

PŘÍČINKOVÉ ČÁRY (PČ) STATICKY NEURČITÝCH (SN) KČI

Analytické řešení

výpočet např. M_b silovou, 3 momentovou metodou, tabulky

Tabulka 14.11. Primární moment a reakce jednostranně dokonale vetknutého nosníku konstantního průřezu

Zatěž. případ	Schéma zatížení	$\bar{M}_{ba}$	$\bar{V}_{ab} = \bar{R}_a$	$\bar{V}_{ba} = -\bar{R}_b$
1		$\frac{Fab}{2l^2}(l+a)$	$\frac{Fb^2}{2l^3}(2l+a)$	$-\frac{Fa}{2l^3}(3l^2-a^2)$

$M_b = -\frac{Fu(l-u)}{2l^2}(l+u)$ $F=1, l=10$

$M_b = -\frac{u(10-u)}{200} \cdot (10+u) = -\frac{u(100-u^2)}{200}$

$M_b = \frac{u^3 - 100u}{200}$ křivky 3^o

R_a podobně jako M_b nebo ze silové/momentové podmínky rovnováhy

$\sum M_{bi} = 0: M_b + 1 \cdot (10-u) - R_a \cdot 10 = 0$

$R_a = \frac{M_b + 10 - u}{10}$

$R_a = \frac{1}{10} \left[\frac{u^3 - 100u}{200} + 10 - u \right]$

$R_a = \frac{1}{10} \left[\frac{u^3 - 100u + 2000 - 200u}{200} \right] = \frac{u^3 - 300u + 2000}{2000}$

R_b podobně jako M_b nebo ze silové/momentové podmínky rovnováhy

$\sum F_{zi} = 0 \uparrow$
 $R_a + R_b - 1 = 0$
 $R_b = 1 - R_a$

V_{x1} F za x_1

$V_{x1}^L = R_a$ nebo $V_{x1}^P = -R_b + 1$

F před x_1

$V_{x1}^L = R_a - 1$ nebo $V_{x2}^P = -R_b$

M_{x1} F za x_1

$M_{x1}^L = R_a \cdot 4$ nebo $M_{x1}^P = M_b + R_b \cdot 6 - 1 \cdot (4-4)$

F před x_1

$M_{x1}^L = R_a \cdot 4 - 1 \cdot (4-u)$ nebo $M_{x1}^P = M_b + R_b \cdot 6$

KINEMATICKÁ

Δ $\rightarrow$ 17 mm

Δ $\rightarrow$ 17 mm

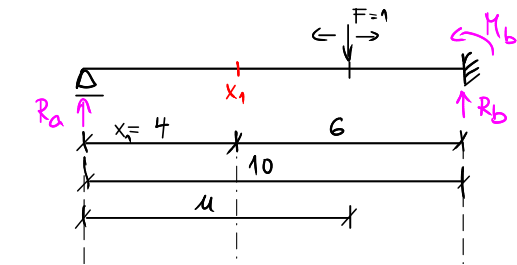
Δ $\rightarrow$ 17 mm

Δ $\rightarrow$ 17 mm

Δ $\rightarrow$ 17 mm

Δ $\rightarrow$ 17 mm

Δ $\rightarrow$ 17 mm



M_b

$M_{b1} = \frac{1^3 - 100 \cdot 1}{200} = -0,495 \checkmark$
 $M_{b4} = \frac{4^3 - 100 \cdot 4}{200} = -1,68 \checkmark$

R_a

$R_{a1} = \frac{-0,495 + 10 - 1}{10} = 0,8505 \checkmark$ nebo
 $R_{a1} = \frac{1^3 - 300 \cdot 1 + 2000}{2000} = 0,8505 \checkmark$
 $R_{a4} = \frac{-1,68 + 10 - 4}{10} = 0,432 \checkmark$

R_b

$R_{b1} = 1 - R_{a1} = 1 - 0,8505 = 0,1495 \checkmark$
 $R_{b4} = 1 - R_{a4} = 1 - 0,432 = 0,568 \checkmark$

V_{x1}

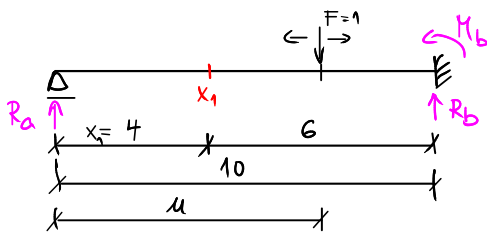
$R_a - 1 = -R_b$

$-0,4 + \frac{1,68 - 0}{10} = -0,568 \checkmark$

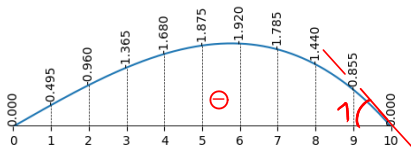
M_{x1}

$M_x = M_{x10} + \frac{M_a x^2 + M_b x}{l}$

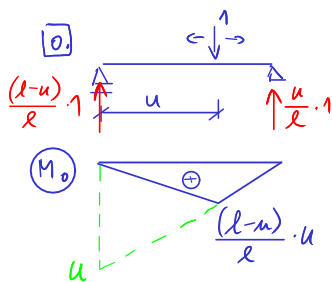
$2,4 + \frac{0 + (-1,68) \cdot 4}{10} = 1,728 \checkmark$
 $R_a \cdot 4 = 0,432 \cdot 4 = 1,728 \checkmark$
 $R_b \cdot 6 + M_b = 0,568 \cdot 6 - 1,68 = 1,728 \checkmark$



