9/5/19

Σύμμικτα Υποστυλώματα

#18

Δοκιμή: $\{N_{pl,c,Rd} = N_c\}$

$$N_{pl,Rd} = N_{pl,a,Rd} + N_{pl,s,Rd} + N_{pl,c,Rd}$$

$$N_{pl,Rd} = A_a \cdot f_{yd} + A_s \cdot f_{sd} + 0{,}85 \cdot A_c \cdot f_{cd}$$

$$N_{pl,Rd} = A_a \cdot f_{yk} + A_s \cdot f_{sk} + 0{,}85 \cdot A_c * f_{ck}$$

- $f_{yk} = 23{,}5\ kN/cm^2 \rightarrow f_{yd} = 23{,}5\ kN/cm^2$
- $f_{sk} = 50\ kN/cm^2 \rightarrow f_{sd} = \frac{50}{1{,}15} = 43{,}47\ kN/cm^2$
- $f_{ck} = 2\ kN/cm^2 \rightarrow f_{cd} = \frac{2}{1{,}15} = 1{,}333\ kN/cm^2$

$$N_{pl,Rd}^{k} = 149{,}1 \cdot 23{,}5 + 39{,}2 \cdot 50 + 0{,}85 \cdot 2 \cdot 1836{,}7$$

$$N_{pl,Rd} = 149{,}1 \cdot 23{,}5 + 39{,}2 \cdot 43{,}47 + 0{,}85 \cdot 1836{,}7 \cdot 1{,}333 = 7288{,}94 \simeq 7289$$

$$\frac{N_{pa,Rd}}{N_{pl,Rd}} = \frac{3503{,}85}{7289} \begin{matrix} > 0{,}2 \\ < 0{,}9 \end{matrix}$$

$\rightarrow$ άρα το υποστύλωμα έχει να διαχωρίσει σύμμικτο.

ΑΣΚΗΣΗ 2 #19

$\bar{\lambda} > 0,5 \rightsquigarrow$ όχι αμελείωση της αντοχής χάλυβα, σκυροδέματος C20/25, S235

επδ. είναι εγκιβωτισμένο το σκυρόδεμα δεν έχω x0,85

- $A_c = \pi \cdot \frac{(25^{cm} - 2 \cdot 0,8^{cm})^2}{4} \Rightarrow A_c = 430,05\ cm^2$

- $A_a = \frac{\pi \cdot 25^2}{4} = 60,82\ cm^2 \Rightarrow A_a = 60,82\ cm^2$

- $N_{pl,Rd} = A_a \cdot f_{yd} + A_c \cdot f_{cd} = 60,82 \cdot 23,5 + 430,05 \cdot 1,333 = 2003\ kN$

- $N_{pl,Rk} = A_a \cdot f_{yk} + A_c \cdot f_{ck} = 60,82 \cdot 23,5 + 430,05 \cdot 2 = 2289\ kN$

- $\frac{N_{a,Rd}}{N_{pl,Rd}} = \frac{1429,27}{2003} = 0,714 > 0,2$ $\rightsquigarrow$ Άρα Σύμμικτο Υποστύλωμα
$< 0,9$

- $\bar{\lambda} = \frac{\lambda}{\lambda_1}$, $\lambda_1 = \pi \sqrt{\frac{E}{f_y}}$

$\lambda = \frac{L_a}{i}$, $i = \frac{I}{A}$ $\Big\} \rightarrow \lambda^2 = \frac{L^2}{I} \cdot A$

$\left\{\frac{L^2 \cdot A}{I}\right\} \cdot \left\{\frac{A \cdot f_y}{\pi^2 \cdot E}\right\} = \frac{N_{pl}}{N_{cr}}$

$N_{cr} = \frac{\pi^2 \cdot E \cdot I}{L^2}$

$\Rightarrow A_{\sigma\chi} \cdot \lambda^2 = \frac{N_{pl}}{N_{cr}} \Rightarrow$

$\Rightarrow \bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}} = \sqrt{\frac{N_{pl,Rk}}{N_{cr,EP}}}$

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$\bar{\lambda} = \sqrt{\frac{N_{pl}}{N_{cr}}}$ → θεωρητική τιμή

