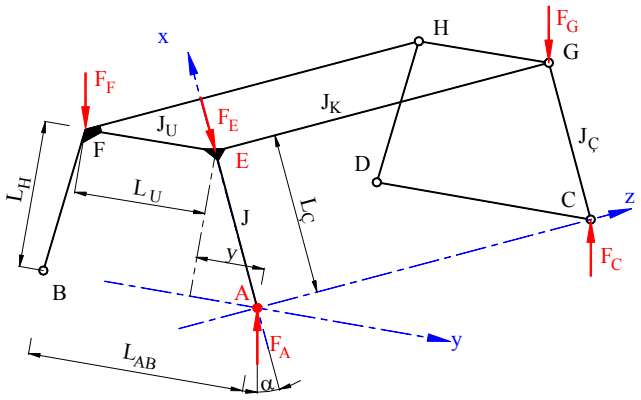
İki düzlemdeki çerçevelerin sabit kesitli ortak çubuğu.

Sistem ve bilinen değerler:



Resim 1

Malzeme := "S235" $f_y := 235 \cdot MPa$

$\gamma_M := 1.1$

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

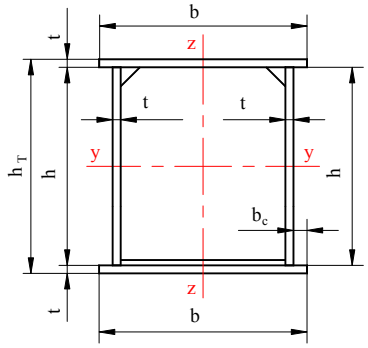
$f_{EM} = 213.6 \cdot MPa$

Elastiklik modülü $E := 210000 \cdot MPa$

Kiriş $L_K := 18 \cdot m$ $J_{yK} := 7447 \cdot 10^6 \cdot mm^4$

Uç bağlantı $L_U := 2 \cdot m$ $J_{yU} := 703 \cdot 10^6 \cdot mm^4$

Kabul: Eğrinin şekli parabol $L_H := 8 \cdot m$



Resim 2

$\alpha := 10 \cdot deg$ $F_A := 400 \cdot kN$ $F_G := 0.4 \cdot F_A$ $F_F := 0.9 \cdot F_A$

$b := 600 \cdot mm$ $h := 580 \cdot mm$ $t := 10 \cdot mm$ $b_ç := 10 \cdot mm$

$h_T := h + 2 \cdot t$ $h_T = 600.0 \cdot mm$ $z := 0.5 \cdot (h + t)$ $z = 295 \cdot mm$

$J_y := 2 \cdot \frac{b \cdot t^3}{12} + 2 \cdot \frac{t \cdot h^3}{12} + 2 \cdot t \cdot b \cdot z^2$ $J_y = 1369.6 \cdot 10^6 \cdot mm^4$

$W_y := \frac{2 \cdot J_y}{h_T}$ $W_y = 4565.3 \cdot 10^3 \cdot mm^3$

$A_0 := 2 \cdot t \cdot (b + h)$ $A_0 = 23600 \cdot mm^2$

$y := 0.5 \cdot (b + t) - b_ç$ $y = 295 \cdot mm$ $J_z := 2 \cdot \frac{b^3 \cdot t}{12} + 2 \cdot \frac{t^3 \cdot h}{12} + 2 \cdot t \cdot h \cdot y^2$ $J_z = 1369.6 \cdot 10^6 \cdot mm^4$

$W_z := \frac{2 \cdot J_z}{b}$ $W_z = 4565.3 \cdot 10^3 \cdot mm^3$

$k_{xz} := \frac{L_K^2}{J_{yK}}$ $k_{xz} = 43507 \frac{1}{m^2}$ $k_{xy} := \frac{L_U^2}{J_{yU}}$ $k_{xy} = 5690 \frac{1}{m^2}$

