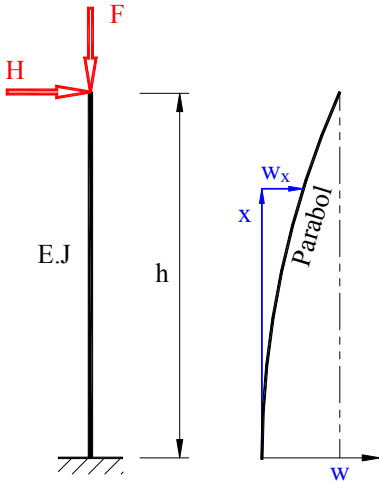


Zorlama: Aksel kuvvet ve yatay tek kuvvet

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

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

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

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

Kabul: Eğrinin şekli parabol

$H_y := 60 \cdot \text{kN}$

Yatay kuvvet y yönünde olduğundan hesaplar z eksenine göre yapılır.

$b := 480 \cdot \text{mm}$

$h := 480 \cdot \text{mm}$

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

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

$y := 0.5 \cdot (b + t) - b_c$

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

$J_z := 2 \cdot \frac{b^3 \cdot t}{12} + 2 \cdot \frac{t^3 \cdot h}{12} + 2 \cdot t \cdot h \cdot y^2$

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

$W_z := \frac{2 \cdot J_z}{b}$

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

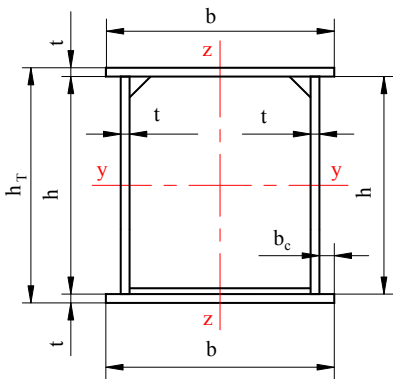
$EJ_z := E \cdot J_z$

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

$A_0 := 2 \cdot t \cdot (b + h)$

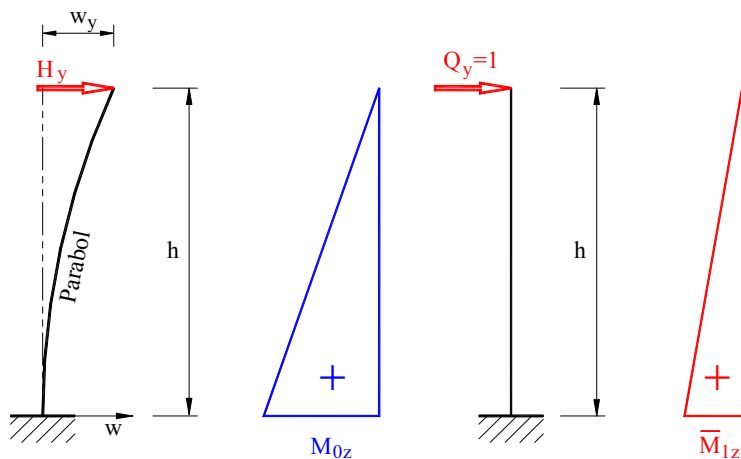
$A_0 = 19200 \cdot \text{mm}^2$

Resim 1



Resim 2

Çözüm: 1. dereceli hesaplama kuralına göre



$M_{0z} := H_y \cdot h_S$

$M_{1z} := h_S$

$w_{0y} = \int_0^{h_S} M_{0z} \cdot M_{1z} \cdot \frac{1}{EJ_z} dx$

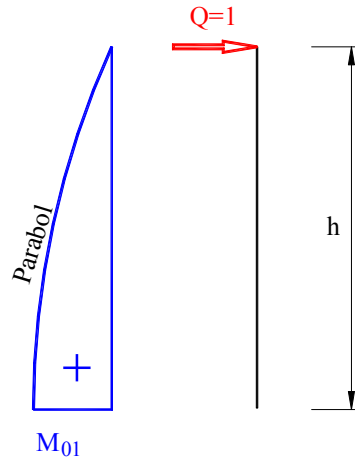
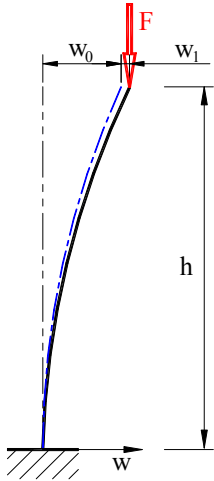
$w_{0y} = \frac{1}{3} \cdot M_{0z} \cdot M_{1z} \cdot \frac{h_S}{EJ_z}$

