NOVATEUR PUBLICATIONS
International Journal of Research Publications in Engineering and Technology [IJRPET]
ISSN: 2454-7875
VOLUME 3, ISSUE 3, March-2017

STRESS ANALYSIS OF RIVETED LAP JOINT USING FINITE ELEMENT METHOD

MR. B. C. HUSKAMURI
Student of Mechanical Department, Solapur University, NBNSCOE Solapur,India.

PROF. H. D. LAGDIVE
Mechanical Department, Solapur University, NBNSCOE Solapur,India.

ABSTRACT:

Rivets are permanent, non-threaded, one-piece fasteners that join parts together by fitting through a pre-drilled hole and deformed the head by mechanically upsetting from one end. In this paper the results of experimental analysis based on lap-shear test on riveted connection are presented. For experimentation specimens were prepared and different thickness and configurations were considered. The results of experimental test allowed the influence of various parameters such as plate width and pitch. These results are compared with the Ansys result. The experimental test using Universal Testing Machine and shear stress results are calculated. These results were compared with model simulation in FEA software.

KEYWORDS: Shear Test, Pitch, Universal Testing Machine, FEA software.

1. INTRODUCTION:

Manufacturing large and complex structures is usually possible only when they are composed of assemblies of smaller parts joined together by variety of joining techniques since most products are impossible to be produced as a single piece. Manufacturing components and then joining them into a single product is easier and less expensive then manufacturing the whole product at once. In order to ensure the manufacturability, and reduce the overall manufacturing cost, certain fastening and joining method should be utilized.

Mechanical fasteners can be described as devices that mechanically join two or more objects of an assembly with desired permanence, stability and strength. Mechanical fasteners offer several options for joining and fastening mechanical components together. Mechanical fastening methods can be categorized into two main types: permanent (welding, bonding, riveting etc.) and detachable joints (bolt, screw, pin etc.) Selection of appropriate method among these alternatives should be based on permanence, cost and strength of the fastener.

A rivet is short cylindrical bar with a head integral to it. A cylindrical portion of the rivet is called shank and lower portion of shank is known as tail (Fig.1.1). The rivets are used to make permanent fastening between the plates. A rivet is a permanent mechanical fastener. Effective transmission is possible if the pairs don't have any short of disorder in manufacturing and assembling. The function of rivet in a joint is to make the connection that has strength and tightness. The tightness is necessary in order to contribute to strength.

Riveting is now-a-days extensively used in the following fields: by using automobile industry, aircraft, machine frame, structural work, tanks, ship building, and fabrication of metal structures.

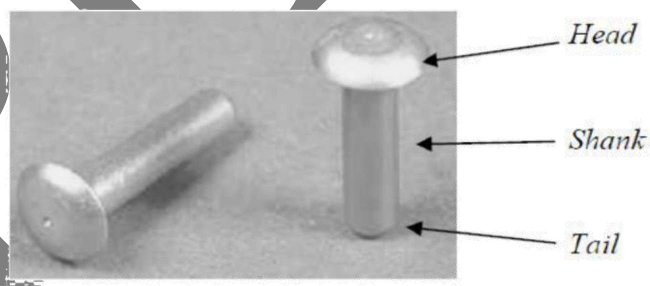
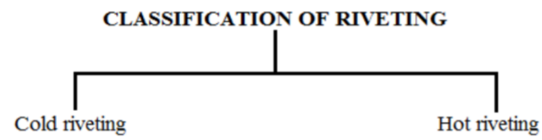


Fig.1.1 Solid rivets

1.4 CLASSIFICATION OF RIVETING:



COLD RIVETING: In this riveting method a rivet is inserted in a pre-drilled or punched hole and deformed the head by mechanically upsetting or hydraulic press from one end.

HOT RIVETING : In this riveting method a rivet is heated and inserted in a pre-drilled or punched hole and deformed the head by mechanically upsetting from one end.

