Çukurova Üniversitesi

BETONARME 1

BİLEŞİK EĞİLME ETKİSİ ALTINDAKİ ELEMANLARIN TAŞIMA GÜCÜ

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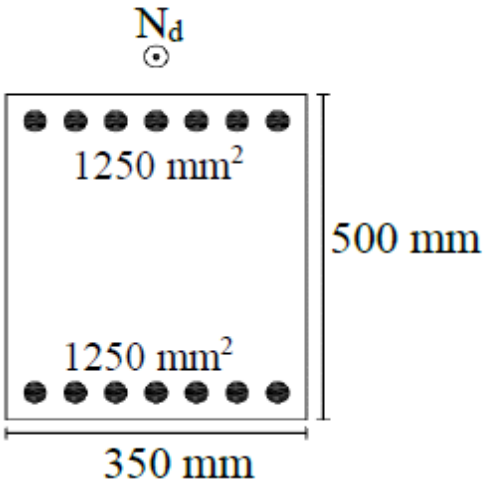
Arş. Gör. Sedat KARAAHMETLİ

Soru 1



Şekilde verilen kolona N_d=1200 kN eksenel kuvvet etkidiğine göre;

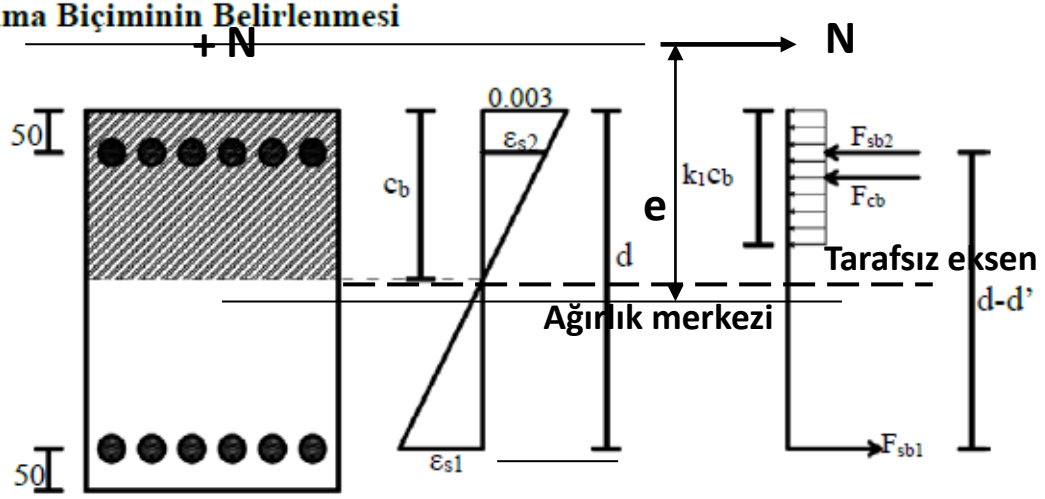
a) Temel denklemleri kullanarak,

b) $N = N_0 - \frac{M}{M_b}(N_0 - N_b)$ yaklaşık denklemini kullanarak kolonun taşıma gücü momentini hesaplayınız.

C20-S420 Paspayı= 40 mm

a)

Kırılma Biçiminin Belirlenmesi



$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$\frac{c_b}{d - c_b} = \frac{0.003}{0.001825} \quad \rightarrow \quad c_b = 286.01\ mm$$

$$k_1 c_b = 243.11\ mm$$

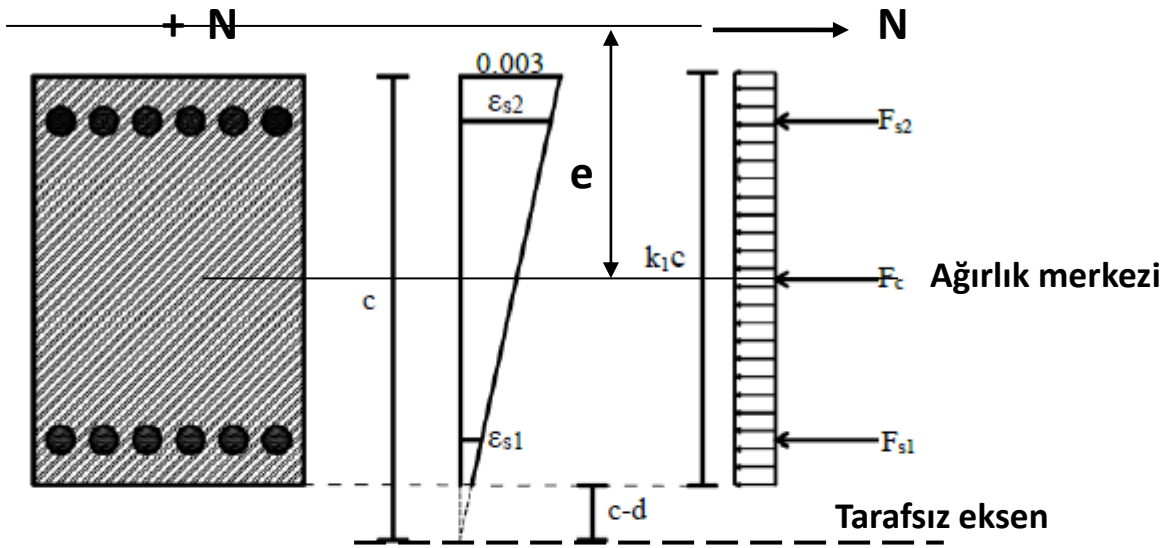
$$N_b = F_c = 0.85 f_{cd} k_1 c_b b_w + A_{s2} f_{yd} - A_{s1} f_{yd}$$

$$= 0.85 * 13 * 243.11 * 350 * 10^{-3} + 1250 * 365 - 1250 * 365 = 940.2\ \ kN$$

$N_b < N_d$ *olduğundan basınç kırılmasıdır.*

$$\sigma_{s2} = f_{yd} \qquad \sigma_{s1} < f_{yd}$$

Denge Denklemi



$$N = F_c + F_{s2} + F_{s1}$$

$$1200 * 10^3 = 0.85 * 13 * k_1 c * 350 + 1250 * 365 + 1250 * 600 * \left(\frac{c - 450}{c} \right)$$

$$0 = 3287c^2 + 6250c - 345000000$$

$$c = 323\ mm$$

$$k_1 c = 274.56\ mm$$

$$\sigma_{s1} = 600 * \left(\frac{323 - 460}{323} \right) = -254.47\ MPa$$

Taşıma Gücü Momenti

$$M_r = 0.85 f_{cd} k_1 c b_w \left(\frac{h}{2} - \frac{k_1 c}{2} \right) + F_2 \left(\frac{d''}{2} \right) + F_1 \left(\frac{d''}{2} \right)$$

$$= 0.85 * 13 * 274.56 * 350 \left(\frac{500}{2} - \frac{274.56}{2} \right) + 1250 * 365 * \left(\frac{420}{2} \right) + 1250 * (-194) * \left(-\frac{420}{2} \right)$$

$$= 282.3 \; kN.m$$

b)

$$N = N_o - \frac{M}{M_b}\left(N_o - N_b\right)$$

$$N = 1200\ kN$$

$$N_b = 940.2\ kN$$

$$N_o = 0.85 f_{cd} \mathrm{A_c} + \mathrm{A_{st}} f_{yd}$$

$$= 0.85*13*350*500 + 2500*365 = 2846.3\ kN$$

$$M_b = 0.85 f_{cd} k_1 c_b b_w \left(\frac{h}{2} - \frac{k_1 c_b}{2}\right) + F_2\left(\frac{d''}{2}\right) + F_1\left(\frac{d''}{2}\right)$$

