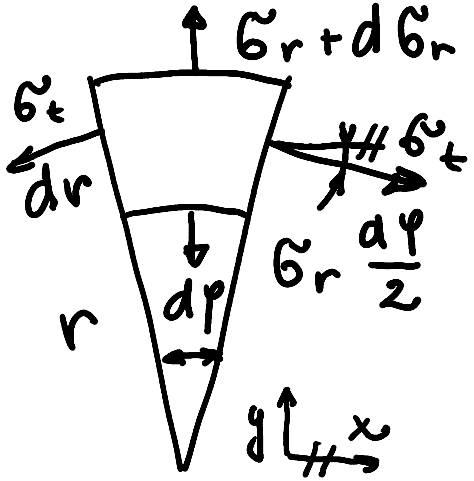


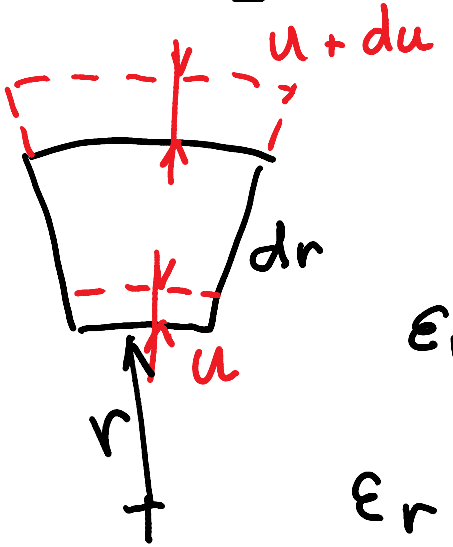
dz debelina d ploča

$$\Sigma F_{iy} = 0 = (\sigma_r + d\sigma_r)\cdot(r+dr)\,d\varphi\,dz - \sigma_r \cdot r \cdot d\varphi \cdot dz - 2\sigma_t \cdot \sin\frac{d\varphi}{2}\cdot dr \cdot dz$$

$$= \sigma_r r + d\sigma_r \cdot r + \sigma_r \cdot dr + d\sigma_r \cdot dr - \sigma_r r - \sigma_t \cdot dr$$

$$\sigma_t = r\cdot\frac{d\sigma_r}{dr} + \sigma_r = \frac{d}{dr}(r\sigma_r)$$

$$\sin\frac{d\varphi}{2} \cong \frac{d\varphi}{2}$$



$$\varepsilon_r = \frac{u + du + dr - u - dr}{dr} = \frac{du}{dr}$$

$$\varepsilon_t = \frac{(r+u)\,d\varphi - r\,d\varphi}{r\,d\varphi} = \frac{u}{r}$$

$$\varepsilon_r = \frac{d}{dr}(r\varepsilon_t)$$

$$\varepsilon_r = \frac{1}{E}(\sigma_r - \nu\sigma_t) \qquad \varepsilon_t = \frac{1}{E}(\sigma_t - \nu\sigma_r)$$

$$\varepsilon_r = \frac{d}{dr}(r \cdot \varepsilon_t)$$

$$\frac{1}{E}(\sigma_r - \nu\sigma_t) = \frac{d}{dr}(r\sigma_t - \nu r\sigma_r)\frac{1}{E}$$

$$\sigma_r - \nu\frac{d}{dr}(r\sigma_r) = \frac{d}{dr}\left(r\frac{d}{dr}(r\sigma_r) - \nu r\sigma_r\right)$$

$$\sigma_r = \frac{d}{dr}\left(r\frac{d}{dr}(r\sigma_r)\right) = \frac{d}{dr}(r\sigma_r) + r\frac{d^2}{dr^2}(r\sigma_r)$$

$$\sigma_r = \sigma_r + r\left(\frac{d}{dr}\left(\sigma_r + r\frac{d\sigma_r}{dr}\right)\right) + r\frac{d\sigma_r}{dr}$$

$$0 = r\left(\frac{d\sigma_r}{dr} + \frac{d\sigma_r}{dr} + r\frac{d^2\sigma_r}{dr^2}\right) + r\frac{d\sigma_r}{dr}$$

