1 3rd Year Design and Production

Joints – Lecture 3

2 Welded Joints

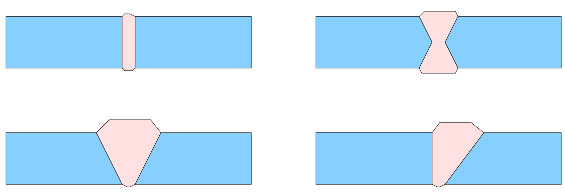
2.1 Description

- Weld is formed by melting metal of two parts to be joined
- When the metal solidifies, a joint is formed
- Additional metal, in form of welding rod, is also added to joint
- Some metals are easier welded than others
  - Steels are generally easily welded
  - Aluminium is more difficult
- Heat can come from flame, laser, electrical current, electrical arc
- Chemical-Flux is used to improve joint, protective atmosphere may be used also

3 Welded Joints

3.1 Joint Geometry – Butt Welds

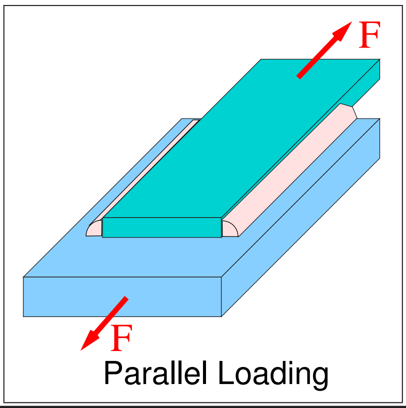
- Parts are joined end-to-end
- Good joint can be as strong as parent plate **for static loading**
  - Fatigue is a different story
- Use of grooves, as shown, improves joint strength



4 Welded Joints

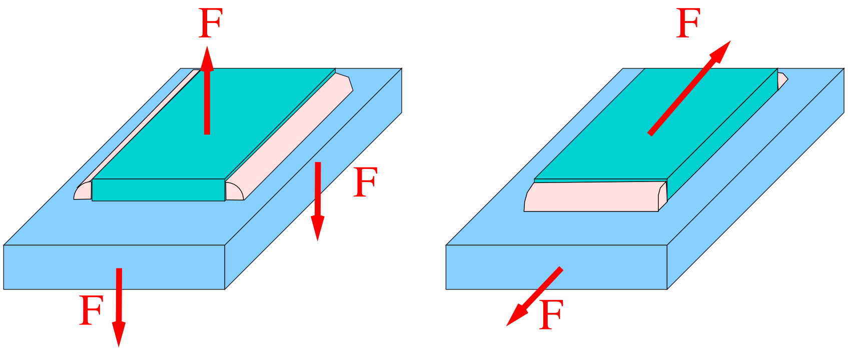
4.1 Joint Geometry – Fillet Welds

- Parts welded are in different planes
- Classify according to direction of loading
  - Parallel loading (both plates exert shear load on weld)
  - Transverse loading (on plate exerts shear load on weld, other exerts a tensile/compressive load)



5 Welded Joints

5.1 Joint Geometry – Fillet Welds

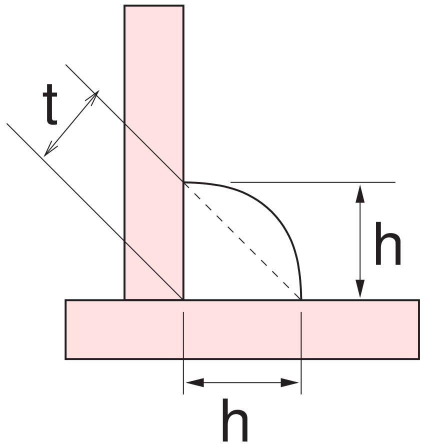


Transverse Loading

6 Welded Joints

6.1 Joint Geometry – Terminology

- Weld Bead
- Leg Length (h)
- Weld Throat (t)



7 Welded Joints

7.1 Failure

- Overload (material failure due to excessive stress)
- Poor Weld (often due to bad technique or ill conceived design)
  - Not enough weld material
  - Impurities in weld
  - Holes/porosity in weld
  - Failure to fill or penetrate joint
  - Inappropriate material/technique selection
- Adverse and untreated metallurgical changes in weld area (heat affected zone)

8 Welded Joints

8.1 Failure

1. Assume good welding technique
2. Assume no adverse material changes
3. Assume weld either convex or flat (i.e. not concave)
4. Assume leg lengths equal
    - Therefore $t = 0.707h$
5. Assume weld will fail before plates
6. Assume distortion energy theory is applicable for estimating the shear yield strength (i.e. $S_{sy} = 0.58S_y$)
7. Assume failure occurs at the minimum weld section t
8. Assume "throat area" is given by $A = tL$, where L is the length of the weld.

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9 Welded Joints

9.1 Failure

- Static Strength:

  $$F = S_{ys}A/\mathrm{FS}$$

  S_{ys} is the shear yield strength, FS is the factor of safety, and A is the weld area at the critical section
- Static Torsion and Bending loads give rise to shear and moment, so use

  $$\tau = \frac{Tr}{J} \qquad \text{and} \qquad \sigma = \frac{Mc}{I}$$

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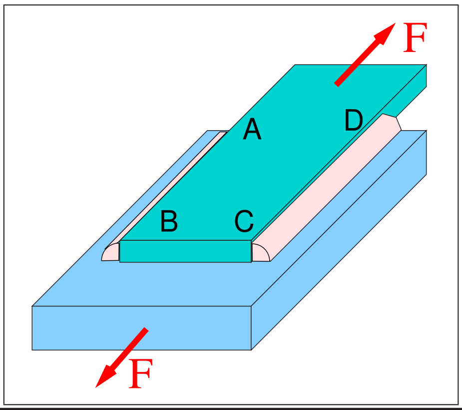
10 Welded Joints

10.1 Sample Problem

Two 12 mm thick steel plates ($S_y = 350\mathrm{MPa}$) are welded together (leg length of 6 mm). The welds are as shown in the figure below, (along AB and CD), each with a length of 50 mm. The yield strength of the weld metal is 350 MPa. Using a safety factor of 3, what static load F can be carried? If the welds were at AD and BC (50 mm each), what would the strength be?



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11 Welded Joints

11.1 Eccentric Loading

- In-Plane loading – Torsional loads

- Weld experiences two shear stress components
- Direct shear stress = P/A
- Torsion induced shear = Tr/J

- Out-of-Plane loading – Bending loads
  - Weld experiences both shear and normal stress components
  - Direct shear stress = P/A
  - Bending induced stress = Mc/I
  - Combine to give overall effective ”shear” stress

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12 Welded Joints

12.1 J – Polar Moment of Inertia

- Calculated with respect to centroid of weld group

$$J = \sum (I_x + I_y)$$

- Find centroid of weld-group
- Use parallel axis theorem to calcuate I values
- Calculate J for each weld segment

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13 Welded Joints

13.1 Parallel Axis Theorem

- Moment of Inertia (about centroid axes)

$$I_{xc} = \int y^2 \mathrm{d}A \qquad I_{yc} = \int x^2 \mathrm{d}A$$

- Moment of Inertia (about axis parallel to centroid axis)

$$I_x = \int (y + d_1)^2 \mathrm{d}A = I_{xc} + A(d_1)^2$$
$$I_y = \int (x + d_2)^2 \mathrm{d}A = I_{yc} + A(d_2)^2$$