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Studijski program: **GRAĐEVINARSTVO**

Modul: **PŽA, HVE, MTI**

Godina/Semestar: **III godina / V semestar**

Naziv predmeta (šifra): **Betonske konstrukcije 1**  
**(B2S3BK, B2H3BK, B2M3BK, B1S3BK)**

Nastavnik: **Jelena Dragaš**

Naslov predavanja: **Dimenzionisanje stubova**

Datum : 24.11.2022.

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Beograd, 2021.

*Sva autorska prava autora prezentacije i/ili video snimaka su zaštićena. Snimak ili prezentacija se mogu koristiti samo za nastavu na daljinu studenta Građevinskog fakulteta Univerziteta u Beogradu u školskoj 2021/2022. i ne mogu se koristiti za druge svrhe bez pismene saglasnosti autora materijala.*

# Zadatak 19 – 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

## **a1. zategnuta spoljašnja ivica stuba – Nmax**

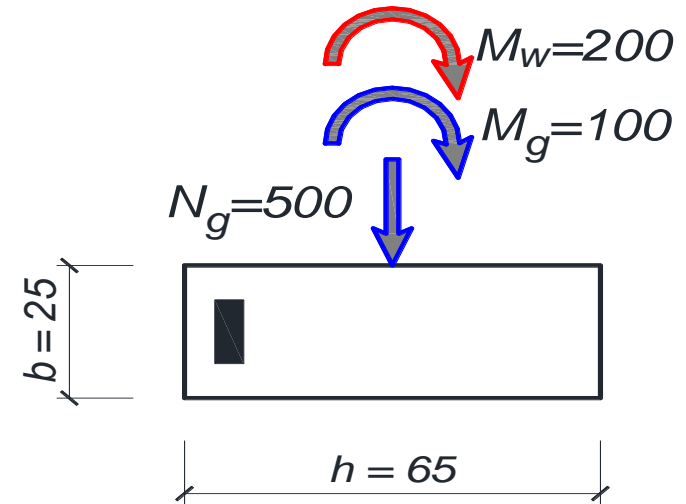
$$M_{Ed} = 1.35 \times 100 + 1.5 \times 200 = 435 \text{ kNm}$$

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

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

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

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

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

$$\varepsilon_{s2} = \frac{\xi_{lim} - \frac{d_2}{d}}{\xi_{lim}} \varepsilon_{cu2} = \frac{0.584 - \frac{5}{58}}{0.584} \cdot 3.5 = 2.98 > 2.175 = \frac{435}{200} \left( = \frac{f_{yd}}{E_s} \right) \quad A_{s1} > A_{s2}$$

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

## a1. zategnuta spoljašnja ivica stuba – Nmin

$$M_{Ed} = 1.0 \times 100 + 1.5 \times 200 = 400 \text{ kNm}$$

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

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

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

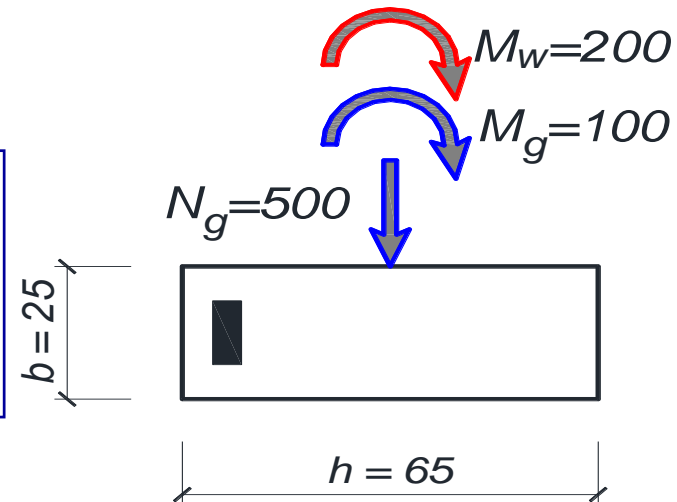
**“povoljno”  
dejstvo stalnog  
opterećenja**

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

$$M_{Eds} = 400 + 500 \times \left( \frac{0.65}{2} - 0.07 \right) = 527.5 \text{ kNm}$$

$$k = \frac{58}{\sqrt{\frac{527.5 \times 10^2}{25 \times 1.42}}} = 1.504 \Rightarrow \varepsilon_{s1} < 2.5\text{‰}$$

