Shearing and Bearing Stress

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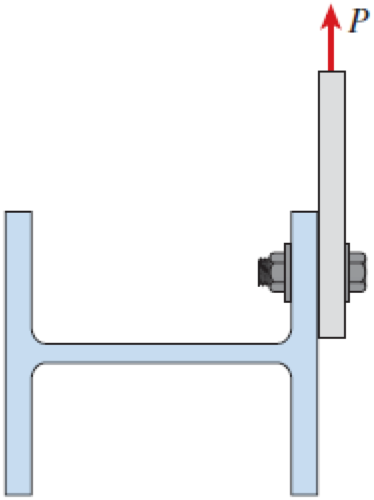
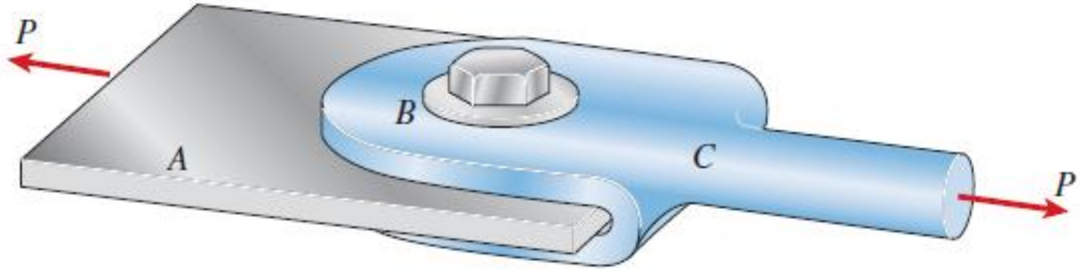
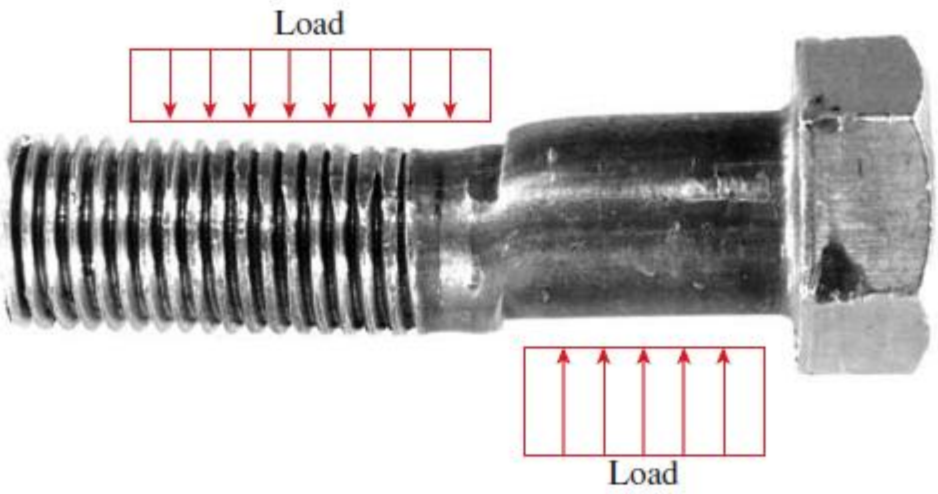
Introduction to Pin Shearing and Bearing

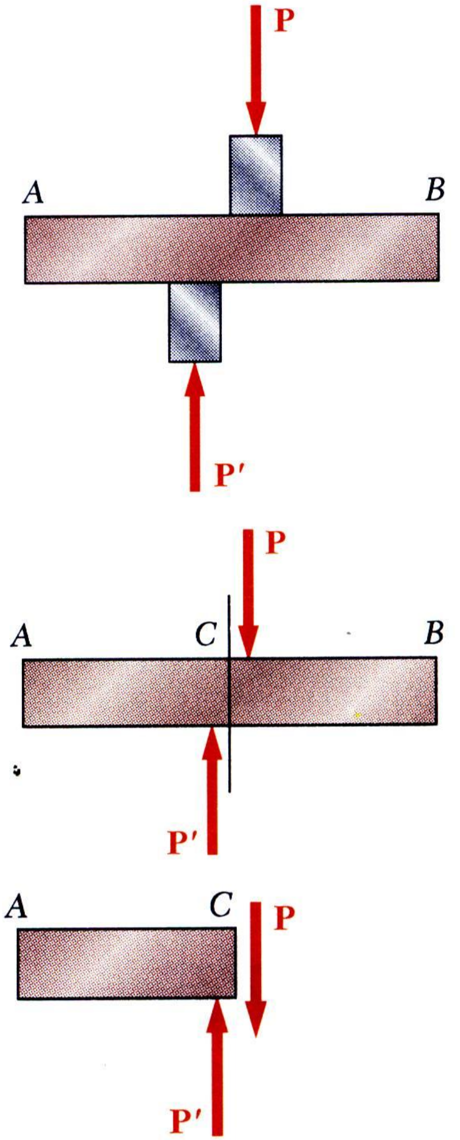






Failure of a bolt in single shear

Shearing Stress



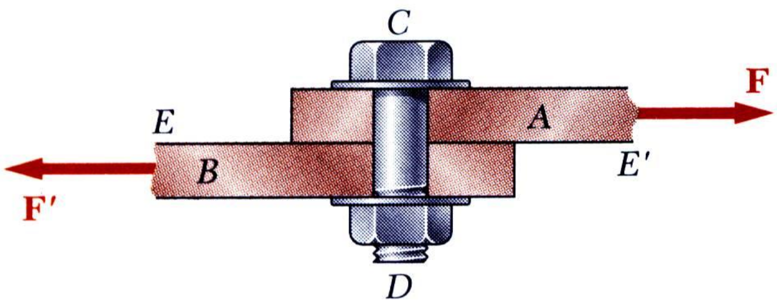
- Forces *P* and *P'* are applied transversely to the member *AB*.
- Corresponding internal forces act in the plane of section *C* and are called *shearing* forces.
- The resultant of the internal shear force distribution is defined as the *shear* of the section and is equal to the load *P*.
- The corresponding average shearing stress is,

