Analysis & Testing of Lap Length on Strength of Riveted-Adhesive Joint.

Punam Mote[1], Prof. Yogesh Ingulkar[2].

[1]P.G. Student, M.E. Mechanical Engineering, Dhole Patil College of Engg. Pune.
[2]Professor & HOD M.E. Mechanical Engineering, Dhole Patil College of Engg. Pune.

Abstract: The cylindrical portion of the rivet is called shank or body and lower portion of shank is known as tail. Use of rivets is to make long-lasting fastening between the plates specimen such as in structural work, ship building, bridges, tanks and boiler shells. Adhesives act as a strength enhancer for many traditional joints such as weld, spot, rivet etc. Many time design constraints don't allow modifications, where there is need of strength enhancement of joint. We can use various industrial adhesive for achieving strength. Tensile test will be done using UTM machine for both specimens. Similarly, both specimens will be modeled using CAD software and analysis with FEA package. Comparative analysis is done in present study between traditional bolted joint and adhesively bonded bolted joint.

Keywords: Rivets, Adhesive, FEA, ANSYS.

I. INTRODUCTION

Often tiny machine elements square measure joined along to make a bigger machine half. Design process of joints is as extensive as that of machine components because a unsteady joint may spoil the utility of a carefully designed machine part. Classifications of Mechanical joints are mostly into two classes viz., non-permanent joints and permanent joints. Non-permanent joints can be assembled and dissembled without damaging the components. Case of such joints are threaded fasteners (like screw-joints), keys and couplings etc. Permanent joints cannot be dissembled without damaging the components. These can be two kinds joints depending upon the nature of force that holds the two parts. The forces on specimen may be of mechanical source, for example, riveted joints, joints formed by press or interference fit etc, where two components are joined by mechanically. The specimen components can also be joined by molecular force, for example, welded joints, brazed joints, joints with adhesives etc. Now days riveted joints were very often used to join structural members permanently. However, vital improvement in attachment and fast joints has draped the utilization of those joints. Even then, rivets are used in structures, ship body, bridge, tanks and shells, where high joint strength is required.

Types of riveted joints:

Riveted joints are mainly of two types

1. Lap joints
2. Butt joints

Lap Joints: The plate specimens that are to be joined are brought face to face of each other such that an overlap exists. Rivets are normally inserted on the overlapping portion. Single or multiple variable rows of rivets are used to give strength to the joint. Count upon the number of rows the riveted joints may be divided as single riveted lap joint, double or triple riveted lap joint etc. When various joints are used, the adjustment of rivets between two nearby rows may be of two kinds. In chain riveting the nearby rows have rivets in the same transverse line. In zig-zag connecting, on the other hand, the adjacent rows of rivets are staggered.

Butt Joints: In this type of joint, the specimen plates are brought to each other without forming any overhang. Riveted joints are formed between each individual of the plates and one or two cover plates. Depending upon the number of covers specimen plates the butt joints may be single strap or double strap butt joints. The strength of a rivet joint is calculated by its efficiency. The potency of a joint is outlined because the quantitative relation between the strength of a riveted joint to the strength of Associate in Nursing unrivetted joints or a solid plate.

II. LITERATURE REVIEW

G.P. Marques et al. [1] The applications of adhesive joints are increasing in various industrial applications because they offer several advantages over traditional methods. The combination of adhesive bonding with spot-welding enables some advantages over adhesive joints such as increased stiffness, and higher static and fatigue strength. This work relates to the adhesive selection for single-lap adhesive joints by the bonding and hybrid (bonded and welded) techniques with different overlap lengths (LO). The adhesives are the brittle Araldite AV138®, and the ductile Araldite® 2015 and Sikaforce® 7752. The experimental results were compared against a Finite Element (FE) study coupled with Cohesive Zone Modelling (CZM). The results validated the numerical technique and also showed varying strength improvements of the hybrid joints over bonded joints depending of the adhesive.