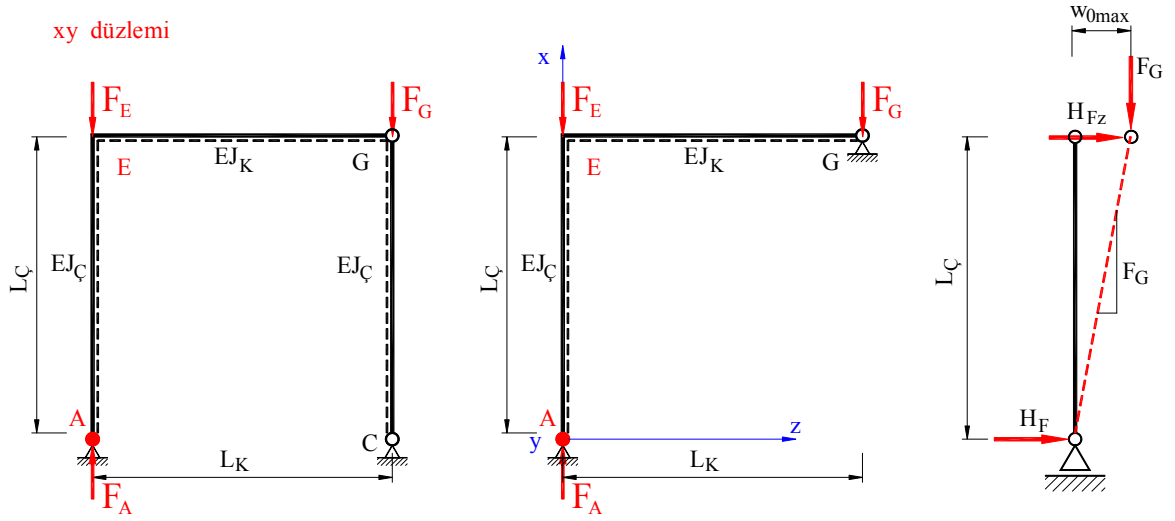
$k_{xz} > k_{xy}$ olduğundan burkulma hesabı xz kesitinde yapılacaktır.

$F_E := F_A \cdot \cos(\alpha)^{-1}$ $F_E = 406.2 \cdot kN$

$L_Ç := L_H \cdot \cos(\alpha)^{-1}$ $L_Ç = 8.1\ m$

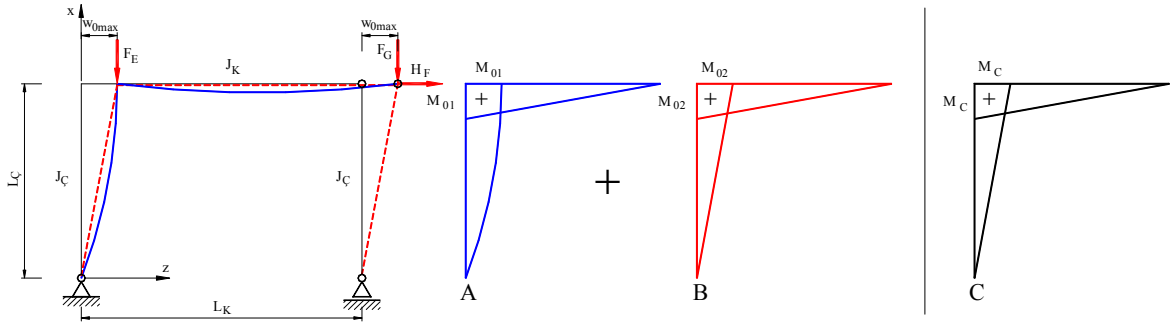
Vianelloya göre çözüm:

Resim 3



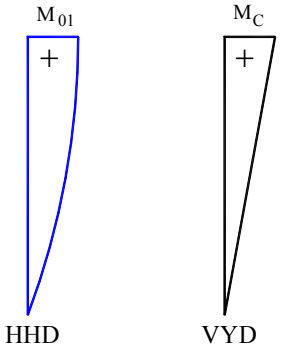
xz kesiti

Resim 4



$$F_E \cdot w_{0max} = H_{Fz} \cdot L_Ç \qquad H_{Fz} = \frac{F_E \cdot w_{0max}}{L_Ç}$$

AE çubuğunda F_E etkili 1. sehim



$$w_{11} = \int_0^{L_Ç} \frac{M_{01} \cdot M_C}{E \cdot J_y} dx$$

Momentler:

$$M_C = L_Ç$$

$$M_{01} = F_E \cdot w_{0max}$$

$E \cdot J_y$ = sabit

İntegral tablosundan

Parabol + Üçgen

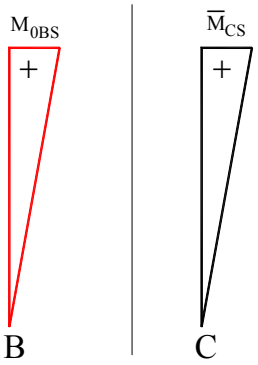
$$w_{11} = \frac{5}{12} \cdot \frac{F_E \cdot w_{0max} \cdot L_Ç^2}{E \cdot J_y}$$

$F_E \cdot w_{0max}$ = sabit

$$w_{11} := \frac{5}{12} \cdot \frac{L_Ç^2}{E \cdot J_y} \qquad w_{11} = 95.6 \times 10^{-9} \frac{1}{N}$$

