Development of (Aluminum and E-Glass Fibre) Hybrid composite double lap riveted joint for tension and validate by FEA Software

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Abstract - *Riveted joints play an important role in structural members used in automobile, shipping and aviation industry. Rivets are used to fasten metal plates and steel section in structural works such as bridges and roof trusses and in the construction of pressure vessels such as storage tanks and boilers. These have very effective designs subjected to pronounced vibration loads where welded joints are less reliable. These joints may also be employed to connect metals which are difficult to weld together and in the joints which permit no heating welded due to possible tempering or warping of the finished machine parts. Composite riveted joints have wide applications in aerospace industry. In present study, the composite plate having aluminums facings and the glass fiber epoxy as an intermediate layers are tested analytically and Experimentally. The composite specimen is tested for the tensile strength using universal testing machine. The experimental results are compared with the FEA results for the for the purpose of Accuracy.*

Key Words: Aluminium, E-Glass Fibre, FRP laminates, riveted joint, Fibre orientation

1. INTRODUCTION

A rivet is a short cylindrical bar with a head integral with it. Rivets are used to make permanent fastening between two or three plates. Conventional structural rivets are widely used in aircraft, transportation equipment, and other products requiring high joint strength. They are also used in the construction of buildings, boilers, bridges, and ships, but in recent decades these applications have made increasing use of welding. Because of vital safety considerations, the design of riveted connections for these latter applications is governed by construction codes. Significant initial tension is attainable in rivets by installing them at a red heat. The tension develops upon cooling and thermal contraction. Whereas the development of modern welding equipment has reduced the importance of rivets for heavy structural applications, the development of modern riveting machines has greatly expanded their use in fastening smaller components in a multitude of industrial products associated with the automotive, appliance, electronic, furniture, business machine, and other fields.

Rivets have frequently replaced threaded fasteners in these applications because of lower installation cost. Rivets are much cheaper than bolts, and modern high-speed riveting machines - some of which fasten over 1000 assemblies per hour - give low assembly cost. Rivets can also serve as pivot shafts (as in folding lawn furniture), electrical contacts, stops, and inserts. In comparison with threaded fasteners, rivets are not susceptible to unintended loosening, but in some cases they impede desired disassembly and servicing. On the other hand, making an electrical device so that it cannot be disassembled and tampered with by the layman may constitute a safety feature.

Rivets can be made from most ductile material, with carbon steel, aluminum, brass and copper being most commonly used. Various plating's, paints, and oxide coatings may be applied. In general, a rivet cannot provide as strong an attachment as a bolt or screw of the same diameter. As with bolts, care must be taken in selecting materials to be used together because of possible galvanic action. Industrial rivets are of two basic types: tubular, and blind. Each type comes in a multitude of varieties. The semi tubular version is the most common. Self-piercing rivets make their own holes as they are installed by a riveting machine. Full tubular rivets are generally used for leather, plastics, wood, fabric, or other soft materials. Bifurcated, or split, rivets can be used to join light-gage metals. Metal-piercing rivets can fasten metals like steel and aluminum with hardness up to about RB 50 (approximately 93 BHN). Blind rivets require access to only one side of the joint. Compression rivets are made in two parts. The diameters are selected to provide an appropriate interference fit at each interface. Compression rivets can be used with wood, brittle plastics, or other materials with little danger of splitting during setting (installation). One common application is in the cutlery field, where the flush surfaces and interference fits provide no crevices for food and dirt particles to accumulate, as in riveted knife handles.

2. PROBLEM DEFINITION:

Fiber-reinforced polymer (FRP) elements are commonly joined with mechanical connections such as steel profiles. However, the use of bolts and rivets is not material-adapted due to the anisotropic character and brittle behavior of FRP materials, and usually leads to over-sizing of components.

Adhesively bonded connection is far more appropriate and allows better load transfer. Nevertheless the stiff and relatively brittle epoxy adhesives currently used cause shear and through thickness peaks at joint edges. The use of ductile and/or flexible adhesives reduces shear and through-thickness stress concentrations and creates even distribution, increasing the joint's robustness . In addition, ductile and flexible adhesives allow large deformations and develop elasto-plastic or elastic hinges in the structures, which for compensate the lack of ductility of FRP materials. Bonded joints with ductile and flexible adhesives are adapted to FRP elements.

3. SAMPLE PREPARATION AND MANUFACTURING:

The specimens of composite plates are manufactured using hand layup method.6 samples are used for experimental testing (tensile). The specimen consists of laminate arranged symmetrically one after other. Sequentially layers are composed of aluminium, glass fiber and aluminium. The dimensions of the specimen are 50*200mm.The thickness of aluminium plate kept constant as 1.5mm.

Fig -1: 45^0 Fibre Orientation **Fig -2**: 0^0 Fibre Orientation

The fiber orientations of the glass fiber used are 0^0,30^0,45^0,90^0,-30^0,-45^0 unidirectional.

Sample of glass fiber plate manufacturing shows in the fig. 1 (45^0 Fibre orientations) and fig. 2 (0^0 Fibre orientations), in fig. 3 shows total 18 plates of hybrid composites. All these plate used to prepare riveted joint. Similar orientation of fibre is riveted to each other. Hand layup method is used for manufacturing of a composite specimen. In this, a glass fiber is glued with epoxy to form layers of required thickness.