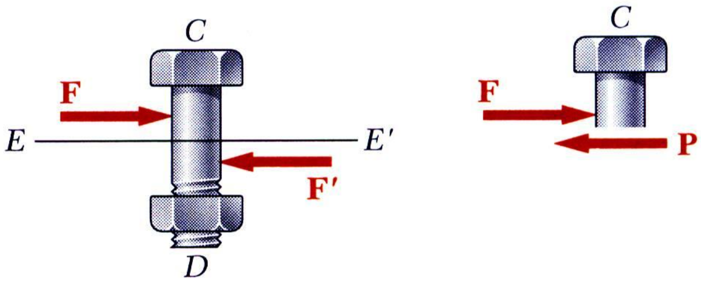
$$\tau_{\text{ave}} = \frac{P}{A}$$

- Shearing stress distribution varies from zero at the member surfaces to maximum values that may be much larger than the average value.
- The shearing stress distribution cannot be assumed to be uniform.

Shearing Stress

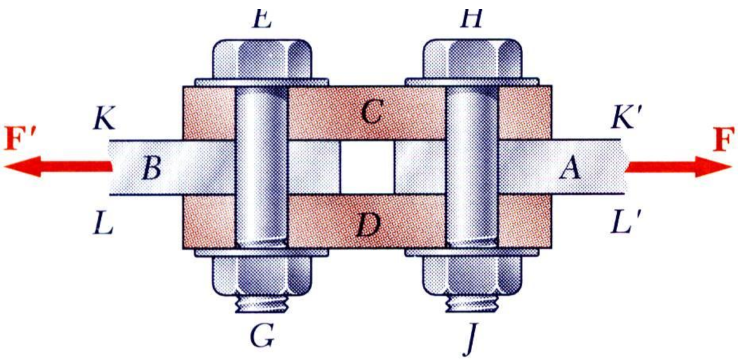
Single Shear

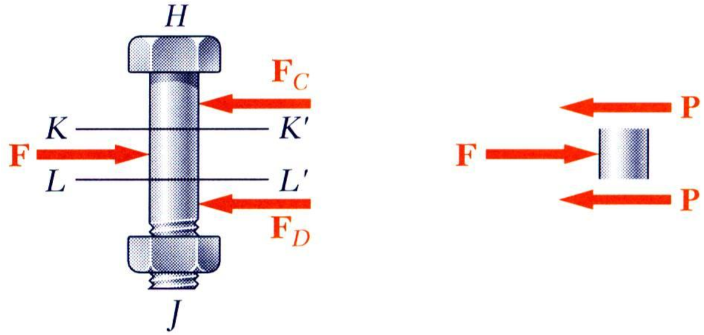




$$\tau_{\text{ave}} = \frac{P}{A} = \frac{F}{A}$$

