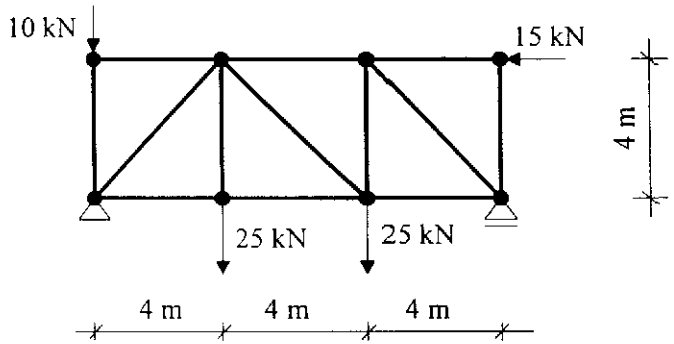
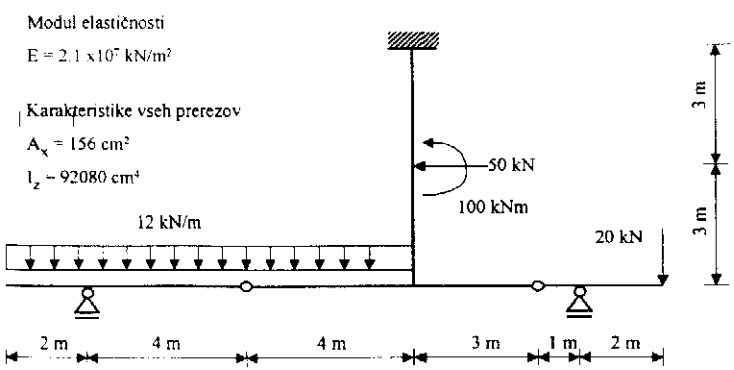
Šolsko leto 2002/03

a št 2.

nstrukcije, prikazane na spodnjih slikah najprej izračunaj notranje sile analitično, rezultate preveri s programom OKVIR. Analiziraj kinematično stabilnost in no določenost prikazanih konstrukcij.

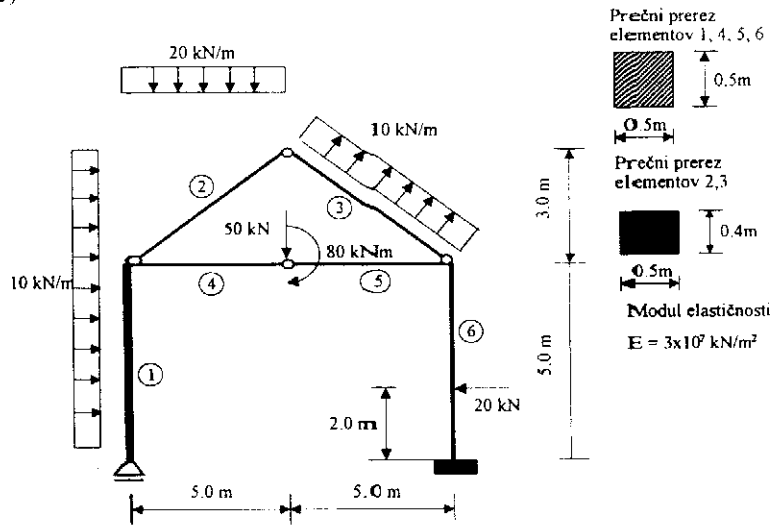


Slika 1.



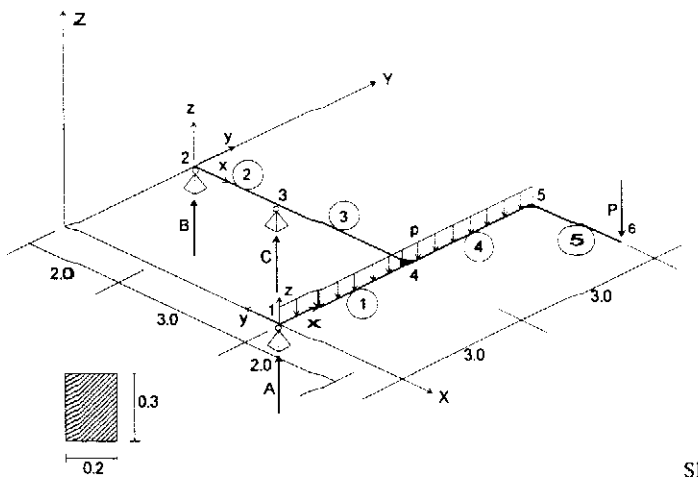
Slika 2.