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



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

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

$$\Delta M = 527.5 - 427.2 = 100.3 \text{ kNm}$$

$$\text{pretp. } d_2 = 5 \text{ cm} \Rightarrow A_{s2} = \frac{100.3 \times 10^2}{(58 - 5) \times 43.5} = 4.35 \text{ cm}^2$$

$$\varepsilon_{s2} = \frac{\xi_{lim} - \frac{d_2}{d}}{\xi_{lim}} \varepsilon_{cu2} = \frac{0.584 - \frac{5}{58}}{0.584} \cdot 3.5 = 2.98 > 2.175 = \frac{435}{200} \left( = \frac{f_{yd}}{E_s} \right)$$

$$A_{s1} = 47.222 \times \frac{25 \times 58}{100} \times \frac{1.42}{43.5} - \frac{500}{43.5} + 4.35 = 15.21 \text{ cm}^2$$

**a1. Mmax, Nmax**

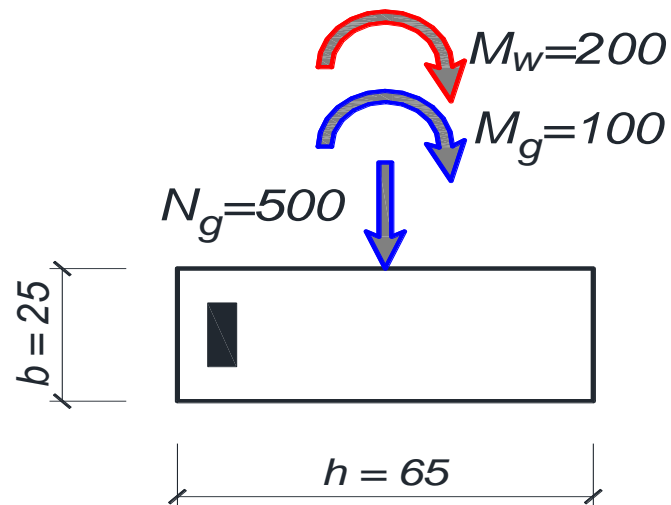
$$A_{s1} = 14.63 \text{ cm}^2$$

$$A_{s2} = 7.8 \text{ cm}^2$$

**a2. Mmax, Nmin**

$$A_{s1} = 15.21 \text{ cm}^2$$

$$A_{s2} = 4.35 \text{ cm}^2$$



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

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

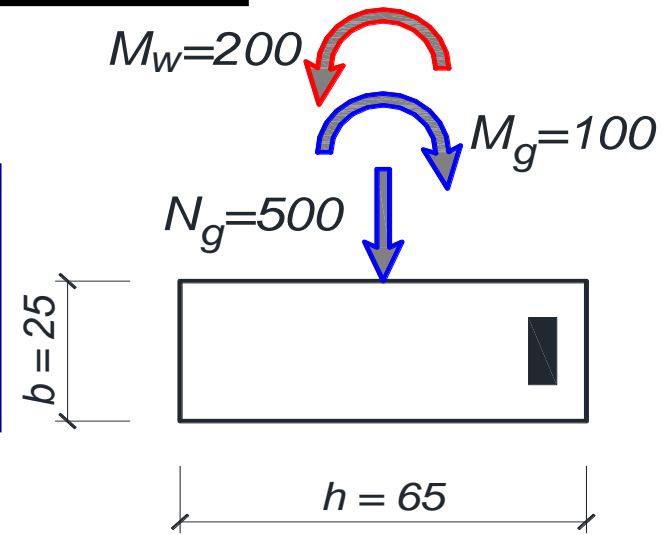
$$N_{Ed} = 1.0 \times 500 = 500 \text{ kN}$$

