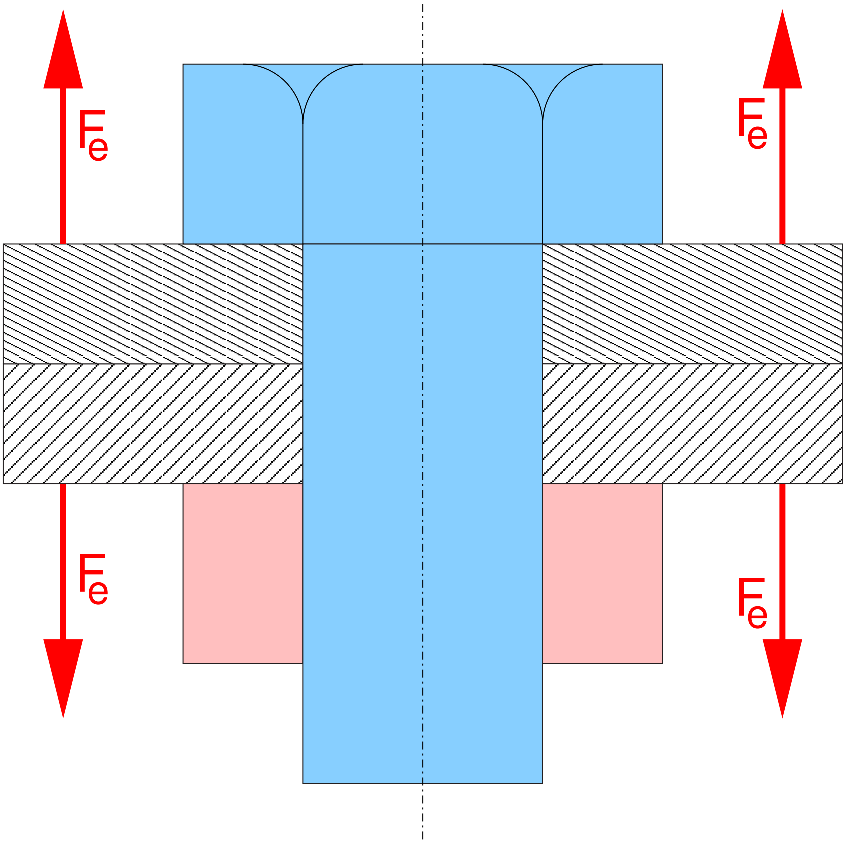
1 3rd Year Design and Production

Joints – Lecture 5

2 Bolted Joints

2.1 Description



3 Bolted Joints

3.1 Characteristics

- Low skill, but results are consistent
- Joint can be disassembled and reassembled
- Poorer load transmission than welds
- Good control of clamping force (vs rivets)
- Unintentional loosening can occur (vs rivets, welds)

4 Bolted Joints

4.1 Tightening

- Load on bolt is considered to be tensile.
- Objective is to create a tensile force within the bolt close to point at which plastic deformation begins to occur
  - Proof Load S_p
  - S_y usually at 0.2% strain
  - S_p less than S_y
- Initial force $F_i = k_i A_t S_p$
  - A_t is stress area of the thread
  - $0.75 < k_i < 1.0$, for static loading $k_i = 0.9$

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5 Bolted Joints

5.1 Tightening

High Tightening force results in

- Reduced likelihood of separation of clamped members
- Better shear resistance due to friction between clamped members
- Tension typically decreases 10% in a couple of months in any case due to creep, wear, corrosion and “unwinding” of torque in screw.

5.2 Torque

- Tightening torque given by
  - $T = 0.2 F_i D_m$
  - D_m is the major thread diameter
  - Control with torque wrench is $\pm 30\%$

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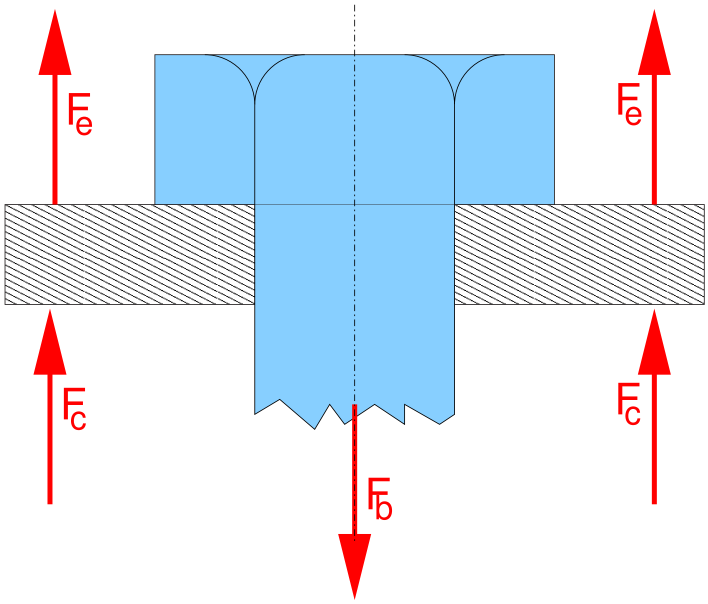
6 Bolted Joints

6.1 Forces



- F_e represents external forces
- F_b is the tensile force in the bolt
- F_c is the compressive clamping force on the plate

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7 Bolted Joints

7.1 Elasticity

- Joint tightening involves elastic distortion
  - Elongation of the bolt
  - Compression of the clamped members
- Failure occurs when the plates separate
  - Clamping compression is overcome
- No external force $F_e = 0$ means that $F_b = F_c = F_i$
- NONzero F_e means F_b increases, or F_c decreases, or both.

$$F_e = \Delta F_b - \Delta F_c$$

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8 Bolted Joints

8.1 Elasticity

- Relative changes of F_b and F_c depend on relative elasticity

$$\delta_b = \frac{\Delta F_b}{k_b} \qquad \text{while} \qquad \delta_c = -\frac{\Delta F_c}{k_c}$$

- k_b and k_c are spring stiffnesses, while δ terms are deflections.
- Equating deflections $\delta_b = \delta_c$ means

$$\Delta F_c = \frac{-k_c}{k_b} \Delta F_b$$

- Substitute this into our expresion for F_e and we get two equations

$$\Delta F_b = \left(\frac{k_b}{k_c + k_b} \right) F_e \qquad \text{and} \qquad \Delta F_c = \left(\frac{-k_c}{k_c + k_b} \right) F_e$$

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9 Bolted Joints

9.1 Elasticity

- Allowing for the initial load, F_i:

$$F_b = F_i + \left(\frac{k_b}{k_c + k_b} \right) F_e$$

$$F_c = F_i - \left(\frac{k_c}{k_c + k_b} \right) F_e$$