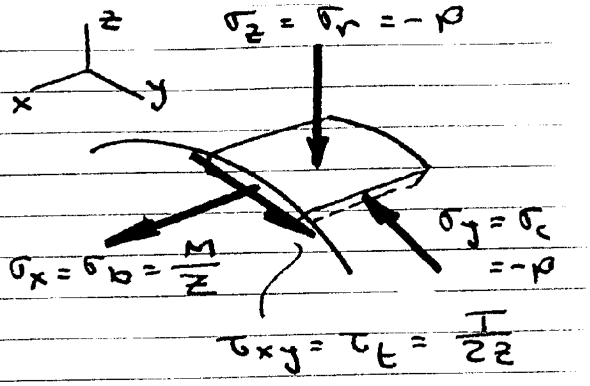
11



consider element on surface where σ_b, τ_t are known to be maxima. The loading is as shown (Note how this differs from thin cylinder + M + T). Clearly the z-direction is principal, however we'll have to resolve in x-y plane in order to find all three principals, prior to implementing the failure criterion.

The stress state is thus:

$\sigma_x = M/Z \quad \sigma_y = -p \quad \tau_{xy} = T/2Z \quad \sigma_z = -p$ (prin.)

In the x-y plane:

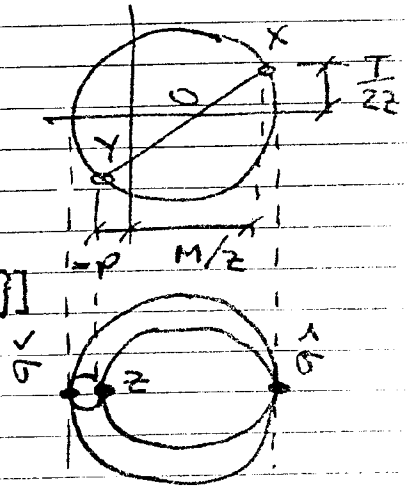
$\bar{\sigma} = \frac{1}{2}(M/Z - p)$

& base length of Δ under O-X:

$= M/Z - \bar{\sigma} = \frac{1}{2}(M/Z + p)$

$\therefore \tilde{\sigma} = \sqrt{[\frac{1}{2}(M/Z+p))^2 + (T/2Z)^2]}$

$= \frac{1}{2}\sqrt{[(M/Z+p)^2 + (T/Z)^2]}$



In the x-y plane still,

(A) $\hat{\sigma} = \bar{\sigma} + \tilde{\sigma} = \frac{1}{2}\left[\frac{M}{Z} - p + \sqrt{\{(M/Z+p)^2 + (\frac{T}{Z})^2\}}\right]$

$\check{\sigma} = \bar{\sigma} - \tilde{\sigma} = \frac{1}{2}\left[\frac{M}{Z} - p - \sqrt{- - -}\right]$

From the 3-Mohr's circle, clearly $\sigma_z \not< \check{\sigma}$ since $\sigma_z = \sigma_y = -p$. That is $\check{\sigma}$ is minimum of $\underline{\underline{3}}$ principals.

Applying max. shear stress theory:

$\sigma_e = \hat{\sigma} - \check{\sigma}$ ($\hat{\sigma}$, $\check{\sigma}$ max, min $\underline{\underline{3\text{-}D}}$ stresses)

$= \sqrt{[(M/Z+p)^2 + (T/Z)^2]}$ from (A) above

So the shaft design equation is

$S/n = \sigma_e$, or

$n\sqrt{[(M/Z+p)^2 + (T/Z)^2]} = S$

– which degenerates to eq (11b) of Notes, when $p \to 0$

The bottom of the shaft should also be checked