



Preddiplomski sveučilišni studij Građevinarstvo

PROGRAM IZ KOLEGIJA
GRAĐEVNA STATIKA I

Nositelj kolegija:
Izv.prof.dr.sc. Silva Lozančić, dipl.ing.građ.

Asistent:
Doc.dr.sc. Tanja Kalman Šipoš, dipl.ing.građ.

IVAN HORVATIĆ

Ime i prezime studenta

12345

Broj indeksa

ivan.horvatic@gmail.com

e-mail adresa

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Datum predaje

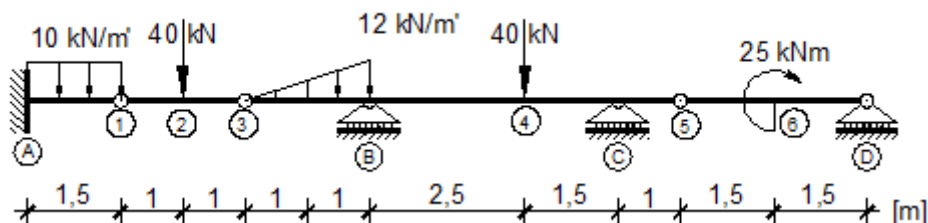
GRAĐEVNA STATIKA I

1. PROGRAM

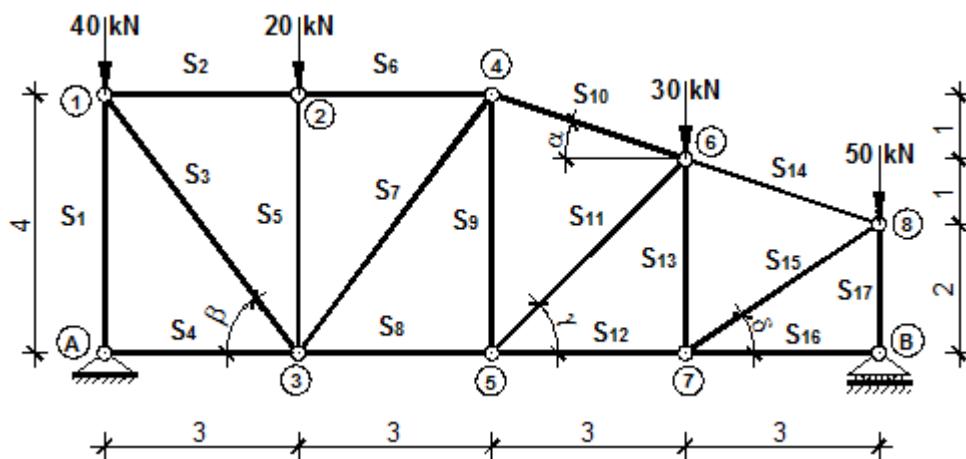
Student: **IVAN HORVATIĆ**

Akademski godina: 2017/18

1. Za zadani gerberov nosač:
 - a) analitičkim postupkom odrediti i nacrtati M i V dijagrame za Gerberov nosač;
 - b) Za dio 3-B dijagram poprečnih sila izračunati pomoću diferencijalnih odnosa.
 - c) izraditi numerički model u programu Autodesk Robot i priložiti rješenja za usporedbu rezultata

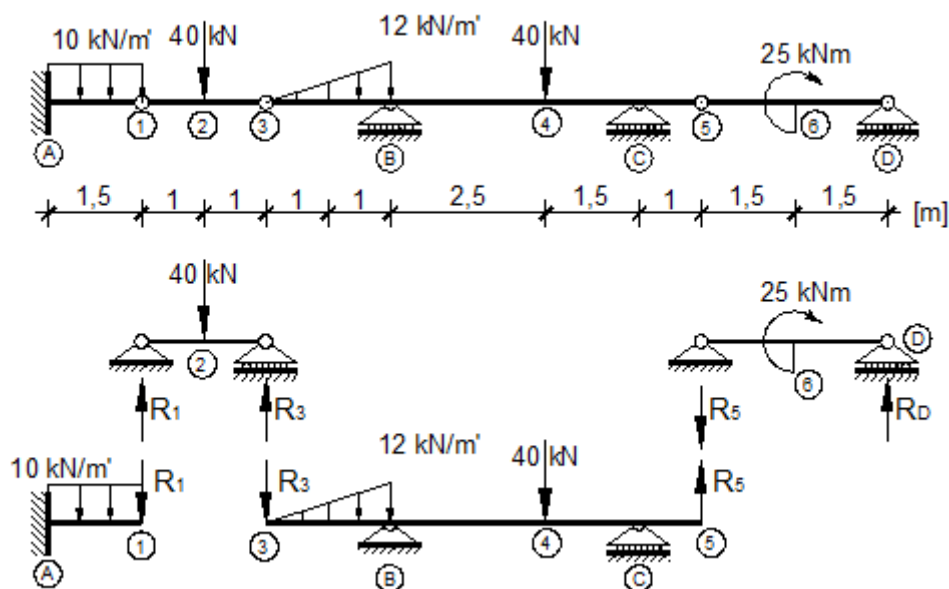


2. Za zadani rešetkasti nosač odrediti:
 - a) reakcije i sile u zadanim čvorovima rešetke A, 1, 2 i 3 pomoću metode čvorova;
 - b) sile u štapovima S₂, S₃ i S₄ metodom Culmanna, a u štapovima S₁₄, S₁₅ i S₁₆ metodom Rittera.
 - c) izraditi numerički model u programu Autodesk Robot i priložiti rješenja za usporedbu rezultata



1. ZADATAK

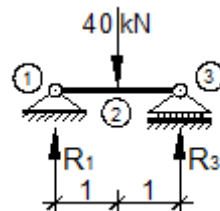
a) Analitičkim postupkom odrediti i nacrtati M i V dijagrame za Gerberov nosač. Za dio 3-B dijagram poprečnih sila izračunati pomoću diferencijalnih odnosa.



