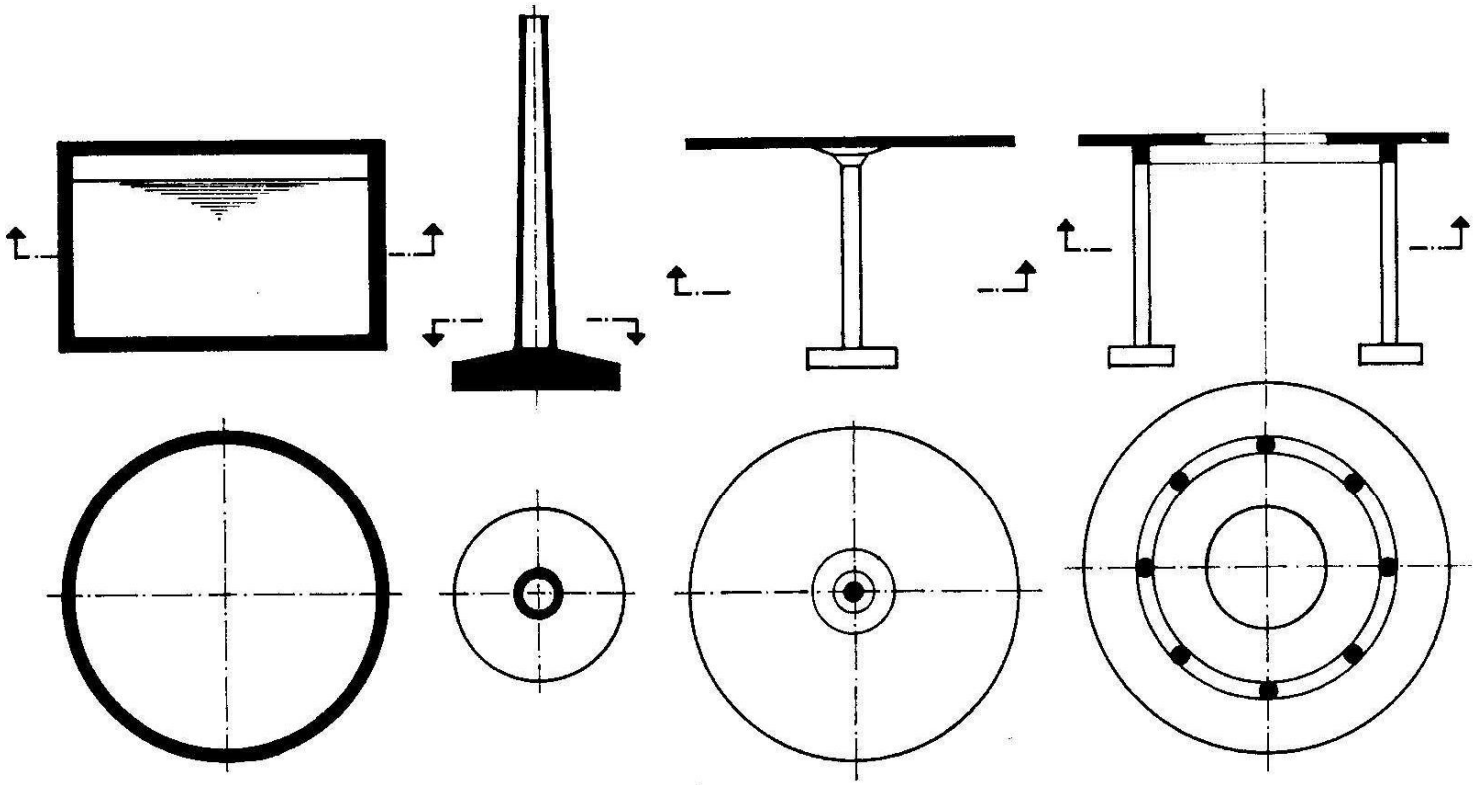
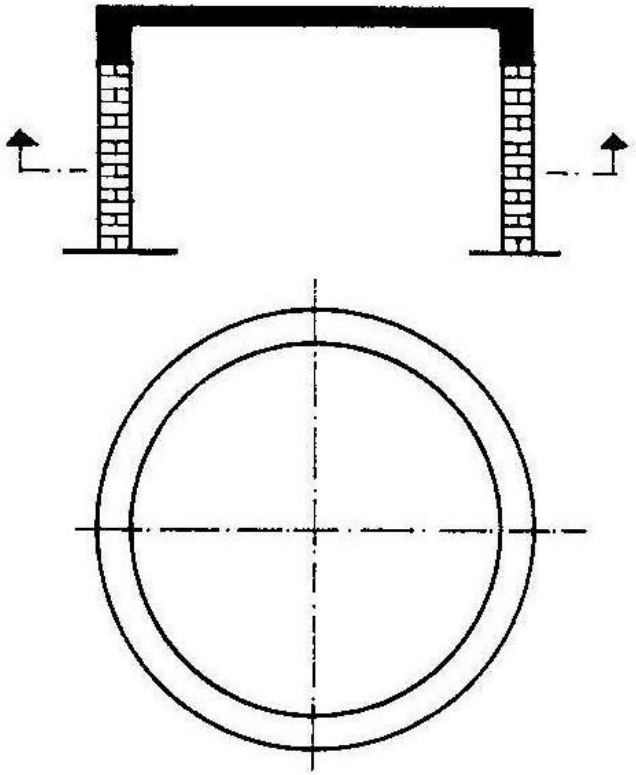
Kružne i prstenaste armiranobetonske ploče

Kružne ploče mogu biti deo međuspratne konstrukcije, ali se najčešće javljaju kao ploče kružnih nadstrešnica, krovne i temeljne ploče kružnih rezervoara, temeljne ploče dimnjaka, tornjeva i sličnih konstrukcija. Kružne ploče sa većim srednjim otvorom nazivaju se prstenaste ploče.

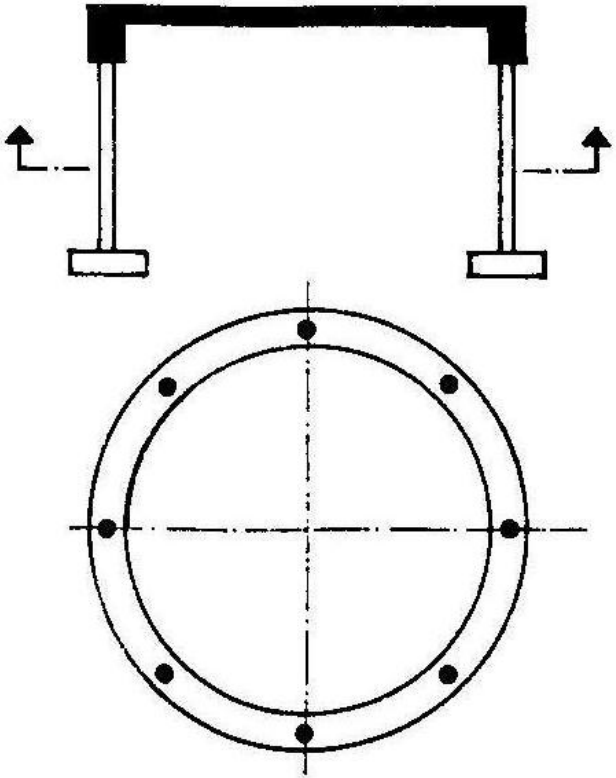


Načini oslanjanja kružnih ploča

a) Kontinualno oslanjanje na zid (od opeke ili armiranobetonski)

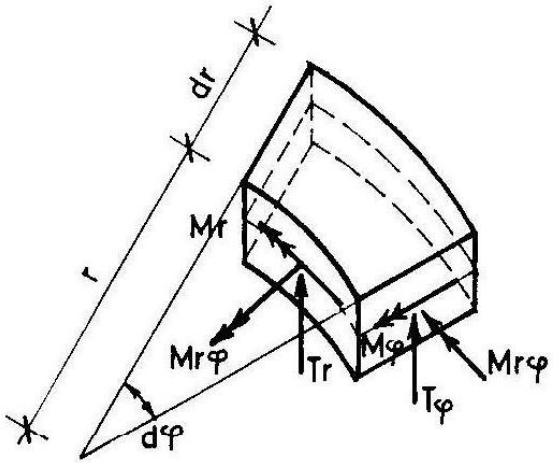


b) oslanjanje na stubove preko kružne grede



Presečne sile u ploči

Za delovanje opterećenja upravno na srednju površ ploče, pri savijanju se javljaju pomeranja u pravcu normale na srednju površ (w), kao i pomeranja u radijalnom (u) i tangencijalnom (v) pravcu. Pomeranja na odstojanju *z* od srednje ravni ploče su:



$$w_z = w(r,\phi) \quad , \quad u_z = -\frac{\partial w}{\partial r} z \quad , \quad v_z = -\frac{z}{r}\frac{\partial w}{\partial \phi}$$

Dilatacije u radijalnom i tangencijalnom pravcu i klizanja se mogu izraziti preko ovih pomeranja:

$$\varepsilon_r = \frac{\partial u}{\partial r} = -z\frac{\partial^2 w}{\partial r^2} \quad , \quad \varepsilon_\phi = \frac{u}{r} + \frac{1}{r}\frac{\partial v}{\partial \phi} = -\frac{z}{r}\frac{\partial w}{\partial r} - \frac{z}{r^2}\frac{\partial^2 w}{\partial \phi^2} \quad , \quad \varepsilon_z = 0$$

$$\gamma_{r\phi} = \frac{1}{r}\frac{\partial u}{\partial \phi} + \frac{\partial v}{\partial r} - \frac{v}{r} = -2z\left(\frac{1}{r}\frac{\partial^2 w}{\partial r \partial \phi} - \frac{1}{r^2}\frac{\partial w}{\partial \phi}\right) \qquad \gamma_{zr} = \gamma_{z\phi} = 0$$

