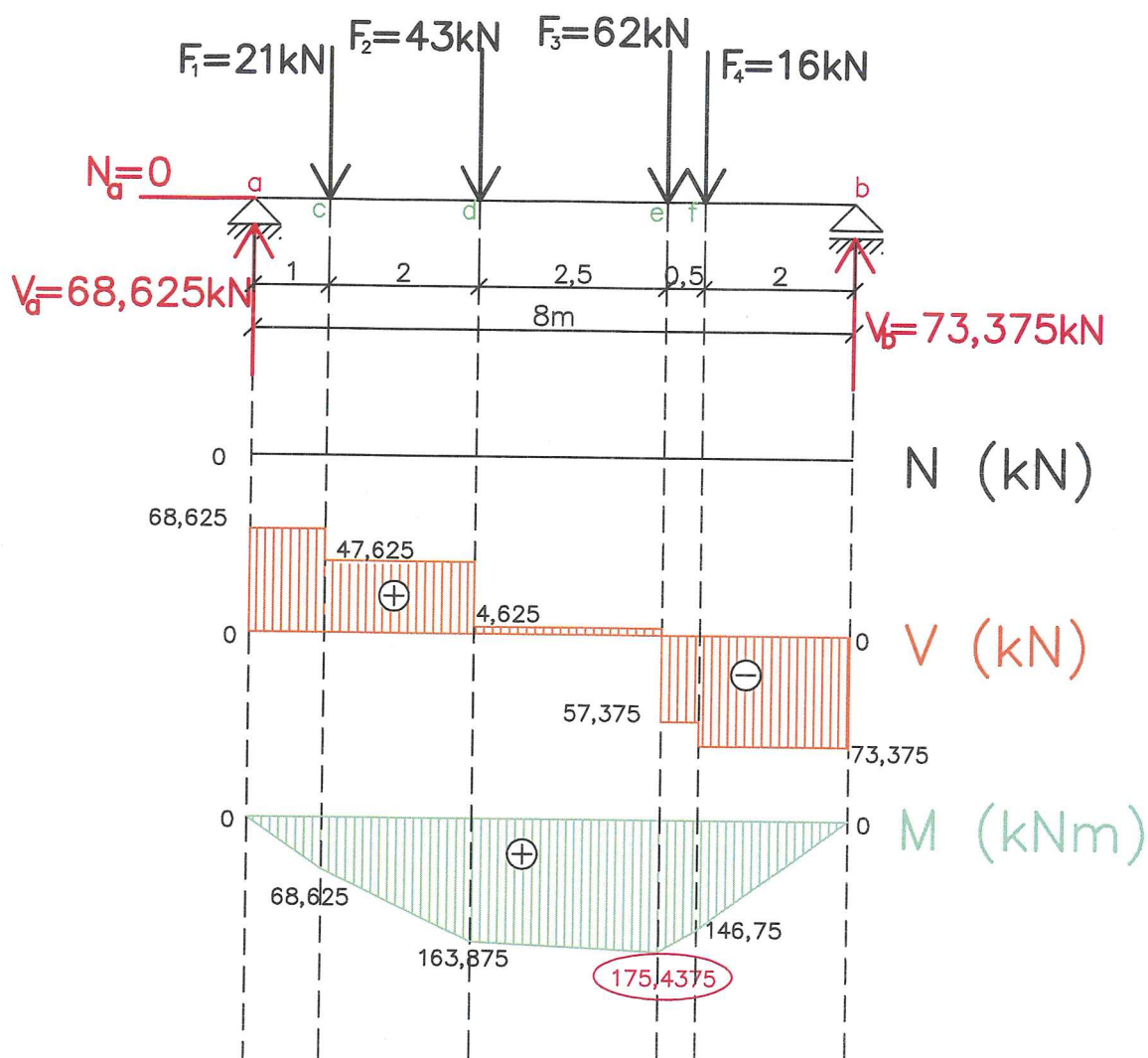


1.6. Klíče příkladů k domácímu procvičení

1.5.1



Reakce:

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ - \end{array}$$

$$V_a \cdot 8 - F_1 \cdot 7 - F_2 \cdot 5 - F_3 \cdot 2,5 - F_4 \cdot 2 = 0$$

$$V_a \cdot 8 - 21 \cdot 7 - 43 \cdot 5 - 62 \cdot 2,5 - 16 \cdot 2 = 0$$

$$V_a = \underline{68,625\text{ kN}} \quad \curvearrowright$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} + \\ - \end{array}$$

$$V_a - F_1 - F_2 - F_3 - F_4 + V_b = 0$$

$$68,625 - 21 - 43 - 62 - 16 + V_b = 0$$

$$V_b = \underline{73,375\text{ kN}} \uparrow$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ + \end{array}$$

$$N_a = \underline{0}$$

Průběhy:

N: nevyskytují se

V: $V_a^L = V_a = 68,625 \text{ kN}$

$V_c^L = V_a^L - F_1 = 68,625 - 21 = 47,625 \text{ kN}$

$V_d^L = V_c^L - F_2 = 47,625 - 43 = 4,625 \text{ kN}$

$V_e^L = V_d^L - F_3 = 4,625 - 62 = -57,375 \text{ kN}$

$V_f^L = V_e^L - F_4 = -57,375 - 16 = -73,375 \text{ kN}$

$V_b^L = V_f^L + V_b = -73,375 + 73,375 = 0$ Návrat k základní čáře.

M: $M_a^L = 0$

$M_c^L = V_a \cdot 1 = 68,625 \cdot 1 = 68,625 \text{ kNm}$

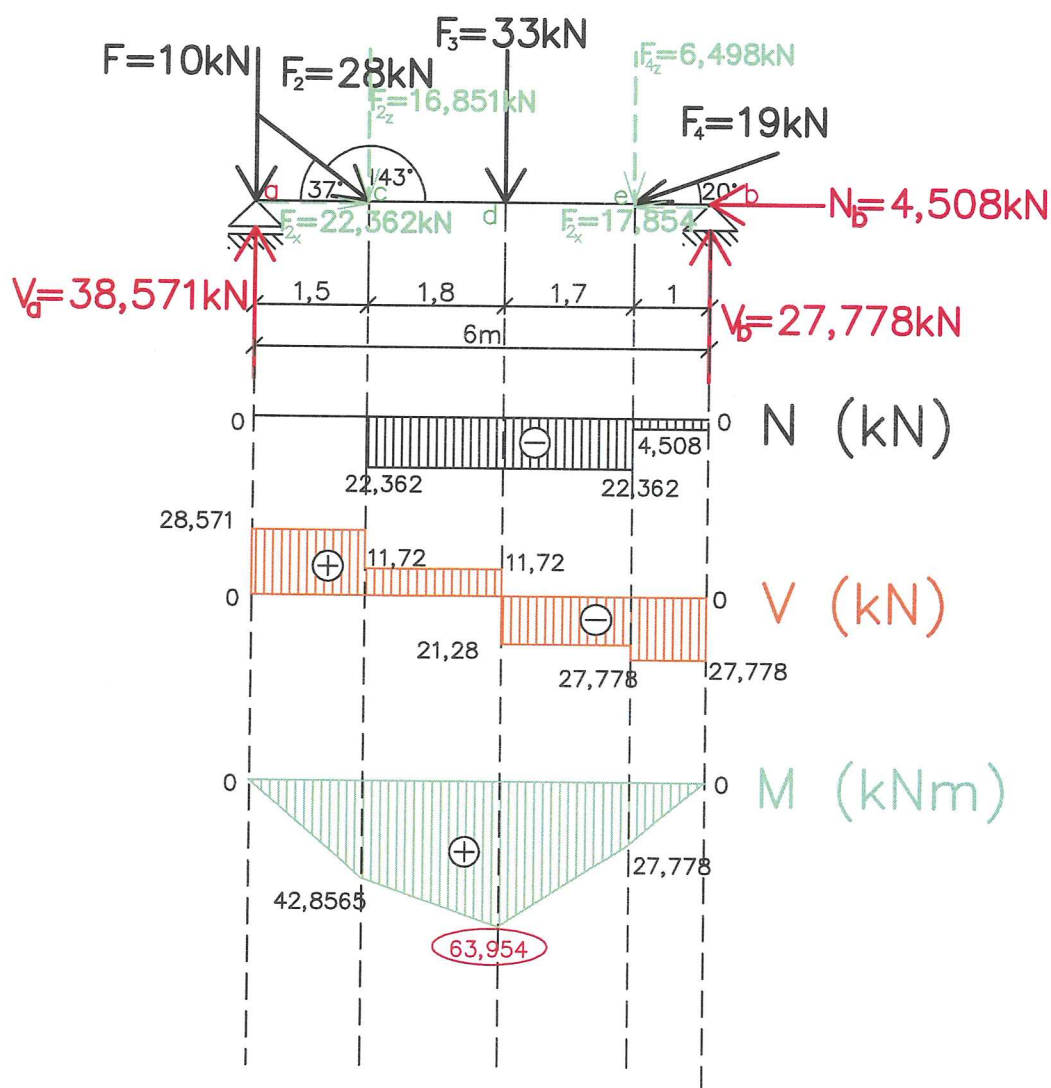
$M_d^L = V_a \cdot 3 - F_1 \cdot 2 = 68,625 \cdot 3 - 21 \cdot 2 = 163,875 \text{ kNm}$

$M_e^P = V_b \cdot 2,5 - F_4 \cdot 0,5 = 73,375 \cdot 2,5 - 16 \cdot 0,5 = 175,4375 \text{ kNm}$ (nebezpečný průřez)

$M_f^P = V_b \cdot 2 = 73,375 \cdot 2 = 146,75 \text{ kNm}$

$M_b^P = 0$

1.5.2



$$F_{2x} = F_2 \cdot \cos 37^\circ = 28 \cdot \cos 37^\circ = \underline{22,362 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \sin 37^\circ = 28 \cdot \sin 37^\circ = \underline{16,851 \text{ kN}}$$

$$F_{4x} = F_4 \cdot \cos 20^\circ = 19 \cdot \cos 20^\circ = \underline{17,854 \text{ kN}}$$

$$F_{4z} = F_4 \cdot \sin 20^\circ = 19 \cdot \sin 20^\circ = \underline{6,498 \text{ kN}}$$

Reakce:

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$V_a \cdot 6 - F_1 \cdot 6 - F_{2z} \cdot 4,5 - F_3 \cdot 2,7 - F_{4z} \cdot 1 = 0$$

$$V_a \cdot 6 - 10 \cdot 6 - 16,851 \cdot 4,5 - 33 \cdot 2,7 - 6,498 \cdot 1 = 0$$

$$V_a = \underline{38,571 \text{ kN}} \quad \curvearrowright$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} + \\ \uparrow \\ - \\ \downarrow \end{array}$$

$$V_a - F_1 - F_{2z} - F_3 - F_{4z} + V_b = 0$$

$$38,571 - 10 - 16,851 - 33 - 6,498 + V_b = 0$$

$$V_b = \underline{27,778 \text{ kN}} \uparrow$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ \leftarrow \\ + \\ \rightarrow \end{array}$$

$$F_{2x} - F_{4x} + N_b = 0$$

$$22,362 - 17,854 + N_b = 0$$

$$N_b = \underline{-4,508 \text{ kN}} \leftarrow$$

Průběhy:

N: $N_a^L = 0$

$$N_c^L = -F_{2x} = -22,362 \text{ kN}$$

$$N_d^L = N_c^L = -22,362 \text{ kN}$$

$$N_e^L = N_d^L + F_{4x} = -22,362 + 17,854 = -4,508 \text{ kN}$$

$$N_b^L = N_e^L + N_b = -4,508 + 4,508 = 0 \text{ Vracíme se k základní čáře.}$$

V: $V_a^L = V_a - F_1 = 38,571 - 10 = \underline{28,571 \text{ kN}}$

$$V_c^L = V_a^L - F_{2z} = 28,571 - 16,851 = \underline{11,72 \text{ kN}}$$

$$V_d^L = V_c^L - F_3 = 11,72 - 33 = \underline{-21,28 \text{ kN}}$$

$$V_e^L = V_d^L - F_{4z} = -21,28 - 6,498 = \underline{-27,778 \text{ kN}}$$

$$V_b^L = V_e^L + V_b = -27,778 + 27,778 = 0 \text{ Vracíme se k základní čáře.}$$

M: $M_a^L = 0$

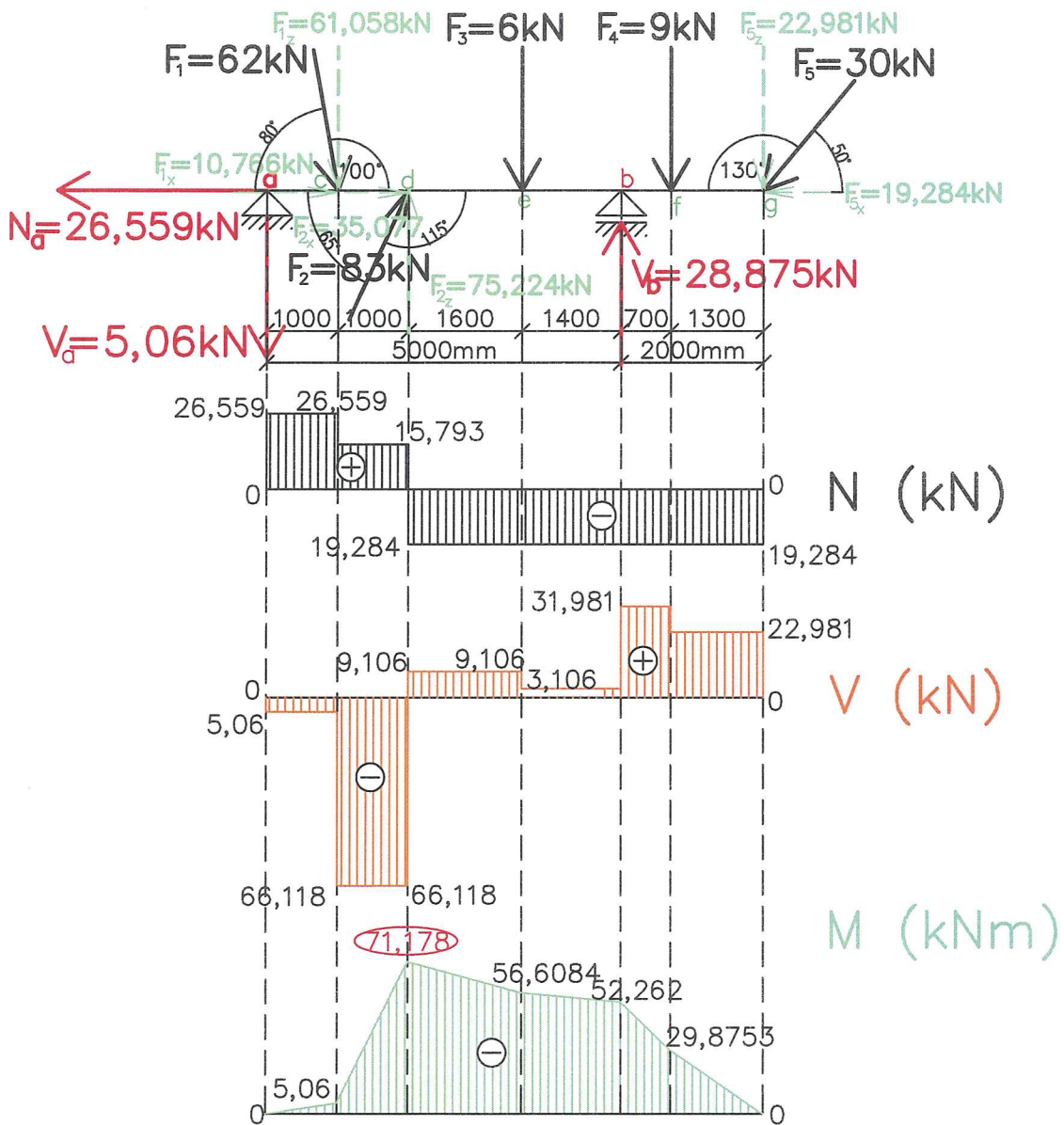
$$M_c^L = V_a \cdot 1,5 - F_1 \cdot 1,5 = 38,571 \cdot 1,5 - 10 \cdot 1,5 = \underline{42,8565 \text{ kNm}}$$

$$M_d^P = V_b \cdot 2,7 - F_{4z} \cdot 1,7 = 27,778 \cdot 2,7 - 6,498 \cdot 1,7 = \underline{63,954 \text{ kNm}}$$

$$M_e^P = V_b \cdot 1 = 27,778 \cdot 1 = \underline{27,778 \text{ kNm}}$$

$$M_b^P = 0$$

1.5.3



$$F_{1x} = F_1 \cdot \cos 80^\circ = 62 \cdot \cos 80^\circ = \underline{10,766 \text{ kN}}$$

$$F_{1z} = F_1 \cdot \sin 80^\circ = 62 \cdot \sin 80^\circ = \underline{61,058 \text{ kN}}$$

$$F_{2x} = F_2 \cdot \cos 65^\circ = 83 \cdot \cos 65^\circ = \underline{35,077 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \sin 65^\circ = 83 \cdot \sin 65^\circ = \underline{75,224 \text{ kN}}$$

$$F_{5x} = F_5 \cdot \cos 50^\circ = 30 \cdot \cos 50^\circ = \underline{19,284 \text{ kN}}$$

$$F_{5z} = F_5 \cdot \sin 50^\circ = 30 \cdot \sin 50^\circ = \underline{22,981 \text{ kN}}$$

Reakce:

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$V_a \cdot 5 - F_{1z} \cdot 4 + F_{2z} \cdot 3 - F_3 \cdot 1,4 + F_4 \cdot 0,7 + F_{5z} \cdot 2 = 0$$

$$V_a \cdot 5 - 61,058 \cdot 4 + 75,224 \cdot 3 - 6 \cdot 1,4 + 9 \cdot 0,7 + 22,981 \cdot 2 = 0$$

$$V_a = \underline{-5,06 \text{ kN}} \quad \curvearrowleft$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} + \\ \uparrow \\ - \\ \downarrow \end{array}$$

$$-V_a - F_{1z} + F_{2z} - F_3 + V_b - F_4 - F_{5z} = 0$$

$$-5,06 - 61,058 + 75,224 - 6 + V_b - 9 - 22,981 = 0$$

$$V_b = \underline{28,875 \text{ kN}} \uparrow$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ \leftarrow \\ + \\ \rightarrow \end{array}$$

$$N_a + F_{1x} + F_{2x} - F_{5x} = 0$$

$$N_a + 10,766 + 35,077 - 19,284 = 0$$

$$N_a = \underline{-26,559 \text{ kN}} \leftarrow$$

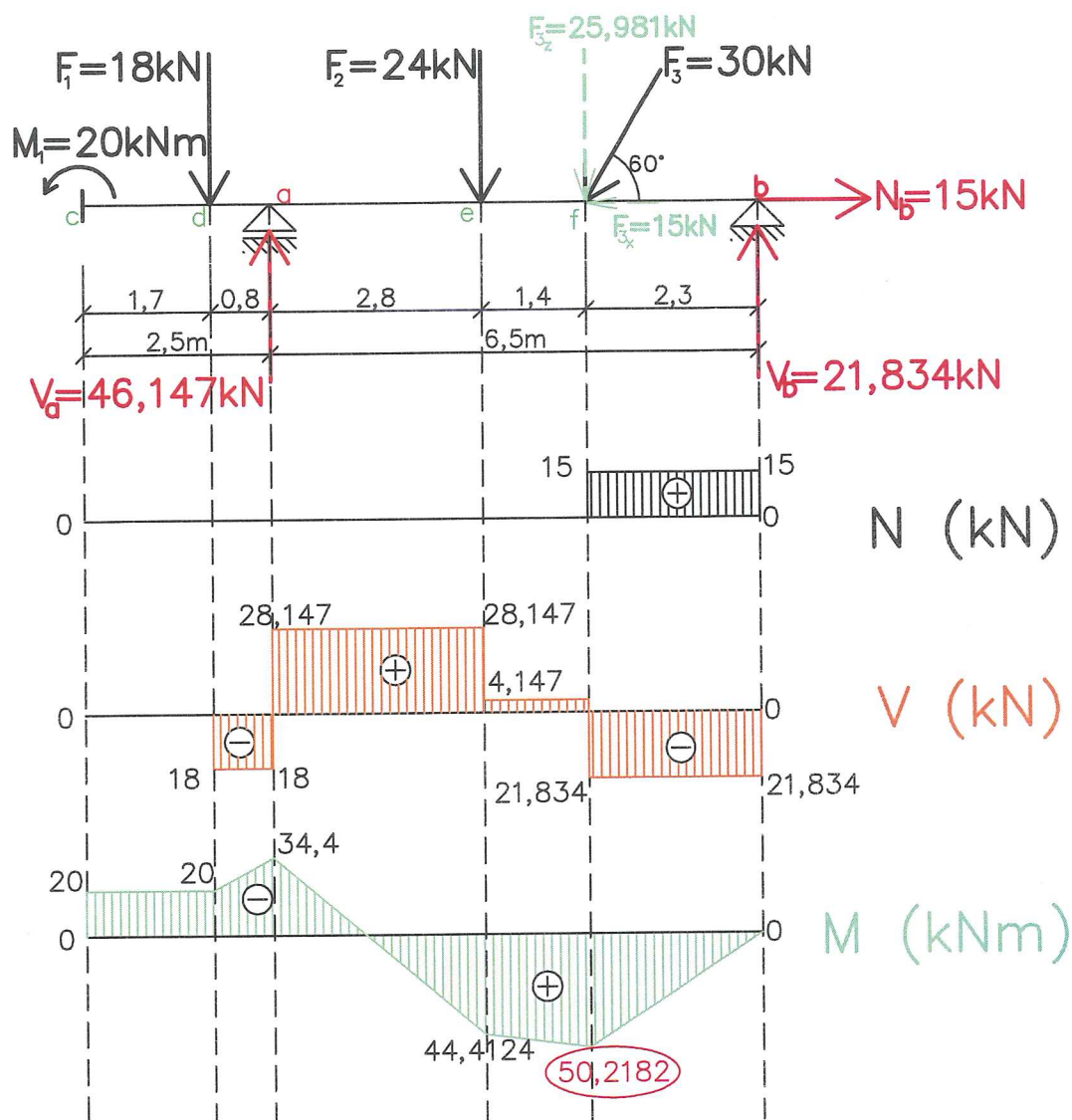
Průběhy:

N: $N_a^L = N_a = \underline{26,559 \text{ kN}}$
 $N_c^L = N_a^L - F_{1x} = 26,559 - 10,766 = \underline{15,793 \text{ kN}}$
 $N_d^L = N_c^L - F_{2x} = 15,739 - 35,077 = \underline{-19,284 \text{ kN}}$
 $N_e^L = N_d^L = N_b^L = N_f^L = \underline{-19,284 \text{ kN}}$
 $N_g^L = N_f^L + F_{5x} = -19,284 + 19,284 = \underline{0}$ Vracíme se k základní čáře.

V: $V_a^L = -V_a = \underline{-5,06 \text{ kN}}$
 $V_c^L = V_a^L - F_{1z} = -5,06 - 61,058 = \underline{-66,118 \text{ kN}}$
 $V_d^L = V_c^L + F_{2z} = -66,118 + 75,224 = \underline{9,106 \text{ kN}}$
 $V_e^L = V_d^L - F_3 = 9,106 - 6 = \underline{3,106 \text{ kN}}$
 $V_b^L = V_e^L + V_b = 3,106 + 28,875 = \underline{31,981 \text{ kN}}$
 $V_f^L = V_b^L - F_4 = 31,981 - 9 = \underline{22,981 \text{ kN}}$
 $V_g^L = V_f^L - F_{5z} = 22,981 - 22,981 = \underline{0}$ Vracíme se k základní čáře.

M: $M_a^L = \underline{0}$
 $M_c^L = -V_a \cdot 1 = -5,06 \cdot 1 = \underline{-5,06 \text{ kNm}}$
 $M_d^L = -V_a \cdot 2 - F_{1z} \cdot 1 = -5,06 \cdot 2 - 61,058 \cdot 1 = \underline{-71,178 \text{ kNm}}$ (nebezpečný průřez)
 $M_e^L = -V_a \cdot 3,6 - F_{1z} \cdot 2,6 + F_{2z} \cdot 1,6 = -5,06 \cdot 3,6 - 61,058 \cdot 2,6 + 75,224 \cdot 1,6 = \underline{-56,6084 \text{ kNm}}$
 $M_b^P = -F_{5z} \cdot 2 - F_4 \cdot 0,7 = -22,981 \cdot 2 - 9 \cdot 0,7 = \underline{-52,262 \text{ kNm}}$
 $M_f^P = -F_{5z} \cdot 1,3 = -22,981 \cdot 1,3 = \underline{-29,8753 \text{ kNm}}$
 $M_g^P = \underline{0}$

1.5.4



Reakce: Při výpočtu nezapomínejte na osamělé břemeno ohybového momentu M_1

$$F_{3x} = F_3 \cdot \cos 60^\circ = 30 \cdot \cos 60^\circ = 15 \text{ kN}$$

$$F_{3z} = F_3 \cdot \sin 60^\circ = 30 \cdot \sin 60^\circ = 25,981 \text{ kN}$$

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ - \end{array}$$

$$-M_1 - F_1 \cdot 7,3 + V_a \cdot 6,5 - F_2 \cdot 3,7 - F_{3z} \cdot 2,3 = 0$$

$$-20 - 18 \cdot 7,3 + V_a \cdot 6,5 - 24 \cdot 3,7 - 25,981 \cdot 2,3 = 0$$

$$V_a = 46,147 \text{ kN} \quad \curvearrowright$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ - \end{array}$$

$$-F_1 + V_a - F_2 - F_{3z} + V_b = 0$$

$$-18 + 46,147 - 24 - 25,981 + V_b = 0$$

$$V_b = 21,834 \text{ kN} \uparrow$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ + \end{array}$$

$$-F_{3x} + N_b = 0$$

$$-15 + N_b = 0$$

$$N_b = 15 \text{ kN} \rightarrow$$

Průběhy:

N: $N_c^L = N_d^L = N_a^L = N_e^L = 0$

$N_f^L = F_{3x} = 15 \text{ kN}$

$N_b = N_f^L - N_b = 15 - 15 = 0$ Vracíme se k základní čáře.

V: $V_c^L = 0$

$V_d^L = V_c^L - F_1 = 0 - 18 = -18 \text{ kN}$

$V_a^L = V_d^L + V_a = -18 + 46,147 = 28,147 \text{ kN}$

$V_e^L = V_a^L - F_2 = 28,147 - 24 = 4,147 \text{ kN}$

$V_f^L = V_e^L - F_{3z} = 4,147 - 25,981 = -21,834 \text{ kN}$

$V_b^L = V_f^L + V_b = -21,834 + 21,834 = 0$ Vracíme se k základní čáře.

M: $M_c^L = -M_1 = -20 \text{ kNm}$

Na konci nosníku působí osamělý moment a to je nutné zohlednit!

$M_d^L = -M_1 = -20 \text{ kNm}$

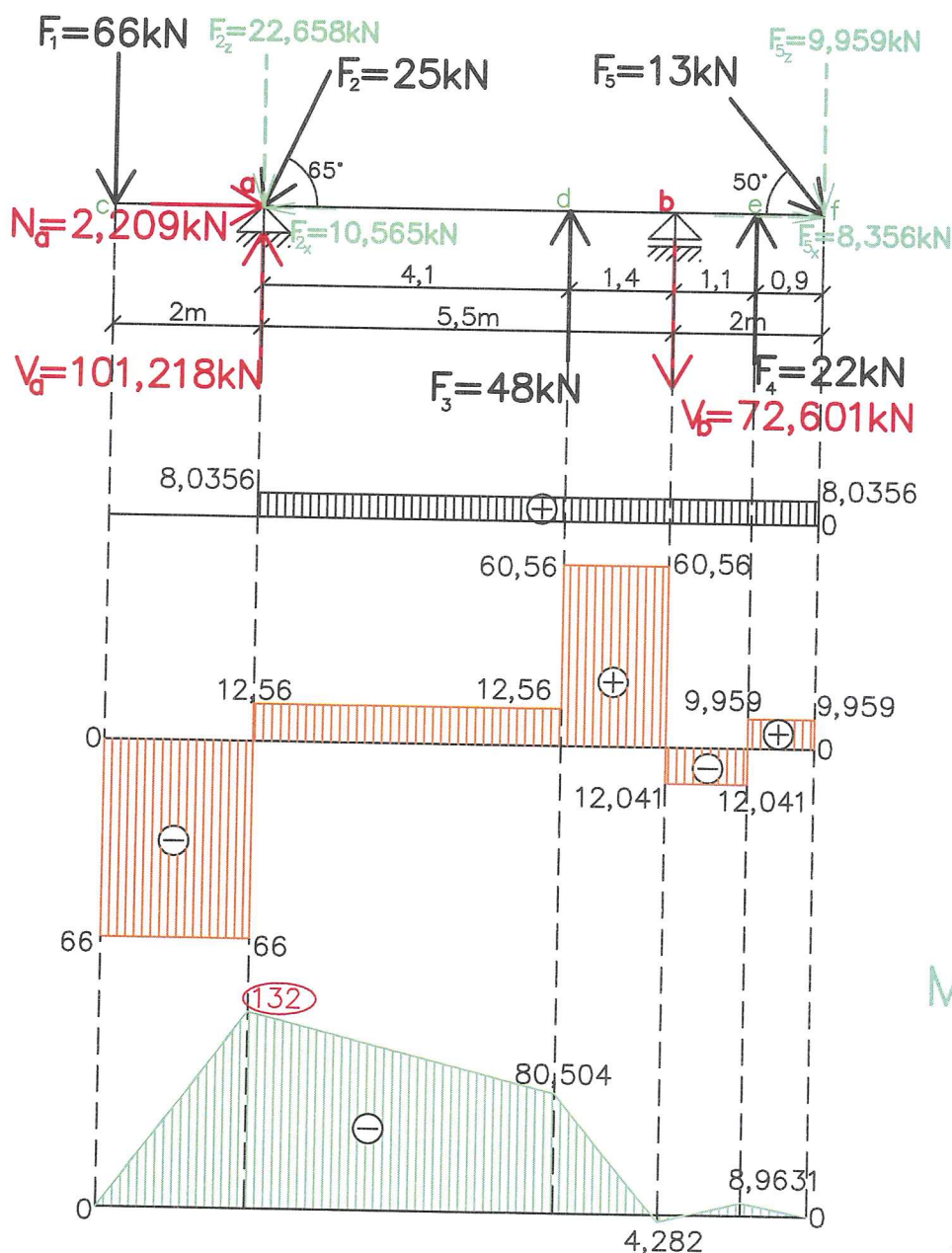
$M_a^L = -M_1 - F_1 \cdot 0,8 = -20 - 18 \cdot 0,8 = -34,4 \text{ kNm}$

$M_e^P = V_b \cdot 3,7 - F_{3z} \cdot 1,4 = 21,834 \cdot 3,7 - 25,981 \cdot 1,4 = 44,4124 \text{ kNm}$

$M_f^P = V_b \cdot 2,3 = 21,834 \cdot 2,3 = 50,2182 \text{ kNm}$

$M_b^P = 0$

1.5.5



N (kN)

V (kN)

M (kNm)

Reakce:

$$F_{2x} = F_2 \cdot \cos 65^\circ = 25 \cdot \cos 65^\circ = \underline{10,565 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \sin 65^\circ = 25 \cdot \sin 65^\circ = \underline{22,658 \text{ kN}}$$

$$F_{5x} = F_5 \cdot \cos 50^\circ = 13 \cdot \cos 50^\circ = \underline{8,356 \text{ kN}}$$

$$F_{5z} = F_5 \cdot \sin 50^\circ = 13 \cdot \sin 50^\circ = \underline{9,959 \text{ kN}}$$

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$-F_1 \cdot 7,5 - F_{2z} \cdot 5,5 + V_a \cdot 5,5 + F_3 \cdot 1,4 - F_4 \cdot 1,1 + F_{5z} \cdot 2 = 0$$

$$-66 \cdot 7,5 - 22,658 \cdot 5,5 + V_a \cdot 5,5 + 48 \cdot 1,4 - 22 \cdot 1,1 + 9,959 \cdot 2 = 0$$

$$V_a = \underline{101,218 \text{ kN}} \quad \curvearrowright$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \uparrow \\ - \\ \downarrow \end{array}$$

$$-F_1 - F_{2z} + V_a + F_3 + V_b + F_4 - F_{5z} = 0$$

$$-66 - 22,658 + 101,218 + 48 + V_b + 22 - 9,959 = 0$$

$$V_b = \underline{-72,601 \text{ kN}} \downarrow$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ \leftarrow \\ + \\ \rightarrow \end{array}$$

$$N_a - F_{2x} + F_{5x} = 0$$

$$N_a - 10,565 + 8,356 = 0$$

$$N_a = \underline{2,209 \text{ kN}} \rightarrow$$

Průběhy:

$$\underline{N}: \quad N_c^L = 0$$

$$N_a^L = N_c^L - N_a + F_{2x} = 0 - 2,209 + 10,565 = 8,356 \text{ kN}$$

$$N_d^L = N_a^L = N_b^L = N_e^L = \underline{8,356 \text{ kN}}$$

$$N_f^L = N_e^L - F_{5x} = 8,356 - 8,356 = 0 \text{ Vracíme se k základní čáře.}$$

$$\underline{V}: \quad V_c^L = -F_1 = \underline{-66 \text{ kN}}$$

$$V_a^L = V_c^L + V_a - F_{2z} = -66 + 101,218 - 22,658 = \underline{12,56 \text{ kN}}$$

$$V_d^L = V_a^L + F_3 = 12,56 + 48 = \underline{60,56 \text{ kN}}$$

$$V_b^L = V_d^L - V_b = 60,56 - 72,601 = \underline{-12,041 \text{ kN}}$$

$$V_e^L = V_b^L + F_4 = -12,041 + 22 = \underline{9,959 \text{ kN}}$$

$$V_f^L = V_e^L - F_{5z} = 9,959 - 9,959 = 0 \text{ Vracíme se k základní čáře.}$$

$$\underline{M}: \quad M_c^L = 0$$

$$M_a^L = -F_1 \cdot 2 = -66 \cdot 2 = \underline{-132 \text{ kNm}} \text{ (nebezpečný průřez)}$$

