YAPI STATİĞİ 2

DERS NOTLARI(2-4.1)

Sürekli Kirişlerin Clapeyron Denklemleri İle Çözümü

Üç Moment Denklemleri

Güncelleme:20.04.2024

Prof. Dr. Cengiz Dündar

SÜREKLİ KİRİŞLER

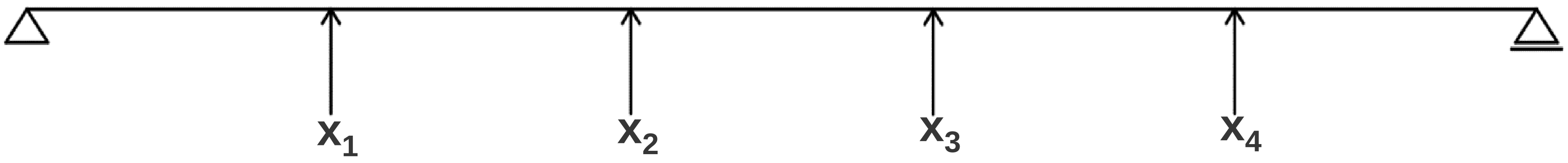
n+1-3=n-2 sistemin hiperstatiklik derecesi 7-3=4

n+2-3=n-1
8-3=5

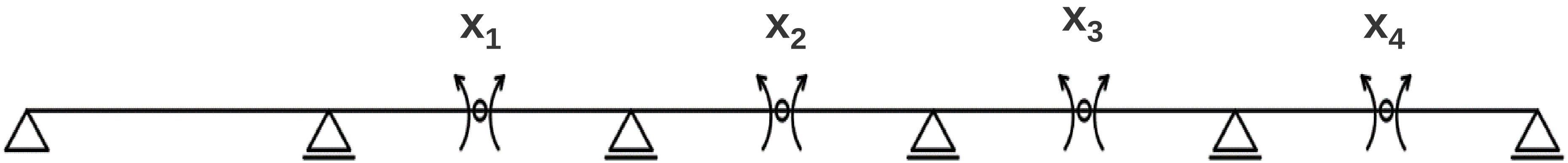
Kenar mesnetlerinden biri sabit veya ankastre olan ara mesnetleri de kayıcı olan dolu gövdeli doğru eksenli sistemlere sürekli kiriş denir. Sürekli bir kirişte hiperstatiklik derecesi ara mesnet sayısına eşittir.

İZOSTATİK ESAS SİSTEM VE BİLİNMEYENLERİN SEÇİMİ

İzostatik esas sistem mesnetler üzerindeki eğilme momentleri kaldırılacak şekilde yapılan kesimler ile elde edilir. Bu suretle elde edilen İzostatik esas sistem yan yana gelmiş basit kirişlerden meydana gelir.

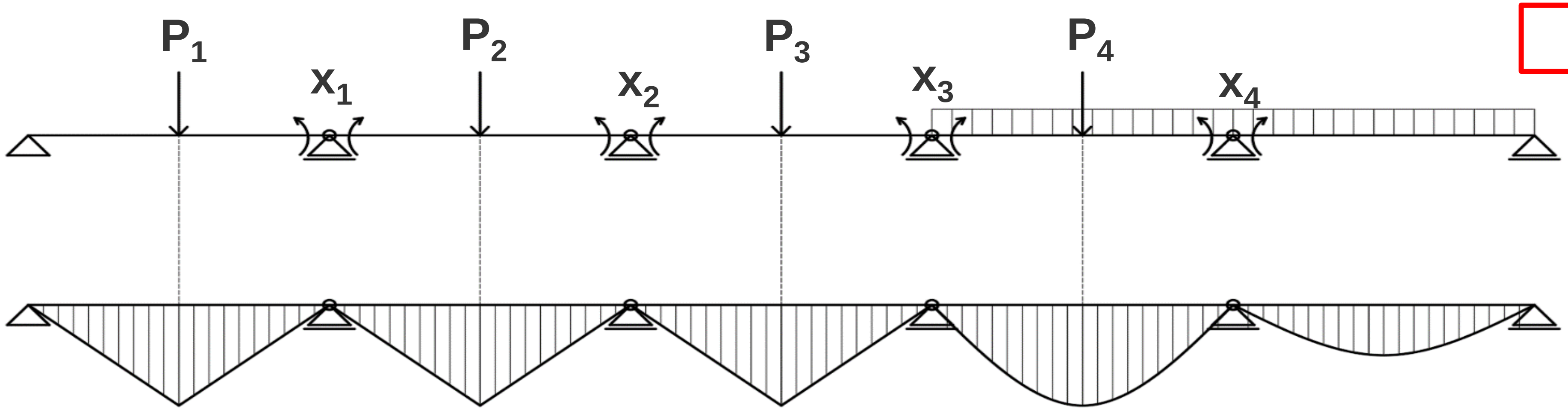


İzostatik esas sistem



İzostatik esas sistem

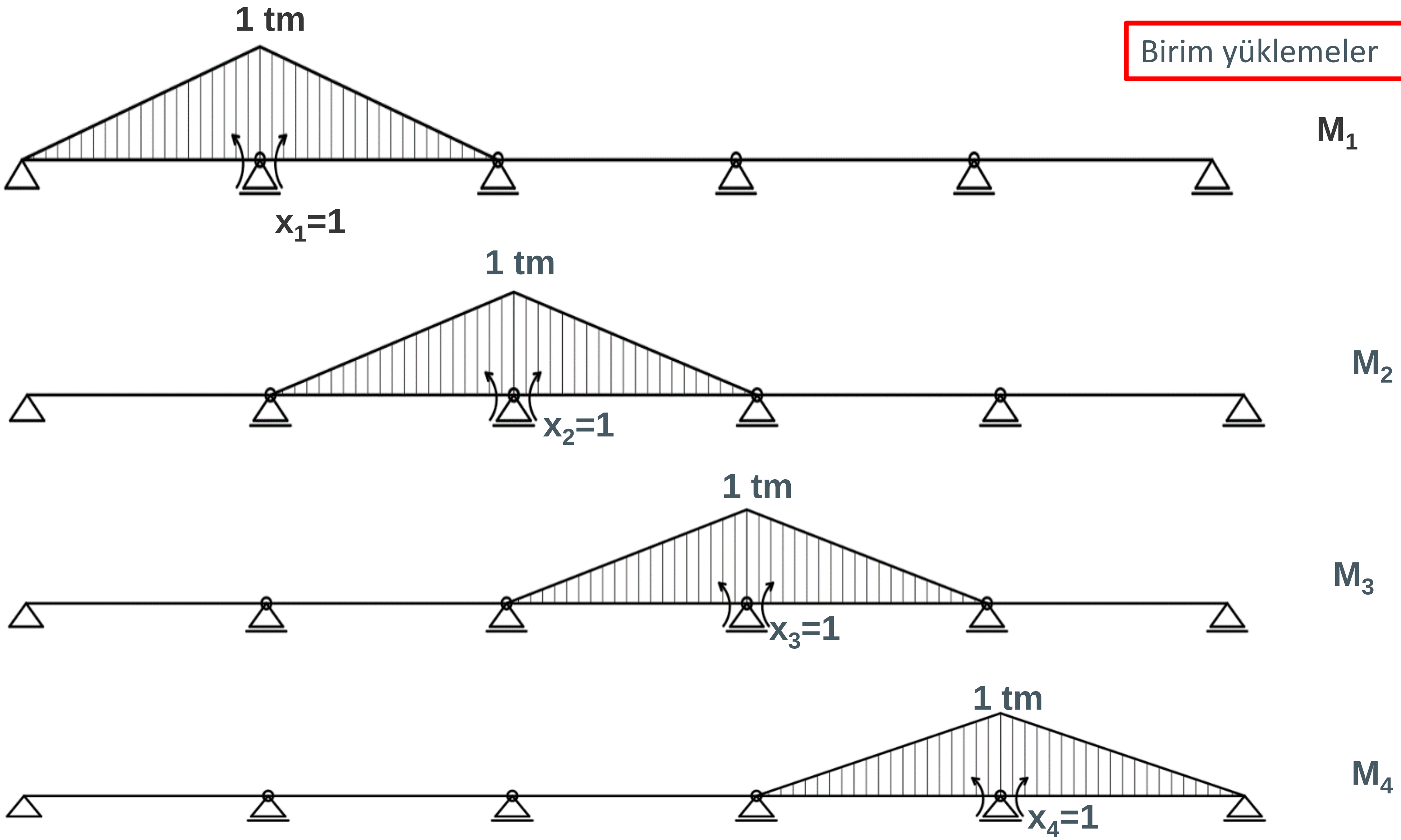
Dış yük



En uygun izostatik esas sistem

M_0

Birim yüklemeler



Her ara mesnet için süreklilik denklemi yazılır

$$\delta_{11}X_1 + \delta_{12}X_2 + 0 * X_3 + 0 * X_4 + \delta_{10} = 0$$

$$\delta_{21}X_1 + \delta_{22}X_2 + \delta_{23}X_3 + 0 * X_4 + \delta_{20} = 0$$

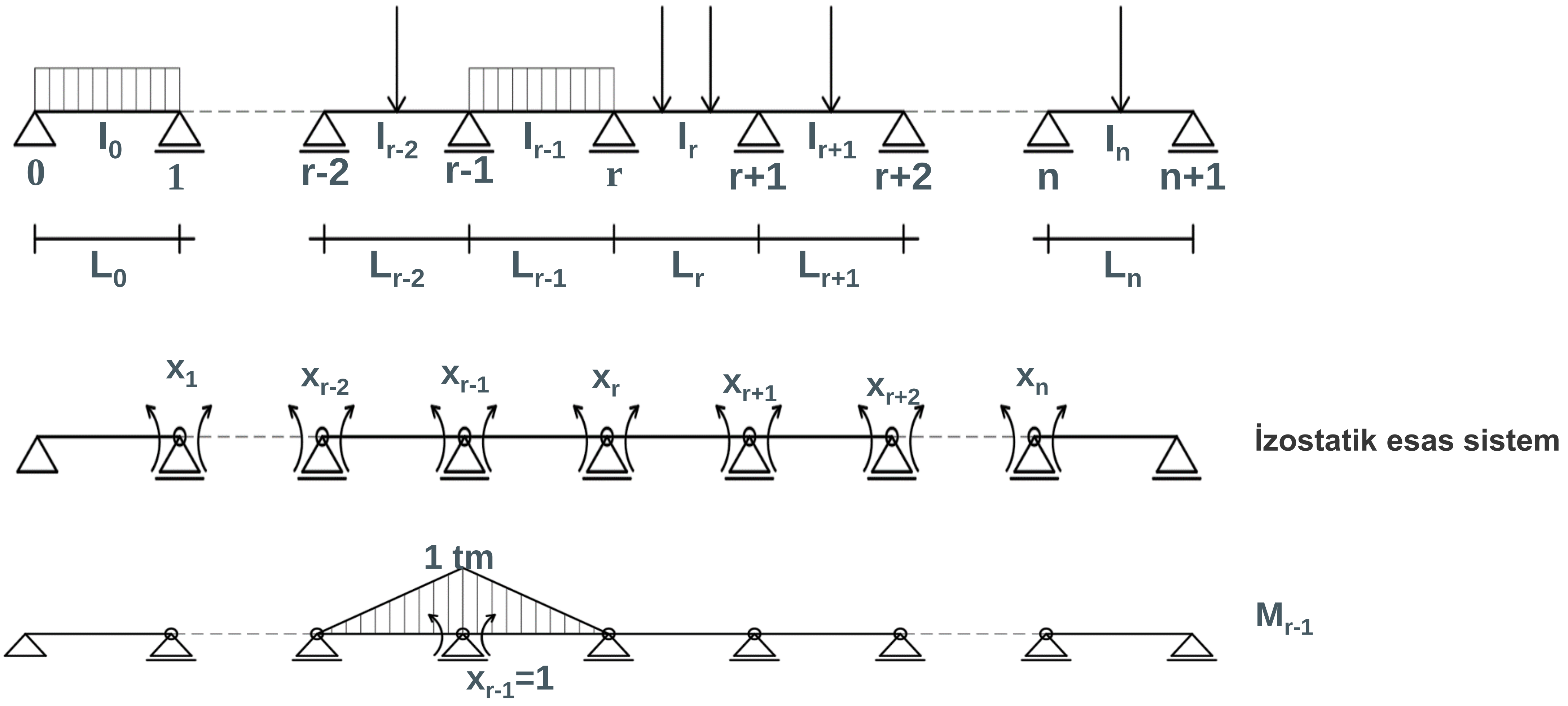
$$0 * X_1 + \delta_{32}X_2 + \delta_{33}X_3 + \delta_{34}X_4 + \delta_{30} = 0$$

$$0 * X_1 + 0 * X_2 + \delta_{43}X_3 + \delta_{44}X_4 + \delta_{40} = 0$$

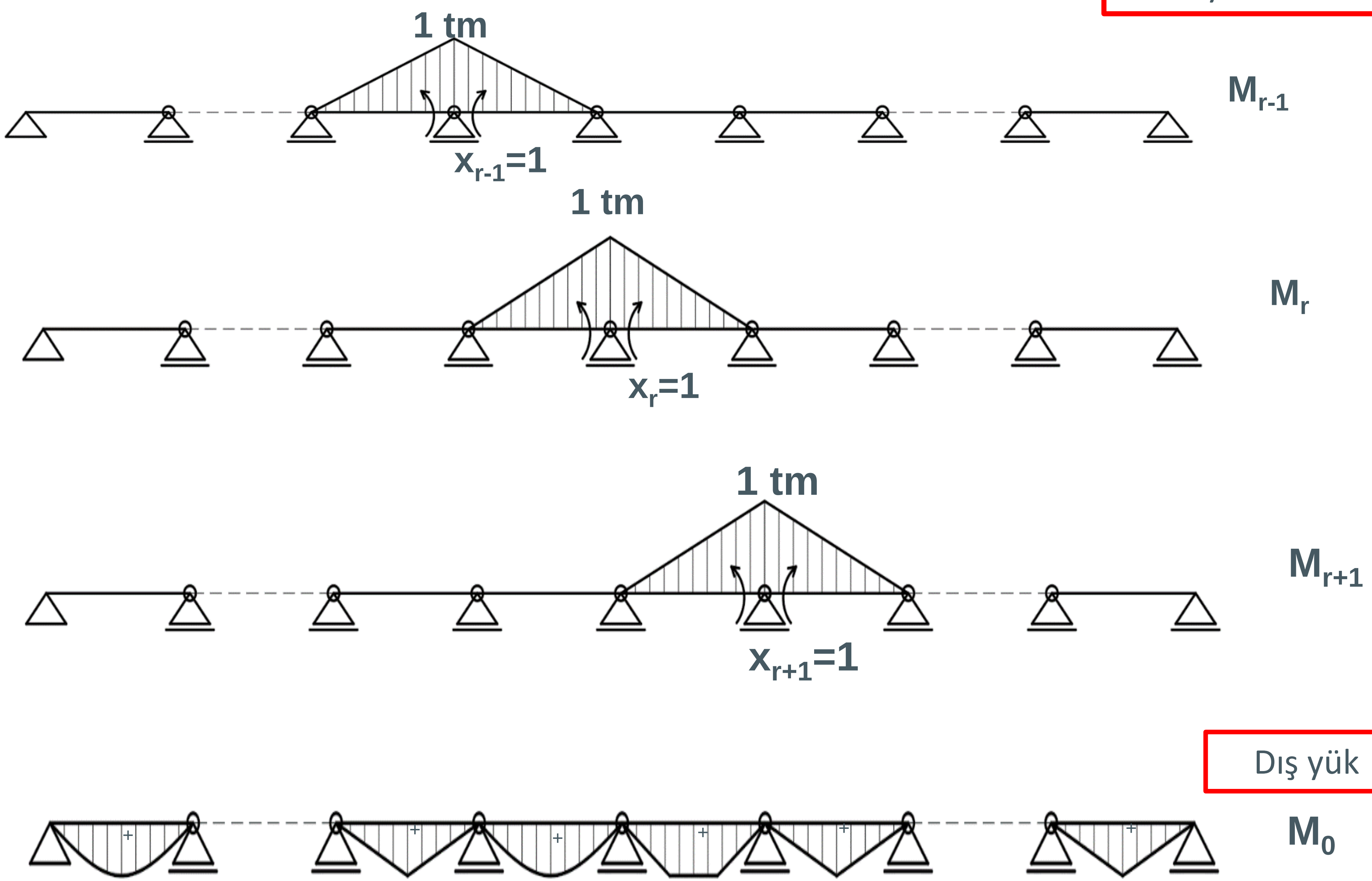
r inci açık süreklilik denklemi

$$\delta_{rr-1}X_{r-1} + \delta_{rr}X_r + \delta_{rr+1}X_{r+1} + \delta_{r0} = 0$$

SÜREKLİ KİRİŞLERİN ÇÖZÜMÜ İÇİN ÜÇ MOMENT DENKLEMLERİ (CLAPEYRON, 1857)



Birim yüklemeler



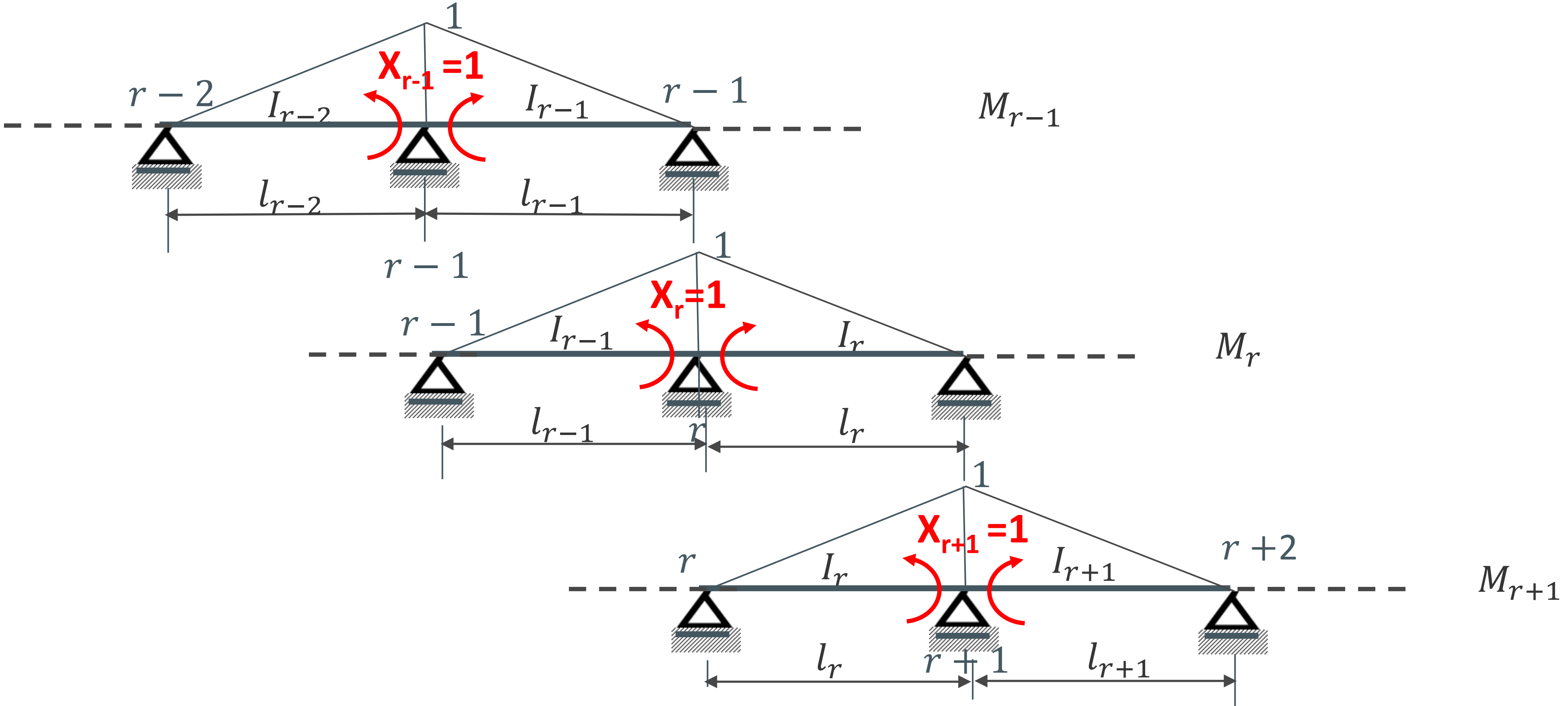
Dış yük

r inci açık süreklilik denklemi

$$\delta_{rr-1} = \int M_r M_{r-1} \frac{ds}{EI} = \frac{1}{6} l_{r-1}(1)(1) \frac{1}{EI_{r-1}} = \frac{1}{6E} \frac{l_{r-1}}{I_{r-1}}$$

$$\delta_{rr} = \int M_r M_r \frac{ds}{EI} = \frac{1}{3} l_{r-1}(1)(1) \frac{1}{EI_{r-1}} + \frac{1}{3} l_r(1)(1) \frac{1}{EI_r} = \frac{1}{6E} 2(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r})$$

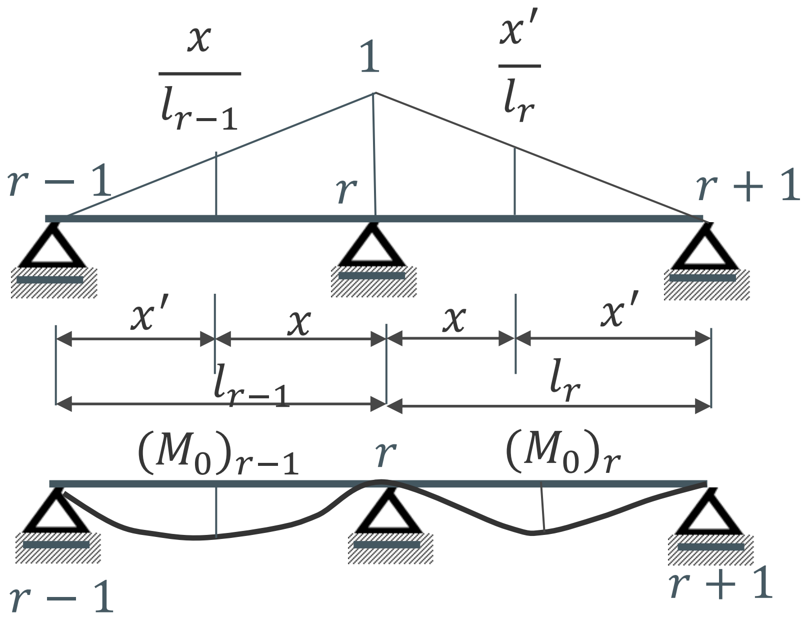
$$\delta_{rr+1} = \int M_r M_{r+1} \frac{ds}{EI} = \frac{1}{6} l_r(1)(1) \frac{1}{EI_r} = \frac{1}{6E} \frac{l_r}{I_r}$$



$$\delta_{r0} = \int M_r M_0 \frac{ds}{EI} = \int (M_0)_{r-1} \frac{x}{l_{r-1}} dx \frac{1}{EI_{r-1}} + \int (M_0)_r \frac{x'}{l_r} dx \frac{1}{EI_r}$$

$$\delta_{r0} = \frac{1}{EI_{r-1}} \frac{1}{l_{r-1}} \int (M_0)_{r-1} x dx + \frac{1}{EI_r} \frac{1}{l_r} \int (M_0)_r x' dx$$

$$\delta_{r0} = \frac{1}{6E} \left[\frac{l_{r-1}}{I_{r-1}} \frac{6}{{l_{r-1}}^2} \int (M_0)_{r-1} x dx + \frac{l_r}{I_r} \frac{6}{{l_r}^2} \int (M_0)_r x' dx \right]$$



$$\delta_{r0} = \frac{1}{6E}\left[\frac{l_{r-1}}{I_{r-1}}\frac{6}{{l_{r-1}}^2}\int (M_0)_{r-1} x dx \; + \frac{l_r}{I_r}\frac{6}{{l_r}^2}\int (M_0)_r x' dx\right]$$

Pay ve payda 1. terim $\frac{6(l_{r-1})}{6(l_{r-1})}$ 2. terim $\frac{6(l_r)}{6(l_r)}$ ile çarpalım

$$\boldsymbol{\mathcal{R}}_{r-1} = \frac{6}{{l_{r-1}}^2}\int (M_0)_{r-1} x dx$$

$$\boldsymbol{\mathcal{L}}_r = \frac{6}{{l_r}^2}\int (M_0)_r x' dx$$

YÜK TERİMLERİ

$$\delta_{r0} = \frac{1}{6E}\left[\frac{l_{r-1}}{I_{r-1}}\boldsymbol{\mathcal{R}}_{r-1} + \frac{l_r}{I_r}\boldsymbol{\mathcal{L}}_r\right]$$

$$\delta_{rr-1} = \frac{1}{6E}\frac{l_{r-1}}{I_{r-1}}$$

$$\delta_{rr} = \frac{1}{6E}2(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r})$$

$$\delta_{rr+1} = \frac{1}{6E}\frac{l_r}{I_r}$$

$$\delta_{r0} = \frac{1}{6E}\left[\frac{l_{r-1}}{I_{r-1}}\mathcal{R}_{r-1} + \frac{l_r}{I_r}\mathcal{L}_r\right]$$

$$\delta_{rr-1}X_{r-1} + \delta_{rr}X_r + \delta_{rr+1}X_{r+1} + \delta_{r0} = 0$$

CLAPEYRON DENKLEMI

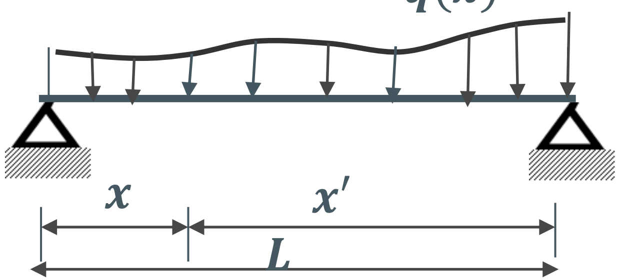
$$\frac{1}{6E}\frac{l_{r-1}}{I_{r-1}}X_{r-1} + \frac{1}{6E}2\left(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r}\right)X_r + \frac{1}{6E}\frac{l_r}{I_r}X_{r+1} + \frac{1}{6E}\left[\frac{l_{r-1}}{I_{r-1}}\mathcal{R}_{r-1} + \frac{l_r}{I_r}\mathcal{L}_r\right] = 0$$

$$\frac{l_{r-1}}{I_{r-1}}X_{r-1} + 2\left(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r}\right)X_r + \frac{l_r}{I_r}X_{r+1} + \left[\frac{l_{r-1}}{I_{r-1}}\mathcal{R}_{r-1} + \frac{l_r}{I_r}\mathcal{L}_r\right] = 0$$