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

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

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

**“povoljno”  
dejstvo stalnog  
opterećenja**



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

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

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



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

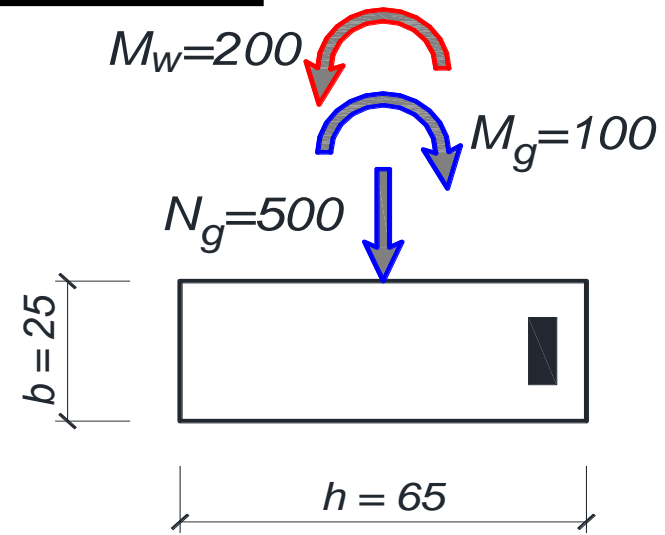
$$M_{Ed} = 1.35 \times (-100) + 1.5 \times 200 = 165 \text{ kNm}$$

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

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

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

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



$$M_{Eds} = 165 + 675 \times \left( \frac{0.65}{2} - 0.05 \right) = 350.6 \text{ kNm}$$

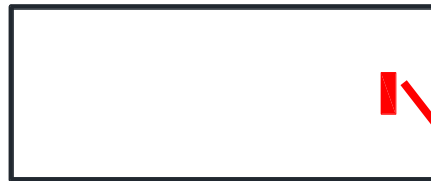
$$k = \frac{60}{\sqrt{\frac{350.6 \times 10^2}{25 \times 1.42}}} = 1.909 \Rightarrow \begin{aligned} \varepsilon_c / \varepsilon_{s1} &= 3.5 / 5.0\text{‰} \\ \omega_1 &= 33.333\% \end{aligned}$$

$$A_{s1} = 33.333 \times \frac{25 \times 60}{100} \times \frac{1.42}{43.5} - \frac{675}{43.5} = 0.8 \text{ cm}^2$$

14.63      7.8  
15.21      4.35

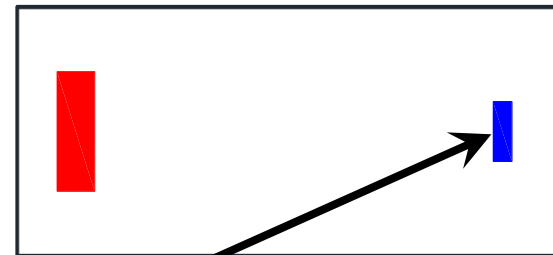


0.8  
4.0



POTREBNO:

15.21      7.8



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>)

spolja :  $A_{s,potr.} = 15.21 \text{ cm}^2$

$$A_{s1,min} = \begin{cases} 0.26 \cdot \frac{2.6}{500} \cdot 25 \cdot 60 = 2.0 \text{ cm}^2 \\ 0.0013 \cdot 25 \cdot 60 = 1.95 \text{ cm}^2 \end{cases}$$

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

$A_{s1,min} = 2.0 \text{ cm}^2$

# Zadatak 20 – 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

# KOMBINACIJE OPTERECENJA

## Promenljiva dejstva na stambene zgrade

Promenljivo dejstvo	Korisno		
	opterećenje	Sneg na krovu	Vetar
Karakteristična vrednost, $Q_k$	$Q_{k,es}$	$Q_{k,n}$	$F_{k,w}$
Vrednost za kombinaciju, za granično stanje nosivosti,			
$\psi_0 \cdot Q_k$	$0.7 \cdot Q_{k,es}$	$0.5 \cdot Q_{k,n}$	$0.6 \cdot F_{k,w}$

- Dominantno promenljivo dejstvo: **KORISNO**

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

- Dominantno promenljivo dejstvo: **SNEG**

$$1,35 \cdot G_k + 1,5 \cdot (Q_{k,n} + 0,7 \cdot Q_{k,es} + 0,6 \cdot F_{k,w}) = 1,35 \cdot G_k + 1,5 \cdot Q_{k,n} + 1,05 \cdot Q_{k,es} + 0,9 \cdot F_{k,w}$$