M_b



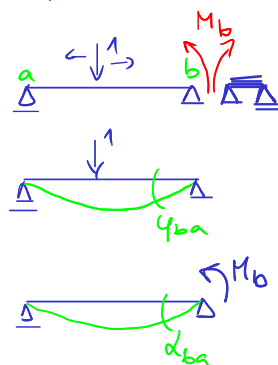
M_b silovou metodu - $m_s = 1 \times$



$$\delta_{11} = \frac{1}{2} l \cdot 1 \cdot \left(\frac{2}{3} 1\right) \frac{1}{EI} = \frac{l}{3EI}$$

$$\begin{aligned} \delta_{10} &= \frac{1}{EI} \left[\frac{1}{2} u \cdot l \cdot \left(\frac{1}{3} 1\right) - \frac{1}{2} u \cdot u \cdot \left(\frac{1}{3} \frac{u}{l}\right) \right] = \\ &= \frac{1}{EI} \left[\frac{1}{6} ul - \frac{1}{6} \frac{u^3}{l} \right] = \frac{ul^2 - u^3}{6EI l} \\ \delta_{10} + \delta_{11} X_1 &= 0 \Rightarrow X_1 = M_b = - \frac{\delta_{10}}{\delta_{11}} \\ M_b &= \frac{u^3 - 100u}{200} \end{aligned}$$

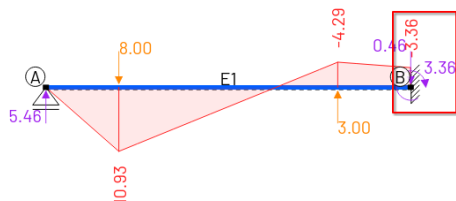
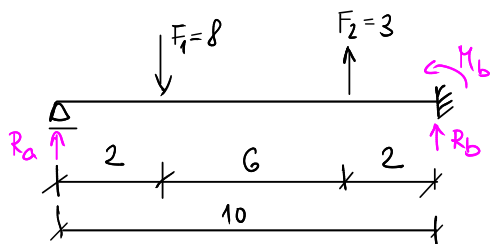
Metoda třímomentových rovnic



$$\begin{aligned} y_{ba} + \alpha_{ba} \cdot M_b &= 0 \\ \alpha_{ba} &= \left| \frac{\tan 5.2}{13a} \right| = \frac{l}{3EI} \\ y_{ba} &= \left| \frac{\tan 5.2}{8b} \right| = \frac{F a b (l+a)}{6EI l} \\ F &= 1 \quad l = 10 \quad a = u \\ b &= l - u \end{aligned}$$

$$\begin{aligned} M_b &= - \frac{y_{ba}}{\alpha_{ba}} = - \frac{F a b (l+a)}{2 l^2} = - \frac{1 \cdot u \cdot (10-u) (10+u)}{2 \cdot 10^2} \\ M_b &= \frac{u^3 - 100u}{200} \end{aligned}$$

Určení účinků od zatížení vzhledem k PC



$$\eta_{M_b} = \frac{u^3 - 100u}{200}$$

$$\eta_{M_b}(u=2) = \frac{2^3 - 100 \cdot 2}{200} = -0.96$$

$$\eta_{M_b}(u=8) = \frac{8^3 - 100 \cdot 8}{200} = -1.44$$

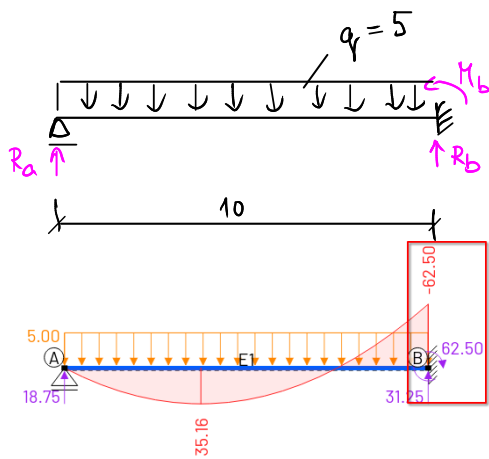
$$M_b = F_1 \eta_{M_b}(u=2) - F_2 \eta_{M_b}(u=8) = 8 \cdot (-0.96) - 3 \cdot (-1.44)$$

$$M_b = -3.36 \text{ kNm} \quad (\checkmark)$$

osamělá břemena

$$S_x = \sum_{i=1}^n F_i \eta_i$$

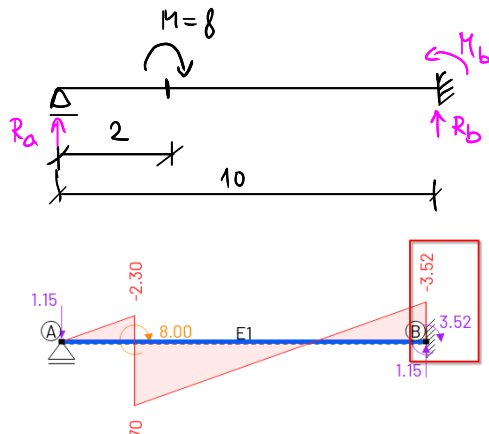
spojíte zatížení: $S_x = \int_a^b \eta(u) q(u) du$



$$M_b = \int_0^{10} \eta_{M_b}(u) du \cdot q = \int_0^{10} \frac{u^3 - 100u}{200} du \cdot 5 =$$

$$= \frac{5}{200} \left[\frac{u^4}{4} - 100 \cdot \frac{u^2}{2} \right]_0^{10} = \frac{5}{200} \left[\frac{10^4}{4} - 100 \cdot \frac{10^2}{2} \right]$$