M.Y. Tsai et al. [2] The mechanics of double-lap joints with unidirectional ([016]) and quasi-isotropic ([0/90/_45/45]2S) composite adherends under tensile loading are investigated experimentally using moiré interferometry, numerically with a finite element method and analytically through a one-dimensional closed-form solution. Full-field moiré interferometer was employed to determine in-plane deformations of the edge surface of the joint overlaps. A linear-elastic two-dimensional finite part model was developed for comparison with the experimental results and to produce deformation and stress distributions for the joints. Shear-lag solutions, with and without the inclusion of shear deformations of the adhered, were applied to the prediction of the adhesive shear stress distributions. These stress distributions and mechanics of the joints are discussed in detail using the results obtained from experimental, numerical and theoretical analyses.

Bruno Pedrosaa et al. [3] The maintenance and safety of ancient bridges is a major concern of governmental authorities. In specific, the safety of old riveted bridges fabricated and placed into service at the end of the 19th century deserves particular attention. These structures are susceptible to exhibit high fatigue damage levels due to their long operational period with increasing traffic intensity associated to an original design not covering the fatigue phenomenon.

Lei Pana et al. [4] Adhesive failure is considered a key issue of bond-riveted structures exposed to chlorides. In this study, polyaniline (PANI) modified epoxy adhesive was creatively utilized for protective purposes, and the properties of both Epoxy and Epoxy/PANI coated aluminium alloys were studied by electrochemical impedance spectroscopy (EIS) in 3.5 wt% NaCl solution. The polarization current densities between both adhesives at increasing immersion times and Carbon Fiber Reinforced Plastics (CFRP) were analyzed by zero resistance ammeter (ZRA) testing. Single-lap shear experiments were carried out to evaluate the evolution of mechanical performances at the joints between adhesives.

Li Huang et al. [5] The fatigue behavior of self-piercing riveted (SPR) joints of aluminum alloy 6111-T4 has been experimentally and numerically investigated in current study. The dominant fatigue failure mode under tensile-shear (TS) loading is the corner crack at riveted hole with approximate quarter-elliptical crack front, and interrupted tests revealed that the crack growth life was much shorter than crack initiation life. A fatigue parameter, SmithWatson-Topper (SWT) was proposed for crack initiation prediction in the 3D finite element analysis, while a structural load-based crack growth approach was introduced for crack growth life estimation. Good agreement was found between predictions and experimental results.

III. PROBLEM STATEMENT

Traditional joints such as weld, spot, rivet, etc. are used for connecting various Automotive, Aerospace, etc. parts.
To enhance strength of already existing joints without changing existing design can be achieved by use of industrial adhesives.

IV. OBJECTIVE

1. Traditional Riveted joint using FEA.
2. Strength analysis of adhesively bonded riveted joint using FEA.
3. Tensile test for both joints using UTM.
4. Comparative analysis between FEA and Experimental model. Conclusions and Future scope.

V. METHODOLOGY

Finite Element Discretization using Ansys

↓

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 & Future scope.

VI. CAD

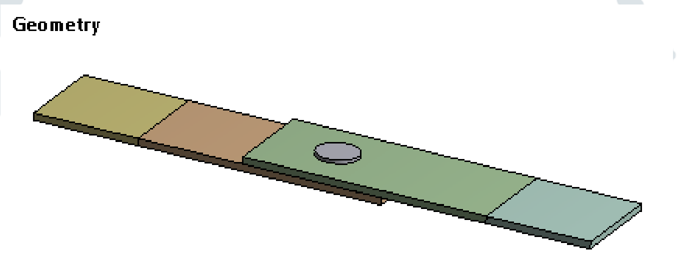


Figure 1: Riveted Joint

VII. ANALYSIS

Structural Steel :

