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Comparative Study of Static Analysis of Pop up (Blind) Riveted Lap Joint and Solid Riveted Lap Joint

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***Abstract*–Recently there is maximum aluminium is used in Automotive, Aeronautical industries. Due to its formability, light weight and resistance to corrosion. This paper deals with the analysis of stress induced in tensile shear testing. Due to the interference between rivet and plate, the effect of stress state is examined by using CAE software and analytically . By the use of CAE software, the analysis of present work is done. The present work shows the strength of solid rivet joint to sustain the load is more than Blind rivet. Fracture analysis of sheared riveted joints are studied and in this cracks observed to the outer panel at a plane perpendicular to the loading. And also behaviour of stresses and fracture are analysed and predict the which joint is better between Solid riveted joint and blind riveted joint.**

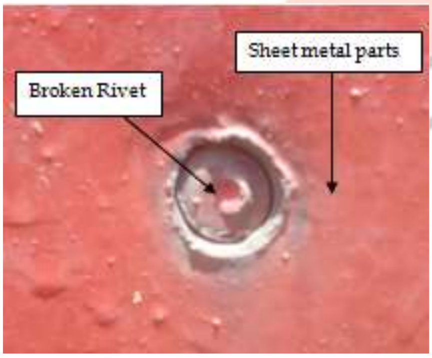
***Index Terms* – Aluminium 2023 T3, Aluminium 6061 T6, CAE Software Abaqus, Pop up Rivet (Blind Rivet) Riveted lap joint, Solid Rivet, Static Analysis, Tensile shear test.**

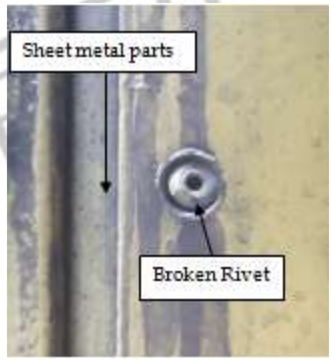
I. Introduction

In engineering, it is required that two sheets or panels are joined together. A riveted joint is easily conceived between two sheets or panels overlapping at edges, making holes through thickness of panels by piercing operation, then rivets are passed through the holes and creating the head at the end of the stem on the other side. A number of rivets pass through the row of holes, which are equally distributed along the edges of the plate.

The maximum use of blind rivet joint is used in bus body panels to fix with inner part after some years the rivets break or the hole expands due to which the joint is fail and there is chances of injury or parts may fall down and for servicing this cost is required more .So for selection of appropriate rivet joint is necessary based on performance, cost and strength of the fasteners.

The present work deals with the study of failure of Pop up (Blind Rivets). It is used in mostly buses, in this lap joint is present as shown in figure. The material of pop up (blind rivet) is Al 2023 T3 and body panels are Al 6061 T6. To overcome this problem we suggest the solid rivet joint instead of Pop up (blind) Riveted joints of same material. Thickness of outer panel is 2mm. and Inner panel is 3mm.





1.1 Rivet

Rivets are the fasteners used for the permanent joint. In market there is various types of rivets are present snap, Snap Head, Pan head, Mushroom head, Countersunk head 120º,Flat counter sunk 90º ,Flat counter sunk head 60º,Round counter sunk head 60º,Blind Rivet or Pop up Rivet. For our study Solid and blind Rivet is necessary so the details about these are as follows.[5]

1.2 Blind rivet

Blind rivets are also known as pop rivets (POP is the brand name of the original manufacturer) are tubular and are supplied with a mandrel as shown. The rivet assembly is inserted into a hole drilled through the parts to be joined and a separate tool is required to draw the mandrel into the rivet. Due to this, expands the blind end of the rivet and then the mandrel snaps off. Diameter of this rivet used od is 5mm and id is 3mm.

These types of blind rivets have non-locking mandrels may fall out, due to vibration or other reasons, leaving a hollow rivet that has a lower load-carrying capability than solid rivets. Because of the mandrels they are more prone to failure from corrosion and vibration. [8]

1.3 SOLID RIVET

A Rivet consists of a smooth cylindrical shaft with a head on one end. The end opposite the head is called the tail. On installation the rivet is placed in a punched or drilled hole and the tail is upset or bucked (i.e. deformed) so that it expands to about 1.5 times the original shaft diameter, holding the rivet in place in other words pounding creates a new head on the other end by smashing the “tail” material flatter, resulting in a rivet that is roughly a dumbbell shape. Diameter of this rivet used 5mm. [8]