Άσκηση 3 #20

$N_{Ed} < \chi \cdot N_{pl,Rd}$ όπου $N_{b,Rd} = \chi \cdot N_{pl,Rd}$ {αντοχή σε λύγισμα}

Έλεγχος περί τον άξονα y-y:

- $(EI)_{eff,y} = E_a \cdot I_{a,y} + E_s \cdot I_{s,y} + K_c \cdot E_{cm} \cdot I_{c,y}$, $K_e = 0,60$
- $N_{cr,y} = \frac{\pi^2 \cdot (EI)_{eff,y}}{\ell^2}$

$E_a = E_s = 21000$ kN/cm²

- $E_{cm} = 29$ GPa $= 29000000$ kN/m² $= \frac{29000000}{10000} \frac{kN/m^2}{m^2} = 2900$ kN/cm²
- $I_{a,y} = 25170$ cm⁴
- $I_{s,y} = 4 \times 2 \times 4,9 \cdot (22,5-4)^2 =$ χωρίς το I_0 γιατί είναι πολύ μικρό
  $= 13416$ cm⁴
- $I_{c,y} = \frac{45 \times 45^3}{12} - 25170 - 13416 = 303134$ cm⁴

$(E \cdot I)_{eff,y} = 21000 \times 25170 + 21000 \times 13416 + 0,6 \times 2900 \times 303132 =$

$= 528570000 + 281736000 + 879082800 \times 0,6$

↳ διαφέρεται σε τραχυκρόνια δειγματία

Για μακροχρόνια διαρκεία

$$E_{c,eff} = E_{cm} * \frac{1}{\left(1 + \frac{N_{G,Ed}}{N_{Ed}} \times \phi_t\right)} = 0,57 \cdot E_{cm}$$

$\frac{N_{G,Ed}}{N_{Ed}} \sim 0,30$

$\phi_t = 2,5$

Άρα: $(E \cdot I)^{(y)}_{eff,\infty} = 5285700007 + 28173600 +$

$+ 0,6 \times 0,57 \times 87908280 =$

$= 11109523 18 \rightarrow N_{cr,y} = \frac{\pi^2 \cdot (E \cdot I)^{(y)}_{eff,\infty}}{l^2 = 8\,m} =$

δύσκολος δρόμος

$\Rightarrow N_{cr,y} = 17132,3\ kN \Rightarrow$

$\Rightarrow \boxed{N_{cr,y} = 17132\ kN}$

Αμφίπλευρη πυρόπαγμα περί τον άξονα y:

$\bar{\lambda}_y = \sqrt{\frac{N_{pl,Rk}}{N_{cr,y}}} = \sqrt{\frac{8586}{17132}} = 0,708 \Rightarrow \boxed{\bar{\lambda}_y = 0,708}$

$\downarrow$

$\phi_y = 0,5\left[1 + 0,34 \cdot (0,708 - 0,2) + 0,708^2\right]$

$\Rightarrow \boxed{\phi_y = 0,837}$

$\downarrow$

$\chi_y = \frac{1}{0,837 + \sqrt{0,837^2 - 0,708^2}} \Rightarrow \leftarrow$

$\Rightarrow \boxed{\chi_y = 0,78}$

άρα: $N_{b,Rd,y} = \chi_y \cdot N_{pl,Rd} = 0,708 \cdot 7289 = 5685$.

Ίδια διαδικασία για άξονα z:

- $I_{a,z} = 8563\ cm^4$
- $I_{s,y} = 13416\ cm^4$, ίδιο, τετραγωνική διατομή.
- $I_{c,y} = 319740\ cm^4$

- $(EI)_{eff,z} = 21000 \times 8563 + 21000 \times 13416 + 0,5 \times 0,6 \times 2900 \times 319740 =$
  $= 778677132\ kNcm^2$

  - ο συντελεστής ερπυσμού δεν αλλάζει, έχει να κάνει με τα εξωτερικά χαρακτηριστικά περίβλημα.