Properties of Outline Row 4: ARALDITE

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	1.16E-09	tonne mm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulu...	
6	Young's Modulus	1600	MPa
7	Poisson's Ratio	0.42	
8	Bulk Modulus	3.3333E+09	Pa
9	Shear Modulus	5.6338E+08	Pa
10	Tensile Yield Strength	40	MPa

Figure 2 Material properties of araldite

Properties of Outline Row 5: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modu...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

Figure. 3 Material properties of structural steel

1. LAP JOINT -40 MM WITHOUT ADHESIVE

Mesh :

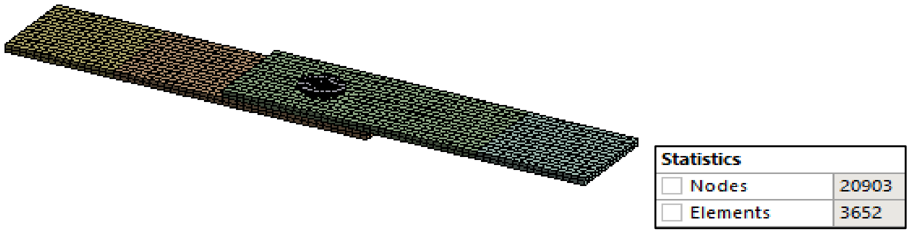


Figure 4: Meshing of Lap Joint -40 Mm Without Adhesive

Boundary condition :

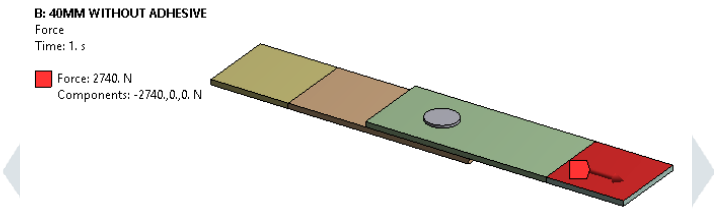


Figure 5: Boundary condition of Lap Joint -40 Mm Without Adhesive

Total Deformation :

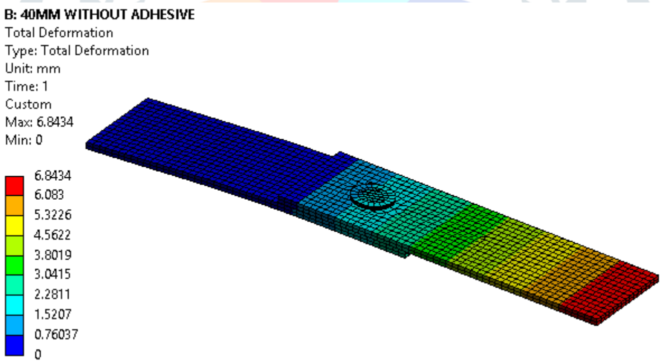


Figure 6: Total Deformation of Lap Joint - 40 Mm Without Adhesive

Principal stress :

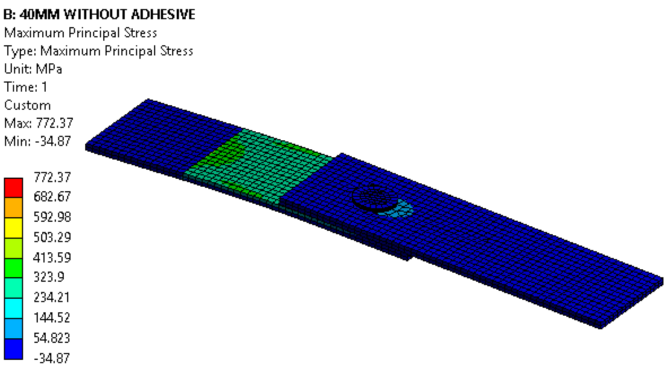
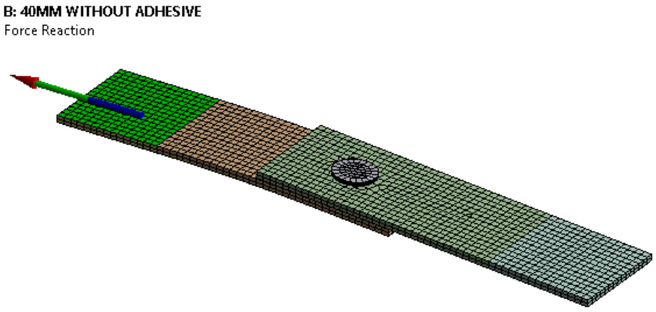


