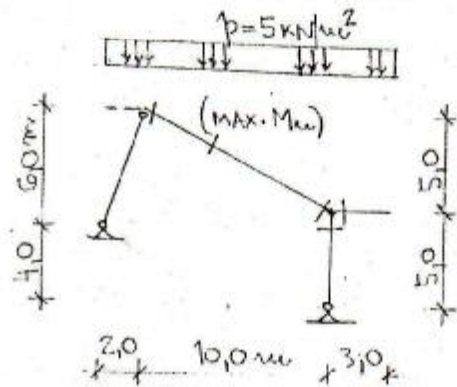
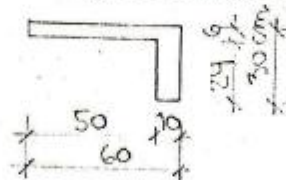


Statički sistem:



Detalj sedišta POS 4:



Za neko srednje polje konstrukcije na skici potrebno je:

1. Odrediti potrebnu armaturu za ploče POS 1 i POS 2 u karakterističnim presecima. Za usvojenu armaturu odrediti razmak i karakterističnu širinu prslina za ploču POS 2.
2. Sračunati statičke uticaje i nacrtati dijagrame sila u preseku za gredu POS 3, a zatim odrediti potrebnu armaturu za osiguranje oslonačkog preseka od glavnih napona zatezanja.
3. Odrediti potrebnu površinu armature za montažno sedišta POS 4, prikazano na posebnom detalju.
4. Izvršiti analizu opterećenja i nacrtati dijagrame sila u preseku od stalnog i korisnog opterećenja za POS 5, POS S1, POS S2.
5. Dimenzionisati gredu POS 5 u karakterističnim presecima prema M i N sračunatim u prethodnoj tački i po potrebi izvršiti osiguranje od glavnih napona zatezanja.
6. Dimenzionisati stub POS S1 u merodavnom preseku prema M i N. Sopstvenu težinu stuba zanemariti.
7. Odrediti potrebnu armaturu za stub POS S2 ($l_i = 1$).
8. Skicirati plan armature za POS 5, POS S1, POS S2 i prikazati karakteristične poprečne preseke.

Dimenzije:

POS 1, POS 2: $d_p = 12 \text{ cm}$

POS 5: $b/d = 30/80 \text{ cm}$

POS 3: $b/d = 50/80 \text{ cm}$

POS S1: $b/d = 30/d$ ($d = ?$)

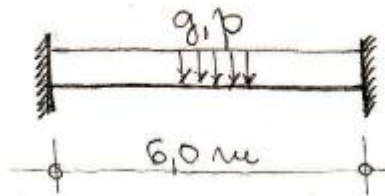
POS 4: prema skici

POS S2: $b/d = 30/30 \text{ cm}$

Zadate dimenzije ne menjati! Sva dimenzionisanja izvršiti po teoriji granične nosivosti, dosledno prema BAB 87.

POS 1 - КОНТИНУАЛНА ПЛОЧА

1.



$$q = 0,12 \cdot 25,0 = 3,0 \text{ kN/m}^2$$
$$p = 5,0 \text{ kN/m}^2$$

а) СТАЛНО ОПТЕРЕЋЕЊЕ

$$M_{q0} = 3,0 \cdot 6,0^2 / 12 = 9,0 \text{ kNm/m}^2$$

$$M_{qP} = 3,0 \cdot 6,0^2 / 24 = 4,5 \text{ kNm/m}^2$$

$$T_q = 3,0 \cdot 6,0 / 2 = 9,0 \text{ kN/m}^2$$

б) ПОВРЕМЕНО ОПТЕРЕЋЕЊЕ

$$M_{p0} = 5,0 \cdot 6,0^2 / 12 = 15,0 \text{ kNm/m}^2$$

$$M_{pP} = 5,0 \cdot 6,0^2 / 24 = 7,5 \text{ kNm/m}^2$$

$$T_p = 5,0 \cdot 6,0 / 2 = 15,0 \text{ kN/m}^2$$

ОСЛОЊАЦ:

$$b/d/r_v = 100/12/3,5 \text{ cm}$$

$$M_u = 1,6 \cdot 9,0 + 1,8 \cdot 15,0 = 41,4 \text{ kNm/m}^2$$

$$k_v = \frac{9,5}{\sqrt{\frac{41,4}{2,55}}} = 2,358 \longrightarrow \varepsilon_b/\varepsilon_a = 3,35/10\%$$
$$\bar{\mu} = 20,100\%$$

$$A_a = 20,100 \cdot 9,50 \cdot \frac{2,55}{40} = 12,17 \text{ cm}^2/\text{m}^2$$

УСВОЈЕНО $\boxed{R\phi 14/12,5}$ (12,32 cm²/m²)

$$A_{ap} = 0,2 \cdot 12,17 = 2,44 \text{ cm}^2/\text{m}^2$$

УСВОЈЕНО $\boxed{R\phi 8/20}$ (2,51 cm²/m²)

ПЛОЧЕ:

$$M_{uE} = 1,6 \cdot 4,50 + 1,8 \cdot 7,50 = 20,70 \text{ kNm/m}^2$$

$$k_v = \frac{9,5}{\sqrt{\frac{20,7}{2,55}}} = 3,334 \longrightarrow \varepsilon_b/\varepsilon_a = 1,8/10\%$$
$$\bar{\mu} = 9,610\%$$

$$A_a = 9,610 \cdot 9,50 \cdot \frac{2,55}{40,0} = 5,82 \text{ cm}^2/\text{m}^2$$

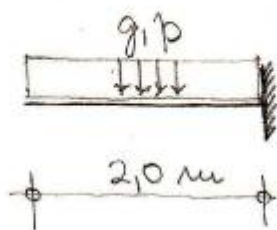
УСВОЈЕНО $\boxed{R\phi 10/12,5}$ (6,28 cm²/m²)

$$A_{ap} = 0,20 \cdot 5,82 = 1,16 \text{ cm}^2/\text{m}^2$$

$$\text{MIN. } A_{ap} = 0,085 \cdot 12,0 = 1,02 \text{ cm}^2/\text{m}^2$$

УСВОЈЕНО $\boxed{R\phi 8/30}$ (1,67 cm²/m²)