$$0 = \frac{d^2\sigma_r}{dr^2} + \frac{3}{r}\frac{d\sigma_r}{dr}$$

$$\sigma_r = C r^n$$

$$\frac{d\sigma_r}{dr} = C \cdot n r^{n-1}$$

$$\frac{d^2\sigma_r}{dr^2} = C n(n-1) r^{n-2}$$

$$0 = \frac{d^2\sigma_r}{dr^2} + \frac{3}{r}\frac{d\sigma_r}{dr}$$

$$0 = C n(n-1) r^{n-2} + \frac{3}{r} C n r^{n-1}$$

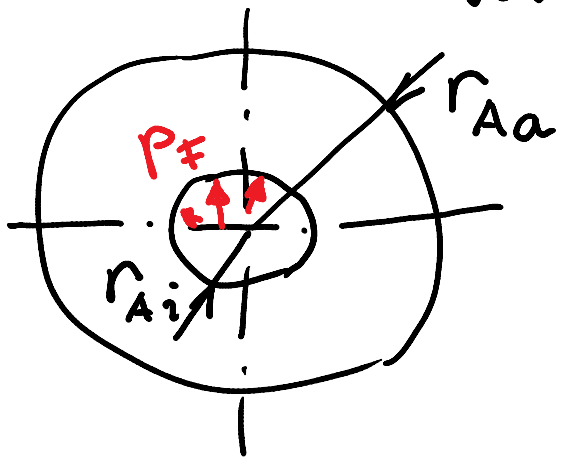
$$0 = n(n-1) + 3n = n^2 - n + 3n = n^2 + 2n = n(n+2)$$

$$n_1 = 0 \; ; \; n_2 = -2$$

$$\sigma_r = C_1 r^{n_1} + C_2 r^{n_2} = C_1 r^0 + C_2 r^{-2} = C_1 + \frac{C_2}{r^2}$$

$$\sigma_t = \frac{d}{dr}(r\sigma_r) = \frac{d}{dr}\left(r C_1 + \frac{C_2}{r}\right) = C_1 - \frac{C_2}{r^2}$$

VOTEL VALJ Z NOTRANJIM TLAKOM



$$r = r_{Ai} \quad \sigma_r = -p_F$$

$$r = r_{Aa} \quad \sigma_r = 0$$

$$-p_F = C_1 + C_2 \frac{1}{r_{Ai}^2} \quad |\cdot(-1)$$

$$0 = C_1 + C_2 \frac{1}{r_{Aa}^2}$$

$$p_F = C_2 \left(\frac{1}{r_{Aa}^2} - \frac{1}{r_{Ai}^2} \right) = C_2 \frac{r_{Ai}^2 - r_{Aa}^2}{r_{Aa}^2 \cdot r_{Ai}^2}$$

$$Q_A = \frac{r_{Ai}}{r_{Aa}}$$

$$C_2 = -p_F \cdot \frac{r_{Aa}^2 \cdot r_{Ai}^2}{r_{Aa}^2 - r_{Ai}^2} = -\frac{r_{Ai}^2}{1 - Q_A^2} p_F$$

$$0 \leq Q_A \leq 1$$

$$C_1 = +p_F \frac{r_{Ai}^2}{r_{Aa}^2 - r_{Ai}^2} = \frac{Q_A^2}{1 - Q_A^2} p_F$$

KONTROLA

$$\sigma_{r_{Ai}} = \rho_F \frac{Q_A^2}{1-Q_A^2} + (-1)\,\rho_F \frac{r_{Ai}^2}{1-Q_A^2}\,\frac{1}{r_{Ai}^2}$$

$$= \rho_F \frac{Q_A^2 - 1}{1-Q_A^2} = -\rho_F$$

$$\sigma_{r_{Aa}} = \rho_F \frac{Q_A^2}{1-Q_A^2} - \rho_F \frac{r_{Ai}^2}{1-Q_A^2}\,\frac{1}{r_{Aa}^2} = \phi$$

$$\sigma_{t_{Ai}} = \rho_F \frac{Q_A^2}{1-Q_A^2} + \rho_F \frac{1}{1-Q_A^2} = \rho_F \frac{1+Q_A^2}{1-Q_A^2}$$

$$\sigma_{t_{Aa}} = \rho_F \frac{Q_A^2}{1-Q_A^2} + \rho_F \frac{Q_A^2}{1-Q_A^2} = \rho_F \frac{2Q_A^2}{1-Q_A^2}$$

