## Sign Convention for Shear Stresses

This book adopts the following convention:

> ***Positive shear stresses tend to rotate the element in a clockwise direction.***
>
> ***Negative shear stresses tend to rotate the element in a counterclockwise direction.***

A double subscript notation is used to denote shear stresses in a plane. For example, in Figure 3–5(c), drawn for the $x$–$y$ plane, the pair of shear stresses, $\tau_{xy}$, indicates a shear stress acting on the element face that is perpendicular to the $x$-axis and parallel to the $y$-axis. Then $\tau_{yx}$ acts on the face that is perpendicular to the $y$-axis and parallel to the $x$-axis. In this example, $\tau_{xy}$ is positive and $\tau_{yx}$ is negative.

## 3–4 NORMAL STRESSES DUE TO DIRECT AXIAL LOAD

*Stress* can be defined as the internal resistance offered by a unit area of a material to an externally applied load. *Normal stresses* ($\sigma$) are either *tensile* (positive) or *compressive* (negative).

For a load-carrying member in which the external load is uniformly distributed across the cross-sectional area of the member, the magnitude of the stress can be calculated from the direct stress formula:

**➪ Direct Tensile or Compressive Stress**

$$\sigma = \text{force/area} = F/A \qquad \textbf{(3–1)}$$

The units for stress are always *force per unit area*, as is evident from Equation (3–1). Common units in the U.S. Customary system and the SI metric system follow.

| *U.S. Customary Units* | *SI Metric Units* |
|---|---|
| lb/in$^2$ = psi | N/m$^2$ = pascal = Pa |
| kips/in$^2$ = ksi | N/mm$^2$ = megapascal |
| Note: 1.0 kip = 1000 lb | = $10^6$ Pa = MPa |
| 1.0 ksi = 1000 psi | |

The conditions on the use of Equation (3–1) are as follows:

1. The load-carrying member must be straight.
2. The line of action of the load must pass through the centroid of the cross section of the member.
3. The member must be of uniform cross section near where the stress is being computed.
4. The material must be homogeneous and isotropic.
5. In the case of compression members, the member must be short to prevent buckling. The conditions under which buckling is expected are discussed in Chapter 6.

**Example Problem 3–1** A tensile force of 9500 N is applied to a 12-mm-diameter round bar, as shown in Figure 3–6. Compute the direct tensile stress in the bar.

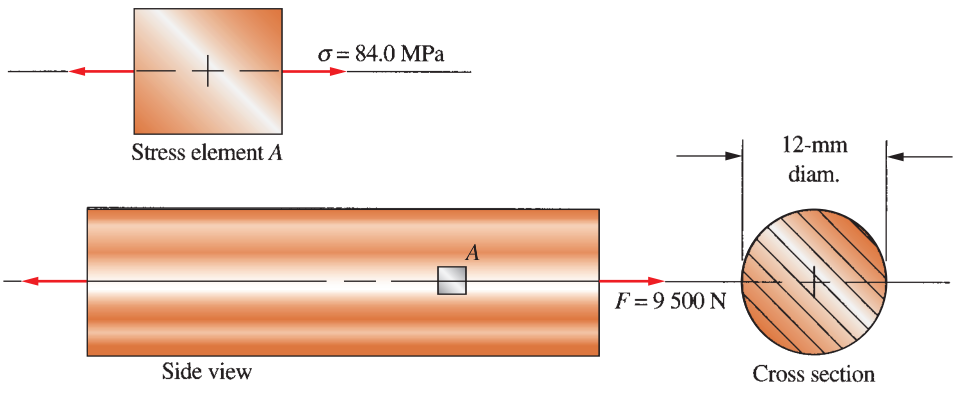


**FIGURE 3–6** Tensile stress in a round bar

**Solution**

Objective: Compute the tensile stress in the round bar.

Given: Force = $F$ = 9500 N; diameter = $D$ = 12 mm.

Analysis: Use the direct tensile stress formula, Equation (3–1): $\sigma = F/A$. Compute the cross-sectional area from $A = \pi D^2/4$.

Results:

$$A = \pi D^2/4 = \pi(12\text{ mm})^2/4 = 113\text{ mm}^2$$

$$\sigma = F/A = (9500\text{ N})/(113\text{ mm}^2) = 84.0\text{ N/mm}^2 = 84.0\text{ MPa}$$

Comment: The results are shown on stress element $A$ in Figure 3–6, which can be taken to be anywhere within the bar because, ideally, the stress is uniform on any cross section. The cube form of the element is as shown in Figure 3–5 (a).