POS 2 — КОНЗОЛНА ПЛОЧА



$$q = 0,12 \cdot 25,0 = 3,0 \text{ kN/m}^2 \\ p = 5,0 \text{ kN/m}^2$$

а) СТАЛНО ОПТЕРЕЋЕЊЕ

$$M_g = 3,0 \cdot 2,0^2 / 2 = 6,0 \text{ kNm/m}^1$$

$$T_g = 3,0 \cdot 2,0 = 6,0 \text{ kN/m}^1$$

б) ПОВРЕМЕНО ОПТЕРЕЋЕЊЕ

$$M_p = 5,0 \cdot 2,0^2 / 2 = 10,0 \text{ kNm/m}^1$$

$$T_p = 5,0 \cdot 2,0 = 10,0 \text{ kN/m}^1$$

ДИМЕНЗИОНИСАЊЕ

$$M_u = 1,8 \cdot 6,0 + 1,8 \cdot 10,0 = 27,6 \text{ kNm/m}^1$$

$$b/d/r = 100/12/9,5 \text{ cm}$$

$$k_r = \frac{9,5}{\sqrt{\frac{27,60}{2,55}}} = 2,888$$

$$\varepsilon_b/\varepsilon_a = 2,25/10\% \\ \mu = 12,925\%$$

$$A_a = 12,925 \cdot 9,5 \cdot \frac{2,55}{40} = 7,83 \text{ cm}^2/\text{m}^1$$

УСВОЈЕНО

$$\boxed{R\phi 10/10} \quad (7,85 \text{ cm}^2/\text{m}^1)$$

$$A_{ap} = 0,20 \cdot 7,83 = 1,57 \text{ cm}^2/\text{m}^1$$

УСВОЈЕНО

$$\boxed{R\phi 8/30} \quad (1,67 \text{ cm}^2/\text{m}^1)$$

ПРОРАЧУН ПРСЛИНА

$$f_{sz,ef} = \text{MIN.} \left\{ \begin{array}{l} 2,5 + 7,5 \cdot 1,0 = 10,0 \text{ cm} \\ 12,0/2 = 6,0 \text{ cm} \end{array} \right\} = 6,0 \text{ cm}$$

$$\mu_{z,ef} = \frac{7,85}{100,0 \cdot 6,0} = 1,309\%$$

$$e_\phi = 10 \text{ cm}$$

$$a_0 = 2,5 - 1,0/2 = 2,0 \text{ cm}$$

$$k_1 = 0,4 \quad (\text{RA } 400/500)$$

$$k_2 = 0,125 \quad (\text{САБИЈАЊЕ})$$

$$l_{ps} = 2 \cdot (2,0 + \frac{10,0}{10}) + 0,4 \cdot 0,125 \cdot \frac{10}{1,309 \cdot 10^{-2}} = 9,82 \text{ cm}$$

$$\boxed{l_{ps} = 9,82 \text{ cm}}$$

$$\mu_1 = \frac{A_{a1}}{b \cdot h} = \frac{7,85}{100,0 \cdot 9,5} = 0,827\%$$

$$\mu_2 = 0$$

$$\eta = \frac{210}{34} = 6,18$$

$$s^2 + 2 \cdot 6,18 \cdot 0,827 \cdot 10^{-2} \cdot s - 2 \cdot 6,18 \cdot 0,827 \cdot 10^{-2} = 0$$

$$s^2 + 0,102 \cdot s - 0,102 = 0 \quad \rightarrow \quad \boxed{s = 0,273}$$

$$z_B = R \left(1 - \frac{s}{3}\right) = \left(1 - \frac{0,273}{3}\right) \cdot 9,5 = 8,64 \text{ cm}$$

$$M = M_g + M_p = 6,0 + 10,0 = 16,0 \text{ kNm/m'}$$

$$\sigma_{a1} = \frac{16,0 \cdot 10^2}{8,64 \cdot 7,85} = 235,9 \text{ kN/cm}^2 = 235,9 \text{ MPa}$$

$$\epsilon_{a1} = \frac{235,9}{210 \cdot 10^3} = 1,123\%$$

$$f_{B25} = 0,7 \cdot 2,9 \cdot \left(0,6 + \frac{0,4}{\sqrt{0,12}}\right) = 2,60 \text{ MPa} = 0,26 \text{ kN/cm}^2$$

$$W_{B1} = \frac{100,0 \cdot 12,0^2}{6} = 2400 \text{ cm}^3$$

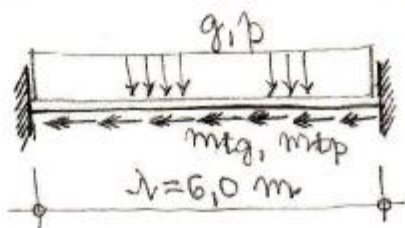
$$M^* \approx 0,26 \cdot 2400,0 \cdot 10^{-2} = 6,23 \text{ kNm/m'}$$

$$\left. \begin{array}{l} \beta_1 = 1,0 \text{ (RA 400/500)} \\ \beta_2 = 1,0 \text{ (}\xi = 0\text{)} \end{array} \right\} \xi_a = 1 - 1,0 \cdot 1,0 \cdot \left(\frac{6,23}{16,0}\right)^2 = 0,848$$

$$a_{pk} = 1,7 \cdot 0,848 \cdot 1,123 \cdot 10^{-3} \cdot 9,82 \text{ cm} = 15,9 \cdot 10^{-3} \text{ cm}$$

$$\boxed{a_{pk} = 0,159 \text{ mm}} < a_{pk, \text{dop.}} = 0,2 \text{ mm}$$

POS 3 — КОНТИНУАЛНА ГРЕДА



— СОПСТВЕНА ТЕЖИНА ГРЕДЕ: $0,50 \cdot 0,80 \cdot 25,0 = 10,0 \text{ kN/m'}$
 — СТАЛНО ОПТЕРЕТЕЊЕ СА POS 2: $R_{g2} = 6,0 \text{ kN/m'}$

— КОРИСНО ОПТЕРЕТЕЊЕ СА POS 2:

$R_{p2} =$

$$\boxed{g = 16,0 \text{ kN/m'}}$$

$$\boxed{p = 10,0 \text{ kN/m'}}$$

— ПОДЕЉЕНИ МОМЕНТИ ТОРЗИЈЕ:

$$\boxed{m_{tg} = M_{g2} = 6,0 \text{ kNm/m'}}$$

$$\boxed{m_{tp} = M_{p2} = 10,0 \text{ kNm/m'}}$$

а) СТАЛНО ОПТЕРЕЋЕЊЕ

$$M_g^o = 16,0 \cdot 6,0^2 / 12 = 48,0 \text{ kNm}$$

$$M_g^p = 16,0 \cdot 6,0^2 / 24 = 24,0 \text{ kNm}$$

$$T_g = 16,0 \cdot 6,0 / 2 = 48,0 \text{ kN}$$

$$M_{Tg} = 6,0 \cdot 6,0 / 2 = 18,0 \text{ kNm}$$

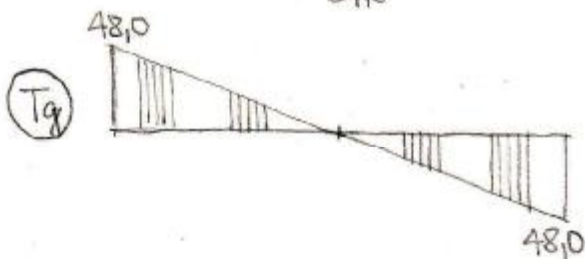
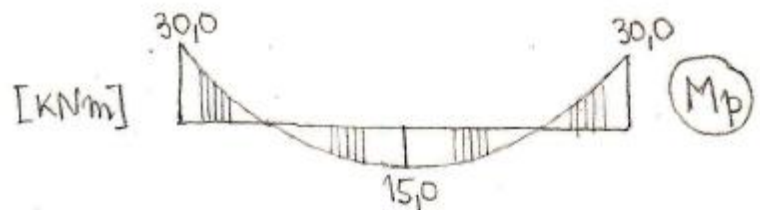
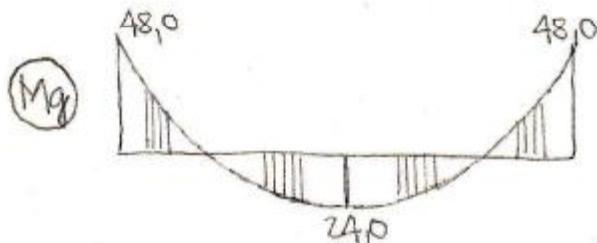
б) ПОВРЕМЕНО ОПТЕРЕЋЕЊЕ

$$M_p^o = 10,0 \cdot 6,0^2 / 12 = 30,0 \text{ kNm}$$

$$M_p^p = 10,0 \cdot 6,0^2 / 24 = 15,0 \text{ kNm}$$

$$T_p = 10,0 \cdot 6,0 / 2 = 30,0 \text{ kN}$$

$$M_{Tp} = 10,0 \cdot 6,0 / 2 = 30,0 \text{ kNm}$$

ОСИГУРАЊЕ ОД ГЛАВНИХ НАПОНА ЗАТЕЗАЊА

$$M_{Tc} = 1,6 \cdot 18,0 + 1,8 \cdot 30,0 = 82,8 \text{ kNm}$$

$$T_{c} = 1,6 \cdot 48,0 + 1,8 \cdot 30,0 = 130,8 \text{ kN}$$

$$b/d/h = 50/80/75 \text{ cm}$$

$$z = 0,9 \cdot 75,0 = 67,5 \text{ cm}$$

$$A_{b0} = (50,0 - 2 \cdot 4,0) \cdot (80,0 - 2 \cdot 4,0) = 42,0 \cdot 72,0 = 3024 \text{ cm}^2$$

$$O_{b0} = 2 \cdot (42 + 72) = 228,0 \text{ cm}$$

$$\delta \leq \frac{d_{bc}}{8} = \frac{42,0}{8} = 5,25 \text{ cm} \rightarrow \text{УСВОЈЕНО } \delta = 5,0 \text{ cm}$$

$$\left. \begin{aligned} \tau_{n,T} &= \frac{130,8}{50,0 \cdot 67,5} = 0,039 \text{ kN/cm}^2 \\ \tau_{n,MT} &= \frac{82,8 \cdot 10^2}{2 \cdot 3024 \cdot 5,0} = 0,274 \text{ kN/cm}^2 \end{aligned} \right\} \tau_n = 0,313 \frac{\text{kN}}{\text{cm}^2} > \tau_c = 0,13 \text{ kN/cm}^2 < 3\tau_c$$

$$T_{bc} = \frac{1}{2} \cdot \frac{0,039}{0,313} \cdot (3 \cdot 0,13 - 0,313) \cdot 50,0 \cdot 67,5 = 16,20 \text{ kN}$$

$$T_{Ru} = 130,8 - 16,2 = 114,6 \text{ kN}$$

$$\tau_{Ru} = \frac{114,6}{50,0 \cdot 67,5} = 0,034 \text{ kN/cm}^2$$

$$M_{T\beta u} = \frac{0,274}{0,313} \cdot (3,013 - 0,313) \cdot 3024,0 \cdot 5,0 \cdot 10^{-2} = 10,26 \text{ kNm}$$

$$M_{TKu} = 82,8 - 10,26 = 72,54 \text{ kNm}$$

ЗАЈЕДНИЧКЕ УЗЕЦТИЈЕ : $\theta = 45^\circ$; $\alpha = 90^\circ$:

$$a_{e1}^{(1)} = \left(\frac{0,034 \cdot 50}{2 \cdot 40,0} + \frac{72,54 \cdot 10^2}{2 \cdot 3024 \cdot 40,0} \right) \cdot e_u = (0,021 + 0,030) \cdot e_u = 0,051 \cdot e_u$$

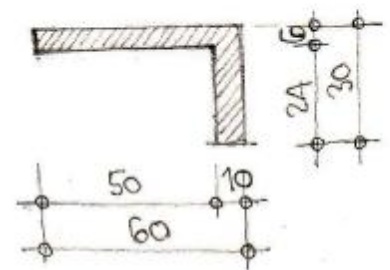
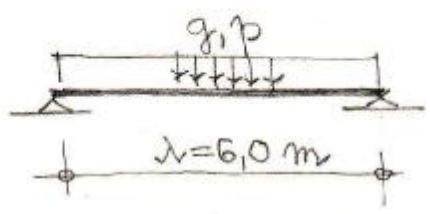
$$UR\emptyset 10 : a_{e1}^{(1)} = 0,785 \text{ cm}^2 \rightarrow e_u \leq \frac{0,785}{0,051} = 15,3 \text{ cm}$$

УСВОЈЕНО : UR \emptyset 10/15

$$Z_{Aa} = \frac{M_{TKu}}{2 \cdot A_{\beta 0} \cdot \beta v} \cdot 0_{\beta 0} = \frac{82,8 \cdot 10^2}{2 \cdot 3024,0 \cdot 40,0} \cdot 228,0 = 7,80 \text{ cm}^2$$