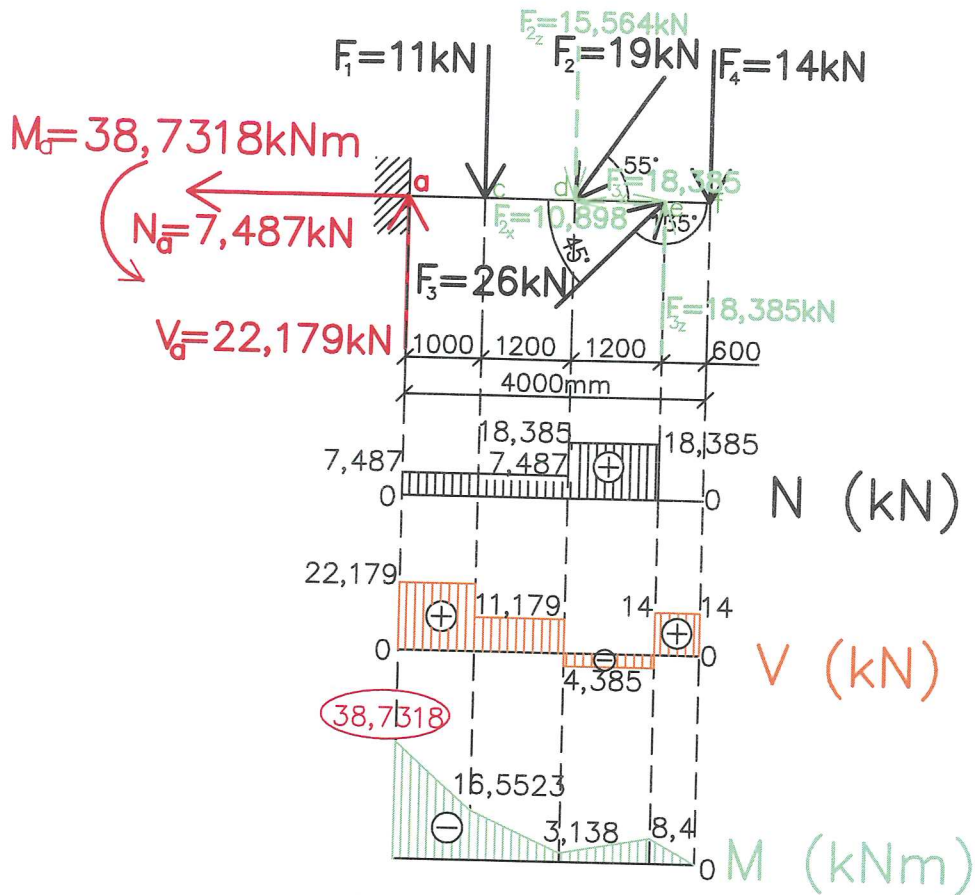
$$M_d^L = -F_1 \cdot 6,1 - F_{2z} \cdot 4,1 + V_a \cdot 4,1 = -66 \cdot 6,1 - 22,658 \cdot 4,1 + 101,218 \cdot 4,1 = \underline{-80,504 \text{ kNm}}$$

$$M_b^P = -F_{5z} \cdot 2 + F_4 \cdot 1,1 = -9,959 \cdot 2 + 22 \cdot 1,1 = \underline{4,282 \text{ kNm}}$$

$$M_e^P = -F_{5z} \cdot 0,9 = -9,959 \cdot 0,9 = \underline{-8,9631 \text{ kNm}}$$

$$M_f^P = 0$$

1.5.6



Reakce:

$$F_{2x} = F_2 \cdot \cos 55^\circ = 19 \cdot \cos 55^\circ = \underline{10,898 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \sin 55^\circ = 19 \cdot \sin 55^\circ = \underline{15,564 \text{ kN}}$$

$$F_{3x} = F_3 \cdot \cos 45^\circ = 26 \cdot \cos 45^\circ = \underline{18,385 \text{ kN}}$$

$$F_{3z} = F_3 \cdot \sin 45^\circ = 26 \cdot \sin 45^\circ = \underline{18,385 \text{ kN}}$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \leftarrow \rightarrow$$

$$N_a - F_{2x} + F_{3x} = 0$$

$$N_a - 10,898 + 18,385 = 0$$

$$N_a = \underline{-7,487 \text{ kN}} \quad \leftarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \uparrow \downarrow$$

$$V_a - F_1 - F_{2z} + F_{3z} - F_4 = 0$$

$$V_a - 11 - 15,564 + 18,385 - 14 = 0$$

$$V_a = \underline{22,179 \text{ kN}} \quad \uparrow$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \curvearrowright \quad \curvearrowleft$$

$$M_a + F_1 \cdot 1 + F_{2z} \cdot 2,2 - F_{3z} \cdot 3,4 + F_4 \cdot 4 = 0$$

$$M_a + 11 \cdot 1 + 15,564 \cdot 2,2 - 18,385 \cdot 3,4 + 14 \cdot 4 = 0$$

$$M_a = \underline{-38,7318 \text{ kNm}} \quad \curvearrowleft$$

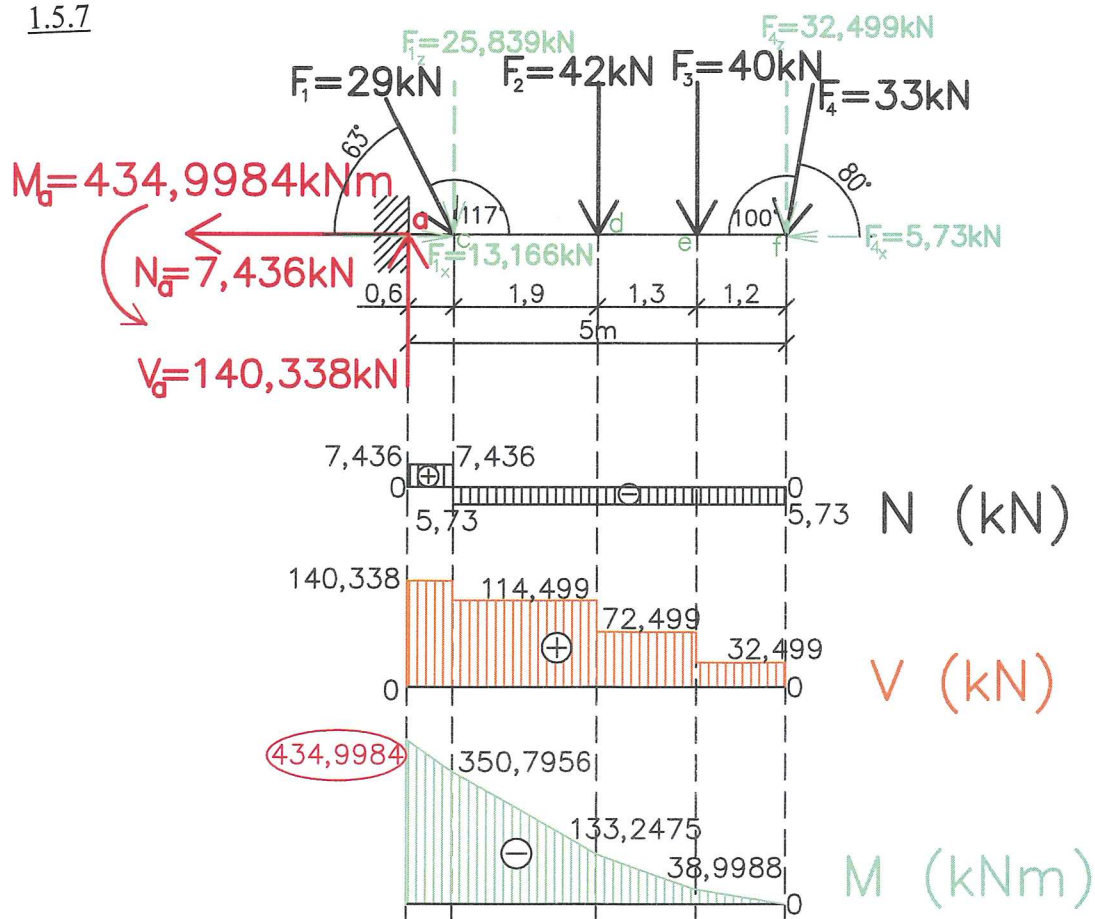
Průběhy:

N: $N_a^L = N_a = \underline{7,487 \text{ kN}}$
 $N_c^L = N_a^L = \underline{7,487 \text{ kN}}$
 $N_d^L = N_c^L + F_{2x} = 7,487 + 10,898 = \underline{18,385 \text{ kN}}$
 $N_e^L = N_d^L - F_{3x} = 18,385 - 18,385 = \underline{0}$ Vracíme se k základní čáře.
 $N_f^L = N_e^L = \underline{0}$

V: $V_a^L = V_a = \underline{22,179 \text{ kN}}$
 $V_c^L = V_a^L - F_1 = 22,179 - 11 = \underline{11,179 \text{ kN}}$
 $V_d^L = V_c^L - F_{2z} = 11,179 - 15,564 = \underline{-4,385 \text{ kN}}$
 $V_e^L = V_d^L + F_{3z} = -4,385 + 18,385 = \underline{14 \text{ kN}}$
 $V_f^L = V_e^L - F_4 = 14 - 14 = \underline{0}$ Vracíme se k základní čáře.

M: $M_f^P = \underline{0}$
 $M_e^P = -F_4 \cdot 0,6 = -14 \cdot 0,6 = \underline{-8,4 \text{ kNm}}$
 $M_d^P = -F_4 \cdot 1,8 + F_{3z} \cdot 1,2 = -14 \cdot 1,8 + 18,385 \cdot 1,2 = \underline{-3,138 \text{ kNm}}$
 $M_c^L = -M_a + V_a \cdot 1 = -38,7313 + 22,179 \cdot 1 = \underline{-16,5523 \text{ kNm}}$
 $M_a^L = -M_a = \underline{38,7318 \text{ kNm}}$ (nebezpečný průřez)

1.5.7



Reakce:

$$F_{1x} = F_1 \cdot \cos 63^\circ = 29 \cdot \cos 63^\circ = \underline{13,166 \text{ kN}}$$

$$F_{1z} = F_1 \cdot \sin 63^\circ = 29 \cdot \sin 63^\circ = \underline{25,839 \text{ kN}}$$

$$F_{4x} = F_4 \cdot \cos 80^\circ = 33 \cdot \cos 80^\circ = \underline{5,73 \text{ kN}}$$

$$F_{4z} = F_4 \cdot \sin 80^\circ = 33 \cdot \sin 80^\circ = \underline{32,499 \text{ kN}}$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \quad + \\ \leftarrow \quad \rightarrow \end{array}$$

$$\begin{aligned} N_a + F_{1x} - F_{4x} &= 0 \\ N_a + 13,166 - 5,73 &= 0 \\ N_a &= \underline{-7,436 \text{ kN}} \quad \leftarrow \end{aligned}$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \uparrow \\ - \\ \downarrow \end{array}$$

$$\begin{aligned} V_a - F_{1z} - F_2 - F_3 - F_{4z} &= 0 \\ V_a - 25,839 - 42 - 40 - 32,499 &= 0 \\ V_a &= \underline{140,338 \text{ kN}} \quad \uparrow \end{aligned}$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} + \quad - \\ \curvearrowright \quad \curvearrowleft \end{array}$$

$$\begin{aligned} M_a + F_{1z} \cdot 0,6 + F_2 \cdot 2,5 + F_3 \cdot 3,8 + F_{4z} \cdot 5 &= 0 \\ M_a + 25,839 \cdot 0,6 + 42 \cdot 2,5 + 40 \cdot 3,8 + 32,499 \cdot 5 &= 0 \\ M_a &= \underline{-434,9984 \text{ kNm}} \quad \curvearrowleft \end{aligned}$$

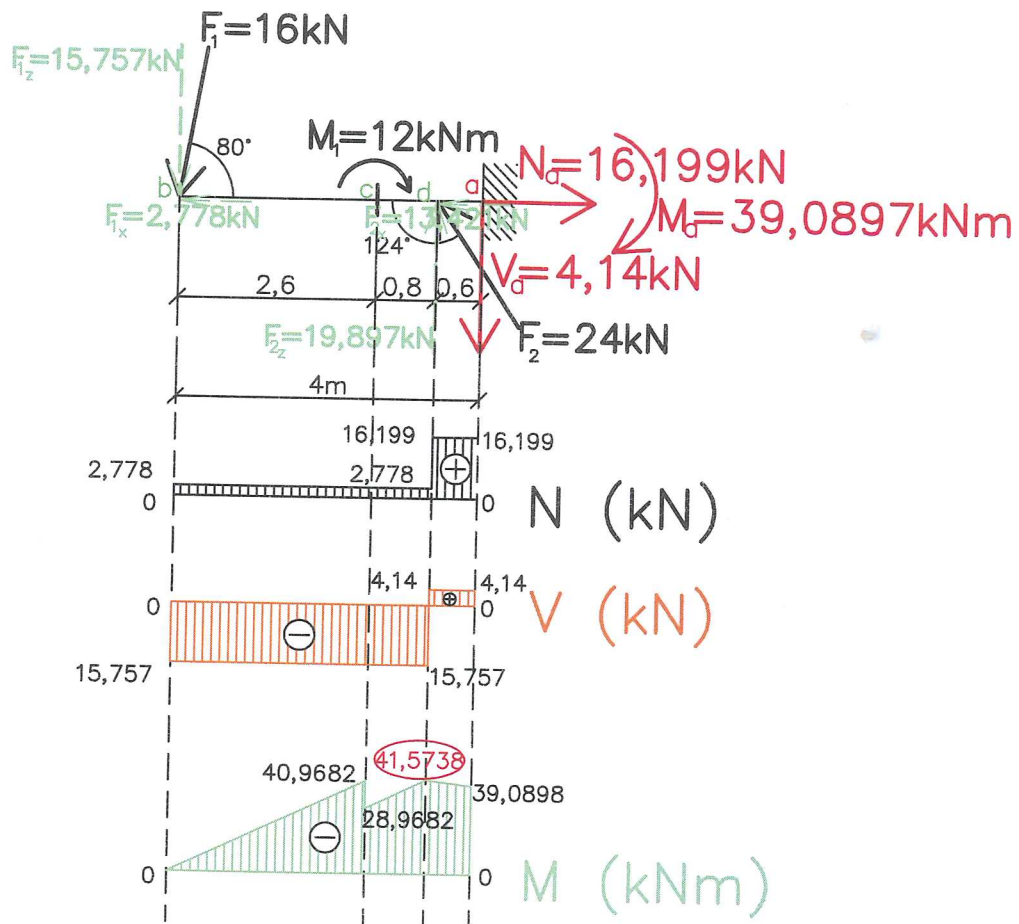
Průběhy:

N: $N_a^L = N_a = \underline{7,436 \text{ kN}}$
 $N_c^L = N_a^L - F_{1x} = 7,436 - 13,166 = \underline{-5,73 \text{ kN}}$
 $N_d^L = N_c^L = N_e^L = \underline{-5,73 \text{ kN}}$
 $N_f^L = N_e^L + F_{4x} = -5,73 + 5,73 = \underline{0}$ Vracíme se k základní čáře.

V: $V_a^L = V_a = \underline{140,338 \text{ kN}}$
 $V_c^L = V_a^L - F_{1z} = 140,338 - 25,839 = \underline{114,499 \text{ kN}}$
 $V_d^L = V_c^L - F_2 = 114,499 - 42 = \underline{72,499 \text{ kN}}$
 $V_e^L = V_d^L - F_3 = 72,499 - 40 = \underline{32,499 \text{ kN}}$
 $V_f^L = V_e^L - F_{4z} = 32,499 - 32,499 = \underline{0}$ Vracíme se k základní čáře.

M: $M_f^P = \underline{0}$
 $M_e^P = -F_{4z} \cdot 1,2 = -32,499 \cdot 1,2 = \underline{-38,9988 \text{ kNm}}$
 $M_d^{P'} = -F_{4z} \cdot 2,5 - F_3 \cdot 1,3 = -32,499 \cdot 2,5 - 40 \cdot 1,3 = \underline{-133,2475 \text{ kNm}}$
 $M_c^L = -M_a + V_a \cdot 0,6 = -434,9984 + 140,338 \cdot 0,6 = \underline{-350,7956 \text{ kNm}}$
 $M_a^L = -M_a = \underline{-434,9984 \text{ kNm}}$ (nebezpečný průřez)

1.5.8



Reakce:

$$F_{1x} = F_1 \cdot \cos 80^\circ = 16 \cdot \cos 80^\circ = 2,778 \text{ kN}$$

$$F_{1z} = F_1 \cdot \sin 80^\circ = 16 \cdot \sin 80^\circ = 15,757 \text{ kN}$$

$$F_{2x} = F_2 \cdot \cos 56^\circ = 24 \cdot \cos 56^\circ = 13,421 \text{ kN}$$

$$F_{2z} = F_2 \cdot \sin 56^\circ = 24 \cdot \sin 56^\circ = 19,897 \text{ kN}$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \leftarrow \begin{array}{c} - \\ + \end{array} \rightarrow$$

$$\begin{aligned} -F_{1x} - F_{2x} + N_a &= 0 \\ -2,778 - 13,421 + N_a &= 0 \\ N_a &= 16,199 \text{ kN} \rightarrow \end{aligned}$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} \uparrow + \\ \downarrow - \end{array}$$

$$\begin{aligned} -F_{1z} + F_{2z} + V_a &= 0 \\ -15,757 + 19,897 + V_a &= 0 \\ V_a &= -4,14 \text{ kN} \downarrow \end{aligned}$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} \curvearrowright + \\ \curvearrowleft - \end{array}$$

$$-F_{1z} \cdot 4 + M_1 + F_{2z} \cdot 0,6 + M_a = 0$$

$$-15,757 \cdot 4 + 12 + 19,897 \cdot 0,6 + M_a = 0$$

$$M_a = \underline{39,0898 \text{ kNm}} \quad \curvearrowright$$

Průběhy:

N: $N_b^L = F_{1x} = \underline{2,778 \text{ kN}}$

$$N_c^L = N_b^L = \underline{2,778 \text{ kN}}$$

$$N_d^L = N_c^L + F_{2x} = 2,778 + 13,421 = \underline{16,199 \text{ kN}}$$

$$N_a^L = N_d^L - N_a = 16,199 - 16,199 = \underline{0} \text{ Vracíme se k základní čáře.}$$

V: $V_b^L = -F_{1z} = \underline{-15,757 \text{ kN}}$

$$V_c^L = V_b^L = \underline{-15,757 \text{ kN}}$$

$$V_d^L = V_c^L + F_{2z} = -15,757 + 19,897 = \underline{4,14 \text{ kN}}$$

$$V_a^L = V_d^L - V_a = 4,14 - 4,14 = \underline{0} \text{ Vracíme se k základní čáře.}$$

M: $M_b^L = \underline{0}$

$$M_c^L = -F_{1z} \cdot 2,6 = -15,757 \cdot 2,6 = \underline{-40,9682 \text{ kNm}}$$

