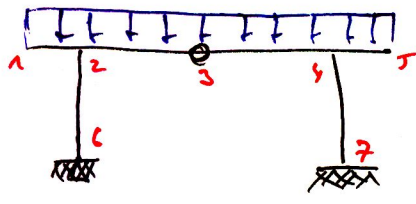
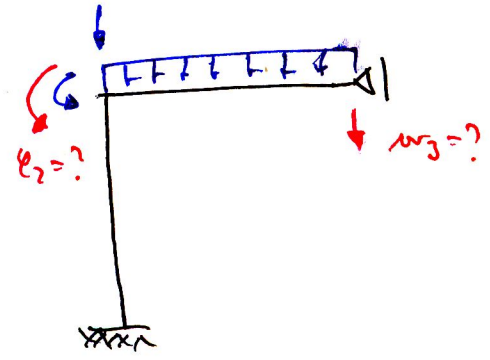
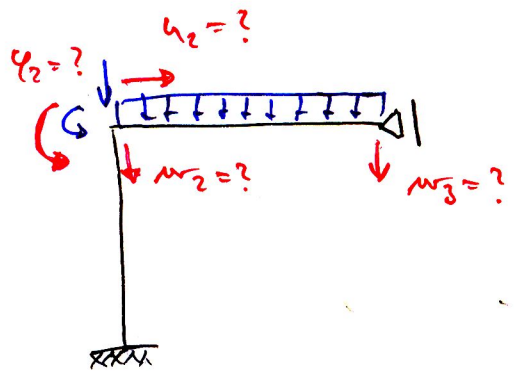
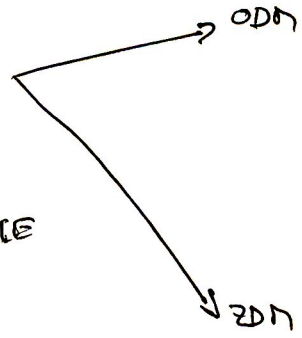


ODN a ZDN - udbe neznamych

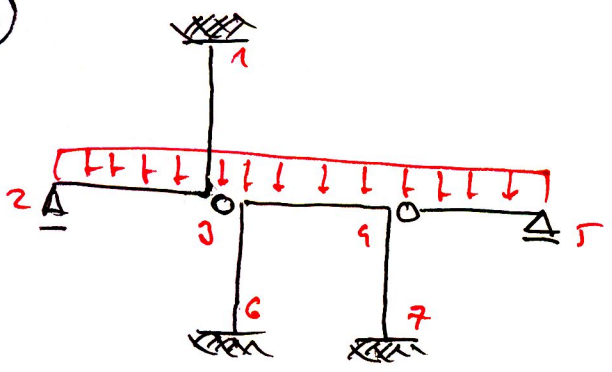
2



SYMETRICKÉ ZATÍŽENÍ + KČE



3



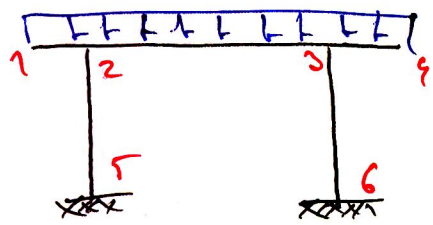
ODN $\varphi_3^I \varphi_3^{II} \varphi_4 u_2 u_3 u_4 u_5 w_3 w_4$

ZDN $\varphi_3^I \varphi_3^{II} \varphi_4 u_2 = u_3 = u_4 = u_5$

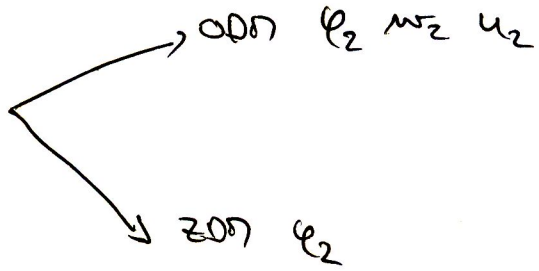
podmínky rovnováhy pro neznámá momenta:

$$\begin{aligned} M_{32} + M_{31} &= 0 \\ M_{34} + M_{35} &= 0 \\ M_{43} + M_{47} &= 0 \end{aligned}$$

