



Studijski program:

**Građevinarstvo**

Godina/Semestar:

**III godina / V semestar**

Naziv predmeta (šifra):

**Teorija betonskih konstrukcija 1  
(B3O3B1)**

Nastavnik:

**Jelena Carević / Stefan Ž. Mitrović / Milica Vidović**

Naslov vežbi:

**Kombinacije opterećenja. Centrično  
zatezanje. Mali ekscentricitet- sila  
zatezanja**

Datum :

**06.11.2024.**

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*Beograd, 2023.*

*Sva autorska prava autora prezentacije i/ili video snimaka su zaštićena. Snimak ili prezentacija se mogu koristiti samo za nastavu studenta Građevinskog fakulteta Univerziteta u Beogradu u školskoj 2023/2024 i ne mogu se koristiti za druge svrhe bez pismene saglasnosti autora materijala.*



## Zadatak 20 – KOMBINOVANJE OPTEREĆENJA

*Odrediti potrebnu površinu armature za stub poznatih dimenzija, pravougaonog poprečnog preseka, koji je opterećen momentima savijanja usled stalnog ( $M_G$ ) i opterećenja vetrom ( $M_w$ ). Podaci za proračun:*

$$M_G = 100 \text{ kNm}$$

$$M_w = \pm 200 \text{ kNm}$$

$$b = 25 \text{ cm}$$

$$h = 65 \text{ cm}$$

*C25/30*

*B500B*

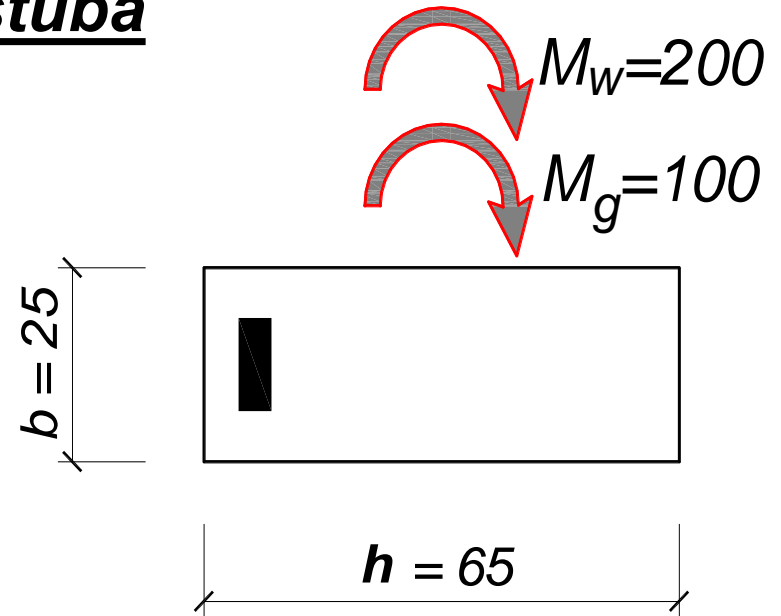
## **a. zategnuta spoljašnja ivica stuba**

$$M_{Ed} = 1.35 \times 100 + 1.5 \times 200 = 435 \text{ kNm}$$

$$\text{pretp. } d_1 = 7 \text{ cm}$$

$$d = 65 - 7 = 58 \text{ cm}$$

$$C25/30 \Rightarrow f_{cd} = 14.2 \text{ MPa}$$



$$k = \frac{58}{\sqrt{\frac{435 \times 10^2}{25 \times 1.42}}} = 1.657$$

**Kako je  $\varepsilon_{s1} < 2.5\text{‰}$ , presek se **OBOSTRANO ARMIRA**.**

$$M_{Rd,lim} = \left( \frac{58}{1.672} \right)^2 \times 25 \times 1.42 \times 10^{-2} = 427.2 \text{ kNm}$$

$$\Delta M = 435 - 427.2 = 7.8 \text{ kNm}$$

## **a. zategnuta spoljašnja ivica stuba**

$$M_{Rd,lim} = \left( \frac{58}{1.672} \right)^2 \times 25 \times 1.42 \times 10^{-2} = 427.2 \text{ kNm}$$

$$\Delta M = 435 - 427.2 = 7.8 \text{ kNm}$$

$$\text{pretp. } d_2 = 5 \text{ cm} \Rightarrow A_{s2} = \frac{7.8 \times 10^2}{(58 - 5) \times 43.5} = 0.34 \text{ cm}^2$$

*usvojeno:*                      **2Ø16** (4.02 cm<sup>2</sup>)

$$A_{s1} = 47.222 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} + 0.34 = 22.69 \text{ cm}^2$$

*usvojeno:*                      **5Ø25** (24.55 cm<sup>2</sup>)

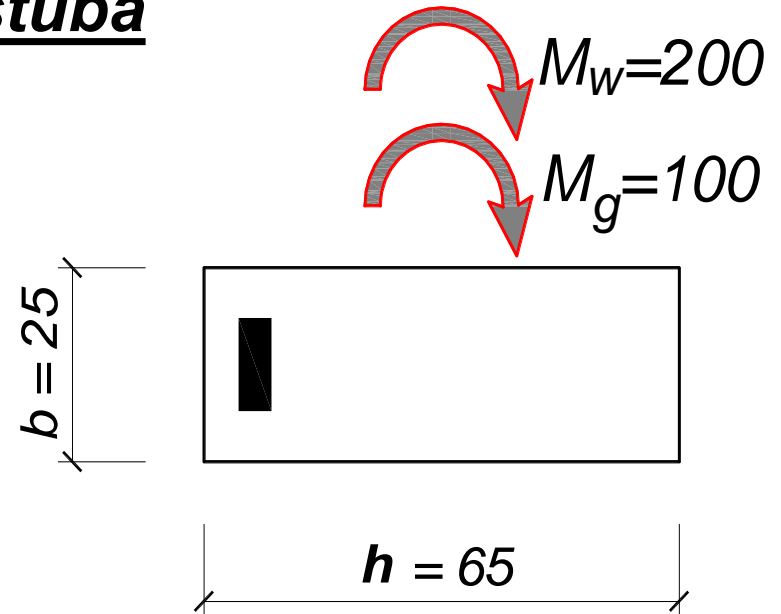
## a. zategnuta spoljašnja ivica stuba

$$M_{Ed} = 1.35 \times 100 + 1.5 \times 200 = 435 \text{ kNm}$$

$$\text{pretp. } d_1 = 7 \text{ cm}$$

$$d = 65 - 7 = 58 \text{ cm}$$

$$C25/30 \Rightarrow f_{cd} = 14.2 \text{ MPa}$$



$$k = \frac{58}{\sqrt{\frac{435 \times 10^2}{25 \times 1.42}}} = 1.657$$

$$\varepsilon_c / \varepsilon_{s1} = 3.5 / 2.321\text{‰} \Rightarrow \omega_1 = 48.673\%$$

$$A_{s1} = 48.673 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} = 23.04 \text{ cm}^2$$

$$\varepsilon_{s1} < 2.5\text{‰}, \text{ ali}$$

$$\varepsilon_{s1} > \varepsilon_{yd} (= f_{yd} / E_s)$$

usvojeno: **5Ø25** (24.55 cm<sup>2</sup>)

## **b. zategnuta unutrašnja ivica stuba**

$$M_{Ed} = 1.0 \times (-100) + 1.5 \times 200 = 200 \text{ kNm}$$

$$\text{pretp. } d_1 = 5 \text{ cm}$$

$$d = 65 - 5 = 60 \text{ cm}$$

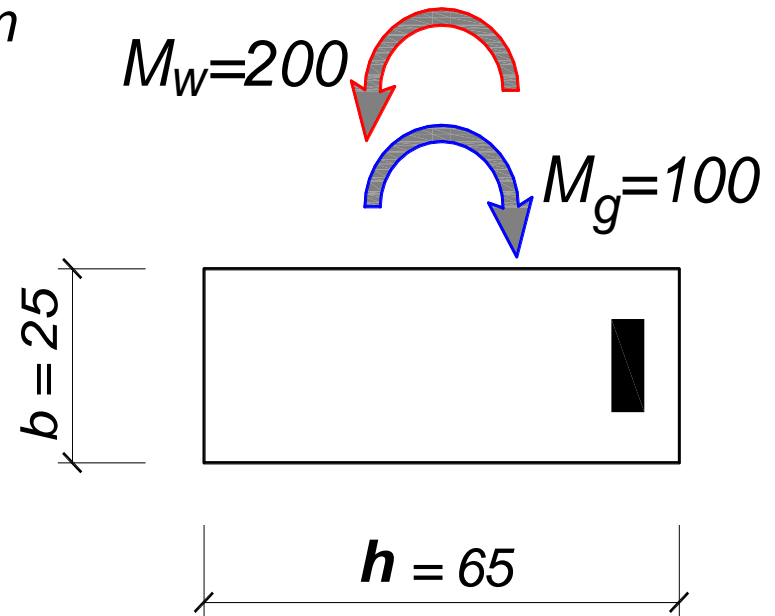
$$C25/30 \Rightarrow f_{cd} = 14.2 \text{ MPa}$$

$$k = \frac{60}{\sqrt{\frac{200 \times 10^2}{25 \times 1.42}}} = 2.528$$

$$\varepsilon_c / \varepsilon_{s1} = 3.5 / 13.18\% \Rightarrow \omega_1 = 16.982\%$$

$$A_{s1} = 16.982 \times \frac{25 \times 60}{100} \times \frac{1.42}{43.5} = 8.31 \text{ cm}^2$$

