

15.) Příloha C - Digitální archiv posouzení prutů

SOK var.1 - diditální archiv posudků				
prvek	průřez	fáze	extrém	využití
		MSÚ		%
horní pas	horni pas u4,5,6 - kraj	ST14 - 90°	N	54,3
horní pas	horni pas u4,5,6 - kraj	ST14 - 90°	Mz	55
dolní pas	dolni pas u1	ST4 - výsun - 2	My	23,4
dolní pas	dolni pas u3,4,5,6	ST14 - 90°	Mz	19,7
podélník	podelnik	ST14 - 90°	N	24,5
podélník	podelnik	ST14 - 90°	My	17,2
diagonála	diagonala d1	ST14 - 90°	My	20,5
diagonála	diagonala d1	ST14 - 90°	Mz	20,6
svislice	stojka v0	ST12 - 70°	My	43,7
svislice	stojka v0	ST4 - výsun - 2	Mz	29,4
horní příčnick	pricnik	ST14 - 90°	My	65,9
NOK var.1 - diditální archiv posudků				
prvek	průřez	fáze	extrém	využití
		MSÚ		%
horní pas	nový - horní pas	ST15 - 100°	N	21,6
horní pas	nový - horní pas	ST15 - 100°	Mz	9,6
dolní pas	nový - dolni pas 0	ST24 - demontáž otáčedla	My	14,5
dolní pas	nový - dolní pas 2	ST14 - 90°	Mz	17,7
podélník	nový - podélník	ST15 - 100°	N	10,5
podélník	nový - podélník	ST15 - 100°	My	22,9
diagonála	nový - diagonála - 1	ST24 - demontáž otáčedla	N	23,5
diagonála	nový - koncová svislice	ST14 - 90°	My	13,3
horní příčnick	nový - příčnick 1 - horní	ST15 - 100°	Mz	46,5
dolní příčnick	nový - pricnik dole 0	ST14 - 90°	My	15,5
rošt var.1 - diditální archiv posudků				
prvek	průřez	fáze	extrém	využití
		MSÚ		%
podélník	rošt1 - HEB500	ST14 - 90°	N	42,4
podélník	rošt1 - HEB500	ST14 - 90°	Mz	12,9
spojka	rost nozicka1 - HEB300	ST14 - 90°	N	12
spojka	rošt2 - HEB500	ST14 - 90°	Mz	13,3
koncový příčr	rošt4 - RHS500/300/16.0	ST5 - sepnutí	N	5,3
koncový příčr	rošt4 - RHS500/300/16.0	ST23 - 180°	My	3,2

HORNÍ PAS

Profil: horní pas u4,5,6 - kraj

Extrém: Mz - ST14 - 90°

Průřezové charakteristiky:

$A := 2.8108 \cdot 10^{-2} \text{ m}^2$
 $h := 0.42 \text{ m}$ $b := 0.52 \text{ m}$

$I_y := 3.7818 \cdot 10^{-4} \text{ m}^4$

$I_z := 6.7997 \cdot 10^{-4} \text{ m}^4$

$W_{y.pl} := 2.2052 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 4.1144 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 1.1540 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 2.6153 \cdot 10^{-3} \text{ m}^3$

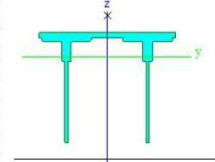
$i_y := 116 \text{ mm}$

$i_z := 156 \text{ mm}$

$I_w := 9.1883 \cdot 10^{-6} \text{ m}^6$

$I_t := 7.5104 \cdot 10^{-6} \text{ m}^4$

A [m²]	2.8108e-02	
A y, z [m²]	1.0504e-02	1.1354e-02
I y, z [m⁴]	3.7818e-04	6.7997e-04
I w [m⁶], I t [m⁴]	9.1883e-06	7.5104e-06
W _{el} y, z [m³]	1.1540e-03	2.6153e-03
W _{pl} y, z [m³]	2.2052e-03	4.1144e-03
d y, z [mm]	0	157
c YUCS, ZUCS [mm]	35	101
α [deg]	0.00	
A L, D [m²/m]	2.6455e+00	2.6455e+00
M _{pl,y} +, - [Nm]	5.18e+05	5.18e+05
M _{pl,z} +, - [Nm]	9.67e+05	9.67e+05



Průřezy

Jméno	horní pas u4,5,6-kraj
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	✓

$E := 210 \text{ GPa}$

$G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

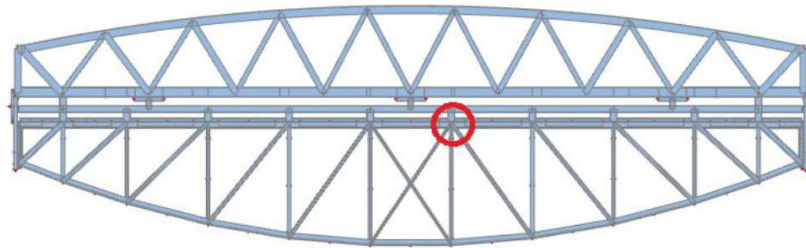
$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

$A_{vy} := 1.0504 \cdot 10^{-2} \text{ m}^2$

$A_{vz} := 1.1354 \cdot 10^{-2} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-2099.3	3.13	0.91	0.69	26.44	40.24

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = (2.099 \cdot 10^3) \text{ kN}$

tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 120 \text{ mm}$

$t_f := 20 \text{ mm}$

stojna

$C_w := 310 \text{ mm}$

$t_w := 12 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 6 \implies > 1. \text{ třída}$

$\frac{C_w}{t_w} = 25.833 \implies > 1. \text{ třída}$

$W_y := W_{y.pl} = 0.002 \text{ m}^3$

$W_z := W_{z.pl} = 0.004 \text{ m}^3$

MSÚ - SOK - horní pas

vzd. styků:

$$L_y := 5.9 \text{ m}$$

$$L_z := \frac{5.9}{2} \text{ m}$$

$$t_f = 20 \text{ mm} > 40 \text{ mm}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$N_{Ed,t} = 0 \text{ kN}$$

$$\frac{h}{b} = 0.808 > 2$$

křivka a

$$L_{Lt} = 5.9 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 5.9 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 2.95 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 5.9 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 50.862 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.513$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 18.91 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.191$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.685$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.878 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.878$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.517$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.003 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 5391.63 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 423 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (5.931 \cdot 10^3) \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 789.22 \text{ kN} \cdot \text{m}$$

posouzení v tahu:

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_w = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (9.188 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (7.51 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (6.8 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 0.954$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.959$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 1.326 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.538 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.267 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.513$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 0.93 < \frac{1}{\lambda'_{LT}{}^2} = 14.052$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.93$$

Interakce tlak - ohyb

$$M_{Ed,y} = 26.44 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = (2.099 \cdot 10^3) \text{ kN}$$

$$M_{Ed,z} = 40.24 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.14$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.14$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.139$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.04$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.91$$

$$\Rightarrow k_{zz} := k_{zz_12} = 0.915$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.97$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.191$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.95$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.79$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.791$$

třída 3,4

$$k_{yz_34} := k_{zz} = 0.915$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.549$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.549$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.139 \quad k_{yz} = 0.549 \quad k_{zy} = 0.791 \quad k_{zz} = 0.915$$

$$\chi_y = 0.878 \quad \chi_z = 1 \quad \chi_{LT} = 0.93$$

$$N_{Ed.c} = (2.099 \cdot 10^3) \text{ kN}$$

$$M_{Ed.y} = 26.44 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 40.24 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (5.392 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 422.997 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 789.217 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.55$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.493$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 55 (1)\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.878$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.443 < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.067 < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.055 < 1 \implies \text{Vyhovuje}$$

$$V_{Ed.z} = 0.91 \text{ kN}$$

Smyk ve směru Z

$$A_{vz} = (1.135 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.383 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.066 (1)\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 3.13 \text{ kN}$$

$$A_{vy} = (1.05 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.28 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.245 (1)\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

HORNÍ PAS

Profil: horní pas u4,5,6 - kraj

Extrém: N - ST14 - 90°

Průřezové charakteristiky:

$A := 2.8108 \cdot 10^{-2} \text{ m}^2$

$h := 0.42 \text{ m} \quad b := 0.52 \text{ m}$

$I_y := 3.7818 \cdot 10^{-4} \text{ m}^4$

$I_z := 6.7997 \cdot 10^{-4} \text{ m}^4$

$W_{y,pl} := 2.2052 \cdot 10^{-3} \text{ m}^3$

$W_{z,pl} := 4.1144 \cdot 10^{-3} \text{ m}^3$

$W_{y,el} := 1.1540 \cdot 10^{-3} \text{ m}^3$

$W_{z,el} := 2.6153 \cdot 10^{-3} \text{ m}^3$

$i_y := 116 \text{ mm}$

$i_z := 156 \text{ mm}$

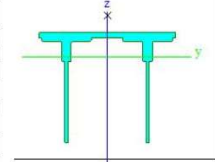
$I_w := 9.1883 \cdot 10^{-6} \text{ m}^6$

$I_t := 7.5104 \cdot 10^{-6} \text{ m}^4$

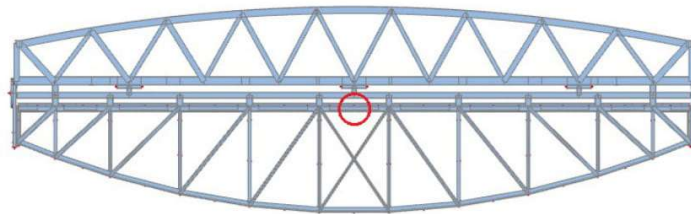
A [m²]	2.8108e-02	
A _{y, z} [m²]	1.0504e-02	1.1354e-02
I _{y, z} [m⁴]	3.7818e-04	6.7997e-04
I _w [m⁶], I _t [m⁴]	9.1883e-06	7.5104e-06
W _{pl, y, z} [m³]	1.1540e-03	2.6153e-03
W _{el, y, z} [m³]	2.2052e-03	4.1144e-03
d _{y, z} [mm]	0	157
c _{YUCS, ZUCS} [mm]	35	101
α [deg]	0.00	
A _{L, D} [m²/m]	2.6455e+00	2.6455e+00
M _{pl, y, z} [Nm]	5.18e+05	5.18e+05
M _{pl, y, z} [Nm]	9.67e+05	9.67e+05

Průřezy

Jméno	horní pas u4,5,6-kraj
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	



$A_{vy} := 1.0504 \cdot 10^{-2} \text{ m}^2 \quad A_{vz} := 1.1354 \cdot 10^{-2} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-2099.44	15.66	0.92	2.26	27.98	24.96

tlaková normálová síla ==> $N_{Ed,c} := \min(0, N_{Ed}) \cdot (-1) = (2.099 \cdot 10^3) \text{ kN}$
 tahová normálová síla ==> $N_{Ed,t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 120 \text{ mm}$ $t_f := 20 \text{ mm}$ $\frac{C_f}{t_f} = 6$ ==> 1. třída
stojna $C_w := 310 \text{ mm}$ $t_w := 12 \text{ mm}$ $\frac{C_w}{t_w} = 25.833$ ==> 1. třída

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 6$ ==> 1. třída $\frac{C_w}{t_w} = 25.833$ ==> 1. třída

$W_y := W_{y,pl} = 0.002 \text{ m}^3 \quad W_z := W_{z,pl} = 0.004 \text{ m}^3$

MSÚ - SOK - horní pas

vzd. styků:

$$L_y := 5.9 \text{ m}$$

$$L_z := \frac{5.9}{2} \text{ m}$$

$$t_f = 20 \text{ mm} > 40 \text{ mm}$$

křivka b

$$\alpha = 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$N_{Ed,t} = 0 \text{ kN}$$

$$\frac{h}{b} = 0.808 > 2$$

křivka a

$$L_{Lt} = 5.9 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 5.9 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 2.95 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 5.9 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 50.862 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.513$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 18.91 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.191$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.685$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.878 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.878$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.517$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.003 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 5391.63 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 423 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (5.931 \cdot 10^3) \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 789.22 \text{ kN} \cdot \text{m}$$

posouzení v tahu:

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_w = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (9.188 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (7.51 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (6.8 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 0.954$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.959$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 1.326 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.538 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.267 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.513$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.93 < \frac{1}{\lambda'_{LT}{}^2} = 14.052$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.93$$

Interakce tlak - ohyb

$$M_{Ed,y} = 27.98 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = (2.099 \cdot 10^3) \text{ kN}$$

$$M_{Ed,z} = 24.96 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.14$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.14$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.139$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.04$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.91$$

$$\Rightarrow k_{zz} := k_{zz_12} = 0.915$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.97$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.191$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.95$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.79$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.791$$

třída 3,4

$$k_{yz_34} := k_{zz} = 0.915$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.549$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.549$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.139 \quad k_{yz} = 0.549 \quad k_{zy} = 0.791 \quad k_{zz} = 0.915$$

$$\chi_y = 0.878 \quad \chi_z = 1 \quad \chi_{LT} = 0.93$$

$$N_{Ed.c} = (2.099 \cdot 10^3) \text{ kN}$$

$$M_{Ed.y} = 27.98 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 24.96 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (5.392 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 422.997 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 789.217 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.543$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.477$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 54.3 (1)\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.878$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.443 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.071 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.034 < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 0.92 \text{ kN}$$

$$A_{vz} = (1.135 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.383 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.067 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 15.66 \text{ kN}$$

$$A_{vy} = (1.05 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.28 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 1.224 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

DOLNÍ PAS

Profil: dolní pas u1
 Extrém: My - ST4 - výsun - 2
 Průřezové charakteristiky:

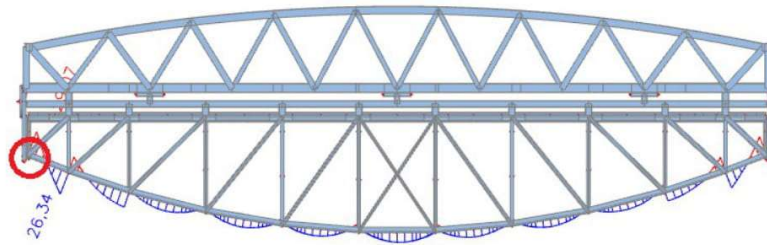
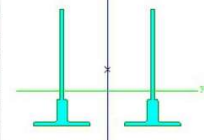
$A := 1.7708 \cdot 10^{-2} \text{ m}^2$
 $h := 0.4 \text{ m}$ $b := 0.504 \text{ m}$
 $I_y := 2.6605 \cdot 10^{-4} \text{ m}^4$
 $I_z := 4.4562 \cdot 10^{-4} \text{ m}^4$
 $W_{y.pl} := 1.7356 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 2.7624 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 9.5228 \cdot 10^{-4} \text{ m}^3$
 $W_{z.el} := 1.7683 \cdot 10^{-3} \text{ m}^3$
 $i_y := 123 \text{ mm}$
 $i_z := 159 \text{ mm}$

$I_w := 6.9645 \cdot 10^{-6} \text{ m}^6$
 $I_t := 2.7459 \cdot 10^{-6} \text{ m}^4$

A [m²]	1,7708e-02	
A y, z [m²]	6,2225e-03	9,8160e-03
I y, z [m⁴]	2,6605e-04	4,4562e-04
I w [m⁴], I t [m⁴]	6,9645e-06	2,7459e-06
W _{el} y, z [m³]	9,5228e-04	1,7683e-03
W _{pl} y, z [m³]	1,7356e-03	2,7624e-03
d y, z [mm]	0	72
c YUCS, ZUCS [mm]	73	-75
α [deg]	0,00	
A L, D [m²/m]	2,3335e+00	2,3335e+00
M _{ply} +, - [Nm]	4,08e+05	4,08e+05
M _{plz} +, - [Nm]	6,49e+05	6,49e+05

Průřezy

Jméno	dolní pas u1
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	<input checked="" type="checkbox"/>



vnitřní síly:	N_{Ed}	$V_{Ed.y}$	$V_{Ed.z}$	$M_{Ed.x}$	$M_{Ed.y}$	$M_{Ed.z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	875.06	0.91	19.09	0	29.07	2.63

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 875.06 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 68 \text{ mm}$ $C_w := 310 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$
 $t_f := 12 \text{ mm}$ $t_w := 12 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 5.667 \implies > 1. \text{ třída}$ $\frac{C_w}{t_w} = 25.833 \implies > 1. \text{ třída}$

$W_y := W_{y.pl} = 0.002 \text{ m}^3$ $W_z := W_{z.pl} = 0.003 \text{ m}^3$

MSÚ - SOK - dolní pas

vzd. styků:

$$L_y := 3.2 \text{ m}$$

$$L_z := 3.2 \text{ m}$$

$$t_f = 12 \text{ mm} > 40 \text{ mm}$$

křivka b
 $\alpha := 0.34$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 0.794 > 2$$

křivka a

$$L_{Lt} = 3.2 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 3.2 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 3.2 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.2 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 26.016 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.263$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 20.126 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.203$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.545$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.978 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.978$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.521$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.999 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.999$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 3396.72 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 332.92 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (3.736 \cdot 10^3) \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 529.88 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 875.06 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0.234 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (6.965 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (2.746 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (4.456 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.533$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.991$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.698 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (1.201 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.175 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.488$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 1.002 < \frac{1}{\lambda'_{LT}{}^2} = 32.794$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 1$$

Interakce tlak - ohyb

$$M_{Ed,y} = 29.07 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 2.63 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.203$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.8$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.803$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.6$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 0.6 \quad k_{zy} = 0.803 \quad k_{zz} = 1$$

$$\chi_y = 0.978 \quad \chi_z = 0.999 \quad \chi_{LT} = 1$$

$$N_{Ed.c} = 0 \text{ kN} \quad M_{Ed.y} = 29.07 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 2.63 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (3.397 \cdot 10^3) \text{ kN} \quad M_{y.Rd} = 332.92 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 529.879 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.09$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.075$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 9 (1)\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.978$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.087 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.005 < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 19.09 \text{ kN}$$

$$A_{vz} = (9.816 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.196 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 1.596 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 0.91 \text{ kN}$$

$$A_{vy} = (6.223 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 758.031 \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.12 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

DOLNÍ PAS

Profil: dolní pas u3,4,5,6

Extrém: Mz - ST14 - 90°

Průřezové charakteristiky:

$A := 2.7708 \cdot 10^{-2} \text{ m}^2$

$h := 0.425 \text{ m} \quad b := 0.512 \text{ m}$

$I_y := 3.7982 \cdot 10^{-4} \text{ m}^4$

$I_z := 7.2237 \cdot 10^{-4} \text{ m}^4$

$W_{y.pl} := 2.2222 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 4.3226 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 1.1600 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 2.8214 \cdot 10^{-3} \text{ m}^3$

$i_y := 117 \text{ mm}$

$i_z := 161 \text{ mm}$

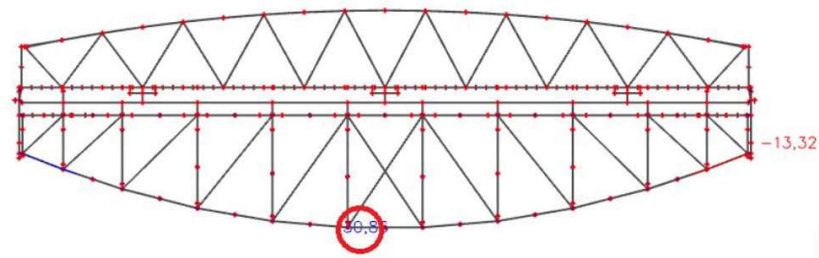
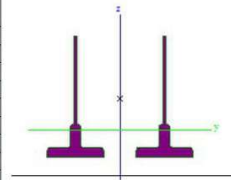
$I_w := 1.0959 \cdot 10^{-5} \text{ m}^6$

$I_t := 9.567 \cdot 10^{-6} \text{ m}^4$

A [m²]	2,7708e-02	
A y, z [m²]	1,6621e-02	1,1466e-02
I y, z [m⁴]	3,7982e-04	7,2237e-04
I w [m⁶], I t [m⁴]	1,0959e-05	9,5670e-06
W _{el} y, z [m³]	1,1600e-03	2,8214e-03
W _{pl} y, z [m³]	2,2222e-03	4,3226e-03
d y, z [mm]	0	109
c YUCS, ZUCS [mm]	15	-119
α [deg]	0,00	
A L, D [m²/m]	2,4655e+00	2,4655e+00
M _{pl} +, - [Nm]	5,22e+05	5,22e+05
M _{pl} +, - [Nm]	1,02e+06	1,02e+06

Průřezy

Jméno	dolní pas u3,4,5,6
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	<input checked="" type="checkbox"/>



vnitřní síly:

N_{Ed}	$V_{Ed.y}$	$V_{Ed.z}$	$M_{Ed.x}$	$M_{Ed.y}$	$M_{Ed.z}$
(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
-780.29	0.16	0.44	0.27	2.71	30.86

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 780.29 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 72 \text{ mm}$ $t_f := 37 \text{ mm}$ *stojna* $C_w := 310 \text{ mm}$ $t_w := 12 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 1.946 ==> 1. \text{ třída}$ $\frac{C_w}{t_w} = 25.833 ==> 1. \text{ třída}$