1



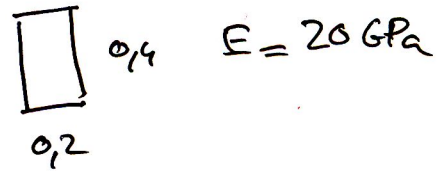
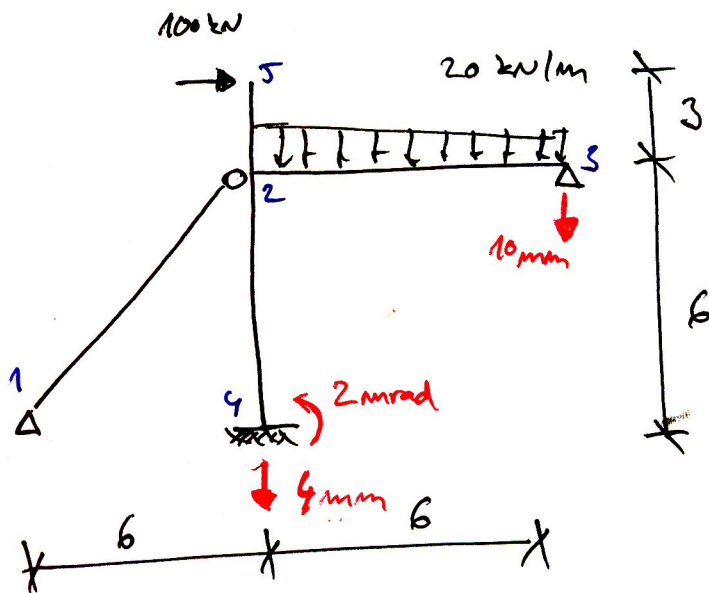
SYMETRICKÉ ZATÍŽENÍ + KČE



ODN $\varphi_2 w_2 u_2$

ZDN φ_2

ODM - uliu přemístění podpor



$E = 20 \text{ GPa}$

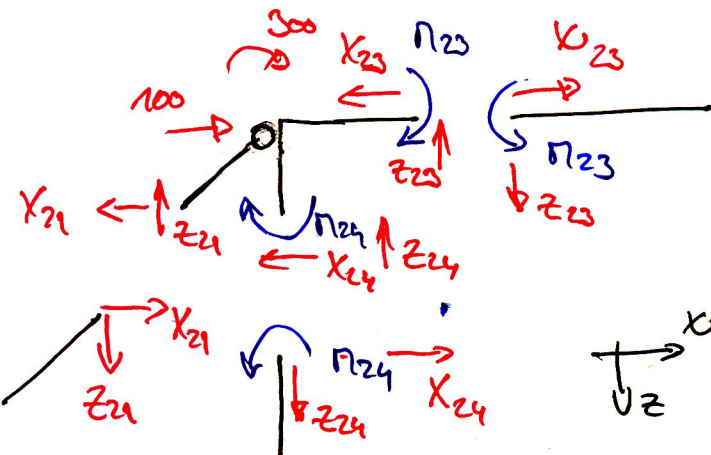
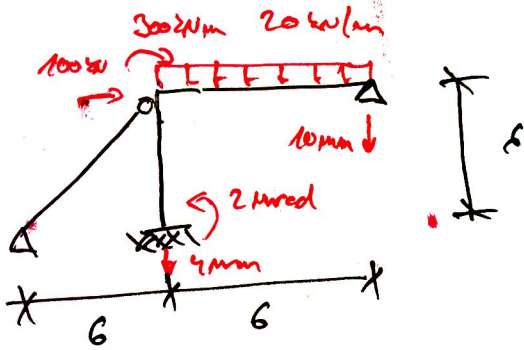
$A = 0,028 \text{ m}^2$

$I = \frac{1}{12} 0,2 \cdot 0,14^3 = 0,001067 \text{ m}^4$

$EA = 1600 \text{ MN}$

$EI = 21,33 \text{ MNm}^2$

neznámé: u_2, w_2, φ_2



(1) $M_{23} + \varphi_{24} + 300 = 0$

(2) $Z_{23} + Z_{24} + Z_{21} = 0$

(3) $X_{21} + X_{23} + X_{24} = 100$

$$M_{23} = \frac{1L_0^2}{8} + \frac{3k_{23}}{2} \left(\varphi_2 + \frac{w_3 - w_2}{L_{23}} \right) =$$

$$= \frac{20 \cdot 6^2}{8} + \frac{3 \cdot 7,11}{2} \left(\varphi_2 + \frac{10}{6} - \frac{w_2}{6} \right) =$$