$M_b = -62,5 \text{ kNm}$ (2)



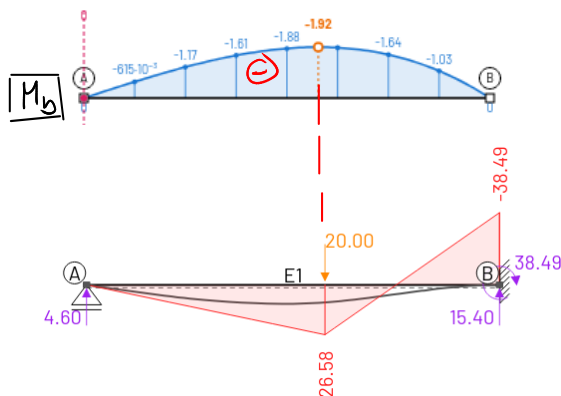
moment: $S_x = M \cdot \eta'(x)$

$$M_b = M \cdot \frac{d\eta_{M_b}}{du}(u=2) = \frac{8}{200} (u^3 - 100u)' =$$

$$= \frac{8}{200} \cdot (3u^2 - 100) = \frac{8}{200} (3 \cdot 2^2 - 100)$$

$M_b = -3,52 \text{ kNm}$ (2)

Kam umístit $F=20 \text{ kN}$, aby byl $M_{b\max}$ a určete jeho hodnotu.



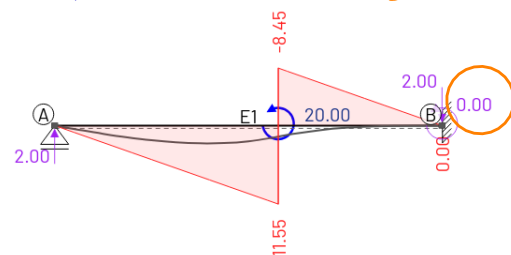
$$\frac{d\eta_{M_b}(u)}{du} = 0 \quad \left(\frac{u^3 - 100u}{200} \right)' = 0$$

$$\frac{1}{200} (3u^2 - 100) = 0 \Rightarrow u^2 = \frac{100}{3} \Rightarrow u = \underline{\underline{5,7435 \text{ m}}}$$

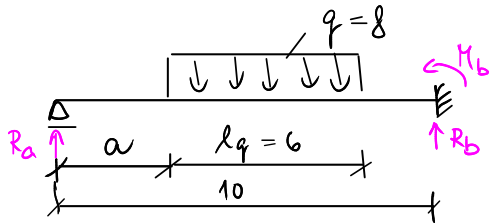
$$M_b = \eta_{M_b}(u=5,7435) \cdot F$$

$$M_b = \frac{5,7435^3 - 100 \cdot 5,7435}{200} \cdot 20 = \underline{\underline{-38,49 \text{ kNm}}}$$

Jak velká bude reakce M_b pokud zde umístíme $M=20 \text{ kNm}$? $M_b=0$
(protože $M_b = M \cdot \frac{d\eta}{du} = M \cdot 0$)



Umístění spojitěho zatížení $l_q = 6\text{m}$ $q = 8\text{kN/m}$, aby M_b bylo max.



$$q(u) = q = \text{konst.}$$

$$M_b = \int_a^{a+6} \eta_{M_b}(u) q(u) du \quad \eta_{M_b} = \frac{u^3 - 100u}{200}$$

$$\frac{dM_b(a)}{da} = q \cdot [\eta_{M_b}(a+6) - \eta_{M_b}(a)] = 0$$

$$8 \cdot \left[\frac{(a+6)^3 - 100(a+6)}{200} - \frac{a^3 - 100a}{200} \right] = 0$$

$$\frac{8}{200} [a^3 + 3a^2 \cdot 6 + 3a \cdot 6^2 + 6^3 - 100a - 600 - a^3 + 100a] = 0$$

$$\frac{8}{200} [18a^2 + 108a - 384] = 0$$

$$D = b^2 - 4ac = 108^2 - 4 \cdot 18 \cdot (-384) = 39312$$

$$a_{1,2} = \frac{-b \pm \sqrt{D}}{2a} = \frac{-108 \pm \sqrt{39312}}{2 \cdot 18} = \frac{2,50757}{-8,50757} \text{m}$$

$$\eta_{M_b}(u=2,50757) = \frac{2,50757^3 - 100 \cdot 2,50757}{200} = -1,17495$$

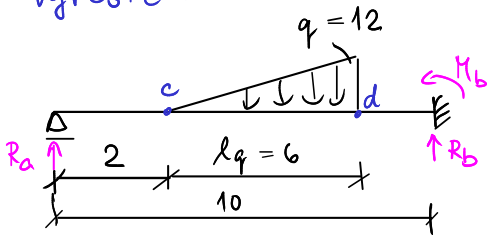
$$\eta_{M_b}(u=a+6=8,50757) = \frac{8,50757^3 - 100 \cdot 8,50757}{200} = -1,17495$$

stejně pořadnice
na začátku
a konci q

$$M_b = \int_{2,50757}^{8,50757} \eta_{M_b}(u) du \cdot q = 80,19 \text{ kNm}$$

pokud toto vím, můžu
přímo psát a řešit
 $\eta_{M_b}(a) = \eta_{M_b}(a+6)$

Vyřešte nosník s lineárním zatížením



$$M_b = \int_c^d q(u) \eta_{M_b}(u) du$$

$$M_b = \int_2^8 \left(\frac{12}{6}u - 4 \right) \left(\frac{u^3 - 100u}{200} \right) du = \frac{1}{200} \int_2^8 (2u - 4)(u^3 - 100u) du$$

