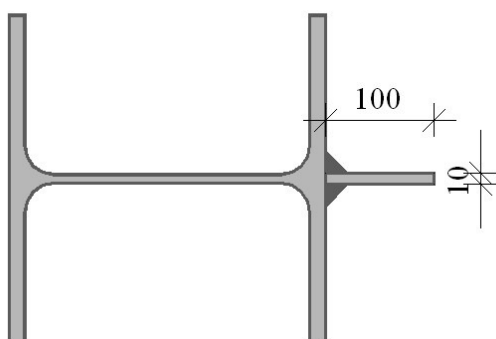
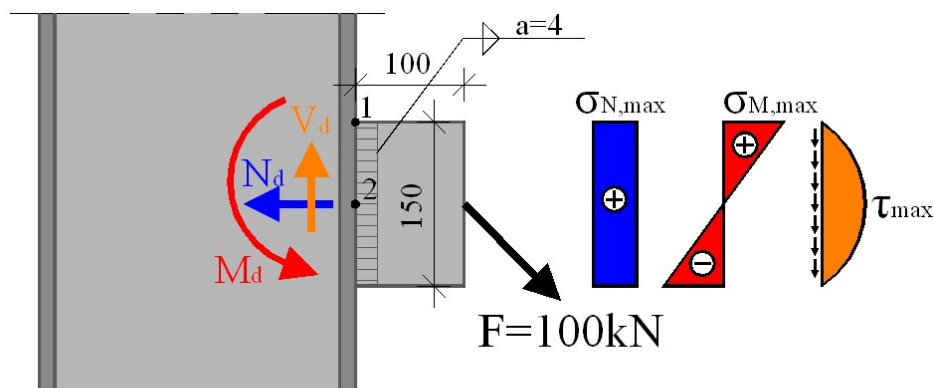


Harjutus 1.

Kontrollida joonisel toodud keevisliite kandevõimet!
Terases tugevusklass S355.



Sisejõud:

$$V = 100 \cdot 0.707 = 71 \text{ kN}$$

$$N = 100 \cdot 0.707 = 71 \text{ kN}$$

$$M = 100 \cdot 0.707 \cdot 0.1 = 7.1 \text{ kNm}$$

Ristlõike parameetrid:

Keevis:

$$A_w = 2 \cdot h_w \cdot a_w = 2 \cdot 7 \cdot 150 = 2100 \text{ mm}^2$$

$$W_{w,y} = \frac{2 \cdot h_w \cdot a_w^2}{6} = \frac{2 \cdot 7 \cdot 150^2}{6} = 52500 \text{ mm}^3$$

Ribateras:

$$A = h \cdot t = 150 \cdot 10 = 1500 \text{ mm}^2$$

$$W_y = \frac{h \cdot t^2}{6} = \frac{10 \cdot 150^2}{6} = 37500 \text{ mm}^3$$

Pinged:

$$\sigma_{w1,d} = \frac{N}{A_w} + \frac{M}{W_{w,y}} = \frac{71 \cdot 10^3}{2100} + \frac{7.1 \cdot 10^6}{52500} = 34 + 134 = 172 \text{ N/mm}^2$$

$$\tau_{w2,d} = \frac{V \cdot S}{I \cdot b} = 1.5 \cdot \frac{V}{A_w} = \frac{1.5 \cdot 71 \cdot 10^3}{2100} = 51 \text{ N/mm}^2$$

$$\sigma_{1,d} = \frac{N}{A} + \frac{M}{W_y} = \frac{71 \cdot 10^3}{1500} + \frac{14.1 \cdot 10^6}{37500} = 47 + 189 = 236 \text{ N/mm}^2 < 355 \text{ N/mm}^2$$

$$\tau_{2,d} = \frac{V \cdot S}{I \cdot b} = 1.5 \cdot \frac{V}{A} = \frac{1.5 \cdot 141 \cdot 10^3}{1500} = 71 \text{ N/mm}^2 < \frac{355}{\sqrt{3}} = 205 \text{ N/mm}^2$$

