this point. The most difficult task for the machine designer in this context is to correctly determine the locations, types, and magnitudes of all the applied stresses acting on the part. The calculation of the principal stresses is then *pro forma* using equations 4.4 to 4.6.

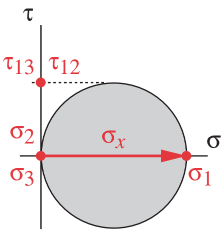

FIGURE 4-8

Mohr's Circles for Unidirectional Tensile Stress (Two circles are coincident and the third is a point, since $\sigma_2 = \sigma_3 = 0$)

4.7 AXIAL TENSION *View the Lecture 3 Stress Distribution Video (50:52)**

Axial loading in tension (Figure 4-9) is one of the simplest types of loading that can be applied to an element. It is assumed that the load is applied through the area centroid of the element and that the two opposing forces are colinear along the *x* axis. At some distance away from the ends where the forces are applied, the stress distribution across the cross section of the element is essentially uniform, as shown in Figure 4-10. This is one reason that this loading method is used to test material properties, as was described in Chapter 2. The applied normal stress for pure axial tension can be calculated from

$$\sigma_x = \frac{P}{A} \tag{4.7}$$

where *P* is the applied force and *A* is the cross-sectional area at the point of interest. This is an applied normal stress. The principal normal stresses and the maximum shear stress can be found from equations 4-6. The Mohr's circle for this case was shown in Figure 4-8. The allowable load for any particular tension member can be determined by a comparison of the principal stresses with the appropriate strength of the material. For example, if the material is ductile, then the tensile yield strength, S_y, could be compared to the principal normal stress and the safety factor calculated as $N = S_y / \sigma_1$. Failure criteria will be dealt with in detail in Chapter 5.

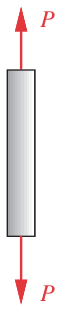

FIGURE 4-9

A Bar in Axial Tension

The change in length Δs of a member of uniform cross section loaded in pure axial tension is given by

$$\Delta s = \frac{Pl}{AE} \tag{4.8}$$

where *P* is the applied force, *A* is the cross-sectional area, *l* is the loaded length, and *E* is Young's modulus for the material.

Tension loading is very common, occurring in cables, struts, bolts, and many other axially loaded elements. The designer needs to check carefully for the presence of other loads on the member that, if present in combination with the tensile load, will create a different stress state than the pure axial tension described here.

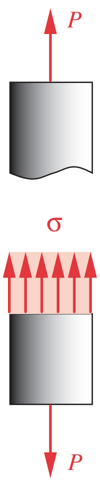

FIGURE 4-10

Stress Distribution Across a Bar in Axial Tension

4.8 DIRECT SHEAR STRESS, BEARING STRESS, AND TEAROUT

These types of loading occur mainly in pin-jointed, bolted, or riveted connections. Possible modes of failure are direct shear of the connector (pin, rivet, or bolt), bearing failure of connector or surrounding material, or a tearing out of the material surrounding the connector. See the Case Studies later in this chapter for examples of the calculation of these types of stresses.

* http://www.designofmachinery.com/MD/03_Stress_Distribution.mp4