Kada se komponente napona izraze preko komponenti deformacija:

$$\sigma_r = \frac{E}{1-\nu^2}(\varepsilon_r + \nu\varepsilon_\phi) = \frac{-Ez}{1-\nu^2}\left(\frac{\partial^2 w}{\partial r^2} + \frac{\nu}{r}\frac{\partial w}{\partial \phi} + \frac{\nu}{r^2}\frac{\partial^2 w}{\partial \phi^2}\right)$$

$$\sigma_\phi = \frac{E}{1-\nu^2}(\varepsilon_\phi + \nu\varepsilon_r) = \frac{-Ez}{1-\nu^2}\left(\frac{1}{r}\frac{\partial w}{\partial r} + \frac{1}{r^2}\frac{\partial^2 w}{\partial \phi^2} + \nu\frac{\partial^2 w}{\partial r^2}\right)$$

$$\tau_{r\phi} = G\,\gamma_{r\phi} = \frac{-Ez}{(1+\nu)}\left(\frac{1}{r}\frac{\partial^2 w}{\partial r \partial \phi} - \frac{1}{r^2}\frac{\partial w}{\partial \phi}\right),$$

i kada se sile u preseku izraze preko komponenti napona, dobijaju se veze u sledećem obliku:

$$M_r = \int_{-d/2}^{d/2} \sigma_r\, z\, dz \qquad M_\phi = \int_{-d/2}^{d/2} \sigma_\phi\, z\, dz \qquad M_{r\phi} = \int_{-d/2}^{d/2} \tau_{r\phi}\, z\, dz$$

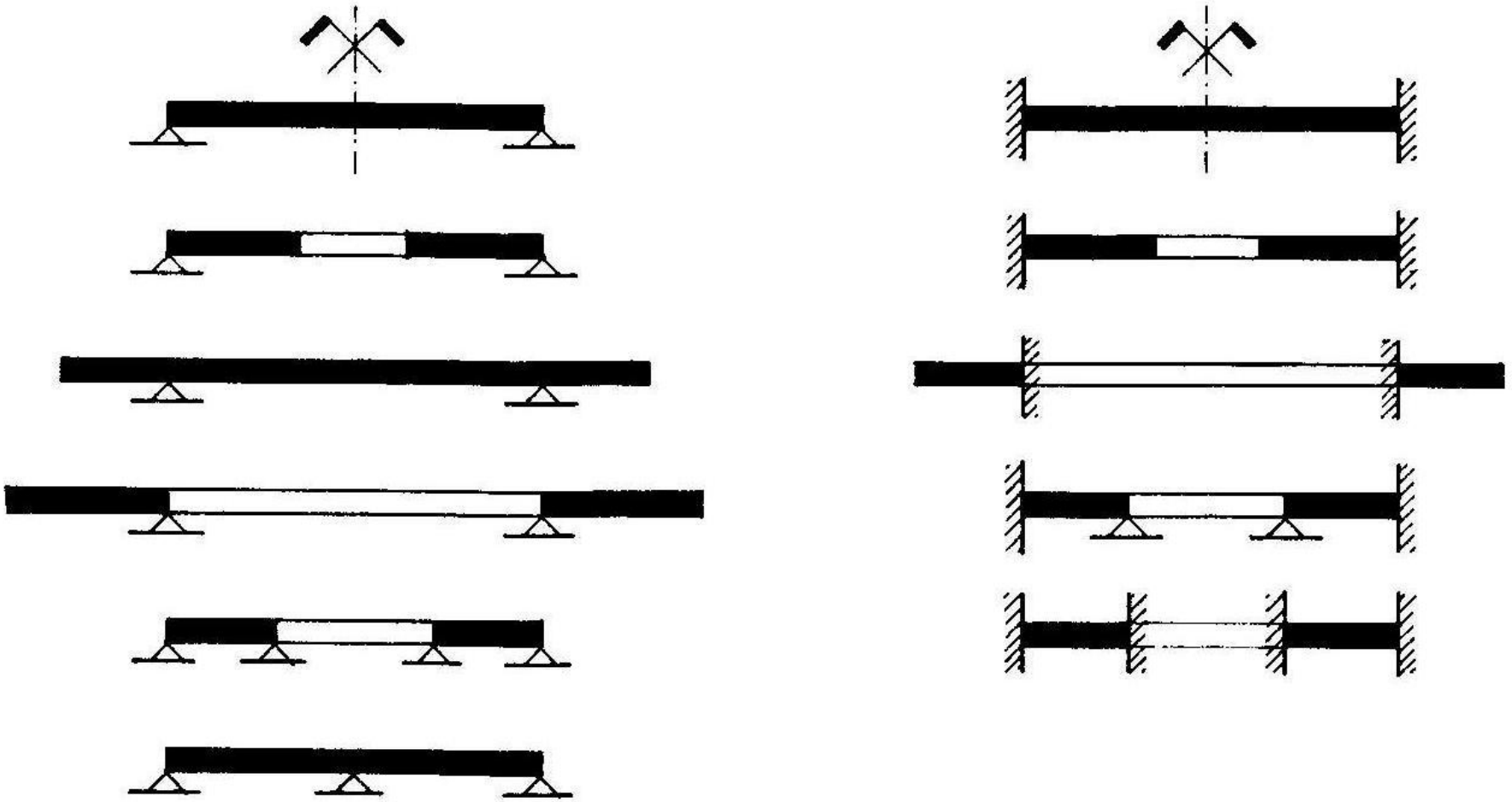
$$T_r = \int_{-d/2}^{d/2} \tau_{rz}\, dz \qquad T_\phi = \int_{-d/2}^{d/2} \tau_{\phi z}\, dz$$

Posle integracije i koristeći veze napona i pomeranja, dobijaju se momenti savijanja i torzije u funkciji ugiba tačaka ploče:

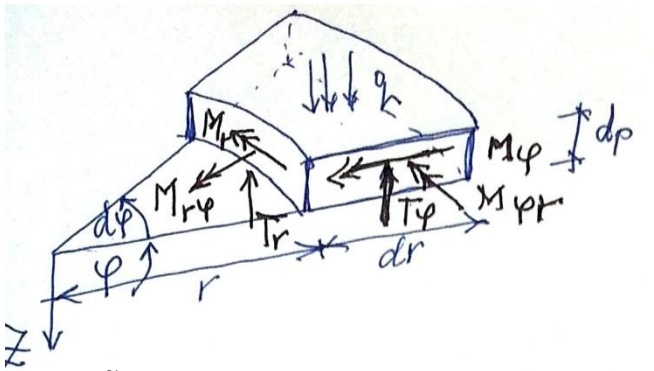
$$M_r = -K\left[\frac{\partial^2 w}{\partial r^2} + \nu\left(\frac{1}{r^2}\frac{\partial^2 w}{\partial \phi^2} + \frac{1}{r}\frac{\partial w}{\partial r}\right)\right]$$

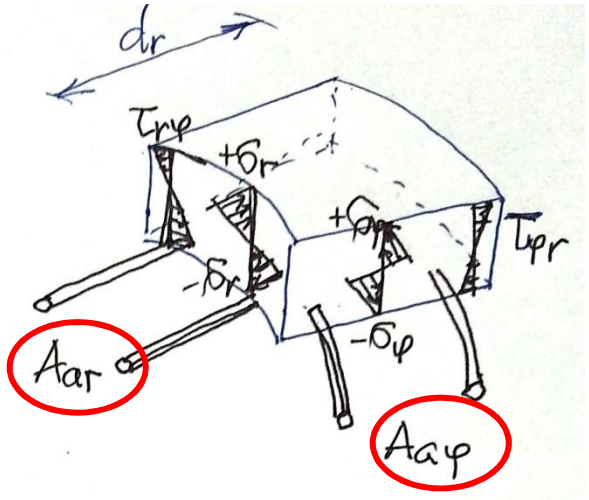
$$M_\phi = -K\left[\nu\frac{\partial^2 w}{\partial r^2} + \frac{1}{r^2}\frac{\partial^2 w}{\partial \phi^2} + \frac{1}{r}\frac{\partial w}{\partial r}\right]$$

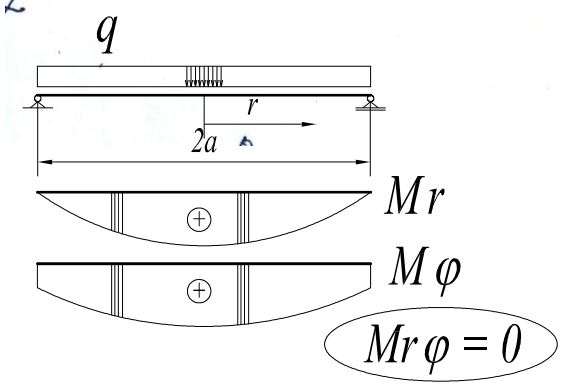
Statički sistemi kružnih i prstenastih ploča