$W_y := W_{y.pl} = 0.002 \text{ m}^3$ $W_z := W_{z.pl} = 0.004 \text{ m}^3$

MSÚ - SOK - dolní pas

vzd. styků:

$$L_y := 5.9 \text{ m}$$

$$L_z := \frac{5.9}{2} \text{ m}$$

$$t_f = 37 \text{ mm} > 40 \text{ mm}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 0.83 > 2$$

křivka a

$$L_{Lt} = 5.9 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 5.9 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 2.95 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 5.9 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 50.427 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.509$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 18.323 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.185$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.682$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.88 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.88$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.515$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.005 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 5314.9 \text{ kN}$$

$$M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 426.26 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (5.846 \cdot 10^3) \text{ kN}$$

$$M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 829.15 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (1.096 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (9.567 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (7.224 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 0.923$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.958$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 1.305 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (7.485 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.25 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.508$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.944 < \frac{1}{\lambda'_{LT}{}^2} = 15.963$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.944$$

Interakce tlak - ohyb

$$M_{Ed,y} = 2.71 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 780.29 \text{ kN}$$

$$M_{Ed,z} = 30.86 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.05$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.05$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.052$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.02$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.97$$

$$\Rightarrow k_{zz} := k_{zz_12} = 0.966$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.185$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.78$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.785$$

třída 3,4

$$k_{yz_34} := k_{zz} = 0.966$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.58$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.58$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.052 \quad k_{yz} = 0.58 \quad k_{zy} = 0.785 \quad k_{zz} = 0.966$$

$$\chi_y = 0.88 \quad \chi_z = 1 \quad \chi_{LT} = 0.944$$

$$N_{Ed.c} = 780.29 \text{ kN}$$

$$M_{Ed.y} = 2.71 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 30.86 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (5.315 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 426.258 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 829.153 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.197$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.19$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 19.7 (1)\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.88$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.167 < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.007 < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.039 < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 0.44 \text{ kN}$$

$$A_{vz} = (1.147 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.397 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.032 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 0.16 \text{ kN}$$

$$A_{vy} = (1.662 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (2.025 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.008 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

PODÉLNÍK

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

Profil: podélník

Extrém: My - ST14 - 90°

Průřezové charakteristiky:

$A := 1.8198 \cdot 10^{-2} \text{ m}^2$
 $h := 0.66 \text{ m} \quad b := 0.27 \text{ m}$

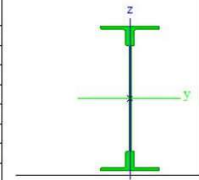
$I_y := 1.3371 \cdot 10^{-3} \text{ m}^4$
 $I_z := 4.6313 \cdot 10^{-5} \text{ m}^4$
 $W_{y.pl} := 4.6446 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 5.7613 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 4.0519 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 3.4306 \cdot 10^{-3} \text{ m}^3$
 $i_y := 271 \text{ mm}$
 $i_z := 50 \text{ mm}$

$I_w := 4.6780 \cdot 10^{-6} \text{ m}^6$
 $I_t := 3.1181 \cdot 10^{-6} \text{ m}^4$

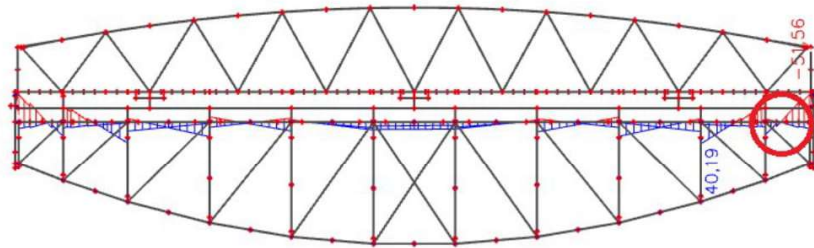
A [m²]	1,8198e-02	
A y, z [m²]	8,6045e-03	7,1661e-03
I y, z [m⁴]	1,3371e-03	4,6313e-05
I w [m⁶], t [m²]	4,6780e-06	3,1181e-06
W _{el} y, z [m³]	4,0519e-03	3,4306e-04
W _{pl} y, z [m³]	4,6446e-03	5,7613e-04
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	-206	4
α [deg]	0,00	
A L, D [m²/m]	2,3438e+00	2,3438e+00
M _{oh} ±, - [Nm]	1,09e+06	1,09e+06
M _{pl} ±, - [Nm]	1,35e+05	1,35e+05

Průřezy

Jméno	podélník
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	<input checked="" type="checkbox"/>



$A_{vy} := 8.6045 \cdot 10^{-3} \text{ m}^2 \quad A_{vz} := 7.1661 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-70.68	11	26.42	1.27	51.56	2.71

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 70.68 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 105 \text{ mm}$ $t_f := 14 \text{ mm}$ *stojna* $C_w := 480 \text{ mm}$ $t_w := 10 \text{ mm}$
 $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 7.5 \quad ==> 1. \text{ třída}$

$\frac{C_w}{t_w} = 48 \quad ==> 4. \text{ třída}$

odhadnuto z
tvaru My
 $\psi := -0.2$

součinitel kritického napětí
 $k_\sigma := 4$

štíhlost

$$\lambda_{p_0} := \frac{C_w}{\frac{t_w}{28.4 \cdot \varepsilon \cdot k_\sigma^{0.5}}} = 0.801$$

$$\lambda_{p_{lim}} := 0.5 + (0.085 - 0.055 \cdot \psi)^{0.5} = 0.81$$

$$\Rightarrow \lambda_{p_-} := \max(\lambda_{p_0}, \lambda_{p_{lim}}) = 0.81$$

rekukční součinitel

$$\rho := \frac{\lambda_{p_-} - 0.055 \cdot (3 + \psi)}{\lambda_{p_-}^2} = 1$$

\Rightarrow redukce průřezu se neuplatní

$$C_w \cdot \rho = 480 \text{ mm}$$

$h = 0.66 \text{ m}$
 $b = 0.27 \text{ m}$

$$A_{eff} := A$$

$$I_{y,eff} := I_y$$

$$I_{z,eff} := I_z$$

$$W_{y,eff} := \frac{I_{y,eff}}{\frac{h}{2}} = 0.004 \text{ m}^3$$

$$W_{z,eff} := \frac{I_{z,eff}}{\frac{b}{2}} = (3.431 \cdot 10^{-4}) \text{ m}^3$$

\Rightarrow

$$W_y := W_{y,eff} = 0.004 \text{ m}^3 \quad W_z := W_{z,eff} = (3.431 \cdot 10^{-4}) \text{ m}^3$$

$$\frac{W_y}{W_{y,el}} = 1$$

MSÚ - SOK - podélník

vzd. styků:

$$L_y := 3.2 \text{ m}$$

$$L_z := 3.2 \text{ m}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 2.444 > 2$$

křivka a

$$L_{Lt} = 3.2 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 3.2 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 3.2 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.2 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 11.808 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.119$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 64 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.646$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.493$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.029 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.784$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.813 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.813$$

prostá únosnost

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M1}} = 3490.71 \text{ kN}$$

$$M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 777.21 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (3.84 \cdot 10^3) \text{ kN}$$

$$M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 65.81 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_w = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (4.678 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (3.118 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (4.631 \cdot 10^{-5}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 1.948$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.979$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.144 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (3.278 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.511 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.609$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.734 < \frac{1}{\lambda'_{LT}{}^2} = 3.835$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.734$$

Interakce tlak - ohyb

podle tvaru ohybového momentu na prutu:

$$M_{Ed.y} = 51.56 \text{ kN} \cdot \text{m} \quad N_{Ed.c} = 70.68 \text{ kN}$$

$$M_{Ed.z} = 2.71 \text{ kN} \cdot \text{m}$$

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.001$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.02$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.01$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.646$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.998$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.01$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.606$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.01$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.001 \quad k_{yz} = 1.01 \quad k_{zy} = 0.998 \quad k_{zz} = 1.01$$

$$\chi_y = 1 \quad \chi_z = 0.813 \quad \chi_{LT} = 0.734$$

$$N_{Ed.c} = 70.68 \text{ kN}$$

$$M_{Ed.y} = 51.56 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 2.71 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (3.491 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 777.212 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 65.805 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.167$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.172$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 17.2 (1)\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.813$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.025 < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.09 < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.056 < 1 \quad ==> \text{Vyhovuje}$$

$$V_{Ed.z} = 26.42 \text{ kN}$$

Smyk ve směru Z

$$A_{vz} = (7.166 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 872.981 \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 3.026 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

$$V_{Ed.y} = 11 \text{ kN}$$

Smyk ve směru Y

$$A_{vy} = (8.605 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.048 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 1.049 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

PODÉLNÍK

$E := 210 \text{ GPa}$

$G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

Profil: podélník

Extrém: N - ST11 - 90°

Průřezové charakteristiky:

$A := 1.8198 \cdot 10^{-2} \text{ m}^2$

$h := 0.66 \text{ m} \quad b := 0.27 \text{ m}$

$I_y := 1.3371 \cdot 10^{-3} \text{ m}^4$

$I_z := 4.6313 \cdot 10^{-5} \text{ m}^4$

$W_{y.pl} := 4.6446 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 5.7613 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 4.0519 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 3.4306 \cdot 10^{-3} \text{ m}^3$

$i_y := 271 \text{ mm}$

$i_z := 50 \text{ mm}$

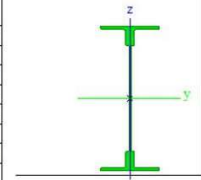
$I_w := 4.6780 \cdot 10^{-6} \text{ m}^6$

$I_t := 3.1181 \cdot 10^{-6} \text{ m}^4$

A [m²]	1,8198e-02	
A y, z [m²]	8,6045e-03	7,1661e-03
I y, z [m⁴]	1,3371e-03	4,6313e-05
I w [m⁶], t [m²]	4,6780e-06	3,1181e-06
W _{el} y, z [m³]	4,0519e-03	3,4306e-04
W _{pl} y, z [m³]	4,6446e-03	5,7613e-04
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	-206	4
α [deg]	0,00	
A L, D [m²/m]	2,3438e+00	2,3438e+00
M _{pl,y} ±, - [Nm]	1,09e+06	1,09e+06
M _{pl,z} ±, - [Nm]	1,35e+05	1,35e+05

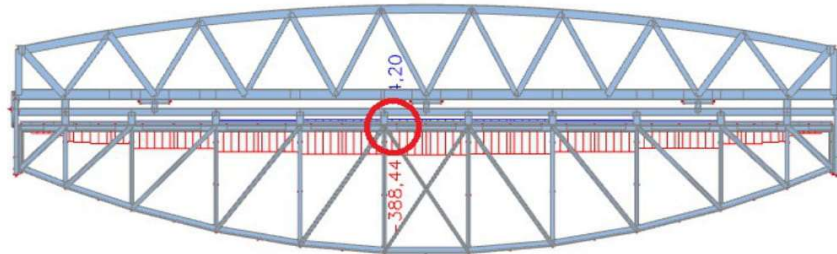
Průřezy

Jméno	podélník
Typ	Obecný průřez
Material	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	



$A_{vy} := 8.6045 \cdot 10^{-3} \text{ m}^2$

$A_{vz} := 7.1661 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-388.44	5.65	0.22	0	5.9	3.84

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 388.44 \text{ kN}$

tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 105 \text{ mm}$

$t_f := 14 \text{ mm}$

stojna

$C_w := 480 \text{ mm}$

$t_w := 10 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 7.5 \quad ==> 1. \text{ třída}$

$\frac{C_w}{t_w} = 48 \quad ==> 4. \text{ třída}$

dominantní
zatížení je tlak
 $\psi := 1$

součinitel kritického napětí
 $k_{\sigma} := 4$

štíhlost

$$\lambda_{p_0} := \frac{C_w}{t_w} = 0.801$$

$$\lambda_{p_{lim}} := 0.5 + (0.085 - 0.055 \cdot \psi)^{0.5} = 0.673$$

$$\Rightarrow \lambda_{p_-} := \max(\lambda_{p_0}, \lambda_{p_{lim}}) = 0.801$$

rekukční součinitel

$$\rho := \frac{\lambda_{p_-} - 0.055 \cdot (3 + \psi)}{\lambda_{p_-}^2} = 0.906$$

\Rightarrow redukce stojny

$$C_w \cdot \rho = 435 \text{ mm}$$

$h = 0.66 \text{ m}$
 $b = 0.27 \text{ m}$

$$A_{eff} := 0.01774695 \text{ m}^2$$

$$I_{y,eff} := 0.00133691 \text{ m}^4$$

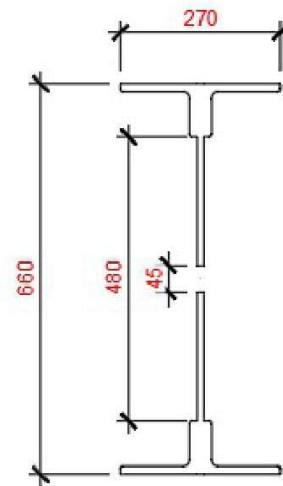
$$I_{z,eff} := 0.00004631 \text{ m}^4$$

$$W_{y,eff} := \frac{I_{y,eff}}{\frac{h}{2}} = 0.004 \text{ m}^3$$

$$W_{z,eff} := \frac{I_{z,eff}}{\frac{b}{2}} = (3.43 \cdot 10^{-4}) \text{ m}^3$$

\Rightarrow

$$W_y := W_{y,eff} = 0.004 \text{ m}^3 \quad W_z := W_{z,eff} = (3.43 \cdot 10^{-4}) \text{ m}^3$$



MSÚ - SOK - podélník

vzd. styků:

$$L_y := 5.9 \text{ m}$$

$$L_z := \frac{5.9}{4} \text{ m}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 2.444 > 2$$

křivka a

$$L_{Lt} = 5.9 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 5.9 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 1.475 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 5.9 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 21.771 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.22$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 29.5 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.298$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.527$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.993 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.993$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.561$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.965 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.965$$

prostá únosnost

$$N_{Rd} := A_{eff} \cdot \frac{f_y}{\gamma_{M1}} = 3404.19 \text{ kN}$$

$$M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 777.1 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (3.84 \cdot 10^3) \text{ kN}$$

$$M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 65.8 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_w = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (4.678 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (3.118 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (4.631 \cdot 10^{-5}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 1.057$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.961$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 1.398 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (1.16 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.859 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.825$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.517 < \frac{1}{\lambda'_{LT}{}^2} = 1.357$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.517$$

Interakce tlak - ohyb

podle tvaru ohybového momentu na prutu:

$$M_{Ed,y} = 5.9 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 388.44 \text{ kN}$$

$$M_{Ed,z} = 3.84 \text{ kN} \cdot \text{m}$$

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.02$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.015$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.02$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.021$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.298$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.9$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.992$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.021$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.613$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.021$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.015 \quad k_{yz} = 1.021 \quad k_{zy} = 0.992 \quad k_{zz} = 1.021$$

$$\chi_y = 0.993 \quad \chi_z = 0.965 \quad \chi_{LT} = 0.517$$

$$N_{Ed.c} = 388.44 \text{ kN}$$

$$M_{Ed.y} = 5.9 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 3.84 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (3.404 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 777.102 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 65.801 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.245$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.248$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 24.8 (1)\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.965$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.118 < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.015 < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.113 < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 0.22 \text{ kN}$$

$$A_{vz} = (7.166 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 872.981 \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.025 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 5.65 \text{ kN}$$

$$A_{vy} = (8.605 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.048 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.539 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

DIAGONÁLA

Profil: diagonala d1

Extrém: My - ST14 - 90°

Průřezové charakteristiky:

$A := 1.7708 \cdot 10^{-2} \text{ m}^2$

$h := 0.544 \text{ m} \quad b := 0.4 \text{ m}$

$I_y := 6.5633 \cdot 10^{-4} \text{ m}^4$

$I_z := 3.7762 \cdot 10^{-4} \text{ m}^4$

$W_{y.pl} := 3.3811 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 2.3656 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 2.413 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 1.8881 \cdot 10^{-3} \text{ m}^3$

$i_y := 193 \text{ mm}$

$i_z := 146 \text{ mm}$

$I_w := 9.4045 \cdot 10^{-6} \text{ m}^6$

$I_t := 1.8954 \cdot 10^{-6} \text{ m}^4$

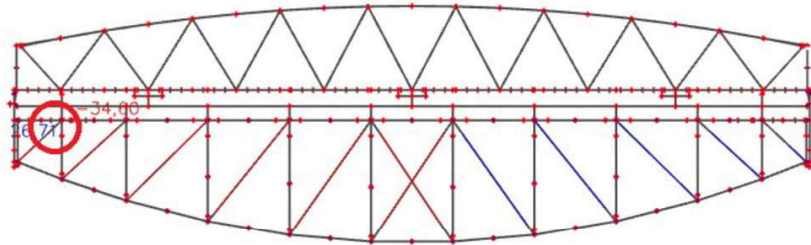
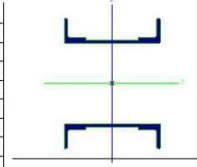
$A_{wy} := 1.0254 \cdot 10^{-2} \text{ m}^2$

$A_{vz} := 5.8527 \cdot 10^{-3} \text{ m}^2$

Průřezy

Jméno	diagonala d1
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	<input checked="" type="checkbox"/>

A [m²]	1,7708e-02	
A y, z [m²]	1,0254e-02	5,8527e-03
I y, z [m⁴]	6,5633e-04	3,7762e-04
I w [m⁶], t [m⁴]	9,4045e-06	1,8954e-06
W _{el} y, z [m³]	2,4130e-03	1,8881e-03
W _{pl} y, z [m³]	3,3811e-03	2,3656e-03
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	6	42
α [deg]	0,00	
A L, D [m²/m]	2,3335e+00	2,3335e+00
M _{pl} +, - [Nm]	7,95e+05	7,95e+05
M _{pl} +, - [Nm]	5,56e+05	5,56e+05



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-144.2	9.58	15.8	0	34.6	25.73

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 144.2 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 220 \text{ mm}$

$t_f := 12 \text{ mm}$

stojna

$C_w := 68 \text{ mm}$

$t_w := 12 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 18.333 \quad ==> 4. \text{ třída}$

$\frac{C_w}{t_w} = 5.667 \quad ==> 1. \text{ třída}$

odhadnuto ze
tvaru momentu
 $\psi := -0.5$

součinitel kritického napětí
 $k_\sigma := 0.43$

štíhlost

$$\lambda_{p_0} := \frac{C_f}{28.4 \cdot \varepsilon \cdot k_\sigma^{0.5}} = 0.933$$

$$\lambda_{p_{lim}} := 0.5 + (0.085 - 0.055 \cdot \psi)^{0.5} = 0.835$$

$$\Rightarrow \lambda_{p_-} := \max(\lambda_{p_0}, \lambda_{p_{lim}}) = 0.933$$

rekukční součinitel

$$\rho := \frac{\lambda_{p_-} - 0.055 \cdot (3 + \psi)}{\lambda_{p_-}^2} = 0.914$$

\Rightarrow redukce pásnice

$$C_f \cdot \rho = 201 \text{ mm}$$

$h = 0.544 \text{ m}$
 $b = 0.4 \text{ m}$

$$A_{eff} := 0.01722692 \text{ m}^2$$

$$I_{y,eff} := 0.00064144 \text{ m}^4$$

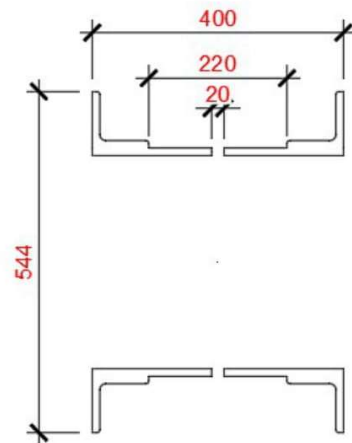
$$I_{z,eff} := 0.00037757 \text{ m}^4$$

$$W_{y,eff} := \frac{I_{y,eff}}{\frac{h}{2}} = 0.002 \text{ m}^3$$

$$W_{z,eff} := \frac{I_{z,eff}}{\frac{b}{2}} = 0.002 \text{ m}^3$$

\Rightarrow

$$W_y := W_{y,eff} = 0.002 \text{ m}^3 \quad W_z := W_{z,eff} = 0.002 \text{ m}^3$$



MSÚ - SOK - Diagonála

vzd. styků:

$$L_y := 4.4 \text{ m}$$

$$L_z := 4.4 \text{ m}$$

$$t_f = 12 \text{ mm} > 40 \text{ mm}$$

křivka b
 $\alpha := 0.34$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 1.36 > 2$$

křivka a

$$L_{Lt} = 4.4 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 4.4 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 4.4 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 4.4 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 22.798 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.23$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 30.137 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.304$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.532$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.989 \quad \Rightarrow \quad \chi_y := \min(\chi_{y-}, 1) = 0.989$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.564$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.963 \quad \Rightarrow \quad \chi_z := \min(\chi_{z-}, 1) = 0.963$$

prostá únosnost

$$N_{Rd} := A_{eff} \cdot \frac{f_y}{\gamma_{M1}} = 3304.44 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 452.35 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (3.736 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 362.12 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad \Rightarrow \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1,0} := 0.94 \quad C_{1,1} := 0.96$$

$$I_w = (9.405 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (1.895 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (3.776 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.577$$

$$C_1 := C_{1,0} + (C_{1,1} - C_{1,0}) \cdot k_{wt} = 0.992$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.741 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.785 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.271 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.514$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.927 < \frac{1}{\lambda'_{LT}{}^2} = 13.637 \quad \Rightarrow \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.927$$

