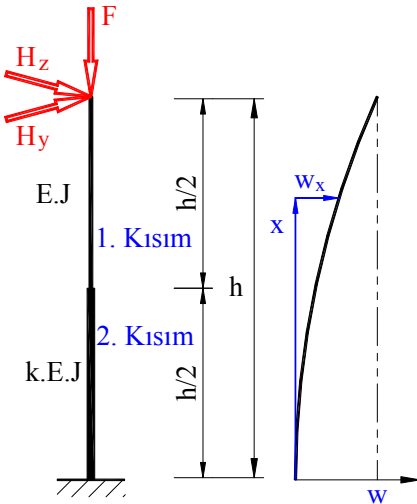
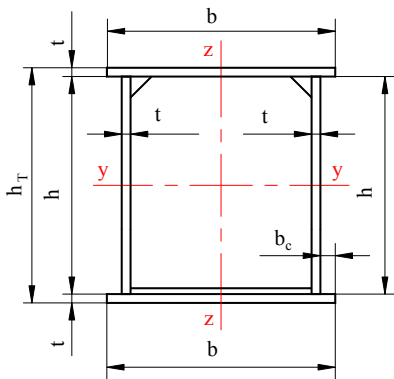


Zorlama: Aksenal kuvvet ve iki eksenli eğilme momenti.

Bilinen değerler:



Resim 1



Resim 2

2. Kısım:

$$k := 1.5$$

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

$$f_{EM} = 214 \cdot \text{MPa}$$

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

Kabul: Eğrinin şekli parabol

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

$$H_z := 40 \cdot \text{kN}$$

1. Kısım

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

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

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

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

$$h_{T1} := h_1 + 2 \cdot t \quad h_{T1} = 340 \cdot \text{mm} \quad z_1 := 0.5 \cdot (h_1 + t)$$

$$z_1 = 165 \cdot \text{mm}$$

$$J_{y1} := 2 \cdot \frac{b_1 \cdot t^3}{12} + 2 \cdot \frac{t \cdot h_1^3}{12} + 2 \cdot t \cdot b_1 \cdot z_1^2$$

$$J_{y1} = 228.9 \cdot 10^6 \cdot \text{mm}^4$$

$$W_{y1} := \frac{2 \cdot J_{y1}}{h_{T1}}$$

$$W_{y1} = 1346.5 \cdot 10^3 \cdot \text{mm}^3$$

$$EJ_{y1} := E \cdot J_{y1}$$

$$EJ_{y1} = 48.1 \cdot \text{MN} \cdot \text{m}^2$$

$$A_1 := 2 \cdot t \cdot (b_1 + h_1)$$

$$A_1 = 12800 \cdot \text{mm}^2$$

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

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

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

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

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

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

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

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

$$b_2 := k \cdot b_1$$

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

$$h_2 := k \cdot h_1$$

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

$$h_{T2} := h_2 + 2 \cdot t$$

$$h_{T2} = 500 \cdot \text{mm}$$

$$z_2 := 0.5 \cdot (h_2 + t)$$

$$z_2 = 245 \cdot \text{mm}$$

$$J_{y2} := 2 \cdot \frac{b_2 \cdot t^3}{12} + 2 \cdot \frac{t \cdot h_2^3}{12} + 2 \cdot t \cdot b_2 \cdot z_2^2$$

$$J_{y2} = 760.6 \cdot 10^6 \cdot \text{mm}^4$$

$$W_{y2} := \frac{2 \cdot J_{y2}}{h_{T2}}$$

$$W_{y2} = 3042.6 \cdot 10^3 \cdot \text{mm}^3$$

$$EJ_{y2} := E \cdot J_{y2}$$

$$EJ_{y2} = 159.7 \cdot \text{MN} \cdot \text{m}^2$$

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

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

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

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

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

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

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

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

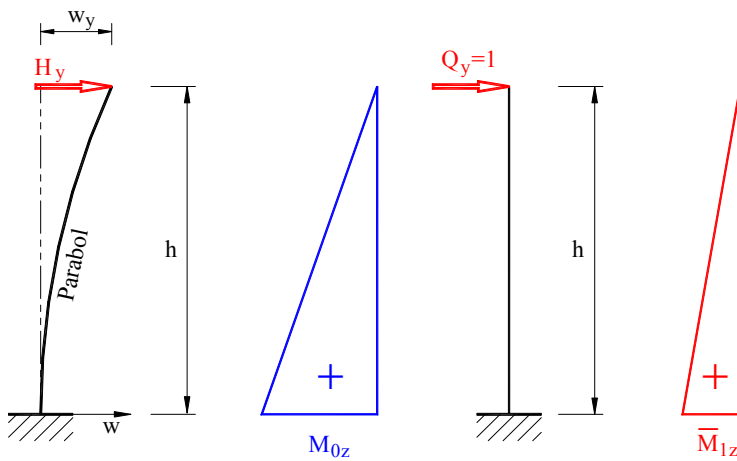
$$k_{Jz} := \frac{J_{z2}}{J_{z1}}$$

$$k_{Jz} = 3.428$$

$$A_2 := 2 \cdot t \cdot (b_2 + h_2)$$

$$A_2 = 19200 \cdot \text{mm}^2$$

Çözüm: 1. dereceli hesaplama kuralına göre



Resim 3

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

$$M_{0z} = 240 \cdot \text{kN} \cdot \text{m}$$

$$M_{1z} := h_s$$

$$w_{0y1} = \int_0^{h_s} \frac{2}{h_s} M_{0z} \cdot M_{1z} \cdot \frac{1}{EJ_{z1}} dx$$

$$w_{0y2} = \int_0^{h_s} \frac{2}{h_s} M_{0z} \cdot M_{1z} \cdot \frac{1}{k \cdot EJ_{z1}} dx$$

$$w_{0y} = w_{0y1} + w_{0y2} = \frac{1}{3} \cdot H_y \cdot h_s \cdot h_s \cdot \frac{h_s}{2 \cdot EJ_{z1}} + \frac{1}{3} \cdot H_y \cdot h_s \cdot h_s \cdot \frac{h_s}{2 \cdot k \cdot EJ_{z1}}$$

