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# Efficiency of Riveted Joints: Lozenge Joint

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***Abstract:** Mechanically fastened joints have proven to be weak links in an aircraft structure. Therefore it is important to design and manufacture these joints with high quality [1]. Strength and Tightness are the two important qualities of Riveted Joint. Failure of the joint can be prevented by strength and tightness. Tightness is necessary to prevent leakage. In this paper various procedures were used to improve the efficiency of a Riveted Joint. Efficiency of Riveted Joint depends on various factors like number of rivets, Pitch of rivets, number of straps, width of the plate, diameter of rivet and thickness of plates etc.*
***Keywords:** Lozenge joint, Riveted joint, Fasteners, Eccentric load, Efficiency.*

## I. INTRODUCTION

Permanent fasteners and temporary fasteners are the two classifications in fastenings. The fastenings which cannot be disassembled without damaging the source components are called as permanent fastenings and those fastenings which can be detached without destroying the joining components are called as temporary or detachable fastenings. the examples of permanent fastenings are soldering, brazing, welding and riveted joints. Soldering is a low temperature analog to brazing. Soldering takes place with fillers that melt at below 450$^{o}$c. In welding the two metals or thermo plastics must be similar. In fabrication, welding is extensively used and sometimes one can find it as the alternative method for casting or forging and replacement for bolted and riveted joints. The rivets are used to make permanent fastenings between the plates such as in structural work, ship building, bridges, tanks and boiler shell. The riveted joints are widely used for joining light metals.

## II. METHODS OF RIVETING

Punching and drilling are the two commonly used methods of riveting. Punching is the economical method of riveting but it injures the material around hole. Drilling is used in most pressure vessel work. To make tight flush joint between the plates, the plates are drilled together and then separated to remove the burrs and chips [2].
Manufacturing complex structures is 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 economical than manufacturing the total product at once.

## III. DESIGN STRESSES

The riveted joints are analyzed based on the following assumptions [2]:

*1)* Rivets are loaded in shear the load is distributed in proportion to the shear area of the rivets.
*2)* There are no bending or direct stresses in rivets.
*3)* Rivet holes in plate do not weaken the plate in compression.
*4)* After assembly rivet completely fills in the rivet hole.
*5)* Strength of the joint may not be affected due to friction between the adjacent surfaces.

### *A. Failures of Riveted Joints*

*1) Tearing of the plate at an edge:* A joint may fail due to tearing of the plate at an edge as shown in figure 1. This can be avoided by keeping the margin, m=1.5d, where d is the diameter of the rivet hole.

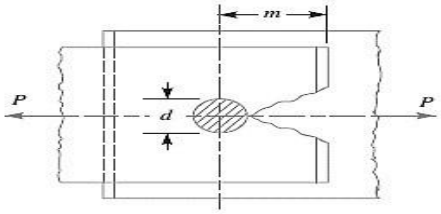


Fig: 1- Tearing of the plate at an edge

2) *Tearing of the plate across a row of rivet:* The resistance offered by the plate against tearing is known as tearing resistance or tearing value of the plate. To prevent this failure the tearing resistance must be greater than the applied load per pitch length. Tearing of the plate across a row of rivet is shown in figure 2.

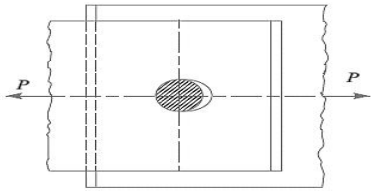


Fig: 2- Tearing of the plate across a row of rivet

3) *Shearing of the rivets:* The plates which are connected by the rivets exert tensile stress on the rivets and if the rivets are unable to resist the stress they are sheared off as shown in figure 3. The resistance offered by a rivet to be sheared off is known as shearing resistance or shearing value. To prevent the failure due to shear, the shearing resistance must be greater than the applied load per pitch length [3].

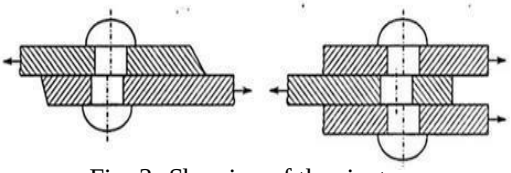

Fig: 3- Shearing of the rivets

4) *Crushing of the plate or rivet*: Sometimes under tensile stress rivets crushed instead of shear off as shown in figure 4. Due to this the rivet hole comes in to an oval shape and joint becomes loose. This failure is known as bearing failure. When the crushing resistance is greater than the applied load per pitch length, then this type of failure will occur [4].