# KOMBINACIJE OPTEREĆENJA

## Promenljiva dejstva na stambene zgrade

Promenljivo dejstvo	Korisno opterećenje		
	Sneg na krovu	Vetar	
Karakteristična vrednost, $Q_k$	$Q_{k,es}$	$Q_{k,n}$	$F_{k,w}$
Vrednost za kombinaciju, za granično stanje nosivosti,			
$\psi_0 \cdot Q_k$	$0.7 \cdot Q_{k,es}$	$0.5 \cdot Q_{k,n}$	$0.6 \cdot F_{k,w}$

- Dominantno promenljivo dejstvo: VETAR

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

- Koeficijent “povoljnog” dejstva stalnog opterećenja:  $\gamma_{Gj,inf} = 1,0$

## a. zategnuta spoljašnja ivica stuba

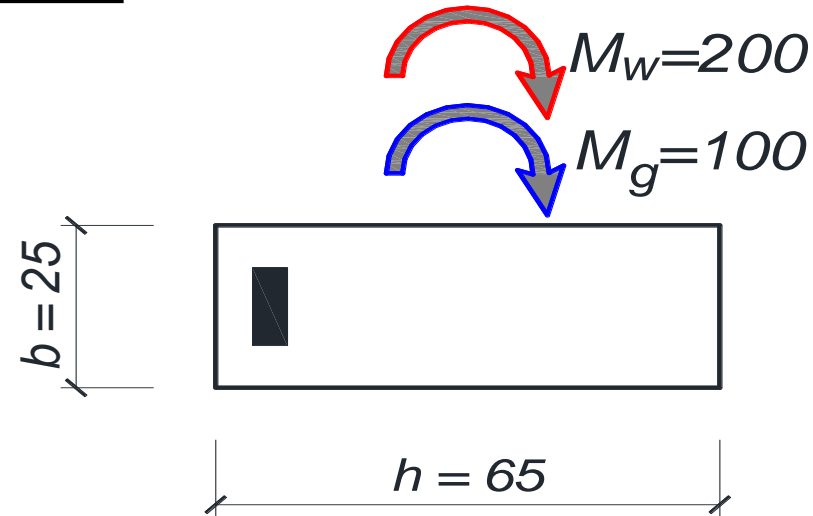
### a.1 MINIMALNA sila pritiska

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

$$N_{Ed} = 0$$

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

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



$$k = \frac{58}{\sqrt{\frac{435 \times 10^2}{25 \times 14.2}}} = 1.657 \Rightarrow \varepsilon_{s1} < 2.5\text{‰}$$

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

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

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

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

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

$$\varepsilon_{s2} = \frac{\xi_{lim} - \frac{d_2}{d}}{\xi_{lim}} \varepsilon_{cu2} = \frac{0.584 - \frac{5}{58}}{0.584} \cdot 3.5 = 2.98 > 2.175 = \frac{435}{200} \left( = \frac{f_{yd}}{E_s} \right)$$

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

## a. zategnuta spoljašnja ivica stuba

### a.2 MAKSIMALNA sila pritiska

#### a.2.1 dominantno promenljivo – **VETAR**

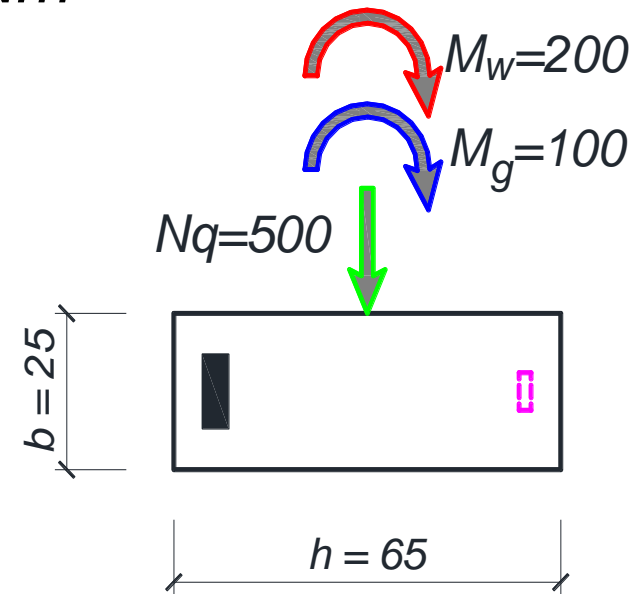
$$1,35 \cdot G_k + 1,5 \cdot (F_{k,w} + 0,5 \cdot Q_{k,n} + 0,7 \cdot Q_{k,es}) = 1,35 \cdot G_k + 1,5 \cdot F_{k,w} + 0,75 \cdot Q_{k,n} + 1,05 \cdot Q_{k,es}$$

