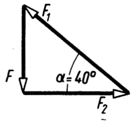
763.

a)



$$\sin\alpha = \frac{F}{F_1} \implies F_1 = \frac{F}{\sin\alpha} = \frac{86\,\text{kN}}{\sin 40^\circ} = 133{,}8\,\text{kN}$$

$$\tan\alpha = \frac{F}{F_2} \implies F_2 = \frac{F}{\tan\alpha} = \frac{86\,\text{kN}}{\tan 40^\circ} = 102{,}5\,\text{kN}$$

b) $\sigma_z = \dfrac{F_1}{2 \cdot b s} = \dfrac{F_1}{2 \cdot b \cdot \frac{b}{10}} = \dfrac{5 F_1}{b^2}$

$$b_{\text{erf}} = \sqrt{\frac{5 F_1}{\sigma_{z\,\text{zul}}}} = \sqrt{\frac{5 \cdot 133{,}8 \cdot 10^3\,\text{N}}{140\,\frac{\text{N}}{\text{mm}^2}}} = 69{,}1\,\text{mm}$$

gewählt 2 ▭ 70 X 7

c) $\tau_{\text{schw}} = \dfrac{\frac{F_1}{2}}{2a(l-2a)} = \dfrac{F_1}{4a(l-2a)}$

$$l_{\text{erf}} = \frac{F_1}{\tau_{\text{schw zul}}\, 4a} + 2a = \frac{133\,800\,\text{N}}{90\,\frac{\text{N}}{\text{mm}^2} \cdot 4 \cdot 5\,\text{mm}} + 10\,\text{mm}$$

$l_{\text{erf}} = 84{,}3\,\text{mm}$

$l = 85\,\text{mm}$ ausgeführt

d) $\tau_a = \dfrac{F_2}{mnS}$

$S = \frac{\pi}{4} d^2 = \frac{\pi}{4} (20\,\text{mm})^2 = 314\,\text{mm}^2$ (Schaftquerschnitt)

$$n_{a\,\text{erf}} = \frac{F_2}{\tau_{a\,\text{zul}}\, mS} = \frac{102\,500\,\text{N}}{70\,\frac{\text{N}}{\text{mm}^2} \cdot 2 \cdot 314\,\text{mm}^2} = 2{,}3$$

$\sigma_l = \dfrac{F_2}{n d s}$

$$n_{l\,\text{erf}} = \frac{F_2}{\sigma_{l\,\text{zul}}\, d s} = \frac{102\,500\,\text{N}}{160\,\frac{\text{N}}{\text{mm}^2} \cdot 20\,\text{mm} \cdot 8\,\text{mm}} = 4$$

ausgeführt $n = 4$ Schrauben M20

764.

a) $\sigma_{z\,\text{vorh}} = \dfrac{F}{b s} = \dfrac{50\,000\,\text{N}}{100\,\text{mm} \cdot 12\,\text{mm}} = 41{,}7\,\dfrac{\text{N}}{\text{mm}^2}$

b) $\tau_{\text{schw}} = \dfrac{F}{S_{\text{schw}}} = \dfrac{F}{a(l-4a)} = \dfrac{50\,000\,\text{N}}{6\,\text{mm} \cdot (500 - 4 \cdot 6)\,\text{mm}}$

$\tau_{\text{schw}} = 17{,}5\,\dfrac{\text{N}}{\text{mm}^2}$

765.

$\tau_a = \dfrac{F}{S} = \dfrac{F}{\frac{\pi}{4} d_2^2} = \dfrac{4F}{\pi d_2^2}$; $\quad M = F d_1$ (Kräftepaar)

$$\tau_a = \frac{4\,\frac{M}{d_1}}{\pi d_2^2} = \frac{4M}{\pi d_2^2 d_1}$$

$$d_{2\,\text{erf}} = \sqrt{\frac{4M}{\tau_{a\,\text{zul}}\, \pi d_1}} = \sqrt{\frac{4 \cdot 7500\,\text{Nmm}}{50\,\frac{\text{N}}{\text{mm}^2} \cdot \pi \cdot 14\,\text{mm}}} = 3{,}7\,\text{mm}$$

$d = 4\,\text{mm}$ ausgeführt

Flächenmomente 2. Grades und Widerstandsmomente

766.

a) $A = \frac{\pi}{4} d^2 = 2827\,\text{mm}^2$

$W_p = \frac{\pi}{16} d^3 = 42{,}4 \cdot 10^3\,\text{mm}^3$

b) $A = \frac{\pi}{4}(D^2 - d^2) = \frac{\pi}{4}\left[\left(\frac{10}{8} d\right)^2 - d^2\right] = \frac{\pi}{4}\left(\frac{100}{64} d^2 - \frac{64}{64} d^2\right)$