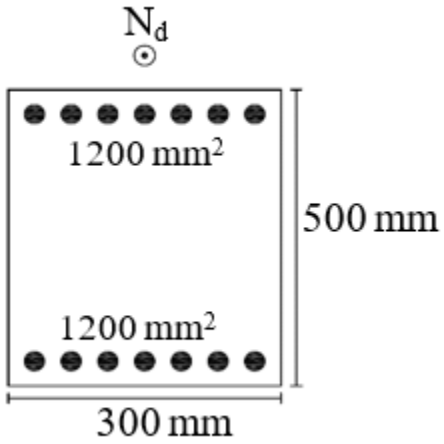
$$= 0.85*13*243.11*350\left(\frac{500}{2} - \frac{243.11}{2}\right) + 1250*365*\left(\frac{420}{2}\right) + 1250*(-365)*\left(-\frac{420}{2}\right)$$

$$= 312.4\ kN.m$$

$$N = N_o - \frac{M}{M_b}\left(N_o - N_b\right) \quad \Rightarrow \quad 1200 = 2846.3 - \frac{M}{312.4}\left(2846.3 - 940.2\right)$$

$$M = 270\ kN.m$$

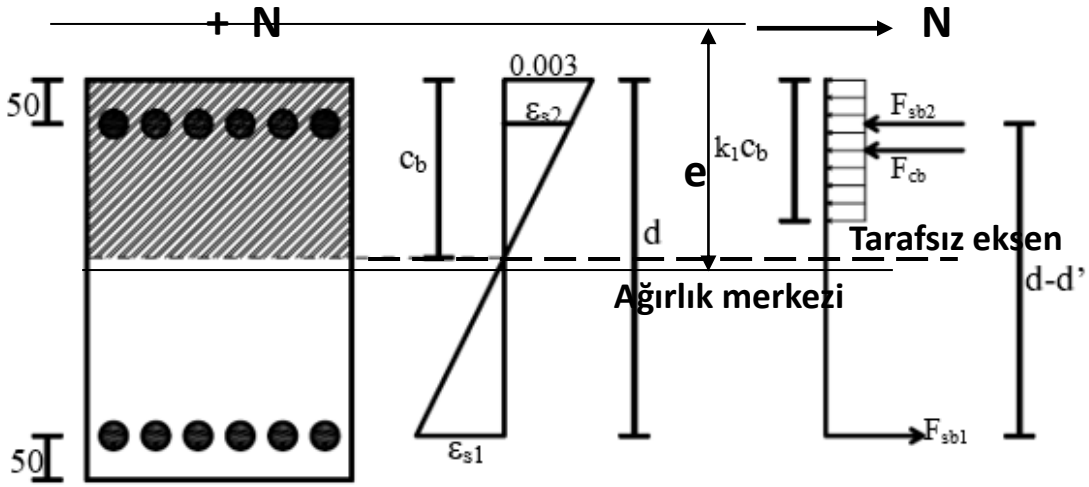
Soru 2



Şekilde verilen kolona N_d=850 kN eksenel kuvvet etkidiğine göre kolonun taşıma gücü momentini hesaplayınız.

C25-S420 Paspayı= 50 mm

Kırılma Biçiminin Belirlenmesi



$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$\frac{c_b}{d - c_b} = \frac{0.003}{0.001825} \quad \rightarrow \quad c_b = 280\ mm$$

$$k_1 c_b = 237.8\ mm$$

$$N_b = 0.85 f_{cd} k_1 c_b b_w + A_{s2} f_{yd} - A_{s1} f_{yd}$$

$$= 0.85 * 13 * 237.8 * 300 * 10^{-3} + 1200 * 365 - 1200 * 365 = 1031\ kN$$

$N_b > N_d$ *olduğundan çekme kırılmasıdır.*

$$\sigma_{s1} = f_{yd}$$

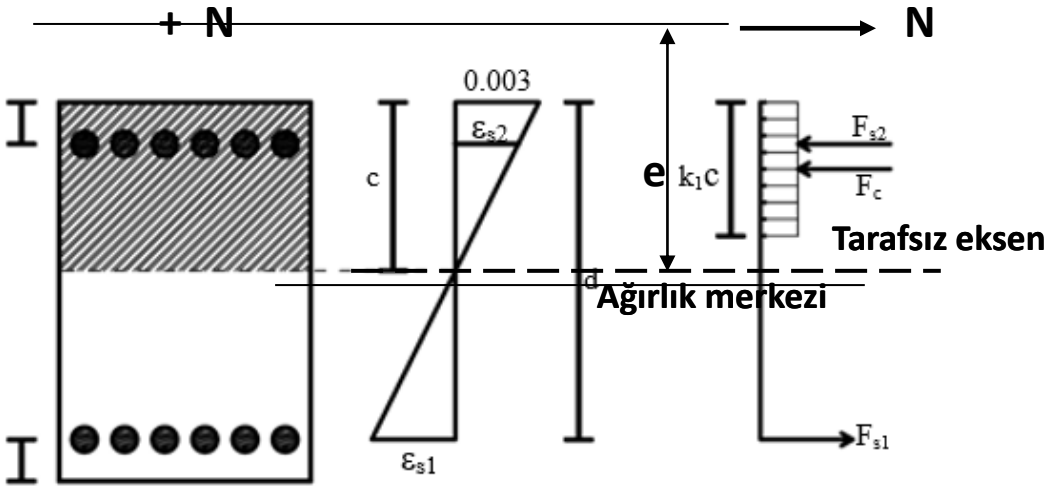
Basınç Donatısının Akıp Akmadığının Kontrolü

$$\Psi_c = 0.72\left(\frac{d'}{h}\right)\frac{0.003E_s}{0.003E_s - f_{yd}} = 0.72\left(\frac{50}{500}\right)\frac{0.003*2*10^5}{0.003*2*10^5 - 365} = 0.184$$

$$\Psi = \frac{N}{bhf_{cd}} = \frac{850000}{300*500*17} = 0.333$$

$\Psi > \Psi_c$ *olduğundan basınç donatısı akmıştır.*

Denge Denklemi



$$N = F_c + F_{s2} + F_{s1}$$

$$850 * 10^3 = 0.85 * 17 * 0.85 * c * 300 + 1200 * 365 - 1250 * 365$$

$$c = 230.7 \ mm$$

$$k_1 c = 196.1 \ mm$$

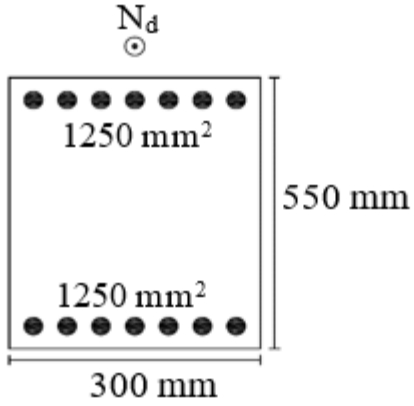
Taşıma Gücü Momenti

$$M_r = 0.85 f_{cd} k_1 c b_w \left(\frac{h}{2} - \frac{k_1 c}{2} \right) + F_2 \left(\frac{d''}{2} \right) + F_1 \left(\frac{d''}{2} \right)$$

$$= 0.85 * 17 * 196.1 * 300 \left(\frac{500}{2} - \frac{196.1}{2} \right) + 1200 * 365 * \left(\frac{400}{2} \right) + 1200 * (-365) * \left(-\frac{400}{2} \right)$$

$$= 304.4 \ kN.m$$

Soru 3



Şekilde verilen kolona N_d=1800 kN eksenel kuvvet etkidiğine göre;

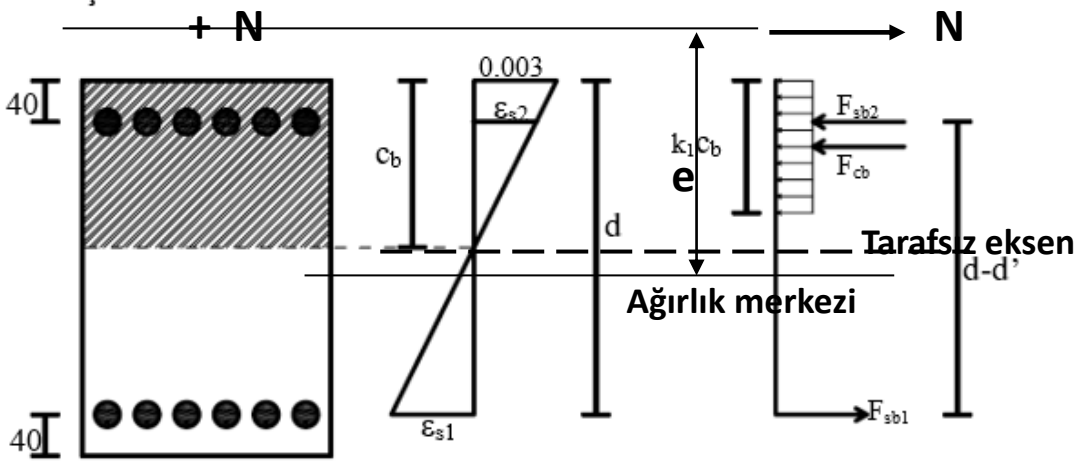
a) Temel denklemleri kullanarak,

b) $N = N_0 - \frac{M}{M_b}(N_0 - N_b)$ yaklaşık denklemini kullanarak kolonun taşıma gücü momentini hesaplayınız.

