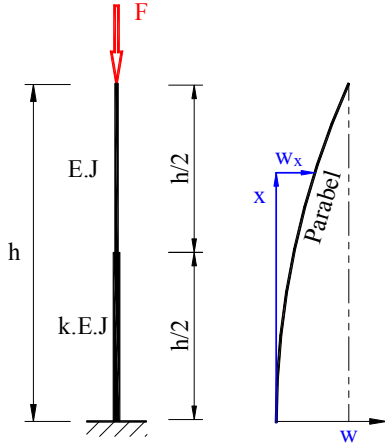


Zorlama: Yalnız aksel kuvvet

Bilinen değerler:



Malzeme := "S235"

$f_y := 235 \cdot \text{MPa}$

$E := 210000 \cdot \text{MPa}$

$\gamma_M := 1.1$

$h_S := 4 \cdot \text{m}$

Emniyetli akma mukavemeti

$f_{EM} := \frac{f_y}{\gamma_M}$

$f_{EM} = 213.6 \cdot \text{MPa}$

Kabul: Eğrinin şekli parabol

$F_x := 700 \cdot \text{kN}$

z eksenini değerleri daha zayıf olduğundan hesaplar z eksenine göre yapılır.

1. Kısım

$b_1 := 320 \cdot \text{mm}$

$h_1 := 320 \cdot \text{mm}$

$t := 10 \cdot \text{mm}$

$b_c := 10 \cdot \text{mm}$

$y_1 := 0.5 \cdot (b_1 + t) - b_c$

$y_1 = 155 \cdot \text{mm}$

$J_{z1} := 2 \cdot \frac{b_1^3 \cdot t}{12} + 2 \cdot \frac{t^3 \cdot h_1}{12} + 2 \cdot t \cdot h_1 \cdot y_1^2$

$J_{z1} = 208.4 \cdot 10^6 \cdot \text{mm}^4$

$W_{z1} := \frac{2 \cdot J_{z1}}{b_1}$

$W_{z1} = 1302.7 \cdot 10^3 \cdot \text{mm}^3$

$EJ_{z1} := E \cdot J_{z1}$

$EJ_{z1} = 43.8 \cdot \text{MN} \cdot \text{m}^2$

$A_{\text{tot}1} := 2 \cdot t \cdot (b_1 + h_1)$

$A_{\text{tot}1} = 12800 \cdot \text{mm}^2$

2. Kısım:

$k := 1.5$

$b_2 := k \cdot b_1$

$b_2 = 480 \cdot \text{mm}$

$h_2 := k \cdot h_1$

$h_2 = 480 \cdot \text{mm}$

$h_{2T} := h_2 + 2 \cdot t$

$h_{2T} = 500 \cdot \text{mm}$

$y_2 := 0.5 \cdot (b_2 + t) - b_c$

$y_2 = 235 \cdot \text{mm}$

$J_{z2} := 2 \cdot \frac{b_2^3 \cdot t}{12} + 2 \cdot \frac{t^3 \cdot h_2}{12} + 2 \cdot t \cdot h_2 \cdot y_2^2$