УСВОЈЕНО : 10 R \emptyset 10 (7,85 cm²)

POS 4 — МОНТАЖНО СЕДИШТЕ



$$A_{\beta} = 60,0 \cdot 30,0 - 50,0 \cdot 24,0 = 600,0 \text{ cm}^2$$

$$g = A_{\beta} \cdot \gamma_{\beta} = 600,0 \cdot 10^{-4} \cdot 25,0 = 1,50 \text{ kN/cm}^1$$

$$p = 0,60 \cdot 5,00 = 3,00 \text{ kN/cm}^1$$

$$R_g = 1,50 \cdot 6,0 / 2 = 4,5 \text{ kN}$$

$$M_g = 1,50 \cdot 6,0^2 / 8 = 6,75 \text{ kNm}$$

$$R_p = 3,00 \cdot 6,0 / 2 = 9,0 \text{ kN}$$

$$M_p = 3,0 \cdot 6,0^2 / 8 = 13,5 \text{ kNm}$$

$$M_{ku} = 1,6 \cdot 6,75 + 1,8 \cdot 13,5 = 35,1 \text{ kNm}$$

$$B = \min \left\{ \begin{array}{l} 10,0 + 8 \cdot 6,0 = 58,0 \text{ cm} \\ 10,0 + \frac{1}{3} \cdot 0,25 \cdot 600,0 = 60,0 \text{ cm} \\ 60 \text{ cm} \end{array} \right\} = 58 \text{ cm}$$

$$B/d/h = 58,0 / 30,0 / 25,0 \text{ cm}$$

$$f_{\beta} = 0,9 \cdot 2,55 = 2,295 \text{ kN/cm}^2$$

$$k_v = \frac{25,0}{\sqrt{\frac{35,1 \cdot 10^2}{58,0 \cdot 2,295}}} = 4,868 \rightarrow \begin{array}{l} E_{\beta}/E_a = 1,1/10\% \\ \bar{\mu} = 4,451\% \\ \delta = 0,099 \end{array}$$

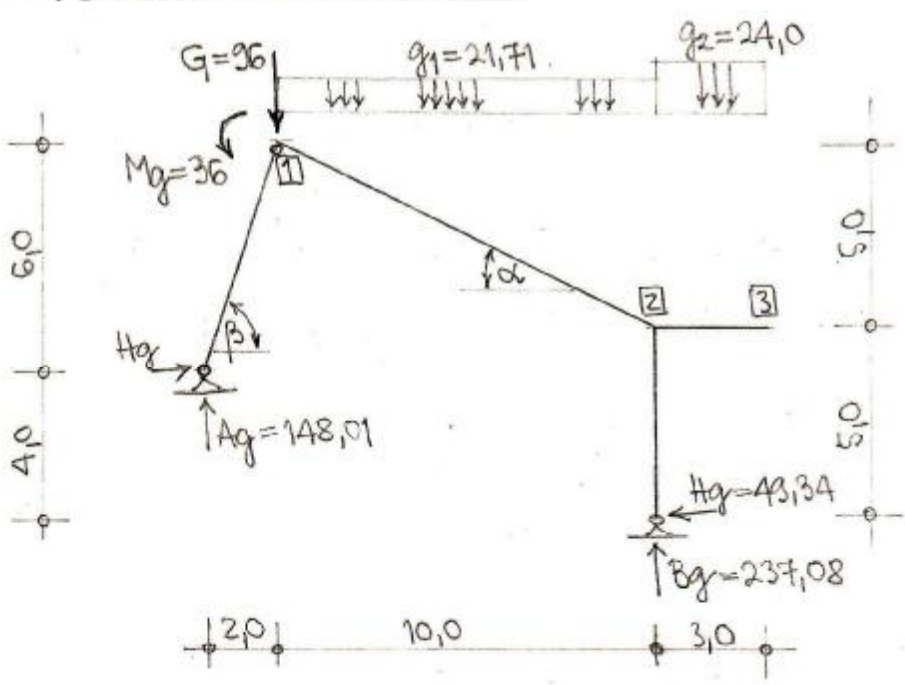
$$\delta \cdot h = 0,099 \cdot 25,0 = 2,5 \text{ cm} < d_p = 6,0 \text{ cm}$$

$$A_a = 4,451 \cdot \frac{25,0 \cdot 58,0}{100} \cdot \frac{2,295}{40,0} = 3,70 \text{ м}^2$$

УСВОЈЕНО 1RØ22 (3,80 м²)

POS 5, POS S1, POS S2

а) СТАЛНО ОПТЕРЕЋЕЊЕ



$$\begin{aligned} \operatorname{tg} \alpha &= \frac{5,0}{10,0} = 0,50 \\ \alpha &= 26,57^\circ \\ \cos \alpha &= 0,894 \\ \operatorname{tg} \beta &= \frac{6,0}{2,0} = 3,0 \\ \beta &= 71,57^\circ \end{aligned}$$

ДЕО 1-2:

- СОПСТВЕНА ТЕЖИНА: $\frac{0,30 \cdot 0,80 \cdot 25,0}{0,894} = 6,71 \text{ кН/м'}$
- ОД СЕДИШТА POS 4: $\frac{2Rg_4}{B_4} = \frac{2 \cdot 4,50}{0,60} = 15,0 \text{ кН/м'}$

$g_1 = 21,71 \text{ кН/м'}$

ДЕО 2-3:

- СОПСТВЕНА ТЕЖИНА: $0,30 \cdot 0,80 \cdot 25,0 = 6,0 \text{ кН/м'}$
- ОД ПЛОЧЕ POS 1: $2Rg_1 = 2 \cdot 9,0 = 18,0 \text{ кН/м'}$

