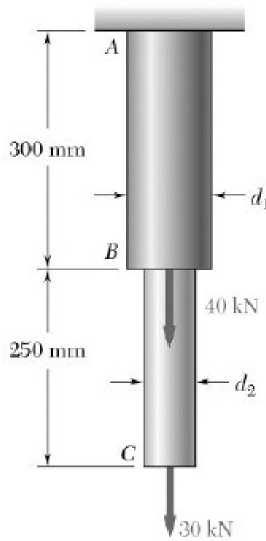
Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Knowing that the average normal stress must not exceed 175 MPa in rod AB and 150 MPa in rod BC, determine the smallest allowable values of d_1 and d_2.



(a) Rod AB

$$P = 40 + 30 = 70 \text{ kN} = 70 \times 10^3 \text{N}$$

$$\sigma_{AB} = \frac{P}{A_{AB}} = \frac{P}{\frac{\pi}{4}d_1^2} = \frac{4P}{\pi d_1^2}$$

$$d_1 = \sqrt{\frac{4P}{\pi \sigma_{AB}}} = \sqrt{\frac{(4)(70 \times 10^3)}{\pi(175 \times 10^6)}} = 22.6 \times 10^{-3} \text{m}$$

$d_1 = 22.6$ mm ◀

(b) Rod BC

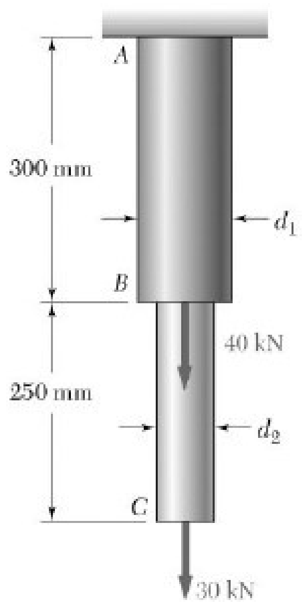
$$P = 30 \text{ kN} = 30 \times 10^3 \text{N}$$

$$\sigma_{BC} = \frac{P}{A_{BC}} = \frac{P}{\frac{\pi}{4}d_2^2} = \frac{4P}{\pi d_2^2}$$

$$d_2 = \sqrt{\frac{4P}{\pi \sigma_{BC}}} = \sqrt{\frac{(4)(30 \times 10^3)}{\pi(150 \times 10^6)}} = 15.96 \times 10^{-3} \text{m}$$

$d_2 = 15.96$ mm ◀

Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Knowing that $d_1 = 50$ mm and $d_2 = 30$ mm, find the average normal stress at the midsection of (*a*) rod *AB*, (*b*) rod *BC*.



(*a*) Rod *AB*

$$P = 40 + 30 = 70\text{ kN} = 70\times10^3\text{N}$$

$$A = \frac{\pi}{4}d_1^2 = \frac{\pi}{4}(50)^2 = 1.9635\times10^3\text{mm}^2 = 1.9635\times10^{-3}\text{m}^2$$

$$\sigma_{AB} = \frac{P}{A} = \frac{70\times10^3}{1.9635\times10^{-3}} = 35.7\times10^6\text{Pa}$$

$\sigma_{AB} = 35.7$ MPa ◀

(*b*) Rod *BC*

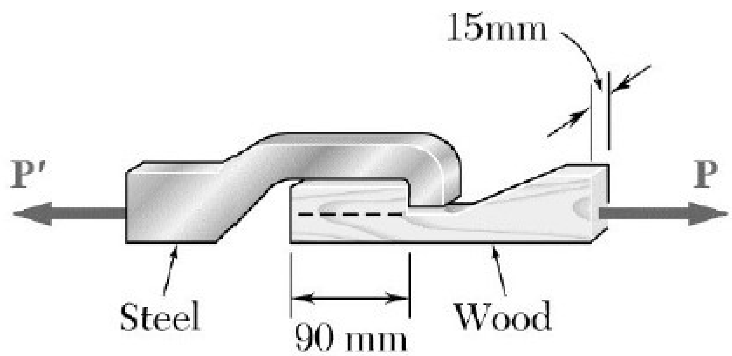
$$P = 30\text{ kN} = 30\times10^3\text{N}$$

$$A = \frac{\pi}{4}d_2^2 = \frac{\pi}{4}(30)^2 = 706.86\text{ mm}^2 = 706.86\times10^{-6}\text{m}^2$$

$$\sigma_{BC} = \frac{P}{A} = \frac{30\times10^3}{706.86\times10^{-6}} = 42.4\times10^6\text{Pa}$$

$\sigma_{BC} = 42.4$ MPa ◀

When the force **P** reached 8 kN, the wooden specimen shown failed in shear along the surface indicated by the dashed line. Determine the average shearing stress along that surface at the time of failure.