Statički uticaji i dimenzionisanje

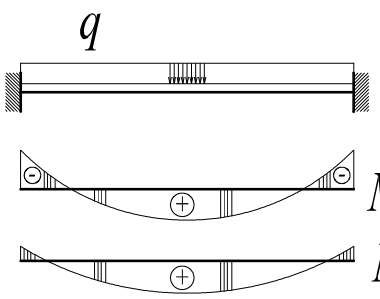






$Mr\varphi = 0$

$$\rho = \frac{r}{a}$$



$Mr\varphi = 0$

$$M_r = \frac{q \cdot a^2}{16}\left[(1-\rho^2)(3+\nu)\right]$$

$$M_\varphi = \frac{q \cdot a^2}{16}\left[(3+\nu)-\rho^2(1+3\nu)\right]$$

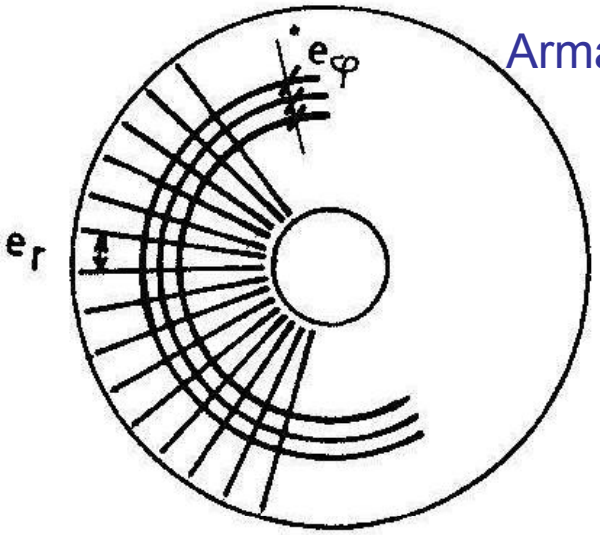
$$M_r = \frac{q \cdot a^2}{16}\left[(1+\nu)-(3+\nu)\rho^2\right]$$

$$M_\varphi = \frac{q \cdot a^2}{16}\left[(1+\nu)-(1+3\nu)\rho^2\right]$$

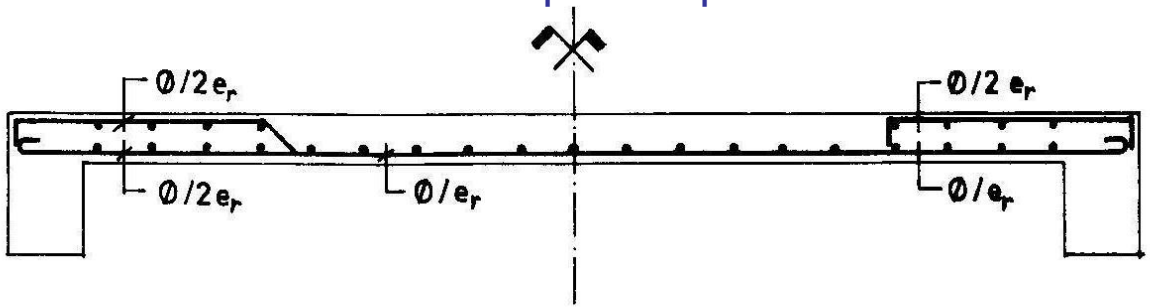
Dimenzionisanje ploče se vrši kao dimenzionisanje pravougaonih preseka na čisto savijanje, dimenzija d_p i b = 100 cm, prema radijalnim i tangencijalnim momentima savijanja, a pri tome je: $h_x \neq h_y$

Armiranje kružnih i prstenastih ploča

Armatura prstenaste ploče – osnova

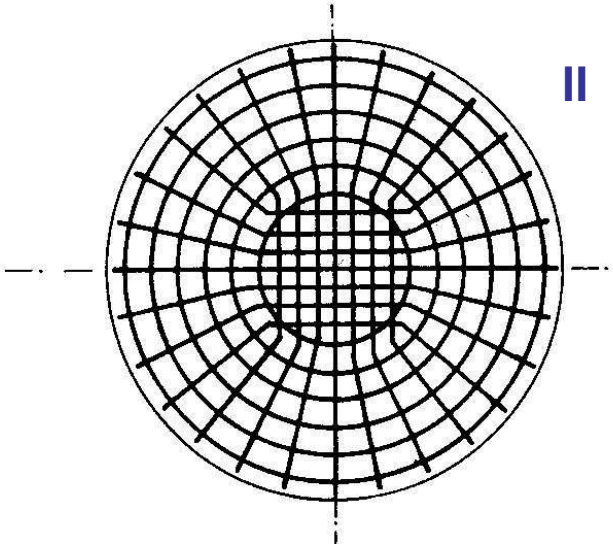


Armatura kružnih ploča - presek



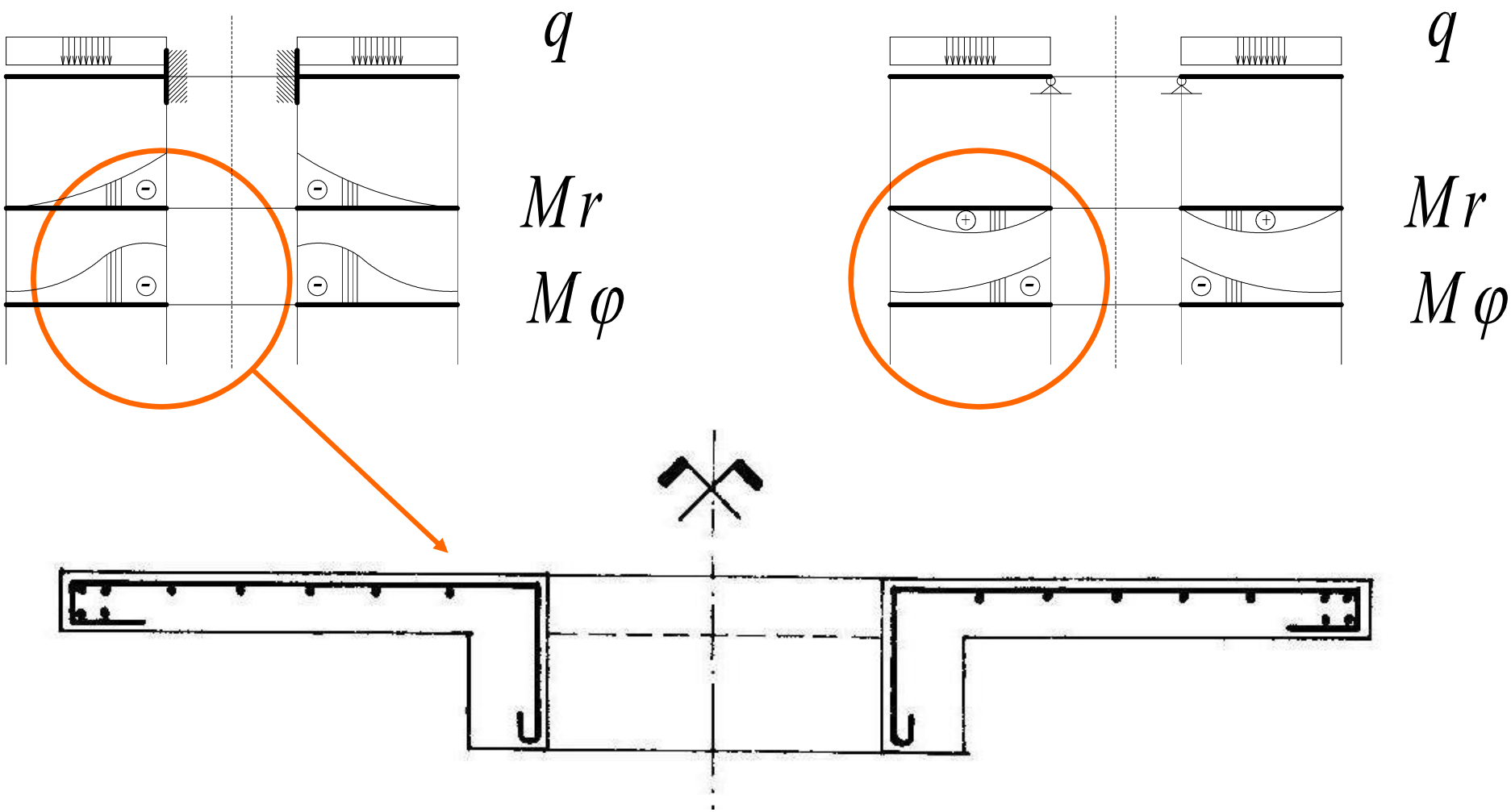
Armatura kružnih ploča – osnova:

I varijanta

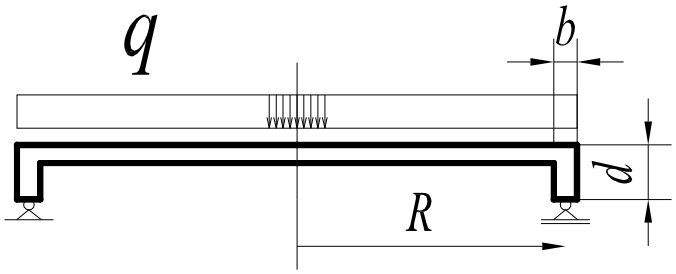


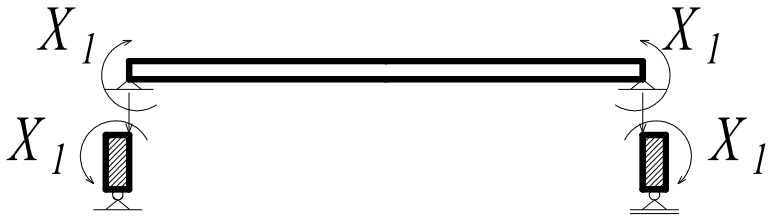
II varijanta

Armiranje prstenastih ploča oslonjenih duž unutrašnje ivice



Kružna ploča monolitno vezana sa kružnom gredom





$$X_1\delta_{11} + \delta_{1p} = 0$$

δ_{11} - zajednički ugao obrtanja oslonačkog preseka i ploče u osnovnom sistemu pri delovanju $X_1=1$