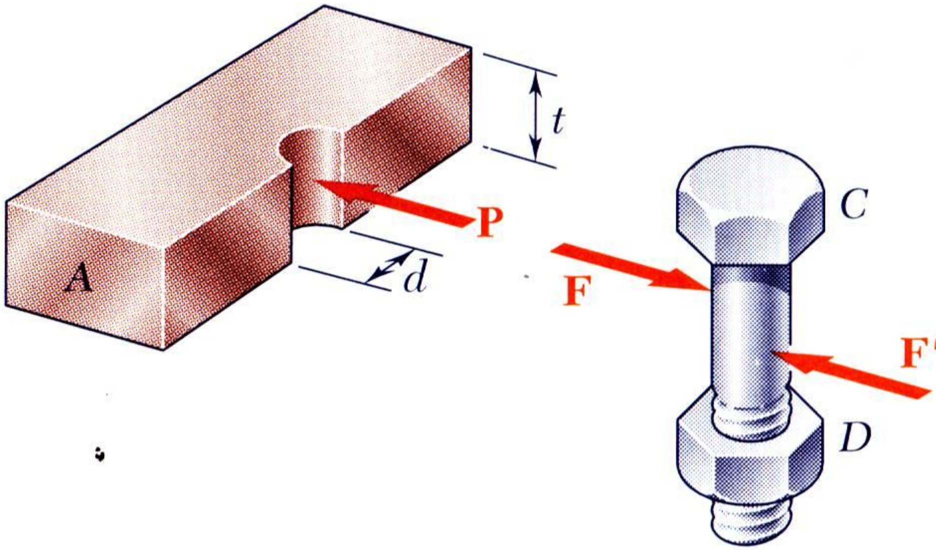
Double Shear

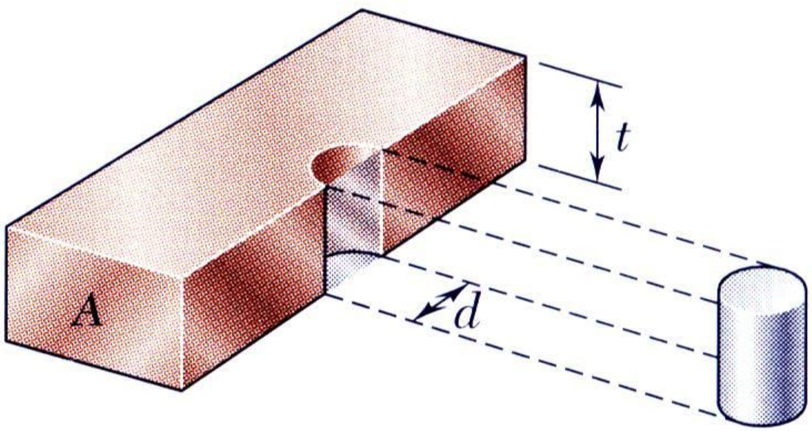




$$\tau_{\text{ave}} = \frac{P}{A} = \frac{F}{2A}$$

Bearing Stress





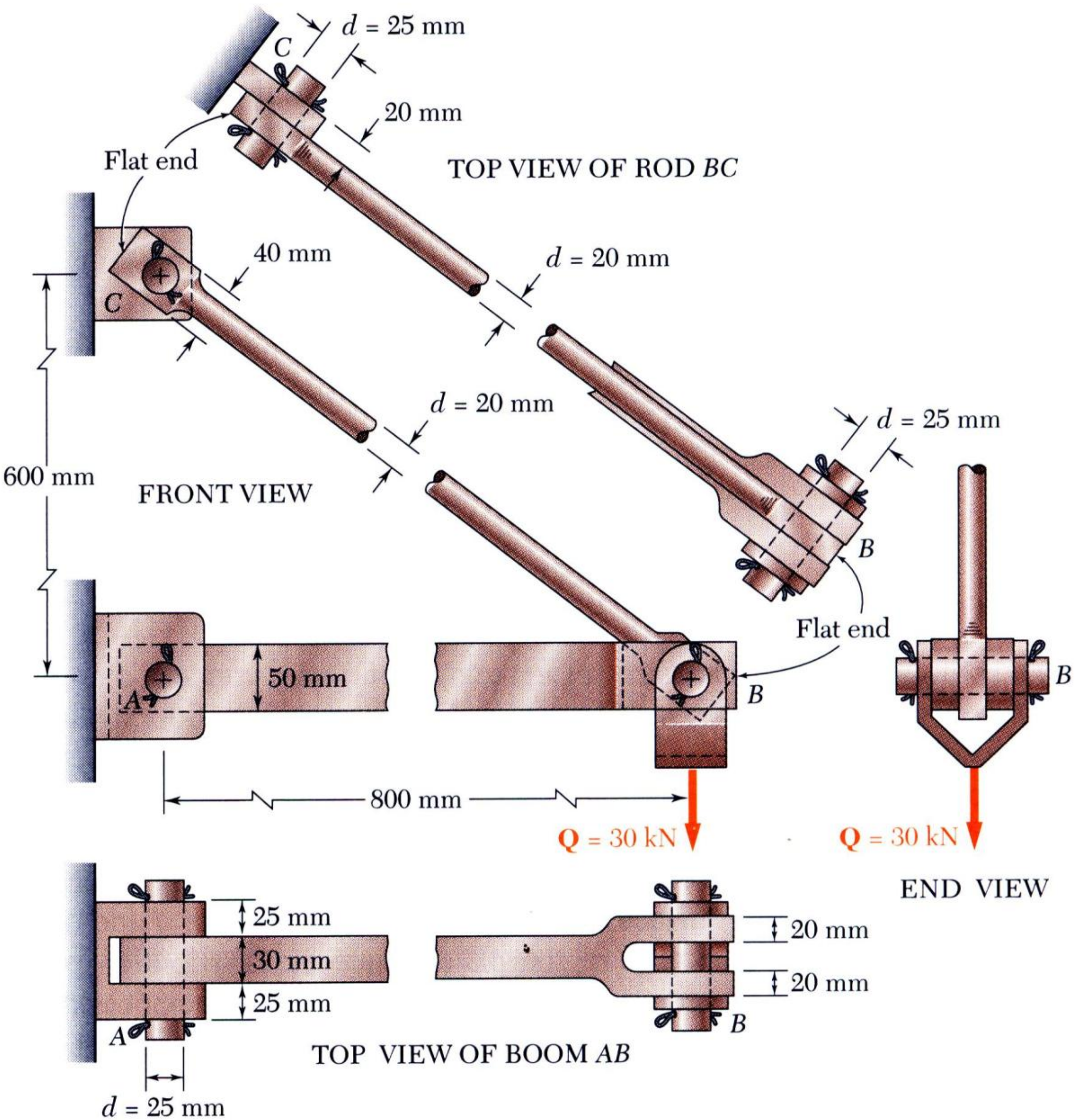
- Bolts, rivets, and pins create stresses on the points of contact or *bearing surfaces* of the members they connect.

- The resultant of the force distribution on the surface is equal and opposite to the force exerted on the pin.