ÜÇ MOMENT DENKLEMİ

Bu moment denklemi bütün mesnetler için yazılır

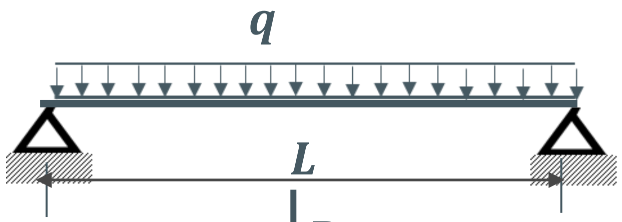
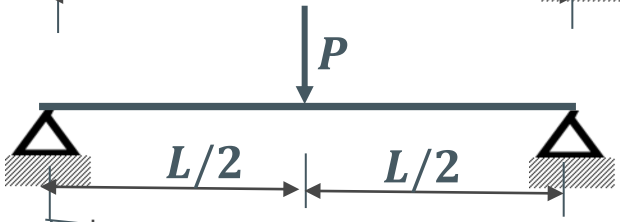
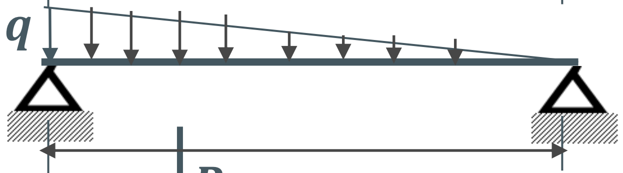
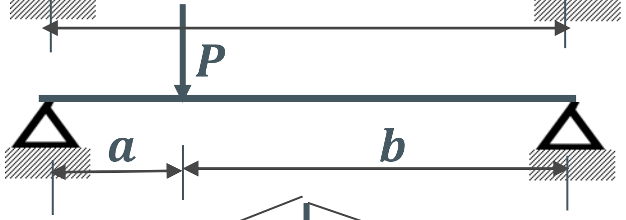
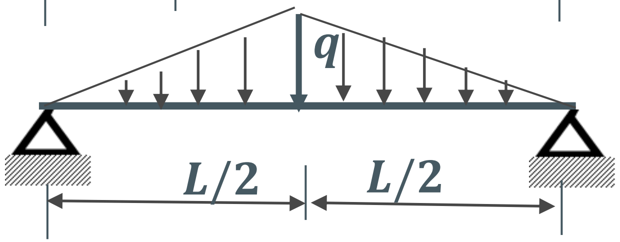
YÜK TERİMLERİ



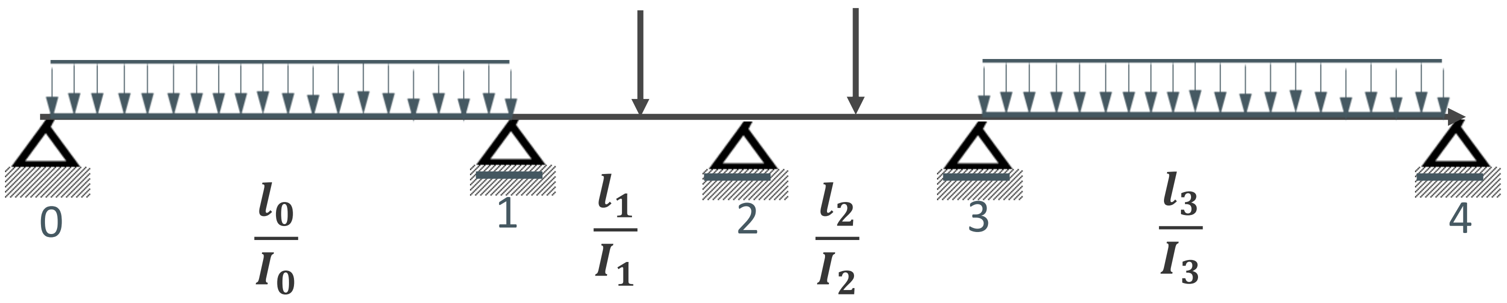
$$\mathcal{L} = \frac{6}{L^2}\int M_0(x)(L-x)dx$$

$$\mathcal{R} = \frac{6}{L^2}\int M_0(x)xdx$$

$$M_0(x) = \frac{ql}{2}x - \frac{qx^2}{2} \;\rightarrow \mathcal{R} = \frac{6}{l^2}\int_0^l M_0(x)xdx = \frac{ql^2}{4}$$

	$\mathcal{L}$	$\mathcal{R}$
	$\frac{ql^2}{4}$	$\frac{ql^2}{4}$
	$\frac{3}{8}PL$	$\frac{3}{8}PL$
	$\frac{8}{60}qL^2$	$\frac{7}{60}qL^2$
	$\frac{Pab(b+L)}{L^2}$	$\frac{Pab(a+L)}{L^2}$
	$\frac{5}{32}qL^2$	$\frac{5}{32}qL^2$

CLAPEYRON DENKLEMLERİNİN UYGULANIŞI



$$\frac{l_{r-1}}{I_{r-1}}X_{r-1}+\ 2\left(\frac{l_{r-1}}{I_{r-1}}+\frac{l_r}{I_r}\right)X_r+\ \frac{l_r}{I_r}X_{r+1}+\ \left[\frac{l_{r-1}}{I_{r-1}}\boldsymbol{\mathcal{R}}_{r-1}+\frac{l_r}{I_r}\boldsymbol{\mathcal{L}}_r\right]=0$$

1 mesnedi için Clapeyron denklemi

$$\frac{l_0}{I_0}X_0 + 2\left(\frac{l_0}{I_0}+\frac{l_1}{I_1}\right)X_1 + \frac{l_1}{I_1}X_2 + \left[\frac{l_0}{I_0}\boldsymbol{\mathcal{R}}_0 + \frac{l_1}{I_1}\boldsymbol{\mathcal{L}}_1\right] = 0$$

2 mesnedi için Clapeyron denklemi

$$\frac{l_1}{I_1}X_1 + 2\left(\frac{l_1}{I_1}+\frac{l_2}{I_2}\right)X_2 + \frac{l_2}{I_2}X_3 + \left[\frac{l_1}{I_1}\boldsymbol{\mathcal{R}}_1 + \frac{l_2}{I_2}\boldsymbol{\mathcal{L}}_2\right] = 0$$

3 mesnedi için Clapeyron denklemi

$$\frac{l_2}{I_2}X_2 + 2\left(\frac{l_2}{I_2}+\frac{l_3}{I_3}\right)X_3 + \frac{l_3}{I_3}X_4 + \left[\frac{l_2}{I_2}\boldsymbol{\mathcal{R}}_2 + \frac{l_3}{I_3}\boldsymbol{\mathcal{L}}_3\right] = 0$$

X_0 X_1 X_2 X_3 X_4

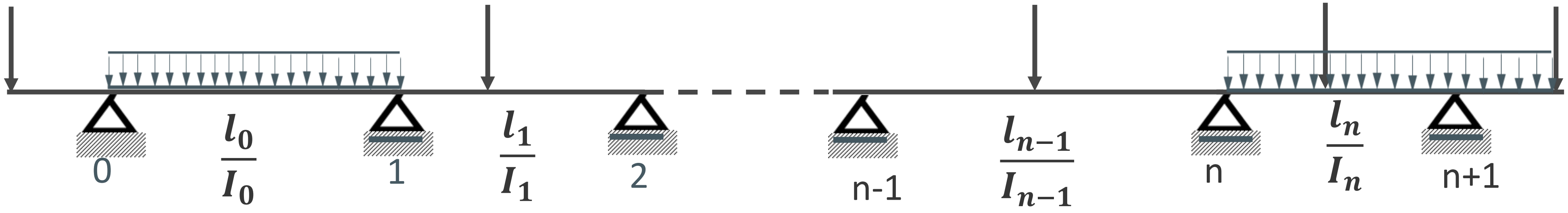
$\frac{l_0}{I_0}$	$\frac{l_1}{I_1}$	$\frac{l_2}{I_2}$	$\frac{l_3}{I_3}$
$\boldsymbol{\mathcal{L}}_0$ $\boldsymbol{\mathcal{R}}_0$	$\boldsymbol{\mathcal{L}}_1$ $\boldsymbol{\mathcal{R}}_1$	$\boldsymbol{\mathcal{L}}_2$ $\boldsymbol{\mathcal{R}}_2$	$\boldsymbol{\mathcal{L}}_3$ $\boldsymbol{\mathcal{R}}_3$
$\frac{l_0}{I_0}\boldsymbol{\mathcal{L}}_0$ $\frac{l_0}{I_0}\boldsymbol{\mathcal{R}}_0$	$\frac{l_1}{I_1}\boldsymbol{\mathcal{L}}_1$ $\frac{l_1}{I_1}\boldsymbol{\mathcal{R}}_1$	$\frac{l_2}{I_2}\boldsymbol{\mathcal{L}}_2$ $\frac{l_2}{I_2}\boldsymbol{\mathcal{R}}_2$	$\frac{l_3}{I_3}\boldsymbol{\mathcal{L}}_3$ $\frac{l_3}{I_3}\boldsymbol{\mathcal{R}}_3$

Kenar mesnetlerde herhangi bir moment yok.

Dolayısıyla X_1 X_2 ve X_3 hesaplanır.

ÖZEL DURUMLAR

1. **Kenar mesnette konsol bulunması hali**



X_0 X_1 X_2 X_{n-1} X_n X_{n+1}

$\frac{l_0}{I_0}$	$\frac{l_1}{I_1}$		$\frac{l_{n-1}}{I_{n-1}}$	$\frac{l_n}{I_n}$
$\mathcal{L}_0$ $\mathcal{R}_0$	$\mathcal{L}_1$ $\mathcal{R}_1$		$\mathcal{L}_{n-1}$ $\mathcal{R}_{n-1}$	$\mathcal{L}_n$ $\mathcal{R}_n$
$\frac{l_0}{I_0}\mathcal{L}_0$ $\frac{l_0}{I_0}\mathcal{R}_0$	$\frac{l_1}{I_1}\mathcal{L}_1$ $\frac{l_1}{I_1}\mathcal{R}_1$		$\frac{l_{n-1}}{I_{n-1}}\mathcal{L}_{n-1}$ $\frac{l_{n-1}}{I_{n-1}}\mathcal{R}_{n-1}$	$\frac{l_n}{I_n}\mathcal{L}_n$ $\frac{l_n}{I_n}\mathcal{R}_n$

Denklem takımları aynen yazılır. X_0 ve X_{n+1} değerleri konsoldan gelen moment olarak yazılır.

1 mesnedi için Clapeyron denklemi

$$\frac{l_0}{I_0}X_0 + 2\left(\frac{l_0}{I_0}+\frac{l_1}{I_1}\right)X_1 + \frac{l_1}{I_1}X_2 + \left[\frac{l_0}{I_0}\boldsymbol{\mathcal{R}}_0 + \frac{l_1}{I_1}\boldsymbol{\mathcal{L}}_1\right] = 0$$

—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—

—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—

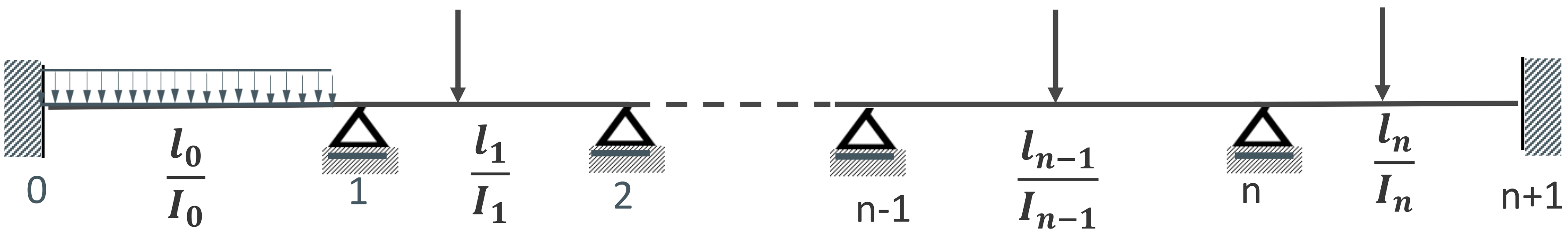
—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—··—

n mesnedi için Clapeyron denklemi

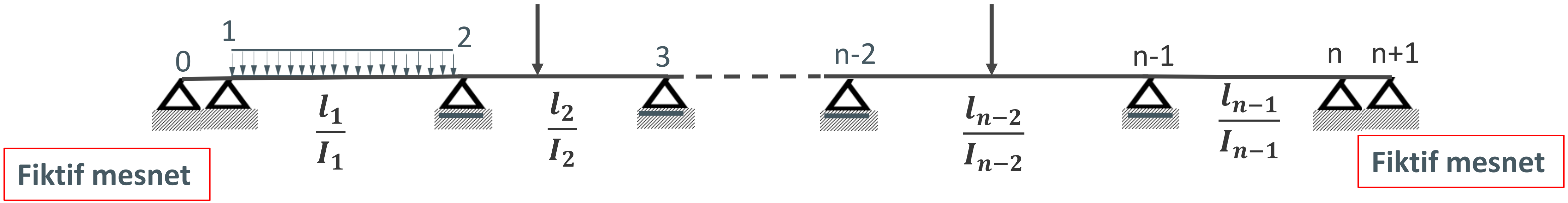
$$\frac{l_{n-1}}{I_{n-1}}X_{n-1} + 2\left(\frac{l_{n-1}}{I_{n-1}}+\frac{l_n}{I_n}\right)X_n + \frac{l_n}{I_n}X_{n+1} + \left[\frac{l_{n-1}}{I_{n-1}}\boldsymbol{\mathcal{R}}_{n-1} + \frac{l_n}{I_n}\boldsymbol{\mathcal{L}}_n\right] = 0$$

X_0 ve X_{n+1} yerine konsol momentleri yazılır.

2. Kenar mesnedin ankastre olması hali



Eş değer sistem



L_0 ve L_n açıklıkları sıfır alınır.

X_0	X_1	X_2	X_{n-1}	X_n	X_{n+1}
$\mathbf{0}$	$\boldsymbol{\frac{l_1}{I_1}}$		$\boldsymbol{\frac{l_{n-1}}{I_{n-1}}}$	$\mathbf{0}$	
0 0	$\mathcal{L}_1$ $\mathcal{R}_1$		$\mathcal{L}_{n-1}$ $\mathcal{R}_{n-1}$	0 0	
0 0	$\frac{l_1}{I_1}\mathcal{L}_1$ $\frac{l_1}{I_1}\mathcal{R}_1$		$\frac{l_{n-1}}{I_{n-1}}\mathcal{L}_{n-1}$ $\frac{l_{n-1}}{I_{n-1}}\mathcal{R}_{n-1}$	0 0	

1. mesnet için Clapeyron denklemi

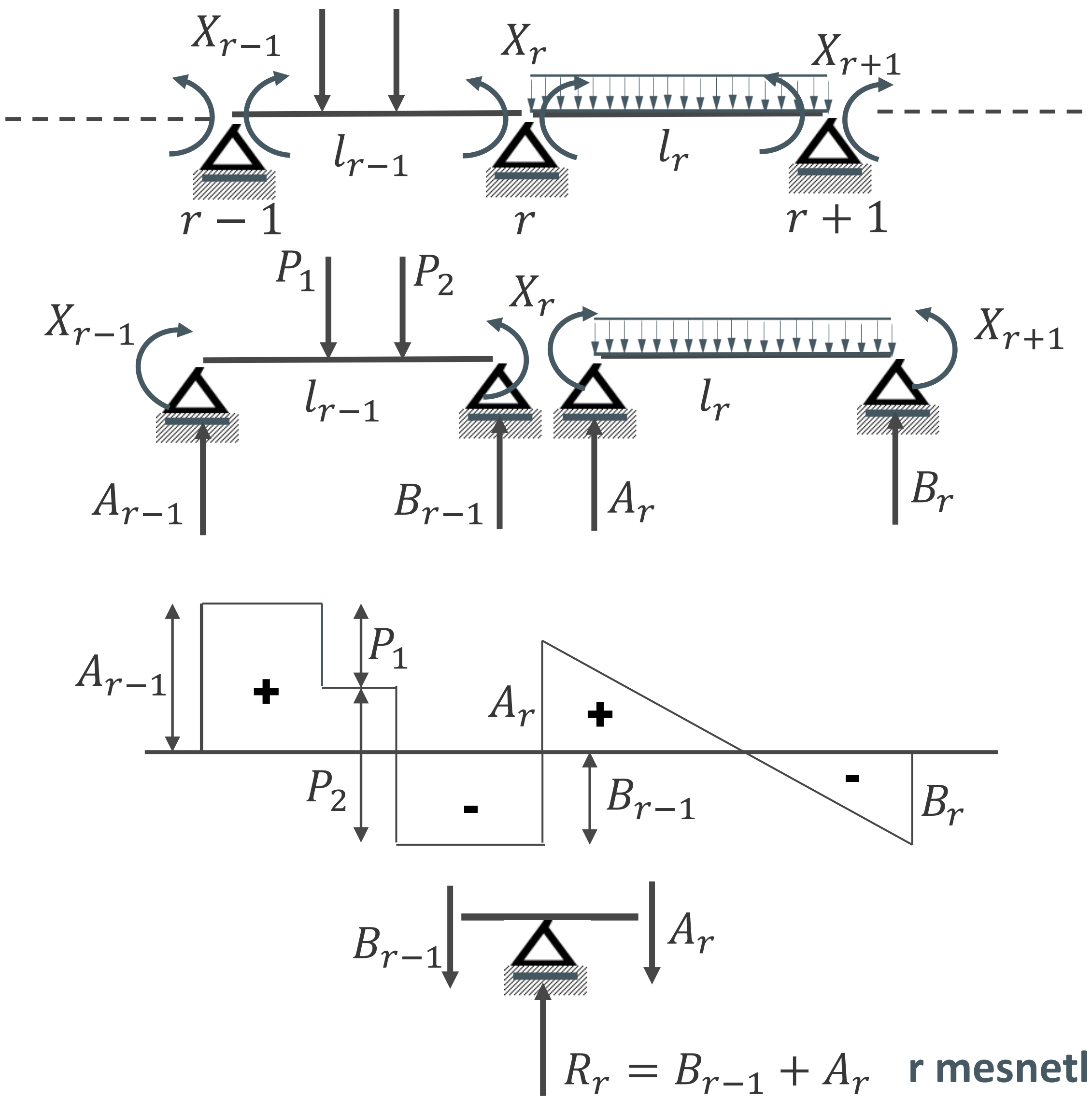
$$0 * X_0 + 2\left(0 + \frac{l_1}{I_1}\right)X_1 + \frac{l_1}{I_1}X_2 + \left[0 * 0 + \frac{l_1}{I_1}\mathcal{L}_1\right] = 0$$

X_1ve X_n ankastre mesnetten gelen moment değeri olur. X_0 = X_{n+1} =0

n. mesnet için Clapeyron denklemi

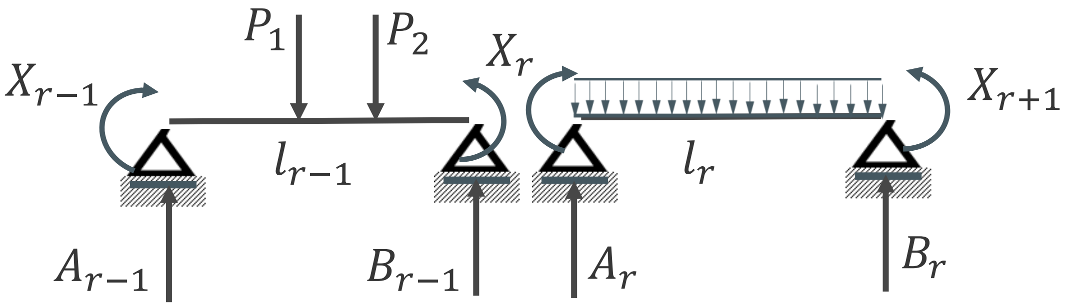
$$\frac{l_{n-1}}{I_{n-1}}X_{n-1} + 2\left(\frac{l_{n-1}}{I_{n-1}} + 0\right)X_n + 0 * X_{n+1} + \left[\frac{l_{n-1}}{I_{n-1}}\mathcal{R}_{n-1} + 0\right] = 0$$

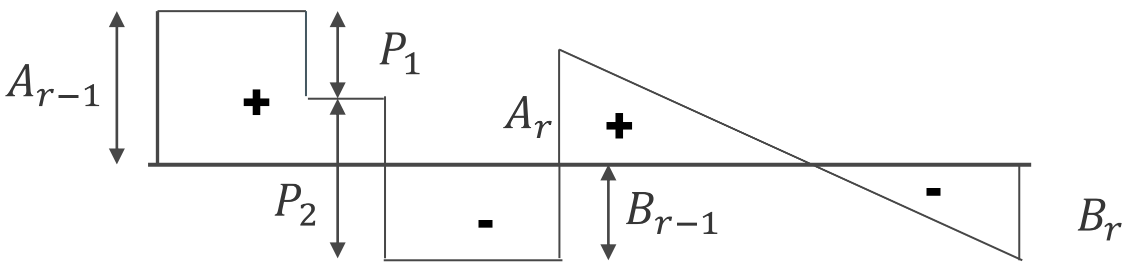
Kesit tesirleri ve mesnet reaksiyonlarının hesaplanması



Xr-1 , Xr , X r+1 tayin edildi

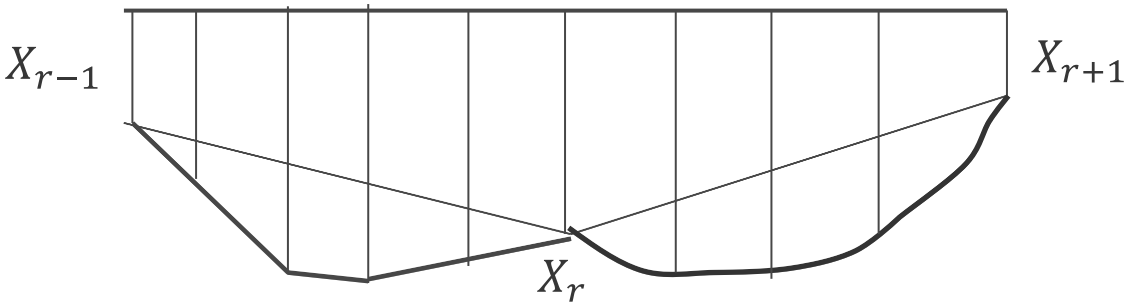
$R_r = B_{r-1} + A_r$ r mesnetlindeki mesnet reaksiyonu



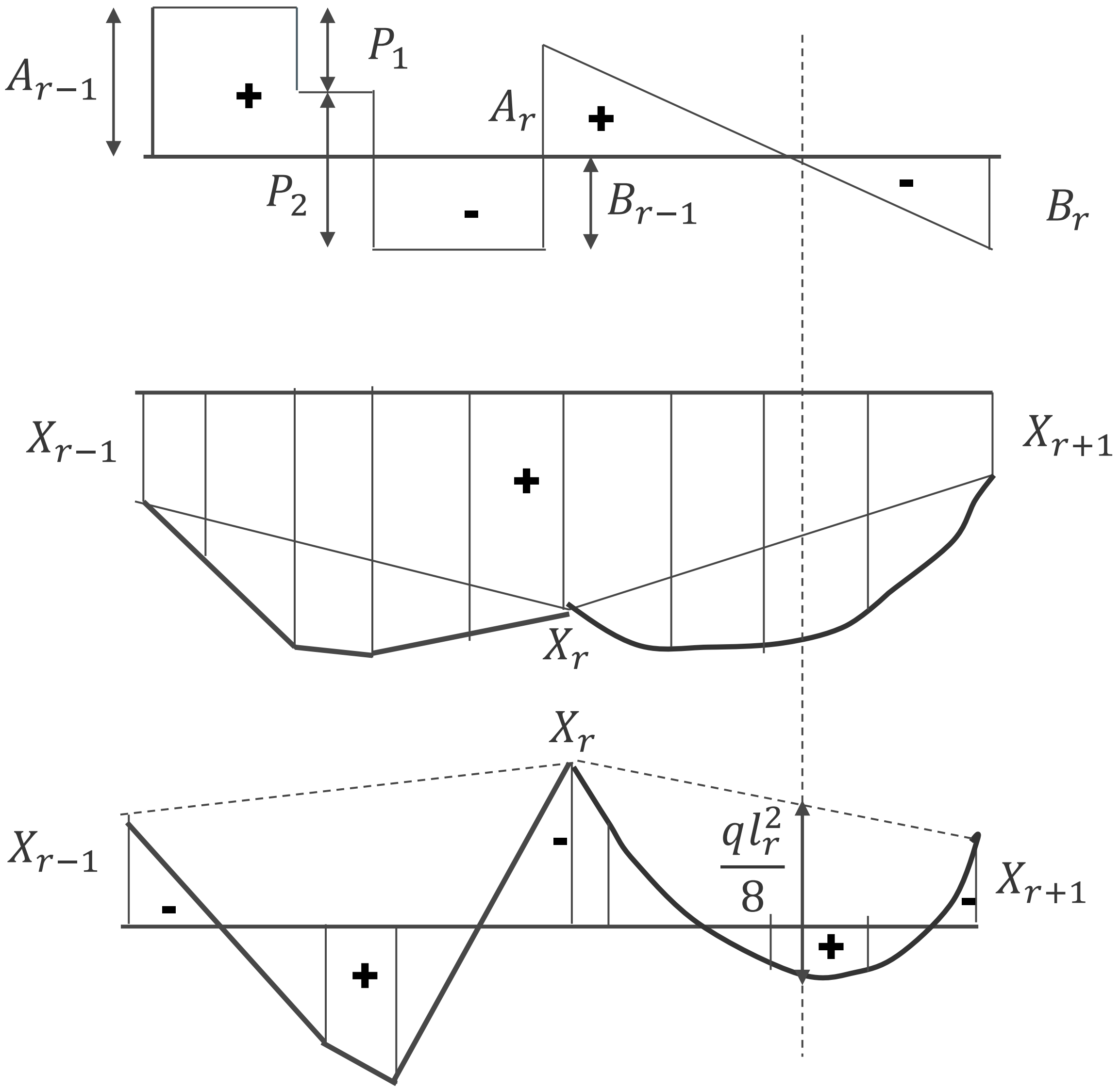


(T)

