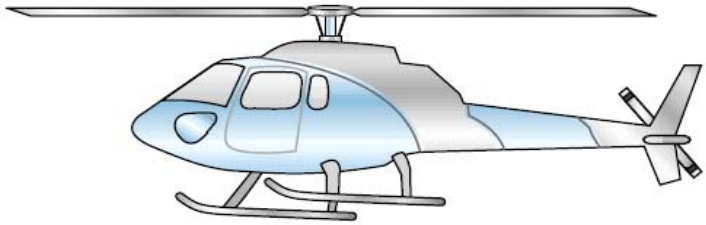
Primjer 6.1

Vratilo elise helikoptera pokreće elisu koja obezbjeđuje podižuću silu kako bi se helikopter održao u zraku. Kao posljedica se javlja kombinacija uvijanja i aksijalnog naprezanja. Ako je prečnik vratila 50 mm, moment uvijanja 2.4 kNm i zatežuća sila 125 kN, odrediti maksimalan zatežući, maksimalan pritisni napon ,te maksimalan tangencijalni napon vratila.



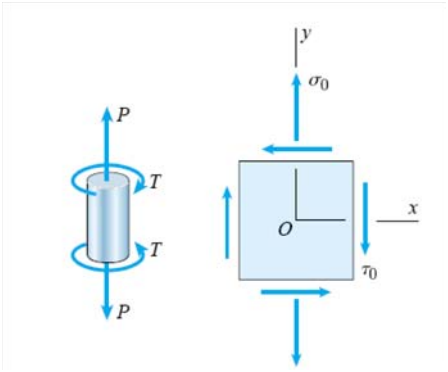
****

$d := 50mm$ $A := \frac{d^2 \cdot \pi}{4}$ $I_0 := \frac{d^3 \cdot \pi}{16}$ $r := \frac{d}{2}$

$T := 2.4kN \cdot m$

$F := 125kN$

****



$$\sigma_z := \frac{F}{A} = 63.662\,MPa$$

$$\tau := \frac{T}{I_0} = 97.785\,MPa$$

$$\sigma_{12} = \frac{\sigma_x + \sigma_y}{2} + pm \cdot \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2} \qquad \sigma_x = 0 \qquad \sigma_y = \sigma_z$$

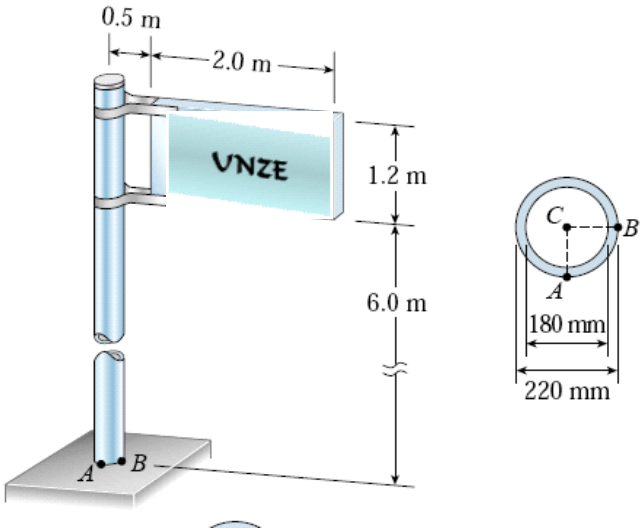
$$\sigma_1 := \frac{\sigma_z}{2} + \sqrt{\left(\frac{0 - \sigma_z}{2}\right)^2 + \tau^2} = 134.666\,\text{MPa}$$

$$\sigma_2 := \frac{\sigma_z}{2} - \sqrt{\left(\frac{0 - \sigma_z}{2}\right)^2 + \tau^2} = -71.004\,\text{MPa}$$

$$\tau_{max} := \sqrt{\left(\frac{0 - \sigma_z}{2}\right)^2 + \tau^2} = 102.835\,\text{MPa}$$

Primjer 6.2

Tabla dimenzija 2 x 1.2 m, kao na slici, postavljena je na stub u obliku cijevi unutrašnjeg prečnika 220 mm i vanjskog prečnika 180 mm. Početak znaka je 0.5 m od ose cijevi stuba, te 6 m iznad zemlje. Odrediti glavne napone i maksimalan tangencijalni napon u tačkama *A* i *B* na dnu stuba ako na znak djeluje vjetar koji izaziva pritisak 2 kPa.