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

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

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

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



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



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

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

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

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

$$\varepsilon_{s2} = \frac{\xi_{lim} - \frac{d_2}{d}}{\xi_{lim}} \varepsilon_{cu2} = \frac{0.584 - \frac{5}{58}}{0.584} \cdot 3.5 = 2.98 > 2.175 = \frac{435}{200} \left( = \frac{f_{yd}}{E_s} \right)$$

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

## a. zategnuta spoljašnja ivica stuba

### a.2 MAKSIMALNA sila pritiska

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

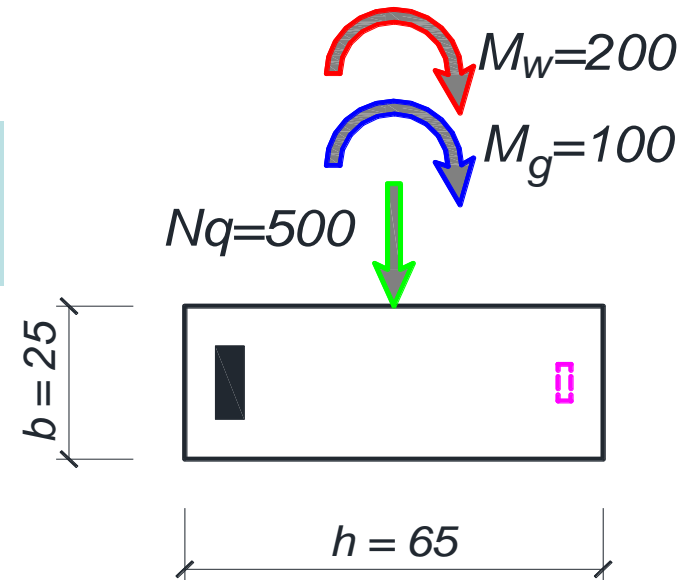
$$1,35 \cdot G_k + 1,5 \cdot (Q_{k,es} + 0,5 \cdot Q_{k,n} + 0,6 \cdot F_{k,w}) = 1,35 \cdot G_k + 1,5 \cdot Q_{k,es} + 0,75 \cdot Q_{k,n} + 0,9 \cdot F_{k,w}$$

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

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

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

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



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

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

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

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

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

$$\varepsilon_{s2} = \frac{\xi_{lim} - \frac{d_2}{d}}{\xi_{lim}} \varepsilon_{cu2} = \frac{0.584 - \frac{5}{58}}{0.584} \cdot 3.5 = 2.98 > 2.175 = \frac{435}{200} \left( = \frac{f_{yd}}{E_s} \right)$$

