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Experimental and Finite Element Analysis of Adhesively Bonded Riveted Joint

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Abstract: The cylindrical portion of the rivet is called shank or body• and lower portion of shank is known as tail. use of rivets are 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 modelled using CAD software and analysis with FEA package. Comparative analysis is done in present study between traditional riveted joint and adhesively bonded riveted joint.

Keywords: Rivet, Adhesive, FEA, ANSYS, UTM.

I. INTRODUCTION

Often small machine components are joined together to form a larger machine part. 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. Classification 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 can be of mechanical origin, for example, riveted joints, joints formed by press or interference fit etc, where two components are joined by applying mechanical force. 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, significant improvement in welding and bolted joints has curtained the use of these 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:* The plates specimen 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 riveting, on the other hand, the adjacent rows of rivets are staggered.
2) *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. Like lap joints, the arrangement of the rivets may be of various kinds, namely, single row, double or triple chain or zigzag. The strength of a rivet joint is calculated by its efficiency. The efficiency of a joint is defined as the ratio between the strength of a riveted joint to the strength of an rivetted 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 element model was developed for comparison with the experimental results and to provide deformation and stress distributions for the joints. Shear-lag solutions, with and without the inclusion of shear deformations of the adherend, 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.

R.D.S.G. Campilho et. al [3]: Adhesive bonding does not involve drilling operations and it distributes the load over a larger area than mechanical joints. However, peak stresses tend to develop near the overlap edges because of differential straining of the adherends and load asymmetry.

As a result, premature failures can be expected, especially for brittle adhesives. Moreover, bonded joints are very sensitive to the surface treatment of the material, service temperature, humidity and ageing. To surpass these limitations, the combination of adhesive bonding with spot-welding is a choice to be considered, adding a few advantages like superior static strength and stiffness, higher peeling and fatigue strength and easier fabrication, as fixtures during the adhesive curing are not needed. The experimental and numerical study presented here evaluates hybrid spot-welded/bonded single-lap joints in comparison with the purely spot-welded and bonded equivalents.

Additionally, bonded joints are very sensitive to the surface treatment, service temperature, humidity and ageing. Hybrid joints combine adhesive bonding with another joining technique, and have previously been considered to improve damage tolerance (either static or fatigue) or repair of structures, combined with ease of fabrication because of adhesive curing without fixtures requirement.

Bruno Pedrosaa et al. [4] The maintenance and safety of ancient bridges is a major concern of governmental authorities. In particular, 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.

This paper reviews recent fatigue behaviour investigations on single and double shear riveted joints performed by Universities of Porto (Portugal), Trás-os-Montes e Alto Douro (Portugal), and Wrocław (Poland), in particular concerning the fatigue characterization of riveted joints extracted from representative Portuguese riveted bridges, namely the Eiffel, Luiz I, Fão, Pinhão and Trezóibridges.

In order to overcome the influence of scatter and establish a reliable assessment for the obtained experimental data, two statistical approaches were used: implement linearized boundaries following the recommendation in ASTM E739 standard and defining probabilistic SeN fields using the Castillo & Fernández-Canteli model. This statistical analysis allows to propose design SeN curves for single and double riveted joints and evaluate the applicability (safety) of using the design curves suggested in Eurocode 3 as well as design curves proposed by Taras and Greiner.

Lei Pana et al. [5] Adhesive failure is considered a key issue of bond-riveted structures exposed to chlorides. In addition, existence of carbon fiber makes the galvanic corrosion at rivet joints in AA5083/Cf /Epoxy laminates accelerated. 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.

The electrochemical results suggested that addition of polyaniline improved the adhesive resistance by roughly an order of magnitude and retarded the corrosion process. Moreover, the current density of Epoxy/PANI adhesive and CFRP reduced as immersion time extended.