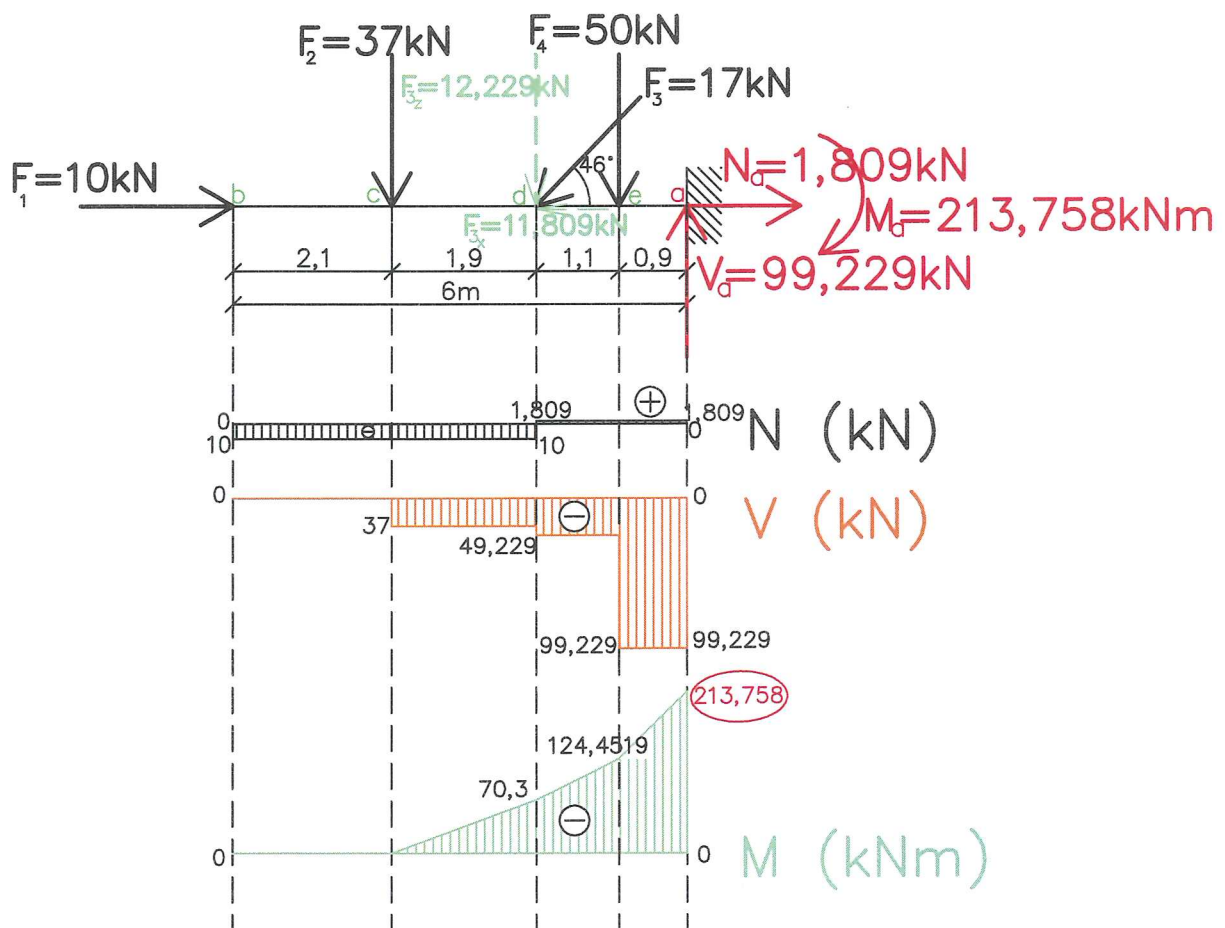
! Pozor v působišti c působí osamělý moment M_1 , proto se zde bude měnit průběh ohybových momentů skokem a to právě o hodnotu zde působícího momentu M_1 !

$$M_c^L = M_c^L + M_1 = -40,9682 + 12 = \underline{-28,9682 \text{ kNm}}$$

$$M_d^L = -F_{1z} \cdot 3,4 + M_1 = -15,757 \cdot 3,4 + 12 = \underline{-41,5738 \text{ kNm}} \text{ (nebezpečný průřez)}$$

$$M_a^P = M_a = \underline{-39,0898 \text{ kNm}}$$

1.5.9



Reakce:

$$F_{3x} = F_3 \cdot \cos 46^\circ = 17 \cdot \cos 46^\circ = \underline{11,809 \text{ kN}}$$

$$F_{3z} = F_3 \cdot \sin 46^\circ = 17 \cdot \sin 46^\circ = \underline{12,229 \text{ kN}}$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \quad + \\ \leftarrow \quad \rightarrow \end{array}$$

$$\begin{aligned} F_1 - F_{3x} + N_a &= 0 \\ 10 - 11,809 + N_a &= 0 \\ N_a &= \underline{1,809 \text{ kN}} \rightarrow \end{aligned}$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \updownarrow \\ - \end{array}$$

$$\begin{aligned} -F_2 - F_{3z} - F_4 + V_a &= 0 \\ -37 - 12,229 - 50 + V_a &= 0 \\ V_a &= \underline{99,229 \text{ kN}} \uparrow \end{aligned}$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} + \quad - \\ \curvearrowright \quad \curvearrowleft \end{array}$$

$$\begin{aligned} -F_2 \cdot 3,9 - F_{3z} \cdot 2 - F_4 \cdot 0,9 + M_a &= 0 \\ -37 \cdot 3,9 - 12,229 \cdot 2 - 50 \cdot 0,9 + M_a &= 0 \\ M_a &= \underline{213,758 \text{ kNm}} \quad \curvearrowright \end{aligned}$$

Průběhy:

N: $N_b^L = -F_1 = \underline{-10 \text{ kN}}$
 $N_c^L = N_b^L = \underline{-10 \text{ kN}}$
 $N_d^L = N_c^L + F_{3x} = -10 + 11,809 = \underline{1,809 \text{ kN}}$
 $N_e^L = N_d^L = \underline{1,809 \text{ kN}}$
 $N_a^L = N_e^L - N_a = 1,809 - 1,809 = \underline{0}$ Vracíme se k základní čáře.

V: $V_b^L = \underline{0}$
 $V_c^L = V_b^L - F_2 = 0 - 37 = \underline{-37 \text{ kN}}$
 $V_d^L = V_c^L - F_{3z} = -37 - 12,229 = \underline{-49,229 \text{ kN}}$
 $V_e^L = V_d^L - F_4 = -49,229 - 50 = \underline{-99,229 \text{ kN}}$
 $V_a^L = V_e^L + V_a = -99,229 + 99,229 = \underline{0}$ Vracíme se k základní čáře.

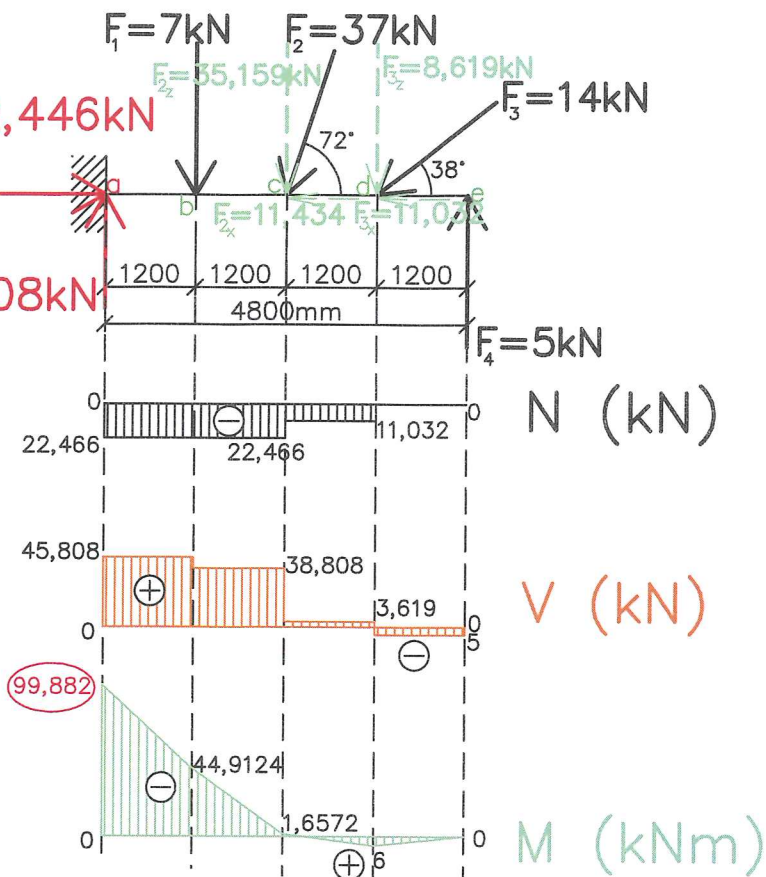
M: $M_b^L = \underline{0}$
 $M_c^L = \underline{0}$
 $M_d^L = -F_2 \cdot 1,9 = -37 \cdot 1,9 = \underline{-70,3 \text{ kNm}}$
 $M_e^L = -F_2 \cdot 3 - F_{3z} \cdot 1,1 = -37 \cdot 3 - 12,229 \cdot 1,1 = \underline{-124,4519 \text{ kNm}}$
 $M_a^P = -M_a = \underline{-213,758 \text{ kNm}}$ (nebezpečný průřez)

1.5.10

$$M_a = 99,882 \text{ kNm}$$

$$V_a = 45,808 \text{ kN}$$

$$N_a = 22,446 \text{ kN}$$



Reakce:

$$F_{2x} = F_2 \cdot \cos 72^\circ = 37 \cdot \cos 72^\circ = 11,434 \text{ kN}$$

$$F_{2z} = F_2 \cdot \sin 72^\circ = 37 \cdot \sin 72^\circ = 35,189 \text{ kN}$$

$$F_{3x} = F_3 \cdot \cos 38^\circ = 14 \cdot \cos 38^\circ = 11,032 \text{ kN}$$

$$F_{3z} = F_3 \cdot \sin 38^\circ = 14 \cdot \sin 38^\circ = 8,619 \text{ kN}$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \leftarrow \rightarrow$$

$$N_a - F_{2x} - F_{3x} = 0$$

$$N_a - 11,434 - 11,032 = 0$$

$$N_a = 22,466 \text{ kN} \rightarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \uparrow \downarrow$$

$$V_a - F_1 - F_{2z} - F_{3z} + F_4 = 0$$

$$V_a - 7 - 35,189 - 8,619 + 5 = 0$$

$$V_a = 45,808 \text{ kN} \uparrow$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \curvearrowright \curvearrowleft$$

$$M_a + F_1 \cdot 1,2 + F_{2z} \cdot 2,4 + F_{3z} \cdot 3,6 - F_4 \cdot 4,8 = 0$$

$$M_a + 7 \cdot 1,2 + 35,189 \cdot 2,4 + 8,619 \cdot 3,6 - 5 \cdot 4,8 = 0$$

$$M_a = -99,882 \text{ kNm} \quad \curvearrowleft$$

Průběhy:

$$N: \quad N_a^L = -N_a = -22,466 \text{ kN}$$

$$N_b^L = N_a^L = -22,466 \text{ kN}$$

$$N_c^L = N_b^L + F_{2x} = -22,466 + 11,434 = -11,032 \text{ kN}$$

$$N_d^L = N_c^L + F_{3x} = -11,032 + 11,032 = 0$$

$$N_e^L = N_b^L = 0 \text{ Vracíme se k základní čáře.}$$

V: $V_a^L = V_a = 45,808 \text{ kN}$

$$V_b^L = V_a^L - F_1 = 45,808 - 7 = 38,808 \text{ kN}$$

$$V_c^L = V_b^L - F_{2z} = 38,808 - 35,189 = 3,619 \text{ kN}$$

$$V_d^L = V_c^L - F_{3z} = 3,619 - 8,619 = -5 \text{ kN}$$

$$V_e^L = V_d^L + F_4 = -5 + 5 = 0 \text{ Vracíme se k základní čáře.}$$

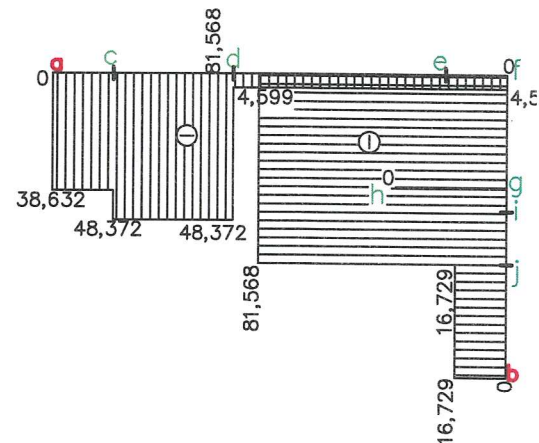
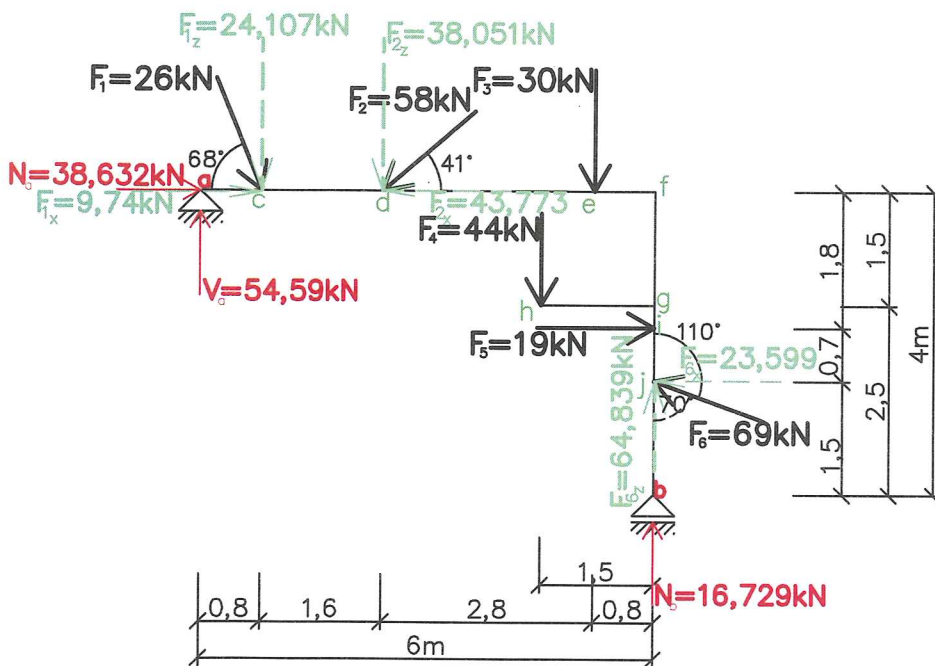
M: $M_a^L = -M_a = -99,882 \text{ kNm}$ (nebezpečný průřez)

$$M_b^L = -M_a + V_a \cdot 1,2 = -99,882 + 45,808 \cdot 1,2 = -44,9124 \text{ kNm}$$

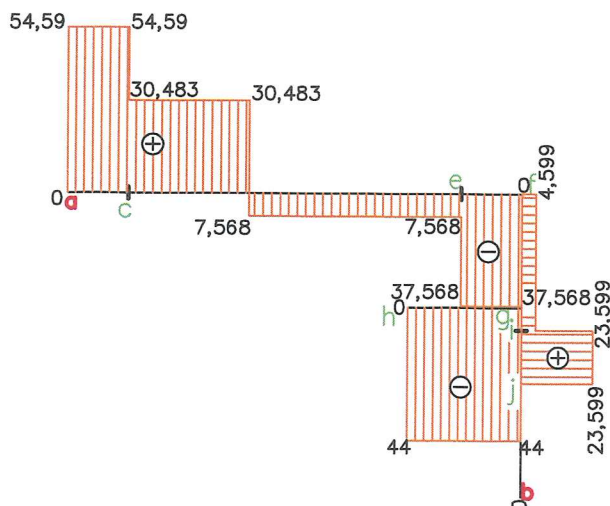
$$M_c^L = F_4 \cdot 2,4 - F_{3z} \cdot 1,2 = 5 \cdot 2,4 - 8,619 \cdot 1,2 = 1,6572 \text{ kNm}$$

$$M_d^L = F_4 \cdot 1,2 = 5 \cdot 1,2 = 6 \text{ kNm}$$

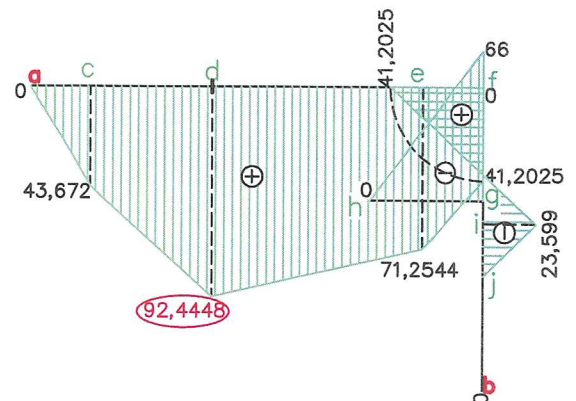
1.5.11



N (kN)



V (kN)



M (kNm)

