

$$l_1 = 1 \mu$$

$$l_2 = 1,4 \mu$$

$$l_3 = 1,1 \mu$$

$$a_4 = 0,8 \mu$$

$$a_2 = 2a_3 = 1,3 \mu$$

$$F_1 = 40 \text{ kN}$$

$$F_2 = 20 \text{ kN}$$

$$F_3 = 30 \text{ kN}$$

$$\sigma_T = 850 \text{ MPa}$$

$$q = 40 \text{ kN}/\mu \quad n_T = 1,3 ; \text{ max } 45^\circ$$

$$0 < \underline{I} < (L_1 + L_2 + L_3 - a_1 - a_2 - a_3)$$

$$N_z' = -q z_1 \Big|_0^{(L_1 + L_2 + L_3 - a_1 - a_2 - a_3)} =$$

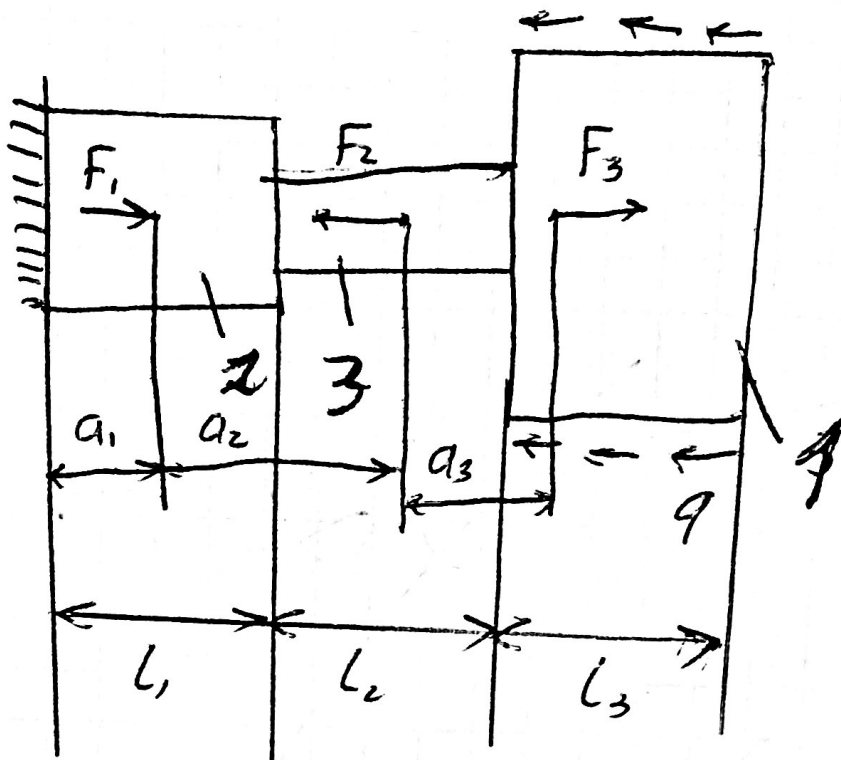
$$N_z'(L_1 + L_2 + L_3 - a_1 - a_2 - a_3) = -q(L_1 + L_2 + L_3 - a_1 - a_2 - a_3) =$$

