

ЈУНИ 2003.

1. На стубу направљеном од челичне цеви испу-
бене бетоном мереће су, према скици, локалне
деформације меритим тракама. Определити пресе-
чне силе на основу резултата мерења датих у
таблици.

Ст.	M1	M2	M3	M4
0	11370	10215	9962	10117
P	11343	10182	9931	10092
0	11367	10211	9965	10120

$$E_b = 0,35 \cdot 10^4 \frac{\text{кН}}{\text{см}^2}$$

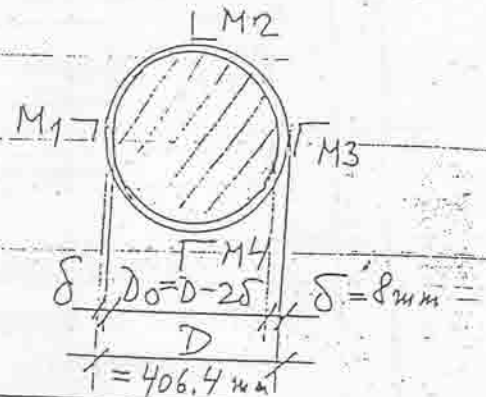
$$E_c = 21 \cdot 10^4 \frac{\text{кН}}{\text{см}^2}$$

$$\nu_b = 0,18$$

$$\nu_c = 0,30$$

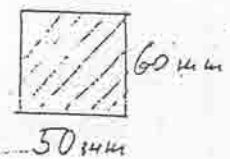
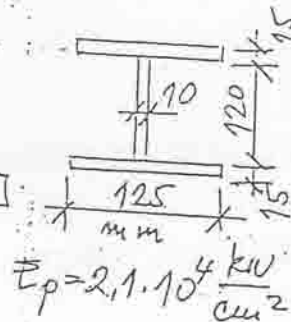
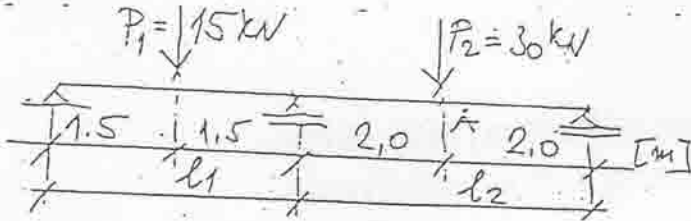
$$k_i/k_c = 1$$

$$J = D^4 \pi / 64$$



2. За прототип према скици конструисати модел користећи
једначину предвиђања за утиб тачке А и услов да:
 $\epsilon_{lim} = 200 \cdot 10^{-6} \text{ mm/mm}$. Определити размену за утиб
коју треба приказати изразом у коме се експлицитно
изразављају све величине које утичу на вредност раз-
ре, као и бити бројну вредност.

прототип:



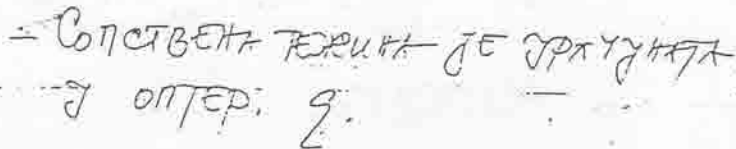
$$E_m = 0,7 \cdot 10^4 \frac{\text{кН}}{\text{см}^2}$$

$$M_A = \frac{P_2 l_2 (8 l_1 + 5 l_2) - 3 P_1 l_1^2}{32 (l_1 + l_2)}$$

$$\nu_A = \frac{l_2^2}{768 E J} \frac{P_2 l_2 (16 l_1 + 7 l_2) - 9 P_1 (l_1)^2}{(l_1 + l_2)}$$

1/12

14

$$\lim_{x \rightarrow 0} \frac{1}{x} = \infty$$
$$\sigma_{\tilde{z}d} = -0,05 \cdot \sigma_{\phi g}$$


	M1	M2	M3	M4
(P-0) ₁	-27	-33	-31	-25
(P-0) ₂	-24	-29	-34	-28
Δs_{R2}	-25.5	-31	-32.5	-26.5
$E \cdot b$	-25.5	-31	-32.5	-26.5
$\bar{\sigma}$	-0,536	-0,651	-0,682	-0,556

$$\varepsilon = \frac{k_i}{k_t} \cdot \Delta \bar{\sigma}_{sR} \cdot \rho = 1 \cdot \Delta \bar{\sigma}_{sR} \cdot 1 \cdot 10^{-8}$$

$$\bar{\sigma} = E \cdot \varepsilon = 2,1 \cdot 10^4 \cdot \varepsilon$$

— I_{km}/cm^2 —

5

— ГЕОМЕТРИЧЕСКАЯ ПОДСЛУЖИТЕЛЬНАЯ ПРЕСЕКТА:

$$D = 40,64 \text{ см} \quad \delta = 2,2 \text{ см}$$

$$D_0 = D - 2\delta = 40,64 - 2 \cdot 2,2 = 39,04 \text{ см}$$

$$I_{\bar{\sigma}} = \frac{(D^2 - D_0^2) \cdot \pi}{4} = \frac{(40,64^2 - 39,04^2) \cdot \pi}{4} = 100,072 \text{ см}^2$$

$$I_b = \frac{D_0^2 \cdot \pi}{4} = \frac{39,04^2 \cdot \pi}{4} = 1196,435 \text{ см}^2$$

$$J_{\bar{\sigma}} = \frac{(D^4 - D_0^4) \cdot \pi}{64} = \frac{(40,64^4 - 39,04^4) \cdot \pi}{64} = 19863,812 \text{ см}^4$$

$$J_b = \frac{D_0^4 \cdot \pi}{64} = \frac{39,04^4 \cdot \pi}{64} = 113969,570 \text{ см}^4$$

$$A_i = I_{\bar{\sigma}} + \frac{F_2}{F_{\bar{\sigma}}} \cdot I_b = 100,072 + \frac{0,35}{2,1} \cdot 1196,435 = 100,072 + 0,16 \cdot 1196,435$$

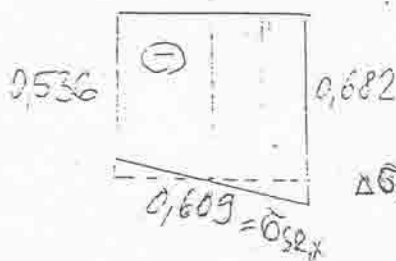
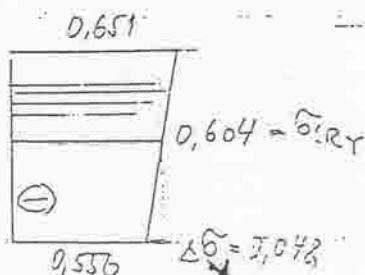
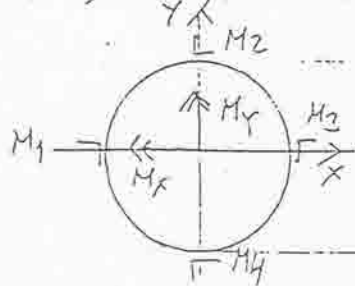
$$A_i = 299,484 \text{ см}^2$$

$$J_i = J_{\bar{\sigma}} + \frac{F_2}{F_{\bar{\sigma}}} \cdot J_b = 19863,812 + \frac{0,35}{2,1} \cdot 113969,570 = 32858,746 \text{ см}^4$$

$$W_i = \frac{32858,746}{40,64} \cdot 2 = 1992,340 \text{ см}^3$$

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— ОПРЕДЕЛЕНИЕ ПРЕДЕЛЬНЫХ СИЛ:



$[kN/cm^2]$

$$\Delta \bar{\sigma}_x = 0,073$$

$$N_{(x)} = \sigma_{xR} \cdot A_i = -0,609 \cdot 299,484 = -182,39 \text{ кН}$$

$$N_{(y)} = -0,604 \cdot 299,484 = -180,89 \text{ кН}$$

$$N = \frac{1}{2}(-182,39 - 180,89) = -181,5 \text{ кН}$$

$$M_x = 0,042 \cdot 1992,34 = 84,79 \text{ кН/см}$$

$$M_y = 0,073 \cdot 1992,34 = 139,6 \text{ кН/см}$$

10

$$M = \sqrt{0,918^2 + 1,396^2} = 1,670 \text{ кН/см}$$

30

$$M_{AP} = 0,725 \cdot 15 \cdot 2,0 = 21,75 \text{ kNm}$$

$$\epsilon_{AP} = \frac{M_{AP}}{W_{AP} \cdot E_P} = \frac{21,75}{247,97 \cdot 2,1 \cdot 10^4} = 418 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$$

$$\epsilon_{Am} = \frac{M_{Am}}{W_{Am} E_m} = 200 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$$

$$\gamma_E = \frac{418}{200} = 2,09$$

$$\gamma_E = \frac{\frac{0,725 P_b l_p}{W_p \cdot E_P}}{\frac{0,725 P_m l_m}{W_m E_m}} = \left(\frac{P_p}{P_m} \right) \left(\frac{l_p}{l_m} \right) \cdot \frac{1}{W_p} \cdot \frac{1}{E_P} = \gamma_P \cdot \gamma_l \cdot \frac{1}{\gamma_W \cdot \gamma_E}$$

$$\Rightarrow \text{РАЗМЕРА ЗА СЪЛЪ: } \gamma_P = \frac{\gamma_W \cdot \gamma_E \cdot \gamma_l}{\gamma_I} = C_W \cdot \gamma_E \cdot \gamma_l \cdot \frac{1}{\gamma_I}$$

