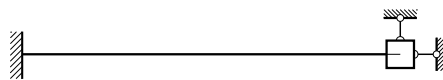
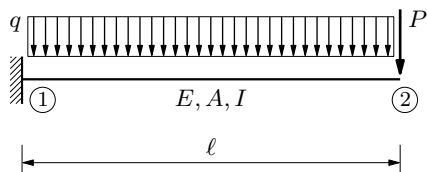


Opća metoda pomaka — konzola



$$u_1 = w_1 = \varphi_1 = 0$$

nepoznanice: u_2, w_2, φ_2

veza duljina pomaka i kutova zaokreta krajeva štapa i duljina pomaka i kutova zaokreta čvorova:

$$u_{1,2} = u_1 \qquad u_{2,1} = u_2$$

$$w_{1,2} = w_1 \qquad w_{2,1} = w_2$$

$$\varphi_{1,2} = \varphi_1 \qquad \varphi_{2,1} = \varphi_2$$

izrazi za vrijednosti sila upetosti (odjeljak 12.3.2. *Sile upetosti* na stranici 282 skripata [<http://master.grad.hr/nastava/gs/gs1.pdf>]):

$$\bar{N}_{1,2} = 0 \qquad \bar{N}_{2,1} = 0$$

$$\bar{T}_{1,2} = -\frac{q\ell}{2} \qquad \bar{T}_{2,1} = -\frac{q\ell}{2}$$

$$\bar{M}_{1,2} = \frac{q\ell^2}{12} \qquad \bar{M}_{2,1} = -\frac{q\ell^2}{12}$$

izrazi za vrijednosti sila u stanju prisilnih pomaka (odgovarajuće komponente matrice krutosti ravnoga štapa navedene u odjeljku 12.3.3. *Odnos između sila na krajevima i pomaka krajeva* na stranici 285 skripata, uz $k^f = k$):

$$n_{1,2} = -k^a u_2 \qquad n_{2,1} = k^a u_2$$

$$t_{1,2} = -\frac{12k}{\ell^2} w_2 - \frac{6k}{\ell} \varphi_2 \qquad t_{1,2} = \frac{12k}{\ell^2} w_2 + \frac{6k}{\ell} \varphi_2$$

$$m_{1,2} = \frac{6k}{\ell} w_2 + 2k \varphi_2 \qquad m_{1,2} = \frac{6k}{\ell} w_2 + 4k \varphi_2$$

izrazi za (ukupne) vrijednosti sila na krajevima:

$$N_{1,2} = \bar{N}_{1,2} + n_{1,2} = -k^a u_2, \qquad N_{2,1} = \bar{N}_{2,1} + n_{2,1} = k^a u_2$$

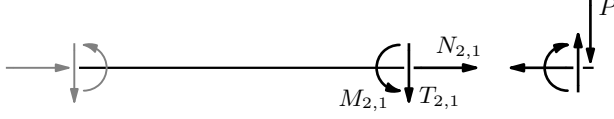
$$T_{1,2} = \bar{T}_{1,2} + t_{1,2} = -\frac{q\ell}{2} - \frac{12k}{\ell^2} w_2 - \frac{6k}{\ell} \varphi_2$$

$$T_{2,1} = \bar{T}_{1,2} + t_{1,2} = -\frac{q\ell}{2} + \frac{12k}{\ell^2} w_2 + \frac{6k}{\ell} \varphi_2$$

$$M_{1,2} = \bar{M}_{1,2} + m_{1,2} = \frac{q \ell^2}{12} + \frac{6k}{\ell} w_2 + 2k \varphi_2$$

$$M_{2,1} = \bar{M}_{1,2} + m_{1,2} = -\frac{q \ell^2}{12} + \frac{6k}{\ell} w_2 + 4k \varphi_2$$

jednadžbe ravnoteže sile u čvoru 2:



$$-N_{2,1} = 0, \quad N_{2,1} = 0 : \quad k^a u_2 = 0 \quad \Rightarrow \quad u_2 = 0 \quad \Rightarrow \quad N_{1,2} = N_{2,1} = 0$$