The mechanical properties testing identified the Epoxy/PANI adhesive with lower sensitivity towards degradation in salt-spray environment than the Epoxy adhesive. Furthermore, strength failure (-2.5% of maximum load) did not obviously appear in rivets surrounded by the Epoxy/PANI adhesive. Overall, these data are promising for future design of this joint.

Peter B. Keatinga et al. [6] Single shear lap joints have been a common method to fasten steel plates in railroad bridges and can be highly susceptible to fatigue cracking under the cyclic loading bridges experience. To better comprehend the fatigue process of these connections, it is important to understand the stress state near the rivet hole. While the fatigue behavior of these riveted connections has been studied, few have been carried out on stress distribution and crack formation in riveted lap joints fastening thick steel plates. This study is to provide information regarding the stress distributions developed in a single shear lap joint connecting plates of varying thicknesses.

Results from the stress contour analysis are utilized to detect possible regions for fatigue crack nucleation under cyclic heavy axle loads. The study also provides information regarding the fatigue crack geometry typically found in single shear lap joints.

Francesco Vivioa et.al [7] Fatigue reliability evaluation of a lap shear riveted joint has been faced using a Detail Fatigue Rating (DFR) method combined with FE simulations performed with a new rivet element. The Rivet Element, based on a closed-form solution of a theoretical model of the rivet joint, is able to accurately evaluate, in FE analysis, both local and overall stiffness of riveted joints with a very low contribution of dofs.

The classic DFR approach needs global FE analysis of the complete structure in order to detect loads acting on the joint and the stress concentration factors, sacrificing necessarily the computation time or the accuracy of the results. In the paper is proposed the combination of a FE model of the complete structure with Rivet Elements and the introduction of suitable analytical formulations to evaluate stress concentration factors, starting from the values of loads on rivets. The elaboration of these results with this new DFR-Rivet Element approach allows assessing fatigue reliability of actual structures with a reduction of at least 95% of the total computation time, compared to classic DFR approach, which is already one of the fastest methods for the evaluation of the fatigue reliability of riveted structures.

M. Skorupa et al. [8] A semi-empirical fatigue life prediction model for riveted lap joints representative of the aircraft fuselage skin connections is developed.

The effect of the interference fit between the rivet and the hole is taken into account utilizing fatigue test results for 2024-T3 Alclad aluminium alloy coupons with an open and filled hole. The effect of contact surface friction is considered based on comparisons between the fatigue lives of lap joints from 2024-T3 Alclad sheets and universal rivets with the Alclad contact surface and the fatigue lives of similar joints with the Teflon interfoil which eliminates friction between the sheets. Dependencies between coefficients incorporated into the model to account for the above mentioned effects and several quantities related to the amount of rivet squeezing, and thus representative of the riveting process, are provided.

The fatigue life is assumed to be controlled by the local stress amplitude at the critical location of a joint. Analyses of the fatigue test results for the 2024-T3 riveted joints prove that the local stress estimated using the superposition approach can adequately represent the combined effect of the applied loading, interference between the rivet and the hole and faying surface friction condition on the fatigue life.

The adequacy of the proposed model is substantiated by a good agreement between the fatigue lives predicted and observed for lap joints from D16 aluminium alloy sheets and round head rivets.

III.OBJECTIVES

A. To analysis of single lap riveted joint bonded by different thickness.
B. To analysis of single lap joint with different overlapping lengths.
C. To check strength of joints (with adhesive and without adhesive) using UTM.
D. To analysis of single lap riveted joint by using FEA and experimental.
E. Strength analysis of adhesively bonded single lap riveted joint using FEA.
F. Comparative analysis between FEA and Experimental model.

