Introduction to Aerospace Engineering

Lecture slides

Structural joints

Welded, mechanically fastened, bonded

Faculty of Aerospace Engineering

10-1-2012

Learning objectives

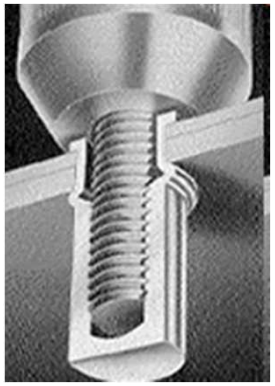
Student should be able to…

- Describe the different joint types
- Mechanically fastened joints
  - Explain the difference between tension and shear joints
  - Describe the load transfer mechanisms
  - Describe the failure modes
- Welded joints
- Adhesive bonded joints

Mechanically fastened joints

Types of joints

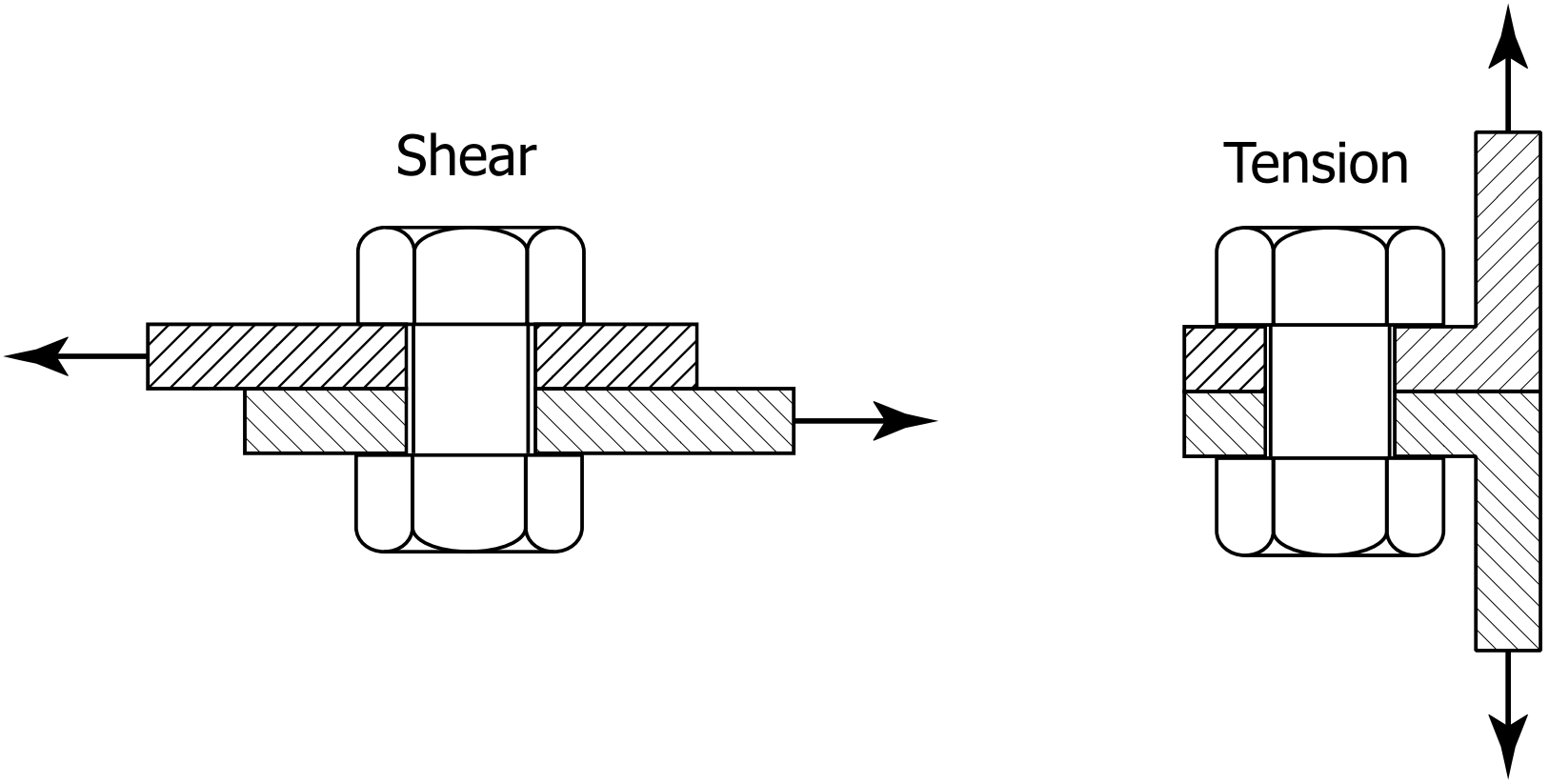
- Types of fasteners
  - Threaded fasteners
  - Rivets
  - Blind fasteners
  - Nails



Mechanically fastened joints

Types of joints

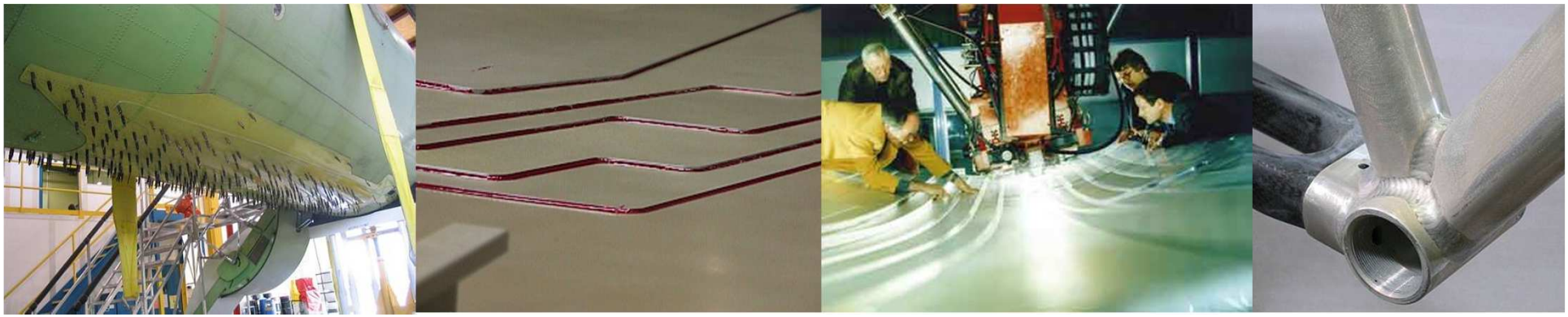
- Joints classified by loading mode of fastener



Mechanically fastened joints

Types of joints

- Tensile joint
  - Mechanical joint (bolts)
  - Welding (laser beam, friction stir welding)
- Shear joint
  - Mechanical joint (rivets, bolts)
  - Welding (laser beam, friction stir, spot welding)
  - Adhesive bonding

