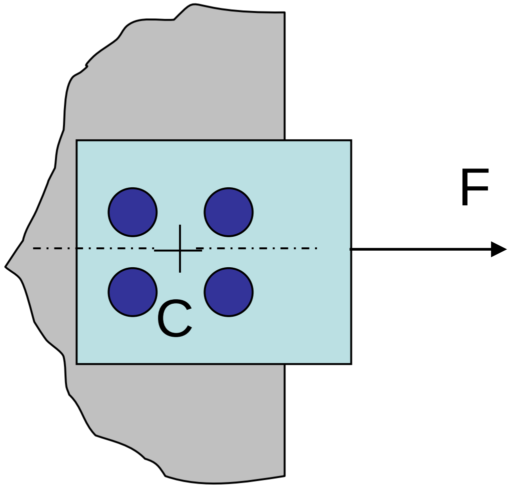
Riveted Joints 2

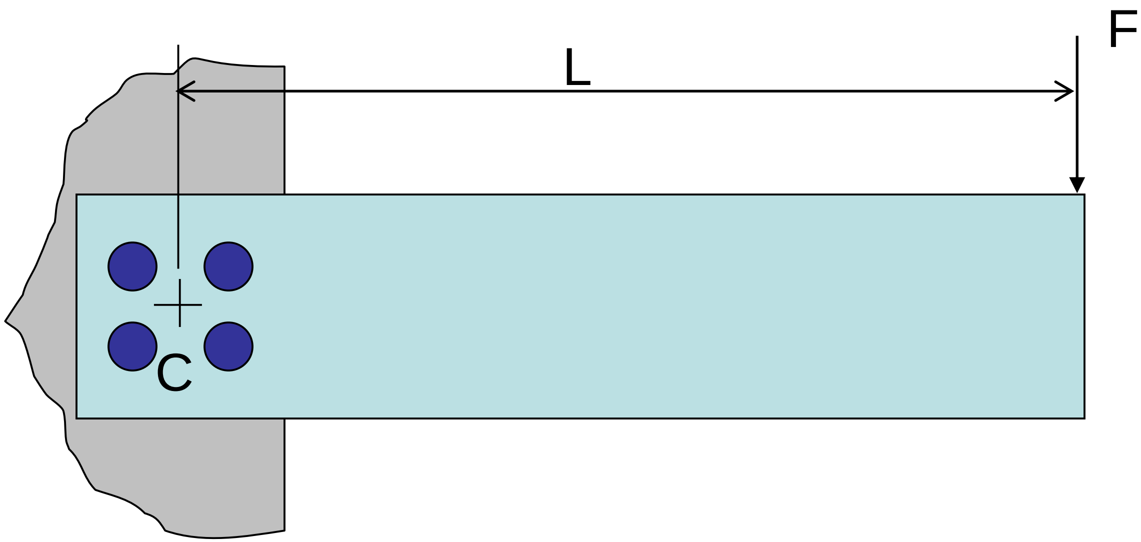
Centric loading

- If possible, the line of application of the load should pass through the centroid of the riveted area.
- This is called centric loading.
- The rivets are subjected to only direct (primary) shear.



Eccentric Loading

- When the line of action of the applied force does not pass through the centroid of riveted area we have eccentric loading.
- The applied force tends to twist the joint about the centroid of the rivet group.
- Secondary shear is created because of the moment of the force.