****

$d_s := 220mm$ $d_u := 180mm$

$h := 1.2m$ $w := 2m$ $A := h \cdot w$ $I := \frac{d_s^4 - d_u^4}{64} \cdot \pi$

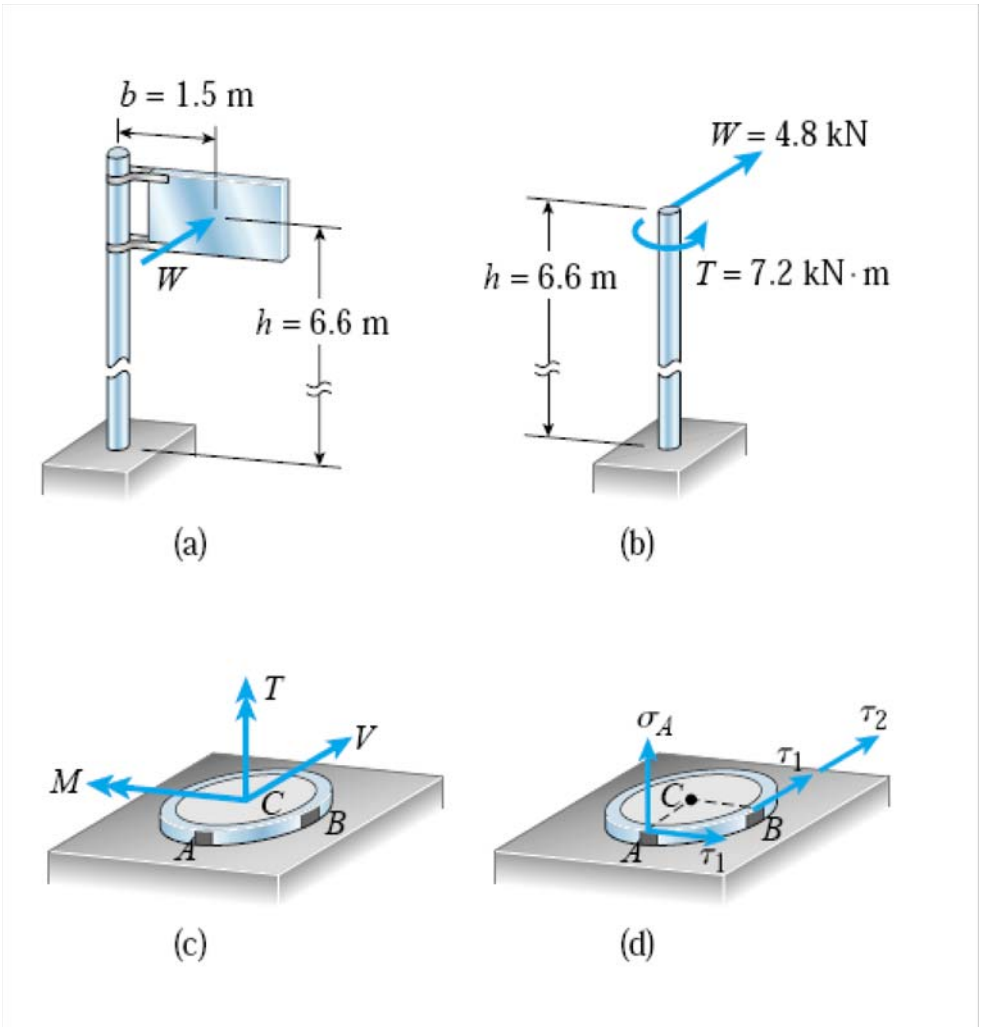
$e := 0.5m$

$I_0 := 2I$

$l := 6m$

$p := 2kPa$ $A_p := \frac{d_s^2 - d_u^2}{4} \cdot \pi$

****



Moment uvijanja i tangencijalna sila

$$T := p \cdot A \cdot \left(e + \frac{w}{2} \right) = 7.2\,kN \cdot m \qquad V := p \cdot A = 4.8\,kN$$