DEFORMACIJE VAJA

$$u = r\,\varepsilon_t \quad ; \quad \varepsilon_t = \frac{1}{E}\left(\sigma_t - \nu\,\sigma_r\right)$$

$$\Delta r_{Ai} = r_{Ai}\,\frac{1}{E_{Ai}}\left(\sigma_{tAi} - \nu_A\,\sigma_{rAi}\right)$$

$$\Delta r_{Ai} = \frac{r_{Ai}\,p_F}{E_A}\left(\frac{1+Q_A^2}{1-Q_A^2} + \nu_A\right)$$

$u \leftarrow \Delta r_{Ai}$

$r \leftarrow r_{Ai}$

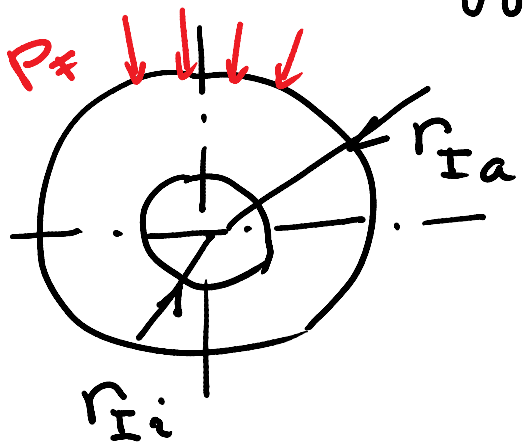
$E \leftarrow E_A$

$\sigma_t \leftarrow \sigma_{tAi}$

$\sigma_r \leftarrow \sigma_{rAi}$

$\nu \leftarrow \nu_A$

UOTEL UALJ Z ZUNANJIM TLAKOM



$$r = r_{Ii} \qquad \sigma_r = \phi$$

$$r = r_{Ia} \qquad \sigma_r = -p_F$$

$$Q_I = \frac{r_{Ii}}{r_{Ia}}$$

$$\phi \leq Q_I \leq 1$$

$$\phi = C_1 + C_2 \frac{1}{r_{Ii}^2}$$

$$-p_F = C_1 + C_2 \frac{1}{r_{Ia}^2} \qquad |-1$$

$$p_F = C_2 \left(\frac{1}{r_{Ii}^2} - \frac{1}{r_{Ia}^2} \right) = C_2 \frac{r_{Ia}^2 - r_{Ii}^2}{r_{Ii}^2 \, r_{Ia}^2}$$