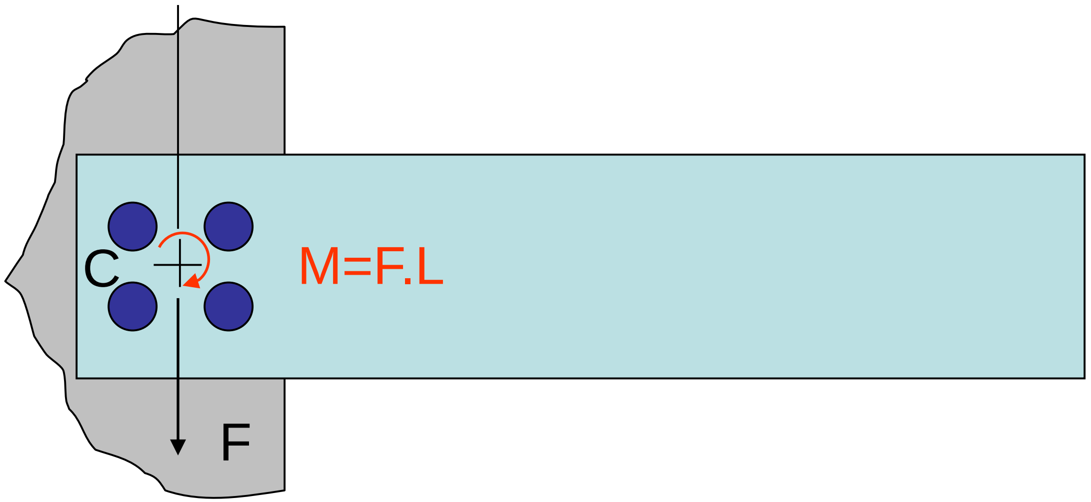


F' Direct shear force on a rivet

τ' Direct shear stress on a rivet

F'' Secondary shear force on a rivet

τ'' Secondary shear stress on a rivet



In eccentric loading the total force on a rivet is the superposition (vector sum) of direct and secondary shear forces.

Direct Shear

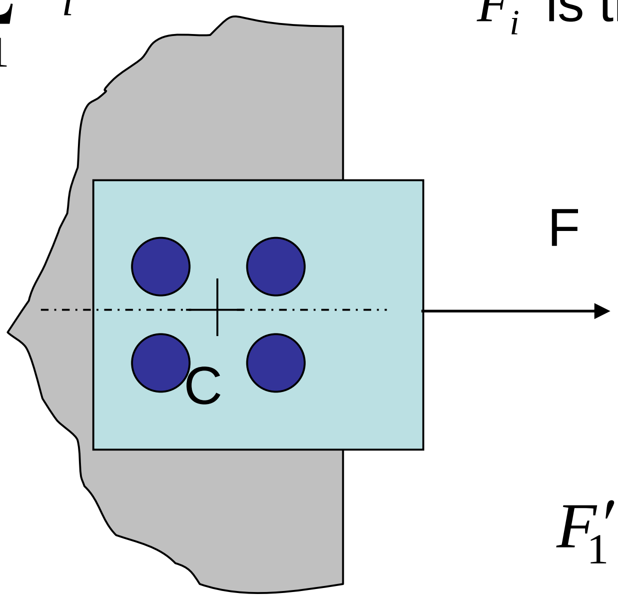
- It is assumed that all the rivets in a joint experience the same shear stress.

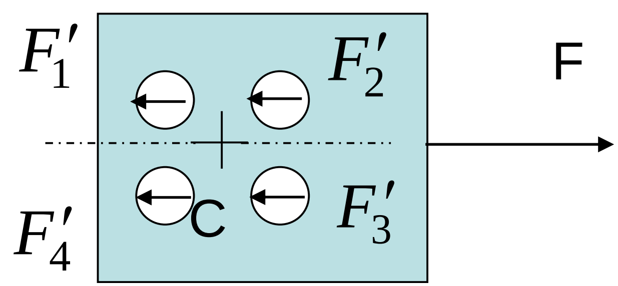
$$\tau' = \frac{F}{\sum_{i=1}^{n} A_i} \qquad F_i' = \tau' A_i$$