1. Prosta greda 1-3

a) Reakcije:

$$\begin{aligned} \sum M_1 = 0 \quad + \curvearrowright \quad & -40 \cdot 1 + R_3 \cdot 2 = 0 \quad R_3 = 20 \text{ kN} \\ \sum M_3 = 0 \quad + \curvearrowright \quad & 40 \cdot 1 - R_1 \cdot 2 = 0 \quad R_1 = 20 \text{ kN} \end{aligned}$$



b) Momenti savijanja: M (positive moment diagram)

$$\begin{aligned} M_1 &= M_3 = 0 \text{ kNm} \\ M_2 &= R_1 \cdot 1 = 20 \text{ kNm} \end{aligned}$$

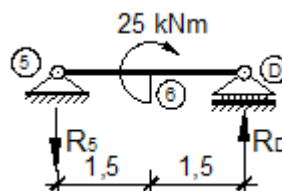
c) Poprečne sile V (shear force diagram)

$$\begin{aligned} V_1 &= R_1 = 20 \text{ kN} = V_2^{\text{lijevo}} \\ V_2^{\text{desno}} &= -R_3 = -20 \text{ kN} = V_3 \end{aligned}$$

2. Prosta greda 6-D

a) Reakcije:

$$\begin{aligned} \sum M_5 = 0 \quad + \curvearrowright \quad & -25 + R_D \cdot 3 = 0 \quad R_D = 8,33 \text{ kN} \\ \sum M_D = 0 \quad + \curvearrowright \quad & -25 + R_5 \cdot 3 = 0 \quad R_5 = 8,33 \text{ kN} \end{aligned}$$



b) Momenti savijanja: M (positive moment diagram)

$$M_5 = M_D = 0 \text{ kNm}$$

$$M_6^{\text{lijevo}} = -R_6 \cdot 1,5 = -12,5 \text{ kNm}$$

$$M_6^{\text{desno}} = -12,5 + 25 = 12,5 \text{ kNm}$$

c) *Poprečne sile* 

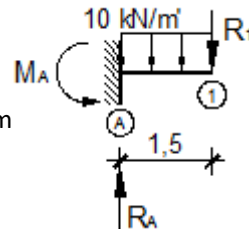
$$V_5 = -R_5 = -8,33 \text{ kN} = V_6 = V_D$$

3. Konzola A-1

a) *Reakcije:*

$$\sum M_A = 0 \quad + \curvearrowright \quad -10 \cdot 1,5 \cdot 0,75 - R_1 \cdot 1,5 + M_A = 0 \quad M_A = 41,25 \text{ kNm}$$

$$\sum F_y = 0 \quad -10 \cdot 1,5 - R_1 + R_A = 0 \quad R_A = 35 \text{ kN}$$



b) *Momenti savijanja:* 

$$M_A = -41,25 \text{ kNm}$$

$$M_1 = 0 \text{ kNm}$$

c) *Poprečne sile* 

$$V_A = R_A = 35 \text{ kN}$$

$$V_1 = R_1 = 20 \text{ kN}$$

4. Greda s prepustom 3-5

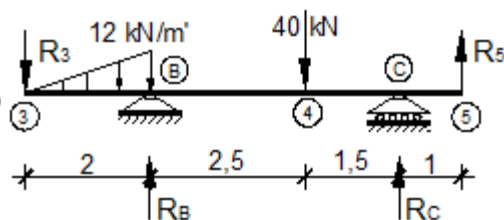
a) *Reakcije:*

$$\sum M_B = 0 \quad + \curvearrowright \quad R_3 \cdot 2 + \frac{12 \cdot 2}{2} \cdot 0,67 - 40 \cdot 2,5 + R_5 \cdot 5 + R_C \cdot 4 = 0$$

$$R_C = 2,58 \text{ kN}$$

$$\sum M_C = 0 \quad + \curvearrowright \quad R_3 \cdot 6 + \frac{12 \cdot 2}{2} \cdot 4,67 + 40 \cdot 1,5 + R_5 \cdot 1 - R_B \cdot 4 = 0$$