Figure 7: Principal stress of Lap Joint -40 Mm Without Adhesive

Reaction force :



Maximum Value Over Time	
X Axis	2740. N
Y Axis	2.4668e-007 N
Z Axis	-2.5541e-006 N
Total	2740. N

Figure 8: Reaction force of Lap Joint -40 Mm Without Adhesive

2. LAP JOINT -40 MM WITH ADHESIVE

Geometry :

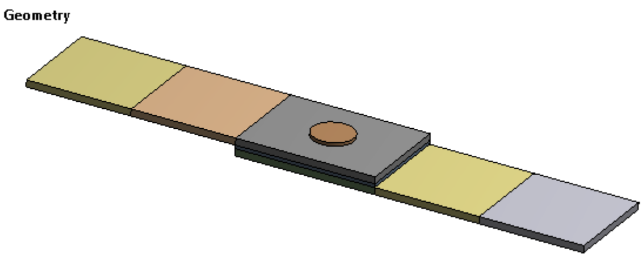


Figure 9: Riveted Joint

Boundary condition :

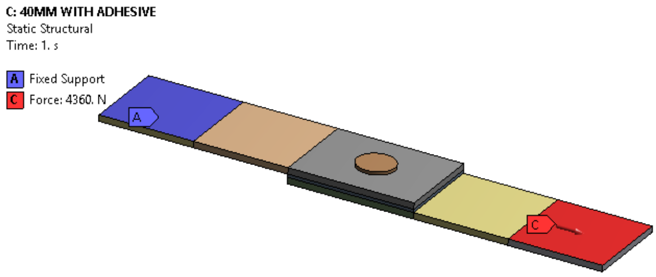


Figure 10: Boundary condition of Lap Joint -40 Mm With Adhesive

Total Deformation :

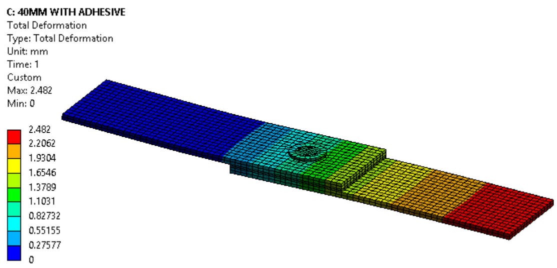


Figure 11: Total Deformation of Lap Joint -40 Mm With Adhesive

Principal stress :

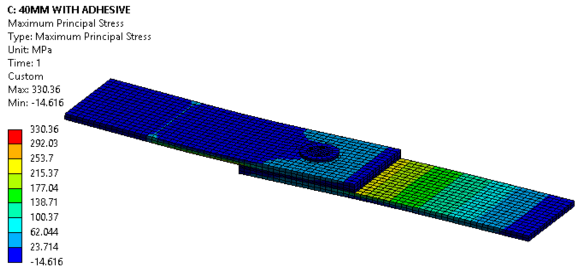


Figure 12: Principal stress of Lap Joint -40 Mm With Adhesive.

