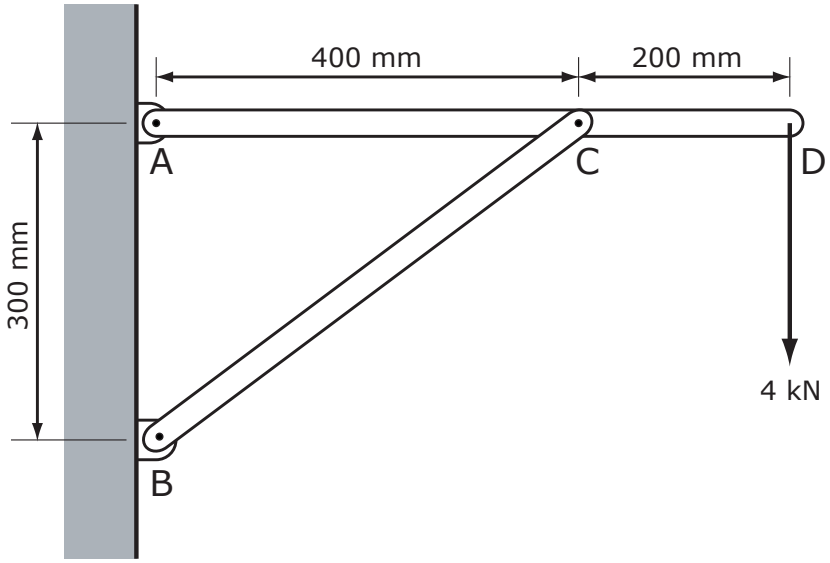
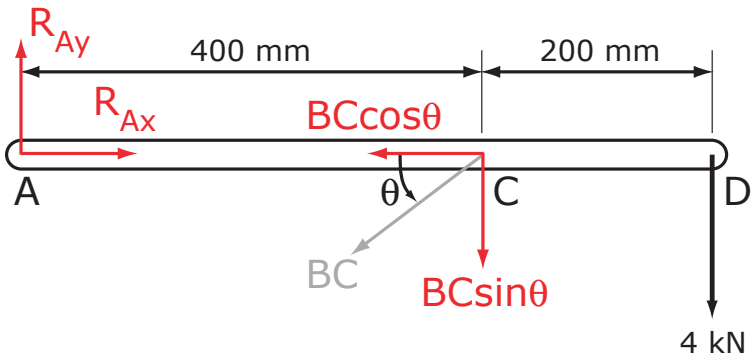
(Cheng, 9-26) Bolts at A and B are in double shear. The allowable stress, τ_{allow}, is 120 MPa. Find the required size for the bolts at A and B.



Solution:

Let $\angle ABC = \theta$. Length BC is 500 mm (Pythagoras), so $\sin\theta = 3/5$ and $\cos\theta = 4/5$. Draw the FBD for the three force member, ACD.



First, take moments about A to find the tension in the strut BC:

$$\begin{aligned} \Sigma M_A &= -BC\sin\theta\cdot(400) - 4(600) \\ &= 0 \\ BC &= -\frac{4\times 600}{400\times(3/5)} \\ &= -10 \text{ kN} \end{aligned}$$

Now, sum the y-components of the forces on ACD to find the R_{Ay}:

$$\begin{aligned} \Sigma F_y &= R_{Ay} - BC\sin\theta - 4 \\ &= 0 \\ R_{Ay} &= BC\sin\theta + 4 \\ &= -10\,(3/5) + 4 \\ &= -2 \text{ kN} \end{aligned}$$

Do the same for the x-components:

$$\begin{aligned}
\Sigma F_x &= R_{Ax} - BC\cos\theta \\
&= 0 \\
R_{Ax} &= BC\cos\theta \\
&= -10\,(4/5) \\
&= -8 \text{ kN}
\end{aligned}$$

Now, we can find the magnitude of the reaction at A:

$$\begin{aligned}
R_A &= \sqrt{(R_{Ax})^2 + (R_{Ay})^2} \\
&= \sqrt{(-8)^2 + 2^2} \\
&= 8.2462 \text{ kN} \\
&= 8\,246.2 \text{ N}
\end{aligned}$$

The reaction at B is given by the magnitude of the force in two-force member BC:

$$R_B = 10 \text{ kN}$$

Now we are in a position to find the shear stresses in the bolts at A and at B. The bolts are in double shear, so the shear force is shared equally between the two shear planes.

At A:

$$\begin{aligned}
\tau_A &= \text{force/area} \\
&= \frac{R_A}{2 \times A} \\
&= \frac{R_A}{2 \times (\pi d^2/4)} \\
d &= \sqrt{\frac{R_A}{(\pi/2) \times \tau_A}} \\
&= \sqrt{\frac{8\,246.2}{(\pi/2) \times 120}} \\
&= 6.6142 \text{ mm}
\end{aligned}$$

Thus, the size of bolt required at A is 7 mm.

At B: Similarly,

$$\begin{aligned}
d &= \sqrt{\frac{R_B}{(\pi/2) \times \tau_B}} \\
&= \sqrt{\frac{10\,000}{(\pi/2) \times 120}} \\
&= 7.2837 \text{ mm}
\end{aligned}$$

Thus, the size of bolt required at B is 8 mm.