$$R_B = 61,09 \text{ kN}$$



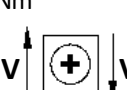
b) *Momenti savijanja:* 

$$M_3 = M_5 = 0 \text{ kNm}$$

$$M_B = -R_3 \cdot 2 - \frac{12 \cdot 2}{2} \cdot 0,67 = -48,04 \text{ kNm}$$

$$M_4 = R_5 \cdot 2,5 + R_C \cdot 1,5 = 24,69 \text{ kNm}$$

$$M_C = R_5 \cdot 1 = 8,33 \text{ kNm}$$

c) *Poprečne sile* 

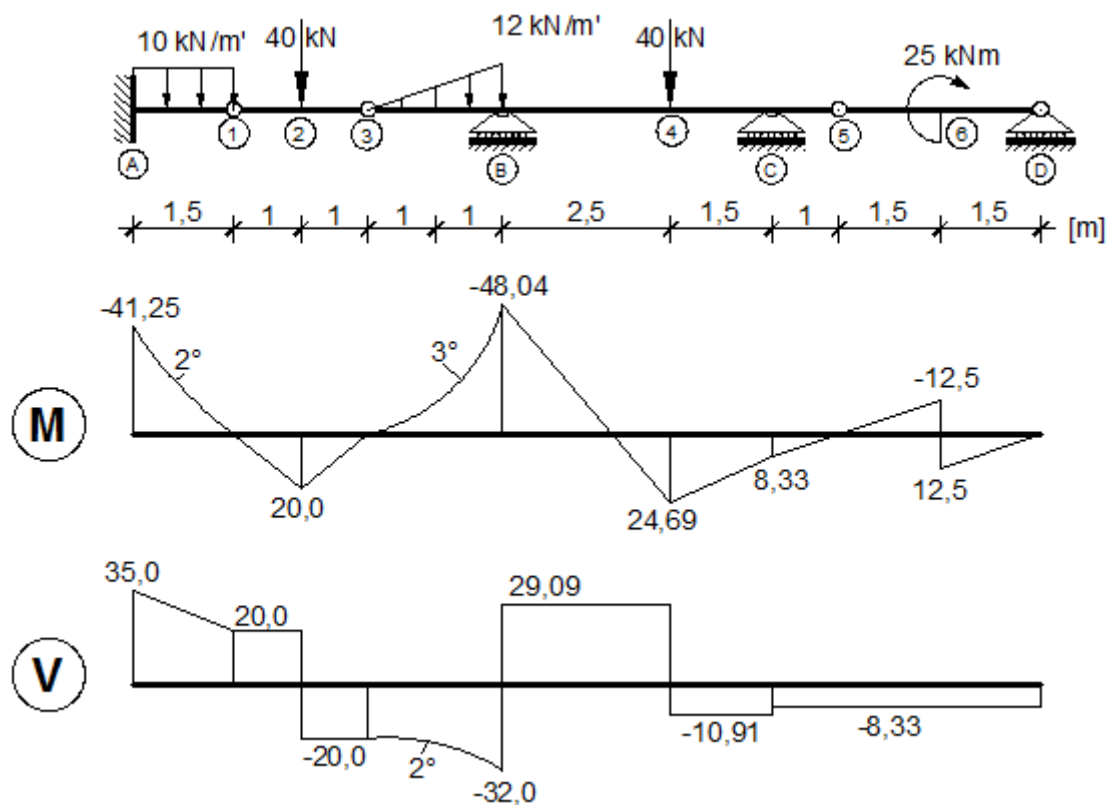
$$V_3 = -R_3 = -20 \text{ kN}$$

$$V_B^{\text{lijevo}} = -R_3 - \frac{12 \cdot 2}{2} = -32 \text{ kN}$$

$$V_B^{\text{desno}} = -32 + R_B = 29,09 \text{ kN} = V_4^{\text{lijevo}}$$

$$V_4^{\text{desno}} = 29,09 - 40 = -10,91 \text{ kN} = V_C^{\text{lijevo}}$$

$$V_C^{\text{desno}} = V_5 = -R_5 = -8,33 \text{ kN}$$



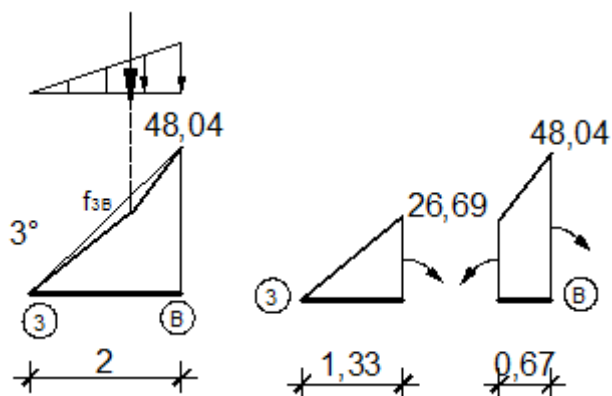
- Određivanje dijagrama poprečnih sila iz poznatog dijagrama momenata

