Riveted Joints

Introduction

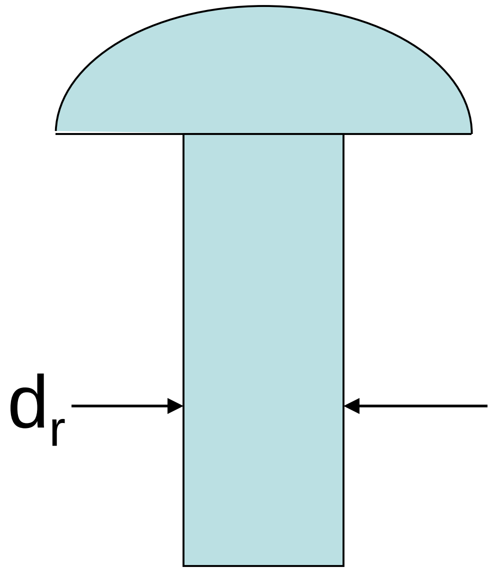
- Joints can be broadly classified as
  - permanent joints, and
  - detachable joints
- permanent joints are not supposed to be detached throughout their service life.
- Examples are;
  - rivets
  - welds
  - bonded joints

Design issues for permanent Joints

- Strength
- fluid tightness
- Where the joint is to be made (plant or on-site)
- precision required in relative positioning of parts to be joined.

Riveted joints

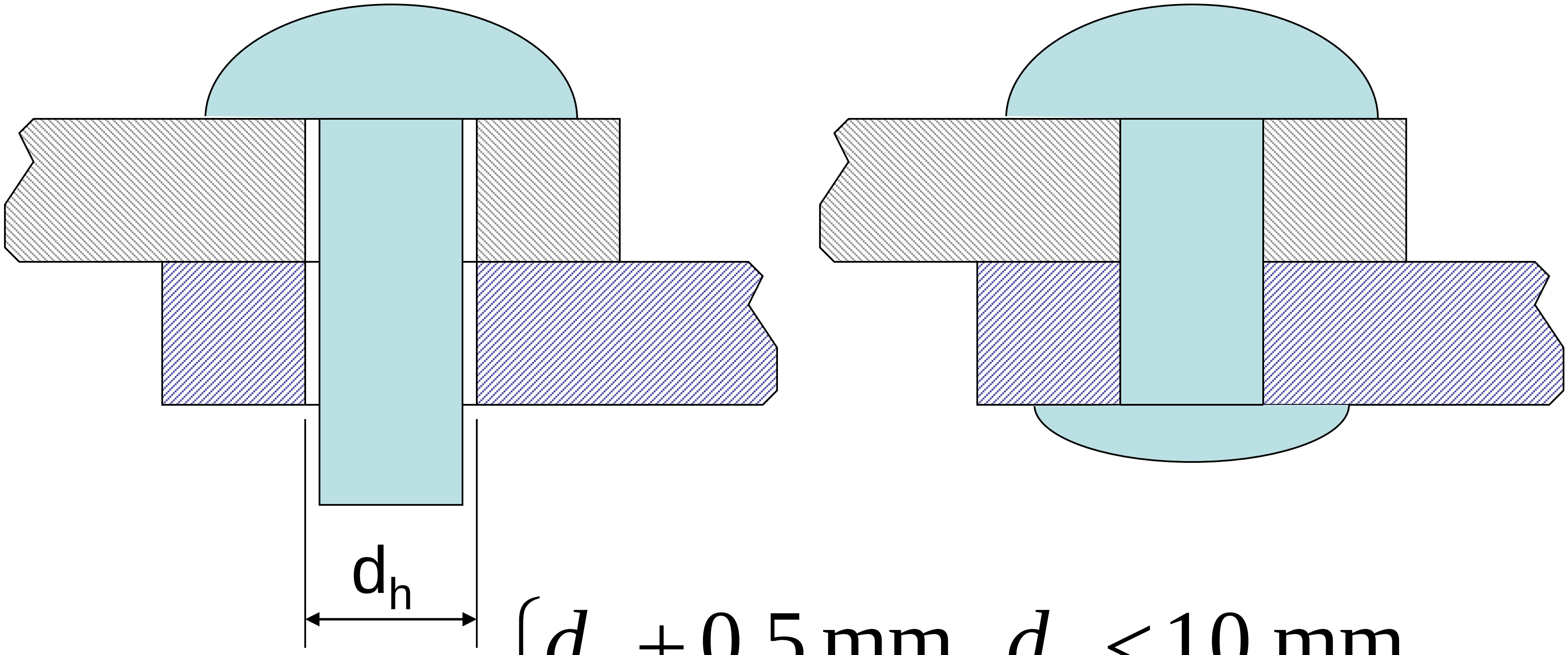
- Rivet: A Short metal bar with a head already formed at one end.
- Rivets are standard parts (TS 94) with a given diameter, mostly made of steel.