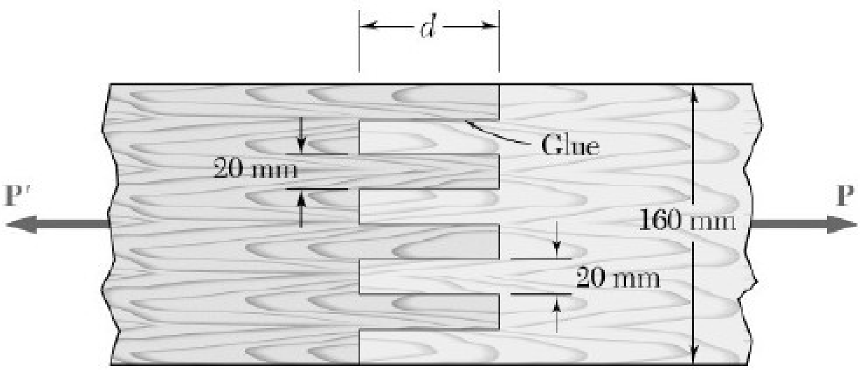


Area being sheared: $A = 90 \text{ mm} \times 15 \text{ mm} = 1350 \text{ mm}^2 = 1350 \times 10^{-6} \text{m}^2$

Force: $P = 8 \times 10^3 \text{ N}$

Shearing stress: $\tau = \dfrac{P}{A} - \dfrac{8 \times 10^3}{1350 \times 10^{-6}} = 5.93 \times 10^6 \text{ Pa}$ $\tau = 5.93 \text{ MPa}$ ◀

Two wooden planks, each 22 mm thick and 160 mm wide, are joined by the glued mortise joint shown. Knowing that the joint will fail when the average shearing stress in the glue reaches 820 kPa, determine the smallest allowable length d of the cuts if the joint is to withstand an axial load of magnitude $P = 7.6$ kN.



Seven surfaces carry the total load $P = 7.6 \text{ kN} = 7.6 \times 10^3$.

Let $t = 22$ mm.

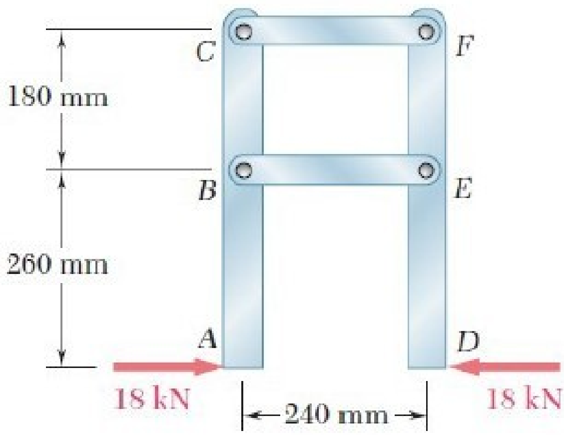
Each glue area is $A = dt$

$$\tau = \frac{P}{7A} \qquad A = \frac{P}{7\tau} = \frac{7.6 \times 10^3}{(7)(820 \times 10^3)} = 1.32404 \times 10^{-3} \text{m}^2$$

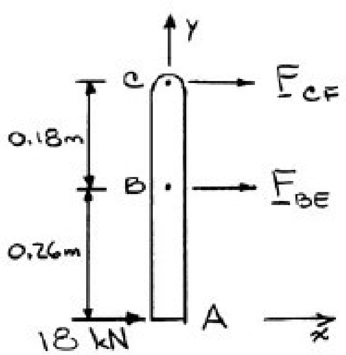
$$= 1.32404 \times 10^3 \text{mm}^2$$

$$d = \frac{A}{t} = \frac{1.32404 \times 10^3}{22} = 60.2 \qquad d = 60.2 \text{ mm} \blacktriangleleft$$

Members *ABC* and *DEF* are joined with steel links (E = 200 GPa). Each of the links is made of a pair of 25 × 35-mm plates. Determine the change in length of (*a*) member *BE*, (*b*) member *CF*.