Resim 5

AE çubuğunda H_F etkili 2. sehim



$$w_{12} = \int_0^{L_Ç} \frac{M_{02}\cdot M_C}{E\cdot J_y}\,dx$$

Momentler:

$M_C = L_Ç$

$M_{02} = H_F\cdot L_Ç = F_E\cdot w_{0max}$

$E\cdot J_y$ = sabit

İntegral tablosundan

Üçgen + Üçgen

$$w_{12} = \frac{1}{3}\cdot\frac{F_E\cdot w_{0max}\cdot L_Ç^{2}}{E\cdot J_y}$$

$F_E\cdot w_{0max}$ = sabit

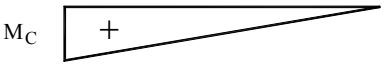
$$w_{12} := \frac{1}{3}\cdot\frac{L_Ç^{2}}{E\cdot J_y} \qquad w_{12} = 76.5\times 10^{-9}\cdot\frac{1}{N}$$

Resim 6

EG Kirişinde F_E etkili 3. sehim

Resim 7

HHD



VYD

$M_{01} = F_E\cdot w_{0max}$

$M_C = L_K$

$$w_{13} = \int_0^{L_K} \frac{M_{01}\cdot M_C}{E\cdot J_{yK}}\,dx$$

$E\cdot J_{yK}$ = sabit

İntegral tablosundan

Üçgen + Üçgen

$$w_{13} = \frac{1}{3}\cdot\frac{F_E\cdot w_{0max}\cdot L_K^{2}}{E\cdot J_{yK}}$$

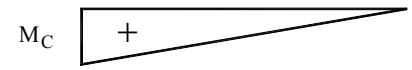
$F_E\cdot w_{0max}$ = sabit

$$w_{13} := \frac{1}{3}\cdot\frac{L_K^{2}}{E\cdot J_{yK}} \qquad w_{13} = 0.00000\cdot\frac{1}{N}$$

EG Kirişinde H_F etkili 4. sehim

Resim 8

HHD



VYD

$M_{02} = F_E\cdot w_{0max}$

$M_C = L_K$

$$w_{14} = \int_0^{L_K} \frac{M_{02}\cdot M_C}{E\cdot J_{yK}}\,dx$$

$E\cdot J_{yK}$ = sabit

İntegral tablosundan

Üçgen + Üçgen

$$w_{14} = \frac{1}{3}\cdot\frac{F_E\cdot w_{0max}\cdot L_K^{2}}{E\cdot J_{yK}}$$

$F_E\cdot w_{0max}$ = sabit

$$w_{14} := \frac{1}{3}\cdot\frac{L_K^{2}}{E\cdot J_{yK}} \qquad w_{14} = 0.00000\,\frac{1}{N}$$

$w_{01} = F_E\cdot w_{0max}\cdot(w_{11} + w_{12} + w_{13} + w_{14})$ $\quad F_E = F_{kr}$ $\quad w_{01} = w_{0max}$

kabul edersek

$$F_{kr} := \frac{1}{w_{11} + w_{12} + w_{13} + w_{14}}$$

$F_{kr} = 3224\cdot kN$

$F_A = 400\cdot kN$

Teori dosyasındaki sonuçlara göre

$$F_{wF} := \frac{12\cdot E}{\left(\frac{9\cdot L_Ç^{2}}{J_y} + \frac{8\cdot L_K^{2}}{J_{yK}}\right)}$$

$F_{wF} = 3223.7\cdot kN$

Sonuç: Çubukta burkulma tehlikesi yoktur.

Mukavemet hesabı:

Dayanak kuvveti A dan

Eylemsizlik radyusu

$$i_y := \sqrt{\frac{J_y}{A_0}} \qquad i_y = 240.9\cdot mm$$

Euler e göre hesaplanan burkulma boyu

$$L_{By} := \sqrt{\frac{E\cdot J_y\cdot \pi^2}{F_{kr}}} \qquad L_{By} = 29.674\,m$$

Narinlik

$$\lambda_{Ky} := \frac{L_{By}}{i_y} \qquad \lambda_{Ky} = 123.2$$

Akma narinliği

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

Bağıntılı narinlik

$$\lambda_{By} := \frac{\lambda_{Ky}}{\lambda_E} \qquad \lambda_{By} = 1.312$$

$$k_{ely} := \frac{W_y}{A_0} \qquad k_{ely} = 193.4\cdot mm$$

Akma kuvveti

$$F_{pl} := A_0\cdot f_{EM} \qquad F_{pl} = 5041.8\cdot kN$$

Burkulma parametresi

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

$$w_{0maxz} := k_{ely}\cdot\alpha_B\cdot(\lambda_{By} - 0.2) \qquad w_{0maxz} = 73.1\cdot mm$$