$$w_{0y} = \frac{1}{3} \cdot H_y \cdot h_s \cdot h_s \cdot \frac{h_s}{2 \cdot EJ_{z1}} \cdot \left(1 + \frac{1}{k}\right) \quad w_{0y} := \frac{H_y \cdot h_s^3}{6 \cdot EJ_{z1}} \cdot \left(1 + \frac{1}{k}\right)$$

$$w_{0y} = 24.370 \cdot \text{mm}$$

Resim 4

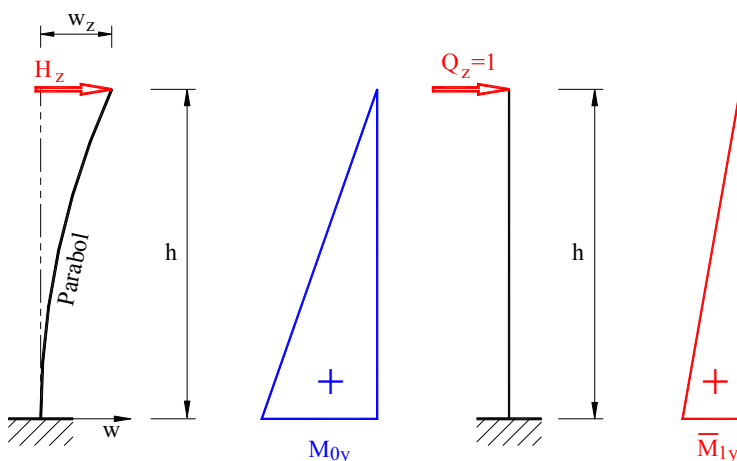
$$M_{0y} := H_z \cdot h_s$$

$$M_{0y} = 160 \cdot \text{kN} \cdot \text{m}$$

$$M_{1y} := h_s$$

$$w_{0z1} = \int_0^{h_s} \frac{2}{h_s} M_{0y} \cdot M_{1y} \cdot \frac{1}{EJ_{y1}} dx$$

$$w_{0z2} = \int_0^{h_s} \frac{2}{h_s} M_{0y} \cdot M_{1y} \cdot \frac{1}{k \cdot EJ_{y1}} dx$$



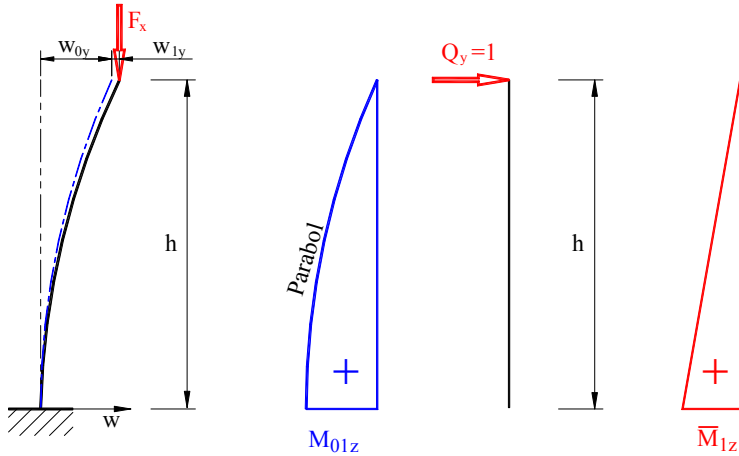
$$w_{0z} = w_{0z1} + w_{0z2} = \frac{1}{3} \cdot H_z \cdot h_S \cdot h_S \cdot \frac{h_S}{2} \cdot \frac{1}{EJ_{y1}} + \frac{1}{3} \cdot H_z \cdot h_S \cdot h_S \cdot \frac{h_S}{2} \cdot \frac{1}{k \cdot EJ_{y1}}$$

$$w_{0z} = \frac{1}{3} \cdot H_z \cdot h_S \cdot h_S \cdot \frac{h_S}{2 \cdot EJ_{y1}} \cdot \left(1 + \frac{1}{k}\right)$$

$$w_{0z} := \frac{H_z \cdot h_S^3}{6 \cdot EJ_{y1}} \cdot \left(1 + \frac{1}{k}\right)$$

$$w_{0z} = 14.793 \cdot \text{mm}$$

Vianelloya göre



Resim 5

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

$$M_{01z} = 17.1 \cdot \text{kN} \cdot \text{m}$$

$$M_{1z} = h_S$$

$$w_{11y} = \int_0^{h_S} M_{01z} \cdot M_{1z} \cdot \frac{1}{EJ_{z1}} dx$$

$$w_{12y} = \int_0^{h_S} M_{01z} \cdot M_1 \cdot \frac{1}{k \cdot EJ_{z1}} dx$$

$$w_{1y} = w_{11y} + w_{12y} = \frac{5}{12} \cdot F_x \cdot w_{0y} \cdot h_S \cdot \frac{h_S}{2 \cdot E \cdot J_{z1}} + \frac{5}{12} \cdot F_x \cdot w_{0z} \cdot h_S \cdot \frac{h_S}{2 \cdot k \cdot E \cdot J_{z1}}$$

$$w_{1y} := \frac{5 \cdot F_x \cdot w_{0y} \cdot h_S^2}{24 \cdot EJ_{z1}} \cdot \left(1 + \frac{1}{k}\right)$$

$$w_{1y} = 2.165 \cdot \text{mm}$$

Resim 6

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

$$M_{01y} = 10.4 \cdot \text{kN} \cdot \text{m}$$

$$M_{1y} = h_S$$

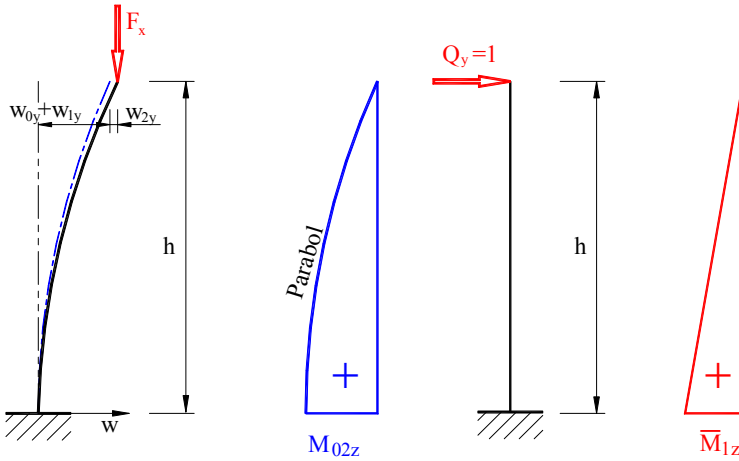
$$w_{11z} = \int_0^{h_S} M_{01y} \cdot M_{1y} \cdot \frac{1}{EJ_{y1}} dx$$