Dio 3-B

$$f_{3B} = 5,33 \text{ kNm}$$

$$M = \frac{2 \cdot 48,04}{3} = 32,03 \text{ kNm}$$

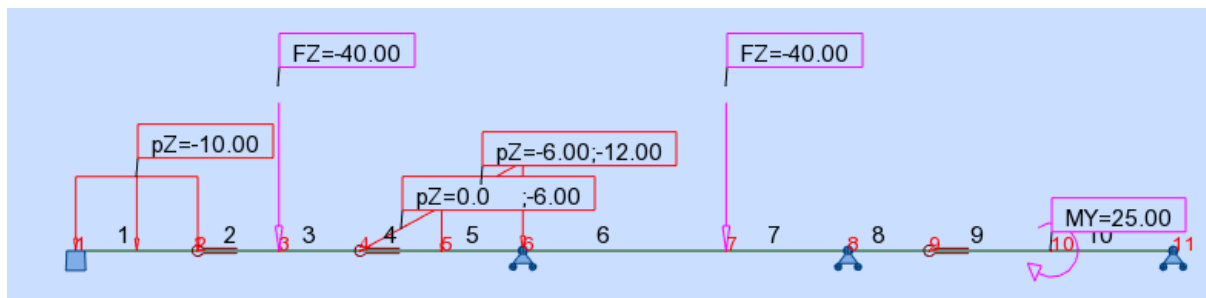
$$M - f_{3B} = 26,69 \text{ kNm}$$



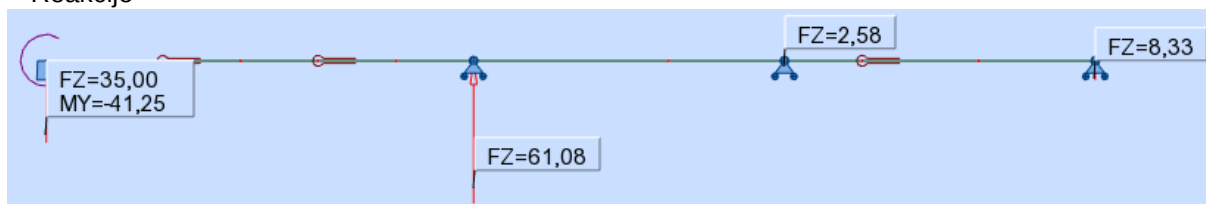
$$V_{3B} = \frac{-26,69}{1,33} = -20,0 \text{ kN}; \quad V_{B3} = \frac{26,69 - 48,04}{0,67} = -32,0 \text{ kN}$$

b) Kontrola proračuna računalom

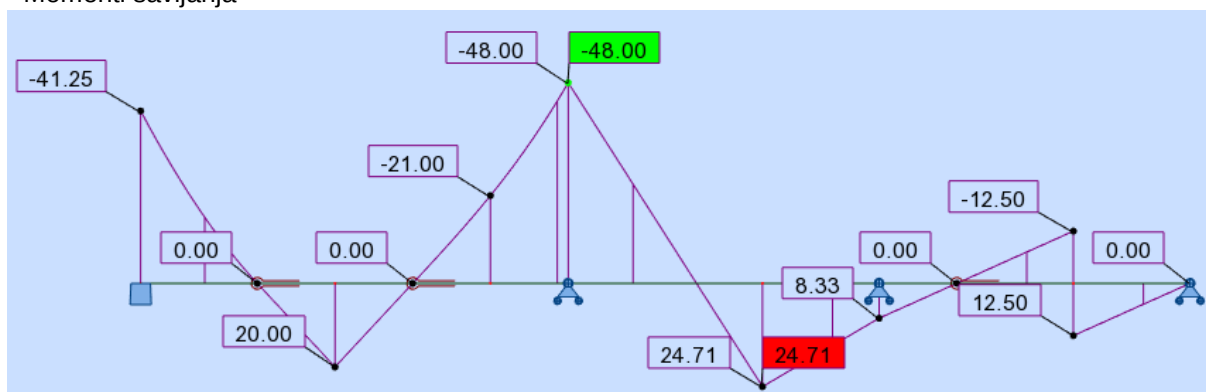
- Numerički model



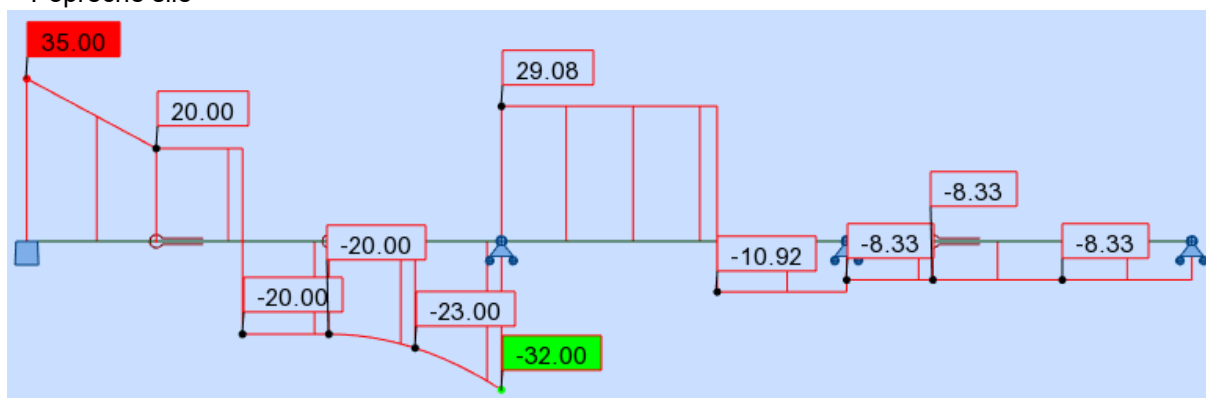
- Reakcije



- Momenti savijanja



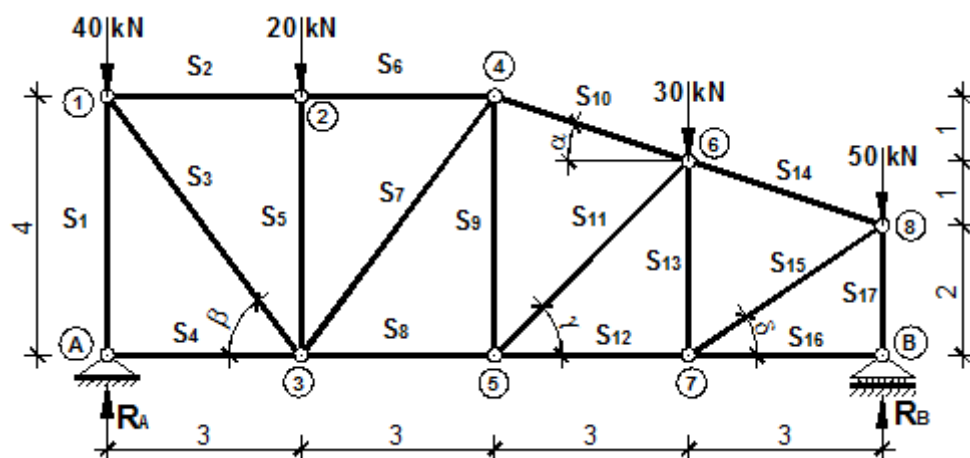
- Poprečne sile



2. ZADATAK

Za zadani rešetkasti nosač odrediti:

a) reakcije i sile u zadanim čvorovima rešetke A, 1, 2 i 3 pomoću metode čvorova;



$$\begin{array}{llll} \operatorname{tg} \alpha = \frac{1}{3} \Rightarrow \alpha = 18,43^\circ & \operatorname{tg} \beta = \frac{4}{3} \Rightarrow \beta = 53,13^\circ & \operatorname{tg} \gamma = \frac{3}{3} \Rightarrow \gamma = 45^\circ & \operatorname{tg} \delta = \frac{2}{3} \Rightarrow \delta = 33,69^\circ \\ \sin \alpha = 0,32 & \sin \beta = 0,80 & \sin \gamma = 0,71 & \sin \delta = 0,55 \\ \cos \alpha = 0,95 & \cos \beta = 0,60 & \cos \gamma = 0,71 & \cos \delta = 0,83 \end{array}$$

1. Reakcije

$$\sum M_A = 0 \quad + \curvearrowright \quad -20 \cdot 3 - 30 \cdot 9 - 50 \cdot 12 + R_B \cdot 12 = 0 \quad R_B = 77,5 \text{ kN}$$

$$\sum M_B = 0 \quad + \curvearrowright \quad 40 \cdot 12 + 20 \cdot 9 + 30 \cdot 3 - R_A \cdot 12 = 0 \quad R_A = 62,5 \text{ kN}$$

Kontrola reakcija:

$$\sum F_y = 0$$

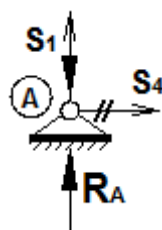
$$R_A + R_B = 40 + 20 + 30 + 50 \\ 140 = 140$$

Čvor A

Napomena: Uvijek pretpostavka vlačnih sila (+) →!

$$\sum F_x = 0 \quad S_4 = 0 \text{ kN}$$

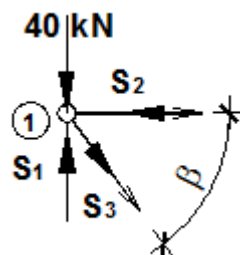
$$\sum F_y = 0 \quad S_1 + R_A = 0 \quad S_1 = -62,5 \text{ kN (tlak)}$$



Čvor 1

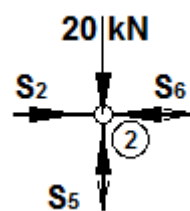
$$\sum F_y = 0 \quad S_1 - 40 - S_3 \cdot \sin \beta = 0 \\ S_3 = 28,13 \text{ kN (vlak)}$$

$$\sum F_x = 0 \quad S_2 + S_3 \cdot \cos \beta = 0 \quad S_2 = -16,88 \text{ kN (tlak)}$$



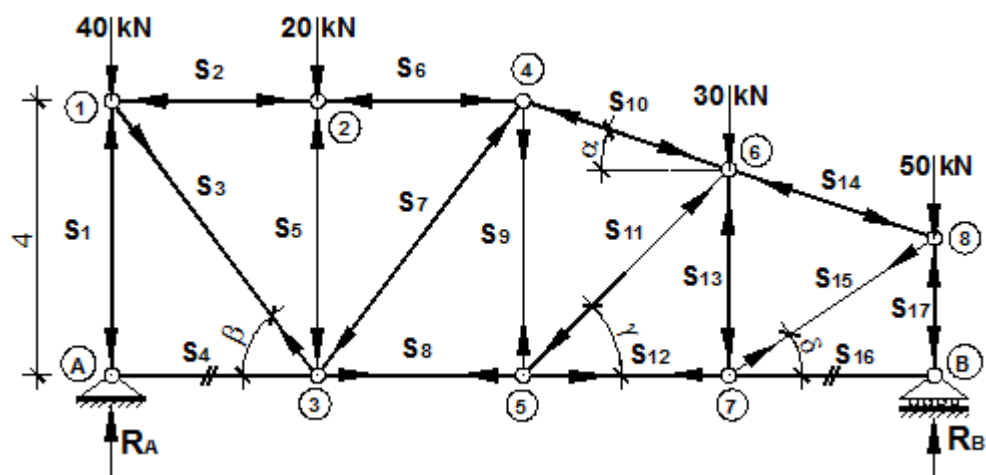
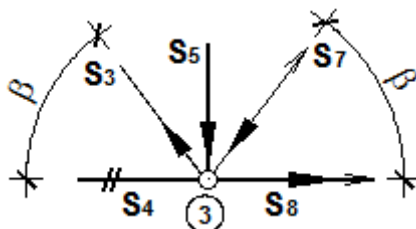
Čvor 2

$$\begin{aligned}\sum F_y = 0 & \quad -S_5 - 20 = 0 \\ & \quad S_5 = -20,0 \text{ kN (tlak)} \\ \sum F_x = 0 & \quad S_2 + S_6 = 0 \quad S_6 = -16,88 \text{ N (tlak)}\end{aligned}$$