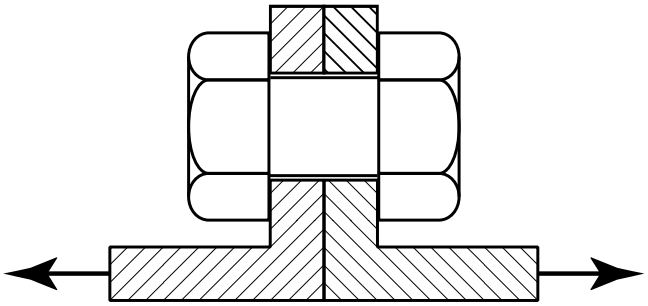


Mechanically fastened joints

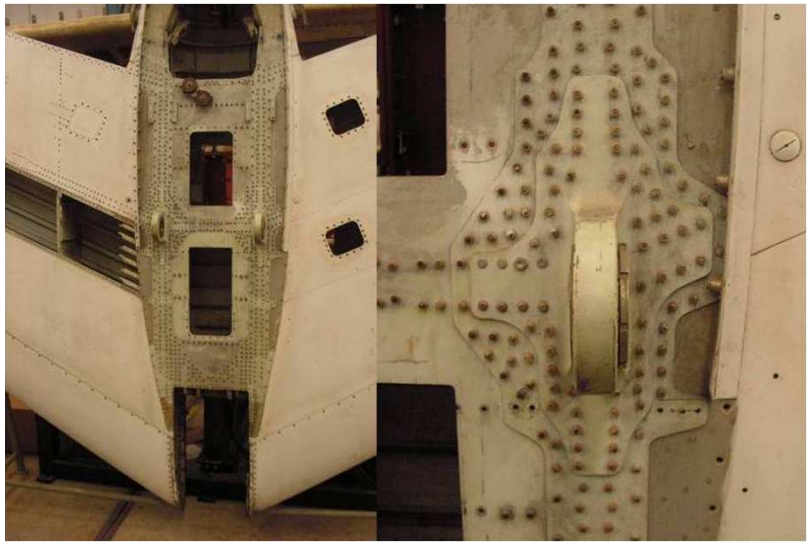
Joining – tensile joint

- Many variations
  - T- and angle-clips
  - Angle- and channel-fittings
  - Flanges

Tension



Fokker F-28 horizontal stabilizer (flange)



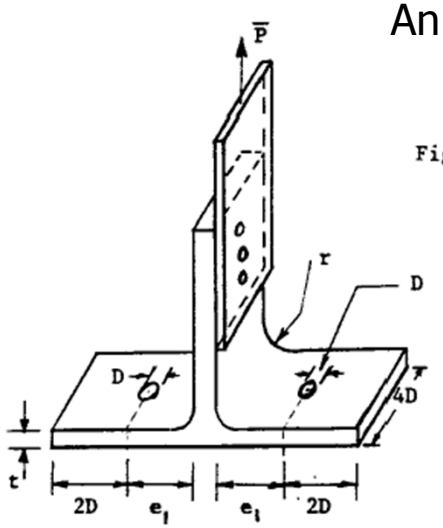


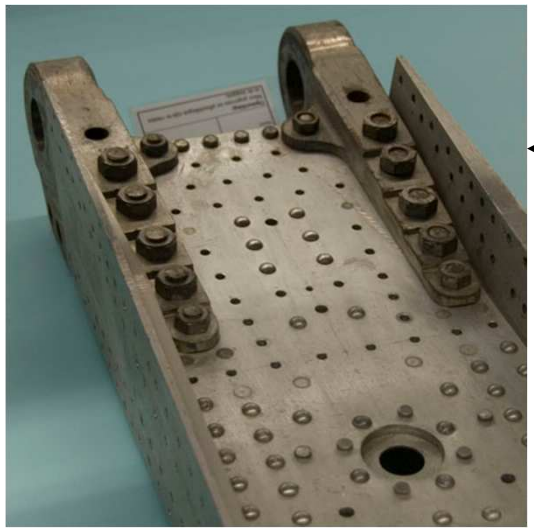
Fig.4

Channel fitting from
An MK8 Meteor

Mechanically fastened joints

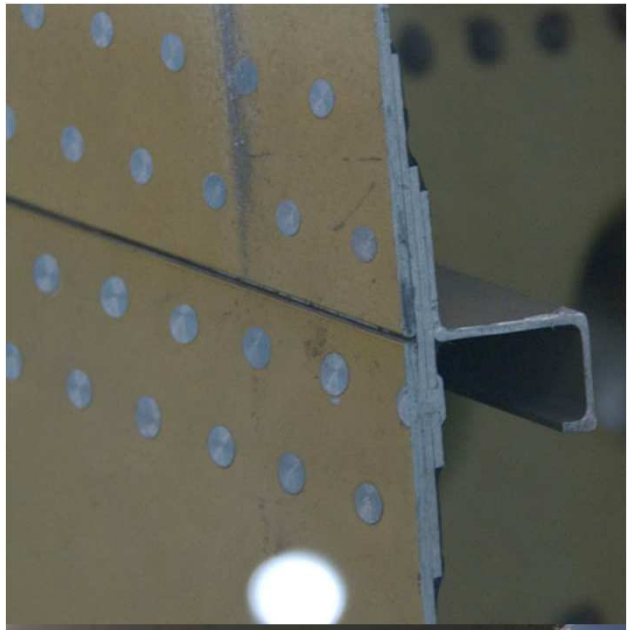
Joining – shear joint

- Fuselage skin joints
- Shear clips
- Stringer-to-skin connections
- Lugs



Wing spar connection lug

Fuselage butt joint

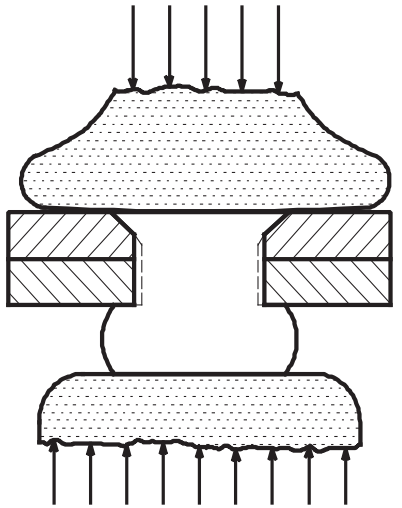


Fuselage lap joint

Mechanically fastened joints

Benefits of rivets

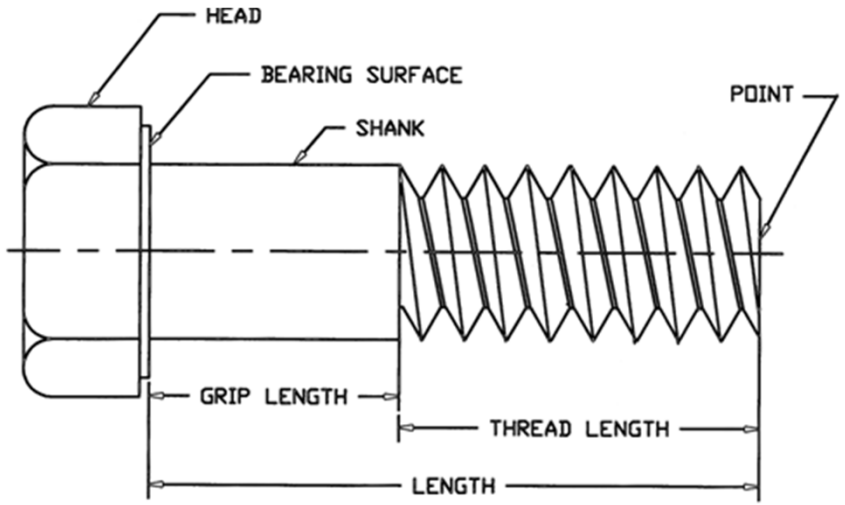
- Low cost
  - Installation
  - Unit
- Hole filling properties
  - K_t reduction
  - Residual stress
  - Load transfer
- Permanency
  - Can not vibrate loose



Mechanically fastened joints

Benefits of threaded fasteners

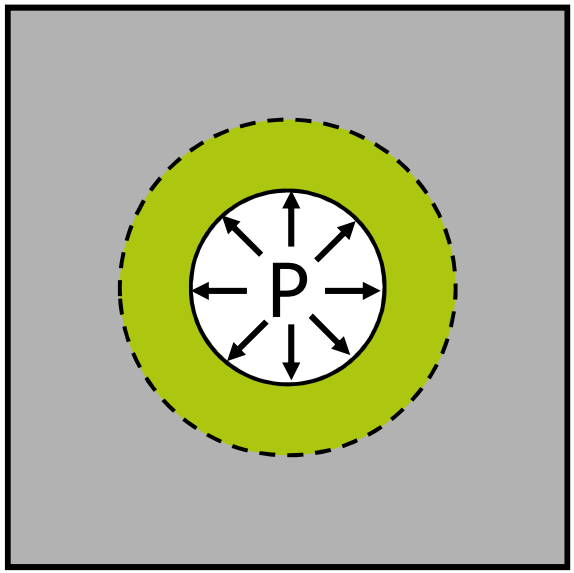
- Removable
  - Assembly/disassembly
  - Reusability
- High strength
  - Wider range of materials
  - Heat treatments
  - Case hardening
- Multi-purpose
  - Shear bolts
  - Tension bolts
  - Tension-shear bolts