$$C_2 = p_F \frac{r_{Ii}^2 \, r_{Ia}^2}{r_{Ia}^2 - r_{Ii}^2}$$

$$= p_F \frac{r_{Ii}^2}{1 - Q_I^2}$$

$$C_1 = -\frac{C_2}{r_{Ii}^2} = -p_F \frac{1}{1 - Q_I^2}$$

$$r_{Ii} \to \phi \to C_2 = \phi \wedge C_1 = -p_F$$

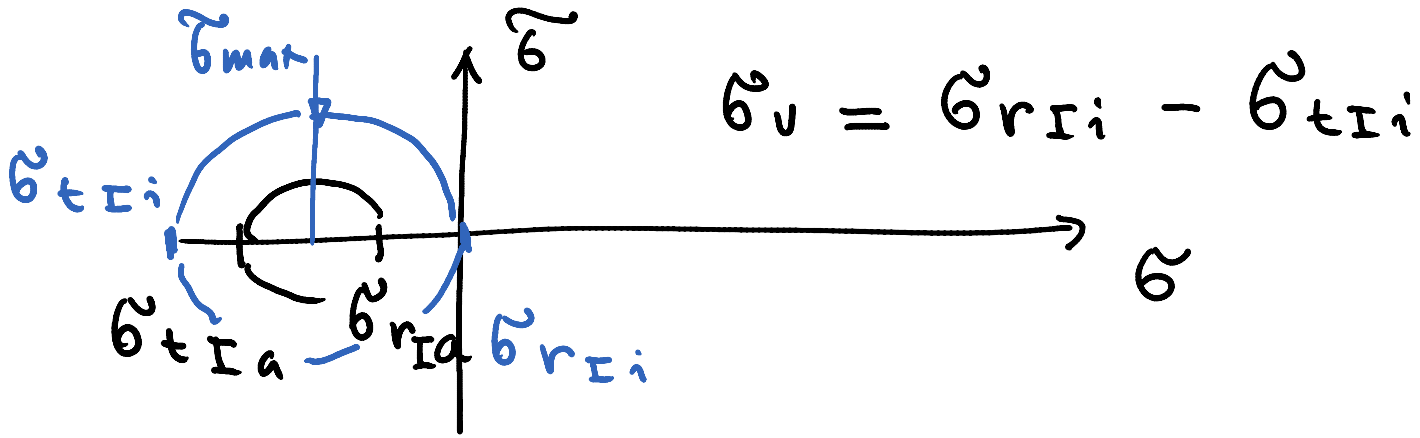
KONTROLA

$$\tilde{\sigma}_{r_{Ia}} = -\frac{p_F}{1-Q_I^2} + p_F \frac{r_{Ii}^2}{1-Q_I^2}\frac{1}{r_{Ia}^2} = -p_F \frac{-Q_I^2+1}{1-Q_I^2} = -p_F$$

$$\tilde{\sigma}_{r_{Ii}} = -\frac{p_F}{1-Q_I^2} + p_F \frac{r_{Ii}^2}{1-Q_I^2}\frac{1}{r_{Ii}^2} = 0$$

$$\tilde{\sigma}_{t_{Ia}} = -\frac{p_F}{1-Q_I^2} - \frac{Q_I^2}{1-Q_I^2} p_F = -p_F \frac{1+Q_I^2}{1-Q_I^2}$$

$$\tilde{\sigma}_{t_{Ii}} = -\frac{p_F}{1-Q_I^2} - \frac{p_F}{1-Q_I^2} = -p_F \frac{2}{1-Q_I^2}$$



$$\tilde{\sigma}_v = \tilde{\sigma}_{r_{Ii}} - \tilde{\sigma}_{t_{Ii}}$$

DEFORMACIJE VALJA

$$u = r\,\varepsilon_t \quad ; \quad \varepsilon_t = \frac{1}{E}\left(\sigma_t - \nu\sigma_r\right)$$

$$\Delta r_{Ia} = r_{Ia}\cdot\frac{1}{E_I}\left(\sigma_{t\,Ia} - \nu_I\,\sigma_{r\,Ia}\right)$$

$$= r_{Ia}\,\frac{1}{E_I}\left(-\frac{1+Q_I^2}{1-Q_I^2} + \nu_I\right)p_f$$

$$= -\frac{r_{Ia}\,p_f}{E_I}\left(\frac{1+Q_I^2}{1-Q_I^2} - \nu_I\right)$$

$u \leftarrow \Delta r_{Ia}$

$r \leftarrow r_{Ia}$

$\sigma_t \leftarrow \sigma_{t\,Ia}$

$\sigma_r \leftarrow \sigma_{r\,Ia}$

$E \leftarrow E_I$

$\nu = \nu_I$

POLNA GRED

$$r_{Ii} = \phi \qquad \sigma_t = C_1 \;;\; \sigma_r = C_1 \qquad Q_I = \phi$$

$$\sigma_{r\,Ii} = \sigma_{r\,Ia} = \sigma_{t\,Ii} = \sigma_{t\,Ia} = -\frac{\rho_F}{1 - Q_I^2} = -\rho_F$$

$$\Delta r_{Ia} = -\frac{r_{Ia} \cdot \rho_F}{E_I}(1 - \nu_I)$$

ENOOSNO NAPETOSTNO STANJE KER IMAMO
ENO SAMO GLAVNO NAPETOST !

PRIMERJALNE NAPETOSTI V KRITIČNIH TOČKAH

DIN 7190 $\quad \sigma_V = \sqrt{(\sigma_t - \sigma_r)^2 + 4\tau^2} \qquad \tau = \phi$

$2\tau_{max} = (\sigma_t - \sigma_r)$ — MODIFICIRANA HIPOTEZA NAJVEČJIH STRIŽNIH NAPETOSTI

