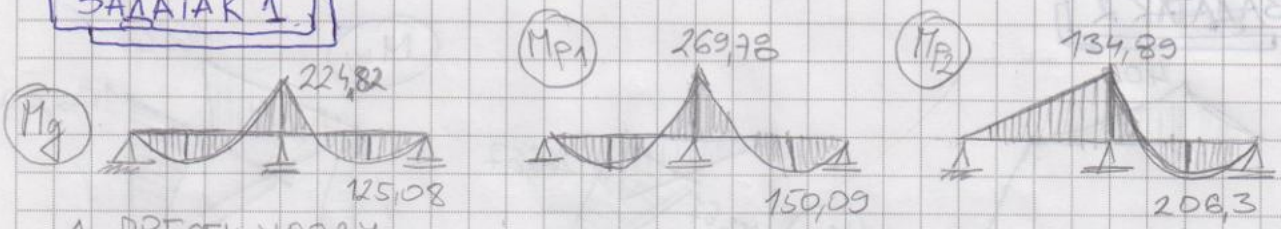
ЗАДАТАК 1



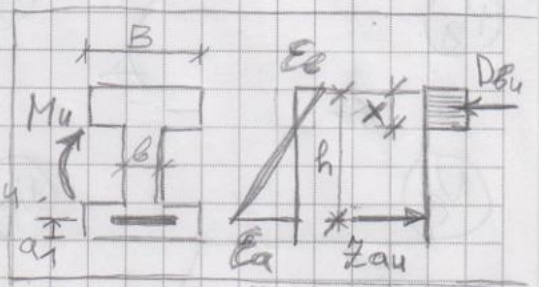
1. ПРЕСЕК У ПОЉУ

$M_u = 1{,}6 \cdot 125{,}08 + 1{,}8 \cdot 206{,}3 = 571{,}47$ kNm

ПРЕТП. $a_1 = 7$ cm $\Rightarrow h = 70 - 7 = 63$ cm

ПРЕТП. НЕУТРАЛНА ЛИНИЈА ЈЕ У ПЛОЧИ.

$D_{bu} = x \cdot f_b \cdot B = x \cdot 2{,}05 \cdot 60$



СКИЦА

$\Sigma M = 0 \Rightarrow D_{bu} \cdot \left(h - \frac{x}{2}\right) = M_u$

$x \cdot 2{,}05 \cdot 60 \cdot \left(63 - \frac{x}{2}\right) = 57147$ kNcm

$61{,}5x^2 - 7749x + 57147 = 0$

$x = 7{,}866$ cm $< d_p = 15$ cm

$\Sigma N = 0 \Rightarrow D_{bu} = Z_{au}$

$7{,}866 \cdot 2{,}05 \cdot 60 = 50 \cdot A_a$

$A_a = \frac{967{,}52}{50} = 19{,}35$ cm^2

усв. $7\phi 20$ ($21{,}98$ cm^2)

2. ПРЕСЕК НАД ОСЛОНЦЕМ

$M_u = 1{,}6 \cdot 224{,}82 + 1{,}8 \cdot 269{,}78 = 845{,}32$ kNm

ПРЕТ. $a_1 = 7$ cm и НЕУТРАЛНА ЛИНИЈА У ПЛОЧИ

$\Sigma M = 0 \Rightarrow D_{bu} \cdot \left(h - \frac{x}{2}\right) = M_u$

$x \cdot 2{,}05 \cdot 60 \cdot \left(63 - \frac{x}{2}\right) = 84532$ kNcm

$61{,}5x^2 - 7749x + 84532 = 0$

$x = 12{,}064$ cm $< d_p = 15$ cm

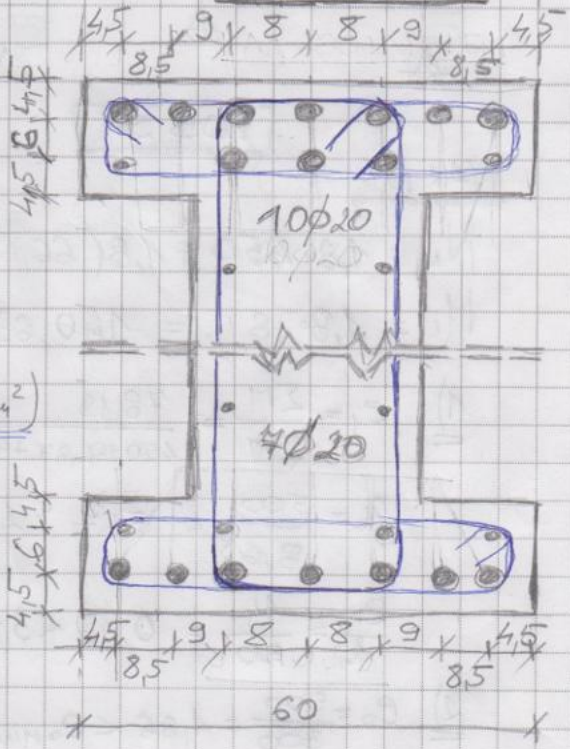
$\Sigma N = 0 \Rightarrow D_{bu} = Z_{au}$