Mechanically fastened joints

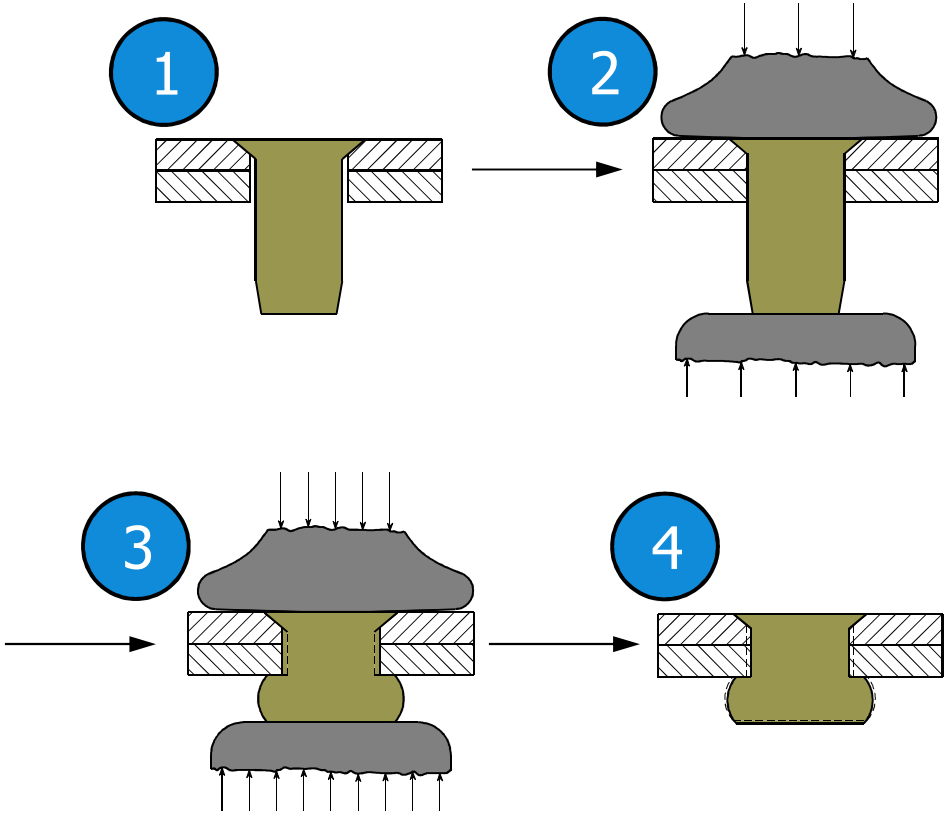
Joint characteristics

- Solid rivets: squeezing ⇒ Interference



Plastic region

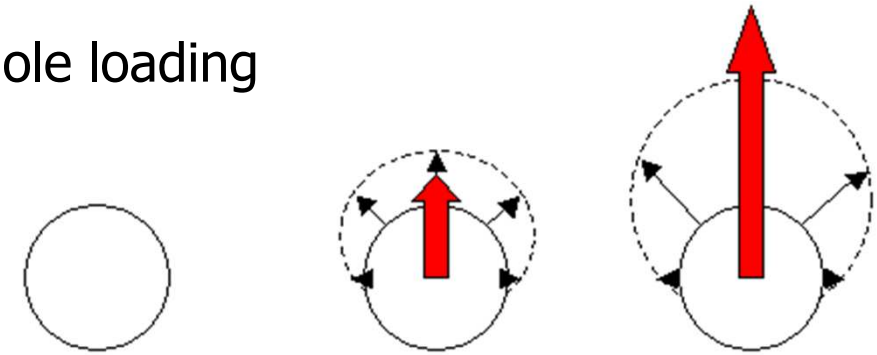
Elastic region



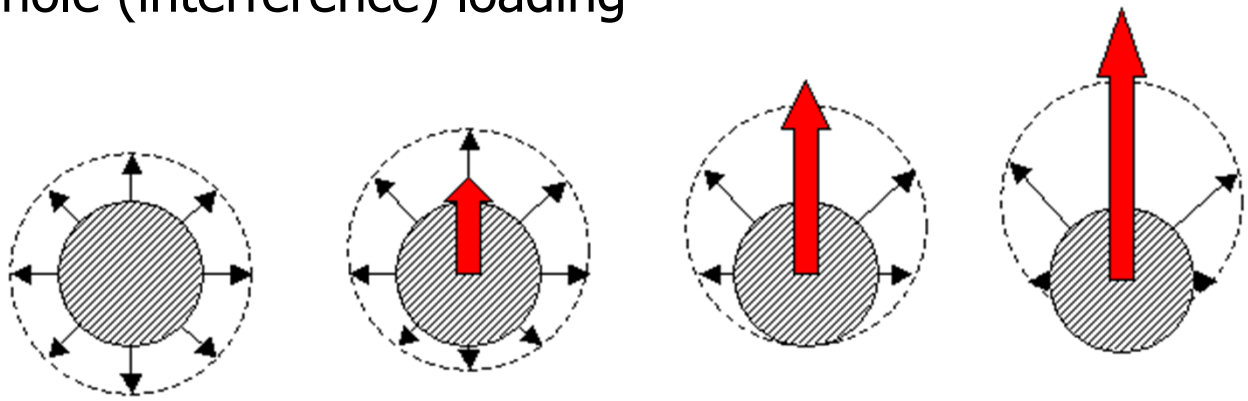
Mechanically fastened joints

Joint characteristics

- Open hole loading



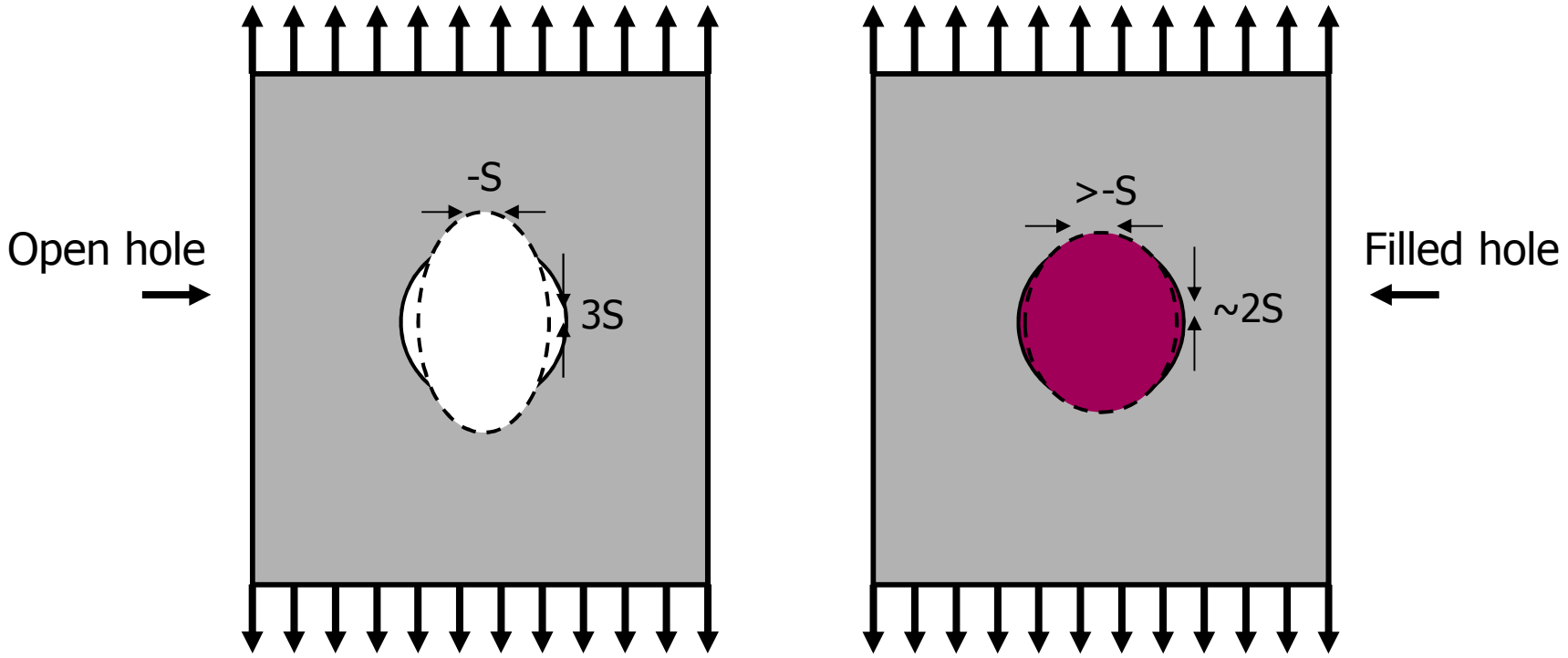
- Filled hole (interference) loading



Mechanically fastened joints

Joint characteristics

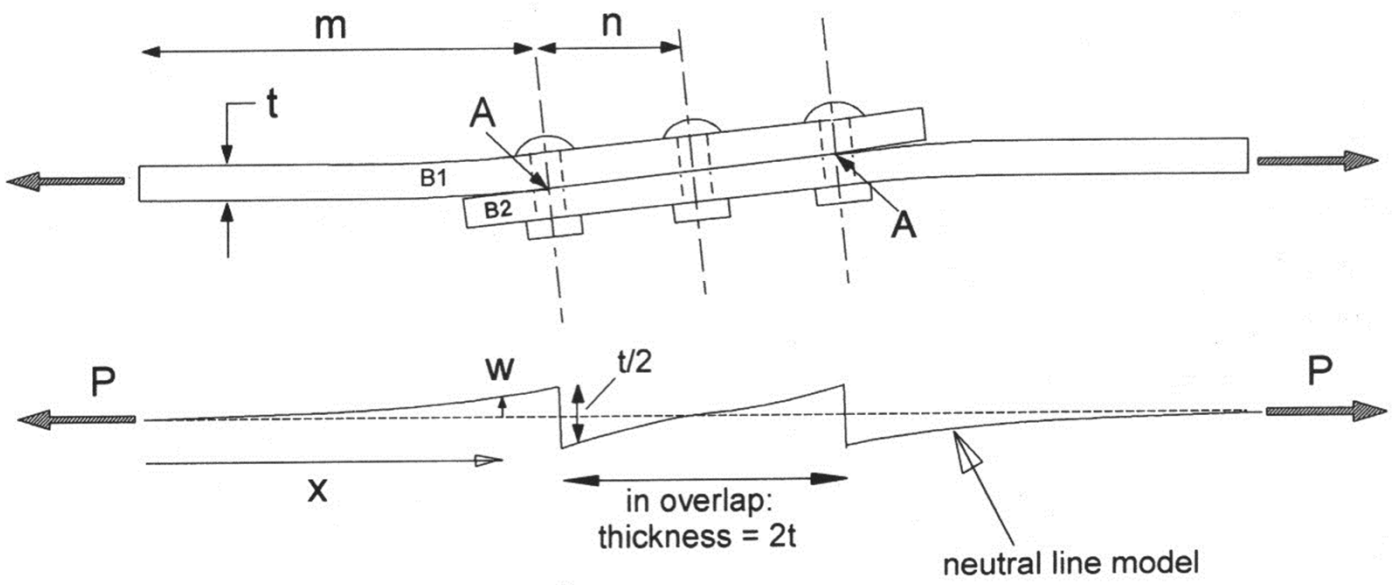
- Constrained deformation
  - Reduction of stress concentration factor K_t



