

# Mechanical Design II

Lecture # 2

Welded Joints( Chapter 9)

- Riveted Joints
- Adhesive Bonding

S G Khan



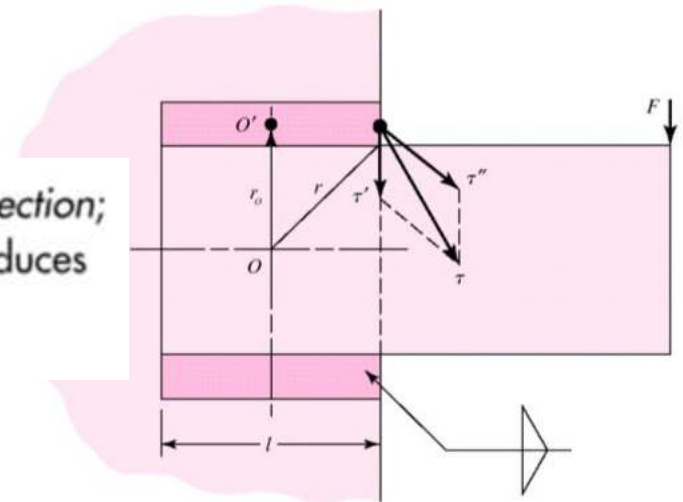
# Stresses in Welded Joints in Torsion



Figure 9–12 illustrates a cantilever of length  $l$  welded to a column by two fillet welds. The reaction at the support of a cantilever always consists of a shear force  $V$  and a moment  $M$ . The shear force produces a *primary shear* in the welds of magnitude

$$\tau' = \frac{V}{A}$$

This is a *moment connection*; such a connection produces *torsion* in the welds.



where  $A$  is the throat area of all the welds.

The moment at the support produces *secondary shear* or *torsion* of the welds, and this stress is given by the equation

$$\tau'' = \frac{Mr}{J}$$

(Shigly et al,2004)

Weld 1 has a throat width  $b_1 = 0.707h_1$ .

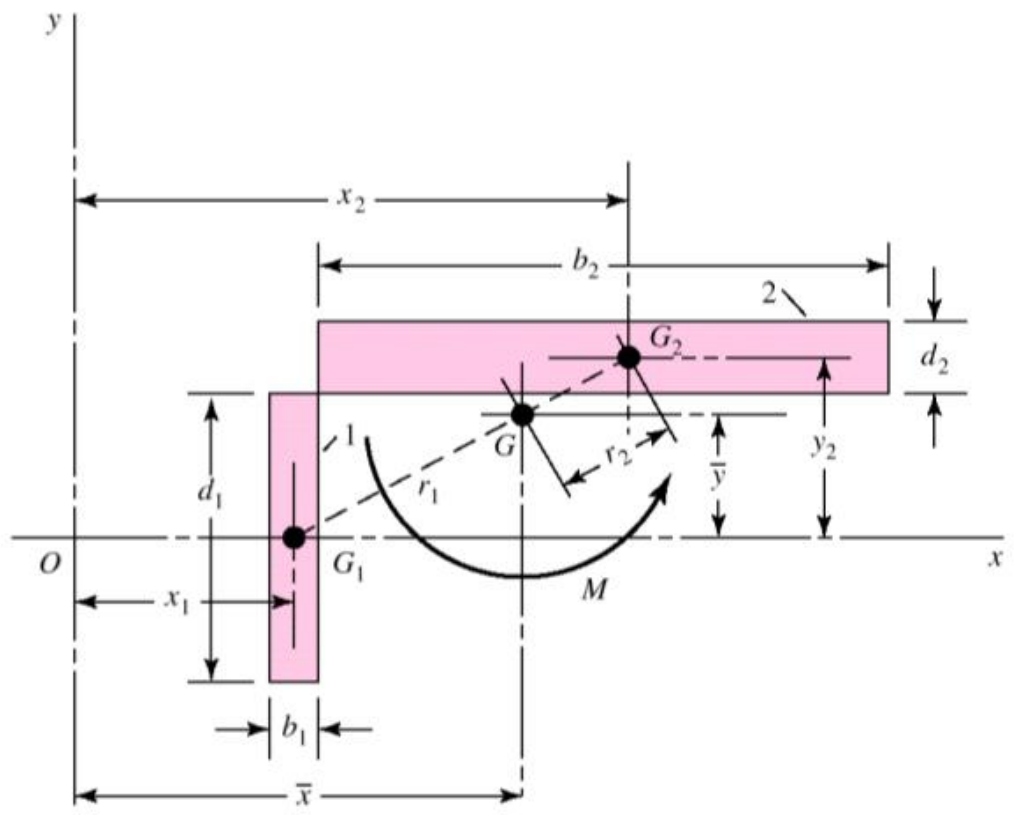
Similarly for weld 2

$$d_2 = 0.707h_2$$

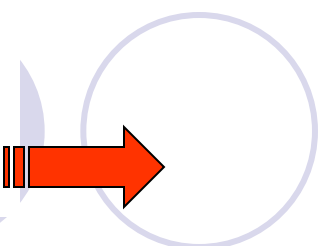


$$A = A_1 + A_2 = b_1d_1 + b_2d_2$$

$$\tau' = \frac{V}{A}$$

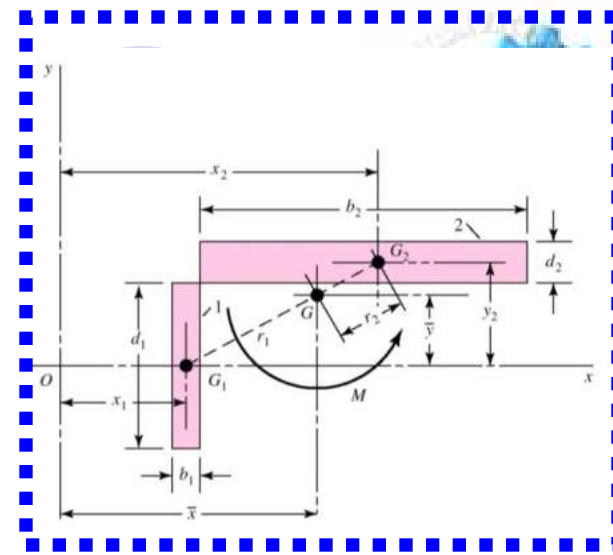


(Shigly et al, 2004)