(M)



X_{r-1}, X_r, X_{r+1} > 0 ise



(T)

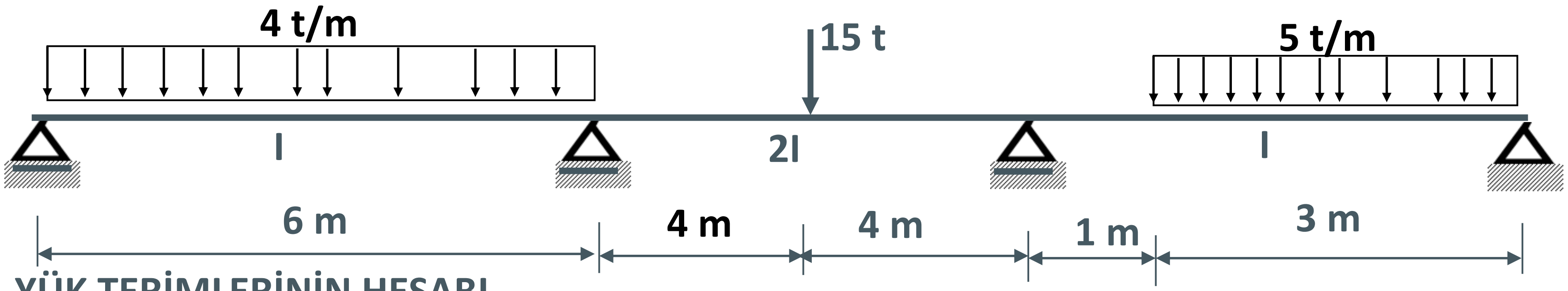
(M)

$X_{r-1}, X_r, X_{r+1} > 0$ ise

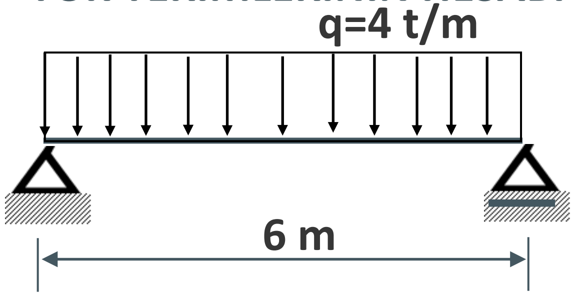
(M)

$X_{r-1}, X_r, X_{r+1} < 0$ ise

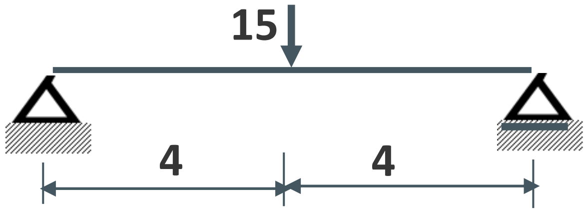
ÖRNEK 1



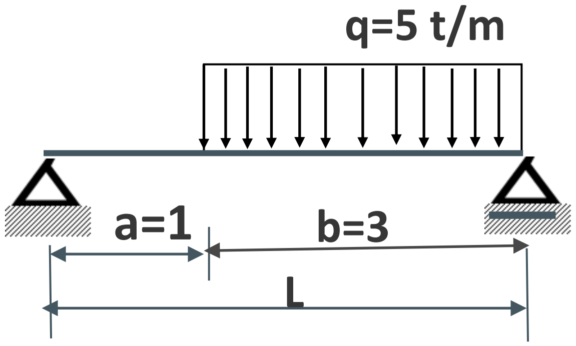
YÜK TERİMLERİNİN HESABI



$$L = R = \frac{qL^2}{4} = \frac{4 * 6^2}{4} = 36$$



$$L = R = \frac{3}{8}P * L = \frac{3}{8}15 * 8 = 45$$



$$L = \frac{qb^2}{4}(2 - \frac{b^2}{L^2}) = \frac{5 * 3^2}{4}(2 - \frac{3^2}{4^2}) = 16.2$$

$$R = \frac{qb^2}{4}(2 - \frac{b}{L})^2 = \frac{5 * 3^2}{4}(2 - \frac{3}{4})^2 = 17.8$$

X_0	X_1		X_2		X_3
$\frac{6}{I}$		$\frac{8}{2I}=\frac{4}{I}$		$\frac{4}{I}$	
36	36	45	45	16.2	17.8
$\frac{216}{I}$	$\frac{216}{I}$	$\frac{180}{I}$	$\frac{180}{I}$	$\frac{64.8}{I}$	$\frac{71.2}{I}$

1. MESNET İÇİN CLAPEYRON DENKLEMİ

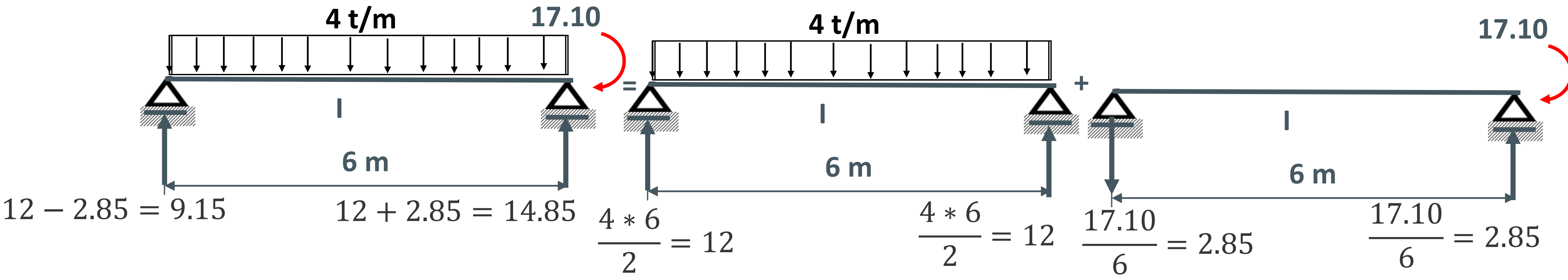
$$\frac{6}{I} * X_0 + 2\left(\frac{6}{I}+\frac{4}{I}\right)X_1 + \frac{4}{I}X_2 + \frac{216}{I} + \frac{180}{I} = 0$$

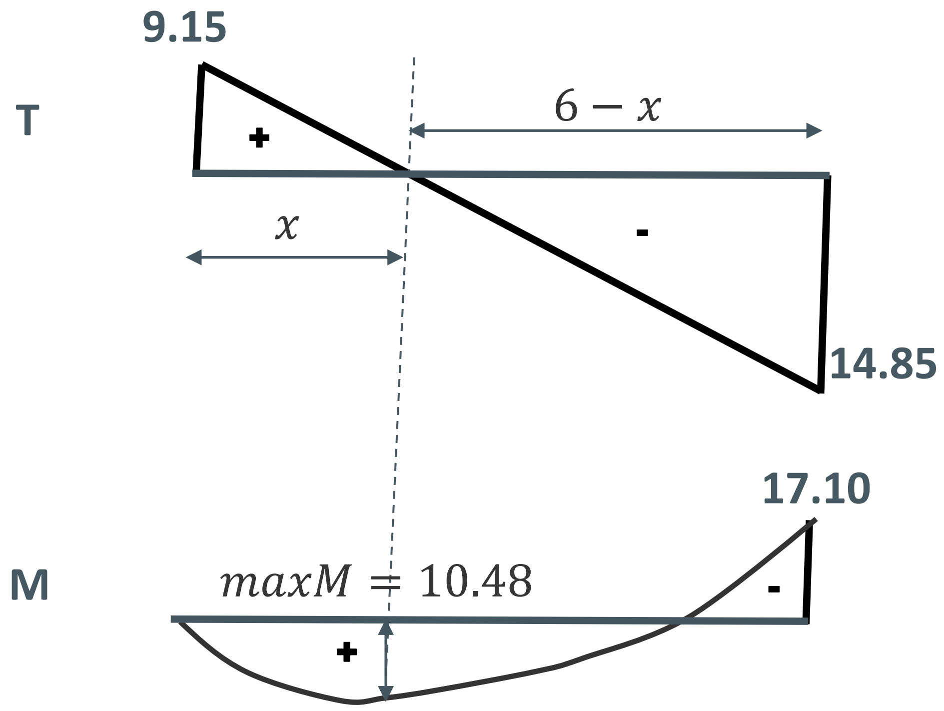
2. MESNET İÇİN CLAPEYRON DENKLEMİ

$$\frac{4}{I}X_1 + 2\left(\frac{4}{I}+\frac{4}{I}\right)X_2 + \frac{4}{I} * X_3 + \frac{180}{I} + \frac{64.8}{I} = 0$$

$$X_0 = X_3 = 0$$

$X_1 = -17.10\ tm$ $\quad$ $X_2 = -10.85\ tm$

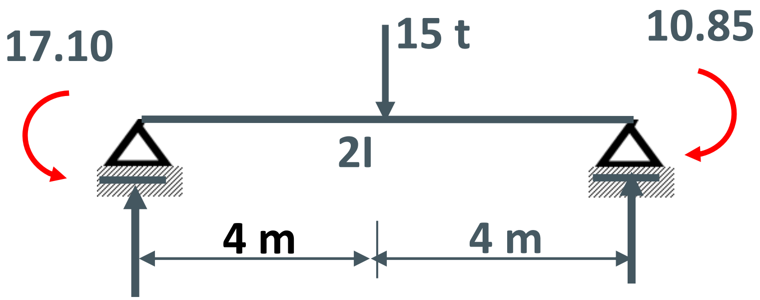




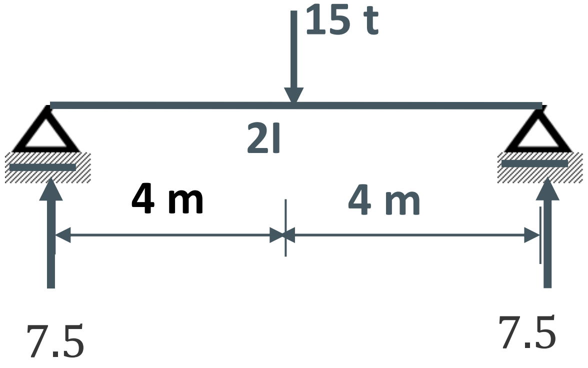
$$\frac{9.15}{x} = \frac{14.85}{6-x} \rightarrow 14.85x = 54.84 - 9.15x$$

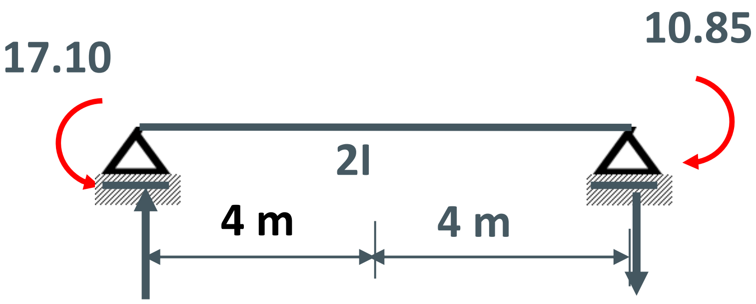
$$24x = 54.9 \rightarrow x = \frac{54.9}{24} = 2.29\ m$$

$$maxM = \frac{1}{2} 2.29 * 9.15 = 10.48\ tm$$

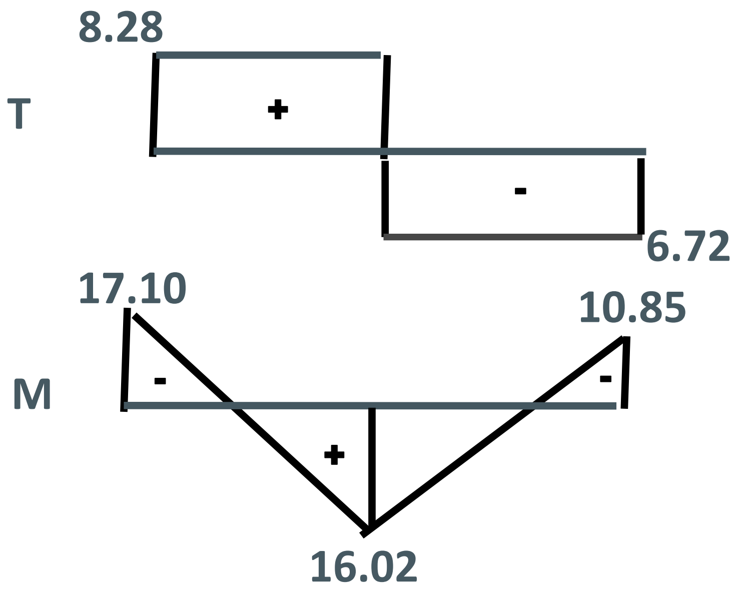


$7.5 + 0.78 = 8.28$ $\quad$ $7.5 - 0.78 = 6.72$

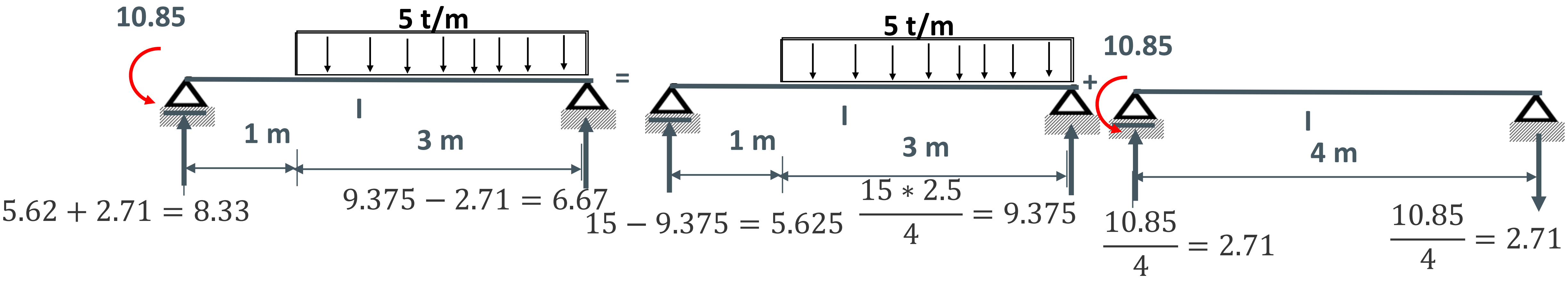


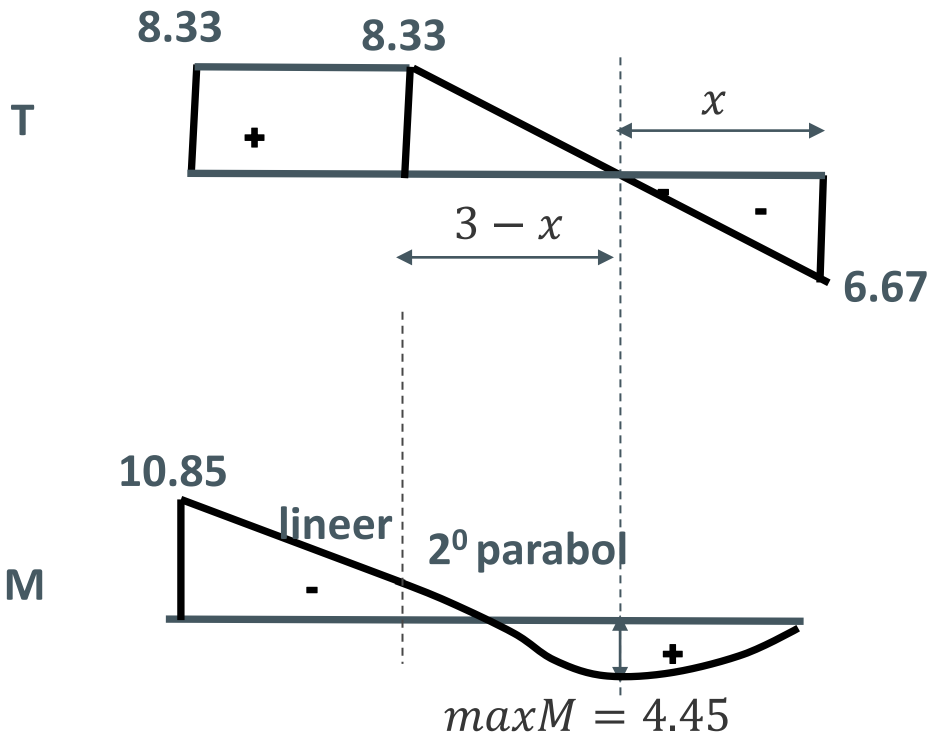


$$\frac{17.10 - 10.85}{8} = 0.78$$



$$maxM = 8.28 * 4 - 17.10 == 16.02$$

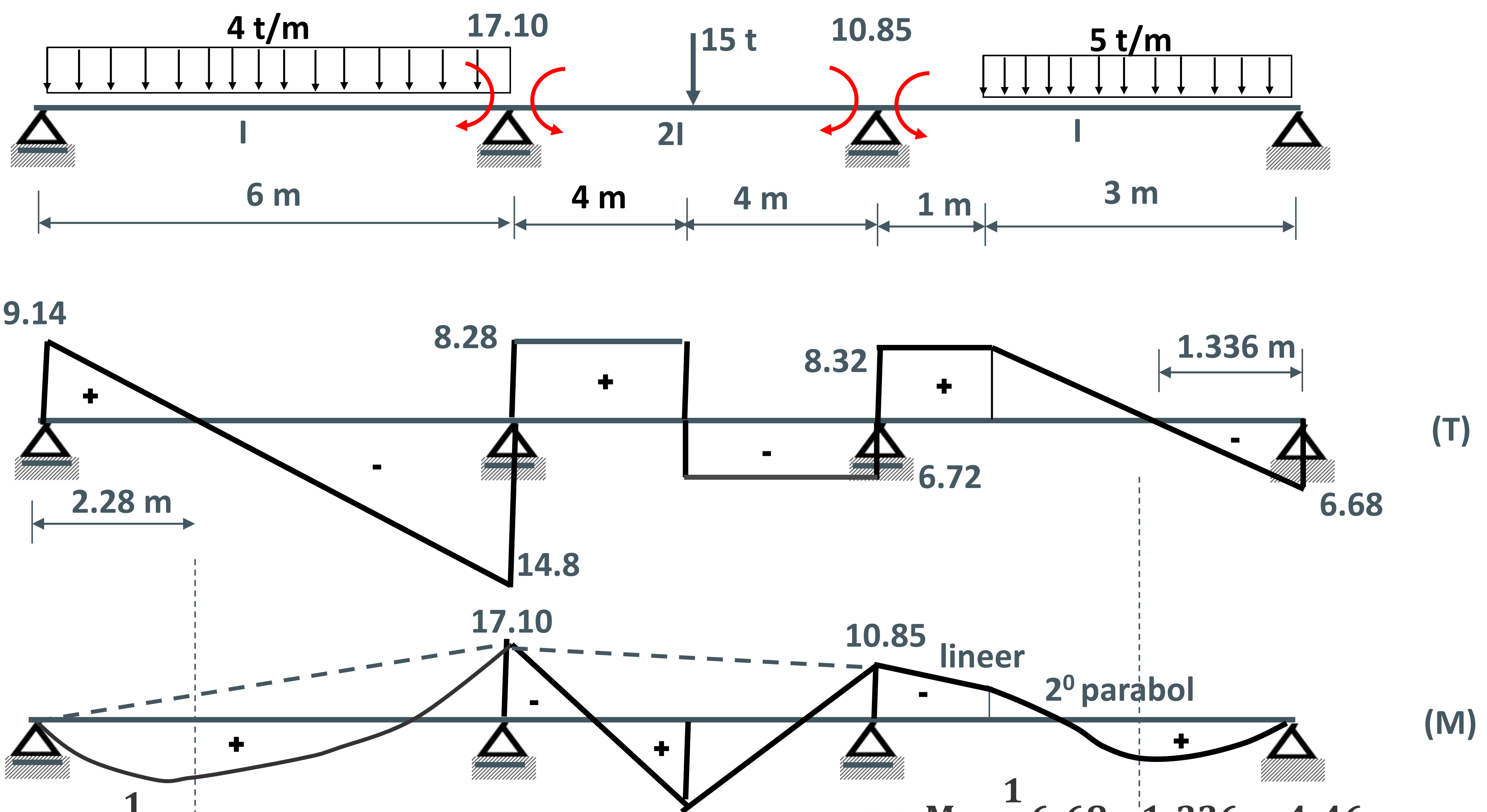




$$\frac{6.67}{x} = \frac{8.33}{3-x} \rightarrow 8.33x = 20.01 - 6.67x$$

$$15x = 20.01 \rightarrow x = \frac{20.01}{15} = 1.334\ m$$

$$maxM = \frac{1}{2} 1.334 * 6.67 = 4.45\ tm$$



$$\text{maxM} = \frac{1}{2}2.28 * 9.14 = 10.5$$

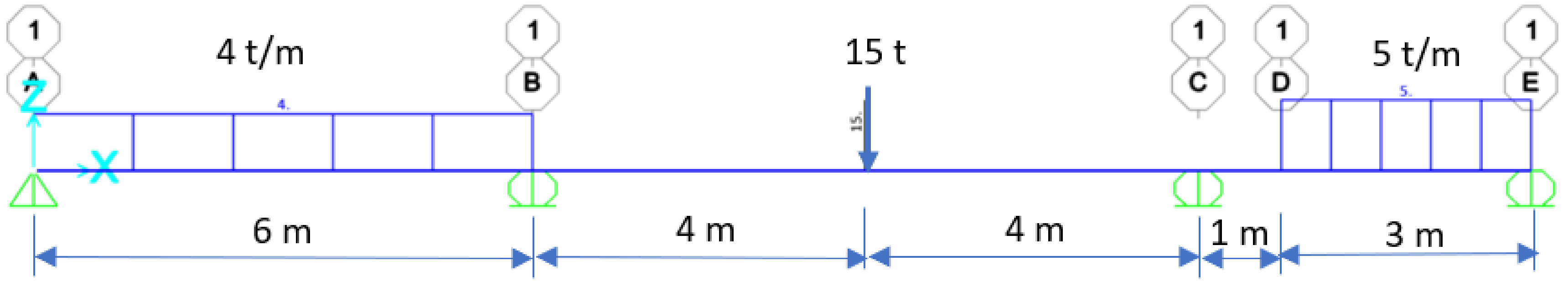
$$\text{maxM} = \frac{1}{2}6.68 * 1,336 = 4.46$$

