EGZAMIN MK (MK3) KB studia mgr stacj. dnia 15 IX 2016 r.

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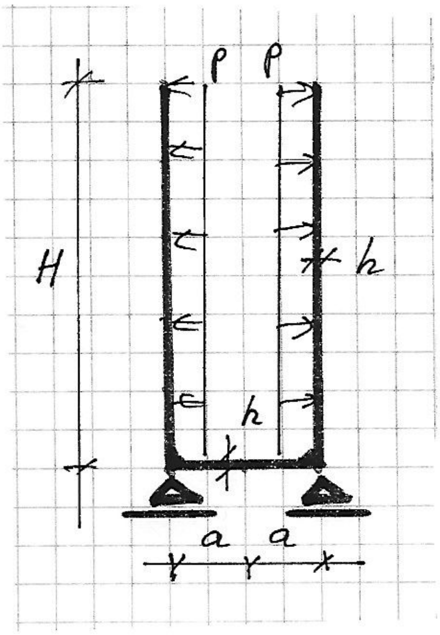
Zadanie 1.

Dany jest wysoki zbiornik walcowy, obciążony jak na rysunku. Znaleźć wykresy sił tarczowych N_1, N_2 i momentów zginających M_1, M_2.

H=5a, h=a/10, współczynnik Poissona=0.2.

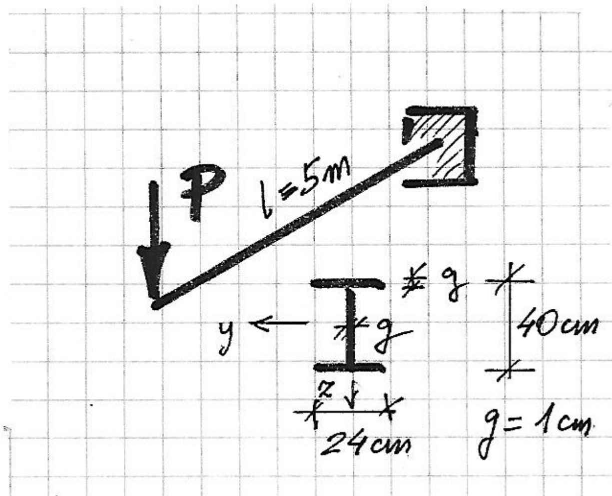


Zadanie 2.

Znaleźć siłę krytyczną P (przyłożoną w środku ciężkości SC przekroju) zwichrzenia pręta cienkościennego o schemacie wspornika o długości l = 5.0 m. Dane dotyczące przekroju:

h = 40 cm
b = 24 cm
grubość g=1cm

J_y=24533 cm^4
J_z=2304 cm^4
J_ω=921600 cm^6
J_s=29,33 cm^4

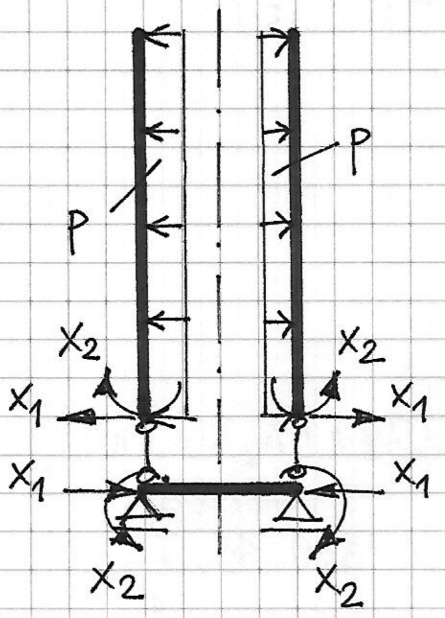


Przyjąć: stal, współczynnik Poissona=0.3; E=205 GPa.

Pozostałe charakterystyki wyznaczyć samodzielnie.

