ANEXA 4

MĂRIMI GEOMETRICE

SECȚIUNEA Axele principale: 1 şi 2 Axele centrale: z şi y	ARIA A	DISTANȚE MAXIME până la punctele extreme de la axele principale	MOMENTE DE INERȚIE PRINCIPALE față de axele inițiale alese	MODULE DE REZISTENȚĂ $W_z = \frac{I_z}{y_{max}}$, $W_y = \frac{I_y}{z_{max}}$ RAZE DE INERȚIE $i_1 = \sqrt{I_1 / A}$, $i_2 = \sqrt{I_2 / A}$
1	2	3	4	5
1. Dreptunghi înclinat	A= b·h	$z_1 = \frac{h \cdot \cos\alpha + b \cdot \sin\alpha}{2}$ $y_1 = \frac{h \cdot \sin\alpha + b \cdot \cos\alpha}{2}$	$I_z = A\left(\frac{h^2+b^2}{24} + \frac{h^2-b^2}{24}\cos 2\alpha\right)$ $I_y = A\left(\frac{h^2+b^2}{24} + \frac{h^2-b^2}{24}\sin 2\alpha\right)$ Pentru: $\alpha \neq 0^\circ$ $I_z \neq I_1, I_y \neq I_2$	$i_z = \sqrt{\frac{h^2+b^2}{24} + \frac{h^2-b^2}{24}\cos 2\alpha}$ $i_z = \sqrt{\frac{h^2+b^2}{24} + \frac{h^2-b^2}{24}\cos 2\alpha}$
2. Dreptunghi cu gol simetric	A=h·(B-b)	$z_{max} = \frac{B}{2}$ $y_{max} = \frac{h}{2}$	$I_y = I_1 = \frac{B^2 - b^2}{12} h$ $I_y = I_{21} = \frac{B-b}{12} h^3$	$W_1 = \frac{B^3 - b^3}{6B} h$ $W_1 = \frac{B^3 - b^3}{6B} h$ $i_1 = \sqrt{\frac{B^2 + Bb + b^2}{12}}$ $i_2 = \frac{h}{\sqrt{12}}$

1	2	3	4	5
3. Pătrat cu gol simetric	A= H^2-h^2	$z_1 = y_1 = \frac{H}{2}$ $u_1 = v_1 = \frac{H \cdot \sqrt{2}}{2}$	$I_z = I_y = I_u = I_v = \frac{H^2 - h^2}{12}$	$W_z = W_y = \frac{H^4 - h^4}{6H}$ $W_u = W_v = \frac{H^4 - h^4}{6H\sqrt{2}}$ $i_z = i_y = i_y = i_v =$ $= \sqrt{\frac{H^2 + h^2}{12}}$
4. Secțiuni compuse simetrice	A= =(B·H-b·h)	$y_1 = \frac{H}{2}$ $z_1 = \frac{B}{2}$ $z_3 = \frac{B^2 \cdot H - b^2 \cdot h}{2(B \cdot H - b \cdot h)}$	$I_z = I_1 = \frac{B \cdot H^3 - b \cdot h^3}{12}$ $I_{y_1} = I_2 = \frac{B^3 \cdot H - b^3 \cdot h}{12}$ $I_{y_2} = I_2 = \frac{B^3(H - h) + (B - b)^3 h}{12}$ $I_{y_3} = I_2 = I_{y_1} + B \cdot H \cdot \left(z_3 - \frac{B}{2}\right)^2$ $b \cdot h \left(z \quad b\right)^2$	$W_z = \frac{B \cdot H^3 - b \cdot h^3}{6H}$ $W_{y_1} = W_{y_2} = \frac{B^3 \cdot H - b^3 \cdot h}{6B}$ $W_{y_3} = \frac{I_{y_3}}{z_3}$ $i_z = \sqrt{\frac{B \cdot H^3 - b^3 \cdot h}{12(B \cdot H - b \cdot h)}}$
5. Secțiuni compuse simetrice	A= =B·H+b·h	$z_1 = \frac{H}{2}$ $y_1 = \frac{B}{2}$ $z_3 = \frac{b^2 \cdot h + B \cdot H(B + 2b)}{2(B \cdot H + b \cdot h)}$	$I_z = I_1 = \frac{B \cdot H^3 + b \cdot h^3}{12}$ $I_{y_1} = I_2 = \frac{B^3(H - h) + (B + b)^3 h}{12}$ $I_{y_2} = I_2 = \frac{(B + b)^3 H - b^3(H - h)}{12}$ $I_{y_3} = I_2 = \frac{B^3 h + b^3 h}{12} +$ $+ BH\left(z_3 - \frac{B}{2} - b\right)^2 + bh\left(z_3 - \frac{b}{2}\right)$	$W_z = \frac{BH^3 + bh^3}{6H}$ $W_{y_1} = \frac{B^3(H - h) + (B + b)^3 h}{6(B + b)}$ $W_{y_2} = \frac{(B + b)H - b(H - h)}{6(B + b)}$ $W_{y_3} = \frac{I_{y_3}}{z_3}$