$$w_{12z} = \int_0^{h_S} M_{01y} \cdot M_1 \cdot \frac{1}{k \cdot EJ_{y1}} dx$$

$$w_{1z} = w_{11z} + w_{12z} = \frac{5}{12} \cdot F_x \cdot w_{0z} \cdot h_S \cdot \frac{h_S}{2 \cdot E \cdot J_{y1}} + \frac{5}{12} \cdot F_x \cdot w_{0z} \cdot h_S \cdot \frac{h_S}{2 \cdot k \cdot E \cdot J_{y1}}$$

$$w_{1z} := \frac{5 \cdot F_x \cdot w_{0z} \cdot h_S^2}{24 \cdot EJ_{y1}} \cdot \left(1 + \frac{1}{k}\right)$$

$$w_{1z} = 1.197 \cdot \text{mm}$$



$$w_{2y} = w_{21y} + w_{22y} = \frac{5}{12} \cdot F_x \cdot w_{02y} \cdot h_s \cdot \frac{h_s}{2 \cdot E \cdot J_{y1}} + \frac{5}{12} \cdot F_x \cdot w_{02y} \cdot h_s \cdot \frac{h_s}{2 \cdot k \cdot E \cdot J_{y1}}$$

$$w_{2y} := \frac{5 \cdot F_x \cdot w_{1y} \cdot h_s^2}{24 \cdot E J_{y1}} \cdot \left(1 + \frac{1}{k}\right)$$

Resim 7

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

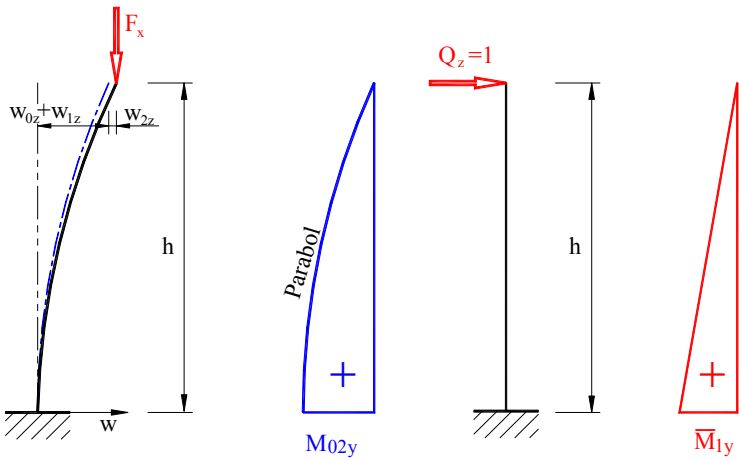
$$M_{02z} = 1.5 \cdot \text{kN} \cdot \text{m}$$

$$M_{1z} = h_s$$

$$w_{21y} = \int_0^{h_s} M_{02z} \cdot M_{1z} \cdot \frac{1}{E J_{z1}} dx$$

$$w_{12y} = \int_0^{h_s} M_{02z} \cdot M_{1z} \cdot \frac{1}{k \cdot E J_{z1}} dx$$

$$w_{2y} = 0.175 \cdot \text{mm}$$



$$w_{2z} = w_{21z} + w_{22z} = \frac{5}{12} \cdot F_x \cdot w_{1z} \cdot h_s \cdot \frac{h_s}{2 \cdot E \cdot J_{y1}} + \frac{5}{12} \cdot F_x \cdot w_{1z} \cdot h_s \cdot \frac{h_s}{2 \cdot k \cdot E \cdot J_{y1}}$$

$$w_{2z} := \frac{5 \cdot F_x \cdot w_{1z} \cdot h_s^2}{24 \cdot E J_{y1}} \cdot \left(1 + \frac{1}{k}\right)$$

Böylece devam ederseniz

$$w_{3y} := \frac{5 \cdot F_x \cdot w_{2z} \cdot h_s^2}{24 \cdot E J_{y1}} \cdot \left(1 + \frac{1}{k}\right)$$

$$w_{3z} := \frac{5 \cdot F_x \cdot w_{2y} \cdot h_s^2}{24 \cdot E J_{z1}} \cdot \left(1 + \frac{1}{k}\right)$$

Resim 8

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

$$M_{02y} = 0.8 \cdot \text{kN} \cdot \text{m}$$

$$M_{1y} = h_s$$

$$w_{21z} = \int_0^{h_s} M_{02y} \cdot M_{1y} \cdot \frac{1}{E J_{y1}} dx$$

$$w_{12z} = \int_0^{h_s} M_{02y} \cdot M_{1y} \cdot \frac{1}{k \cdot E J_{y1}} dx$$

$$w_{2z} = 0.097 \cdot \text{mm}$$

$$w_{3y} = 0.008 \cdot \text{mm}$$

$$w_{3z} = 0.016 \cdot \text{mm}$$

Toplam sehim

$$w_{\text{Toty}} := w_{0y} + w_{1y} + w_{2y} + w_{3y}$$

$$w_{\text{Toty}} = 26.718 \cdot \text{mm}$$

$$w_{\text{Totz}} := w_{0z} + w_{1z} + w_{2z} + w_{3z}$$

$$w_{\text{Totz}} = 16.102 \cdot \text{mm}$$

Toplam Moment

$$M_{\text{Toty}} := H_z \cdot h_S + F_x \cdot w_{\text{Totz}}$$

$$M_{\text{Toty}} = 171.27 \cdot \text{kN} \cdot \text{m}$$

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

$$M_{\text{Totz}} = 258.7 \cdot \text{kN} \cdot \text{m}$$

Kritik burkulma kuvveti

$$w_{1y} = \frac{5 \cdot F_x \cdot w_{0z} \cdot h_S^2}{24 \cdot E J_{y1}} \cdot \left(1 + \frac{1}{k} \right)$$