Čvor 3

$$\begin{aligned}\sum F_y = 0 & \quad +S_3 \cdot \sin\beta - S_5 + S_7 \cdot \sin\beta = 0 \\ & \quad S_7 = -3,13 \text{ kN (tlak)} \\ \sum F_x = 0 & \quad -S_3 \cdot \cos\beta - S_7 \cdot \cos\beta + S_8 = 0 \\ & \quad S_8 = 18,75 \text{ kN (vlak)}\end{aligned}$$



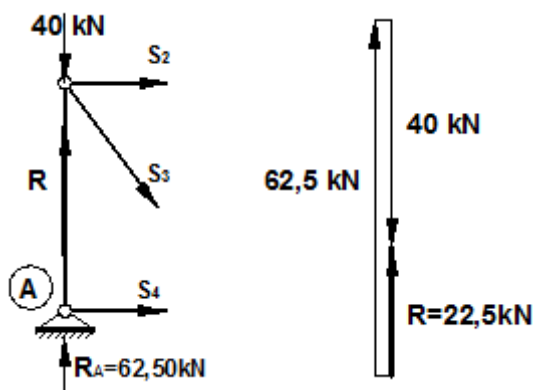
Oznaka	kN	tlak/vlak
S ₁	62,50	tlak
S ₂	16,87	tlak
S ₃	28,12	vlak
S ₄	0	-
S ₅	20,0	tlak
S ₆	16,87	tlak
S ₇	3,12	tlak
S ₈	18,75	vlak

b) sile u štapovima S_2 , S_3 i S_4 metodom Culmanna, a u štapovima S_{14} , S_{15} i S_{16} metodom Rittera.

b1) Metoda Culmanna

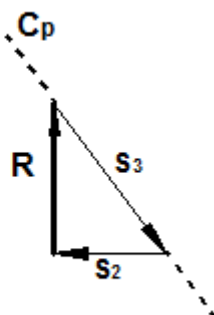
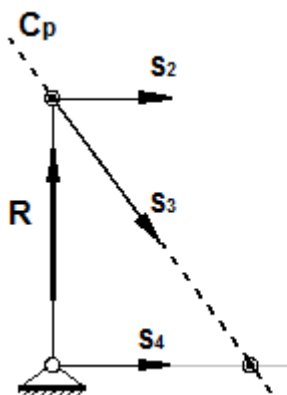
- Položaj rezultante

Za skicirani isječak rešetke (za određivanje sile u presjeku) tražimo vrijednost i položaj rezultante sile pomoću verižnog poligona. U ovom slučaju kada su obje djelujuće sile na jednom istom pravcu nije potrebno raditi verižni poligon jer se rezultanta sile nalazi na pravcu postojećih sila.



- Culmannov pravac

Culmannov pravac određen je dvjema točkama. Prva točka je sjecište rezultante sile i bilo kojeg pravca nepoznatih sila (S_2). Druga točka je mjesto gdje se sijeku preostala dva pravca sile zadanog presjeka (S_3 i S_4). Spajanjem prve i druge točke dobivamo Culmannov pravac C_p .



Očitane vrijednosti sile:

$S_2 = 16,70 \text{ kN}$ (tlak);

$S_3 = 28,05 \text{ kN}$ (vlak);

$S_4 = 0 \text{ kN}$

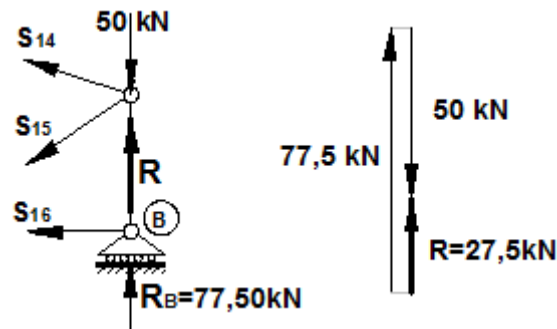
- Određivanje vrijednosti sile u označenim štapovima rešetke

Na Culmannov pravac prvo nanese rezultantu, a zatim silu koja se sječe sa rezultantom u prvoj točki (S_2) i to s iste strane Culmannovog pravca. S druge strane Culmannovog pravca nanose se pravci sile iz druge točke (u ovom slučaju samo pravac sile S_3). Očitavaju se vrijednosti sile i predznaci prema pravilu ravnoteže sile (zatvoren krug sile).

b2) Metoda Rittera

- Položaj rezultante

Za skicirani isječak rešetke (za zadani presjek) tražimo vrijednost i položaj rezultante sila pomoću verižnog poligona. S obzirom da obje sile na isječku djeluju na jednom istom pravcu nije potrebno raditi verižni poligon jer se rezultanta sila nalazi na pravcu postojećih sila.

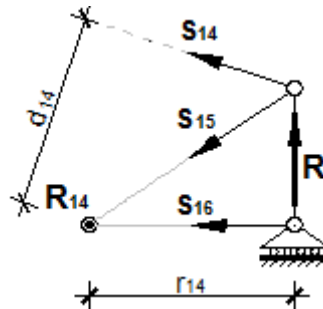


- Položaj ritterovih točaka i određivanje nepoznatih sila u presjeku

Za pravac sile S_{14} ritterova točka se nalazi na sjecištu preostala dva pravca sila u presjeku S_{15} i S_{16} (da bi ostala samo jedna nepoznanica S_{14} koja se rješava pomoću uvjeta ravnoteže $\sum M_{R14}=0$). Zatim se očitava udaljenost d_{14} između ritterove točke i nepoznate sile S_{14} , i udaljenost r_{14} između ritterove točke i rezultante R . Udaljenosti se određuju kao okomice na pravce sila do točke R_{14} .