$$\tau'' = \frac{Mr}{J}$$


$$I_x = \frac{b_1 d_1^3}{12}$$

$$I_y = \frac{d_1 b_1^3}{12}$$



Thus the second polar moment of area of weld 1 about its own centroid is

$$J_{G1} = I_x + I_y = \frac{b_1 d_1^3}{12} + \frac{d_1 b_1^3}{12}$$

In a similar manner, the second polar moment of area of weld 2 about its centroid is

$$J_{G2} = \frac{b_2 d_2^3}{12} + \frac{d_2 b_2^3}{12}$$

The centroid  $G$  of the weld group is located at

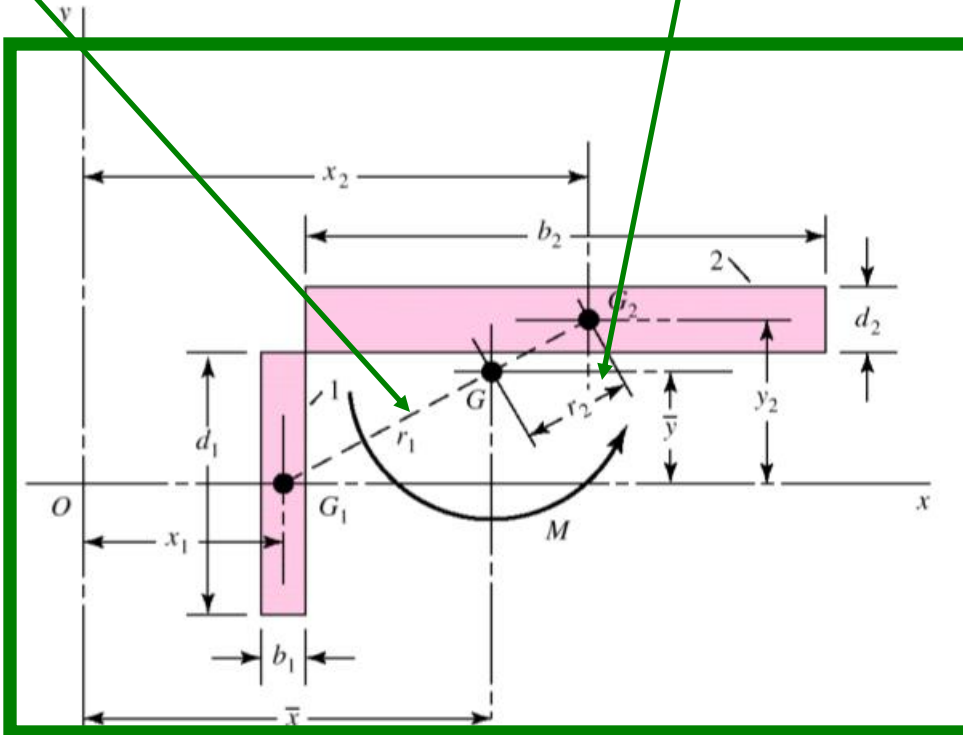
$$\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A}$$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$$



$$r_1 = [(\bar{x} - x_1)^2 + \bar{y}^2]^{1/2}$$

$$r_2 = [(y_2 - \bar{y})^2 + (x_2 - \bar{x})^2]^{1/2}$$



**From parallel Axis Theorem**

$$J = (J_{G1} + A_1 r_1^2) + (J_{G2} + A_2 r_2^2)$$

$$J = 0.707h J_u$$

(Shigly et al, 2004)



# Stresses in Welded Joints in Bending

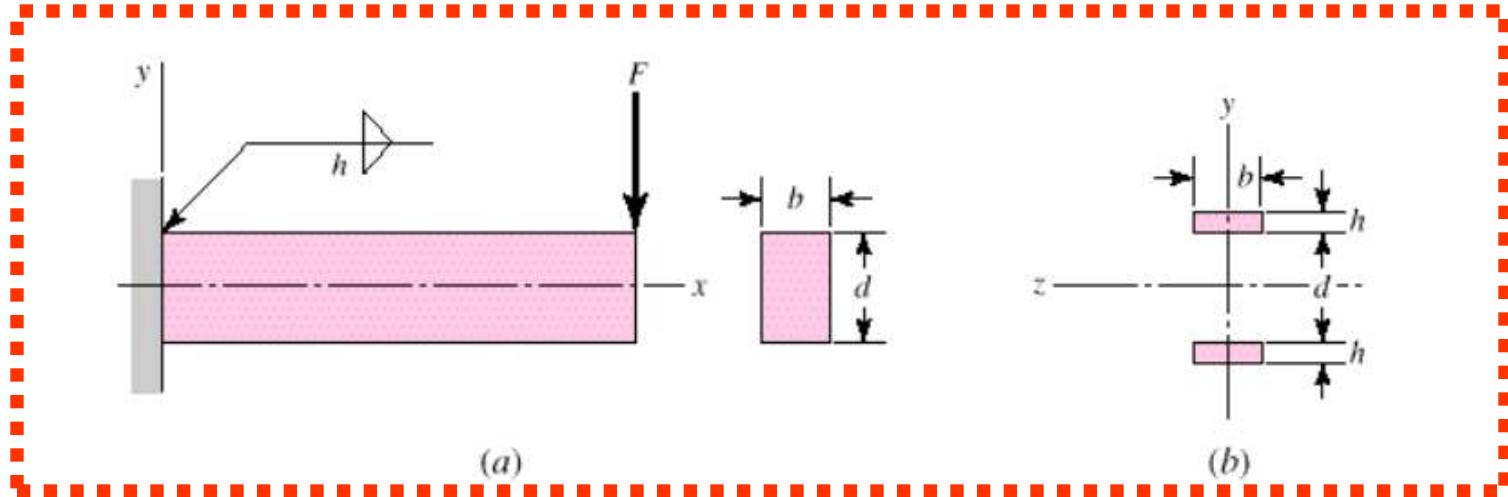
- FIGURE 9-17A and B Shigley

Lets consider a Cantilever welded to support by fillet welds at top and bottom. A free body diagram of the beam would show a shear-force reaction  $V$  and a moment reaction  $M$

The shear force produces a primary shear in welds of Magnitude

$$\tau = V/A$$

Where  $A$  is the total throat area



# Stresses in Welded Joints in Bending....

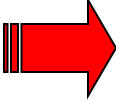


 The moment  $M$  induces a throat shear stress component of  **$0.707\tau$**   
In the welds.