Mechanically fastened joints

Joint characteristics

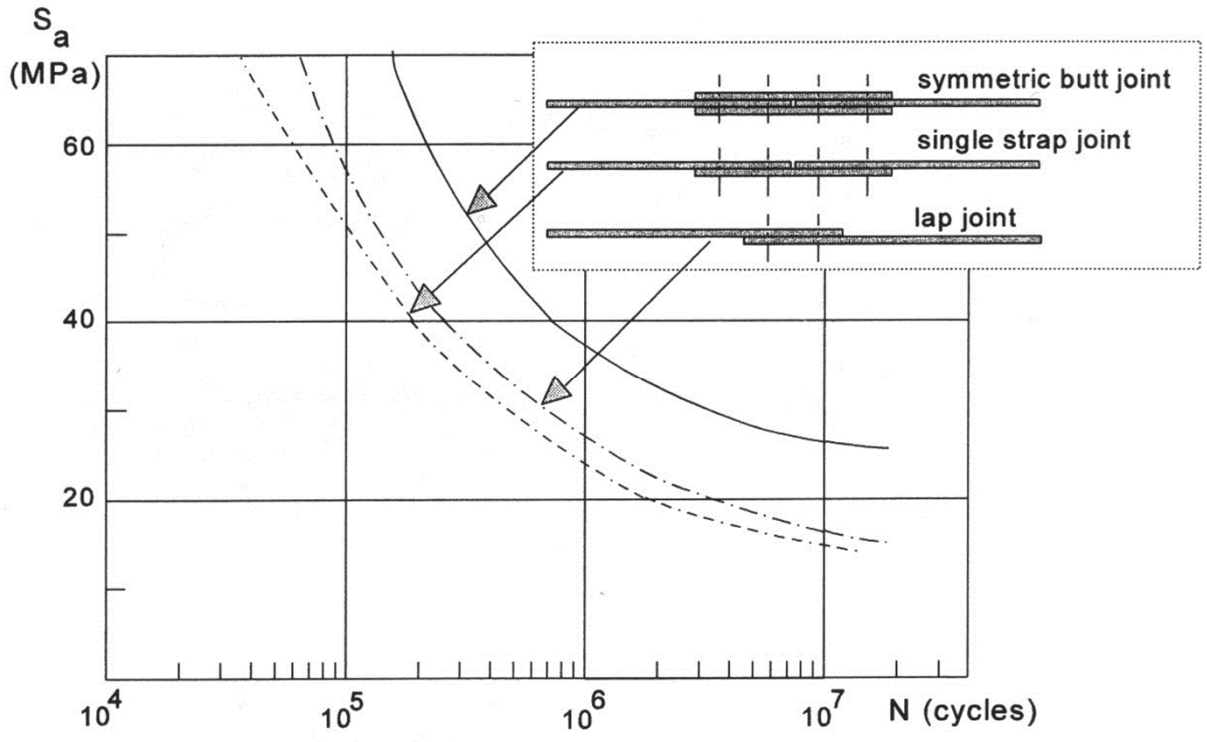
- Secondary bending ⇒ peel stress



Mechanically fastened joints

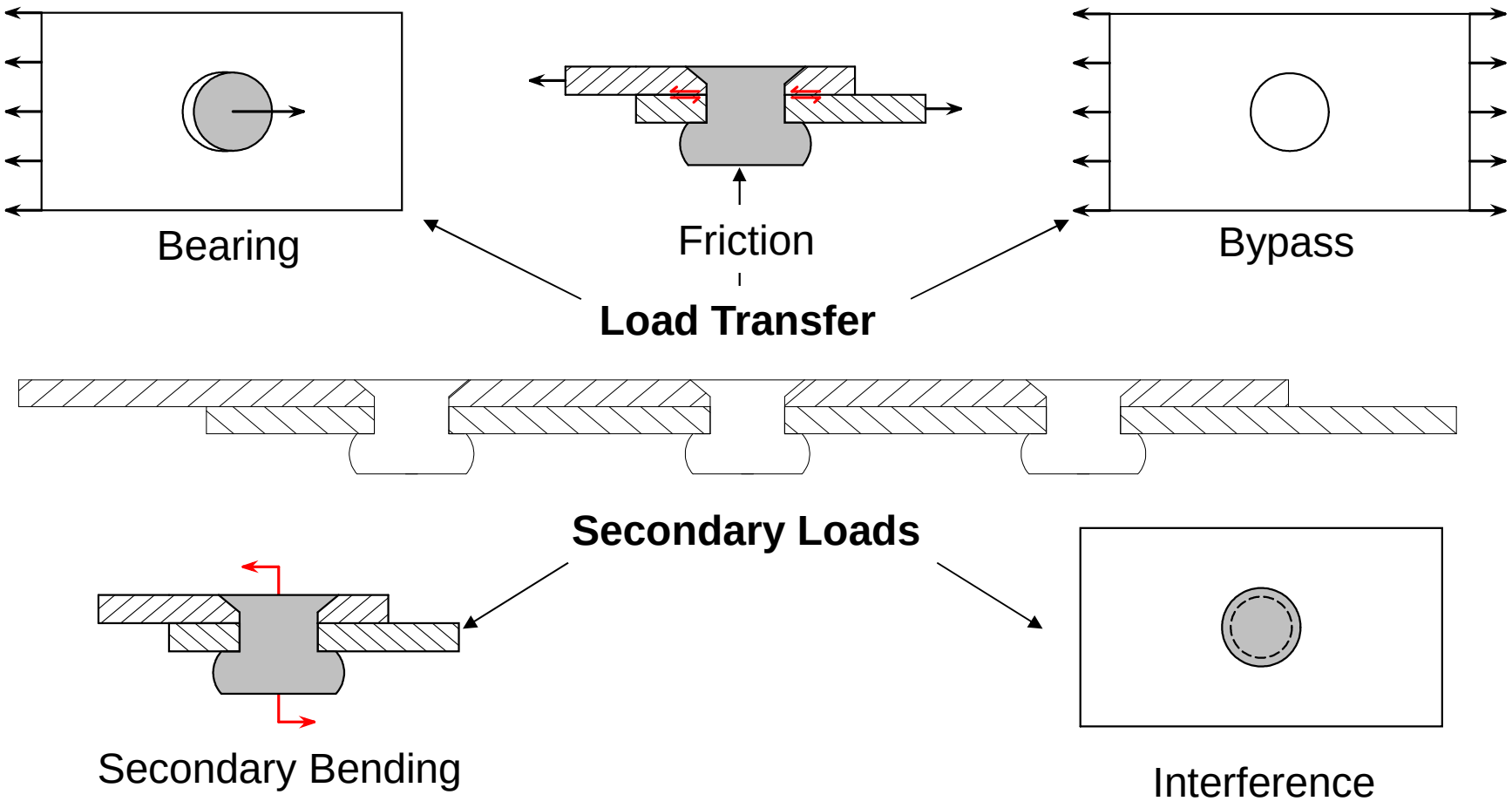
Joint characteristics

- Secondary bending ⇒ peel stress



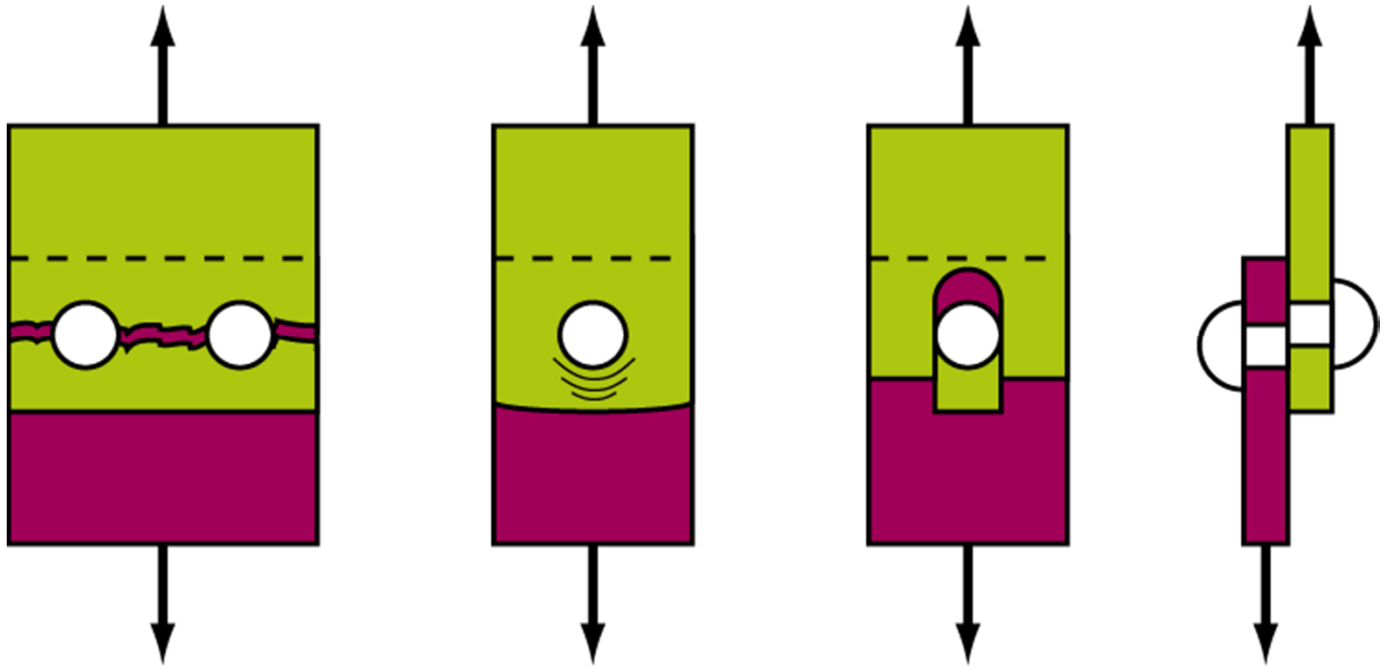
Mechanically fastened joints

