Experimental Investigation and Simulation of Crack Propagation in Hybrid Lap Joints Under Stress Concentrations

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ABSTRACT

The rivet's cylindrical body is referred to as the shank, while the bottom part is termed the tail. For long-lasting connection between plate specimens, rivets are used in structural work, shipbuilding, bridge construction, tanks, and boiler shells. Adhesives strengthen a variety of conventional joins, including rivets, spots, and welds. Many times, design limitations prevent changes when joint strength improvement is required. To get strength, we can employ a variety of industrial adhesives. To get the best specimen study of lap strength joint and single and double rivet joint, specimens of lap length 40 and 60 mm with single and double rivet with and without adhesive are examined in this study. Both specimens will undergo a tensile test utilizing a UTM machine. Likewise, CAD software will be used to model both specimens, and a FEA application will be used for analysis. The current study compares and contrasts typical bolted joints with adhesively bonded bolted joints.

Keywords: Multipurpose, Fixture, Molding, Optimization, and Impact

1. INTRODUCTION

Small machine parts are frequently combined to create larger machine parts. Because an unsteady joint can ruin the usefulness of a meticulously constructed machine part, the design procedure for joints is just as thorough as that for machine components. Mechanical joints are often divided into two classes: permanent joints and non-permanent joints. It is possible to construct and disassemble non-permanent couplings without causing any harm to the constituent parts. Examples of these junctions include couplings, keys, and threaded fasteners (such as screw joints). It is impossible to disassemble permanent couplings without causing harm to the constituent parts. Depending on the type of force holding the two pieces together, these joints can be of two types. The forces acting on the specimen may be mechanical in nature, such as in the case of riveted joints, press-fit joints, interference-fit joints, etc., in which two parts are united by means of mechanical force. Additionally, the components of the specimen can be connected by molecular force, such as adhesive junctions, brazed joints, and welded joints, among others. These days, riveted connections are frequently employed to permanently attach structural parts. The usage of bolted and welded connections has been limited, nonetheless, by notable advancements in these joints. Even so, rivets are utilized in constructions where great joint strength is needed, such as ship bodies, bridges, tanks, and shells.

Types of riveted joints:

Riveted joints are mainly of two types

1. **Lap joints**
2. **Butt joints**

- Lap joints: As seen in the illustration, the plates that need to be attached are brought face to face such that there is overlap. On the part that overlaps, rivets are placed. The joint is strengthened by the application of one or more rows of rivets. The riveted joints can be categorized as single riveted or multiple riveted depending on the number of rows. lap joint, lap joint that is double or triple riveted, etc. There are two possible rivet configurations between two adjacent rows when numerous joints are utilized. Adjacent rows in chain riveting have rivets along the same transverse line. Conversely, adjacent rivet rows are spaced apart in zigzag riveting. In the diagram below, many kinds of lap joints are illustrated.

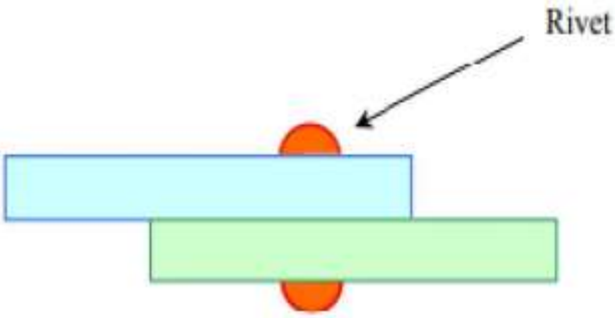

Figure 1: Lap Joint

- Butt joints: These joints bring the plates together without allowing them to overlap. Between each plate and one or two cover plates, riveted joints are created. The number of cover plates determines whether the butt joints are single strap or double strap. Figure depicts a single strap butt joint. below. Similar to lap joints, there are several different types of rivet arrangements, including single row, double or triple chain, and zigzag. The graphic depicts a few different kinds of joints. The effectiveness of a rivet joint determines its strength. The ratio of a riveted junction's strength to that of an unrivetted joint or a solid plate is known as the joint's efficiency. Evidently, the riveted joint's effectiveness is dependent not only on the size and individual rivet strength, as well as the general configuration and joint type.