*usvojeno:*                      **2Ø25 (9.82 cm<sup>2</sup>)**



## Zadatak 21 – KOMBINOVANJE OPTEREĆENJA

*Odrediti potrebnu površinu armature za stub poznatih dimenzija, pravougaonog poprečnog preseka, opterećen zadatim uticajima. Podaci za proračun:*

$$M_G = 100 \text{ kNm}$$

$$N_G = 500 \text{ kN}$$

$$M_w = \pm 200 \text{ kNm}$$

$$b = 25 \text{ cm}$$

$$h = 65 \text{ cm}$$

C25/30

B500 B

## a. zategnuta spoljašnja ivica stuba

$$M_{Ed} = 1.35 \times 100 + 1.5 \times 200 = 435 \text{ kNm}$$

$$N_{Ed} = 1.35 \times 500 = 675 \text{ kN}$$

$$\text{pretp. } d_1 = 7 \text{ cm}$$

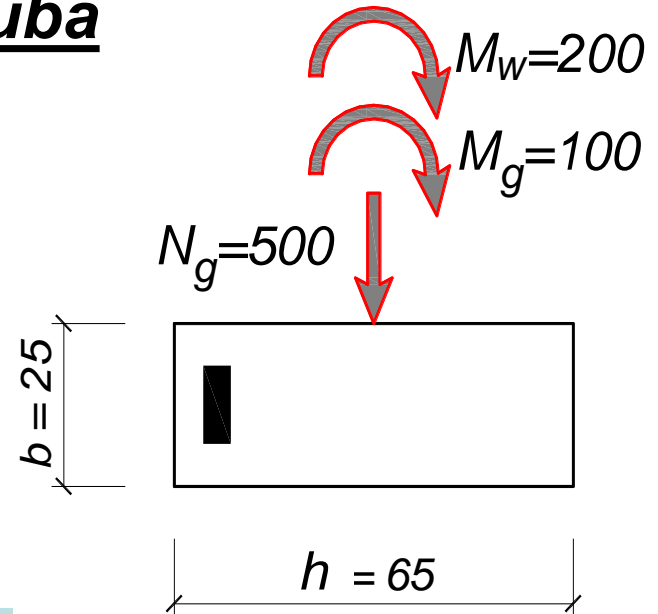
$$d = 65 - 7 = 58 \text{ cm}$$

$$C25/30 \Rightarrow f_{cd} = 14.2 \text{ MPa}$$

$$M_{Eds} = 435 + 675 \times \left( \frac{0.65}{2} - 0.07 \right) = 607.1 \text{ kNm}$$

$$k = \frac{58}{\sqrt{\frac{607.1 \times 10^2}{25 \times 1.42}}} = 1.402 \Rightarrow \varepsilon_{s1} < 2.5\text{‰}$$

**Kako je  $\varepsilon_{s1} < 2.5\text{‰}$ , presek se OBOSTRANO ARMIRA.**





**usvojeno**  $\varepsilon_{s1,lim} = 2.5\text{‰} \Rightarrow k_{lim} = 1.672, \omega_{Rd,lim} = 47.222\%$

$$M_{Rd,lim} = \left( \frac{58}{1.672} \right)^2 \times 25 \times 1.42 \times 10^{-2} = 427.2 \text{ kNm}$$

$$\Delta M = 607.1 - 427.2 = 179.9 \text{ kNm}$$

$$\text{pretp. } d_2 = 5 \text{ cm} \Rightarrow A_{s2} = \frac{179.9 \times 10^2}{(58 - 5) \times 43.5} = 7.8 \text{ cm}^2$$

$$A_{s1} = 47.222 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} - \frac{675}{43.5} + 7.8 = 14.63 \text{ cm}^2$$

## **b. zategnuta unutrašnja ivica stuba**

$$M_{Ed} = 1.0 \times (-100) + 1.5 \times 200 = 200 \text{ kNm}$$

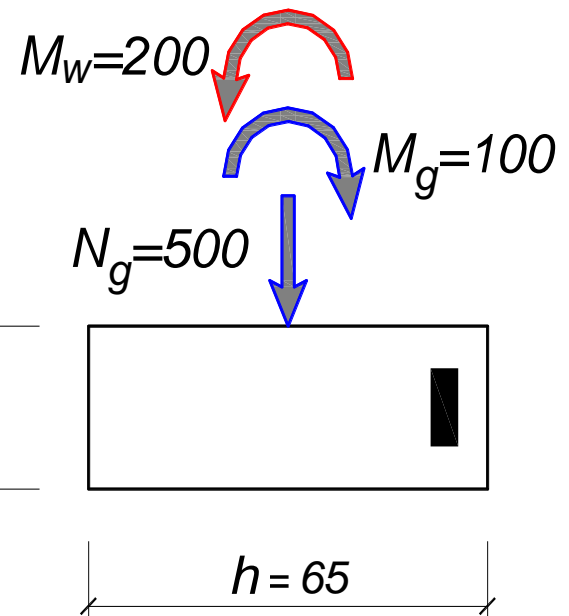
$$N_{Ed} = 1.0 \times 500 = 500 \text{ kN}$$

$$\text{pretp. } d_1 = 5 \text{ cm}$$

$$d = 65 - 5 = 60 \text{ cm}$$

$$C25/30 \Rightarrow f_{cd} = 14.2 \text{ MPa}$$

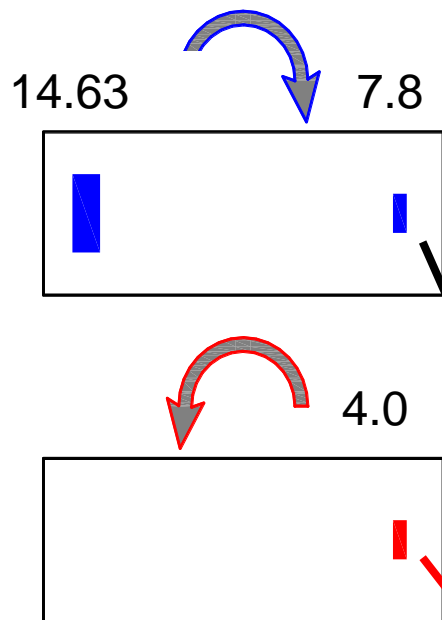
**“povoljno”  
dejstvo stalnog  
opterećenja**



$$M_{Eds} = 200 + 500 \times \left( \frac{0.65}{2} - 0.05 \right) = 337.5 \text{ kNm}$$

$$k = \frac{60}{\sqrt{\frac{337.5 \times 10^2}{25 \times 1.42}}} = 1.946 \Rightarrow \begin{aligned} \varepsilon_c / \varepsilon_{s1} &= 3.5 / 5.435\% \\ \omega_1 &= 31.646\% \end{aligned}$$

$$A_{s1} = 31.646 \times \frac{25 \times 60}{100} \times \frac{1.42}{43.5} - \frac{500}{43.5} = 4.0 \text{ cm}^2$$



*POTREBNO:*



$$\text{unutra: } A_{s,potr.} = \max. \left\{ \begin{matrix} 7.8 \\ 4.0 \end{matrix} \right\} = 7.8 \text{ cm}^2$$