$\downarrow$

$N_{cr,z} = 12088\ kN$

$\downarrow$

$\lambda_z = 0,846$

$\downarrow$

$\Phi_z = 1,016 \rightarrow \chi_z = 0,633$

$N_{b,Rd,z} = 4614\ kN$

Άρα: $N_{b,Rd} = \min\{5685 ; 4614\} \Rightarrow$

$$\Rightarrow \boxed{N_{b,Rd} = 4614\ kN}$$

#21 Ρ.Α. κύκλου $\frac{\pi r^4}{4} = \frac{\pi \cdot (\frac{d}{2})^4}{2} = \frac{\pi d^4}{64}$

ΑΣΚΗΣΗ 4

εσωτερικό

- $I_a = \frac{\pi \times d^4}{64} = \frac{\pi \times (25 - 2 \cdot 0,8)^4}{64} = 19174 - 14714 = 4457\ cm^4$
- $I_c = 14714\ cm^4$
- $(EI)_{eff} = E_a \cdot I_a + k_e \cdot E_{cm} \cdot I_c = 21000 \times 4457 + 0,6 \times 2900 \times 14717 =$
  $= 119204580\ kN \cdot cm^2$
- $N_{cr} = \frac{\pi^2 (EI)_{eff}}{(350)^2} = 9604\ kN$
- $\bar{\lambda} = \sqrt{\frac{2289}{9604}} = 0,488 < 0,5$, $e = 0 < 0,1$
- $\eta_a = \eta_{a,0} = 0,25 \cdot (3 + 2 \cdot 0,488) = 0,994$
- $\eta_c = \eta_{c,0} = 4,9 - 18,5 \cdot 0,488 + 17 \cdot 0,488^2 = -0,079$ → αν βγει <0 το παίρνω 0

$\Rightarrow \eta_c = 0$

- $N_{pl,Rd} = 60,82 \times 0,994 \times 23,5 + 430,05 \times \left(\frac{2}{1,5}\right)$ → χωρίς 0,85 διότι περίοδος σε εξ. κατ.
- $N_{pl,Rd} = 1420,7 + 573,4 = 1994,1\ kN = 1994\ kN$.

$\frac{N_{pa,Rd}}{N_{pl,Rd}} = \frac{1420,7}{1994} = 0,712 > 0,2$, $< 0,9$

για $\rho_s < 3\%$ → κατηγ. α ~εδώ $\rho_s = 0$, όρα α.

οπότε: $\Phi = 0,5 \cdot \left[1 + 0,21 \cdot (0,488 - 0,2) + 0,488^2 \right] = 0,649$

$$\chi = \frac{1}{\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2}} = 0,928$$

$N_{b,Rd} = \chi \cdot N_{pl,Rd} = 0,928 \times 1994 = 1850\ kN$ ~ΣΕ λυγηρό αυτοχή.

Ζητά έλεγχο για αξονική φορτία

$N_{Ed} = 1,35 \times 480 + 1,50 \times 750 = 648 + 1125 \Rightarrow N_{Ed} = 1773\ kN < N_{b,Rd} = 1850\ kN.$

AS2K/24 # 22

- $N_{Ed} = 2500\ kN$
- $q_{Ed,z} = 30\ kN/cm$
- $e_{0,6} = \frac{L}{200}$. $e_{0,7} = \frac{L}{150}$

$$M_{Ed,y}^{(I)} = N_{Ed} \cdot e_{0,y} + \frac{q_{Ed,z} \cdot l^2}{8} = 2500 \times \frac{8,00}{200} + \frac{30 \times 8,0}{8} = 100 + 240 =$$

$$= 340\ kN \cdot m$$

$$\frac{N_{Ed}}{N_{w,eff,y}} = \frac{2500}{7132} = 0,146 \rangle 0,10$$

$$M_{Ed,y}^{(II)} = M_{Ed,y}^{(I)} \times \frac{1}{1 - \frac{N_{Ed}}{N_{cr,eff,y}^{(II)}}}$$

$$N_{cr,eff\,II,y} = \frac{\pi^2 \cdot (E \cdot I)_{eff\,II}}{L^2}$$

$$(EI)_{eff,II} = \frac{k_0}{0,9} \cdot \left(\frac{k_v}{0,5} \right) = 75476138\ kN \cdot cm^2$$

$$N_{cr,eff,II,y} = 14723\ kN$$

- $M_{N,Rd,y} = \frac{7289 - 2500}{7289 - 2081} \times 815,4 = 750\ kN \cdot m$

- $\frac{M_{Ed}^{II}}{M_{N,Rd,y}} = \frac{409,5}{750} \approx 0,54 < 0,9$ ok.