$$k_{23} = \frac{2EI}{L_{23}} = \frac{2 \cdot 21,33}{6} =$$

$$= 7,11 \text{ MNm}$$

$$= 90 + 10,665 \varphi_2 + 17,775 - 1,776 w_2 = -1,776 w_2 + 10,665 \varphi_2 + 107,775$$

$$= -78,565 \text{ kNm}$$

$$M_{24} = k_{24} \cdot \left(\varphi_4 + 2\varphi_2 + 3 \frac{u_2 - u_4}{L_{24}} \right) =$$

$$= 7,11 \cdot (2 + 2\varphi_2 + 0,5u_2) = 14,22 + 14,22 \varphi_2 + 3,555 u_2 = -221,439 \text{ kNm}$$

$$X_{21}^l = X_{21}^l \cos \alpha - Z_{21}^l \sin \alpha = 0,707 X_{21}^l + 0,707 Z_{21}^l$$

$$Z_{21}^l = X_{21}^l \sin \alpha + Z_{21}^l \cos \alpha = -0,707 X_{21}^l + 0,707 Z_{21}^l$$

$$u_2^l = u_2 \cos \alpha + w_2 \sin \alpha = 0,707 u_2 - 0,707 w_2$$

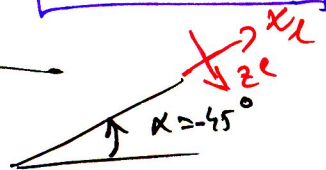
$$w_2^l = -u_2 \sin \alpha + w_2 \cos \alpha = 0,707 u_2 + 0,707 w_2$$

$$X_{21}^l = u_{12} \cdot (u_2^l - w_2^l) = 133,311 u_2 - 133,311 w_2$$

$$n_{12} = \frac{EA}{6\sqrt{2}} = \frac{1600}{6\sqrt{2}} = 181,56$$

$$Z_{21}^l = 0$$

$$= -281,819 \text{ kN}$$



$$X_{21} = 94,251 u_2 - 94,251 w_2 = -199,247 \text{ kN}$$

$$Z_{21} = -94,251 u_2 + 94,251 w_2 = 199,247 \text{ kN}$$

$$Z_{24} = m_{24} \cdot (w_2 - w_4) = \frac{1600}{6} \cdot (w_2 - 4) = 266,67 w_2 - 1066,67 = -152,285 \text{ kN}$$

$$X_{24} = \frac{3k_{24}}{6} \left(2 \text{ rad} + \varphi_2 + 2 \frac{u_2}{6} \right) =$$

$$k_{24} = \frac{2 \cdot 21,33}{6} = 7,11 \text{ MNm}$$

$$= 7,11 + 3,555 \varphi_2 + 1,185 u_2 = -51,415 \text{ kN}$$

$$X_{23} = m_{23} (u_2 - u_3) = \frac{1600}{6} u_2 = 266,67 u_2 = 350,644 \text{ kN}$$

$$Z_{23} = -\frac{5 \cdot 20 \cdot 6}{8} - \frac{3k_{23}}{2 \cdot 6} \left(\varphi_2 + \frac{10 - w_2}{6} \right) = -75 - 1,776 \varphi_2 - 2,9625 + 0,29625 w_2 =$$

$$= 0,29625 w_2 - 77,963 - 1,776 \varphi_2 =$$

$$= -46,947 \text{ kN}$$

$$(1) 362,106 u_2 - 99,251 w_2 + 3,555 \varphi_2 = 92,89$$

$$(2) -99,251 u_2 + 361,217 w_2 - 1,775 \varphi_2 = 1144,63$$

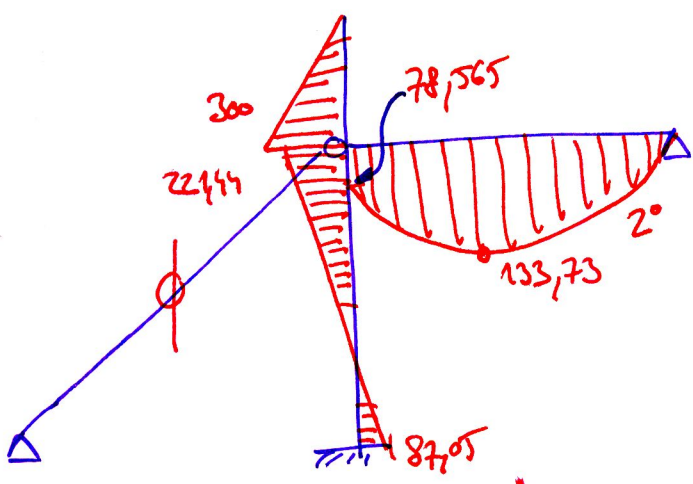
$$(3) 3,555 u_2 - 1,776 w_2 + 14,885 \varphi_2 = -421,995$$

→ Verem!