$$\sigma_{dop} = \frac{2}{\sqrt{3}} \frac{Re\ ali\ R_{p0.2}}{\nu}$$

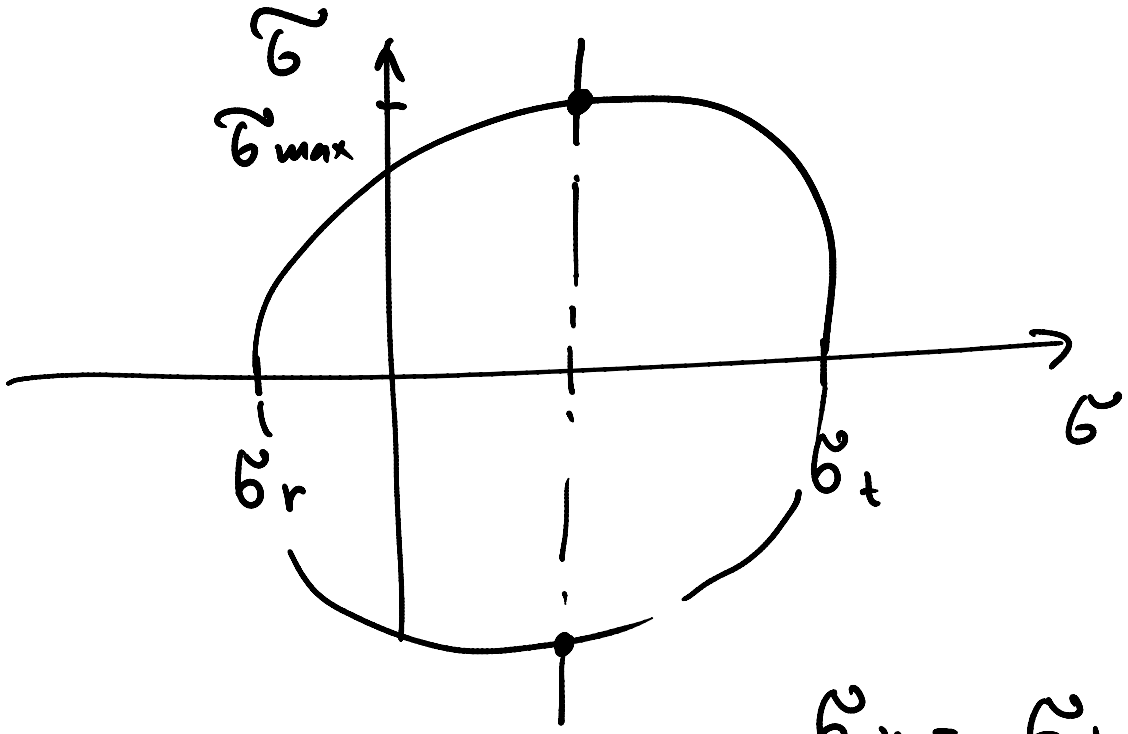
ν – VARNOST PROTI PLASTIČNI DEFORMACIJI

MAKSIMALEN DOPUSTNI TLAK

$$\sigma_V = \sigma_{tAi} - \sigma_{rAi} = \left(\frac{1+Q_A^2}{1-Q_A^2} + 1\right) p_{FmaxA} = \sigma_{dop}$$

$$\frac{1 + Q_A^2 + 1 - Q_A^2}{1 - Q_A^2}\, p_{FmaxA} = \frac{2}{\sqrt{3}} \frac{Re\ ali\ R_{p0.2}}{\nu}$$

$$p_{FmaxA} = \frac{Re\ ali\ R_{p0.2}}{\sqrt{3}\ \nu_A} \left(1 - Q_A^2\right)$$



$$\sigma_v = \sigma_t - \sigma_r = 2\,\tau_{max}$$

$$\sigma_v = |\sigma_{tIi}| = \frac{\alpha p_{F max I}}{1 - Q_I^2} = \sigma_{dop} = \frac{\alpha}{\sqrt{3}} \frac{Re\ All\ R_{p0.2}}{\nu_I}$$

$$p_{F max I} = \frac{Re\ All\ R_{p0.2}}{\nu_I} \frac{1 - Q_I^2}{\sqrt{3}}$$

VOTEL VALJ Z TUNANJIM TLAKOM

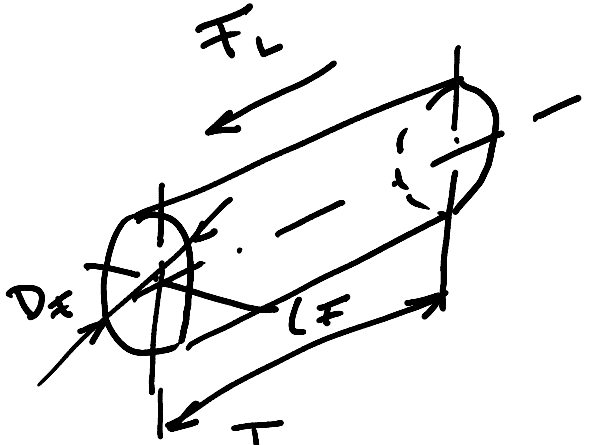
$$\sigma_v = \sqrt{\sigma^2 + 4\tau^2} = |\sigma| = p_{F max I}$$