$J_{z2} = 714.6 \cdot 10^6 \cdot \text{mm}^4$

$W_{z2} := \frac{2 \cdot J_{z2}}{b_2}$

$W_{z2} = 2977.3 \cdot 10^3 \cdot \text{mm}^3$

$EJ_{z2} := E \cdot J_{z2}$

$EJ_{z2} = 150.1 \cdot \text{MN} \cdot \text{m}^2$

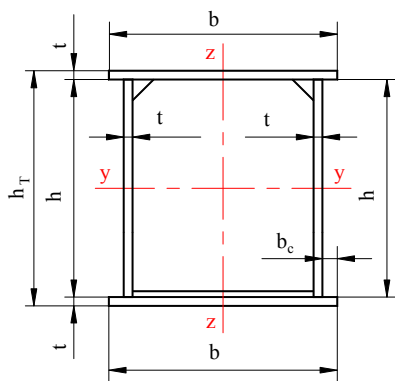
$k_{Jz} := \frac{J_{z2}}{J_{z1}}$

$k_{Jz} = 3.428$

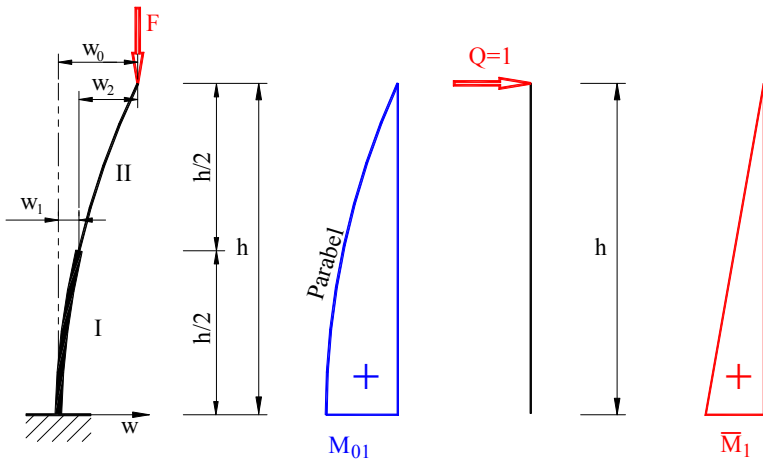
$A_{\text{tot}2} := 2 \cdot t \cdot (b_2 + h_2)$

$A_{\text{tot}2} = 19200 \cdot \text{mm}^2$

Resim 1



Resim 2

Çözüm:

$$M_{01} = F_x \cdot w_0$$

$$M_1 := 0.5 \cdot h_S$$

$$w_{01} = \int_0^{h_S/2} M_{01} \cdot M_1 \cdot \frac{1}{EJ_{z1}} dx$$

$$w_{02} = \int_0^{h_S/2} M_{01} \cdot M_1 \cdot \frac{1}{k \cdot EJ_{z1}} dx$$

$$w_0 = w_{01} + w_{02} = \frac{5}{12} \cdot M_{01} \cdot M_1 \cdot \frac{h_S}{2 \cdot EJ_{z1}} + \frac{5}{12} \cdot M_{01} \cdot M_1 \cdot \frac{h_S}{k \cdot 2 \cdot EJ_{z1}}$$

$$w_1 = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{12 \cdot 2k \cdot EJ} = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{48EJ} \quad w_2 = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{12 \cdot 2EJ} = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{24EJ}$$

$$w_0 = w_1 + w_2 = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{48EJ} + \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{24EJ} \quad w_0 = \frac{15 \cdot F_x \cdot w_0 \cdot h_S^2}{48EJ} \quad w_0 = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^2}{16EJ}$$

Kritik burkulma kuvveti

eğer $F_x = F_{kr}$ kabul edersek:

$$F_{kr} := \frac{16}{5} \cdot \frac{EJ_{z1}}{h_S^2}$$

$$F_{kr} = 8753.9 \text{ kN}$$

$$F_x = 700 \text{ kN}$$

Sonuç: Çubukta burkulma tehlikesi yoktur.

Mukavemet hesabı:

Eylemsizlik radyusu $i_{z1} := \sqrt{\frac{J_{z1}}{A_{tot1}}} \quad i_{z1} = 127.6 \text{ mm}$

$i_{z2} := \sqrt{\frac{J_{z2}}{A_{tot2}}} \quad i_{z2} = 192.9 \text{ mm}$

Euler burkulma boyu $L_{B1} := \sqrt{\frac{EJ_{z1} \cdot \pi^2}{F_{kr}}} \quad L_{B1} = 7.025 \text{ m}$

$L_{B2} := \sqrt{\frac{k \cdot EJ_{z1} \cdot \pi^2}{F_{kr}}} \quad L_{B2} = 8.604 \text{ m}$

Akma narinliği $\lambda_E := \pi \cdot \sqrt{\frac{E}{f_y}} \quad \lambda_E = 93.9$