eğer $F_x = F_{kr}$ ve $w_{0z} = w_{1y}$ veya $\alpha_F = \frac{w_{1y}}{w_{0z}} = 1$ kabul edersek:

$$1 = \frac{5 \cdot F_{kry} \cdot h_S^3}{24 \cdot E J_{y1}} \cdot \left(\frac{k+1}{k} \right)$$

$$F_{kry} := \frac{24}{5} \cdot \frac{E J_{y1}}{h_S^2} \cdot \frac{k}{k+1}$$

$$F_{kry} = 8652.7 \cdot \text{kN}$$

$$w_{1z} = \frac{5 \cdot F_x \cdot w_{0z} \cdot h_S^2}{24 \cdot E J_{z1}} \cdot \left(1 + \frac{1}{k} \right)$$

$$\alpha_F = \frac{w_{1z}}{w_{0z}} = 1$$

kabul edersek:

$$1 = \frac{5 \cdot F_{krz} \cdot h_S^3}{24 \cdot E J_{z1}} \cdot \left(\frac{k+1}{k} \right)$$

$$F_{krz} := \frac{24}{5} \cdot \frac{E J_{z1}}{h_S^2} \cdot \frac{k}{k+1}$$

$$F_{krz} = 7878.5 \cdot \text{kN}$$

$$F_{kr} := F_{kry}$$

$$F_{kr} = 8653 \cdot \text{kN}$$

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

Sonuç: Çubukta burkulma tehlikesi yoktur.

2. Kısımda mukavemet hesabı:

Eylemsizlik radyusu

$$i_{y2} := \sqrt{\frac{J_{y2}}{A_2}}$$

$$i_{y2} = 199 \cdot \text{mm}$$

Euler burkulma boyu

$$L_{B2y} := \sqrt{\frac{E J_{y2} \cdot \pi^2}{F_{kry}}}$$

$$L_{B2y} = 13.498 \cdot \text{m}$$

Akma narinliği

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

$$\lambda_E = 93.9$$

Narinlik

$$\lambda_{y2} := \frac{L_{B2y}}{i_{y2}}$$

$$\lambda_{y2} = 67.8$$

Bağıntılı narinlik

$$\lambda_{By2} := \frac{\lambda_{y2}}{\lambda_E}$$

$$\lambda_{By2} = 0.722$$

Merkez noktası mesafesi

$$k_{ely2} := \frac{W_{y2}}{A_2}$$

$$k_{ely2} = 158.5 \cdot \text{mm}$$

Akma kuvveti

$$F_{pl2} := A_2 \cdot f_{EM}$$

$$F_{pl2} = 4101.8 \cdot \text{kN}$$

Burkulma parametresi	$\alpha_B := 0.34$	Kaynaklı kutular her ekseninde.	
Burkulma yardımcı faktörü	$\varphi_{By2} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{By2} - 0.2) + \lambda_{By2}^2 \right]$		$\varphi_{By2} = 0.85$
Azaltma faktörü	$\chi_{By2} := \frac{1}{\varphi_{By2} + \sqrt{\varphi_{By2}^2 - \lambda_{By2}^2}}$		$\chi_{By2} = 0.771$
Kuvvetin mukavemet emniyeti	$S_{Fy2} := \frac{F_x}{\chi_{By2} \cdot F_{pl2}}$		$S_{Fy2} = 0.221$
Eylemsizlik radyusu	$i_{z2} := \sqrt{\frac{J_{z2}}{A_2}}$		$i_{z2} = 192.9 \cdot \text{mm}$
Euler burkulma boyu	$L_{Bz2} := \sqrt{\frac{EJ_{z2} \cdot \pi^2}{F_{krz}}}$		$L_{Bz2} = 13.711 \text{ m}$
Narinlik	$\lambda_{z2} := \frac{L_{Bz2}}{i_{z2}}$		$\lambda_{z2} = 71.1$
Bağıntılı narinlik	$\lambda_{Bz2} := \frac{\lambda_{z2}}{\lambda_E}$		$\lambda_{Bz2} = 0.757$
Merkez noktası mesafesi	$k_{elz2} := \frac{W_{z2}}{A_2}$		$k_{elz2} = 155.1 \cdot \text{mm}$
Burkulma yardımcı faktörü	$\varphi_{Bz2} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{Bz2} - 0.2) + \lambda_{Bz2}^2 \right]$		$\varphi_{Bz2} = 0.88$
Azaltma faktörü	$\chi_{Bz2} := \frac{1}{\varphi_{Bz2} + \sqrt{\varphi_{Bz2}^2 - \lambda_{Bz2}^2}}$		$\chi_{Bz2} = 0.751$
Kuvvetin mukavemet emniyeti	$S_{Fz2} := \frac{F_x}{\chi_{Bz2} \cdot F_{pl2}}$		$S_{Fz2} = 0.227$

Moment kontrolü:

2. Kısımda toplam Moment	$M_{2y} := M_{Toty}$	$M_{2y} = 171.27 \cdot \text{kN} \cdot \text{m}$	
	$M_{2z} := M_{Totz}$	$M_{2z} = 258.7 \cdot \text{kN} \cdot \text{m}$	
	$M_{ply2} := W_{y2} \cdot f_{EM}$	$M_{ply2} = 650 \cdot \text{kN} \cdot \text{m}$	
	$M_{plz2} := W_{z2} \cdot f_{EM}$	$M_{plz2} = 636.1 \cdot \text{kN} \cdot \text{m}$	
	$M_{2yF} := F_x \cdot W_{Toty}$	$M_{2yF} = 18.7 \cdot \text{kN} \cdot \text{m}$	
	$M_{2zF} := F_x \cdot W_{Totz}$	$M_{2zF} = 11.3 \cdot \text{kN} \cdot \text{m}$	
	$\Delta M_{2y} := \frac{M_{2yF}}{M_{2y}}$	$\Delta M_{2y} = 0.109$	
	$\Delta M_{2z} := \frac{M_{2zF}}{M_{2z}}$	$\Delta M_{2z} = 0.044$	
	$\Delta M < 1$		