$$\delta_{11} = \varphi_{plo} + \varphi_{prs}$$

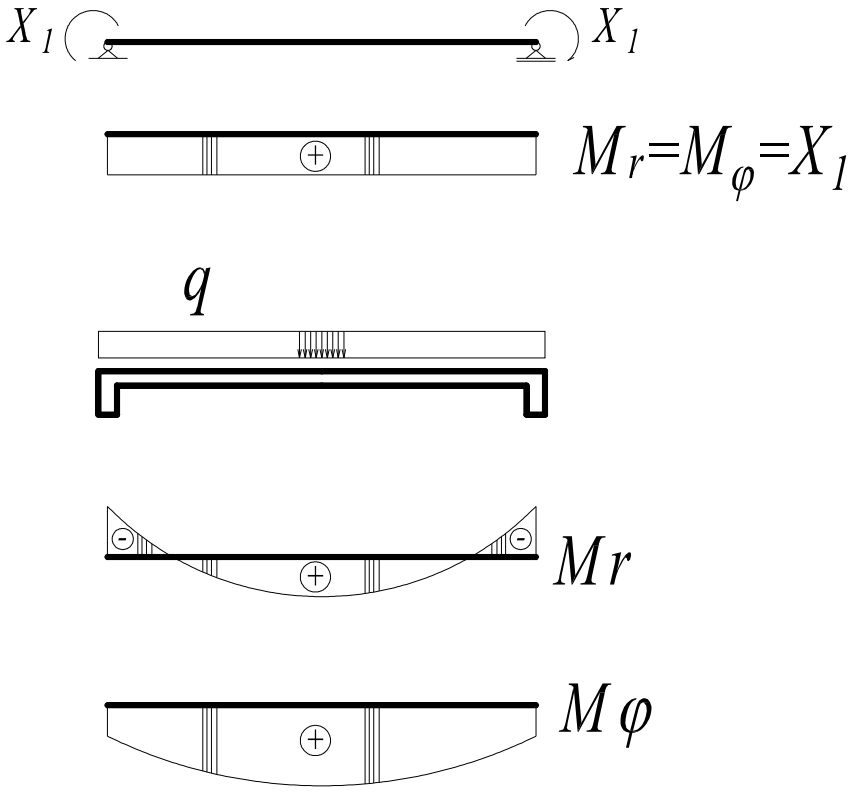
δ_{1p} - ugao obrtanja oslonačkog preseka u osnovnom sistemu od spoljašnjeg opterećenja

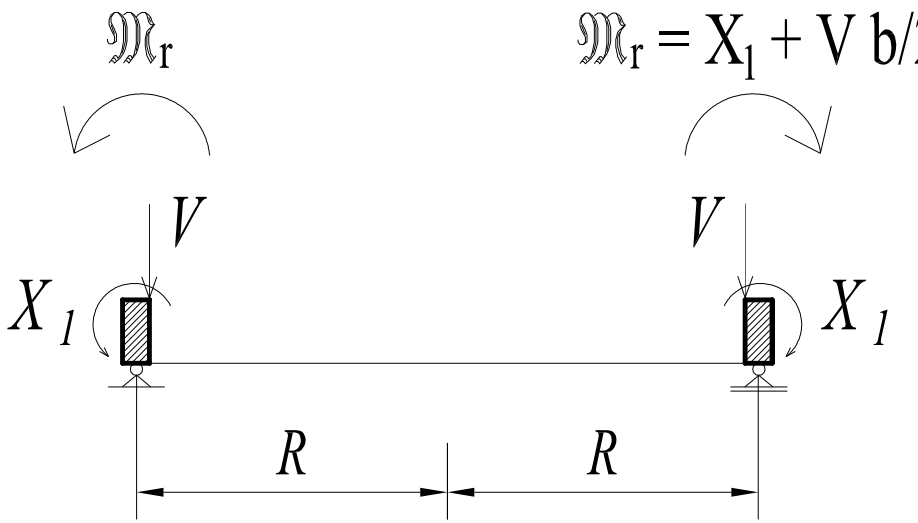
$$\varphi_{plo} = \frac{\cancel{X_1}\cancel{R}^{1}}{EI_{plo}} \qquad \varphi_{prs} = \frac{\cancel{X_1}\cancel{R^2}^{1}}{EI_{prs}} \qquad I_{plo} = \frac{d_p^{\,3}}{12} \qquad I_{prs} = \frac{bd^3}{12}$$

$$\delta_{1p} = 0.125\frac{q \cdot R^3}{EI_{plo}}$$

Moment savijanja u ploči

$M_r = X_1 + M_r^q$ M_r^q - radijalni moment u ploči u osnovnom sistemu

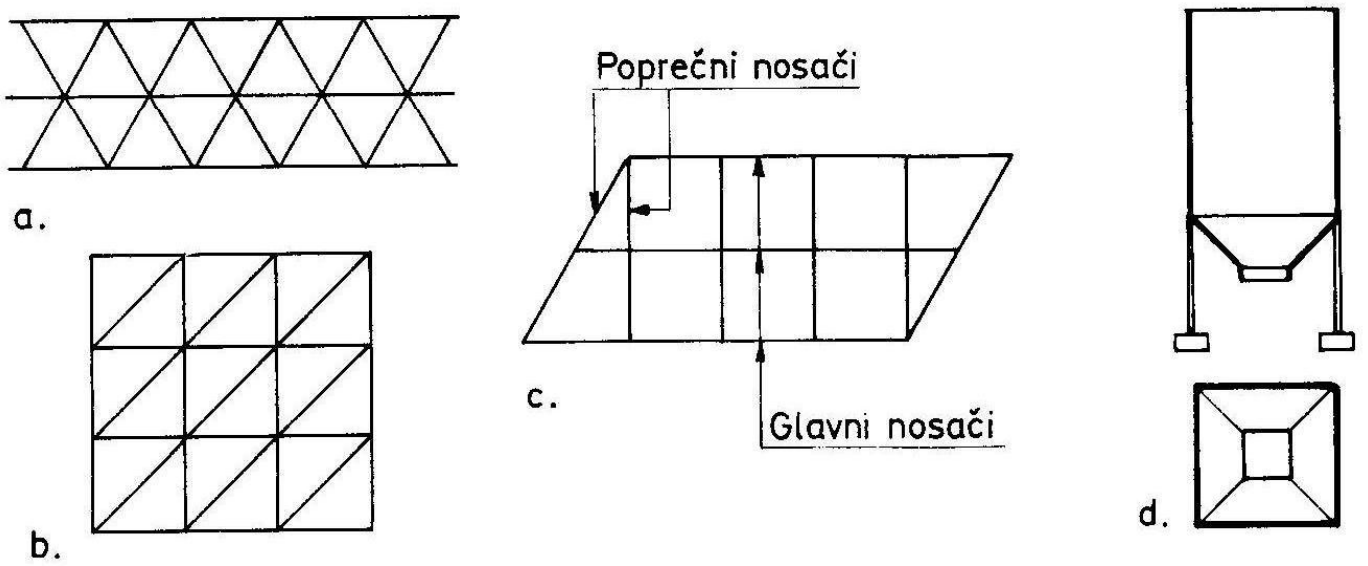




$M_{\text{savijana prstena}} = \mathfrak{M}_r R$

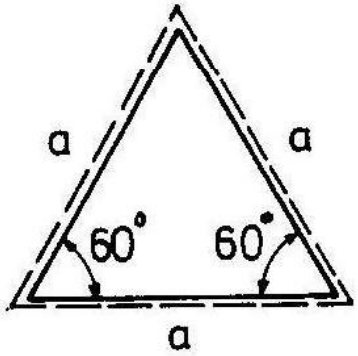
Trougaone i trapezne ploče

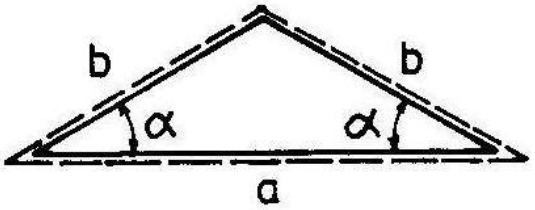
Ove ploče se javljaju kod međuspratnih konstrukcija kod kojih se grede, na koje se oslanjaju ploče, seku pod uglom – najčešće je to ugao od 60°- tako da grede formiraju trougaoni raster. Trougaone ploče su vrlo ekonomične jer je njihov statički rad vrlo racionalan, tako da se u njima javljaju relativno mali momenti savijanja. Mogu biti pojedinačne ploče, ili kontinualne.