$$-T_{2,1} + P = 0, \quad T_{2,1} - P = 0 : \quad -\frac{q \ell}{2} + \frac{12k}{\ell^2} w_2 + \frac{6k}{\ell} \varphi_2 - P = 0$$

$$-M_{2,1} = 0, \quad M_{2,1} = 0 : \quad -\frac{q \ell^2}{12} + \frac{6k}{\ell} w_2 + 4k \varphi_2 = 0$$

sustav jednadžbi:

$$\frac{12k}{\ell^2} w_2 + \frac{6k}{\ell} \varphi_2 = \frac{q \ell}{2} + P \quad (\mathfrak{A})$$

$$\frac{6k}{\ell} w_2 + 4k \varphi_2 = \frac{q \ell^2}{12} \quad (\mathfrak{B})$$

rješavanje sustava (i rješenje):

$$\varphi_2 = \frac{q \ell^2}{48k} - \frac{3}{2\ell} w_2 \quad (\text{iz } (\mathfrak{B}))$$

$$\frac{12k}{\ell^2} w_2 + \frac{6k}{\ell} \left(-\frac{3}{2\ell} w_2 + \frac{q \ell^2}{48k} \right) = \frac{q \ell}{2} + P \quad (\text{u } (\mathfrak{A}))$$

$$\left(\frac{12k}{\ell^2} - \frac{9k}{\ell^2} \right) w_2 = \frac{q \ell}{2} + P - \frac{q \ell}{8}$$

$$\frac{3k}{\ell^2} w_2 = \frac{3q \ell}{8} + P \quad \Rightarrow \quad w_2 = \frac{\ell^2}{3k} \left(\frac{3q \ell}{8} + P \right)$$

$$\varphi_2 = \frac{q \ell^2}{48k} - \frac{3}{2\ell} \frac{\ell^2}{3k} \left(\frac{3q \ell}{8} + P \right) = \frac{q \ell^2}{48k} - \frac{3q \ell^2}{16k} - \frac{P \ell}{2k} = -\frac{q \ell^2}{6k} - \frac{P \ell}{2k}$$

vrijednosti sila na krajevima:

$$T_{1,2} = -\frac{q \ell}{2} - \frac{12k}{\ell^2} \frac{\ell^2}{3k} \left(\frac{3q \ell}{8} + P \right) - \frac{6k}{\ell} \left(-\frac{q \ell^2}{6k} - \frac{P \ell}{2k} \right)$$

$$= -\frac{q \ell}{2} - \frac{3q \ell}{2} - 4P + q \ell + 3P = -q \ell - P$$

$$\begin{aligned}
T_{2,1} &= -\frac{q\ell}{2} + \frac{12k}{\ell^2} \frac{\ell^2}{3k} \left(\frac{3q\ell}{8} + P \right) + \frac{6k}{\ell} \left(-\frac{q\ell^2}{6k} - \frac{P\ell}{2k} \right) \\
&= -\frac{q\ell}{2} + \frac{3q\ell}{2} + 4P - q\ell - 3P = P
\end{aligned}$$

$$\begin{aligned}
M_{1,2} &= \frac{q\ell^2}{12} + \frac{6k}{\ell} \frac{\ell^2}{3k} \left(\frac{3q\ell}{8} + P \right) + 2k \left(-\frac{q\ell^2}{6k} - \frac{P\ell}{2k} \right) \\
&= \frac{q\ell^2}{12} + \frac{3q\ell^2}{4} + 2P\ell - \frac{1q\ell^2}{3} - P\ell = \frac{q\ell^2}{2} + P\ell
\end{aligned}$$

$$\begin{aligned}
M_{2,1} &= -\frac{q\ell^2}{12} + \frac{6k}{\ell} \frac{\ell^2}{3k} \left(\frac{3q\ell}{8} + P \right) + 4k \left(-\frac{q\ell^2}{6k} - \frac{P\ell}{2k} \right) \\
&= -\frac{q\ell^2}{12} + \frac{3q\ell^2}{4} + 2P\ell - \frac{2q\ell^2}{3} - 2P\ell = 0
\end{aligned}$$