LITERATURE REVIEW:

Many research works has been done in the field of rivet lap joint. Every researcher has done experimental or software investigation on rivet joint for confirmation of the results obtained by theory with the

IJRPET

experimental results. Following is the literature review of some papers giving more information about contribution of various researchers in failure analysis of riveted lap joint.

"Experimental investigation on shear behaviour of riveted connections in steel structures" M. D'Aniello, F. Portioli, L. Fiorino, R. Landolfo In this reference paper, riveted lap joint parameters are varied and observed failure mode for each test, when joint length increases bending will become less influence on behaviour of connection, as width of plate increased ultimately increased strength of joint.

"Fatigue Crack Growth In Aluminium Lithium Riveted Lap Joints", Babak Anasori, Franklin Saillot, David Stanley, Jonathan Awerbuch, and Tein-Min Tan in their paper, identified the fatigue crack initiation sites and fatigue crack growth rate in riveted lap joint by using fractographic examination. As number of cycles increases failure rate increase and also affected by the grain direction.

"Investigation Of Load Transmission Throughout A Riveted Lap Joint", Małgorzata Skorupa, Tomasz Machniewicz, Andrzej Skorupa, Adam Korbel in their paper, determined the effect of friction between the mating sheets on the fatigue life, for this specimens of riveted lap joint of with and without the Teflon interlayer sheets were used , at the same time it was observed that overall effect of friction become less when the rivets are more severely squeezed.

"Experimental and numerical studies on failure modes of riveted joints under tensile load", Nanjiang Chena,, Hongyu Luo , Min Wan , Jean-loup Chenot in their paper, observed the three failure modes such as tensile strength, shank breaking and head breaking ,studied numerically and for experimentation three sizes of riveted joint carried out, it was observed that calculated result are not very pricise as compaired with experimental result, by this study it was easy to identify failure mode of riveted joint when they are under tensile load

"A Numerical Analysis of Riveted Lap Joint Containing Multiple-site Damage", Dazhao YU in their paper, investigates the accuracy of the efficient modelling methods to determine stress intensity factors (SIFs) for riveted lap joints with Multiple-site Damage (MSD) of mechanically fastened joints, in this also three crack scenarios were studied by using efficient model, the effect of pillowing corrosion and fastener interference were also included in the model. After analysis the results shows that the effect of Multiple-site Damage and thinning of the material is to increase substantially stress intensity factors (SIFs) values compare to that of a single crack without corrosion. For a given cyclic stress range, stress intensity factors decreases with increasing rivet interference level. This is particularly true for shorter crack lengths.

"Observations and analyses of secondary bending for riveted lap joints", M.Skorupa, A.Korbel, A.Skorupa, T.Machniewicz in their paper, analyses and studied the secondary bending of riveted lap joint by experimentally and compared the result using analytical model, it was prepaired in schijve method. For study the effect of secondary bending on the riveted joint, fatigue test was performed. It is observed that the effect of some variables in joint geometry, such as the sheet thickness or rivet row spacing, on the fatigue performance of riveted lap joint was influenced in variations in secondary bending. Variation in pitch slightly cause load transfer in the joint, in addition change in sheet thickness a stress concentration around the hole was varied, Specifically, reducing the thickness of the sheets and increasing the distance between rivet rows lead to considerably longer fatigue lives.

"The Structure Of The Strength Of Riveted Joints Determined In The Lap Joint Tensile Shear Test", Jacek Mucha, Waldemar Witkowski in their paper, load capacity of riveted lap joint was analysed by tensile shear test. For this analysis sheet thickness, rivets and different materials of sheets are used. It was observed that during tensile shear test, differences in the shearing force were obtained for different arrangements of the sheet material. During the test it was also observed that several parameters are influenced in stress concentration of joint such as clearance between the rivet and hole, rivet diameter, hole diameter and squeeze force.