Reaction force:

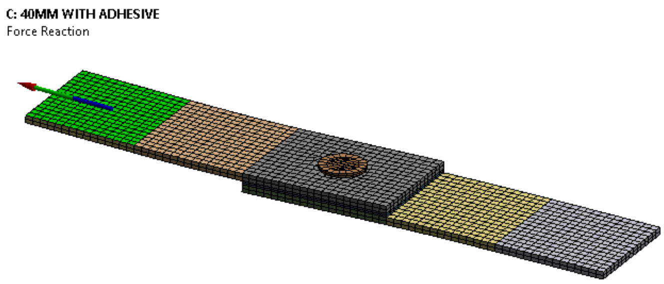


Figure 13: Reacting force

3. LAP JOINT -60 MM WITHOUT ADHESIVE

Total Deformation :

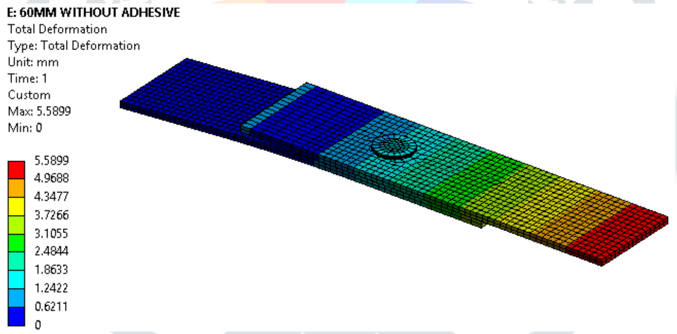


Figure 14: Total Deformation of Lap Joint --60 Mm Without Adhesive

Principal stress :

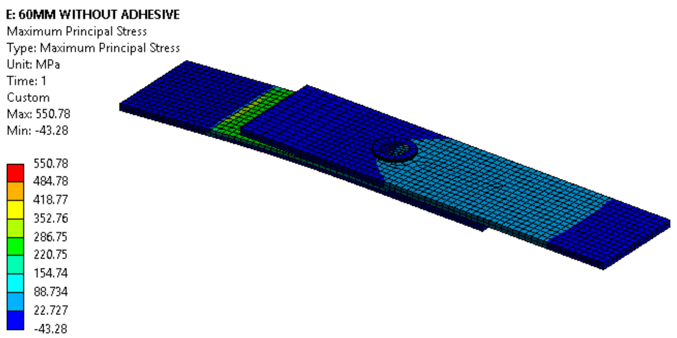
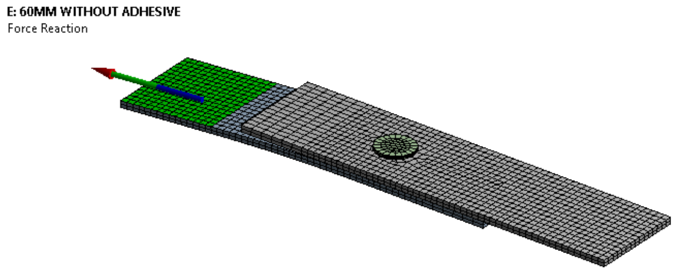


Figure 15: Principal stress of Lap Joint -60 Mm With Adhesive

Reaction force :



Maximum Value Over Time	
X Axis	2240. N
Y Axis	3.5828e-007 N
Z Axis	-2.1191e-006 N
Total	2240. N

Figure 16: Reacting force of Lap Joint --60 Mm Without Adhesive

4. LAP JOINT -60 MM WITH ADHESIVE

Geometry :

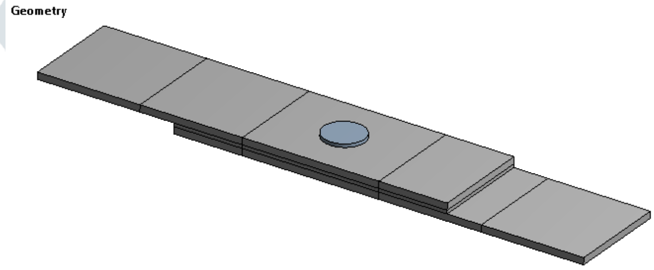


Figure 17: Riveted Joint

Total Deformation :