Load transfer mechanism



Mechanically fastened joints

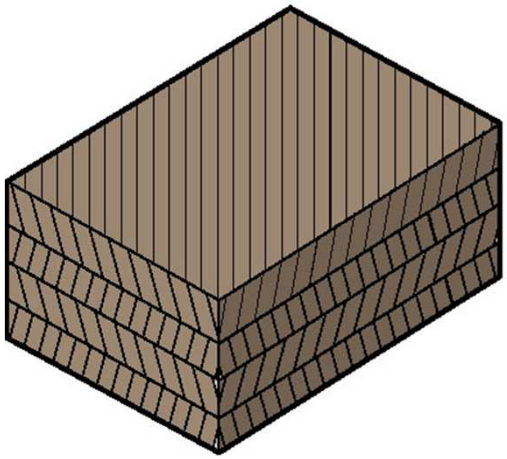
Failure modes

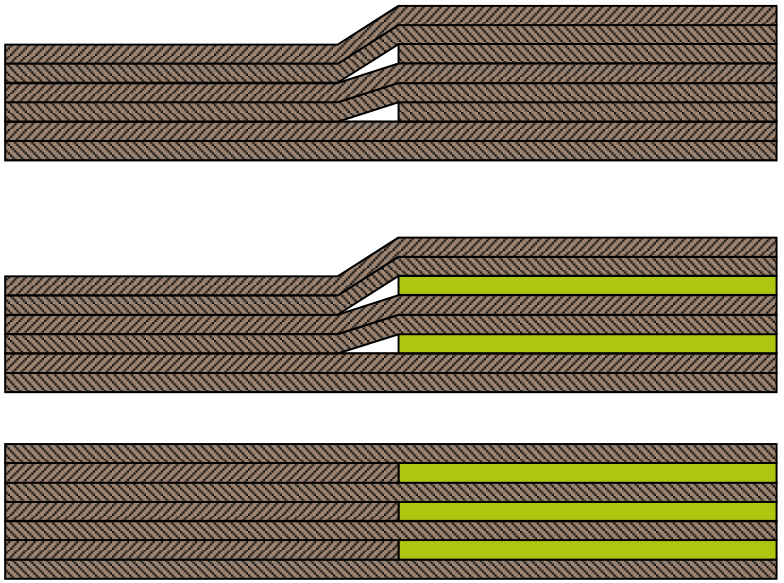


Mechanically fastened joints

Composites

- Reinforcing laminate edge for bearing by
  - Additional composite plies
  - Adding metallic inserts
  - Replacing composite by metallic plies