$$\text{maxM} = 8.28 * 4 - 17.10 == 16.02$$

$$\text{maxM} = 10.5 - \frac{1}{2}14.8 * (6 - 2.28) + 8.28 * 4 = 16.09$$

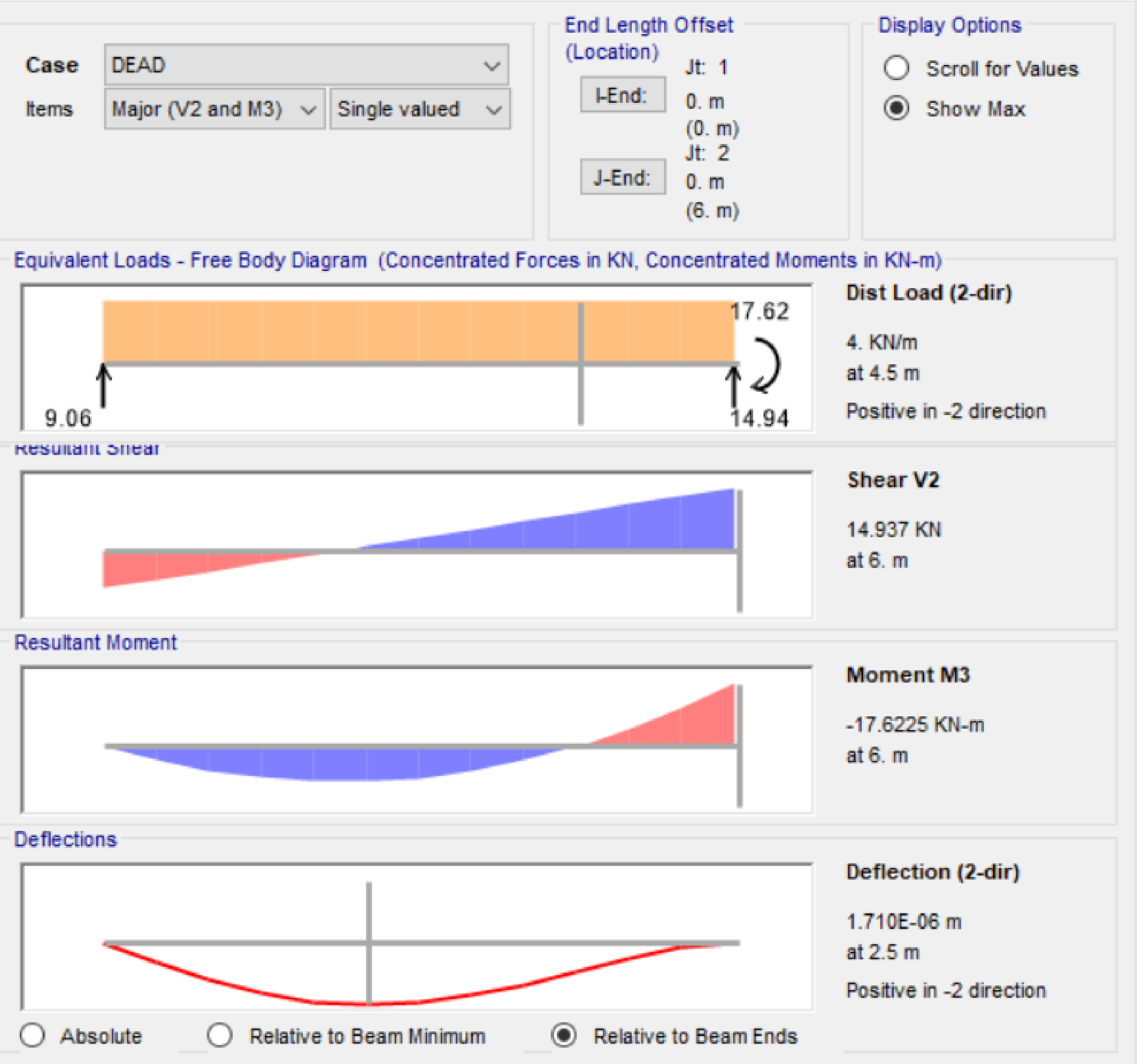
SAP2000 ÇÖZÜMLERİ

Örnek 1 Sap2000 Çözümü

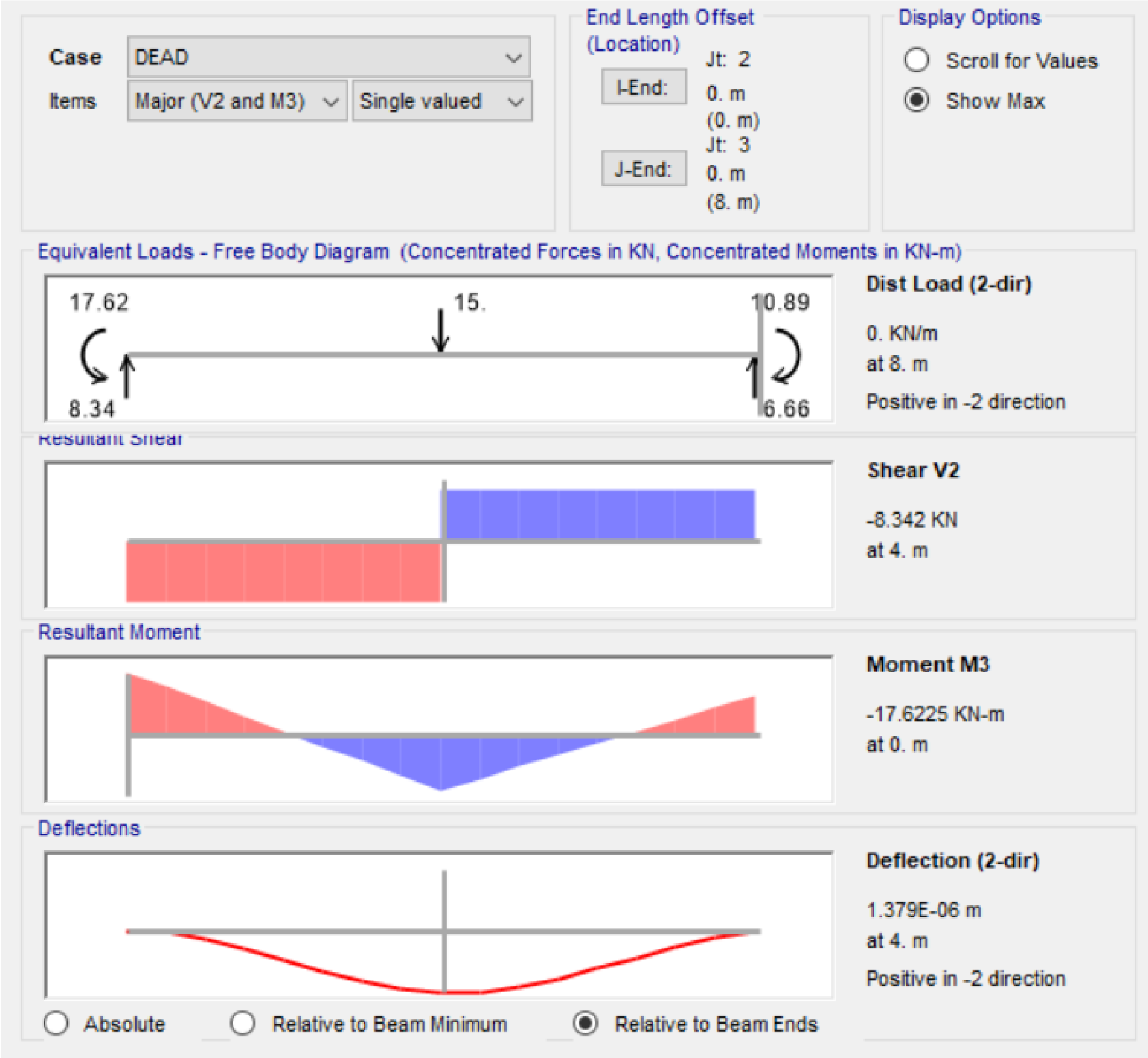


Mesnet Reaksiyonları

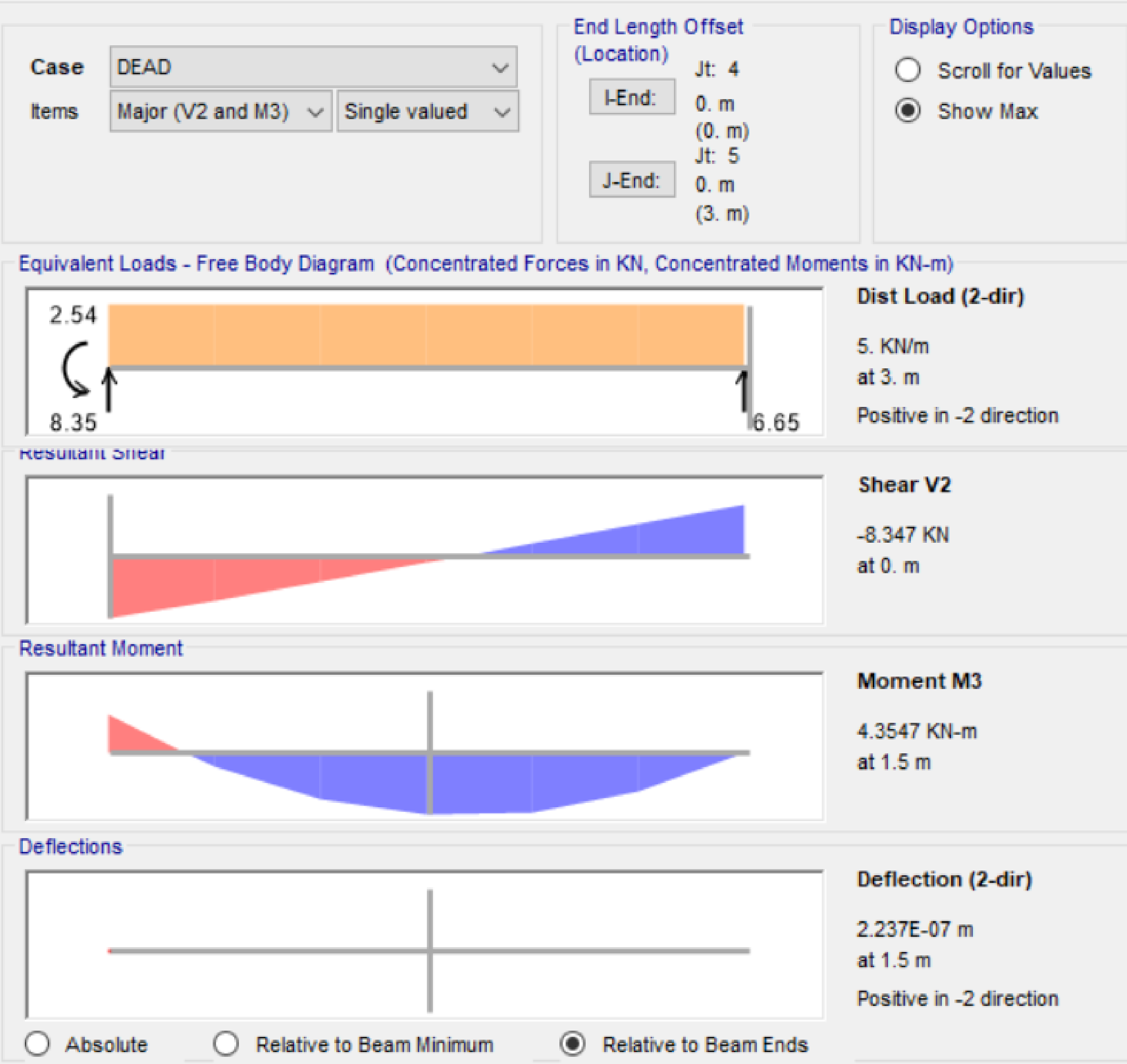
1.AÇIKLIK



2.AÇIKLIK



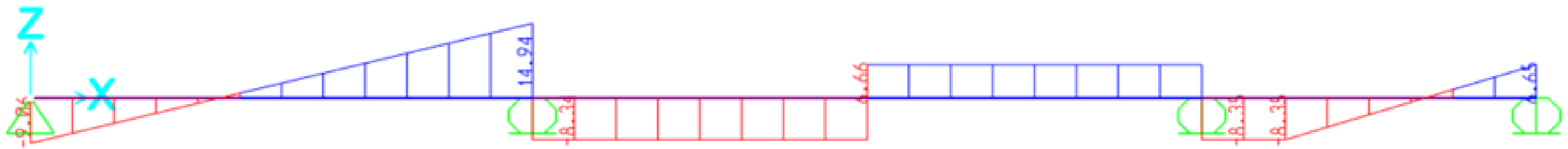
3.AÇIKLIK



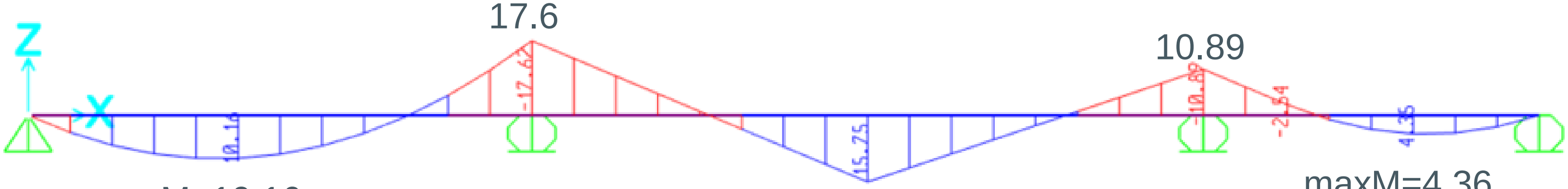
Case
DEAD
Items
Major (V2 and M3)
Single valued
End Length Offset
(Location)
Jt: 4
I-End:
0. m
(0. m)
Jt: 5
J-End:
0. m
(3. m)
Display Options
Scroll for Values
Show Max
Equivalent Loads - Free Body Diagram (Concentrated Forces in KN, Concentrated Moments in KN-m)
2.54
8.35
6.65
Dist Load (2-dir)
5. KN/m
at 3. m
Positive in -2 direction
Resultant Shear
Shear V2
-8.347 KN
at 0. m
Resultant Moment
Moment M3
4.3547 KN-m
at 1.5 m
Deflections
Deflection (2-dir)
2.237E-07 m
at 1.5 m
Positive in -2 direction
Absolute
Relative to Beam Minimum
Relative to Beam Ends

SAP2000 ÇÖZÜMLERİ

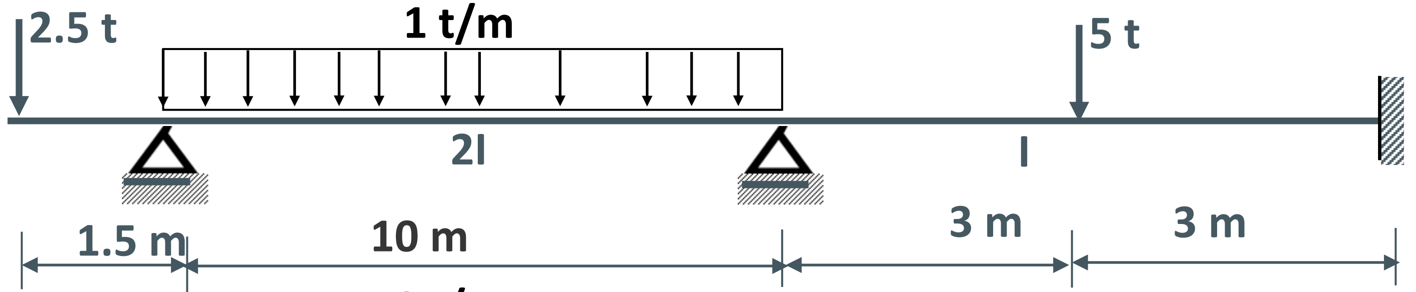
Kesme Kuvveti Diyagramı

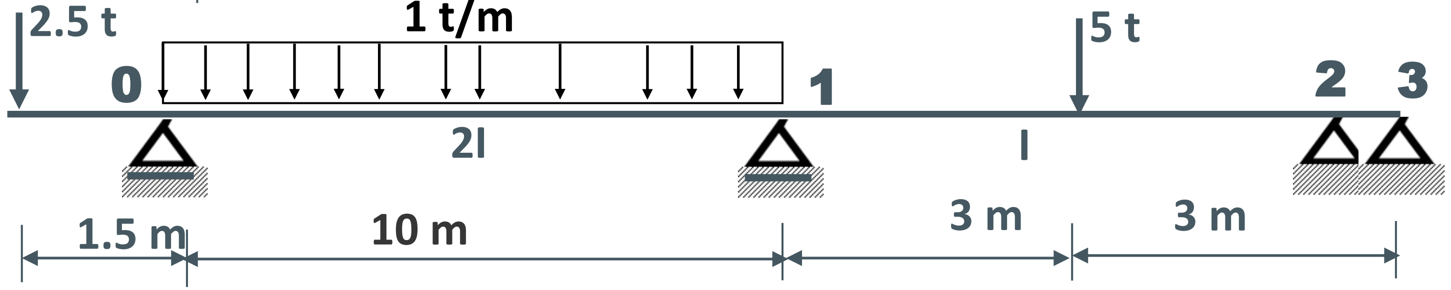


Moment Diyagramı

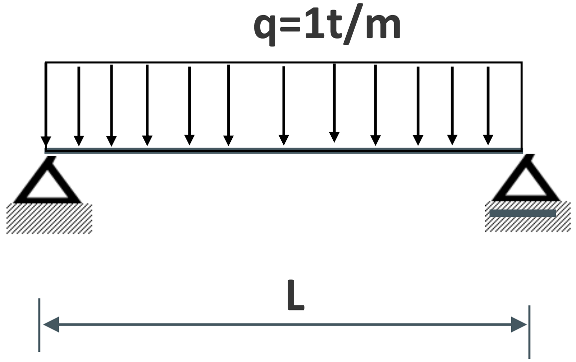


ÖRNEK 2

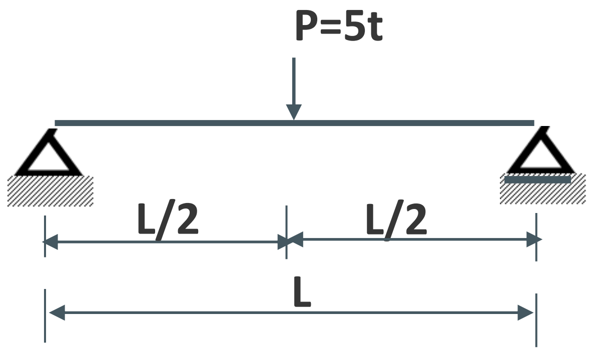




Eş değer sistem



$$R = L = \frac{qL^2}{4} = \frac{1 * 10^2}{4} = 25$$



$$R = L = \frac{3}{8} P * L = \frac{3}{8} 5 * 6 = 11.25$$

X_0		X_1		X_2	X_3
$\frac{10}{2I}$		$\frac{6}{I}$		0	
25	**25**	**11.25**	**11.25**	**0**	
$\frac{125}{I}$	$\frac{125}{I}$	$\frac{67.5}{I}$	$\frac{67.5}{I}$	0	

1. MESNET İÇİN CLAPEYRON DENKLEMİ

$$\frac{5}{I}X_0 + 2(\frac{5}{I} + \frac{6}{I})X_1 + \frac{6}{I}X_2 + \frac{125}{I} + \frac{67.5}{I} = 0$$

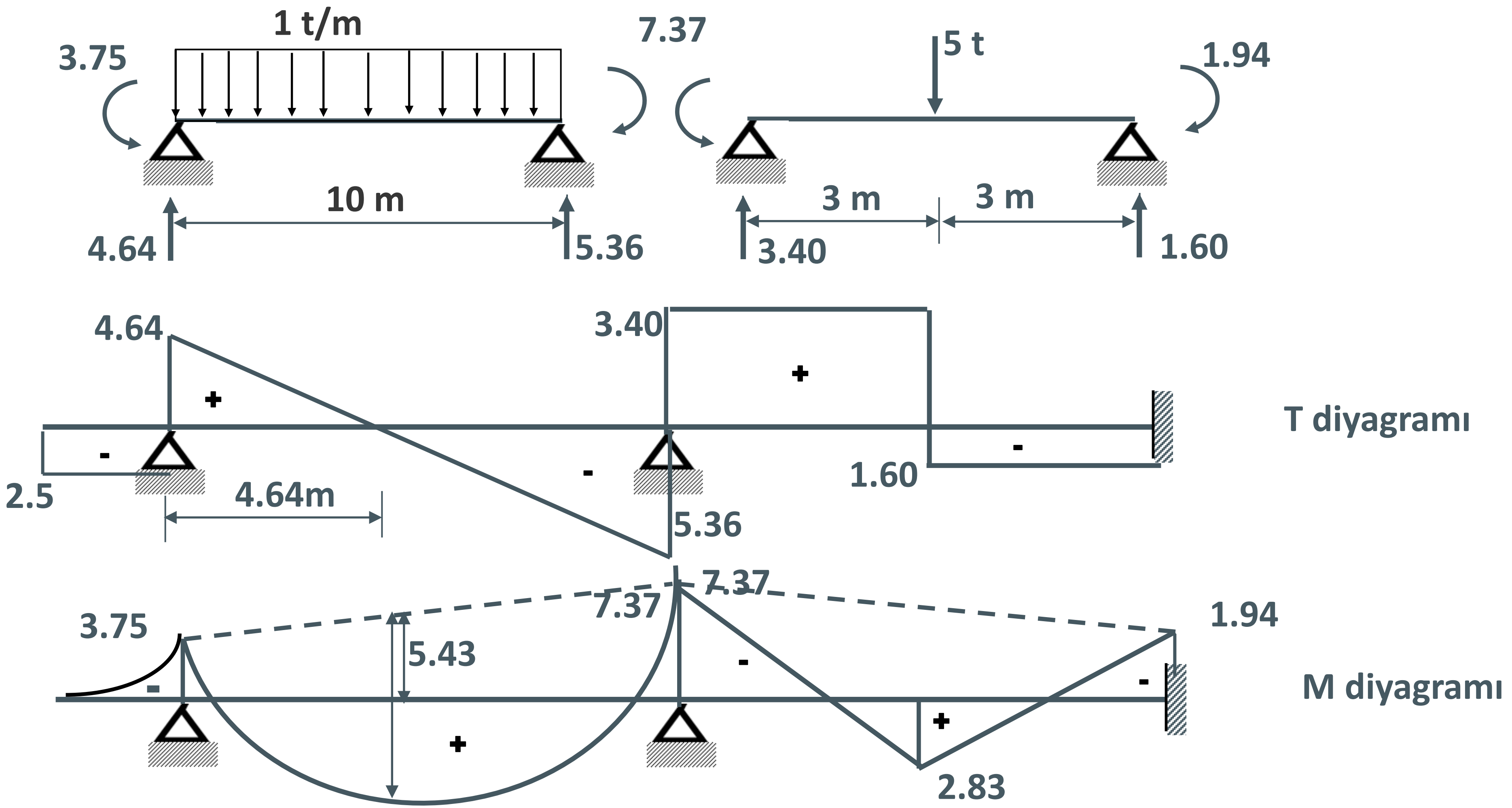
2. MESNET İÇİN CLAPEYRON DENKLEMİ

$$\frac{6}{I}X_1 + 2(\frac{6}{I} + 0)X_2 + 0 * X_2 + \frac{67.5}{I} + 0 = 0$$

$$5X_0 + 22X_1 + 6X_2 + 192.5 = 0 \qquad X_0 = -2.5 * 1.5 = -3.75\ tm$$

$$6X_1 + 12X_2 + 67.5 = 0$$

$$\left.\begin{array}{l} 22X_1 + 6X_2 + 173.75 = 0 \\ 6X_1 + 12X_2 + 67.5 = 0 \end{array}\right\} \quad \begin{array}{l} X_1 = -7.37\ tm \\ X_2 = -1.94\ tm \end{array}$$