3)



Slika 3.

4)



Slika 4.

P = 10kN
p = 5kN/m

Kinematična stabilnost in statična določenost konstrukcij v ravnini

—

$V_0 = 8$
$s = 13$
$p = 3$
$V = 36$

$f = 2V_0 - s - p = 2 \cdot 8 - 13 - 3 = 0$

$n = p + V - 3s = 3 + 36 - 3 \cdot 13 = 0$

—

$V_0 = 6$
$s = 5$
$k = 2$
$p = 5$
$V = 10$

$f = 2V_0 - s - k - p = 2 \cdot 6 - 5 - 2 - 5 = 0$

$n = p + V - 3s = 5 + 10 - 3 \cdot 5 = 0$

—

$V_0 = 6$
$s = 6$
$k = 2$
$p = 4$
$V = 14$

$f = 2V_0 - s - k - p = 2 \cdot 6 - 6 - 2 - 4 = 0$

$n = p + V - 3s = 4 + 14 - 3 \cdot 6 = 0$

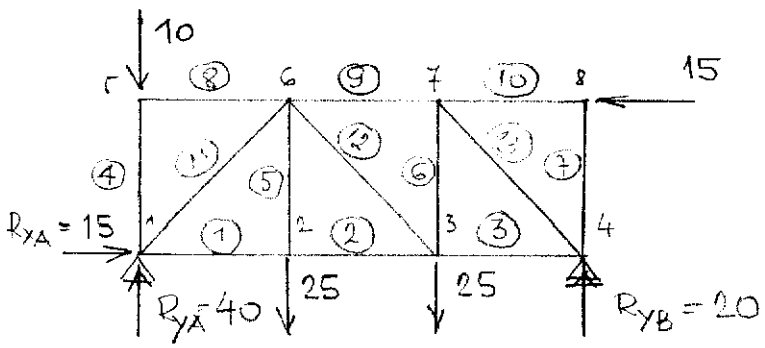
—

$V_0 = 6$
$s = 5$
$k = 4$
$p = 3$
$V = 12$

$f = 2V_0 - s - k - p = 2 \cdot 6 - 5 - 4 - 3 = 0$

$n = p + V - 3s = 3 + 12 - 3 \cdot 5 = 0$

Naloga ___



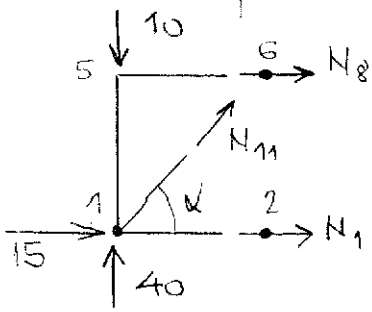
Račun reakcij:

$R_{yA} \cdot 12 - 25 \cdot (8+4) - 15 \cdot 4 - 10 \cdot 12 = 0$

$R_{yA} = 40$

$R_{yB} = 10 + 25 + 25 - 40 = 20$

Sile v palicah <u>1 - 3</u> (račun s prerezno metodo)



(sl. 1)

$\Sigma M_z^6 = 0: \; N_1 \cdot 4 - 40 \cdot 4 + 10 \cdot 4 + 15 \cdot 4 = 0 \Rightarrow N_1 = 15 \text{ kN}$

Na enak način izračunamo sili v palicah 2 in 3

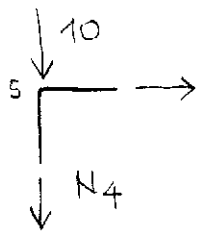
$\Sigma M_z^6 = 0: \; N_2 \cdot 4 - 40 \cdot 4 + 10 \cdot 4 + 15 \cdot 4 = 0 \Rightarrow N_2 = 15 \text{ kN}$

Pri računu sile v palici 3 upoštevamo desni del konstrukcije

$\Sigma M_z^7 = 0: \; -N_3 \cdot 4 + 20 \cdot 4 = 0 \Rightarrow N_3 = 20 \text{ kN}$

Sile v palicah 8 - 10

V palici 8 je osna sila $N_8 = 0$. To ugotovimo z izrezno metodo, izrežemo vozlišče 5



$\Sigma F_x^5 = 0 \Rightarrow N_8 = 0$

sl. 2

Na enak način izračunamo, da je v palici 10 $N_{10} = -15\,kN$. Pri tem izrežemo vozlišče 8.