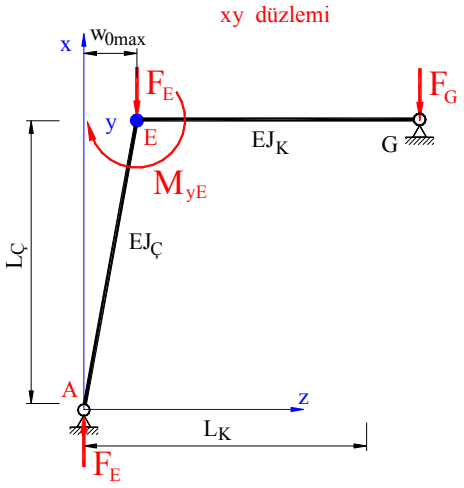
$$\varphi_{By} := 0.5\cdot\left[1 + \alpha_B\cdot(\lambda_{By} - 0.2) + \lambda_{By}^2\right] \qquad \varphi_{By} = 1.55$$

Azaltma faktörü

$$\chi_{By} := \frac{1}{\varphi_{By} + \sqrt{\varphi_{By}^2 - \lambda_{By}^2}} \qquad \chi_{By} = 0.421$$

$$S_{Fy} := \frac{F_E}{\chi_{By}\cdot F_{pl}} \qquad S_{Fy} = 0.191$$

Eğilme momenti M_y



Resim 10

Plastikliğin
en küçük momenti

$M_{ply} := W_y \cdot f_{EM}$ $\quad M_{ply} = 975.3 \cdot kN \cdot m$

$M_{0y} := 0 \cdot kN \cdot m$

$M_{Ey} := F_E \cdot w_{0maxz}$ $\quad M_{Ey} = 29.7 \cdot kN \cdot m$

$-1 \le \psi_y \le 1$ $\quad \psi_y := \dfrac{M_{0y}}{M_{Ey}}$ $\quad \psi_y = 0.000$

$\beta_{My} := 1.8 - 0.7 \cdot \psi_y$ $\quad \beta_{My} = 1.8$

$\alpha_{pl} \ge 1$ $\quad \alpha_{ply} := \dfrac{M_{ply}}{M_{Ey}}$ $\quad \alpha_{ply} = 32.8$

$a_y \le 0.8$ $\quad a_{yx} := \lambda_{By} \cdot (2 \cdot \beta_{My} - 4) + (\alpha_{ply} - 1)$ $\quad a_{yx} = 31.3$

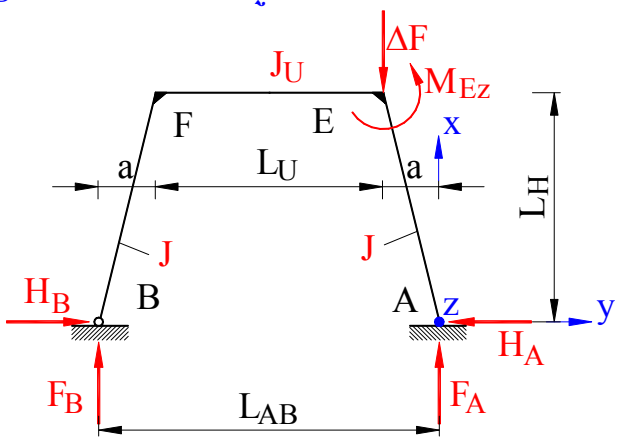
$a_y := \begin{cases} a_{yx} & \text{if } a_{yx} \le 0.8 \\ 0.8 & \text{otherwise} \end{cases}$ $\quad a_y = 0.8$

$k_y \le 1,5$ $\quad k_{yx} := 1 - \dfrac{F_E}{\chi_{By} \cdot F_{pl}} \cdot a_y$ $\quad k_{yx} = 0.847$

$k_y := \begin{cases} k_{yx} & \text{if } k_{yx} \le 1.5 \\ 1.5 & \text{otherwise} \end{cases}$ $\quad k_y = 0.847$