1	2	3	4	5
6. Secțiune dublu T	A= =(Bt$_1$+bt$_2$+ +gt)	$y_1 = y$ $= \frac{Bt_1^2 + bt_2\left(2H - t_2\right) +}{2(Bt_1 + bt_2 +}$ $\frac{+ gh\left(2t_1 + h\right)}{+ gh)}$ $y_2 = H - y_1$	$I_y = \frac{B^3t_1 + b^3t_2 + g^3h}{12}$ $I_z = \frac{By_1^3 - (B-g)(y_1 - t_1)^3}{3} +$ $+ \frac{by_2^3 - (b-g)(y_2 - t_2)^3}{3}$	$W_y = \frac{B^3t_1 + b^3t_2 + g^3h}{6B}$ $W_{z1} = \frac{I_z}{y_1}, \quad W_{z2} = \frac{I_z}{y_2}$ $i_y = \sqrt{\frac{B^3t_1 + b^3t_2 + g^3h}{12\left(Bt_1 + bt_2 + gh\right)}}$ $i_z = \sqrt{\frac{I_z}{A}}$
7. Secțiune Z	A= =(BH-bh)	$e_1 = \frac{H}{2}\left(\cos\alpha + \frac{2B-g}{H} si\right.$ $e_2 = \frac{h}{2}\left(-\sin\alpha + \frac{2B-g}{H}\right.$ $e_2^{'} = \frac{H}{2}\left(\sin\alpha + \frac{g}{H}\cos\alpha\right)$	$I_z = \frac{BH^3 - bh^3}{12}$ $I_y = \frac{g^3h + 2B^3t}{12} + \frac{Bt}{2}(B-g)^2$ $I_{zy} = -\frac{Bt}{2}(B-g)(H-t)$ $I_1, I_2 = \frac{I_z + I_y}{2} \pm \sqrt{\left(\frac{I_z - I_y}{2}\right)^2 + I_{zy}^2}$ $\alpha_1 = \frac{1}{2}\mathrm{arctg}\frac{2I_{zy}}{I_z - I_y}$	$W_1 = \frac{I_1}{e_1}, \quad W_2 = \frac{I_2}{e_2}$ $i_1 = \sqrt{\frac{I_1}{A}}, \quad i_2 = \sqrt{\frac{I_2}{A}}$ $i_z = \sqrt{\frac{BH^3 - bh^3}{12\left(BH - bh\right)}}$
8. Cornier	A= =(BH-bh)	$z_1 = \frac{B^2H - b^2h}{2\left(BH - bh\right)}$ $y_1 = \frac{BH^2 - bh^2}{2\left(BH - bh\right)}$ $z_2 = B - z_1, \quad y_2 = H - y_1$ $e_1 = y_1\cos\alpha + z_2\sin\alpha$ $e_2 = z_1\cos\alpha - \left(y_2 - t\right)\sin\alpha$	$I_z = \frac{By_2^3 - b\left(y_2 - t\right)^3 + gy_1^3}{3}$ $I_y = \frac{Hz_2^3 - h\left(z_2 - g\right)^3 + tz_1^3}{3}$ $I_{zy} = \frac{BH}{4}\left(B - 2z_1\right)\left(H - 2y_1\right) -$ $- \frac{bh}{4}\left(b - 2z_1\right)\left(h - 2y_2\right)$ $\alpha_1 = \frac{1}{2}\mathrm{arctg}\frac{2I_{zy}}{I_z - I_y}$	$W_1 = \frac{I_1}{e_{1\max}}$ $W_2 = \frac{I_2}{e_{2\max}}$