- Corresponding average force intensity is called the bearing stress,

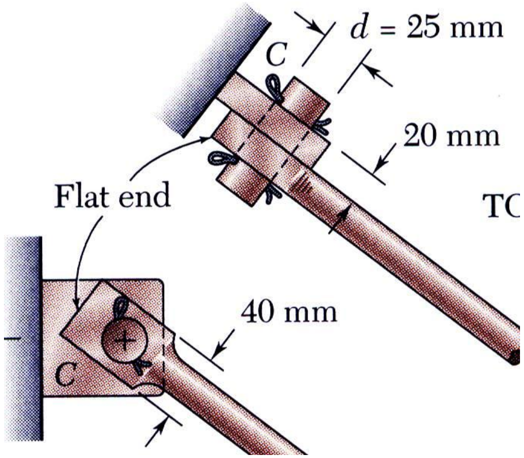
$$\sigma_{\mathrm{b}} = \frac{P}{A} = \frac{P}{t\,d}$$

Stress Analysis & Design Example



- Would like to determine the stresses in the members and connections of the structure shown.
- From a statics analysis:
  $F_{AB} = 40$ kN (compression)
  $F_{BC} = 50$ kN (tension)
- Must consider maximum normal stresses in *AB* and *BC*, and the shearing stress and bearing stress at each pinned connection

Rod & Boom Normal Stresses



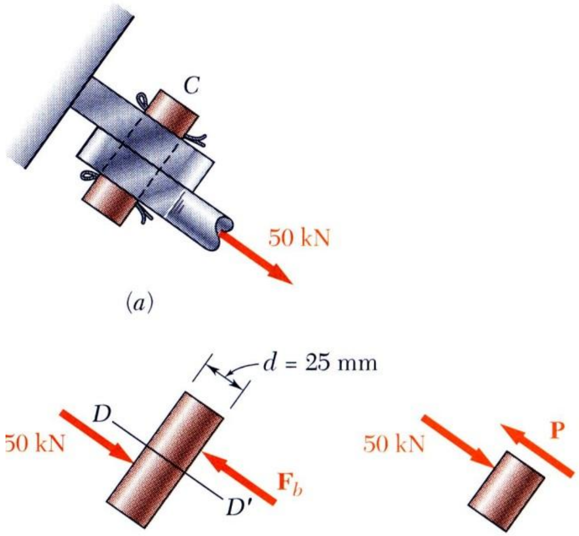
- The rod is in tension with an axial force of 50 kN.
- At the rod center, the average normal stress in the circular cross-section ($A = 314\text{x}10^{-6}\text{m}^2$) is σ_{BC} = +159 MPa.
- At the flattened rod ends, the smallest cross-sectional area occurs at the pin centerline,

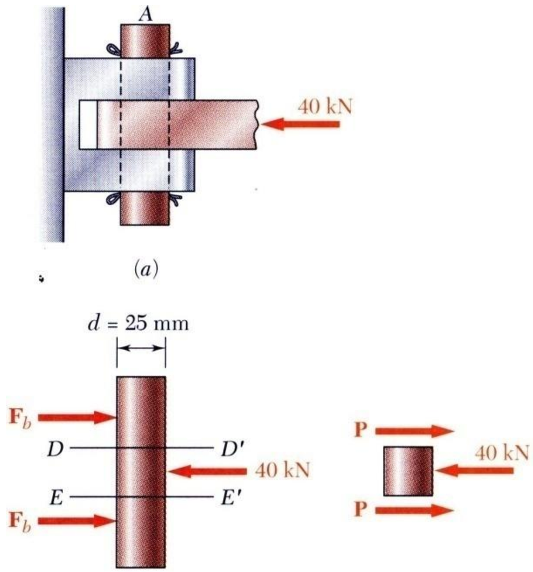
$$A = (20\,\text{mm})(40\,\text{mm} - 25\,\text{mm}) = 300\times10^{-6}\,\text{m}^2$$

$$\sigma_{BC,end} = \frac{P}{A} = \frac{50\times10^3\,N}{300\times10^{-6}\,\text{m}^2} = 167\,\text{MPa}$$

- The boom is in compression with an axial force of 40 kN and average normal stress of –26.7 MPa.
- The minimum area sections at the boom ends are unstressed since the boom is in compression.

Pin Shearing Stresses





- The cross-sectional area for pins at *A*, *B*, and *C*,

$$A = \pi r^2 = \pi\left(\frac{25\,\text{mm}}{2}\right)^2 = 491\times10^{-6}\,\text{m}^2$$

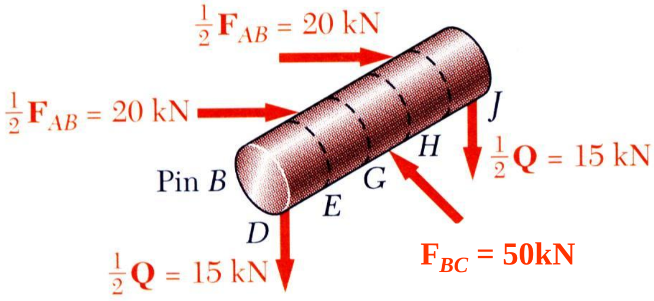
- The force on the pin at *C* is equal to the force exerted by the rod *BC*,

$$\tau_{C,ave} = \frac{P}{A} = \frac{50\times10^3\,\text{N}}{491\times10^{-6}\,\text{m}^2} = 102\,\text{MPa}$$