DESIGN AND PREPERATION OF SPECIMEN:

FACTORS AFFECTING STRENGTH OF RIVETED JOINT:

After doing literature survey some parameters are observed which affects strength of riveted joint. The henceforth chapter discuss the effect of parameters on strength of riveted joint.

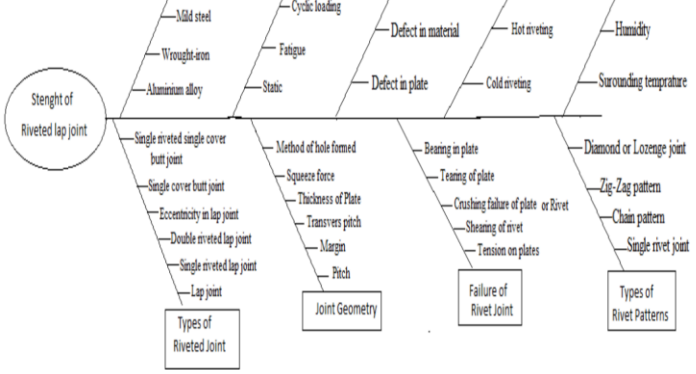


Fig.3.1 Cause effect diagram for riveted joint

IJPRET

PARAMETERS AND ITS SELECTION:

Sr. No.	Parameter	Selection	Reason for Selection
1	Type of loading	Shear loading	Maximum components are observed under Shear loading.
2	Type of material	Aluminium Alloy	Wide range of application.[
3	Geometry of joint	Linear Pitch and Thickness of Plate	Varying this parameters affect the strength of the joint.
4	Type of joint	Lap Joint	The parameters under study are Linear Pitch and Thickness of Plate.

EXPERIMENTATION, RESULTS & DISCUSSION:

EXPERIMENTATION:

The shear test on the specimen has carried out using UTM as shown in fig.

SPECIMEN DETAILS:

CASE-I

Variation of parameters at the end of third chapter it is concluded to consider linear pitch and Thickness of plate specimen as parameter to be varied in single chain riveting for experimentation and dimensions are considered for specimen as follows.

Table. I Specimen details

Sp. No.	Thickness of Plate	Margin (m =1.5d)	Pitch (p =3d)	Pitch (p =3d)	Pitch (p =3d)
			S1	S2	S3
1	3mm	7.5	15	18 (increasing pitch by 3mm)	21 (increasing pitch by 3mm)
2	5mm				
3	6mm				

CASE-II

Variation of parameters at the end of third chapter it is concluded to consider linear pitch, Thickness of plate and transverse pitch specimen as parameter to be varied in single chain riveting for experimentation and dimensions are considered for specimen as follows.

Sp. No.	Thickness of Plate	Margin (m =1.5d)	Pitch (p =3d)	Transverse Pitch (Pt=0.8p)	Pitch	Transverse Pitch (Pt=0.8p)	Pitch	Transverse Pitch (Pt=0.8p)
			D1		D2		D3	
1	3mm	7.5	15	12	18 (increasing pitch by 3mm)	14.4	21 (increasing pitch by 3mm)	16.8
2	5mm							
3	6mm							

