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Numerical & Experimental Comparison of Bonded, Riveted and Hybrid Joints

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ABSTRACT

Joints are very important factor in any service. Now a days Hybrid Joints are widely used because of their healthy results. Composite materials have been widely used as structural elements in automotive and aerospace structures due to their superior properties. Automotive structures are a huge assembly of skins and laps of sheets 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. Modeling, static analysis of 3D models and Manufacturing of the composite joints (bonded, riveted and hybrid) were carried out using FEA software. The results were interpreted in terms of Von Misses stress. Various joint like bonded, riveted and hybrid joint were prepared by Carbon fiber composite laminates. And then undergo for tensile test by UTM with data acquisition system. The results will then be compared with the joints. The Best Joint is identified by their load Bearing Capacity.

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I. INTRODUCTION

The joining of parts made of composite materials is a complex matter. Bonded joints offer higher strength to mass ratios as well as higher static and fatigue strength than other joining methods. However, in an attempt to further improve the performance of bonded joints, research on the combination of bonded joints with bolts or rivets, called hybrid joints, has become of major interest.

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. Hybrid joints have a combination of adhesive bonding and mechanical fasteners. The advantages of using a combined bonded-riveted design apply mainly in are pair situation. It is generally accepted that a bonded joint is stronger than a mechanically fastened joint and a well-designed bonded joint is stronger than a hybrid joint.

II. LITERATURE REVIEW

Mark Ouellet and Aurelian Vadean worked on the performance of a hybrid (bolted/bonded) joint depends on many parameters and its design becomes complex when the design aims to create a synergy between these two joining methods which are commonly used for composite plates. In this paper, Axiomatic Design is applied to analyze the parameters that influence the load transfer between the different components of the joint as well as the maximum stress in the adhesive. A first decomposition of the joint into functional requirements and design parameters leads to a coupled design. A decoupled design is obtained through the reordering and reformulation of both functional requirements and design parameters. The design matrix is then used to propose a new design through physical integration of the design parameters. Comparison between this new design and baseline geometry shows a reduction in the maximal stress concentration inside the joint. This improvement should result in higher load transfer capability while maintaining similar dimensions.

Raviraja.S and L.Nafeez Ahmed proposed a paper on "FEA and Experimental Evaluation of Bonded, Riveted and Hybrid Joints in Glass Fibre Epoxy Composite Laminates" in which they studied Modelling, static analysis of 3D models and Manufacturing of the composite joints (bonded, riveted and hybrid) were carried out using FEA software. The results were interpreted in terms of Von Misses stress. To utilize the full potential of composite materials like Glass Fibre - epoxy as structural elements, the strength and stress distribution of these joints namely, bonded, riveted and hybrid joints must be understood while conducting experimental works. Various joint like bonded, riveted and hybrid joint were prepared by glass fibre epoxy composite laminates. And then undergo for tensile test by universal testing machine with data acquisition system. The results will then be compared with the joints. The Best Joint is identified by their load Bearing Capacity.

Ana C. F. Silva, Daniel F. O. Braga, M. A. V. de Figueiredo worked on "Ultimate tensile strength optimization of different FSW aluminium alloy joints" they proposed Friction stir welding (FSW) is a highly reliable joining process. However, there is still lack of optimized FSW parameters for different joint configurations. The present manuscript presents a set of optimization studies for different friction stir welding joint geometries of AA6082-T6 aluminium alloy: butt, lap and T joints. The optimization process was performed using Taguchi orthogonal arrays (OA) for designing experiments, analyses of the average effects (main effect plot) and variance (ANOVA). Welded joints were manufactured according to orthogonal arrays, selected using the Taguchi method, for each type of joint, and the ultimate tensile strength (UTS) was evaluated for statistical optimization. As a major asset for the current state of the art, this manuscript contribution is focused on the determination of the most relevant FSW parameters on UTS for a complete range of joints, as well as their interactions. In the particular case of lap and T joints, parameter optimization studies are lacking in the literature, and as such, this work aims at tackling the issue. The parameter combinations to achieve the best mechanical properties for each joint configuration were derived.

They put an conclusion that 1)the strengthening of simple joints (clinching, riveting and spot welding) by application of adhesive significantly improve static strength, 2) the increase of the load capacity of the rivet – adhesive hybrid joint in comparison to purely riveted one is higher more than 10 times. In comparison to simple adhesive Bond this difference is approximately equal to 10%. However, energy consumed by the specimen to the final failure is several times higher in case of the hybrid joints, 3) the spot welded – adhesive hybrid joint has almost 2.5 times higher load capacity in comparison to the simple weld spot joint, 4) the greater force values were obtained for hybrid specimens prepared by clinching before curing, 5) the final failure of the hybrid joined structural system significantly depends on the type of the applied adhesive during specimen manufacturing and the surface adhesive area. The high fracture properties of the adhesive layer can significantly influence the level of loading capacity and increase the energy absorption capacity up to the final failure, 6) the stiffening effects of the hybrid joint lead to higher reliability and durability of the structural joints.