$12{,}064 \cdot 2{,}05 \cdot 60 = 50 \cdot A_a$

$A_a = \frac{1483{,}87}{50} = 29{,}68$ cm^2

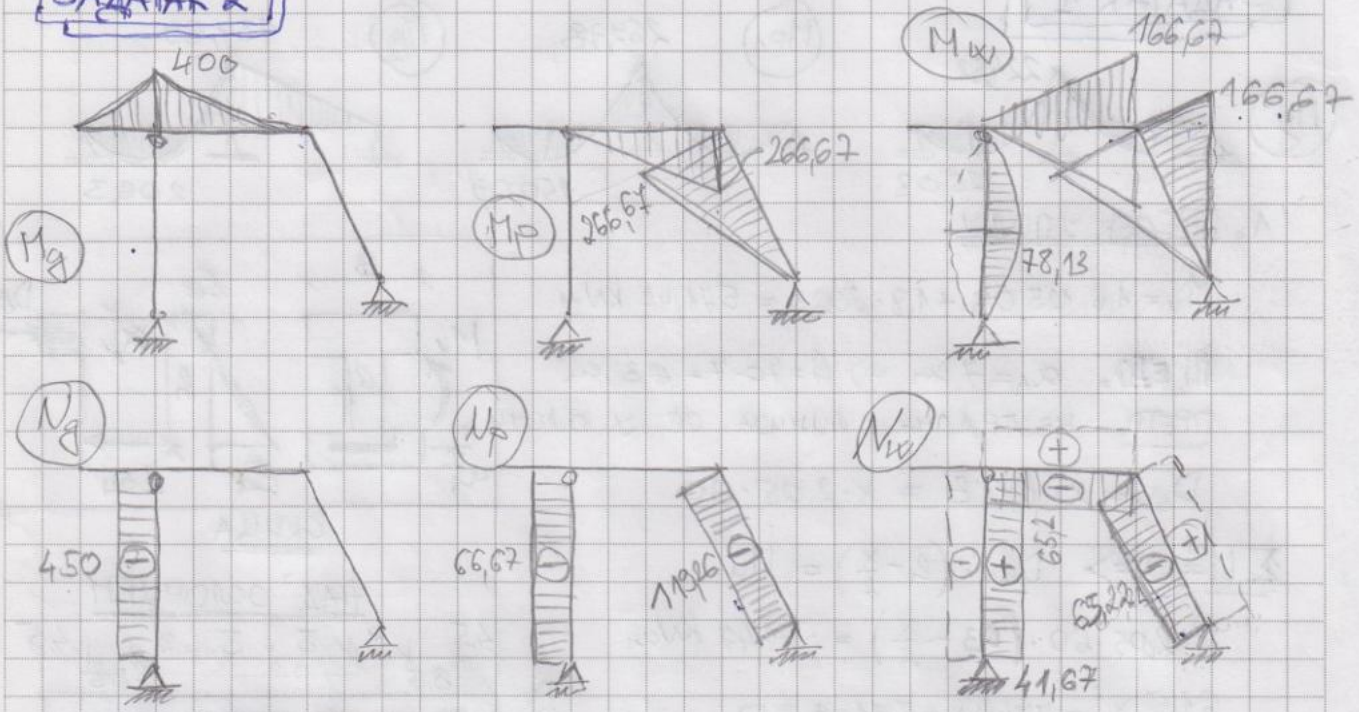
усв. $10\phi 20$ ($31{,}4$ cm^2)