$g_2 = 24,0 \text{ кН/м'}$

УТИЦАЈ POS 3:

$$\begin{aligned} G &= 2Rg_3 = 2 \cdot 48,0 = 96,0 \text{ кН} \\ M_b &= 2Mtg_3 = 2 \cdot 18,0 = 36,0 \text{ кНм} \end{aligned}$$

$$A_g = H_g \cdot \operatorname{tg} \beta = 3,0 \cdot H_g$$

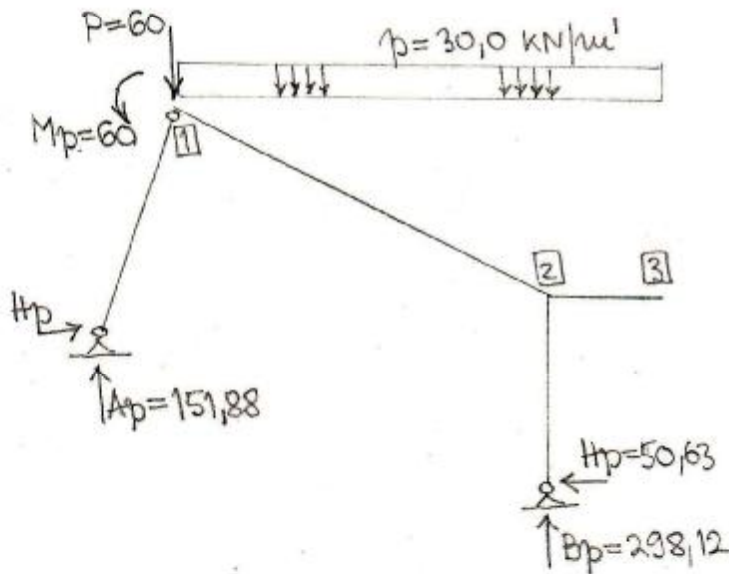
$$12,0 \cdot A_g + 4,0 \cdot H_g = 36,0 + 96,0 \cdot 10,0 + 21,71 \cdot \frac{10,0^2}{2} - 24,0 \cdot \frac{3,0^2}{2}$$

$$40 \cdot H_g = 1973,41 \text{ кН}$$

$$\sum V_g = 21,71 \cdot 10,0 + 96,0 + 24,0 \cdot 3,0 = 385,08 \text{ kN}$$

$A_g = 148,01 \text{ kN}$ $B_g = 237,08 \text{ kN}$ $H_g = 49,34 \text{ kN}$
--

δ) ПОВРЕМЕНО ОПТЕРЕЋЕЊЕ



ΔEO 1-2:

$$p_1 = \frac{2R_{p4}}{B_4} = \frac{2 \cdot 9,0}{0,60} = 30,0 \text{ kN/m}^1$$

ΔEO 2-3:

$$p_2 = 2R_{p1} = 2 \cdot 15,0 = 30,0 \text{ kN/m}^1 = p_1$$

$$\left. \begin{aligned} P &= 2R_{p3} = 2 \cdot 30,0 = 60,0 \text{ kN} \\ M_p &= 2M_{Tp3} = 2 \cdot 30,0 = 60,0 \text{ kNm} \end{aligned} \right\} \text{УТИЦАЈ СА ПОС 3}$$

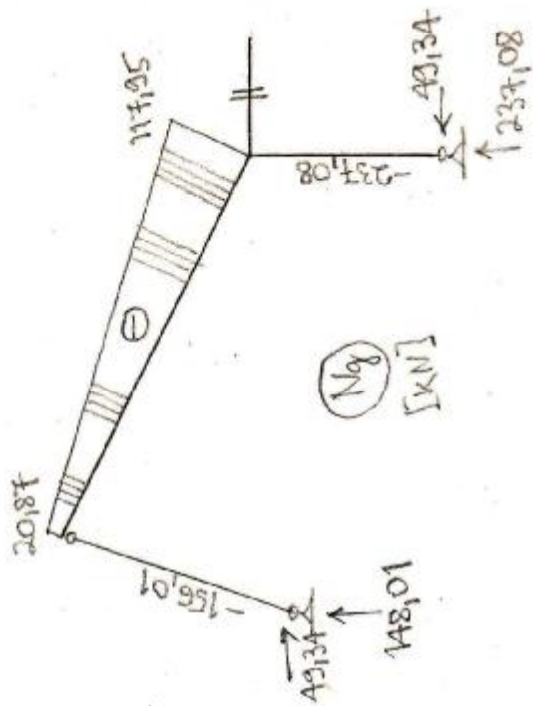
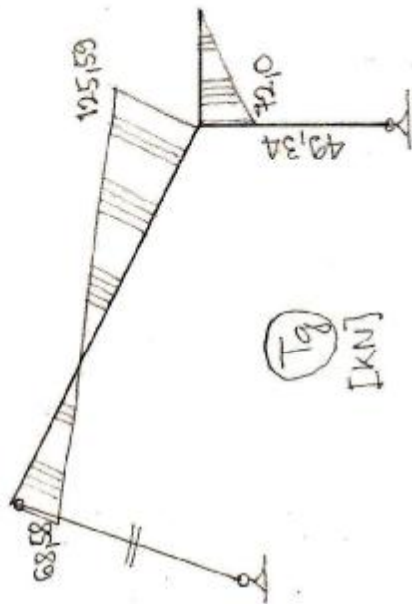
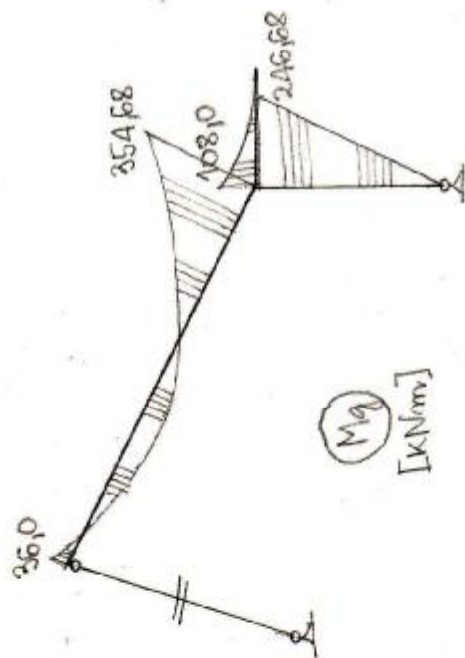
$$\sum V_p = 60,0 + 30,0 \cdot 13,0 = 450,0 \text{ kN}$$

$$12 \cdot A_p + 4 \cdot H_p = 60,0 + 60,0 \cdot 10,0 + 30,0 \cdot 13,0 \cdot (6,50 - 3,0) = 2025 \text{ kNm}$$