Interakce tlak - ohyb

$$M_{Ed,y} = 34.6 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 144.2 \text{ kN}$$

$$M_{Ed,z} = 25.73 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.006$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.008$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.304$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.9$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.997$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.008$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.605$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.008$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.006 \quad k_{yz} = 1.008 \quad k_{zy} = 0.997 \quad k_{zz} = 1.008$$

$$\chi_y = 0.989 \quad \chi_z = 0.963 \quad \chi_{LT} = 0.927$$

$$N_{Ed.c} = 144.2 \text{ kN}$$

$$M_{Ed.y} = 34.6 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 25.73 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (3.304 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 452.352 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 362.124 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.204$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.205$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 20.5 (1)\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.963$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.045 < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.083 < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.077 < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 15.8 \text{ kN}$$

$$A_{vz} = (5.853 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 712.981 \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 2.2 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 9.58 \text{ kN}$$

$$A_{vy} = (1.025 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.249 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.8 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

DIAGONÁLA

Profil: diagonala d1
 Extrém: My - ST14 - 90°
 Průřezové charakteristiky:

$A := 1.7708 \cdot 10^{-2} \text{ m}^2$
 $h := 0.544 \text{ m} \quad b := 0.4 \text{ m}$
 $I_y := 6.5633 \cdot 10^{-4} \text{ m}^4$
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 $W_{y.pl} := 3.3811 \cdot 10^{-3} \text{ m}^3$
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 $i_y := 193 \text{ mm}$
 $i_z := 146 \text{ mm}$

$I_w := 9.4045 \cdot 10^{-6} \text{ m}^6$
 $I_t := 1.8954 \cdot 10^{-6} \text{ m}^4$

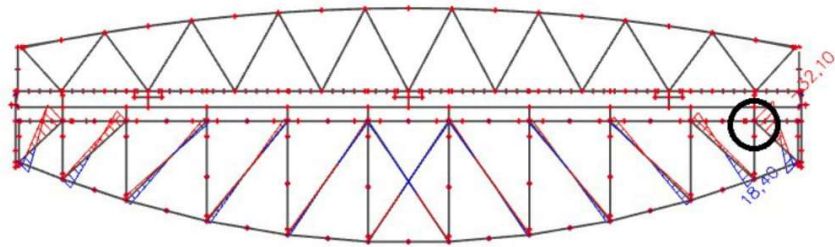
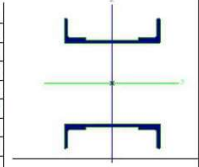
$A_{vy} := 1.0254 \cdot 10^{-2} \text{ m}^2$

$A_{vz} := 5.8527 \cdot 10^{-3} \text{ m}^2$

Průřezy

Jméno	diagonala d1
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	<input checked="" type="checkbox"/>

A [m²]	1,7708e-02	
A _{y, z} [m²]	1,0254e-02	5,8527e-03
I _{y, z} [m⁴]	6,5633e-04	3,7762e-04
I _w [m⁶], I _t [m⁴]	9,4045e-06	1,8954e-06
W _{el, y, z} [m³]	2,4130e-03	1,8881e-03
W _{pl, y, z} [m³]	3,3811e-03	2,3656e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	6	42
α [deg]	0,00	
A _{L, D} [m²/m]	2,3335e+00	2,3335e+00
M _{pl, y, z} [Nm]	7,95e+05	7,95e+05
M _{pl, y, z} [Nm]	5,56e+05	5,56e+05



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-94.82	11.51	15.06	0	33.58	32.1

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 94.82 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice
 $C_f := 220 \text{ mm}$
 $t_f := 12 \text{ mm}$

stojna
 $C_w := 68 \text{ mm}$
 $t_w := 12 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

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$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 18.333 \implies 4. \text{ třída}$

$\frac{C_w}{t_w} = 5.667 \implies 1. \text{ třída}$

odhadnuto ze
tvaru momentu
 $\psi := -0.5$

součinitel kritického napětí
 $k_\sigma := 0.43$

štíhlost

$$\lambda_{p_0} := \frac{C_f}{\frac{t_f}{28.4 \cdot \varepsilon \cdot k_\sigma^{0.5}}} = 0.933$$

$$\lambda_{p_{lim}} := 0.5 + (0.085 - 0.055 \cdot \psi)^{0.5} = 0.835$$

$$\Rightarrow \lambda_{p_-} := \max(\lambda_{p_0}, \lambda_{p_{lim}}) = 0.933$$

rekukční součinitel

$$\rho := \frac{\lambda_{p_-} - 0.055 \cdot (3 + \psi)}{\lambda_{p_-}^2} = 0.914$$

\Rightarrow redukce pásnice

$$C_f \cdot \rho = 201 \text{ mm}$$

$h = 0.544 \text{ m}$
 $b = 0.4 \text{ m}$

$$A_{eff} := 0.01722692 \text{ m}^2$$

$$I_{y,eff} := 0.00064144 \text{ m}^4$$

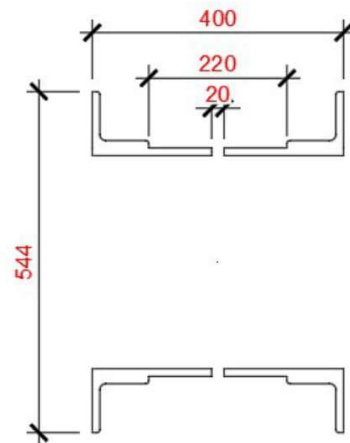
$$I_{z,eff} := 0.00037757 \text{ m}^4$$

$$W_{y,eff} := \frac{I_{y,eff}}{\frac{h}{2}} = 0.002 \text{ m}^3$$

$$W_{z,eff} := \frac{I_{z,eff}}{\frac{b}{2}} = 0.002 \text{ m}^3$$

\Rightarrow

$$W_y := W_{y,eff} = 0.002 \text{ m}^3 \quad W_z := W_{z,eff} = 0.002 \text{ m}^3$$



MSÚ - SOK - Diagonála

vzd. styků:

$$L_y := 4.4 \text{ m}$$

$$L_z := 4.4 \text{ m}$$

$$t_f = 12 \text{ mm} > 40 \text{ mm}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 1.36 > 2$$

křivka a

$$L_{Lt} = 4.4 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 4.4 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 4.4 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 4.4 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 22.798 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.23$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 30.137 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.304$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.532$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.989 \quad \Rightarrow \quad \chi_y := \min(\chi_{y-}, 1) = 0.989$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.564$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.963 \quad \Rightarrow \quad \chi_z := \min(\chi_{z-}, 1) = 0.963$$

prostá únosnost

$$N_{Rd} := A_{eff} \cdot \frac{f_y}{\gamma_{M1}} = 3304.44 \text{ kN} \quad M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 452.35 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (3.736 \cdot 10^3) \text{ kN} \quad M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 362.12 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad \Rightarrow \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_w = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (9.405 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (1.895 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (3.776 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.577$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.992$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.741 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.785 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.271 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.514$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.927 < \frac{1}{\lambda'_{LT}{}^2} = 13.637 \quad \Rightarrow \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.927$$

Interakce tlak - ohyb

podle tvaru ohybového momentu na prutu:

$$M_{Ed.y} = 33.58 \text{ kN} \cdot \text{m} \quad N_{Ed.c} = 94.82 \text{ kN}$$

$$M_{Ed.z} = 32.1 \text{ kN} \cdot \text{m}$$

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.004$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.005$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.304$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 0.9$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.998$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.005$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.603$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.005$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.004 \quad k_{yz} = 1.005 \quad k_{zy} = 0.998 \quad k_{zz} = 1.005$$

$$\chi_y = 0.989 \quad \chi_z = 0.963 \quad \chi_{LT} = 0.927$$

$$N_{Ed.c} = 94.82 \text{ kN}$$

$$M_{Ed.y} = 33.58 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 32.1 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (3.304 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 452.352 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 362.124 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.206$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.206$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 20.6 (1)\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.963$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.03 < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.08 < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.096 < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 15.06 \text{ kN}$$

$$A_{vz} = (5.853 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 712.981 \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 2.1 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 11.51 \text{ kN}$$

$$A_{vy} = (1.025 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.249 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.9 (1)\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

vzd. styků:

$$L_y := 3.3 \text{ m}$$

$$L_z := 3.3 \text{ m}$$

$t_f = 8 \text{ mm}$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 0.885 > 2$$

křivka a

$$L_{Lt} = 3.3 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 3.3 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 3.3 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.3 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 21.429 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.216$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 19.298 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.195$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.526$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.994 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.994$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.518$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.002 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 1882.77 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 282.41 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (2.071 \cdot 10^3) \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 249.46 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (4.879 \cdot 10^{-7}) \text{ m}^6 \quad I_t = (2.207 \cdot 10^{-7}) \text{ m}^4 \quad I_z = (2.862 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.294$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.986$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.467 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (2.419 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.358 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.544$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.855 < \frac{1}{\lambda'_{LT}{}^2} = 7.787$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.855$$

Interakce tlak - ohyb

$$M_{Ed,y} = 84.85 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 63.9 \text{ kN}$$

$$M_{Ed,z} = 18.21 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.001$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.99$$

$$\Rightarrow k_{zz} := k_{zz_12} = 0.993$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.195$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.79$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.795$$

třída 3,4

$$k_{yz_34} := k_{zz} = 0.993$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.596$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.596$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.001 \quad k_{yz} = 0.596 \quad k_{zy} = 0.795 \quad k_{zz} = 0.993$$

$$\chi_y = 0.994 \quad \chi_z = 1 \quad \chi_{LT} = 0.855$$

$$N_{Ed.c} = 63.9 \text{ kN}$$

$$M_{Ed.y} = 84.85 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 18.21 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (1.883 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 282.414 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 249.46 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.437$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.398$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 43.7 \text{ (1)\%} < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.994$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.034 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.351 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.085 < 1 \quad ==> \text{ Vyhovuje}$$

$$V_{Ed.z} = 79.66 \text{ kN}$$

Smyk ve směru Z

$$A_{vz} = (8.219 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.001 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 7.956 \text{ (1)\%} < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 10.3 \text{ kN}$$

$$A_{vy} = (8.357 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.018 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 1.012 \text{ (1)\%} < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

SVISLICE

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

Profil: stojka v0
 Extrém: N - ST4 - výsun - 2
 Průřezové charakteristiky:

$A := 9.8154 \cdot 10^{-3} \text{ m}^2$
 $h := 0.46 \text{ m}$ $b := 0.52 \text{ m}$

$I_y := 2.316 \cdot 10^{-4} \text{ m}^4$

$I_z := 2.8622 \cdot 10^{-4} \text{ m}^4$

$W_{y.pl} := 1.4723 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 1.3005 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 1.007 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 1.1009 \cdot 10^{-3} \text{ m}^3$

$i_y := 154 \text{ mm}$

$i_z := 171 \text{ mm}$

$I_w := 4.8794 \cdot 10^{-7} \text{ m}^6$

$I_t := 2.2065 \cdot 10^{-7} \text{ m}^4$

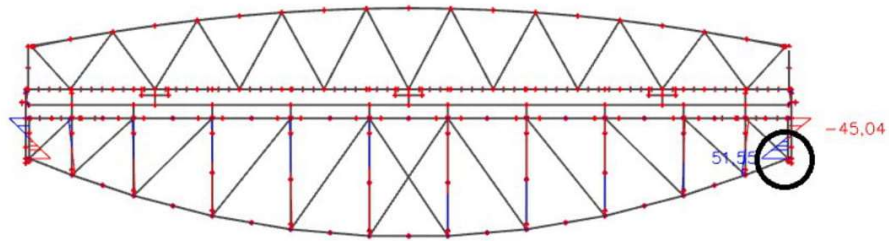
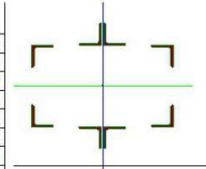
$A_{wy} := 8.3565 \cdot 10^{-3} \text{ m}^2$

$A_{vz} := 8.2194 \cdot 10^{-3} \text{ m}^2$

Průřezy

Jméno	stojka v0
Typ	Obecný průřez
Materiál	S 235
Výroba	obecný
Posudek rovinného vzpěru y-y	d
Posudek rovinného vzpěru z-z	d
Klopení	Výchozí
Použití 2D MKP výpočet	<input checked="" type="checkbox"/>

A [m²]	9.8154e-03	
A _{y, z} [m²]	8.3565e-03	8.2194e-03
I _{y, z} [m⁴]	2.3161e-04	2.8622e-04
I _w [m⁶], I _t [m⁴]	4.8794e-07	2.2065e-07
W _{el, y, z} [m³]	1.0070e-03	1.1009e-03
W _{pl, y, z} [m³]	1.4723e-03	1.3005e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	27	58
α [deg]	0.00	
A _{L, D} [m²/m]	2.4910e+00	2.4910e+00
M _{pl, +, -} [Nm]	3.46e+05	3.46e+05
M _{pl, +, -} [Nm]	3.06e+05	3.06e+05



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-83.49	32.11	2.27	0.02	3.04	51.55

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 83.49 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 62 \text{ mm}$

$t_f := 8 \text{ mm}$

stojna

$C_w := 62 \text{ mm}$

$t_w := 8 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

$\frac{C_f}{t_f} = 7.75 \implies > 1. \text{ třída}$

$\frac{C_w}{t_w} = 7.75 \implies > 1. \text{ třída}$

$W_y := W_{y.pl} = 0.001 \text{ m}^3$

$W_z := W_{z.pl} = 0.001 \text{ m}^3$

vzd. styků:

$$L_y := 3.3 \text{ m}$$

$$L_z := 3.3 \text{ m}$$

$$t_f = 8 \text{ mm}$$

křivka b

$$\alpha = 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 0.885 > 2$$

křivka a

$$L_{Lt} = 3.3 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 3.3 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 3.3 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.3 \text{ m}$$

štíhlost:

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 21.429 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.216$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 19.298 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.195$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.526$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.994 \quad \Rightarrow \quad \chi_y := \min(\chi_{y-}, 1) = 0.994$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.518$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.002 \quad \Rightarrow \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 1882.77 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 282.41 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (2.071 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 249.46 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad \Rightarrow \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (4.879 \cdot 10^{-7}) \text{ m}^6 \quad I_t = (2.207 \cdot 10^{-7}) \text{ m}^4 \quad I_z = (2.862 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.294$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.986$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.467 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (2.419 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.358 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.544$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.855 < \frac{1}{\lambda'_{LT}{}^2} = 7.787$$

$$\Rightarrow \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.855$$

Interakce tlak - ohyb

$$M_{Ed,y} = 3.04 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 83.49 \text{ kN}$$

$$M_{Ed,z} = 51.55 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.001$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.99$$

$$\Rightarrow k_{zz} := k_{zz_12} = 0.991$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.195$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.79$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.795$$

třída 3,4

$$k_{yz_34} := k_{zz} = 0.991$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.594$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.594$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.001 \quad k_{yz} = 0.594 \quad k_{zy} = 0.795 \quad k_{zz} = 0.991$$

$$\chi_y = 0.994 \quad \chi_z = 1 \quad \chi_{LT} = 0.855$$

$$N_{Ed.c} = 83.49 \text{ kN}$$

$$M_{Ed.y} = 3.04 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 51.55 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (1.883 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 282.414 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 249.46 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.201$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.294$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 29.4 \text{ (1)\%} < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.994$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.045 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.013 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.242 < 1 \quad ==> \text{ Vyhovuje}$$

$$V_{Ed.z} = 2.27 \text{ kN}$$

Smyk ve směru Z

$$A_{vz} = (8.219 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.001 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.227 \text{ (1)\%} < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

$$V_{Ed.y} = 32.11 \text{ kN}$$

Smyk ve směru Y

$$A_{vy} = (8.357 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.018 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 3.154 \text{ (1)\%} < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 211 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 1.055$

HORNÍ PŘÍČNÍK

Profil: pricnik

Extrém: My - ST14 - 90°

Průřezové charakteristiky:

$A := 1.608 \cdot 10^{-2} \text{ m}^2$
 $h := 0.8 \text{ m}$ $b := 0.19 \text{ m}$

$I_y := 1.5628 \cdot 10^{-3} \text{ m}^4$

$I_z := 1.4115 \cdot 10^{-5} \text{ m}^4$

$W_{y.pl} := 4.6272 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 2.7647 \cdot 10^{-4} \text{ m}^3$

$W_{y.el} := 3.9071 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 1.4858 \cdot 10^{-4} \text{ m}^3$

$i_y := 311 \text{ mm}$

$i_z := 30 \text{ mm}$

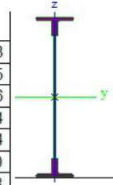
$I_w := 2.1068 \cdot 10^{-6} \text{ m}^6$

$I_t := 2.2363 \cdot 10^{-6} \text{ m}^4$

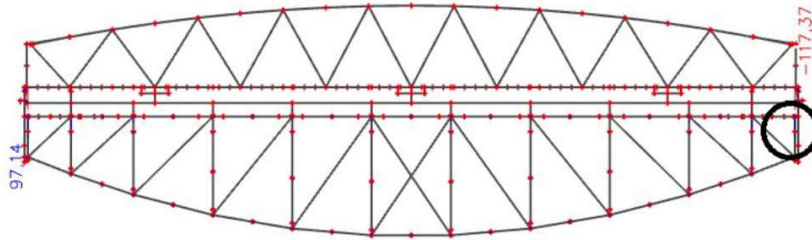
Průřezy

Jméno	pricnik	
Typ	Obecný průřez	
Materiál	S 235	
Výroba	obecný	
Posudek rovinného vzpěru y-y	d	
Posudek rovinného vzpěru z-z	d	
Klopení	Výchozí	
Použití 2D MKP výpočet	✓	

A [m²]	1,6108e-02	
A _{y, z} [m²]	6,1084e-03	8,1980e-03
I _{y, z} [m⁴]	1,5628e-03	1,4115e-05
I _w [m⁶], t [m⁴]	2,1068e-06	2,2363e-06
W _{el, y, z} [m³]	3,9071e-03	1,4858e-04
W _{pl, y, z} [m³]	4,6272e-03	2,7647e-04
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	-110	-8
α [deg]	0,00	
A _{L, D} [m²/m]	2,3055e+00	2,3055e+00
M _{pl, y, z} +, - [Nm]	1,09e+06	1,09e+06
M _{pl, z, y} +, - [Nm]	6,50e+04	6,50e+04



$A_{vy} := 6.1084 \cdot 10^{-3} \text{ m}^2$ $A_{vz} := 8.198 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	39.16	51.82	71.93	0.02	117.37	24.7

tlaková normálová síla ==> $N_{Ed,c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed,t} := \max(0, N_{Ed}) = 39.16 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 68 \text{ mm}$

$t_f := 12 \text{ mm}$

stojna

$C_w := 620 \text{ mm}$

$t_w := 10 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 34.826 \\ 40.103 \\ 44.324 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 9.498 \\ 10.553 \\ 14.775 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 75.985 \\ 87.593 \\ 130.862 \end{bmatrix}$

Průřez ohýbán

$\frac{C_f}{t_f} = 5.667 \implies > 1. \text{ třída}$

$\frac{C_w}{t_w} = 62 \implies > 1. \text{ třída}$

==>

$W_y := W_{y.pl} = 0.005 \text{ m}^3$

$W_z := W_{z.pl} = (2.765 \cdot 10^{-4}) \text{ m}^3$

MSÚ - SOK - Horní příčník

vzd. styků:

$$L_y := 1.8 \text{ m}$$

$$L_z := 1.8 \text{ m}$$

$t_f = 12 \text{ mm}$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

$$\frac{h}{b} = 4.211 > 2$$

křivka a

$$L_{Lt} = 1.8 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 1.8 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 1.8 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 1.8 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 5.788 \quad \lambda_1 := 93.9 \cdot \varepsilon = 99.096 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.058$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 60 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.605$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.478$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.051 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.752$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.834 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.834$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 3084.44 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 887.58 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (3.393 \cdot 10^3) \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 53.03 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 39.16 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0.012 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_w = 1 \quad C_{1,0} := 2.56 \quad C_{1,1} := 2.73$$

$$I_w = (2.107 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (2.236 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (1.412 \cdot 10^{-5}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.745$$

$$C_1 := C_{1,0} + (C_{1,1} - C_{1,0}) \cdot k_{wt} = 3.027$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 8.841 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (1.124 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.295 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.522$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.907 < \frac{1}{\lambda'_{LT}{}^2} = 11.509$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.907$$

Interakce tlak - ohyb

$$M_{Ed,y} = 117.37 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 24.7 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1$$

$$\psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.605$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

$$\Rightarrow k_{zy} := k_{zy_12.8} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.6$$

Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 0.6 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 1 \quad \chi_z = 0.834 \quad \chi_{LT} = 0.907$$

$$N_{Ed.c} = 0 \text{ kN} \quad M_{Ed.y} = 117.37 \text{ kN} \cdot \text{m} \quad M_{y.Rd} \cdot \chi_{LT} = 805.289 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 24.7 \text{ kN} \cdot \text{m} \quad M_{z.Rd} \cdot \chi_{LT} = 48.115 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (3.084 \cdot 10^3) \text{ kN} \quad M_{y.Rd} = 887.581 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 53.032 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.454$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.659$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 65.9 (1)\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.834$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.146 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.513 < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 71.93 \text{ kN}$$

$$A_{vz} = (8.198 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 998.688 \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 7.2 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 51.82 \text{ kN}$$

$$A_{vy} = (6.108 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 744.131 \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 7 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

HORNÍ PAS

Profil: nový horní pas
 Extrém: Mz - ST15 - 100°
 Průřezové charakteristiky:

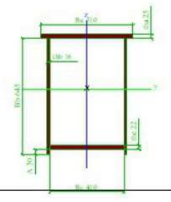
$A := 4.241 \cdot 10^{-2} \text{ m}^2$
 $h := 0.670 \text{ m}$ $b := 0.51 \text{ m}$
 $I_y := 2.7915 \cdot 10^{-3} \text{ m}^4$
 $I_z := 1.3396 \cdot 10^{-3} \text{ m}^4$
 $W_{y.pl} := 1.003 \cdot 10^{-2} \text{ m}^3$
 $W_{z.pl} := 6.9465 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 7.6828 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 5.2532 \cdot 10^{-3} \text{ m}^3$
 $i_y := 257 \text{ mm}$
 $i_z := 178 \text{ mm}$

$I_w := 9.612 \cdot 10^{-6} \text{ m}^6$
 $I_t := 2.4375 \cdot 10^{-3} \text{ m}^4$

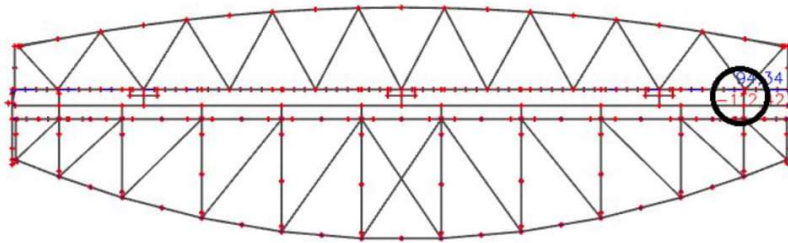
Průřezy

Jméno	nový - horní pas
Typ	Stěna komory
Detailní	510; 25; 645; 16; 410; 22; 30
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m ²]	4,2410e-02	
A y, z [m ²]	2,0547e-02	2,0412e-02
I y, z [m ⁴]	2,7915e-03	1,3396e-03
I w [m ⁶], I t [m ⁴]	9,6120e-06	2,4375e-03
W el y, z [m ³]	7,6828e-03	5,2532e-03
W pl y, z [m ³]	1,0030e-02	6,9465e-03
d y, z [mm]	0	7
c YUCS, ZUCS [mm]	255	363
α [deg]	0,00	
A L, D [m ² /m]	2,4200e+00	4,4260e+00
M plz +, - [Nm]	3,56e+06	3,56e+06
M plz +, - [Nm]	2,47e+06	2,47e+06



$A_{vy} := 2.0547 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 2.0412 \cdot 10^{-2} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed.y}$	$V_{Ed.z}$	$M_{Ed.x}$	$M_{Ed.y}$	$M_{Ed.z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	717.39	57.44	49.1	11.04	4.16	112.42

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 717.39 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 34 \text{ mm}$ $C_w := 593 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 25 \text{ mm}$ $t_w := 16 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 1.36 \implies > 1. \text{ třída}$

$\frac{C_w}{t_w} = 37.063 \implies > 4. \text{ třída}$

MSÚ - NOK - horní pas

odhadnuto z
tvaru My
 $\psi := -0.2$

součinitel kritického napětí
 $k_\sigma := 4$

štíhlost

$$\lambda_{p_0} := \frac{C_w}{\frac{t_w}{28.4 \cdot \varepsilon \cdot k_\sigma^{0.5}}} = 0.802$$

$$\lambda_{p_{lim}} := 0.5 + (0.085 - 0.055 \cdot \psi)^{0.5} = 0.81$$

$$\Rightarrow \lambda_{p_-} := \max(\lambda_{p_0}, \lambda_{p_{lim}}) = 0.81$$

rekukční součinitel

$$\rho := \frac{\lambda_{p_-} - 0.055 \cdot (3 + \psi)}{\lambda_{p_-}^2} = 1$$

\Rightarrow redukce stojny se neuplatní

$$C_w \cdot \rho = 593 \text{ mm}$$

$$C_w - C_w \cdot \rho = (1.11 \cdot 10^{-16}) \text{ m}$$

$h = 0.67 \text{ m}$
 $b = 0.51 \text{ m}$
 $z_d := 0.3633 \text{ m}$
 $z_h := h - z_d$
 $z_h = 0.307 \text{ m}$

$$A_{eff} := A$$

$$I_{y,eff} := I_y$$

$$I_{z,eff} := I_z$$

$$\frac{I_{y,eff}}{I_y} = 1$$

$$W_{y,eff} := \frac{I_{y,eff}}{z_d} = 0.008 \text{ m}^3$$

$$W_{z,eff} := \frac{I_{z,eff}}{z_d} = 0.004 \text{ m}^3$$

\Rightarrow

$$\frac{W_{y,eff}}{W_{y,el}} = 1$$

$$W_y := W_{y,eff} = 0.008 \text{ m}^3$$

$$W_z := W_{z,eff} = 0.004 \text{ m}^3$$

MSÚ - NOK - horní pas

vzd. styků:

$$L_y := 6.35 \text{ m}$$

$$L_z := \frac{6.35}{2} \text{ m}$$

$t_f = 25 \text{ mm}$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 6.35 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 3.175 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 6.35 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 24.708 \quad \lambda_1 := 93.9 \cdot \epsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.323$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 17.837 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.233$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.573$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.955 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.955$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.533$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.988 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.988$$

prostá únosnost

$$N_{Rd} := A_{eff} \cdot \frac{f_y}{\gamma_{M1}} = 13686.86 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 2479.75 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (1.506 \cdot 10^4) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 1190 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 717.39 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0.048 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení: ==> uzavřený průřez neklopí

Kroucení:

$$\tau := \frac{M_{Ed.x}}{I_t} \cdot t_f = 0.113 \text{ MPa} \quad ==> \quad \text{Vliv kroucení je zanedbán}$$

Interakce tlak - ohyb

podle tvaru ohybového momentu na prutu:

$$M_{Ed,y} = 4.16 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 112.42 \text{ kN} \cdot \text{m}$$

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.233$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.83$$

$$\Rightarrow k_{zy} := k_{zy_34} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 1 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 0.955 \quad \chi_z = 0.988 \quad \chi_{LT} := 1$$

$$N_{Ed.c} = 0 \text{ kN}$$

$$M_{Ed.y} = 4.16 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 112.42 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (1.369 \cdot 10^4) \text{ kN}$$

$$M_{y.Rd} = (2.48 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = (1.19 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.096$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.096$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 9.6 (1)\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.955$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.002 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.094 < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 49.1 \text{ kN}$$

$$A_{vz} = (2.041 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.184 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 1.174 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 57.44 \text{ kN}$$

$$A_{vy} = (2.055 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.211 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 1.364 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

HORNÍ PAS

Profil: nový horní pas
 Extrém: N - ST15 - 100°
 Průřezové charakteristiky:

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

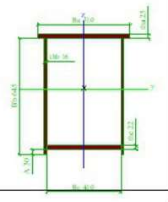
$A := 4.241 \cdot 10^{-2} \text{ m}^2$
 $h := 0.670 \text{ m} \quad b := 0.51 \text{ m}$
 $I_y := 2.7915 \cdot 10^{-3} \text{ m}^4$
 $I_z := 1.3396 \cdot 10^{-3} \text{ m}^4$
 $W_{y.pl} := 1.003 \cdot 10^{-2} \text{ m}^3$
 $W_{z.pl} := 6.9465 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 7.6828 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 5.2532 \cdot 10^{-3} \text{ m}^3$
 $i_y := 257 \text{ mm}$
 $i_z := 178 \text{ mm}$

$I_w := 9.612 \cdot 10^{-6} \text{ m}^6$
 $I_t := 2.4375 \cdot 10^{-3} \text{ m}^4$

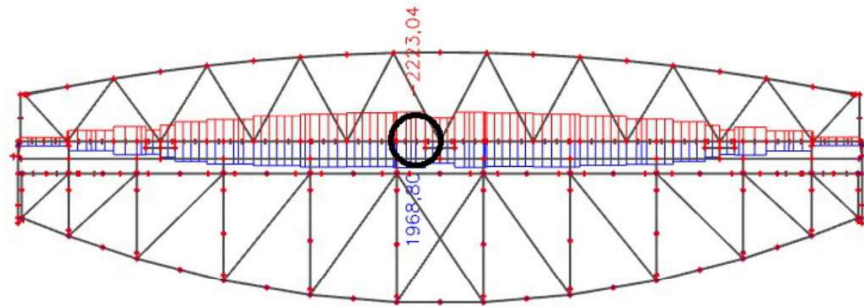
Průřezy

Jméno	nový - horní pas
Typ	Stěna komory
Detailní	510; 25; 645; 16; 410; 22; 30
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití 2D MKP výpočet	

A [m ²]	4,2410e-02	
A _{y, z} [m ²]	2,0547e-02	2,0412e-02
I _{y, z} [m ⁴]	2,7915e-03	1,3396e-03
I _w [m ⁶], I _t [m ⁴]	9,6120e-06	2,4375e-03
W _{el, y, z} [m ³]	7,6828e-03	5,2532e-03
W _{pl, y, z} [m ³]	1,0030e-02	6,9465e-03
d _{y, z} [mm]	0	7
c _{YUCS, ZUCS} [mm]	255	363
α [deg]	0,00	
A _{L, D} [m ² /m]	2,4200e+00	4,4260e+00
M _{pl, y, z} +, - [Nm]	3,56e+06	3,56e+06
M _{pl, y, z} +, - [Nm]	2,47e+06	2,47e+06



$A_{vy} := 2.0547 \cdot 10^{-2} \text{ m}^2 \quad A_{vz} := 2.0412 \cdot 10^{-2} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-2223.04	15.51	26.1	6.51	39.97	33.55

tlaková normálová síla ==> $N_{Ed,c} := \min(0, N_{Ed}) \cdot (-1) = (2.223 \cdot 10^3) \text{ kN}$
 tahová normálová síla ==> $N_{Ed,t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 34 \text{ mm}$ $t_f := 25 \text{ mm}$ *stojna* $C_w := 593 \text{ mm}$ $t_w := 16 \text{ mm}$
 $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 1.36 \quad ==> 1. \text{ třída}$

$\frac{C_w}{t_w} = 37.063 \quad ==> 4. \text{ třída}$

MSÚ - NOK - horní pas

dominantní
zatížení je tlak
 $\psi := 1$

součinitel kritického napětí
 $k_\sigma := 4$

štíhlost

$$\lambda_{p_0} := \frac{C_w}{t_w} = 0.802$$

$$\lambda_{p_0} := \frac{C_w}{28.4 \cdot \varepsilon \cdot k_\sigma^{0.5}} = 0.802$$

$$\lambda_{p_{lim}} := 0.5 + (0.085 - 0.055 \cdot \psi)^{0.5} = 0.673$$

$$\Rightarrow \lambda_{p_-} := \max(\lambda_{p_0}, \lambda_{p_{lim}}) = 0.802$$

rekukční součinitel

$$\rho := \frac{\lambda_{p_-} - 0.055 \cdot (3 + \psi)}{\lambda_{p_-}^2} = 0.905$$

\Rightarrow redukce stojny

$$C_w \cdot \rho = 537 \text{ mm}$$

$$C_w - C_w \cdot \rho = 0.056 \text{ m}$$

$$h = 0.67 \text{ m}$$

$$b = 0.51 \text{ m}$$

$$z_d := 0.364 \text{ m}$$

$$z_h := h - z_d$$

$$z_h = 0.306 \text{ m}$$

$$A_{eff} := 0.04061800 \text{ m}^2$$

$$I_{y,eff} := 0.00279060 \text{ m}^4$$

$$I_{z,eff} := 0.00125823 \text{ m}^4$$

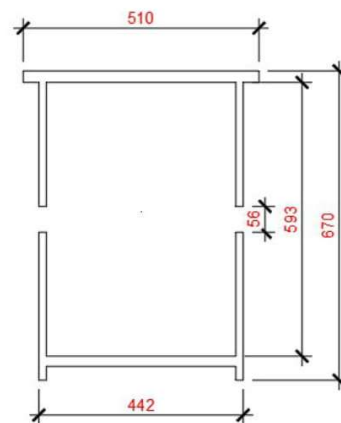
$$W_{y,eff} := \frac{I_{y,eff}}{z_d} = 0.008 \text{ m}^3$$

$$W_{z,eff} := \frac{I_{z,eff}}{z_d} = 0.003 \text{ m}^3$$

\Rightarrow

$$W_y := W_{y,eff} = 0.008 \text{ m}^3$$

$$W_z := W_{z,eff} = 0.003 \text{ m}^3$$



MSÚ - NOK - horní pas

vzd. styků:

$$L_y := 6.35 \text{ m}$$

$$L_z := \frac{6.35}{2} \text{ m}$$

$t_f = 25 \text{ mm}$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 6.35 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 3.175 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 6.35 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 24.708 \quad \lambda_1 := 93.9 \cdot \epsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.323$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 17.837 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.233$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.573$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.955 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.955$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.533$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.988 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.988$$

prostá únosnost

$$N_{Rd} := A_{eff} \cdot \frac{f_y}{\gamma_{M1}} = 13108.54 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 2474.18 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (1.506 \cdot 10^4) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 1115.56 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení: ==> uzavřený průřez neklopí

Kroucení:

$$\tau := \frac{M_{Ed,x}}{I_t} \cdot t_f = 0.067 \text{ MPa} \quad ==> \quad \text{Vliv kroucení je zanedbán}$$

Interakce tlak - ohyb

$$M_{Ed.y} = 39.97 \text{ kN} \cdot \text{m} \quad N_{Ed.c} = (2.223 \cdot 10^3) \text{ kN}$$

$$M_{Ed.z} = 33.55 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_{34}} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.03$$

třída 1,2

$$k_{yy_{12}} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.02$$

$$\Rightarrow k_{yy} := k_{yy_{34}} = 1.034$$

třída 3,4

$$k_{zz_{34}} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.02$$

třída 1,2

$$k_{zz_{12}} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.98$$

$$\Rightarrow k_{zz} := k_{zz_{34}} = 1.024$$

třída 3,4

$$k_{zy_{34}} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.233$

$$k_{zy_{12.8}} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_{12.0}} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 0.83$$

$$\Rightarrow k_{zy} := k_{zy_{34}} = 0.989$$

třída 3,4

$$k_{yz_{34}} := k_{zz} = 1.024$$

třída 1,2

$$k_{yz_{12}} := 0.6 \cdot k_{zz} = 0.614$$

$$\Rightarrow k_{yz} := k_{yz_{34}} = 1.024$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.034 \quad k_{yz} = 1.024 \quad k_{zy} = 0.989 \quad k_{zz} = 1.024$$

$$\chi_y = 0.955 \quad \chi_z = 0.988 \quad \chi_{LT} := 1$$

$$N_{Ed.c} = (2.223 \cdot 10^3) \text{ kN}$$

$$M_{Ed.y} = 39.97 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 33.55 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (1.311 \cdot 10^4) \text{ kN}$$

$$M_{y.Rd} = (2.474 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = (1.116 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.225$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.218$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 22.5 (1)\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.955$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.177 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.016 < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.03 < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 26.1 \text{ kN}$$

$$A_{vz} = (2.041 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.184 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.624 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 15.51 \text{ kN}$$

$$A_{vy} = (2.055 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.211 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.368 (1)\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

DOLNÍ PAS

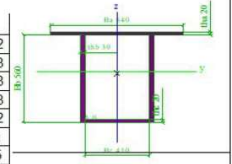
Profil: nový - dolní pas 0
 Extrém: My - ST24 - demontáž otáčedla
 Průřezové charakteristiky:

$A := 5.86 \cdot 10^{-2} \text{ m}^2$
 $h := 0.58 \text{ m} \quad b := 0.84 \text{ m}$
 $I_y := 2.769 \cdot 10^{-3} \text{ m}^4$
 $I_z := 2.7315 \cdot 10^{-3} \text{ m}^4$
 $W_{y.pl} := 1.1482 \cdot 10^{-2} \text{ m}^3$
 $W_{z.pl} := 1.176 \cdot 10^{-2} \text{ m}^3$
 $W_{y.el} := 8.5106 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 6.5035 \cdot 10^{-3} \text{ m}^3$
 $i_y := 217 \text{ mm}$
 $i_z := 216 \text{ mm}$

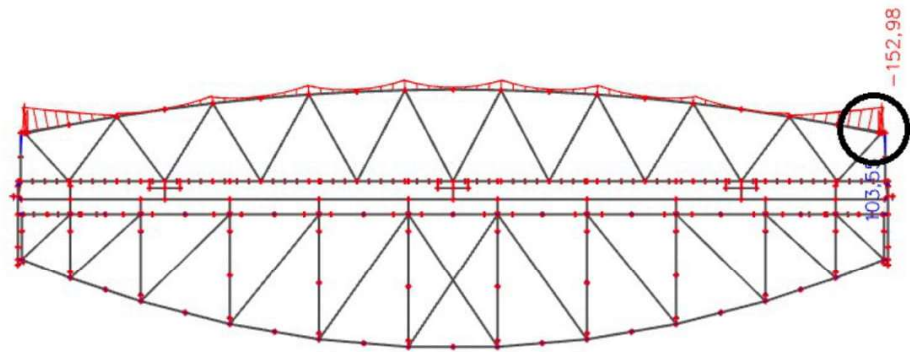
Průřezy

Jméno	nový - dolní pas 0
Typ	Stěna komory
Detailní	840; 20; 560; 30; 410; 20; 0
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití	2D MKP výpočet

A [m²]	5,8600e-02	
A _{y, z} [m²]	2,3587e-02	3,3841e-02
I _{y, z} [m⁴]	2,7690e-03	2,7315e-03
I _w [m⁴]	5,1493e-06	2,9996e-03
W _{el, y, z} [m³]	8,5106e-03	6,5035e-03
W _{pl, y, z} [m³]	1,1482e-02	1,1760e-02
d _{y, z} [mm]	0	-11
c YUCS, ZUCS [mm]	420	325
α [deg]	0,00	
A _{L, D} [m²/m]	2,8400e+00	4,7400e+00
M _{pl, y, z} +, - [Nm]	4,08e+06	4,08e+06
M _{pl, y, z} +, - [Nm]	4,17e+06	4,17e+06



$I_w := 5.1493 \cdot 10^{-6} \text{ m}^6$
 $I_t := 2.9996 \cdot 10^{-3} \text{ m}^4$
 $A_{vy} := 2.3587 \cdot 10^{-2} \text{ m}^2$
 $A_{vz} := 3.3841 \cdot 10^{-2} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	56.57	5.25	1005.21	8.78	152.98	0.96

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 56.57 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 185 \text{ mm}$ $C_w := 560 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 20 \text{ mm}$ $t_w := 30 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 9.25 \quad ==> 3. \text{ třída}$

$\frac{C_w}{t_w} = 18.667 \quad ==> 1. \text{ třída}$

$W_y := W_{y.el} = 0.009 \text{ m}^3$ $W_z := W_{z.el} = 0.007 \text{ m}^3$

MSÚ - NOK - Dolní pas

vzd. styků:

$$L_y := 0.5 \text{ m}$$

$$L_z := 0.5 \text{ m}$$

$$t_f = 20 \text{ mm}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 0.5 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 0.5 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 0.5 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 2.304 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.03$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 2.315 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.03$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.472$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.061 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.472$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.061 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 18911.82 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 2746.6 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (2.08 \cdot 10^4) \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 2098.86 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 56.57 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0.003 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení: ==> uzavřený průřez neklopí

Kroucení:

$$\tau := \frac{M_{Ed,x}}{I_t} \cdot t_f = 0.059 \text{ MPa} \quad ==> \quad \text{Vliv kroucení je zanedbán}$$

Interakce tlak - ohyb

$$M_{Ed,y} = 152.98 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 0.96 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.03$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.63$$

$$\Rightarrow k_{zy} := k_{zy_34} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 1 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 1 \quad \chi_z = 1 \quad \chi_{LT} := 1$$

$$N_{Ed.c} = 0 \text{ kN}$$

$$M_{Ed.y} = 152.98 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 0.96 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (1.891 \cdot 10^4) \text{ kN}$$

$$M_{y.Rd} = (2.747 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = (2.099 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.056$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.056$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 5.6\% \quad < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 1$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 \quad < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.056 \quad < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0 \quad < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 1005.21 \text{ kN}$$

$$A_{vz} = (3.384 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (6.936 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 14.493\% \quad < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 5.25 \text{ kN}$$

$$A_{vy} = (2.359 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.834 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.109\% \quad < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