*usvojeno: 3Ø20 (9.42 cm<sup>2</sup>)*

$$\text{spolja: } A_{s,potr.} = 14.63 \text{ cm}^2$$

*usvojeno: 5Ø20 (15.7 cm<sup>2</sup>)*

## Zadatak 22 – KOMBINOVANJE OPTEREĆENJA

*Dimenzionisati stub poznatih dimenzija, pravougaonog poprečnog preseka, opterećen zadatim uticajima. Opterećenja  $q$  i  $w$  su povremena i NE MORAJU delovati istovremeno. Podaci za proračun:*

$$M_G = 100 \text{ kNm}$$

$$N_Q = 500 \text{ kN}$$

$$M_w = \pm 200 \text{ kNm}$$

$$b = 25 \text{ cm}$$

$$h = 65 \text{ cm}$$

C25/30

B500B

## a. zategnuta spoljašnja ivica stuba

### a.1 MINIMALNA sila pritiska

$$M_{Ed} = 1.35 \times 100 + 1.5 \times 200 = 435 \text{ kNm}$$

$$N_{Ed} = 0$$

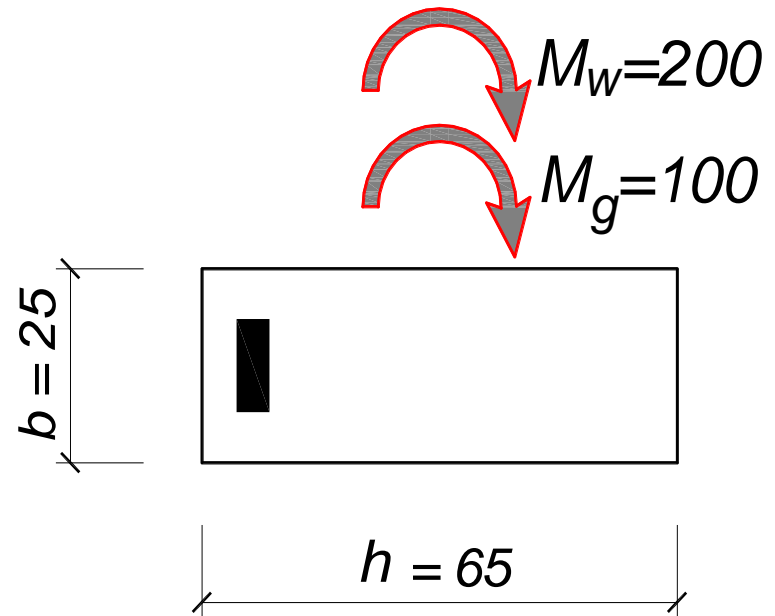
$$\text{pretp. } d_1 = 7 \text{ cm} \Rightarrow d = 65 - 7 = 58 \text{ cm}$$

$$C25/30 \Rightarrow f_{cd} = 14.2 \text{ MPa}$$

$$k = \frac{58}{\sqrt{\frac{435 \times 10^2}{25 \times 1.42}}} = 1.657$$

$$\varepsilon_c / \varepsilon_{s1} = 3.5 / 2.321\text{‰} \Rightarrow \omega_1 = 48.673\%$$

$$A_{s1} = 48.673 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} = 23.04 \text{ cm}^2$$



*usvojeno:*

**5Ø25 (24.55 cm<sup>2</sup>)**

## a. zategnuta spoljašnja ivica stuba

### a.2 MAKSIMALNA sila pritiska

#### a.2.1 dominantno promenljivo – VETAR

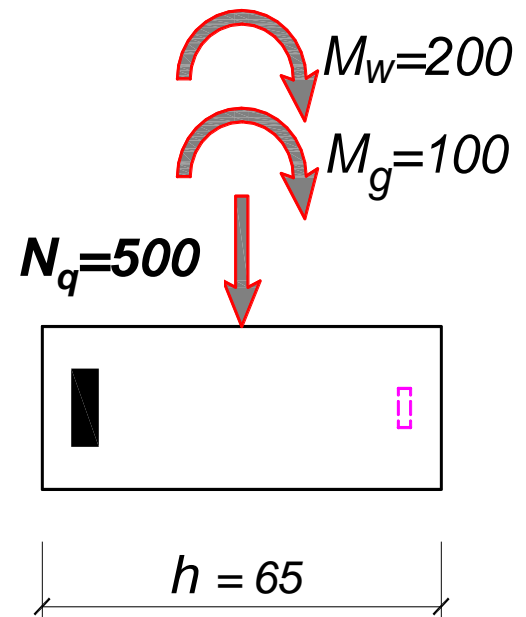
$$1,35 \cdot G_k + 1,5 \cdot (F_{k,w} + 0,5 \cdot Q_{k,n} + 0,7 \cdot Q_{k,es}) = 1,35 \cdot G_k + 1,5 \cdot F_{k,w} + 0,75 \cdot Q_{k,n} + 1,05 \cdot Q_{k,es}$$

$$M_{Ed} = 1,35 \times 100 + 1,5 \times 200 = 435 \text{ kNm}$$

$$N_{Ed} = 1,5 \times 0,7 \times 500 = 525 \text{ kN}$$

$$M_{Eds} = 435 + 525 \times \left( \frac{0,65}{2} - 0,07 \right) = 568,9 \text{ kNm}$$

$$k = \frac{58}{\sqrt{\frac{568,9 \times 10^2}{25 \times 1,42}}} = 1,449 \Rightarrow \varepsilon_{s1} < 2,5\%$$



**Kako je  $\varepsilon_{s1} < 2,5\%$ , presek se **OBOSTRANO** ARMIRA.**

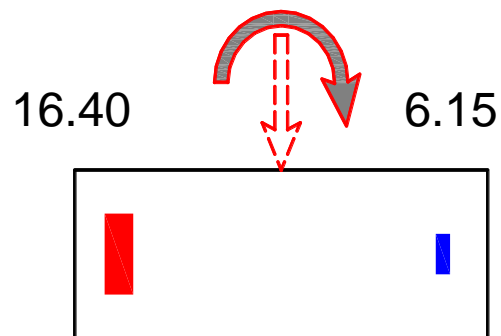
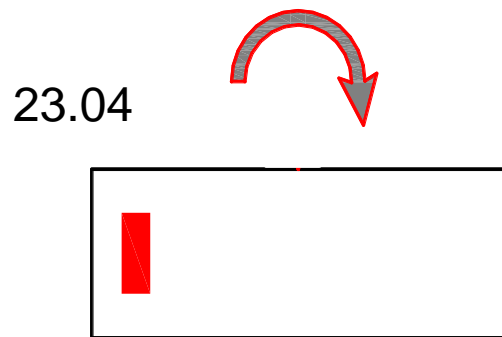
**usvojeno**  $\varepsilon_{s1,lim} = 2.5\text{‰} \Rightarrow k_{lim} = 1.672, \omega_{Rd,lim} = 47.222\%$

$$M_{Rd,lim} = \left( \frac{58}{1.672} \right)^2 \times 25 \times 1.42 \times 10^{-2} = 427.2 \text{ kNm}$$

$$\Delta M = 568.9 - 427.2 = 141.7 \text{ kNm}$$

$$\text{pretp. } d_2 = 5 \text{ cm} \Rightarrow A_{s2} = \frac{141.7 \times 10^2}{(58 - 5) \times 43.5} = 6.15 \text{ cm}^2$$

$$A_{s1} = 47.222 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} - \frac{525}{43.5} + 6.15 = 16.4 \text{ cm}^2$$



*POTREBNO:*

23.04                      6.15



$$spolja : A_{s,potr.} = \max. \left\{ \begin{matrix} 23.04 \\ 16.40 \end{matrix} \right\} = 23.04 \text{ cm}^2$$

$$unutra : A_{s,potr.} = \max. \left\{ \begin{matrix} 0 \\ 6.15 \end{matrix} \right\} = 6.15 \text{ cm}^2$$



## a. zategnuta spoljašnja ivica stuba

### a.2 MAKSIMALNA sila pritiska

#### a.2.2 dominantno promenljivo – **KORISNO**

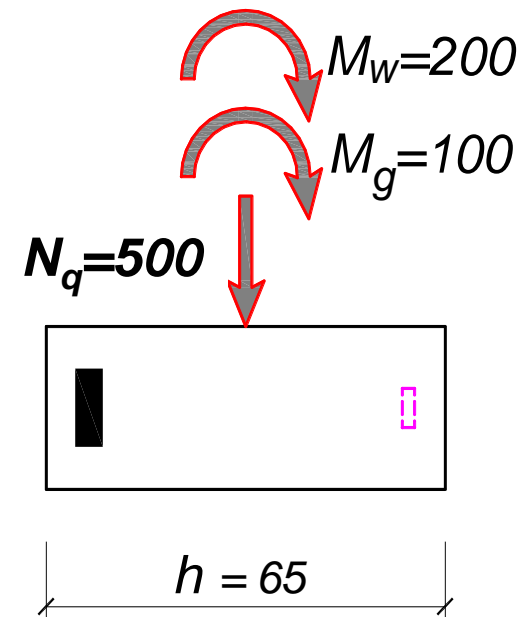
$$1,35 \cdot G_k + 1,5 \cdot (Q_{k,es} + 0,5 \cdot Q_{k,n} + 0,6 \cdot F_{k,w}) = 1,35 \cdot G_k + 1,5 \cdot Q_{k,es} + 0,75 \cdot Q_{k,n} + 0,9 \cdot F_{k,w}$$

$$M_{Ed} = 1,35 \times 100 + 1,5 \times 0,6 \times 200 = 315 \text{ kNm}$$

$$N_{Ed} = 1,5 \times 500 = 750 \text{ kN}$$

$$M_{Eds} = 315 + 750 \times \left( \frac{0,65}{2} - 0,07 \right) = 506,3 \text{ kNm}$$

$$k = \frac{58}{\sqrt{\frac{506,3 \times 10^2}{25 \times 1,42}}} = 1,536 \Rightarrow \varepsilon_{s1} < 2,5\%$$