Moment savijanja

$$M := p \cdot A \cdot \left(l + \frac{h}{2} \right) = 31.68\,kN \cdot m$$

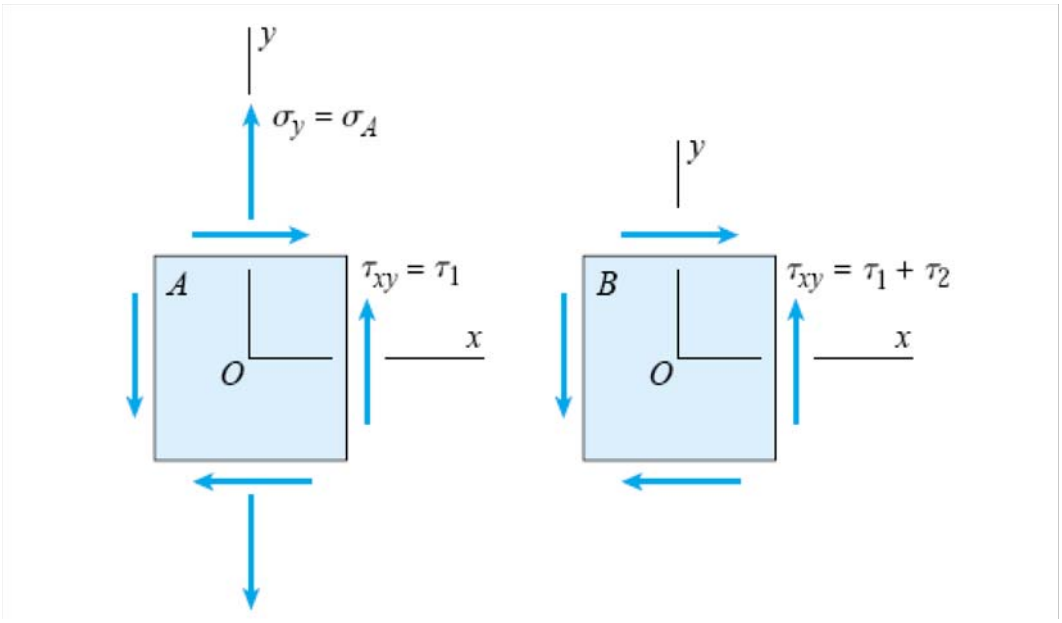
Naponi u tačkama *A* i *B*

$$\sigma_A := \frac{M \cdot \frac{d_s}{2}}{I} = 54.913\,\text{MPa}$$

$$\tau_T := T \cdot \frac{\frac{d_s}{2}}{I_0} = 6.24\,\text{MPa}$$

$$\tau_V := \frac{4V}{3A_p} \cdot \left[\frac{\left(\frac{d_s}{2}\right)^2 + \frac{d_s}{2} \cdot \frac{d_u}{2} + \left(\frac{d_u}{2}\right)^2}{\left(\frac{d_s}{2}\right)^2 + \left(\frac{d_u}{2}\right)^2} \right] = 0.759\,\text{MPa}$$

Elementi napona



$$\sigma_{12} = \frac{\sigma_x + \sigma_y}{2} + pm \cdot \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

Tačka *A*

$$\sigma_x = 0 \qquad \sigma_y = \sigma_A \qquad \tau := \tau_T$$

$$\sigma_{1A} := \frac{\sigma_A}{2} + \sqrt{\left(\frac{0 - \sigma_A}{2}\right)^2 + \tau_T^2} = 55.613\,MPa$$

$$\sigma_{2A} := \frac{\sigma_A}{2} - \sqrt{\left(\frac{0 - \sigma_A}{2}\right)^2 + \tau_T^2} = -0.7\,MPa$$

$$\tau_{maxA} := \sqrt{\left(\frac{0 - \sigma_A}{2}\right)^2 + \tau_T^2} = 28.157\,MPa$$