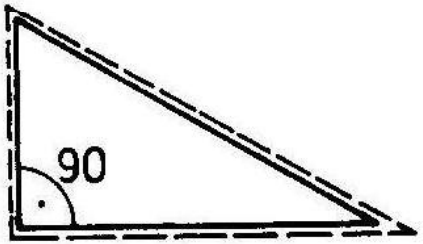


Pojedinačne trougaone ploče

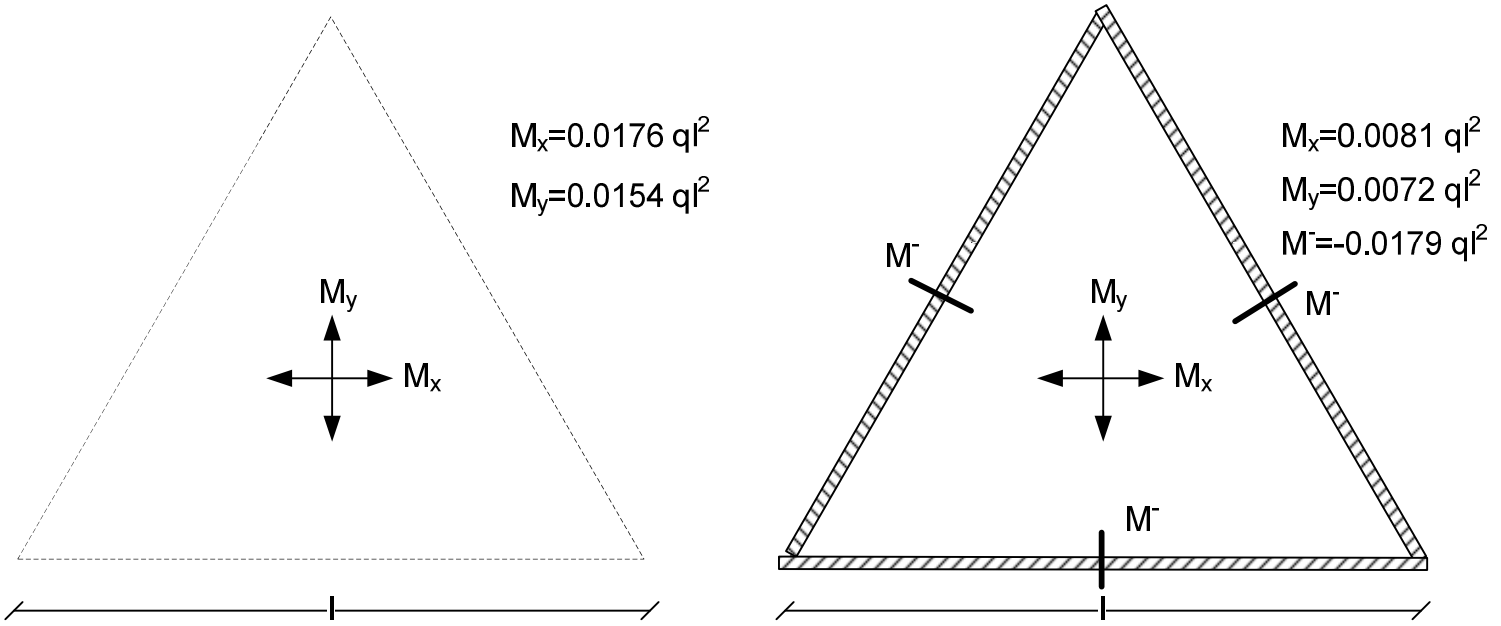
Pojedinačne trougaone ploče se najčešće projektuju kao jednakostranični trouglovi sa unutrašnjim uglovima od 60º, ali mogu biti i u obliku pravouglih ili raznokrakih trouglova:







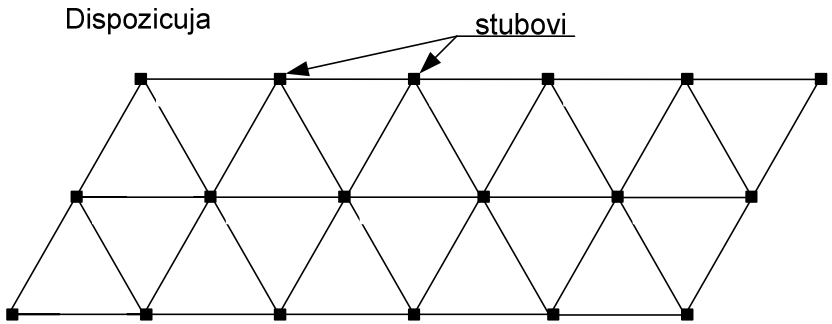
Konturni uslovi su: slobodno linijsko oslanjanje duž pojedinih stranica, puno uklještenje, ili elastično uklještenje pojedinih stranica .



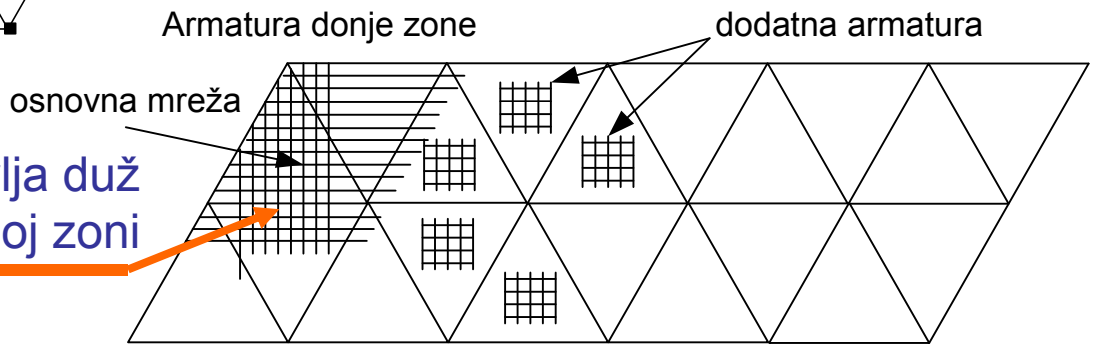
slobodno linijsko oslanjanje

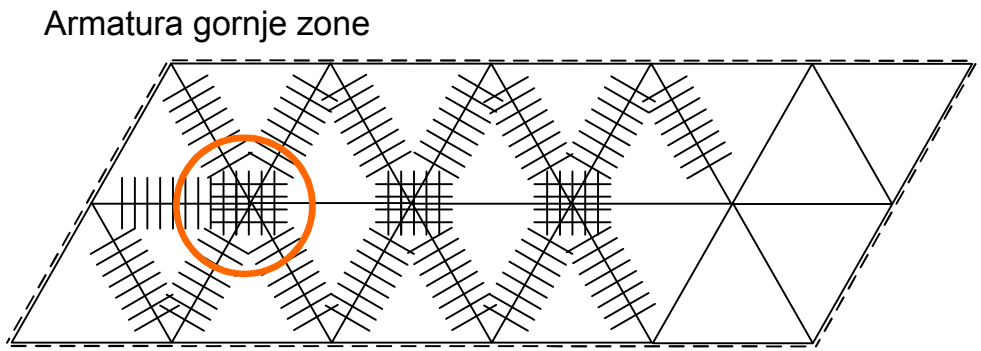
puno uklještenje

Armiranje kontinualnih trougaonih ploča



Osnovna mreža se postavlja duž svih polja u donjoj zoni





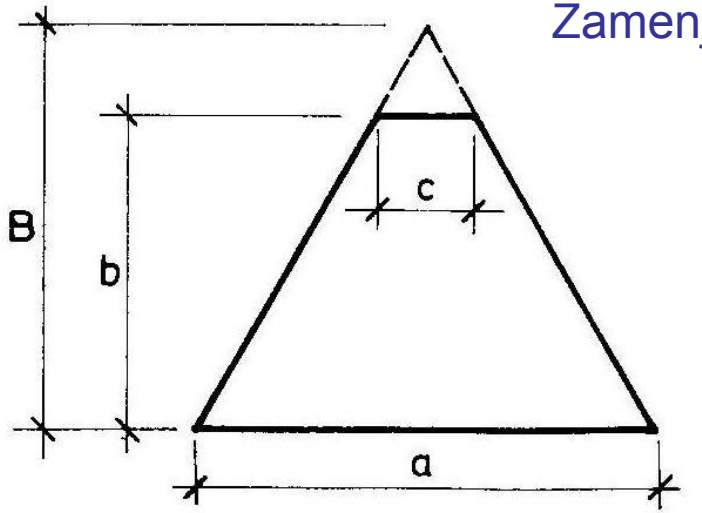
Trapezne ploče

Trapezne ploče se ponašaju slično kao krstasto armirane ili trougaone ploče, pa se tako i proračunavaju i armiraju. Za praktičnu upotrebu ove ploče dovoljno tačno se mogu tretirati kao pravougaone krstasto armirane ploče kada je **c/a > 0.25**. U tom slučaju treba redukovati dužine stranica prema sledećim izrazima:

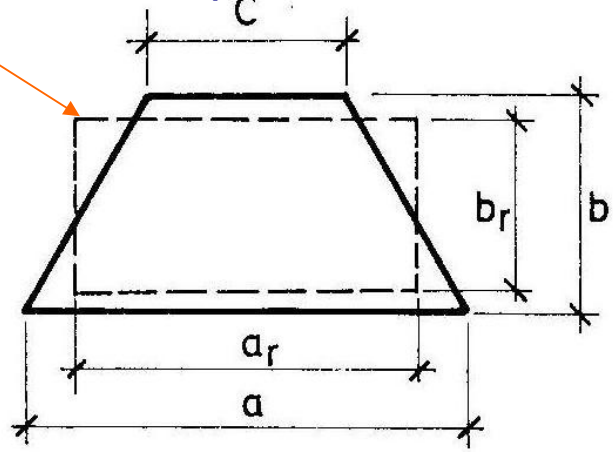
$$a_r=2/3(2c+a)a/(a+c) \quad i \quad b_r=b-a(a-c)/(b(a+c))$$

Kada je **c/a ≤ 0.25** trapezne ploče se analiziraju kao trougaone ploče sa visinom