Standard d_r sizes [mm]:1,1.4, 1.7,2,2.6,3,3.5,4,5,…,10,12,14,…

Same material is used for the rivet and parts to be joined to prevent galvanic corrosion.

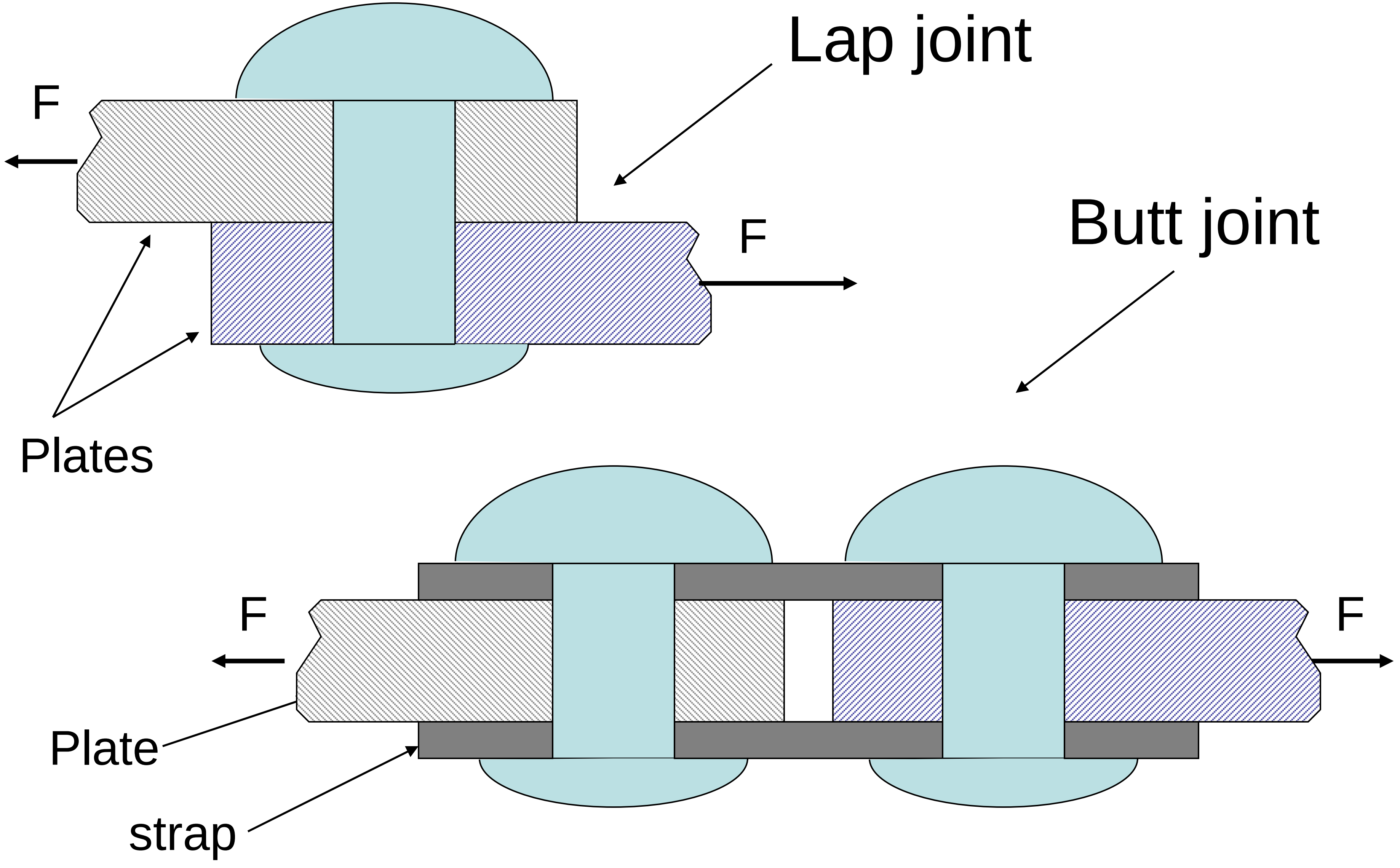
Riveted joints



$$d_h = \begin{cases} d_r + 0.5\,\text{mm}, & d_r < 10\ \text{mm} \\ d_r + 1.0\,\text{mm}, & d_r \geq 10\ \text{mm} \end{cases}$$

- When the bottom head is formed, rivet shank expands and fills the gap.

Types of riveted joints