$$\mathbf{maxM = 3.4 * 3 - 7.37 = 2.83\ tm}$$

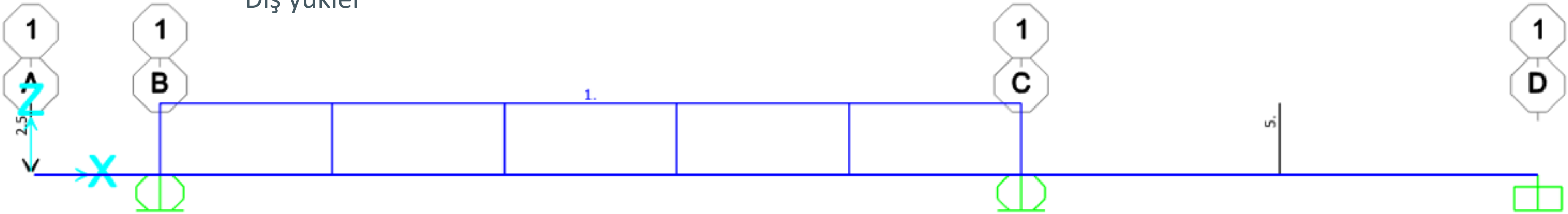
maxM=7.01

$$\mathbf{maxM = -2.5 * 1.5 + \frac{1}{2} 4.64 * 4.64 = 7.01\ tm}$$

$$\mathbf{maxM = \frac{1 * 10^2}{8} - 5.43 = 7.07\ tm}$$

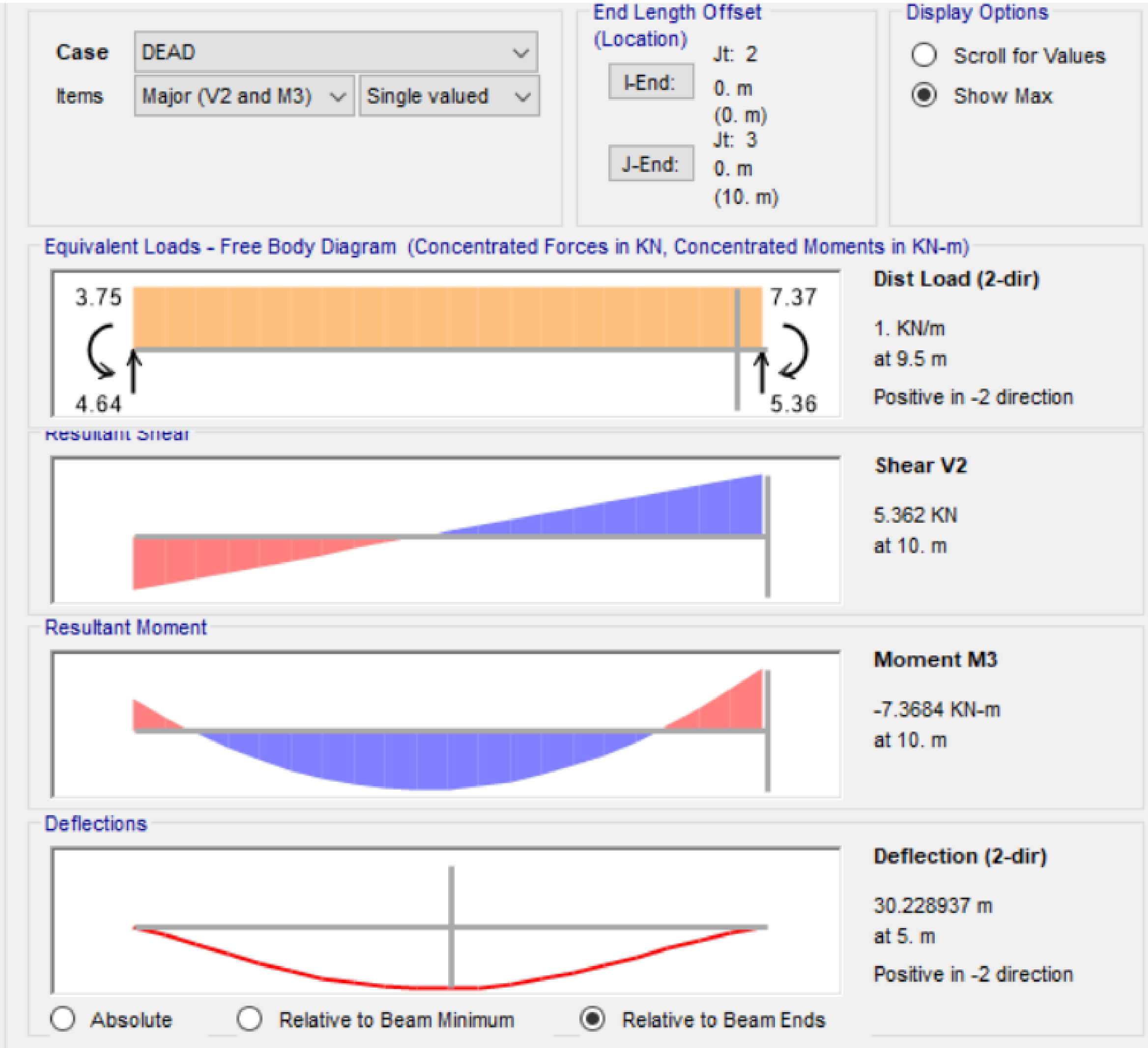
SAP2000 ÇÖZÜMLERİ

Dış yükler

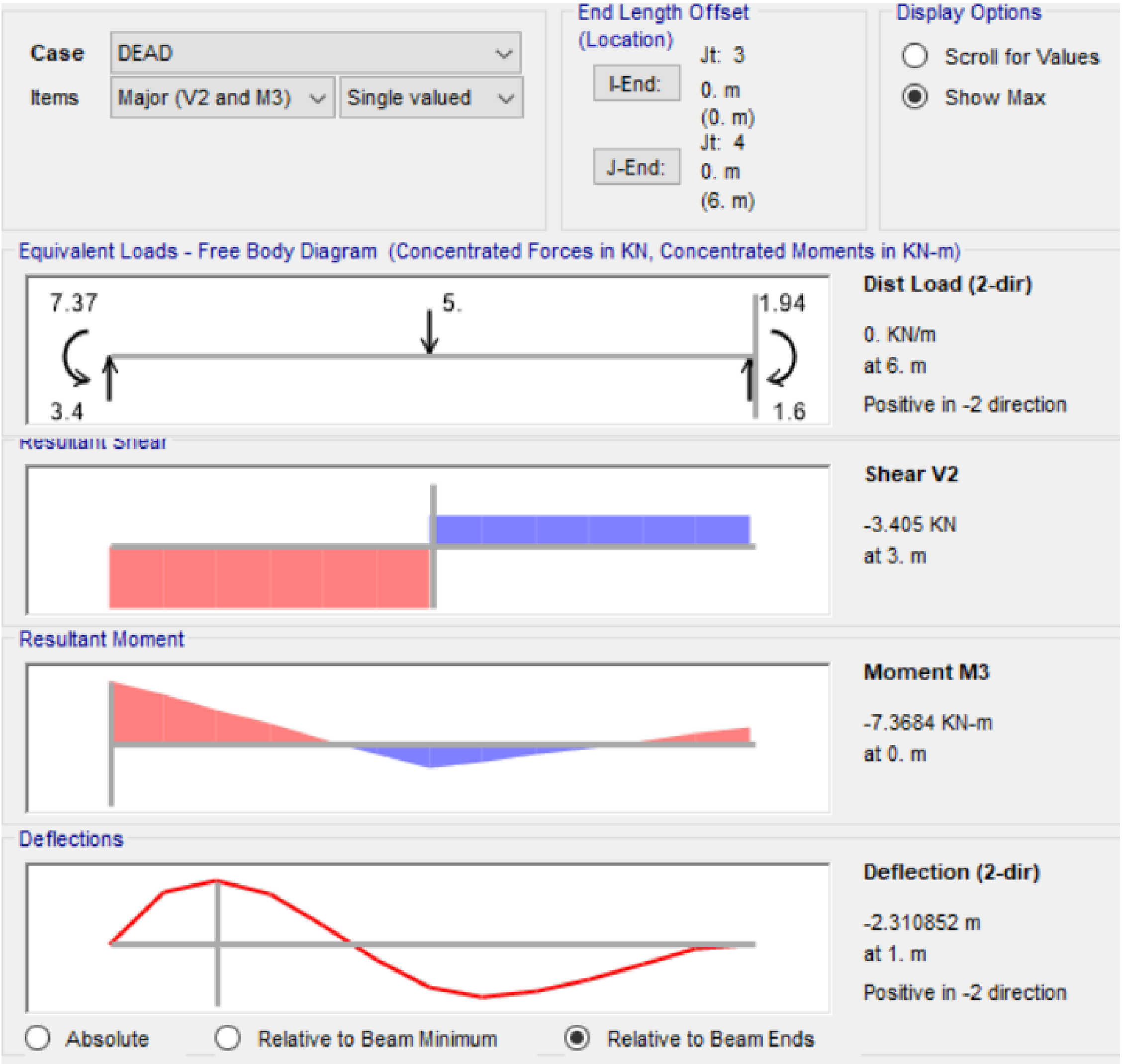


Mesnet tepkileri

1.AÇIKLIK

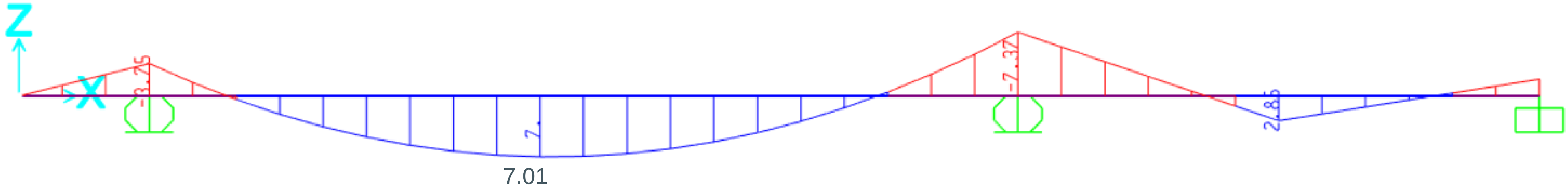


2.AÇIKLIK

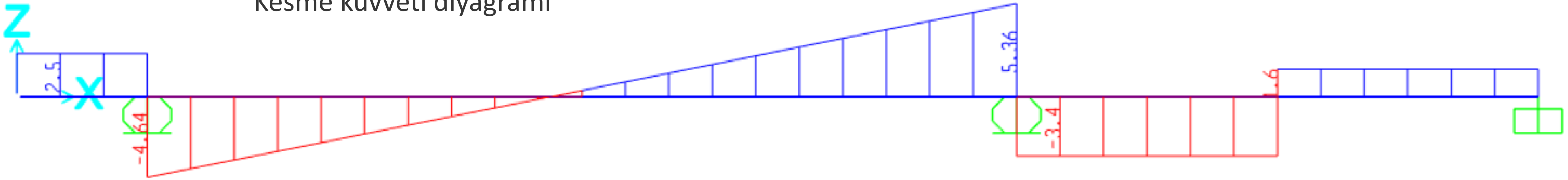


SAP2000 ÇÖZÜMLERİ

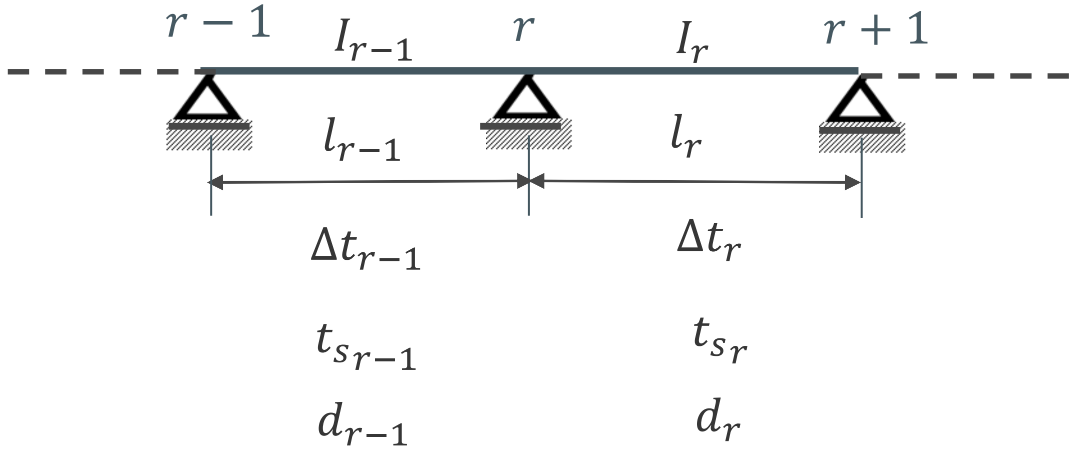
Moment diyagramı



Kesme kuvveti diyagramı



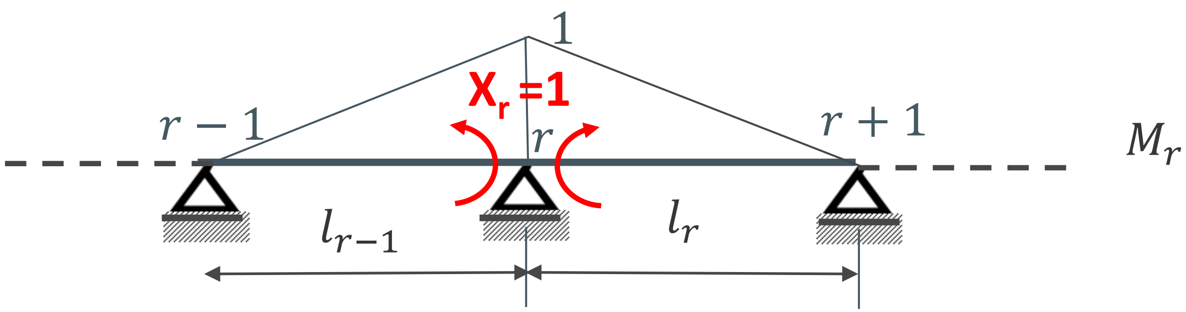
SICAKLIK DEĞİŞMESİ HALİNDE SÜREKLİ KİRİŞLERİN ÇÖZÜMÜ



$$\delta_{rr-1} = \frac{1}{6E}\frac{l_{r-1}}{I_{r-1}}$$

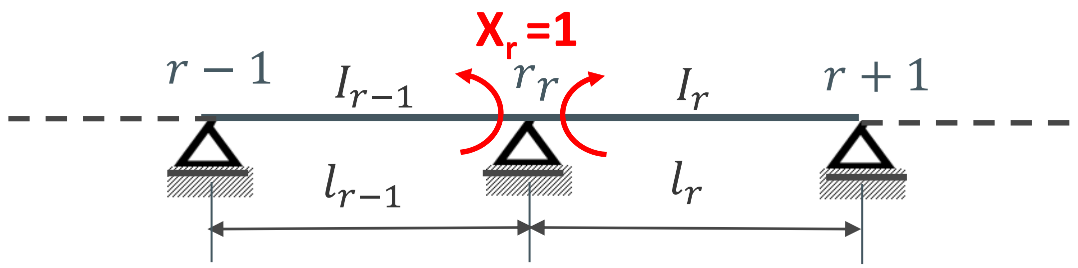
$$\delta_{rr} = \frac{1}{6E}2\left(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r}\right)$$

$$\delta_{rr+1} = \frac{1}{6E}\frac{l_r}{I_r}$$



Dış yük=0

$$\delta_{rr-1}X_{r-1} + \delta_{rr}X_r + \delta_{rr+1}X_{r+1} + \delta_{rt} = 0$$



$$\delta_{rt} = \int M_r \frac{\varepsilon \Delta t}{d} ds + \int N_r \varepsilon t_s ds \qquad N_r = 0$$

$$\delta_{rt} = \int M_r \frac{\varepsilon \Delta t}{d} ds = \varepsilon \left[\frac{\Delta t}{d} \int M_r \, ds \right]$$

$$\delta_{rt} = \frac{\varepsilon}{2} \left[\frac{\Delta t_{r-1}}{d_{r-1}} l_{r-1} + \frac{\Delta t_r}{d_r} l_r \right]$$

$$\frac{1}{6E} \frac{l_{r-1}}{I_{r-1}} X_{r-1} + \frac{1}{6E} 2 \left(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r} \right) X_r + \frac{1}{6E} \frac{l_r}{I_r} X_{r+1} + \frac{\varepsilon}{2} \left[\frac{\Delta t_{r-1}}{d_{r-1}} l_{r-1} + \frac{\Delta t_r}{d_r} l_r \right] = 0$$

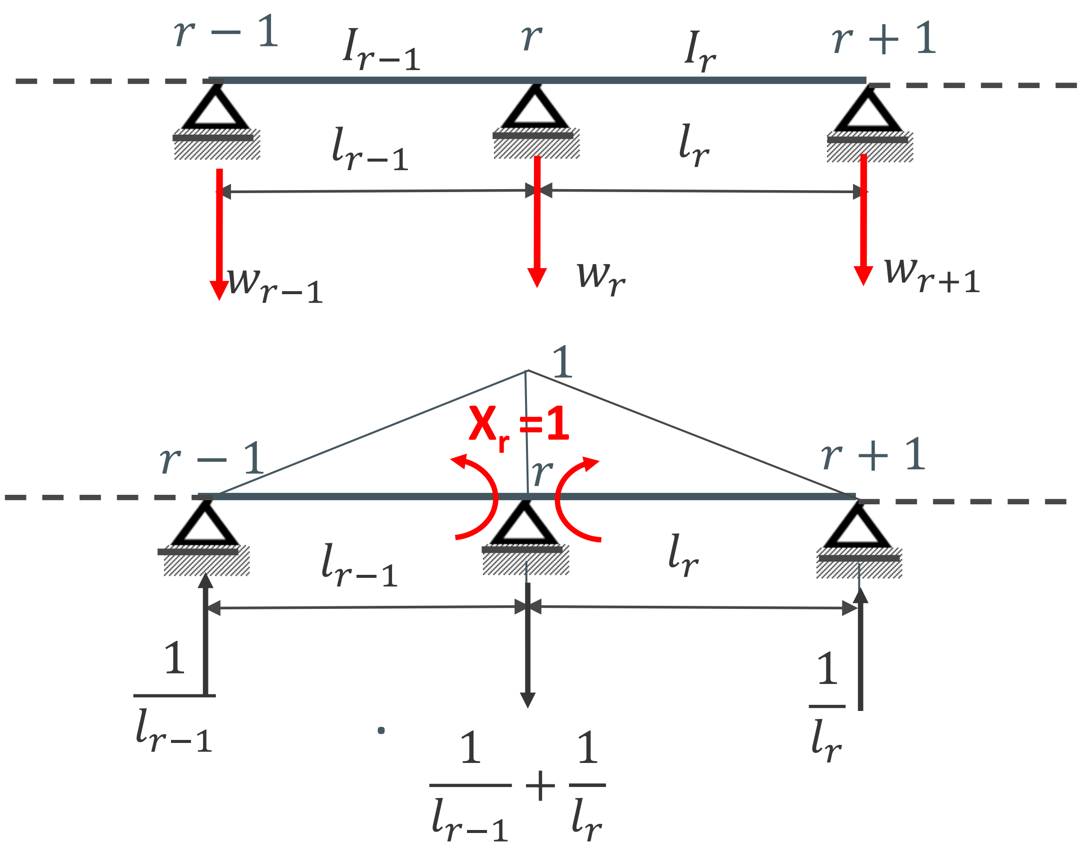
$$\frac{l_{r-1}}{I_{r-1}} X_{r-1} + 2 \left(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r} \right) X_r + \frac{l_r}{I_r} X_{r+1} + 3E\varepsilon \left[\frac{\Delta t_{r-1}}{d_{r-1}} l_{r-1} + \frac{\Delta t_r}{d_r} l_r \right] = 0$$

$\boldsymbol{X_{r-1}}$ $\boldsymbol{X_r}$ $\boldsymbol{X_{r+1}}$

$\frac{l_{r-1}}{I_{r-1}}$	$\frac{l_r}{I_r}$
$\frac{\Delta t_{r-1}}{d_{r-1}} l_{r-1}$	$\frac{\Delta t_r}{d_r} l_r$

MESNET ÇÖKMELERİ İÇİN SÜREKLİ KİRİŞLERİN ÇÖZÜMÜ

Dış yük =0 **Δt = 0**

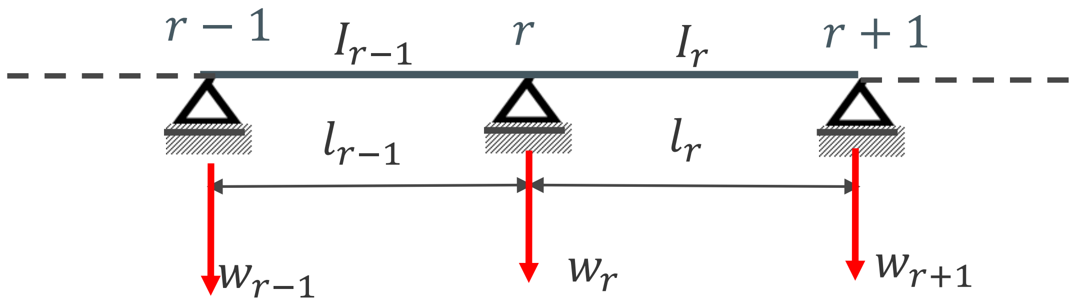


$$\delta_{rr-1}X_{r-1} + \delta_{rr}X_r + \delta_{rr+1}X_{r+1} = J_r$$

$$J_r = -\frac{1}{l_{r-1}}w_{r-1} + \left(\frac{1}{l_{r-1}} + \frac{1}{l_r}\right)w_r - \frac{1}{l_r}w_{r+1}$$

$$J_r = \frac{(w_r - w_{r-1})}{l_{r-1}} + \frac{(w_r - w_{r+1})}{l_r}$$

J_r= izostatik esas sistemde X_r = 1 için dış kuvvetlerin hiperstatik sistemin mesnet çökmelerinde yaptığı iş



$$\frac{l_{r-1}}{I_{r-1}}X_{r-1} + 2\left(\frac{l_{r-1}}{I_{r-1}} + \frac{l_r}{I_r}\right)X_r + \frac{l_r}{I_r}X_{r+1} = 6E\left[\frac{(w_r - w_{r-1})}{l_{r-1}} + \frac{(w_r - w_{r+1})}{l_r}\right]$$

$\boldsymbol{X_{r-1}}$ $\boldsymbol{X_r}$ $\boldsymbol{X_{r+1}}$

$\frac{l_{r-1}}{I_{r-1}}$		$\frac{l_r}{I_r}$	
$\frac{(w_{r-1} - w_r)}{l_{r-1}}$	$\frac{(w_r - w_{r-1})}{l_{r-1}}$	$\frac{(w_r - w_{r+1})}{l_r}$	$\frac{(w_{r+1} - w_r)}{l_r}$

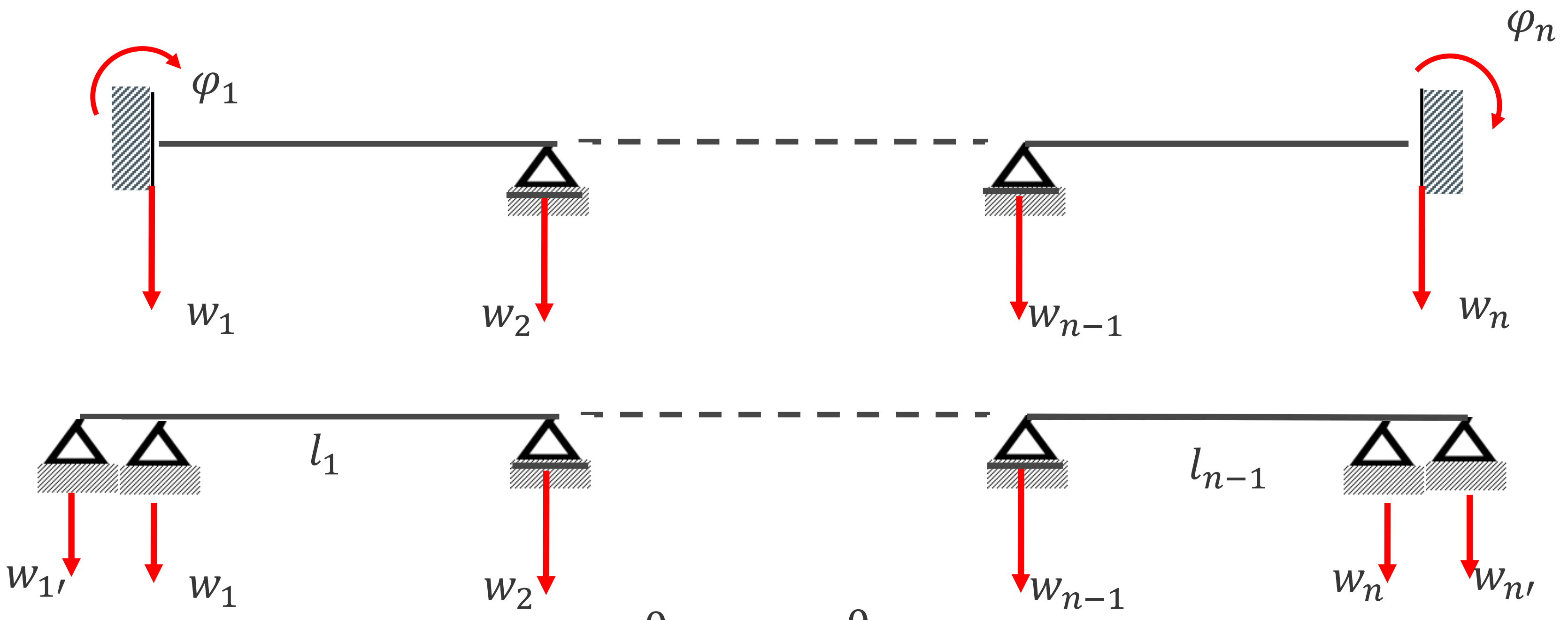
ÖZEL HAL

Ankastre mesnet hali

$$0 + \; 2\left(0+\frac{l_1}{I_1}\right)X_1 + \frac{l_1}{I_1}X_2 = 6E\left[\frac{(w_1 - w_{1'})}{l_{1'}} + \frac{(w_1 - w_2)}{l_1}\right]$$

$$2\frac{l_1}{I_1}X_1 + \frac{l_1}{I_1}X_2 = 6E\left[\varphi_1 + \frac{(w_1 - w_2)}{l_1}\right]$$

1 mesnedi

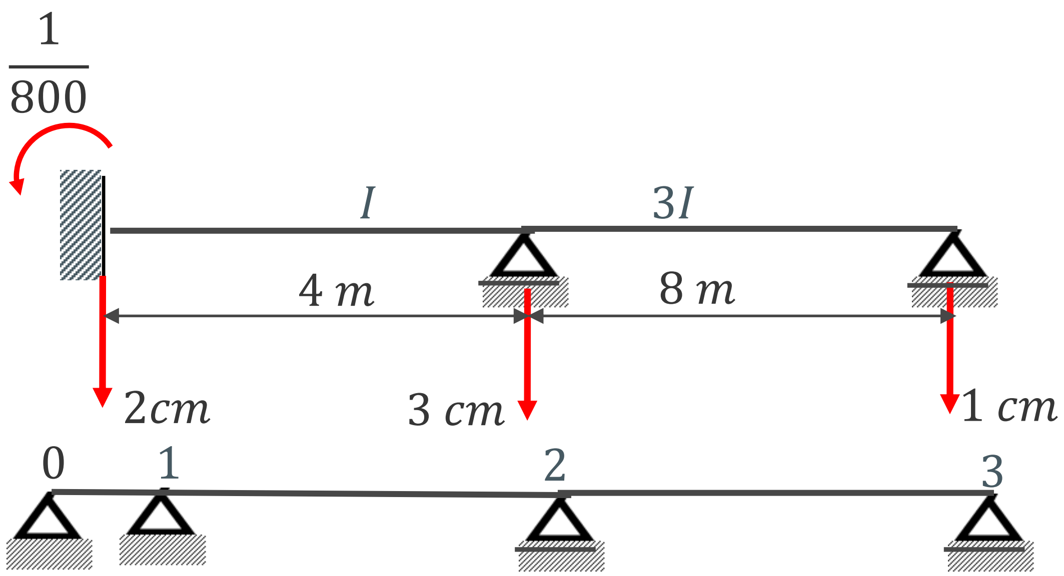


$$\frac{l_{n-1}}{I_{n-1}} X_{n-1} + 2\left(\frac{l_{n-1}}{I_{n-1}} + \cancelto{0}{\frac{l_n}{I_n}}\right) X_n + \cancelto{0}{\frac{l_n}{I_n}} X_n = 6E\left[\frac{(w_n - w_{n-1})}{l_{n-1}} + \frac{(w_n - w_{n'})}{l_{n'}}\right]$$

$$\frac{l_{n-1}}{I_{n-1}} X_{n-1} + 2\,\frac{l_{n-1}}{I_{n-1}} X_n = 6E\left[\frac{(w_n - w_{n-1})}{l_{n-1}} - \varphi_n\right]$$

n mesnedi

ÖRNEK 3



	$\frac{4}{I}$	$\frac{8}{3I}$
$-\frac{1}{800}$	$-\frac{0.01}{4}$ $\quad$ $\frac{0.01}{4}$	$\frac{0.02}{8}$ $\quad$ $-\frac{0.02}{8}$

Sistem betonarme E=2.1*10^{6} t/m^{2}

I = 80 dm ^{4}

$$\boldsymbol{EI = 2.1 * 10^6 * 80 * 10^{-4} = 16000\ tm^2}$$

$$0 + 2\left(0 + \frac{4}{I}\right)X_1 + \frac{4}{I}X_2 = 6E(-\frac{1}{800} - \frac{0.01}{4})$$

$$\frac{4}{I}X_1 + 2\left(\frac{4}{I} + \frac{8}{3I}\right)X_2 + 0 = 6E(\frac{0.01}{4} + \frac{0.02}{8})$$

$$8X_1 + 4X_2 = 6EI(-\frac{1}{800} - \frac{0.01}{4})$$

$$4X_1 + 13.33X_2 = 6EI(\frac{0.01}{4} + \frac{0.02}{8})$$

$$X_1 = -4.63 * 10^{-3}EI \quad ve \quad X_2 = 3.64 * 10^{-3}EI.$$

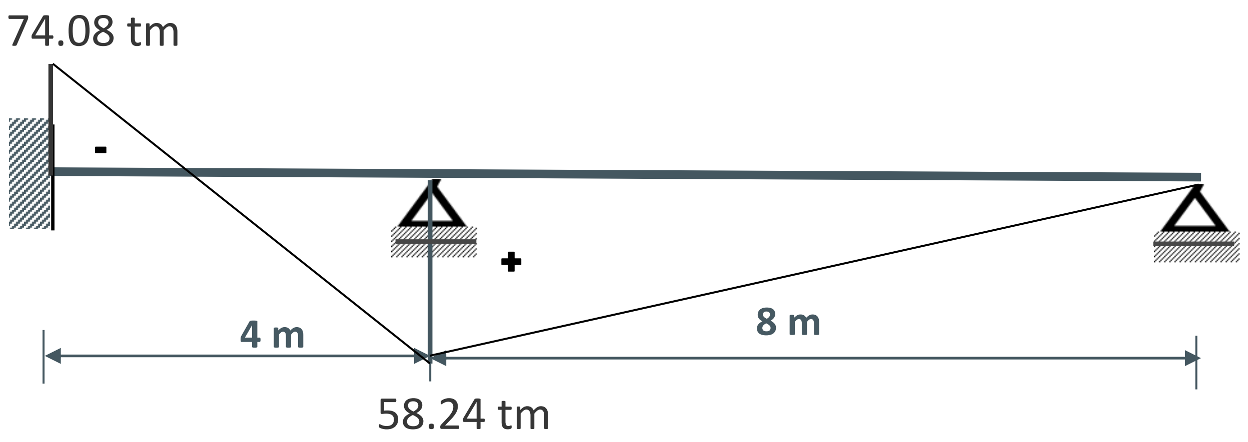
Sistem betonarme E=2.1*10⁶ t/m²

I = 80 dm ⁴

$$\boldsymbol{EI = 2.1 * 10^{6} * 80 * 10^{-4} = 16000\ tm^{2}}$$

$$X_1 = -4.63 * 10^{-3} EI \quad ve \quad X_2 = 3.64 * 10^{-3} EI.$$

$$X_1 = -4.63 * 10^{-3} * 16000 = -74.08\ tm \quad ve \quad X_2 = 3.64 * 10^{-3} * 16000 = 58.24\ tm$$



