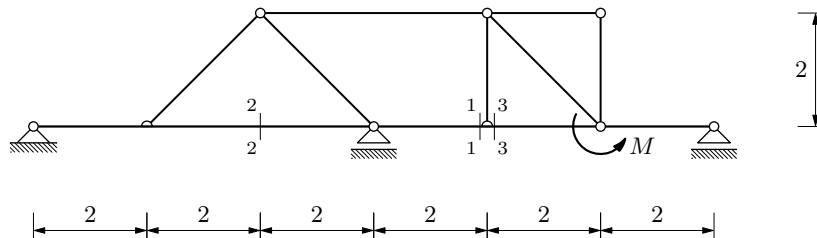


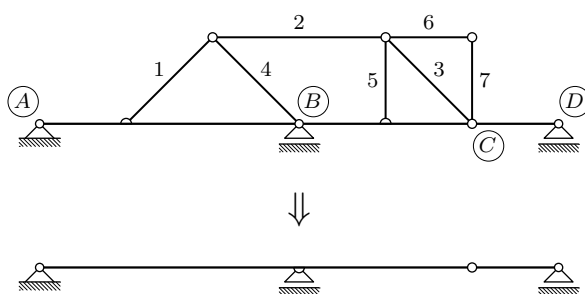
Ojačani Gerberov nosač – grafički postupak

Grafičkim postupkom odredite $[N, T, M]_{1-1}$, $[N, T, M]_{2-2}$ i $[N, T, M]_{3-3}$.

$M = 75 \text{ kNm}$ (neposredno lijevo od zgloba)



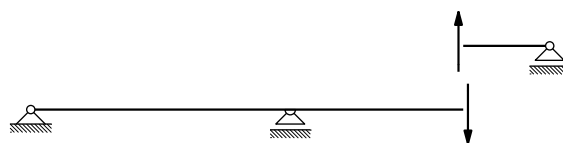
„prepoznavanje” sistema:



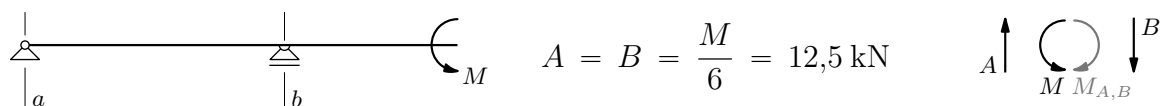
štap 2 „nadoknađuje” zglob B , pa poprečni presjek u tom zglobu zajedno s poprečnim presjekom štapa 2 može, kao i „puni” poprečni presjek, osim sila preuzeti i moment, za razliku od presjeka u zglobu C koji ne može preuzeti moment

$\Rightarrow$ zadani se nosač u odnosu na podlogu ponaša kao Gerberov nosač

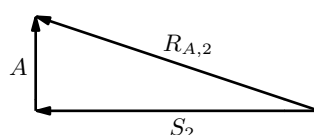
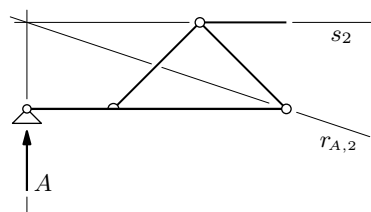
„mehanizam” prijenosa opterećenja:



vrijednosti reakcija:



vrijednost sile u štapi 2:



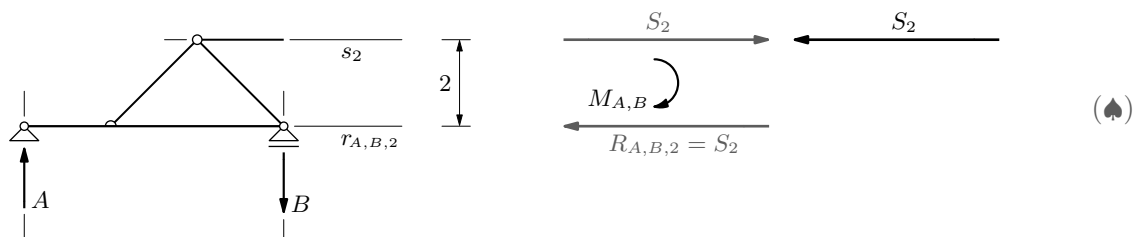
mjerilo sila:

1 cm :: 10 kN

očitano:

$S_2 = 37,5 \text{ kN}$ (tlak)