Pingete kontroll punktis 1:

$$\sigma_{\perp} = \tau_{\perp} = \frac{172}{\sqrt{2}} = 122 \text{ N/mm}^2$$

$$\sqrt{122^2 + 3 \cdot 122^2} = 244 \text{ N/mm}^2 < \frac{510}{0.9 \cdot 1.25} = 453 \text{ N/mm}^2$$

$$122 < \frac{0.9 \cdot 510}{1.25} = 367 \text{ N/mm}^2$$

Pingete kontroll punktis 2:

$$\sigma_{\perp} = \tau_{\perp} = \frac{34}{\sqrt{2}} = 24 \text{ N/mm}^2$$

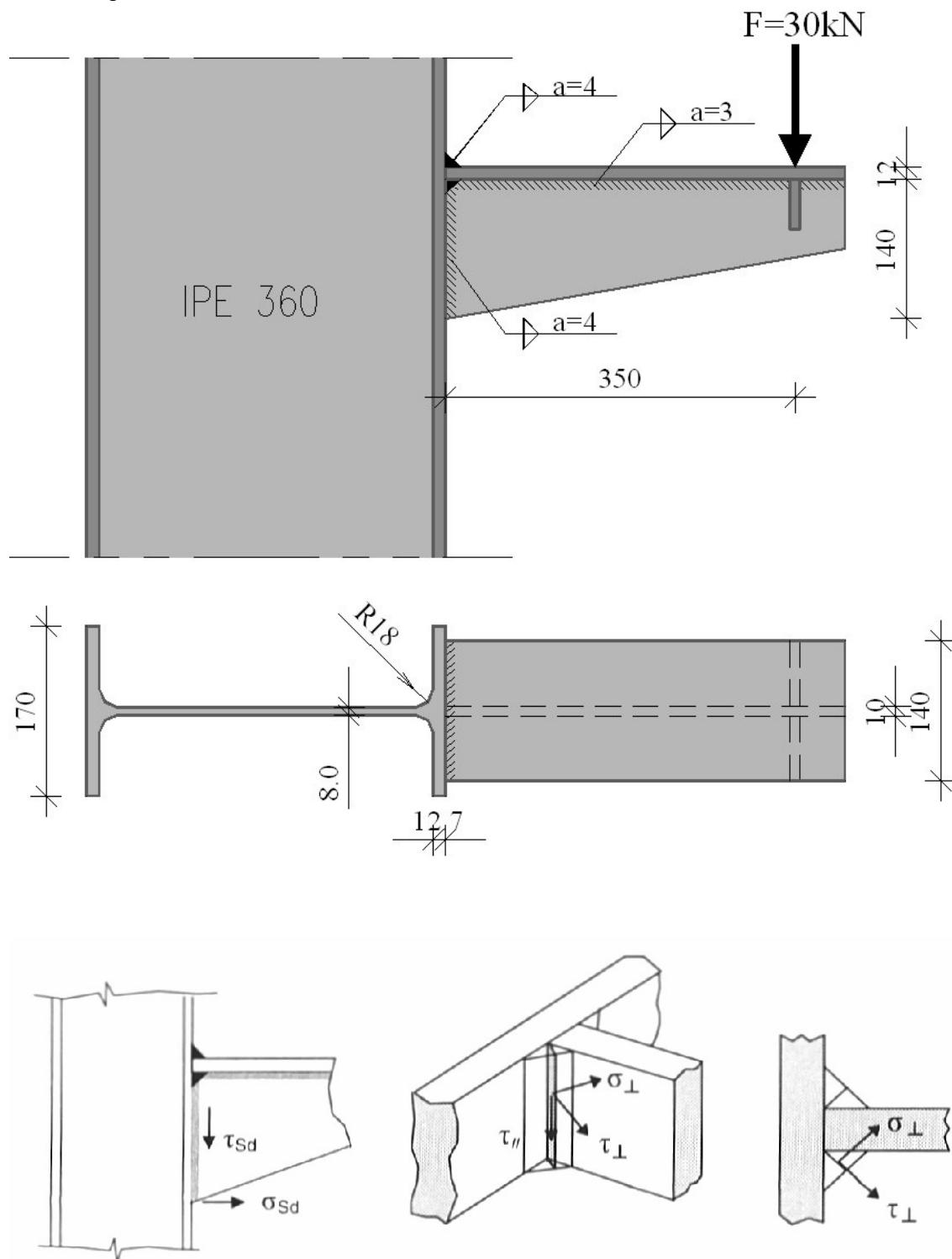
$$\tau_{\parallel} = 71 \text{ N/mm}^2$$

$$\sqrt{24^2 + 3 \cdot (24^2 + 71^2)} = 132 \text{ N/mm}^2 < \frac{510}{0.9 \cdot 1.25} = 453 \text{ N/mm}^2$$