F is the centric load on the joint

A_i is the cross sectional area of i^{th} rivet

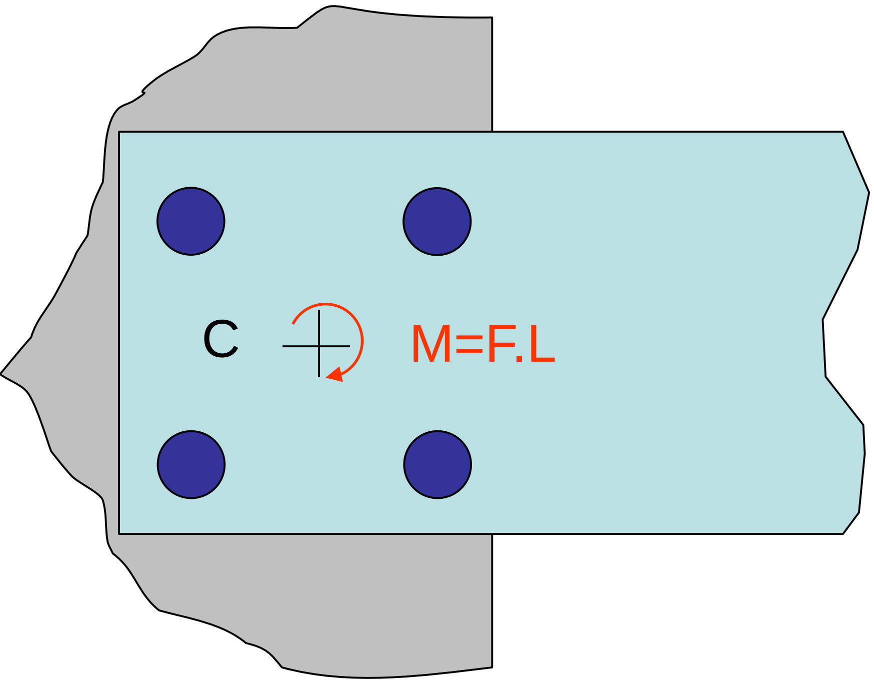
F_i' is the force on i^{th} rivet

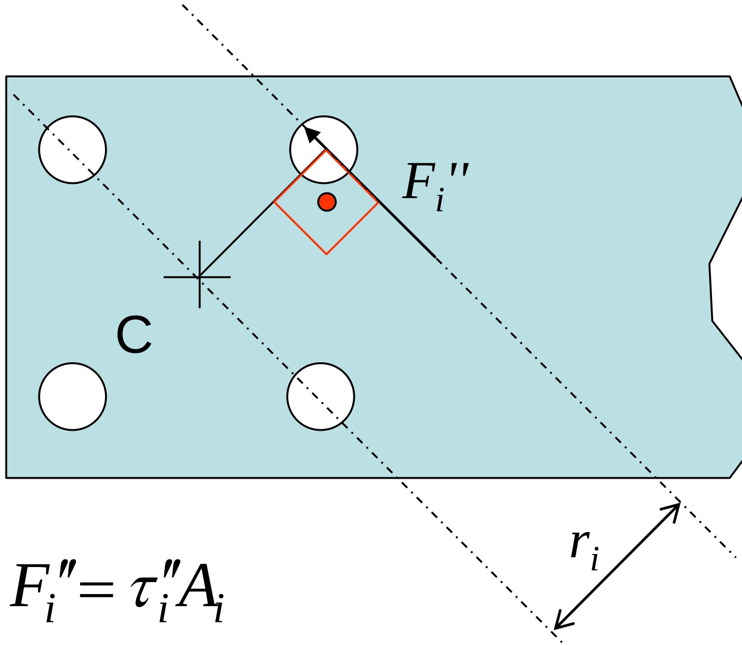




$$F_1' = F_2' = F_3' = F_4'$$ for identical rivets

Secondary shear

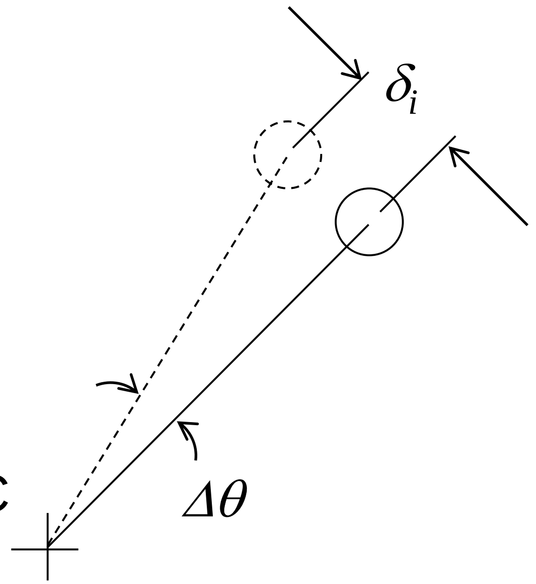




$$F_i'' = \tau_i'' A_i$$

Secondary shear force on i[th] rivet, F_i'' is perpendicular to the line joining the centroid of the rivet group and the center of the rivet. The distance between the centroid C and center of i[th] rivet is r_i.

Assumptions: Rivet group rotates an infinitessimal amount like a rigid body about the centroid of the rivet group. Secondary shear stress on a rivet is proportional to its displacement.



