Static Failure Criteria - Part III

Brittle materials

Unlike ductile materials, brittle materials simply facture after stress exceeds fracture strength of the material.

Tensile fracture strength = S_{ft}

Compressive fracture strength = S_{fc}

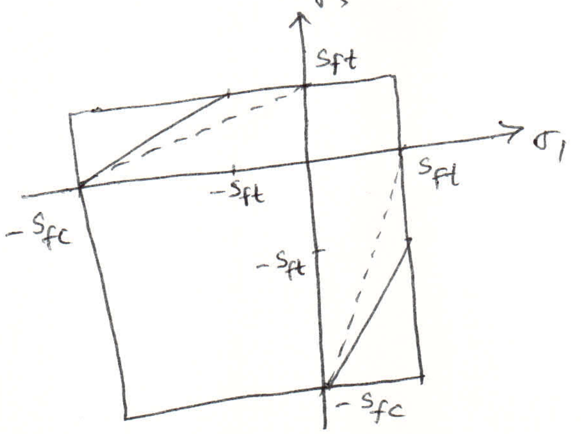
shear fracture strength = S_{fs}

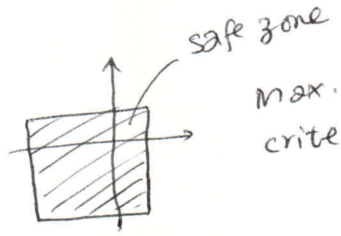
$S_{ft} < S_{fs} < S_{fc}$

S_{fc} is usually 10 to 15 times larger than S_{ft}.

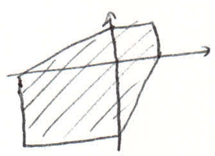
Brittle materials are weakest in tension and strongest in compression.

The max. shear stress and max. normal stress criteria are shown below. von Mises distortion theory is not applicable to brittle materials because they do not yield like ~~brittle~~ ductile materials.

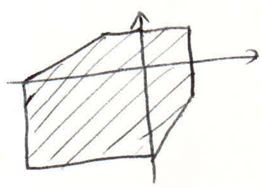




Max. normal stress criterion



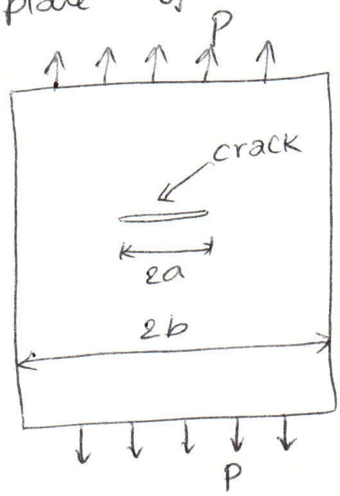
max. shear stress criterion also called **Coulomb - Mohr** criterion



Modified - Mohr criterion (based on empirical data).

Brittle materials are very sensitive to microscopic cracks inside the object or on the surface of the object. when loaded, cracks quickly propagate and break the object. we will now discuss a criterion to assess the failure of a brittle material object in the presence of a known crack.

Let there ~~be~~ be a crack of length $2a$ inside a plate of width $2b$, which is under tension.



b is much larger than a.

That is, $b \gg a$.

At the tip of the crack, stress is very intense. we define a **stress intensity factor, K** as

$$K = \sigma_{nom}\sqrt{\pi a} \quad \text{for } b \gg a$$

$$= \beta\, \sigma_{nom}\sqrt{\pi a} \quad \text{for } a \text{ not too small compared to } b$$

where $\beta = \sqrt{\sec\left(\frac{\pi a}{2b}\right)}$.

σ_{nom} = usual stress

$= \frac{\text{force}}{\text{area}}$ (in this case)

$= \frac{P}{A}$

<u>Note</u> K (one of many K's you will see in this course), has units of $Pa\sqrt{m}$ or $psi\sqrt{in}$.

Every material can only withstand certain K. That is called <u>fracture toughness</u> of the material. → denoted by K_c.

K_c is measured experimentally like S_y, S_{ft}, S_{fc}, S_{fs}, etc.

$$\boxed{FS = \text{factor of safety} = \frac{K_c}{K}}$$ for brittle material objects with cracks