$A = \dfrac{\pi}{256} d^2 (100 - 64) = \dfrac{\pi \cdot 36}{256} d^2$

$$d = \sqrt{\frac{256 \cdot A}{36\pi}} = \sqrt{\frac{256 \cdot 2827\,\text{mm}^2}{36\pi}} = 80\,\text{mm}$$

$d = 80\,\text{mm}$; $\quad D = \frac{10}{8} d = 100\,\text{mm}$

c) $W_p = \dfrac{\pi}{16}\left(\dfrac{D^4 - d^4}{D}\right)$

$W_p = \dfrac{\pi}{16}\left(\dfrac{10^4\,\text{cm}^4 - 8^4\,\text{cm}^4}{10\,\text{cm}}\right) = 115{,}9\,\text{cm}^3$

$W_p = 115{,}9 \cdot 10^3\,\text{mm}^3$

767.

a) $W = \dfrac{b h^2}{6}$

$W = \dfrac{160\,\text{mm} \cdot (40\,\text{mm})^2}{6} = 42{,}7 \cdot 10^3\,\text{mm}^3$

b) $W = \dfrac{h^3}{6}$

$W = \dfrac{(80\,\text{mm})^3}{6} = 85{,}3 \cdot 10^3\,\text{mm}^3$

c) $W = \dfrac{b h^2}{6} = \dfrac{40\,\text{mm} \cdot (160\,\text{mm})^2}{6} = 170{,}7 \cdot 10^3\,\text{mm}^3$

d) $W = \dfrac{b h^2}{6} = \dfrac{20\,\text{mm} \cdot (320\,\text{mm})^2}{6} = 341{,}3 \cdot 10^3\,\text{mm}^3$

e) $W = \dfrac{BH^3 - bh^3}{6H}$

$W = \dfrac{80\,\text{mm} \cdot (110\,\text{mm})^3 - 48\,\text{mm} \cdot (50\,\text{mm})^3}{6 \cdot 110\,\text{mm}}$

$W = 152{,}2 \cdot 10^3\,\text{mm}^3$

f) $W = \dfrac{90\,\text{mm} \cdot (320\,\text{mm})^3 - 80\,\text{mm} \cdot (280\,\text{mm})^2}{6 \cdot 320\,\text{mm}}$

$W = 621{,}4 \cdot 10^3\,\text{mm}^3$

768.

a) $I_x = \dfrac{BH^3 + bh^3}{12}$

$I_x = \dfrac{80\,\text{mm} \cdot (240\,\text{mm})^3 + 100\,\text{mm} \cdot (30\,\text{mm})^3}{12}$

$I_x = \dfrac{(1106 \cdot 10^6 + 2{,}7 \cdot 10^6)\,\text{mm}^4}{12} = 92{,}4 \cdot 10^6\,\text{mm}^4$

b) $W_x = \dfrac{I_x}{\dfrac{H}{2}} = \dfrac{92{,}4 \cdot 10^6\,\text{mm}^4}{120\,\text{mm}} = 770 \cdot 10^3\,\text{mm}^3$

Hinweis: Um die großen Zahlenwerte zu vermeiden, kann man in cm rechnen:

$$I_x = \frac{BH^3 + bh^3}{12} = \frac{8\,\text{cm} \cdot (24\,\text{cm})^3 + 10\,\text{cm} \cdot (3\,\text{cm})^3}{12}$$

$I_x = 9{,}24 \cdot 10^3\,\text{cm}^4 = 9{,}24 \cdot 10^3 \cdot 10^4\,\text{mm}^4$
$I_x = 92{,}4 \cdot 10^6\,\text{mm}^4$ (wie oben)

769.

a) $I_x = \dfrac{BH^3 + bh^3}{12}$

$$I_x = \frac{30\,\text{mm} \cdot (50\,\text{mm})^3 + 50\,\text{mm} \cdot (10\,\text{mm})^3}{12}$$

$I_x = 31{,}7 \cdot 10^4\,\text{mm}^4$

$$I_y = \frac{BH^3 - bh^3}{12}$$

$$I_y = \frac{50\,\text{mm} \cdot (80\,\text{mm})^3 - 40\,\text{mm} \cdot (50\,\text{mm})^3}{12}$$

$I_y = 171{,}7 \cdot 10^4\,\text{mm}^4$

b) $W_x = \dfrac{I_x}{\dfrac{H}{2}} = \dfrac{31{,}7 \cdot 10^4\,\text{mm}^4}{25\,\text{mm}} = 12{,}7 \cdot 10^3\,\text{mm}^3$

$W_y = \dfrac{I_y}{\dfrac{H}{2}} = \dfrac{171{,}7 \cdot 10^4\,\text{mm}^4}{40\,\text{mm}} = 42{,}9 \cdot 10^3\,\text{mm}^3$

