

## PROBLEM 1.1

Two solid cylindrical rods $A B$ and $B C$ are welded together at $B$ and loaded as shown. Knowing that $d_{1}=30 \mathrm{~mm}$ and $d_{2}=50 \mathrm{~mm}$, find the average normal stress at the midsection of $(a) \operatorname{rod} A B,(b) \operatorname{rod} B C$.

## SOLUTION

(a) $\operatorname{Rod} A B$ :

Force:

$$
P=60 \times 10^{3} \mathrm{~N} \quad \text { tension }
$$

Area:

$$
A=\frac{\pi}{4} d_{1}^{2}=\frac{\pi}{4}\left(30 \times 10^{-3}\right)^{2}=706.86 \times 10^{-6} \mathrm{~m}^{2}
$$

Normal stress: $\quad \sigma_{A B}=\frac{P}{A}=\frac{60 \times 10^{3}}{706.86 \times 10^{-6}}=84.882 \times 10^{6} \mathrm{~Pa}$

$$
\sigma_{A B}=84.9 \mathrm{MPa}
$$

(b) $\operatorname{Rod} B C$ :

Force: $\quad P=60 \times 10^{3}-(2)\left(125 \times 10^{3}\right)=-190 \times 10^{3} \mathrm{~N}$
Area: $\quad A=\frac{\pi}{4} d_{2}^{2}=\frac{\pi}{4}\left(50 \times 10^{-3}\right)^{2}=1.96350 \times 10^{-3} \mathrm{~m}^{2}$
Normal stress: $\quad \sigma_{B C}=\frac{P}{A}=\frac{-190 \times 10^{3}}{1.96350 \times 10^{-3}}=-96.766 \times 10^{6} \mathrm{~Pa}$

$$
\sigma_{B C}=-96.8 \mathrm{MPa}
$$

PROPRIETARY MATERIAL. Copyright © 2015 McGraw-Hill Education. This is proprietary material solely for authorized instructor use. Not authorized for sale or distribution in any manner. This document may not be copied, scanned, duplicated, forwarded, distributed, or posted on a website, in whole or part.


## PROBLEM 1.2

Two solid cylindrical rods $A B$ and $B C$ are welded together at $B$ and loaded as shown. Knowing that the average normal stress must not exceed 150 MPa in either rod, determine the smallest allowable values of the diameters $d_{1}$ and $d_{2}$.

## SOLUTION

(a) $\operatorname{Rod} A B$ :

Force:

$$
P=60 \times 10^{3} \mathrm{~N}
$$

Stress: $\quad \sigma_{A B}=150 \times 10^{6} \mathrm{~Pa}$
Area:

$$
A=\frac{\pi}{4} d_{1}^{2}
$$

$$
\sigma_{A B}=\frac{P}{A} \quad \therefore \quad A=\frac{P}{\sigma_{A B}}
$$

$$
\frac{\pi}{4} d_{1}^{2}=\frac{P}{\sigma_{A B}}
$$

$$
d_{1}^{2}=\frac{4 P}{\pi \sigma_{A B}}=\frac{(4)\left(60 \times 10^{3}\right)}{\pi\left(150 \times 10^{6}\right)}=509.30 \times 10^{-6} \mathrm{~m}^{2}
$$

$$
d_{1}=22.568 \times 10^{-3} \mathrm{~m}
$$

$$
d_{1}=22.6 \mathrm{~mm}
$$

(b) $\operatorname{Rod} B C$ :

Force:

$$
P=60 \times 10^{3}-(2)\left(125 \times 10^{3}\right)=-190 \times 10^{3} \mathrm{~N}
$$

Stress: $\quad \sigma_{B C}=-150 \times 10^{6} \mathrm{~Pa}$
Area:

$$
\begin{aligned}
A & =\frac{\pi}{4} d_{2}^{2} \\
\sigma_{B C} & =\frac{P}{A}=\frac{4 P}{\pi d_{2}^{2}} \\
d_{2}^{2} & =\frac{4 P}{\pi \sigma_{B C}}=\frac{(4)\left(-190 \times 10^{3}\right)}{\pi\left(-150 \times 10^{6}\right)}=1.61277 \times 10^{-3} \mathrm{~m}^{2} \\
d_{2} & =40.159 \times 10^{-3} \mathrm{~m}
\end{aligned}
$$

$$
d_{2}=40.2 \mathrm{~mm}
$$

PROPRIETARY MATERIAL. Copyright © 2015 McGraw-Hill Education. This is proprietary material solely for authorized instructor use. Not authorized for sale or distribution in any manner. This document may not be copied, scanned, duplicated, forwarded, distributed, or posted on a website, in whole or part.


## PROBLEM 1.3

Two solid cylindrical rods $A B$ and $B C$ are welded together at $B$ and loaded as shown. Knowing that $P=10 \mathrm{kips}$, find the average normal stress at the midsection of $(a) \operatorname{rod} A B,(b) \operatorname{rod} B C$.

## SOLUTION

(a) $\operatorname{Rod} A B$ :

$$
\begin{aligned}
& P=12+10=22 \mathrm{kips} \\
& A=\frac{\pi}{4} d_{1}^{2}=\frac{\pi}{4}(1.25)^{2}=1.22718 \mathrm{in}^{2}
\end{aligned}
$$

$$
\sigma_{A B}=\frac{P}{A}=\frac{22}{1.22718}=17.927 \mathrm{ksi} \quad \sigma_{A B}=17.93 \mathrm{ksi}
$$

(b) $\operatorname{Rod} B C$ :

$$
\begin{aligned}
P & =10 \mathrm{kips} \\
A & =\frac{\pi}{4} d_{2}^{2}=\frac{\pi}{4}(0.75)^{2}=0.44179 \mathrm{in}^{2} \\
\sigma_{A B} & =\frac{P}{A}=\frac{10}{0.44179}=22.635 \mathrm{ksi} \quad \sigma_{A B}=22.6 \mathrm{ksi}
\end{aligned}
$$