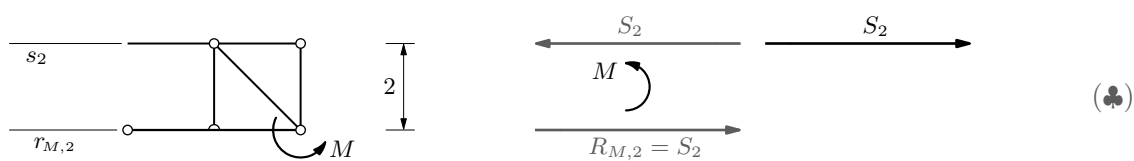
ili:



$$R_{A,B,2} = S_2 \quad (\text{vrijednost} \leftrightarrow \text{intenzitet} \ \& \ \text{smisao djelovanja})$$

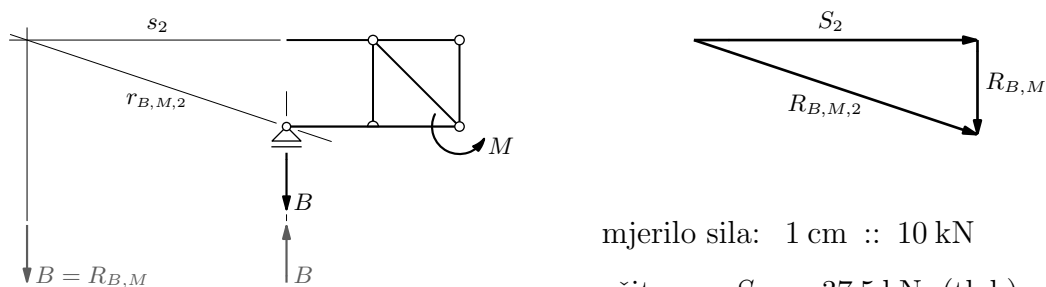
$$S_2 = \frac{M_{A,B}}{2} = 37,5 \text{ kN} \quad (\text{tlak})$$

ili:



$$S_2 = \frac{M}{2} = 37,5 \text{ kN} \quad (\text{tlak})$$

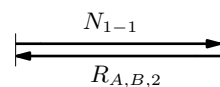
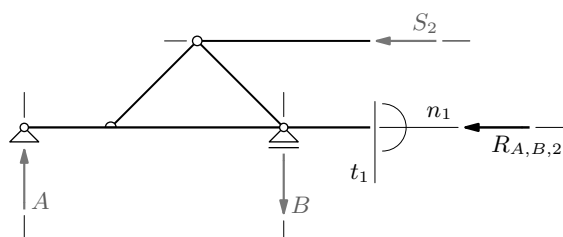
ili:



mjerilo sila: 1 cm :: 10 kN

očitano: $S_2 = 37,5 \text{ kN}$ (tlak)

vrijednosti sila u presjeku 1-1:

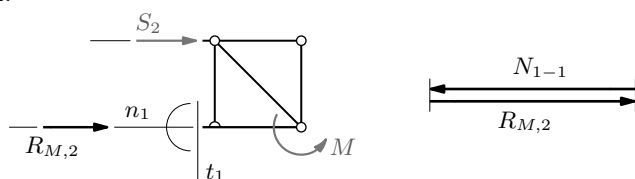


$R_{A,B,2}$ sa slike (♠)

$$N_{1,1} = R_{A,B,2} = 37,5 \text{ kN} \quad (\text{vlak})$$

$$T_{1,1} = 0 \quad \& \quad M_{1,1} = 0$$

ili:

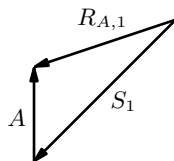
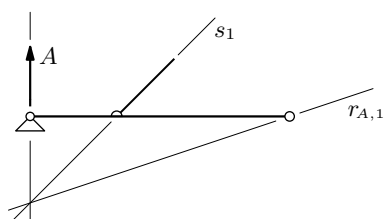