DOLNÍ PAS

Profil: nový - dolní pas 2

Extrém: Mz - ST14 - 90°

Průřezové charakteristiky:

$A := 4.54 \cdot 10^{-2} \text{ m}^2$
 $h := 0.585 \text{ m}$ $b := 0.51 \text{ m}$

$I_y := 2.3894 \cdot 10^{-3} \text{ m}^4$

$I_z := 1.4561 \cdot 10^{-3} \text{ m}^4$

$W_{y.pl} := 9.5682 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 7.4922 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 7.9184 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 5.7103 \cdot 10^{-3} \text{ m}^3$

$i_y := 229 \text{ mm}$

$i_z := 179 \text{ mm}$

$I_w := 3.8893 \cdot 10^{-6} \text{ m}^6$

$I_t := 2.3012 \cdot 10^{-3} \text{ m}^4$

$A_{vy} := 2.2149 \cdot 10^{-2} \text{ m}^2$

$A_{vz} := 2.3012 \cdot 10^{-2} \text{ m}^2$

$E := 210 \text{ GPa}$

$G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

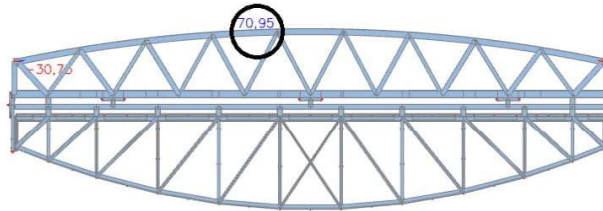
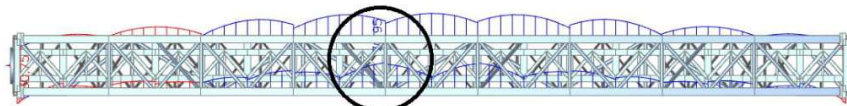
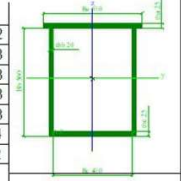
$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

Průřezy

Jméno	nový - dolní pas 2
Typ	Stěna komory
Detailní	510; 25; 560; 20; 410; 25; 0
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m²]	4,5400e-02	
A _{y, z} [m²]	2,2149e-02	2,3012e-02
I _{y, z} [m⁴]	2,3894e-03	1,4561e-03
I _w [m⁶], I _t [m⁴]	3,8893e-06	2,5736e-03
W _{el, y, z} [m³]	7,9184e-03	5,7103e-03
W _{pl, y, z} [m³]	9,5682e-03	7,4922e-03
d _{y, z} [mm]	0	-4
c _{YUCS, ZUCS} [mm]	255	302
α [deg]	0,00	
A _{L, D} [m²/m]	2,1900e+00	4,0800e+00
M _{ply +, -} [Nm]	3,40e+06	3,40e+06
M _{plz +, -} [Nm]	2,66e+06	2,66e+06



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-1791.73	4.5	38.55	0.35	32.8	70.95

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = (1.792 \cdot 10^3) \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 34 \text{ mm}$

$t_f := 25 \text{ mm}$

stojna

$C_w := 535 \text{ mm}$

$t_w := 20 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 1.36 \implies > 1. \text{ třída}$

$\frac{C_w}{t_w} = 26.75 \implies > 1. \text{ třída}$

$W_y := W_{y.pl} = 0.01 \text{ m}^3$

$W_z := W_{z.pl} = 0.007 \text{ m}^3$

MSÚ - NOK - Dolní pas

vzd. styků:

$$L_y := 6.35 \text{ m}$$

$$L_z := 6.35 \text{ m}$$

$$t_f = 25 \text{ mm}$$

křivka b

$$\alpha := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 6.35 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 6.35 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 6.35 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 27.729 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.363$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 35.475 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.464$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.594$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.941 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.941$$

$$\phi_z := 0.5 \cdot (1 + \alpha \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.653$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.9 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.9$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 14651.82 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 3087.92 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = 16117 \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 2417.94 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení: ==> uzavřený průřez neklopí

Kroucení:

$$\tau := \frac{M_{Ed,x}}{I_t} \cdot t_f = 0.004 \text{ MPa} \quad ==> \text{ Vliv kroucení je zanedbán}$$

Interakce tlak - ohyb

$$M_{Ed,y} = 32.8 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = (1.792 \cdot 10^3) \text{ kN}$$

$$M_{Ed,z} = 70.95 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.03$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.02$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.021$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.04$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.04$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1.045$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.464$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.982$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.045$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.627$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.627$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.021 \quad k_{yz} = 0.627 \quad k_{zy} = 0.982 \quad k_{zz} = 1.045$$

$$\chi_y = 0.941 \quad \chi_z = 0.9 \quad \chi_{LT} := 1$$

$$N_{Ed.c} = 1791.7 \text{ kN}$$

$$M_{Ed.y} = 32.8 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 71 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = 14651.8 \text{ kN}$$

$$M_{y.Rd} = 3087.9 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 2417.937 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.159$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.177$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 17.7\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.9$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 13.6\% < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 1.1\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 2.9\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 38.55 \text{ kN}$$

$$A_{vz} = (2.301 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.717 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.817\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 4.5 \text{ kN}$$

$$A_{vy} = (2.215 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.54 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.099\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

PODÉLNÍK

Profil: nový - podélník
 Extrém: My - ST15 - 100°
 Průřezové charakteristiky:

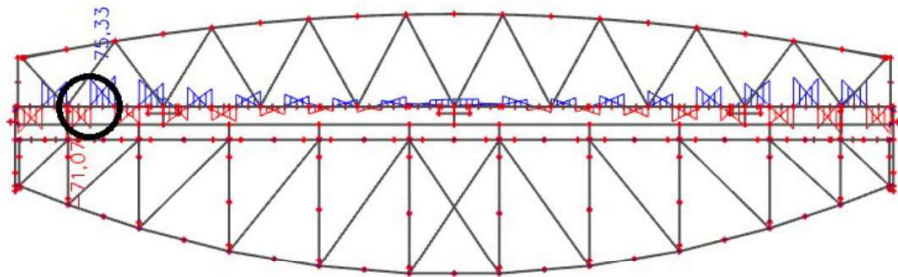
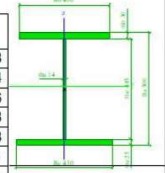
$A := 2.898 \cdot 10^{-2} \text{ m}^2$
 $h := 0.50 \text{ m}$ $b := 0.43 \text{ m}$
 $I_y := 1.3712 \cdot 10^{-3} \text{ m}^4$
 $I_z := 3.2574 \cdot 10^{-4} \text{ m}^4$
 $W_{y.pl} := 6.0414 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 2.3774 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 5.3009 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 1.5151 \cdot 10^{-3} \text{ m}^3$
 $i_y := 218 \text{ mm}$
 $i_z := 106 \text{ mm}$

$I_w := 1.817 \cdot 10^{-5} \text{ m}^6$ $I_t := 6.2718 \cdot 10^{-6} \text{ m}^4$ $A_{vy} := 2.0716 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 7.0467 \cdot 10^{-3} \text{ m}^2$

Průřezy

Jméno	nový - podélník	
Typ	lwn	
Detailní	500; 14; 400; 30; 430; 25; 445; 6	
Materiál	S 235	
Výroba	svařovaný	
Posudek rovinného vzpěru y-y	b	
Posudek rovinného vzpěru z-z	c	
Klopení	Výchozí	
Použití 2D MKP výpočet	x	

A [m²]	2.8980e-02	
A _{y, z} [m²]	2.0716e-02	7.0467e-03
I _{y, z} [m⁴]	1.3712e-03	3.2574e-04
I _w [m⁶], I _t [m⁴]	1.8170e-05	6.2718e-06
W _{el, y, z} [m³]	5.3009e-03	1.5151e-03
W _{pl, y, z} [m³]	6.0414e-03	2.3774e-03
d _{y, z} [mm]	0	-14
c _{YUCS, ZUCS} [mm]	215	259
α [deg]	0.00	
A _{L, D} [m²/m]	2.6320e+00	2.6320e+00
M _{ply +, -} [Nm]	1.42e+06	1.42e+06
M _{viz +, -} [Nm]	5.59e+05	5.59e+05



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-225.73	45.88	45.61	0	75.33	78.62

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 225.73 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 208 \text{ mm}$ $t_f := 25 \text{ mm}$ *stojna* $C_w := 445 \text{ mm}$ $t_w := 14 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 8.32 \implies 3. \text{ třída}$

$\frac{C_w}{t_w} = 31.786 \implies 3. \text{ třída}$

$W_y := W_{y.el} = 0.005 \text{ m}^3$ $W_z := W_{z.el} = 0.002 \text{ m}^3$

MSÚ - NOK - Podélník

vzd. styků:

$$L_y := 1.6 \text{ m}$$

$$L_z := 1.6 \text{ m}$$

$t_f = 25 \text{ mm}$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 1.6 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 1.6 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 1.6 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 1.6 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 7.339 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.096$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 15.094 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.198$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.487$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.037 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.519$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.001 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M1}} = 9352.64 \text{ kN} \quad M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1710.75 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (1.029 \cdot 10^4) \text{ kN} \quad M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 488.96 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (1.817 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (6.272 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (3.257 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 5.415$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 1.048$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 5.772 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.64 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.168 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.486$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 1.006 < \frac{1}{\lambda'_{LT}{}^2} = 35.284$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 1$$

Interakce tlak - ohyb

$$M_{Ed,y} = 75.33 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 225.73 \text{ kN}$$

$$M_{Ed,z} = 78.62 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.001$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.003$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.198$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.8$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.998$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.003$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.602$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.003$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.001 \quad k_{yz} = 1.003 \quad k_{zy} = 0.998 \quad k_{zz} = 1.003$$

$$\chi_y = 1 \quad \chi_z = 1 \quad \chi_{LT} = 1$$

$$N_{Ed.c} = 225.73 \text{ kN}$$

$$M_{Ed.y} = 75.33 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 78.62 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (9.353 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.711 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 488.964 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.229$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.229$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 22.9\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 1$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 2.414\% < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 4.403\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 16.079\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 45.61 \text{ kN}$$

$$A_{vz} = (7.047 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.444 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 3.158\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 45.88 \text{ kN}$$

$$A_{vy} = (2.072 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.246 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 1.081\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

MSÚ - NOK - Podélník

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

PODÉLNÍK

Profil: nový - podélník
 Extrém: N - ST15 - 100°
 Průřezové charakteristiky:

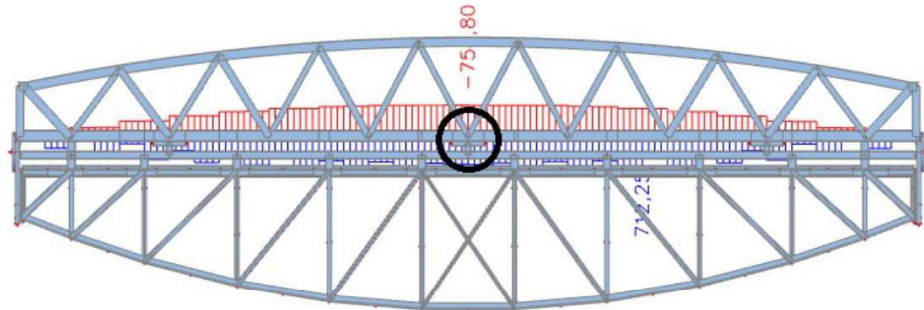
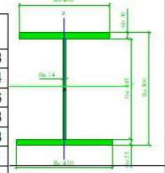
$A := 2.898 \cdot 10^{-2} \text{ m}^2$
 $h := 0.50 \text{ m}$ $b := 0.43 \text{ m}$
 $I_y := 1.3712 \cdot 10^{-3} \text{ m}^4$
 $I_z := 3.2574 \cdot 10^{-4} \text{ m}^4$
 $W_{y.pl} := 6.0414 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 2.3774 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 5.3009 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 1.5151 \cdot 10^{-3} \text{ m}^3$
 $i_y := 218 \text{ mm}$
 $i_z := 106 \text{ mm}$

$I_w := 1.817 \cdot 10^{-5} \text{ m}^6$
 $I_t := 6.2718 \cdot 10^{-6} \text{ m}^4$ $A_{vy} := 2.0716 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 7.0467 \cdot 10^{-3} \text{ m}^2$

Průřezy

Jméno	nový - podélník
Typ	lwn
Detailní	500; 14; 400; 30; 430; 25; 445; 6
Materiál	S 235
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	c
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m²]	2.8980e-02	
A _{y, z} [m²]	2.0716e-02	7.0467e-03
I _{y, z} [m⁴]	1.3712e-03	3.2574e-04
I _w [m⁶], I _t [m⁴]	1.8170e-05	6.2718e-06
W _{el, y, z} [m³]	5.3009e-03	1.5151e-03
W _{pl, y, z} [m³]	6.0414e-03	2.3774e-03
d _{y, z} [mm]	0	-14
c _{YUCS, ZUCS} [mm]	215	259
α [deg]	0.00	
A _{L, D} [m²/m]	2.6320e+00	2.6320e+00
M _{pl, y, z} +, - [Nm]	1.42e+06	1.42e+06
M _{pl, y, z} +, - [Nm]	5.59e+05	5.59e+05



vnitřní síly:

N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
-758.8	5.64	1.87	0	4.61	10.32

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 758.8 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 208 \text{ mm}$ $t_f := 25 \text{ mm}$
stojna $C_w := 445 \text{ mm}$ $t_w := 14 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 8.32 \implies 3. \text{ třída}$ $\frac{C_w}{t_w} = 31.786 \implies 3. \text{ třída}$

$W_y := W_{y.el} = 0.005 \text{ m}^3$ $W_z := W_{z.el} = 0.002 \text{ m}^3$

MSÚ - NOK - Podélník

vzd. styků:

$$L_y := 1.6 \text{ m}$$

$$L_z := 1.6 \text{ m}$$

$t_f = 25 \text{ mm}$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 1.6 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 1.6 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 1.6 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 1.6 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 7.339 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.096$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 15.094 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.198$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.487$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.037 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.519$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 1.001 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 1$$

prostá únosnost

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M1}} = 9352.64 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1710.75 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (1.029 \cdot 10^4) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 488.96 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1,0} := 0.94 \quad C_{1,1} := 0.96$$

$$I_w = (1.817 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (6.272 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (3.257 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 5.415$$

$$C_1 := C_{1,0} + (C_{1,1} - C_{1,0}) \cdot k_{wt} = 1.048$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 5.772 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.64 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.168 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.486$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 1.006 < \frac{1}{\lambda'_{LT}{}^2} = 35.284$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 1$$

Interakce tlak - ohyb

$$M_{Ed,y} = 4.61 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 758.8 \text{ kN}$$

$$M_{Ed,z} = 10.32 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 0.99$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.005$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 0.98$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.01$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.198$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.8$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.995$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.01$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.606$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.01$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.005 \quad k_{yz} = 1.01 \quad k_{zy} = 0.995 \quad k_{zz} = 1.01$$

$$\chi_y = 1 \quad \chi_z = 1 \quad \chi_{LT} = 1$$

$$N_{Ed.c} = 758.8 \text{ kN}$$

$$M_{Ed.y} = 4.61 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 10.32 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (9.353 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.711 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 488.964 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.105$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.105$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 10.5\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 1$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 8.113\% < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.269\% < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 2.111\% < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 1.87 \text{ kN}$$

$$A_{vz} = (7.047 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.444 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.129\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 5.64 \text{ kN}$$

$$A_{vy} = (2.072 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.246 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.133\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$$E := 210 \text{ GPa}$$

$$G := 80 \text{ GPa}$$

$$f_y := 355 \text{ MPa}$$

$$\gamma_{M0} := 1$$

$$\gamma_{M1} := 1.1$$

$$\gamma_{M2} := 1.25$$

$$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$$

DIAGONÁLA

Profil: nový - koncová svislice

Extrém: My - ST14 - 90°

Průřezové charakteristiky:

$$A := 2.332 \cdot 10^{-2} \text{ m}^2$$

$$h := 0.45 \text{ m} \quad b := 0.46 \text{ m}$$

$$I_y := 9.2007 \cdot 10^{-4} \text{ m}^4$$

$$I_z := 3.2451 \cdot 10^{-4} \text{ m}^4$$

$$W_{y.pl} := 4.4603 \cdot 10^{-3} \text{ m}^3$$

$$W_{z.pl} := 2.1308 \cdot 10^{-3} \text{ m}^3$$

$$W_{y.el} := 4.0892 \cdot 10^{-3} \text{ m}^3$$

$$W_{z.el} := 1.4109 \cdot 10^{-3} \text{ m}^3$$

$$i_y := 199 \text{ mm}$$

$$i_z := 118 \text{ mm}$$

$$I_w := 1.4998 \cdot 10^{-5} \text{ m}^6$$

$$I_t := 2.701 \cdot 10^{-6} \text{ m}^4$$

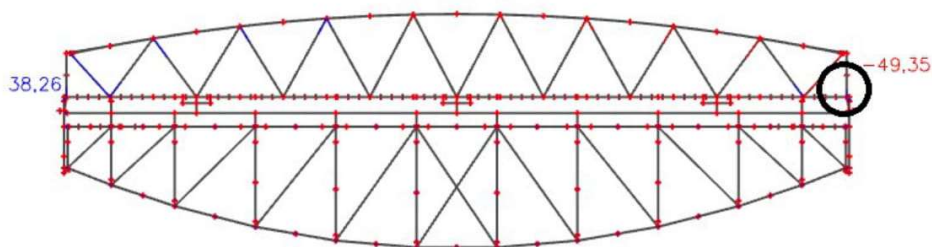
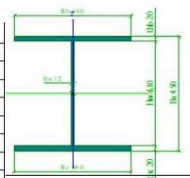
$$A_{vy} := 1.6647 \cdot 10^{-2} \text{ m}^2$$

$$A_{vz} := 5.4479 \cdot 10^{-3} \text{ m}^2$$

Průřezy

Jméno	nový - koncová svislice
Typ	hwn
Detailní	450; 12; 460; 20; 460; 20; 410; 6
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	c
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m²]	2,3320e-02	
A _{y, z} [m²]	1,6647e-02	5,4479e-03
I _{y, z} [m⁴]	9,2007e-04	3,2451e-04
I _w [m⁶], I _t [m⁴]	1,4998e-05	2,7010e-06
W _{el, y, z} [m³]	4,0892e-03	1,4109e-03
W _{pl, y, z} [m³]	4,4603e-03	2,1308e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	230	225
α [deg]	0,00	
A _{L, D} [m²/m]	2,7160e+00	2,7160e+00
M _{pl, y, z} +, - [Nm]	1,58e+06	1,58e+06
M _{pl, y, z} +, - [Nm]	7,56e+05	7,56e+05



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	114.96	21.44	22.64	0	49.35	37.15

$$\text{tlaková normálová síla} ==> N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$$

$$\text{tahová normálová síla} ==> N_{Ed.t} := \max(0, N_{Ed}) = 114.96 \text{ kN}$$

zatřídění průřezu:

pásnice

$$C_f := 219 \text{ mm}$$

$$t_f := 20 \text{ mm}$$

stojna

$$C_w := 400 \text{ mm}$$

$$t_w := 12 \text{ mm}$$

$$\text{tlak.w} := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$$

$$\text{tlak.f} := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$$

$$\text{ohyb.w} := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$$

$$\frac{C_f}{t_f} = 10.95 ==> 3. \text{ třída}$$

$$\frac{C_w}{t_w} = 33.333 ==> 3. \text{ třída}$$

$$W_y := W_{y.el} = 0.004 \text{ m}^3$$

$$W_z := W_{z.el} = 0.001 \text{ m}^3$$

MSÚ - NOK - Diagonála

vzd. styků:

$$L_y := 3.2 \text{ m}$$

$$L_z := 3.2 \text{ m}$$

$t_f = 20 \text{ mm}$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 3.2 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 3.2 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 3.2 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.2 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 16.08 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.21$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 27.119 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.355$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.524$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.996 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.996$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.601$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.921 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.921$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 7526 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1319.7 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (8.279 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 455.34 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 114.96 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 1.389\% < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (1.5 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (2.701 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (3.245 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 3.748$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 1.015$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 3.937 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (1.483 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.313 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.528$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.892 < \frac{1}{\lambda'_{LT}{}^2} = 10.218$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.892$$

Interakce tlak - ohyb

$$M_{Ed,y} = 49.35 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 37.15 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.355$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.95$$

$$\Rightarrow k_{zy} := k_{zy_34} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 1 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 0.996 \quad \chi_z = 0.921 \quad \chi_{LT} = 0.892$$

$$N_{Ed.c} = 0 \text{ kN}$$

$$M_{Ed.y} = 49.35 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 37.15 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.526 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.32 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 455.336 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.133$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.133$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 13.3\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.921$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 4.2\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 9.1\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 22.64 \text{ kN}$$

$$A_{vz} = (5.448 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.117 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 2.028\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 21.44 \text{ kN}$$

$$A_{vy} = (1.665 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (3.412 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.628\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

