



LIK

LABORATORIJ ZA
ISPITIVANJE
KONSTRUKCIJA

IMK

INSTITUT ZA
MATERIJALE I
KONSTRUKCIJE

Ispitivanje konstrukcija - FEBRUAR - 2004. -28.02.2004... pismeni deo ispita

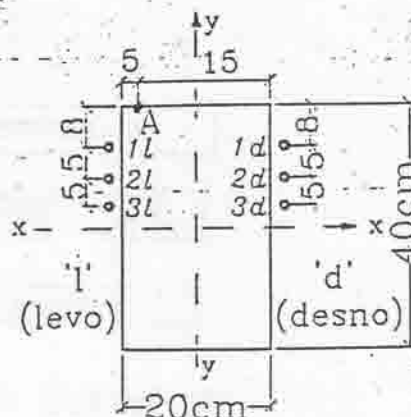
1. Na prethodnonapregnutoj gredi, prorečnog preseka datog na skici izmerene su frekvencije slobodnog oscilovanja žica za prednaprezanje $\Phi 7 \text{ mm}$ ($l_i = 100 \text{ cm}$)

$$\begin{aligned} f_1 &= 130 \text{ Hz} & d_1 &= 160 \text{ Hz} \\ f_2 &= 135 \text{ Hz} & d_2 &= 165 \text{ Hz} \\ f_3 &= 139 \text{ Hz} & d_3 &= 168 \text{ Hz} \end{aligned}$$

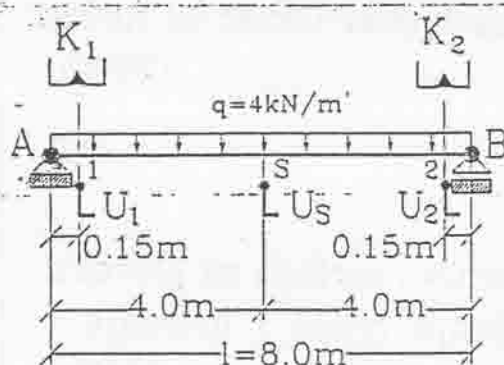
Odrediti:

a/ Silu prethodnog naprezanja

b/ Dilataciju u tački A, $E_b = 0.35 \times 10^4 \text{ kN/cm}^2$



2. Na grednom nosaču prema skici merene su opšte deformacije, ugiibi i obrtanja u tačkama 1, S, 2. Naći maksimalni mereni ugiib i uporediti ga sa računuskim ($p_u = 0.01 \text{ mm}$).

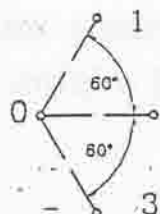


stanje	U ₁	U _S	U ₂	K ₁	K ₂
0	0428	1151	1101	0 + 028	0 + 121
q	0740	3281	1621	4 + 230	4 + 074

I-260 $J_{xx} = 5740 \text{ cm}^4$

3. Na armiranobetonskom elementu merene su putem rozete lokalne deformacije. Merenje je izvršeno instrumentom Pfender sa maksimalnom veličinom baze pomenutog instrumenta. Odrediti deformacijsko i naponsko stanje u datoj tački metodom po izboru (analitički ili grafički).

stanje	0 - 1	0 - 2	0 - 3	'K'
0	0631	0428	0718	0279
opt.	0636	0410	0710	0281
0	0632	0427	0718	0279



"K"

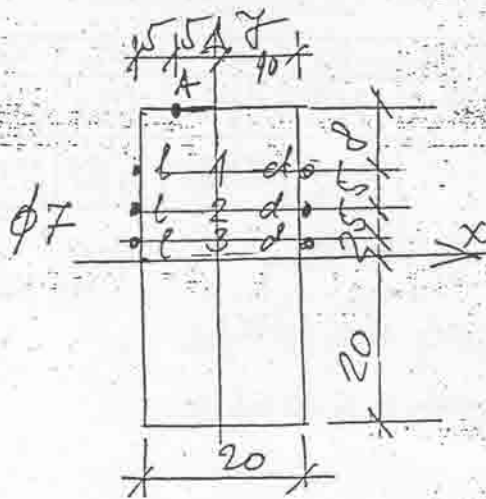
$$E_b = 0.32 \times 10^4 \text{ kN/cm}^2$$