$$M_b = \frac{1}{200} \left[2 \frac{u^5}{5} - 4 \frac{u^4}{4} - 200 \frac{u^3}{3} + 400 \frac{u^2}{2} \right]_2^8$$

$$M_b = \frac{1}{200} \left[\frac{2}{5} 8^5 - 8^4 - \frac{200}{3} \cdot 8^3 + 200 \cdot 8^2 - \frac{2}{5} 2^5 + 2^4 + \frac{200}{3} \cdot 2^3 - 200 \cdot 2^2 \right]$$

$$M_b = -62,928 \text{ kNm}$$

$$\eta_{M_b}(u) = \frac{u^3 - 100u}{200}$$

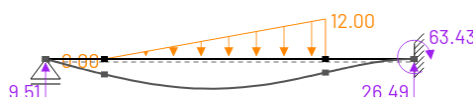
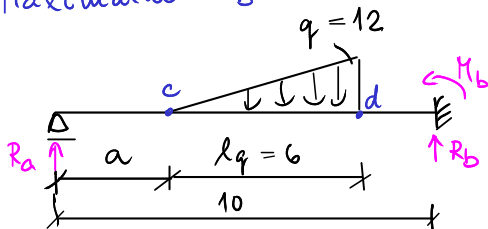
Maximální M_b od tohoto zatížení

$$q(u) = \frac{q}{l_q} u - \frac{a}{l_q} q = \frac{q}{l_q} (u - a) = 2(u - a)$$

$$M_b(a) = \int_a^{a+l_q} \eta_{M_b}(u) q(u) du \rightarrow \max M_b : M'_b(a) = 0$$

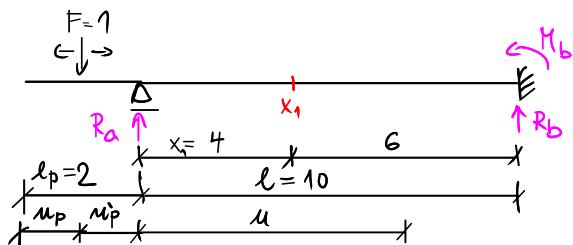
$$a = 1,5976185 \text{m}$$

řešeno
sympy

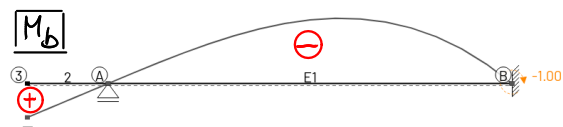


$$M_b = -63,429 \text{ kNm}$$

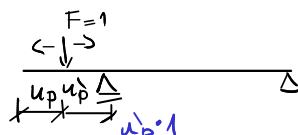
Previslý konec



$$M_a = -F u_p = -\dot{u}_p = -(l_p - u_p) = u_p - l_p = \underline{u_p - 2}$$



Silová metoda



(M₀)



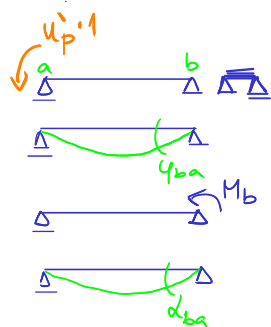
$$\delta_{10} = -\frac{1}{EI} \left[\frac{1}{2} u_p \cdot l \cdot \left(\frac{1}{3} \cdot 1 \right) \right] = -\frac{u_p \cdot l}{6EI}$$

$$\delta_{11} = \frac{1}{EI} \left[\frac{1}{2} \cdot 1 \cdot l \cdot \left(\frac{2}{3} \cdot 1 \right) \right] = \frac{l}{3EI}$$

$$X_1 = M_b = -\frac{\delta_{10}}{\delta_{11}} = \frac{\frac{u_p \cdot l}{6EI} \cdot 2}{\frac{l}{3EI}} = \frac{u_p}{2} = \frac{1}{2}(l_p - u_p)$$

$$M_b = -\frac{\gamma_{ba}}{\gamma_{ba}} = +\frac{\frac{u_p \cdot l}{6EI}}{\frac{l}{3EI}} = \frac{u_p}{2} \checkmark$$

Metoda třímomentových rovnic



$$\gamma_{ba} + \alpha_{ba} \cdot M_b = 0$$

$$\alpha_{ba} = \left| \frac{\tan 5.2}{13a} \right| = \frac{l}{3EI}$$

$$\gamma_{ba} = \left| \frac{\tan 5.2}{12b} \right| = -\frac{l}{6EI} \cdot u_p$$

$$F=1 \quad l=10 \quad a=u \quad b=l-u$$

Sklon musí navazovat na PC v poli:

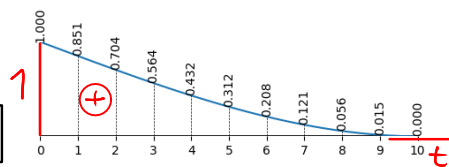
$$\eta_{M_b}(u) = \frac{u^3 - 100u}{200}$$

$$\text{sklon v } u=0: \quad \eta'_{M_b} = \frac{d\eta_{M_b}(u)}{du} = \frac{3u^2 - 100}{200}$$

$$k = \eta'_{M_b}(u=0) = \frac{3 \cdot 0 - 100}{200} = -\frac{1}{2} \checkmark \quad \left(-\frac{1}{2}u_p + \frac{1}{2}l_p \right)$$