Silo v palici 9 določimo s prerezno metodo. Upostevamo desni del konstrukcije.

$\Sigma M_z^3 = 0: \; -N_9 \cdot 4 - 15 \cdot 4 - 20 \cdot 4 = 0 \Rightarrow N_9 = -35\,kN$

Sile v palicah 11 - 13

Sile v palicah 11 - 13 določimo s prerezno metodo

Silo v palici 11 določimo iz pogoja da vsota vseh vertikalnih sil mora biti 0 (glej sl. 1)

$\Sigma F_y = 0: \; 40 - 10 + N_{11} \cdot \cos\alpha = 0 \qquad \cos\alpha = 0{,}707$

$N_{11} = -42.43\,kN$

Na enak način določimo sili v palicah 12 in 13

$-N_{12} \cdot \cos\alpha - 25 + 40 - 10 = 0$

$N_{12} = +7{,}07\,kN$

$N_{13} \cos\alpha + 20 = 0$

$N_{13} = -28.28\,kN$

Sile v palicah 4 - 7

Iz pogoja da je $\Sigma F_y = 0$ v vozlišču 5 (glej sl 2) izračunamo, da je

Na enak način določimo silo v palici 7, le da v tem primeru obravnavamo vsoto sil F_y v vozlišču 8

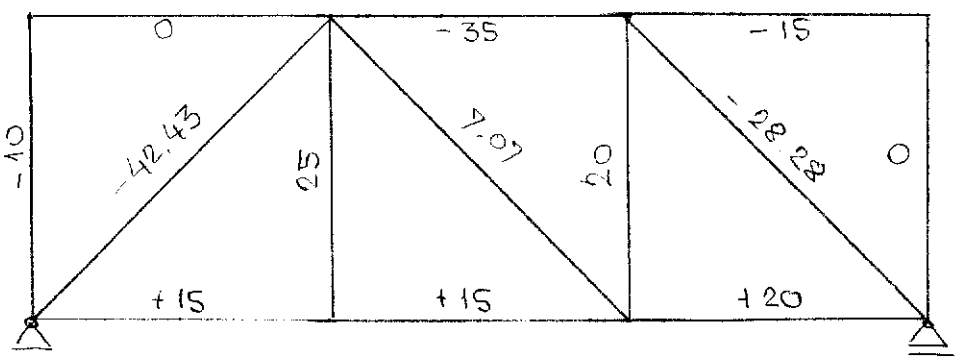
$$N_7 = 0\,kN$$

Silo v palici 5 določimo iz pogoja $F_y = 0$ v vozlišču 2

$$N_5 - 25 = 0 \Rightarrow N_5 = 25\,kN$$

Silo v palici 6 določimo s prerezno metodo. Prerežemo palice 3, 6, 9. Iz pogoja $\Sigma F_y = 0$ izračunamo.