$w_{0y} = \frac{1}{3} \cdot H_y \cdot h_S \cdot h_S \cdot \frac{h_S}{EJ_z}$

$w_{0y} := \frac{H_y \cdot h_S^3}{3 \cdot EJ_z}$

$w_{0y} = 8.530 \cdot \text{mm}$

Vianelloya göre



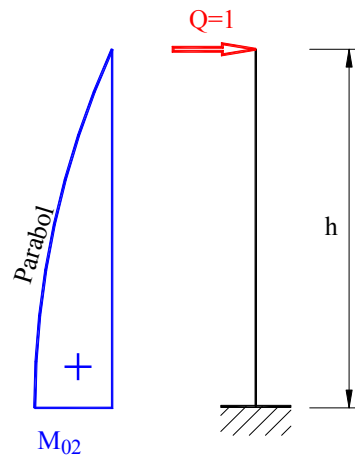
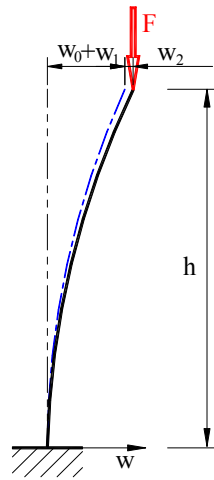
$$M_{01} := F_x \cdot w_{0y}$$

$$w_1 = \int_0^{h_S} M_{01} \cdot M_1 \cdot \frac{1}{EJ_z} dx$$

$$w_1 = \frac{5}{12} \cdot M_{01} \cdot M_1 \cdot \frac{h_S}{EJ_z}$$

$$w_1 := \frac{5 \cdot F_x \cdot w_{0y} \cdot h_S^2}{12 \cdot EJ_z}$$

$$w_1 = 0.265 \cdot \text{mm}$$



$$M_{02} := F_x \cdot w_1$$

$$w_2 = \int_0^{h_S} M_{02} \cdot M_1 \cdot \frac{1}{EJ_z} dx$$

$$w_2 = \frac{5}{12} \cdot M_{02} \cdot M_1 \cdot \frac{h_S}{EJ_z}$$

$$w_2 := \frac{5 \cdot F_x \cdot w_1 \cdot h_S^2}{12 \cdot EJ_z}$$

$$w_2 = 0.008 \cdot \text{mm}$$

Böylece devam edersek

$$w_3 := \frac{5 \cdot F_x \cdot w_2 \cdot h_S^2}{12 \cdot EJ_z}$$

$$w_3 = 0.000 \cdot \text{mm}$$

Toplam sehım

$$w_{\text{Tot}} := w_{0y} + w_1 + w_2 + w_3$$

$$w_{\text{Tot}} = 8.804 \cdot \text{mm}$$

Toplam Moment

$$M_{\text{Tot}} := H_y \cdot h_S + F_x \cdot w_{\text{Tot}}$$

$$M_{\text{Tot}} = 246.16 \cdot \text{kN} \cdot \text{m}$$

Kritik burkulma kuvveti

$$w_1 = \frac{5 \cdot F_x \cdot w_{0y} \cdot h_S^3}{12 \cdot EJ_z}$$

eğer $F_x = F_{kr}$ ve $w_{0y} = w_1$

veya

$$\alpha_F = \frac{w_1}{w_0} = 1$$

$$1 = \frac{5 \cdot F_{kr} \cdot h_S^3}{12 \cdot EJ_z}$$

$$F_{kr} := \frac{12}{5} \cdot \frac{EJ_z}{h_S^2}$$

$$F_{kr} = 22508.6 \cdot \text{kN}$$

Sonuç: Çubukta burkulma tehlikesi yoktur.**Mukavemet hesabı:**

$$i_z := \sqrt{\frac{J_z}{A_0}} \quad i_z = 192.9 \cdot \text{mm}$$

$$L_B := \sqrt{\frac{E \cdot J_z \cdot \pi^2}{F_{kr}}} \quad L_B = 8.112 \text{ m}$$

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

$$\lambda_z := \frac{L_B}{i_z} \quad \lambda_z = 42$$

$$\lambda_{Bz} := \frac{\lambda_z}{\lambda_E} \quad \lambda_{Bz} = 0.448$$

$$F_{pl} := A_0 \cdot f_{EM} \quad F_{pl} = 4101.8 \cdot \text{kN}$$

$$\alpha_B := 0.34 \quad \text{Kaynaklı kutular her ekseninde.}$$

$$\varphi_{Kz} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{Bz} - 0.2) + \lambda_{Bz}^2 \right] \quad \varphi_{Kz} = 0.64$$

$$\chi_{Kz} := \frac{1}{\varphi_{Kz} + \sqrt{\varphi_{Kz}^2 - \lambda_{Bz}^2}} \quad \chi_{Kz} = 0.907$$

$$S_{Fz} := \frac{F_x}{\chi_{Kz} \cdot F_{pl}} \quad S_{Fz} = 0.188$$

Burkulma sehimi momenti:

$$M_{plz} := W_z \cdot f_{EM} \quad M_{plz} = 636.1 \cdot \text{kN} \cdot \text{m}$$

$$M_{bvor} := H_y \cdot h_S + F_x \cdot W_{Tot} \quad M_{bvor} = 246.2 \cdot \text{kN} \cdot \text{m}$$

$$M_0 := F_x \cdot W_{Tot} \quad M_0 = 6.2 \cdot \text{kN} \cdot \text{m}$$

$$\Delta M < 1 \quad \Delta M := \frac{M_0}{M_{bvor}} \quad \Delta M = 0.025$$

$$\beta_{mz} := 0.66 + 0.44 \cdot \Delta M \quad \beta_{mz} = 0.67$$

$$S_{Mz} := \frac{\beta_{mz} \cdot M_{bvor}}{M_{plz}} \quad S_{Mz} = 0.260$$

$$S_{Totz} := S_{Fz} + S_{Mz} \quad S_{Totz} = 0.448$$

Sonuç: S_{Totz} değeri 1 den küçük olduğundan konstrüksiyon fonksiyonunu yapar.

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