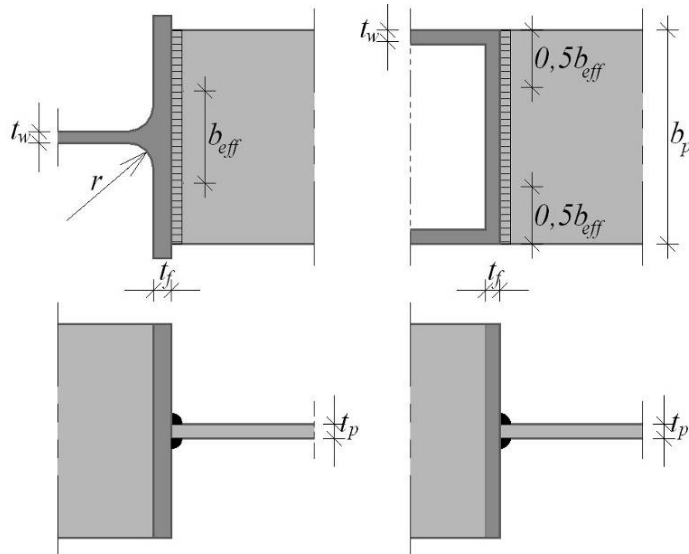
Kandevõime on tagatud suure varuga!

Harjutus 2.

Kontrollida joonisel toodud liite kandevõimet.
Terase tugevusklass S235.



Jäiga toetuspinna leidmine



$$b_{\text{eff}} = t_w + 2s + 7kt_f \geq \frac{f_{y,p}}{f_{u,p}} b_p, \quad \text{kus} \quad k = (t_f/t_p) \cdot (f_{y,f}/f_{y,p}) \leq 1$$

Kui $b_{\text{eff}} < \frac{f_{y,p}}{f_{u,p}} b_p$, tuleb liide jäigastada, näiteks põikribidega plaadi kinnituskohas

$f_{y,f}$ - I- või H-profiili vöö materjali voolavuspiir

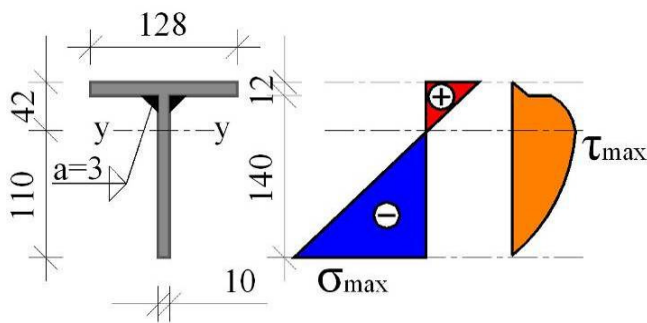
$f_{y,p}$ - vöö külge keevitatud plaadi materjali voolavuspiir

$f_{u,p}$ - vöö külge keevitatud plaadi materjali tõmbetugevus

$s = r$ valtsitud I- ja H-profiilidel ja $s = \sqrt{2a}$ keevitatud I- ja H-profiilidel

$$b_{\text{eff}} = 8 + 2 \cdot 18 + 7 \cdot 12 = 128 \text{ mm} < 140 \text{ mm}$$

Terasosa kontroll



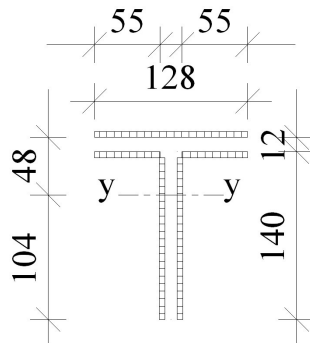
$$y = \sum \frac{S}{A} = \frac{140 \cdot 10 \cdot 70 + 128 \cdot 12 \cdot 146}{140 \cdot 10 + 128 \cdot 12} = 110 \text{ mm}$$

$$I_y = \sum I + A \cdot a^2 = \frac{10 \cdot 140^3}{12} + 10 \cdot 140 \cdot (110 - 70)^2 + \frac{128 \cdot 12^3}{12} + 128 \cdot 12 \cdot (42 - 6)^2 = 653.5755 \text{ mm}^4$$

$$M_{Rd} = \frac{6535755 \cdot 235}{110} = 13.96 \text{ kNm} > 10.5 \text{ kNm}$$

$$V_{Rd} = \frac{10 \cdot 140 \cdot 235}{\sqrt{3}} = 190 \text{ kN} > 30 \text{ kN}$$