$$\nu_b = 0.15$$

4. Mehanizam za uvećanje čitanja kod datog ugibomera je sastavljen od 4 para zupčanika. Odrediti:

a/ Odnos poluprečnika zupčanika trećeg para ($r_6/r_5 = ?$) ako su odnosi $r_2/r_1 = 2$; $r_4/r_3 = 5$; i $r_8/r_7 = 10$ i ako je broj podela na brojčaniku velike kazaljke 100, a broj podela na brojčaniku male kazaljke 20, pri čemu je opseg instrumenta 2 mm.

b/ Opseg instrumenta ako je $r_2/r_1 = r_6/r_5 = 2$; $r_4/r_3 = r_7/r_8 = 5$, a najveća moguća razlika čitanja koja se može ostvariti ista je kao za slučaj konstrukcije ugibomera prema vrednostima u tački a/



$$A = 20 \cdot 40 = 800 \text{ cm}^2$$

$$J_{x-x} = \frac{40^3 \cdot 20}{12} = \frac{1}{3} 320000 \text{ cm}^4$$

$$J_{y-y} = \frac{20^3 \cdot 40}{12} = \frac{1}{3} 80000 \text{ cm}^4$$

$$W_x^A = \frac{J_{x-x}}{20} = \frac{16000}{3} \text{ cm}^3$$

$$W_y^A = \frac{J_{y-y}}{5} = \frac{16000}{3} \text{ cm}^3 \quad 2$$

$$a) \quad \sigma_{zi} = c \cdot l_i^2 \cdot f_i^2$$

$$l_i = 100 \text{ cm} \quad A_{z(1)} = \frac{9 \cdot \pi^2}{4} = 9385 \text{ cm}^2$$

$$i=1 \quad \sigma_{z1l} = 3,2 \cdot 10^{-7} \cdot 100^2 \cdot 130^2 = 54,08 \text{ kN/cm}^2 \quad N_{z1l} = \sigma_{z1l} \cdot A_{z(1)} = 20,82 \text{ kN}$$

$$\sigma_{z1d} = 3,2 \cdot 10^{-7} \cdot 100^2 \cdot 160^2 = 81,92 \text{ kN/cm}^2 \quad N_{z1d} = 31,54 \text{ kN}$$

$$i=2 \quad \sigma_{z2l} = 3,2 \cdot 10^{-3} \cdot 135^2 = 58,32 \text{ kN/cm}^2 \quad N_{z2l} = 22,45 \text{ kN}$$

$$\sigma_{z2d} = 3,2 \cdot 10^{-3} \cdot 165^2 = 87,12 \text{ kN/cm}^2 \quad N_{z2d} = 33,54 \text{ kN}$$

$$i=3 \quad \sigma_{z3l} = 3,2 \cdot 10^{-3} \cdot 139^2 = 61,83 \text{ kN/cm}^2 \quad N_{z3l} = 23,80 \text{ kN}$$

$$\sigma_{z3d} = 3,2 \cdot 10^{-3} \cdot 168^2 = 90,32 \text{ kN/cm}^2 \quad N_{z3d} = 34,77 \text{ kN}$$

$$N_k = \sum N_i = (20,82 + 22,45 + 23,80) + (31,54 + 33,54 + 34,77) = 67,07 + 99,85 = 166,92 \text{ kN} \quad 14$$