Ra silová metoda

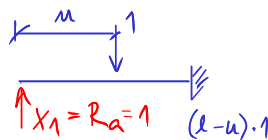
Ra



$$R_a = X_1 = - \frac{f_{10}}{f_{11}} = + \frac{\frac{1}{6EI} (u^3 - 300u + 2000)}{\frac{1}{3EI} 1000}$$

$$R_a = \frac{u^3 - 300u + 2000}{2000}$$

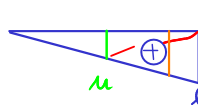
Ra



M0



M1



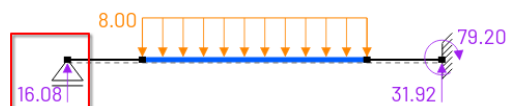
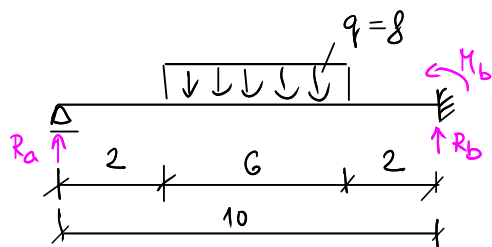
$$f_{11} = \frac{1}{EI} \left[\frac{1}{2} l \cdot l \cdot \left(\frac{2}{3} l \right) \right] = \frac{l^3}{3EI}$$

$$f_{10} = \frac{1}{EI} \left[\frac{1}{2} (l-u)^2 \cdot 1 \cdot \left(\frac{1}{3} u + \frac{2}{3} l \right) \right]$$

$$f_{11} X_1 + f_{10} = 0$$

$$\begin{aligned} f_{10} &= \frac{1}{EI} \left[\frac{1}{2} (l^2 - 2lu + u^2) \cdot 1 \cdot \left(\frac{1}{3} u + \frac{2}{3} l \right) \right] = \\ &= \frac{1}{EI} \left[\frac{1}{2} \left(\frac{100}{3} u + \frac{2000}{3} - \frac{20}{3} u^2 - \frac{400}{3} u + \frac{1}{3} u^3 + \frac{20}{3} u^2 \right) \right] = \\ &= \frac{1}{6EI} [u^3 - 300u + 2000] \end{aligned}$$

Vröcte reakci Ra od zatížení q = 8 kN/m



$$R_a = \int_2^8 \eta_{Ra}(u) du \cdot q = \int_2^8 \frac{u^3 - 300u + 2000}{2000} du \cdot 8 =$$

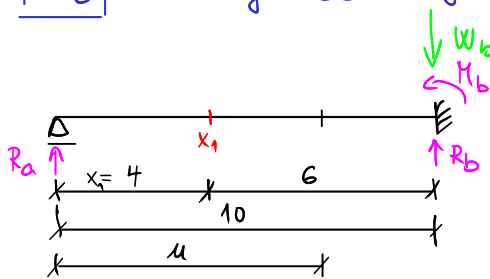
$$= \frac{8}{2000} \left[\frac{u^4}{4} - 300 \frac{u^2}{2} + 2000u \right]_2^8 =$$

$$= \frac{8}{2000} \left[\frac{8^4}{4} - 300 \frac{8^2}{2} + 2000 \cdot 8 - \frac{2^4}{4} + 300 \cdot \frac{2^2}{2} - 2000 \cdot 2 \right]$$

$$R_a = 16,08 \text{ kN}$$

R_b

integrace diferenciálních rovnic < kinematická metoda
jednotkový posun $w_b=1$
(kladný posun ↓)



① $q(u) = 0$

② $V(u) = -\int q(u) du = 0 + C_1$

③ $M(u) = \int V(u) = C_1 u + C_2$

④ $\varphi(u) = -\int \frac{M(u)}{EI} du = -\frac{1}{EI} \left[C_1 \frac{u^2}{2} + C_2 u + C_3 \right]$

⑤ $w(u) = \int \varphi(u) du = -\frac{1}{EI} \left[C_1 \frac{u^3}{6} + C_2 \frac{u^2}{2} + C_3 u + C_4 \right]$

$w_a = w(u=0) = 0$ $w_b = w(u=10) = 1$ $\varphi_b = \varphi(u=10) = 0$
 $M_a = M(u=0) = 0$

③ $M(u=0): C_1 \cdot 0 + C_2 = 0 \Rightarrow \underline{C_2 = 0}$

④ $\varphi(u=10): -\frac{1}{EI} \left[C_1 \cdot \frac{10^2}{2} + 0 \cdot u + C_3 \right] = 0$
 $50 C_1 + C_3 = 0$

⑤ $w(u=0): -\frac{1}{EI} [C_1 \cdot 0 + C_2 \cdot 0 + C_3 \cdot 0 + C_4] = 0 \Rightarrow \underline{C_4 = 0}$

$w(u=10): -\frac{1}{EI} \left[C_1 \cdot \frac{10^3}{6} + 0 \cdot \frac{10^2}{2} + C_3 \cdot 10 + 0 \right] = 1$
 $\frac{500}{3} C_1 + 10 C_3 = -EI \quad / \cdot \frac{3}{10}$