Tačka *B*

$\sigma_x = \sigma_y = 0$ $\tau := \tau_T + \tau_V$

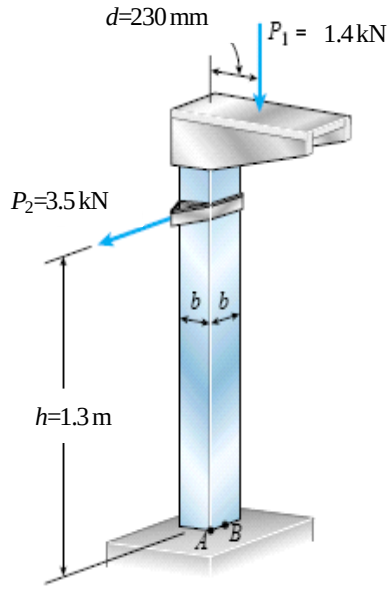
$\sigma_{1A} := \tau = 6.999\,\text{MPa}$

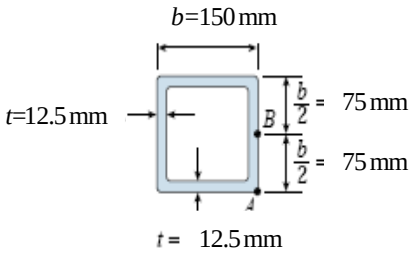
$\sigma_{2A} := -\tau = -6.999\,\text{MPa}$

$\tau_{maxA} := \tau = 6.999\,\text{MPa}$

Primjer 6.3

Stub od cijevi kvadratnog poprečnog presjeka služi kao nosačhorizontalne platforme Vanjska dimezija cijevi je 15 cm a debljina stjenke je 12.5 mm. Platforma ima dimen 170 x 610 mm i nosi kontinuirano opterećenje od 140 kPa koje djeluje na gornjoj površini. Rezultanta ovog opterećenja je vertikalna sila od 14.5 kN i djeluje na sredin platforme, udaljenom 230 mm od ose cijevi. Druga sila od 3.5 kN djeluje horizontaln na stub 1.3 m od osnove. Odrediti glavne normalne napone i maksimalan tangencijal napon u tačkama *A* i *B* na osnovi.