НАД ОСЛОНЦЕМ



У ПОЉУ

ЗАДАТАК 2



POS S1

MAX N_u

$N_u = 1{,}6 \cdot 450 + 1{,}8(66{,}67 + 41{,}67) = 915{,}01$ KN

$M_u = 1{,}8 \cdot 78{,}13 = 140{,}63$ KNm

1) $e_1 = \frac{\Sigma M}{\Sigma N} = \frac{78{,}13}{450+66{,}67+41{,}67} = 0{,}14$ cm / $i_B = \frac{30}{\sqrt{12}} = 8{,}66$ / $l_i = 500$ cm

$\lambda = \frac{500}{8{,}66} = 57{,}7 > 25$ ⇒ УЗЕТИ

$\frac{e_1}{d} = \frac{14}{30} = 0{,}46 < 3{,}5$ ⇒ ИЗВИЈАЊЕ СЕ МОРА УЗЕТИ У ОБЗИР

2) $e_0 = \frac{500}{300} = 1{,}66 < e_{0\,MIN} = 2$ cm ⇒ УСВ. $e_0 = 2{,}0$ cm

3) $\frac{N_g}{N} = \frac{450}{558{,}34} = 0{,}81 > 0{,}2$

$\lambda = 57{,}7 > 50$

⇒ ТЕЧЕЊЕ СЕ МОРА УЗЕТИ У ОБЗИР

$J_c = \frac{30^3 \cdot 40}{12} = 90000$ cm^4 $\quad E_b = 34$ GPa $= 34 \cdot 10^6$

$N_E = 34 \cdot 10^6 \cdot 90\,000 \cdot 10^{-8} \cdot \frac{\pi^2}{5^2} = 12080$ KN

$\alpha_E = \frac{450}{12080} = 0{,}037$; $\varphi_g = \frac{M_g}{N} = 0$; $d_m = \frac{2 \cdot 30 \cdot 40}{2(30+40)} = 17{,}14$ cm ≈ 20 cm

$e_p = (2+0) \cdot \left(e^{\frac{0{,}037}{1-0{,}037} \cdot 2{,}5} - 1\right) = 0{,}2$ cm

4) $e_1/d = \frac{14}{30} = 0,46 > 0,3 \Rightarrow e_2 = 30 \cdot \frac{57,7-25}{160} = 6,13$ cm

5) $e_2 = 14 + 2,0 + 0,2 + 6,13 = 22,33$ cm

$M_u = 0,2233 \cdot 915 = 204,32$ kNm

$N_u = 915$ kN

$m_u = \frac{204,32 \cdot 10^2}{40 \cdot 30^2 \cdot 2,55} = 0,223$ } ПРЕТП. $a_1/d = 0,2$ ПБАБ-2 ДИАГРАМ 2.4.13.

$n_u = \frac{915}{40 \cdot 30 \cdot 2,55} = 0,299$ } $\bar{\mu} = 0,21\ \%$ $\varepsilon_{a1} > 3‰$

MIN N_u *

$N_u = 1,0 \cdot 450 - 1,8 \cdot 41,67 = 375$ kN

$M_u = 1,8 \cdot 78,13 = 140,63$ kNm

1) $e_1 = \frac{\Sigma M}{\Sigma N} = \frac{140,63}{375} = 19,1$ cm $= e_1/d = \frac{19,1}{30} = 0,63 < 3,5$ } ИЗВИЧАНЕ СЕ УЗИМА У ОБЗИР

2) $e_0 = 2,0$ cm

3) $\frac{N_g}{N} = \frac{450}{408,33} > 0,2 \Rightarrow e_\varphi = 0,2$ cm

4) $\frac{e_1}{d} = \frac{19,1}{30} = 0,64 > 0,3 \Rightarrow e_2 = 30 \cdot \frac{57,7-25}{160} = 6,13$ cm

5) $e_2 = 19,1 + 2,0 + 0,2 + 6,13 = 27,43$ cm

$M_u = 0,2743 \cdot 375 = 102,86$ kNm

$N_u = 375$ kN

$m_u = \frac{102,86 \cdot 10^2}{40 \cdot 30^2 \cdot 2,55} = 0,112$ } ПРЕТП. $a_1/d = 0,2$ ПБАБ-2 ДИАГРАМ 2.4.13

$n_u = \frac{375}{40 \cdot 30 \cdot 2,55} = 0,123$ } $\bar{\mu} = 0,09\ \%$ $\varepsilon_{a1} > 3‰$