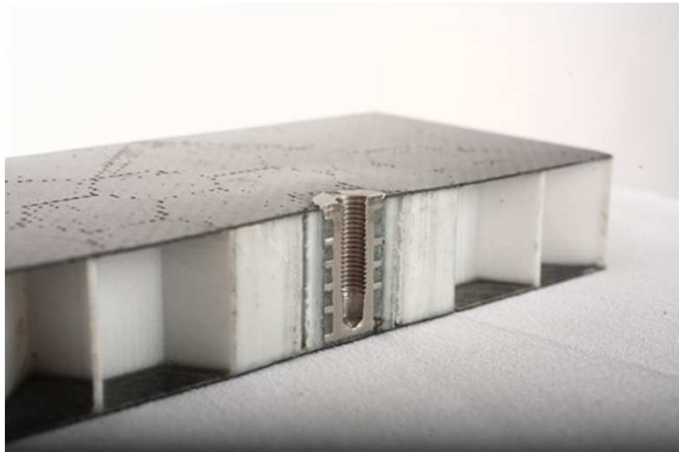


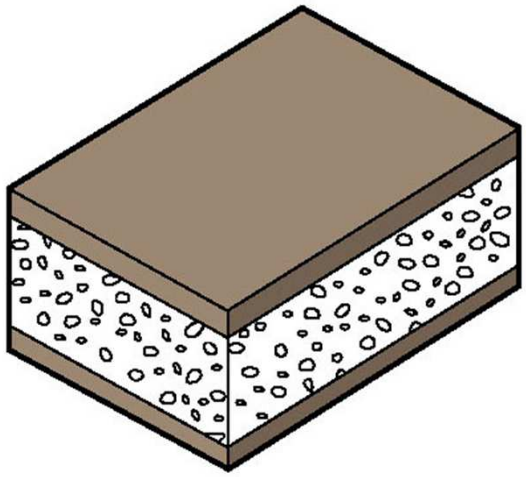


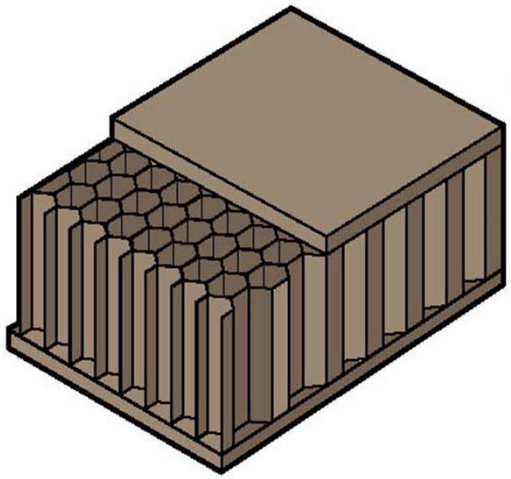
Mechanically fastened joints

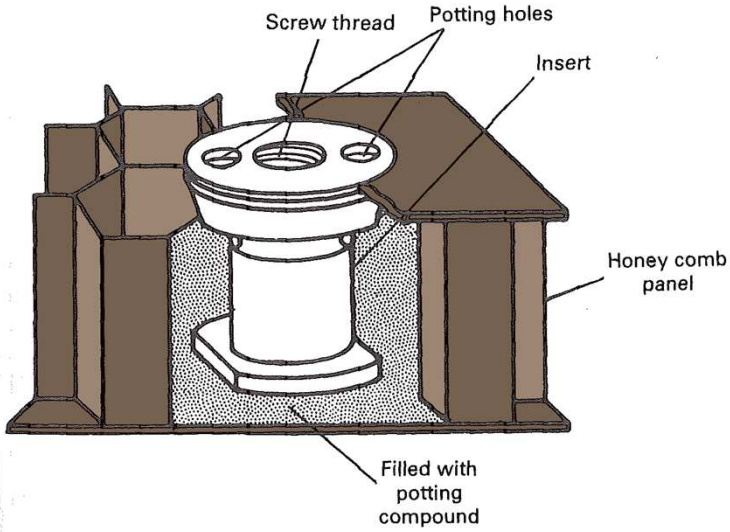
Composites

- Bolted joint
  - Honeycomb inserts: attached to both facings, surrounded by filling compound