$$b) \quad N = -N_k = -166,92 \text{ kN}$$

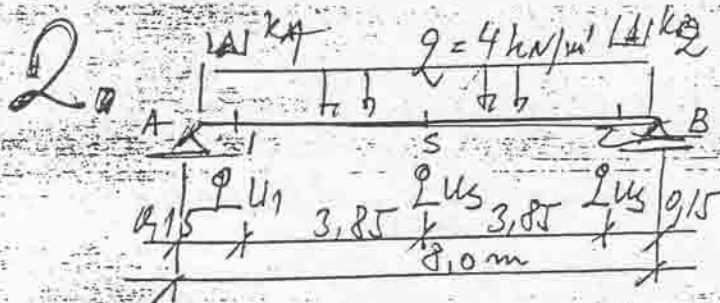
$$M_x = \sum_{i=1}^3 (N_{il} + N_{id}) \cdot e_{y_i} = (20,82 + 31,54) \cdot 12 + (22,45 + 33,54) \cdot 7 + (23,80 + 34,77) \cdot 2 = 1137,39 \text{ kNcm}$$

$$M_y = \sum_i (N_{id} - N_{il}) \cdot 10 = (\sum N_{id} - \sum N_{il}) \cdot 10 = (99,85 - 67,07) \cdot 10 = 32,78 \text{ kNcm}$$

$$\sigma_A = \frac{N}{A} + \frac{M_x}{W_x^A} + \frac{M_y}{W_y^A} = -\frac{166,92}{800} - \frac{1137,39}{16000} \cdot 3 + \frac{32,78}{16000} \cdot 3 = -0,209 - 0,213 + 0,006 = -0,416 \text{ kN/cm}^2$$

$$\epsilon_A = \frac{\sigma_A}{E_b} = -\frac{0,416}{935 \cdot 10^4} = -118,86 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}} = -0,119 \% \quad 14$$

(30)



Ст.	u_1	u_3	u_2	k_1	k_2
2-0	3.12	21.30	5.20	1452	1297
Ст.	3.12	21.30	5.20	1539.12	1374.82

$\rho_n = 0.01 \text{ mm}$ $\rho_k = 1.06$

$f_{d1} = 0.00746$

$f_{d2} = 0.00667$

Номерная поправка:

$u_A = u_1 - 150 \cdot f_{d1} = 3.12 - 150 \cdot 0.00746 = 3.12 - 1.12 = 2.0 \text{ mm}$

$u_B = u_2 - 150 \cdot f_{d2} = 5.20 - 150 \cdot 0.00667 = 5.20 - 1.00 = 4.20 \text{ mm}$

Смещение измеренный глуб средней поправки:

$u_{\text{ср}} = u_{\text{смер}} - \frac{u_A + u_B}{2} = 21.30 - \frac{2.0 + 4.2}{2} = 18.20 \text{ mm}$

Результатный глуб:

$u_{\text{гр}} = \frac{5}{384} \frac{ql^4}{EI} = \frac{5}{384} \cdot \frac{4 \cdot 8.0^4}{21.5740} = 0.0177 \text{ m} = 17.7 \text{ mm}$

$u_{\text{гр}} \leq u_{\text{смер}} \quad (-2.8\%)$

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3. Результаты измерения:

	0-1	0-2	0-3	к-к
Δ_1	5	-18	-8	+2
Δ_2	4	-17	-8	+2
$\Delta_{\text{ср}}$	4.5	-17.5	-8	+2
$\frac{\Delta_{\text{ср}}}{\Delta_{\text{ср}}}$	2.5	-19.5	-10	
ϵ	2.5	-19.5	-100	

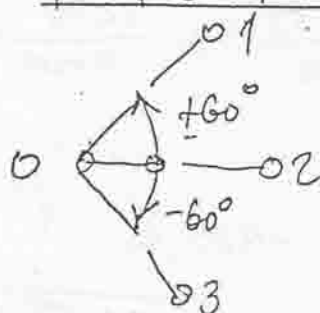
$\epsilon = (\Delta_{\text{ср}} - \Delta_{\text{к}}) \cdot \rho_{\text{ср}}$

$\rho_{\text{ср}} = 10 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$ за $l_{\text{макс}} = 100 \text{ mm}$

$\epsilon_f = 0.32 \cdot 10^4 \text{ kN/cm}^2$

$\nu_f = 0.15$

(+ ЗАТЕЗАБЕ)



$\epsilon_{0-1} = \epsilon_{+60} = 2.5 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$