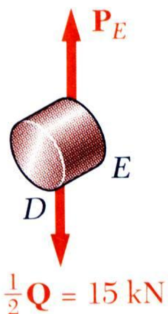
- The pin at *A* is in double shear with a total force equal to the force exerted by the boom *AB*,

$$\tau_{A,ave} = \frac{P}{A} = \frac{20\,\text{kN}}{491\times10^{-6}\,\text{m}^2} = 40.7\,\text{MPa}$$

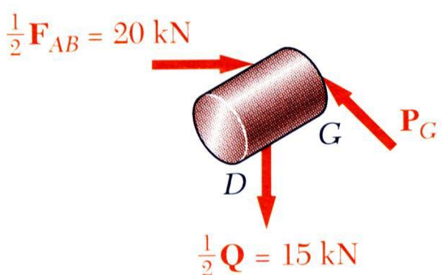
Pin Shearing Stresses



(a)



(b)



- Divide the pin at *B* into sections to determine the section with the largest shear force,

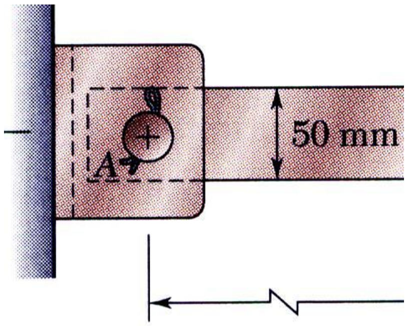
$$P_E = 15\,\text{kN}$$

$$P_G = 25\,\text{kN} \;\; \text{(largest)}$$

- Evaluate the corresponding average shearing stress,

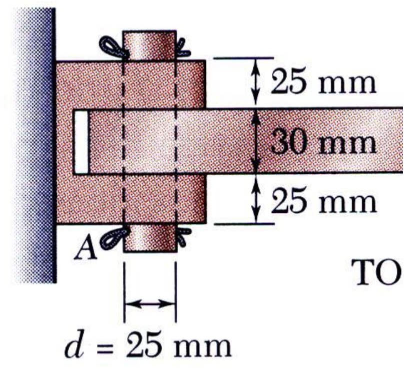
$$\tau_{B,ave} = \frac{P_G}{A} = \frac{25\,\text{kN}}{491\times 10^{-6}\,\text{m}^2} = 50.9\,\text{MPa}$$

Pin Bearing Stresses



- To determine the bearing stress at A in the boom AB, we have t = 30 mm and d = 25 mm,

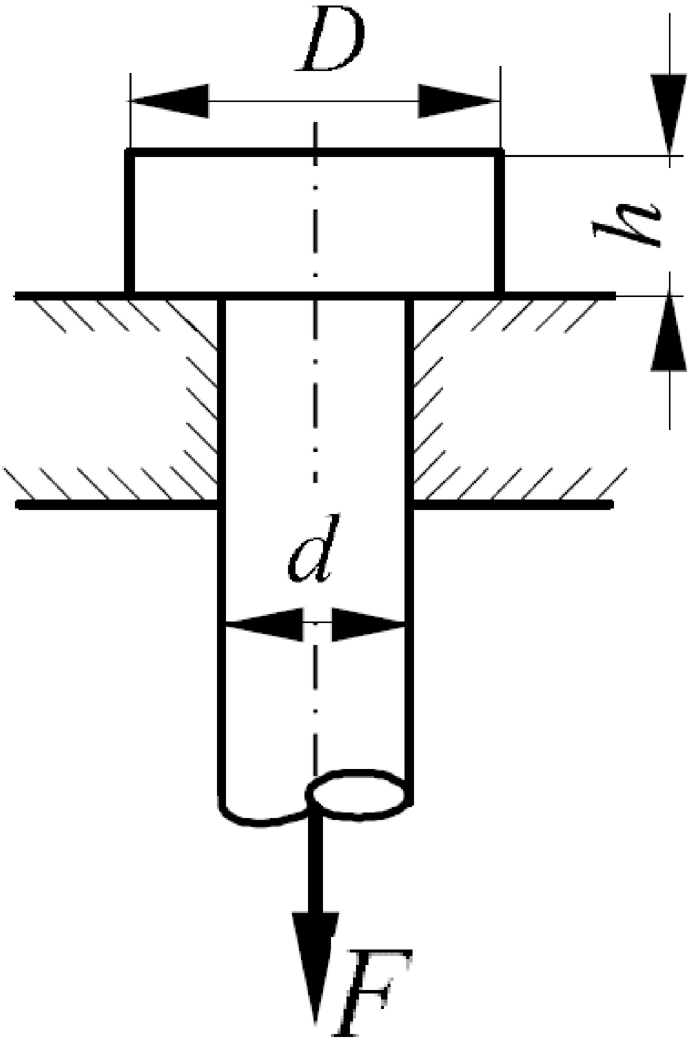
$$\sigma_b = \frac{P}{td} = \frac{40\,\mathrm{kN}}{(30\,\mathrm{mm})(25\,\mathrm{mm})} = 53.3\,\mathrm{MPa}$$