Treating the two welds as of the Figure 9.17b as lines we find the unit second moment of area to be

$$I_u = bd^2/2$$

The second moment of area  $I$ , based on weld throat area, is

  $I = 0.707hI_u = 0.707h \frac{bd^2}{2}$

# Stresses in Welded Joints in Bending....



The nominal throat Shear Stress is found to be

$$\tau = \frac{Mc}{I} = \frac{Md/2}{0.707h \, bd^2 / 2} = \frac{1.414M}{bdh}$$

# Static Loading

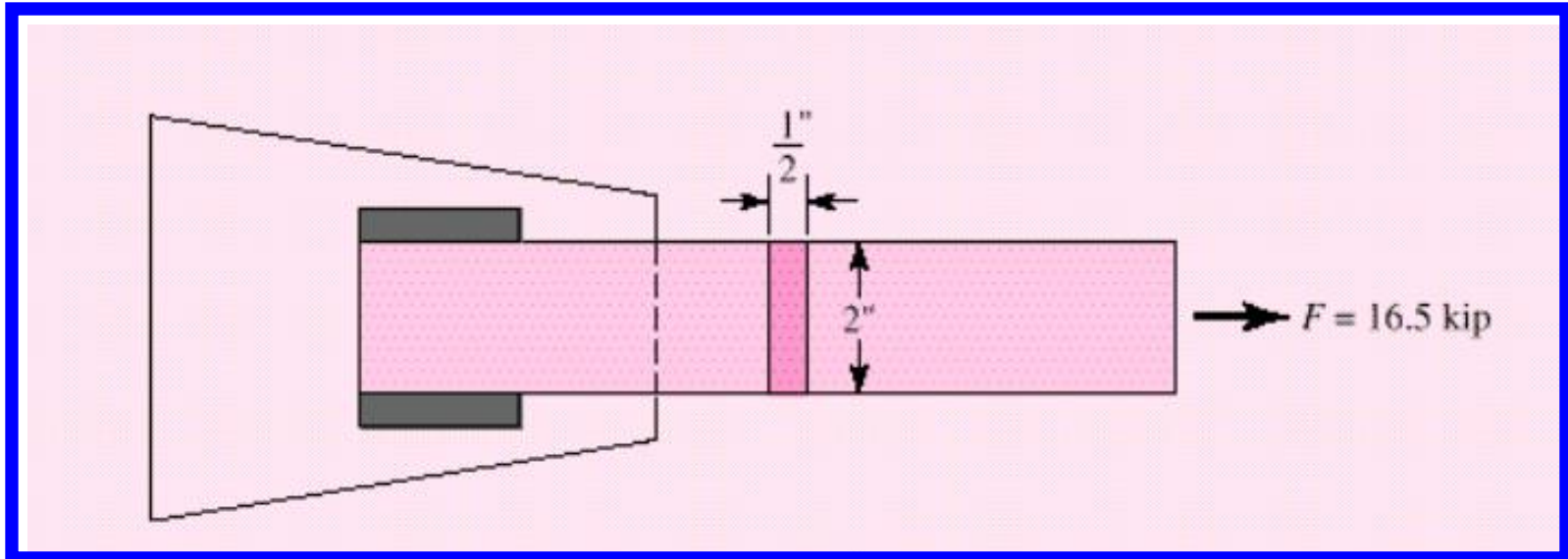
Comparing Conventional Methods and Welding codes



## Example 9.2

A  $\frac{1}{2}$ -inch by 2-inch rectangular –Cross-section 1015bar carries a static load of 16.5kip. It is welded to a gusset plate with a  $\frac{3}{8}$  inch fillet weld 2 inch long on both sides with an E70XX electrode as depicted in figure 9-18, Use the welding codes method

- Is the weld metal strength satisfactory?
- Is the attachment strength Satisfactory?



Sol

(a) From Table 9–6, allowable force per unit length for a  $\frac{3}{8}$ -in E70 electrode metal is 5.57 kip/in of weldment; thus

$$F = 5.57l = 5.57(4) = 22.28 \text{ kip}$$

Since  $22.28 > 16.5$  kip, weld metal strength is satisfactory.

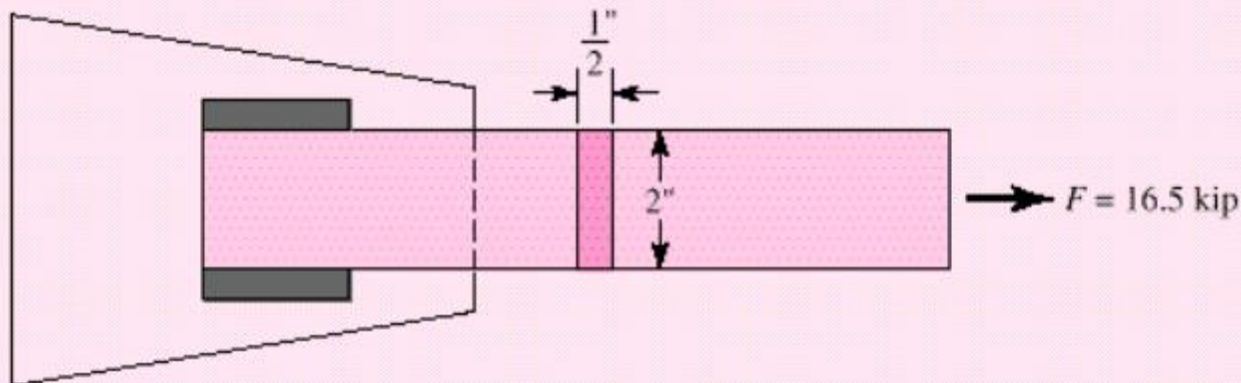
(b) Check shear in attachment adjacent to the welds. From Table 9–4 and Table A–20, from which  $S_y = 27.5$  kpsi, the allowable attachment shear stress is

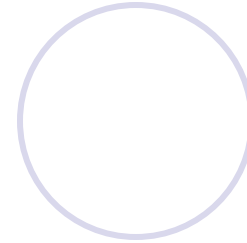
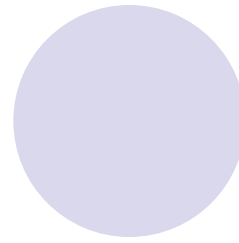
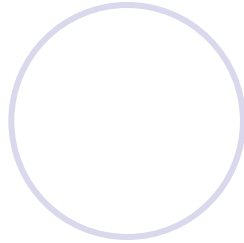
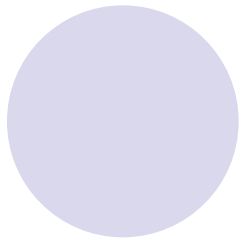
$$\tau_{\text{all}} = 0.4S_y = 0.4(27.5) = 11 \text{ kpsi}$$