**Kako je  $\varepsilon_{s1} < 2,5\%$ , presek se **OBOSTRANO** ARMIRA.**

**usvojeno**  $\varepsilon_{s1,lim} = 2.5\text{‰} \Rightarrow k_{lim} = 1.672, \omega_{Rd,lim} = 47.222\%$

$$M_{Rd,lim} = \left( \frac{58}{1.672} \right)^2 \times 25 \times 1.42 \times 10^{-2} = 427.2 \text{ kNm}$$

$$\Delta M = 506.3 - 427.2 = 79.1 \text{ kNm}$$

$$\text{pretp. } d_2 = 5 \text{ cm} \Rightarrow A_{s2} = \frac{79.1 \times 10^2}{(58 - 5) \times 43.5} = 3.43 \text{ cm}^2$$

$$A_{s1} = 47.222 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} - \frac{750}{43.5} + 3.43 = 8.54 \text{ cm}^2$$

## **b. zategnuta unutrašnja ivica stuba**

### **b.1 MINIMALNA sila pritiska**

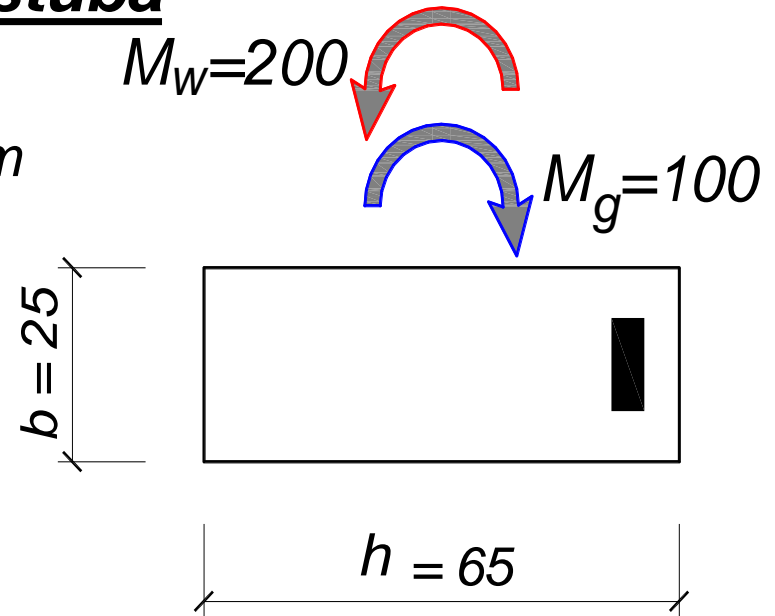
$$M_{Ed} = 1.0 \times (-100) + 1.5 \times 200 = 200 \text{ kNm}$$

$$N_{Ed} = 0$$

(videti primer 1b)

pretp.  $d_1 = 5 \text{ cm} \Rightarrow d = 65 - 5 = 60 \text{ cm}$

C25/30  $\Rightarrow f_{cd} = 14.2 \text{ MPa}$



$$k = \frac{60}{\sqrt{\frac{200 \times 10^2}{25 \times 1.42}}} = 2.528$$

$$\varepsilon_c / \varepsilon_{s1} = 3.5 / 13.18\% \Rightarrow \omega_1 = 16.982\%$$

$$A_{s1} = 16.982 \times \frac{25 \times 60}{100} \times \frac{1.42}{43.5} = 8.31 \text{ cm}^2$$

usvojeno:

**2Ø25 (9.82 cm<sup>2</sup>)**

## **b. zategnuta spoljašnja ivica stuba**

b.2 **MAKSIMALNA** sila pritiska

dominantno promenljivo – VETAR

$$1,35 \cdot G_k + 1,5 \cdot (F_{k,w} + 0,5 \cdot Q_{k,n} + 0,7 \cdot Q_{k,es}) = 1,35 \cdot G_k + 1,5 \cdot F_{k,w} + 0,75 \cdot Q_{k,n} + 1,05 \cdot Q_{k,es}$$

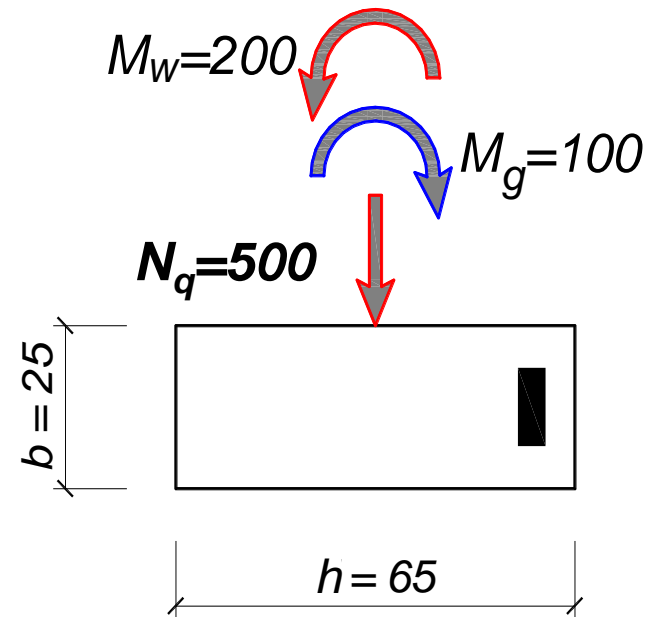
$$M_{Ed} = 1,0 \times (-100) + 1,5 \times 200 = 200 \text{ kNm}$$

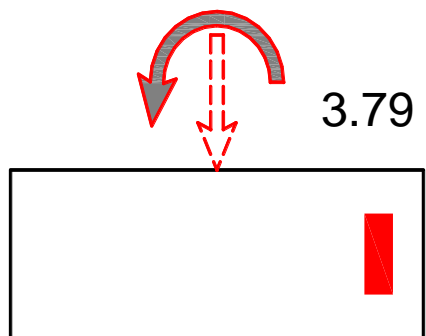
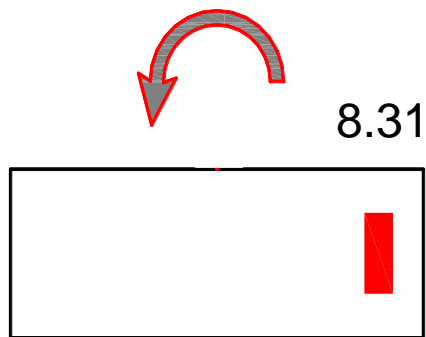
$$N_{Ed} = 1,5 \times 0,7 \times 500 = 525 \text{ kN}$$

$$M_{Eds} = 200 + 525 \times \left( \frac{0,65}{2} - 0,05 \right) = 443,4 \text{ kNm}$$

$$k = \frac{60}{\sqrt{\frac{344,4 \times 10^2}{25 \times 1,42}}} = 1,926 \Rightarrow \begin{aligned} \varepsilon_c / \varepsilon_{s1} &= 3,5 / 5,247\% \\ \omega &= 32,391\% \end{aligned}$$

$$A_{a1} = 32,391 \times \frac{25 \times 60}{100} \times \frac{1,42}{43,5} - \frac{525}{43,5} = 3,79 \text{ cm}^2$$





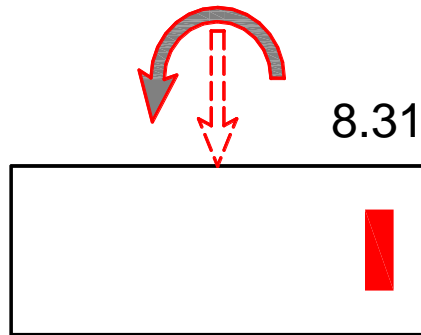
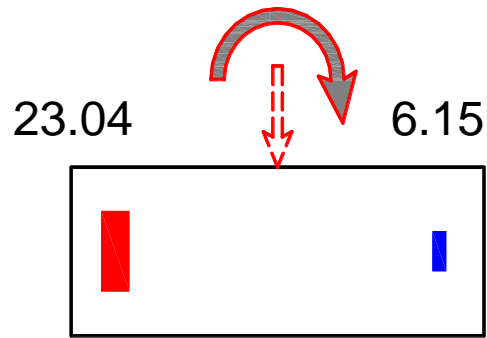
*POTREBNO:*

8.31

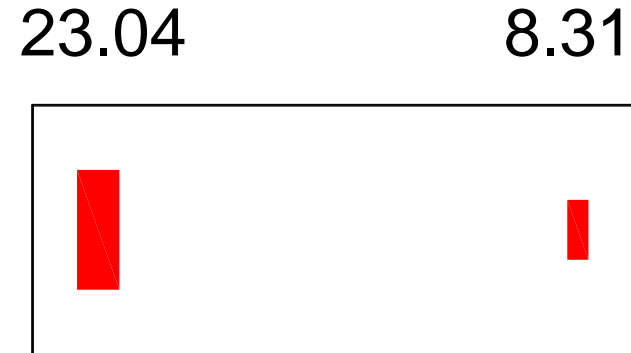


*spolja:*  $A_{s,potr.} = 0$

*unutra:*  $A_{s,potr.} = \max. \left\{ \begin{matrix} 8.31 \\ 3.79 \end{matrix} \right\} = 8.31 \text{ cm}^2$