$50 C_1 + C_3 = 0 \quad / \cdot (-1)$

$50 C_1 + 3 C_3 = -\frac{3}{10} EI$

$2 C_3 = -\frac{3}{10} EI$

$C_3 = -\frac{3}{20} EI$

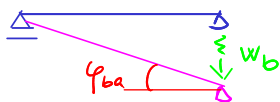
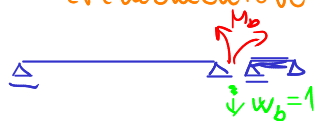
$C_1 = \frac{3EI}{1000}$

⑤ $w(u) = \int \varphi(u) du = -\frac{1}{EI} \left[C_1 \frac{u^3}{6} + C_2 \frac{u^2}{2} + C_3 u + C_4 \right]$

$w(u) = \eta_{R_b}(u) = -\frac{1}{EI} \left[\frac{3EI}{1000} \frac{u^3}{6} - \frac{3}{20} EI \right] =$
 $= \frac{-u^3 + 300u}{2000}$

případně si mohou vypočítat
stat. neurčitou veličinu

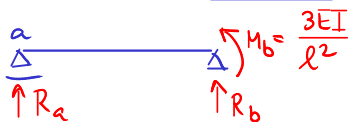
silová metoda
trímomentové rce



$\alpha_{ba} \cdot M_b + \varphi_{ba} = 0$

$\alpha_{ba} = \frac{l}{3EI}$ $\varphi_{ba} = -\frac{w_b}{l} = -\frac{1}{l}$

$M_b = -\frac{\varphi_{ba}}{\alpha_{ba}} = \frac{3EI}{l^2}$



$\sum M_{ai} = 0 \oplus \uparrow$

$M_b + R_b \cdot l = 0$

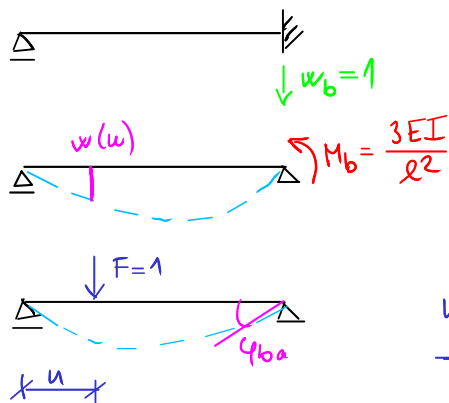
$R_b = -\frac{3EI}{l^3}$

$V(u=10) = -R_b$
 $C_1 = R_b = \frac{3EI}{1000}$

Rozdíli:

počítání MTR vs počítání soustavu rovnic

R_b výsledek získaný MTR + Bettiho věta
 předchozí strana

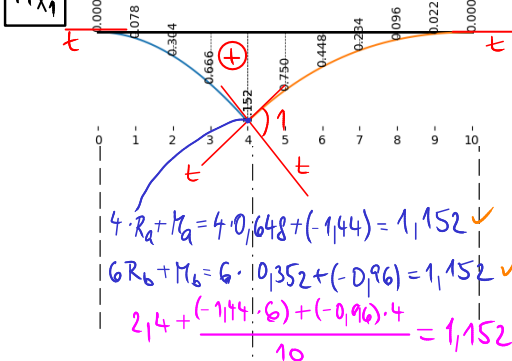
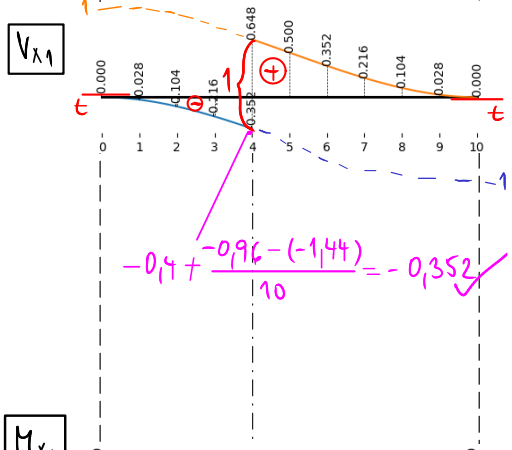
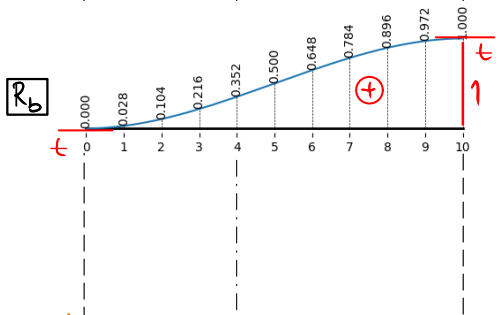
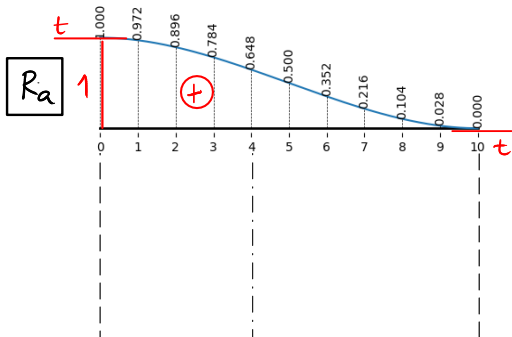
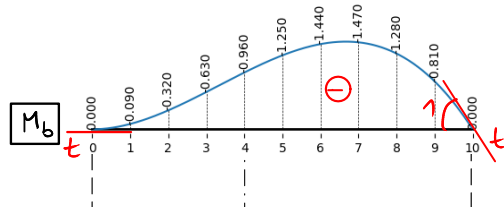
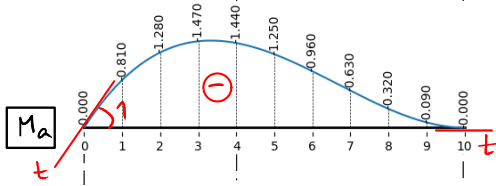
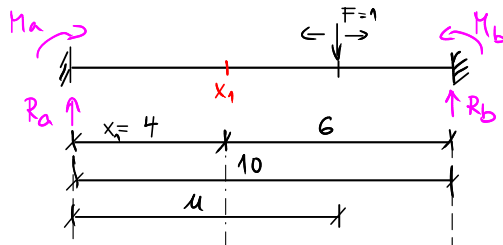