The shear stress  $\tau$  on the base metal adjacent to the weld is

$$\tau = \frac{F}{2hl} = \frac{16.5}{2(0.375)2} = 11 \text{ kpsi}$$

Since  $\tau_{\text{all}} \geq \tau$ , the attachment is satisfactory near the weld beads. The tensile stress in the shank of the attachment  $\sigma$  is





The tensile stress in the shank of the attachment  $\sigma$  is

$$\sigma = \frac{F}{tl} = \frac{16.5}{(1/2)2} = 16.5 \text{ kpsi}$$

The allowable tensile stress  $\sigma_{\text{all}}$ , from Table 9–4, is  $0.6S_y$  and, with welding code safety level preserved,

$$\sigma_{\text{all}} = 0.6S_y = 0.6(27.5) = 16.5 \text{ kpsi}$$

Since  $\sigma_{\text{all}} \geq \sigma$ , the shank tensile stress is satisfactory.

# Rivets



Rivets=> are used for permanent Joint

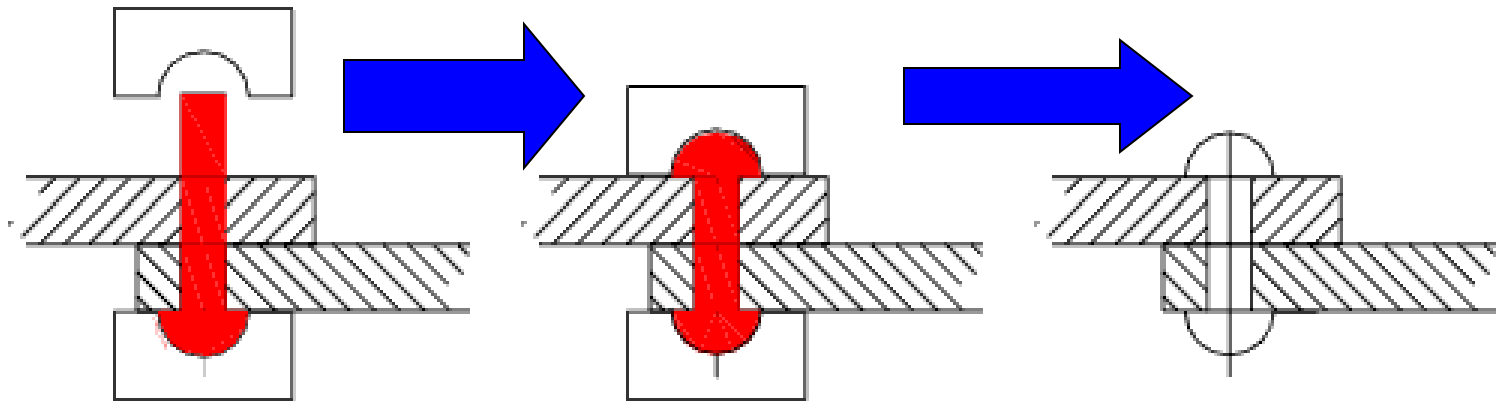
Generally rivet material is the same as that of the plats to be permanently joined



# What is Rivet?

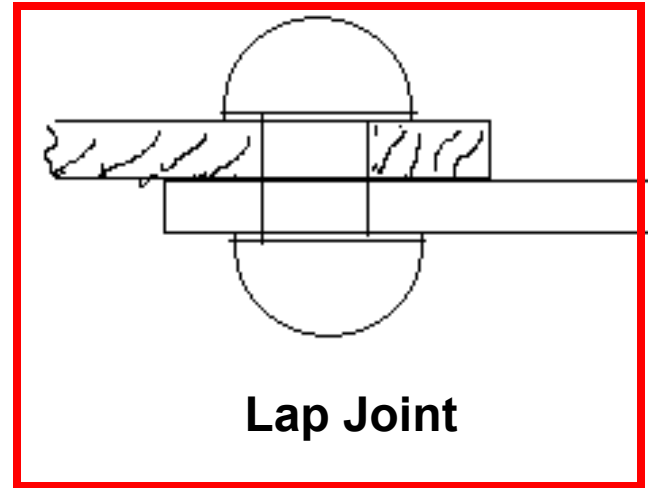
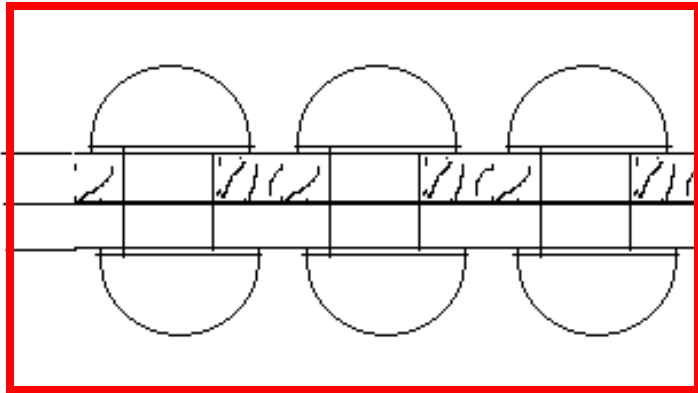


A rivet is a cylindrical body called a shank with a head. A hot rivet is inserted into a hole passing through two clamped plates to be attached and the head is supported whilst a head is formed on the other end of the shank using a hammer or a special shaped tool. The plates are thus permanently attached. Cold rivets can be used for smaller sizes the - forming processes being dependent on the ductility of the rivet material.

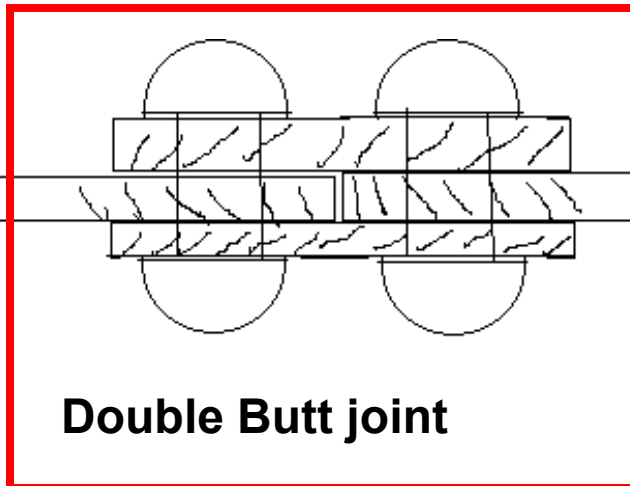


There are strict standards and codes for riveted joints used for structural/pressure vessels engineering but the standards are less rigorous for using riveted joints in general mechanical engineering.