*POTREBNO:*



$$\textit{spolja} : A_{s, \textit{potr.}} = \max. \left\{ \begin{matrix} 23.04 \\ 0 \end{matrix} \right\} = 23.04 \text{ cm}^2$$

**5Ø25 (24.55 cm<sup>2</sup>)**

$$\textit{unutra} : A_{s, \textit{potr.}} = \max. \left\{ \begin{matrix} 6.15 \\ 8.31 \end{matrix} \right\} = 8.31 \text{ cm}^2$$

**2Ø25 (9.82 cm<sup>2</sup>)**

# Zadatak 23 – KOMBINOVANJE OPTEREĆENJA

$N_Q = 800 \text{ kN}$

$M_G = 100 \text{ kNm}$

$M_W = \pm 200 \text{ kNm}$

$M_{Ed} = 1.35 \cdot 100 + 1.5 \cdot 200 = 435 \text{ kNm}$   
 $N_{Ed} = 0$

$\Rightarrow A_{s1} = 24.8 \text{ cm}^2 \quad A_{s2} = 0.3 \text{ cm}^2$

$M_{Ed} = 1.35 \cdot 100 + 1.5 \cdot 200 = 435 \text{ kNm}$   
 $N_{Ed} = 1.5 \cdot 0.7 \cdot 800 = 840 \text{ kN}$

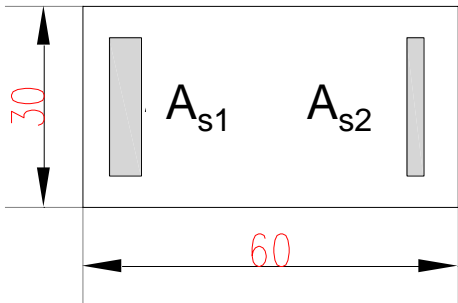
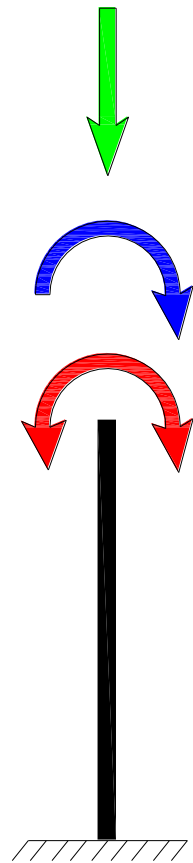
$\Rightarrow A_{s1} = 14.3 \text{ cm}^2 \quad A_{s2} = 9.14 \text{ cm}^2$

$M_{Ed} = 1.35 \cdot 100 + 1.5 \cdot 0.6 \cdot 200 = 315 \text{ kNm}$   
 $N_{Ed} = 1.5 \cdot 800 = 1200 \text{ kN}$

$\Rightarrow A_{s1} = 4.7 \text{ cm}^2 \quad A_{s2} = 7.8 \text{ cm}^2$

$M_{Ed} = 1.0 \cdot (-100) + 1.5 \cdot 200 = 200 \text{ kNm}$   
 $N_{Ed} = 0$

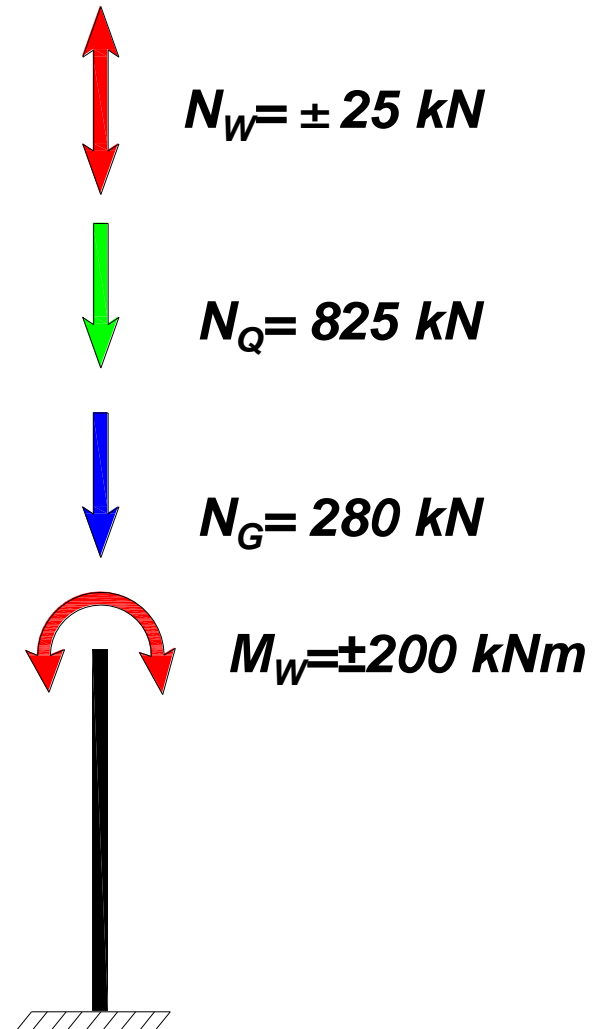
$\Rightarrow A_{s2} = 9.77 \text{ cm}^2$



# DODATNI ZADATAK



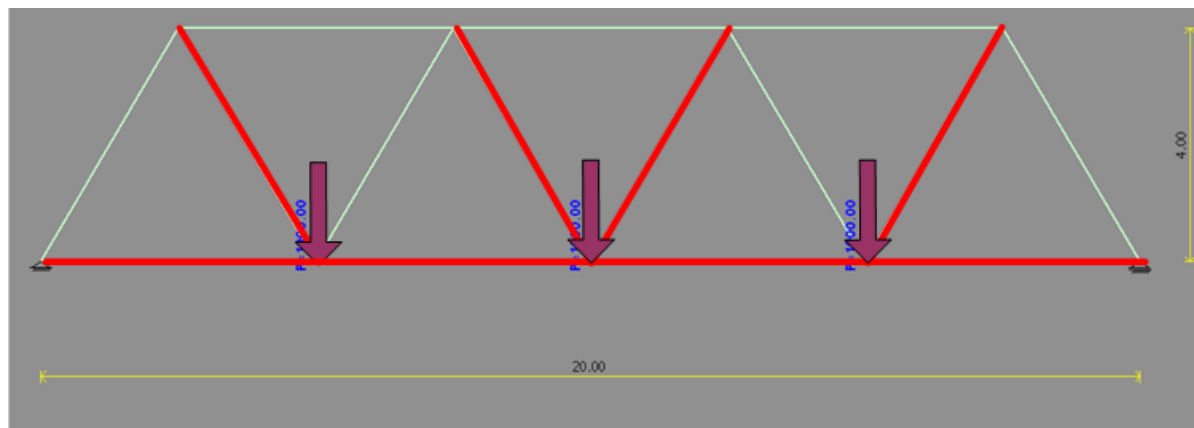
*Dimenzionisati stub prikazan  
na skici.*



C30/37	B500 B
b/h=30/60 cm	



# Centrično zatezanje



# Zadatak 17 – CENTRIČNO ZATEZANJE

Odrediti potrebnu površinu armature i oblikovati poprečni presek, pravougaonog oblika, centrično zategnutog elementa. Podaci za proračun:

$$N_{G,k} = -400 \text{ kN}$$


C25/30

XD1

$$N_{Q,k} = -500 \text{ kN}$$

B500 B

Treba li?