POLNA GRED

$$p_{F max I} = \frac{2}{\sqrt{3}} \frac{Re\ All\ R_{p0.2}}{\nu_I}$$

$$p_{F max} = \min \{ p_{F max A}, p_{F max I} \}$$

MINIMALNI POTREBNI TLAČ V ZVEZI



$$K_A \nu F_L \leq F_{RL} = p_{F\min} \pi D_F l_F \cdot \mu$$

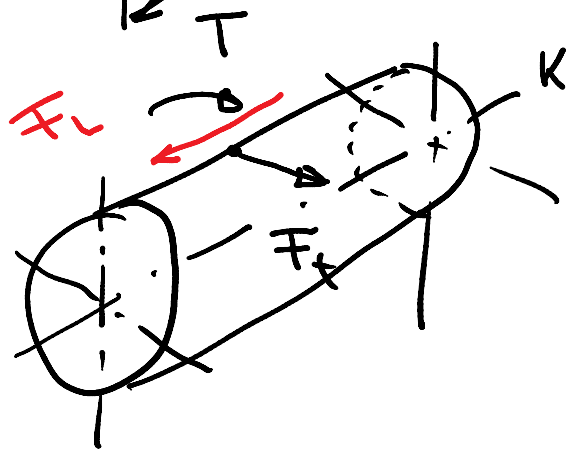
ν – VARNOST PROTI ZDRSU

F_N

K_A – OBRATOVALNI FAKTOR

$\Downarrow$

$p_{F\min}$



$$K_A \nu \frac{T2}{D_F} \leq F_{Rt} = p_{F\min} \pi D_F l_F \mu$$

$$F_{res} = \sqrt{F_L^2 + F_t^2}$$

$$K_A \cdot \nu F_{res} \leq F_{Rres} = p_{F\min} \pi D_F l_F \mu$$

$$\frac{T2}{D_F} = F_t$$

TEORETIČNA MINIMALNA IN MAKSIMALNA NADMERA

$$Z_{min} = 2(\Delta r_{Ai} - \Delta r_{Ia}) = D_F \cdot p_{Fmin}\left(\left(\frac{1+Q_A^2}{1-Q_A^2} + \nu_A\right)\frac{1}{E_A} + \left(\left(\frac{1+Q_I^2}{1-Q_I^2} - \nu_I\right)\frac{1}{E_I}\right)\right.$$

p_{Fmax} ← MINIMALNI MAKSIMALNI TLAK

Z_{max}

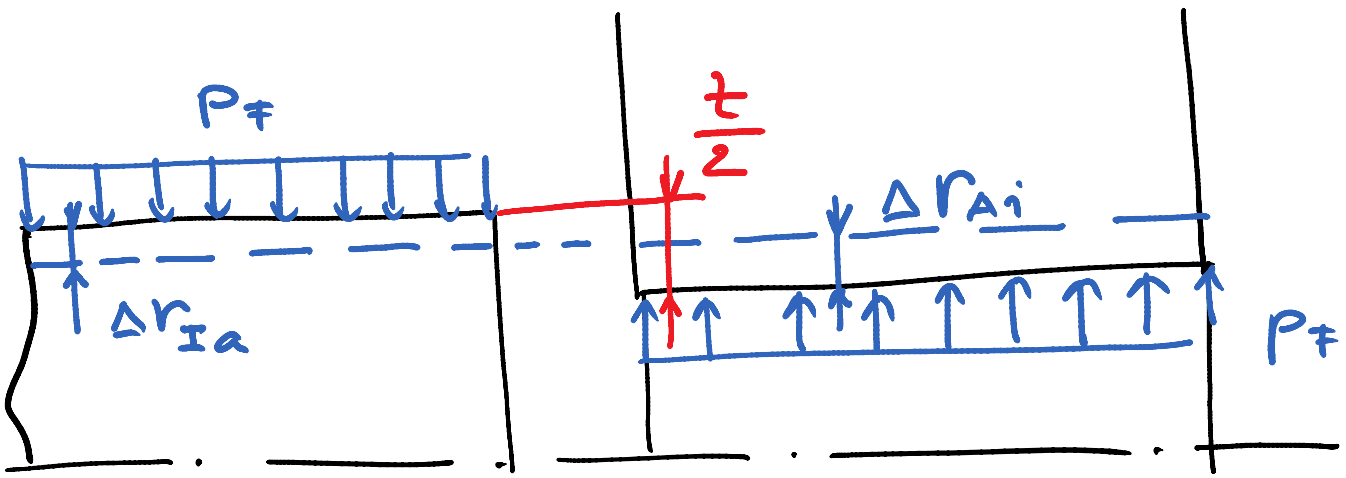
DEJANSKA MINIMALNA IN MAKSIMALNA NADMERA