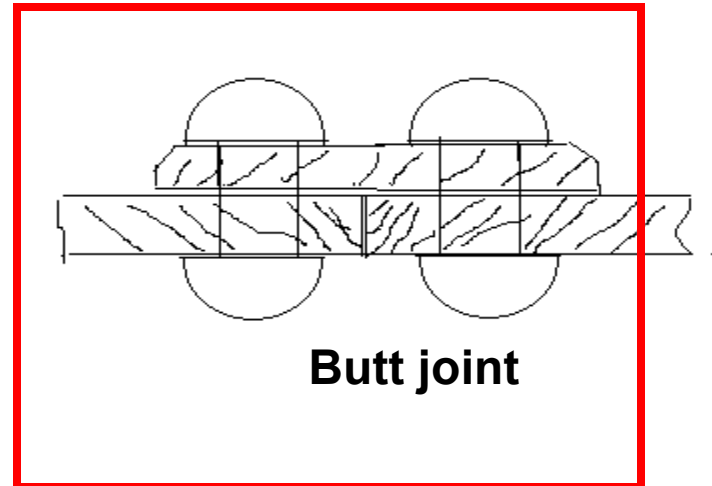
# Types of Riveted Joints.....



**Lap Joint**

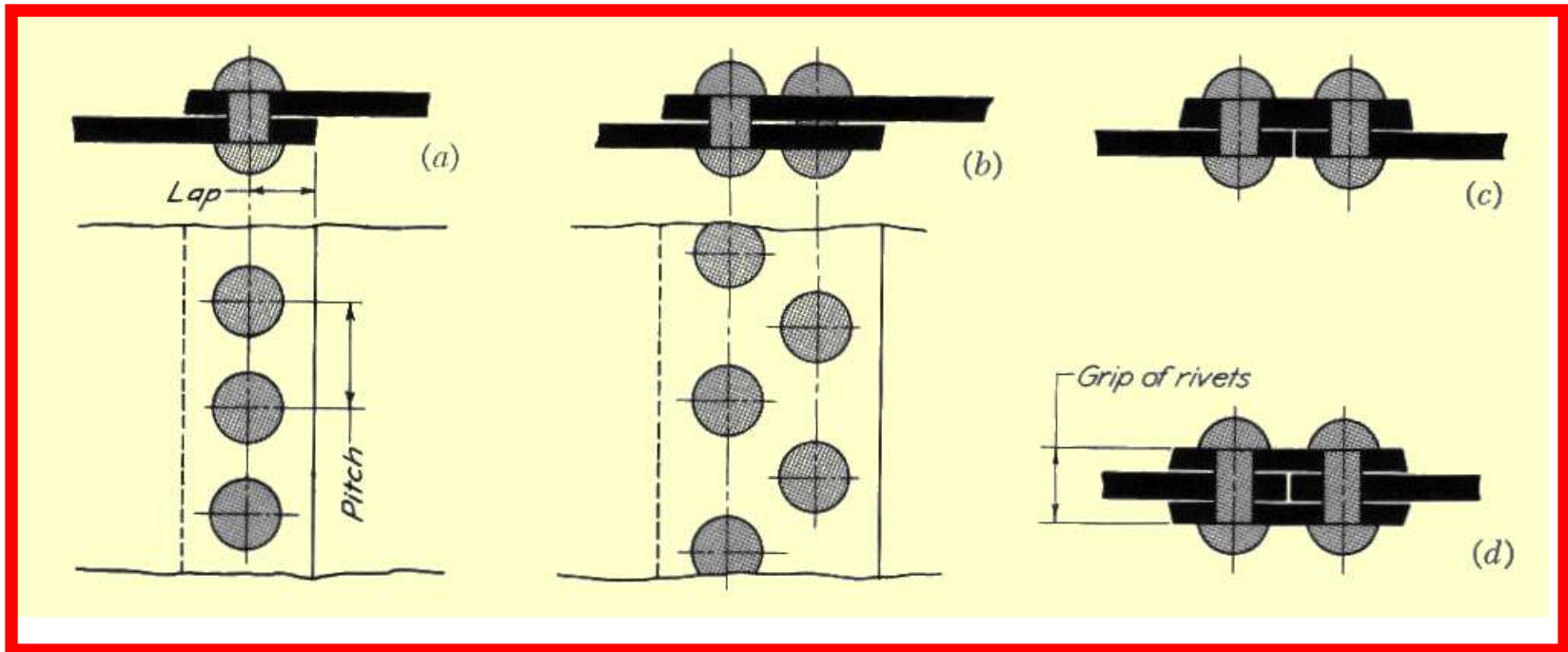


**Double Butt joint**



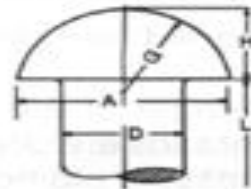
**Butt joint**

# Riveted Joint...



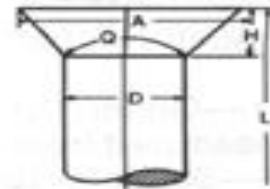


### BUTTON (ROUND) HEAD



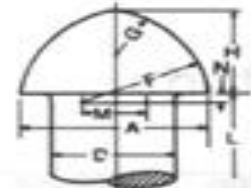
Dimensions  
 $A = 1.75 D$   $H = 0.75 D$   
 $G = 0.885 D$

### COUNTERSUNK HEAD



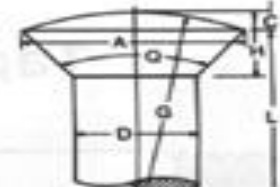
Dimensions  
 $A = 1.81 D$   $H = 1.192 \left( \frac{\text{Max } A-D}{2} \right)$   
 $Q = 78 \text{ deg.}$

### HIGH BUTTON (ACORN) HEAD



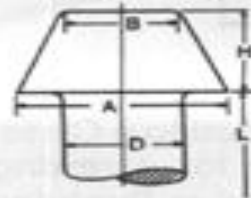
Dimensions  
 $A = 1.50 + 1/32$   $G = 0.75 D - 9/32$   
 $H = 0.75 D + 1/8$   $F = 0.75 D + 9/32$   
 $M = 0.50 \text{ in.}$   $N = 0.094 \text{ in.}$