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IV. METHODOLOGY

CAD modeling of traditional & adhesively bonded riveted joint

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Finite Element Discretization using Ansys

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Nonlinear Static stress analysis using Ansys for both joints

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Specimen testing under tensile loading for both specimens using UTM machine

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Force vs Deflection diagrams will be used for drawing conclusions

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Composite Analysis FEA & Experimental

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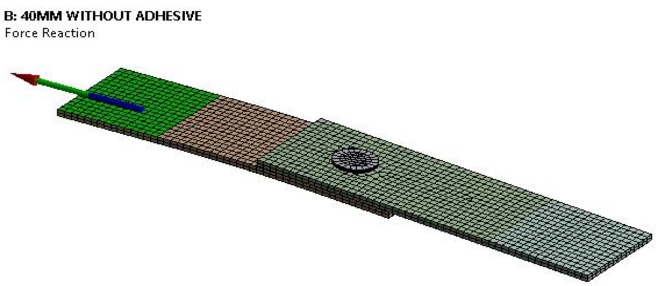
Conclusion & Future scope

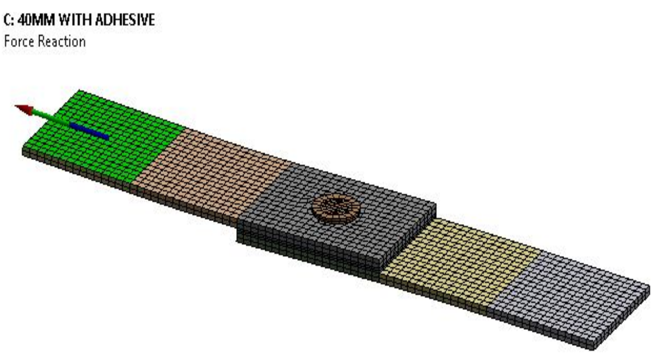
V. ANALYSIS BY FEA

A. Reaction Force



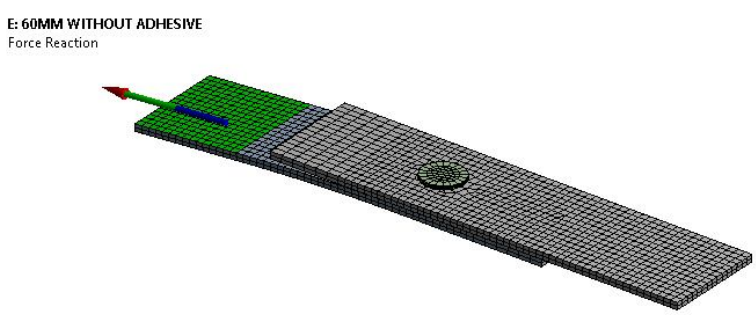
Maximum Value Over Time	
X Axis	2740. N
Y Axis	2.4668e-007 N
Z Axis	-2.5541e-006 N
Total	2740. N

Figure 1: Reaction force of Lap Joint 40 mm Without Adhesive



X Axis	4360 N
Total	4360 N

Figure 2: Reaction force of Lap Joint 40 mm With Adhesive



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

Figure 3: Reaction force of Lap Joint 60mm without adhesive

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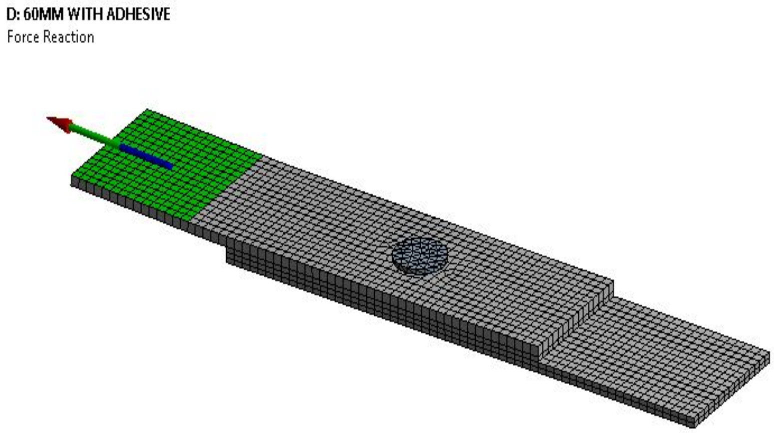
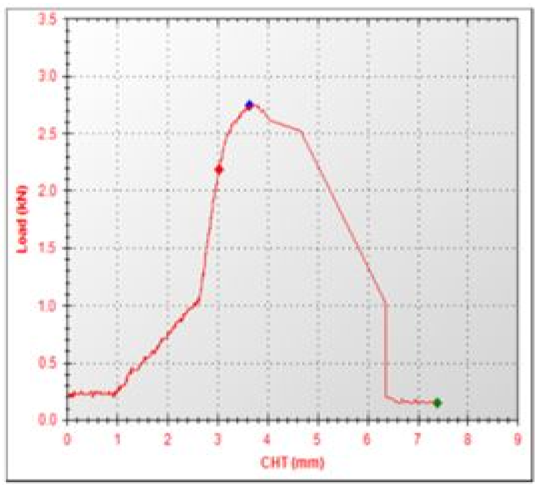


