ENGR 2541 - Mechanics of Materials

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1 Axial Stress

1.1 Overview

Mechanics of materials provides a means to analyze the effects of *stresses* and *deformations*. Statics covered finding a balance of forces, including internal forces such as *shear*, *bending*, and *tension/compression*. Finding these internal forces is imperative to be able to determine the integrity of a structure. In addition to the internal forces, the integrity of a structure is also partially determined by the *dimensions* and *materials* of that structure.

In the analysis of a rod, for example, the ability for that rod to withstand the internal forces (its structural integrity) is determined by the cross-sectional area and the material of the rod.

(a) Resultant Force

(b) Elementary Forces

Figure 1: Axial force is the resultant of distributed elementary forces

1.2 Analyzing Axial Stress

In Figure 1, the *stress* being experiences by the object is the **force per unit area**, denoted by the Greek letter sigma (σ).

Stress

Stress can be calculated by dividing the total axial force by the cross-sectional area:

$$\sigma = \frac{P}{A} \quad \textbf{1.1}$$

By convention, a positive force indicates **tensile stress** while a negative force indicates **compressive stress**.

(a) Tensile Stress

(b) Compressive Stress

Figure 2: Tensile vs. Compressive Force

The cross section, as seen in Figure 3, is perpendicular to the axial forces. The corresponding stress in the object in described as *normal stress*.

Thus, the formula of $\sigma = \frac{P}{A}$ gives the normal stress of an object under axial loading.

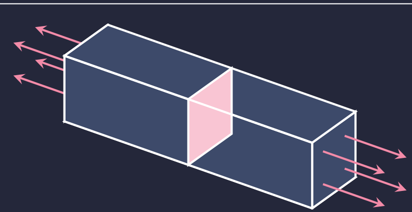

Figure 3: Normal Stress

1.3 Stress Points

The formula of $\sigma = \frac{P}{A}$ is only useful for *averages* or *ranges*. This can calculate the average value of the stress over the entire cross section. However, what about calculating at specific points?

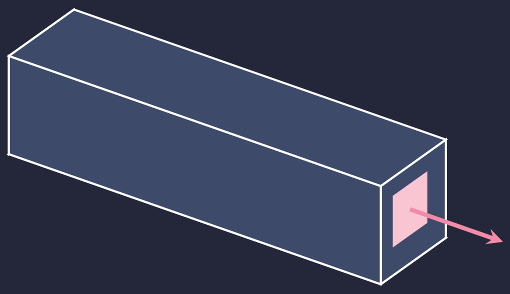

Figure 4: Stress Points

In Figure 4, to find the stress of the highlighted area, the working equation can still be applied, just now with a smaller area. To find the stress at a single point, rather than just a smaller area, stress must be calculated as the area approaches zero.

Stress at a Single Point

$$\sigma = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A} \tag{1.2}$$