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



## Mmax, Nmin

## Mmax, Nmax

*Dominantan vetar*  
**Mmax**

*Dominantno korisno*  
**Nmax**

$$A_{s1} = 22.69 \text{ cm}^2$$

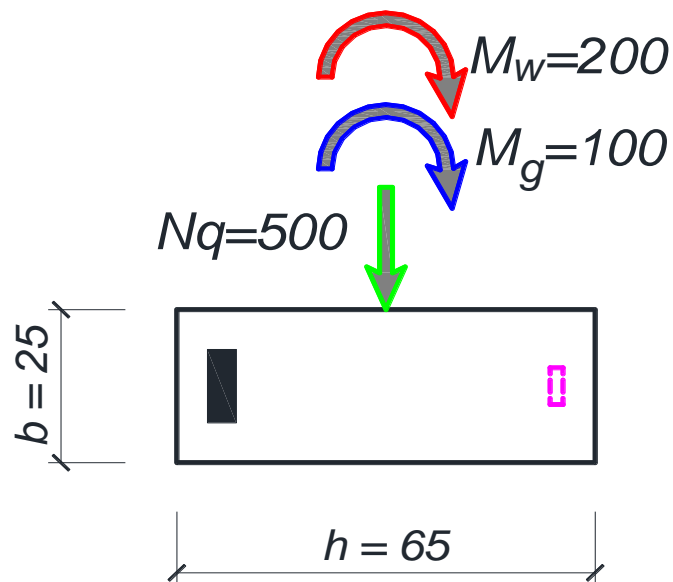
$$A_{s1} = 16.40 \text{ cm}^2$$

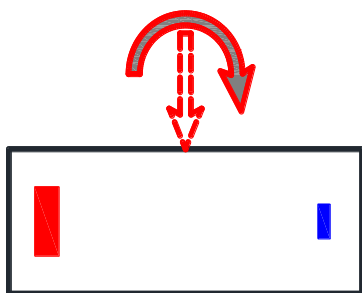
$$A_{s1} = 8.54 \text{ cm}^2$$

$$A_{s2} = 0.34 \text{ cm}^2$$

$$A_{s2} = 6.15 \text{ cm}^2$$

$$A_{s2} = 3.43 \text{ cm}^2$$





POTREBNO:

22.69

6.15



$$\text{spolja: } A_{s,potr.} = \max. \left\{ \begin{array}{l} 22.69 \\ 16.40 \\ 8.54 \end{array} \right\} = 22.69 \text{ cm}^2$$

$$\text{unutra: } A_{s,potr.} = \max. \left\{ \begin{array}{l} 0.34 \\ 6.15 \\ 3.43 \end{array} \right\} = 6.15 \text{ cm}^2$$

$$A_{s1,min} = \begin{cases} 0.26 \cdot \frac{2.6}{500} \cdot 25 \cdot 60 = 2.0 \text{ cm}^2 \\ 0.0013 \cdot 25 \cdot 60 = 1.95 \text{ cm}^2 \end{cases}$$

$$A_{s1,min} = 2.0 \text{ cm}^2$$

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

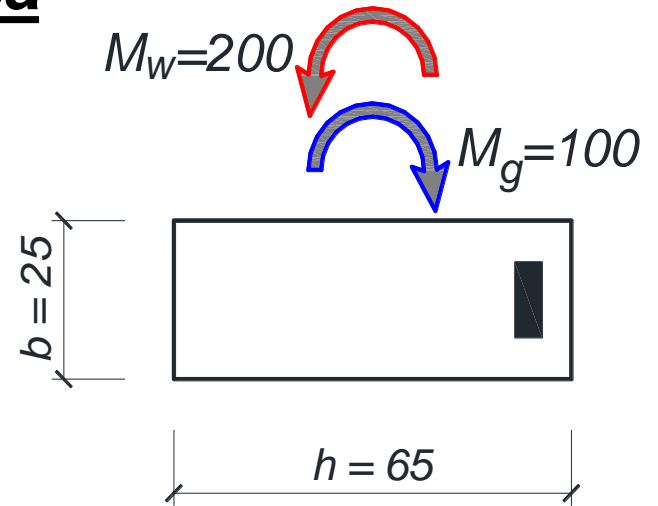
### **b.1 MINIMALNA sila pritiska**

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

$$N_{Ed} = 0$$

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

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



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

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

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

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

### **b.2 MAKSIMALNA sila pritiska**

#### **b.2.1 dominantno promenljivo – VETAR**

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

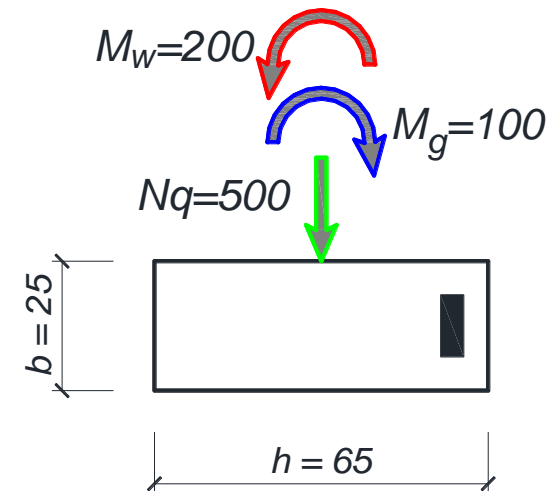
$$M_{Ed} = 1.0 \times (-100) + 1.5 \times 200 = 200 \text{ kNm}$$