$$\ddot{U}_{min} = \ddot{U}_u = Z_{min} + G$$

$$\ddot{U}_{max} = \ddot{U}_o = Z_{max} + G$$

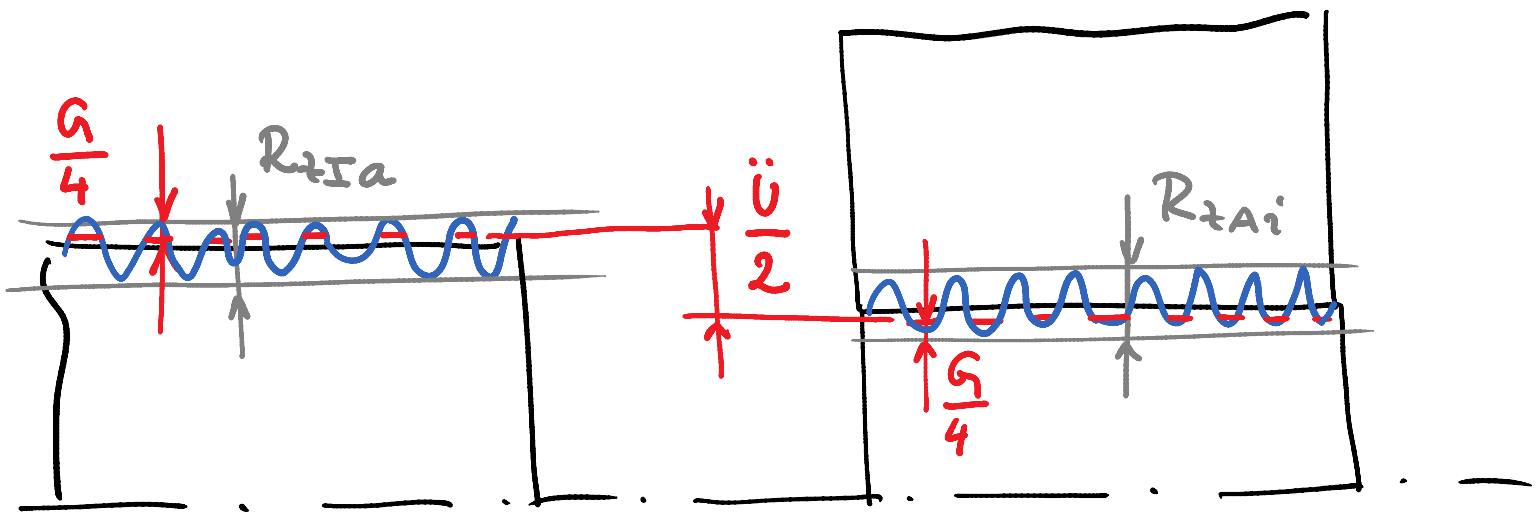
R_z = NAJVEČJA VIŠINA PROFILA

$$G = \left(\frac{R_{zAi} + R_{zIa}}{2} \cdot K\right) \cdot 0.8$$



$p_f = p_{f\,max} \rightarrow z_{max}$

$p_f = p_{f\,min} \rightarrow z_{min}$



$$\overline{R_z} = \frac{R_{zIa} + R_{zAi}}{2}$$

$$G = \overline{R_z} \cdot 2 \cdot 0{,}8$$

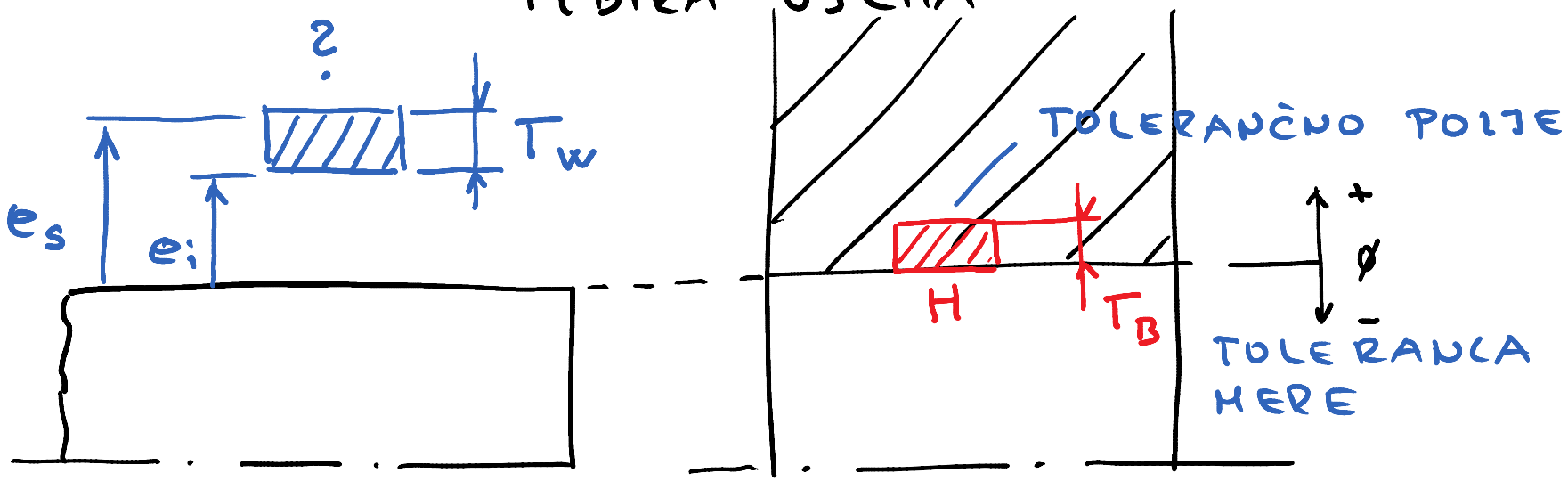
$$\frac{G}{4} = \frac{\overline{R_z}}{2} \cdot 0{,}8$$

$p_f = p_{min} \rightarrow \ddot{U}_{min}$

$p_f = p_{max} \rightarrow \ddot{U}_{max}$

$$\ddot{u} = z + G$$

IZBIRA UJEMA



$e_i \geq Ü_{min} + ES$

$e_s \leq Ü_{max}$

$EI = Ø$