$R_{M,2}$ sa slike (♣)

$$N_{1,1} = R_{M,2} = 37,5 \text{ kN} \quad (\text{vlak})$$

$$T_{1,1} = 0 \quad \& \quad M_{1,1} = 0$$

vrijednost sile u štapu 1:



mjerilo sila:

$$1 \text{ cm} :: 10 \text{ kN}$$

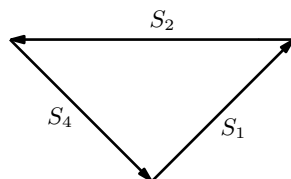
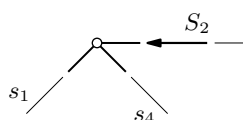
očitano:

$$S_1 = 26,5 \text{ kN} \quad (\text{tlak})$$

$$R_{A,1} = 19,75 \text{ kN}$$

()

ili:



mjerilo sila:

$$1 \text{ cm} :: 10 \text{ kN}$$

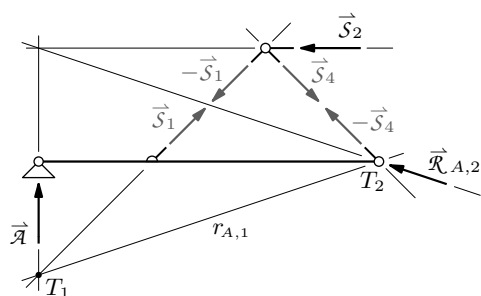
očitano:

$$S_1 = 26,5 \text{ kN} \quad (\text{tlak})$$

$$S_4 = 26,5 \text{ kN} \quad (\text{vlak})$$

()

ili:



($\mp \vec{S}_1$ i $\mp \vec{S}_4$ — pretpostavljene orijentacije)

$\vec{R}_{A,1} = \vec{A} + \vec{S}_1$ na (zāsada) nepoznatom pravcu $r_{A,1}$ kroz T_1

$$-\vec{S}_1 + \vec{S}_2 + \vec{S}_4 = 0 \Rightarrow \vec{S}_1 = \vec{S}_2 + \vec{S}_4$$

$$\vec{R}_{A,1} = \vec{A} + \vec{S}_1 = \vec{A} + (\vec{S}_2 + \vec{S}_4) \quad (\text{)}$$

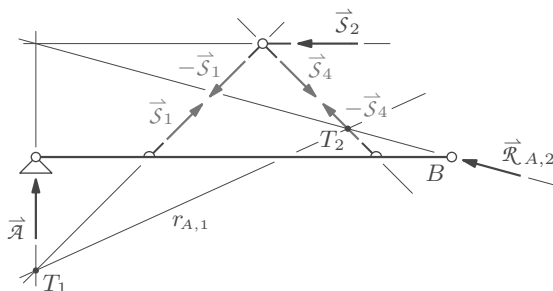
$$\vec{R}_{A,2} = \vec{A} + \vec{S}_2$$

$$\vec{R}_{A,1} = (\vec{A} + \vec{S}_2) + \vec{S}_4 = \vec{R}_{A,2} + \vec{S}_4$$

$\Rightarrow r_{A,1}$ prolazi i kroz T_2 (sjecište pravaca djelovanja sila $\vec{R}_{A,2}$ i $\vec{S}_4$)

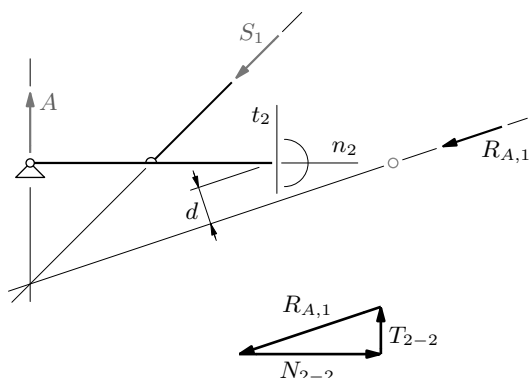
poligon sila kao na slici ()

postupak nalaženja pravca $r_{A,1}$, prikazan na slici () , složeniji je od postupka sa slike () , pa se u našem primjeru i ne čini pretjerano smislenim; no, ako os štapa 4 (pravac djelovanja sile $\vec{S}_4$) ne prolazi zglibom B , postupak sa slike () nije primjenjiv, a postupak sa slike () i u tom slučaju omogućava nalaženja pravca $r_{A,1}$ bez prethodnoga uravnoteživanja čvora kojim prolaze sile $\vec{S}_1$, $\vec{S}_2$ i $\vec{S}_4$, kao na slici () :



vrijednosti sila u presjeku 2-2:

ako je rezultanta $\vec{R}_{A,1}$ poznata (slike (☺) i (☹)):



mjerilo sila: 1 cm :: 10 kN

očitano:

$$N_{2-2} = 18,75 \text{ kN} \quad (\text{vlak})$$

$$T_{2-2} = 6,25 \text{ kN}$$

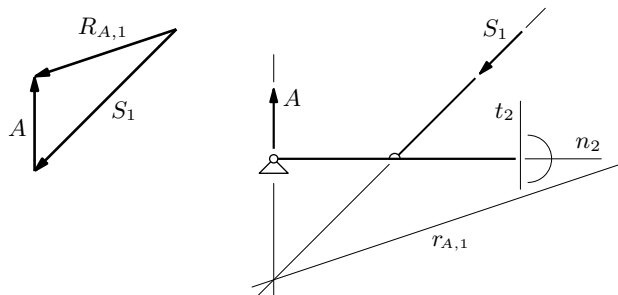
mjerilo duljina: 1 cm :: 1,25 m

očitano:

$$\tilde{d} = 5 \text{ mm} \Rightarrow d = 0,625 \text{ m}$$

$$M_{2-2} = d \cdot R_{A,1} = 0,625 \cdot 19,75 = 12,3 \text{ kNm} \quad \text{☹}$$

ako rezultanta $\vec{R}_{A,1}$ nije poznata (slika (☹☹)):

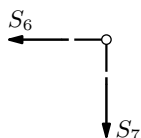


1. $\vec{R}_{A,1} = \vec{A} + \vec{S}_1$ u poligonu sila

2. u planu položaju $r_{A,1}$ prolazi sjecištem pravaca a i s_1 usporedno s $\vec{R}_{A,1}$

3. nastavak kao na prethodnoj slici

vrijednosti sila u štapovima 6 i 7:

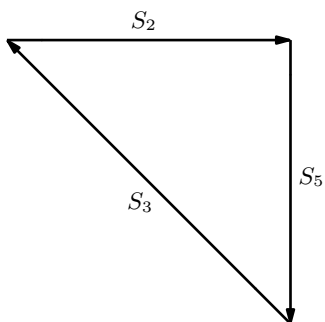
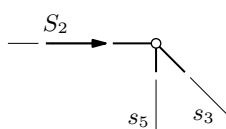


$$\sum F_x = 0 \Rightarrow S_6 = 0$$

$$\sum F_z = 0 \Rightarrow S_7 = 0$$

... i općenije, ako su u čvor spojena samo dva štapa osi koji nisu na pravcu i ako na čvor ne djeluje vanjska sila, vrijednosti su sila u priključenim štapovima jednake nuli

vrijednost sile u štapu 3:



mjerilo sila:

1 cm :: 10 kN

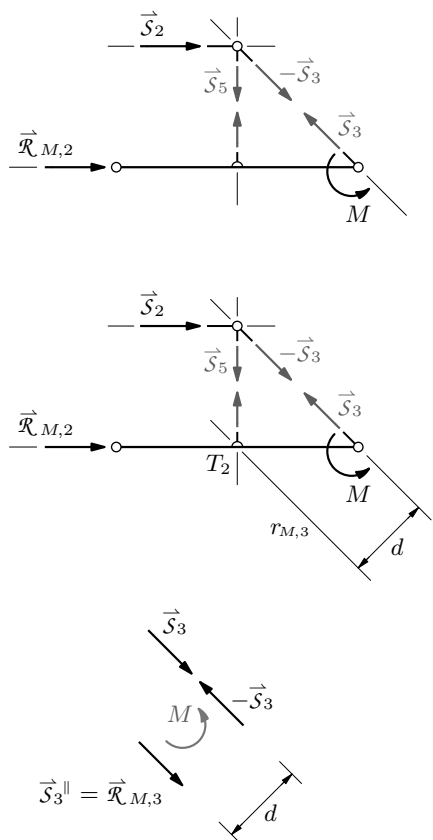
očitano:

$$S_3 = 53 \text{ kN} \quad (\text{tlak})$$

$$S_5 = 37,5 \text{ kN} \quad (\text{vlak})$$

(☺)

ili (bez prethodnoga uravnoteživanja čvora):



