

**Derivation of the normal stress terms in the formulae for  $p_{zi}$  CH6, Sec3, 4.2.2  
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The formulae for the nominal pressures  $p_{zx}$  and  $p_{zy}$  contain the influence of normal stresses.

$$p_{zx} = \frac{t_a}{b} \left( \sigma_{xl} \left( \frac{\pi \cdot b}{a} \right)^2 + 2 \cdot c_y \cdot \sigma_y + \sqrt{2} \tau_1 \right)$$

$$p_{zy} = \frac{t_a}{a} \left( 2 \cdot c_x \cdot \sigma_{xl} + \sigma_y \left( \frac{\pi \cdot a}{n \cdot b} \right)^2 \left( 1 + \frac{A_y}{a \cdot t_a} \right) + \sqrt{2} \tau_1 \right)$$

with  $\sigma_{xl} = \sigma_x \left( 1 + \frac{A_x}{b \cdot t_a} \right)$

The axial acting stresses can be calculated according the TB document *New Req. of GL for Proof of Buckling Strength (inkl DIN18800).pdf*

$$M_\ell = \frac{q \ell^2}{\pi^2} = F_{Kl} \frac{\frac{\pi^2}{\ell^2} F \cdot w_0}{\frac{\pi^2}{\ell^2} F_{Kl} - \frac{\pi^2}{\ell^2} F} = F_{Kl} \frac{p_{zl} \cdot w_0}{c_l - p_{zl}}$$

where:

$p_{zl}$  = load caused by the longitudinal force

$$p_{zl} = \frac{\pi^2}{\ell^2} \cdot F = \frac{\pi^2}{\ell^2} \sigma_a \cdot A$$

The following derivation shows the equivalence of the formula for  $p_{zx}$  and the first term of the formula for  $p_{zx}$ .

$$\frac{t_a}{b} \left( \sigma_{xl} \left( \frac{\pi \cdot b}{a} \right)^2 \right) = \sigma_x \left( \frac{t_a \pi^2 b^2}{a^2 b} + \frac{t_a \pi^2 b^2 A_x}{a^2 b \cdot b t_a} \right)$$

$$= \sigma_x \frac{\pi^2}{a^2} (t_a b + A_x) = \sigma_x \frac{\pi^2}{a^2} A$$

This derivation shows in addition, that the stress  $\sigma_x$  in the formulae for  $p_{zx}$  and  $p_{zy}$  is the axial stress, acting in the stiffener.

$\sigma_x = \sigma_a$  with  $\sigma_a = \sigma_x^* - 0.3 \cdot \sigma_y^*$  where  $\sigma_x^*$  and  $\sigma_y^*$  are FE-stresses.

In case of a transverse stiffener, the stress of the second term with  $\sigma_y$  can be derived accordingly.

In the two formulae for  $p_{zx}$  and  $p_{zy}$  are different assumptions.

- Longitudinal stiffeners
  - are not supported by intermediate transverse stiffeners.
  - act always as secondary members
- Transverse stiffeners
  - are classified in two kind of stiffeners
    - a) small transverse stiffener (secondary member), located between two longitudinals
    - b) transverse stiffener with higher rigidity than the longitudinal stiffener, which is supported by intermediate longitudinal stiffeners and partially constrained at the ends (primary member)

The factor  $c_s$  characterises the support condition at the ends of the transverse stiffener in line with the categorisation. A secondary (transverse stiffener) is simply supported, a primary stiffener is partially constrained.

In case a) the stress acting normal to the stiffener is  $\sigma_x^*$ . No intermediate longitudinals have to be taken into account, so  $A_x$  is zero and the term  $\sigma_{xl} = \sigma_x^*$ . In this case is  $n \neq 1$ .

In case b) the intermediate longitudinal stiffeners provide an additional support for the transverse stiffener and shift the acting normal stress out of the plate plane. It is obvious that the normal stress has to be reduced.

$$\begin{aligned} \frac{t_a}{a}(2c_x\sigma_{xl}) &= \sigma_x \left( \frac{2t_a c_x}{a} + \frac{2t_a c_x A_x}{abt_a} \right) \\ &= 2c_x \sigma_x \left( \frac{t_a}{a} + \frac{A_x}{ab} \right) \end{aligned}$$

Both terms  $\left(\frac{t_a}{a}\right)$  and  $\left(\frac{A_x}{ab}\right)$  are much more smaller than 1 and represent the reduction factors for the normal acting stress  $\sigma_x$  with  $\sigma_x = \sigma_a$ .