C25-S420 Paspayı= 40 mm

a)

Kırılma Biçiminin Belirlenmesi



$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$\frac{c_b}{d - c_b} = \frac{0.003}{0.001825} \quad \rightarrow \quad c_b = 317.1\ mm$$

$$k_1 c_b = 269.53\ mm$$

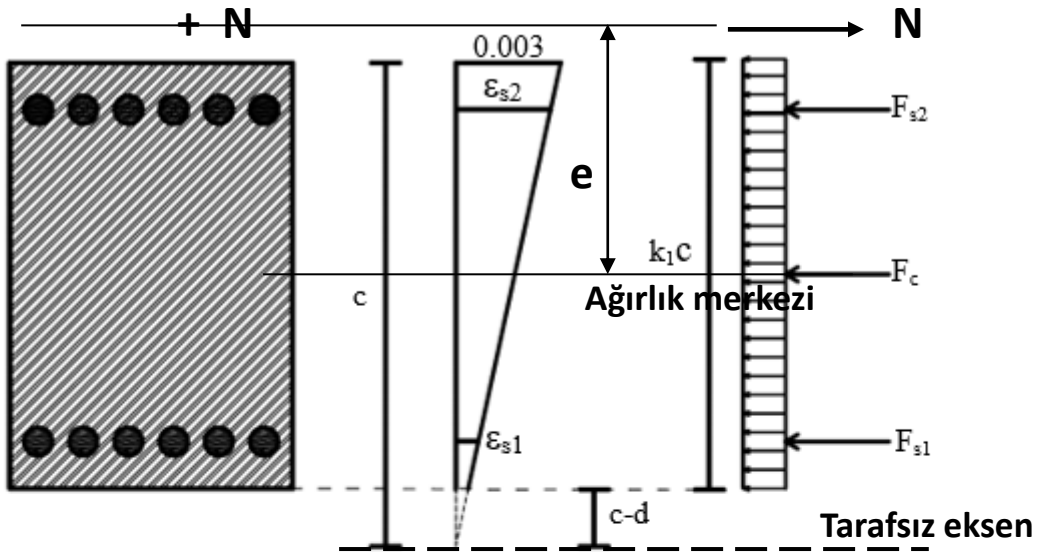
$$N_b = 0.85 f_{cd} k_1 c_b b_w + A_{s2} f_{yd} - A_{s1} f_{yd}$$

$$= 0.85*17*269.53*300*10^{-3} + 1420*365 - 1420*365 = 1168.4\ \ kN$$

$N_b < N_d$ *olduğundan basınç kırılmasıdır.*

$$\sigma_{s2} = f_{yd} \qquad \sigma_{s1} < f_{yd}$$

Denge Denklemi



$$N = F_c + F_{s2} + F_{s1}$$

$$1800 * 10^3 = 0.85 * 17 * k_1c * 300 + 1420 * 365 + 1420 * 600 * \left(\frac{c - 510}{c} \right)$$

$$0 = 3685c^2 - 429700c - 434520000$$

$$c = 406.6 \; mm$$

$$k_1c = 345.63 \; mm$$

$$\sigma_{s1} = 600 * \left(\frac{406.6 - 510}{406.6} \right) = \text{-}152.54 \; MPa$$

Taşıma Gücü Momenti

$$M_r = 0.85 f_{cd} k_1 c b_w \left(\frac{h}{2} - \frac{k_1 c}{2} \right) + F_2 \left(\frac{d''}{2} \right) + F_1 \left(\frac{d''}{2} \right)$$

$$= 0.85 * 17 * 345.63 * 300 \left(\frac{550}{2} - \frac{345.63}{2} \right) + 1420 * 365 * \left(\frac{470}{2} \right) + 1420 * (-152.54) * \left(-\frac{470}{2} \right)$$

$$= 325.81 \, kN.m$$

b)

$$N = N_o - \frac{M}{M_b}\left(N_o - N_b\right)$$

$$N = 1800\ kN$$

$$N_b = 1168.4\ kN$$

$$N_o = 0.85 f_{cd} \mathrm{A_c} + \mathrm{A_{st}} f_{yd}$$

$$= 0.85*17*300*550+2840*365 = 3420.9\ kN$$

$$M_b = 0.85 f_{cd} k_1 c_b b_w \left(\frac{h}{2} - \frac{k_1 c_b}{2}\right) + F_2\left(\frac{d''}{2}\right) + F_1\left(\frac{d''}{2}\right)$$

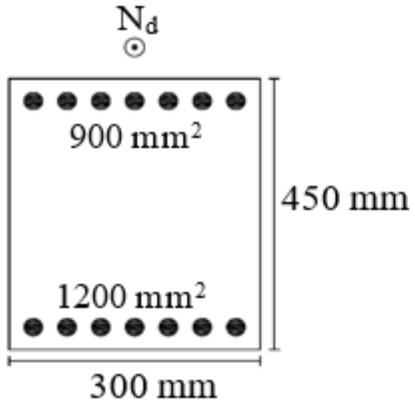
$$= 0.85*17*269.5*300\left(\frac{550}{2} - \frac{269.5}{2}\right) + 1420*365*\left(\frac{470}{2}\right) + 1420*(-365)*\left(-\frac{470}{2}\right)$$

$$= 407.5\ kN.m$$

$$N = N_o - \frac{M}{M_b}\left(N_o - N_b\right) \quad \Rightarrow \quad 1800 = 3420.9 - \frac{M}{407.5}\left(3420.9 - 1168.4\right)$$

$$M = 293\ kN.m$$

Soru 4



Şekilde verilen kolon;

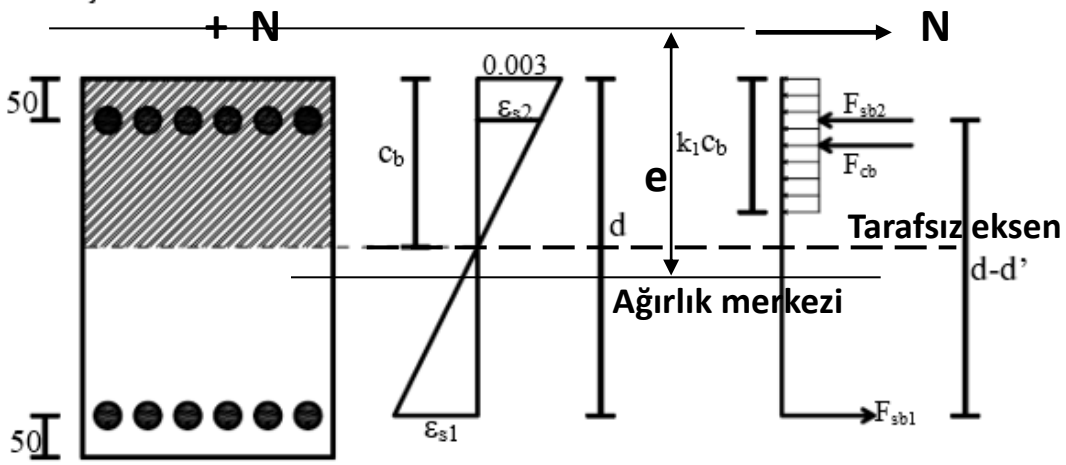
a) N_d=750 kN,

b) N_d=500 kN eksenel kuvvete maruz kaldığına göre taşıma gücü momentlerini hesaplayınız.