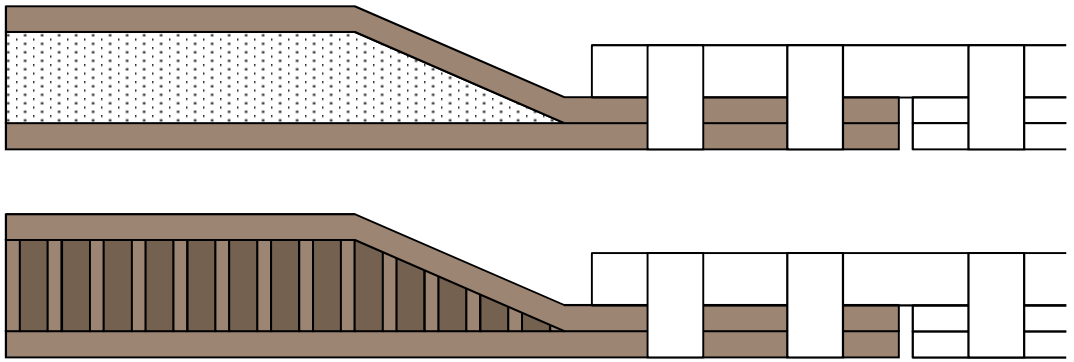


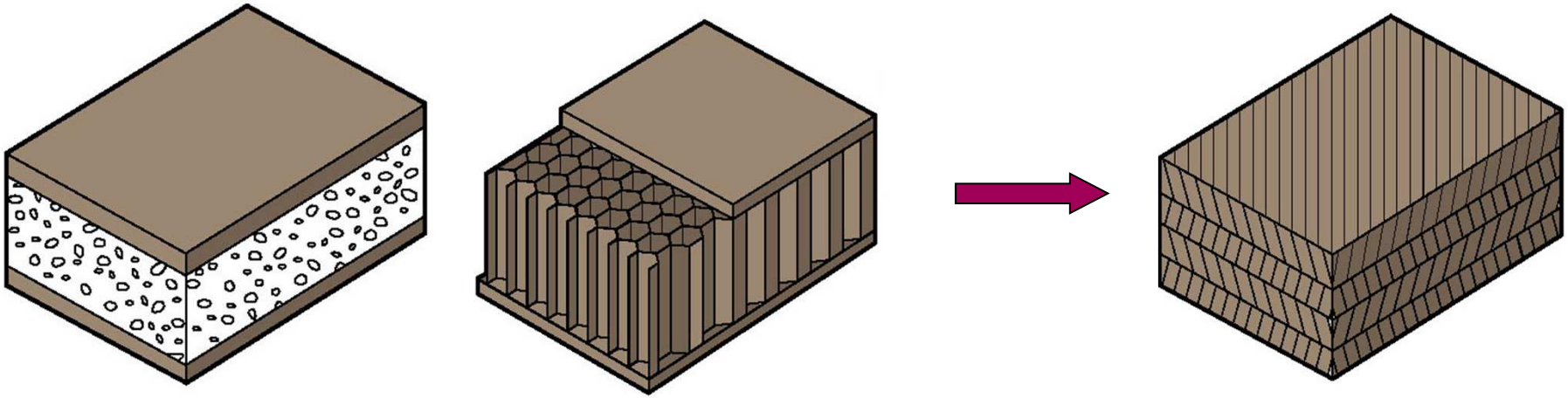


Mechanically fastened joints

Composites

- Bolted joint
  - Taper to laminate





Welded joints

Metals

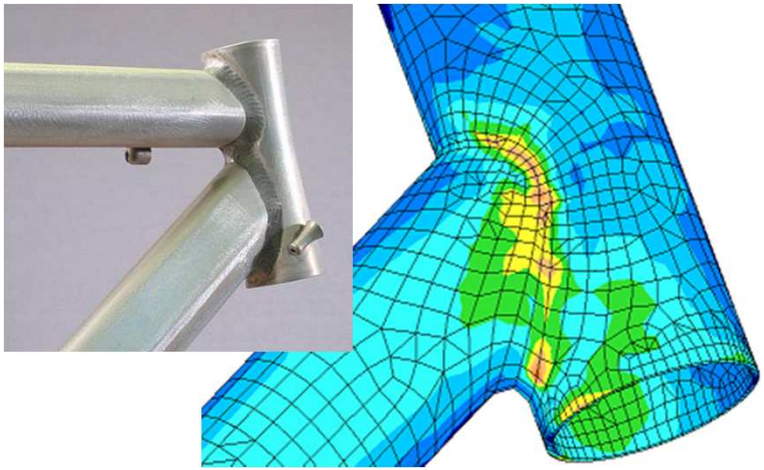
- Laser beam welding

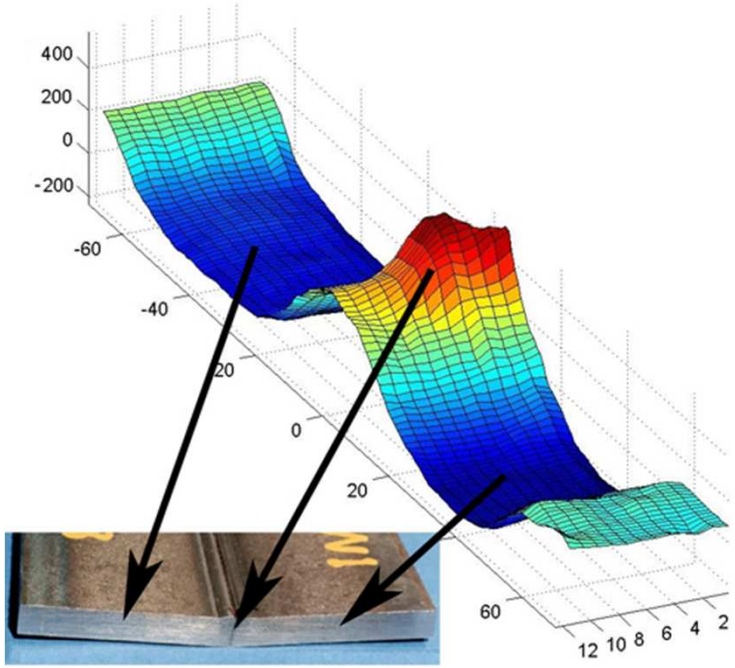
Friction stir welding

Welded joints

Metals

- Welding
  - Laser beam welding, friction stir welding, spot welding
- Formation of residual stresses
  - Stress concentrations
  - Elastic 'spring back'