$$-N_6 + 20 = 0 \Rightarrow N_6 = 20\,kN$$



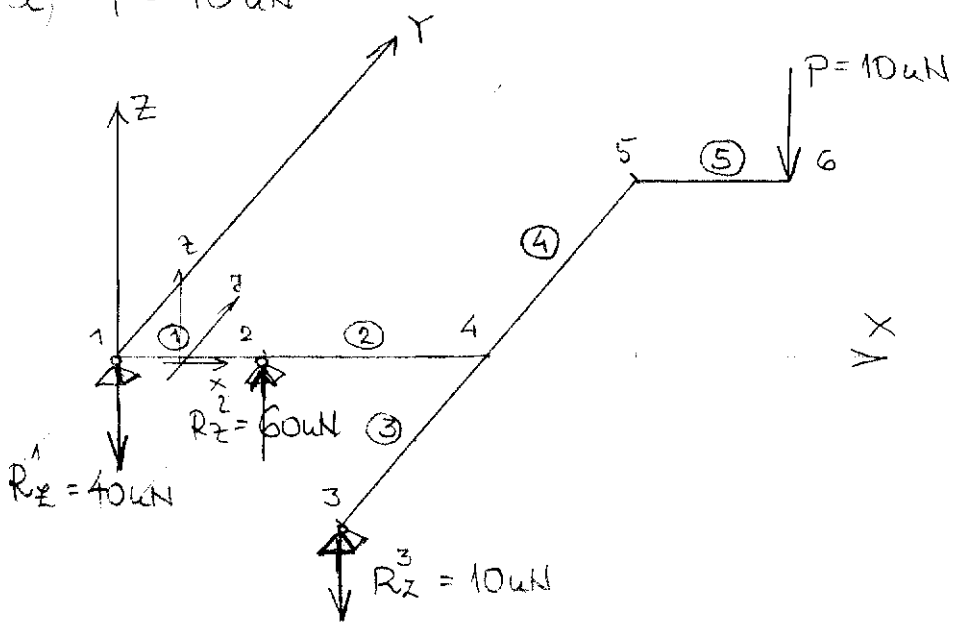
Opomba: Zaradi preglednosti poteka osnih sil v tdolžnih palic ne rišemo, saj je vemo, da je potek osnih sil v eni palici (palica je vedno konstanten.

Naloga —

Na primeru podane konstrukcije bo prikazana uporaba principa superpozicije. Princip superpozicije lahko uporabimo, ker konstrukcijo računamo po teoriji I. reda (glej osnovne predpostavke v knjigi SLK I - prof. Jenčeva Duhovnika).

Princip superpozicije nam omogoča, da notranje sile v konstrukciji izračunamo najprej za primer ko je konstrukcija obremenjena le z koncentrirano silo $P = 10\,kN$, nato pa še z enakomerno porazdeljeno obtežbo $p = 5\,kN/m$.

a) $P = 10\,kN$



Račun reakcij:

$\Sigma M_x^2 = 0: -P \cdot 3 + R_z^3 \cdot 3 = 0 \Rightarrow R_z^3 = P = 10kN$

$\Sigma M_y^2 = 0: P \cdot 5 + R_z^3 \cdot 3 - R_z^1 \cdot 2 = 0$

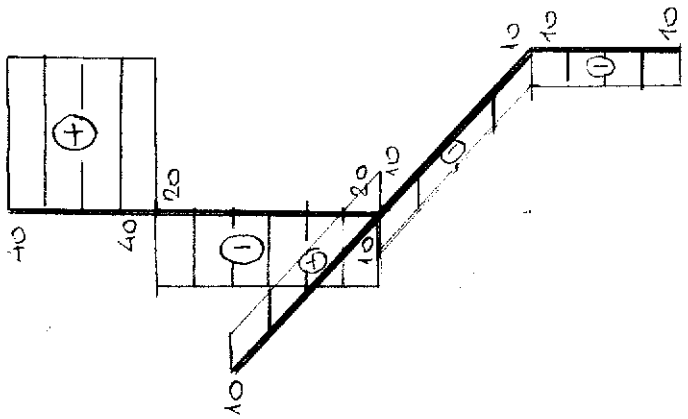
$5P + 3P - 2R_z^1 = 0 \Rightarrow R_z^1 = 4P = 40kN$

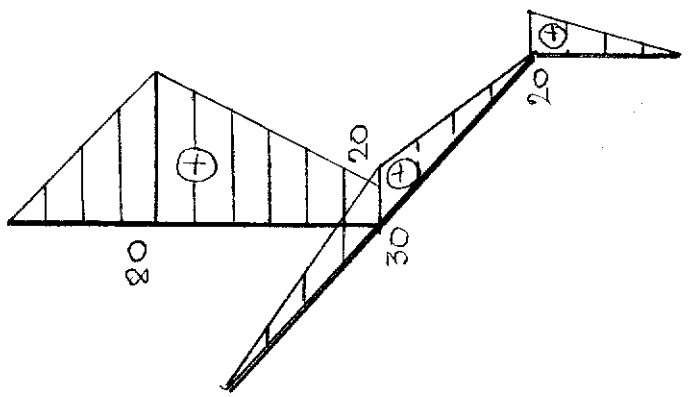
$\Sigma F_z = 0: -P - P - 4P + R_z^2 = 0 \Rightarrow R_z^2 = 6P = 60kN$