C20-S420 Paspayı= 40 mm

a)

Kırılma Biçiminin Belirlenmesi



$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$\frac{c_b}{d - c_b} = \frac{0.003}{0.001825} \quad \rightarrow \quad c_b = 254.92\ mm$$

$$k_1 c_b = 216.7\ mm$$

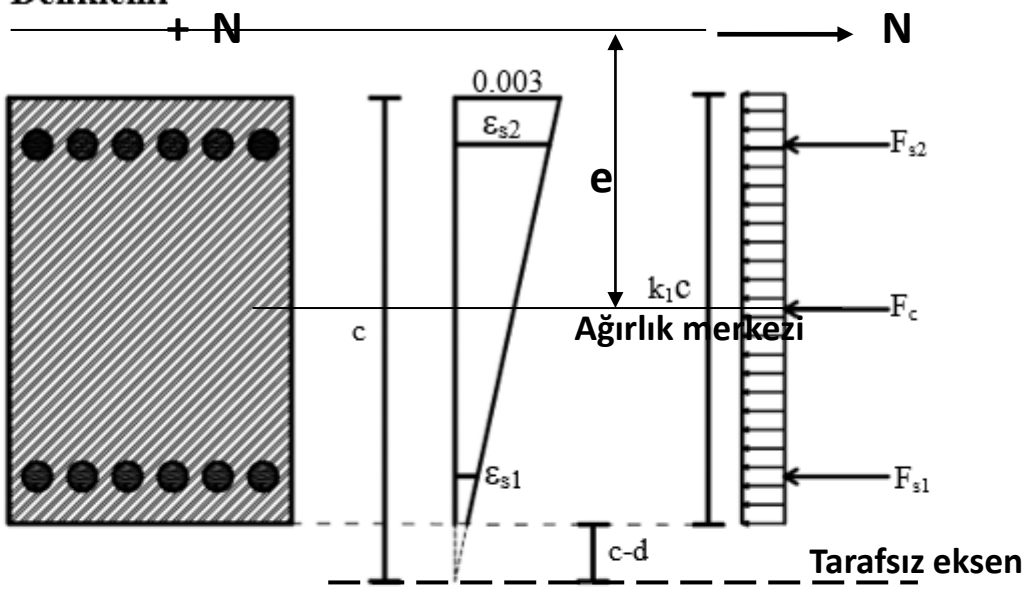
$$N_b = 0.85 f_{cd} k_1 c_b b_w + A_{s2} f_{yd} - A_{s1} f_{yd}$$

$$= 0.85 * 13 * 216.7 * 300 * 10^{-3} + 900 * 365 - 1200 * 365 = 608.8\ kN$$

$N_b < N_d$ *olduğundan basınç kırılmasıdır.*

$$\sigma_{s2} = f_{yd} \qquad \sigma_{s1} < f_{yd}$$

Denge Denklemi



$$N = F_c + F_{s2} + F_{s1}$$

$$750 * 10^3 = 0.85 * 13 * k_1c * 300 + 900 * 365 + 1200 * 600 * \left(\frac{c - 410}{c} \right)$$

$$0 = 2818c^2 + 298500c - 295200000$$

$$c = 275\ mm$$

$$k_1c = 233.76\ mm$$

$$\sigma_{s1} = 600 * \left(\frac{275 - 410}{275} \right) = -294.51\ MPa$$

Taşıma Gücü Momenti

$$M_r = 0.85 f_{cd} k_1 c b_w \left(\frac{h}{2} - \frac{k_1 c}{2} \right) + F_2 \left(\frac{d''}{2} \right) + F_1 \left(\frac{d''}{2} \right)$$

$$= 0.85 * 13 * 233.76 * 300 \left(\frac{450}{2} - \frac{233.76}{2} \right) + 900 * 365 * \left(\frac{410}{2} \right) + 1200 * (-294.51) * \left(-\frac{410}{2} \right)$$

$$= 209.94 \ kN.m$$

b)

Kırılma Biçiminin Belirlenmesi

$N_b = 608.8 \ \ kN \qquad N_d = 500 \ \ kN$

$N_b > N_d \quad olduğundan\ çekme\ kırılmasıdır.$

$$\sigma_{s1} = f_{yd}$$

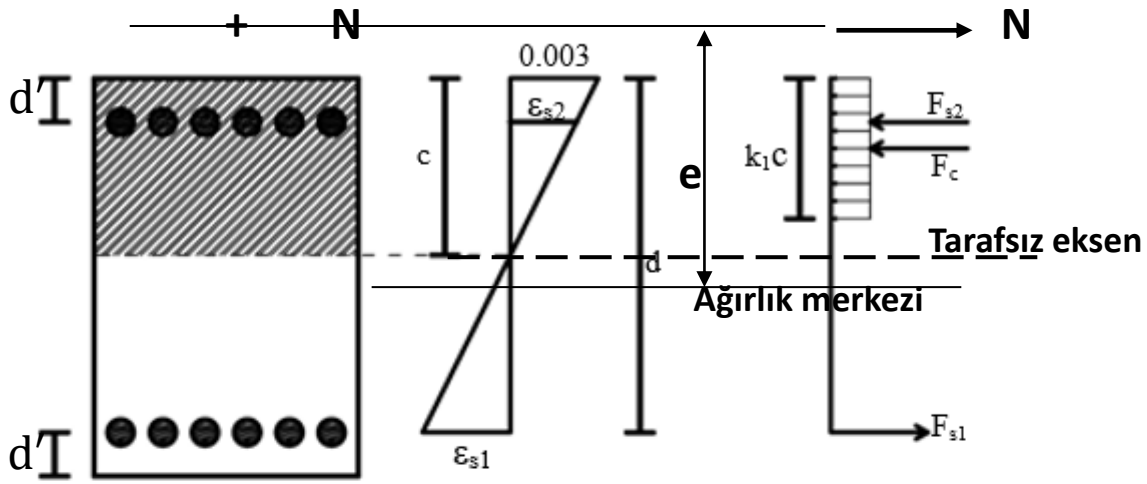
Basınç Donatısının Akıp Akmadığının Kontrolü

$$\Psi_c = 0.72\left(\frac{d'}{h}\right)\frac{0.003E_s}{0.003E_s - f_{yd}} = 0.72\left(\frac{40}{450}\right)\frac{0.003*2*10^5}{0.003*2*10^5 - 365} = 0.163$$

$$\Psi = \frac{N}{bhf_{cd}} = \frac{500000}{300*450*13} = 0.285$$

$\Psi > \Psi_c \ olduğundan\ basınç\ donatısı\ akmıştır.$

Denge Denklemi



$$N = F_c + F_{s2} + F_{s1}$$

$$500 * 10^3 = 0.85 * 13 * 0.85 * c * 300 + 900 * 365 - 1200 * 365$$

$$c = 216.3\ mm$$

$$k_1 c = 183.9\ mm$$

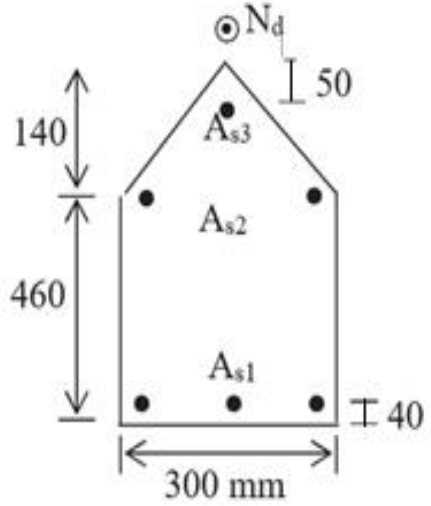
Taşıma Gücü Momenti

$$M_r = 0.85 f_{cd} k_1 c b_w \left(\frac{h}{2} - \frac{k_1 c}{2} \right) + F_2 \left(\frac{d''}{2} \right) + F_1 \left(\frac{d''}{2} \right)$$

$$= 0.85 * 13 * 183.9 * 300 \left(\frac{450}{2} - \frac{183.9}{2} \right) + 900 * 365 * \left(\frac{410}{2} \right) + 1200 * (-365) * \left(-\frac{410}{2} \right)$$

$$= 222.91\ kN.m$$

Soru 5



Şekilde verilen kolona N_d=1150 kN eksenel kuvvet etki etmesi durumunda kolonun;

a) N_b, N_o ve M_b değerlerini hesaplayınız.

b) $N=N_o - \frac{M}{M_b}(N_o - N_b)$ denklemini kullanarak taşıma gücü momentini bulunuz. Malzeme C25, S420.