Reakce:

$$F_{1x} = F_1 \cdot \cos 68^\circ = 26 \cdot \cos 68^\circ = \underline{9,74 \text{ kN}}$$

$$F_{1z} = F_1 \cdot \sin 68^\circ = 26 \cdot \sin 68^\circ = \underline{24,107 \text{ kN}}$$

$$F_{2x} = F_2 \cdot \cos 41^\circ = 58 \cdot \cos 41^\circ = \underline{43,773 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \sin 41^\circ = 58 \cdot \sin 41^\circ = \underline{38,051 \text{ kN}}$$

$$F_{6x} = F_6 \cdot \cos 70^\circ = 69 \cdot \cos 70^\circ = \underline{23,599 \text{ kN}}$$

$$F_{6z} = F_6 \cdot \sin 70^\circ = 69 \cdot \sin 70^\circ = \underline{64,839 \text{ kN}}$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$F_{1z} \cdot 0,8 + F_{2z} \cdot 2,4 + F_3 \cdot 5,2 + F_4 \cdot 4,5 - F_5 \cdot 1,8 + F_{6x} \cdot 2,5 - F_{6z} \cdot 6 + N_b \cdot 6 = 0$$

$$24,107 \cdot 0,8 + 38,051 \cdot 2,4 + 30 \cdot 5,2 + 44 \cdot 4,5 - 19 \cdot 1,8 + 23,599 \cdot 2,5 - 64,839 \cdot 6 + N_b \cdot 6 = 0$$

$$N_b = \underline{-16,729 \text{ kN}} \quad \curvearrowleft$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ \leftarrow \end{array} \quad \begin{array}{c} + \\ \rightarrow \end{array}$$

$$N_a + F_{1x} - F_{2x} + F_5 - F_{6x} = 0$$

$$N_a + 9,74 - 43,773 + 19 - 23,599 = 0$$

$$N_a = \underline{38,632 \text{ kN}} \rightarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \uparrow \\ - \\ \downarrow \end{array}$$

$$V_a - F_{1z} - F_{2z} - F_3 - F_4 + F_{6z} + N_b = 0$$

$$V_a - 24,107 - 38,051 - 30 - 44 + 64,839 + 16,729 = 0$$

$$V_a = \underline{54,59 \text{ kN}} \uparrow$$

Průběhy:

N: VODOROVNÉ RAMENO

$$N_a^L = -N_a = -\underline{38,632 \text{ kN}}$$

$$N_c^L = N_a^L - F_{1x} = -38,632 - 9,74 = -\underline{48,372 \text{ kN}}$$

$$N_d^L = N_c^L + F_{2x} = -48,372 + 43,773 = -\underline{4,599 \text{ kN}}$$

$$N_e^L = N_d^L = N_f^L = -\underline{4,599 \text{ kN}}$$

SVISLÉ RAMENO

$$N_b^P = -N_b = -\underline{16,729 \text{ kN}}$$

$$N_j^P = N_b^P - F_{6z} = -16,729 - 64,839 = -\underline{81,568 \text{ kN}}$$

$$N_i^P = N_j^P = N_g^P = N_f^P = -\underline{81,568 \text{ kN}}$$

KONZOLA

$$N_n^L = \underline{0}$$

$$N_g^L = \underline{0}$$

V: VODOROVNÉ RAMENO

$$V_a^L = V_a = \underline{54,59 \text{ kN}}$$

$$V_c^L = V_a^L - F_{1z} = 54,59 - 24,107 = \underline{30,483 \text{ kN}}$$

$$V_d^L = V_c^L - F_{2z} = 30,483 - 38,051 = -\underline{7,568 \text{ kN}}$$

$$V_e^L = V_d^L - F_3 = -7,568 - 30 = -\underline{37,568 \text{ kN}}$$

$$V_f^L = V_e^L = -\underline{37,568 \text{ kN}}$$

SVISLÉ RAMENO

$$V_b^P = \underline{0}$$

$$V_j^P = F_{6x} = \underline{23,599 \text{ kN}}$$

$$V_i^P = V_j^P - F_5 = 23,599 - 19 = 4,599 \text{ kN}$$

$$V_g^P = V_i^P = V_f^P = 4,599 \text{ kN}$$

KONZOLA

$$V_h^L = -F_4 = -44 \text{ kN}$$

$$V_g^L = V_h^L = -44 \text{ kN}$$

M:

$$M_a^L = 0$$

$$M_c^L = V_a \cdot 0,8 = 54,59 \cdot 0,8 = 43,672 \text{ kNm}$$

$$M_d^L = V_a \cdot 2,4 - F_{1z} \cdot 1,6 = 54,59 \cdot 2,4 - 24,107 \cdot 1,6 = 92,4448 \text{ kNm (nebezpečný průřez)}$$

$$M_e^L = V_a \cdot 5,2 - F_{1z} \cdot 4,4 - F_{2z} \cdot 2,8 = 54,59 \cdot 5,2 - 24,107 \cdot 4,4 - 38,051 \cdot 2,8 = 71,2544 \text{ kNm}$$

$$M_f^P = -F_{6x} \cdot 2,5 + F_5 \cdot 1,8 + F_4 \cdot 1,5 = -23,599 \cdot 2,5 + 19 \cdot 1,8 + 44 \cdot 1,5 = 41,2025 \text{ kNm}$$

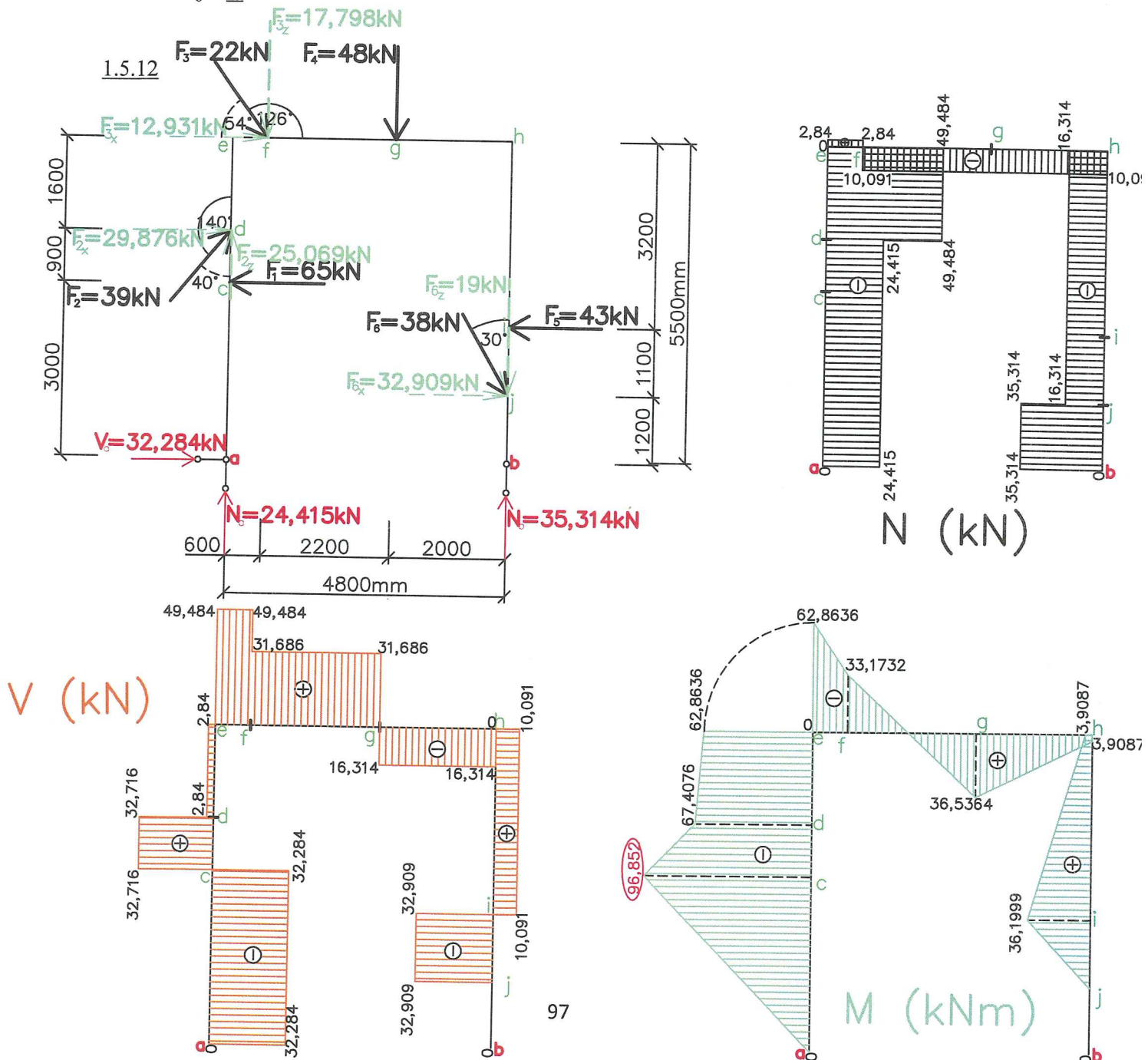
$$M_g^L = -F_4 \cdot 1,5 = -44 \cdot 1,5 = -66 \text{ kNm}$$

$$M_n^L = 0$$

$$M_i^P = -F_{6x} \cdot 0,7 = -23,599 \cdot 0,7 = -16,5193 \text{ kNm}$$

$$M_j^P = 0$$

$$M_b^P = 0$$



Reakce:

$$F_{2x} = F_2 \cdot \cos 40^\circ = 39 \cdot \cos 40^\circ = \underline{29,876 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \sin 40^\circ = 39 \cdot \sin 40^\circ = \underline{25,069 \text{ kN}}$$

$$F_{3x} = F_3 \cdot \cos 54^\circ = 22 \cdot \cos 54^\circ = \underline{12,931 \text{ kN}}$$

$$F_{3z} = F_3 \cdot \sin 54^\circ = 22 \cdot \sin 54^\circ = \underline{17,798 \text{ kN}}$$

$$F_{6x} = F_6 \cdot \cos 30^\circ = 38 \cdot \cos 30^\circ = \underline{32,909 \text{ kN}}$$

$$F_{6z} = F_6 \cdot \sin 30^\circ = 38 \cdot \sin 30^\circ = \underline{19 \text{ kN}}$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$-F_1 \cdot 3 + F_{2x} \cdot 3,9 + F_{3x} \cdot 5,5 + F_{3z} \cdot 0,6 + F_4 \cdot 2,8 - F_5 \cdot 2,3 + F_{6x} \cdot 1,2 + F_{6z} \cdot 4,8 + N_b \cdot 4,8 = 0$$
$$-65 \cdot 3 + 29,876 \cdot 3,9 + 12,931 \cdot 5,5 + 17,798 \cdot 0,6 + 48 \cdot 2,8 - 43 \cdot 2,3 + 32,909 \cdot 1,2 + 19 \cdot 4,8 + N_b \cdot 4,8 = 0$$

$$N_b = \underline{-35,314 \text{ kN}} \quad \curvearrowleft$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \quad + \\ \longleftrightarrow \end{array}$$

$$V_a - F_1 + F_{2x} + F_{3x} - F_5 + F_{6x} = 0$$

$$V_a - 65 + 29,876 + 12,931 - 43 + 32,909 = 0$$

$$V_a = \underline{32,284 \text{ kN}} \rightarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \updownarrow \\ - \end{array}$$

$$N_a + F_{2z} - F_{3z} - F_4 - F_{6z} + N_b = 0$$

$$N_a + 25,069 - 17,798 - 48 - 19 + 35,314 = 0$$

$$N_a = \underline{24,415 \text{ kN}} \uparrow$$

Průběhy:

N: LEVÉ SVISLÉ RAMENO

$$N_a^L = -N_a = -\underline{24,415 \text{ kN}}$$

$$N_c^L = N_a^L = -\underline{24,415 \text{ kN}}$$

$$N_d^L = N_c^L - F_{2z} = -24,415 - 25,069 = -\underline{49,484 \text{ kN}}$$

$$N_e^L = N_d^L = -\underline{49,484 \text{ kN}}$$

VODOROVNÉ RAMENO

$$N_e^L = -V_a + F_1 - F_{2x} = -32,284 + 65 - 29,876 = \underline{2,84 \text{ kN}}$$

$$N_f^L = N_e^L - F_{2x} = 2,84 - 12,931 = -\underline{10,091 \text{ kN}}$$

$$N_g^L = N_h^L = N_f^L = -\underline{10,091 \text{ kN}}$$

PRAVÉ SVISLÉ RAMENO

$$N_b^P = -N_b = -\underline{35,314 \text{ kN}}$$

$$N_j^P = N_b^P + F_{6z} = -35,314 + 19 = -\underline{16,314 \text{ kN}}$$

$$N_i^P = N_h^P = N_j^P = -\underline{16,314 \text{ kN}}$$

V: LEVÉ SVISLÉ RAMENO

$$V_a^L = -V_a = -\underline{32,284 \text{ kN}}$$

$$V_c^L = V_a^L + F_1 = -32,284 + 65 = \underline{32,716 \text{ kN}}$$

$$V_d^L = V_c^L - F_{2x} = 32,716 - 29,876 = \underline{2,84 \text{ kN}}$$

$$V_e^L = V_d^L = \underline{2,84 \text{ kN}}$$

VODOROVNÉ RAMENO

$$V_e^L = N_a + F_{2z} = 24,415 + 25,069 = \underline{49,484 \text{ kN}}$$

$$V_f^L = V_e^L - F_{3z} = 49,484 - 17,798 = \underline{31,686 \text{ kN}}$$

$$V_g^L = V_f^L - F_4 = 31,686 - 48 = -\underline{16,314 \text{ kN}}$$

$$V_h^L = V_g^L = -16,314 \text{ kN}$$

PRAVÉ SVISLÉ RAMENO

$$V_b^P = 0$$

$$V_j^P = -F_{6x} = -32,909 \text{ kN}$$

$$V_i^P = V_j^P + F_5 = -32,909 + 43 = 10,091 \text{ kN}$$

$$V_h^P = V_i^P = 10,091 \text{ kN}$$

M:

$$M_a^L = 0$$

$$M_c^L = -V_a \cdot 3 = -32,284 \cdot 3 = -96,852 \text{ kNm (nebezpečný průřez)}$$

$$M_d^L = -V_a \cdot 3,9 + F_1 \cdot 0,9 = -32,284 \cdot 3,9 + 65 \cdot 0,9 = -67,4076 \text{ kNm}$$

$$M_e^L = -V_a \cdot 5,5 + F_1 \cdot 2,5 - F_{2x} \cdot 1,6 = -32,284 \cdot 5,5 + 65 \cdot 2,5 - 29,876 \cdot 1,6 = -62,836 \text{ kNm}$$

$$M_f^L = N_a \cdot 0,6 - V_a \cdot 5,5 + F_1 \cdot 2,5 - F_{2x} \cdot 1,6 + F_{2z} \cdot 0,6 = 24,415 \cdot 0,6 - 32,284 \cdot 5,5 + 65 \cdot 2,5 - 29,876 \cdot 1,6 + 25,069 \cdot 0,6 = -33,1732 \text{ kNm}$$

$$M_g^P = N_b \cdot 2 - F_{6z} \cdot 2 + F_{6x} \cdot 4,3 - F_5 \cdot 3,2 = 35,314 \cdot 2 - 19 \cdot 2 + 32,909 \cdot 4,3 - 43 \cdot 3,2 = 36,5364 \text{ kNm}$$

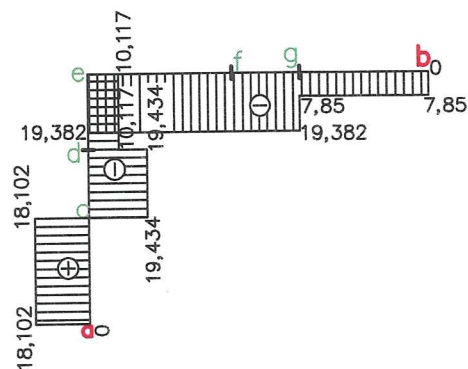
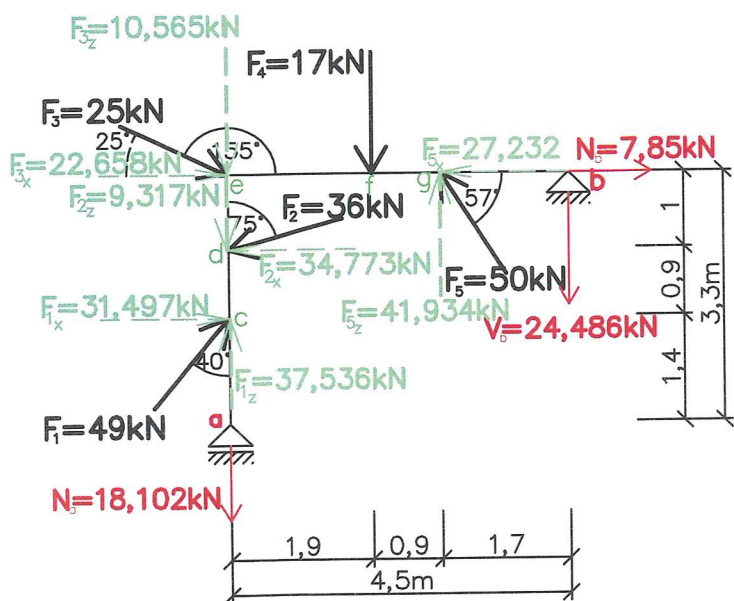
$$M_h^P = F_{6x} \cdot 4,3 - F_5 \cdot 3,2 = 32,909 \cdot 4,3 - 43 \cdot 3,2 = 3,9087 \text{ kNm}$$

$$M_i^P = F_{6x} \cdot 1,1 = 32,909 \cdot 1,1 = 36,1999 \text{ kNm}$$

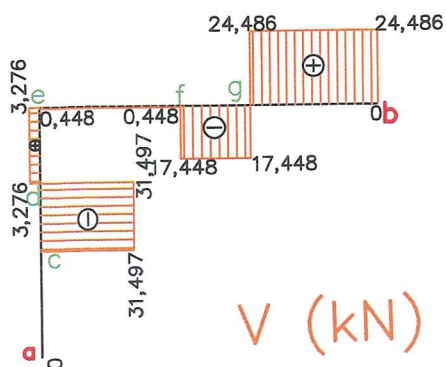
$$M_j^P = 0$$

$$M_b^P = 0$$

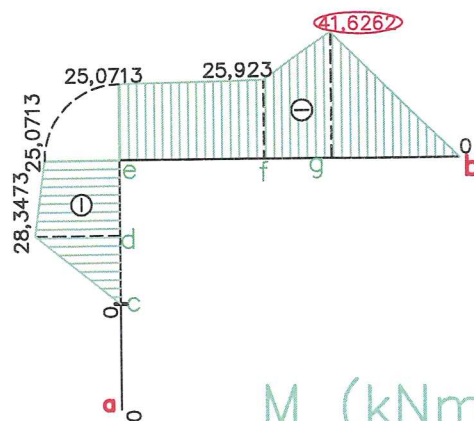
1.5.13



N (kN)