$$N_{Ed} = 1.5 \times 0.7 \times 500 = 525 \text{ kN}$$

$$M_{Eds} = 200 + 525 \times \left( \frac{0.65}{2} - 0.05 \right) = 443.4 \text{ kNm}$$

$$k = \frac{60}{\sqrt{\frac{344.4 \times 10^2}{25 \times 1.42}}} = 1.926 \Rightarrow \begin{aligned} \varepsilon_c / \varepsilon_{s1} &= 3.5 / 5.247\% \\ \omega &= 32.391\% \end{aligned}$$

$$A_{s1} = 32.391 \times \frac{25 \times 60}{100} \times \frac{1.42}{43.5} - \frac{525}{43.5} = 3.79 \text{ cm}^2$$



## b. zategnuta unutrašnja ivica stuba

### b.2 MAKSIMALNA sila pritiska

#### b.2.2 dominantno promenljivo – KORISNO

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

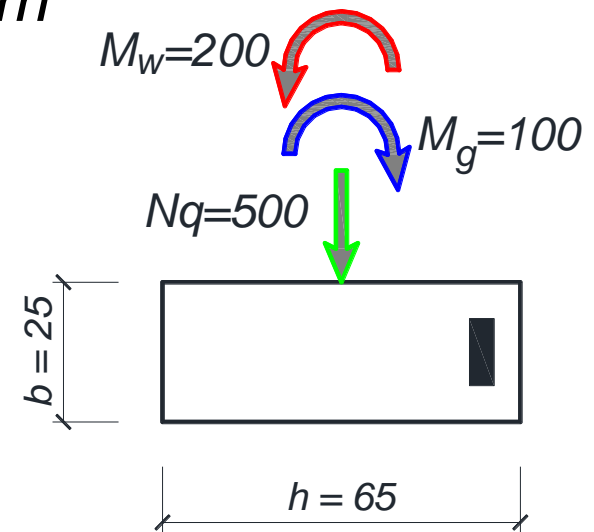
$$M_{Ed} = 1.0 \times (-100) + 1.5 \times 0.6 \times 200 = 80 \text{ kNm}$$

$$N_{Ed} = 1.5 \times 500 = 750 \text{ kN}$$

$$M_{Eds} = 80 + 750 \times \left( \frac{0.65}{2} - 0.05 \right) = 286.25 \text{ kNm}$$

$$k = \frac{60}{\sqrt{\frac{286.25 \times 10^2}{25 \times 1.42}}} = 2.113 \Rightarrow \begin{aligned} \varepsilon_c / \varepsilon_{s1} &= 3.5 / 7.40\% \\ \omega &= 25.994\% \end{aligned}$$

~~$$A_{s1} = 25.994 \times \frac{25 \times 60}{100} \times \frac{1.42}{43.5} - \frac{750}{43.5} = -4.51 \text{ cm}^2$$~~





## Mmax, Nmin

$$A_{s1} = 8.31 \text{ cm}^2$$

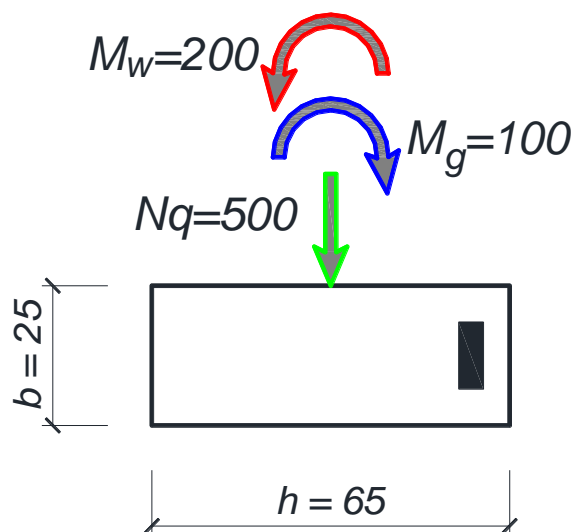
## Mmax, Nmax

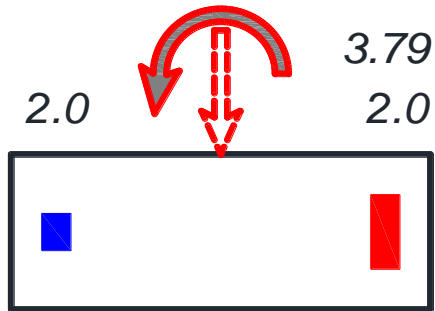
*Dominantan vetar*  
**Mmax**

$$A_{s1} = 3.79 \text{ cm}^2$$

*Dominantno korisno*  
**Nmax**

$$A_{s1} = -4.51 \text{ cm}^2$$





POTREBNO:

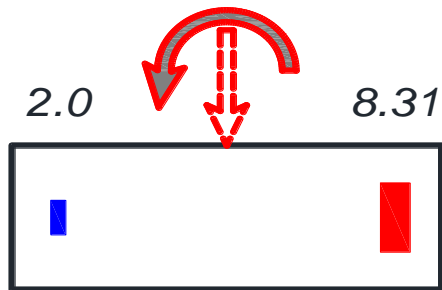
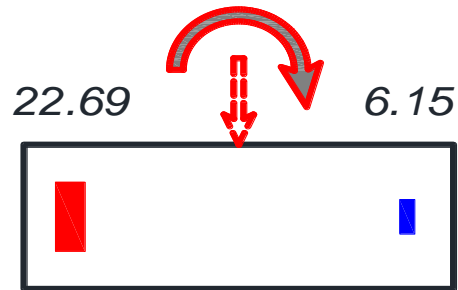


$$\text{spolja: } A_{s, \text{potr.}} = \max. \left\{ \begin{array}{l} 0 \\ 2.0 \end{array} \right\} = 2.0 \text{ cm}^2$$

$$\text{unutra: } A_{s, \text{potr.}} = \max. \left\{ \begin{array}{l} 8.31 \\ 3.79 \\ 2.0 \end{array} \right\} = 8.31 \text{ cm}^2$$

$$A_{s1, \text{min}} = \begin{cases} 0.26 \cdot \frac{2.6}{500} \cdot 25 \cdot 60 = 2.0 \text{ cm}^2 \\ 0.0013 \cdot 25 \cdot 60 = 1.95 \text{ cm}^2 \end{cases}$$

$$A_{s1, \text{min}} = 2.0 \text{ cm}^2$$



**POTREBNO:**

22.69

8.31



$$\textit{spolja: } A_{s,potr.} = \max. \left\{ \begin{array}{l} 22.69 \\ 2.0 \end{array} \right\} = 22.69 \text{ cm}^2$$

**5Ø25 (24.55 cm<sup>2</sup>)**

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

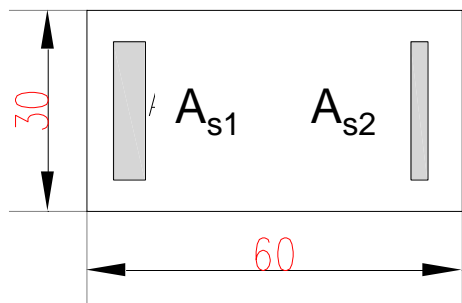
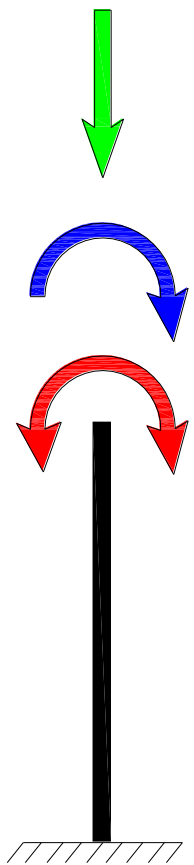
**2Ø25 (9.82 cm<sup>2</sup>)**

# Zadatak 21 – KOMBINOVANJE OPTEREĆENJA

$N_Q = 800 \text{ kN}$

$M_G = 500 \text{ kNm}$

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



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

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

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

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

$M_{Ed} = 1.35 \cdot 100 + 1.5 \cdot 0.6 \cdot 200 = 435 \text{ kNm}$   
 $N_{Ed} = 1.5 \cdot 800 = 1200 \text{ kN}$

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

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

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

# Zadatak 21 – KOMBINOVANJE OPTEREĆENJA

*Dimenzionisati stub prikazan na skici.*

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