Keevise kontroll



$$a_w = 4 \text{ mm}$$

$$y = \sum \frac{S}{A} = \frac{128 \cdot 4 \cdot 152 + 2 \cdot 55 \cdot 4 \cdot 140 + 2 \cdot 4 \cdot 136 \cdot 68}{128 \cdot 4 + 2 \cdot 4 \cdot 55 + 2 \cdot 136 \cdot 4} = 104 \text{ mm}$$

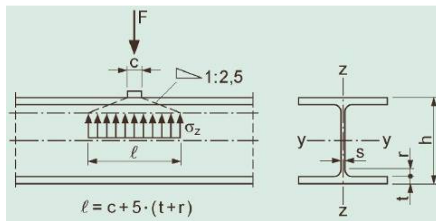
$$I_y = \sum I + A \cdot a^2 = \frac{128 \cdot 4^3}{12} + 128 \cdot 4 \cdot 48^2 + \frac{110 \cdot 4^3}{12} + 110 \cdot 4 \cdot 36^2 + \frac{2 \cdot 4 \cdot 136^3}{12} + 2 \cdot 4 \cdot 136 \cdot 36^2 = 4838176 \text{ mm}^4$$

$$\sigma_w = \frac{10.5 \cdot 10^6 \cdot 104}{4838176} = 226 \text{ N/mm}^2 \rightarrow \sigma_{\perp} = \tau_{\perp} = \frac{226}{\sqrt{2}} = 160 \text{ N/mm}^2$$

$$\tau_{II} = \frac{30 \cdot 10^3}{2 \cdot 4 \cdot 136} = 28 \text{ N/mm}^2$$

$$\sqrt{160^2 + 3 \cdot (160^2 + 28^2)} = 323 \text{ N/mm}^2 < \frac{360}{0.8 \cdot 1.25} = 360 \text{ N/mm}^2$$

Seina kontroll koondatud koormusele

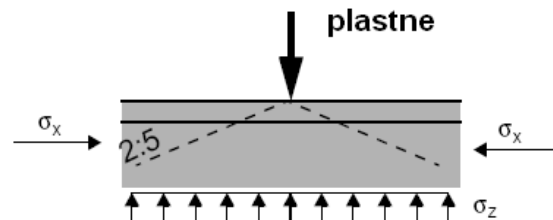
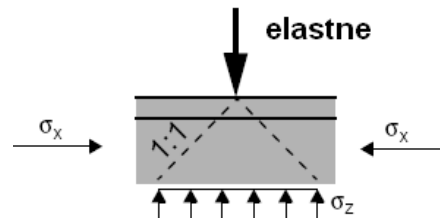


Eeldades elastset pingete jagunemist:

$$L_{\text{eff}} = 2 \cdot 12 = 24 \text{ mm}$$

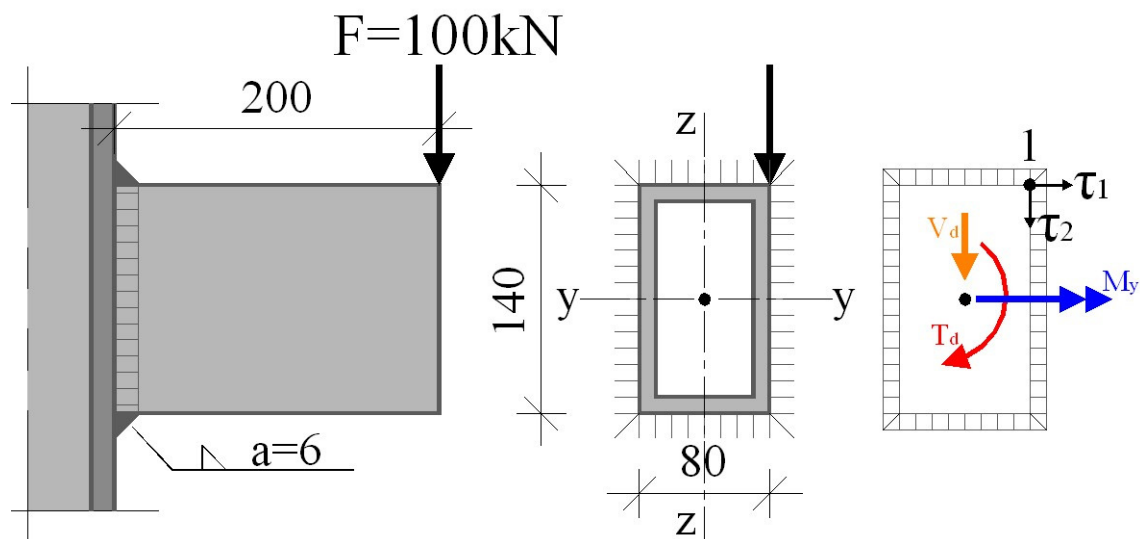
$$F_{\text{Rd}} = 24 \cdot 10 \cdot 235 = 56.4 \text{ kN} > 30 \text{ kN}$$

Kandevõime on tagatud!