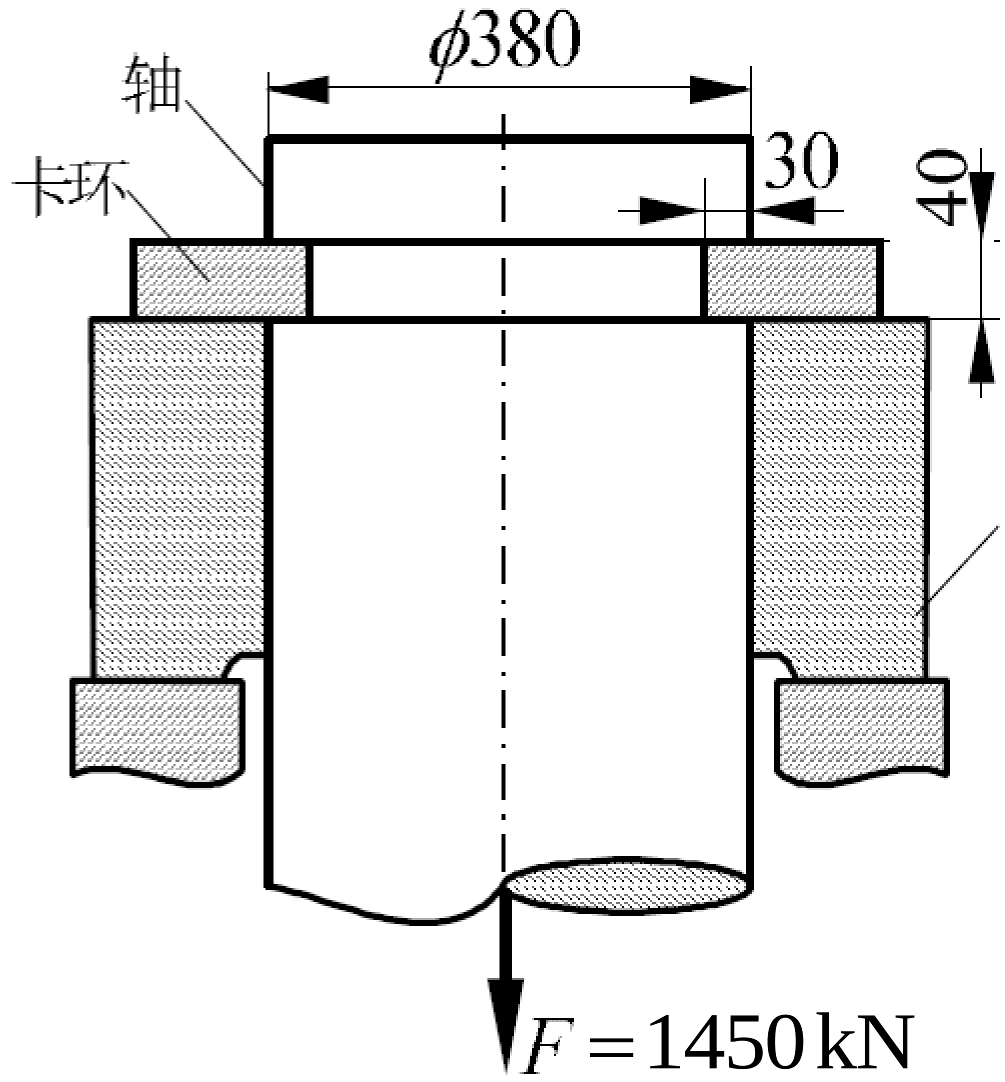


- To determine the bearing stress at A in the bracket, we have t = 2(25 mm) = 50 mm and d = 25 mm,

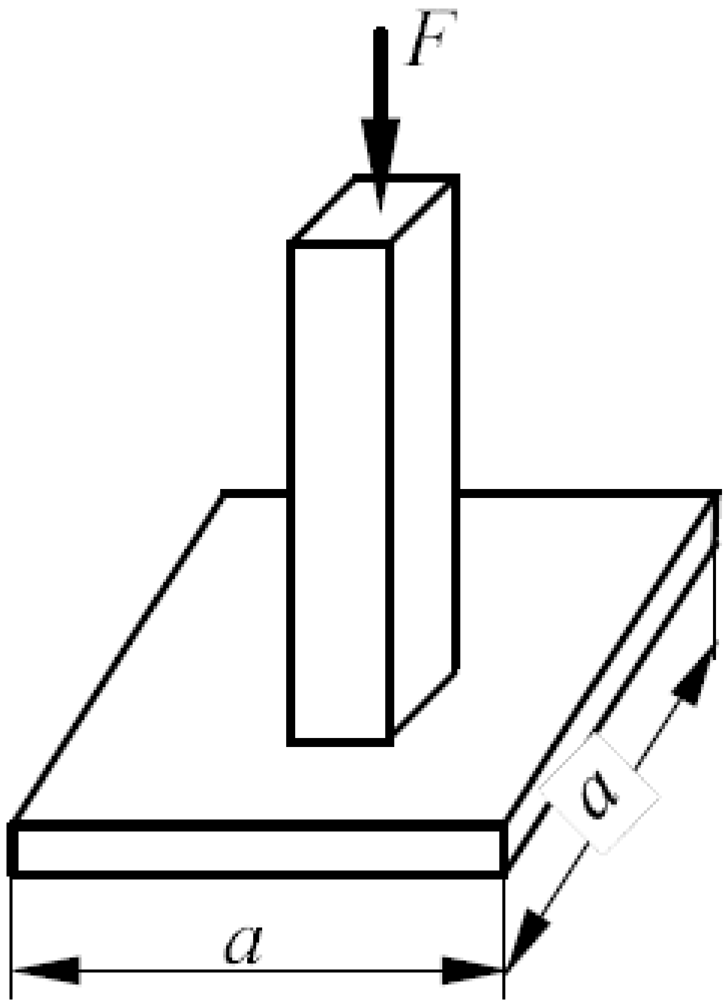
$$\sigma_b = \frac{P}{td} = \frac{40\,\mathrm{kN}}{(50\,\mathrm{mm})(25\,\mathrm{mm})} = 32.0\,\mathrm{MPa}$$