$A_{a1} = A_{a2} = 0,21 \cdot 40 \cdot 30 \cdot \frac{2,55}{40} = 16,1$ cm^2

$\mu_{MIN} = \frac{57,7}{50} - 0,4 = 0,754\ \% > 0,6\ \% \Rightarrow \mu_{MIN} = 0,754\ \%$

$A_{a,MIN} = 0,754 \cdot \frac{40 \cdot 30}{100} = 9,05$ cm^2

усв. $\pm$ 8 Ø 16 ($\pm 16,1 = 32,2$ cm^2)

* НИЈЕ ПОТРЕБНО/НЕОПХОДНО

РОС S2

1) $N_u^{MAX} = 1,8 \cdot (119,26 + 65,22) = 332,06$ KN

$M_u^{MIN} = 1,8 \cdot (266,67 - 166,67) = 180$ KNm

2) $N_u = 1,8 \cdot (119,26 - 65,22) = 97,27$ KN

$M_u = 1,8 \cdot (266,67 + 166,67) = 480$ KNm } M^{MAX} (ЛЕВА СТРАНА)

3) $N_u = 1,8 \cdot 119,26 = 214,67$ KN

$M_u = 1,8 \cdot 266,67 = 480$ KNm

4) $N_u = 1,8 \cdot 65,22 = 117,4$ KN

$M_u = 1,8 \cdot 166,67 = 300$ KNm } (ДЕСНА СТРАНА) M_{MAX}

5) $N_u = 1,8 \cdot 65,22 = 117,4$ KN

$M_u = 1,8 \cdot 166,67 = 300$ KNm } N^{MIN} (ЛЕВА СТРАНА)

1. M^{MAX} (ЗАТЕГНАТА ДЕСНА СТРАНА)

$M_u = 300$ KNm

$N_u = 117,4$ KN

ПРЕТП. $a_1 = 7$ cm $\Rightarrow$ $h = 60 - 7 = 53$ cm

$M_{au} = 300 + 117,40 \cdot \left(\frac{0,6}{2} - 0,07\right) = 327,00$ KNm

$k = \frac{53}{\sqrt{\frac{327,0 \cdot 10^2}{40 \cdot 2,55}}} = 2,960 \Rightarrow \varepsilon_a/\varepsilon_b = 10/2,15‰$ $\bar{\mu} = 12,209\%$

$A_a = 12,209 \cdot \frac{40 \cdot 53}{100} \cdot \frac{2,55}{40} - \frac{117,4}{40} = 13,57$ cm^2

2. M^{MAX} (ЗАТЕГНАТА ЛЕВА СТРАНА)

$M_u = 780$ KNm

$N_u = 97,27$ KN

ПРЕТП. $a_1 = 7$ cm $\Rightarrow$ $h = 53$ cm

$M_{au} = 480 + \left(\frac{0,6}{2} - 0,07\right) \cdot 97,27 = 802,37$ KNm

$k = \frac{53}{\sqrt{\frac{802,37 \cdot 10^2}{40 \cdot 2,55}}} = 1,89 \Rightarrow \varepsilon_a/\varepsilon_b = 4,85/3,5‰$ $\mu = 33,932\%$

$$A_a = 33{,}932 \cdot \frac{40}{100} \cdot \frac{53}{100} \cdot \frac{2{,}55}{40} - \frac{97{,}27}{40} = 43{,}43 \text{ cm}^2$$

3. N^{MIN} (ЛЕВА СТРАНА)

M_u = 300 KNm ПРЕТП. a_1=7 cm $\Rightarrow$ h = 53 cm

Z_u = 117,4 KN

$$M_{au} = 300 - 117{,}4 \cdot \left(\frac{0{,}6}{2} - 0{,}07\right) = 273{,}0 \text{ KNm}$$

$$k = \frac{53}{\sqrt{\frac{273{,}0 \cdot 10^2}{40 \cdot 2{,}55}}} = 3{,}240 \Rightarrow \varepsilon_a/\varepsilon_b = 10/1{,}875‰ ; \mu = 10{,}177\%$$

$$A_{a_2} = 10{,}177 \cdot \frac{40 \cdot 53}{100} \cdot \frac{2{,}55}{40} + \frac{117{,}4}{40} = 16{,}69 \text{ cm}^2$$