Loading Types

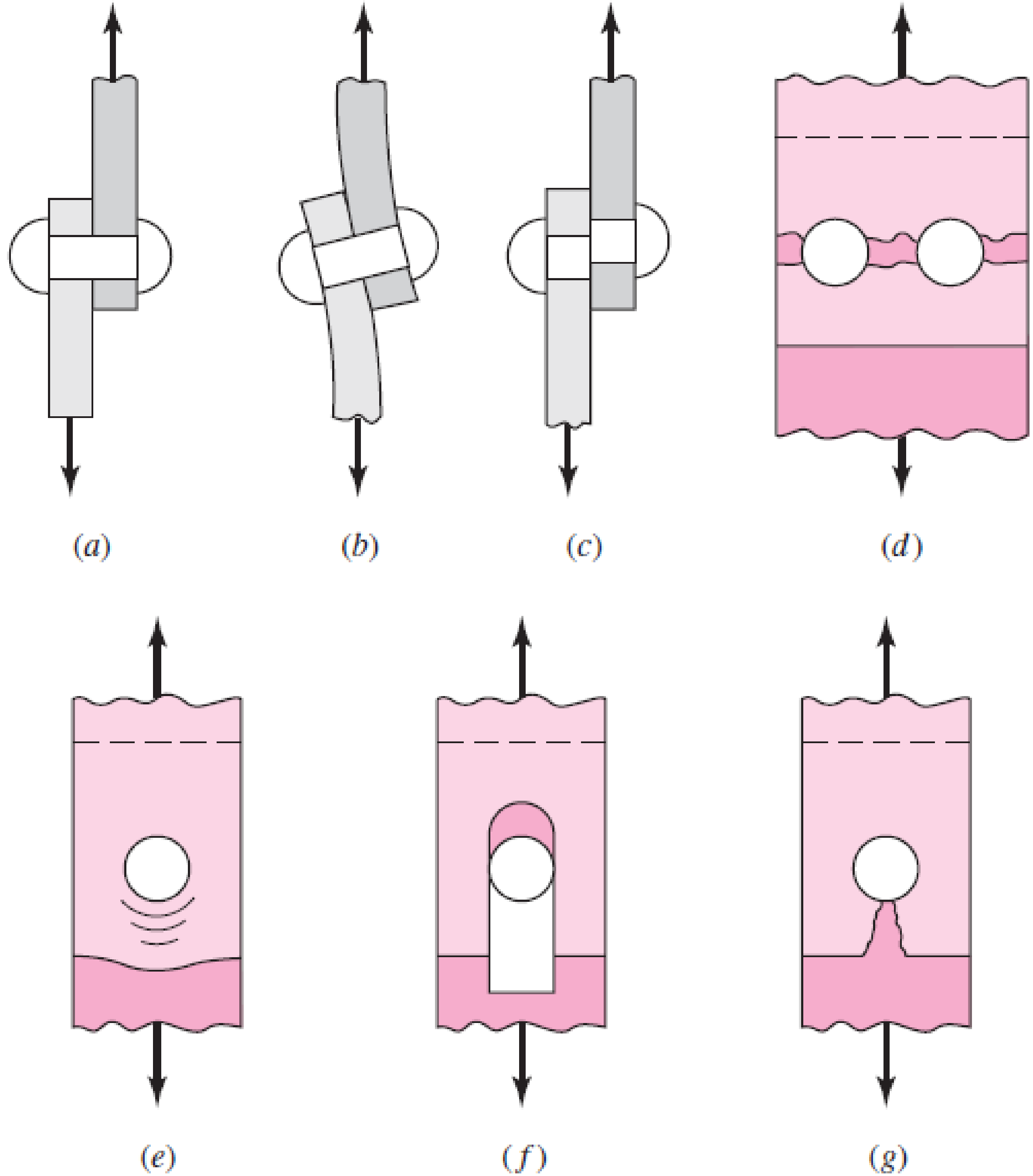
- There are two types of loading
  - Centric :Line of action of the applied force passes through the centroid of the rivets, which form a single joint.
  - Eccentric: Line of action of the applied force does not pass through the centroid of the rivets, which form a single joint.
- Note that load carrying mechanism is always shear and rivets are not loaded axially.