$$F \cdot w(u) = M_b \cdot \varphi_{ba}(u)$$

$$w(u) = \frac{3EI}{10^2} \cdot \frac{-u^3 + 100u}{60EI}$$

$$w(u) = \frac{-u^3 + 100u}{2000} = \eta_{R_b}(u)$$

$$\begin{aligned} \varphi_{ba}(u) &= |\text{tab. 5.8b}| = \\ &= \frac{F a b (l+a)}{6 E I l} = \\ &= \frac{1 \cdot u \cdot (10-u) (10+u)}{6 E I \cdot 10} = \\ &= \frac{-u^3 + 100u}{60 E I} \end{aligned}$$



Analytické řešení

výpočet silovou, 3 momentovou metodou, tabulky

Tabulka 14.10. Primární momenty a reakce oboustranně dokonale velkého nosníku konstantního průřezu

Zatěž. případ	Schéma zatížení	M_{ab}	M_{ba}	$V_a = R_a$	$V_b = -R_b$
1		$-\frac{Fab^2}{l^2}$	$-\frac{Fa^2b}{l^2}$	$\frac{Fb^2}{l^2}(1+2a)$	$-\frac{Fa^2}{l^2}(1+2b)$

$$M_a = -\frac{Fm(l-u)^2}{l^2} \quad F=1 \quad l=10$$

$$M_a = -\frac{u(10-u)^2}{100} = -\frac{u^3 - 20u^2 + 100u}{100}$$

$$M_b = -\frac{Fa^2b}{l^2}$$

$$M_b = -\frac{u^2(10-u)}{100} = -\frac{u^3 - 10u^2}{100}$$

R_a podobně jako M_b nebo ze silové/momentové podmínky rovnováhy

$$\sum M_{bi} = 0 \oplus \rightarrow$$

$$M_a + R_a \cdot 10 - 1 \cdot (10-u) - M_b = 0$$

$$10R_a = (10-u) + \frac{u^3 - 20u^2 + 100u}{100} + \frac{u^3 - 10u^2}{100}$$

$$R_a = \frac{2u^3 - 30u^2 + 1000}{1000}$$

R_b podobně jako M_b nebo ze silové/momentové podmínky rovnováhy

$$\sum F_{zi} = 0 \oplus \rightarrow$$

$$R_a + R_b - 1 = 0$$

$$R_b = 1 - R_a$$

$$V_{x1} \quad F \text{ za } x_1$$

$$V_{x1}^L = R_a \quad \text{nebo} \quad V_{x1}^P = -R_b + 1$$

$$F \text{ před } x_1$$

$$V_{x1}^L = R_a - 1 \quad \text{nebo} \quad V_{x1}^P = -R_b$$

$$M_{x1} \quad F \text{ za } x_1$$

$$M_{x1}^L = R_a \cdot 4 + M_a \quad \text{nebo} \quad M_{x1}^P = M_b + R_b \cdot 6 - 1 \cdot (u-4)$$

$$F \text{ před } x_1$$

$$M_{x1}^L = R_a \cdot 4 - 1(4-u) + M_a$$

$$\text{nebo } M_{x1}^P = M_b + R_b \cdot 6$$

$$V_x = V_{x1} + \frac{M_b - M_a}{l}$$

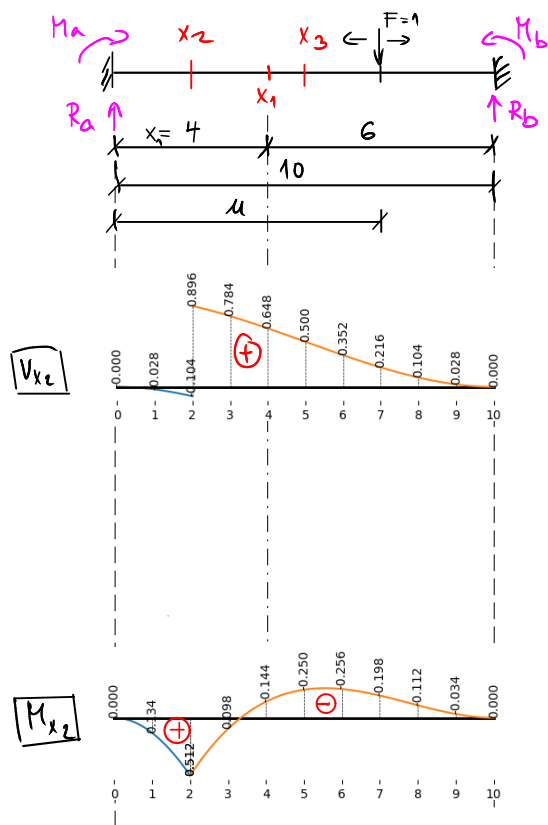
$$M_x = M_{x1} + \frac{H_a x^2 + M_b x}{l}$$