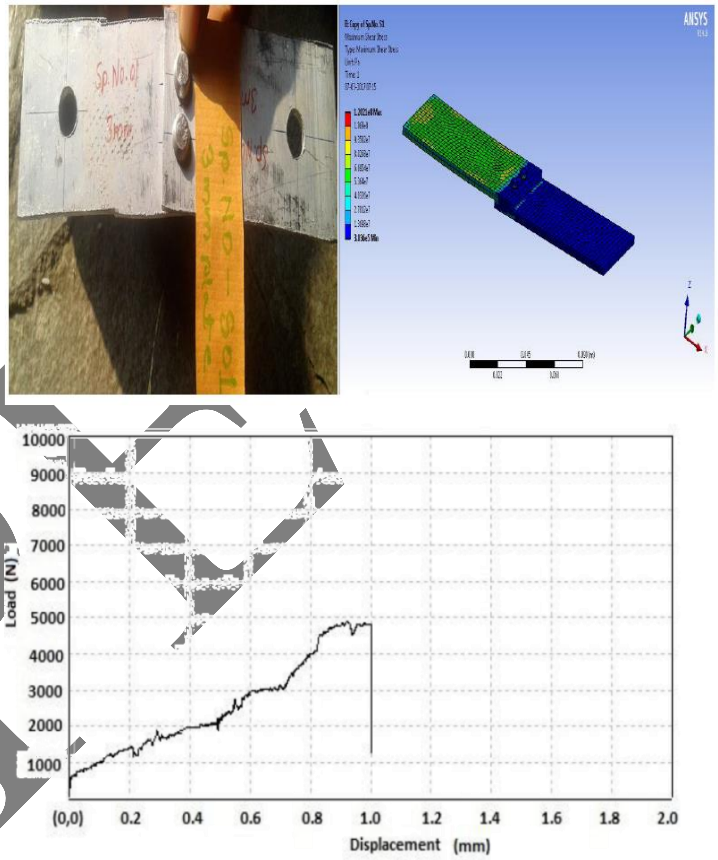
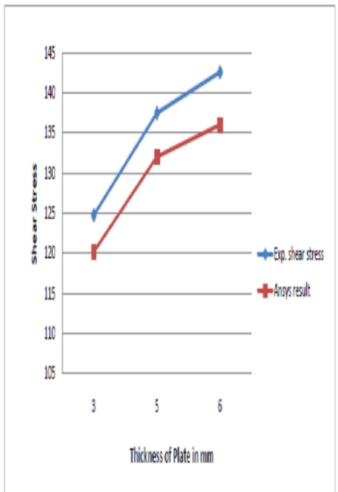


Fig. Exp. graph and Simulation in Ansys

Table 4.1 Experimental and Ansys Result (for S1)

Sp. No.	Shear Stress		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	124.77	120.21	3.65
2	137.51	132.05	3.97
3	142.60	136.02	4.61



NOVATEUR PUBLICATIONS
International Journal of Research Publications in Engineering and Technology [IJRPET]
ISSN: 2454-7875
VOLUME 3, ISSUE 3, March-2017

Table 4.2 Experimental and Ansys Result (for S2)

Sp. No.	Shear Stress		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	132.42	126.42	4.53
2	142.60	118.27	17.06
3	173.24	151.8	12.37

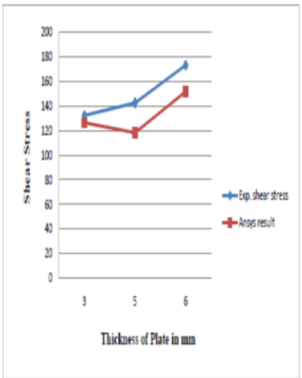


Table 4.3 Experimental and Ansys Result (for S3)

Sp. No.	Shear Stress		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	134.96	127.96	5.18
2	150.24	135.99	9.48
3	183.35	174.36	4.90

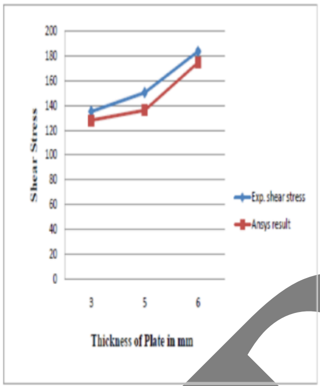


Table 4.1 Experimental and Ansys Result (for D1)

Sp. No.	Shear Stress		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	134.96	128.7	5.10
2	131.14	125.4	4.37
3	120.96	116.45	3.72

