Issue 3, (Part -2) March 2015, pp.53-61

Fig 5.8 to Fig. 5.9 Testing Of Hybrid Joint (Before & After)

5.***1.*** GRAPHS

1.1 LOAD VS DISPLACEMENT:



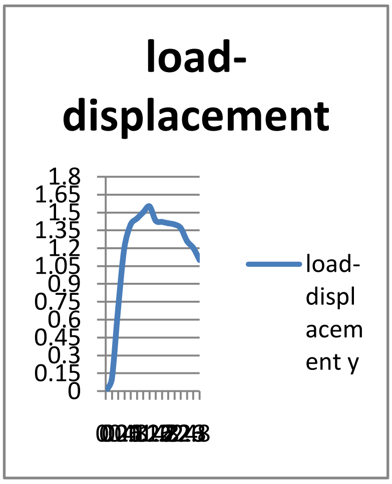


Fig 5.11 load vs displacement graph of riveted joint ***Fig 5.12 load vs displacement graph of hybrid joint***

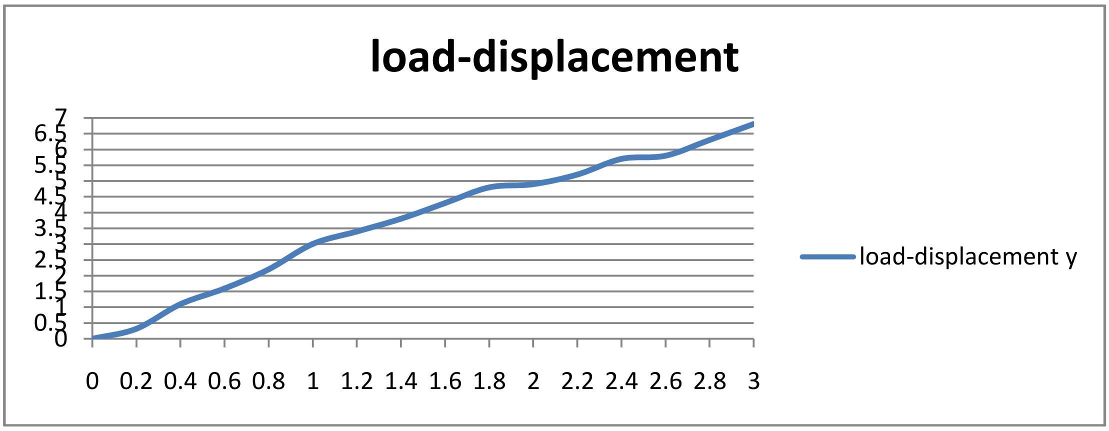


Fig 5.10 load vs displacement graph of bonded joint

4.6 COMPARISON GRAPH

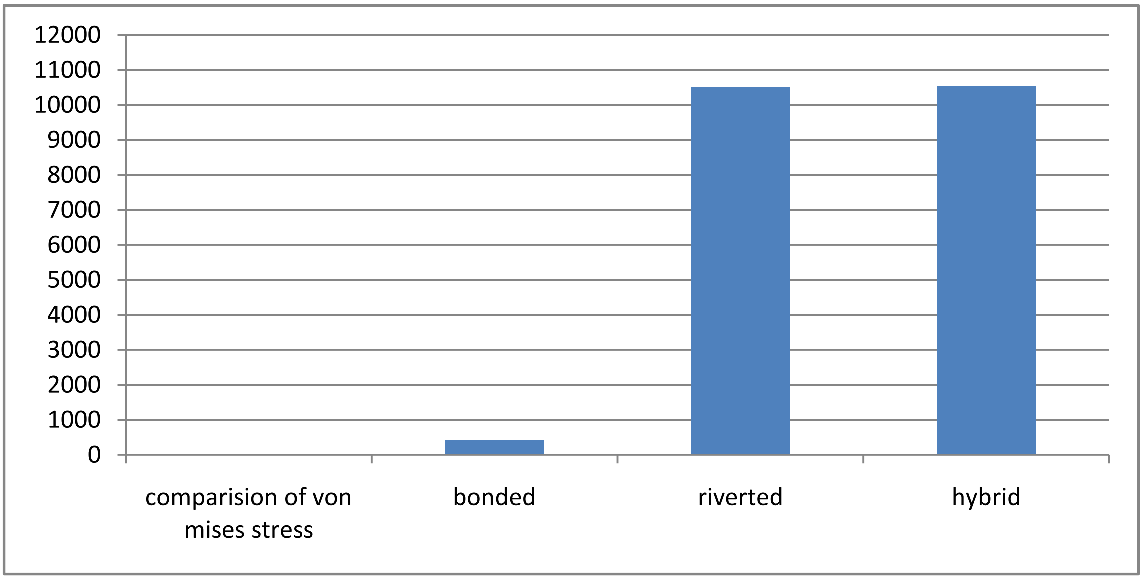


Fig5.12 comparison of von-misses stress

VI. MODELLING ANALYSIS

We created model of joints (bonded, riveted and hybrid) by using CATIA software. The models are shown below