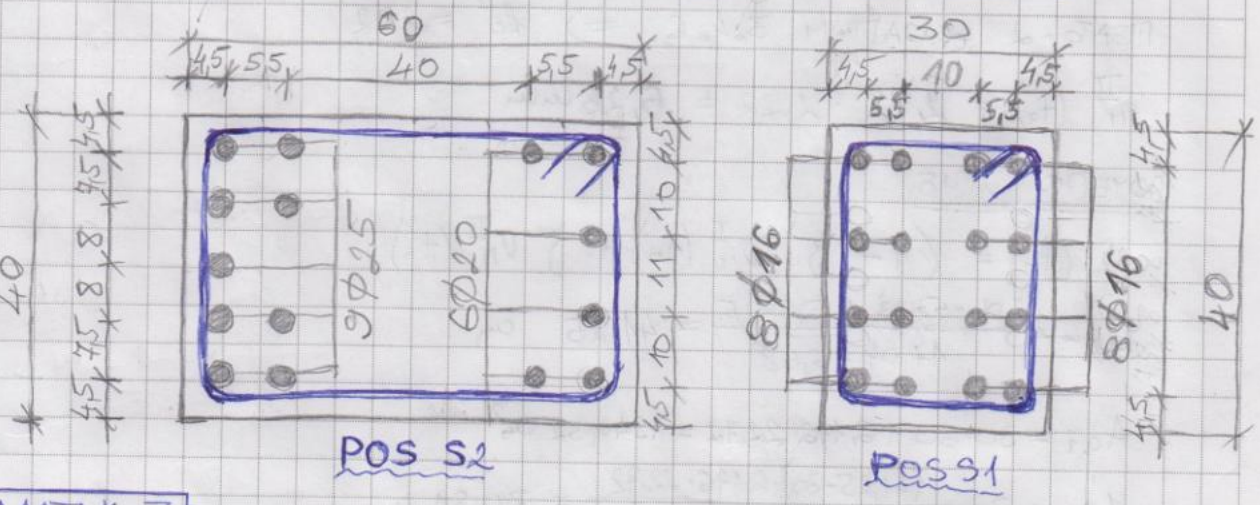
$$A_{a,MIN} = 0{,}6 \cdot \frac{40 \cdot 60}{100} = 14{,}4 \text{ cm}^2$$

ЛЕВА СТРАНА

9Ф25 (44,19 cm²)

ДЕСНА СТРАНА

6Ф20 (18,84 cm²)



ЗАДАТАК 3

3.1.

$A_{a1} = 6 \cdot 2{,}84 = 17{,}04 \text{ cm}^2$ / $a_1 = 6{,}67$ cm / $h = 53{,}33$ cm / $\mu_1 = \frac{17{,}04}{30 \cdot 53{,}3} = 1{,}065\%$

$A_{a2} = 2 \cdot 2{,}84 = 5{,}68 \text{ cm}^2$ / $a_2 = 5$ cm / $\mu_2 = \frac{5{,}68}{30 \cdot 53{,}3} = 0{,}355\%$ / $\alpha_1 = \frac{5}{53{,}3} = 0{,}0938$

RA 400/500 $\Rightarrow$ $\sigma_V = 40$ KN/cm², $E_a = 210$ GPa

MB 40 $\Rightarrow$ $f_B = 2{,}55$ KN/cm², $E_B = 34$ GPa

$n = \frac{210}{34} = 6{,}176$

ПОЛОЖАЈ НЕУТРАЛНЕ ЛИНИЈЕ:

$$S^2 + 2 \cdot 6{,}176 \cdot (1{,}065 + 0{,}355) \cdot 10^{-2} \cdot S - 2 \cdot 6{,}176 \cdot (1{,}065 + 0{,}355 \cdot 0{,}09375) \cdot 10^{-2} = 0$$

$$S^2 + S \cdot 0{,}1754 - 0{,}13557 = 0 \Rightarrow S = 0{,}2909$$

$$J_B = \frac{30 \cdot 60^3}{12} = 540\,000 \text{ cm}^4$$

$$v_{B,g} = \frac{5}{384} \cdot \frac{50 \cdot 5^4}{34 \cdot 10^6 \cdot 540000 \cdot 10^{-8}} \cdot 10^3 = 2{,}22 \text{ mm}$$