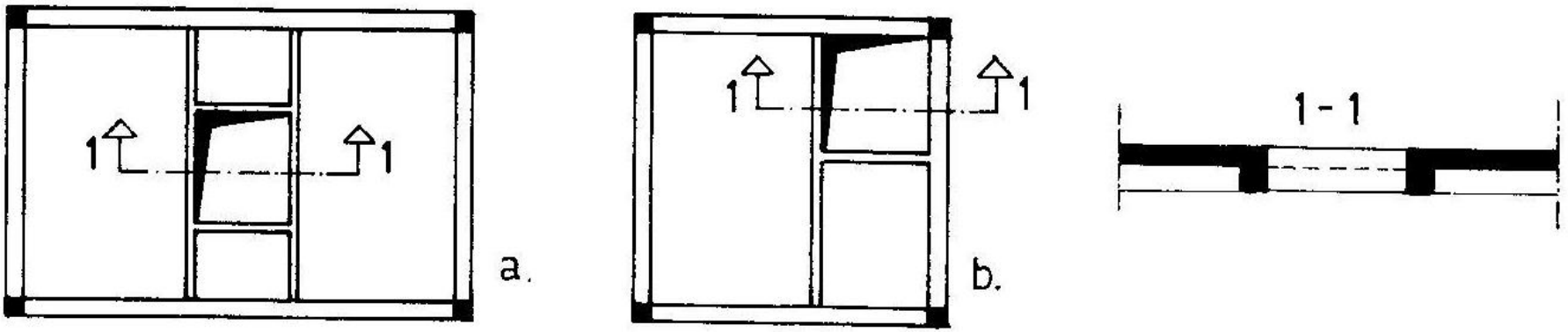
$$B=ba/(a-c)$$

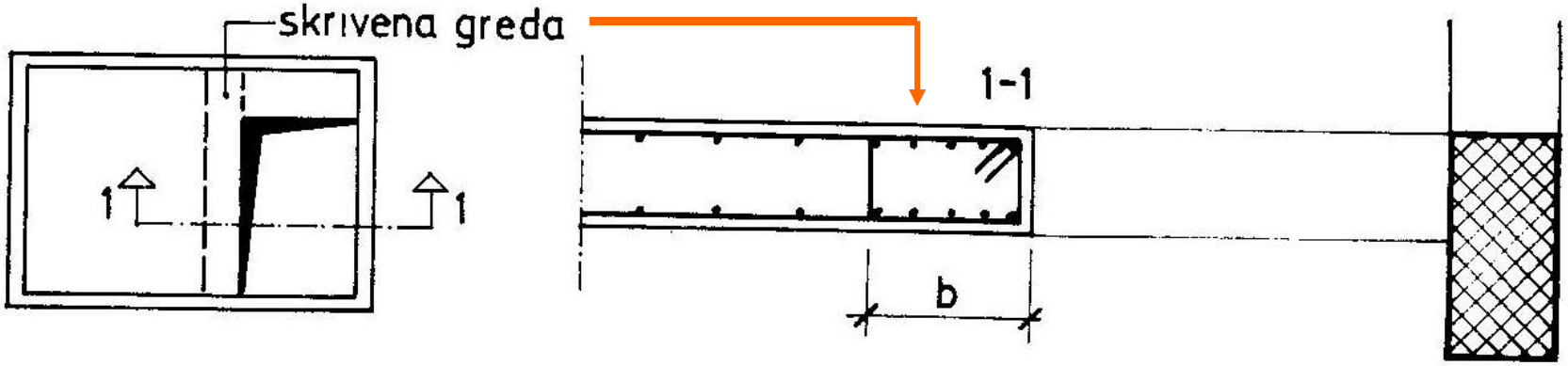


Zamenjujuća krstasto arm.ploča .