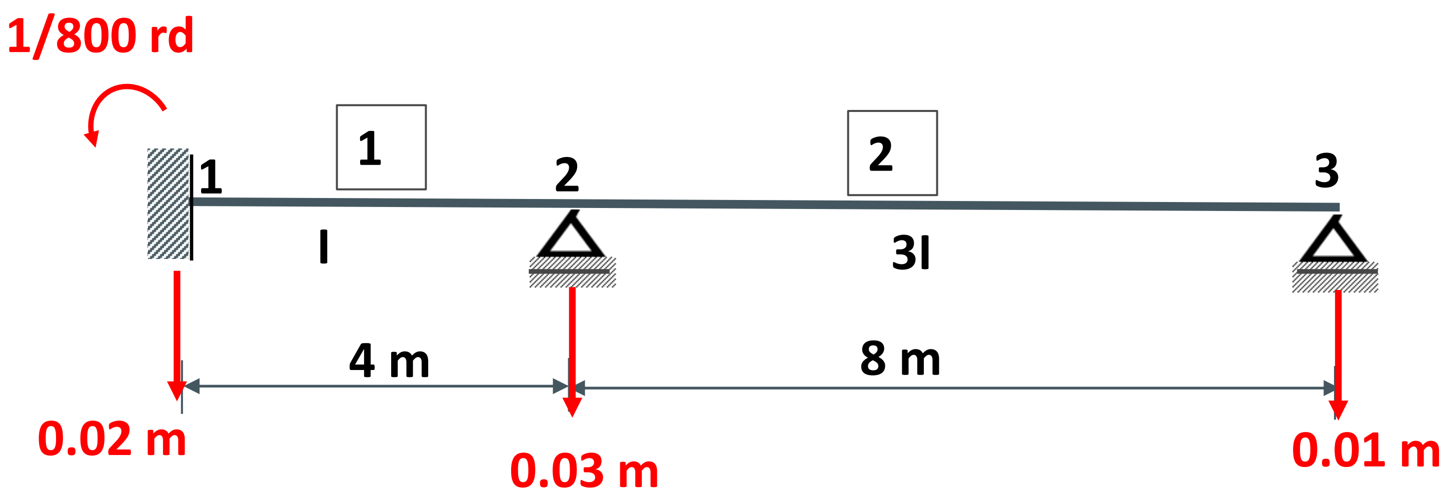
MOMENT DİYAGRAMI

SAP 2000 ÇÖZÜMÜ

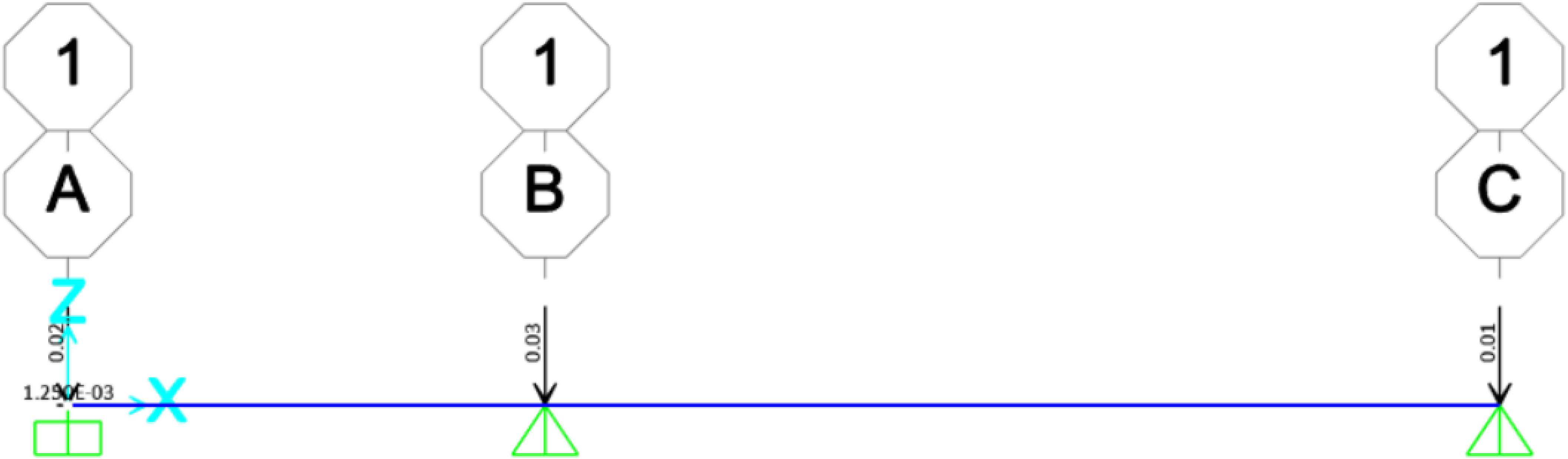
Sistem betonarme E=2.1*10^6 t/m^2

I = 80 dm ^{4}

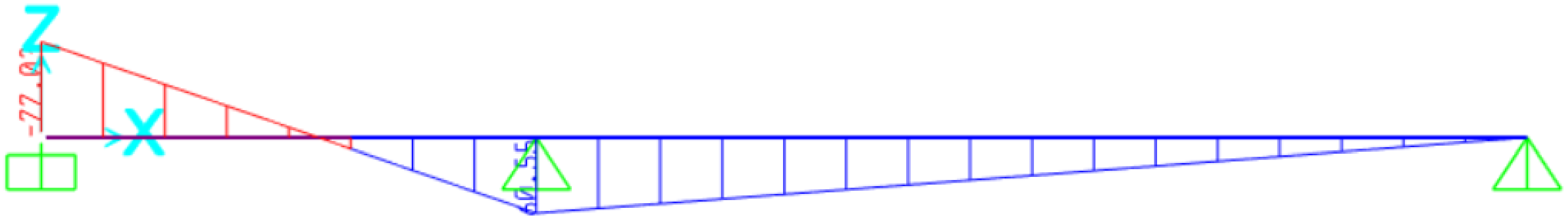
$$EI = 2.1 * 10^6 * 80 * 10^{-4} = 16000\ tm^2..$$



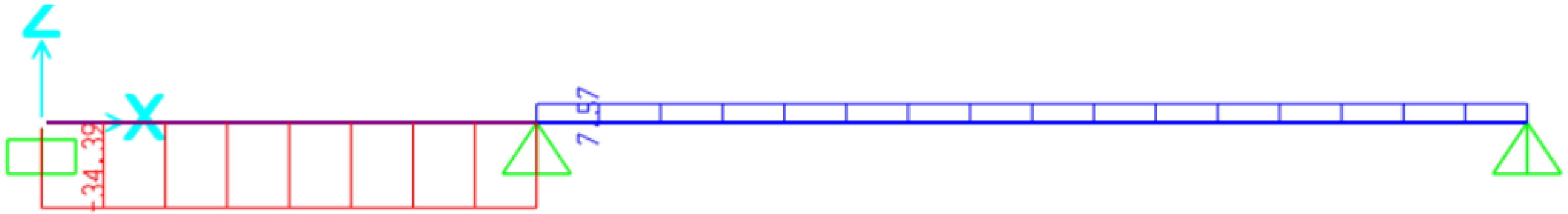
Mesnet çökmeleri



Moment diyagramı



Kesme kuvveti diyagramı

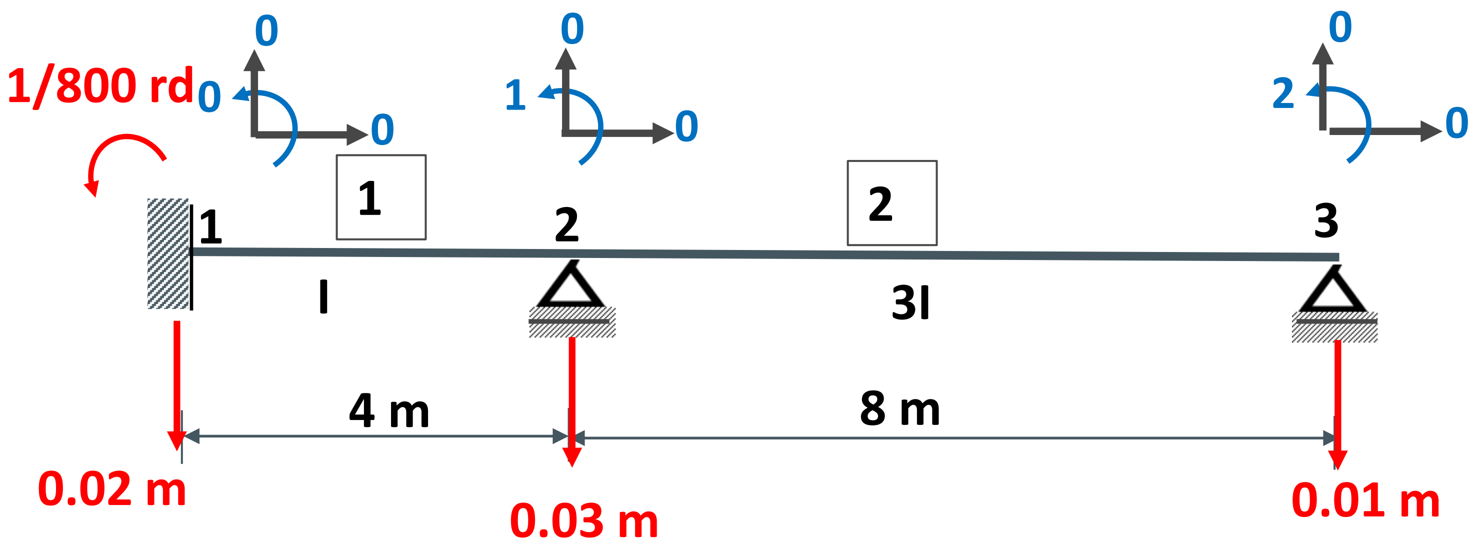


SDB88* ÇÖZÜMÜ

Sistem betonarme E=2.1*10^6 t/m^2

I = 80 dm ^{4}

$$EI = 2.1 * 10^6 * 80 * 10^{-4} = 16000\ tm^2..$$



*Dündar, C., Kıral, E., Mengi, Y., Yapı Mekaniğinde Bilgisayar Programları, Genişletilmiş 3. Baskı, Teknik Yayınevi, 1987.

6 DUZLEMI ICERISINDE YUKLU GENEL CERCEVELERIN STATIK HESABI :

MESNET COKMELERI

ELEMAN SAYISI ------------= 2
DEPLASMAN SAYISI -------= 2
DUGUM SAYISI -------------= 3
ELASTISITE MODULU -----= 2100000
YUKLEME SAYISI -----------= 3
KAYMA DEFORMASYONLARI IHMAL EDILIYOR

DUGUM	X	Y
1	0.00	0.00
2	4.00	0.00
3	12.00	0.00

ELEMAN	i	j	BOYU	ALAN	ATALET	K O D	N U M A R A L A R I				
1	1	2	4.00	1.000	0.0080	0	0	0	0	0	1
2	2	3	8.00	1.000	0.0240	0	0	1	0	0	2

YUKLEME NO = 1

ELEMAN NO	B I L I N E N	D E P L A S M A N	V E K T O R U			
1	0.00000	-0.02000	0.00125	0.00000	-0.03000	0.00000
2	0.00000	-0.03000	0.00000	0.00000	-0.01000	0.00000

MESNET COKMELERI

ANKASTRELIK UC KUVVETLERI

ELEMAN	Ni	Ti	Mi	Nj	Tj	Mj
1	0.000	39.375	84.000	0.000	-39.375	73.500
2	0.000	-23.625	-94.500	0.000	23.625	-94.500

UC KUVVETLERI

ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	77.82	61.15	34.74	-34.74	0.00	
2	-61.15	-0.00	-7.64	7.64	0.00	

YUKLEME NO = 2

SADECE DIS YUK (Eleman 1 q=2 t/m)

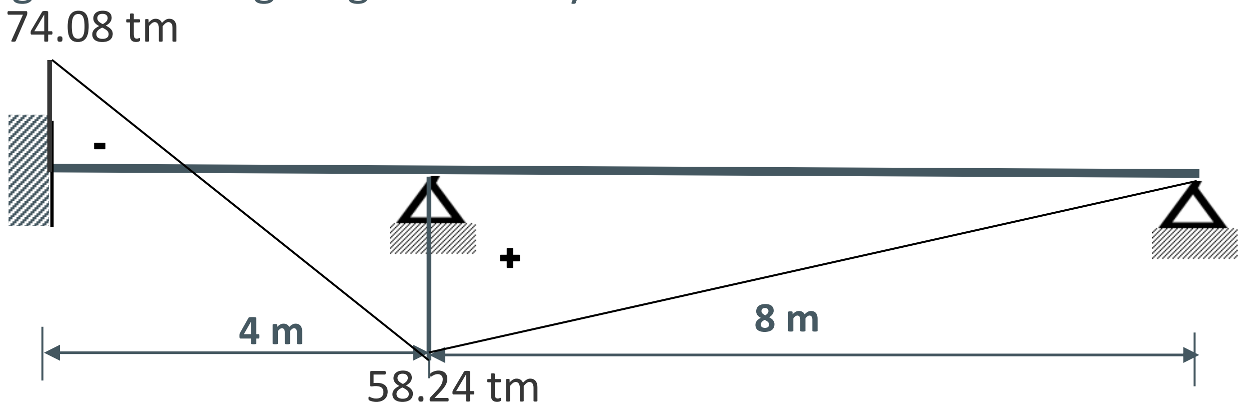
ANKASTRELIK UC KUVVETLERI

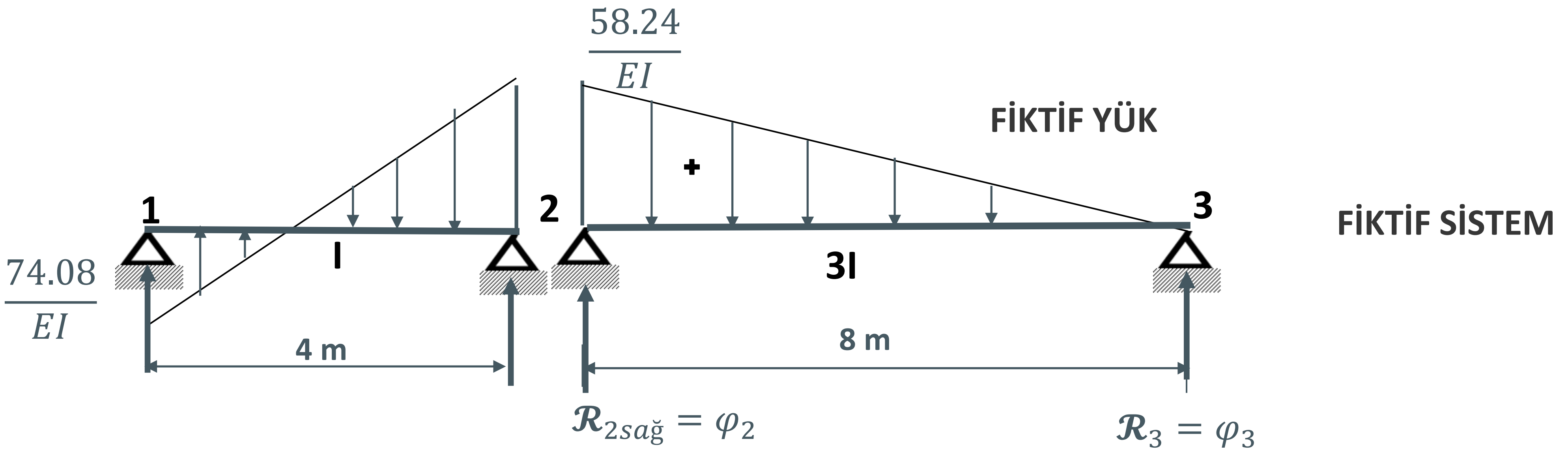
ELEMAN	Ni	Ti	Mi	Nj	Tj	Mj
1	0.000	-4.000	-2.667	0.000	-4.000	2.667
2	0.000	0.000	0.000	0.000	0.000	0.000

UC KUVVETLERI

ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	3.29	-1.41	4.47	3.53	0.00	1.70
2	1.41	0.00	0.18	-0.18	0.00	

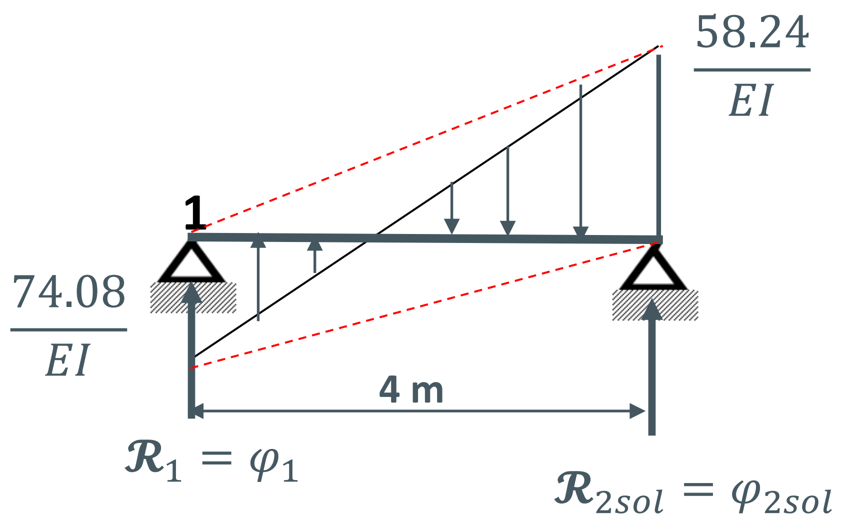
moment diyagramı verildiğine göre Mohr yöntemi ile 2 ve 3 noktalarında dönmeleri hesaplayınız





$$\sum \mathfrak{M}_2 = 0 \rightarrow \mathcal{R}_3 * 8 - \frac{1}{2}\frac{58.24}{E3I} * 8 * \frac{1}{3} * 8 = 0 \rightarrow \mathcal{R}_3 = \varphi_3 = \frac{77.6533}{E3I} = \frac{25.8844}{EI}$$

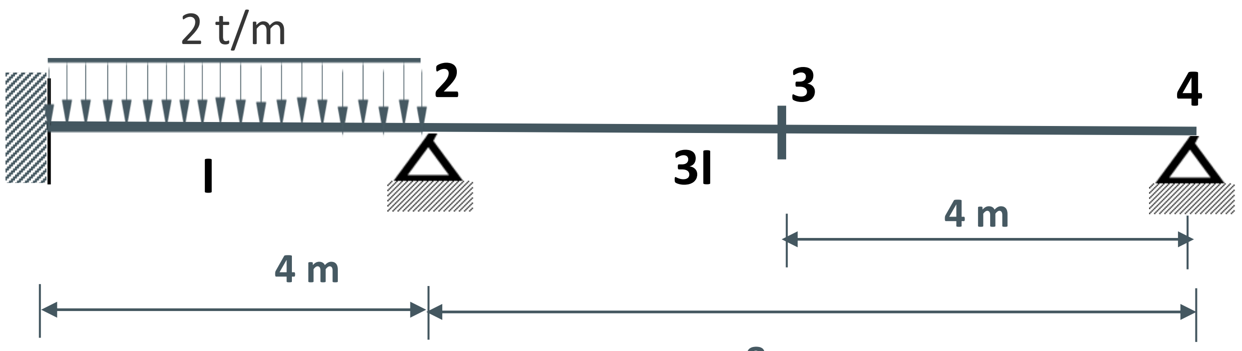
$$\rightarrow \qquad \mathcal{R}_{2sağ} = \varphi_2 = \frac{1}{2}\frac{58.24}{E3I} * 8 - \frac{77.6533}{E3I} = \frac{155.3067}{E3I} = \frac{51.7689}{EI}$$

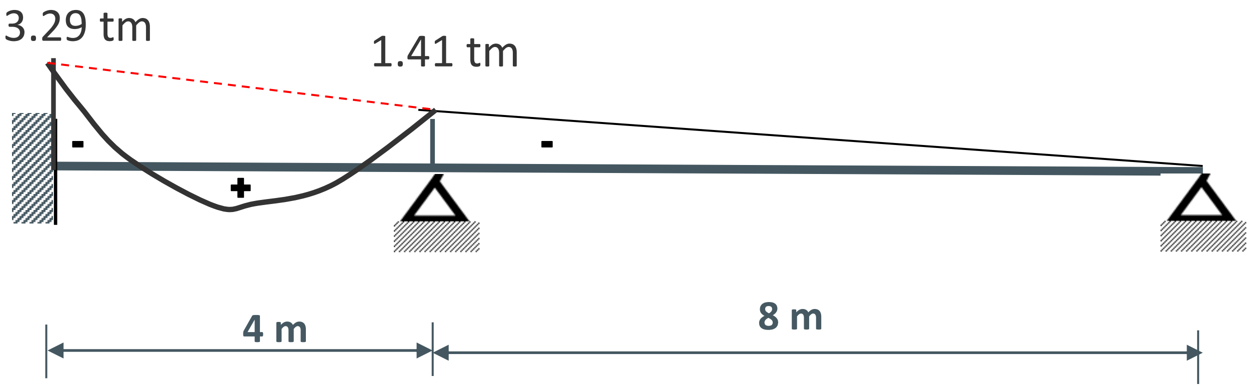


$$\sum \mathfrak{M}_1 = 0 \rightarrow \mathcal{R}_{2sol} * 4 + \frac{1}{2}\frac{74.08}{EI} * 4 * \frac{1}{3} * 4 - \frac{1}{2}\frac{58.24}{EI} * 4 * (\frac{2}{3}4) = 0 \ \rightarrow \mathcal{R}_{2sol} = \varphi_{2sol} = \frac{28.2666}{EI}$$

$$\rightarrow \qquad \mathcal{R}_1 = \varphi_1 = \frac{1}{2}\frac{58.24}{EI} * 4 - \frac{1}{2}\frac{74.08}{EI} * 4 - \frac{28.2666}{EI} = \frac{59.9466}{EI}$$

Dış yük altında moment diyagramı verildiğine göre Mohr yöntemi ile 2 ve 4 noktalarında dönmeleri 3 noktasında düşey deplasmanı hesaplayınız





6 DUZLEMI ICERISINDE YUKLU GENEL CERCEVELERIN STATIK HESABI :

ELEMAN SAYISI ---------= 3
DEPLASMAN SAYISI ------= 4
DUGUM SAYISI ----------= 4
ELASTISITE MODULU -----= 1
YUKLEME SAYISI --------= 1
KAYMA DEFORMASYONLARI IHMAL EDILIYOR

DUGUM	X	Y
1	0.00	0.00
2	4.00	0.00
3	8.00	0.00
4	12.00	0.00

ELEMAN	i	j	BOYU	ALAN	ATALET	K O D	N U M A R A L A R I				
1	1	2	4.00	1.000	1.0000	0	0	0	0	0	1
2	2	3	4.00	1.000	3.0000	0	0	1	0	2	3
3	3	4	4.00	1.000	3.0000	0	2	3	0	0	4

UÇ DEPLASMANLAR

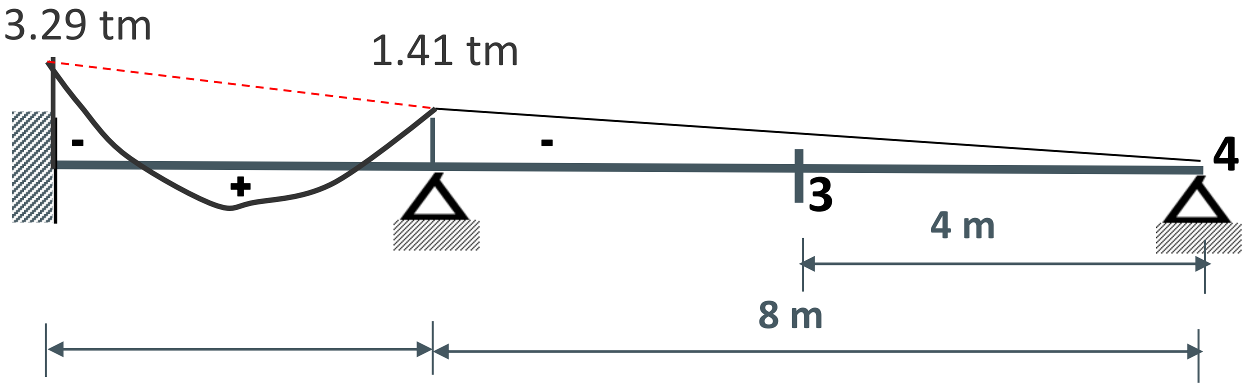
1	1.254902
2	-1.882353
3	-0.156863
4	-0.627451

ANKASTRELIK UC KUVVETLERI

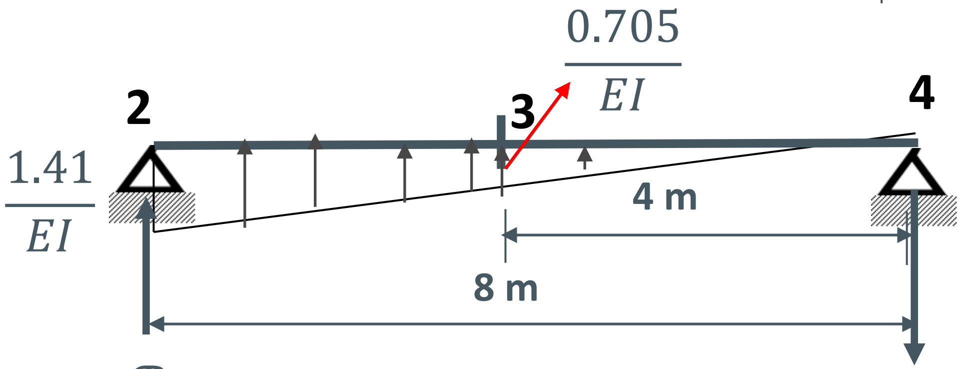
ELEMAN	Ni	Ti	Mi	Nj	Tj	Mj
1	0.000	-4.000	-2.667	0.000	-4.000	2.667
2	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000