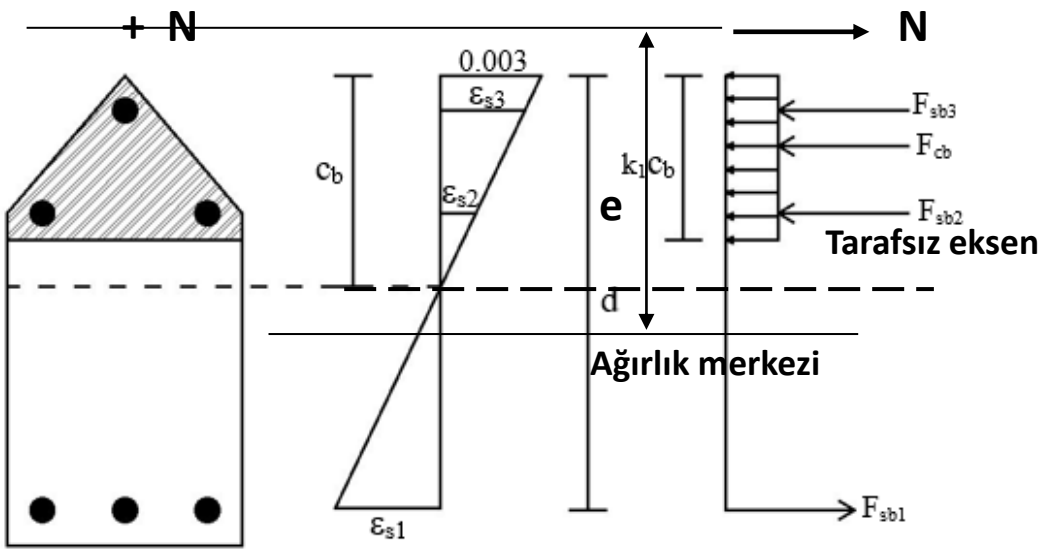
A_{s1}=1245 mm^2, A_{s2}=830 mm^2 ve A_{s3}=415 mm^2.

.

a)

$$N_o = 0.85 f_{cd} A_c + A_{st} f_{yd}$$

$$= 0.85*17*\left(\frac{140*300}{2} + 300*460\right) + 2490*365 = 3206.4 \ \ kN$$



$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$\frac{c_b}{d - c_b} = \frac{0.003}{0.001825} \quad \rightarrow \quad c_b = 348.2 \ mm$$

$$k_1 c_b = 295.96 \ mm$$

$$-\varepsilon_{si} = 0.003 \frac{x_p - c_b - x_i}{c_b}$$

$$x_p = \frac{\left(\frac{140*300}{2} * \frac{2}{3} * 140\right) + \left(460*300*\left(\frac{460}{2} + 140\right)\right)}{\frac{140*300}{2} + 460*300} = 333.46\ mm$$

$$\varepsilon_3 = -0.003 \frac{333.46 - 348.2 - 283.46}{348.2} = 0.0026 > \varepsilon_{sy} \rightarrow \sigma_3 = 365\ MPa$$

$$\varepsilon_2 = -0.003 \frac{333.46 - 348.2 - 193.46}{348.2} = 0.0018 < \varepsilon_{sy} \rightarrow \sigma_2 = 360\ MPa$$

$$\varepsilon_1 = -0.003 \frac{333.46 - 348.2 - (-226.54)}{348.2} = -0.00182 \cong \varepsilon_{sy} \rightarrow \sigma_1 = -365\ MPa$$

$$N_b = 0.85 f_{cd} A_{ccb} + A_{s3}\sigma_3 + A_{s2}\sigma_2 + A_{s1}\sigma_1$$

$$= 0.85*17*\left(\frac{140*300}{2} + 300*(295.97 - 140)\right) + 415*365 + 830*360 + 1245*(-365) = 975.43kN$$

$$\bar{x} = \frac{\left[\left(\frac{140*300}{2}*\frac{2}{3}*140\right)\right]+\left((295.97-140)*300*\left(140+\frac{(295.97-140)}{2}\right)\right)}{67791}$$

$$\bar{x} = 179.37\ mm$$

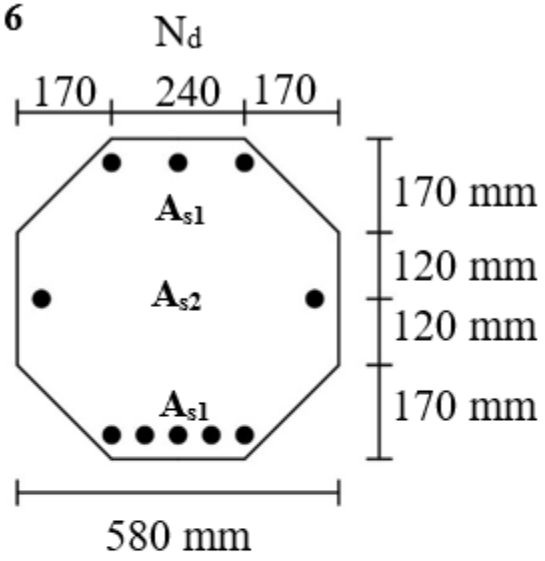
$$M_b = 0.85 f_{cd} A_{ccb}\left(x_p - \bar{x}\right) + \sum_{i=1}^{n} A_{si}\sigma_{si}x_i$$

$$= 0.85 \times 17 \times 67791 \times (333.46 - 179.37)$$
$$+1245 \times (-365) \times \{-(560 - 333.46)\} + 830 \times 360 \times (333.46 - 140) +$$
$$415 \times 365 \times (333.46 - 50) = 354.63\ kNm$$

$$N = N_o - \frac{M}{M_b}(N_o - N_b) \quad \Rightarrow \quad 1150 = 3206.4 - \frac{M}{354.63}(3206.4 - 975.43)$$

$$M = 326.9\ kNm$$

Soru 6



Şekilde verilen kolona N_d=1500 kN eksenel kuvvet etkidiğine göre;

a) Deneme yanılma yöntemiyle
b) Ara donatı olmadan deneme yanılma yöntemiyle
c) Ara donatı olmadan temel denklemleri kullanarak

d) $N = N_0 - \frac{M}{M_b}(N_0 - N_b)$ yaklaşık denklemini kullanarak ara donatı olmadan kolonun taşıma gücü momentini hesaplayınız.

C20-S420 Paspayı= 40 mm

(A_{s1}=770 mm² A_{s2}=308 mm² A_{s3}=462 mm²)

$x_p = 290\ mm$

$x_3 = 250\ mm$

$x_2 = 0\ mm$

$x_1 = -250\ mm$

a) 1.İterasyon

$$x_p = 290\ mm$$
$$x_3 = 250\ mm$$
$$x_2 = 0\ mm$$
$$x_1 = -250\ mm$$

c=170 cm, k_1c=144.50 cm

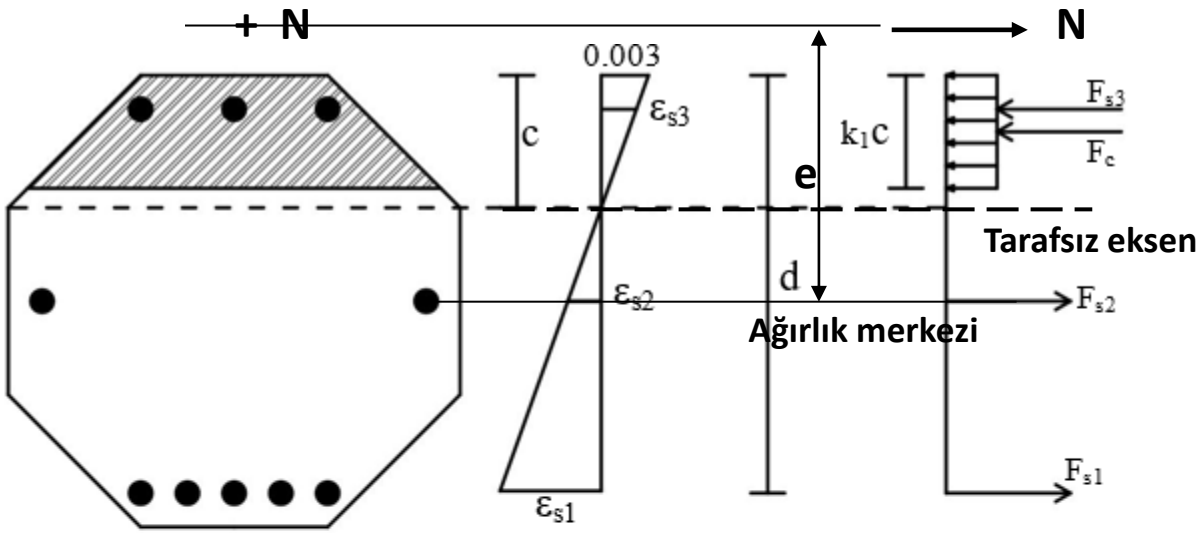
$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$-\varepsilon_{si} = 0.003\frac{x_p - c - x_i}{c}$$