Narinlik	$\lambda_{z1} := \frac{L_{B1}}{i_{z1}}$	$\lambda_{z1} = 55.1$
	$\lambda_{z2} := \frac{L_{B2}}{i_{z2}}$	$\lambda_{z2} = 44.6$
Bağıntılı narinlik	$\lambda_{Bz1} := \frac{\lambda_{z1}}{\lambda_E}$	$\lambda_{Bz1} = 0.586$
	$\lambda_{Bz2} := \frac{\lambda_{z2}}{\lambda_E}$	$\lambda_{Bz2} = 0.475$
Merkez noktası mesafesi	$k_{el1} := \frac{W_{z1}}{A_{tot1}}$	$k_{el1} = 101.8 \cdot \text{mm}$
	$k_{el2} := \frac{W_{z2}}{A_{tot2}}$	$k_{el2} = 155.1 \cdot \text{mm}$
Akma kuvveti	$F_{pl1} := A_{tot1} \cdot f_{EM}$	$F_{pl1} = 2734.5 \cdot \text{kN}$
	$F_{pl2} := A_{tot2} \cdot f_{EM}$	$F_{pl2} = 4101.8 \cdot \text{kN}$
Burkulma parametresi	$\alpha_B := 0.34$ Kaynaklı kutular her ekseninde.	
Max burkulma sehimi	$w_{01max} := k_{el1} \cdot \alpha_B \cdot (\lambda_{Bz1} - 0.2)$	$w_{01max} = 13.4 \cdot \text{mm}$
	$w_{02max} := k_{el2} \cdot \alpha_B \cdot (\lambda_{Bz2} - 0.2)$	$w_{02max} = 14.5 \cdot \text{mm}$
Burkulma yardımcı faktörü	$\varphi_{Bz1} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{Bz1} - 0.2) + \lambda_{Bz1}^2 \right]$	$\varphi_{Bz1} = 0.74$
	$\varphi_{Bz2} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{Bz2} - 0.2) + \lambda_{Bz2}^2 \right]$	$\varphi_{Bz2} = 0.66$
Azaltma faktörü	$\chi_{Bz1} := \frac{1}{\varphi_{Bz1} + \sqrt{\varphi_{Bz1}^2 - \lambda_{Bz1}^2}}$	$\chi_{Bz1} = 0.844$
	$\chi_{Bz2} := \frac{1}{\varphi_{Bz2} + \sqrt{\varphi_{Bz2}^2 - \lambda_{Bz2}^2}}$	$\chi_{Bz2} = 0.895$
Kuvvetin mukavemet emniyeti	$S_{Fz1} := \frac{F_x}{\chi_{Bz1} \cdot F_{pl1}}$	$S_{Fz1} = 0.303$
	$S_{Fz2} := \frac{F_x}{\chi_{Bz2} \cdot F_{pl2}}$	$S_{Fz2} = 0.191$
<i>Burkulma sehimi momenti:</i>		
	$M_{plz1} := W_{z1} \cdot f_{EM}$	$M_{plz1} = 278.3 \cdot \text{kN} \cdot \text{m}$
	$M_{plz2} := W_{z2} \cdot f_{EM}$	$M_{plz2} = 636.1 \cdot \text{kN} \cdot \text{m}$

$$M_{bvor1} := F_x \cdot w_{01max}$$

$$M_{bvor1} = 9.4 \cdot \text{kN} \cdot \text{m}$$

$$M_{bvor2} := F_x \cdot w_{02max}$$

$$M_{bvor2} = 10.1 \cdot \text{kN} \cdot \text{m}$$

$$M_{01} := F_x \cdot w_{01max}$$

$$M_{01} = 9.4 \cdot \text{kN} \cdot \text{m}$$

$$M_{02} := F_x \cdot w_{02max}$$

$$M_{02} = 10.1 \cdot \text{kN} \cdot \text{m}$$

$$\Delta M < 1$$

$$\Delta M1 := \frac{M_{01}}{M_{bvor1}}$$

$$\Delta M1 = 1.000$$

$$\Delta M2 := \frac{M_{02}}{M_{bvor2}}$$

$$\Delta M2 = 1.000$$

$$\beta_{mz1} := 0.66 + 0.44 \cdot \Delta M1$$

$$\beta_{mz1} = 1.10$$

$$\beta_{mz2} := 0.66 + 0.44 \cdot \Delta M2$$

$$\beta_{mz2} = 1.10$$

$$S_{Mz1} := \frac{\beta_{mz1} \cdot M_{bvor1}}{M_{plz1}}$$

$$S_{Mz1} = 0.037$$

$$S_{Mz2} := \frac{\beta_{mz2} \cdot M_{bvor2}}{M_{plz2}}$$

$$S_{Mz2} = 0.018$$

$$\Delta n := 0.1$$

$$S_1 := S_{Fz1} + S_{Mz1} + \Delta n$$

$$S_1 = 0.440$$

$$S_2 := S_{Fz2} + S_{Mz2} + \Delta n$$

$$S_2 = 0.308$$

Sonuç: S_1 ve S_2 değerleri 1 den küçük olduğundan konstrüksiyon fonksiyonunu yapar.

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