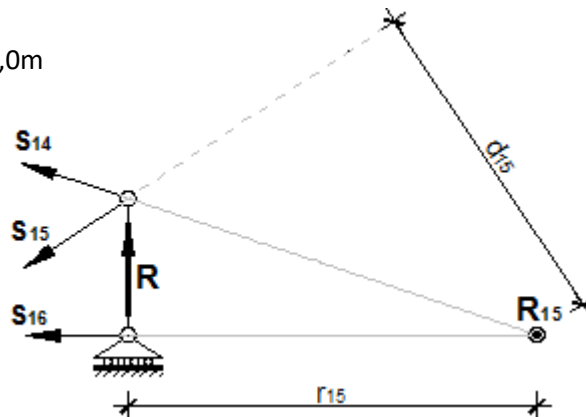
Očitane udaljenosti: $d_{14}=2,85\text{m}$; $r_{14}=3,0\text{m}$

$$\begin{aligned}\sum M_{R14} &= 0 \quad (+) \\ R \cdot r_{14} + S_{14} \cdot d_{14} &= 0 \\ S_{14} &= -28,95\text{kN} \text{ (tlak)}\end{aligned}$$



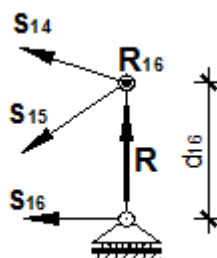
Očitane udaljenosti: $d_{15}=5,0\text{m}$; $r_{15}=6,0\text{m}$

$$\begin{aligned}\sum M_{R15} &= 0 \quad (+) \\ -R \cdot r_{15} + S_{15} \cdot d_{15} &= 0 \\ S_{15} &= 33,0\text{kN} \text{ (vlak)}\end{aligned}$$



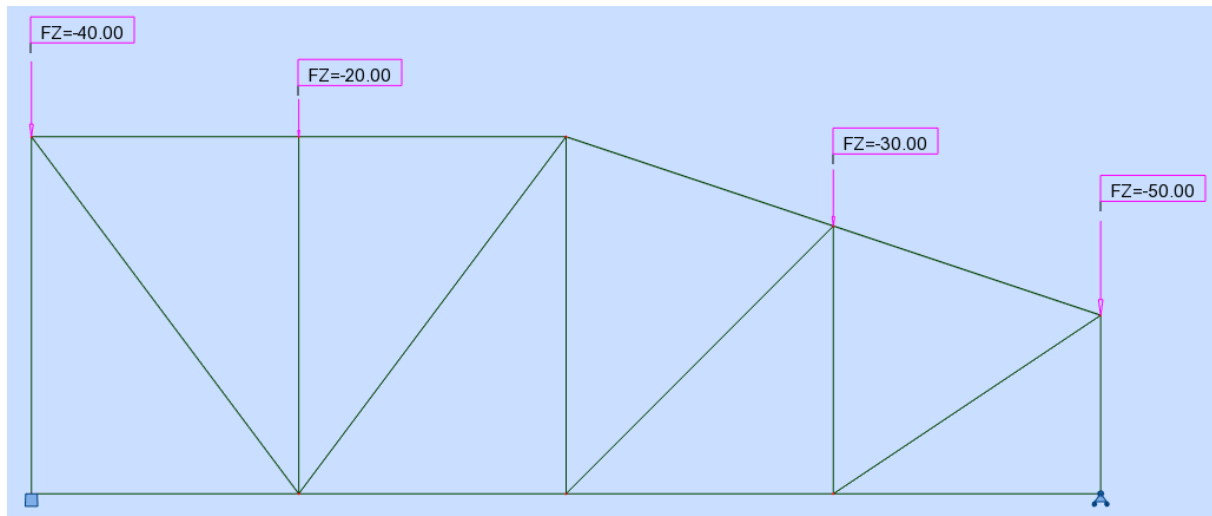
Očitane udaljenosti: $d_{16}=2,0\text{m}$; $r_{16}=0,0\text{m}$

$$\begin{aligned}\sum M_{R16} &= 0 \quad (+) \\ R \cdot r_{16} - S_{16} \cdot d_{16} &= 0 \\ S_{16} &= 0,0\text{kN}\end{aligned}$$