C25/30   $f_{cd} = 0.85 \cdot 25 / 1.5 = 14.2 \text{ MPa} = 1.42 \text{ kN/cm}^2$

B500 B   $f_{yd} = 500 / 1.15 = 435 \text{ MPa} = 43.5 \text{ kN/cm}^2$

## Zadatak 17 – **CENTRIČNO ZATEZANJE**

Granična sila **ZATEZANJA**:

$$N_{Ed} = 1.35 \cdot (-400) + 1.5 \cdot (-500) = -1290 \text{ kN}$$

Proračun površine armature:

$$A_{s1} = \frac{N_{Ed}}{f_{yd}} = \frac{1290}{43.5} = 29.7 \text{ cm}^2$$

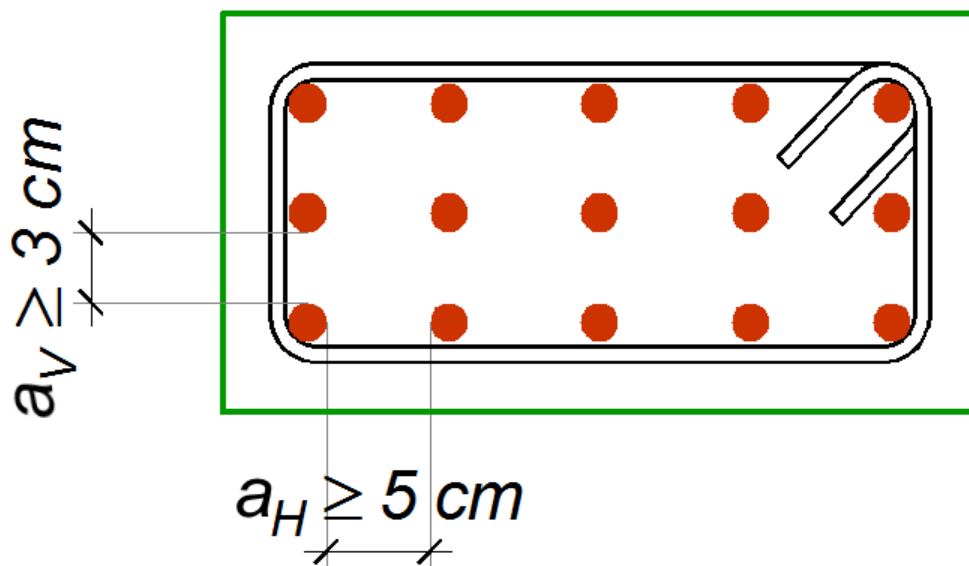
Usvojeno: **15 Ø16** (30.15 cm<sup>2</sup>)



# Zadatak 17 – CENTRIČNO ZATEZANJE

$$b \geq 2c_{\text{nom}} + 2\varnothing_s + m \times \varnothing + (m-1) \times a_H$$

$$h \geq 2c_{\text{nom}} + 2\varnothing_s + n \times \varnothing + (n-1) \times a_V$$



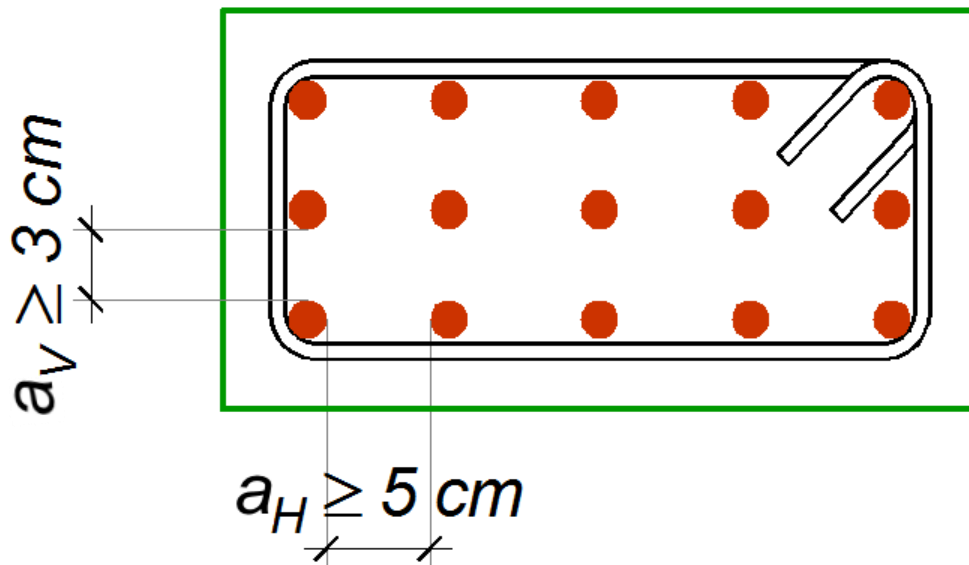
XD1  $\Rightarrow c_{\text{nom}} = 35 + 10 = 45 \text{ mm}$

Pretp.  $\Rightarrow \varnothing_s = 8 \text{ mm}$

Oznaka klase izloženosti	Minimalni zaštitni slojevi iz uslova trajnosti, $c_{\text{min,dur}}$ , za klasu konstrukcija S4									
	10	15	20	25	30	35	40	45	50	55
X0										
XC1										
XC2										
XC3										
XC4										
XD1										
XD2										
XD3										
XS1										
XS2										
XS3										

# Zadatak 17 – CENTRIČNO ZATEZANJE

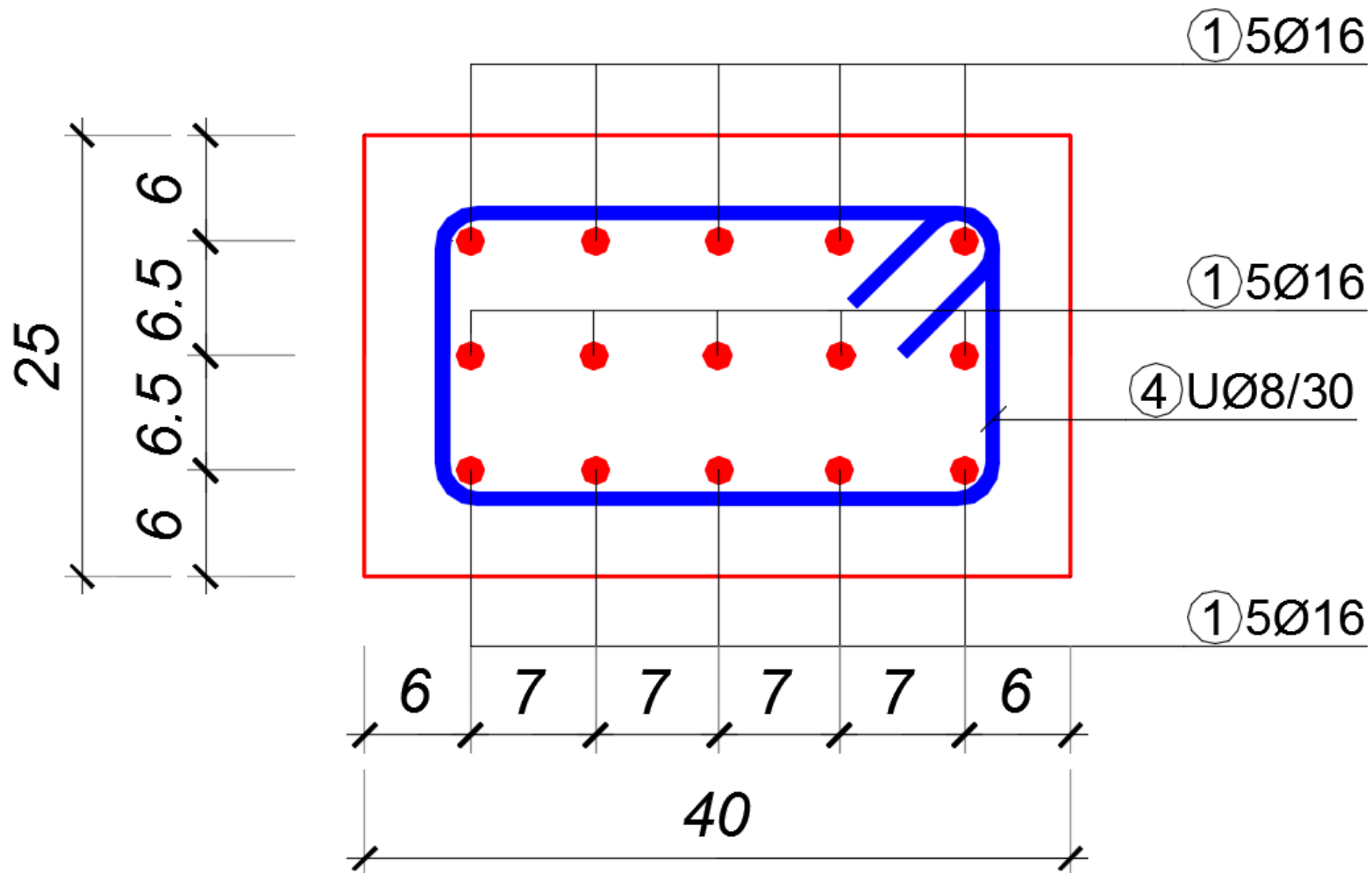
$$b \geq 2c_{\text{nom}} + 2\varnothing_s + m \times \varnothing + (m-1) \times a_H$$
$$h \geq 2c_{\text{nom}} + 2\varnothing_s + n \times \varnothing + (n-1) \times a_V$$