****

$d := 230mm$ $h := 1.3m$

$b := 150mm$ $t := 12.5mm$ $A_p := b^2 - (b - 2t)^2$

$$I := \frac{b^4 - (b - 2t)^4}{12}$$

$A_m := 2t \cdot (b - 2t)$

$P_1 := 14.5kN$ $P_2 := 3.5kN$

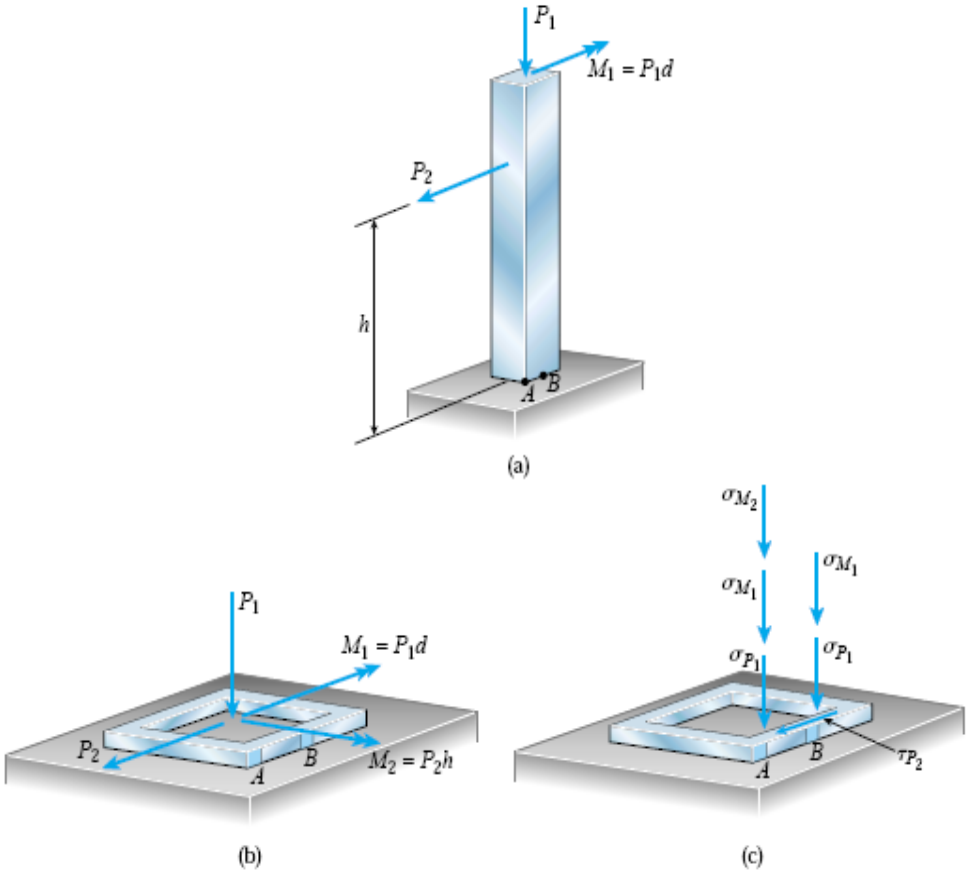
****

Naponi u tačkama *A* i *B*

$$M_1 := P_1 \cdot d = 3.335 \times 10^3 \,\mathrm{N \cdot m}$$

$$M_2 := P_2 \cdot h = 4.55 \times 10^3 \,\mathrm{N \cdot m}$$

$$\sigma_{P1} := \frac{P_1}{A_p} = 2.109 \,\mathrm{MPa}$$



$$\sigma_{12} = \frac{\sigma_x + \sigma_y}{2} + \mathrm{pm} \cdot \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}$$

$$\sigma_{M1} := \frac{M_1 \cdot \frac{b}{2}}{I} = 11.451\,\text{MPa}$$

$$\tau_{P2} := \frac{P_2}{A_m} = 1.12\,\text{MPa}$$

$$\sigma_{M2} := \frac{M_2 \cdot \frac{b}{2}}{I} = 15.623\,\text{MPa}$$

Tačka *A* - jednoosno aksijalno naprezanje

$$\sigma_A := -\left(\sigma_{P1} + \sigma_{M1} + \sigma_{M2}\right) = -29.184\,\text{MPa}$$ pritisak!!!

$$\tau_{maxA} := \left|\frac{\sigma_A}{2}\right| = 14.592\,\text{MPa}$$

Tačka *B*

$\sigma_x = 0$ $\sigma_y = \sigma_A$ $\tau_{xy} = \tau_{P2}$

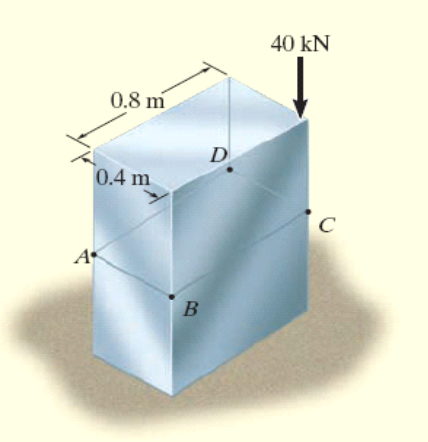
$$\sigma_{1A} := \frac{\sigma_A}{2} + \sqrt{\left(\frac{0 - \sigma_A}{2}\right)^2 + \tau_{P2}^2} = 0.043\,\text{MPa}$$