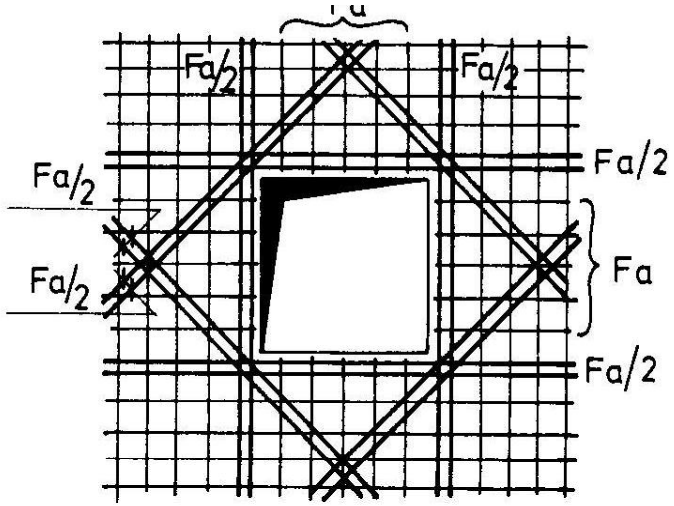


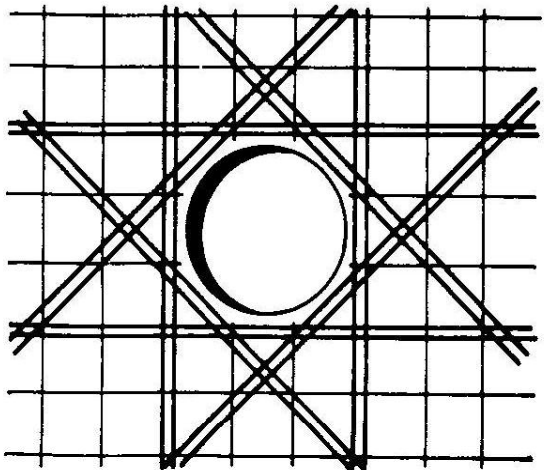
Otvori u pločama

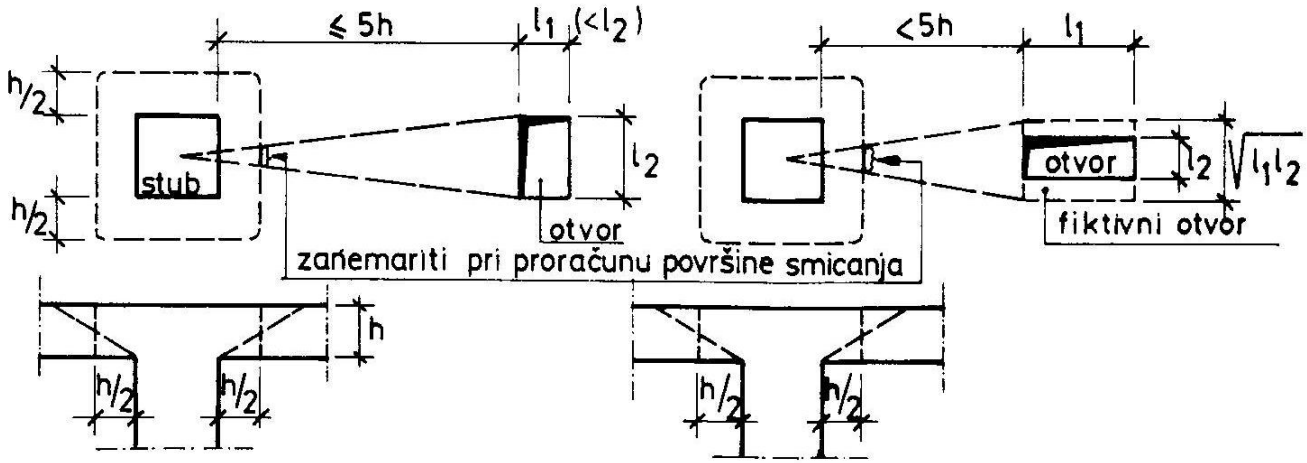




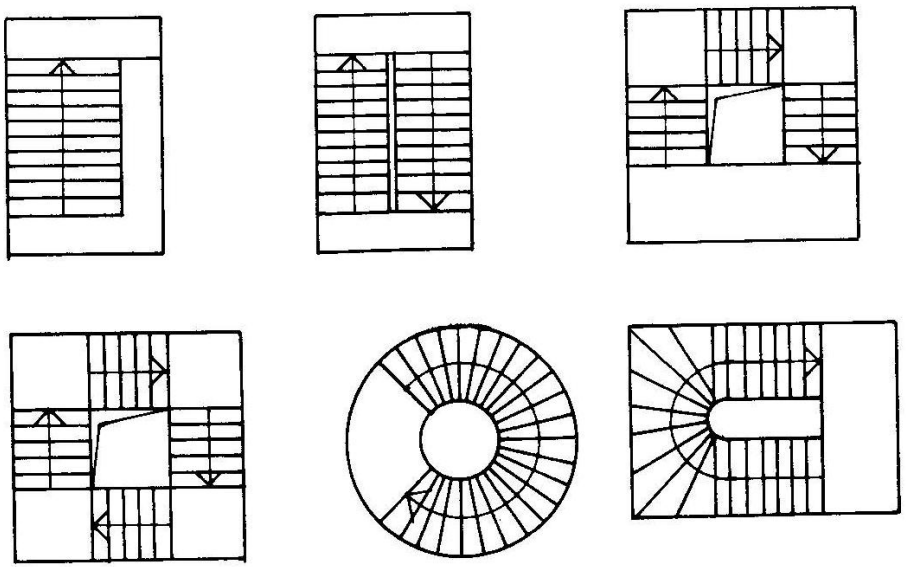
Armiranje otvora





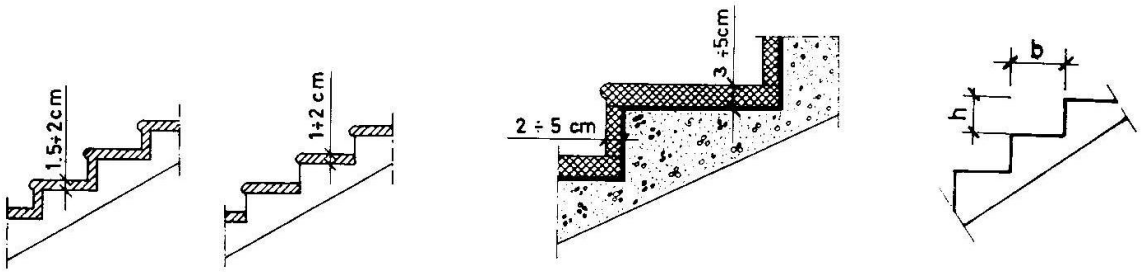


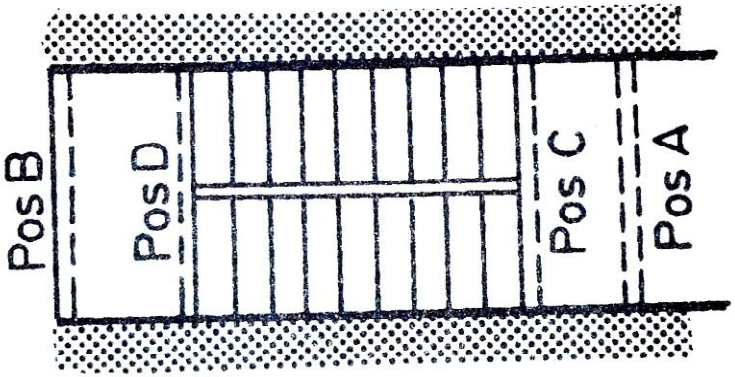
Stepeništa

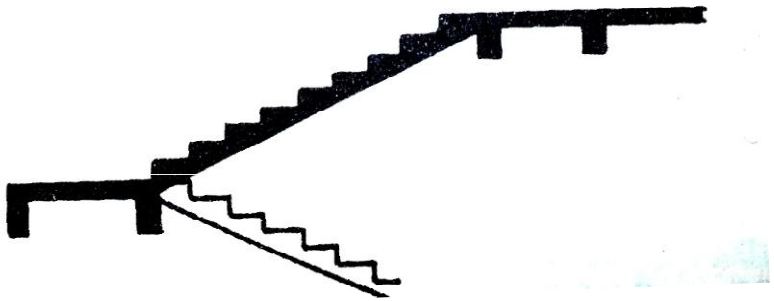


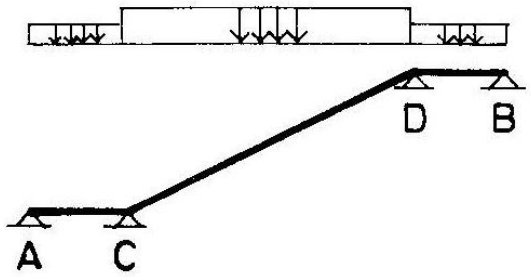
b+2h=63cm

b+h=46cm

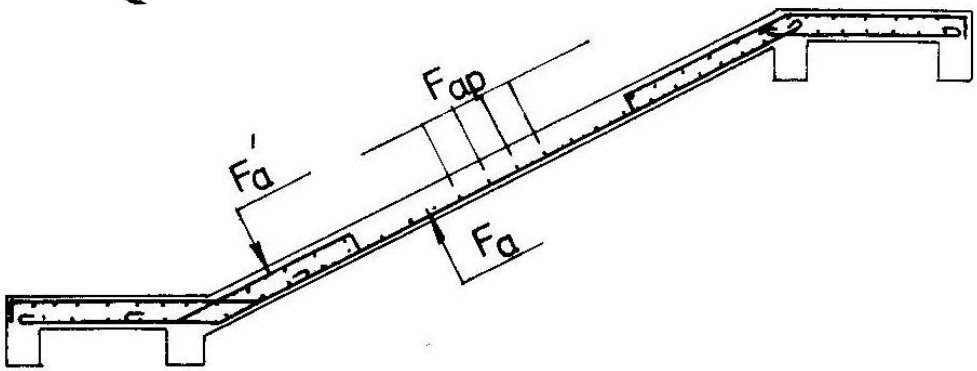








a)

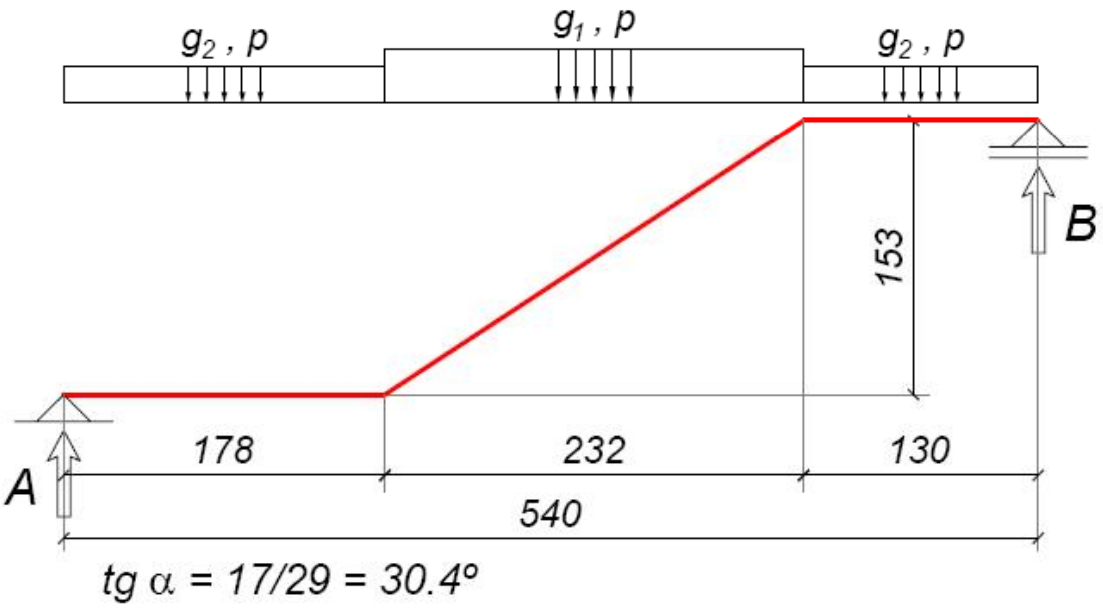


b)

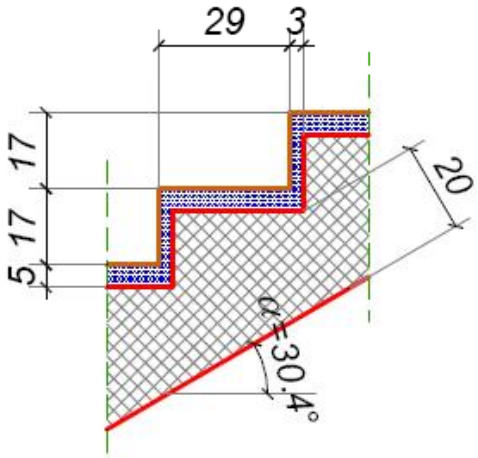
PRORAČUN STEPENIŠTA

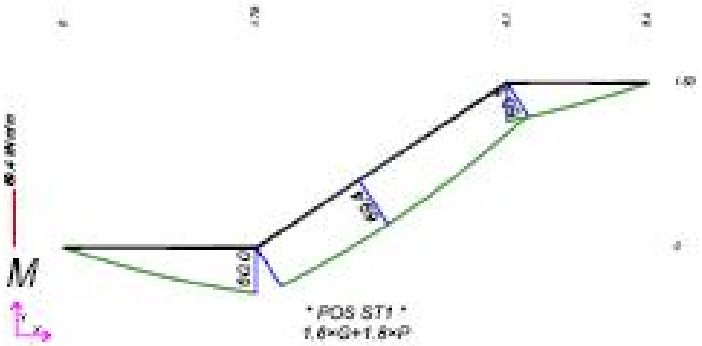
POS ST1

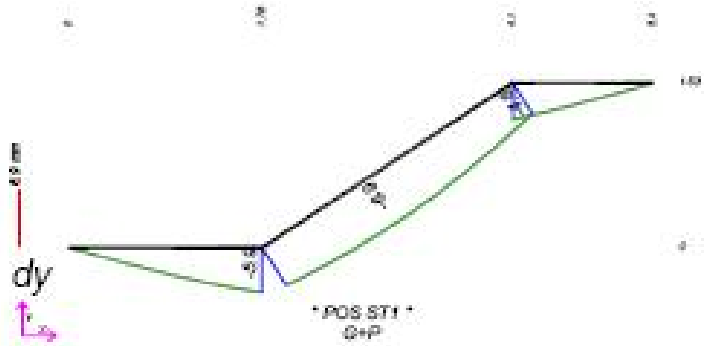
Stepenište je statičkog sistema kolenaste ploče, debljine d_p = 20 cm. Savladava visinsku razliku od 306 cm između prizemlja i sprata (18 visina po 17 cm). Stepenici su dimenzija 17/29 cm. Debljina vertikalne obloge stepenika je 3 cm, a horizontalne 5 cm.