Maximum Value Over Time	
X Axis	4280. N
Y Axis	6.9317e-009 N
Z Axis	1.008e-002 N
Total	4280. N

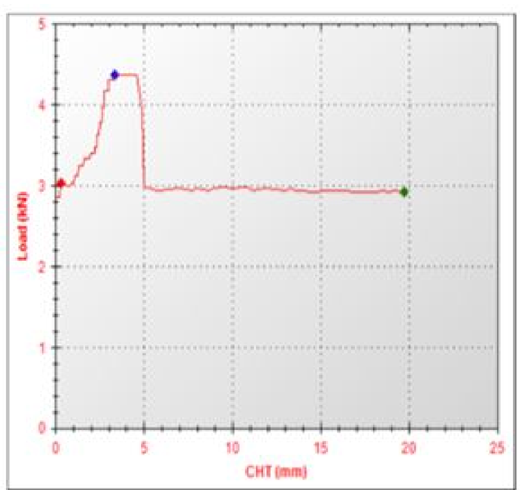
Figure 4: Reaction force of Lap Joint 60mm with adhesive

VI. EXPERIMENTAL ANALYSIS BY UTM



Reaction Force (Testing) = 2700 N

Figure 5: Experimental graph of 40mm lap without adhesive



Reaction Force (Testing) = 4350N

Figure 6: Experimental graph of 40mm lap with adhesive

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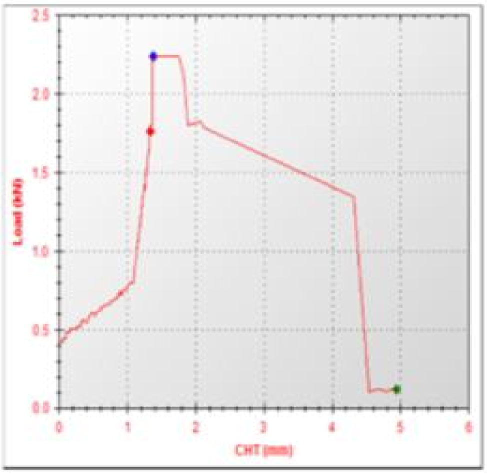
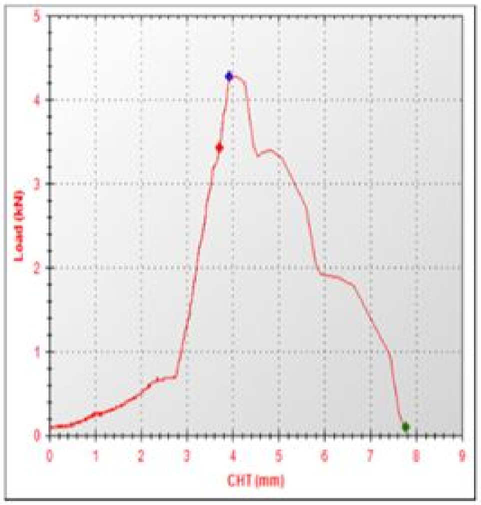