Harjutus 3.

Kontrollida joonisel toodud keevisliite kandevõimet!
Terase tugevusklass S355.



Sisejõud:

$$V = 100\text{kN}$$

$$M = 100 \cdot 0.2 = 20\text{kNm}$$

$$T = 100 \cdot 0.04 = 4\text{kNm}$$

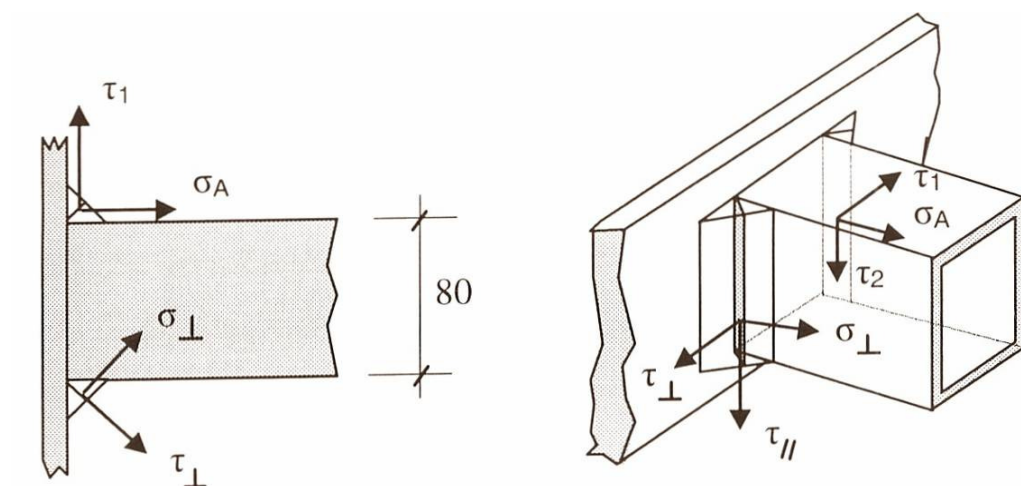
Keevise parameetrid:

$$A_w = 2 \cdot a_w \cdot (h + b) = 2640\text{mm}^2$$

$$I_y = 2 \cdot \left(a_w \cdot b \cdot \left(\frac{h}{2} \right)^2 + \frac{b \cdot a_w^3}{12} + \frac{a_w \cdot h^3}{12} \right) = 7450880\text{mm}^4$$

$$I_z = 2 \cdot \left(a_w \cdot h \cdot \left(\frac{b}{2} \right)^2 + \frac{h \cdot a_w^3}{12} + \frac{a_w \cdot b^3}{12} \right) = 3205040\text{mm}^4$$

$$I_p = I_y + I_z = 10655920\text{mm}^4$$



Pinged punktis 1:

$$\sigma = \frac{M_y}{I_y} \cdot z = \frac{20 \cdot 10^6 \cdot 70}{7450880} = 187 \text{ N/mm}^2$$

$$\tau_1 = \frac{T}{I_p} \cdot a = \frac{4 \cdot 10^6 \cdot 70}{10655920} = 26 \text{ N/mm}^2$$

$$\tau_2 = \frac{T}{I_p} \cdot a + \frac{V}{A_w} = \frac{4 \cdot 10^6 \cdot 40}{10655920} + \frac{100 \cdot 10^3}{2 \cdot 140 \cdot 6} = 15 + 59 = 74 \text{ N/mm}^2$$

Keevise kontroll lihtsustatud meetodiga:

$$\sigma_{\text{res}} = \sqrt{\sigma^2 + \tau_1 + \tau_2} = \sqrt{187^2 + 26^2 + 74^2} = 202 \text{ N/mm}^2 < \frac{510}{\sqrt{3 \cdot 0.9 \cdot 1.25}} = 409 \text{ N/mm}^2 \quad \boxed{49\%}$$

Kandevõime on tagatud suure varuga!