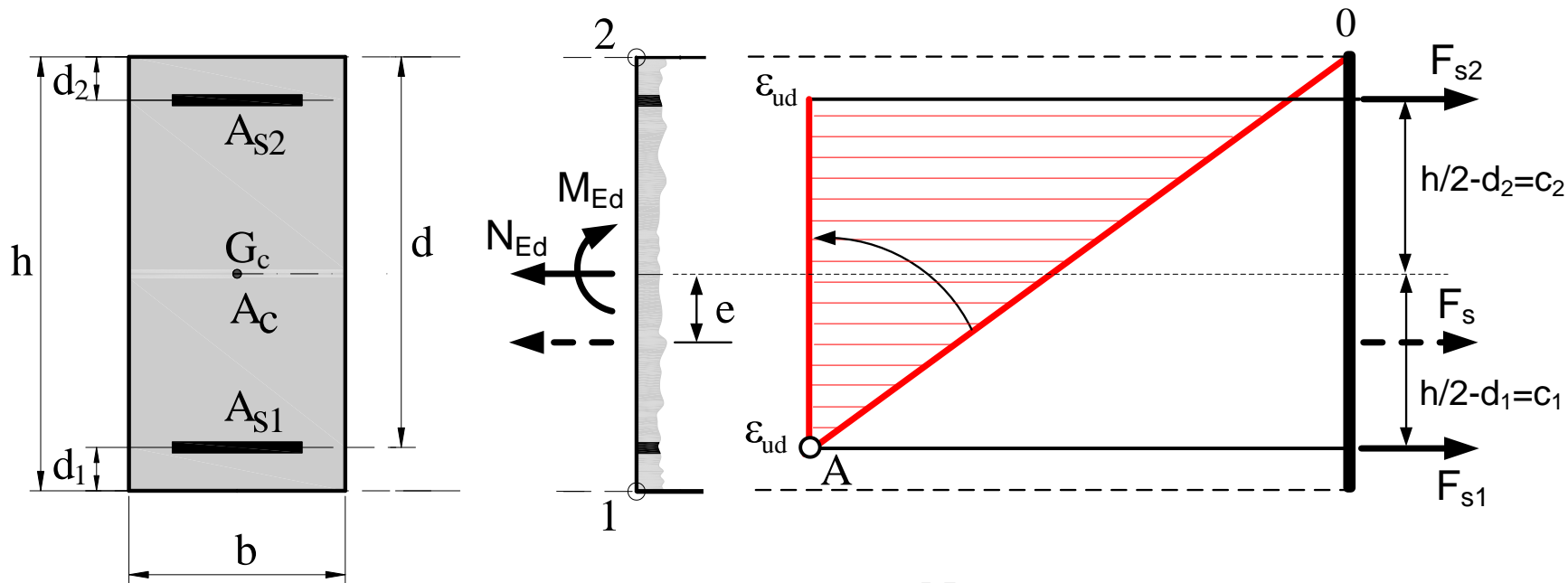
$$b \geq 2 \times 4.5 + 2 \times 0.8 + 5 \times 1.6 + (5-1) \times 5.0 = 38.6 \text{ cm} \Rightarrow b = 40 \text{ cm}$$

$$d \geq 2 \times 4.5 + 2 \times 0.8 + 3 \times 1.6 + (3-1) \times 3.0 = 21.4 \text{ cm} \Rightarrow d = 25 \text{ cm}$$

# Zadatak 17 – CENTRIČNO ZATEZANJE



# ULS – MALI EKSCENTRICITET, SILA ZATEZANJA

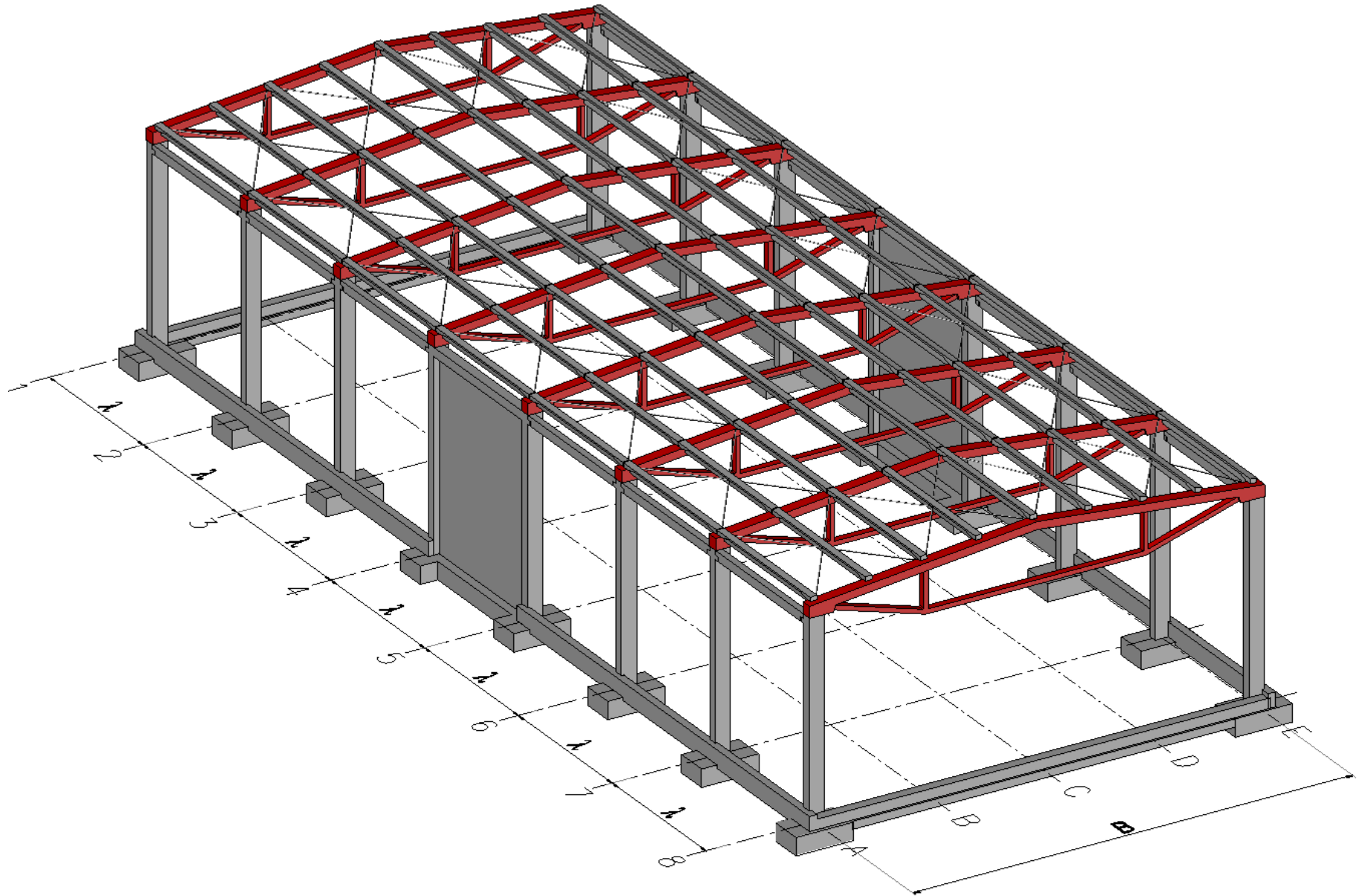


$$A_s = A_{s1} + A_{s2} = \frac{N_{Ed}}{f_{yd}}$$

$$A_{s1} = \frac{N_{Ed}}{f_{yd}} \frac{c_2 + e}{c_1 + c_2}$$

$$A_{s2} = \frac{N_{Ed}}{f_{yd}} \frac{c_1 - e}{c_1 + c_2}$$

# ULS – MALI EKSCENTRICITET, SILA ZATEZANJA





# Zadatak 18 – EKSCENTRIČNO ZATEZANJE

Dimenzionisati pravougaoni poprečni presek zadatih dimenzija, opterećen silom zatezanja i momentom savijanja u fazi malog ekscentriciteta.

Podaci za proračun:

$$N_{G,k} = -400 \text{ kN}$$

$$M_{G,k} = 10 \text{ kNm}$$

$$b = 40 \text{ cm}$$

$$N_{Q,k} = -500 \text{ kN}$$

$$h = 25 \text{ cm}$$

B500 B

$$f_{yd} = 500/1.15 = 435 \text{ MPa} = 43.5 \text{ kN/cm}^2$$

## Zadatak 18 – EKSCENTRIČNO ZATEZANJE

$$N_{Ed} = 1.35 \cdot (-400) + 1.5 \cdot (-500) = -1290 \text{ kN}$$

$$M_{Ed} = 1.35 \cdot 10 = 13.5 \text{ kNm}$$

$$e = \frac{M_{Ed}}{N_{Ed}} = \frac{13.5 \times 10^2}{1290} = 1.05 \text{ cm}$$

pretp.  $d_1 = d_2 = 6 \text{ cm}$

$$c_1 = c_2 = h/2 - d_1 = 25/2 - 6 = 6.5 \text{ cm}$$

$$A_s = A_{s1} + A_{s2} = \frac{N_{Ed}}{f_{yd}} = \frac{1290}{43.5} = 29.7 \text{ cm}^2$$