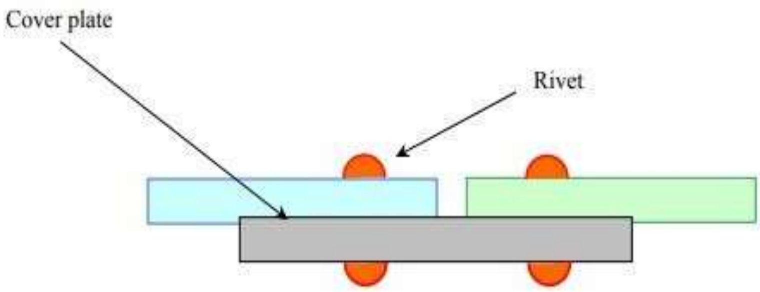

Figure 2: Butt Joint

2. LITERATURE REVIEW

Because adhesive joins have a number of advantages over conventional techniques, their use is growing in a variety of industrial applications. Some benefits over adhesive joints, like greater stiffness and higher static and fatigue strength, are made possible by the combination of spot welding and adhesive bonding. The adhesive is related to this work.

choose between hybrid (bonded and welded) and bonding procedures for single-lap adhesive junctions with varying overlap lengths (LO). The two types of adhesives are ductile and brittle araldite. A Finite Element (FE) research combined with Cohesive Zone Modelling (CZM) was used to compare the experimental results. The findings supported the numerical method and demonstrated that, depending on the glue, the hybrid joints' strength improvements over bonded joints varied. The mechanics of double-lap joints with unidirectional and quasi-isotropic composite adherents under tensile loading are examined theoretically using a one-dimensional closed-form solution, computationally using a finite element approach, and empirically using moiré

interferometry. Using a full-field moiré interferometer,
ascertain the joint overlaps' edge surface's in-plane deformations. In order to compare the experimental data and provide deformation and stress distributions for the joints, a linear-elastic two-dimensional finite element model was created. The adhesive shear stress distributions were predicted using shear-lag solutions, both with and without the inclusion of shear deformations of the attached. The findings from experimental, computational, and theoretical investigations are used to provide a detailed discussion of these stress distributions and the mechanics of the joints.

3. PROBLEM STATEMENT

Conventional joins like spot, rivet, and weld are used to link different parts in the automotive, aerospace, and other industries. Industrial adhesives can be used to increase the strength of existing joints without altering their design.

4. OBJECTIVE

- Using CATIA software, a specimen of 30 and 50 mm lap length with single and double rivets, with and without adhesive, was designed.
- Conventional Using FEA, the maximum equivalent stress, shear stress, and deformation of the corresponding specimen are determined for riveted joints.
- FEA is used to analyze the strength of an adhesively bonded riveted connection.
- UTM tensile test for both joints.
- Comparison between the experimental and FEA models. Conclusions and Future scope.

5. METHODOLOGY

Finite Element Discretization using Ansys

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Nonlinear Static stress analysis using Ansys for both joints

⇩

Specimen testing under tensile loading for both specimens using UTM machine

⇩

Force vs Deflection diagrams will be used for drawing conclusions

⇩

Composite Analysis FEA & Experimental

⇩

Conclusion and Future Scope

Step 1: I conducted a literature review before beginning this endeavor. I compiled a large number of research papers that are pertinent to this subject. I discovered riveted joints after reading these studies.
Step 2: The components needed for my project are then determined.

Step 3: Using CATIA software, the 3D model and drafting will be completed following component selection.
Step 4: ANSYS will be utilized to analyze the components through FEA.

Step 5: The Universal Testing Machine will be used to record the experimental observations.
Step 6: Results and conclusions will be drawn after a comparison of the reaction forces between simulation and experimental data.