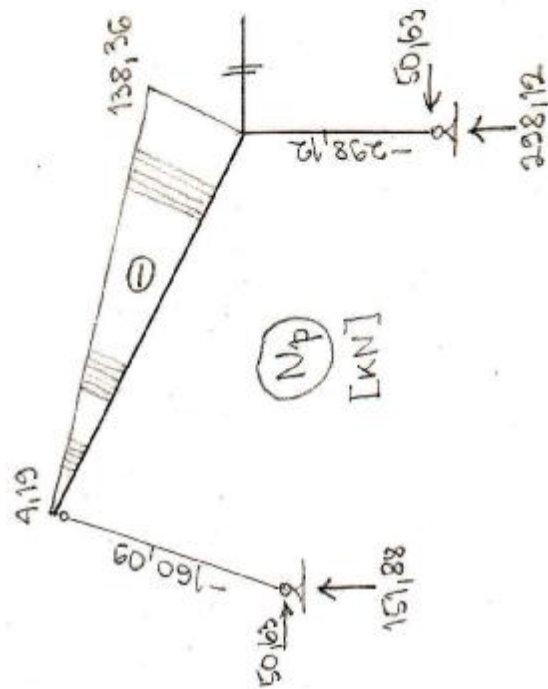
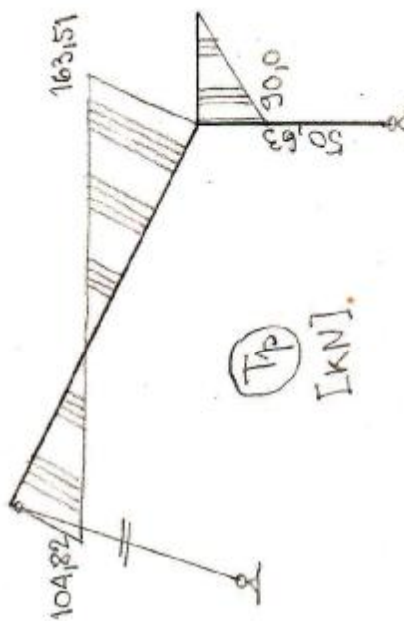
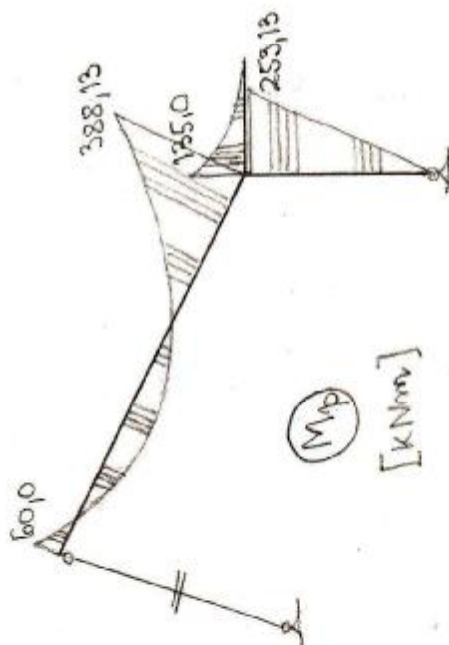
$$A_p = H_p \cdot \operatorname{tg} \beta = 3,0 \cdot H_p \rightarrow 40 \cdot H_p = 2025,0$$

$A_p = 151,88 \text{ kN}$ $B_p = 298,12 \text{ kN}$ $H_p = 50,63 \text{ kN}$
--

α) ΣΤΑΘΟ ΟΠΤΕΡΕΪΜΕ



δ) ΠΟΒΡΕΜΟ ΟΠΤΕΡΕΪΜΕ



ДИМЕНЗИОНИСАЊЕ

ПРЕСЕК 1-1

$$M_u = 1,6 \cdot 354,68 + 1,8 \cdot 388,13 = 1266,1 \text{ kNm}$$

$$N_u = 1,6 \cdot 117,95 + 1,8 \cdot 138,36 = 437,8 \text{ kN}$$

$$b/d/h = 30/80/71 \text{ cm}$$

$$M_{all} = 1266,1 + 437,8 \cdot \left(\frac{0,80}{2} - 0,09 \right) = 1401,8 \text{ kNm}$$

$$k_f = \frac{71,0}{\sqrt{\frac{1401,8}{0,30 \cdot 2,55}}} = 1,659 \longrightarrow \varepsilon_b / \varepsilon_{a1} = 3,5 / 2,35\%$$

$\varepsilon_{a1} < 3\% \longrightarrow$ ЛВОСТРУКО АРМИРАЊЕ

УСВОЈЕНО: $\varepsilon_b / \varepsilon_{a1} = 3,5 / 5,0\% \longrightarrow k_f = 1,903$
 $\mu = 33,332\%$

$$M_{abv} = \left(\frac{71,0}{1,903} \right)^2 \cdot 0,30 \cdot 2,55 = 1064,9 \text{ kNm}$$

$$\Delta M_{all} = 1401,8 - 1064,9 = 336,9 \text{ kNm}$$

ПРЕТП. $a_2 = 5,0 \text{ cm}$

$$A_{a1} = 33,332 \cdot \frac{30,0 \cdot 71,0 \cdot 2,55}{100 \cdot 40} + \frac{336,9 \cdot 10^2}{40 \cdot (71-5)} - \frac{437,8}{40} = 47,08 \text{ cm}^2$$

УСВОЈЕНО 10 R ϕ 25 (49,09 cm²)

$$A_{a2} = \frac{336,9 \cdot 10^{-2}}{40 \cdot (71-5)} = 12,76 \text{ cm}^2$$

УСВОЈЕНО 4 R ϕ 22 (15,21 cm²)

ПРЕСЕК 2-2

$$M_u = 1,6 \cdot 108,0 + 1,8 \cdot 135,0 = 415,8 \text{ kNm}$$

$$b/d/h = 30/80/75 \text{ cm}$$

$$k_f = \frac{75,0}{\sqrt{\frac{415,8}{0,30 \cdot 2,55}}} = 3,217 \longrightarrow \varepsilon_b / \varepsilon_a = 1,9 / 10\%$$

$\mu = 10,365\%$

$$A_a = 10,365 \cdot \frac{30,0 \cdot 75,0 \cdot 2,55}{100 \cdot 40} = 14,87 \text{ cm}^2$$

УСВОЈЕНО 4 R ϕ 22 (15,21 cm²)