$\Delta\theta$: Constant angle of rotation for all rivets

δ_i: Displacement of i[th] rivet

$\delta_i \propto \tau_i''$ therefore $\tau_i'' = k'\delta_i$

where k' is a constant of proportionality

Since $\delta_i = r_i \Delta\theta$ we get $\tau_i'' = k' r_i \Delta\theta$

$$\tau_i'' = r_i \underbrace{\left[k'\Delta\theta\right]}_{k}$$

$$\frac{\tau_i''}{r_i} = k \quad \text{therefore} \quad \frac{\tau_1''}{r_1} = \frac{\tau_2''}{r_2} = \frac{\tau_3''}{r_3} = \frac{\tau_4''}{r_4} = \cdots\cdots = \frac{\tau_n''}{r_n}$$

Note that farthest rivet from C experiences the largest secondary shear stress

$$\frac{F_i''/A_i}{r_i} = k = \frac{F_1''}{A_1 r_1} = \frac{F_2''}{A_2 r_2} = \frac{F_3''}{A_3 r_3} = \frac{F_4''}{A_4 r_4} = \cdots\cdots = \frac{F_n''}{A_n r_n}$$

$$F_1'' = kA_1 r_1 \ , \ F_2'' = kA_2 r_2 \ , \ F_3'' = kA_3 r_3 \ , \ldots. \ F_n'' = kA_n r_n$$

$$M = F_1'' r_1 + F_2'' r_2 + F_3'' r_3 \cdots + F_n'' r_n$$

$$M = k\left(A_1 r_1^{\,2} + A_2 r_2^{\,2} + A_3 r_3^{\,2} \cdots + A_n r_n^{\,2}\right)$$

$$k = \frac{M}{\sum_{j=1}^{n} r_j^{\,2} A_j}$$

$$F_i'' = k r_i A_i = \frac{M r_i A_i}{\sum_{j=1}^{n} r_j^{\,2} A_j}$$

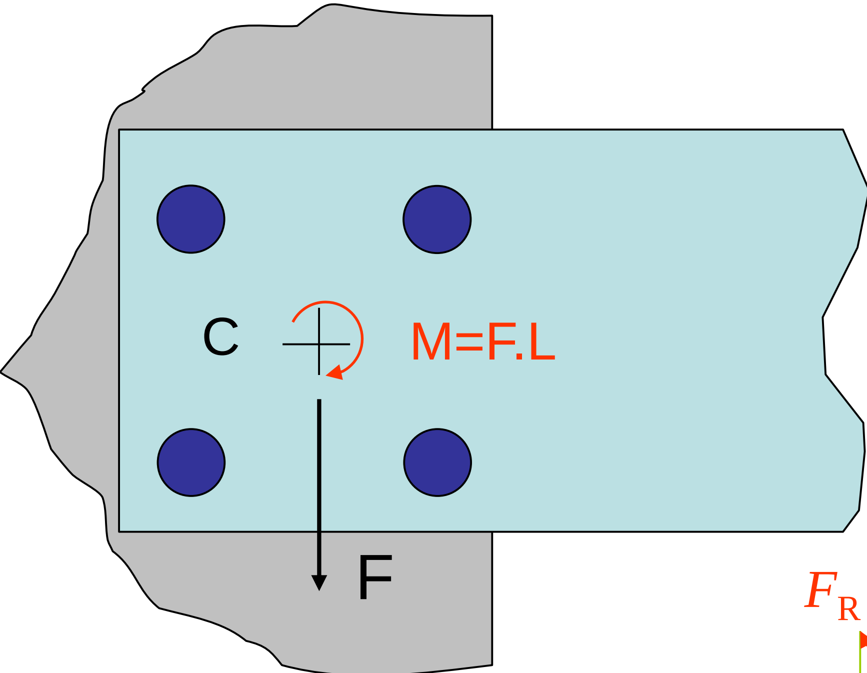
$$\tau_i'' = \frac{F_i''}{A_i} = \frac{M r_i}{\sum_{j=1}^{n} r_j^{\,2} A_j}$$