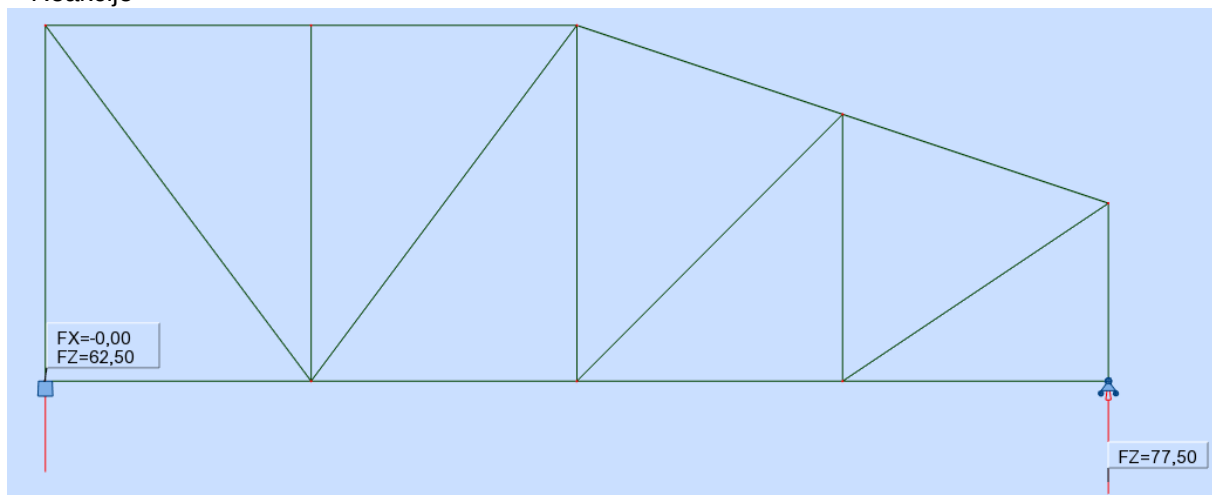


c) Kontrola proračuna računalom

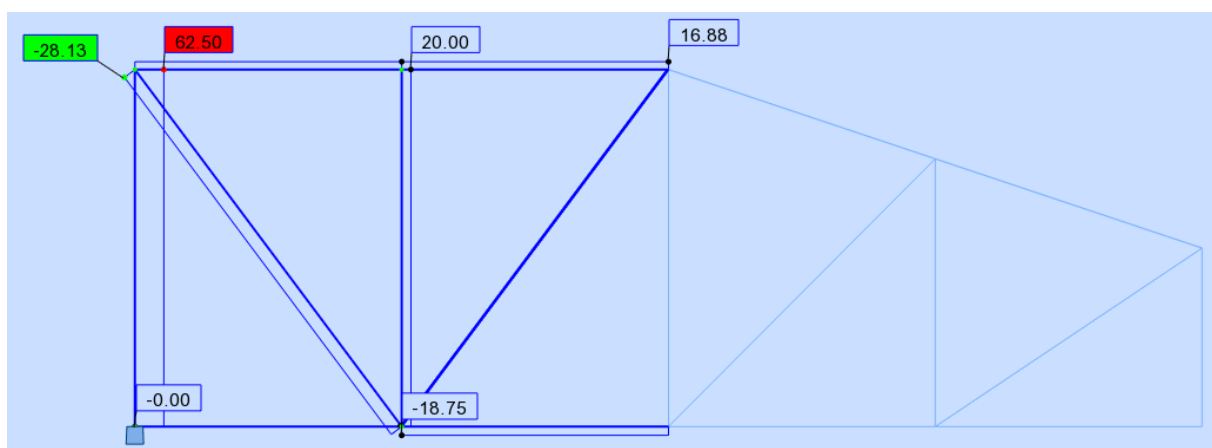
- Numerički model



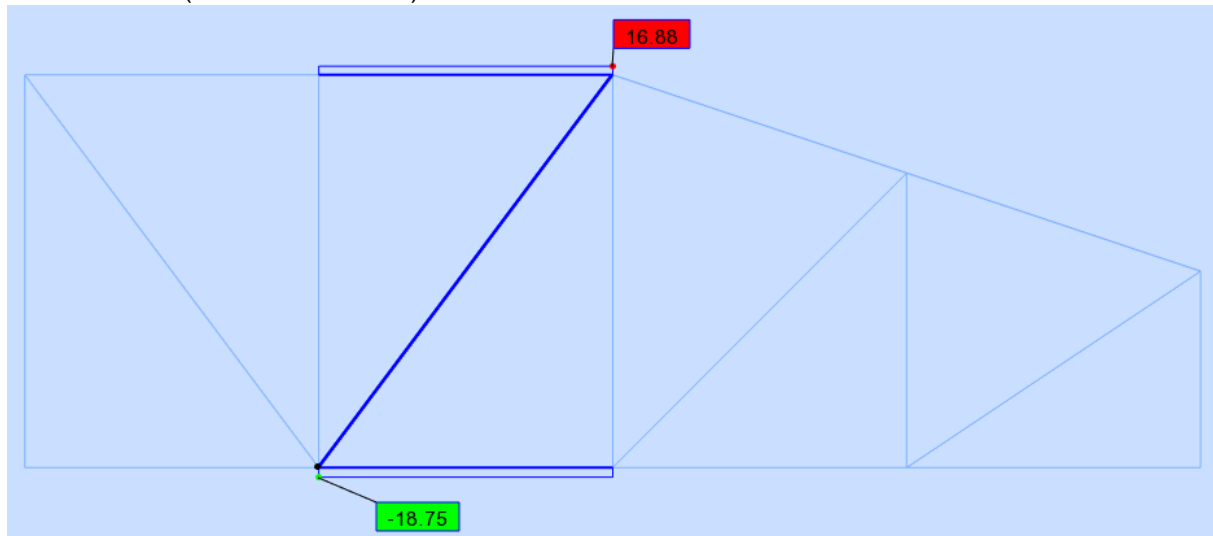
- Reakcije



- Uzdužne sile (analitički postupak)



- Uzdužne sile (metoda Culmanna)



- Uzdužne sile (metoda Rittera)