MSÚ - NOK - Diagonála

DIAGONÁLA

Průřezy

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

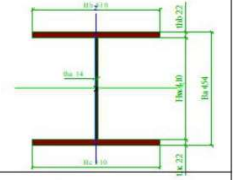
$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

Profil: nový - diagonála - 1
 Extrém: N - ST24 - demontáž otáčedla
 Průřezové charakteristiky:

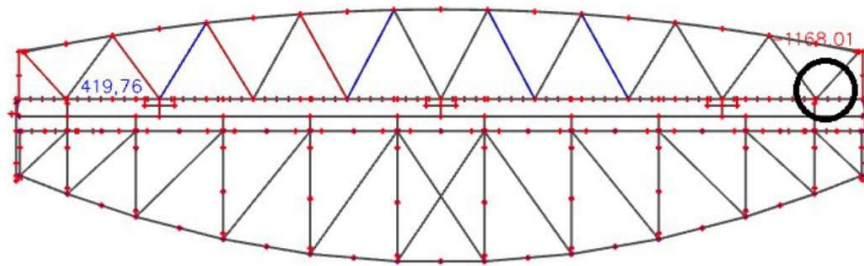
$A := 2.818 \cdot 10^{-2} \text{ m}^2$
 $h := 0.51 \text{ m}$ $b := 0.454 \text{ m}$
 $I_y := 1.1283 \cdot 10^{-3} \text{ m}^4$
 $I_z := 4.8648 \cdot 10^{-4} \text{ m}^4$
 $W_{y.pl} := 5.4354 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 2.8812 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 4.9704 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 1.9078 \cdot 10^{-3} \text{ m}^3$
 $i_y := 200 \text{ mm}$
 $i_z := 131 \text{ mm}$

Jméno	nový - diagonála - 1
Typ	lwn
Detailní	454; 14; 510; 22; 510; 22; 410; 6
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	c
Klopení	Výchozí
Použití 2D MKP výpočet	*

A [m²]	2,8180e-02	
A _{y, z} [m²]	2,0290e-02	6,3485e-03
I _{y, z} [m⁴]	1,1283e-03	4,8648e-04
I _w [m⁴], I _t [m⁴]	2,2693e-05	4,0155e-06
W _{el, y, z} [m³]	4,9704e-03	1,9078e-03
W _{pl, y, z} [m³]	5,4354e-03	2,8812e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	255	227
α [deg]	0,00	
A _{L, D} [m²/m]	2,9200e+00	2,9200e+00
M _{pl, y, z} [Nm]	1,93e+06	1,93e+06
M _{pl, z, y} [Nm]	1,02e+06	1,02e+06



$I_w := 2.2693 \cdot 10^{-5} \text{ m}^6$ $I_t := 4.0155 \cdot 10^{-6} \text{ m}^4$ $A_{vy} := 2.029 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 6.3485 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:

N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
-137.19	79.05	37.64	0	5.21	108.45

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 137.19 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 248 \text{ mm}$ $C_w := 410 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 22 \text{ mm}$ $t_w := 14 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 11.273 \implies 3. \text{ třída}$ $\frac{C_w}{t_w} = 29.286 \implies 2. \text{ třída}$

$W_y := W_{y.el} = 0.005 \text{ m}^3$ $W_z := W_{z.el} = 0.002 \text{ m}^3$

MSÚ - NOK - Diagonála

vzd. styků:

$$L_y := 4.5 \text{ m}$$

$$L_z := 4.5 \text{ m}$$

$$t_f = 22 \text{ mm}$$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 4.5 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 4.5 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 4.5 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 4.5 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 22.5 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.295$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 34.351 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.45$$

vzpěř

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.559$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.966 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.966$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.662$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.871 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.871$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 9094.45 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1604.08 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (1 \cdot 10^4) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 615.7 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (2.269 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (4.016 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (4.865 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.689$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.994$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.851 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (1.14 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.393 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.557$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.826 < \frac{1}{\lambda'_{LT}{}^2} = 6.462$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.826$$

Interakce tlak - ohyb

$$M_{Ed,y} = 5.21 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 137.19 \text{ kN}$$

$$M_{Ed,z} = 108.45 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1.003$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1.005$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.45$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

$$\Rightarrow k_{zy} := k_{zy_34} = 0.999$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.005$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.603$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1.005$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.003 \quad k_{yz} = 1.005 \quad k_{zy} = 0.999 \quad k_{zz} = 1.005$$

$$\chi_y = 0.966 \quad \chi_z = 0.871 \quad \chi_{LT} = 0.826$$

$$N_{Ed.c} = 137.19 \text{ kN}$$

$$M_{Ed.y} = 5.21 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 108.45 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (9.094 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.604 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 615.699 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.234$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.235$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 23.5\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.871$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 1.7\% < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.4\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 21.3\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 37.64 \text{ kN}$$

$$A_{vz} = (6.349 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.301 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 2.893\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 79.05 \text{ kN}$$

$$A_{vy} = (2.029 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.159 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 1.901\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

HORNÍ PŘÍČNÍK

Průřezy

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

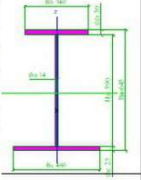
$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

Profil: nový - koncová svislice
 Extrém: Mz - ST15 - 100°
 Průřezové charakteristiky:

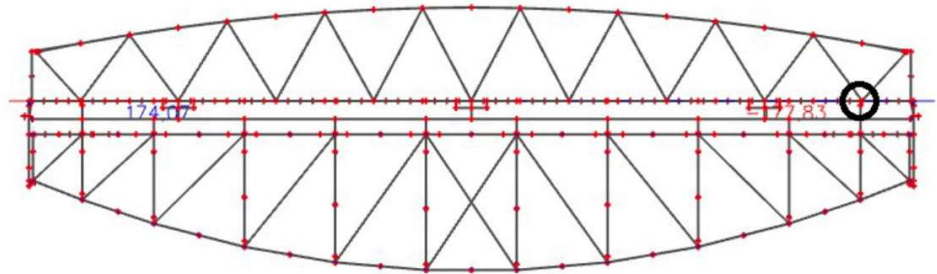
$A := 2.996 \cdot 10^{-2} \text{ m}^2$
 $h := 0.645 \text{ m}$ $b := 0.46 \text{ m}$
 $I_y := 2.3039 \cdot 10^{-3} \text{ m}^4$
 $I_z := 3.0118 \cdot 10^{-4} \text{ m}^4$
 $W_{y.pl} := 7.8864 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 2.2184 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 6.8266 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 1.3095 \cdot 10^{-3} \text{ m}^3$
 $i_y := 277 \text{ mm}$
 $i_z := 100 \text{ mm}$

Jméno	nový - příčník 1 - horní
Typ	lwn
Detailní	645; 14; 340; 30; 460; 25; 590; 0
Materiál	S 355
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	c
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m ²]	2,9960e-02	
A _{y, z} [m ²]	2,0954e-02	9,1288e-03
I _{y, z} [m ⁴]	2,3039e-03	3,0118e-04
I _w [m ⁶], I _t [m ⁴]	2,5238e-05	6,0206e-06
W _{el, y, z} [m ³]	6,8266e-03	1,3095e-03
W _{pl, y, z} [m ³]	7,8864e-03	2,2184e-03
d _{y, z} [mm]	0	-94
c _{YUCS, ZUCS} [mm]	230	308
α [deg]	0,00	
A _{L, D} [m ² /m]	2,8620e+00	2,8620e+00
M _{ply +, -} [Nm]	2,80e+06	2,80e+06
M _{piz +, -} [Nm]	7,88e+05	7,88e+05



$I_w := 2.5238 \cdot 10^{-5} \text{ m}^6$ $A_{vy} := 2.0954 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 9.1288 \cdot 10^{-3} \text{ m}^2$
 $I_t := 6.0206 \cdot 10^{-6} \text{ m}^4$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-28.95	330.98	43.34	0	72.34	177.83

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 28.95 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 219 \text{ mm}$ $C_w := 570 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 20 \text{ mm}$ $t_w := 14 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$
 dominantní je ohyb ==>

$\frac{C_f}{t_f} = 10.95 \implies 3. \text{ třída}$ $\frac{C_w}{t_w} = 40.714 \implies 1. \text{ třída}$

$W_y := W_{y.el} = 0.007 \text{ m}^3$ $W_z := W_{z.el} = 0.001 \text{ m}^3$

MSÚ - NOK - Horní příčník

vzd. styků:

$$L_y := 1.8 \text{ m}$$

$$L_z := 1.8 \text{ m}$$

$t_f = 20 \text{ mm}$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 1.8 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 1.8 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 1.8 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 1.8 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 6.498 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.085$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 18 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.236$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.484$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.041 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.536$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.982 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.982$$

prostá únosnost

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M1}} = 9668.91 \text{ kN} \quad M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 2203.13 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (1.064 \cdot 10^4) \text{ kN} \quad M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 422.61 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (2.524 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (6.021 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (3.012 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 5.79$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 1.056$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 6.203 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (5.976 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.201 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.494$$

$$\chi_{LT-} := \frac{1}{\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5}} = 0.982 < \frac{1}{\lambda'_{LT}{}^2} = 24.657$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.982$$

Interakce tlak - ohyb

podle tvaru ohybového momentu na prutu:

$$M_{Ed.y} = 72.34 \text{ kN} \cdot \text{m} \quad N_{Ed.c} = 28.95 \text{ kN}$$

$$M_{Ed.z} = 177.83 \text{ kN} \cdot \text{m}$$

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.236$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}}\right) = 0.84$$

$$\Rightarrow k_{zy} := k_{zy_34} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 1 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 1 \quad \chi_z = 0.982 \quad \chi_{LT} = 0.982$$

$$N_{Ed.c} = 28.95 \text{ kN}$$

$$M_{Ed.y} = 72.34 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 177.83 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (9.669 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (2.203 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 422.611 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.465$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.465$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 46.5\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.982$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0.3\% < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 3.3\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 42.9\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 43.34 \text{ kN}$$

$$A_{vz} = (9.129 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.871 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 2.316\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 330.98 \text{ kN}$$

$$A_{vy} = (2.095 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (4.295 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 7.707\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

DOLNÍ PŘÍČNÍK

Průřezy

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

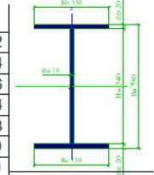
$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

Profil: nový - pricnik dole 0
 Extrém: My - ST14 - 90°
 Průřezové charakteristiky:

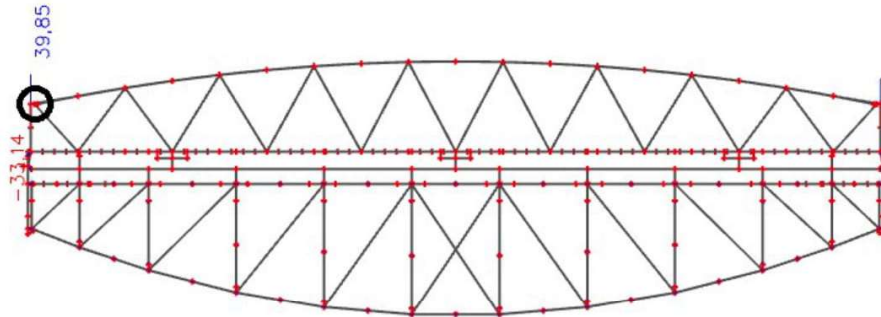
$A := 2.372 \cdot 10^{-2} \text{ m}^2$
 $h := 0.58 \text{ m}$ $b := 0.35 \text{ m}$
 $I_y := 1.3343 \cdot 10^{-3} \text{ m}^4$
 $I_z := 1.4318 \cdot 10^{-4} \text{ m}^4$
 $W_{y.pl} := 5.2322 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 1.2687 \cdot 10^{-3} \text{ m}^3$
 $W_{y.el} := 4.6009 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 8.1817 \cdot 10^{-4} \text{ m}^3$
 $i_y := 237 \text{ mm}$
 $i_z := 78 \text{ mm}$

Jméno	nový - pricnik dole 0
Typ	lwn
Detailní	580; 18; 350; 20; 350; 20; 540; 6
Materiál	S 355 N (EN 10025-3)
Výroba	svařovaný
Posudek rovinného vzpěru y-y	b
Posudek rovinného vzpěru z-z	c
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m²]	2,3720e-02	
A _{y, z} [m²]	1,3192e-02	1,0524e-02
I _{y, z} [m⁴]	1,3343e-03	1,4318e-04
I _w [m⁶], I _t [m⁶]	1,1205e-05	2,9553e-06
W _{el, y, z} [m³]	4,6009e-03	8,1817e-04
W _{pl, y, z} [m³]	5,2322e-03	1,2687e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	175	290
α [deg]	0,00	
A _{L, D} [m²/m]	2,5240e+00	2,5240e+00
M _{plz, +, -} [Nm]	1,86e+06	1,86e+06
M _{plz, +, -} [Nm]	4,50e+05	4,50e+05



$I_w := 1.1205 \cdot 10^{-5} \text{ m}^6$
 $I_t := 2.9553 \cdot 10^{-6} \text{ m}^4$ $A_{vy} := 1.3192 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 1.0524 \cdot 10^{-2} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	176.77	13.44	20.27	0	39.85	23.48

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 176.77 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 166 \text{ mm}$ $t_f := 20 \text{ mm}$
stojna $C_w := 540 \text{ mm}$ $t_w := 18 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

tružez je tažen
 a ohýbán ==>

$\frac{C_f}{t_f} = 8.3$ ==> 3. třída $\frac{C_w}{t_w} = 30$ ==> 1. třída

$W_y := W_{y.el} = 0.005 \text{ m}^3$ $W_z := W_{z.el} = (8.182 \cdot 10^{-4}) \text{ m}^3$

MSÚ - NOK - Dolní příčník

vzd. styků:

$$L_y := 3.6 \text{ m}$$

$$L_z := 3.6 \text{ m}$$

$t_f = 20 \text{ mm}$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 3.6 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 3.6 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 3.6 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.6 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 15.19 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.199$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 46.154 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.604$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.52$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.781$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.783 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.783$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 7655.09 \text{ kN}$$

$$M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1484.84 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = 8420.6 \text{ kN}$$

$$M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 264.05 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 176.77 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 2.099\% < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (1.121 \cdot 10^{-5}) \text{ m}^6 \quad I_t = (2.955 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (1.432 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\frac{E \cdot I_w}{G \cdot I_t}} = 2.753$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.995$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 2.915 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (6.781 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}} \right)^{0.5} = 0.491 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.6$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 0.749 < \frac{1}{\lambda'_{LT}{}^2} = 4.152$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.749$$

Interakce tlak - ohyb

$$M_{Ed,y} = 39.85 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 23.48 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_34} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_34} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.604$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

$$\Rightarrow k_{zy} := k_{zy_34} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_34} = 1$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 1 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 1 \quad \chi_z = 0.783 \quad \chi_{LT} = 0.749$$

$$N_{Ed.c} = 0 \text{ kN} \quad M_{Ed.y} = 39.85 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.655 \cdot 10^3) \text{ kN} \quad M_{Ed.z} = 23.48 \text{ kN} \cdot \text{m}$$

$$M_{y.Rd} = (1.485 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 264.046 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.155$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.155$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 15.5\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.783$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 3.6\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 11.9\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 20.27 \text{ kN}$$

$$A_{vz} = (1.052 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (2.157 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.94\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 13.44 \text{ kN}$$

$$A_{vy} = (1.319 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (2.704 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.497\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

MSÚ - Rošt - Podélník

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

PODÉLNÍK

Profil: rošt1 - HEB500
 Extrém: Mz - ST14 - 90°

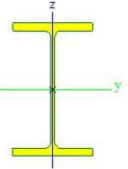
Průřezové charakteristiky:

$A := 2.386 \cdot 10^{-2} \text{ m}^2$
 $h := 0.5 \text{ m}$ $b := 0.3 \text{ m}$
 $I_y := 1.072 \cdot 10^{-3} \text{ m}^4$
 $I_z := 1.262 \cdot 10^{-4} \text{ m}^4$
 $W_{y,pl} := 4.815 \cdot 10^{-3} \text{ m}^3$
 $W_{z,pl} := 1.292 \cdot 10^{-3} \text{ m}^3$
 $W_{y,el} := 4.287 \cdot 10^{-3} \text{ m}^3$
 $W_{z,el} := 8.416 \cdot 10^{-4} \text{ m}^3$
 $i_y := 212 \text{ mm}$
 $i_z := 73 \text{ mm}$

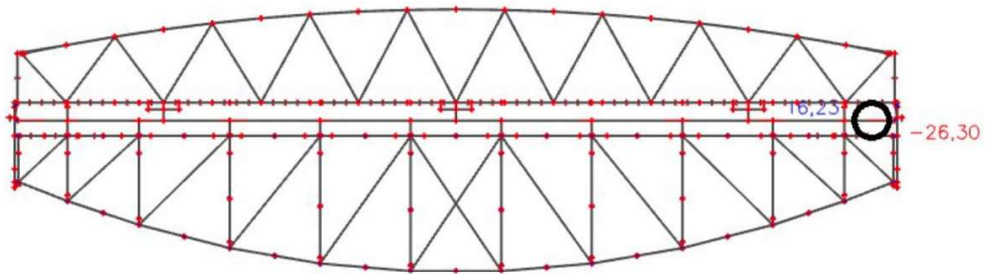
Průřezy

Jméno	rošt1
Typ	HEB500
Zdroj hodnot	Profil Arbed / Structural shapes / Edition Octobre 1995
Materiál	S 355
Výroba	válcovaný
Posudek rovinného vzpěru y-y	a
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m²]	2.3860e-02	
A _{y, z} [m²]	1.6161e-02	7.4905e-03
I _{y, z} [m⁴]	1.0720e-03	1.2620e-04
I _w [m⁴]	7.0177e-06	5.3840e-06
W _{y, z} [m³]	4.2870e-03	8.4160e-04
W _{pl, y, z} [m³]	4.8150e-03	1.2920e-03
d _{y, z} [mm]	0	0
c YUCS, ZUCS [mm]	150	250
α [deg]	0,00	
A _{L, D} [m²/m]	2.1300e+00	2.1244e+00
M _{pl, y, z} [Nm]	1.71e+06	1.71e+06
M _{el, y, z} [Nm]	4.59e+05	4.59e+05



$I_w := 7.0177 \cdot 10^{-6} \text{ m}^6$
 $I_t := 5.384 \cdot 10^{-6} \text{ m}^4$ $A_{vy} := 1.6161 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 7.4905 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	119.29	17.15	27.04	0	7.1	26.3

tlaková normálová síla ==> $N_{Ed,c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed,t} := \max(0, N_{Ed}) = 119.29 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 140 \text{ mm}$ $C_w := 440 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 28 \text{ mm}$ $t_w := 15 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 5 \implies > 1. \text{ třída}$ $\frac{C_w}{t_w} = 29.333 \implies > 2. \text{ třída}$

$W_y := W_{y,pl} = 0.005 \text{ m}^3$ $W_z := W_{z,pl} = 0.001 \text{ m}^3$

Pro prvky roštu je dovolené zpastizování průřezu

MSÚ - Rošt - Podélník

vzd. styků:

$$L_y := 5.9 \text{ m}$$

$$L_z := 5.9 \text{ m}$$

$t_f = 28 \text{ mm}$

křivka a

$$\alpha_y := 0.21$$

křivka b

$$\alpha_z := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 5.9 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 5.9 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 5.9 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 5.9 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 27.83 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.364$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 80.822 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 1.058$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.584$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.962 \quad \Rightarrow \quad \chi_y := \min(\chi_{y-}, 1) = 0.962$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 1.205$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.561 \quad \Rightarrow \quad \chi_z := \min(\chi_{z-}, 1) = 0.561$$

prostá únosnost

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M1}} = 7700.27 \text{ kN} \quad M_{y.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1553.93 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (8.47 \cdot 10^3) \text{ kN} \quad M_{z.Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 416.96 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 119.29 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 1.408\% < 1 \quad \Rightarrow \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (7.018 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (5.384 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (1.262 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\left(\frac{E \cdot I_w}{G \cdot I_t}\right)} = 0.985$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.96$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 1.347 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (2.423 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}}\right)^{0.5} = 0.84 \quad \lambda'_{LT.0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT.0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.811$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 0.526 < \frac{1}{\lambda'_{LT}{}^2} = 1.418$$

$$\Rightarrow \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.526$$

Interakce tlak - ohyb

$$M_{Ed,y} = 7.1 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 26.3 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 1.058$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

$$\Rightarrow k_{zy} := k_{zy_12.8} = 1$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.6$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 0.6 \quad k_{zy} = 1 \quad k_{zz} = 1$$

$$\chi_y = 0.962 \quad \chi_z = 0.561 \quad \chi_{LT} = 0.526$$

$$N_{Ed.c} = 0 \text{ kN} \quad M_{Ed.y} = 7.1 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.7 \cdot 10^3) \text{ kN} \quad M_{Ed.z} = 26.3 \text{ kN} \cdot \text{m}$$

$$M_{y.Rd} = (1.554 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 416.964 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.081$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.129$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 12.9\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.561$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1$$

$$==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.9\% < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 12\% < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 27.04 \text{ kN}$$

$$A_{vz} = (7.491 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.535 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 1.761\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 17.15 \text{ kN}$$

$$A_{vy} = (1.616 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (3.312 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.518\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