Anexa 4 (continuare)

1	2	3	4	5
9. Triunghi	$A = \frac{bh}{2}$	$y_1 = \frac{2}{3}h$ $y_2 = \frac{1}{3}h$	$I_z = \frac{bh^3}{36}$	$W_{z1} = \frac{bh^2}{24}$ $W_{z2} = \frac{bh^2}{12}$ $I_z = \frac{h}{\sqrt{18}}$
10. Romb	$A = \frac{bh}{2}$	$z_1 \frac{b}{2}$ $y_1 = \frac{h}{2}$	$I_z = I_2 = \frac{bh^3}{48}$ $I_y = I_1 = \frac{b^3h}{48}$	$W_z = \frac{bh^2}{24}, \quad W_y = \frac{b^2h}{24}$ $i_z = \frac{h}{\sqrt{48}}, \quad i_y = \frac{b}{\sqrt{48}}$
11. Trapez	$A = \frac{B-b}{2}h$	$y_1 = \frac{2B+b}{B+b} \cdot \frac{h}{3}$ $y_2 = \frac{2b+B}{}$	$I_z = \frac{B^2+4Bb+b^2}{B+b} \cdot \frac{h^3}{36}$ Pentru trapez isoscel $I_y = \frac{h}{48}\left(B^3+B^2b+Bb^2+b^3\right)$	$W_{z1} = \frac{I_z}{y_1}, \quad W_{z2} = \frac{I_z}{y_2}$ $i_z = \frac{h}{6(B+b)} \cdot \sqrt{2\left(B^2+4Bb+b^2\right)}$

Anexa 4 (continuare)