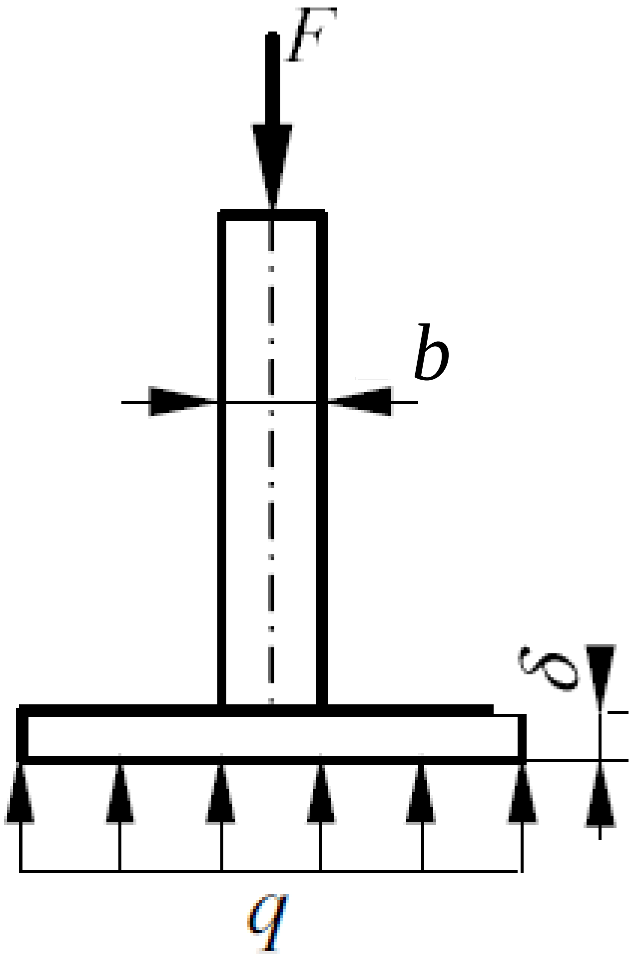
More Examples



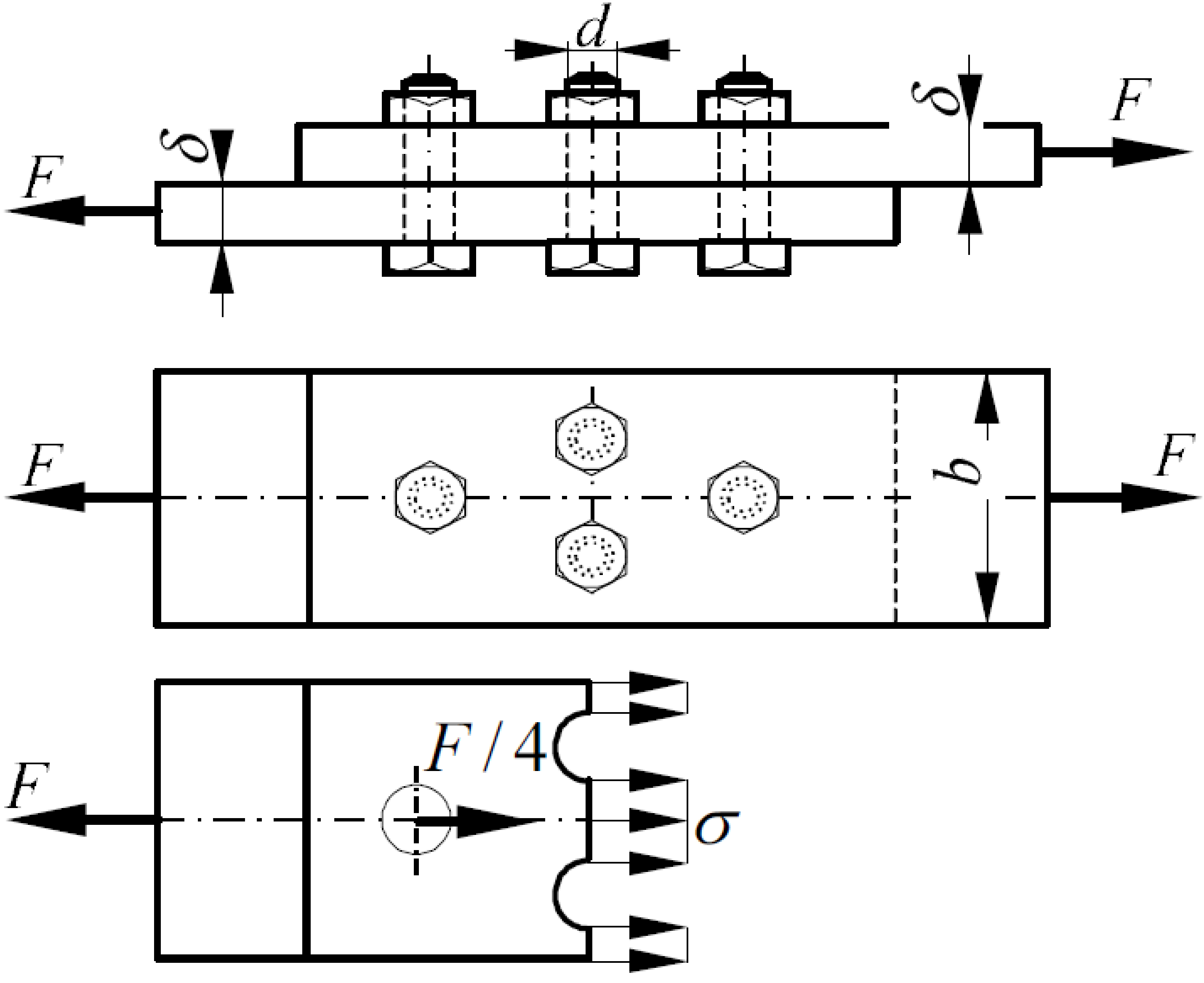


More Examples





More Examples