$S_{My} := \dfrac{M_{Ey}}{M_{ply}} \cdot k_y$ $\quad S_{My} = 0.026$

Eğilme momenti M_z



Resim 9

$\Delta F := F_A - F_F$ $\quad \Delta F = 40.0 \cdot kN$

$a := L_H \cdot \sin(\alpha)$ $\quad a = 1.4\,m$

$L_{AB} := L_U + 2 \cdot a$ $\quad L_{AB} = 4.8\,m$

$M_{Ez} := F_A \cdot a - 0.5 \cdot \Delta F \cdot a \cdot \dfrac{L_U}{L_{AB}}$

$M_{Ez} = 544.0 \cdot kN \cdot m$

Eylemsizlik radyusu $\quad i_z := \sqrt{\dfrac{J_z}{A_0}}$ $\quad i_z = 240.9 \cdot mm$

Euler e göre hesaplanan
burkulma boyu $\quad L_{Bz} := \sqrt{\dfrac{E \cdot J_z \cdot \pi^2}{F_{kr}}}$ $\quad L_{Bz} = 29.674\,m$

Narinlik

$$\lambda_{Kz} := \frac{L_{Bz}}{i_z} \qquad \lambda_{Kz} = 123.2$$

Bağıntılı narinlik

$$\lambda_{Bz} := \frac{\lambda_{Kz}}{\lambda_E} \qquad \lambda_{Bz} = 1.312$$

$$k_{elz} := \frac{W_z}{A_0} \qquad k_{elz} = 193.4 \cdot mm$$

$$w_{0maxy} := k_{elz} \cdot \alpha_B \cdot \left(\lambda_{Bz} - 0.2\right) \qquad w_{0maxy} = 73.1 \cdot mm$$

$$\varphi_{Bz} := 0.5 \cdot \left[1 + \alpha_B \cdot \left(\lambda_{Bz} - 0.2\right) + \lambda_{Bz}^{\,2}\right] \qquad \varphi_{Bz} = 1.55$$

Azaltma faktörü

$$\chi_{Bz} := \frac{1}{\varphi_{Bz} + \sqrt{\varphi_{Bz}^{\,2} - \lambda_{Bz}^{\,2}}} \qquad \chi_{Bz} = 0.421$$

$$S_{Fz} := \frac{F_E}{\chi_{Bz} \cdot F_{pl}} \qquad S_{Fz} = 0.191$$

Plastikliğin en küçük momenti

$$M_{plz} := W_z \cdot f_{EM} \qquad M_{plz} = 975.3 \cdot kN \cdot m$$

$$M_{0z} := 0 \cdot kN \cdot m$$

$-1 \le \psi_z \le 1$

$$\psi_z := \frac{M_{0z}}{M_{Ez}} \qquad \psi_z = 0.000$$

$$\beta_{Mz} := 1.8 - 0.7 \cdot \psi_z \qquad \beta_{Mz} = 1.8$$

$\alpha_{pl} > 1$

$$\alpha_{plz} := \frac{M_{plz}}{M_{Ez}} \qquad \alpha_{plz} = 1.8$$

$a_z \le 0.8$

$$a_{zx} := \lambda_{Bz} \cdot \left(2 \cdot \beta_{Mz} - 4\right) + \left(\alpha_{plz} - 1\right)$$

$$a_z := \begin{cases} a_{zx} & \text{if } a_{zx} \le 0.8 \\ 0.8 & \text{otherwise} \end{cases} \qquad a_z = 0.268$$

$k_z \le 1,5$

$$k_{zx} := 1 - \frac{F_E}{\chi_{Bz} \cdot F_{pl}} \cdot a_z$$

$$k_z := \begin{cases} k_{zx} & \text{if } k_{zx} \le 1.5 \\ 1.5 & \text{otherwise} \end{cases} \qquad k_z = 0.949$$

$$S_{Mz} := \frac{M_{Ez}}{M_{plz}} \cdot k_z \qquad S_{Mz} = 0.529$$

$$S_{Tot} := \frac{F_E}{\chi_{Bz} \cdot F_{pl}} + \frac{M_{Ey}}{M_{ply}} \cdot k_y + \frac{M_{Ez}}{M_{plz}} \cdot k_z \qquad S_{Tot} = 0.746$$

$S_{Tot} < 1$ olduğundan konstrüksiyon fonksiyonunu yapar.

Sistemi emniyetli mukavet değerine göre kontrolü:

$$\sigma_{he} := \frac{F_E}{A_0} + \frac{M_{Ey}}{W_y} + \frac{M_{Ez}}{W_z}$$

$\sigma_{he} = 143 \cdot MPa$

$f_{EM} = 214 \cdot MPa$

$$k_{EM} := \frac{\sigma_{he}}{f_{EM}}$$

$k_{EM} = 0.67$

Sonuç: Sistemin emniyetli mukavet değerine göre kontrolündede görüldüğü gibi konstrüksiyon fonksiyonunu yapar.

SON ==========