$$\varepsilon_3 = -0.003\frac{290-170-250}{170} = 0.00229 > \varepsilon_{sy} \rightarrow \sigma_3 = 365\ MPa$$

$$\varepsilon_2 = -0.003\frac{290-170-0}{170} = -0.00212 > \varepsilon_{sy} \rightarrow \sigma_2 = -365\ MPa$$

$$\varepsilon_1 = -0.003\frac{290-170-(-250)}{170} = -0.00653 > \varepsilon_{sy} \rightarrow \sigma_1 = -365\ MPa$$



$$A_{cc} = k_1 c * 240 + 2 * \frac{k_1 c * k_1 c}{2} = 144.5 * 240 + 2 * \frac{144.5 * 144.5}{2} = 55560.25 \ mm^2$$

$$\sum F = 0 \ \rightarrow \ 0 = 0.85 f_{cd} A_{cc} + F_{s1} + F_{s2} + F_{s3} - N_d$$

$$0 = 0.85 * 13 * 55560.25 + 770 * (-365) + 308 * (-365) + 462 * (365) - 1500 * 10^3$$

$$0 \neq -1110809 \quad c \ büyütülmeli$$

2.İterasyon

c=340 cm, k_1c=289 cm

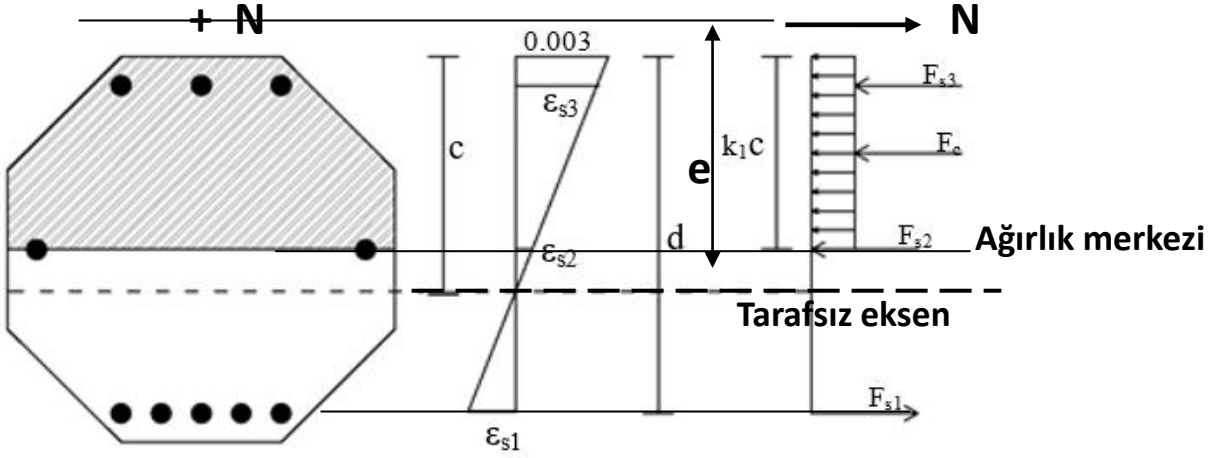
$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$-\varepsilon_{si} = 0.003\frac{x_p - c - x_i}{c}$$

$$\varepsilon_3 = -0.003\frac{290-340-250}{340} = 0.00265 > \varepsilon_{sy} \rightarrow \sigma_3 = 365\ MPa$$

$$\varepsilon_2 = -0.003\frac{290-340-0}{340} = 0.00044 > \varepsilon_{sy} \rightarrow \sigma_2 = 0.00044*2*10^5 = 88\ MPa$$

$$\varepsilon_1 = -0.003\frac{290-340-(-250)}{340} = -0.00176 < \varepsilon_{sy} \rightarrow \sigma_1 = -0.00176*2*10^5 = -353\ MPa$$

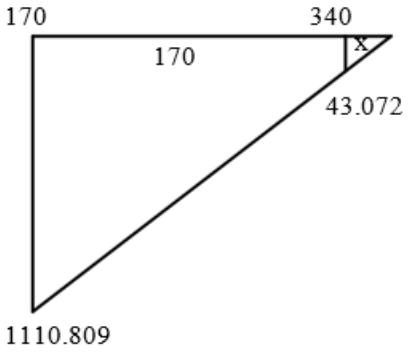


$$A_{cc}=\left(\frac{580+240}{2}*170\right)+(k_1c-170)*580=\left(\frac{580+240}{2}*170\right)+(289-170)*580=138720\ mm^2$$

$$\sum F=0 \ \rightarrow \ 0=0.85f_{cd}A_{cc}+F_{s1}+F_{s2}+F_{s3}-N_d$$

$$0=0.85*13*138720+770*(-353)+308*(88)+462*(365)-1500*10^3$$

$$0\neq -43072 \quad c \ büyütülmeli$$

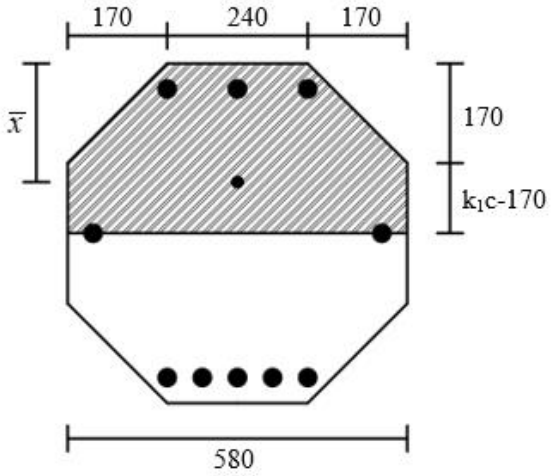


$$\frac{x}{170+x}=\frac{43072}{1110809} \ \rightarrow \ x=6.85\ mm$$

$$c=346.85\ mm$$

c=340≅346.85 olduğundan 340 mm ile devam edilebilir.

Taşıma Gücü Momenti



$$\bar{x} = \frac{\left[2*\left(\frac{170*170}{2}*\frac{2}{3}*170\right)\right]+\left(240*170*\frac{170}{2}\right)+\left(580*119*\left(170+\frac{119}{2}\right)\right)}{138720}$$

$$\bar{x} = 162.8\ mm$$

$$M_r = 0.85 f_{cd} A_{cc}\left(x_p - \bar{x}\right) + \sum_{i=1}^{n} A_{si}\sigma_{si}x_i$$

$$= 0.85*13*1532856\left(290-162.8\right)$$

$$+770*(-363)*\left(-250\right)+308*88*\left(0\right)+462*365*250$$

$$= 305\ kN.m$$

b) 1.İterasyon

c=170 cm, k_1c=144.50 cm

$$\varepsilon_s = \varepsilon_{sy} = \frac{f_{yd}}{E_s} = \frac{365}{200000} = 0.001825$$

$$-\varepsilon_{si} = 0.003\frac{x_p - c - x_i}{c}$$

$$\varepsilon_3 = -0.003\frac{290-170-250}{170} = 0.00229 > \varepsilon_{sy} \quad \rightarrow \quad \sigma_3 = 365\ MPa$$

$$\varepsilon_1 = -0.003\frac{290-170-(-250)}{170} = -0.00653 > \varepsilon_{sy} \quad \rightarrow \quad \sigma_1 = -365\ MPa$$

$$A_{cc} = k_1c * 240 + 2 * \frac{k_1c * k_1c}{2} = 144.5 * 240 + 2 * \frac{144.5 * 144.5}{2} = 55560.25\ mm^2$$

$$\sum F = 0 \ \rightarrow \ 0 = 0.85 f_{cd} A_{cc} + F_{s1} + F_{s3} - N_d$$

$$0 = 0.85 * 13 * 55560.25 + 770 * (-365) + 462 * (365) - 1500 * 10^3$$

$$0 \neq -998434 \ \ c \ büyütülmeli$$

2.İterasyon

c=340 cm, k_1c=289 cm

$$\varepsilon_3 = -0.003\frac{290-340-250}{340} = 0.00265 > \varepsilon_{sy} \rightarrow \sigma_3 = 365\ MPa$$