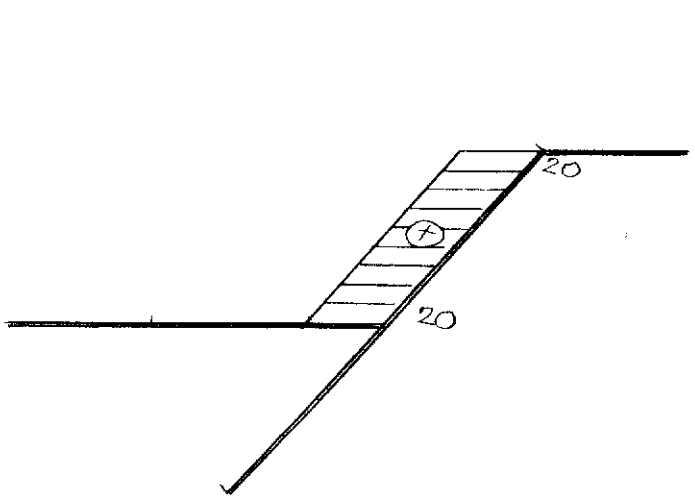
Kontrola:

$\Sigma M_x^6 = 0: \quad -10 \cdot 6 + 60 \cdot 3 - 40 \cdot 3 = 0$

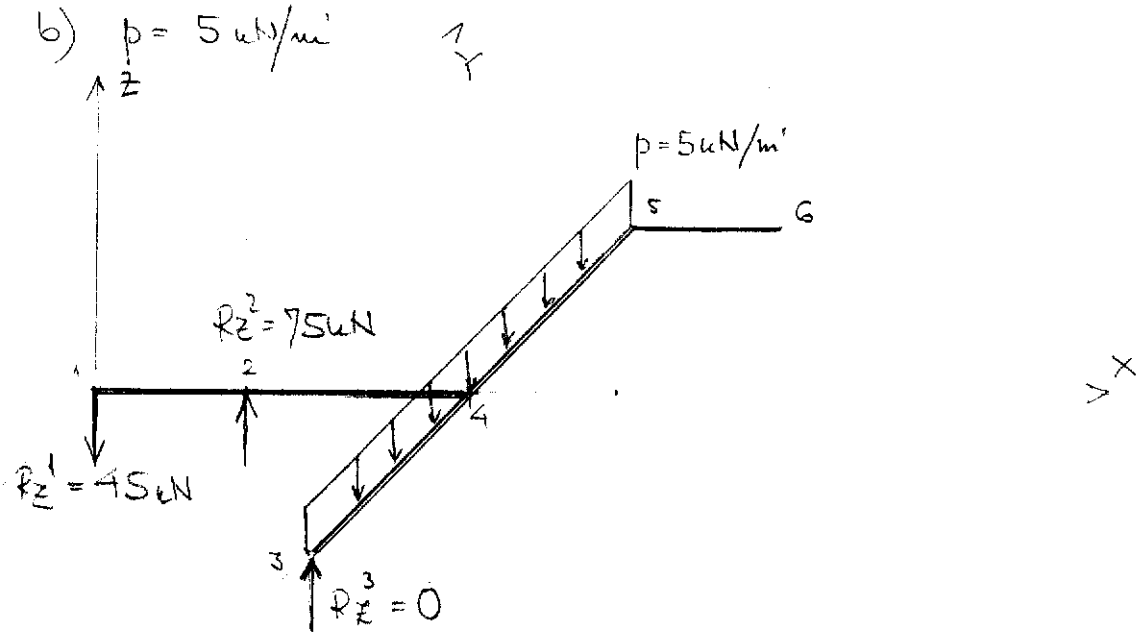
Diagrami notranjih sil







b) $p = 5\ kN/m'$



Račun reakcij:

$\Sigma M_x^2 = 0: \quad 5 \cdot 3 \cdot 1.5 - 5 \cdot 3 \cdot 1.5 - R_Z^3 \cdot 3 = 0 \Rightarrow R_Z^3 = 0$

$\Sigma M_y^2 = 0: \quad 5 \cdot 6 \cdot 3 - R_Z^1 \cdot 2 = 0 \Rightarrow R_Z^1 = 45\ kN$

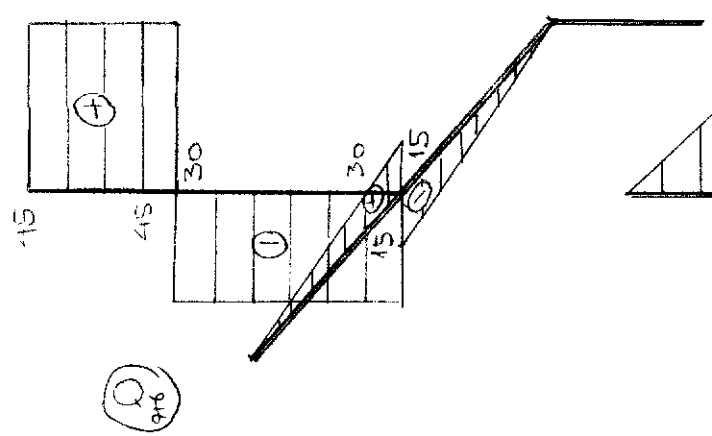
$\Sigma F_Z = 0: \quad -45 - 5 \cdot 6 + R_Z^2 = 0 \Rightarrow R_Z^2 = 75\ kN$

Kontrola:

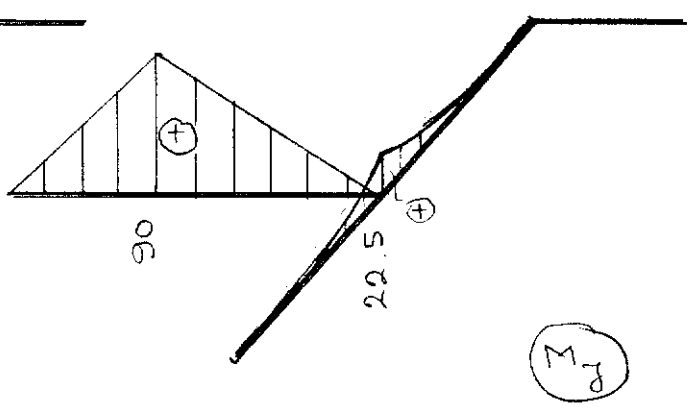
$\Sigma M_x^6 = 0: \quad -45 \cdot 3 + 75 \cdot 3 - 5 \cdot 6 \cdot 3 = 0$