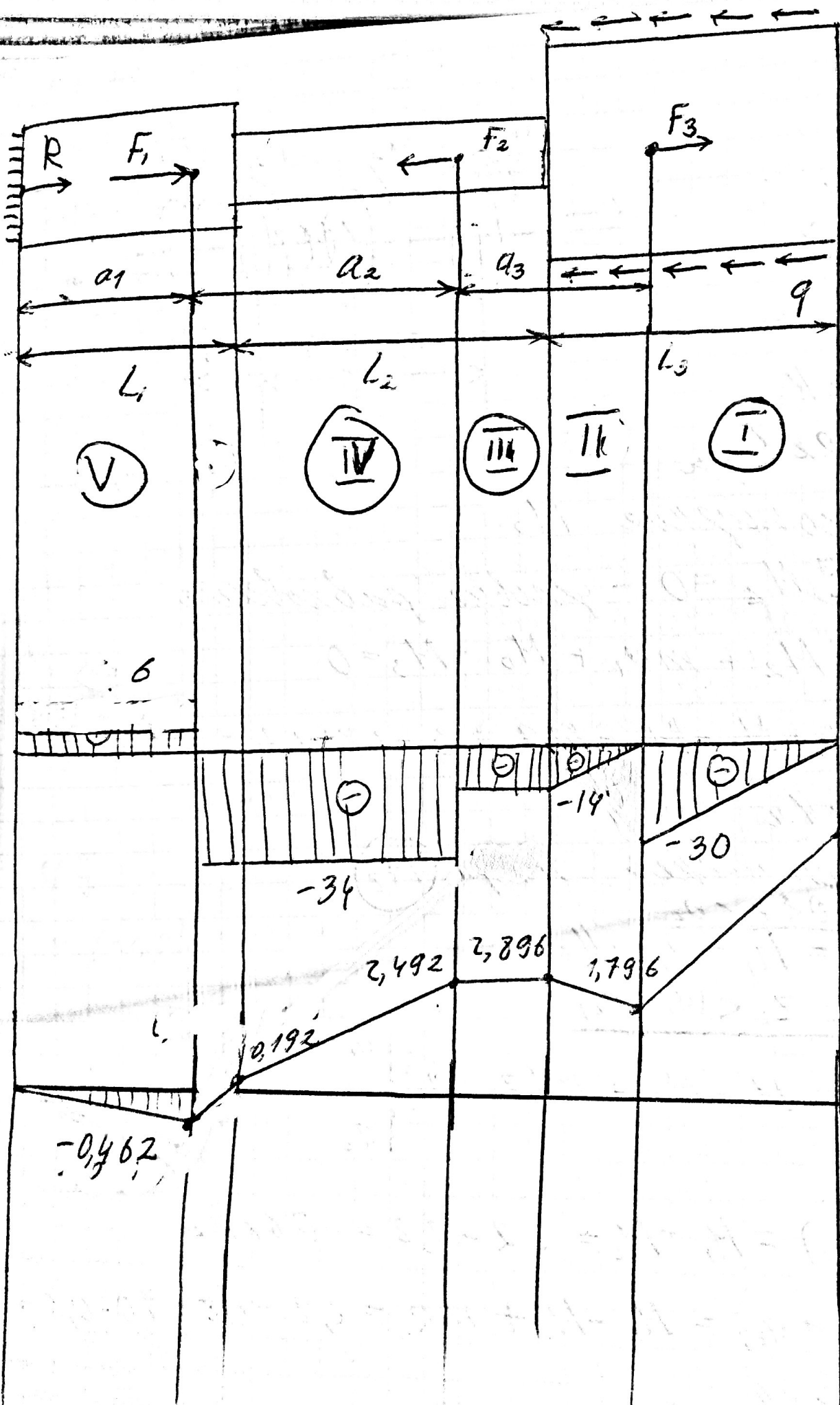
$$= -40(1 + 1,4 + 1,1 - 0,8 - 1,3 - \frac{1,3}{2}) = -30 \text{ kN}$$

$$(L_1 + L_2 + L_3 - a_1 - a_2 - a_3) < \underline{II} < (L_3)$$

$$N_z'' = -q z_2 + F_3 \Big|_{L_1 + L_2 + L_3 - a_1 - a_2 - a_3}^{L_3}$$

$$N_z''(L_1 + L_2 + L_3 - a_1 - a_2 - a_3) = -q(L_1 + L_2 + L_3 - a_1 - a_2 - a_3) +$$





$N_z, \text{кН}$

5,296

$Q, \text{кН}$

-0,462

Определение напряемения

$$0 < \textcircled{I} < (l_1 + l_2 + l_3 - a_1 - a_2 - a_3)$$

$$\sigma_z' = \frac{N_z'}{A_1} = \frac{-q z_1}{A_1} \left| \begin{array}{l} l_1 + l_2 + l_3 - a_1 - a_2 - a_3 \\ 0 \rightarrow 0 \end{array} \right.$$

$$\begin{aligned} \sigma_z' (l_1 + l_2 + l_3 - a_1 - a_2 - a_3) &= \frac{-q (l_1 + l_2 + l_3 - a_1 - a_2 - a_3)}{A_1} \\ &= \frac{-40 (1 + 1,4 + 1,1 - 0,8 - 1,3 - \frac{1,3}{2})}{A_1} \cdot 10^3 = \frac{-30000}{A_1} \end{aligned}$$