$ES = T_B$

SPODNJI IN ZGORNI ODSTOPEK MERE

SISTEM ENOTNE LUŽNJE

$Ü_{min} \leq e_i - T_B$ (ES)

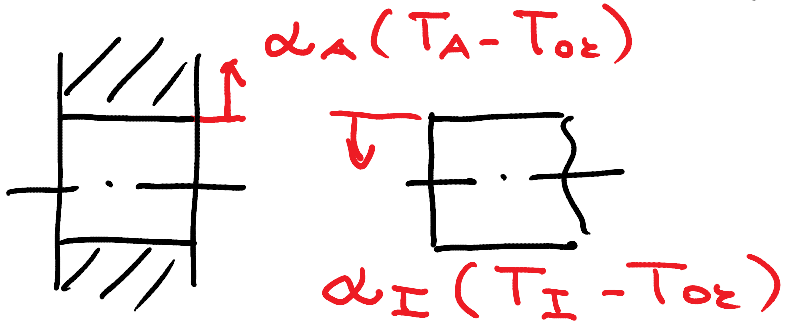
$Ü_{max} \geq e_s - EI$ (Ø) $= e_s$

TOLERANČNA STOPNJA IN D_F DOLOČATA T_B, e_i

MALSIMALNA MONTAŽNA SILA

$$F_e = p_{F\,max} \cdot \pi D_F \cdot l_F \cdot \mu$$

SEGREVANJE ZUNANJEGA ALI OHLAJANJE NOTRANJEGA VALJA



DIN 7190

$$\varepsilon_{th} = \alpha_A (T_A - T_{oz}) - \alpha_I (T_I - T_{oz}) = \frac{\overbrace{\ddot{u}_{max} + 0.001 D_F}}{D_F} \overbrace{2(\Delta r_{Ai} - \Delta r_{Ia})}$$

$$T_A = T_{oz} + \frac{\ddot{u}_{max} + 0.001 D_F}{\alpha_A \cdot D_F} + \frac{\alpha_I}{\alpha_A} (T_I - T_{oz})$$

MONTAŽA Z OLJEM POD TLAKOM