$$\frac{xx'}{l} = \frac{4 \cdot 6}{10} = 2,4$$

$$4 \cdot R_a + M_a = 4 \cdot 0,648 + (-1,44) = 1,152 \checkmark$$

$$6R_b + M_b = 6 \cdot 0,352 + (-0,96) = 1,152 \checkmark$$

$$2,4 + \frac{(-1,44 \cdot 6) + (-0,96) \cdot 4}{10} = 1,152 \checkmark$$



$$V_{x_2} = V_{x_1} \quad F \text{ za } x_2$$

$$V_{x_2}^L = R_a \quad \text{nebo} \quad V_{x_2}^P = -R_b + 1$$

$$F \text{ před } x_2$$

$$V_{x_2}^L = R_a - 1 \quad \text{nebo} \quad V_{x_2}^P = -R_b$$

$$M_{x_2} \quad F \text{ za } x_2$$

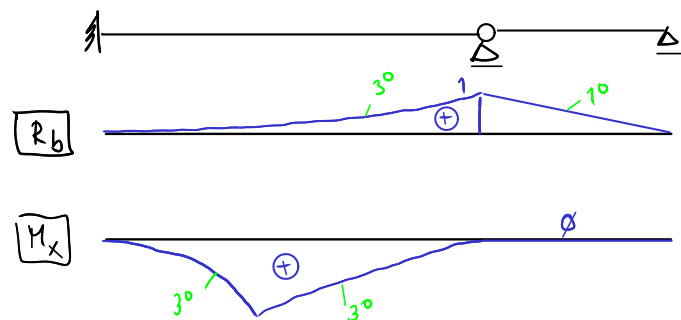
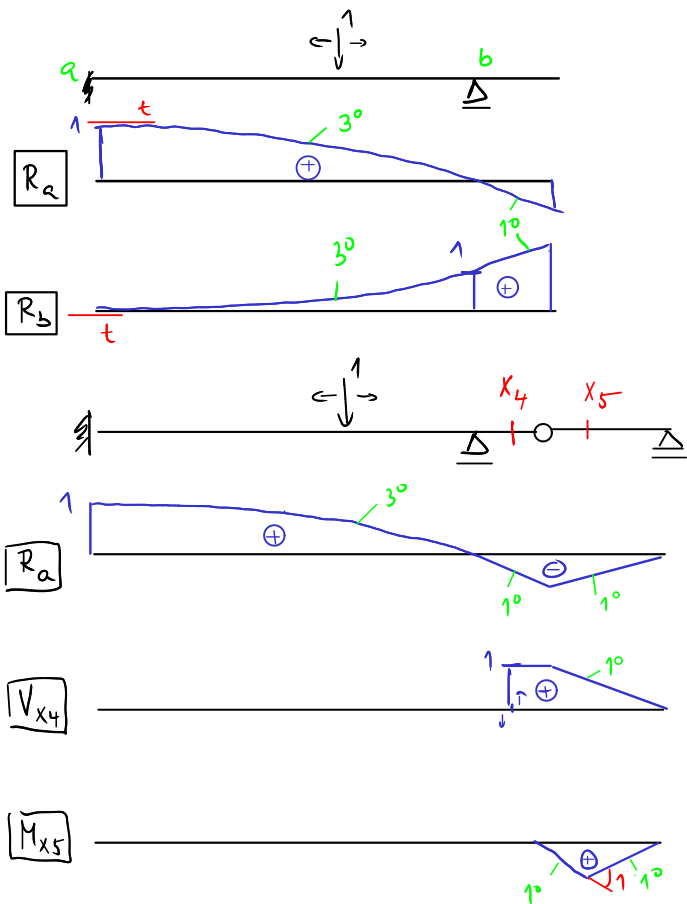
$$M_{x_2}^L = R_a \cdot 2 + M_a \quad \text{nebo} \quad M_{x_2}^P = M_b + R_b \cdot 2 - 1 \cdot (4 - 8)$$

$$F \text{ před } x_2$$

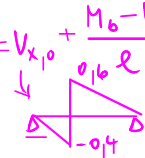
$$M_{x_2}^L = R_a \cdot 2 - 1(2 - 4) + M_a \quad \text{nebo} \quad M_{x_2}^P = M_b + R_b \cdot 8$$

Nosník složený z SN a SU části

↓
křivka 3° ↓
lineární (1°)



Náměty na procvičování / opakování

- 1) Dořešte rovnice M_x , nebo V_x dosazením do podmínek rovnováhy nebo superpozicí např. pro $V_x = V_{x,0} + \frac{M_b - M_a}{l}$. Jednostranně nebo oboustranně vetknutý nosník.
- 

- 2) U rovnice PČ ověřte okrajové podmínky.

Např. str. 1 $\boxed{M_b}$ $M_b(x=0)=0$ $M_b(x=l)=0$ $M'_b(x=l)=1$
 $\boxed{R_a}$ $R_a(x=0)=1$ $R_a(x=l)=0$ $R'_a(x=l)=0$

- 3) Zvolte libovolnou PČ  a vypočítejte pro libovolné zatížení. Např. osamělé břemeno ve vzdálenosti 3 m. Ověřte v softwaru.

- 4) Vyřešte daným způsobem nevyřešenou statickou veličinu:

- statické řešení $\left\{ \begin{array}{l} \text{silová metoda} \\ \text{metoda třímomentových rovnic} \end{array} \right.$ (např. $\frac{5}{R_b}$)
- kinematickou metodou
 - metoda třímomentových rovnic + Bettiho věta $\left(\frac{\text{např.}}{R_a, M_b} \right)$
- integrací dif. rovnice