UC KUVVETLERI

ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	3.29	-1.41	4.47	3.53	0.00	1.70
2	1.41	-0.71	0.18	-0.18	0.00	
3	0.71	0.00	0.18	-0.18	0.00	



ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	3.29	-1.41	4.47	3.53	0.00	1.70
2	1.41	0.00	0.18	-0.18	0.00	



$\mathcal{R}_{2sağ} = \varphi_2$

$\mathcal{R}_4 = \varphi_4 = \frac{0.6266}{EI}$

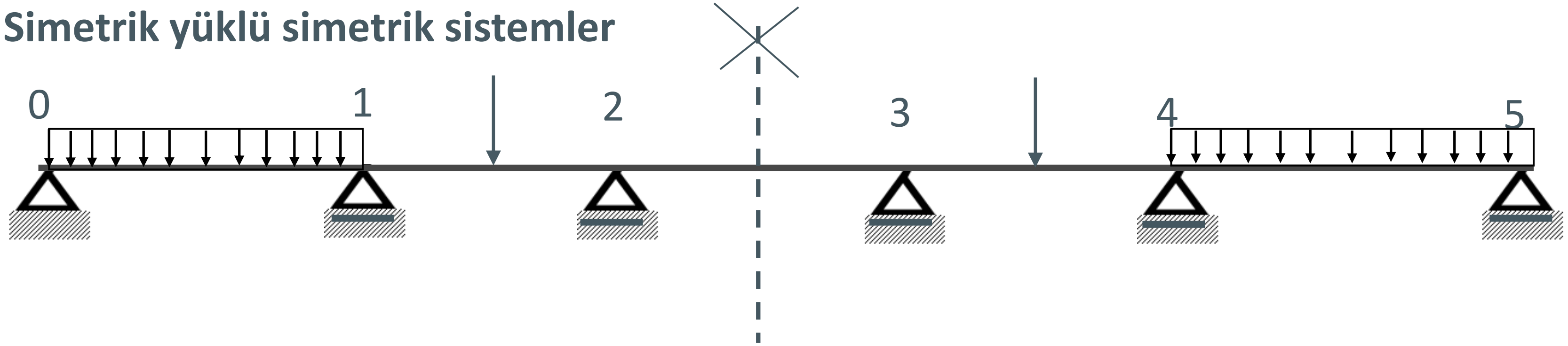
$$\sum \mathfrak{M}_2 = 0 \rightarrow -\mathcal{R}_4 * 8 + \frac{1}{2}\frac{1.41}{E3I} * 8 * \frac{1}{3} * 8 = 0 \rightarrow \mathcal{R}_4 = \varphi_4 = \frac{0.6266}{EI}$$

$$\rightarrow \quad \mathcal{R}_{2sağ} = \varphi_2 = -\frac{1}{2}\frac{1.41}{E3I} * 8 + \frac{0.6266}{EI} = -\frac{1.2534}{EI}$$

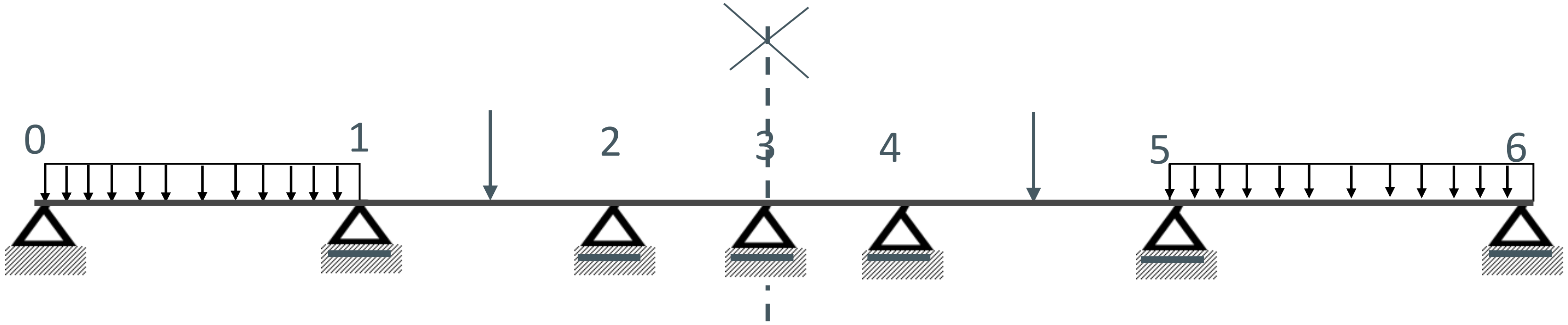
$$\sum \mathfrak{M}_3 = 0 \rightarrow -\mathfrak{M}_3 + \frac{1}{2}\frac{0.705}{E3I} * 4 * \frac{1}{3} * 4 - \frac{0.6266}{EI} * 4 = 0 \rightarrow \mathfrak{M}_3 = \delta_3 = \frac{1.8797}{EI}$$

CLAPEYRON DENKLEMLERİNİN ÖZEL DURUMLARA UYGULANIŞI

1. Simetrik yüklü simetrik sistemler



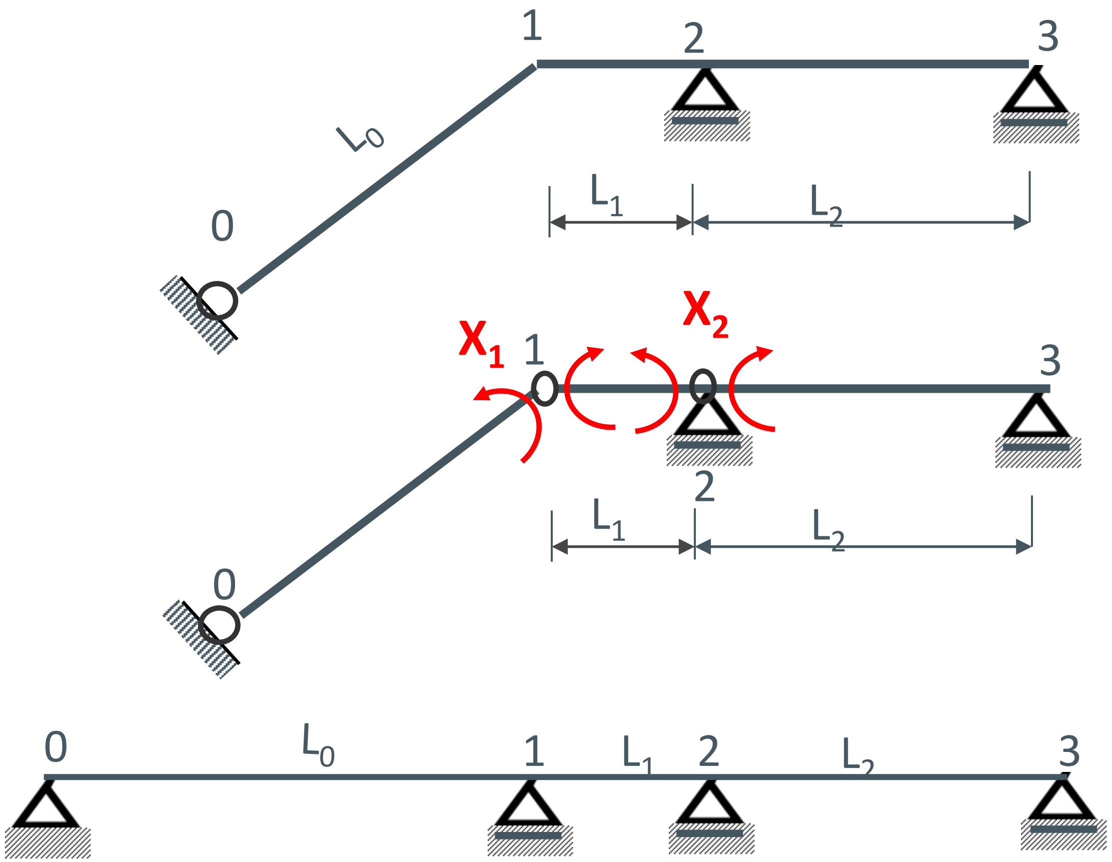
1 ve 2 mesnetleri için Clapeyron denklemleri yazılır ve $X_3=X_2$
$X_1=X_4$ $X_0=X_5$ alınır.



1, 2 ve 3 mesnetleri için Clapeyron denklemleri yazılır ve $X_4=X_2$
$X_5=X_1$ $X_0=X_6$ alınır.

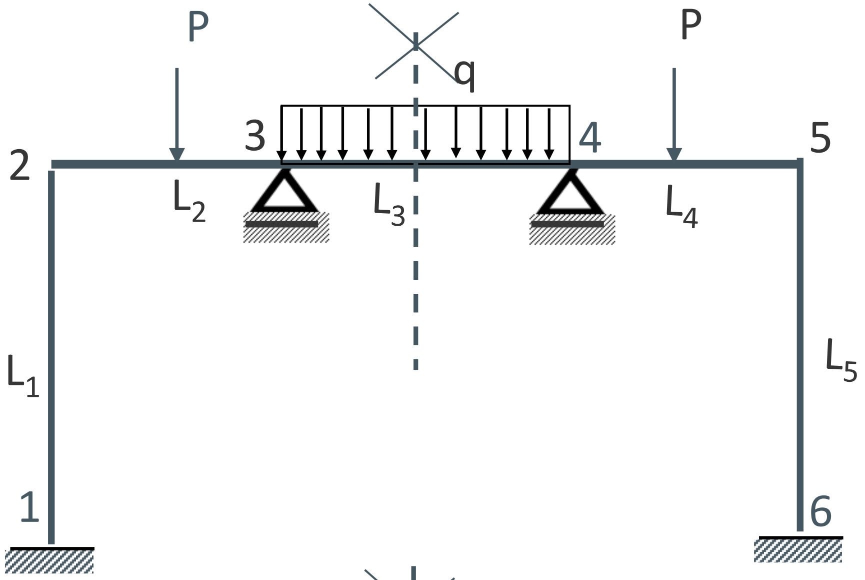
2. Düğüm noktaları sabit sistemler

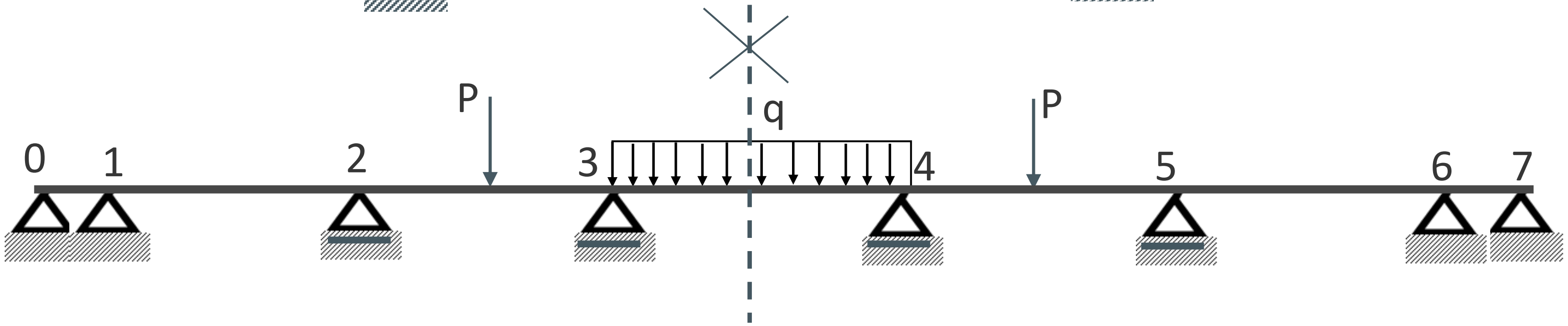
2.1 Eğer bir sistemde bir düğüm noktası kendisine komşu sabit iki düğüm noktasına en az iki çubukla bağlanmışsa bu sistemler düğüm noktaları sabit sistemlerdir.



Eş değer sistem

2.2 Düşey simetrik yüklere maruz simetrik sistemlerde düğüm noktaları sabit sistem olarak düşünülebilir.

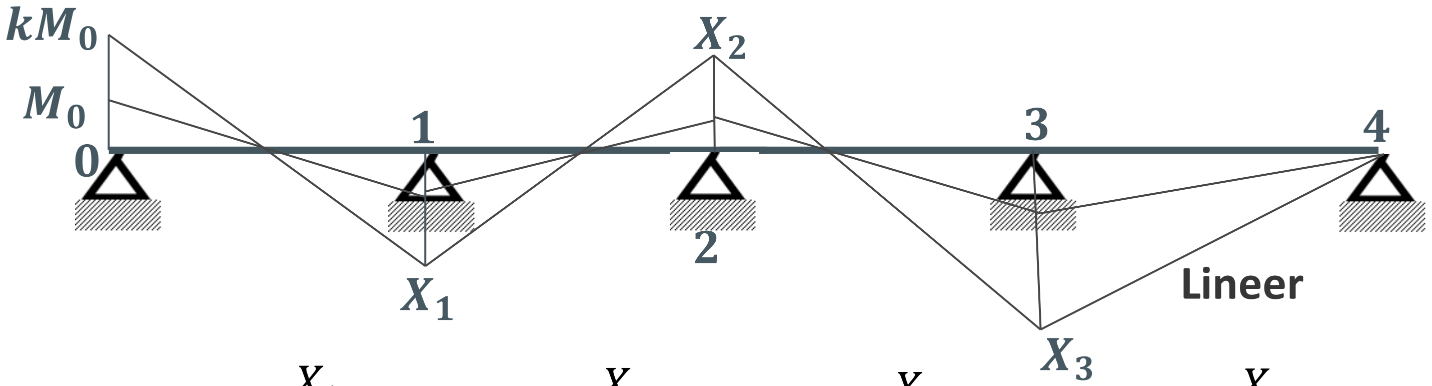




Eş değer sistem

$L_2=L_4$ $L_5=L_1$ **$X_4=X_3$ $X_5=X_2$ $X_6=X_1$**

SÜREKLİ KİRİŞLERDE GEÇİŞ KATSAYILARI VE SABİT NOKTALAR

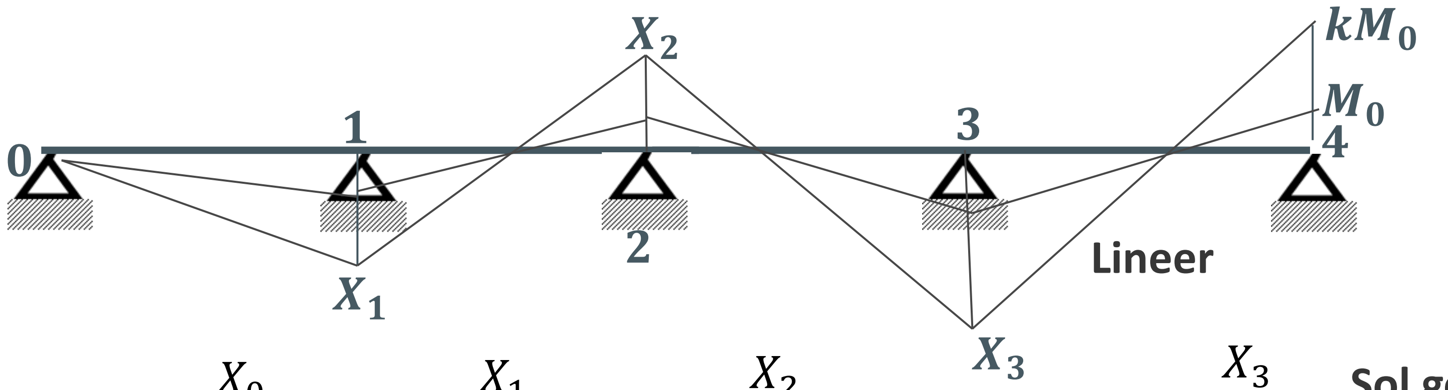


$$\mu_{01} = \frac{X_1}{X_0} \qquad \mu_{12} = \frac{X_2}{X_1} \qquad \mu_{23} = \frac{X_3}{X_2} \qquad \mu_{34} = \frac{X_4}{X_3}$$

Sağ geçiş katsayıları

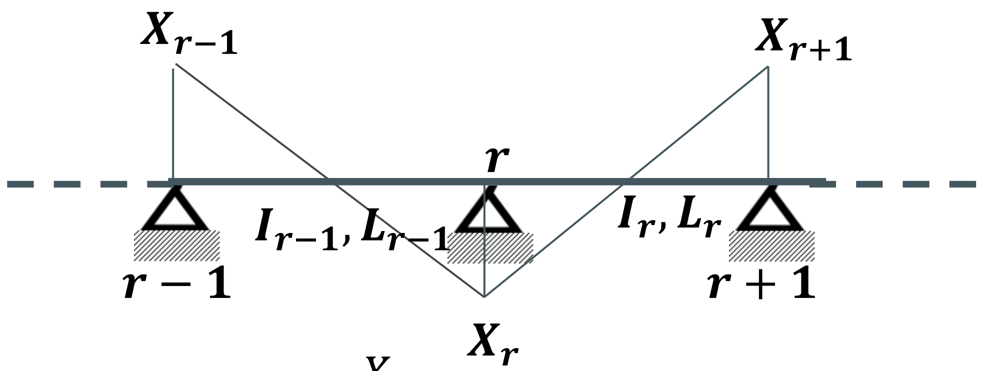
Sürekli kirişin sol kenar mesnedine etkiyen M_0 momentinden meydana gelen moment diyagramı sistemde yük olmadığından lineer olur. M_0 yerine kM_0 momenti etki ederse eğilme momenti k katı olur. O halde her açıklığın sabit bir noktasında moment sıfır olur. **Bu noktalara sağ sabit noktalar** denir.

Aynı şekilde sağ kenar mesnetten bir M_0 momenti etki ederse **sol sabit noktalar** elde edilir..



$\mu_{10} = \frac{X_0}{X_1}$ $\mu_{21} = \frac{X_1}{X_2}$ $\mu_{32} = \frac{X_2}{X_3}$ $\mu_{43} = \frac{X_3}{X_4}$ **Sol geçiş katsayıları**

SÜREKLİ KİRİŞLERDE SAĞ GEÇİŞ KATSAYILARININ HESABI



$$\mu_{r-1,r} = \frac{X_r}{X_{r-1}} \quad \rightarrow X_r = \mu_{r,r-1} * X_{r-1}$$

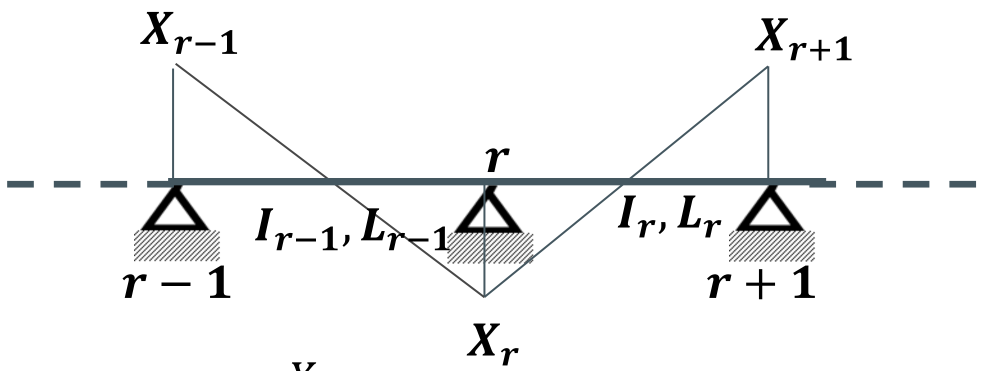
$$\mu_{r,r+1} = \frac{X_{r+1}}{X_r} \quad \rightarrow X_{r+1} = \mu_{r,r+1} * X_r = \mu_{r,r+1} * \mu_{r-1,r} * X_{r-1}$$

$$\frac{L_{r-1}}{I_{r-1}} X_{r-1} + 2\left(\frac{L_{r-1}}{I_{r-1}} + \frac{L_r}{I_r}\right) X_r + \frac{L_r}{I_r} X_{r+1} = 0 \quad ,,,,,,,,(1)$$

$$\frac{L_{r-1}}{I_{r-1}} X_{r-1} + 2\left(\frac{L_{r-1}}{I_{r-1}} + \frac{L_r}{I_r}\right) \mu_{r-1,r} X_{r-1} + \frac{L_r}{I_r} \mu_{r,r+1} * \mu_{r-1,r} X_{r-1} = 0 \quad ,,,,,,,,(2)$$

$$\overrightarrow{\mu_{r-1,r}} = -\frac{1}{\frac{L_r/I_r}{L_{r-1}/I_{r-1}}\left(\overrightarrow{\mu_{r,r+1}} + 2\right) + 2}$$

SÜREKLİ KİRİŞLERDE SOL GEÇİŞ KATSAYILARININ HESABI



$$\mu_{r,r-1} = \frac{X_{r-1}}{X_r} \quad \rightarrow X_{r-1} = \mu_{r-1,r} * X_r \ldots\ldots\ldots.(I)$$

$$\mu_{r+1,r} = \frac{X_r}{X_{r+1}} \quad \rightarrow X_r = \mu_{r+1,r} * X_{r+1} \ldots\ldots\ldots..(II)$$

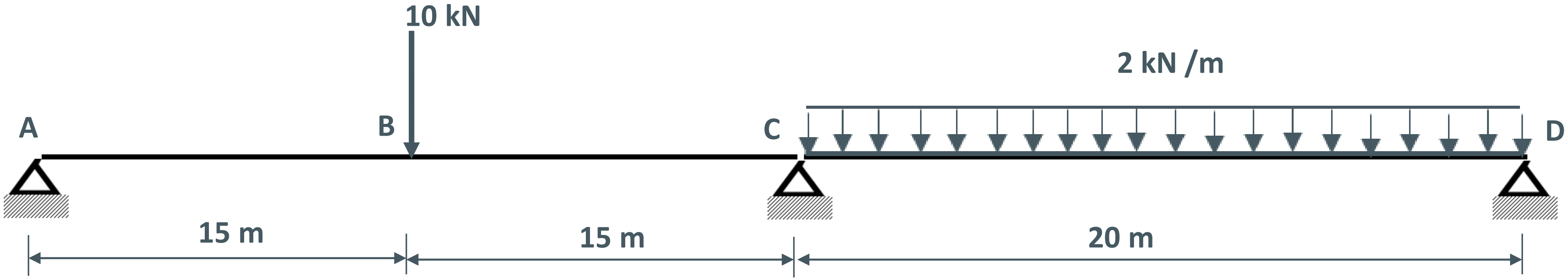
II ifadesi I ifadesinde yerine konursa $\quad X_{r-1} = \mu_{r-1,r} * \mu_{r+1,r} * X_{r+1} \ldots\ldots\ldots.(III)$

$$\frac{L_{r-1}}{I_{r-1}} X_{r-1} + 2\left(\frac{L_{r-1}}{I_{r-1}} + \frac{L_r}{I_r}\right) X_r + \frac{L_r}{I_r} X_{r+1} = 0 \quad ,,,,,,,,(1)$$

$$\frac{L_{r-1}}{I_{r-1}} \mu_{r-1,r} * \mu_{r+1,r} * X_{r+1} + 2\left(\frac{L_{r-1}}{I_{r-1}} + \frac{L_r}{I_r}\right) \mu_{r+1,r} X_{r+1} + \frac{L_r}{I_r} X_{r+1} = 0 \quad ,,,,,,,,(2)$$

$$\overleftarrow{\mu}_{r-1,r} = -\frac{1}{\frac{L_{r-1}/I_{r-1}}{L_r/I_r}\left(\overleftarrow{\mu}_{r,r-1} + 2\right) + 2}$$

Soru 1



a) Şekildeki sürekli kirişin Moment ve Kesme kuvveti diyagramlarını Clapeyron denklemlerini kullanarak çiziniz.

b) A mesnedinde dönme (φ_A) ve B noktasında düşey deplasmanı (δ_B) Mohr Yöntemini kullanarak hesaplayınız.

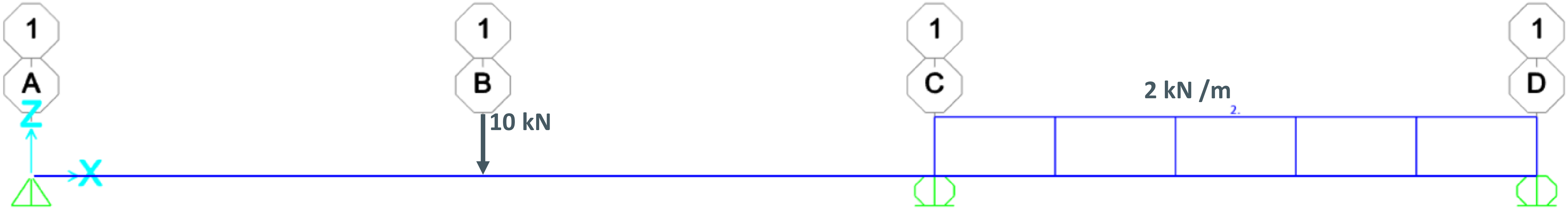
a) Şekildeki sürekli kirişin Moment ve Kesme kuvveti diyagramlarını Clapeyron denklemlerini kullanarak çiziniz.