II. STRESSES IN RIVET JOINTS

The rivet joints are studies by assuming following criteria

- Rivet joints are loaded in shear the load is distributed in proportion to shear area of the rivets
- In rivet joints there are no bending or direct stresses in rivets.
- Rivets holes in plate do not weaken the plate in compression.
- Friction between the surfaces of plates does not affect the strength of the joints.
- When riveted joints are in double shear, the shear force is equally distributed between two aeas of shear.
- After assembly of rivets, rivet completely fills the holes. [1]

2.1 FAILURE MODES IN RIVETED JOINTS

<u>Tension/Tearing of plate between rivet holes:</u> Due to tensile stresses in the plates and plate may tear off across a row of rivets as shown in fig. in such cases, we consider only one pitch length of the plate, since every rivet is responsible for that much length of the plate only.

The resistace required to tearoff the plate is per pitch length [5]

$$P_t = A\,.t.\,\sigma_t = (p-d).t.\sigma_t$$

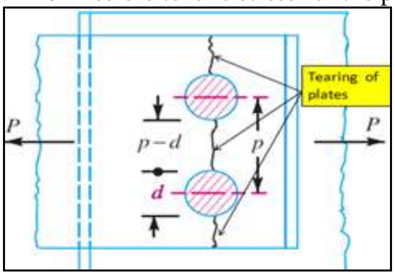
Where P_t=Tearing resistance

d = Diameter of the rivet hole

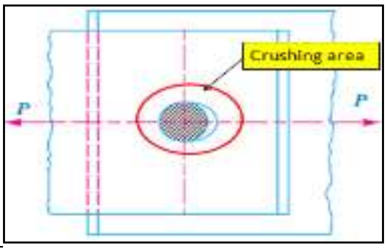
t= thickness of the plate

p= pitch of the rivets

σ_t= Permissible tensile stress for the pate material



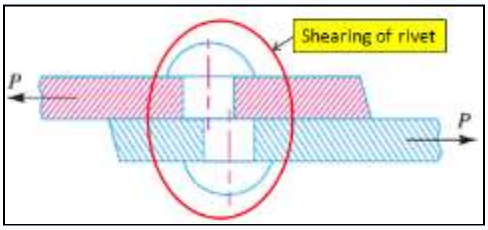
<u>Crushing of the plates or rivets:</u> Sometimes rivets do not actually shear off under the tensile stress, but are crushed as shown. Due to this the rivet hole becomes of an oval shape and hence the joint becomes loose.



The resistance offered by a rivet to be crushed is Pc,[5]

Pc= n.d.t.σc
Where, n= no. of rivets under crushing
d= diameter of rivet under crushing
t= thickness of plate
σc = Crushing strength of rivet.

Sharing strength of Rivets: The shearing strength of rivet calculated by following formula



The shearing strength of rivet Ps,[5]

Ps= n.(π/4).d2. τmax ---- for single riveted shear
Where, n= no. of rivets under crushing
d= diameter of rivet under crushing
τmax=Shear strength of rivet

Maximum shear stress: [1]

$$\tau_{max} = \frac{1}{2}\sqrt{\sigma_t^2 + \tau_s^2}$$

Where, τmax = Maximum shear stress
σt = Permissible tensile stress for the plate material
τs = Safe permissible shear stress

III. Overview of ABAQUS

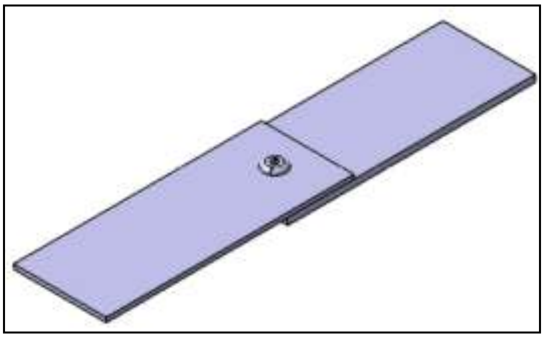
The ABAQUS 6.12 is CAE software used to calculate various stresses in variable loading condition. Used in automotive industries, Aeronautical industries etc. for solving any problem by using Abaqus three steps are involved Pre-processor, Solution and Postprocessor. Abaqus have other features such as sub structuring, sub modeling, random vibration, thermal and design optimization added in program.