($\mp \vec{S}_3$ i $\mp \vec{S}_5$ — pretpostavljene orijentacije)

$$M \ominus -\vec{S}_3 + \vec{S}_3^\parallel$$

(M zamjenjujemo spregom sila $-\vec{S}_3$ i $\vec{S}_3^\parallel$ na zaslada nepoznatom pravcu usporednom s $\mp \vec{S}_3$)

$$\vec{R}_{M,3} = \vec{S}_3 \oplus M = \vec{S}_3^\parallel$$

(vektore sila i momenata ne možemo zbrajati, ali sile i momente kao fizičke veličine možemo (momente shvaćamo kao spregove sila))

$$\vec{S}_2 + \vec{S}_5 - \vec{S}_3 = 0 \Rightarrow \vec{S}_3 = \vec{S}_2 + \vec{S}_5$$

$$\vec{R}_{M,2} = \vec{S}_2 \oplus M$$

$$\begin{aligned} \vec{R}_{M,3} = \vec{S}_3^\parallel &= (\vec{S}_2 + \vec{S}_5) \oplus M \\ &= \vec{S}_5 + (\vec{S}_2 \oplus M) = \vec{S}_5 + \vec{R}_{M,2} \end{aligned}$$

$\Rightarrow r_{M,3}$ prolazi kroz T_2 (sjecište pravaca djelovanja sila $\vec{S}_5$ i $\vec{R}_{M,2}$)

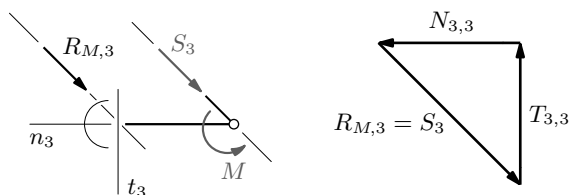
mjerilo duljina: 1 cm :: 1,25 m

očitano: $\tilde{d} = \left(11 + \frac{1}{4}\right) \text{ mm} \Rightarrow d = 1,41 \text{ m}$

$$S_3 = \frac{M}{d} = \frac{75}{1,41} = 53,2 \text{ kN} \simeq 53 \text{ kN} \text{ (tlak)}$$

vrijednosti sila u presjeku 3-3:

ako je rezultanta $\vec{R}_{M,3}$ poznata (slika (☹)):



mjerilo sila: 1 cm :: 20 kN

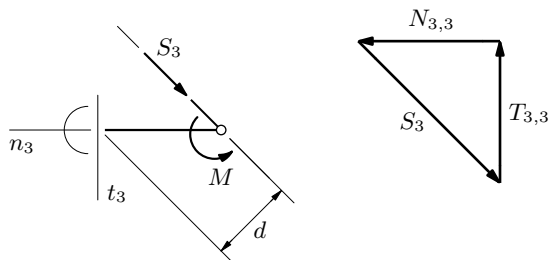
očitano:

$$N_{3,3} = 37,5 \text{ kN} \text{ (vlak)} \quad (\text{☹})$$

$$T_{3,3} = 37,5 \text{ kN}$$

$$M_{3,3} = 0 \cdot R_{M,3} = 0$$

ako rezultanta $\vec{R}_{M,3}$ nije poznata (slika (☺)):



mjerilo duljina: 1 cm :: 1,25 m

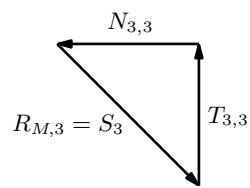
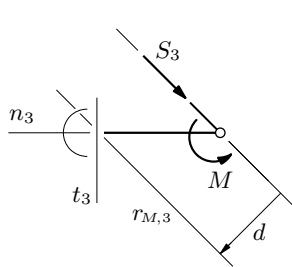
očitano: $d = 1,41 \text{ m}$

mjerilo sila: 1 cm :: 20 kN

očitano: kao na slici (☹)

$$\begin{aligned} M_{3,3} &= |-d \cdot S_3 + M| \\ &= |-1,41 \cdot 53,2 + 75| \\ &= 0,01 \simeq 0 \end{aligned}$$

ili:

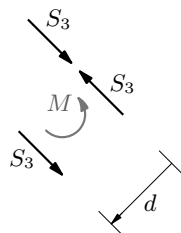


$$d = \frac{M}{S_3} = \frac{75}{53} = 1,415 \text{ m}$$

$$d \cdot \sqrt{2} = 1,415 \cdot \sqrt{2} = 2,0 \text{ m}$$

$\Rightarrow r_{M,3}$ prolazi kroz presjek 3–3

$$\Rightarrow M_{3,3} = 0$$



mjerilo sila: 1 cm :: 20 kN

očitano: kao na slici (9)