Failure types of riveted joints

- Riveted joints can fail due to several reasons under shear loading.
  - bending failure of rivet
  - shearing failure of rivet
  - tensile failure of members
  - bearing failure of rivet and/or members
  - shear tear-out
  - tensile tear-out

Figure 8–23

Modes of failure in shear loading of a bolted or riveted connection: (*a*) shear loading; (*b*) bending of rivet; (*c*) shear of rivet; (*d*) tensile failure of members; (*e*) bearing of rivet on members or bearing of members on rivet; (*f*) shear tear-out; (*g*) tensile tear-out.



Bending of rivet

$$M = \frac{F.t}{2} \qquad \sigma = \frac{M}{I/c}$$

t : grip of the rivet, i.e total thickness of the connected parts

I/c: section modulus of the weakest member or the rivet(s).

Note that bending formula is approximate for rivets, usually one does not use it in design and instead use a large factor of safety.

Shearing Failure of rivet
(centric loading)

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

A : Cross sectional area of all rivets in the rivet group

F : Force carried by the rivet group

Note that, although the rivet body expands to fill the hole, we can use the nominal rivet diameter for additional safety.

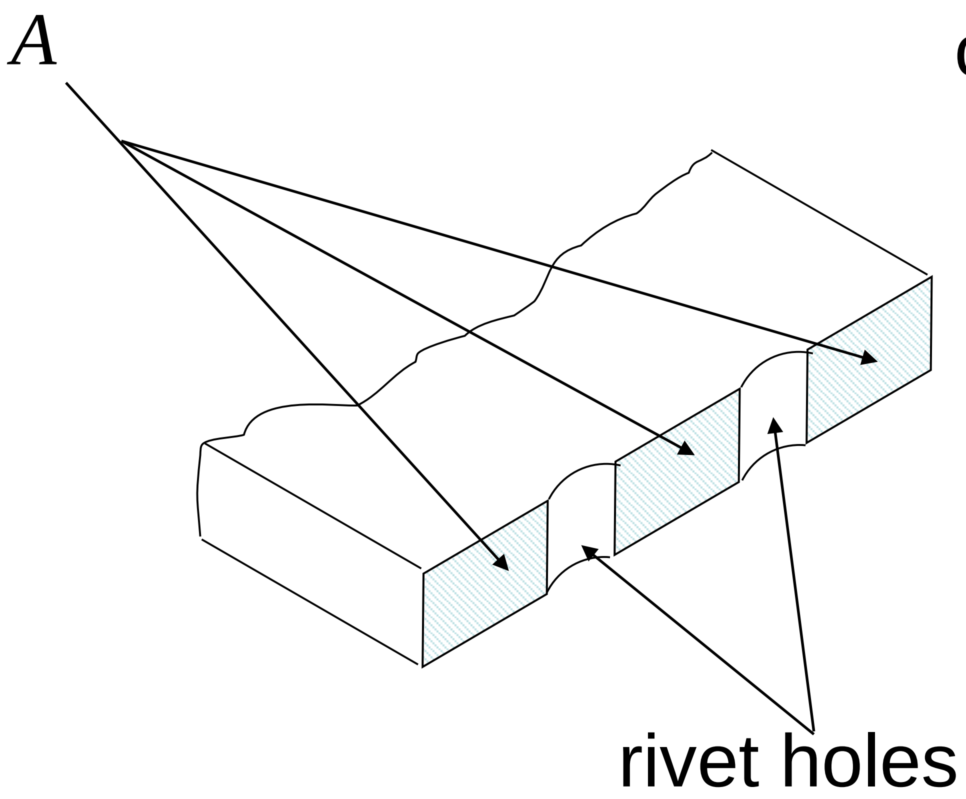
Tensile Failure of Plate

$$\sigma = \frac{F}{A}$$

A : Net cross sectional area of the member plate.

We consider stress concentration

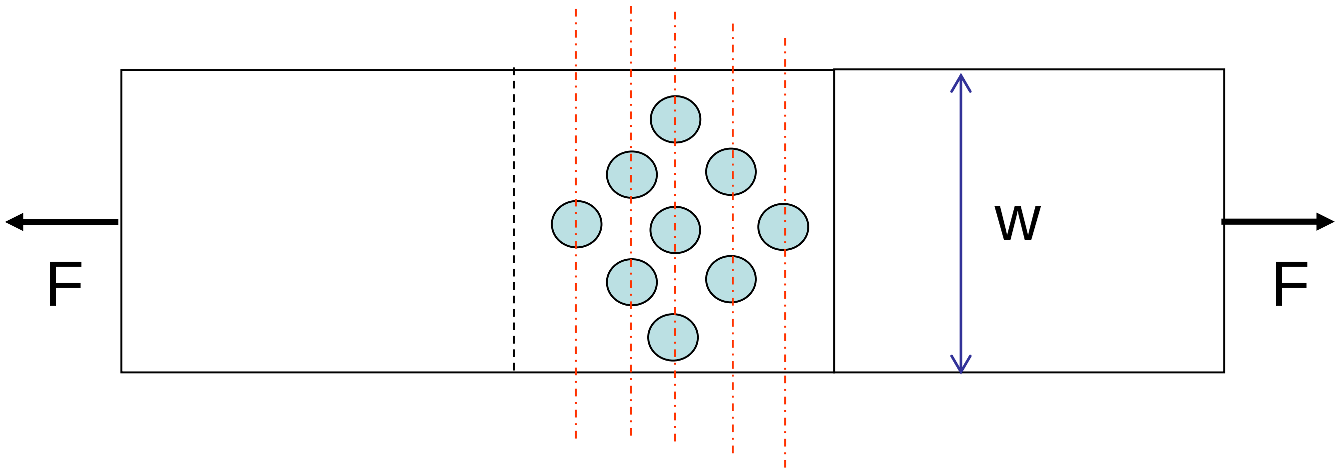
- for brittle plate materials in static loading,
- for both brittle or ductile plate materials in fatigue loading.