III.OBJECTIVE

Objectives of this paper are to identify crucial or significant parameter/s that affects the performance of the joint. Also to find out the better joining technique, to compare the riveted, bonded and hybrid joints for 2 conventional and carbon composite materials under tension to identify the best suited combination of joints with different materials combinations.

Theory:

Composite Joints

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. Reaching a decision about the type of joints to be used requires careful considerations of several parameters together with the knowledge of the service that the joint is expected to provide. Thus a requirement for disassembly and lack of adequate preparation facilities would certainly preclude bonding; a requirement to join thin sheets might rule out the use of mechanical fasteners whereas heavily loaded joints are designed using mechanical attachments.

A short description of the type of joint used in the present work namely, bonded joint is given below.

Bonded Joint

Bonded joints can be made by gluing together pre-cured laminates with the suitable adhesives or by forming joints during the manufacturing process, in which case the joint and the laminate are cured at the same time (co-cured). Here, load transfer between the substrates take place through a distribution of shear stresses in the adhesive.

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. Joint integrity is difficult to confirm by inspection. Thus ensuring a quality of bonding has been a challenging task.

Strength and Load Transfer in Hybrid Joints

When designing a mixed technology of joining, one of the goals is to benefit from the strengths of each joining method or simply to improve the performance of the first one by adding additional joining methods. The distribution of the loading within the joint is one of the main issues the research emphasis. Thus, one of the most important studies was performed by Hart-Smith who conducted an analytical study of the performance of a bonded/bolted composite to titanium stepped lap-joint. Using a high rigidity adhesive, the author predicted that the adhesive would transfer up to 98% of the external load. When using a low rigidity adhesive, Kelly showed that, in a single bolt single-lap hybrid joint, the bolt could transfer up to 32% of the external load. With similar results, In the case of high rigidity adhesive, the bolts start transferring load only after the initial failure of the adhesive, thus helping to slow down the crack propagation. This mechanism confers higher rigidity of hybrid joints at high external loads as well as improved fatigue life compared to bonded joints. Moreover, the addition of bolts in a bonded joint can also ensure structural integrity even after complete adhesive failure.

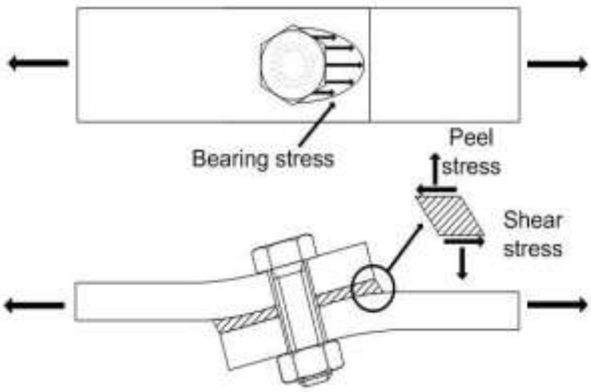


Figure 1: Principal stress in a single-lap hybrid joint.

IV. METHODOLOGY

The methodology we adopted here in this paper is Nemerical and Experimental Procedure. For the numerical evaluation we used Hyperworks CAE Software. The boundary conditions are one end of the geometry is fixed and load is applied at the another end, linear material properties are used, The Graph of Von Mises Stress is to be Plotted for comparison of results with the experimental results. also for experimeantal evaluation we used the UTM along with data acquisition system. the comparison is done and results are predicted.

Specifications:

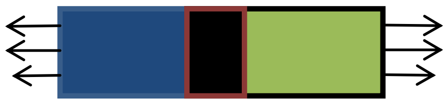
Sr no	Parameter	Value
1.	Thickness of Laminate	2 mm
2.	Thickness of Adhesive	0.2mm
3.	Overlap Length	50mm
4.	Width of Laminate	50mm
5.	Length of Laminate	125mm

COMPONENT	MATERIAL
Plates	AL MS Carbon Fibre

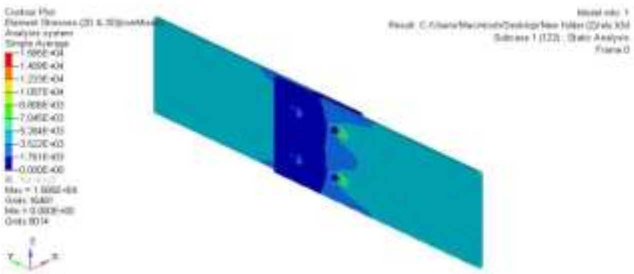
Plate Dimension			
Materials For Plates	1) Aluminium 2) Mild Steel 3) Composite(Carbon Epoxy)		
MATERIAL	**Aluminium**	**Steel**	**Carbon Epoxy**
Young's modulus (N/mm^2)	0.69×10^{11}	2.1×10^{11}	3×10^{6}
Poisson's Ratio	0.33	0.3	0.25
Density (kg/m^3)	2700	7850	1799

The specimen is subjected to a load of 2500N at the ends.