- ТЕЖАЧУКА ПРЕЛЗУЩАТА ЗА СЪЛЪ:

$$\frac{V_{AP}}{l_p} = 0,196 \frac{P_p}{E_P l_p^2} \cdot \frac{l_p^4}{C_P}$$

$$\frac{V_{Am}}{l_m} = 0,196 \frac{P_m}{E_m l_m^2} \cdot \frac{l_m^4}{C_m}$$

$$\left| \frac{\frac{V_{AP}}{l_p}}{\frac{V_{Am}}{l_m}} = \frac{0,196 \frac{P_p}{E_P l_p^2} \cdot \frac{l_p^4}{C_P}}{0,196 \frac{P_m}{E_m l_m^2} \cdot \frac{l_m^4}{C_m}} \right|$$

$$\Rightarrow \gamma_V \cdot \frac{1}{\gamma_I} = \gamma_P \cdot \frac{1}{\gamma_E} \cdot \frac{1}{\gamma_l^2} \cdot \frac{1}{\gamma_J} \cdot \gamma_l^4$$

РАЗМЕРА ЗА СЪЛЪ:

$$\gamma_J = \frac{\gamma_P \cdot \gamma_l^3}{\gamma_E \cdot \gamma_J} = \frac{C_W \cdot \gamma_E \cdot \gamma_l \cdot \frac{\gamma_{V,POP}}{\gamma_l} \cdot \gamma_l^{2-2}}{\gamma_E \cdot C_I \cdot \gamma_{V,POP}^4}$$

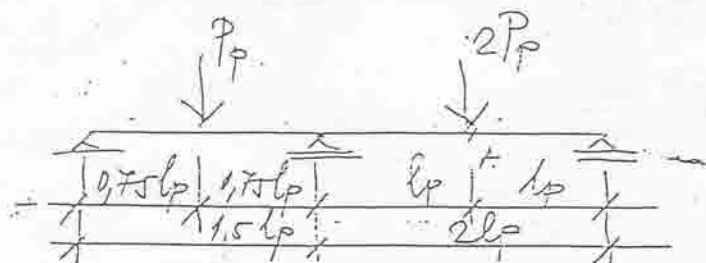
$$\left| \gamma_V = \frac{C_W}{C_I} \cdot \gamma_E \cdot \frac{\gamma_l^2}{\gamma_{V,POP}} \right|$$

$$\text{ПОСТАВА СЪ } \gamma_l = 2$$

$$\left| \gamma_W = \frac{0,529}{0,529} \cdot 2,09 \cdot \frac{2^2}{2,5} = 3,344 \right|$$

02

$$l_0 = 2,0 \text{ m}$$

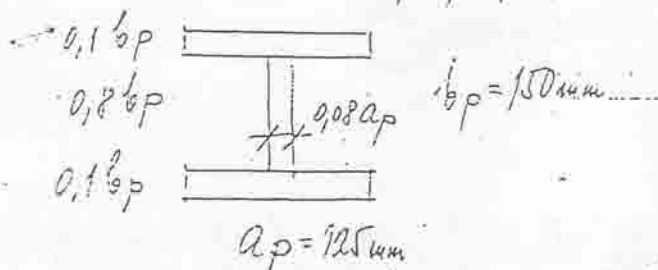


$$V_{AP} = \frac{4\ell_p^2}{58\epsilon_p J_p} \frac{2P_p \cdot 2\ell_p (16 \cdot 1.5 \ell_p + 7.2 \ell_p) - 9P_p (1.5 \ell_p)^2}{1.5 \ell_p + 2 \ell_p} = \frac{\ell_p}{576 \epsilon_p J_p} \text{ 13.15 } P_p \ell_p^2$$

$$V_{xp} = 0,196 \frac{P_{flop}^3}{\epsilon_p \tau_p}$$

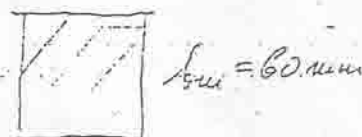
$$M_{Ap} = \frac{2P_p \cdot 2l_p (8 \cdot 1.5 \cdot l_p + 5 \cdot 2 l_p) - 3 \cdot P_p \cdot (1.5 l_p)^2}{32 (1.5 + 2) l_p} = \frac{81.25 P_p l_p^2}{112 l_p} = 0.725 P_p l_p$$