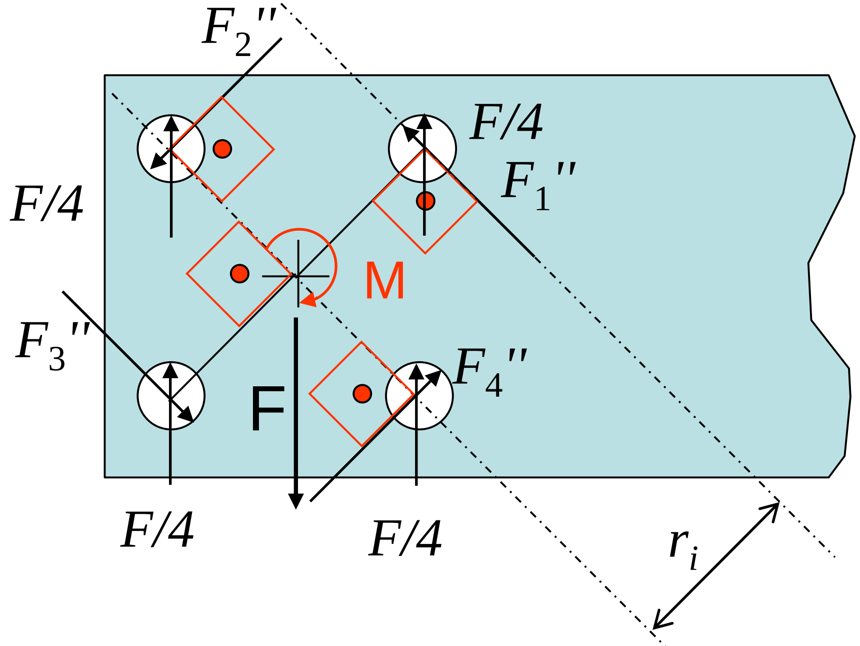
Remarks-1

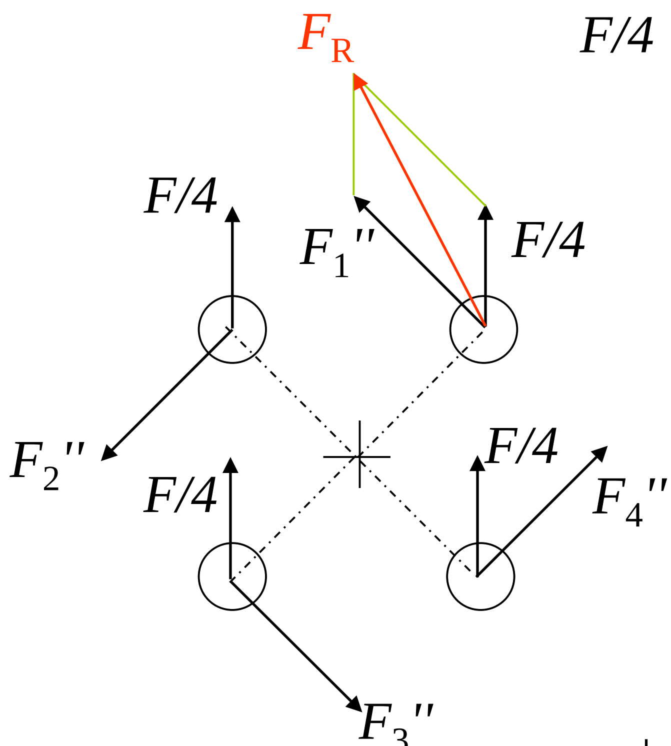
- Note that secondary shear stress expression is similar to torsional shear stress expression ($\tau = Tr/J$) for circular shafts.
- Once secondary shear force (stress) is found, its vector sum with primary shear must be obtained to determine the total shear force (stress) on a rivet.

Remarks-2

- Most critical rivet will be the one for which the resultant of primary and secondary shear forces is the largest.
- Then the rivets which are far away from the centroid, and the rivets whose primary and secondary shear forces are predominantly in the same directions are likely to be critical.







$$\tau' = \frac{F}{4A}$$

$$\tau'' = \frac{(FL)r}{4r^2 A} = \frac{FL}{4rA}$$

$$\tau_R = \left|\vec{\tau}' + \vec{\tau}''\right| = \frac{F}{4A}\sqrt{1 + \sqrt{2}\,\frac{L}{r} + \frac{L^2}{r^2}}$$