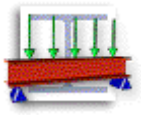
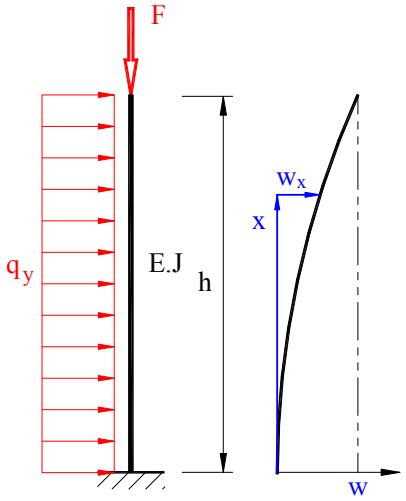
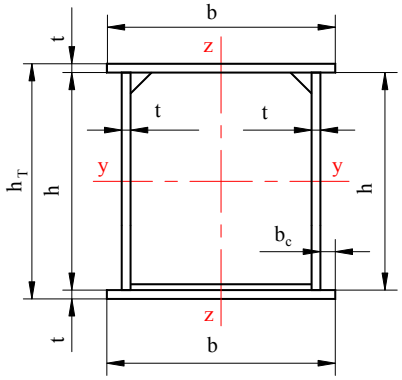


Zorlama: Eksenel kuvvet ve yatay yayılı yük

Bilinen değerler:



Resim 1



Malzeme := "S235"

$f_y := 235 \cdot MPa$ $E := 210000 \cdot MPa$

$\gamma_M := 1.1$ $h_S := 4 \cdot m$

Emniyetli akma mukavemeti $f_{EM} := \frac{f_y}{\gamma_M}$ $f_{EM} = 213.6 \cdot MPa$

$F_x := 700 \cdot kN$

Kabul: Eğrinin şekli parabol $q_y := 30 \cdot kN \cdot m^{-1}$

Yayılı yatay yük y yönünde olduğundan hesaplar z eksenine göre yapılır.

$b := 480 \cdot mm$ $h := 480 \cdot mm$ $t := 10 \cdot mm$ $b_ç := 10 \cdot mm$

$y := 0.5 \cdot (b + t) - b_ç$ $y = 235 \cdot mm$

$J_z := 2 \cdot \frac{b^3 \cdot t}{12} + 2 \cdot \frac{t^3 \cdot h}{12} + 2 \cdot t \cdot h \cdot y^2$ $J_z = 714.6 \cdot 10^6 \cdot mm^4$

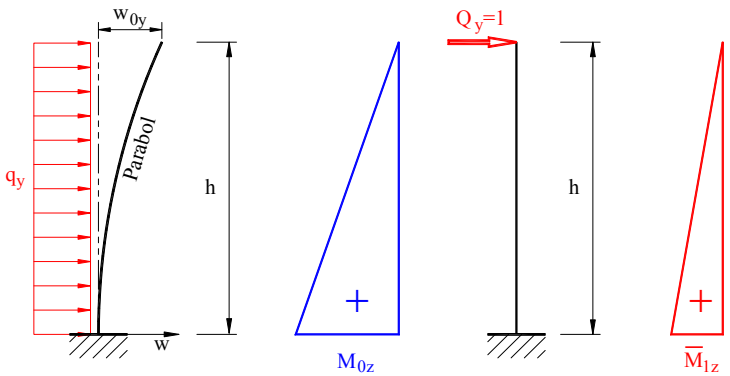
$W_z := \frac{2 \cdot J_z}{b}$ $W_z = 2977.3 \cdot 10^3 \cdot mm^3$

$EJ_z := E \cdot J_z$ $EJ_z = 150.1 \cdot MN \cdot m^2$

$A_0 := 2 \cdot t \cdot (b + h)$ $A_0 = 19200 \cdot mm^2$

Resim 2

Çözüm: 1. dereceli hesaplama kuralına göre



$M_{00} := 0.5 \cdot q_y \cdot h_S^2$ $M_1 := h_S$

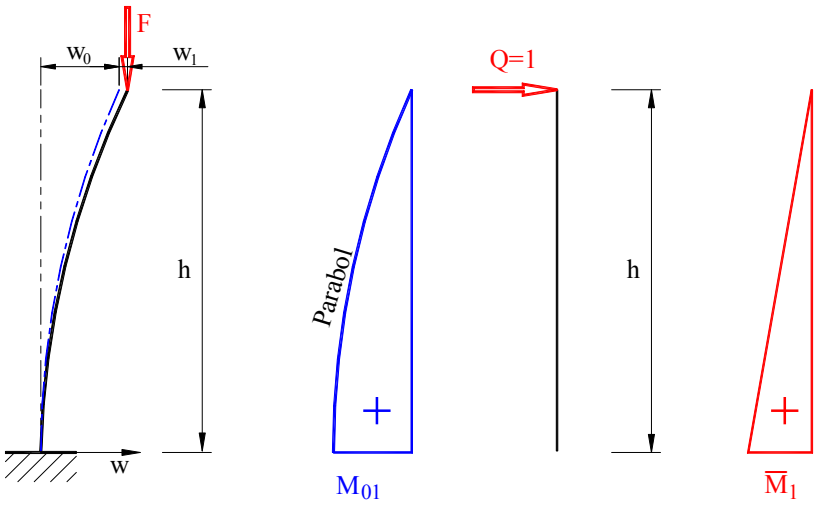
$$w_{0y} = \int_0^{h_S} M_{0z} \cdot M_{1z} \cdot \frac{1}{EJ_z} \, dx$$