### OVAL COUNTERSUNK HEAD



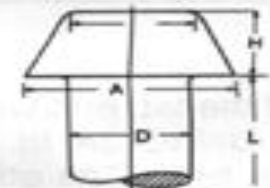
Dimensions  
 $A = 1.81 D$   $Q = 78 \text{ deg.}$   
 $C = 0.19 D$   
 $G = 2.25 D$   $H = 1.192 \left( \frac{\text{Max } A-D}{2} \right)$

### CONE HEAD



Dimensions  
 $A = 1.75 D$   $B = 0.938 D$   
 $H = 0.875 D$

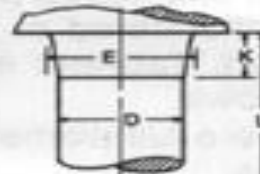
### PAN HEAD



Dimensions  
 $A = 1.60 D$   $B = D$   
 $H = 0.70 D$

### SWELL NECK

Dimensions  
 $E = D + 1/16 \text{ in.}$   
 $K = 0.50 D$



The length (L) is measured from the under side of head to the end of the rivet for all rivets shown except Countersunk and Oval Countersunk; in these two, L is measured from the top of the countersink to the end of the rivet.



**Screws**

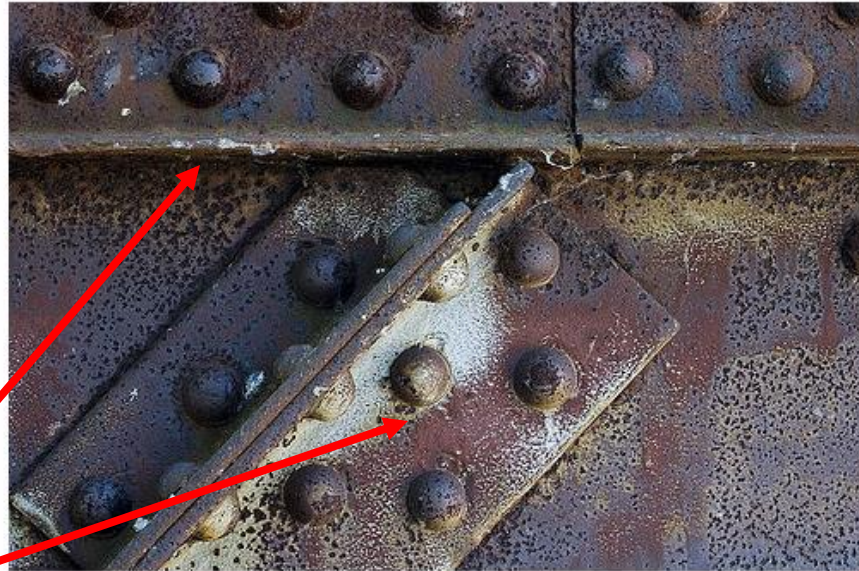
**Rivets**



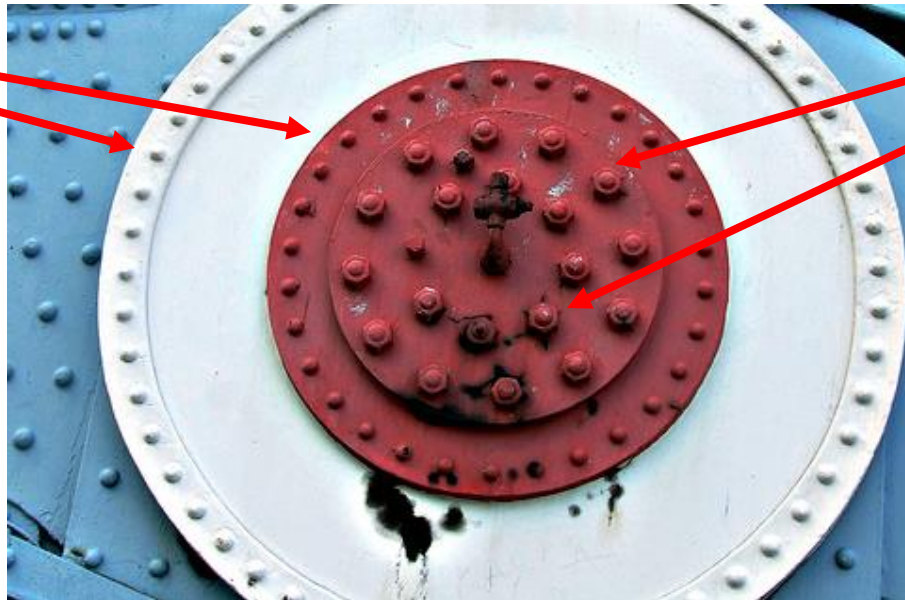
**Rivets**



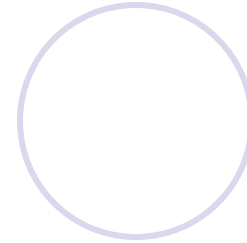
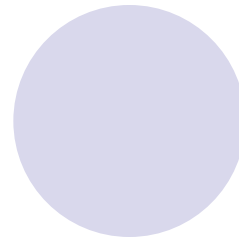
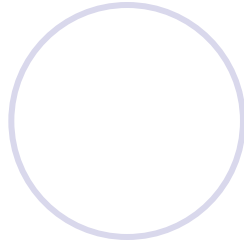
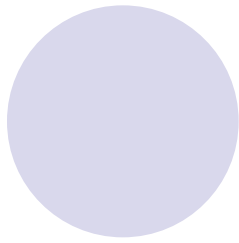
# Bridge Rivets



**Rivets**



**Bolts and Nuts**

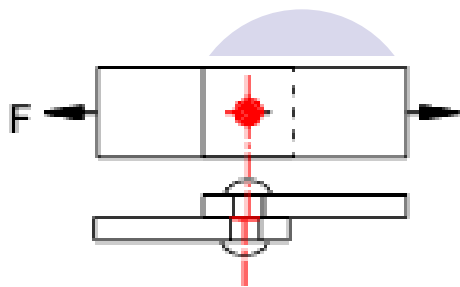


**Rivets are considered to be permanent fasteners. Riveted joints are therefore similar to welded and adhesive joints. When considering the strength of riveted joints similar calculations are used as for bolted joints.**

[http://www.roymech.co.uk/Useful\\_Tables/Rivets.html](http://www.roymech.co.uk/Useful_Tables/Rivets.html)

**Please visit this web page**

(Shigly et al,2003)