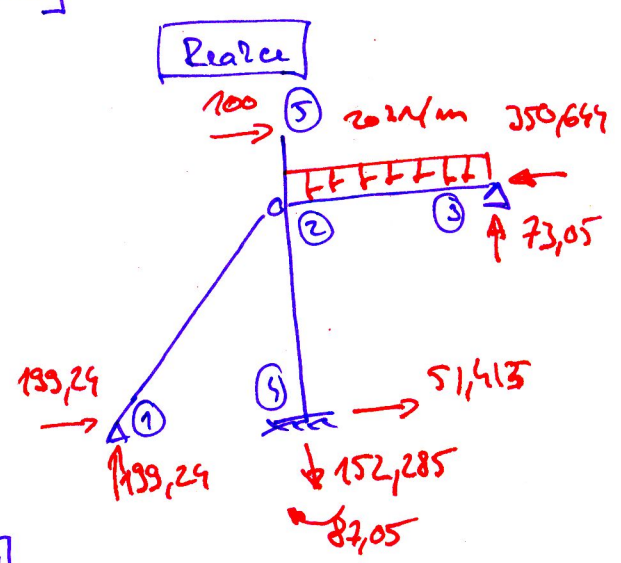
$$u_2 = 1,0145 \text{ mm}$$

$$w_2 = 3,4289 \text{ mm}$$

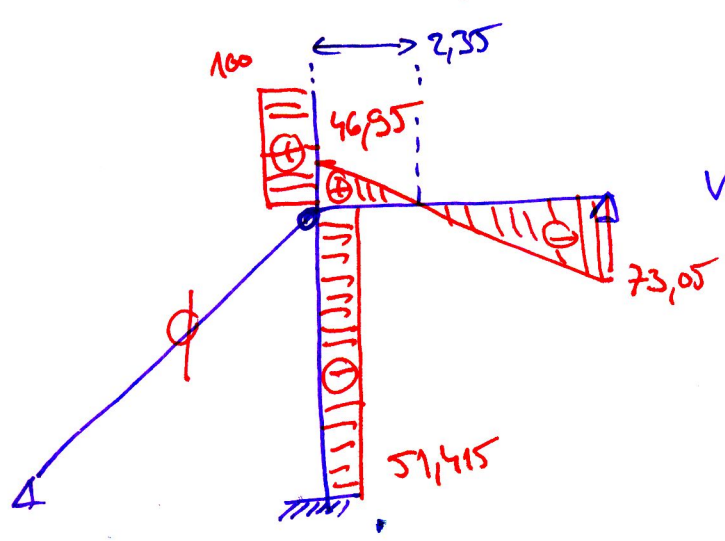
$$\varphi_2 = -16,904 \text{ mm}$$



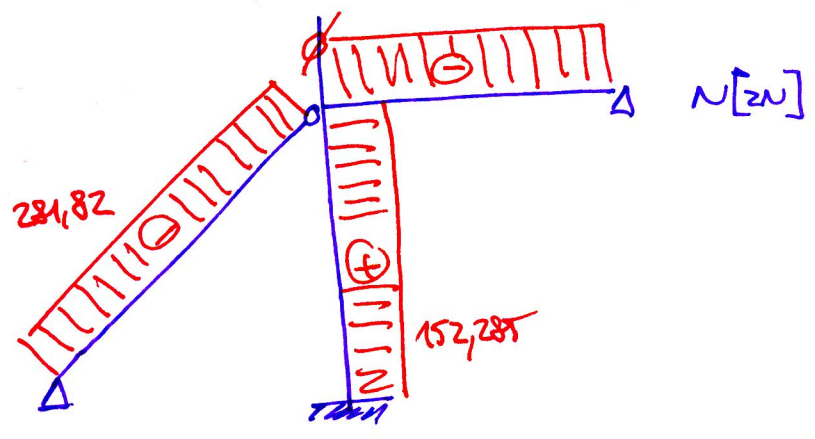
M [kNm]



V [kN]



350,644



N [kN]