770.

a) $I_x = I_y = I_\square - I_\bigcirc = \dfrac{h^4}{12} - \dfrac{\pi}{64} d^4$

$$I_x = \frac{(60\,\text{mm})^4}{12} - \frac{\pi}{64} \cdot (50\,\text{mm})^4 = 77{,}3 \cdot 10^4\,\text{mm}^4 = I_y$$

b) $W_x = W_y = \dfrac{I_x}{\dfrac{h}{2}} = \dfrac{77{,}3 \cdot 10^4\,\text{mm}^4}{30\,\text{mm}} = 25{,}8 \cdot 10^3\,\text{mm}^3$

771.

a) $I_x = \dfrac{BH^3 + bh^3}{12}$

$$I_x = \frac{5\,\text{mm} \cdot (40\,\text{mm})^3 + 25\,\text{mm} \cdot (5\,\text{mm})^3}{12} = 2{,}693 \cdot 10^4\,\text{mm}^4$$

Mit denselben Bezeichnungen am um 90° gedrehten Profil:

$$I_y = \frac{5\,\text{mm} \cdot (30\,\text{mm})^3 + 35\,\text{mm} \cdot (5\,\text{mm})^3}{12} = 1{,}1615 \cdot 10^4\,\text{mm}^4$$

$W_x = \dfrac{I_x}{\dfrac{H}{2}} = \dfrac{2{,}693 \cdot 10^4\,\text{mm}^4}{20\,\text{mm}} = 1{,}346 \cdot 10^3\,\text{mm}^3$

$W_y = \dfrac{I_y}{\dfrac{H}{2}} = \dfrac{11{,}615 \cdot 10^3\,\text{mm}^4}{15\,\text{mm}} = 0{,}774 \cdot 10^3\,\text{mm}^3$

772.

a) $I_{\circledcirc} = \dfrac{\pi}{64}(D^4 - d^4)$

$$= \frac{\pi}{64}[(100\,\text{mm})^4 - (80\,\text{mm})^4] = 2\,898\,117\,\text{mm}^4$$

$I_{\|} = \dfrac{b}{12}(H^3 - h^3)$

$$= \frac{10\,\text{mm}}{12}[(400\,\text{mm})^3 - (100\,\text{mm})^3] = 52\,500\,000\,\text{mm}^4$$

Nach dem Verschiebesatz von Steiner wird:

$I_x = I_{\|} + 2(I_{\circledcirc} + A_{\circledcirc}\, l^2)$

$A_{\circledcirc} = \dfrac{\pi}{4}(D^2 - d^2) = \dfrac{\pi}{4}[(100\,\text{mm})^2 - (80\,\text{mm})^2] = 2827\,\text{mm}^2$

$l^2 = 250^2\,\text{mm}^2 = 62\,500\,\text{mm}^2$
$I_x = [52\,500\,000 + 2(2\,898\,117 + 2\,827 \cdot 62\,500)]\,\text{mm}^4$
$I_x = 4{,}1 \cdot 10^8\,\text{mm}^4$

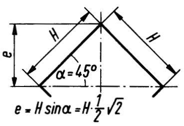
b) $W_x = \dfrac{I_x}{\dfrac{h}{2}} = \dfrac{4{,}1 \cdot 10^8\,\text{mm}^4}{300\,\text{mm}} = 1{,}37 \cdot 10^6\,\text{mm}^3$

773.

a) $I_x = \dfrac{H^4}{12} - \dfrac{h^4}{12}$

$$I_x = \frac{(80\,\text{mm})^4}{12} - \frac{(60\,\text{mm})^4}{12} = 233 \cdot 10^4\,\text{mm}^4$$

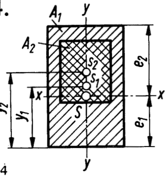
b) $W_x = \dfrac{I_x}{e}$; e Randfaserabstand



$\alpha = 45°$ $\quad e = H \sin\alpha$

$$W_x = \frac{I_x}{H \sin\alpha} = \frac{233 \cdot 10^4\,\text{mm}^4}{80\,\text{mm} \sin 45°} = 41{,}2 \cdot 10^3\,\text{mm}^3$$

774.



$A e_1 = A_1 y_1 - A_2 y_2$

$A_1 = (80 \cdot 50)\,\text{mm}^2 = 4\,000\,\text{mm}^2$
$A_2 = (40 \cdot 34)\,\text{mm}^2 = 1\,360\,\text{mm}^2$
$A = A_1 - A_2 = (4000 - 1360)\,\text{mm}^2 = 2\,640\,\text{mm}^2$
$y_1 = 40\,\text{mm}; \qquad y_2 = 50\,\text{mm}$