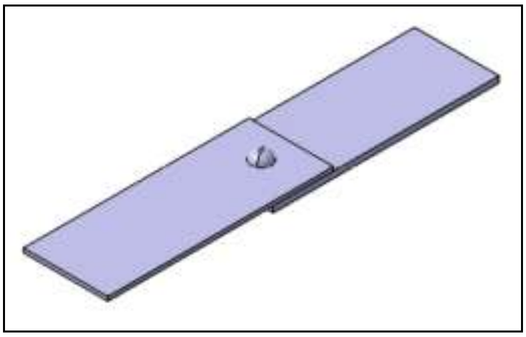
Procedure to solve problem in Abaqus:
Building the model: In this project, parts are prepared with the help of CATIA V5 and Assembly also created in CATIA V5. After assembly creation then it is converted into ".stp" format for Abaqus .
Constraints and Loads: Boundary conditions and Loads are applied on the model.
Meshing models**:** Apply mesh to given Assembly
Analysis type: we have to calculate stresses and displacement in tensile shear test then static analysis is selected. In this Linear and non-linear categorized are present.

IV. Present work details

The Specification of the current parts and assembly is taken as per ISO 12996 standard [6]. CAD model of Blind rivet joint and solid rivet joint is prepared on the basis of this standard. Firstly solve the given problem by CAE software Abaqus and compare with Analytical solution
CAD model with material properties, Boundary condition & meshing property:

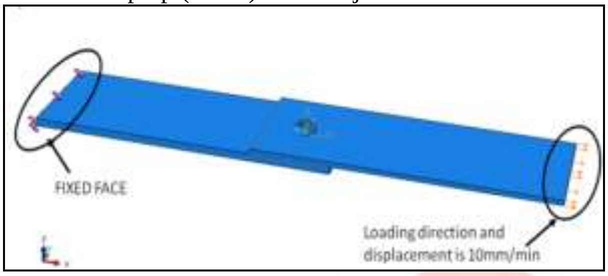
CAD model
Pop up (Blind) Riveted joint Solid Riveted joint



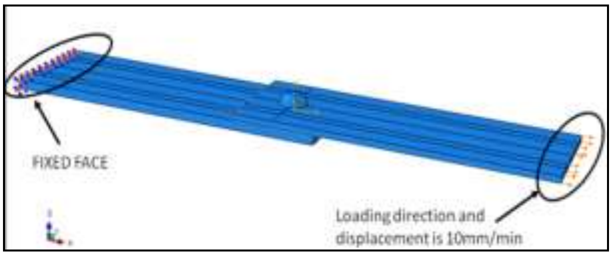


Boundary condition:

Pop up (Blind) Riveted joint

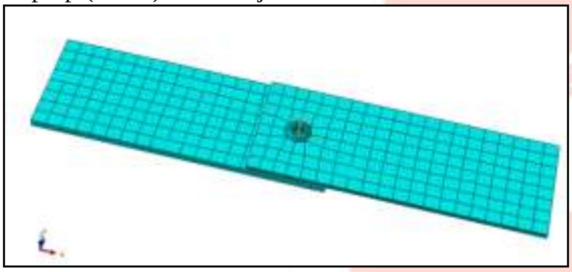


Solid Riveted joint

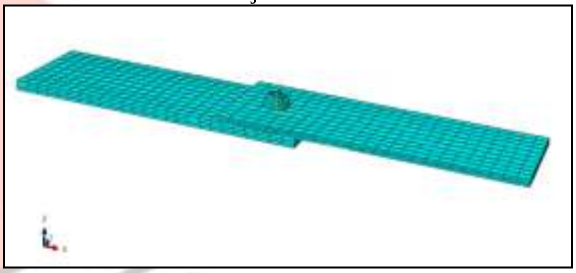


Meshing model:

Pop up (Blind) Riveted joint



Solid Riveted joint



Material properties: [7]

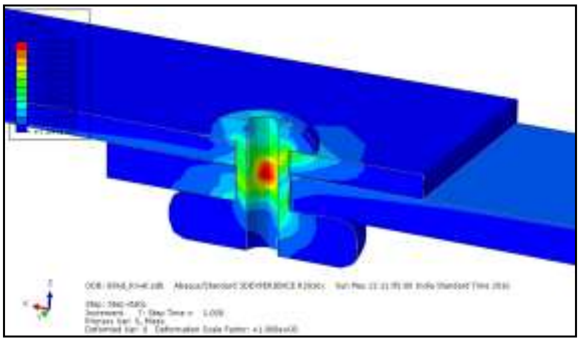
Poperties	**Material**	
	Al 2023 T3 (Rivet)	Al 6061 T6 (Panels)
Youngs modulus	66000Mpa	68000Mpa
Poissions ratio	0.33	0.33
Density	2.7 x10-6 kg/mm3	2.7 x10-6 kg/mm3
Yield strength	200 Mpa	83 Mpa