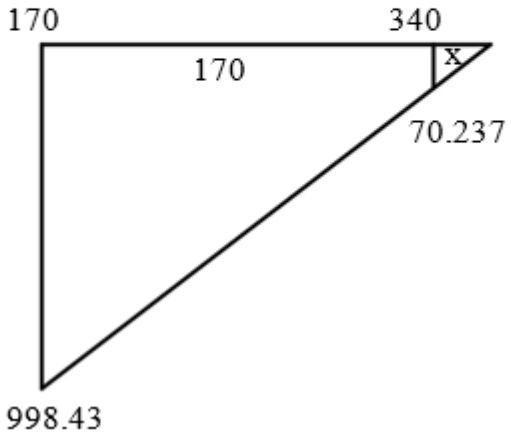
$$\varepsilon_1 = -0.003\frac{290-340-(-250)}{340} = -0.00176 < \varepsilon_{sy} \rightarrow \sigma_1 = -0.00176*2*10^5 = -353\ MPa$$

$$A_{cc} = \left(\frac{580+240}{2}*170\right)+(k_1c-170)*580 = \left(\frac{580+240}{2}*170\right)+(289-170)*580 = 138720\ mm^2$$

$$\sum F = 0 \rightarrow 0 = 0.85 f_{cd} A_{cc} + F_{s1} + F_{s3} - N_d$$

$$0 = 0.85*13*138720 + 770*(-353) + 462*(365) - 1500*10^3$$

$0 \neq -70237$ *c büyütülmeli*



$$\frac{x}{170+x} = \frac{70237}{998434} \rightarrow x = 12.86\ mm$$

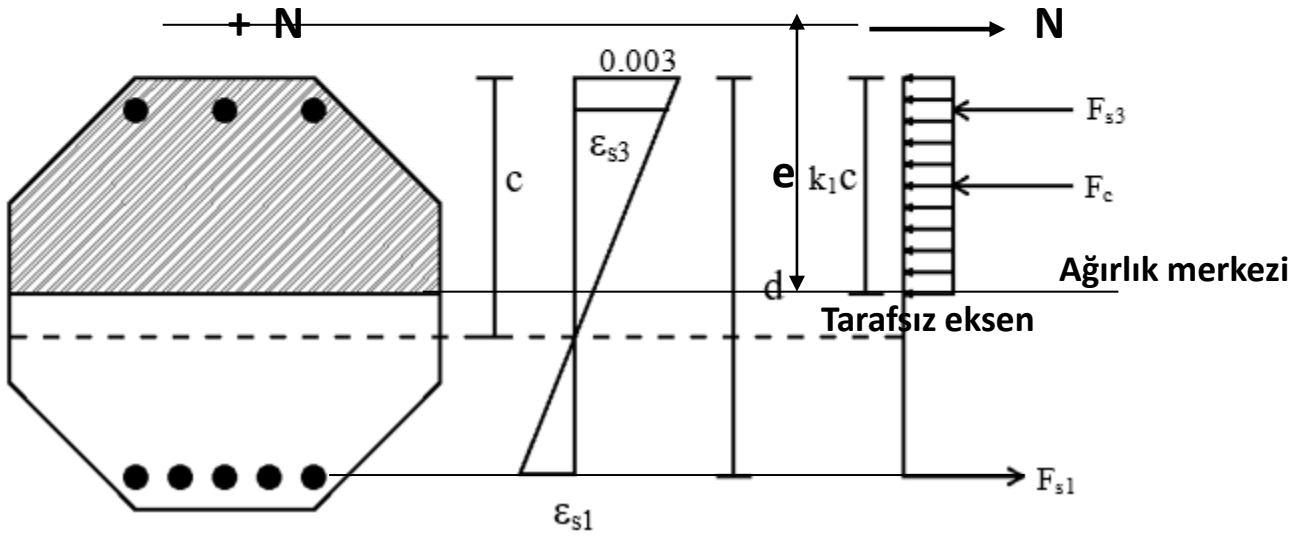
$$c = 352.86\ mm$$

3.İterasyon

c=352.86 cm, k_1c=299.3 cm

$$\varepsilon_3 = -0.003\frac{290-352.86-250}{352.86} = 0.00266 > \varepsilon_{sy} \rightarrow \sigma_3 = 365\ MPa$$

$$\varepsilon_1 = -0.003\frac{290-352.86-(-250)}{352.86} = -0.00159 < \varepsilon_{sy} \rightarrow \sigma_2 = -0.00159*2*10^5 = -318\ MPa$$



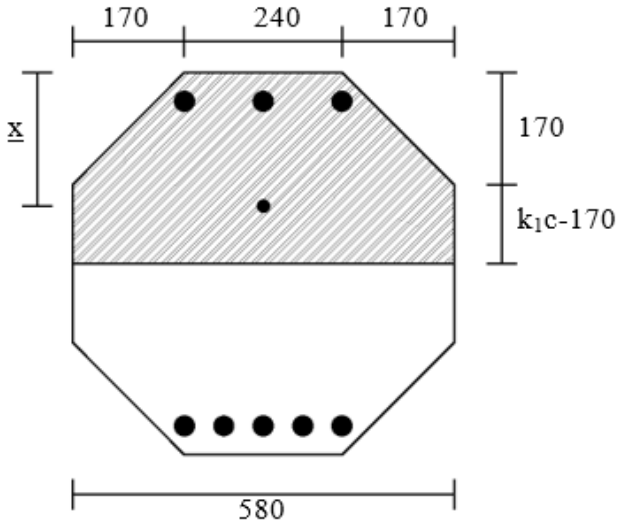
$$A_{cc} = \left(\frac{580+240}{2} * 170 \right) + \left(k_1 c - 170 \right) * 580 = \left(\frac{580+240}{2} * 170 \right) + \left(299.3 - 170 \right) * 580 = 145061 \; mm^2$$

$$\sum F = 0 \;\rightarrow\; 0 = 0.85 f_{cd} A_{cc} + F_{s1} + F_{s2} + F_{s3} - N_d$$

$$0 = 0.85 * 13 * 145061 + 770 * (-318) + 462 * (365) - 1500 * 10^3$$

$$0 \neq 26581 \;\; c \;\; küçültülmeli$$

Taşıma Gücü Momenti



$$\bar{x} = \frac{\left[2*\left(\frac{170*170}{2}*\frac{2}{3}*170\right)\right]+\left(240*170*\frac{170}{2}\right)+\left(580*129.93*\left(170+\frac{129.93}{2}\right)\right)}{145062}$$

$$\bar{x} = 168.6\ mm$$

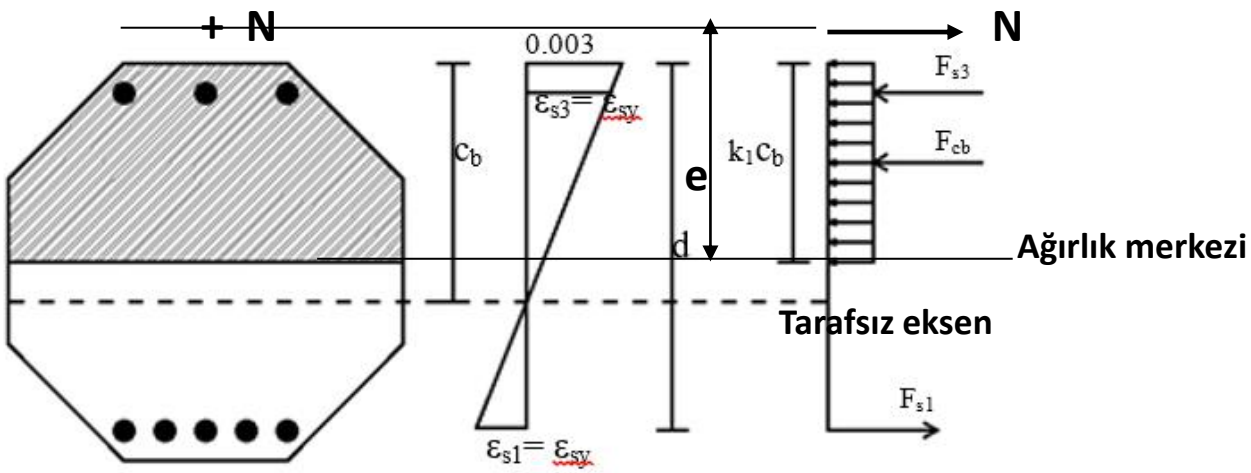
$$M_r = 0.85 f_{cd} A_{cc}\left(x_p - \bar{x}\right) + \sum_{i=1}^{n} A_{si}\sigma_{si}x_i$$