	$\beta_{My2} := 1.8 - 0.7 \cdot \Delta M2y$	$\beta_{My2} = 1.7$
$\alpha_{pl} > 1$	$\alpha_{ply2} := \frac{M_{ply2}}{M_{2y}}$	$\alpha_{ply2} = 3.795$
	$a_{y2} := \lambda_{By2} \cdot (2 \cdot \beta_{My2} - 4) + (\alpha_{ply2} - 1)$	$a_{y2} = 2.396$
	$k_{y2} := 1 - \frac{F_x}{\chi_{By2} \cdot F_{pl2}} \cdot a_{y2}$	$k_{y2} = 0.470$
	$\beta_{Mz2} := 1.8 - 0.7 \cdot \Delta M2z$	$\beta_{Mz2} = 1.8$
$\alpha_{pl} > 1$	$\alpha_{plz2} := \frac{M_{plz2}}{M_{2z}}$	$\alpha_{plz2} = 2.459$
	$a_{z2} := \lambda_{Bz2} \cdot (2 \cdot \beta_{Mz2} - 4) + (\alpha_{plz2} - 1)$	$a_{z2} = 1.11$
	$k_{z2} := 1 - \frac{F_x}{\chi_{Bz2} \cdot F_{pl2}} \cdot a_{z2}$	$k_{z2} = 0.748$
	$S_{2y} := \frac{F_x}{\chi_{By2} \cdot F_{pl2}} + \frac{M_{2y}}{M_{ply2}} \cdot k_{y2} + \frac{M_{2z}}{M_{plz2}} \cdot k_{z2}$	$S_{2y} = 0.649$
	$S_{2z} := \frac{F_x}{\chi_{Bz2} \cdot F_{pl2}} + \frac{M_{2y}}{M_{ply2}} \cdot k_{y2} + \frac{M_{2z}}{M_{plz2}} \cdot k_{z2}$	$S_{2z} = 0.649$

Sonuç: S_{2y} ve S_{2z} değerleri 1 den küçük olduğundan konstrüksiyon fonksiyonunu yapar.

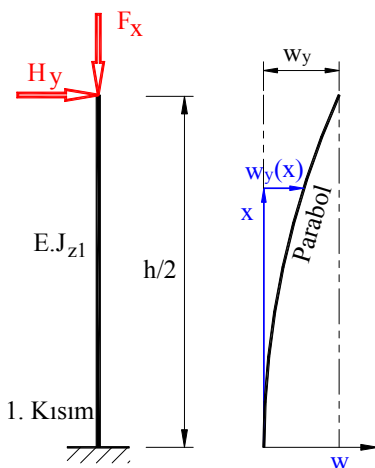
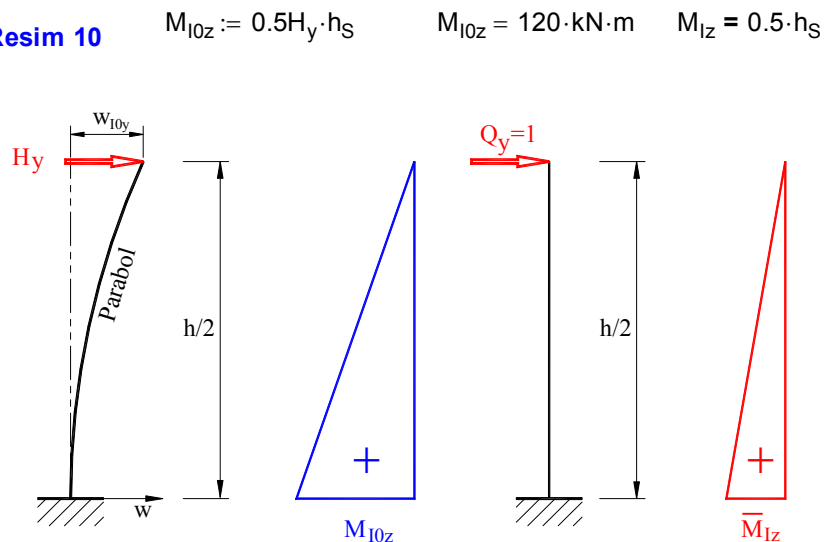
1. Kısımda mukavemet hesabı:

Eylemsizlik radyusu	$i_{z1} := \sqrt{\frac{J_{z1}}{A_1}}$	$i_{z1} = 127.6 \cdot \text{mm}$
Euler burkulma boyu	$L_{Bz1} := \sqrt{\frac{EJ_{z1} \cdot \pi^2}{F_{k1z}}}$	$L_{Bz1} = 7.405 \text{ m}$
Narinlik	$\lambda_{z1} := \frac{L_{Bz1}}{i_{z1}}$	$\lambda_{z1} = 58$
Bağıntılı narinlik	$\lambda_{Bz1} := \frac{\lambda_{z1}}{\lambda_E}$	$\lambda_{Bz1} = 0.618$
Merkez noktası mesafesi	$k_{elz1} := \frac{W_{z1}}{A_1}$	$k_{elz1} = 101.8 \cdot \text{mm}$
Akma kuvveti	$F_{pl1} := A_1 \cdot f_{EM}$	$F_{pl1} = 2734.5 \cdot \text{kN}$
Burkulma yardımcı faktörü	$\varphi_{Bz1} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{Bz1} - 0.2) + \lambda_{Bz1}^2 \right]$	$\varphi_{Bz1} = 0.76$