…

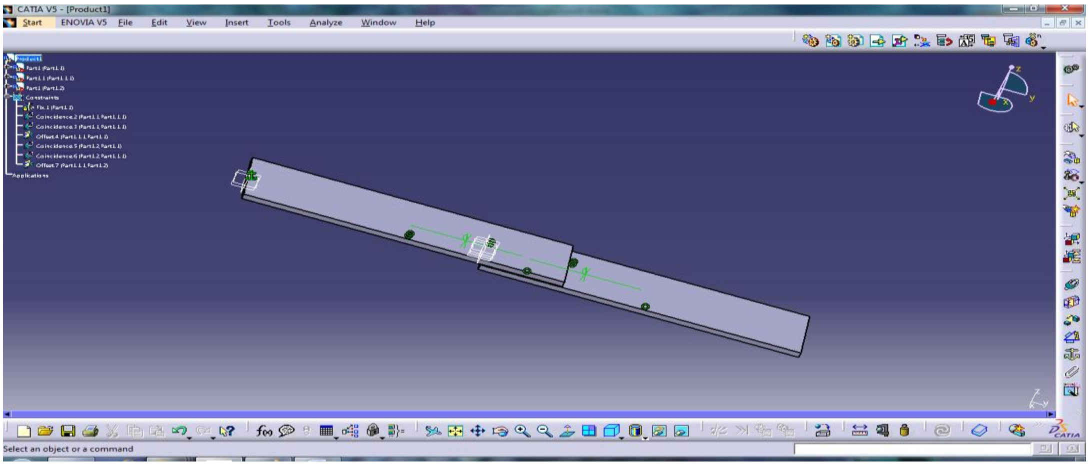


Fig 6.1 Model Of Bonded Joint

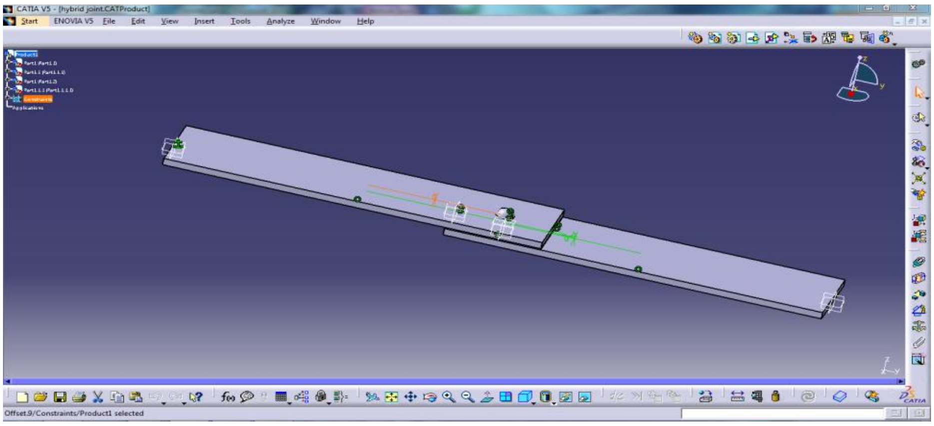


Fig 6.2 Model OF Riveted Joint

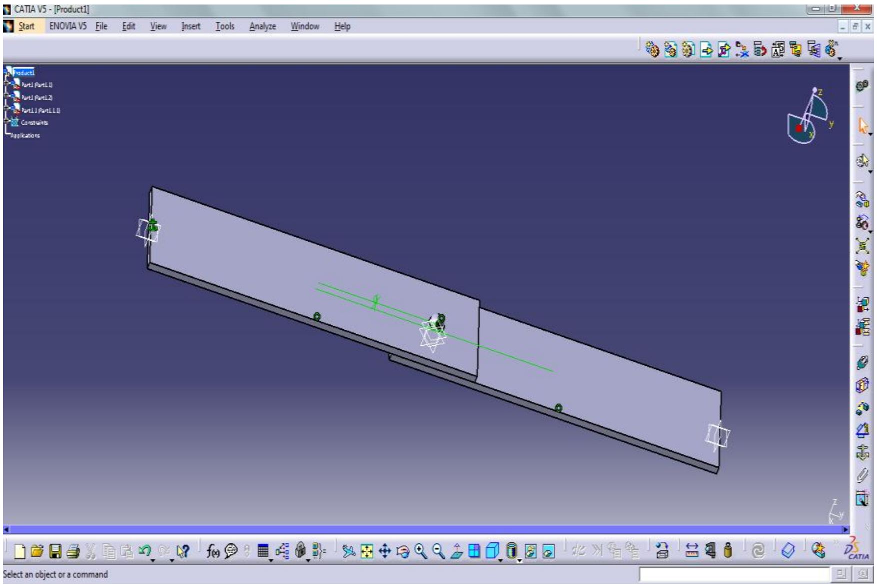


Fig 6.3 Model Of Hybrid Joint

VII. RESULTS AND DISCUSSION

7.1 ANSYS RESULTS:

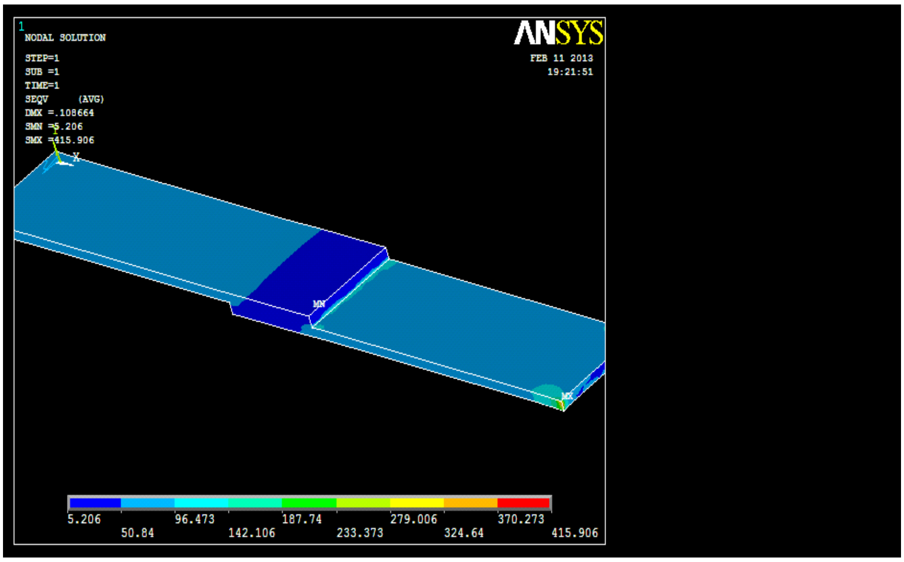


Fig 7.1 Von-Misses Stress of Bonded Joint

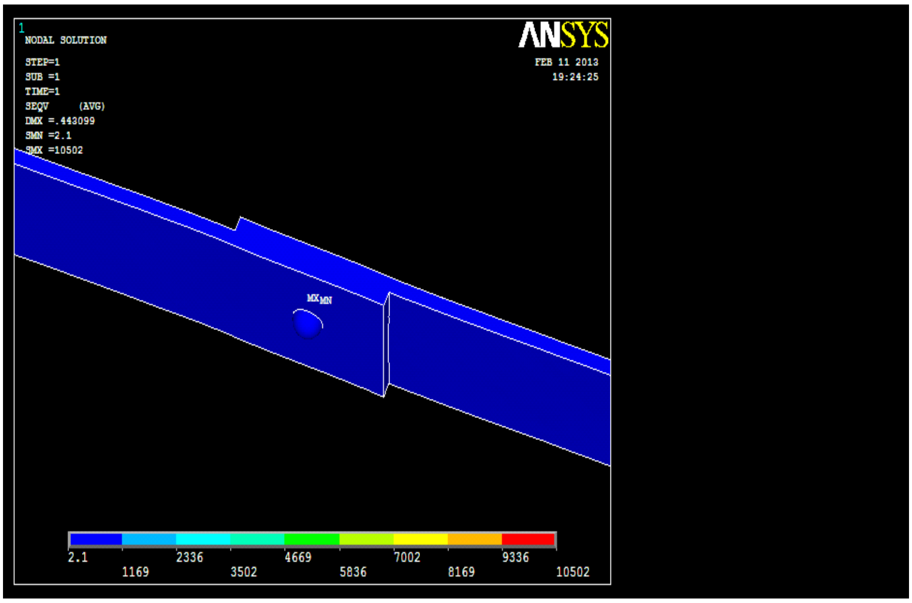


Fig 7.2 Von-Misses Stress of Riveted Joint

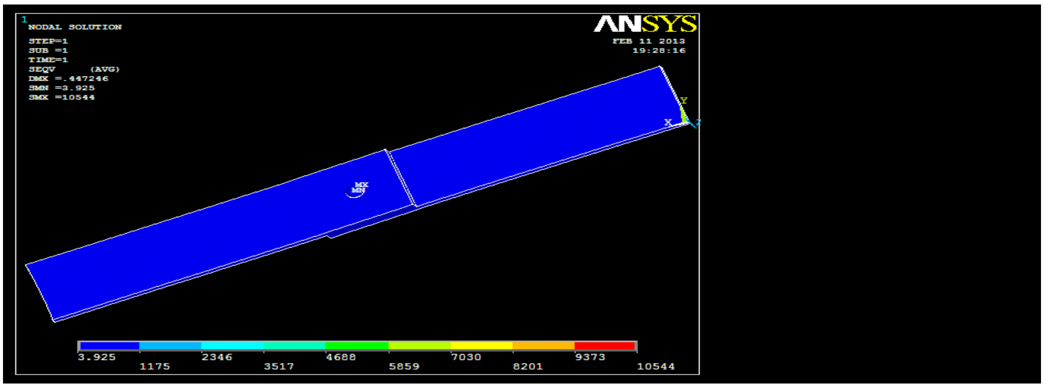


Fig 7.3 Von-Misses Stress of Hybrid Joint

7.2 TEST RESULTS:

SAMPLE ID	DISPLACEMENT (mm)	ULTIMATE TENSILE LOAD (KN)	ULTIMATE TENSILE STRENGTH (Mpa)
BONDED JOINT	3.5	6.17	84.20
RIVETED JOINT	3.7	1.54	24.07
HYBRID JOINT	2.7	7.51	102.13