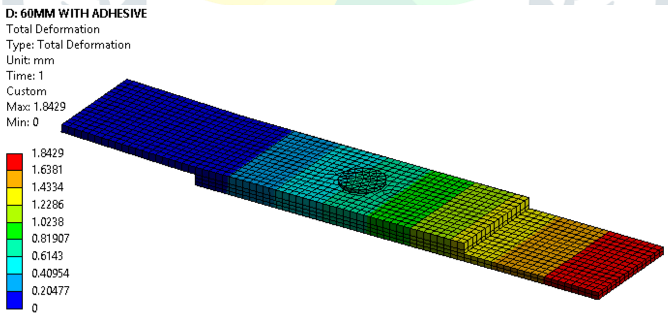


Figure 18: Total Deformation of Lap Joint --60 Mm With Adhesive

Principal stress :

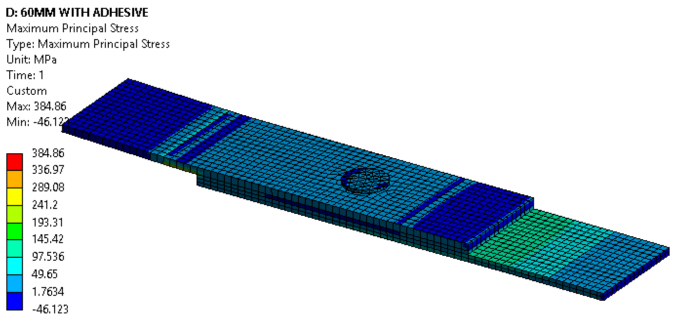
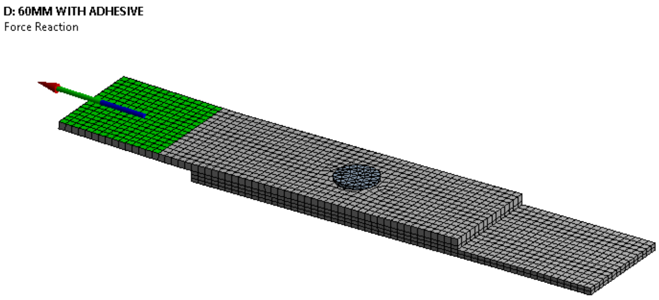


Figure 19: Principal stress of Lap Joint -60 Mm With Adhesive

REACTION FORCE :



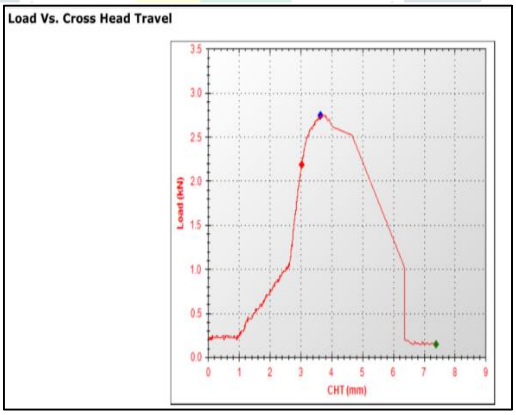
Maximum Value Over Time	
X Axis	4280. N
Y Axis	6.9317e-009 N
Z Axis	1.008e-002 N
Total	4280. N