Azaltma faktörü	$\chi_{Bz1} := \frac{1}{\varphi_{Bz1} + \sqrt{\varphi_{Bz1}^2 - \lambda_{Bz1}^2}}$	$\chi_{Bz1} = 0.828$
Kuvvetin mukavemet emniyeti	$S_{Fz1} := \frac{F_x}{\chi_{Bz1} \cdot F_{pl1}}$	$S_{Fz1} = 0.309$
Eylemsizlik radyusu	$i_{y1} := \sqrt{\frac{J_{y1}}{A_1}}$	$i_{y1} = 133.7 \cdot \text{mm}$
Euler burkulma boyu	$L_{By1} := \sqrt{\frac{EJ_{y1} \cdot \pi^2}{F_{kry}}}$	$L_{By1} = 7.405 \text{ m}$
Narinlik	$\lambda_{y1} := \frac{L_{By1}}{i_{y1}}$	$\lambda_{y1} = 55.4$
Bağıntılı narinlik	$\lambda_{By1} := \frac{\lambda_{y1}}{\lambda_E}$	$\lambda_{By1} = 0.590$
Merkez noktası mesafesi	$k_{ely1} := \frac{W_{y1}}{A_1}$	$k_{ely1} = 105.2 \cdot \text{mm}$
Burkulma yardımcı faktörü	$\varphi_{By1} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{By1} - 0.2) + \lambda_{By1}^2 \right]$	$\varphi_{By1} = 0.74$
Azaltma faktörü	$\chi_{By1} := \frac{1}{\varphi_{By1} + \sqrt{\varphi_{By1}^2 - \lambda_{By1}^2}}$	$\chi_{By1} = 0.842$
Kuvvetin mukavemet emniyeti	$S_{Fy1} := \frac{F_x}{\chi_{By1} \cdot F_{pl1}}$	$S_{Fy1} = 0.304$

1. Kısımda moment kontrolü:

$x1 := 2 \cdot \text{m}$

Resim 9**Resim 10**

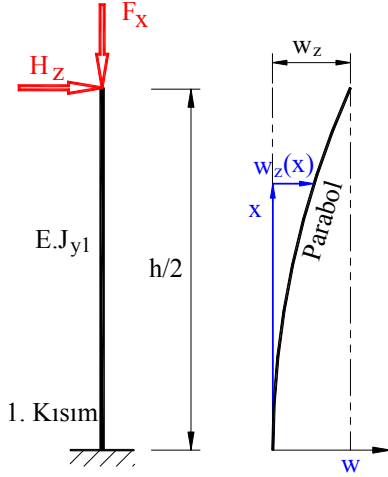
$$w_{10y} = \int_0^{h_S} \frac{1}{E \cdot J_{z1}} M_{I0z} \cdot M_{Iz} \cdot dx$$

$$w_{10y} = \frac{1}{3} \cdot M_{I0z} \cdot M_{Iz} \cdot \frac{h_S}{2 \cdot EJ_{z1}}$$

$$w_{10y} = \frac{1}{3} \cdot \frac{H_y \cdot h_S}{2} \cdot \frac{h_S}{2} \cdot \frac{h_S}{2 \cdot EJ_{z1}}$$

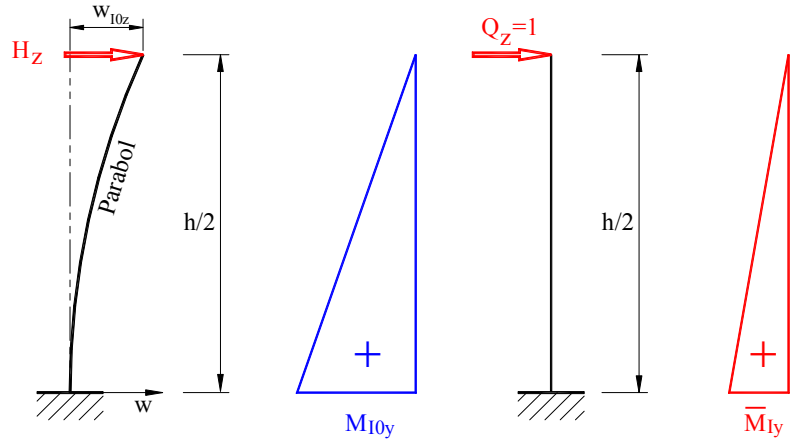
$$w_{10y} := \frac{H_y \cdot h_s^3}{24 \cdot EJ_{z1}} \quad w_{10y} = 3.656 \cdot \text{mm}$$

Resim 11



Resim 12

$$M_{10y} := 0.5 H_z \cdot h_s \quad M_{10y} = 80 \cdot \text{kN} \cdot \text{m} \quad M_{1y} = 0.5 \cdot h_s$$



$$w_{10z} = \int_0^{h_s} M_{10y} \cdot M_{1y} \cdot \frac{1}{EJ_{y1}} dx$$

$$w_{10z} = \frac{1}{3} \cdot M_{10y} \cdot M_{1y} \cdot \frac{h_s}{2 \cdot EJ_{y1}}$$

$$w_{10z} = \frac{1}{3} \cdot \frac{H_z \cdot h_s}{2} \cdot \frac{h_s}{2} \cdot \frac{h_s}{2 \cdot EJ_{y1}}$$

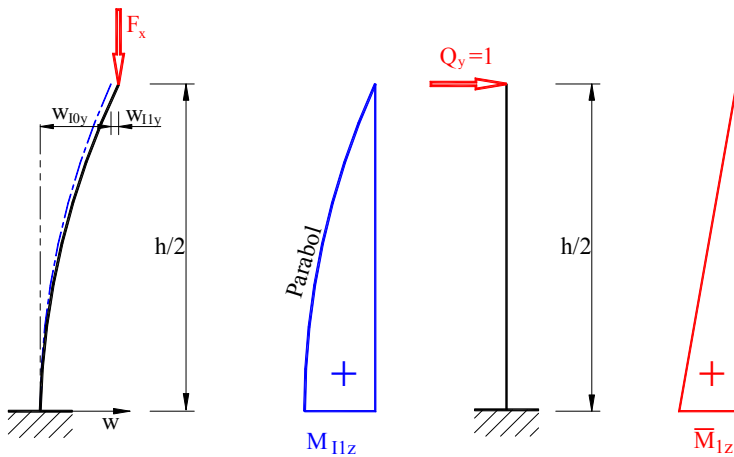
$$w_{10z} := \frac{H_z \cdot h_s^3}{24 \cdot EJ_{y1}} \quad w_{10z} = 2.219 \cdot \text{mm}$$