Thus from the present study, it was found that a well-designed hybrid joint is very efficient when compared to bonded or riveted joints in the case of repair situation in aircraft structures. The experimental and theoretical values shows that the hybrid GFRP joint is so strengthen that compared to bonded and riveted joint.

IX. CONCLUSION

In the present work, FEA for the prediction of stress distribution in bonded, riveted and hybrid joints has been carried out. 3-D models were created and analyzed using ANSYS FEA software and also Tensile Strength of these joints were carried out using Universal Testing Machine (UTM).Different material gives various stress distribution for ANSYS. Stress concentration is again and again analyzed for designing the efficient joints. We have analysis the von-misses stress only along the X-direction for the given material by applying tensile load. Hence we conclude that from both analysis and experimental work the stress distribution and the load withstand is high for hybrid joint compared to rivet and bonded joints.

REFERENCES

[1.] Anotio F.Avila, Buenos, plinio.O…, 2003 “An experimental and numerical study on adhesive joints for composites” Elsevier Ltd
[2.] Baldomir A, Herna’s, Romera L…, 2005 “ benchmarking of three-dimensional finite element models of CFRP single-lap bonded joints” structural mechanics group, school of civil Engineering, University of Laconia.
[3.] Castro P.M.S.T, Goon-calves J.P.M, Maura M.F.S .,29’april 2002. “A three-dimensional finite element model for stress analysis of adhesive joints”
[4.] Chun-gun Kim, Jae-you, Soon Kim…,26’feb 2006, “Failure mode and strength of unite-directional composite single lap bonded jointed with different bonding method”.
[5.] Dieter H.M, 1988, “Metals handbook”,9th edition, (A.S.M.INTERNATIONAL),363;