1	2	3	4	5
12. Coroana circulară (k = d/D)	$A=\frac{\pi D^2}{1}\left(1-k^2\right)$ Inel subțire $A=\pi(D-t)t$ $t=\frac{D-d}{2}$	$z_1=y_1=\frac{D}{2}$ $t=\frac{D-d}{2}$	$I_z=I_y=I_1=I_2=$ $=\frac{\pi D^4}{64}\left(1-k^4\right)$ $I_z=I_y=\frac{\pi t}{64}(D-d)^3$	$W_z=W_y=\frac{\pi D^3}{32}\left(1-k^4\right)$ $i_2=i_y=\sqrt{\frac{D^2+d^2}{4}}$ $W_z=W_y=\pi t\frac{(D-t)^3}{4D}$ $i_2=i_y=\frac{D+t}{2\sqrt{2}}$
13. Sector inelar	$A=\left(R^2-r^2\right)\varphi$ Sector de inel subțire $A=2tR_m\varphi$	$z_0=\frac{2\sin\varphi}{3\varphi}\cdot\frac{R^3-r^3}{R^2-r^2}$ $z_1=z_0-r\cdot\cos\varphi$ $z_2=R-z_0$ $z_0=R_m\frac{\sin\varphi}{\varphi}$ $y_1=R_m\sin\varphi$	$I_z=\frac{R^4-r^4}{8}(2\varphi-\sin 2\varphi)$ $I_y=\frac{R^4-r^4}{8}\left(2\varphi-\sin 2\varphi-\frac{32\sin^2\varphi}{9\varphi}\right)-$ $-\frac{4R^2r^2t\sin^2\varphi}{9(R+r)\varphi}$ $I_2=\frac{tR_m^3}{2}(2\varphi-\sin 2\varphi)$ $I_y=\frac{tR_m^3}{2}\left(2\varphi+\sin 2\varphi-\frac{4}{\varphi}\sin^2\varphi\right)$	$W=\frac{R^4-r^4}{8R}\cdot\frac{2\varphi-\sin 2\varphi}{\sin\varphi}$ $W_{y1}=\frac{I_y}{z_1}$, $W_{y2}=\frac{I_y}{z_2}$ $i_z=\sqrt{\left(R^2-r^2\right)\frac{2\varphi-\sin 2\varphi}{8\varphi}}$ $i_y=\sqrt{\frac{I_y}{A}}$
14. Segment de cerc	$A=$ $=R\frac{2\varphi-\sin 2\varphi}{2}$	$z_1=R\sin\varphi$ $y_o=\frac{4}{3}\frac{R\sin^3\varphi}{2\varphi-\sin 2\varphi}$ $y_1=R-y_o$ $y_2=y_o-R\cos\varphi$	$I_y=I_1=\frac{AR^4}{4}\left(1-\frac{4}{3}\frac{\sin^3\varphi\cos\varphi}{2\varphi-\sin 2\varphi}\right)$ $I_z=I_2=\frac{AR^2}{4}(1+\frac{4\sin^3\varphi\cos\varphi}{2\varphi-\sin 2\varphi}-$ $-\frac{32}{9}\frac{\sin^2\varphi}{2\varphi-\sin 2\varphi})$	$W_y=\frac{I_y}{z_1}$, $W_{z1}=\frac{I_z}{y_1}$, $W_{z2}=\frac{I_z}{y_2}$ $i_y=\frac{R}{2}\sqrt{1-\frac{4}{3}\frac{\sin^2\varphi\cos\varphi}{2\varphi-\sin 2\varphi}}$ $i_z=\sqrt{\frac{I_z}{A}}$

Anexa 4 (continuare)

1	2	3	4	5
15. Semicoroană circulară	$A=\frac{D^2-d^2}{8}\pi$	$y_1=\frac{2}{3\pi}\frac{D^3-d^3}{D^2-d^2}$ $y_2=\frac{D}{2}-y_1$ $z_1=\frac{D}{2}$	$I_y=I_1=\frac{D^4-d^4}{128}\pi$ $I_z=I_2=\frac{D^4-d^4}{128}\left(\pi-\frac{64}{9\pi}\right)-$ $-\frac{D^2d^2}{18\pi}\frac{D-d}{D+d}$	$W_y=\frac{\pi D^3}{64}\left(1-k^4\right)$ $W_{z1}=\frac{I_z}{y_1}$, $W_{z2}=\frac{I_z}{y_2}$ $i_y=\frac{\sqrt{D^2+d^2}}{4}$, $i_z=\sqrt{\frac{I_z}{A}}$
16. Coroană eliptică	$A=\pi(ab-a_1b$	$y_1=b$ $z_1=a$	$I_y=I_1=\frac{\pi}{4}\left(a^3b-a_1^3b_1\right)$ $I_z=I_2=\frac{\pi}{4}\left(ab^3-ab_1^3\right)$	$W_y=\frac{\pi}{4a}\left(a^3b-a_1^3b_1\right)$ $W_z=\frac{\pi}{4b}\left(ab^3-ab_1^3\right)$
17. Hexagon regulat	$A=1{,}5R^2\sqrt{3}$	$y_1=\frac{R}{2}\sqrt{3}$ $z_1=R$	$I_z=I_y=I_1=I_2=\frac{5\sqrt{3}}{16}R^4$	$W_z=\frac{5}{8}R^3$ $W_y=\frac{5\sqrt{3}}{16}R^3$ $i_z=i_y=R\sqrt{\frac{5}{24}}$