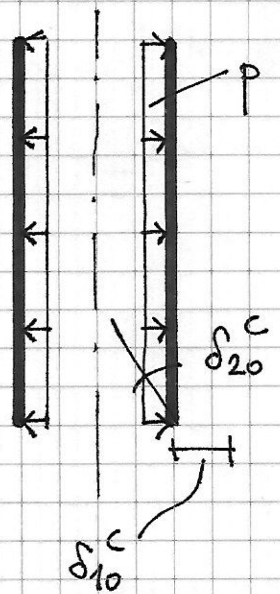
Zadanie 1 / Problem 1

Schemat zastępczy / Primary structure



(A) WALEC / CYLINDER

- Stan bezzgięciowy / Non bending state



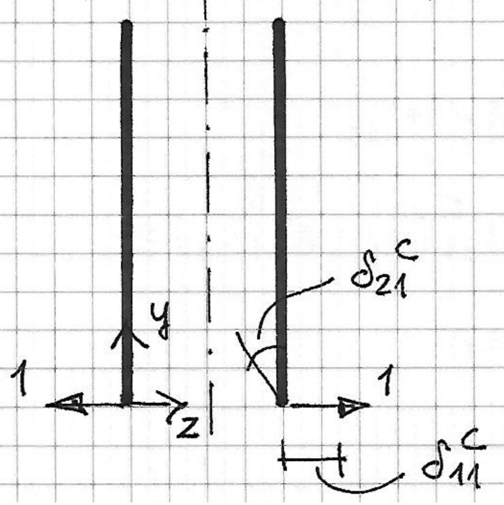
$$\delta_{10}^c = \frac{pa^2}{Eh} = 10\,\frac{pa}{E}$$

$$\delta_{20}^c = 0$$

$$M_{10}^c = 0 \qquad M_{20}^c = 0$$

$$N_{10}^c = pa \qquad N_{20}^c = 0$$

- Zaburzenie $X_1 = 1$ / Perturbation $X_1 = 1$



$$\xi = \frac{y}{a} \qquad \lambda^4 = 3(1-\nu^2)\left(\frac{a}{h}\right)^2 = 288\,,\ \lambda = 4{,}12$$

$$D = \frac{Eh^3}{12(1-\nu^2)} = 0{,}000087\,Ea^3$$

$$w(\xi) = e^{-\lambda\xi}\left[A_1\cos(\lambda\xi) + A_2\sin(\lambda\xi)\right]$$

$$\left.\begin{array}{l} M_2(0) = 0 \\ Q_2(0) = 1 \end{array}\right| \rightarrow \begin{array}{l} A_1 = -82{,}39\,\frac{1}{E} \\ A_2 = 0 \end{array}$$

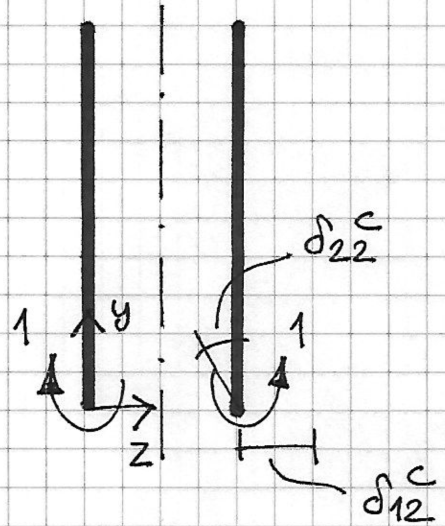
$$\delta_{11}^{c} = 82{,}39\,\frac{1}{E} \qquad \delta_{21}^{c} = 339{,}41\,\frac{1}{Ea}$$

$$M_{11}^{c} = \nu M_{21}^{c} \qquad M_{21}^{c} = a\cdot 0{,}243\, e^{-\lambda\xi}\sin(\lambda\xi)$$

$$= a\cdot 0{,}049\, e^{-\lambda\xi}\sin(\lambda\xi)$$

$$N_{11}^{c} = N_{21}^{c} = 0$$

- Zaburzenie $X_2=1$ / Perturbation $X_2=1$



$$w(\xi) = e^{-\lambda\xi}\left[A_1\cos(\lambda\xi) + A_2\sin(\lambda\xi)\right]$$

$$\left.\begin{array}{l} M_2(0) = 1 \\ Q_2(0) = 0 \end{array}\right| \rightarrow \begin{array}{l} A_1 = -339{,}41\,\frac{1}{Ea} \\ A_2 = 339{,}41\,\frac{1}{Ea} \end{array}$$

$$\delta_{12}^{c} = \delta_{21}^{c} = 339{,}411\,\frac{1}{Ea}$$

$$\delta_{22}^{c} = 2796{,}43\,\frac{1}{Ea^2}$$

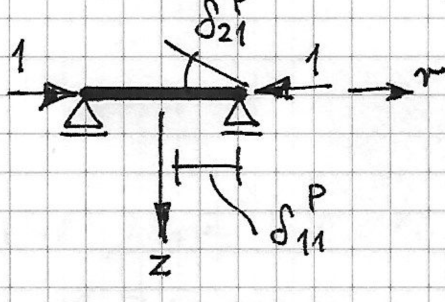
$$M_{12}^{c} = \nu M_{22}^{c} \qquad M_{22}^{c} = e^{-\lambda\xi}\left[\cos(\lambda\xi) + \sin(\lambda\xi)\right]$$