$-135 + 225 - 90 = 0; \quad 0 = 0$ ✓

Diagrami notranjih sil

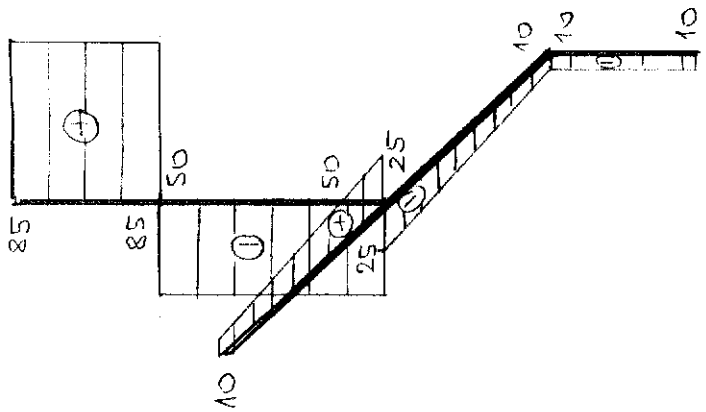


Q_z

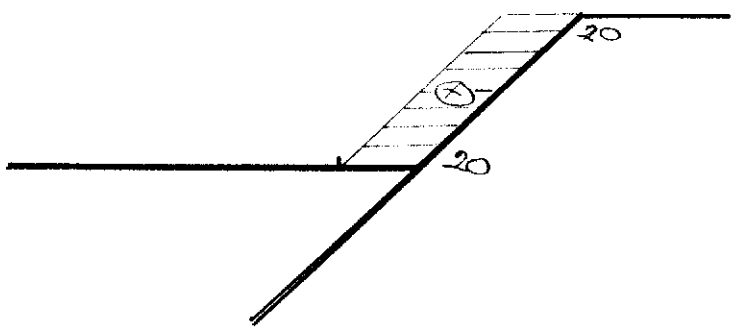


M_y

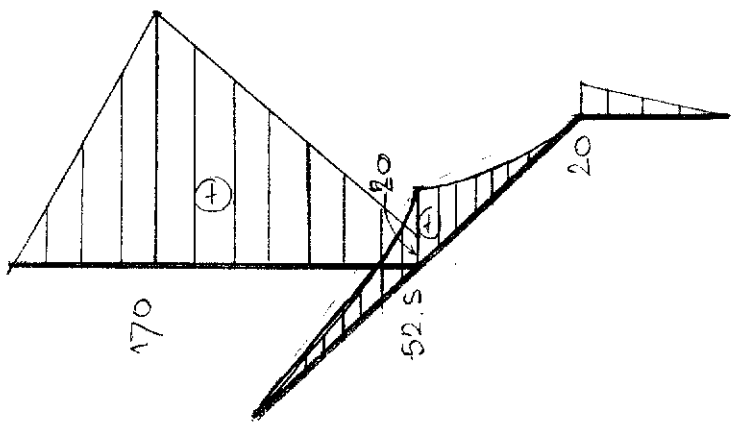
Sumarni diagrami notranjih sil



Q_z



M_x

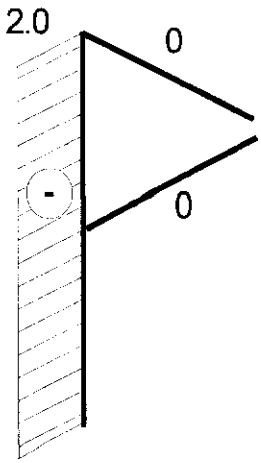


M_y

Diagrami notranjih sil

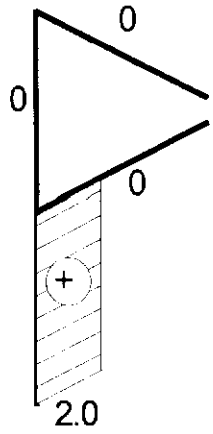
[N]

(+y)



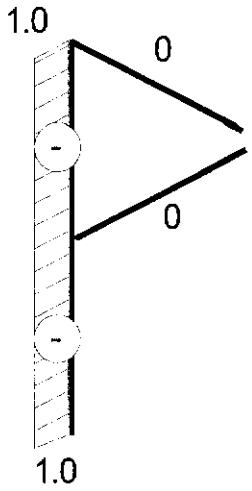
[M_x]

(+y)



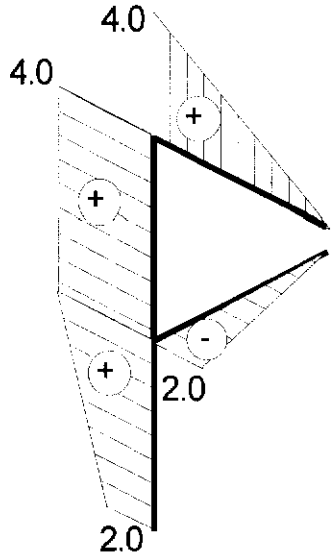
[Q_y]

(+y)



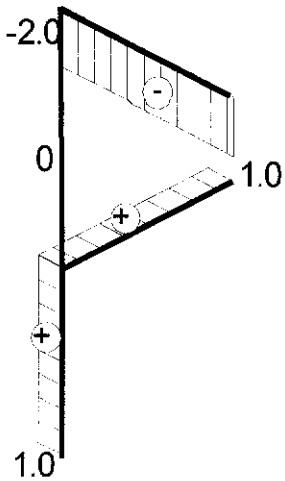
[M_y]

(+z)



[Q_z]

(+z)



[M_z]

(-y)