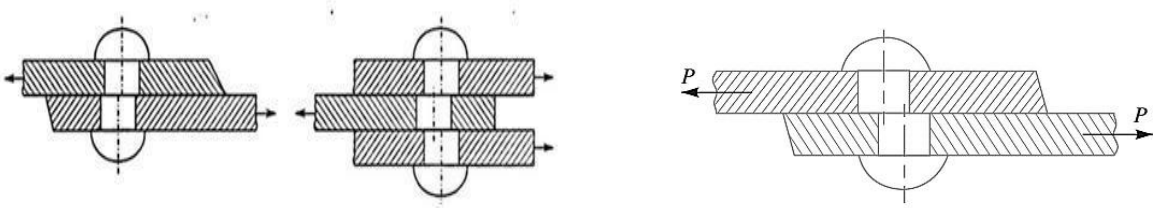


Fig: 4- Crushing of the plate or rivet

*B. Efficiency of riveted joint*

Efficiency of the riveted joint is the ratio of least value of strength of tearing, shearing or crushing to strength of unriveted plate and is given as

$$\frac{strngth\ of\ the\ joint\ in\ the\ weakest\ mode}{strength\ of\ the\ unpunched\ plate}$$

*C. Joints of uniform strength: Lozenge joint*

A riveted joint also known as lozenge joint used for roof, bridge work or girders etc. Diamond riveting is employed in this type of joints which gives uniform strength to the joint. The diameter of the rivet hole is obtained by using Unwin's formula i.e. $d=6\sqrt{t}$, where 't' is the thickness of the plate [5]. The number of rivets required for the joint is obtained by the shearing or crushing resistance of the rivets. Double shear is considered for double strap butt joint. Thickness of the plate is considered based on the number of straps or covers required to make the efficient joint.

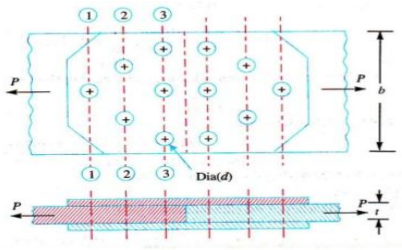


Fig: 5- Lozenge Joint

Efficiency of the lozenge joint is calculated based on number of rows of rivets, number of straps used, pitch of the rivets, width and thickness of the plates etc. For example, consider the triple riveted double strap butt joint as shown in figure 5. Number of rows of rivets is three; hence it forms three sections namely 1-1, 2-2 and 3-3. At section 1-1 there is only one rivet hole. Resistance of the joint in tearing along section 1-1 is given by

$P_{t1}$ = (b-d) t X $\sigma_t$ At section 2-2 there are two rivet holes, resistance of the joint in tearing along 2-2 is

$P_{t2}$ = (b-2d) t X $\sigma_t$ +strength of the one rivet in front of section 2-2

Similarly at section 3-3 there are 3 rivets, the resistance of the joint in tearing along 3-3 is

$P_{t3}$ = (b-3d) t X $\sigma_t$+ strength of 3 rivets in front of section 3-3

The least value of $P_{t1}$, $P_{t2,}$ $P_{t3,}$ $P_{s,}$ and Pc is the strength of the joint. The strength of un riveted plate is b x t x $\sigma_t$. Efficiency of the joint is the ratio of least of $P_{t1}$, $P_{t2,}$ $P_{t3,}$ $P_s$ or $P_c$ to strength of un riveted plate.

## IV. EFFICIENCY

Efficiency of riveted joint depends on many factors. Several attempts were made to increase the efficiency of the joint. In this paper a triple riveted double strap butt joint is considered. The efficiency of the joint is analysed by considering various factors which is given below in several cases.

1) *Case 1:* Arrangement of Rivets in Number of rows: In this case the following dimensions are considered width of the plate = 200mm;

Thickness of the plate = 12.5mm;

Tensile stress ($\sigma_t$) = 80MPA;

Shear stress (Ƭ) = 65MPA;

Compressive stress ($\sigma_c$) =160MPA;

From Unwin's formula i.e. d=6√t, then the diameter of rivet hole is 20mm. Tearing of the plate per pitch length is, $P_t$ = (b-d) t X $\sigma_t$. Shearing strength of the rivet per pitch length is, $P_s = (\pi/4)\ d^2$ x Ƭ for single shear and for double shear $P_s = 2(\pi/4)\ d^2$ x Ƭ, according to boiler regulations double shear is $P_s = 1.875\ (\pi/4)\ d^2$ x Ƭ. The crushing strength of Riveted joint $P_c$ = nxdxtx $\sigma_c$ . The number of rivets required for the joint is known by taking the ratio of Tearing strength of the rivet to the minimum of Ps or Pc [5]. The number of rivets required for this joint is 5. These five rivets can be arranged either in two rows or in three rows. It is observed that the efficiency of the joint is high when the number of rows of rivets is more i.e. efficiency is high when rivets placed in three rows than two rows.

2) *Case 2:* If width of the plate increased: In this case width of the plate is considered as 400 and the remaining values are same as case-1. The number of rivets required for this case is 10. The number of rivets increased to 10 in this case so the number of rows of the rivets may also increased, as the number of rows increases then the efficiency is also increased.

3) *Case 3:* If number of covers reduced to one: In this case number of cover placed used is one so the thickness of cover plate is considered as 15.65mm and diameter of the rivet d=21.5mm. The remaining values are considered same as case-1. The number of rivets required in this case is 8. Efficiency of the riveted joint in this case is 78.5%. It is also observed that the efficiency of the joint also influenced based on pitch i.e. if pitch increases then the efficiency also increases.

## V. CONCLUSIONS

The present study includes the various strategies to increase the efficiency of a riveted uniform strengthen joint. It is concluded that the arrangement of rivets can change the strength and efficiency of the joint when considering the tearing, shearing and crushing of the rivets. Efficiency also depends on various factors like number of cover plates used, diameter of the rivet, pitch of the rivets, number of rows of the rivets and width of the plate. There is lot of scope in this area to increase the efficiency of the joint.

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