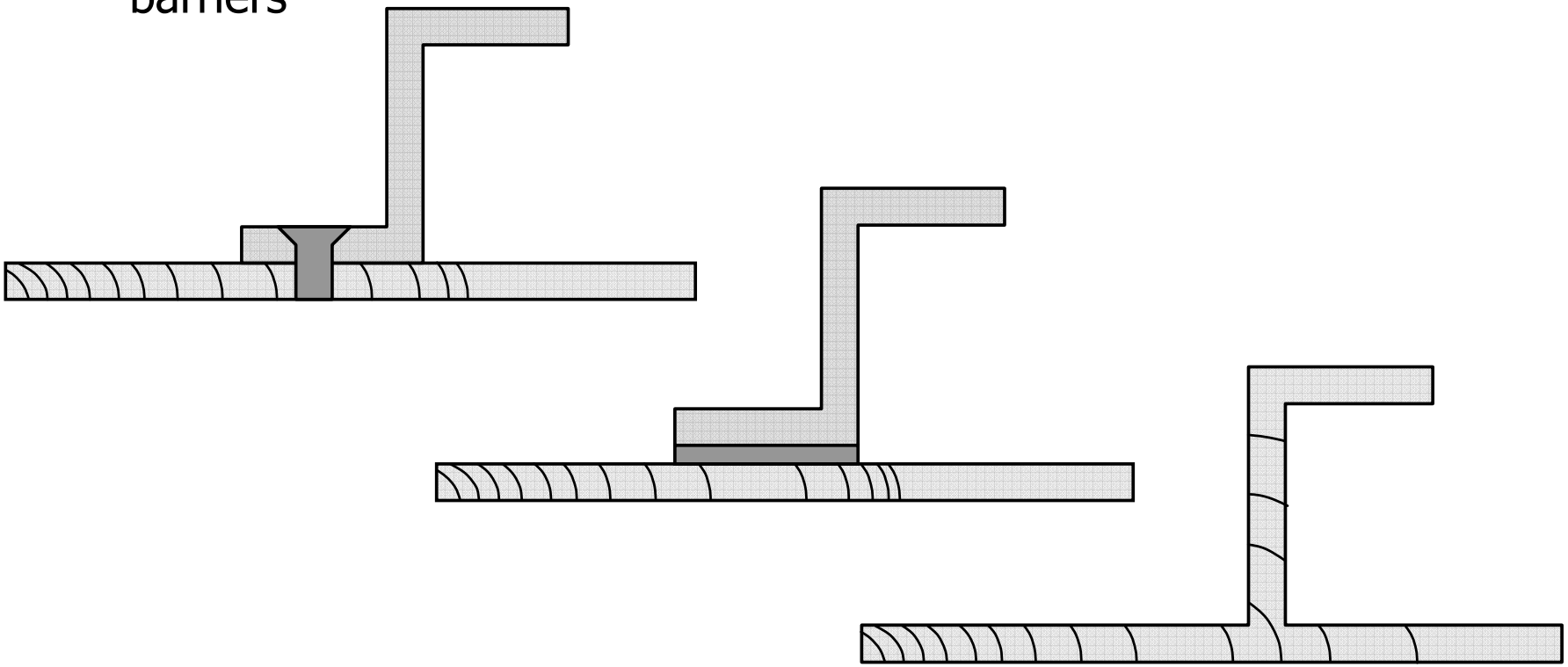




Welded joints

Metals

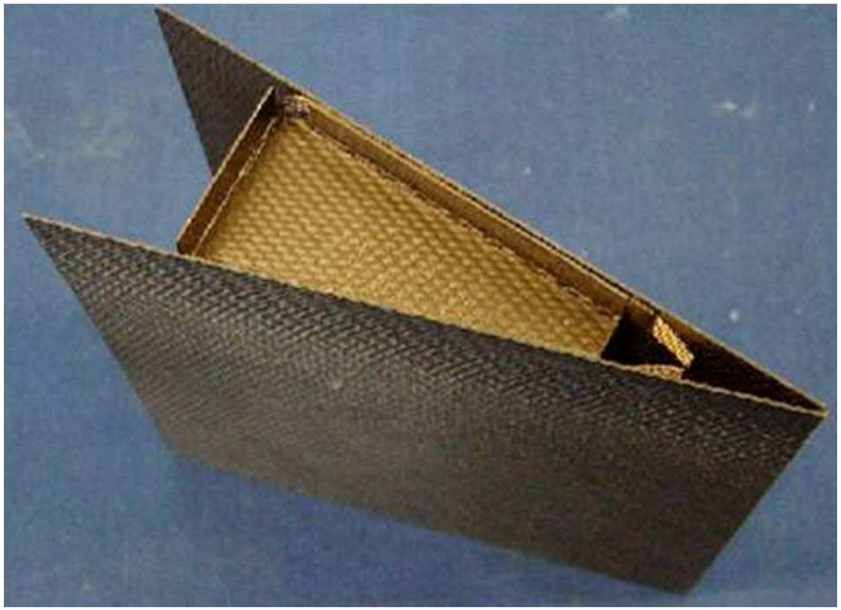
- With multiple components an 'integral design' is created; no crack barriers

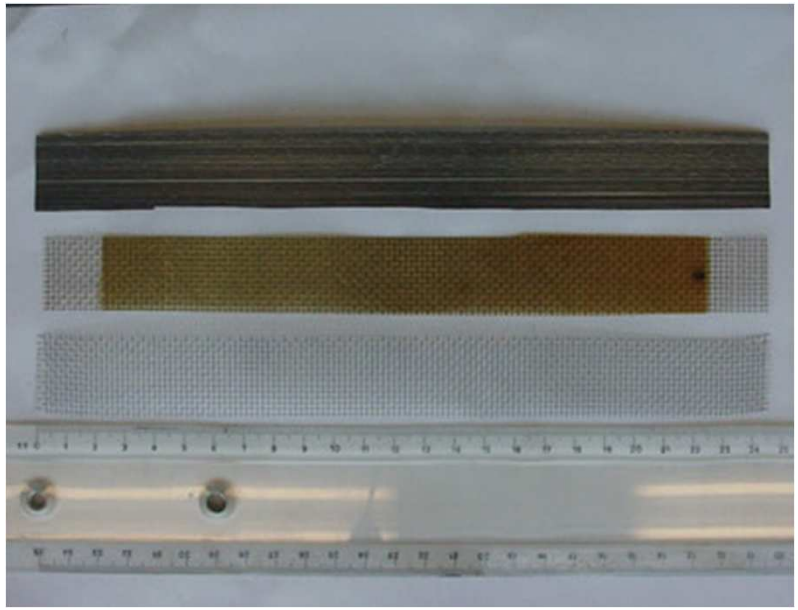


Welded joints

Composites

- Thermoplastic
  - Resistance welding





Bonding

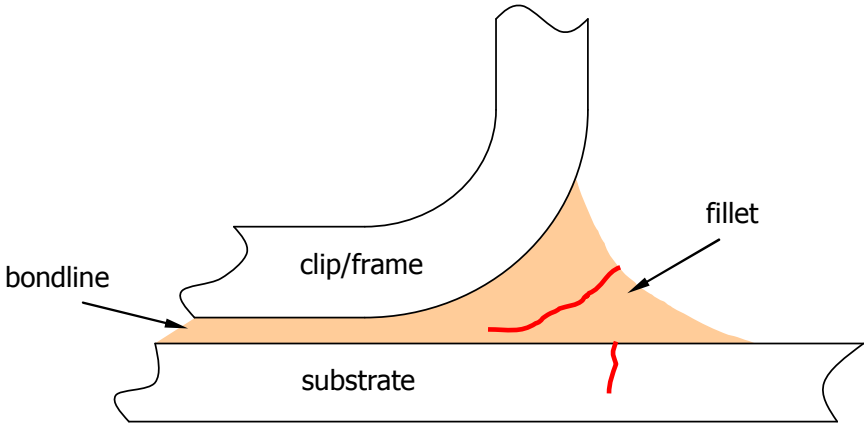
Pretreatment

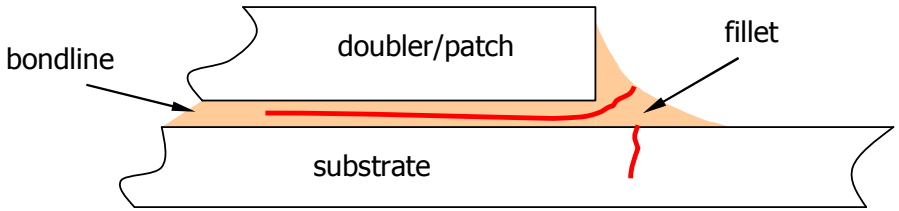
- Metallic components
  - Anodizing
  - Priming

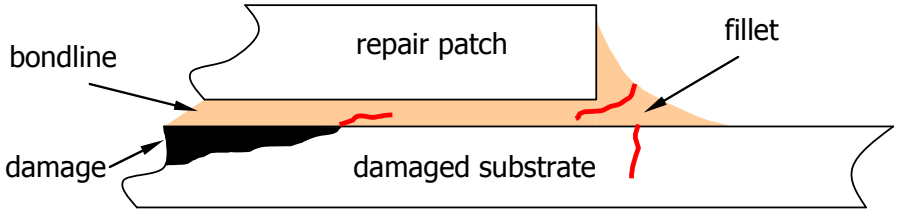
Bonding

Failure modes

- Relevant bonded structures
  - Doublers
  - Clips/frames/stringers
  - Patch repairs
- Failure possible in
  - Substrate
  - Adhesive



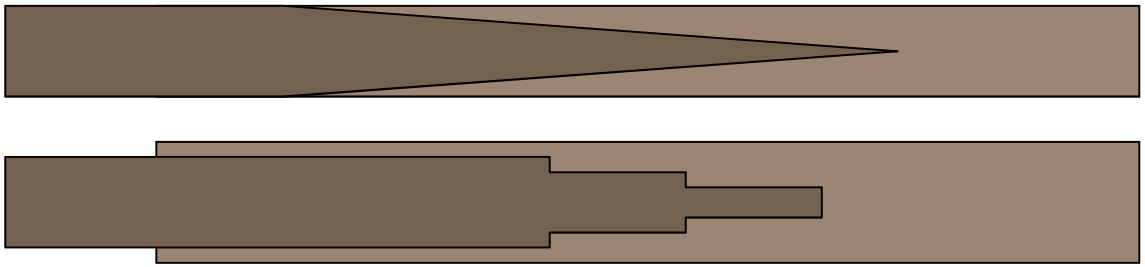


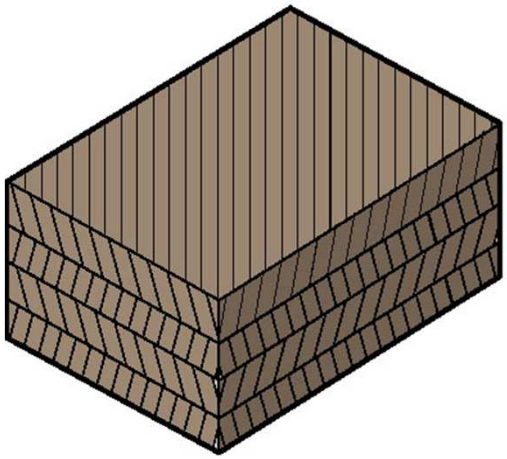


Bonding

Composites

- Bonded joint
  - Scarf joint
  - Stepped lap-joint





Summary

Structural joints

- Different joint types
- Mechanically fastened joints
  - Tension and shear joints
  - Load transfer mechanisms
  - Failure modes
- Welded joints
- Adhesive bonded joints