Rivet Shear Failure

$$\tau = F / (n p_i^* d^2 / 4)$$

$\tau$  = Shear Stress (MPa)  
 $d$  = rivet diameter (mm)  
 $F$  = Total Axial Force (N)  
 $n$  = Number of Rivets

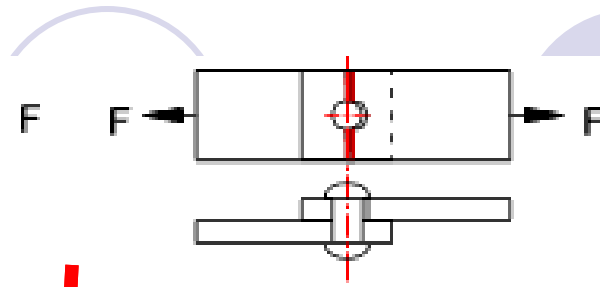
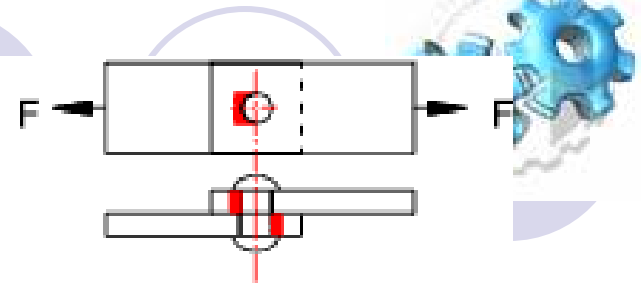


Plate Tensile Failure

$$\sigma_t = F / [t (w - n_r d_1)]$$

$\sigma_t$  = Tensile Stress (MPa)  
 $d_1$  = rivet hole diameter (mm)  
 $n_r$  = Number of Rivets in a row across the plate



Plate/ rivet Bearing Failure

$$\sigma_c = F / (n d t)$$

The Plate/Rivet bearing stress =

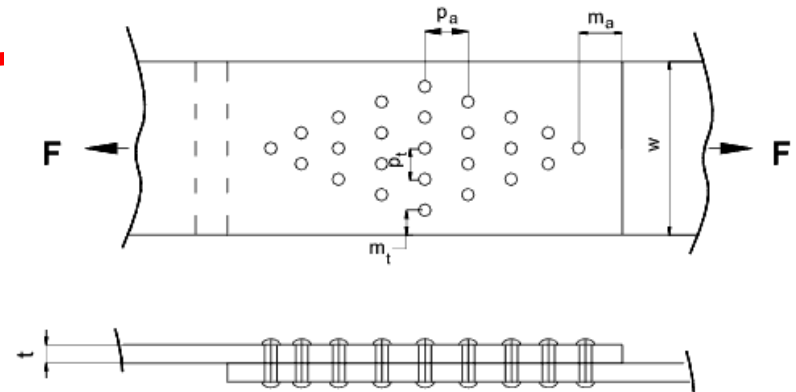


Plate tearing stress..  
 The plate shear stress

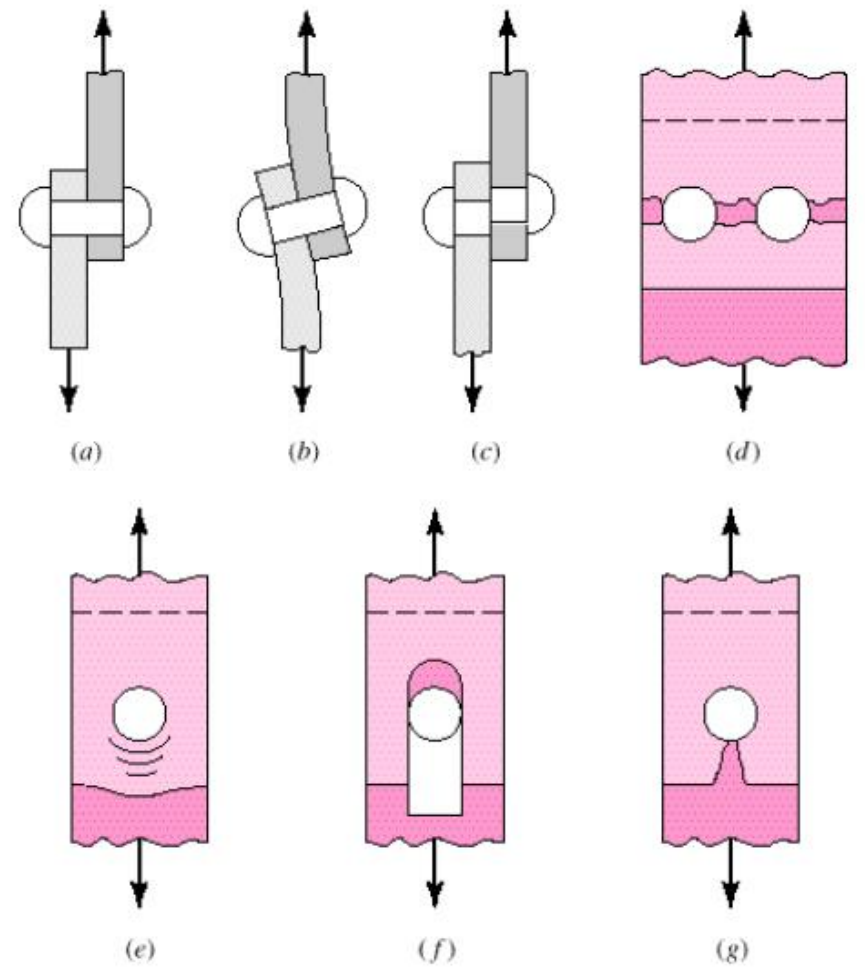
$$\tau_c = F / (2 m_a t)$$

Min metal land behind the rivet ( $m_a$ )



# Modes of failure in riveted joint

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.