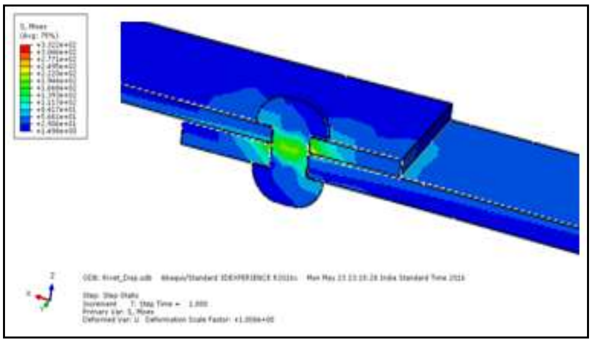
Calculation of stresses by CAE software:

Stresses distributed on Riveted joint:

Pop up (Blind) Riveted joint

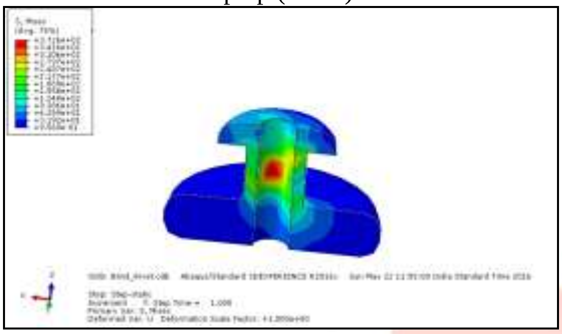
Solid Riveted joint



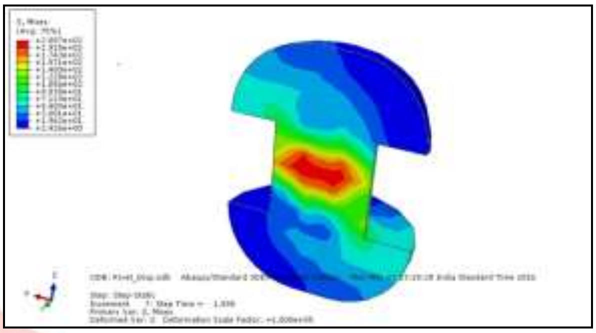


Stresses distributed on Rivet:

Pop up (Blind) Rivet



Solid Rivet



Calculation of stresses by Analytical:

	Load	**Crushing stress on the rivet**	**tearing of rivet across a row of rivet**	**Shearing of rivet**	**Maximim shear stress**[5]
Types of Rivet	P	σc= P/(dxt) Mpa	σt= P/((p-d)xt) Mpa	τs=(4xP)/(πxd2) Mpa	$\tau_{max} = \frac{1}{2}\sqrt{\sigma_t^2 + \tau_s^2}$ Mpa
Pop up (Blind Rivet)	2000	500	16.1	636	318
Solid Rivet	2000	200	16.9	101.8	51.5
	7000	700	59.3	356	180.4

V. Result

Pop up (Blind) Riveted and Solid riveted lap joints tensile shear testing is done in Abquas software as per ISO 12996. Maximum shear stress observed for shearing pop up (Blind) rivet is in between 310 to 341 MPa, maximum shear force is in between 1500N to 2500N and for solid rivet is in between 174 MPa to 191 MPa, maximum shear force is in between 6500N to 8000N.

The analytically maximum shear stress for pop up (Blind) rivet is 318 Mpa, maximum shear force is 2000N and for solid rivet is 180.4 MPa, maximum shear force is 7000N.

VI. Conclusion

From above testing, calculation and result we conclude that, the rivet used in buses is failed due to shearing of rivet and maximum shear force is 2000N and shear stress is 318MPa .proposed solid rivet is sheared to the 7000N and shear stress is 180MPa.

From above conclusion we say that Solid Riveted joint has maximum shear strength as compared to Pop up (Blind) riveted joint.

VII. ACKNOWLEDGEMENT

Thanks to S.T. Mahamandal workshop/Depo to share the details about material and its assembly process and thanks to Prof. Swami Mahesh C. for his valuable guidance and checking journal paper.

VIII. FUTURE SCOPE

There is more scope to analyze the failure of riveted joint by optimizing the panels thickness to calculate strength of joints and Calculate fatigue life of riveted joint.

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