6. DESIGN & ANALYSIS

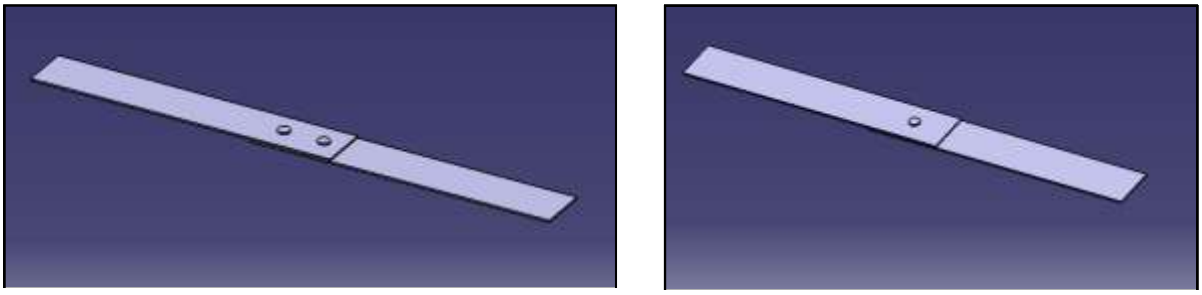

Figure 3: Specimen of length 145 mm, width of 26 mm thickness 1mm along with single and double rivet

Using computer systems (or workstations) to help in design development, modification, analysis, or optimization is known as computer-aided design, or CAD. With CAD software, a designer may be more productive, produce better designs, communicate more effectively through documentation, and build a database for manufacturing. CAD Electronic files for printing, machining, and other production processes are frequently the output format. Another name that is used is CADD, which stands for Computer Aided Design and Drafting.

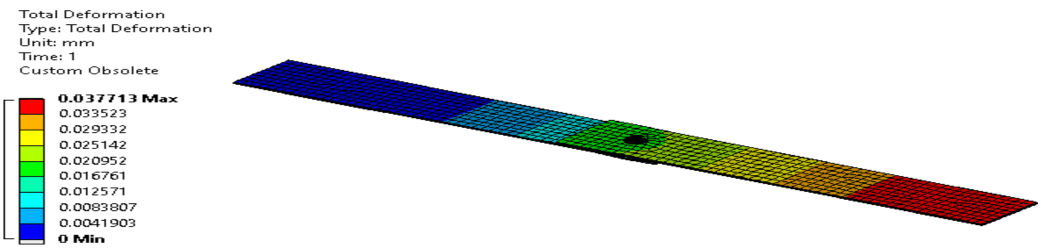

Figure 4: Total deformation of 26mm lap single rivet without adhesive

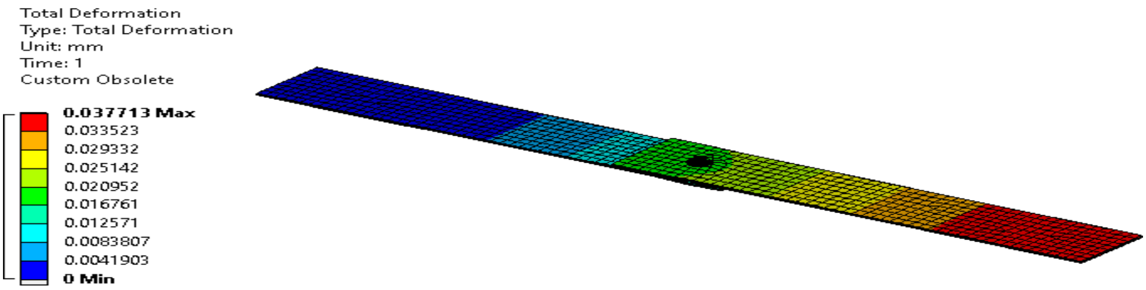

Figure 5: Total deformation of 26mm lap single rivet with adhesive

7. CONCLUSION

The current study examines the strength of lap and rivet joints by manufacturing standard-sized research specimens with and without adhesive and single and double rivets. Experimental and FEA results show that laps measuring 60 mm are stronger than those measuring 26 mm, and that the glue has a greater strength bearing capacity.

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