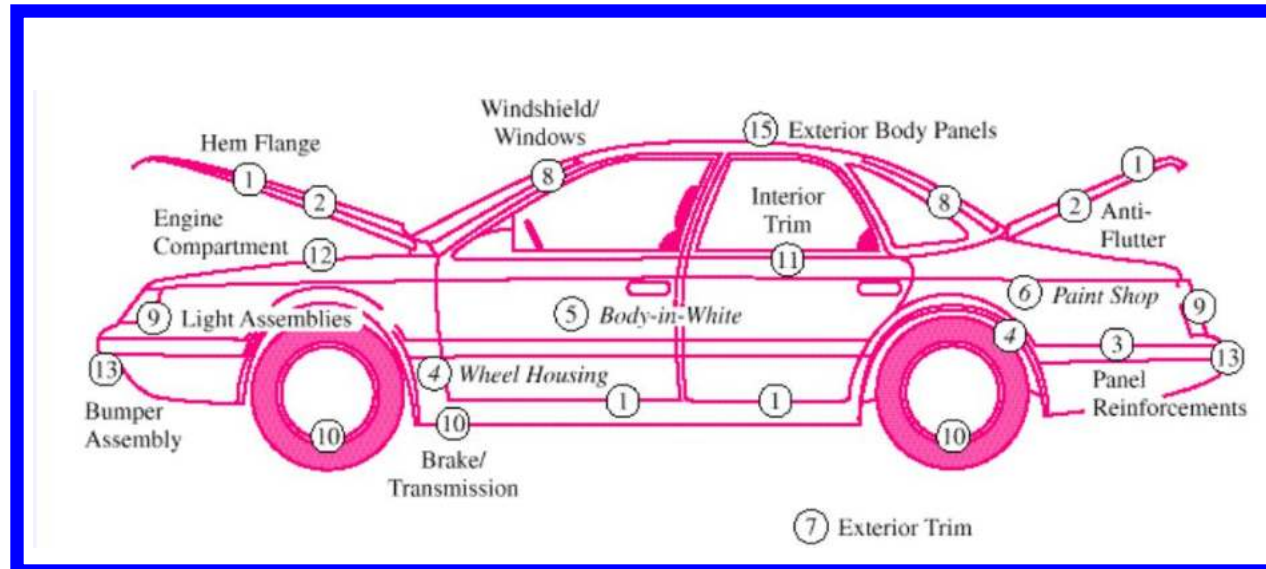


(Shigly et al,2003)

# Adhesive Bonding



Diagram of an automobile body showing at least 15 locations at which adhesives and sealants could be used or are being used. Particular note should be made of the windshield (8), which is considered a load-bearing structure in modern automobiles and is adhesively bonded. Also attention should be paid to hem flange bonding (1), at which adhesives are used to bond and seal. Adhesives are used to bond friction surfaces in brakes and clutches (10). Antiflutter adhesive bonding (2) helps control deformation of hood and trunk lids under wind shear. Thread-sealing adhesives are used in engine applications (12). (A. V. Pocius, *Adhesion*



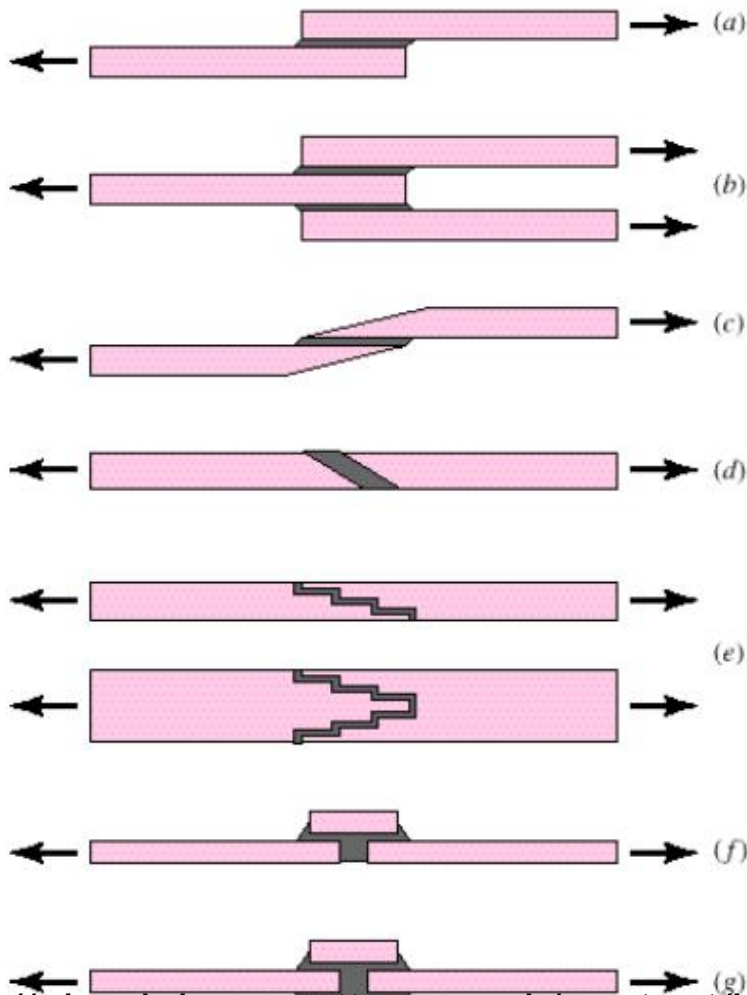
## **Mechanisms of Adhesion**

*Adhesives* are substances that are used to join two or more components together through attractive forces acting across the interfaces. The components being joined are commonly referred to as *adherends* or *substrates*.

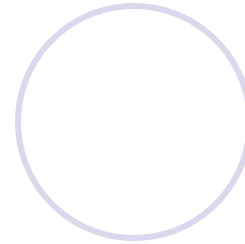
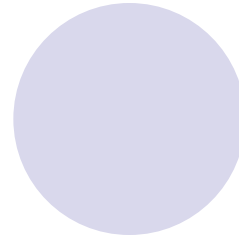
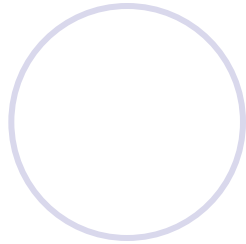
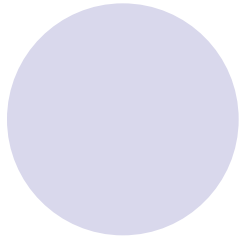
## Types of Adhesive



There are numerous adhesive types for various applications. They may be classified in a variety of ways depending on their chemistries (e.g., epoxies, polyurethanes, polyimides), their form (e.g., paste, liquid, film, pellets, tape), their type (e.g., hot melt, reactive hot melt, thermosetting, pressure sensitive, contact), or their load-carrying capability (structural, semistructural, or nonstructural).



Common types of lap joints used in mechanical design: (a) single lap; (b) double lap; (c) scarf; (d) bevel; (e) step; (f) butt strap; (g) double butt strap; (h) tubular lap. (Adapted from R. D. Adams, J. Comyn, and W. C. Wake, *Structural Adhesive Joints in Engineering*, 2nd ed., Chapman and Hall, New York, 1997.



**Thank You**