Reaction Force (Testing) = 2200N
Figure 7: Experimental graph of 60mm lap without adhesive



Reaction Force = 4190N
Figure 8: Experimental graph of 60mm lap with adhesive

VII. RESULTS

Characteristics	Force Reaction (FEA)	Force Reaction (UTM)
Lap Joint -40 mm Without Adhesive	2740N	2700N
Lap Joint -40 mm With Adhesive	4360N	4350N
Lap Joint -60 mm Without Adhesive	2240N	2200N
Lap Joint -60 mm With Adhesive	4280N	4190N

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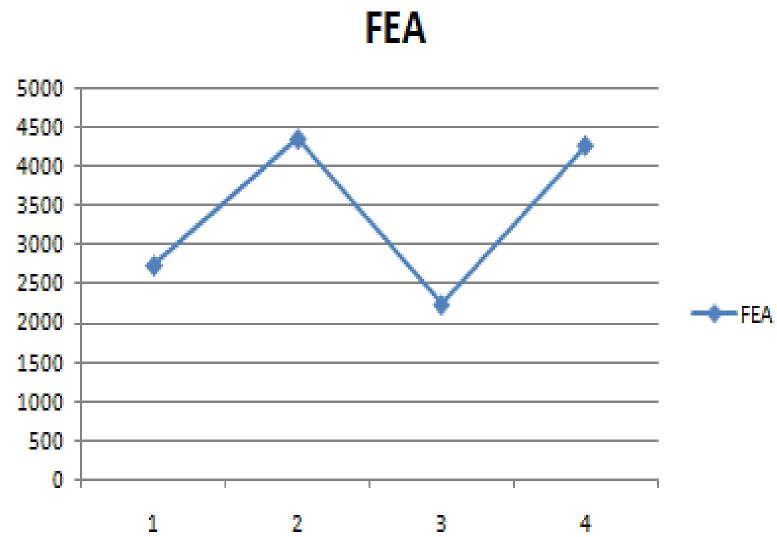

Figure 9: Graph of FEA Readings

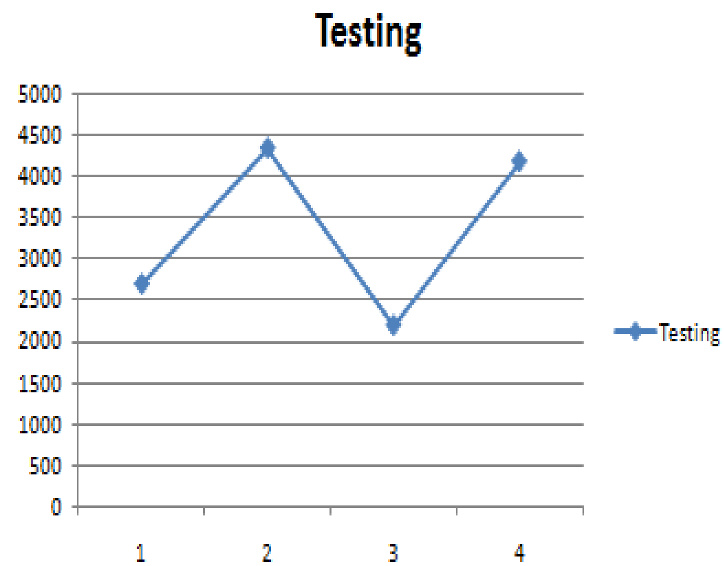

Figure 10: Graph of UTM Testing Readings

VIII. CONCLUSION

A. 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% .

B. Reaction force of FEA result are in good relationship with UTM test.

C. Force Reaction of Lap Joint -40 mm With Adhesive has maximum strength with 4360N.

D. Riveted joint of 40mm lap has 2.42mm deformation with maximum force reaction than 60 mm lap riveted joint

IX. ACKNOWLEDGMENT

It is of immense pleasure to me in expressing sincere and deep appreciation towards my guide Prof. S. A. Pawar., for priceless execution of steering this contribution all the way through this work with soft suggestions, embedded supervision and invariable advocacy. Special thanks to the principal and teaching staff of FTC, COER Sangola. for needful support and encouragement throughout the course.