# Zadatak 18 – EKSCENTRIČNO ZATEZANJE

$$A_{s1} = \frac{N_{Ed}}{f_{yd}} \frac{c_2 + e}{c_1 + c_2} = 29.7 \cdot \frac{6.5 + 1.05}{6.5 + 6.5} = 17.2 \text{ cm}^2$$

$$A_{s2} = \frac{N_{Ed}}{f_{yd}} \frac{c_1 - e}{c_1 + c_2} = 29.7 \cdot \frac{6.5 - 1.05}{6.5 + 6.5} = 12.5 \text{ cm}^2$$

≈ 9Ø16

$d_1 = 8 \text{ cm}$

$c_1 = 25/2 - 8$   
 $= 4.5 \text{ cm}$

≈ 6Ø16

$d_2 = 6 \text{ cm}$

$c_2 = 25/2 - 6 =$   
 $6.5 \text{ cm}$

# Zadatak 18 – EKSCENTRIČNO ZATEZANJE

$$A_{s1} = \frac{N_{Ed}}{f_{yd}} \frac{c_2 + e}{c_1 + c_2} = 29.7 \cdot \frac{6.5 + 1.05}{4.5 + 6.5} = 20.4 \text{ cm}^2$$

$$A_{s2} = \frac{N_{Ed}}{f_{yd}} \frac{c_1 - e}{c_1 + c_2} = 29.7 \cdot \frac{4.5 - 1.05}{4.5 + 6.5} = 9.3 \text{ cm}^2$$

≈ 10Ø16

$$d_1 = 8.25 \text{ cm}$$

$$c_1 = 25/2 - 8.25 \\ = 4.25 \text{ cm}$$

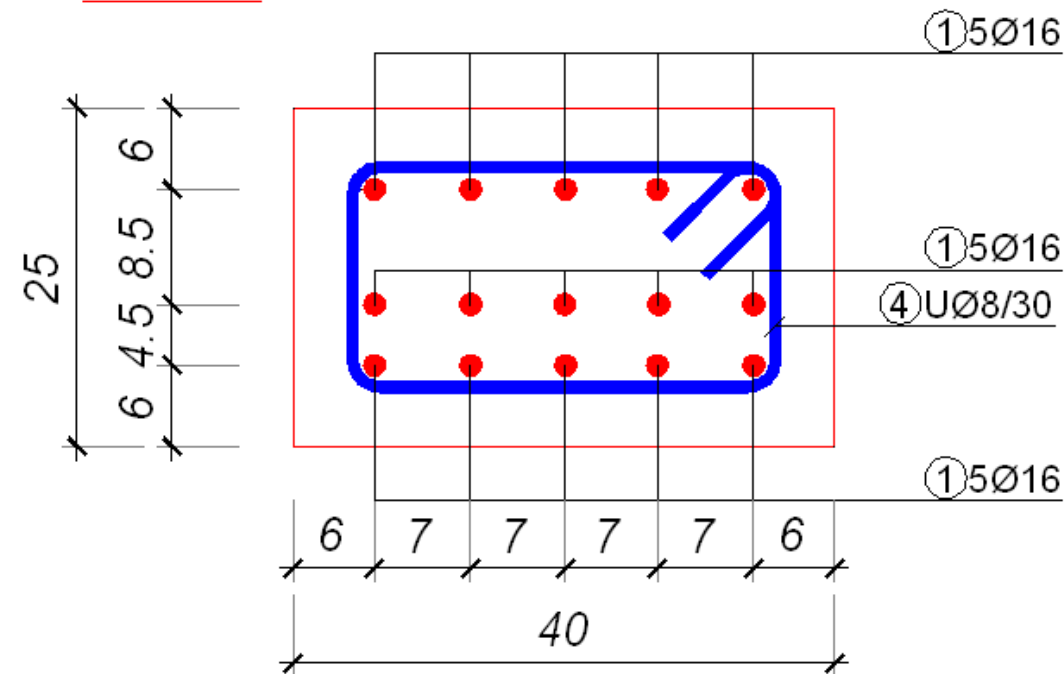
≈ 5Ø16

$$d_2 = 6 \text{ cm}$$

$$c_2 = 25/2 - 6 \\ = 6.5 \text{ cm}$$

# Zadatak 18 – EKSCENTRIČNO ZATEZANJE

XD1



$$d^I = c_{\text{nom}} + \varnothing_s + \varnothing/2$$

$$a^I = 4.5 + 0.8 + 1.6/2 = 6.1 \text{ cm}$$

$$\text{usv. } d^I = 6 \text{ cm}$$

$$d^{II} = d^I + a_v + 2 \times \varnothing/2$$

$$d^{II} = 6 + 3.0 + 2 \times 1.6/2 = 10.6 \text{ cm}$$

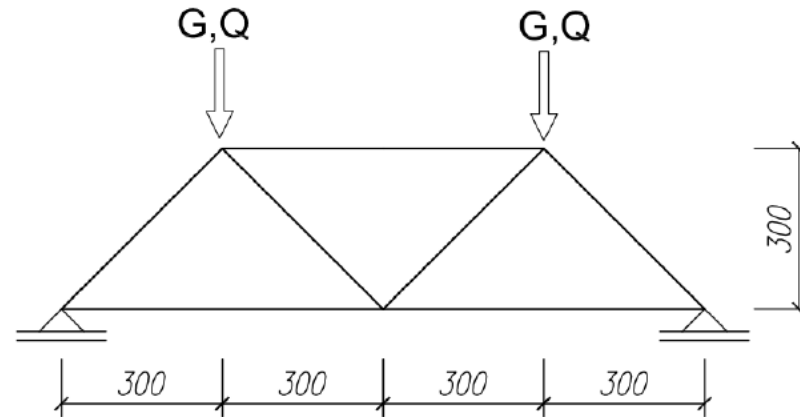
$$\text{usv. } d^{II} = 10.5 \text{ cm}$$

$$a_1 = (5 \times 6 + 5 \times 10.5) / 10$$

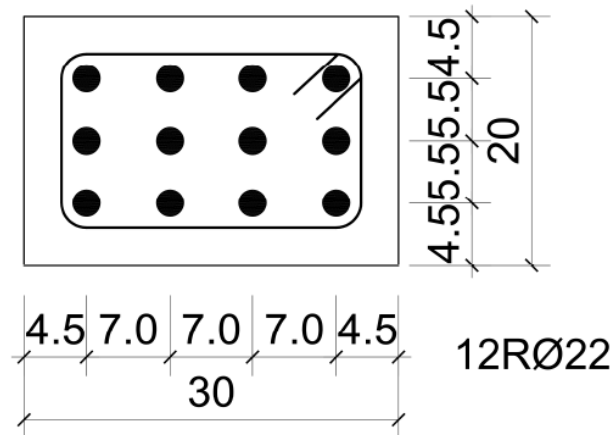
$$d_1 = 8.25 \text{ cm}$$

3. Dimenzionisati donji pojas rešetke prikazane na skici. *Skicirati usvojeni raspored armature u poprečnim presecima uz odgovarajuće oznake i kote.*

**$G=350kN$     $Q=200kN$     $C25/30$     $B500B$     $XC1$**

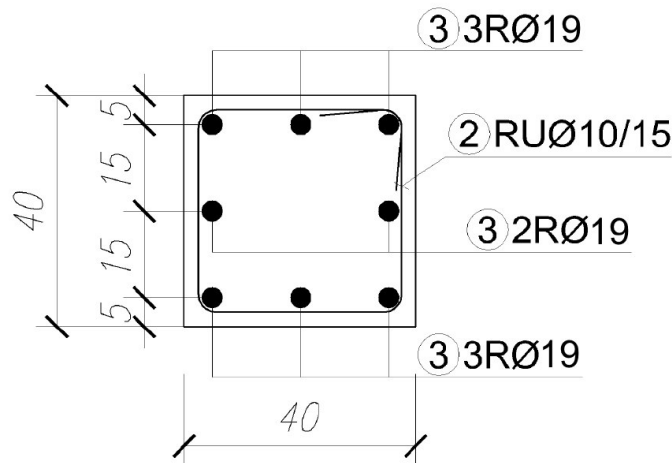


3. Zatega preseka prema skici, opterećena je silom  $Z_G=600$  kN usled stalnog opterećenja. Odrediti koliku silu usled povremenog opterećenja zatega može prihvatiti uz zadovoljenje propisanih koeficijenata sigurnosti.



3. AB presek, armiran prema skici, centrično je napregnut silom pritiska  $N_g = 600 \text{ kN}$  usled stalnog opterećenja. Uz zadovoljenje propisanih koeficijenata sigurnosti odrediti maksimalne vrednosti sila koje mogu delovati na presek:

- maksimalnu centričnu silu pritiska usled povremenog opterećenja  $N_p$
- maksimalnu centričnu silu zatezanja usled povremenog opterećenja  $Z_p$  (10 poena)



4. Dimenzionisati centrično napregnut element pravougaonog poprečnog preseka, opterećen silama  $N_g$  (pritisk),  $N_q$  (zatezanje) i  $N_w$  (alternativnog znaka).