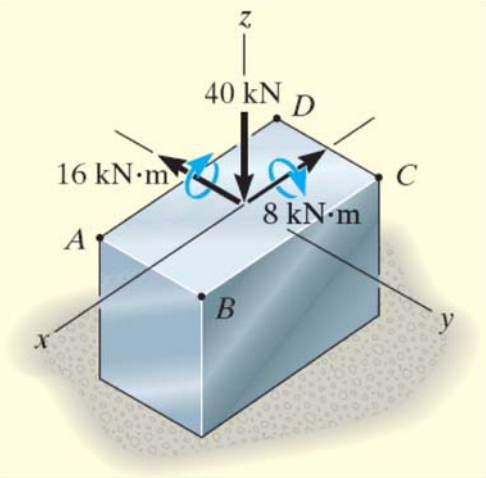
$$\sigma_{2A} := \frac{\sigma_A}{2} - \sqrt{\left(\frac{0 - \sigma_A}{2}\right)^2 + \tau_{P2}^2} = -29.227\,\text{MPa}$$

$$\tau_{maxA} := \sqrt{\left(\frac{0 - \sigma_A}{2}\right)^2 + \tau_{P2}^2} = 14.635\,\text{MPa}$$

Primjer 6.4

Pravougaoni blok izložen je vertikalnoj sili od 40 kN, s napadnom tačkom u uglu blok (slika). Odrediti najveći napon koji djeluje u presjeku *ABCD*. Težinu bloka zanemarit





****

$b := 0.4m \qquad w := 0.8m \qquad I_x := \frac{w \cdot b^3}{12} \qquad I_y := \frac{b \cdot w^3}{12} \qquad A := b \cdot w$

$F := 40kN$

$M_x := F \cdot \frac{b}{2} = 8 \times 10^3 N \cdot m \qquad M_y := F \cdot \frac{w}{2} = 1.6 \times 10^4 N \cdot m$

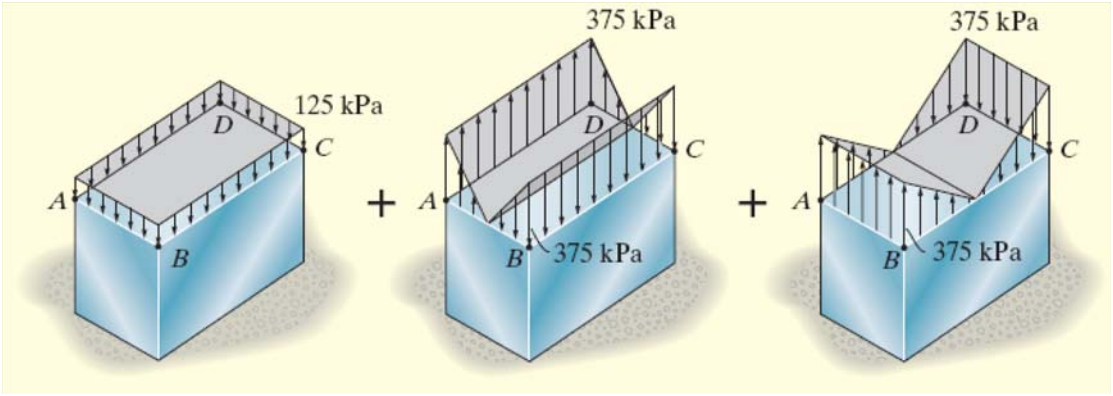
****

Komponente napona

$$\sigma := \frac{F}{A} = 0.125\,MPa$$

$$\sigma_{max1} := \frac{M_x \cdot \frac{b}{2}}{I_x} = 3.75 \times 10^5 Pa$$

$$\sigma_{max2} := \frac{M_y \cdot \frac{w}{2}}{I_y} = 3.75 \times 10^5 Pa$$



$$\sigma_C := -\sigma - \sigma_{max1} - \sigma_{max2} = -0.875\,\text{MPa}$$