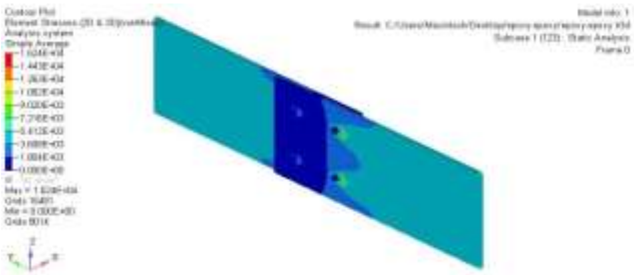
Tensile Test



The specimen is subjected to a load of 2500N at the ends.



(a)



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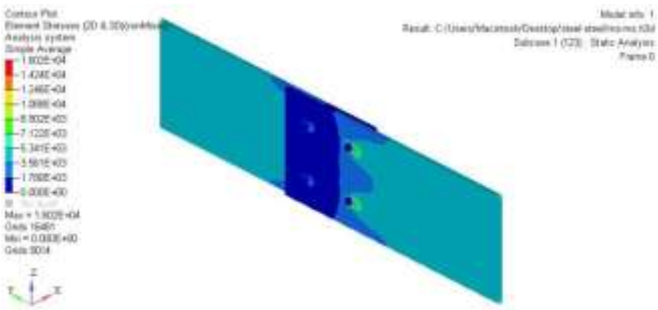

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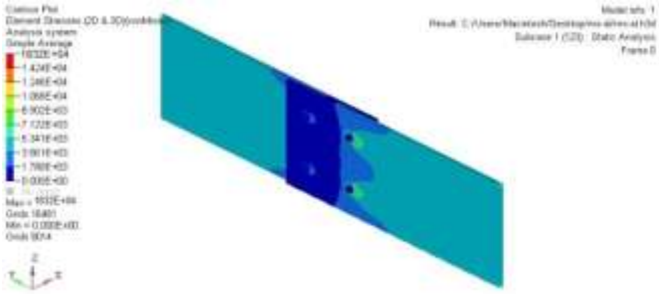

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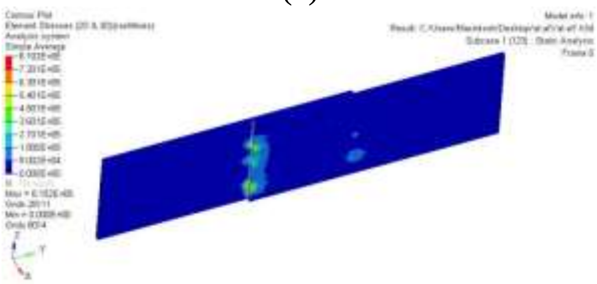
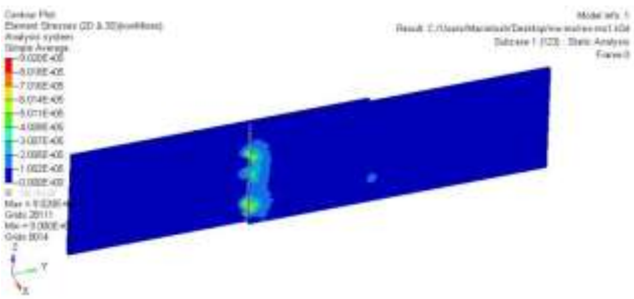


(e)



(f)

Figure: (a) Riveted Plate Al-Al, (b) Riveted Plate Carbon Epoxy-Carbon Epoxy, (c) Riveted Plate MS-MS, (d) Bonded Plate Carbon Epoxy-Carbon Epoxy (e) Bonded Plate AL-AL (f) Bonded Plate MS-MS

V. RESULTS

Tensile Test Results

Sr. No	Combination		Max. Von Mises Stress (SOFTWARE) N/mm^2	Max. Von Mises Stress (Experimental) N/mm^2
1	Riveted	MS-MS	1602	1569
2		AL-AL	1585	1509
3		Composite-Composite	1624	1564
4	Bonded	MS-MS	9120	8976
5		AL-AL	8102	8068
6		Composite-Composite	9780	9570
7	Hybrid	MS-MS	1484	1298
8		AL-AL	1227	1167
9		Composite-Composite	1508	1438

VI. CONCLUSION

The results from the analysis of the models were interpreted in terms of Von Mises stress.

In an elastic body that is subject to a system of loads in 3 dimensions, a complex 3 dimensional system of stresses is developed. A short interpretation of the results of the analysis is given below. In Riveted Joints the stresses developed are comparatively low and acting at the rivet section, it can be concluded that the geometry and number of rivets influences the stresses and the life of the joints. In bonded joints the stresses are developed throughout the cross section of joint and the values of stresses are more comparatively bonded joints cannot be applicable for high loading, the life of bonded joints is less. Hybrid joints provide better strength. These joints are more reliable than the riveted and bonded joints.

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