1 3rd Year Design and Production

Joints – Lecture 1

2 Joining Methods

Various joining methods are used…

- Rivets
- Welds
- Bolts
- Adhesives

Each type of joint has its own characteristics

3 Joining Methods: Riveted/Bolted Joints

3.1 Purpose

Purpose of Rivets/Bolts:

- Transmit force from one structural element to another

3.2 Failure

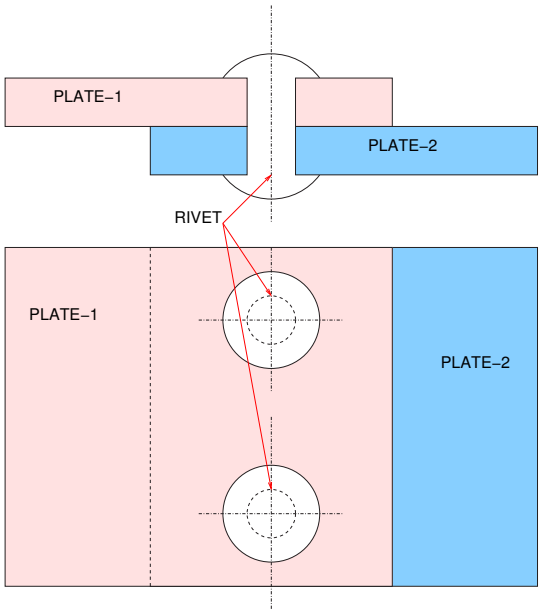
Three possibilities

- Rivets/Bolts fail
  - Shear of rivet/bolt
- Plates fail (e.g. tear-out)
  - Bearing stress between riet/bolt and plate
  - Tensile failure of plate at the riveted/bolted section
- Both fail

4 Joining Methods: Riveted/Bolted Joints

4.1 Applications of Rivets

- Aircraft
- Ship-Building
- Boilers
- Bridges

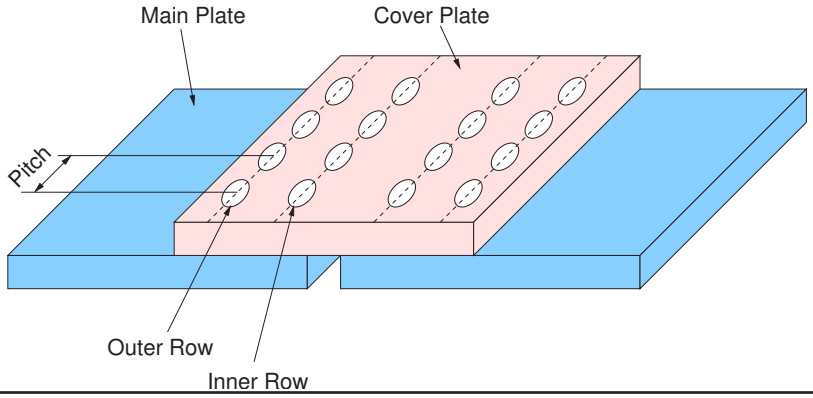


4.2 Considerations

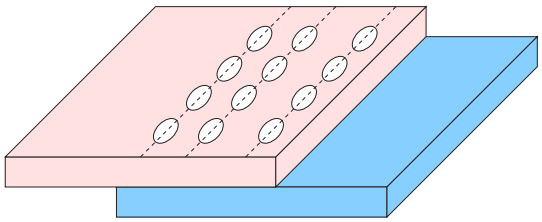
- Faster assembly than with screw-threads
- Cheaper than threaded fasteners
- Do not work/shake loose
- Made from ductile materials, cannot be hardened
  - Plastic deformation required
- Not as strong as a bolt/threaded fstener of the same diameter
- Cannot control clamping force

5 Riveted Joints – Terminology

5.1 Double riveted butt joint with one cover plate

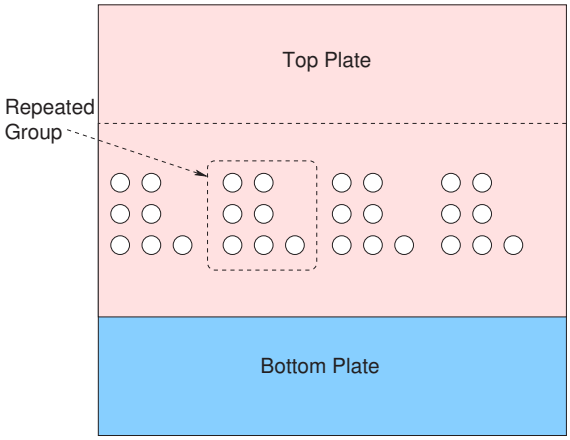


5.2 Triple riveted lap joint



6 Riveted Joints – Terminology

6.1 Repeated Group



7 Riveted Joints – Analysis

7.1 Idealised: Elastic Analysis approach assumes

- Negligible friction
- Rivets completely fill holes
- Stress in rivet directly proportional to the distortion

7.2 Simplified Approach: "Uniform Shear Method" assumes

- Negligible friction and bending under load
- Applied shear loads are resisted equally by each rivet
- Load is distributed evenly (no misalignment)
- There is good fit between the rivets and the plate

8 Riveted Joints – Analysis

8.1 Behaviour of Riveted Joints – Force Transfer

- Rivets are best suited to transmitting shear force
- Generally a riveted joint constitutes a **redundant structure**
- Yielding of a rivet leads to a reduction in its stiffness. Tis reduces the load it is taking, and leads to sme of the shed-load being transferred to other rivets
- Failure occurs due to sequential yielding until stress in all rivets reaches or exceeds their yield strengthh. Then ductile failure occurs in the joint.

8.2 Key Variables

- Rivet and plate cross-sectional area
- Position of centroid of rivet joint when it is subjected to torque or to eccentric loading
- Material properties of the rivet and the plate

9 Riveted Joints – Analysis

9.1 Behaviour of Riveted Joints – Stresses

Three stresses to consider

- Shear Stress in rivet
  - force/area
- Bearing Stress between rivet and plate
  - force/projected-area, i.e. $F/(d \times t)$, d is diameter, t is the plate thickness
- Tensile stress in plate at a row of rivets
  - Force in plate at that section divided by resisting area of plate at that section

9.2 Efficiency of Joint

$$\text{Efficiencey} = \frac{\text{Strength of joint}}{\text{Strength of intact plate}}$$

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10 Riveted Joints – Tear-Out

- **Marginal Failure** or **Tear-out**
- By equilibrium: $2F_p = F_b$
- If shear strength of plate is τ_p then tearout failure will occur when

$$F_b \geq 2(\tau_p)(t)(a)$$

- t is the thickness of the plate, a is the margin
- Rule of thumb: choose a margin 1.5 to 2 times the rivet or bolt diameter