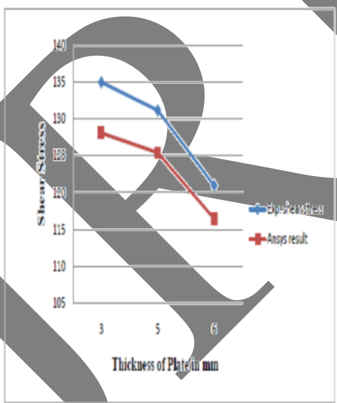


Table 4.2 Experimental and Ansys Result (for D2)

Sp. No.	Shear Stress		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	131.14	127.89	2.47
2	129.87	124.84	3.79
3	126.05	123.48	2.03

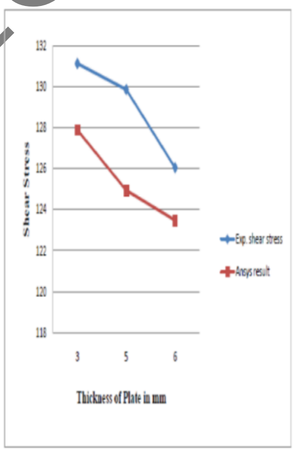
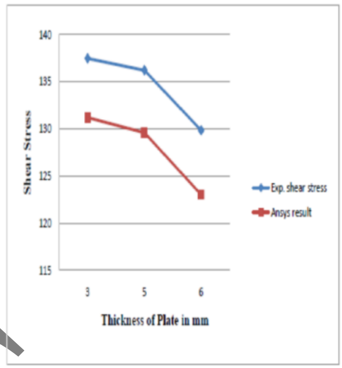


Table 4.3 Experimental and Ansys Result (for D3)

Sp. No.	Shear Stress		Percentage deviation
	Value calculated experimentally	Value calculated by simulation	
1	137.50	131.21	4.57
2	136.24	129.6	4.87
3	129.87	123.04	5.25



On the basis of the result obtained, the effect of selected parameter on the response of connections are analyzed below

EFFECT OF PLATE LENGTH:

Test accentuate that shear behavior is depend on the geometry and load conditions. if length of specimen is increased bending of plate occurs. The influence of bending was most pronounced in specimens with only a single rivet in the direction of the applied shear.

EFFECT OF PITCH:

Test shows that pitch is the one of important parameter which influence on strength of riveted joint. The results shows that were pitch increases strength of joint is also increased.

EFFECT OF PLATE WIDTH:

Plate width is another parameter which effects on the efficiency of joint. As increasing the plate width as ultimately increases the strength of joint.

CONCLUSION AND FUTURE SCOPE:

Various design parameters are considered and effect of this parameter on shear strength of riveted lap joint is discussed. Analytical design procedure was adopted for designing fixture to hold the specimen. The specimen dimensions were finalized and specimens were prepared by varying linear pitch and thickness of plate. The values of stress obtained from experimentation and values obtained by simulation are compared for validation of experimentation.

a) The shear strength obtained in single chain riveting by variation of pitch and thickness of plate shows maximum shear strength of 7.2 KN with pitch 21mm and thickness of plate 6mm. This implies that while using 5 mm rivet diameter for single lap joint pitch 21mm and thickness of plate 6mm is recommended.

b) Increasing the pitch above 21 mm results in poor shear strength and decreasing pitch length below 15 mm will also reduce shear strength.

c) The shear strength obtained in double chain riveting by variation of pitch and thickness of plate shows maximum shear strength of 10.8 KN with pitch 21mm, transvers pitch 16.8 mm and thickness of plate 3 mm. This implies that while using 5 mm rivet diameter for double lap joint pitch 21mm and thickness of plate 3 mm is recommended.

d) Increasing the pitch and transverse pitch and thickness of plate result in decreasing shear strength, and decreasing pitch 15 mm and transverse pitch 12 mm below this plate will cause tear and weaken the joint. From this all, it can be concluded that the experimental analysis is the most suitable and easy technique to identify the shear stress.

SCOPE OF WORK IN FUTURE:

- Experimentation of testing of riveted lap joint by variation of plate material, squeeze force and riveting patterns can be done.