Free body diagram of Member *ABC*:



$+\circlearrowleft \Sigma M_B = 0$:

$(0.26 \text{ m})(18 \text{ kN}) - (0.18 \text{ m})F_{CF} = 0$

$F_{CF} = 26.0 \text{ kN}$

$+\longrightarrow \Sigma F_x = 0$:

$18 \text{ kN} + F_{BE} + 26.0 \text{ kN} = 0$

$F_{BE} = -44.0 \text{ kN}$

Area for link made of two plates:

$A = 2(0.025 \text{ m})(0.035 \text{ m}) = 1.750 \times 10^{-3} \text{ m}^2$

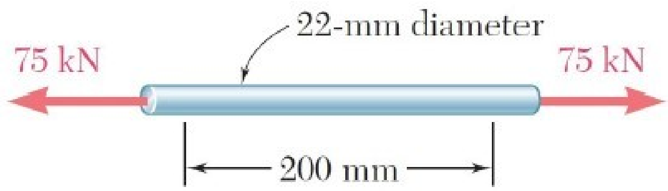
(*a*) $$\delta_{BE} = \frac{F_{BE}L}{EA} = \frac{(-44.0 \times 10^3 \text{ N})(0.240 \text{ m})}{(200 \times 10^9 \text{ Pa})(1.75 \times 10^{-3} \text{ m}^2)}$$
$$= -30.171 \times 10^{-6} \text{ m}$$

$\delta_{BE} = -0.0302 \text{ mm}$ ◀

(*b*) $$\delta_{CF} = \frac{F_{BF}L}{EA} = \frac{(26.0 \times 10^3 \text{ N})(0.240 \text{ m})}{(200 \times 10^9 \text{ Pa})(1.75 \times 10^{-3} \text{ m}^2)}$$
$$= 17.8286 \times 10^{-6} \text{ m}$$

$\delta_{CF} = 0.01783 \text{ mm}$ ◀

In a standard tensile test, a steel rod of 22-mm diameter is subjected to a tension force of 75 kN. Knowing that poission ratio is 0.3 and E=200 Gpa, determine (a) the elongation of the rod in a 200-mm gage length, (b) thechange in diameter of the rod.



$P = 75 \text{ kN} = 75 \times 10^3 \text{ N}$ $\quad A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(0.022)^2 = 380.13 \times 10^{-6} \text{ m}^2$

$$\sigma = \frac{P}{A} = \frac{75 \times 10^3}{380.13 \times 10^{-6}} = 197.301 \times 10^6 \text{ Pa}$$

$$\varepsilon_x = \frac{\sigma}{E} = \frac{197.301 \times 10^6}{200 \times 10^9} = 986.51 \times 10^{-6}$$

$$\delta_x = L\varepsilon_x = (200 \text{ mm})(986.51 \times 10^{-6})$$

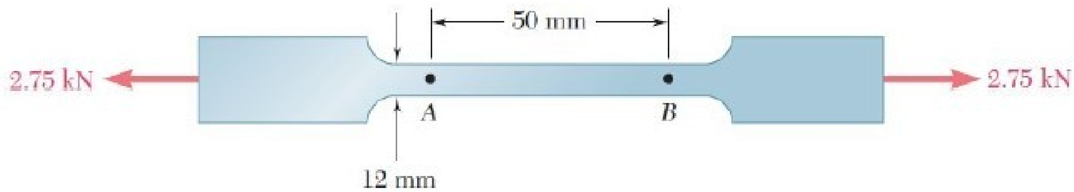
(a) $\delta_x = 0.1973 \text{ mm}$ ◀

$$\varepsilon_y = -\nu\varepsilon_x = -(0.3)(986.51 \times 10^{-6}) = -295.95 \times 10^{-6}$$

$$\delta_y = d\varepsilon_y = (22 \text{ mm})(-295.95 \times 10^{-6})$$

(b) $\delta_y = -0.00651 \text{ mm}$ ◀

A 2.75-kN tensile load is applied to a test coupon made from 1.6-mm flat steel plate (E=200 Gpa, ν =0.30). Determine the resulting change (a) in the 50-mm gage length, (b) in the thickness of portion AB.



$A = (1.6)(12) = 19.20 \text{ mm}^2$

$= 19.20 \times 10^{-6} \text{ m}^2$

$P = 2.75 \times 10^3 \text{ N}$

$\sigma_x = \frac{P}{A} = \frac{2.75 \times 10^3}{19.20 \times 10^{-6}}$

$= 143.229 \times 10^6 \text{ Pa}$

$\varepsilon_x = \frac{\sigma_x}{E} = \frac{143.229 \times 10^6}{200 \times 10^9} = 716.15 \times 10^{-6}$

$\varepsilon_y = \varepsilon_z = -\upsilon \varepsilon_x = -(0.30)(716.15 \times 10^{-6}) = -214.84 \times 10^{-6}$

(a) $L = 0.050 \text{ m}$ $\delta_x = L\varepsilon_x = (0.50)(716.15 \times 10^{-6}) = 35.808 \times 10^{-6} \text{ m}$

0.0358 mm ◀

(b) $t = 0.0016 \text{ m}$ $\delta_z = t\varepsilon_z = (0.0016)(-214.84 \times 10^{-6}) = -343.74 \times 10^{-9} \text{ m}$

−0.000344 mm ◀