Vianelloya göre

Resim 13

$$M_{11z} := F_x \cdot w_{10y}$$

$$M_{1z} = \frac{h}{2}$$



$$w_{11y} = \int_0^{h_s} M_{11z} \cdot M_{1z} \cdot \frac{1}{EJ_{z1}} dx$$

$$w_{11y} = \frac{5}{12} \cdot M_{11z} \cdot M_{1z} \cdot \frac{h_s}{2 \cdot EJ_{z1}}$$

$$w_{11y} = \frac{5}{12} \cdot F_x \cdot w_{10y} \cdot \frac{h_s}{2} \cdot \frac{h_s}{2 \cdot EJ_{z1}}$$

$$w_{11y} := \frac{5 \cdot F_x \cdot w_{10y} \cdot h_s^2}{48 \cdot EJ_{z1}} \quad w_{11y} = 0.097 \cdot \text{mm}$$

Böylece devam edersek

$$w_{12y} := \frac{5 \cdot F_x \cdot w_{11y} \cdot h_s^2}{48 \cdot EJ_{z1}} \quad w_{12y} = 0.003 \cdot \text{mm}$$

$$w_{13y} := \frac{5 \cdot F_x \cdot w_{12y} \cdot h_s^2}{48 \cdot EJ_{z1}} \quad w_{13y} = 0.000 \cdot \text{mm}$$

Toplam sehım

$$w_{1y} := w_{10y} + w_{11y} + w_{12y} + w_{13y} \quad w_{1y} = 3.756 \cdot \text{mm}$$

veya

$$\alpha_{F_{ly}} := \frac{w_{12y}}{w_{11y}}$$

$$\mu_{F_{ly}} := \frac{1}{1 - \alpha_{F_{ly}}}$$

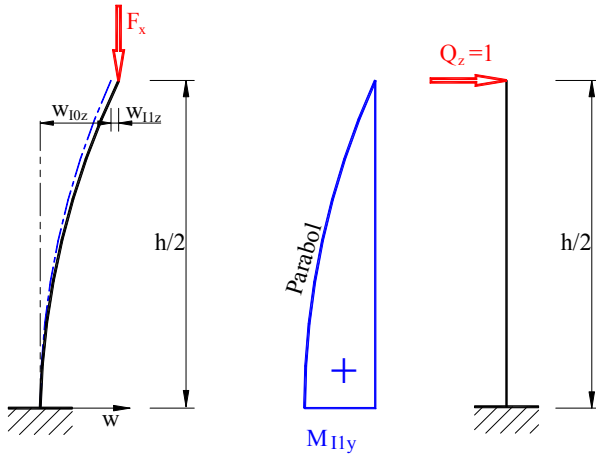
$$w_{lmaxy} := w_{10y} \cdot \mu_{F_{ly}}$$

$$\alpha_{F_{ly}} = 0.027$$

$$\mu_{F_{ly}} = 1.027$$

$$w_{lmaxy} = 3.756 \cdot \text{mm}$$

Resim 14



$$M_{11y} := F_x \cdot w_{10z}$$

$$M_{1y} = \frac{h}{2}$$

$$w_{11z} = \int_0^{h_s} \frac{1}{2} M_{11y} \cdot M_{1y} \cdot \frac{1}{EJ_{y1}} dx$$

$$w_{11z} = \frac{5}{12} M_{11y} \cdot M_{1y} \cdot \frac{h_s}{2 \cdot EJ_{y1}}$$

$$w_{11z} = \frac{5}{12} F_x \cdot w_{10z} \cdot \frac{h_s}{2} \cdot \frac{h_s}{2 \cdot EJ_{y1}}$$

$$w_{11z} := \frac{5 \cdot F_x \cdot w_{10z} \cdot h_s^2}{48 \cdot EJ_{y1}} \quad w_{11z} = 0.054 \cdot \text{mm}$$

Böylece devam ederse

$$w_{12z} := \frac{5 \cdot F_x \cdot w_{11z} \cdot h_s^2}{48 \cdot EJ_{y1}}$$

$$w_{12z} = 0.001 \cdot \text{mm}$$

$$w_{13z} := \frac{5 \cdot F_x \cdot w_{12z} \cdot h_s^2}{48 \cdot EJ_{y1}}$$

$$w_{13z} = 0.000 \cdot \text{mm}$$

Toplam sehım

$$w_{1z} := w_{10z} + w_{11z} + w_{12z} + w_{13z}$$

$$w_{1z} = 2.274 \cdot \text{mm}$$

Toplam Moment

$$M_{1y} := 0.5 \cdot H_z \cdot h_s + F_x \cdot w_{1y}$$

$$M_{1y} = 82.63 \cdot \text{kN} \cdot \text{m}$$

$$M_{1z} := 0.5 \cdot H_y \cdot h_s + F_x \cdot w_{1z}$$

$$M_{1z} = 121.59 \cdot \text{kN} \cdot \text{m}$$

Kritik burkulma kuvveti

$$w_{11} = \frac{5 \cdot F_x \cdot w_{10} \cdot h_s^3}{12 \cdot EJ}$$

$$\alpha_{F_y} = \frac{w_{1y}}{w_{0y}} = 1$$

$$1 = \frac{5 \cdot F_{kry} \cdot h_s^3}{12 \cdot EJ_y}$$

$$F_{kry} := \frac{12}{5} \cdot \frac{EJ_{y1}}{h_s^2}$$

$$F_{kry} = 7210.6 \cdot \text{kN}$$

$$1 = \frac{5 \cdot F_{krz} \cdot h_s^3}{12 \cdot EJ_z}$$

$$F_{krz} := \frac{12}{5} \cdot \frac{EJ_{z1}}{h_s^2}$$

$$F_{krz} = 6565.4 \cdot \text{kN}$$

$$F_{krl} := F_{kry}$$

$$F_{krl} = 7211 \cdot \text{kN}$$

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

Sonuç: 1. kesitte burkulma tehlikesi yoktur.