- ГЕОМЕТРИЈА "прототип"



$$a_p = 125 \text{ mm}$$

4 МОДЕЛ



$$I_{\text{ли}} = 60 \text{ мн}$$

$a_{\text{max}} = 50 \text{ м/с}$

$$\overline{U}_b = \frac{1}{12} a_p b_p^3 - \frac{1}{12} \cdot 2 \cdot 0,46 a_p (0,8 b_p)^3$$

$$T_{\text{max}} = \frac{1}{12} \text{ sec}$$

$$\overline{D}_p = \frac{1}{12} a_{p0}^3 \left(1 - 0,471 \right) = \frac{0,529}{12} a_{p0}^3$$

$$r_{pop} = r_a = r_b = \frac{125}{50} = \frac{150}{60} = 25$$

$$\lambda_{\frac{J}{J_0}} = \frac{J_p}{J_m} = 0,529 \left(\frac{a_p}{a_m} \right) \cdot \left(\frac{b_p}{b_m} \right)^2 = G \cdot \lambda_{p,p}$$

$$W_p = \frac{\bar{U}_p}{f_{p/2}} = \frac{1.058}{12} \cdot a_p \lambda_p^2$$

$$W_{\text{m}} = \frac{E}{12} \cdot \Delta u \cdot L_{\text{m}}^2$$

$$R_W = \frac{V_{iD}}{W_{iD}} = 0,525 \cdot \left(\frac{q_D}{a_m} \right) \left(\frac{L_D}{L_m} \right)^2 = C_W \cdot R_{iD}^3$$

$$r/c = \frac{1.052}{12} \cdot 12.5 \cdot 15^2 = 247,3 \text{ cm}^2$$

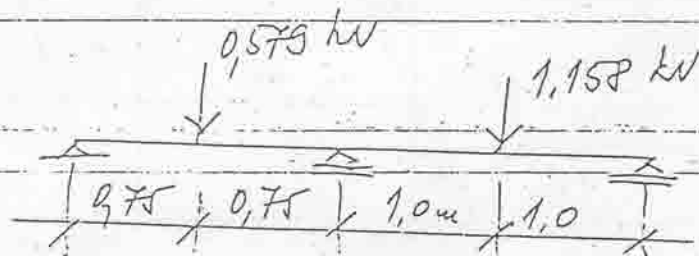
$$n_E = \frac{F_P}{F_m} = \frac{2,1}{0,7} = 3$$

$$r_P = 0,529 \cdot 2,09 \cdot 3 \cdot \frac{25^3}{2} = 25,913$$

$$l_m = \frac{l_P}{n_E} = \frac{2,0 \text{ m}}{2} = 1,0 \text{ m}$$

$$F_m = \frac{F_P}{n_E} = \frac{15,0 \text{ kN}}{25,913} = 0,579 \text{ kN}$$

МОДЕЛ:



(35)

3. — СИЛА ПРЕТХОДНОГ НАПРЕЗАЊА:

$$\tilde{\sigma}_z = c \cdot l_i^2 \cdot f_i^2 = 3,2 \cdot 10^{-7} \cdot 100^2 \cdot 200^2 = 128 \text{ kN/cm}^2$$

$$A_z(1) = \frac{\phi \pi}{4} = 0,7^2 \frac{\pi}{4} = 0,385 \text{ cm}^2$$

$$A_K = 12 A_z(1) = 12 \cdot 0,385 = 4,62 \text{ cm}^2$$

$$N_K = A_K \cdot \tilde{\sigma}_z = 4,62 \cdot 128 = 591,36 \text{ kN}$$

— ТЕОМЕТРИЈСКЕ КАРАКТЕРИСТИКЕ ПРЕСЕКА:

$$A_0 = 40 \cdot 60 - 2 \cdot 12,5 \cdot 30 = 1650 \text{ cm}^2$$

$$J_0 = \frac{1}{12} 40 \cdot 60^3 - \frac{1}{12} 2 \cdot 12,5 \cdot 30^3 = 663750 \text{ cm}^4$$

$$W_g = W_d = \frac{J_0}{l/2} = \frac{663750}{30} = 22125 \text{ cm}^3$$

— КОМПОНЕНТЕ НАПОНА НА ГОРБОТ И ДОЉОЈ КРАЈУ:

— ЗА ПРЕТХОДНОГ НАПРЕЗАЊА: $e_K = 30 - 20 = 10 \text{ cm}$

$$\tilde{\sigma}_{\sigma K} = \frac{N_K}{A_K} \pm \frac{M_K e_K}{W_K} = \frac{591,36}{4,62} \pm \frac{591,36 \cdot 10}{22125} = 0,352 \pm 0,267$$