Fig -3: Aluminum -Glass fiber composite 18 Sample of Specimens

Fig -4: Preparation of riveted joints

4. SAMPLE EXPERIMENTAL TESTING:

The specimen is placed in the universal testing machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen. Machines range from very small table top systems to ones with over 53 MN (12 million lbf) capacity.

Fig -5: UTM machine Sample loaded condition for tensile testing.

5. FINITE ELEMENT ANALYSIS

To validate these results FEA analysis of the composite riveted plate is also done. For this a model is developed using ANSYS and is then analyzed by imposing constraints and various boundary conditions.

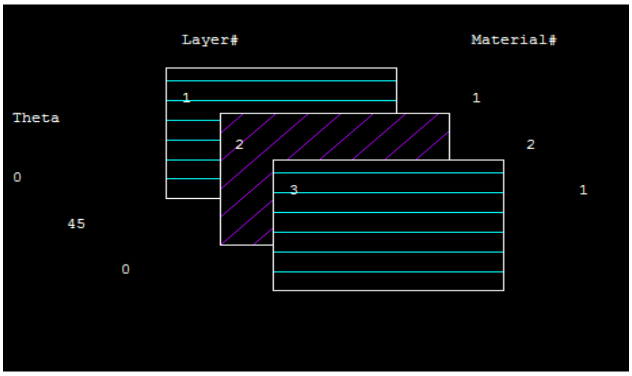

Fig -6: Sample FEA model for 45⁰ orientation

The meshing of composite riveted joints are particularly 2D triangular and 3D hexahedral. Shell 181 element is used for this anlaysis, 3 layup model is developed applying Glass fiber ecpoxy properties for inner face of sandwich material and aluminum properties apply for outer facing material. Since; the key interest is to find out stresses at various locations of composite riveted joints the material properties have to be assigned for each and every layup.

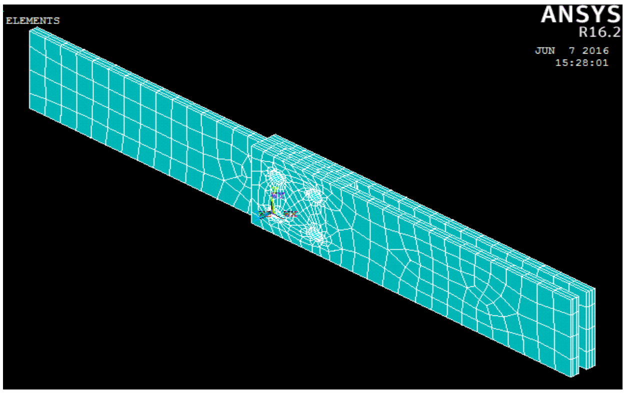

Fig -6: Mesh Model of riveted joint

The model developed with the ANSYS is assigned with all the material properties and the geometrical constraints. The width of all members is 50 mm. The thickness of adhesive layer is 0.2 mm 4 mechanical rivets are used for the purpose of mechanical fastening and these are taken according to design calculation of riveted joints.

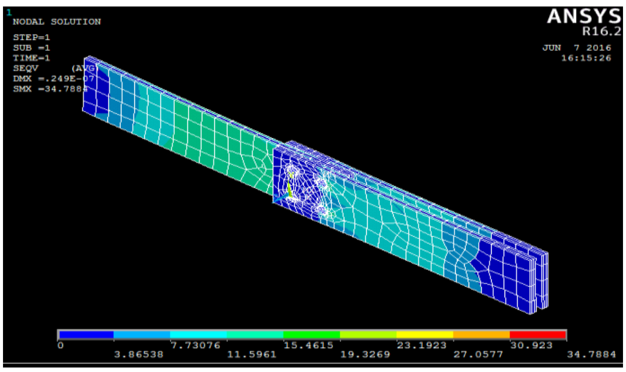

Fig -7: Stress on sandwich plate in FEA Software

Above fig. 7 shows Von-mises stress over the Aluminum-Glass fiber Epoxy hybrid composite riveted joint. The results obtained using Experimental testing and FEA analysis are compared and hence tabulated as below.

Table -1: Validation of Experimental results with FEA result

Sr No	Fibre Orientation	Thickness of Fibre Plate	Experimental Result	ANSYS Result
1	0^0	2mm	31.74 MPa	31.708 MPa
2	30^0	2mm	29.89 MPa	27.53 MPa
3	45^0	2mm	31.28 MPa	34.78 MPa
4	90^0	2mm	28.74 MPa	26.10 MPa
5	-45^0	2mm	29.64 MPa	29.98 MPa
6	-30^0	2mm	30.29 MPa	30.87 MPa

6. CONCLUSIONS

FE models of a double lap sandwich composite riveted joint, under static tensile load. The model comprises a high level of geometrical details in the plates and rivets (such as the geometric clearance in between hole and rivet), the simulation of the sandwich plate with different orientation was done in ANSYS.

The following conclusions drawn from the present Study-

1. The best ply orientation was seen 45^0 in single direction of fibre with maximum thickness (2mm)

2. Design the sandwich composite joint for lightweight application and this purpose is fulfill, 74% weight reduction achieved in composite plate than steel plate.

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