2. $N_{Ed} = 2500\ kN$

$q_{Ed,y} = 10\ kN/m$

$$M_{Ed_z}^{(I)} = 2500 \times \frac{8,0}{150} + 10 \times \frac{8,0^2}{8} = 132,5 + 80 = 212,5\ kN \cdot m$$

$$\frac{N_{Ed}}{N_{cr,eff,z}} = \frac{2500}{12008} = 0,208 > 0,10$$

$$M_{Ed,z}^{II} = M_{Ed,z}^{(I)} \cdot \frac{\beta}{1 - \frac{N_{Ed}}{N_{cr,eff\,II,z}}}$$

$EI_{eff\,II,z} = 6532416\,99\ kN\,cm^2$

$N_{cr,eff\,II,z} = 100\,74\ kN$

$$M_{N,Rd\,z} = \frac{7284 - 2500}{7289 - 2081} = 633,1$$

$M_{N,Rd,z} = 582,2\ kN \cdot m$

$$\frac{M_{Ed\,z}^{II}}{M_{N,Rd\,z}} = \frac{282,6}{582,2} = 0,48 < \alpha_M = 0,9$$

3.) $\frac{M_{Ed,y}}{M_{N,Rd,y}} + \frac{M_{Ed,z}}{M_{N,Rd,z}}^{\text{I ή II}} < 1$

$M_{Ed,y} = N_{Ed} \cdot e_{0,y} + M_y^{K}$ $\quad M_y^1 - M_y^2$ $\quad (M_y^2 + M_y^2) + M_z^2$

$M_{Ed,z} = N_{Ed} \cdot e_{0,z} + M_z^{K}$ $\quad M_z^1$ $\quad M_z^2$ $\quad (M_z^2 + M_z^2) + M_y^2$

Άτεκτα περί τον y-y

$M_{Ed,y}^{(II)} = 409,6$ kN·m

$M_{Ed,z}^{II} = 80 \cdot \frac{1}{1 - \frac{2500}{10074}} = 106$ kN·m $\Big\} \rightarrow \frac{409,6}{750} + \frac{106}{582,2} = 0,54 + 0,18 =$

$= 0,72 < 1,0$

Άτεκτα περί τον z-z:

$M_{Ed,y}^{(II)} = 240 \times \frac{1}{1 - \frac{2500}{14793}} = 289$ kN·m

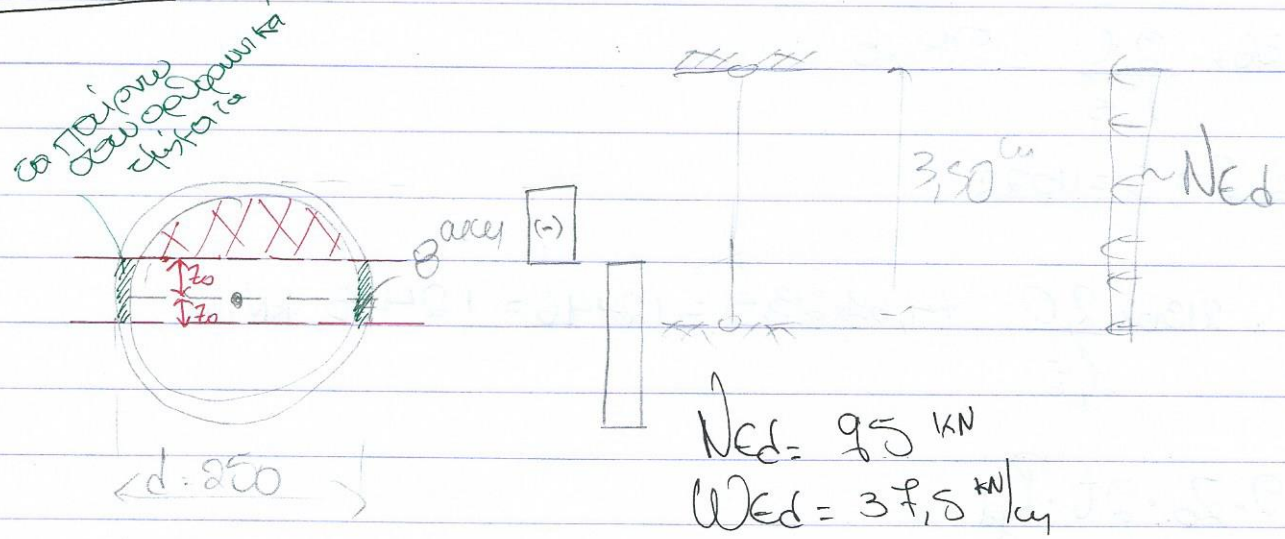
$M_{Ed,z}^{II} = 282,6$ kN·m

$\rightarrow$ Έλεγχος $\rightarrow \frac{284}{750} + \frac{282,6}{582,2} = 0,87 < 1$

#23

Ασκήσεις Μαθήματος

30/5/19



$N_{Ed} = 95$ kN

$W_{Ed} = 37{,}5$ kN/cm

Άνω:

Σημείο Α: $N_{pl,Rd} = 1994$ kN

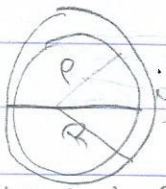
$M = 0$

Σημείο Δ: $N = N_{pl,\phi} \times \frac{1}{2}$

$M = M_{max,Rd} = \frac{1}{2} \cdot M_{pl}^{(\phi)} + M_{pl}^{(a)}$

$M_{pl,\phi} = W_{pl}^{\phi} * f_{cd}$

$M_{pl}^{(a)} = W_{pl,a} \times f_{yd}$



$W_{pl,y}^{(\phi)} = \frac{4R^3}{3}$

$W_{pl,a}^{(y)} = \frac{4}{3}(R^3 - \rho^3)$

Όπου: $W_{pl}^{\phi} = \frac{4}{3}\left(\frac{25 - 2 \cdot 0{,}8}{2}\right)^3 = 2136$ cm^3

$W_{pl,a} = \frac{4}{3}\left(\frac{25}{2}\right)^3 - 2136 = 468{,}7 \simeq 469$ cm^3

$W_{pl,a}^{(y)} = (d-t)^2 \cdot t$

$\cdot N_{pl,}^{c} = 2136 \times \frac{2,0}{1,5} = 2848$

$\cdot N_{pl}^{a} = 469 \times 23,5 = 11022$

$\cdot M_{max,Rd} = \frac{1}{2} \times 2136 \times \frac{2,0}{1,5} + 4,69 \times 23,5 = 12446 = 124,5 \text{ kN.m}$

$\cdot \bar{N}_{pl,c} = 2 \cdot z_0 \cdot 2t \cdot f_{yd}$

$\cdot N_{pl,c} = \pi \cdot \left(\frac{25 - 2 \cdot 0,8}{2}\right) \cdot f_{cd}$

$\cdot \bar{A}_c = \frac{\{A_c - 2 \cdot z_0 \cdot (d - 2 \cdot t)\}}{2}$ → το πάνω, με το κενό σου σχήμα

$\Rightarrow \bar{A}_c = \frac{\left[\pi \times \left(\frac{25 - 2 \cdot 0,8}{2}\right)^2 - 2 \cdot z_0 \cdot (25 - 2 \cdot 0,8)\right]}{2}$

$\cdot \frac{N_{pc} - 2 \cdot z_0 \cdot (d - 2 \cdot t) \cdot f_{cd}}{2} = 2 \cdot z_0 \cdot 2t \cdot f_{yd}$

$\cdot z_0 = \frac{N_{pl,c}}{2d \cdot f_{cd} + 4 \cdot t \cdot (2 f_{yd} - f_{cd})} = \frac{573,4 \text{ kN}}{2 \cdot 25 \cdot \frac{2,0}{1,5} + 4 \cdot 0,8 \left(2 \cdot 23,5 - \frac{2,0}{1,5}\right)}$