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

$$w_{0y} = \frac{1}{3} \cdot \frac{q_y \cdot h_S^2}{2} \cdot h_S \cdot \frac{h_S}{EJ_z}$$

$w_{0y} := \frac{q_y \cdot h_S^4}{6 \cdot EJ_z}$ $w_{0y} = 8.530 \cdot mm$

Vianelloya göre çözüm:



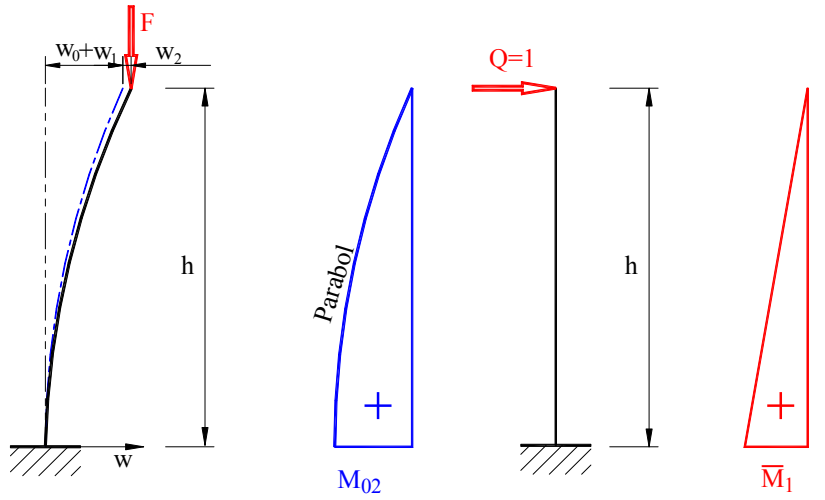
$M_{01z} := F_x \cdot w_{0y}$

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

$$w_{1y} = \frac{5}{12} \cdot M_{01z} \cdot M_{1z} \cdot \frac{h_S}{EJ_z}$$

$$w_{1y} := \frac{5 \cdot F_x \cdot w_{0y} \cdot h_S^{\,2}}{12 \cdot EJ_z}$$

$w_{1y} = 0.265 \cdot mm$



$M_{02z} := F_x \cdot w_{1y}$

$$w_{2y} = \int_0^{h_S} M_{02z} \cdot M_{1z} \cdot \frac{1}{EJ_z}\, dx$$

$$w_{2y} = \frac{5}{12} \cdot M_{02z} \cdot M_{1z} \cdot \frac{h_S}{EJ_z}$$

$$w_{2y} := \frac{5 \cdot F_x \cdot w_{1y} \cdot h_S^{\,2}}{12 \cdot EJ_z}$$

$w_{2y} = 0.008 \cdot mm$

Böylece devam edersek $w_{3y} := \frac{5 \cdot F_x \cdot w_{2y} \cdot h_S^{\,2}}{12 \cdot EJ_z}$ $w_{3y} = 0.000 \cdot mm$

Toplam sehim $w_y := w_{0y} + w_{1y} + w_{2y} + w_{3y}$ $w_y = 8.804 \cdot mm$

Toplam Moment $M_{Tot} := 0.5 \cdot q_y \cdot h_S^{\,2} + F_x \cdot w_y$ $M_{Tot} = 246.16 \cdot kN \cdot m$

Kritik burkulma kuvveti $w_1 = \frac{5 \cdot F_x \cdot w_0 \cdot h_S^{\,3}}{12 \cdot EJ}$ eğer $F_x = Fk_r$ ve $w_0 = w_1$ veya $\alpha_F = \frac{w_1}{w_0} = 1$

$$1 = \frac{5 \cdot F_{kr} \cdot h_S^{\,3}}{12 \cdot EJ} \qquad F_{kr} := \frac{12}{5} \cdot \frac{EJ_z}{h_S^{\,2}}$$

$F_{kr} = 22508.6 \cdot kN$

$F_x = 700 \cdot kN$

Sonuç: Çubukta burkulma tehlikesi yoktur.

Mukavemet hesabı:

Eylemsizlik radyusu $i_z := \sqrt{\frac{J_z}{A_0}}$ $i_z = 192.9 \cdot mm$

Euler burkulma boyu $L_B := \sqrt{\frac{E \cdot J_z \cdot \pi^2}{F_{kr}}}$ $L_B = 8.112\,m$

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

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

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

Akma kuvveti $F_{pl} := A_0 \cdot f_{EM}$ $F_{pl} = 4101.8 \cdot kN$

Burkulma parametresi $\alpha_B := 0.34$ Kaynaklı kutular her eksende.

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

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

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

Burkulma sehimi momenti:

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

$M_{bvor} := 0.5 \cdot q_y \cdot h_S^2 + F_x \cdot w_y$ $M_{bvor} = 246.2 \cdot kN \cdot m$

$M_0 := F_x \cdot w_y$ $M_0 = 6.2 \cdot kN \cdot m$

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

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

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

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

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

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