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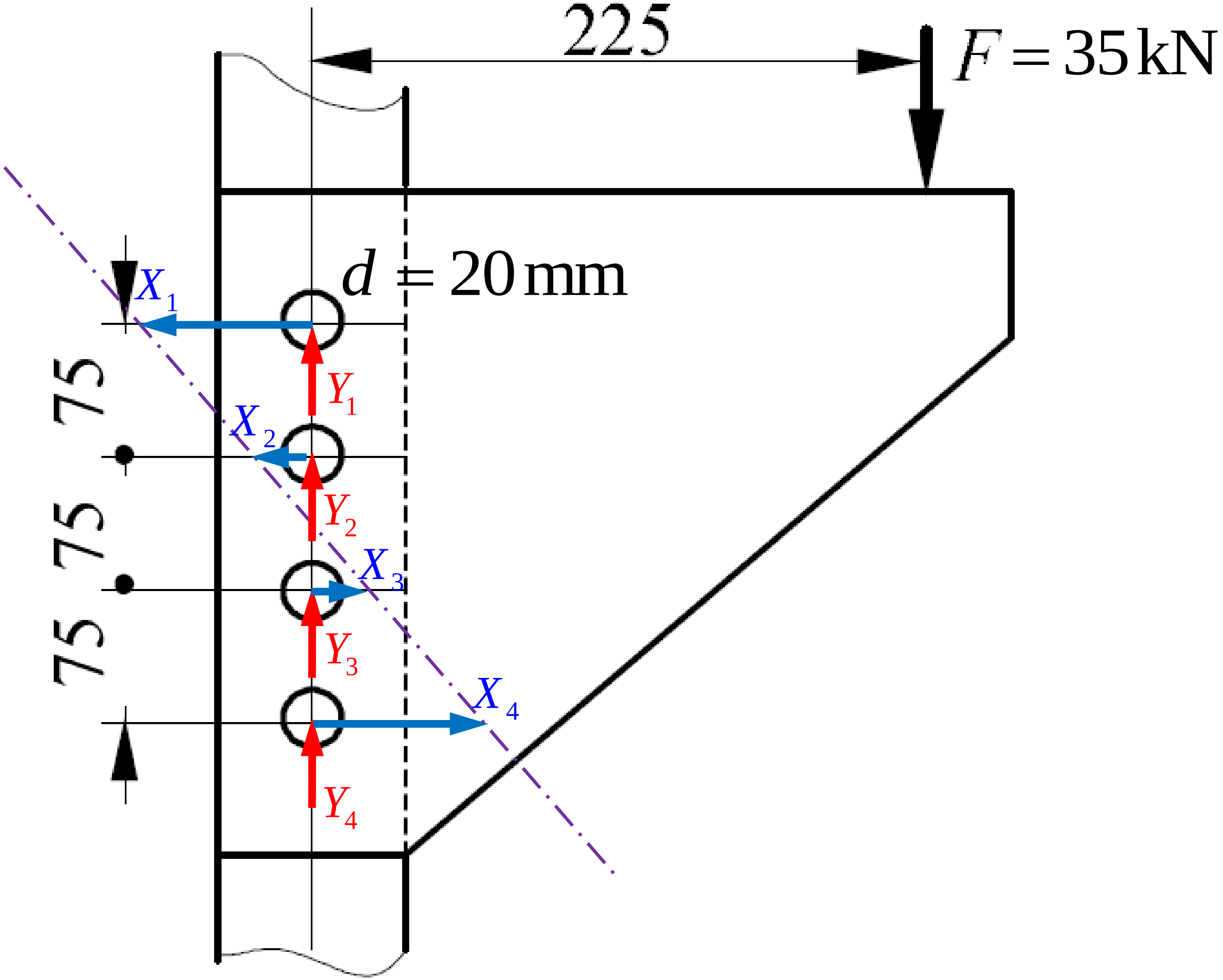

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