$$(l_1 + l_2 + l_3 - a_1 - a_2 - a_3) < \textcircled{II} < l_3$$

$$\sigma_z'' = \frac{N_z''}{A_1} = \frac{-q z_2 + F_3}{A_1} \left| \begin{array}{l} l_3 \\ l_3 + l_1 + l_2 - a_1 - a_2 - a_3 \end{array} \right.$$

$$\begin{aligned} \sigma_z'' (l_3 + l_1 + l_2 - a_1 - a_2 - a_3) &= \frac{-q (l_3 + l_1 + l_2 - a_1 - a_2 - a_3)}{A_1} + \frac{F_3}{A_3} \\ &= \left(\frac{-40 (1,1 + 1 + 1,4 - 0,8 - 1,3 - \frac{1,3}{2})}{A_1} + \frac{30}{A_3} \right) \cdot 10^3 = 0 \end{aligned}$$

$$\sigma_z'' (l_3) = \frac{-q l_3 + F_3}{A_1} = \frac{-40 \cdot 1,1 + 30}{A_1} \cdot 10^3 = \frac{-14000}{A_1}$$

$$L_3 < \textcircled{\text{III}} < (L_1 + L_2 - a_1 - a_2)$$

$$\sigma_z^{\text{III}} = \frac{N_z^{\text{III}}}{A_3} = \frac{-qL_3 + F_3}{A_3} = \frac{-40 \cdot 1,1 + 30}{A_3} \cdot 10^3 =$$
$$= \frac{-14000}{A_3}$$

$$(L_1 + L_2 - a_1 - a_2) < \textcircled{\text{IV}} < L_2 + L_3$$

$$\sigma_z^{\text{IV}} = \frac{-qL_3 + F_3 - F_2}{A_3} = \frac{-40 \cdot 1,1 + 30 - 20}{A_3} \cdot 10^3 =$$
$$= \frac{-34000}{A_3}$$

$$L_2 + L_3 < \textcircled{\text{V}} < L_1 + L_2 + L_3 - a_1$$

$$\sigma_z^{\text{V}} = \frac{-qL_3 + F_3 - F_2}{A_2} = \frac{-34000}{A_2}$$

$$(L_1 + L_2 + L_3 - a_1) < \textcircled{\text{VI}} < L_1 + L_2 + L_3$$

$$\sigma_z^{\text{VI}} = \frac{-qL_3 + F_3 - F_2 + F_1}{A_2} = \frac{-40 \cdot 1,1 + 30 - 20 + 40}{A_2} \cdot 10^3 =$$
$$= \frac{14000}{A_2}$$

Определение ~~из~~ модуля ~~сечения~~ A

$$\sigma_{\max} \leq [\sigma]$$

$$\sigma_{\max} \leq \frac{\sigma_T}{n_T}$$

1-й уравнение

или

$$\frac{30000}{A_1} \leq \frac{\sigma_T}{n_T}$$

$$A_1 \geq \frac{30000 n_T}{\sigma_T} = \frac{30000 \cdot 1,3}{850 \cdot 10^6} = 46 \cdot 10^{-6} \text{ м}^2$$

2-й уравнение

$$\frac{34000}{A_2} \leq \frac{\sigma_T}{n_T}$$

$$A_2 \geq \frac{34000 n_T}{\sigma_T} = \frac{34000 \cdot 1,3}{850 \cdot 10^6} = 52 \cdot 10^{-6} \text{ м}^2$$

3-й уравнение

$$A_3 \geq \frac{34000 n_T}{\sigma_T} = 52 \cdot 10^{-6} \text{ м}^2$$

Прямая \Rightarrow $\sum N_i = 0$

$$\sum N_i = 0$$

$$R + F_1 - F_2 + F_3 - qL_3 = 0$$

$$R = qL_3 - F_3 + F_2 - F_1 = 40 \cdot 1,1 - 30 + 20 - 40 = -6 \text{ кН}$$

$$0 < \textcircled{V} < a_1$$

$$\Delta_1 = \frac{R}{EA_2} a_1 = \frac{-6 \cdot 10^3 \cdot 0,8}{2 \cdot 10^{11} \cdot 52 \cdot 10^{-6}} = -462 \cdot 10^{-6} \text{ м} =$$

$$= -0,462 \text{ мм}$$

$$a_1 < \textcircled{V} < L_1$$

$$\Delta_2 = \frac{R + F_1}{EA_2} (L_1 - a_1) = \frac{-6 \cdot 10^3 + 40 \cdot 10^3}{2 \cdot 10^{11} \cdot 52 \cdot 10^{-6}} (1 - 0,8) =$$