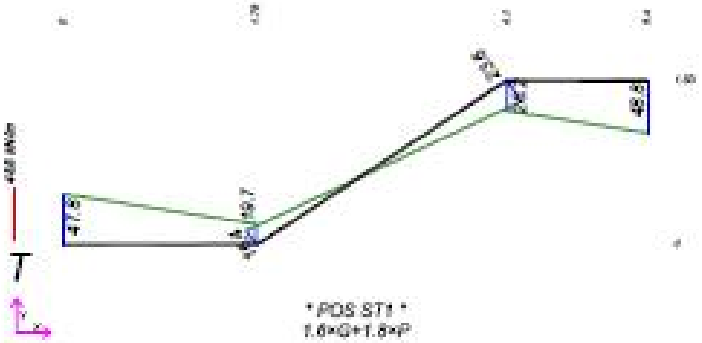


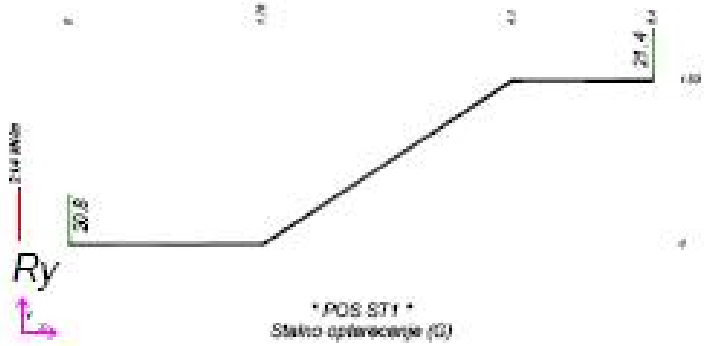
$tg\ \alpha = 17/29 = 30.4^o$

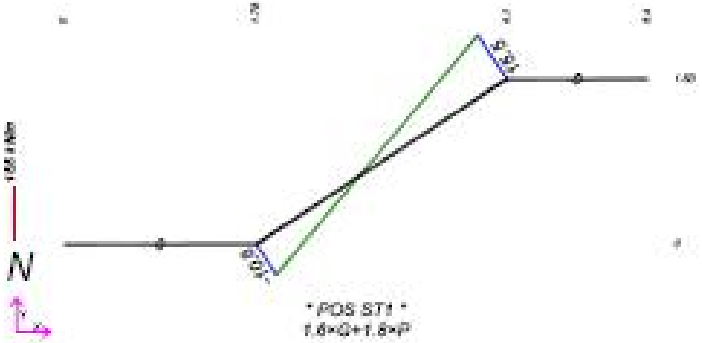


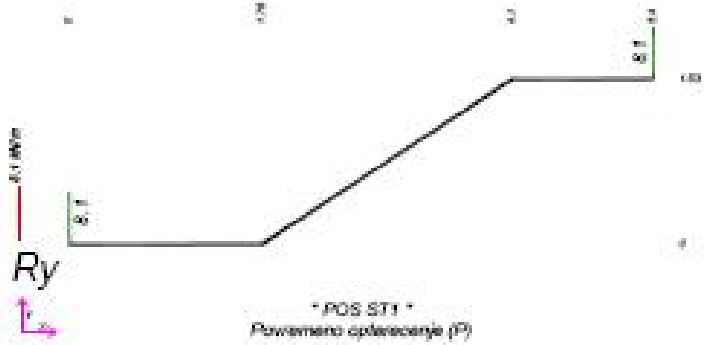

M
* POS ST1 *
1.6×G+1.6×P


dy
* POS ST1 *
G+P

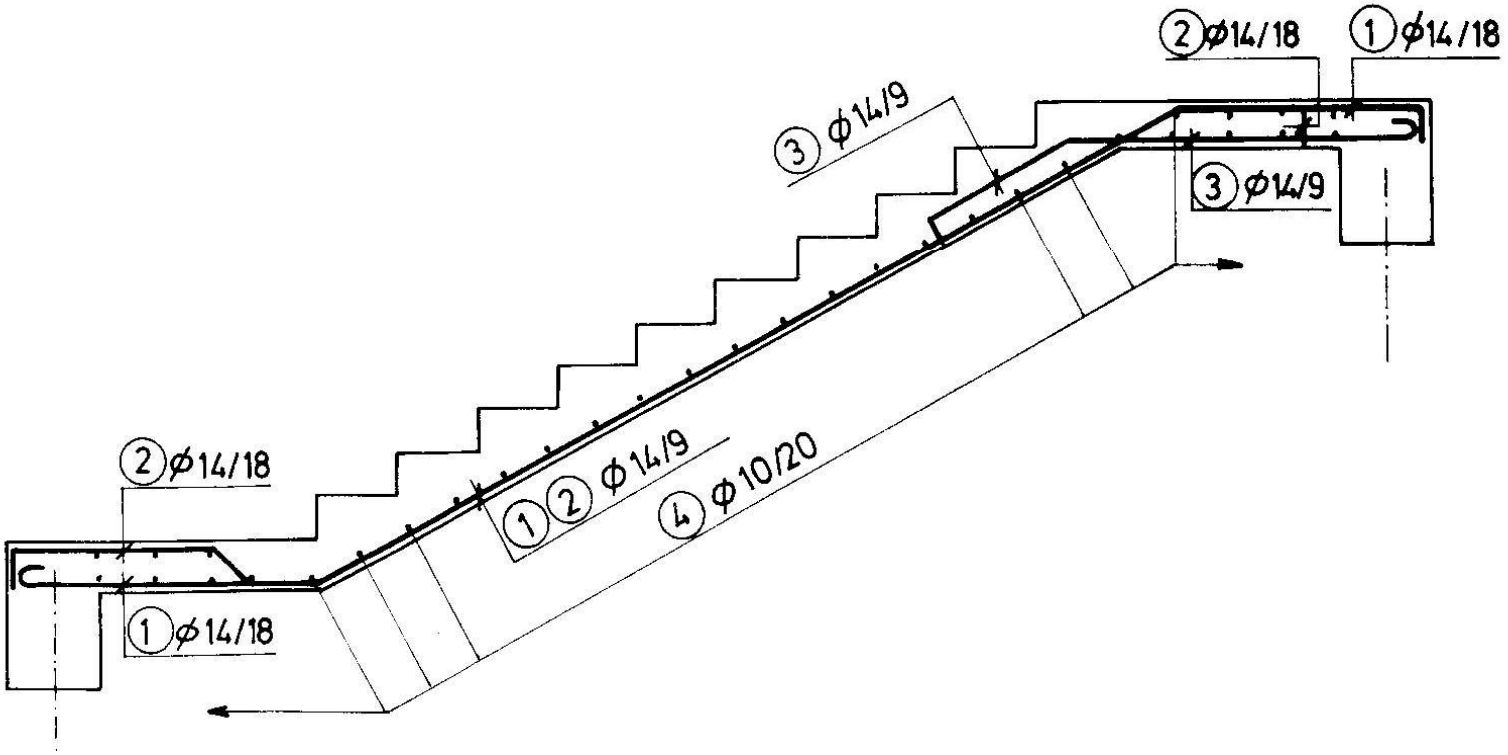

T
* POS ST1 *
1.6×G+1.6×P

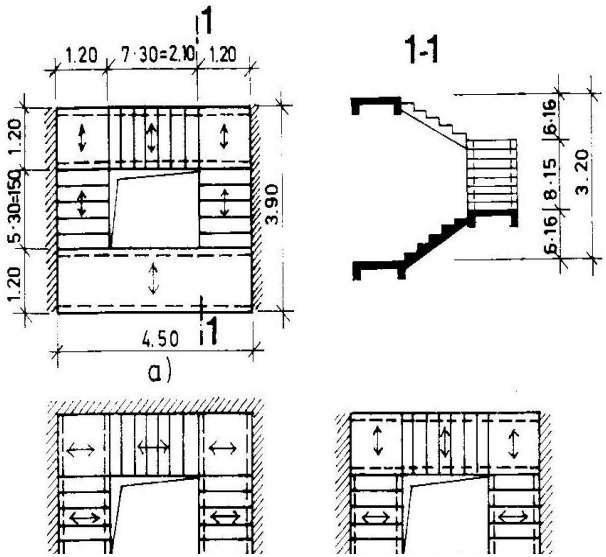

Ry
* POS ST1 *
Stalno opterecenje (G)

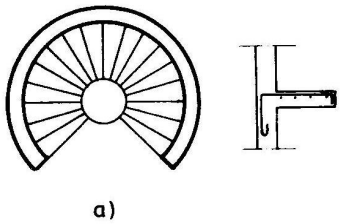

N
* POS ST1 *
1.6×G+1.6×P

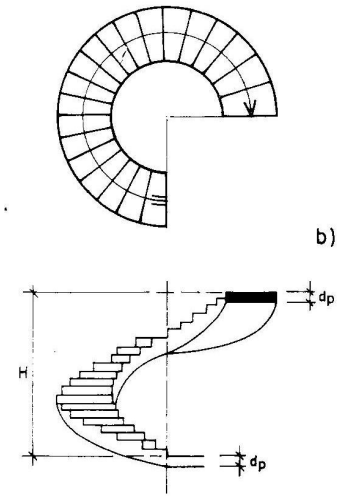

Ry
* POS ST1 *
Povremeno opterecenje (P)

Armiranje stepenišnog kraka

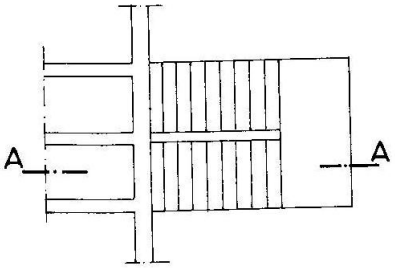


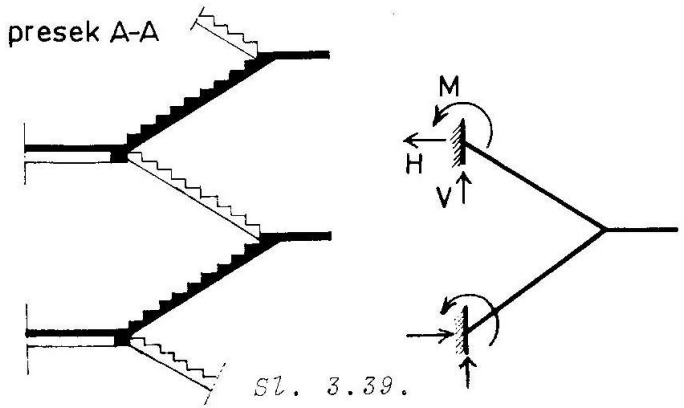

1
1.20
7·30=2.10
1.20
1.20
5·30=150
1.20
3.90
4.50
1
a)
1-1
6.16
8.15
3.20
6.16


a)


b)
dp
H
dp

Sl. 3.37.


A
A


presek A-A
M
H
V

Sl. 3.39.