Figure 20: Reaction force

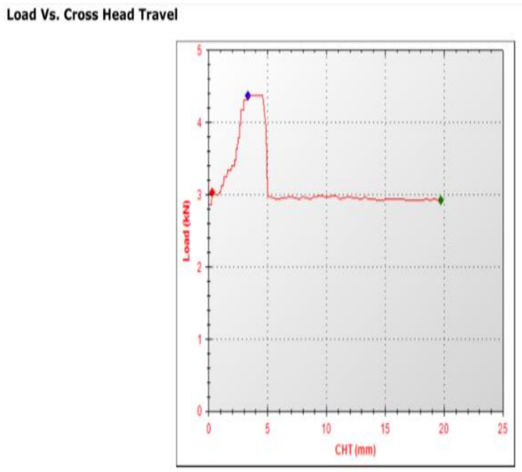
VIII. EXPERIMENTAL TESTING

Figure 21: Experimental testing

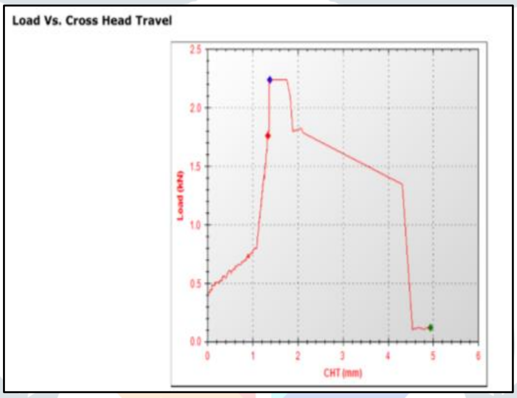
1. Lap Joint -40 Mm without Adhesive :



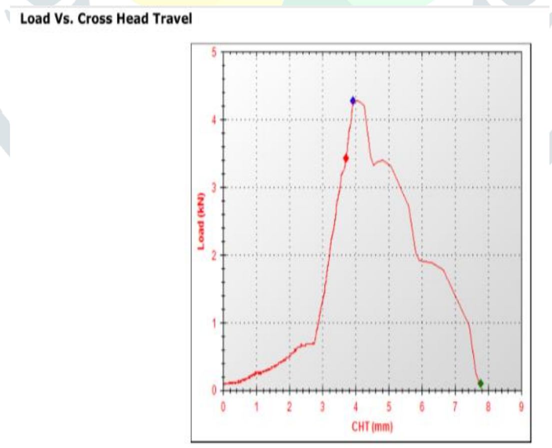
2. Lap Joint -40 Mm With Adhesive :



3. Lap Joint -60 Mm Without Adhesive :



4. Lap Joint -60 Mm With Adhesive :



IX. RESULT

	Total Deformation	Equivalent Stress	Force Reaction
Lap Joint -40 Mm Without Adhesive	6.84mm	772.37MPa	2740N
Lap Joint -40 Mm With Adhesive	52.482mm	330.46MPa	4360N

LAP JOINT -60 MM WITHOUT ADHESIVE	5.58mm	550.78MPa	2240N
LAP JOINT -60 MM WITH ADHESIVE	1.942mm	384.86MPa	4280N

X. CONCLUSION

1. From Above result table it conclude that with the use Adhesive in Lap Riveted joint we can reduce deformation in 40mm lap length specimen joint 64.61% and 60 mm lap length specimen 65.19% .
2. Reaction force of FEA result is in good relationship with UTM test.
3. Force Reaction of Lap Joint -40 Mm with Adhesive has maximum strength with 4360N.
4. Riveted joint of 40mm lap has 2.42mm deformation with maximum force reaction than 60 mm lap riveted joint

REFERENCES

1. Adhesive selection for hybrid spot-welded/bonded single-lap joints: Experimentation and numerical analysis G.P. Marques, R.D.S.G. Campilho, F.J.G. da Silva, R.D.F. Moreira

2. An investigation into the stresses in double-lap adhesive joints with laminated composite adherends M.Y. Tsai, J. Morton

3. Optimization Study Of Hybrid spot-welded/bonded single-lap joints R.D.S.G. Campilhoa,b,n, A.M.G.Pinto a, M.D.Banea c, L.F.M.daSilva

4. Galvanic Corrosion Protection and Durability of Polyaniline-reinforced Epoxy Adhesive for Bond-riveted Joints in AA5083/Cf/Epoxy Laminates Lei Pana, WenyeDinga , Wenliang Maa , Jingling Hua , XiaofeiPanga , Fei Wanga , Jie Tao
5. Fatigue of self-piercing riveted joints in aluminum alloy 6111, Li Huang, Haiding Guo, Yandong Shi, Shiyao Huang and Xuming Su.