$$= 0{,}2\, e^{-\lambda\xi}\left[\cos(\lambda\xi) + \sin(\lambda\xi)\right]$$

$$N_{12}^{c} = N_{22}^{c} = 0$$

Ⓑ PŁYTA / PLATE

- Zaburzenie $X_1=1$ / Perturbation $X_1=1$



$$\rho = \frac{r}{a} \qquad C = \frac{Eh}{1-\nu^2} = 0{,}104\,Ea$$

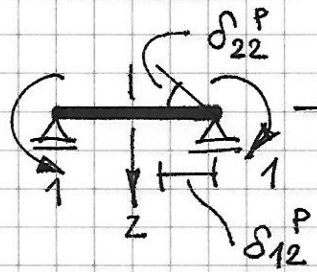
$$u(\rho) = A\rho$$

$$N_2(1) = -1 \rightarrow A = -\frac{8}{E}$$

$$M_{11}^{P} = M_{21}^{P} = 0 \qquad N_{11}^{P}(\rho) = N_{21}^{P}(\rho) = -1$$

$$\delta_{11}^{P} = \frac{8}{E} \qquad \delta_{21}^{P} = 0$$

• Zaburzenie $X_2=1$ / Perturbation $X_2=1$



$$w(\xi)=A_1+A_2\xi^2 \qquad D=\frac{Eh^3}{12(1-\nu^2)}=0{,}000087\,Ea^3$$

$$\left.\begin{array}{l} W(1)=0 \\ M_2(1)=-1 \end{array}\right| \longrightarrow \begin{array}{l} A_1=-4800\,\frac{1}{Ea} \\ A_2=4800\,\frac{1}{Ea} \end{array}$$

$$\delta_{12}^P=\delta_{21}^P=0$$

$$M_{12}^P(\xi)=M_{22}^P(\xi)=-1$$

$$\delta_{22}^P=9600\,\frac{1}{Ea^2}$$

$$N_{12}^P(\xi)=N_{22}^P(\xi)=0$$

(C) OBLICZENIE X_1, X_2 / CALCULATION OF X_1, X_2

$$\begin{cases} \delta_{11}X_1+\delta_{12}X_2+\delta_{10}=0 \\ \delta_{21}X_1+\delta_{22}X_2+\delta_{20}=0 \end{cases}$$

$$\delta_{ij}=\delta_{ij}^C+\delta_{ij}^P \qquad \delta_{i0}=\delta_{i0}^C+\delta_{i0}^P$$

$$\delta_{11}=82{,}39\,\frac{1}{E}+8\cdot\frac{1}{E}=90{,}39\cdot\frac{1}{E}$$

$$\delta_{12}=\delta_{21}=339\cdot\frac{1}{Ea}$$

$$\delta_{22}=2796{,}43\,\frac{1}{Ea^2}+9600\,\frac{1}{Ea^2}=12396\,\frac{1}{Ea^2}$$

$$\delta_{10}=10\,\frac{pa}{E}$$

$$\delta_{20}=0$$

$$X_1=-0{,}123\,pa \qquad X_2=0{,}0034\,pa^2$$

(D) OBLICZENIE M_1, M_2, N_1, N_2 / CALCULATION OF M_1, M_2, N_1, N_2

$$M_1^C(\xi)=M_{11}^C(\xi)X_1+M_{12}^C(\xi)X_2+M_{10}^C(\xi)$$
$$=\left[-0{,}0053\sin(\lambda\xi)+0{,}00068\cos(\lambda\xi)\right]e^{-\lambda\xi}\,pa^2$$

$$M_2^C(\xi)=M_{21}^C(\xi)X_1+M_{22}^C(\xi)X_2+M_{20}^C(\xi)=\left[-0{,}026\sin(\lambda\xi)+0{,}0034\cos(\lambda\xi)\right]e^{-\lambda\xi}\,pa^2$$

$$N_1^C(\xi)=pa \qquad N_2^C(\xi)=0$$

$$M_1^P(\xi)=M_2^P(\xi)=-0{,}0034\,pa^2 \qquad N_1^P(\xi)=N_2^P(\xi)=0{,}123\,pa$$