V (kN)



M (kNm)

Reakce:

$$F_{1x} = F_1 \cdot \sin 40^\circ = 49 \cdot \sin 40^\circ = \underline{31,497 \text{ kN}}$$

$$F_{1z} = F_1 \cdot \cos 40^\circ = 49 \cdot \cos 40^\circ = \underline{37,536 \text{ kN}}$$

$$F_{2x} = F_2 \cdot \sin 75^\circ = 36 \cdot \sin 75^\circ = \underline{34,773 \text{ kN}}$$

$$F_{2z} = F_2 \cdot \cos 75^\circ = 36 \cdot \cos 75^\circ = \underline{9,317 \text{ kN}}$$

$$F_{3x} = F_3 \cdot \cos 25^\circ = 25 \cdot \cos 25^\circ = \underline{22,658 \text{ kN}}$$

$$F_{3z} = F_3 \cdot \sin 25^\circ = 25 \cdot \sin 25^\circ = \underline{10,565 \text{ kN}}$$

$$F_{5x} = F_5 \cdot \cos 57^\circ = 50 \cdot \cos 57^\circ = \underline{27,232 \text{ kN}}$$

$$F_{5z} = F_5 \cdot \sin 57^\circ = 50 \cdot \sin 57^\circ = \underline{41,934 \text{ kN}}$$

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$N_a \cdot 4,5 + F_{1z} \cdot 4,5 - F_{1x} \cdot 1,9 - F_{2z} \cdot 4,5 + F_{2x} \cdot 1 - F_{3z} \cdot 4,5 - F_4 \cdot 2,6 + F_{5z} \cdot 1,7 = 0$$

$$N_b \cdot 4,5 + 37,536 \cdot 4,5 - 31,497 \cdot 1,9 - 9,317 \cdot 4,5 + 34,773 \cdot 1 - 10,565 \cdot 4,5 - 17 \cdot 2,6 + 41,934 \cdot 1,7 = 0$$

$$N_a = \underline{-18,102 \text{ kN}} \quad \curvearrowleft$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \quad + \\ \longleftrightarrow \end{array}$$

$$F_{1x} - F_{2x} + F_{3x} - F_{5x} + N_b = 0$$

$$31,497 - 34,773 + 22,658 - 27,232 + N_b = 0$$

$$N_b = \underline{7,85 \text{ kN}} \rightarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \updownarrow \\ - \end{array}$$

$$-N_a + F_{1z} - F_{2z} - F_{3z} - F_4 + F_{5z} + V_b = 0$$

$$-18,102 + 37,536 - 9,317 - 10,565 - 17 + 41,934 + V_b = 0$$

$$V_b = \underline{-24,486 \text{ kN}} \downarrow$$

Průběhy:

N: SVISLÉ RAMENO

$$N_a^L = N_a = \underline{18,102 \text{ kN}}$$

$$N_c^L = N_a^L - F_{1z} = 18,102 - 37,536 = \underline{-19,434 \text{ kN}}$$

$$N_d^L = N_c^L + F_{2z} = -19,434 + 9,317 = \underline{-10,117 \text{ kN}}$$

$$N_e^L = N_d^L = \underline{-10,117 \text{ kN}}$$

VODOROVNÉ RAMENO

$$N_e^L = -F_{1x} + F_{2x} - F_{3x} = -31,497 + 34,773 - 22,658 = \underline{-19,382 \text{ kN}}$$

$$N_f^L = N_e^L = \underline{-19,382 \text{ kN}}$$

$$N_g^L = N_f^L + F_{5x} = -19,382 + 27,232 = \underline{7,85 \text{ kN}}$$

$$N_b^L = N_g^L - N_b = 7,85 - 7,85 = \underline{0}$$

V: SVISLÉ RAMENO

$$V_a^L = \underline{0}$$

$$V_c^L = V_a^L - F_{1x} = 0 - 31,497 = \underline{-31,497 \text{ kN}}$$

$$V_d^L = V_c^L + F_{2x} = -31,497 + 34,773 = \underline{3,276 \text{ kN}}$$

$$V_e^L = V_d^L = \underline{3,276 \text{ kN}}$$

VODOROVNÉ RAMENO

$$V_b^P = V_b = \underline{24,486 \text{ kN}}$$

$$V_g^P = V_b^P - F_{5z} = 24,486 - 41,934 = \underline{-17,448 \text{ kN}}$$

$$V_f^P = V_g^P + F_4 = -17,448 + 17 = \underline{-0,448 \text{ kN}}$$

$$V_e^P = V_f^P = \underline{-0,448 \text{ kN}}$$

M:

$$M_a^L = 0$$

$$M_c^L = 0$$

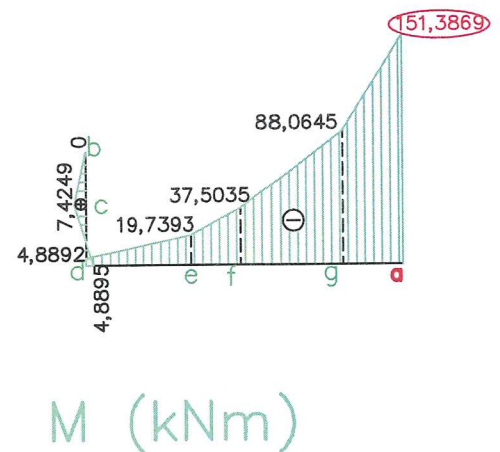
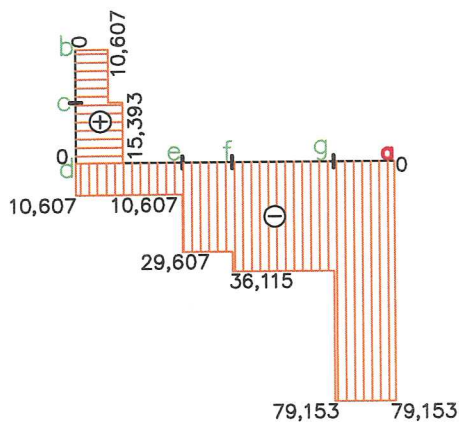
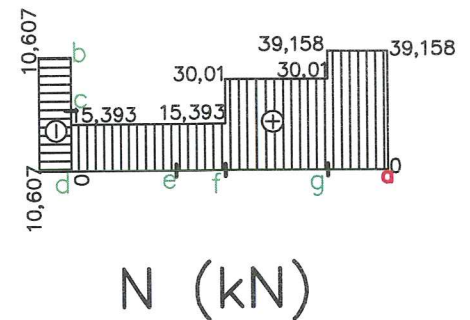
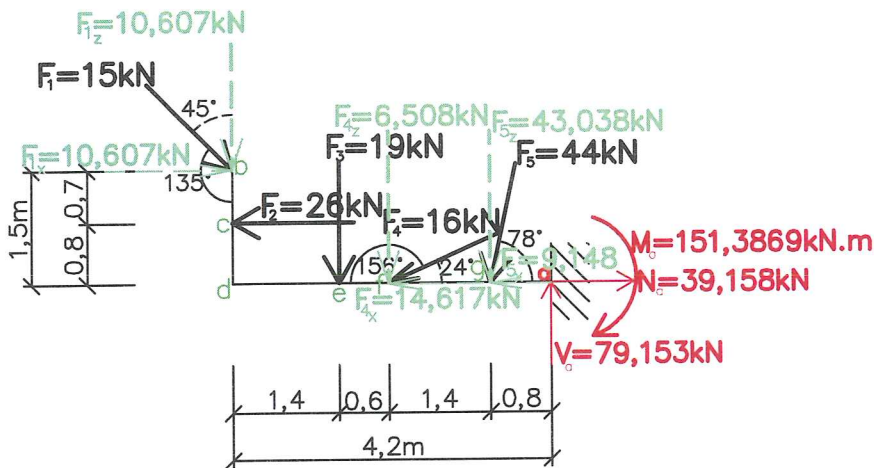
$$M_c^L = -F_{1x} \cdot 0,9 = -31,497 \cdot 0,9 = -28,3473 \text{ kNm}$$

$$M_e^L = -F_{1x} \cdot 1,9 + F_{2x} \cdot 1 = -31,497 \cdot 1,9 + 34,773 \cdot 1 = -25,0713 \text{ kNm}$$

$$M_f^P = -V_b \cdot 2,6 + F_{5z} \cdot 0,9 = -24,486 \cdot 2,6 + 41,934 \cdot 0,9 = -25,923 \text{ kNm}$$

$$M_g^P = -V_b \cdot 1,7 = -24,486 \cdot 1,7 = -41,6262 \text{ kNm (nebezpečný průřez)}$$

1.5.14



Reakce:

$$F_{1x} = F_{1z} = F_1 \cdot \cos 45^\circ = 15 \cdot \cos 45^\circ = 10,607 \text{ kN}$$

$$F_{4x} = F_4 \cdot \cos 24^\circ = 16 \cdot \cos 24^\circ = 14,617 \text{ kN}$$

$$F_{4z} = F_4 \cdot \sin 24^\circ = 16 \cdot \sin 24^\circ = 6,508 \text{ kN}$$

$$F_{5x} = F_5 \cdot \cos 78^\circ = 44 \cdot \cos 78^\circ = 9,148 \text{ kN}$$

$$F_{5z} = F_5 \cdot \sin 78^\circ = 44 \cdot \sin 78^\circ = 43,038 \text{ kN}$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \leftarrow \begin{array}{c} - \\ + \end{array}$$

$$F_{1x} - F_2 - F_{4x} - F_{5x} + N_a = 0$$

$$10,607 - 26 - 14,617 - 9,148 + N_a = 0$$

$$N_a = 39,158 \text{ kN} \rightarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} \uparrow + \\ \downarrow - \end{array}$$

$$-F_{1z} - F_3 - F_{4z} - F_{5z} + V_a = 0$$

$$-10,607 - 19 - 6,508 - 43,038 + V_a = 0$$

$$V_a = \underline{79,153 \text{ kN}} \uparrow$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{cc} + & - \\ \curvearrowright & \curvearrowleft \end{array}$$

$$F_{1x} \cdot 1,5 - F_{1z} \cdot 4,2 - F_2 \cdot 0,8 - F_3 \cdot 2,8 - F_{4z} \cdot 2,2 + F_{5z} \cdot 0,8 + M_a = 0$$

$$10,607 \cdot 1,5 - 10,607 \cdot 4,2 - 26 \cdot 0,8 - 19 \cdot 2,8 - 6,508 \cdot 2,2 - 43,038 \cdot 0,8 + M_a = 0$$

$$M_a = \underline{151,3869 \text{ kNm}} \quad \curvearrowright$$

Průběhy:

N: SVISLÉ RAMENO

$$N_b^L = -F_{1z} = -\underline{10,607 \text{ kN}}$$

$$N_c^L = N_b^L = N_d^L = -\underline{10,607 \text{ kN}}$$

VODOROVNÉ RAMENO

$$N_d^L = -F_{1x} + F_2 = -10,607 + 26 = \underline{15,393 \text{ kN}}$$

$$N_e^L = N_d^L = \underline{15,393 \text{ kN}}$$

$$N_f^L = N_e^L + F_{4x} = 15,393 + 14,617 = \underline{30,01 \text{ kN}}$$

$$N_g^L = N_f^L + F_{5x} = 30,01 + 9,148 = \underline{39,158 \text{ kN}}$$

$$N_a^L = N_g^L - N_a = 39,158 - 39,158 = \underline{0}$$

V: SVISLÉ RAMENO

$$V_b^L = F_{1x} = \underline{10,607 \text{ kN}}$$

$$V_c^L = V_b^L - F_2 = 10,607 - 26 = -\underline{15,393 \text{ kN}}$$

$$V_d^L = V_c^L = -\underline{15,393 \text{ kN}}$$

VODOROVNÉ RAMENO

$$V_d^L = -F_{1z} = -\underline{10,607 \text{ kN}}$$

$$V_e^L = V_d^L - F_3 = -10,607 - 19 = -\underline{29,607 \text{ kN}}$$

$$V_f^L = V_e^L - F_{4z} = -29,607 - 6,508 = -\underline{36,115 \text{ kN}}$$

$$V_g^L = V_f^L - F_{5z} = -36,115 - 43,038 = -\underline{79,153 \text{ kN}}$$

$$V_a^L = V_g^L + V_a = -79,153 + 79,153 = \underline{0}$$

M: $M_b^L = \underline{0}$

$$M_c^L = F_{1x} \cdot 0,7 = 10,607 \cdot 0,7 = \underline{7,4249 \text{ kNm}}$$

$$M_d^L = F_{1x} \cdot 1,5 - F_2 \cdot 0,8 = 10,607 \cdot 1,5 - 26 \cdot 0,8 = -\underline{4,8895 \text{ kNm}}$$

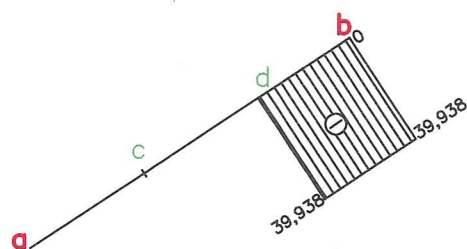
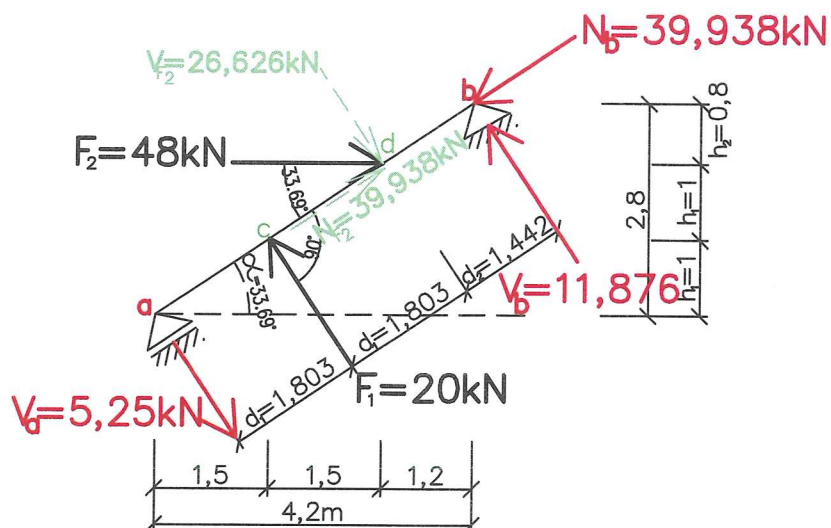
$$M_e^L = F_{1x} \cdot 1,5 - F_{1z} \cdot 1,4 - F_2 \cdot 0,8 = 10,607 \cdot 1,5 - 10,607 \cdot 1,4 - 26 \cdot 0,8 = -\underline{19,7393 \text{ kNm}}$$

$$M_f^P = -M_a + V_a \cdot 2,2 - F_{5z} \cdot 1,4 = -151,3869 + 79,153 \cdot 2,2 - 43,038 \cdot 1,4 = -\underline{37,5035 \text{ kNm}}$$

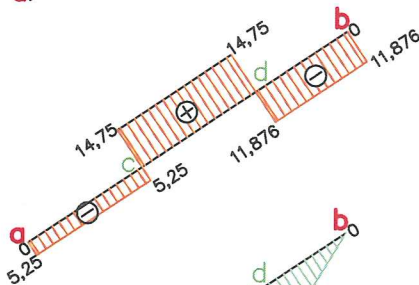
$$M_g^P = -M_a + V_a \cdot 0,8 = -151,3869 + 79,153 \cdot 0,8 = -\underline{88,0645 \text{ kNm}}$$

$$M_a^P = -M_a = -\underline{151,3869 \text{ kN}} \text{ (nebezpečný průřez)}$$

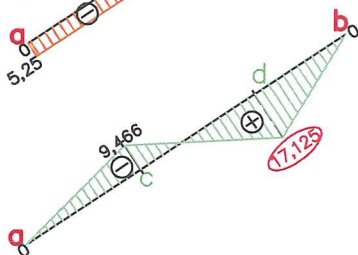
1.5.15



N (kN)



V (kN)



M (kNm)

Výpočet potřebných údajů

$$\tan \alpha = 2,8 / 4,2 = 0,6$$

$$\alpha = 33,69^\circ = 33^\circ 41' 24''$$

$$\cos \alpha = 1,5 / l_1$$

$$l_1 = 1,5 / \cos 33^\circ 41' 24'' = 1,803 \text{ m}$$

$$\cos \alpha = 1,2 / l_2$$

$$l_2 = 1,2 / \cos 33^\circ 41' 24'' = 1,442 \text{ m}$$

$$\tan \alpha = h_1 / 1,5$$

$$h_1 = 1,5 \cdot \tan 33^\circ 41' 24'' = 1 \text{ m}$$

$$\tan \alpha = h_2 / 1,2$$

$$h_2 = 1,2 \cdot \tan 33^\circ 41' 24'' = 0,8 \text{ m}$$

$$N_{F2} = F_2 \cdot \cos 33^\circ 41' 24'' = 48 \cdot \cos 33^\circ 41' 24'' = 39,938 \text{ kN}$$

$$V_{F2} = F_2 \cdot \sin 33^\circ 41' 24'' = 48 \cdot \sin 33^\circ 41' 24'' = 26,626 \text{ kN}$$