ПРЕСЕК 3-3

$$M_u = 1,6 \cdot 36,0 + 1,8 \cdot 60,0 = 165,6 \text{ kNm}$$

$$N_u = 1,6 \cdot 20,87 + 1,8 \cdot 4,19 = 40,93 \text{ kN}$$

$$b/d/h = 30/80/75 \text{ cm}$$

$$M_{au} = 165,6 + 40,93 \cdot \left(\frac{0,80}{2} - 0,05 \right) = 179,9 \text{ kNm}$$

$$k = \frac{75,0}{\sqrt{\frac{179,9}{0,30 \cdot 2,55}}} = 4,890 \longrightarrow \varepsilon_b/\varepsilon_a = 1,1/10\%$$

$$\bar{\mu} = 4,451\%$$

$$A_a = 4,451 \cdot \frac{30 \cdot 0,750}{100} \cdot \frac{2,55}{40} - \frac{40,93}{40} = 5,36 \text{ cm}^2$$

$$\text{MIN. } A_a = 0,20 \cdot \frac{30 \cdot 80}{100} = 4,8 \text{ cm}^2 < \text{ПОТР. } A_a = 5,36 \text{ cm}^2$$

УСЛОВИЕНО 2R ϕ 19 (5,67 cm²)

ПРЕСЕК 4-4 (МЕСТО MAX. M_u)

$$q_u = 1,6 \cdot 21,71 + 1,8 \cdot 30,0 = 88,73 \text{ kN/m}^2$$

$$T_u^{(3)} = 1,6 \cdot 68,58 + 1,8 \cdot 104,82 = 298,4 \text{ kN}$$

$$M_u^{(3)} = -165,6 \text{ kNm}$$

$$M_u = -165,6 + 298,4 \cdot \frac{x}{0,894} - 88,73 \cdot \frac{x^2}{2}$$

$$\frac{dM_u}{dx} = 0 \longrightarrow \frac{298,4}{0,894} - 88,73 \cdot x = 0 \longrightarrow x = 3,76 \text{ m}$$

$$\text{MAX. } M_u = -165,6 + 298,4 \cdot \frac{3,76}{0,894} - 88,73 \cdot \frac{3,76^2}{2} = 461,6 \text{ kNm}$$

$\text{MAX. } M_u = 461,6 \text{ kNm}$

$$\text{ОДГ. } N_u = \frac{N_u^{(1)} - N_u^{(3)}}{10,0} \cdot x + N_u^{(3)} = \frac{437,8 - 40,9}{10} \cdot 3,76 + 40,9 = 190,15 \text{ kN}$$

$\text{ОДГ. } N_u = 190,15 \text{ kN}$

$$b/d/h = 30/80/75 \text{ cm}$$

$$M_{au} = 461,6 + 190,15 \cdot \left(\frac{0,80}{2} - 0,05 \right) = 528,15 \text{ kNm}$$

$$k = \frac{75,0}{\sqrt{\frac{528,15}{0,30 \cdot 2,55}}} = 2,854 \longrightarrow \varepsilon_b/\varepsilon_a = 2,3/10\%$$

$$\bar{\mu} = 13,273\%$$

$$A_a = 13,279 \cdot \frac{30,0 \cdot 75,0}{100} + \frac{2,55}{40} = \frac{190,15}{40} = 4,29 \text{ см}^2$$

УСВОЈЕНО $\boxed{4R\phi 22}$ (15,21 см²)

КОНТРОЛ ПЛАВНИХ НАПОНА ЗАТЕЗАЊА

$$T_u^1 = 1,6 \cdot 125,59 + 1,8 \cdot 163,51 = 495,26 \text{ kN} \approx T_{mu}$$

(ЗАПЕМАРЕНА ПРОМЕНА НОРМАЛНЕ СИЛЕ ДУЖ ОСЕ ШТАПА)

$$T_m^1 = \frac{495,26}{30,0 \cdot 0,9 \cdot 71,0} = 0,258 \text{ kN/cm}^2 > T_c = 0,13 \text{ kN/cm}^2 < 3T_c$$

$$T_{cu} = \frac{1}{2} \cdot (3 \cdot 0,13 - 0,258) \cdot 30,0 \cdot 0,9 \cdot 71,0 = 126,2 \text{ kN}$$

$$T_{ku} = 495,26 - 126,2 = 369,06 \text{ kN}$$

$$T_{ku}^1 = \frac{369,06}{30,0 \cdot 0,9 \cdot 71,0} = 0,193 \text{ kN/cm}^2$$

$$\bar{\lambda} = \lambda_0 \cdot \left(1 - \frac{T_c}{T_m^1}\right) = (10,0 - 3,76) \cdot \left(1 - \frac{0,13}{0,258}\right) = 3,10 \text{ m}$$

$$\lambda = \bar{\lambda} / \cos \alpha = 3,10 / 0,894 = 3,47 \text{ m (по косинусу дужици)}$$

ВЕРТИКАЛНЕ УЗЕГНИЈЕ : $m=2$, $\alpha=90^\circ$; $\theta=45^\circ$:

$$a_{se}^{(1)} = \frac{T_{ku} \cdot b}{m \cdot b_v} \cdot e_u = \frac{0,193 \cdot 30,0}{2 \cdot 40,0} \cdot e_u = 0,072 \cdot e_u$$

$$UR\phi 10 : a_{se}^{(1)} = 0,785 \text{ см}^2 \rightarrow e_u \leq \frac{0,785}{0,072} = 10,88 \text{ см}$$

УСВОЈЕНО : $\boxed{UR\phi 10/10}$ ($m=2$)

ПРЕСЕК 3-3

$$T_u^3 = 1,6 \cdot 68,58 + 1,8 \cdot 104,82 = 298,4 \text{ kN}$$

$$T_m^3 = \frac{298,4}{30,0 \cdot 0,9 \cdot 75} = 0,147 \text{ kN/cm}^2 > T_c = 0,13 \text{ kN/cm}^2$$

$$\bar{\lambda} = 3,76 \cdot \left(1 - \frac{0,13}{0,147}\right) = 0,44 \text{ m} \rightarrow \lambda = \frac{0,44}{0,894} = 0,50 \text{ m}$$

$$T_{ku}^3 = \frac{3}{2} \cdot (0,147 - 0,13) = 0,026 \text{ kN/cm}^2$$

$$UR\phi 8 : a_{se}^{(1)} = 0,503 \text{ см}^2$$

$$e_u \leq \frac{2 \cdot 0,503}{30,0 \cdot 2 \cdot 10^{-2}} = 16,8 \text{ см}$$

УСВОЈЕНО $\boxed{UR\phi 8/15}$ ($m=2$)

$$T_{ku} = \frac{2 \cdot 0,503}{30,0 \cdot 15,0} \cdot 40,0 = 0,089 \text{ kN/cm}^2 > T_{ku}^3 = 0,026 \text{ kN/cm}^2$$