MSÚ - Rošt - Podélník

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

PODÉLNÍK

Profil: rošt1 - HEB500
 Extrém: N - ST14 - 90°

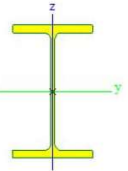
Průřezové charakteristiky:

$A := 2.386 \cdot 10^{-2} \text{ m}^2$
 $h := 0.5 \text{ m}$ $b := 0.3 \text{ m}$
 $I_y := 1.072 \cdot 10^{-3} \text{ m}^4$
 $I_z := 1.262 \cdot 10^{-4} \text{ m}^4$
 $W_{y,pl} := 4.815 \cdot 10^{-3} \text{ m}^3$
 $W_{z,pl} := 1.292 \cdot 10^{-3} \text{ m}^3$
 $W_{y,el} := 4.287 \cdot 10^{-3} \text{ m}^3$
 $W_{z,el} := 8.416 \cdot 10^{-4} \text{ m}^3$
 $i_y := 212 \text{ mm}$
 $i_z := 73 \text{ mm}$

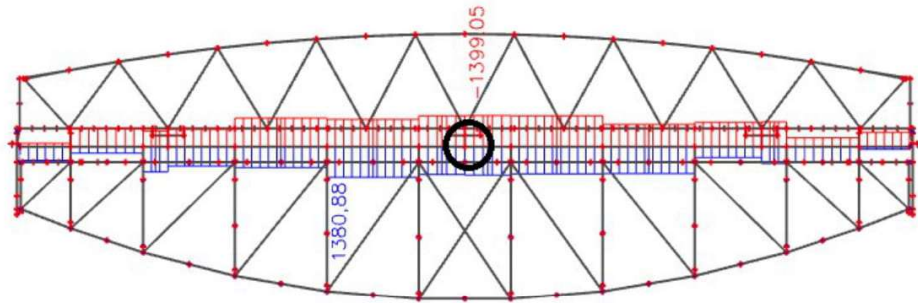
Průřezy

Jméno	rošt1
Typ	HEB500
Zdroj hodnot	Profil Arbed / Structural shapes / Edition Octobre 1995
Materiál	S 355
Výroba	válcovaný
Posudek rovinného vzpěru y-y	a
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití 2D MKP výpočet	x

A [m²]	2.3860e-02	
A _{y, z} [m²]	1.6161e-02	7.4905e-03
I _{y, z} [m⁴]	1.0720e-03	1.2620e-04
I _w [m⁴]	7.0177e-06	5.3840e-06
W _{y, z} [m³]	4.2870e-03	8.4160e-04
W _{pl, y, z} [m³]	4.8150e-03	1.2920e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	150	250
α [deg]	0,00	
A _{L, D} [m²/m]	2.1300e+00	2.1244e+00
M _{pl, y, z} [- [Nm]	1.71e+06	1.71e+06
M _{pl, z, y} [- [Nm]	4.59e+05	4.59e+05



$I_w := 7.0177 \cdot 10^{-6} \text{ m}^6$
 $I_t := 5.384 \cdot 10^{-6} \text{ m}^4$ $A_{vy} := 1.6161 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 7.4905 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-1399.05	2.06	34.85	0	57.9	4.85

tlaková normálová síla ==> $N_{Ed,c} := \min(0, N_{Ed}) \cdot (-1) = (1.399 \cdot 10^3) \text{ kN}$
 tahová normálová síla ==> $N_{Ed,t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 140 \text{ mm}$ $C_w := 440 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 28 \text{ mm}$ $t_w := 15 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 5 \implies 1. \text{ třída}$

$\frac{C_w}{t_w} = 29.333 \implies 2. \text{ třída}$

Pro prvky roštu je dovolené zpastizování průřezu

$W_y := W_{y,pl} = 0.005 \text{ m}^3$ $W_z := W_{z,pl} = 0.001 \text{ m}^3$

MSÚ - Rošt - Podélník

vzd. styků:

$$L_y := 5.9 \text{ m}$$

$$L_z := 5.9 \text{ m}$$

$t_f = 28 \text{ mm}$

křivka a

$$\alpha_y := 0.21$$

křivka b

$$\alpha_z := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 5.9 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 5.9 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 5.9 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 5.9 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 27.83 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.364$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 80.822 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 1.058$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.584$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.962 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.962$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 1.205$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.561 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.561$$

prostá únosnost

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M1}} = 7700.27 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1553.93 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (8.47 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 416.96 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (7.018 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (5.384 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (1.262 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\left(\frac{E \cdot I_w}{G \cdot I_t}\right)} = 0.985$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 0.96$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 1.347 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (2.423 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}}\right)^{0.5} = 0.84 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.811$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 0.526 < \frac{1}{\lambda'_{LT}{}^2} = 1.418$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.526$$

Interakce tlak - ohyb

$$M_{Ed,y} = 57.9 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = (1.399 \cdot 10^3) \text{ kN}$$

$$M_{Ed,z} = 4.85 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

$$\text{třída 3,4} \quad k_{yy_{34}} := \min \left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right) \right) = 1.04$$

$$\text{třída 1,2} \quad k_{yy_{12}} := \min \left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right) \right) = 1.03$$

$$\Rightarrow k_{yy} := k_{yy_{12}} = 1.031$$

$$\text{třída 3,4} \quad k_{zz_{34}} := \min \left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) \right) = 1.19$$

$$\text{třída 1,2} \quad k_{zz_{12}} := \min \left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) \right) = 1.45$$

$$\Rightarrow k_{zz} := k_{zz_{12}} = 1.454$$

$$\text{třída 3,4} \quad k_{zy_{34}} := \min \left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) = 0.98$$

$$\text{třída 1,2; } \lambda_z' > 0.4$$

$$\lambda_z' = 1.058 \quad k_{zy_{12.8}} := \min \left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) = 0.95$$

$$\text{třída 1,2; } \lambda_z' < 0.4 \quad k_{zy_{12.0}} := \min \left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) = 0.96$$

$$\Rightarrow k_{zy} := k_{zy_{12.8}} = 0.954$$

$$\text{třída 3,4} \quad k_{yz_{34}} := k_{zz} = 1.454$$

$$\text{třída 1,2} \quad k_{yz_{12}} := 0.6 \cdot k_{zz} = 0.872$$

$$\Rightarrow k_{yz} := k_{yz_{12}} = 0.872$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.031 \quad k_{yz} = 0.872 \quad k_{zy} = 0.954 \quad k_{zz} = 1.454$$

$$\chi_y = 0.962 \quad \chi_z = 0.561 \quad \chi_{LT} = 0.526$$

$$N_{Ed.c} = (1.399 \cdot 10^3) \text{ kN}$$

$$M_{Ed.y} = 57.9 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 4.85 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.7 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.554 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 416.964 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.281$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.424$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 42.4\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.561$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 32.4\% < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 7.1\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 2.2\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 34.85 \text{ kN}$$

$$A_{vz} = (7.491 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.535 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 2.27\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 2.06 \text{ kN}$$

$$A_{vy} = (1.616 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (3.312 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.062\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

MSÚ - Rošt - Spojka

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

Spojka

Profil: rošt2 - HEB500
 Extrém: Mz - ST14 - 90°

Průřezy

Jméno	rošt2
Typ	HEB500
Zdroj hodnot	Profil Arbed / Structural shapes / Edition Octobre 1995
Materiál	S 355
Výroba	válcovaný
Posudek rovinného vzpěru y-y	a
Posudek rovinného vzpěru z-z	b
Klopení	Výchozí
Použití 2D MKP výpočet	*

Průřezové charakteristiky:

$A := 2.386 \cdot 10^{-2} \text{ m}^2$

$h := 0.5 \text{ m} \quad b := 0.3 \text{ m}$

$I_y := 1.072 \cdot 10^{-3} \text{ m}^4$

$I_z := 1.262 \cdot 10^{-4} \text{ m}^4$

$W_{y,pl} := 4.815 \cdot 10^{-3} \text{ m}^3$

$W_{z,pl} := 1.292 \cdot 10^{-3} \text{ m}^3$

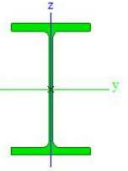
$W_{y,el} := 4.287 \cdot 10^{-3} \text{ m}^3$

$W_{z,el} := 8.416 \cdot 10^{-4} \text{ m}^3$

$i_y := 212 \text{ mm}$

$i_z := 73 \text{ mm}$

A [m²]	2.3860e-02	
A y, z [m²]	1.6161e-02	7.4905e-03
I y, z [m⁴]	1.0720e-03	1.2620e-04
I w [m⁴], I [m⁴]	7.0177e-06	5.3840e-06
W _y , z [m³]	4.2870e-03	8.4160e-04
W _{pl} y, z [m³]	4.8150e-03	1.2920e-03
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	150	250
α [deg]	0.00	
A L, D [m²/m]	2.1300e+00	2.1244e+00
M _{pl,y} , - [Nm]	1.71e+06	1.71e+06
M _{pl,z} , - [Nm]	4.59e+05	4.59e+05

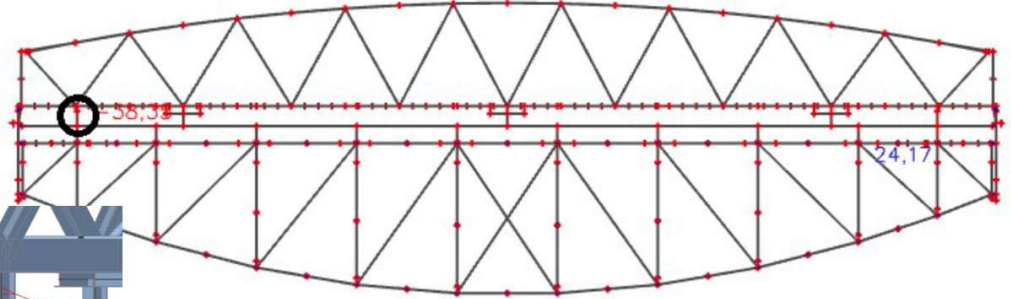
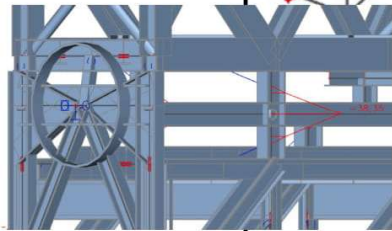


$I_w := 7.0177 \cdot 10^{-6} \text{ m}^6$

$I_t := 5.384 \cdot 10^{-6} \text{ m}^4$

$A_{vy} := 1.6161 \cdot 10^{-2} \text{ m}^2$

$A_{vz} := 7.4905 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:

N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
245.01	70.49	92.41	0	74.18	38.35

tlaková normálová síla ==> $N_{Ed,c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$

tahová normálová síla ==> $N_{Ed,t} := \max(0, N_{Ed}) = 245.01 \text{ kN}$

zatřídění průřezu:

pásnice

$C_f := 140 \text{ mm}$

$t_f := 28 \text{ mm}$

stojna

$C_w := 440 \text{ mm}$

$t_w := 15 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$

$ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 5 \quad ==> 1. \text{ třída}$

$\frac{C_w}{t_w} = 29.333 \quad ==> 2. \text{ třída}$

Pro prvky roštu je dovolené zpatizování průřezu

$W_y := W_{y,pl} = 0.005 \text{ m}^3$

$W_z := W_{z,pl} = 0.001 \text{ m}^3$

MSÚ - Rošt - Spojka

vzd. styků:

$$L_y := 1.2 \text{ m}$$

$$L_z := 1.2 \text{ m}$$

$t_f = 28 \text{ mm}$

křivka a

$$\alpha_y := 0.21$$

křivka b

$$\alpha_z := 0.34$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

křivka a

$$L_{Lt} = 1.2 \text{ m}$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 1.2 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 1.2 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 1.2 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 5.66 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.074$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 16.438 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.215$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.49$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1.027 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.526$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.995 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.995$$

prostá únosnost

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M1}} = 7700.27 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1553.93 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (8.47 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 416.96 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 245.01 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 2.893\% < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$k_z := \beta_z = 1 \quad k_w := \beta_y = 1 \quad C_{1.0} := 0.94 \quad C_{1.1} := 0.96$$

$$I_w = (7.018 \cdot 10^{-6}) \text{ m}^6 \quad I_t = (5.384 \cdot 10^{-6}) \text{ m}^4 \quad I_z = (1.262 \cdot 10^{-4}) \text{ m}^4$$

$$k_{wt} := \frac{\pi}{k_w \cdot L_{Lt}} \cdot \sqrt[2]{\left(\frac{E \cdot I_w}{G \cdot I_t}\right)} = 4.843$$

$$C_1 := C_{1.0} + (C_{1.1} - C_{1.0}) \cdot k_{wt} = 1.037$$

$$\mu_{cr} := \frac{C_1}{k_z} \cdot (1 + k_{wt}^2)^{0.5} = 5.127 \quad M_{cr} := \mu_{cr} \cdot \frac{\pi \cdot (E \cdot I_z \cdot G \cdot I_t)^{0.5}}{L_{Lt}} = (4.535 \cdot 10^4) \text{ kN} \cdot \text{m}$$

$$\lambda'_{LT} := \left(\frac{W_y \cdot f_y}{M_{cr}}\right)^{0.5} = 0.194 \quad \lambda'_{LT,0} := 0.4 \quad \beta := 0.75 \quad \alpha_{LT} := 0.21$$

$$\phi_{LT} := 0.5 \cdot (1 + \alpha_{LT} \cdot (\lambda'_{LT} - \lambda'_{LT,0}) + \beta \cdot \lambda'_{LT}{}^2) = 0.493$$

$$\chi_{LT-} := \frac{1}{(\phi_{LT} + (\phi_{LT}^2 + \beta \cdot \lambda'_{LT}{}^2)^{0.5})} = 0.987 < \frac{1}{\lambda'_{LT}{}^2} = 26.53$$

$$==> \quad \chi_{LT} := \min(\chi_{LT-}, 1) = 0.987$$

Interakce tlak - ohyb

$$M_{Ed,y} = 74.18 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 38.35 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.215$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.82$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.815$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.6$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 0.6 \quad k_{zy} = 0.815 \quad k_{zz} = 1$$

$$\chi_y = 1 \quad \chi_z = 0.995 \quad \chi_{LT} = 0.987$$

$$N_{Ed.c} = 0 \text{ kN}$$

$$M_{Ed.y} = 74.18 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 38.35 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.7 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.554 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 416.964 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.104$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.133$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 13.3\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.995$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 4.8\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 9.3\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 92.41 \text{ kN}$$

$$A_{vz} = (7.491 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.535 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 6.019\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 70.49 \text{ kN}$$

$$A_{vy} = (1.616 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (3.312 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 2.128\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci

MSÚ - Rošt - Spojka

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$
 $\gamma_{M1} := 1.1$
 $\gamma_{M2} := 1.25$

$\varepsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

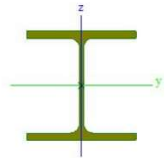
SPOJKA

Profil: rošt1 - HEB300
 Extrém: Mz - ST14 - 90°
 Průřezové charakteristiky:

$A := 1.491 \cdot 10^{-2} \text{ m}^2$
 $h := 0.3 \text{ m}$ $b := 0.3 \text{ m}$
 $I_y := 2.517 \cdot 10^{-4} \text{ m}^4$
 $I_z := 8.563 \cdot 10^{-5} \text{ m}^4$
 $W_{y.pl} := 1.869 \cdot 10^{-3} \text{ m}^3$
 $W_{z.pl} := 8.701 \cdot 10^{-4} \text{ m}^3$
 $W_{y.el} := 1.678 \cdot 10^{-3} \text{ m}^3$
 $W_{z.el} := 5.709 \cdot 10^{-4} \text{ m}^3$
 $i_y := 130 \text{ mm}$
 $i_z := 76 \text{ mm}$
 $I_w := 1.6878 \cdot 10^{-6} \text{ m}^6$
 $I_t := 1.85 \cdot 10^{-6} \text{ m}^4$

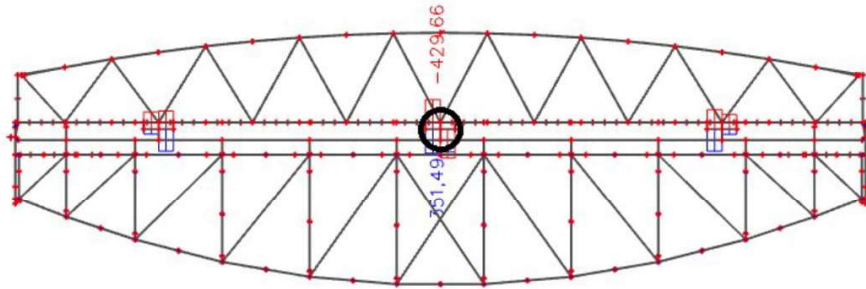
Průřezy

Jméno	rost nozicka1	
Typ	HEB300	
Zdroj hodnot	Profil Arbed / Structural shapes / Edition Octobre 1995	
Materiál	S 355	
Výroba	válcovaný	
Posudek rovinného vzpěru y-y	b	
Posudek rovinného vzpěru z-z	c	
Klopení	Výchozí	
Použití	2D MKP výpočet	



A [m²]	1.4910e-02	
A _{y, z} [m²]	1.0963e-02	3.5436e-03
I _{y, z} [m⁴]	2.5170e-04	8.5630e-05
I _w [m⁶], I _t [m⁴]	1.6878e-06	1.8500e-06
W _{pl, y, z} [m³]	1.6780e-03	5.7090e-04
W _{el, y, z} [m³]	1.8690e-03	8.7010e-04
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	150	150
α [deg]	0.00	
A _{L, D} [m²/m]	1.7300e+00	1.7314e+00
M _{pl, +, -} [Nm]	6.64e+05	6.64e+05
M _{plz, +, -} [Nm]	3.09e+05	3.09e+05

$A_{vy} := 1.0963 \cdot 10^{-2} \text{ m}^2$ $A_{vz} := 3.5436 \cdot 10^{-3} \text{ m}^2$



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-429.66	3.12	3.47	0	9.28	2.25

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 429.66 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice *stojna*
 $C_f := 140 \text{ mm}$ $C_w := 260 \text{ mm}$ $tlak.w := \begin{bmatrix} 33 \cdot \varepsilon \\ 38 \cdot \varepsilon \\ 42 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$
 $t_f := 19 \text{ mm}$ $t_w := 11 \text{ mm}$

$tlak.f := \begin{bmatrix} 9 \cdot \varepsilon \\ 10 \cdot \varepsilon \\ 14 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 7.323 \\ 8.136 \\ 11.391 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \varepsilon \\ 83 \cdot \varepsilon \\ 124 \cdot \varepsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 7.368 \implies 1. \text{ třída}$

$\frac{C_w}{t_w} = 23.636 \implies 1. \text{ třída}$

Pro prvky roštu je dovolené zpastizování průřezu

$W_y := W_{y.pl} = 0.002 \text{ m}^3$ $W_z := W_{z.pl} = (8.701 \cdot 10^{-4}) \text{ m}^3$

MSÚ - Rošt - Spojka

vzd. styků:

$$L_y := 2 \text{ m}$$

$$L_z := 2 \text{ m}$$

$$t_f = 19 \text{ mm}$$

křivka b

$$\alpha_y := 0.34$$

křivka c

$$\alpha_z := 0.49$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr.y} := \beta_y \cdot L_y = 2 \text{ m} \quad L_{cr.z} := \beta_z \cdot L_z = 2 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 2 \text{ m}$$

$$\lambda_y := \frac{L_{cr.y}}{i_y} = 15.385 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.201$$

$$\lambda_z := \frac{L_{cr.z}}{i_z} = 26.316 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.344$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.521$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 1 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 1$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.595$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.926 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.926$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 4811.86 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 603.18 \text{ kN} \cdot \text{m}$$

$$N_{Rd.t} := A \cdot \frac{f_y}{\gamma_{M0}} = (5.293 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 280.81 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed.t} = 0 \text{ kN}$

$$\frac{N_{Ed.t}}{N_{Rd.t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

Průřez je podepřený horním pasem NOK ==> neklopí $\chi_{LT} := 1$

Interakce tlak - ohyb

$$M_{Ed,y} = 9.28 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 429.66 \text{ kN}$$

$$M_{Ed,z} = 2.25 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

$$\text{třída 3,4} \quad k_{yy_{34}} := \min \left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right) \right) = 1.01$$

$$\text{třída 1,2} \quad k_{yy_{12}} := \min \left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}} \right) \right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_{12}} = 1$$

$$\text{třída 3,4} \quad k_{zz_{34}} := \min \left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) \right) = 1.02$$

$$\text{třída 1,2} \quad k_{zz_{12}} := \min \left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) \right) = 1.01$$

$$\Rightarrow k_{zz} := k_{zz_{12}} = 1.009$$

$$\text{třída 3,4} \quad k_{zy_{34}} := \min \left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) = 0.99$$

$$\text{třída 1,2; } \lambda_z' > 0.4$$

$$\lambda_z' = 0.344 \quad k_{zy_{12.8}} := \min \left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) = 0.99$$

$$\text{třída 1,2; } \lambda_z' < 0.4 \quad k_{zy_{12.0}} := \min \left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}} \right) = 0.94$$

$$\Rightarrow k_{zy} := k_{zy_{12.8}} = 0.987$$

$$\text{třída 3,4} \quad k_{yz_{34}} := k_{zz} = 1.009$$

$$\text{třída 1,2} \quad k_{yz_{12}} := 0.6 \cdot k_{zz} = 0.605$$

$$\Rightarrow k_{yz} := k_{yz_{12}} = 0.605$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 0.605 \quad k_{zy} = 0.987 \quad k_{zz} = 1.009$$

$$\chi_y = 1 \quad \chi_z = 0.926 \quad \chi_{LT} = 1$$

$$N_{Ed.c} = 429.66 \text{ kN}$$

$$M_{Ed.y} = 9.28 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 2.25 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (4.812 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = 603.177 \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 280.805 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.11$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.12$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 12\% < 100\% \quad ==> \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.926$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 9.6\% < 1 \quad ==> \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 1.5\% < 1 \quad ==> \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.8\% < 1 \quad ==> \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 3.47 \text{ kN}$$

$$A_{vz} = (3.544 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 726.294 \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.478\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 3.12 \text{ kN}$$

$$A_{vy} = (1.096 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (2.247 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.139\% < 50\% \quad ==> \text{malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\epsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