$$= 654 \cdot 10^{-6} \text{ м} = 0,654 \text{ мм}$$

$$\Delta_{II} = \Delta_1 + \Delta_2 = -0,462 + 0,654 = \underline{0,192 \text{ мм}}$$

$$L_1 < \textcircled{IV} < (a_1 + a_2)$$

$$\Delta_3 = \frac{R + F_1}{EA_3} (-L_2 + a_1 + a_2) = \frac{-6 \cdot 10^3 + 40 \cdot 10^3}{2 \cdot 10^{11} \cdot 52 \cdot 10^{-6}} (-1,4 + 0,8 +$$

$$+ 1,3) = 0,0023 \text{ м} = 2,3 \text{ мм}$$

$$\Delta_{III} = 0,192 + 2,3 = \underline{2,492 \text{ мм}}$$

$$\underline{(a_1 + a_2) < (II) < (L_1 + L_2)}$$

$$\Delta_4 = \frac{R + F_1 - F_2}{EA_3} (L_1 + L_2 - a_1 - a_2) = \frac{(-6 \cdot 10^3 + 40 \cdot 10^3 - 20 \cdot 10^3)}{2 \cdot 10^{11} \cdot 52 \cdot 10^{-6}}$$

$$\cdot (1 + 1,4 - 0,8 - 1,3) = 404 \cdot 10^{-6} \mu = 0,404 \text{ mm}$$

$$\Delta_{IV} = \Delta_{III} + \Delta_4 = 2,492 + 0,404 = \underline{2,896 \text{ mm}}$$

$$\underline{(L_1 + L_2) < (II) < (a_1 + a_2 + a_3)}$$

$$\Delta_5 = \int_z \frac{R + F_1 - F_2 - q(z - L_1 - L_2)}{EA_1} dz =$$

$$= (R + F_1 - F_2)(a_1 + a_2 + a_3) - q \frac{(a_1 + a_2 + a_3 - L_1 - L_2)^2}{2}$$

$$= \frac{(R + F_1 - F_2)(L_1 + L_2)}{EA_1} = \frac{(-6 \cdot 10^3 + 40 \cdot 10^3 - 20 \cdot 10^3) \cdot (0,8 + 1,3 + \frac{1,3}{2} - 1 - 1,4)}{2 \cdot 10^{11} \cdot 46 \cdot 10^{-6}}$$

$$= \frac{40 \cdot 10^3 (0,8 + 1,3 + \frac{1,3}{2} - 1 - 1,4)^2}{2 \cdot 2 \cdot 10^{11} \cdot 46 \cdot 10^{-6}} = -0,0011 \text{ mm}$$

$$= -1,1 \text{ mm}$$

$$\Delta_V = \Delta_{IV} + \Delta_S = 2,896 - 1,1 = \underline{1,796 \mu m}$$

$$(a_1 + a_2 + a_3) < \textcircled{I} < (L_1 + L_2 + L_3)$$

$$\Delta_6 = \int_z \frac{R + F_1 - F_2 + F_3 - q(z_6 - L_1 - L_2)}{EA_1} dz =$$

$$= \frac{(R + F_1 - F_2 + F_3)(L_1 + L_2 + L_3 - a_1 - a_2 - a_3)}{EA_1} -$$

$$- \frac{q \left(L_3 - \left(a_1 + a_2 + a_3 - L_1 - L_2 \right) \right)^2}{2 EA_1} =$$

$$= \frac{(-6 \cdot 10^3 + 40 \cdot 10^3 - 20 \cdot 10^3 + 30 \cdot 10^3) \left(1 + 1,4 + 1,1 - 0,8 - 1,3 - \frac{1,3}{2} \right)}{2 \cdot 10^{11} \cdot 46 \cdot 10^{-6}}$$

$$- \frac{40 \cdot 10^3 \left(1,1 - 0,8 - 1,3 - \frac{1,3}{2} + 1 + 1,4 \right)^2}{2 \cdot 2 \cdot 10^{11} \cdot 46 \cdot 10^{-6}} = 0,0035 \mu =$$

$$= 3,5 \mu m$$

$$\Delta_{V1} = \Delta_V + \Delta_6 = 1,796 + \del{0,00} 3,5 = \underline{5,296 \mu m}$$