$\epsilon_{0-2} = \epsilon_0 = -19.5 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$

$\epsilon_{0-3} = \epsilon_{-60} = -100 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$

$\epsilon_{1,2} = \frac{1}{3} (\epsilon_{60} + \epsilon_0 + \epsilon_{-60}) \pm \frac{1}{3} \sqrt{(2\epsilon_0 - \epsilon_{60} - \epsilon_{-60})^2 + 3(\epsilon_{60} - \epsilon_{-60})^2}$

$$10^6 \cdot E_{1,2} = \frac{1}{3} (25 - 195 - 100) \pm \frac{1}{3} \sqrt{(-2 \cdot 195 - 25 + 100)^2 + 3(-100 - 25)^2} =$$

$$= -90 \pm \frac{1}{3} \sqrt{(-315)^2 + 3(-125)^2} = -90 \pm 127,41$$

$$E_1 = (-90 + 127,41) \cdot 10^{-6} = 37,41 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$$

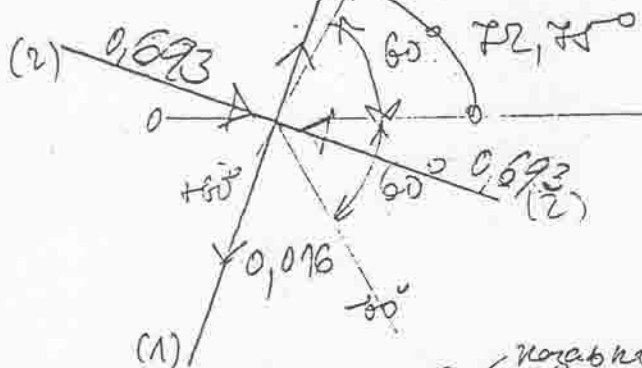
$$E_2 = (-90 - 127,41) \cdot 10^{-6} = -217,41 \cdot 10^{-6} \frac{\text{mm}}{\text{mm}}$$

$$\frac{1}{2} 2d\alpha^* = \left| \frac{E_{60} - E_0}{2E_0 - E_{60} - E_{60}} \right| \sqrt{3} = \left| \frac{-125}{-315} \right| \sqrt{3} = 0,68732$$

$$d\alpha^* = 17,25^\circ \Rightarrow \alpha_0 = 90 - d\alpha^* = 72,75^\circ$$

$$\sigma_1 = \frac{E}{1 - \nu^2} (E_1 + \nu E_2) = \frac{0,32 \cdot 10^4}{1 - 0,15^2} (37,41 - 0,15 \cdot 217,41) \cdot 10^{-6} = 0,016 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_2 = \frac{E}{1 - \nu^2} (E_2 + \nu E_1) = \frac{0,32 \cdot 10^4}{1 - 0,15^2} (-217,41 + 0,15 \cdot 37,41) \cdot 10^{-6} = -0,693 \frac{\text{kN}}{\text{cm}^2}$$



$$4. U_n = \frac{r_2}{r_1} \cdot \frac{r_4}{r_3} \cdot \frac{r_6}{r_5} \cdot \frac{r_8}{r_7} \quad \text{negative}$$

$$a) \left. \begin{array}{l} \Delta \tilde{C}_{\max} = 2000 \\ U_{\max} = O_u = 2 \text{ mm} \end{array} \right\} \Rightarrow U_n = \frac{\Delta \tilde{C}_{\max}}{O_u} = 1000$$

$$1000 = 2 \cdot 5 \cdot \left(\frac{r_6}{r_5} \right) \cdot 10 \Rightarrow \frac{r_6}{r_5} = \frac{1000}{100} = 10$$

$$b) \left. \begin{array}{l} U_n = 2 \cdot 5 \cdot 2 \cdot 5 = 100 \\ \Delta \tilde{C}_{\max} = 2000 \end{array} \right\} \Rightarrow O_u = \frac{\Delta \tilde{C}_{\max}}{U_n} = \frac{2000}{100} = 20 \text{ mm}$$

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