KONCOVÝ PŘÍČNÍK

Profil: rošt4 - RHS500/300/16
 Extrém: My - ST23 - 180°

Průřezové charakteristiky:

$A := 2.43 \cdot 10^{-2} \text{ m}^2$

$h := 0.5 \text{ m} \quad b := 0.3 \text{ m}$

$I_y := 8.178 \cdot 10^{-4} \text{ m}^4$

$I_z := 3.677 \cdot 10^{-4} \text{ m}^4$

$W_{y.pl} := 3.9652 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 2.7812 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 3.271 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 2.451 \cdot 10^{-3} \text{ m}^3$

$i_y := 183 \text{ mm}$

$i_z := 123 \text{ mm}$

$I_w := 1.2 \cdot 10^{-5} \text{ m}^6$

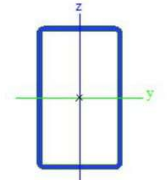
$I_t := 8.033 \cdot 10^{-4} \text{ m}^4$

$A_{vy} := 9.0481 \cdot 10^{-3} \text{ m}^2$

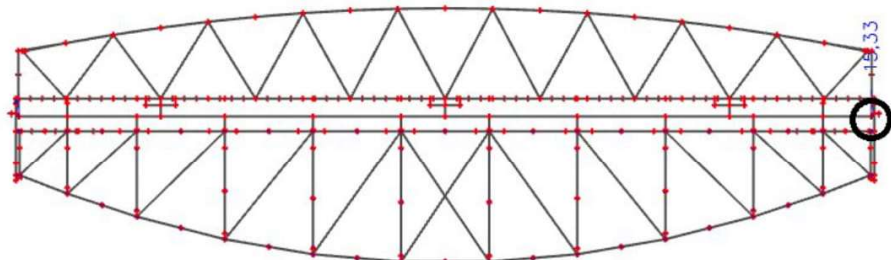
$A_{vz} := 1.508 \cdot 10^{-2} \text{ m}^2$

Průřezy

Jméno	rošt4
Typ	RHS500/300/16.0
Zdroj hodnot	British Standard / BS 5950 part 1 : 1990 & EN 10210-2
Materiál	S 355
Výroba	válcovaný
Posudek rovinného vzpěru y-y	a
Posudek rovinného vzpěru z-z	a
Klopení	Výchozí
Použit 2D MKP výpočet	x



A [m²]	2.4300e-02	
A _{y, z} [m²]	9.0481e-03	1.5080e-02
I _{y, z} [m⁴]	8.1780e-04	3.6770e-04
I _w [m⁶], I _t [m⁴]	1.2000e-05	8.0330e-04
W _{el, y, z} [m³]	3.2710e-03	2.4510e-03
W _{pl, y, z} [m³]	3.9652e-03	2.7812e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	150	250
α [deg]	0.00	
A _{L, D} [m²/m]	1.5600e+00	3.0168e+00
M _{pl, y, z} +, - [Nm]	1.41e+06	1.41e+06
M _{pl, y, z} +, - [Nm]	9.87e+05	9.87e+05



vnitřní síly:

N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
279.48	0.39	0.1	0	15.33	3.92

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 0 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 279.48 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 220 \text{ mm}$ $t_f := 16 \text{ mm}$ *stojna* $C_w := 420 \text{ mm}$ $t_w := 16 \text{ mm}$

$tlak.w := \begin{bmatrix} 33 \cdot \epsilon \\ 38 \cdot \epsilon \\ 42 \cdot \epsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 33 \cdot \epsilon \\ 38 \cdot \epsilon \\ 42 \cdot \epsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \epsilon \\ 83 \cdot \epsilon \\ 124 \cdot \epsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 13.75 \quad ==> 1. \text{ třída}$ $\frac{C_w}{t_w} = 26.25 \quad ==> 1. \text{ třída}$

$W_y := W_{y.pl} = 0.004 \text{ m}^3$ $W_z := W_{z.pl} = 0.003 \text{ m}^3$

Pro prvky roštu je dovolené zpastizování průřezu

MSÚ - Rošt - Koncový příčník

vzd. styků:

$$L_y := 3.6 \text{ m}$$

$$L_z := 3.6 \text{ m}$$

$t_f = 16 \text{ mm}$

křivka a

$$\alpha_y := 0.21$$

křivka b

$$\alpha_z := 0.21$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 3.6 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 3.6 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.6 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 19.672 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.257$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 29.268 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.383$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.539$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.987 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.987$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.593$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.957 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.957$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 7842.27 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1279.68 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (8.627 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 897.57 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 279.48 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 3.24\% < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$\text{uzavřený průřez - neklopí} \quad ==> \quad \chi_{LT} := 1$$

Interakce tlak - ohyb

$$M_{Ed,y} = 15.33 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 0 \text{ kN}$$

$$M_{Ed,z} = 3.92 \text{ kN} \cdot \text{m}$$

podle tvaru ohybového momentu na prutu:

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.383$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.983$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.6$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.6$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1 \quad k_{yz} = 0.6 \quad k_{zy} = 0.983 \quad k_{zz} = 1$$

$$\chi_y = 0.987 \quad \chi_z = 0.957 \quad \chi_{LT} = 1$$

$$N_{Ed.c} = 0 \text{ kN}$$

$$M_{Ed.y} = 15.33 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 3.92 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.842 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.28 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 897.569 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.015$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.016$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 1.6\% < 100\% \quad ==> \text{ Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.957$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 0 < 1 \quad ==> \text{ Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 1.2\% < 1 \quad ==> \text{ Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.4\% < 1 \quad ==> \text{ Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 0.1 \text{ kN}$$

$$A_{vz} = (1.508 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (3.091 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.003\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 0.39 \text{ kN}$$

$$A_{vy} = (9.048 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.854 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.021\% < 50\% \quad ==> \text{ malý smyk vyhovuje}$$

==> Průřez vyhovuje na posuzovanou kombinaci

$E := 210 \text{ GPa}$
 $G := 80 \text{ GPa}$

$f_y := 355 \text{ MPa}$

$\gamma_{M0} := 1$

$\gamma_{M1} := 1.1$

$\gamma_{M2} := 1.25$

$\epsilon := \left(\frac{235 \text{ MPa}}{f_y} \right)^{0.5} = 0.814$

KONCOVÝ PŘÍČNÍK

Profil: rošt4 - RHS500/300/16
 Extrém: N - ST5 - Sepnutí

Průřezové charakteristiky:

$A := 2.43 \cdot 10^{-2} \text{ m}^2$

$h := 0.5 \text{ m} \quad b := 0.3 \text{ m}$

$I_y := 8.178 \cdot 10^{-4} \text{ m}^4$

$I_z := 3.677 \cdot 10^{-4} \text{ m}^4$

$W_{y.pl} := 3.9652 \cdot 10^{-3} \text{ m}^3$

$W_{z.pl} := 2.7812 \cdot 10^{-3} \text{ m}^3$

$W_{y.el} := 3.271 \cdot 10^{-3} \text{ m}^3$

$W_{z.el} := 2.451 \cdot 10^{-3} \text{ m}^3$

$i_y := 183 \text{ mm}$

$i_z := 123 \text{ mm}$

$I_w := 1.2 \cdot 10^{-5} \text{ m}^6$

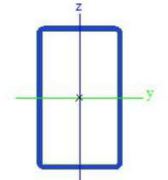
$I_t := 8.033 \cdot 10^{-4} \text{ m}^4$

$A_{vy} := 9.0481 \cdot 10^{-3} \text{ m}^2$

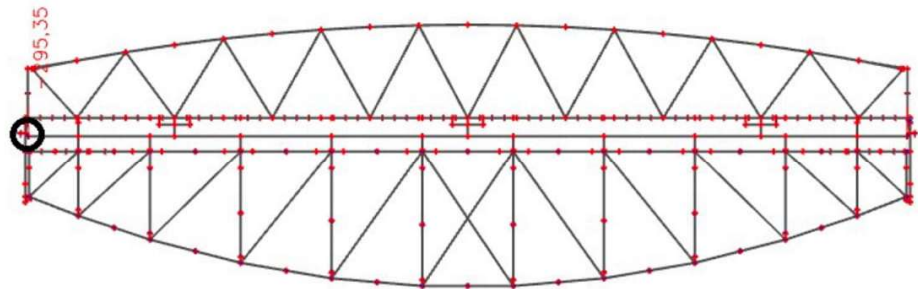
$A_{vz} := 1.508 \cdot 10^{-2} \text{ m}^2$

Průřezy

Jméno	rošt4
Typ	RHS500/300/16.0
Zdroj hodnot	British Standard / BS 5950 part 1 : 1990 & EN 10210-2
Materiál	S 355
Výroba	válcovaný
Posudek rovinného vzpěru y-y	a
Posudek rovinného vzpěru z-z	a
Klopení	Výchozí
Použití 2D MKP výpočet	x



A [m²]	2.4300e-02	
A _{y, z} [m²]	9.0481e-03	1.5080e-02
I _{y, z} [m⁴]	8.1780e-04	3.6770e-04
I _w [m⁶], I _t [m⁴]	1.2000e-05	8.0330e-04
W _{el, y, z} [m³]	3.2710e-03	2.4510e-03
W _{pl, y, z} [m³]	3.9652e-03	2.7812e-03
d _{y, z} [mm]	0	0
c _{YUCS, ZUCS} [mm]	150	250
α [deg]	0.00	
A _{L, D} [m²/m]	1.5600e+00	3.0168e+00
M _{pl, y, z} +, - [Nm]	1.41e+06	1.41e+06
M _{pl, y, z} +, - [Nm]	9.87e+05	9.87e+05



vnitřní síly:	N_{Ed}	$V_{Ed,y}$	$V_{Ed,z}$	$M_{Ed,x}$	$M_{Ed,y}$	$M_{Ed,z}$
	(kN)	(kN)	(kN)	(kN·m)	(kN·m)	(kN·m)
	-295.35	0.39	4.53	0	11.16	4.87

tlaková normálová síla ==> $N_{Ed.c} := \min(0, N_{Ed}) \cdot (-1) = 295.35 \text{ kN}$
 tahová normálová síla ==> $N_{Ed.t} := \max(0, N_{Ed}) = 0 \text{ kN}$

zatřídění průřezu:

pásnice $C_f := 220 \text{ mm}$ $t_f := 16 \text{ mm}$ *stojna* $C_w := 420 \text{ mm}$ $t_w := 16 \text{ mm}$
 $tlak.w := \begin{bmatrix} 33 \cdot \epsilon \\ 38 \cdot \epsilon \\ 42 \cdot \epsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$

$tlak.f := \begin{bmatrix} 33 \cdot \epsilon \\ 38 \cdot \epsilon \\ 42 \cdot \epsilon \end{bmatrix} = \begin{bmatrix} 26.849 \\ 30.917 \\ 34.172 \end{bmatrix}$ $ohyb.w := \begin{bmatrix} 72 \cdot \epsilon \\ 83 \cdot \epsilon \\ 124 \cdot \epsilon \end{bmatrix} = \begin{bmatrix} 58.58 \\ 67.53 \\ 100.888 \end{bmatrix}$

$\frac{C_f}{t_f} = 13.75 \quad ==> 1. \text{ třída}$ $\frac{C_w}{t_w} = 26.25 \quad ==> 1. \text{ třída}$

$W_y := W_{y.pl} = 0.004 \text{ m}^3$ $W_z := W_{z.pl} = 0.003 \text{ m}^3$

Pro prvky roštu je dovolené zpastizování průřezu

MSÚ - Rošt - Koncový příčník

vzd. styků:

$$L_y := 3.6 \text{ m}$$

$$L_z := 3.6 \text{ m}$$

$t_f = 16 \text{ mm}$

křivka a

$$\alpha_y := 0.21$$

křivka b

$$\alpha_z := 0.21$$

$$\gamma_{M0} = 1$$

$$\gamma_{M1} = 1.1$$

vzpěrné délky:

$$\beta_y := 1 \quad \beta_z := 1 \quad \beta_w := 1$$

$$L_{cr,y} := \beta_y \cdot L_y = 3.6 \text{ m} \quad L_{cr,z} := \beta_z \cdot L_z = 3.6 \text{ m} \quad L_{Lt} := \beta_w \cdot L_y = 3.6 \text{ m}$$

$$\lambda_y := \frac{L_{cr,y}}{i_y} = 19.672 \quad \lambda_1 := 93.9 \cdot \varepsilon = 76.399 \quad \lambda_y' := \frac{\lambda_y}{\lambda_1} = 0.257$$

$$\lambda_z := \frac{L_{cr,z}}{i_z} = 29.268 \quad \lambda_z' := \frac{\lambda_z}{\lambda_1} = 0.383$$

vzpěr

$$\phi_y := 0.5 \cdot (1 + \alpha_y \cdot (\lambda_y' - 0.2) + \lambda_y'^2) = 0.539$$

$$\chi_{y-} := \frac{1}{(\phi_y + (\phi_y^2 - \lambda_y'^2)^{0.5})} = 0.987 \quad ==> \quad \chi_y := \min(\chi_{y-}, 1) = 0.987$$

$$\phi_z := 0.5 \cdot (1 + \alpha_z \cdot (\lambda_z' - 0.2) + \lambda_z'^2) = 0.593$$

$$\chi_{z-} := \frac{1}{(\phi_z + (\phi_z^2 - \lambda_z'^2)^{0.5})} = 0.957 \quad ==> \quad \chi_z := \min(\chi_{z-}, 1) = 0.957$$

prostá únosnost

$$N_{Rd} := A \cdot \frac{f_y}{\gamma_{M1}} = 7842.27 \text{ kN} \quad M_{y,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_y = 1279.68 \text{ kN} \cdot \text{m}$$

$$N_{Rd,t} := A \cdot \frac{f_y}{\gamma_{M0}} = (8.627 \cdot 10^3) \text{ kN} \quad M_{z,Rd} := \frac{f_y}{\gamma_{M1}} \cdot W_z = 897.57 \text{ kN} \cdot \text{m}$$

posouzení v tahu: $N_{Ed,t} = 0 \text{ kN}$

$$\frac{N_{Ed,t}}{N_{Rd,t}} = 0 < 1 \quad ==> \quad \text{Vyhovuje}$$

klopení:

$$\text{uzavřený průřez - neklopí} \quad ==> \quad \chi_{LT} := 1$$

Interakce tlak - ohyb

podle tvaru ohybového momentu na prutu:

$$M_{Ed,y} = 11.16 \text{ kN} \cdot \text{m} \quad N_{Ed,c} = 295.35 \text{ kN}$$

$$M_{Ed,z} = 4.87 \text{ kN} \cdot \text{m}$$

$$\psi_y := 1 \quad \psi_z := 1 \quad \psi_{LT} := 1$$

$$C_{my_} := 0.6 + 0.4 \cdot \psi_y = 1$$

$$C_{mz_} := 0.6 + 0.4 \cdot \psi_z = 1$$

$$C_{mLT_} := 0.6 + 0.4 \cdot \psi_{LT} = 1$$

$$C_{my} := \max(C_{my_}, 0.4) = 1$$

$$C_{mz} := \max(C_{mz_}, 0.4) = 1$$

$$C_{mLT} := \max(C_{mLT_}, 0.4) = 1$$

interakční součinitel:

třída 3,4

$$k_{yy_34} := \min\left(C_{my} \cdot \left(1 + 0.6 \cdot \lambda_y' \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{yy_12} := \min\left(C_{my} \cdot \left(1 + (\lambda_y' - 0.2) \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right), C_{my} \cdot \left(1 + 0.8 \cdot \frac{N_{Ed,c}}{\chi_y \cdot N_{Rd}}\right)\right) = 1$$

$$\Rightarrow k_{yy} := k_{yy_12} = 1.002$$

třída 3,4

$$k_{zz_34} := \min\left(C_{mz} \cdot \left(1 + 0.6 \cdot \lambda_z' \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 0.6 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

třída 1,2

$$k_{zz_12} := \min\left(C_{mz} \cdot \left(1 + (2 \cdot \lambda_z' - 0.6) \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right), C_{mz} \cdot \left(1 + 1.4 \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right)\right) = 1.01$$

$$\Rightarrow k_{zz} := k_{zz_12} = 1.007$$

třída 3,4

$$k_{zy_34} := \min\left(1 - \frac{0.05 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.05}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 1$$

třída 1,2; $\lambda_z' > 0.4$
 $\lambda_z' = 0.383$

$$k_{zy_12.8} := \min\left(1 - \frac{0.1 \cdot \lambda_z'}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}, 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.99$$

třída 1,2; $\lambda_z' < 0.4$

$$k_{zy_12.0} := \min\left(0.6 + \lambda_z', 1 - \frac{0.1}{C_{mLT} - 0.25} \cdot \frac{N_{Ed,c}}{\chi_z \cdot N_{Rd}}\right) = 0.98$$

$$\Rightarrow k_{zy} := k_{zy_12.0} = 0.983$$

třída 3,4

$$k_{yz_34} := k_{zz} = 1.007$$

třída 1,2

$$k_{yz_12} := 0.6 \cdot k_{zz} = 0.604$$

$$\Rightarrow k_{yz} := k_{yz_12} = 0.604$$

- Posouzení: Interakce tlak - ohyb

$$k_{yy} = 1.002 \quad k_{yz} = 0.604 \quad k_{zy} = 0.983 \quad k_{zz} = 1.007$$

$$\chi_y = 0.987 \quad \chi_z = 0.957 \quad \chi_{LT} = 1$$

$$N_{Ed.c} = 295.35 \text{ kN}$$

$$M_{Ed.y} = 11.16 \text{ kN} \cdot \text{m}$$

$$M_{Ed.z} = 4.87 \text{ kN} \cdot \text{m}$$

$$N_{Rd} = (7.842 \cdot 10^3) \text{ kN}$$

$$M_{y.Rd} = (1.28 \cdot 10^3) \text{ kN} \cdot \text{m}$$

$$M_{z.Rd} = 897.569 \text{ kN} \cdot \text{m}$$

$$\eta_{yz} := \frac{N_{Ed.c}}{\chi_y \cdot N_{Rd}} + k_{yy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{yz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.05$$

$$\eta_{zy} := \frac{N_{Ed.c}}{\chi_z \cdot N_{Rd}} + k_{zy} \cdot \frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} + k_{zz} \cdot \frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.053$$

$$\eta_{N.M} := \max(\eta_{yz}, \eta_{zy}) = 5.3\% < 100\% \implies \text{Vyhovuje}$$

Tlak

$$\chi := \min(\chi_y, \chi_z) = 0.957$$

$$\frac{N_{Ed.c}}{N_{Rd} \cdot \chi} = 3.9\% < 1 \implies \text{Vyhovuje}$$

Ohyb

$$\frac{M_{Ed.y}}{\chi_{LT} \cdot M_{y.Rd}} = 0.9\% < 1 \implies \text{Vyhovuje}$$

$$\frac{M_{Ed.z}}{\chi_{LT} \cdot M_{z.Rd}} = 0.5\% < 1 \implies \text{Vyhovuje}$$

Smyk ve směru Z

$$V_{Ed.z} = 4.53 \text{ kN}$$

$$A_{vz} = (1.508 \cdot 10^4) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vz} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (3.091 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.z}}{V_{pl.Rd}} = 0.147\% < 50\% \implies \text{malý smyk vyhovuje}$$

Smyk ve směru Y

$$V_{Ed.y} = 0.39 \text{ kN}$$

$$A_{vy} = (9.048 \cdot 10^3) \text{ mm}^2$$

$$V_{pl.Rd} := A_{vy} \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = (1.854 \cdot 10^3) \text{ kN}$$

$$\frac{V_{Ed.y}}{V_{pl.Rd}} = 0.021\% < 50\% \implies \text{malý smyk vyhovuje}$$

\implies Průřez vyhovuje na posuzovanou kombinaci