Reakce

$$\sum_{i=1}^n M_{Di} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$V_a \cdot 5,048 + F_1 \cdot 3,245 - F_2 \cdot 0,8 = 0$$

$$V_a \cdot 5,048 + 20 \cdot 3,245 - 48 \cdot 0,8 = 0$$

$$V_a = \underline{-5,25 \text{ kN}} \quad \curvearrowleft$$

$$\sum_{i=1}^n V_i = 0 \quad \begin{array}{c} \uparrow + \\ \downarrow - \end{array}$$

$$-V_a + F_1 - V_{F2} + V_b = 0$$

$$-5,25 + 20 - 26,626 + V_b = 0$$

$$V_b = \underline{11,876 \text{ kN}} \quad \uparrow$$

$$\sum_{i=1}^n N_i = 0 \quad \begin{array}{c} - \\ \leftarrow + \end{array} \quad \begin{array}{c} + \\ \rightarrow \end{array}$$

$$N_{F2} + N_b = 0$$

$$39,938 + N_b = 0$$

$$N_b = \underline{-39,938 \text{ kN}} \quad \leftarrow$$

Průběhy

N:

$$N_a^L = 0$$

$$N_c^L = 0$$

$$N_d^L = -N_{F2} = \underline{-39,938 \text{ kN}}$$

$$N_b^L = N_d^L + N_b = -39,938 + 39,938 = 0 \quad \text{Vracíme se k základní čáře.}$$

V:

$$V_a^L = -V_a = \underline{5,25 \text{ kN}}$$

$$V_c^L = V_a^L + F_1 = 5,25 + 20 = \underline{25,25 \text{ kN}}$$

$$V_d^L = V_c^L - V_{F2} = 25,25 - 26,626 = \underline{-1,376 \text{ kN}}$$

$$V_b^L = V_d^L + V_b = -1,376 + 11,876 = \underline{10,5 \text{ kN}} \quad \text{Vracíme se k základní čáře.}$$

M:

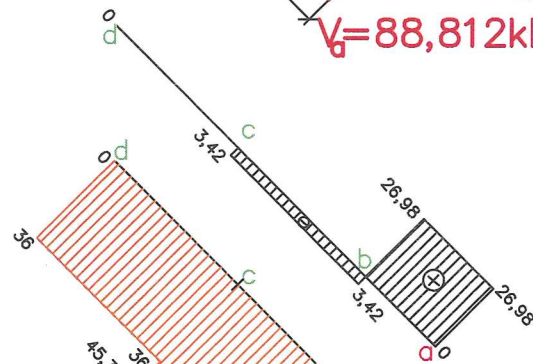
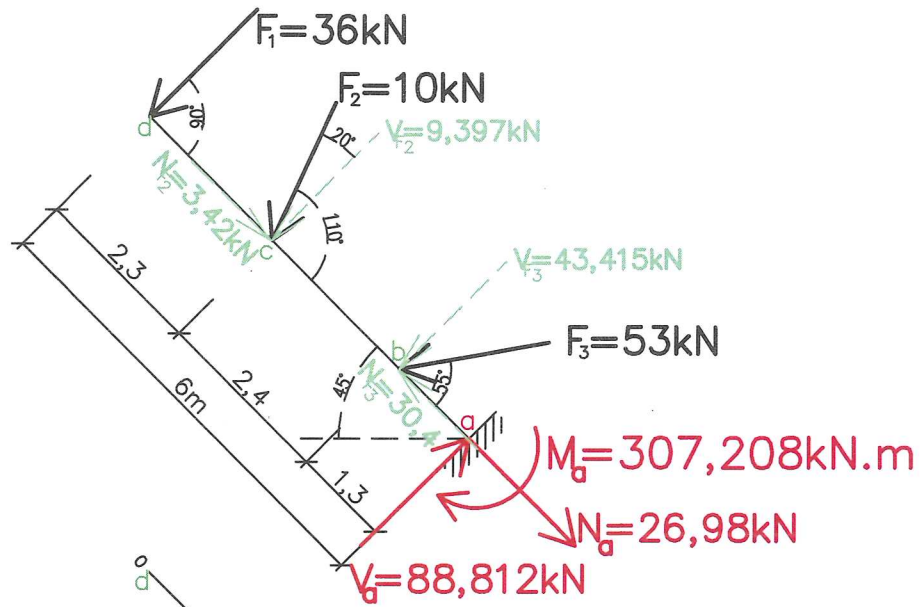
$$M_a^L = 0$$

$$M_c^L = -V_a \cdot 1,803 = -5,25 \cdot 1,803 = \underline{-9,466 \text{ kNm}}$$

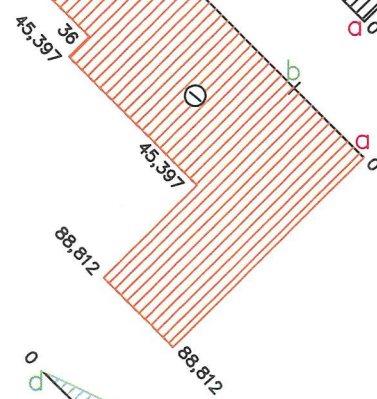
$$M_d^P = V_b \cdot 1,442 = 11,876 \cdot 1,442 = \underline{17,125 \text{ kNm}} \quad (\text{nebezpečný průřez})$$

$$M_b^P = 0$$

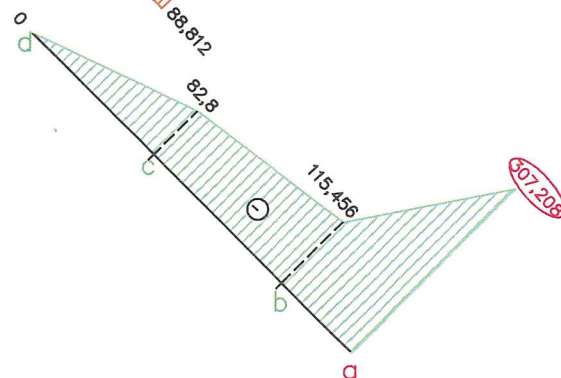
1.5.16



$N \text{ (kN)}$



$V \text{ (kN)}$



$M \text{ (kNm)}$

$$\begin{aligned}
 &F_2 \begin{cases} N_{F2} = F_2 \cdot \sin 20^\circ = 10 \cdot \sin 20^\circ = \underline{3,42 \text{ kN}} \\ V_{F2} = F_2 \cdot \cos 20^\circ = 10 \cdot \cos 20^\circ = \underline{9,397 \text{ kN}} \end{cases} \\
 &F_3 \begin{cases} N_{F3} = F_3 \cdot \cos 55^\circ = 53 \cdot \cos 55^\circ = \underline{30,4 \text{ kN}} \\ V_{F3} = F_3 \cdot \sin 55^\circ = 53 \cdot \sin 55^\circ = \underline{43,415 \text{ kN}} \end{cases}
 \end{aligned}$$

Reakce:

$$\sum_{i=1}^n N_i = 0 \quad \begin{array}{c} - \\ \longleftrightarrow \\ + \end{array}$$

$$N_{F2} - N_{F3} + N_a = 0$$

$$3,42 - 30,4 + N_a = 0$$

$$N_a = \underline{26,98 \text{ kN}} \rightarrow$$

$$\sum_{i=1}^n V_i = 0 \quad \begin{array}{c} + \\ \updownarrow \\ - \end{array}$$

$$-F_1 - V_{F2} - V_{F3} + V_a = 0$$

$$-36 - 9,397 - 43,415 + V_a = 0$$

$$V_a = \underline{88,812 \text{ kN}} \uparrow$$

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} + \\ \curvearrowright \\ - \\ \curvearrowleft \end{array}$$

$$-F_1 \cdot 6 - V_{F2} \cdot 3,7 - V_{F3} \cdot 1,3 + M_a = 0$$

$$-36 \cdot 6 - 9,397 \cdot 3,7 - 43,415 \cdot 1,3 + M_a = 0$$

$$M_a = \underline{307,208 \text{ kNm}} \quad \curvearrowright$$

Průběhy:

N: $N_d^L = \underline{0}$

$$N_c^L = -N_{F2} = \underline{-3,42 \text{ kN}}$$

$$N_b^L = N_c^L + N_{F3} = -3,42 + 30,4 = \underline{26,98 \text{ kN}}$$

$$N_a^L = N_b^L - N_a = 26,98 - 26,98 = \underline{0} \quad \text{Vracíme se k základní čáře.}$$

V: $V_d^L = -F_1 = \underline{-36 \text{ kN}}$

$$V_c^L = V_d^L - V_{F2} = -36 - 9,397 = \underline{-45,397 \text{ kN}}$$

$$V_b^L = V_c^L - V_{F3} = -45,397 - 43,415 = \underline{-88,812 \text{ kN}}$$

$$V_a^L = V_b^L + V_a = -88,812 + 88,812 = \underline{0} \quad \text{Vracíme se k základní čáře.}$$

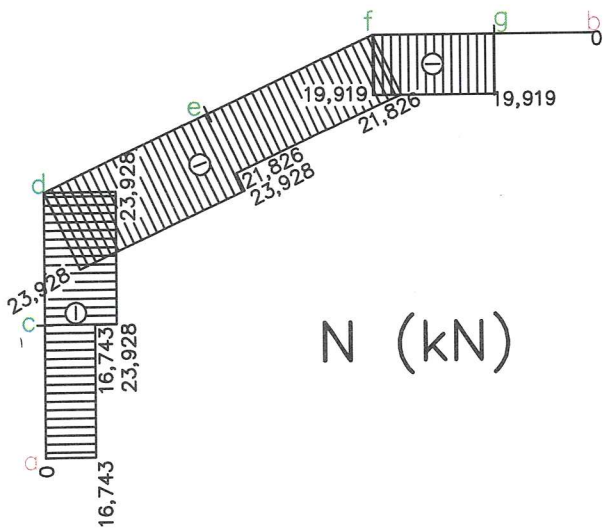
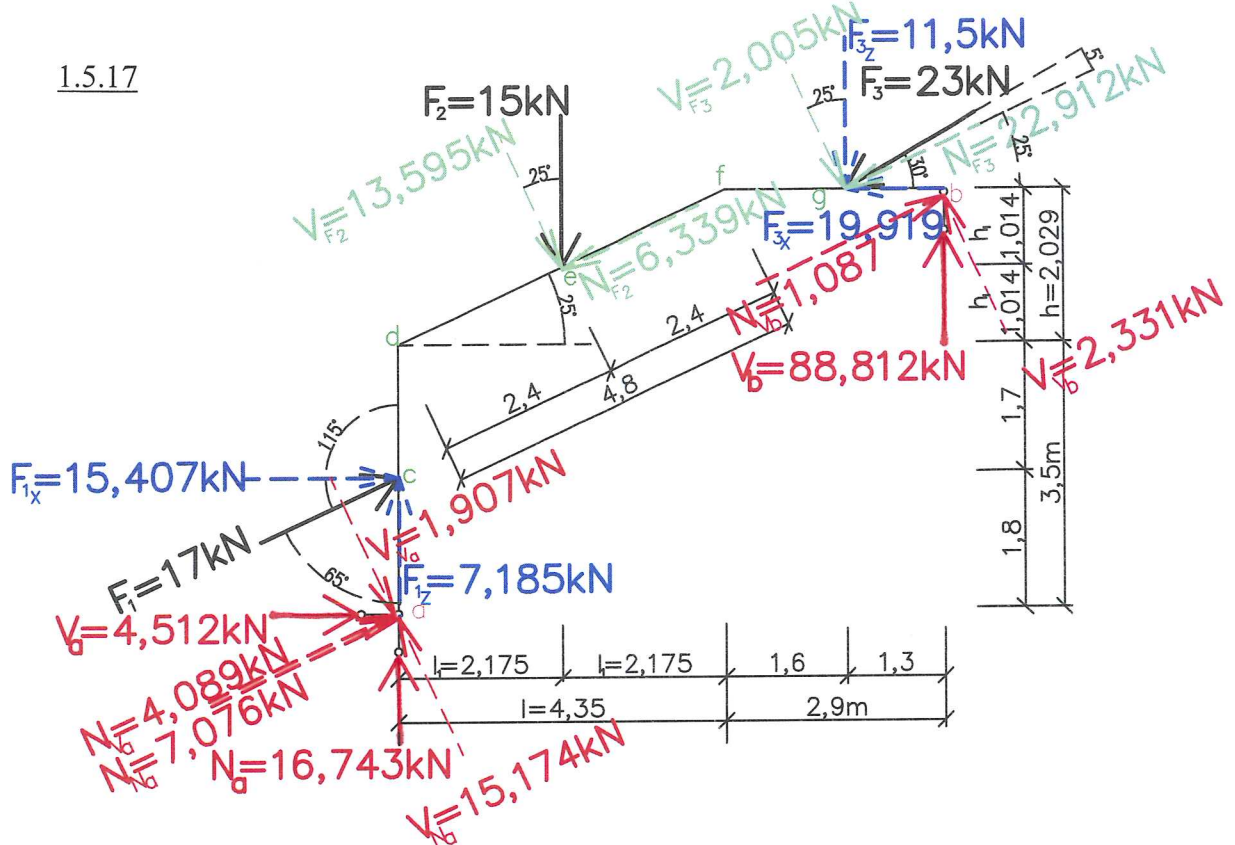
M: $M_d^L = \underline{0}$

$$M_c^L = -F_1 \cdot 2,3 = -36 \cdot 2,3 = \underline{-82,8 \text{ kNm}}$$

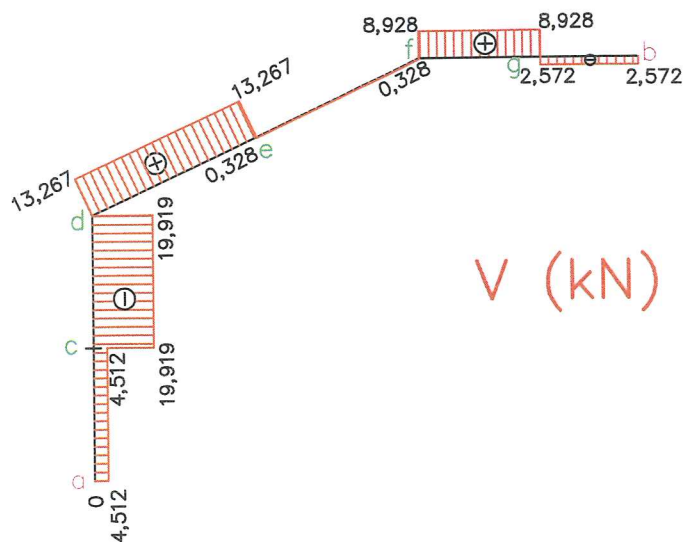
$$M_b^P = -V_a \cdot 1,3 = -88,812 \cdot 1,3 = \underline{-115,456 \text{ kNm}}$$

$$M_b^P = -M_a = -307,208 \text{ kNm (nebezpečný průřez)}$$

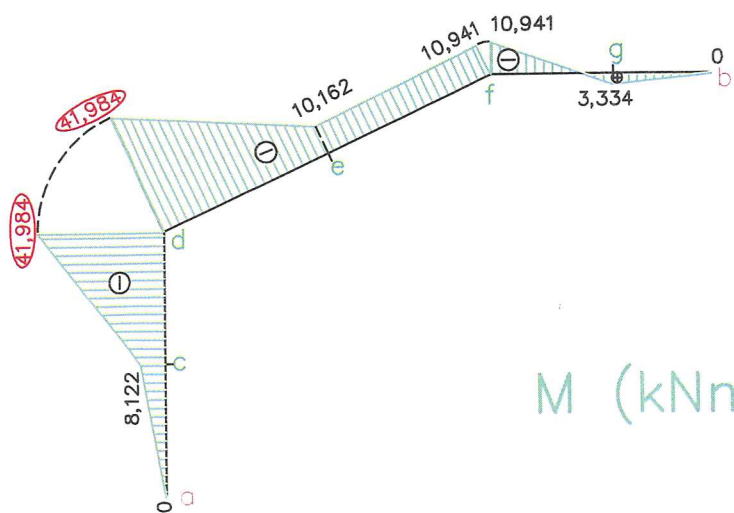
1.5.17



N (kN)



V (kN)



M (kNm)

$$\cos 25^\circ = 1 / 4,8$$

$$l = 4,8 \cdot \cos 25^\circ = \underline{4,35 \text{ m}}$$

$$l_1 = l / 2 = 4,35 / 2 = \underline{2,175 \text{ m}}$$

$$\sin 25^\circ = h / 4,8$$

$$h = 4,8 \cdot \sin 25^\circ = \underline{2,029 \text{ m}}$$

$$h_1 = h / 2 = 2,09 / 2 = \underline{1,0145 \text{ m}}$$

$$F_{1x} = F_1 \cdot \sin 65^\circ = 17 \cdot \sin 65^\circ = \underline{15,407 \text{ kN}}$$

$$F_{1z} = F_1 \cdot \cos 65^\circ = 17 \cdot \cos 65^\circ = \underline{7,185 \text{ kN}}$$

$$F_{3x} = F_3 \cdot \cos 30^\circ = 23 \cdot \cos 30^\circ = \underline{19,919 \text{ kN}}$$

$$F_{3z} = F_3 \cdot \sin 30^\circ = 23 \cdot \sin 30^\circ = \underline{11,5 \text{ kN}}$$

$$N_{F2} = F_2 \cdot \sin 25^\circ = 15 \cdot \sin 25^\circ = \underline{6,339 \text{ kN}}$$

$$V_{F2} = F_2 \cdot \cos 25^\circ = 15 \cdot \cos 25^\circ = \underline{13,595 \text{ kN}}$$

$$N_{F3} = F_3 \cdot \cos 5^\circ = 23 \cdot \cos 5^\circ = \underline{22,912 \text{ kN}}$$

$$V_{F3} = F_3 \cdot \sin 5^\circ = 23 \cdot \sin 5^\circ = \underline{2,005 \text{ kN}}$$