СТАЊЕ I (БЕЗ ПРСЛИНА)

$$\frac{a_1}{d} = \frac{6{,}64}{60} = 0{,}11\dot{} \approx 0{,}1 \qquad \frac{A_{a2}}{A_{a1}} = \frac{5{,}68}{17{,}04} = 0{,}33\dot{}$$

$$\frac{n \cdot A_{a1}}{b \cdot h} = \frac{6{,}176 \cdot 17{,}04}{30 \cdot 53{,}33} = 0{,}0658 \Rightarrow \begin{matrix}\text{ПБАБ-2} \\ \text{ДИЈАГРАМ } 3.4.2\end{matrix} \quad k_a^I = 0{,}87.$$

$$v_M^I(t_0) = 0{,}87 \cdot 2{,}22 = 1{,}93 \text{ mm}$$

СТАЊЕ II (СА ПРСЛИНАМА)

ПБАБ-2 ДИЈАГРАМ 3.4.6. $\Rightarrow k_a^{II} = 2{,}82$

$$v_M^{II}(t_0) = 2{,}82 \cdot 2{,}22 = 6{,}26 \text{ mm}$$

ПОЧЕТНИ УГИБ

$$v_M(t_0) = (1 - \zeta)\, v_M^I(t_0) + \zeta\, v_M^{II}(t_0)$$

$$y_{a2} = \frac{17{,}04 \cdot 53{,}33 + 5{,}68 \cdot 5}{17{,}04 + 5{,}68} = 41{,}25 \text{ cm}$$

$$A_{ai} = 30 \cdot 60 + 6{,}176 \cdot 22{,}72 = 1940{,}32 \text{ cm}^2$$

$$y'_{i2} = 30 + \frac{(41{,}25 - 30) \cdot 6{,}176 \cdot 22{,}72}{1940{,}32} = 30{,}81 \text{ cm}$$

$$J_a = 5{,}68 \cdot (41{,}25 - 5)^2 + 17{,}04 \cdot (41{,}25 - 53{,}33\dot{})^2 = 9951{,}83 \text{ cm}^4$$

$$J_i^I = 540\,000 + 6{,}176 \cdot 9951{,}83 + 1800 (41{,}25 - 30) \cdot (30{,}81 - 30) = 617\,865 \text{ cm}^4$$

$$W_{i1}^I = \frac{617\,865}{60 - 30{,}81} = 21\,167 \text{ cm}^3$$

$$f_{bzs} = 2{,}9 \cdot \left(0{,}6 + \frac{0{,}4}{\sqrt[4]{0{,}6}}\right) = 3{,}06 \text{ MPa} > 2{,}9 \text{ MPa} = f_{bz} = f_{bzm}$$

$$M_r = 0{,}306 \cdot 21167 \cdot 10^{-2} = 64{,}77 \text{ kNm} < M_g = \frac{50 \cdot 5^2}{8} = 156{,}25 \text{ kNm}$$

$\beta_1 = 1,0$ (RA 400/500)
$\beta_2 = 1,0$ (t=0)

$$\zeta_G^{t=0} = 1 - 1,0 \cdot 1,0 \cdot \frac{64,79}{156,25} = 0,587$$

$$v_M^G(t_0) = (1-0,587) \cdot 1,93 + 0,587 \cdot 6,26 = 4,47 \text{ мм}$$

$$v_M(t=3 \text{ год}) = v_M^G(t_0) + 4,4 \text{ мм} = 8,87 \text{ мм}$$

3.2.

$v_{dop} = 12,5$ мм

$\zeta_{G+P}^{t=0} = 0,769$

$$v_M^{G+P}(t_0) = v_{dop} - v_{M,G}^{\infty}(t=3 \text{ год}) = 12,5 - 4,4 = 8,1 \text{ мм}$$

$$v_M^{G+P}(t_0) = (1 - \zeta_{G+P}^{t=0}) \cdot v_{M,G+P}^{I}(t_0) + \zeta_{G+P}^{t=0} \cdot v_{M,G+P}^{II}(t_0)$$

$$v_{M,G+P}^{I}(t_0) = \frac{g+P}{g} \cdot v_{M,G}^{I}(t_0) = \frac{50+P}{50} \cdot 1,93$$

$$v_{M,G+P}^{II}(t_0) = \frac{g+P}{g} v_{M,G}^{II}(t_0) = \frac{50+P}{50} \cdot 6,26$$

$$(1-0,769) \cdot \frac{50+P}{50} \cdot 1,93 + 0,769 \cdot \frac{50+P}{50} \cdot 6,26 = 8,1 \text{ мм}$$

$$0,1052 \cdot P + 5,26 = 8,1 \text{ мм}$$

$$P \leq 27 \text{ kN/m}$$