POS 51

$$M_{u1} = 1,6 \cdot 246,68 + 1,8 \cdot 253,13 = 850,3 \text{ kNm}$$

$$N_{u1} = 1,6 \cdot 237,08 + 1,8 \cdot 238,12 = 915,9 \text{ kN}$$

$$b = 30 \text{ cm}; \quad d = ?$$

$$\text{УСВАЈАМО: } \varepsilon_s / \varepsilon_{sy} = 3,5 / 5,0 \% \rightarrow \begin{aligned} k &= 1,903 \\ \mu &= 33,332\% \end{aligned}$$

1. КОРАК: $M_{u1} = M_u = 850,3 \text{ kNm}$

$$\text{ПОТР. } h_r = 1,903 \cdot \sqrt{\frac{850,3}{0,30 \cdot 2,55}} = 69,4 \text{ cm}$$

$$\text{ПОТР. } d_{I1} = h_r + 6,0 = 69,4 \sim 70 \text{ cm}$$

2. КОРАК: $M_{u1} = 850,3 + 915,9 \cdot \left(\frac{0,70}{2} - 0,06\right) = 1116,0 \text{ kNm}$

$$\text{ПОТР. } h_r = 1,903 \cdot \sqrt{\frac{1116,0}{0,30 \cdot 2,55}} = 72,7 \text{ cm}$$

$$d_{II} \gg 72,7 + 6,0 = 78,7 \text{ cm} \rightarrow d_{II} = 80 \text{ cm}$$

3. КОРАК: $M_{u1} = 850,3 + 915,9 \cdot \left(\frac{0,80}{2} - 0,06\right) = 1161,7 \text{ kNm}$

$$\text{ПОТР. } h_r = 1,903 \cdot \sqrt{\frac{1161,7}{0,30 \cdot 2,55}} = 74,1 \text{ cm}$$

$$d_{III} \gg 74,1 + 6,0 = 80,1 \text{ cm} \approx d_{II} = 80 \text{ cm}$$

УСВОЈЕНО

$$\boxed{d = 80 \text{ cm}}$$

$$\text{ПОТР. } A_s = 33,332 \cdot \frac{30,0 \cdot 74,1}{100} \cdot \frac{2,55}{40} - \frac{915,9}{40} = 24,38 \text{ cm}^2$$

$$\text{УСВОЈЕНО } \boxed{6R\phi 25} \quad (29,45 \text{ cm}^2)$$

$$T_u = 1,6 \cdot 49,34 + 1,8 \cdot 50,63 = 170,1 \text{ kN}$$

$$T_n = \frac{170,1}{30,0 \cdot 0,9 \cdot 74,0} = 0,085 \text{ kN/cm}^2 < T_{r2} = 0,13 \text{ kN/cm}^2$$

НИЈЕ ПОТРЕБНА РАЧУНСКА АРМАТУРА ЗА ПРИХВАТАЊЕ ГЛАВНИХ НАПОНА ЗАТЕЗАЊА.

$$\left. \begin{aligned} l_i = l = 6,33 \text{ m} \\ i_{\text{MIN.}} = \frac{30}{\sqrt{12}} = 8,66 \text{ cm} \end{aligned} \right\} \lambda = \frac{633}{8,66} = 73,0$$

$$e_0 = \frac{l_i}{300} = \frac{633,0}{300} = 2,11 \text{ cm}$$

$$e_g = e_p = 0$$

$$J_B = 30,0 \cdot 30,0^3 / 12 = 67500 \text{ cm}^4$$

$$N_E = E_B \cdot J_B \cdot \frac{f^2}{l_i^2} = 34,0 \cdot 10^6 \cdot 67500 \cdot 10^{-8} \cdot \frac{f^2}{6,33^2} = 5662,7 \text{ kN}$$

$$\alpha_E = \frac{N_g}{N_E} = \frac{156,01}{5662,7} = 0,028 \quad \left. \vphantom{\alpha_E} \right\} e_y = 2,11 \cdot \left(e^{\frac{0,028}{1-0,028} \cdot 2,16} - 1 \right) = 0,16 \text{ cm}$$

$$y_{\infty} = 2,6$$

$$e_d = 30,0 \cdot \frac{73,0 - 25}{100} \cdot \sqrt{0,10 + 0} = 4,56 \text{ cm}$$

$$e = 2,11 + 0,16 + 4,56 = 6,83 \text{ cm}$$

$$N_u = 1,9 \cdot 156,01 + 2,1 \cdot 160,09 = 632,6 \text{ kN}$$

$$M_u = 632,6 \cdot 6,83 \cdot 10^{-2} = 43,18 \text{ kNm}$$

$$m_u = \frac{632,6}{30 \cdot 30 \cdot 2,55} = 0,276$$

$$m_{u1} = \frac{43,18 \cdot 10^2}{30 \cdot 30^2 \cdot 2,55} = 0,063$$

$$\left. \begin{aligned} A_{a2} &= A_{a1} \\ a/d &= 4,5/30 = 0,15 \\ RA &400/500 \end{aligned} \right\}$$

$$\downarrow \text{ДИАГРАМ } 2,4,12. \rightarrow \bar{m}_1 = \bar{m}_2 = 0$$

$$\sigma_k = 1,4 \cdot 10,0 - 0,4 \cdot (10,0 - 1) \cdot \frac{73,0}{125} = 8,34 \text{ MPa} = 0,834 \text{ kN/cm}^2$$

$$\mu = \frac{73,0}{50} - 0,4 = 1,061\%$$

$$N = N_g + N_p = 156,01 + 160,09 = 316,1 \text{ kN}$$

$$A_{B, \text{ПOTP.}} = \frac{316,1}{0,834 \cdot (1 + 10 \cdot 1,061 \cdot 10^{-2})} = 343 \text{ cm}^2 < 900 \text{ cm}^2 = A_B, \text{CTB.}$$

$$A_a = \min \left\{ \begin{aligned} 1,061 \cdot 10^{-2} \cdot 343,0 &= 3,63 \text{ cm}^2 \\ 0,3 \cdot 10^{-2} \cdot 900,0 &= 2,70 \text{ cm}^2 \\ 4\phi 12 &= 4,52 \text{ cm}^2 \end{aligned} \right\} = 4\phi 12$$

УСЛОВИЕНО 4R ϕ 12 (4,52 cm²)

$$\text{MAX. } e_u = 15 \cdot 1,2 = 18 \text{ cm}$$

УСЛОВИЕНО

U ϕ 6/15