Reakce:

$$\sum_{i=1}^n M_{ai} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$F_{1x} \cdot 1,8 + F_2 \cdot 2,175 + F_{3z} \cdot 5,95 - F_{3x} \cdot 5,529 + V_b \cdot 7,25 = 0$$

$$15,407 \cdot 1,8 + 15 \cdot 2,175 + 11,5 \cdot 5,95 - 19,919 \cdot 5,529 + V_b \cdot 7,25 = 0$$

$$V_b = \underline{-2,572 \text{ kN}} \quad \curvearrowleft$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \\ \leftarrow \end{array} \quad \begin{array}{c} + \\ \rightarrow \end{array}$$

$$V_a + F_{1x} - F_{3x} = 0$$

$$V_a + 15,407 - 19,919 = 0$$

$$V_a = \underline{4,512 \text{ kN}} \rightarrow$$

$$\sum_{i=1}^n F_{zi} = 0 \quad \begin{array}{c} + \\ \uparrow \end{array} \quad \begin{array}{c} - \\ \downarrow \end{array}$$

$$N_a + F_{1z} - F_2 - F_{3z} + V_b = 0$$

$$N_a + 7,185 - 15 - 11,5 + 2,572 = 0$$

$$N_a = \underline{16,743 \text{ kN}} \uparrow$$

$$\begin{aligned}
 N_a & \begin{cases} N_{Na} = N_a \cdot \sin 25^\circ = 16,743 \cdot \sin 25^\circ = \underline{7,076 \text{ kN}} \\ V_{Na} = N_a \cdot \cos 25^\circ = 16,743 \cdot \cos 25^\circ = \underline{15,174 \text{ kN}} \end{cases} \\
 V_a & \begin{cases} N_{Va} = V_a \cdot \cos 25^\circ = 4,512 \cdot \cos 25^\circ = \underline{4,089 \text{ kN}} \\ V_{Va} = V_a \cdot \sin 25^\circ = 4,512 \cdot \sin 25^\circ = \underline{1,907 \text{ kN}} \end{cases} \\
 V_b & \begin{cases} N_{Vb} = V_b \cdot \sin 25^\circ = 2,572 \cdot \sin 25^\circ = \underline{1,087 \text{ kN}} \\ V_{Vb} = V_b \cdot \cos 25^\circ = 2,572 \cdot \cos 25^\circ = \underline{2,331 \text{ kN}} \end{cases}
 \end{aligned}$$

Průběhy:

N: SVISLÉ RAMENO:

$$\begin{aligned}
 N_a^L &= -N_a = -16,743 \text{ kN} \\
 N_c^L &= N_a^L - F_{1z} = -16,743 - 7,185 = \underline{-23,928 \text{ kN}} \\
 N_d^L &= N_c^L = \underline{-23,928 \text{ kN}}
 \end{aligned}$$

ŠIKMÉ RAMENO:

$$\begin{aligned}
 N_d^L &= -N_{Na} - N_{Va} - F_1 = -7,076 - 4,089 - 17 = \underline{-28,165 \text{ kN}} \\
 N_e^L &= N_d^L + N_{F2} = -28,165 + 6,339 = \underline{-21,826 \text{ kN}} \\
 N_f^L &= N_e^L = \underline{-21,826 \text{ kN}}
 \end{aligned}$$

VODOROVNÉ RAMENO:

$$\begin{aligned}
 N_b^P &= 0 \\
 N_g^P &= -F_{3x} = \underline{-19,919 \text{ kN}} \\
 N_f^P &= N_g^P = \underline{-19,919 \text{ kN}}
 \end{aligned}$$

V: SVISLÉ RAMENO:

$$\begin{aligned}
 V_a^L &= -V_a = -4,512 \text{ kN} \\
 V_c^L &= V_a^L - F_{1x} = -4,512 - 15,407 = \underline{-19,919 \text{ kN}} \\
 V_d^L &= V_c^L = \underline{-19,919 \text{ kN}}
 \end{aligned}$$

ŠIKMÉ RAMENO:

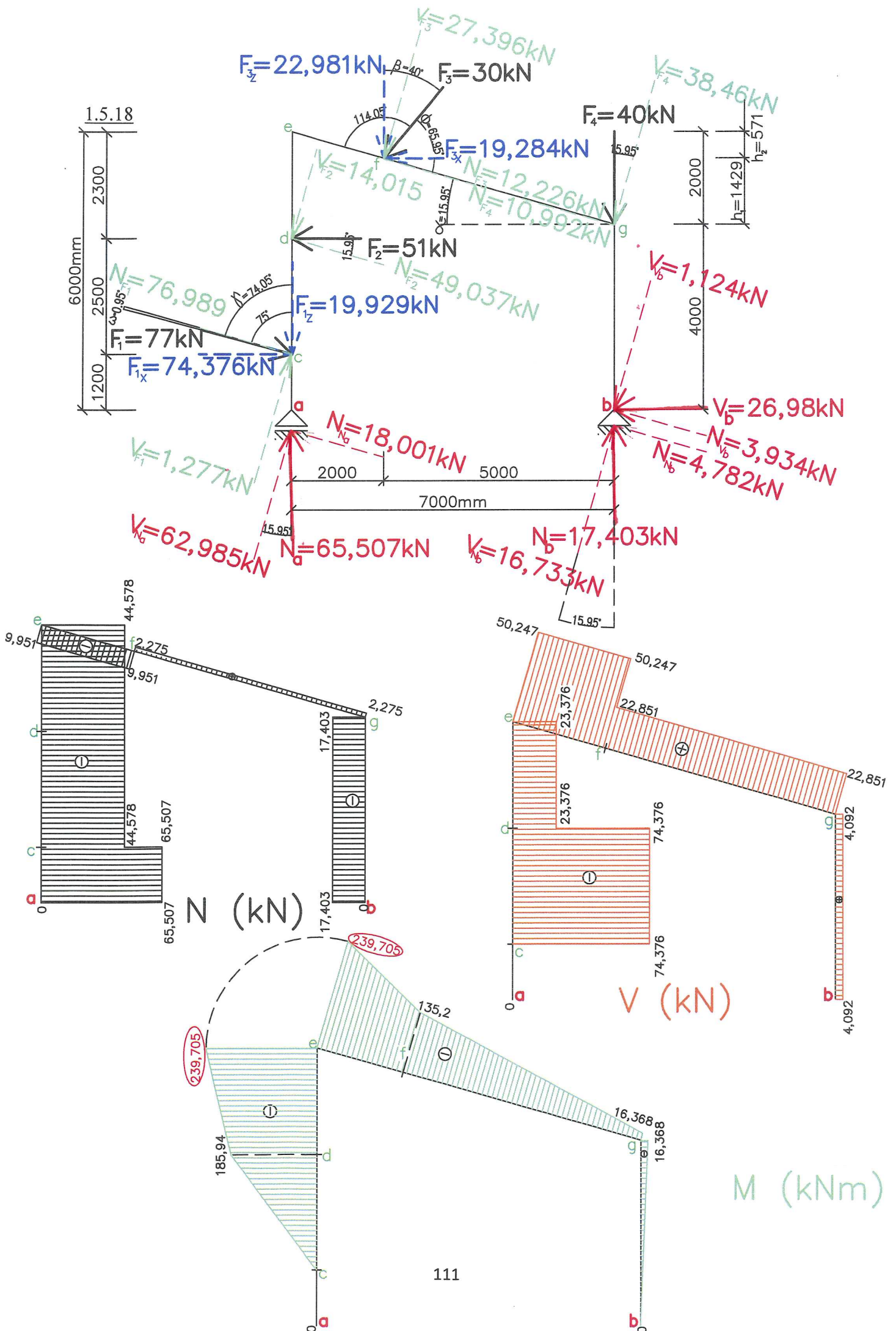
$$\begin{aligned}
 V_d^L &= V_{Na} - V_{Va} = 15,174 - 1,907 = \underline{13,267 \text{ kN}} \\
 V_e^L &= V_d^L - V_{F2} = 13,267 - 13,595 = \underline{-0,328 \text{ kN}} \\
 V_f^L &= V_e^L = \underline{-0,328 \text{ kN}}
 \end{aligned}$$

VODOROVNÉ RAMENO:

$$\begin{aligned}
 V_b^P &= -V_b = -2,572 \text{ kN} \\
 V_g^P &= V_b^P + F_{3z} = -2,572 + 11,5 = \underline{8,928 \text{ kN}} \\
 V_f^P &= V_g^P = \underline{8,928 \text{ kN}}
 \end{aligned}$$

M:

$$\begin{aligned}
 M_a^L &= 0 \\
 M_e^L &= -V_a \cdot 1,8 = -4,512 \cdot 1,8 = \underline{-8,122 \text{ kNm}} \\
 M_d^L &= -V_a \cdot 3,5 - F_{1x} \cdot 1,7 = -4,512 \cdot 3,5 - 15,407 \cdot 1,7 = \underline{-41,984 \text{ kNm}} \text{ (nebezpečný průřez)} \\
 M_e^P &= V_b \cdot 5,075 - F_{3z} \cdot 3,775 + F_{3x} \cdot 1,014 = 2,572 \cdot 5,075 - 11,5 \cdot 3,775 + 19,919 \cdot 1,014 = \\
 &= \underline{-10,162 \text{ kNm}} \\
 M_f^P &= V_b \cdot 2,9 - F_{3z} \cdot 1,6 = 2,579 \cdot 2,9 - 11,5 \cdot 1,6 = \underline{-10,941 \text{ kNm}} \\
 M_g^P &= V_b \cdot 1,3 = 2,572 \cdot 1,3 = \underline{3,344 \text{ kNm}} \\
 M_b^P &= 0
 \end{aligned}$$



$$\operatorname{tg} \alpha = 2 / 7$$

$$\alpha = \underline{15,95^\circ}$$

$$\beta = 15,95^\circ + 114,05^\circ - 90^\circ = \underline{40^\circ}$$

$$\gamma = 90^\circ - 15,95^\circ = \underline{74,05^\circ}$$

$$\omega = 75^\circ - 74,05^\circ = \underline{0,95^\circ}$$

$$\phi = 180^\circ - 114,05^\circ = \underline{65,95^\circ}$$

$$\operatorname{tg} 15,95^\circ = h_1 / 5$$

$$h_1 = 5 \cdot \operatorname{tg} 15,95^\circ = \underline{1,429 \text{ m}}$$

$$F_{1x} = F_1 \cdot \sin 75^\circ = 77 \cdot \sin 75^\circ = \underline{74,376 \text{ kN}}$$

$$F_{1z} = F_1 \cdot \cos 75^\circ = 77 \cdot \cos 75^\circ = \underline{19,929 \text{ kN}}$$

$$F_{3x} = F_3 \cdot \sin 40^\circ = 30 \cdot \sin 40^\circ = \underline{19,284 \text{ kN}}$$

$$F_{3z} = F_3 \cdot \cos 40^\circ = 30 \cdot \cos 40^\circ = \underline{22,981 \text{ kN}}$$

$$N_{F1} = F_1 \cdot \cos 0,95^\circ = 77 \cdot \cos 0,95^\circ = \underline{76,989 \text{ kN}}$$

$$V_{F1} = F_1 \cdot \sin 0,95^\circ = 77 \cdot \sin 0,95^\circ = \underline{1,277 \text{ kN}}$$

$$N_{F2} = F_2 \cdot \cos 15,95^\circ = 51 \cdot \cos 15,95^\circ = \underline{49,037 \text{ kN}}$$

$$V_{F2} = F_2 \cdot \sin 15,95^\circ = 51 \cdot \sin 15,95^\circ = \underline{14,015 \text{ kN}}$$

$$N_{F3} = F_3 \cdot \cos 65,95^\circ = 30 \cdot \cos 65,95^\circ = \underline{12,226 \text{ kN}}$$

$$V_{F3} = F_3 \cdot \sin 65,95^\circ = 30 \cdot \sin 65,95^\circ = \underline{27,396 \text{ kN}}$$

$$N_{F4} = F_4 \cdot \sin 15,95^\circ = 40 \cdot \sin 15,95^\circ = \underline{10,992 \text{ kN}}$$

$$V_{F4} = F_4 \cdot \cos 15,95^\circ = 40 \cdot \cos 15,95^\circ = \underline{38,46 \text{ kN}}$$

Reakce:

$$\sum_{i=1}^n M_{bi} = 0 \quad \begin{array}{c} + \\ \curvearrowright \end{array} \quad \begin{array}{c} - \\ \curvearrowleft \end{array}$$

$$N_a \cdot 7 + F_{1x} \cdot 1,2 - F_{1z} \cdot 7 - F_2 \cdot 3,7 - F_{3x} \cdot 5,429 - F_{3z} \cdot 5 = 0$$

$$N_a \cdot 7 + 74,376 \cdot 1,2 - 19,929 \cdot 7 - 51 \cdot 3,7 - 19,284 \cdot 5,429 - 22,981 \cdot 5 = 0$$

$$N_a = \underline{65,507 \text{ kN}} \quad \curvearrowright$$

$$\sum_{i=1}^n F_{xi} = 0 \quad \begin{array}{c} - \quad + \\ \longleftrightarrow \end{array}$$

$$F_{1x} - F_2 - F_{3x} + V_b = 0$$

$$74,376 - 51 - 19,284 + V_b = 0$$

$$V_b = \underline{-4,092 \text{ kN} \leftarrow}$$

$$\sum_{i=1}^n F_{zi} = 0$$

$\begin{array}{c} \uparrow + \\ \downarrow - \end{array}$

$$N_a - F_{1z} - F_{3z} - F_4 + N_b = 0$$

$$65,507 - 19,929 - 22,981 - 40 + N_b = 0$$

$$N_b = \underline{17,403 \text{ kN} \uparrow}$$

$$N_a \begin{cases} N_{Na} = N_a \cdot \sin 15,95^\circ = 65,507 \cdot \sin 15,95^\circ = \underline{18,001 \text{ kN}} \\ V_{Na} = N_a \cdot \cos 15,95^\circ = 65,507 \cdot \cos 15,95^\circ = \underline{62,985 \text{ kN}} \end{cases}$$

$$N_b \begin{cases} N_{Nb} = N_b \cdot \sin 15,95^\circ = 17,403 \cdot \sin 15,95^\circ = \underline{4,782 \text{ kN}} \\ V_{Nb} = N_b \cdot \cos 15,95^\circ = 17,403 \cdot \cos 15,95^\circ = \underline{16,733 \text{ kN}} \end{cases}$$

$$V_b \begin{cases} N_{Vb} = V_b \cdot \cos 15,95^\circ = 4,092 \cdot \cos 15,95^\circ = \underline{3,934 \text{ kN}} \\ V_{Vb} = V_b \cdot \sin 15,95^\circ = 4,092 \cdot \sin 15,95^\circ = \underline{1,124 \text{ kN}} \end{cases}$$

Průběhy:

N: LEVÉ SVISLÉ RAMENO:

$$N_a^L = -N_a = \underline{-65,507 \text{ kN}}$$

$$N_c^L = N_a^L + F_{1z} = -65,507 + 19,929 = \underline{-44,578 \text{ kN}}$$

$$N_d^L = N_e^L = N_c^L = \underline{-44,578 \text{ kN}}$$

ŠIKMÉ RAMENO:

$$N_e^L = N_{Na} - N_{F1} + N_{F2} = 18,001 - 76,989 + 49,037 = \underline{-9,951 \text{ kN}}$$

$$N_f^L = N_e^L + N_{F3} = -9,951 + 12,226 = \underline{2,275 \text{ kN}}$$

$$N_g^L = N_f^L = \underline{2,275 \text{ kN}}$$

PRAVÉ SVISLÉ RAMENO:

$$N_b^P = -N_b = \underline{-17,403 \text{ kN}}$$

$$N_g^P = N_b^P = \underline{-17,403 \text{ kN}}$$

V: LEVÉ SVISLÉ RAMENO:

$$V_a^L = 0$$

$$V_c^L = -F_x = \underline{-74,376 \text{ kN}}$$

$$V_d^L = V_c^L + F_2 = -74,376 + 51 = \underline{-23,376 \text{ kN}}$$

$$V_e^L = V_d^L = \underline{-23,376 \text{ kN}}$$

ŠIKMÉ RAMENO:

$$V_e^L = V_{Na} + V_{F1} - V_{F2} = 62,985 + 1,277 - 14,015 = \underline{50,247 \text{ kN}}$$

$$V_f^L = V_e^L - V_{F3} = 50,247 - 27,396 = \underline{22,851 \text{ kN}}$$

$$V_g^L = V_f^L = \underline{22,851 \text{ kN}}$$

PRAVÉ SVISLÉ RAMENO:

$$V_b^P = V_b = \underline{4,092 \text{ kN}}$$

$$V_g^P = V_b^P = \underline{4,092 \text{ kN}}$$

M:

$$M_a^L = \underline{0}$$

$$M_c^L = \underline{0}$$

$$M_d^L = -F_{1x} \cdot 2,5 = -74,376 \cdot 2,5 = \underline{-185,94 \text{ kNm}}$$

$$M_e^L = -F_{1x} \cdot 4,8 + F_2 \cdot 2,3 = -74,376 \cdot 4,8 + 51 \cdot 2,3 = \underline{-239,705 \text{ kNm}}$$

$$M_f^P = N_b \cdot 5 - V_b \cdot 5,429 - F_4 \cdot 5 = 17,403 \cdot 5 - 4,092 \cdot 5,429 - 40 \cdot 5 = \underline{-135,2 \text{ kNm}}$$

$$M_g^P = -V_b \cdot 4 = -4,092 \cdot 4 = \underline{-16,368 \text{ kNm}}$$

$$M_b^P = \underline{0}$$