REFERENCES:

1) M. D'Aniello, F. Portioli, L. Fiorino, R. Landolfo, "*Experimental investigation on shear behaviour of riveted connections in steel structures.*" Engineering Structures 33 (2011) 516–531.
2) Babak Anasori, Franklin Saillot, David Stanley, Jonathan Awerbuch, and Tein-Min Tan, "*Fatigue Crack Growth in Aluminum Lithium Riveted Lap Joints.*" Procedia Engineering 74 (2014) 413 – 416.
3) Małgorzata Skorupa, Tomasz Machniewicz, Andrzej Skorupa, Adam Korbel, *"Investigation of load transmission throughout a riveted lap joint."* Procedia Engineering 114 (2015) 361 – 368.
4) Nanjiang Chena, Hongyu Luo , Min Wan , Jean-loup Chenot, "*Experimental and numerical studies on failure modes of riveted joints under tensile load."* Journal of Materials Processing Technology 214 (2014) 2049–2058.
5) Dazhao YU, "*A Numerical Analysis of Riveted Lap Joint Containing Multiple-site Damage."* Appl. Math. Inf. Sci. 7, No. 2L, 699-704 (2013).
6) M. Skorupa, A. Korbel, A. Skorupa, T. Machniewicz, *"Observations and analyses of secondary bending for riveted lap joints.*" International Journal of Fatigue 72 (2015) 1–10.
7) Jacek Mucha, Waldemar Witkowski, "*The structure of the strength of riveted joints determined in the lap joint tensile shear test."* acta mechanica et automatica, vol.9 no.1 (2015).
8) K. Mori, Y. Abe, T. Kato," *Mechanism of superiority of fatigue strength for aluminium alloy sheets joined by mechanical clinching and self-pierce riveting*." Journal of Materials Processing Technology 212 (2012) 1900– 1905.
9) Quentin Collette, Stéphane Sire, Ine Wouters, *"Lap shear tests on repaired wrought-iron riveted connections.*" Engineering Structures 85 (2015) 170–181.
10) J.C. Newman Jr, R. Ramakrishnan," *Fatigue and crack-growth analyses of riveted lap-joints in a retired aircraft"* International Journal of Fatigue 82 (2016) 342–349.
11) S. Sire, L. Gallegos Mayorga, B. Plu, *"Observation of failure scenarios in riveted assemblies: an innovative experimental strategy."* Procedia Engineering 114 (2015) 430 – 436.
12) M. D'Aniello, F. Portioli, R. Landolfo, "*Lap shear tests on hot-driven steel riveted connections strengthened by means of C-FRPs."* Composites: Part B 59 (2014) 140–152.
13) Wang S. And Han Y. , *Finite element analysis for load distribution of multi-fastener joints*. J. Compos. Mater. , 1988,22,124-135.
14) Langrand B., Patronelli L., Deletombe E., Markiewicz E., Drazetic P., 2002, "*Full scale experimental characterization for riveted joint design"*, Aerospace Science and Technology 6, pp. 333-342.
15) Iyer K., Rubin C.A., Hahn, G.T., 2001, "*Influence of interference and clamping on fretting fatigue in single rivet-row lap joints,"* Journal of Tribology, Vol. 123, pp. 686-698.
16) Karasan M.M., 2007, "*Residual Stress Analysis of Riveting Process Using Finite Element Method*", M.S. Thesis, Middle East Technical University, Ankara.
17) Fung C.P., and Smart, J., 1997, "*Riveted Single-Lap-Joints. Part 1: A Numerical Parametric Study,"* Proc. Instn. Mech. Engrs. –G- J. Of Aerospace Engineering, 211 (1), pp. 13–27.
18) Fung C.P., and Smart, J., "*An Experimental And Numerical Analysis Of Riveted Single Lap Joint,"* proceedings of the institution of mechanical engineers,Vol.208,pp,79-90.

IJRPET