$$= 0.85*13*145062(290-168.6)$$

$$+ 770*(-318.2)*(-250) + 462*365*250$$

$$= 298\ kN.m$$

c)



$$\frac{c_b}{d-c_b}=\frac{0.003}{0.001825} \rightarrow c_b=335.8\,mm$$

$$k_1c_b=285.39\,mm$$

$$A_{ccb} = \left(\frac{580+240}{2} * 170\right) + (k_1 c_b - 170) * 580 = \left(\frac{580+240}{2} * 170\right) + (285.39 - 170) * 580 = 136625.4 \ mm^2$$

$$F_{cb} = 0.85 f_{cd} A_{cc} = 0.85 * 13 * 136625 = 1509711 \ N$$

$$F_{s1} = A_{s1} f_{yd} = 770 * (-365) = -280937 \ N$$

$$F_{s2} = A_{s2} f_{yd} = 462 * (365) = 168562 \ N$$

$$N_b = F_{cb} + F_{s1} + F_{s2} = 1509711 + (-280937) + 168562 = 1397336 < N_d \quad (Basınç\ Kırılması)$$

$$\bar{x}_b = \frac{\left[2 * \left(\frac{170 * 170}{2} * \frac{2}{3} * 170\right)\right] + \left(240 * 170 * \frac{170}{2}\right) + \left(580 * 125.39 * \left(170 + \frac{125.39}{2}\right)\right)}{136625.4}$$

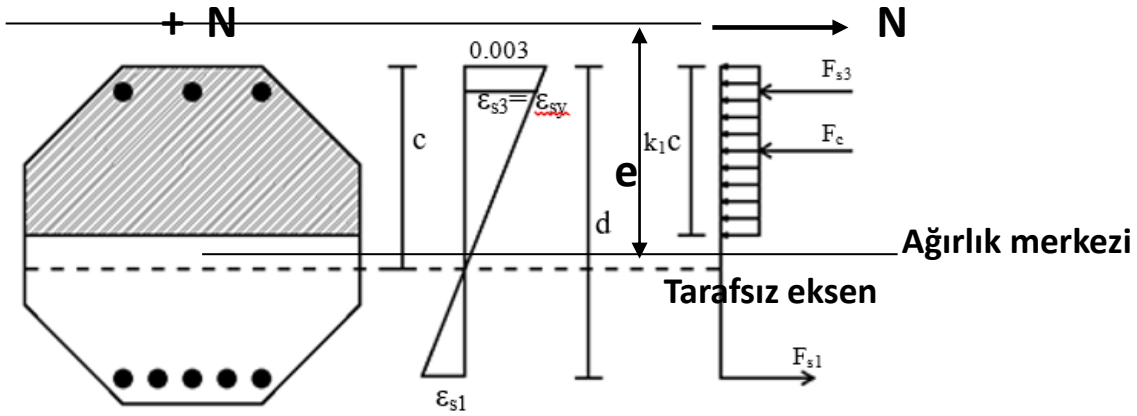
$$\bar{x}_b = 160.89 \ mm$$

$$M_b = 0.85 f_{cd} A_{cc} \left(x_p - \bar{x}\right) + \sum_{i=1}^{n} A_{si} \sigma_{si} x_i$$

$$= 0.85 * 13 * 136625.4 (290 - 168.6) + 770 * (-365) * (-250) + 462 * 365 * 250$$

$$= 307.3 \ kN.m$$

Denge Denklemi



$$A_{cc} = \left(\frac{580+240}{2} * 170\right) + (k_1 c - 170) * 580$$

$$F_c = 0.85 f_{cd} A_{cc} = 0.85 * 13 * \left[\left(\frac{580+240}{2} * 170\right) + (k_1 c - 170) * 580\right]$$

$$F_{s1} = A_{s1} f_{yd} = 770 * 600 * \left(\frac{c-540}{c}\right)$$

$$F_{s2} = A_{s2} f_{yd} = 462 * (365) = 168562\ N$$

$$\sum F = 0$$

$$F_{cb} + F_{s1} + F_{s2} - N_d = 0$$

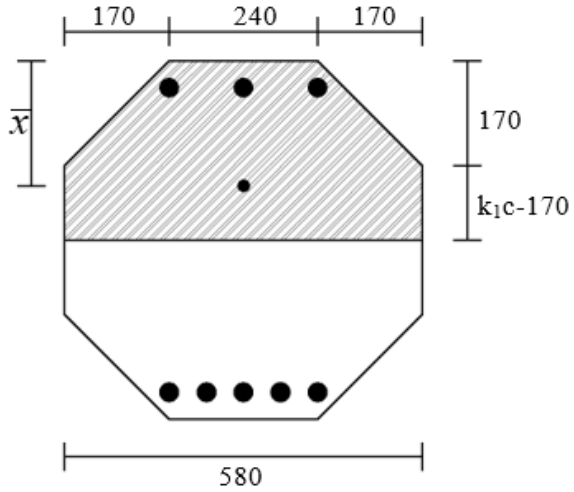
$$0.85 f_{cd} A_{cc} = 0.85 * 13 * \left[\left(\frac{580+240}{2} * 170\right) + (k_1 c - 170) * 580\right]$$

$$+ 770 * 600 * \left(\frac{c-540}{c}\right) + 168562 - 1500 * 10^3 = 0$$

$$5447.65 c^2 - 1188969 c - 249379625 = 0$$

$$c = 349.31 mm$$

$$k_1 c = 296.91 mm$$



$$\sigma_{s1} = 600 * \left(\frac{c - 540}{c} \right) = 600 * \left(\frac{349.3 - 540}{349.3} \right) = -327.6\ MPa$$

$$F_{s1} = A_{s2}\sigma_{s1} = 770 * (-327.6) = -252115\ N$$

$$F_{s2} = A_{s2} f_{yd} = 462 * (365) = 168562\ N$$

$$A_{cc} = \left(\frac{580 + 240}{2} * 170 \right) + (296.91 - 170) * 580 = 143308$$

$$F_c = 0.85 f_{cd} A_{cc} = 0.85 * 13 * 143308 = 1583552\ N$$

$$\bar{x} = \frac{\left[2*\left(\frac{170*170}{2}*\frac{2}{3}*170\right)\right]+\left(240*170*\frac{170}{2}\right)+\left(580*126.91*\left(170+\frac{126.91}{2}\right)\right)}{143308}$$

$$\bar{x} = 166.97\ mm$$

$$M_r = 0.85 f_{cd} A_{cc}\left(x_p - \bar{x}\right) + \sum_{i=1}^{n} A_{si}\sigma_{si}x_i$$

$$= 0.85*13*143308\left(290-166.97\right) + 770*(-327.6)*\left(-250\right) + 462*365*250$$

$$= 300\ kN.m$$

d)

$$N = N_o - \frac{M}{M_b}(N_o - N_b)$$

$$N = 1500\ kN$$

$$N_b = 1397.336\ kN$$

$$N_o = 0.85 f_{cd} A_c + A_{st} f_{yd}$$

$$= 0.85*13*(580*580 - 4*\frac{170*170}{2}) + 1232*365 = 3528.029\ kN$$

$$M_b = 307.3\ kN.m$$

$$N = N_o - \frac{M}{M_b}(N_o - N_b) \quad \Rightarrow \quad 1500 = 3528 - \frac{M}{307.3}(3528 - 1397.3)$$

$$M = 292\ kN.m$$

Excel_1

Excel_2