REFERENCES

[1] G.P. Marques, R.D.S.G. Campilho, F.J.G. da Silva, R.D.F. Moreira, "Adhesive selection for hybrid spot-welded/bonded single-lap joints: Experimentation and numerical analysis", Composites Part B 84 (2016) 248-257.

[2] M.Y. Tsai, J. Morton, "An investigation into the stresses in double-lap adhesive joints with laminated composite adherends", International Journal of Solids and Structures 47 (2010) 3317-3325.

[3] R.D.S.G. Campilho, A. M. G. Pinto, M. D. Banea, L. F. M. da Silva, "Optimization Study Of Hybrid spot-welded/bonded single-lap joints", International Journal of Adhesion & Adhesives 37 (2012) 86-95.

[4] Bruno Pedrosa, Jose A.F.O. Correia, Carlos Rebelo, Grzegorz Lesiuk, Abílio M.P. De Jesus, Antonio A. Fernandes, M. Duda, Rui Calcada, "Fatigue resistance curves for single and double shear riveted joints from old portuguese metallic bridges", Engineering Failure Analysis 96 (2019) 255-273.

[5] Lei Pan, Wenye Ding, Wenliang Ma, Jingling Hu, Xiaofei Pang, Fei Wang, Jie Tao, "Galvanic Corrosion Protection and Durability of Polyaniline-reinforced Epoxy Adhesive for Bond-riveted Joints in AA5083/Cf/Epoxy Laminates", Materials & Design.

[6] Jackeline Kafie-Martinez, Peter B. Keating, Pranav Chakra-Varthy, Jose Correia, Abilio de Jesus, "Stress distributions and crack growth in riveted lap joints fastening thick steel plates", Engineering Failure Analysis 92 (2018) 370-381.

[7] Fabrizio Di Cicco, Pierluigi Fanelli, Francesco Vivio, "Fatigue reliability evaluation of riveted lap joints using a new rivet element and DFR", International Journal of Fatigue.

[8] M. Skorupa, T. Machniewicz, A. Skorupa, A. Korbel, "Fatigue life predictions for riveted lap joints", International Journal of Fatigue 94 (2017) 41-57.

[9] Hui Mei, Ding Zhang, Junchao Xia, Laifei Cheng, "Effect of heat treatment on the riveted joints of two-dimensional C/SiC composites", Composites Parts B.

[10] Li Huang, Haiding Guo, Yandong Shi, Shiyao Huang and Xuming Su "Fatigue of self-piercing riveted joints in aluminum alloy 6111", International Journals of Fatigue.

[11] Ali M. Al-Samhan, "Analysis of Adhesively Bonded Riveted Joints," J. King Saud Univ., Vol. 18, Eng. Sci. (1), pp. 57-66, Riyadh (1426H./2005).

[12] Neha B. Thakare, A. B. Dhumne, "A Review on Design and Analysis of Adhesive Bonded Joint by Finite Element Analysis," SSRG International Journal of Mechanical Engineering (SSRG-IJME)-volume 2 Issue 4-April 2015.

[13] Kale Suresh, K.L.N.Murty & T.Jayananda Kumar, "Analysis of Adhesively Bonded Single Lap Riveted Joint Using ANSYS," International Journal of Mechanical and Industrial Engineering (IJMIE) ISSN No. 2231 –6477, Vol-2.

[14] P. Shiva Shankar and L. Suresh Kumar, "Stress Analysis of Single Lap Riveted Joint for Leak Proof Applications by Adhesive Bonding Using Finite Element Method," International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 4 (2014).