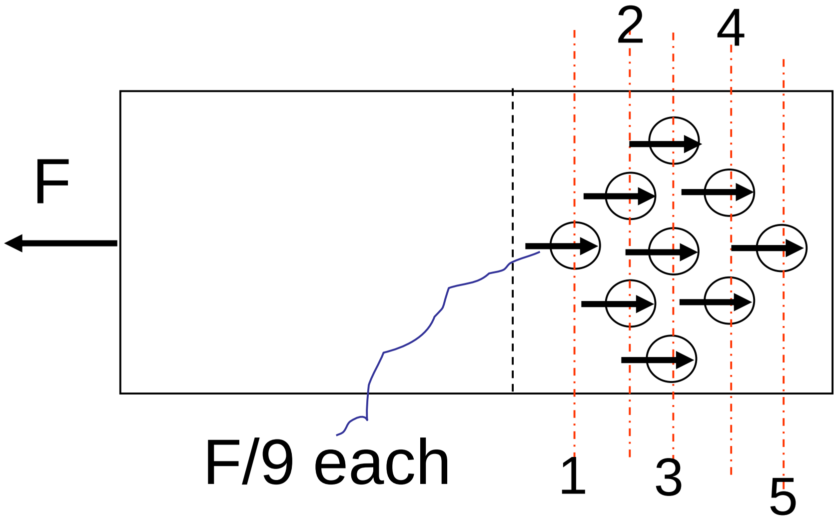


Tensile Failure of Plate

- Critical section(s) of the plate should be determined carefully.
- In centric loading, it is assumed that all the rivets are subjected to the same shear stress.
- If the rivets are identical, then each rivet carries the same amount of force.

Tensile Failure of Plate





$$\sigma_1 = \frac{F}{(w-d)t} \qquad \sigma_2 = \frac{8F/9}{(w-2d)t}$$

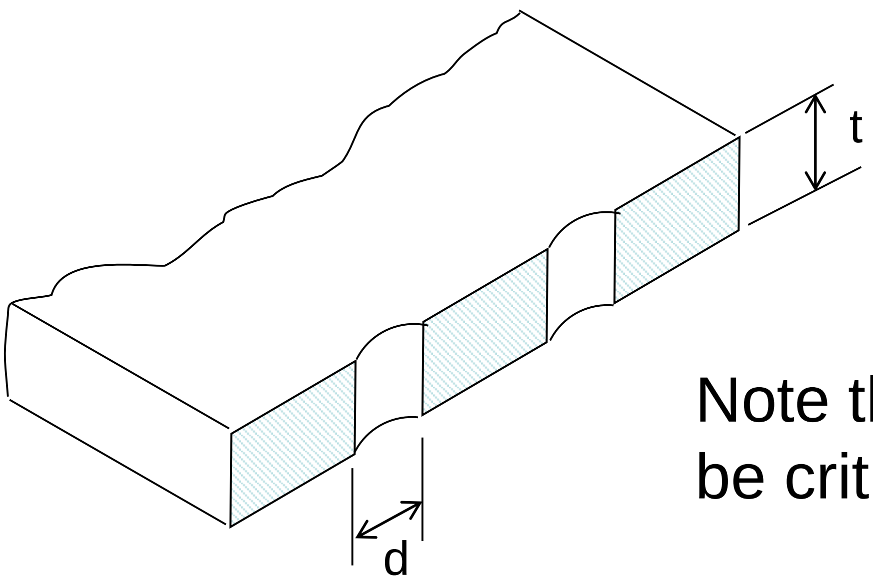
$$\sigma_3 = \frac{2F/3}{(w-3d)t} \qquad \sigma_4 = \frac{F/3}{(w-2d)t}$$

$$\sigma_5 = \frac{F/9}{(w-d)t}$$

Bearing Failure

- We need not consider complicated contact stress distribution.A simplified approach is to use the uniform bearing stress based on the projected contact area.

$$\sigma = \frac{P}{A} \qquad A = td$$



P : Force exerted by each rivet

Note that thinnest plate is likely to be critical.

Tear-out Failures

- To avoid tear-out failures, the rivets should be placed sufficiently far away from the plate edges.