1. Kısımda mukavemet hesabı:

Eylemsizlik radyusu	$i_{z1} := \sqrt{\frac{J_{z1}}{A_1}}$	$i_{z1} = 127.6 \cdot \text{mm}$
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Euler burkulma boyu	$L_{Bz1} := \sqrt{\frac{E \cdot J_{z1} \cdot \pi^2}{F_{Krz}}}$	$L_{Bz1} = 7.405 \text{ m}$
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Narinlik	$\lambda_{z1} := \frac{L_{Bz1}}{i_{z1}}$	$\lambda_{z1} = 58$
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Bağıntılı narinlik	$\lambda_{Bz1} := \frac{\lambda_{z1}}{\lambda_E}$	$\lambda_{Bz1} = 0.618$
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Akma kuvveti	$F_{p11} := A_1 \cdot f_{EM}$	$F_{p11} = 2734.5 \cdot \text{kN}$
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Burkulma yardımcı faktörü	$\varphi_{Kz1} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{Bz1} - 0.2) + \lambda_{Bz1}^2 \right]$	$\varphi_{Kz1} = 0.76$
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Azaltma faktörü	$\chi_{Bz1} := \frac{1}{\varphi_{Kz1} + \sqrt{\varphi_{Kz1}^2 - \lambda_{Bz1}^2}}$	$\chi_{Bz1} = 0.828$
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Kuvvetin mukavemet emniyeti	$S_{Fz1} := \frac{F_x}{\chi_{Bz1} \cdot F_{p11}}$	$S_{Fz1} = 0.309$
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	$i_{y1} := \sqrt{\frac{J_{y1}}{A_1}}$	$i_{y1} = 133.7 \cdot \text{mm}$
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	$L_{By1} := \sqrt{\frac{E \cdot J_{y1} \cdot \pi^2}{F_{Kry}}}$	$L_{By1} = 7.405 \text{ m}$
--	--	-----------------------------

	$\lambda_{y1} := \frac{L_{By1}}{i_{y1}}$	$\lambda_{y1} = 55.4$
--	--	-----------------------

	$\lambda_{By1} := \frac{\lambda_{y1}}{\lambda_E}$	$\lambda_{By1} = 0.590$
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	$\varphi_{Ky1} := 0.5 \cdot \left[1 + \alpha_B \cdot (\lambda_{By1} - 0.2) + \lambda_{By1}^2 \right]$	$\varphi_{Ky1} = 0.74$
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	$\chi_{By1} := \frac{1}{\varphi_{Ky1} + \sqrt{\varphi_{Ky1}^2 - \lambda_{By1}^2}}$	$\chi_{By1} = 0.842$
--	--	----------------------

	$S_{Fy1} := \frac{F_x}{\chi_{By1} \cdot F_{p11}}$	$S_{Fy1} = 0.304$
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Moment:

	$M_{ply1} := W_{y1} \cdot f_{EM}$	$M_{ply1} = 287.7 \cdot \text{kN} \cdot \text{m}$
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	$M_{plz1} := W_{z1} \cdot f_{EM}$	$M_{plz1} = 278.3 \cdot \text{kN} \cdot \text{m}$
--	-----------------------------------	---

	$M_{11y} := H_z \cdot h_S + F_x \cdot W_{1z}$	$M_{11y} = 161.6 \cdot \text{kN} \cdot \text{m}$
--	---	--

	$M_{11z} := H_y \cdot h_S + F_x \cdot W_{1y}$	$M_{11z} = 242.6 \cdot \text{kN} \cdot \text{m}$
--	---	--

$$M_{0Fy} := F_x \cdot w_{Iz} \quad M_{0Fy} = 1.6 \cdot \text{kN} \cdot \text{m}$$

$$M_{0Fz} := F_x \cdot w_{Iy} \quad M_{0Fz} = 2.6 \cdot \text{kN} \cdot \text{m}$$

$$\Delta M < 1 \quad \Delta M_{yl} := \frac{M_{1ly}}{M_{plyl}} \quad \Delta M_{yl} = 0.562$$

$$\Delta M_{zl} := \frac{M_{1lz}}{M_{plzl}} \quad \Delta M_{zl} = 0.872$$

$$\beta_{MyI} := 1.8 - 0.7 \cdot \Delta M_{yl} \quad \beta_{MyI} = 1.4$$

$$\alpha_{plyl} > 1 \quad \alpha_{plyl} := \frac{M_{plyl}}{M_{1ly}} \quad \alpha_{plyl} = 1.780$$

$$a_{yl} := \lambda_{ByI} \cdot (2 \cdot \beta_{MyI} - 4) + (\alpha_{plyl} - 1)$$

$$k_{yl} := 1 - \frac{F_x}{\chi_{ByI} \cdot F_{pII}} \cdot a_{yl} \quad k_{yl} = 0.975$$

$$\beta_{MzI} := 1.8 - 0.7 \cdot \Delta M_{zl} \quad \beta_{MzI} = 1.2$$

$$\alpha_{plzl} > 1 \quad \alpha_{plzl} := \frac{M_{plzl}}{M_{1lz}} \quad \alpha_{plzl} = 1.147$$

$$a_{zl} := \lambda_{BzI} \cdot (2 \cdot \beta_{MzI} - 4) + (\alpha_{plzl} - 1)$$

$$k_{zl} := 1 - \frac{F_x}{\chi_{BzI} \cdot F_{pII}} \cdot a_{zl} \quad k_{zl} = 1.264$$

$$S_{Iy} := \frac{F_x}{\chi_{ByI} \cdot F_{pII}} + \frac{M_{1ly}}{M_{plyl}} \cdot k_{yl} + \frac{M_{1lz}}{M_{plzl}} \cdot k_{zl} \quad S_{Iy} = 1.954$$

$$S_{Iz} := \frac{F_x}{\chi_{BzI} \cdot F_{pII}} + \frac{M_{1ly}}{M_{plyl}} \cdot k_{yl} + \frac{M_{1lz}}{M_{plzl}} \cdot k_{zl} \quad S_{Iz} = 1.959$$

Sonuç: S_{Iy} ve S_{Iz} değerleri 1 den büyük olduğundan konstrüksiyon fonksiyonunu yapamaz.

1. Kısım geometrik değerleri yükseltip hesabı tekrar yapmak gerekir.

SON