$\Rightarrow \boxed{z_0 = 2,69 \text{ cm}}$

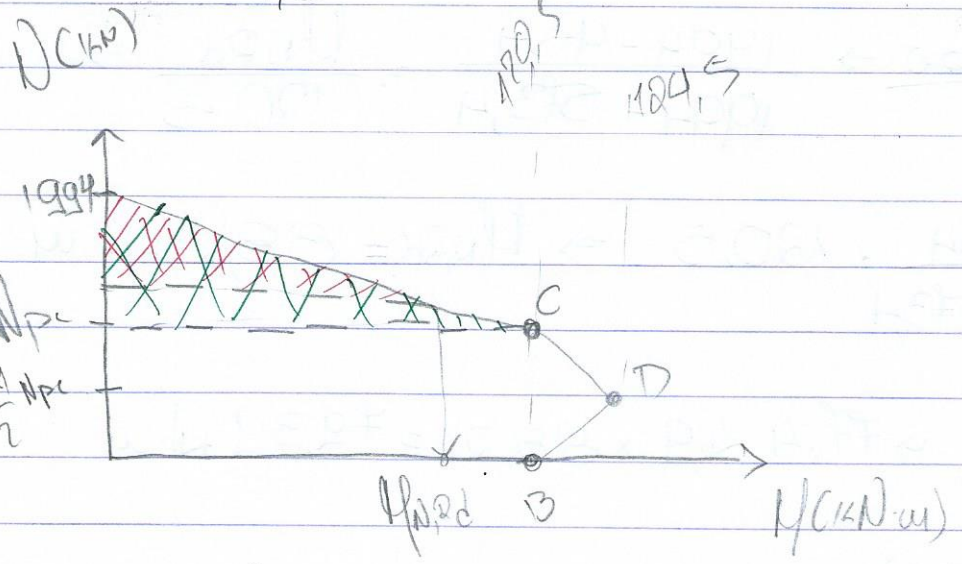
$\cdot W_{pl,a} = \frac{1}{2} \cdot W_{pl,a} - \frac{(d - 2 \cdot t) \cdot (2 \cdot z_0)^2}{4} \cdot \frac{1}{2} =$

$$= \frac{1}{2} \cdot 2136 - (25 - 2 \cdot 0{,}8) \cdot \frac{2{,}69^2}{2}$$

- $\bar{W}_{pl}^{(a)} = 983 \text{ cm}^3$

- $\bar{W}_{pl}^{(a)} = W_{pl}^{(a)} - 2 \cdot t \cdot \frac{(2 \cdot z_0)^2}{4} = 469 - 2 \cdot 0{,}8 \cdot \frac{(2 \cdot 2{,}69)^2}{4} = 457$

$$M_{pl,Rd} = 983 \cdot \frac{20}{1{,}5} + 457 \cdot 23{,}5 = 12050 \text{ kN} \cdot \text{cm} = 120{,}5 \text{ kN} \cdot \text{m}$$



Εντατικά Μεγέθη:

- $N_{Ed} = 954 \text{ kN}$.

- $M_{Ed}^{(I)} = 954 \cdot \frac{3{,}5}{300} + \frac{37{,}5 \cdot 3{,}5^3}{8} = 68{,}55 \text{ kN} \cdot \text{m}$

- $N_{cr}^{eff} = 8619 \text{ kN}$. $\frac{N_{Ed}}{N_{cr,eff}} = \frac{954}{2619} = 0{,}11 > 0{,}1$

$\bullet (EI)_{eff,II} = [21000 \cdot 4457 + 0,5 \cdot 2900 \cdot 14717] \cdot 0,4 =$

$= 1034\,42985.$

$\bullet N_{cr,eff,II} = \frac{\pi^2 \cdot 103442985}{350^2} = 8334$

$\bullet k = \frac{1}{1 - \frac{954}{8334}} = 1,129 \rightsquigarrow M_{Ed}^{II} = 68,55 \cdot 1,129 = 77,4^{kN}$

ομοια τρίγωνα, κοινό + Παράλληλο $\rightarrow \frac{1994-954}{1994-573,4} = \frac{M_{N,Rd}}{120,5} \Rightarrow$

$\Rightarrow M_{N,Rd} = \frac{1994-954}{1994-573,4} \cdot 120,5 \Rightarrow M_{N,Rd} = 88,21\,kN \cdot m$

$M_{Ed}^{(II)} < a_M \times M_{N,Rd} \Rightarrow 77,4 < 0,9 \times 88,21 = 79,39\,kN \cdot m$

↑ (0,4 ~ χάλυβας S235)