X_A $\qquad\qquad$ X_C $\qquad\qquad$ X_D

$\frac{30}{I}$	$\frac{20}{I}$
$\frac{3}{8}PL = \frac{3}{8}10 * 30 = 112.5$ $\quad$ 112.5	$\frac{qL^2}{4} = 200$ $\quad$ 299
$\frac{30}{I}112.5 = \frac{3375}{I}$ $\quad$ $\frac{3375}{I}$	$\frac{20}{I}200 = \frac{4000}{I}$ $\quad$ $\frac{4000}{I}$

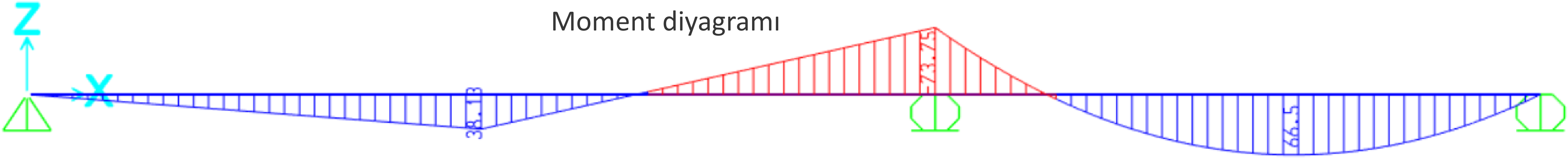
$$\frac{30}{I}X_A + 2\left(\frac{30}{I} + \frac{20}{I}\right)X_C + \frac{20}{I}X_D + \frac{3375}{I} + \frac{4000}{I} = 0$$

$$30 * 0 + 100X_C + 20 * 0 + 7375 = 0 \rightarrow X_C = 73.75\ kNm$$

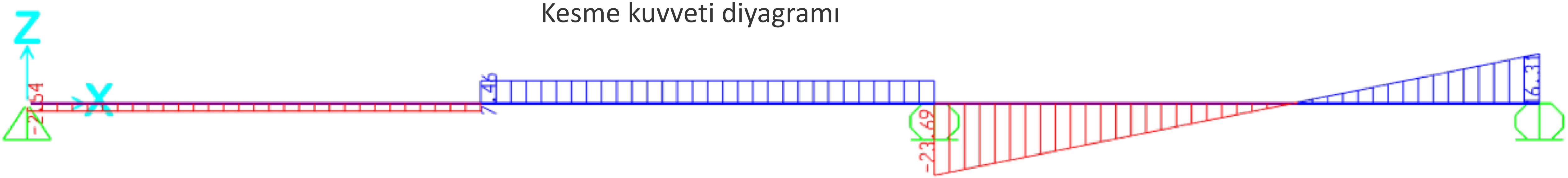


Mesnet tepkileri

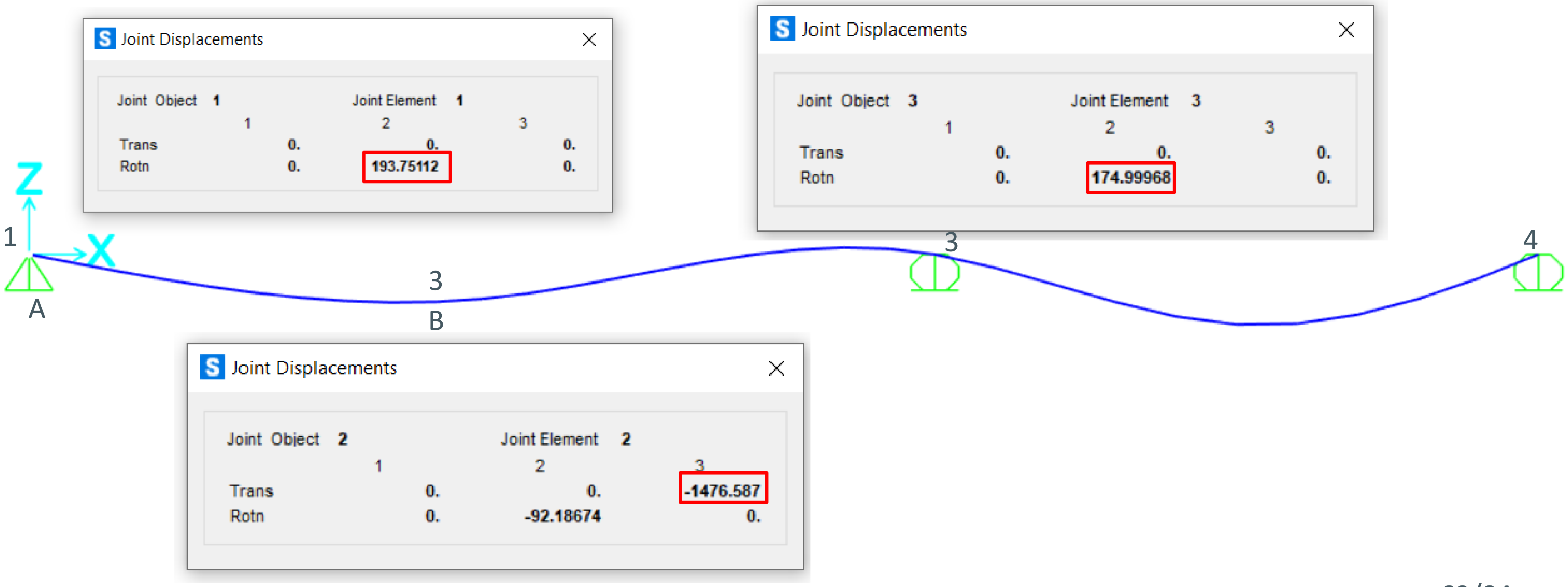
Moment diyagramı



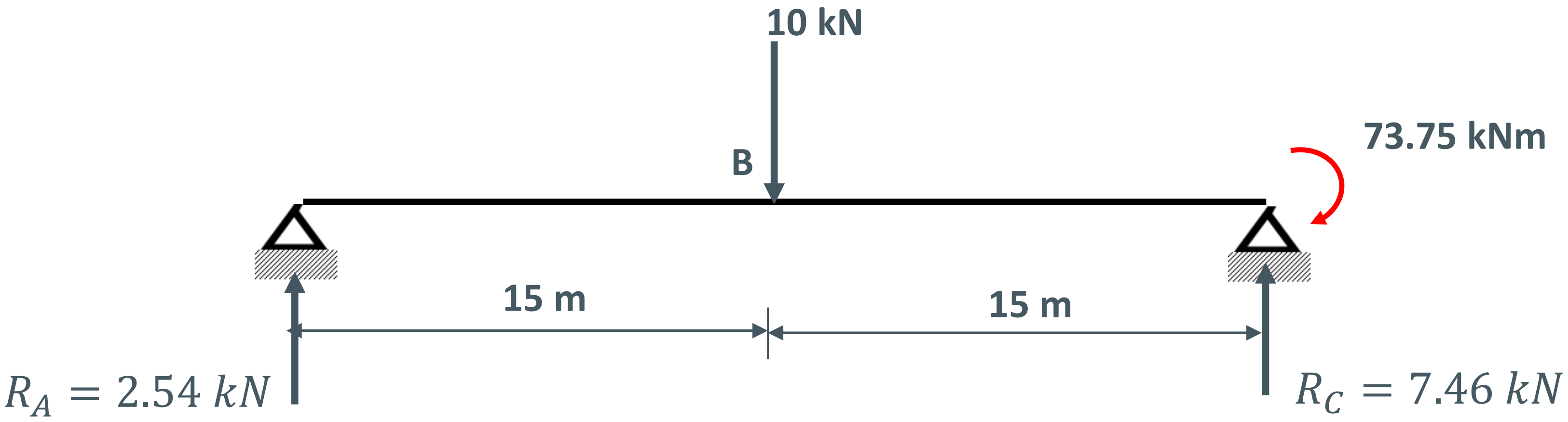
Kesme kuvveti diyagramı



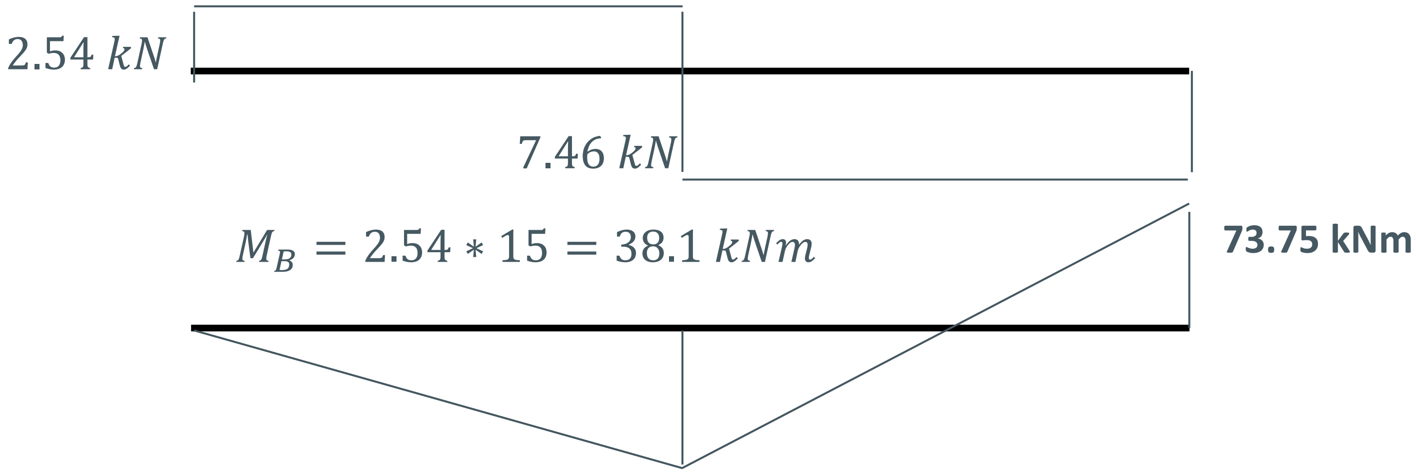
b) A mesnedinde dönme (φ_A) ve B noktasında düşey deplasmanı (δ_B) SAP2000

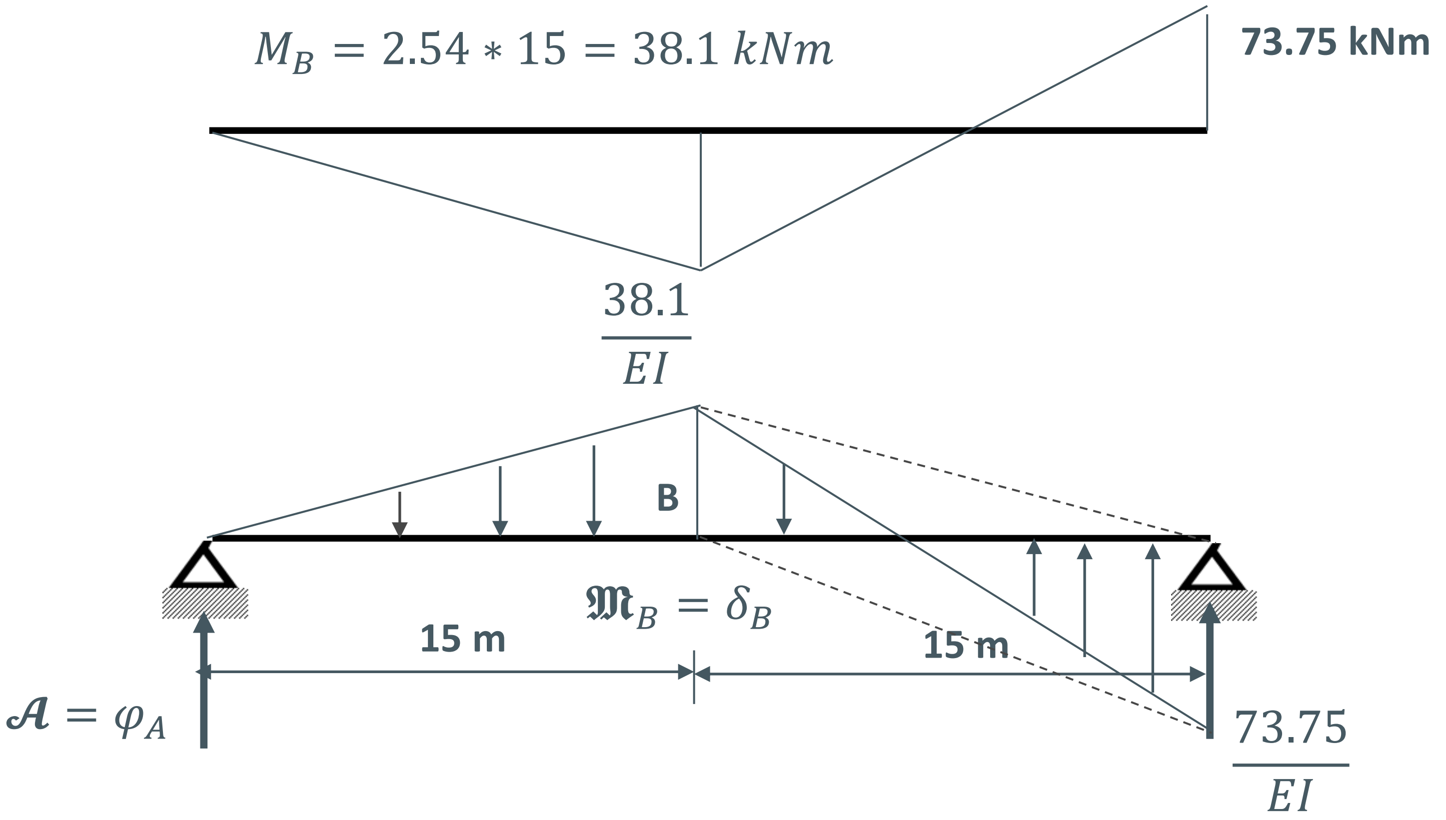


b) A mesnedinde dönme (φ_A) ve B noktasında düşey deplasmanı (δ_B) Mohr Yöntemini kullanarak hesaplayınız.



$$R_A * 30 - 10 * 15 + 73.75 = 0 \rightarrow R_A = 2.54\ kN$$





$$\sum M_C = 0 \quad \mathcal{A} * 30 - \frac{1}{2} 15 * \frac{38.1}{EI}\left(\frac{1}{3} 15 + 15\right) - \frac{1}{2} 15 * \frac{38.1}{EI}\left(\frac{2}{3} * 15\right) + \frac{1}{2} 15 * \frac{73.75}{EI}\left(\frac{1}{3} 15\right) = 0$$

$$\mathcal{A} = \varphi_A = \frac{5006.875}{30EI} = \frac{193.5625}{EI} \rightarrow \sum \mathfrak{M}_B = 0 \rightarrow \mathfrak{M}_B = \delta_B = \frac{193.56 * 15}{EI} - \frac{1}{2} 15 * \frac{38.1}{EI}\left(\frac{1}{3} * 15\right) - = \frac{1474.71}{EI} \surd$$

DUZLEMI ICERISINDE YUKLU GENEL CERCEVELERIN STATIK HESABI :

TOROS ÜNİVERSİTESİ SORU 1

ELEMAN SAYISI ---------= 3
DEPLASMAN SAYISI ------= 5
DUGUM SAYISI ----------= 4
ELASTISITE MODULU -----= 1
YUKLEME SAYISI --------= 1
KAYMA DEFORMASYONLARI IHMAL EDILIYOR

DUGUM	X	Y
1	0.00	0.00
2	15.00	0.00
3	30.00	0.00
4	50.00	0.00

ELEMAN	i	j	BOYU	ALAN	ATALET	K O D N U M A R A L A R I					
1	1	2	15.00	1.000	1.0000	0	0	1	0	2	3
2	2	3	15.00	1.000	1.0000	0	2	3	0	0	4
3	3	4	20.00	1.000	1.0000	0	0	4	0	0	5

YUKLEME NO = 1

DEPLASMANLAR

1	-193.750
2	-1476.563
3	-92.187
4	-125.000
5	420.833

ANKASTRELIK UC KUVVETLERI

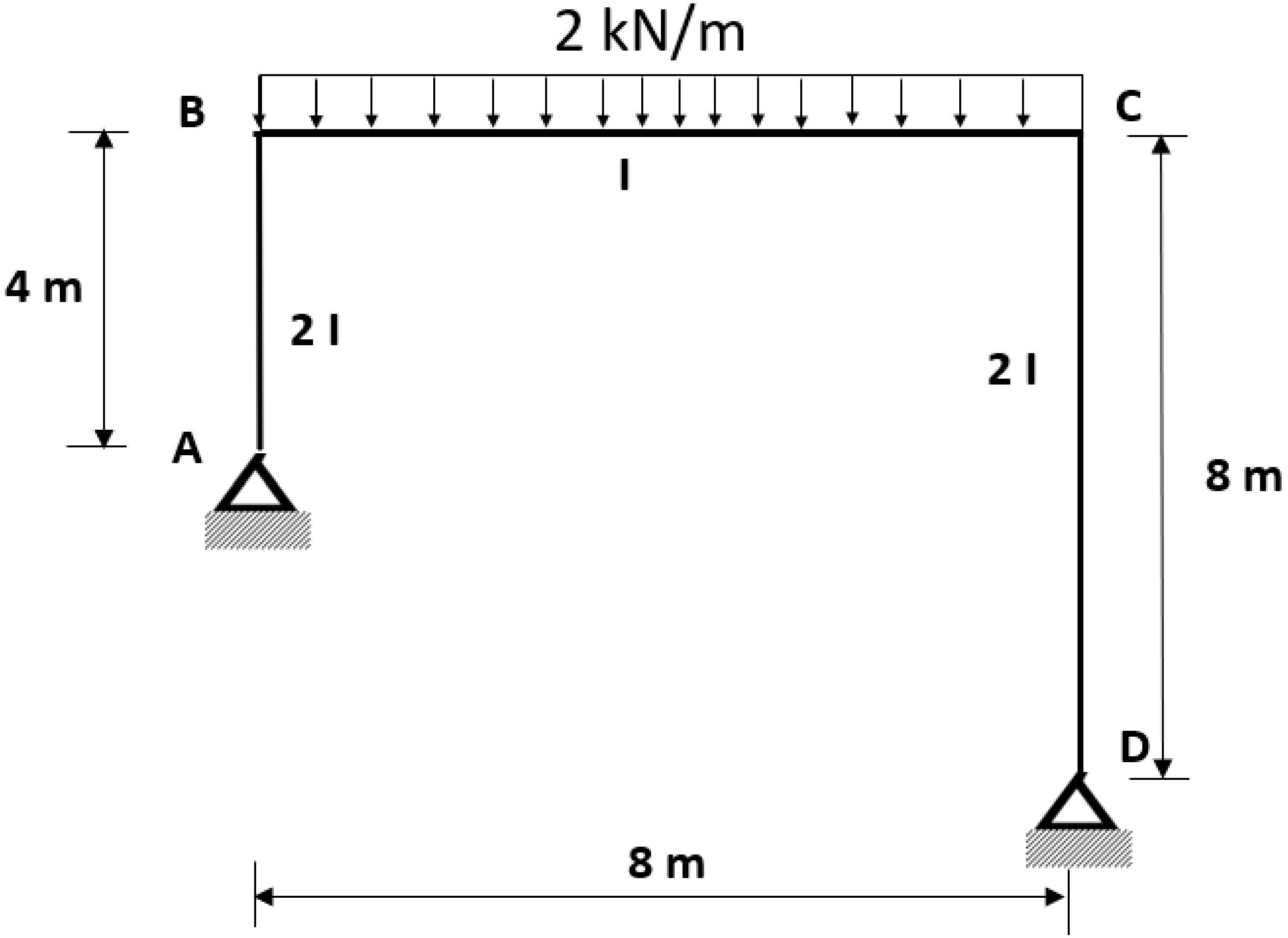
ELEMAN	Ni	Ti	Mi	Nj	Tj	Mj
1	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	-20.000	-66.667	0.000	-20.000	66.667

UC KUVVETLERI

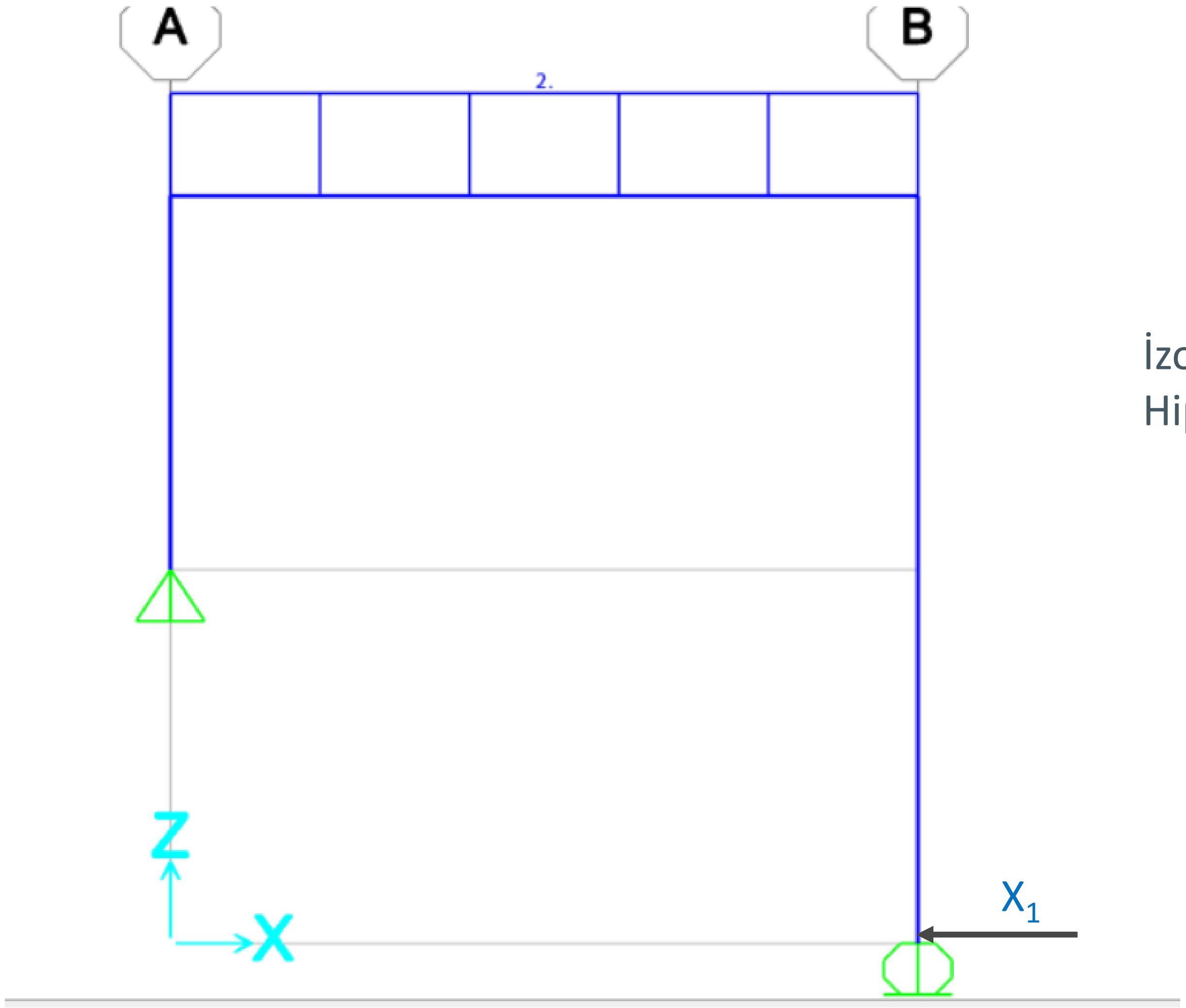
ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	-0.00	38.13	2.54	-2.54	0.00	
2	-38.13	-73.75	-7.46	7.46	0.00	
3	73.75	0.00	23.69	16.31	0.00	66.52

Soru 2:

a) Şekilde verilen çerçeve sistemini kuvvet yöntemini kullanarak moment kesme kuvveti ve normal kuvvet diyagramlarını çiziniz.
b) C noktasının yatay deplasmanını (δ_C) hesaplayınız.



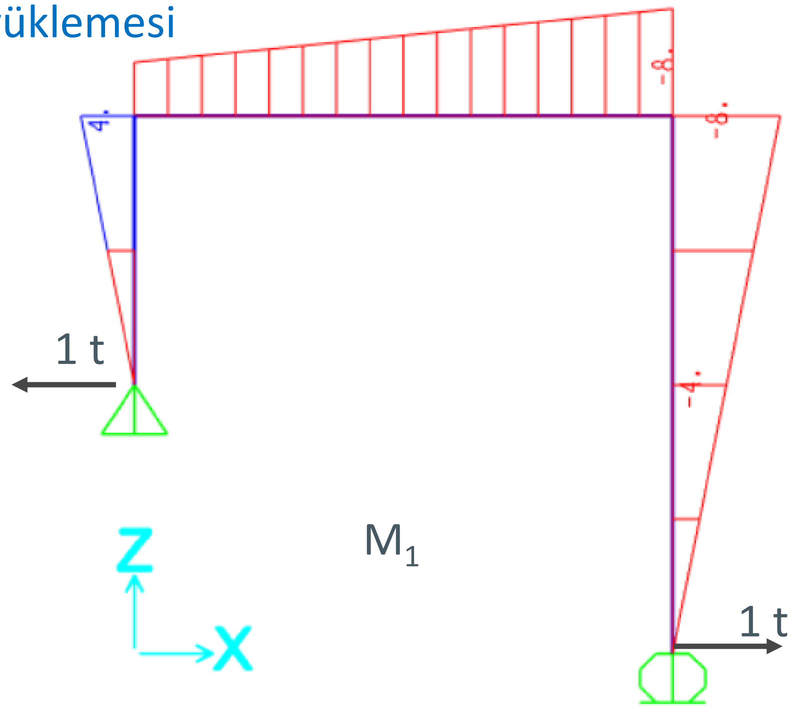
a) Şekilde verilen çerçeve sistemini kuvvet yöntemini kullanarak moment kesme kuvveti ve normal kuvvet diyagramlarını çiziniz.



İzostatik esas sistem

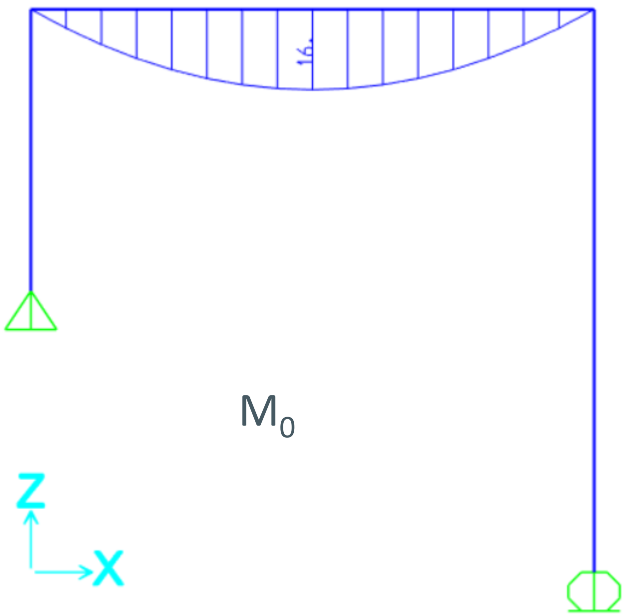
Hiperstatik bilinmeyen X_1

X_1 = 1 birim yüklemesi



İzostatik esas sistemin dış yük altında moment diyagramı

Hiperstatik bilinmeyen X_1 =0



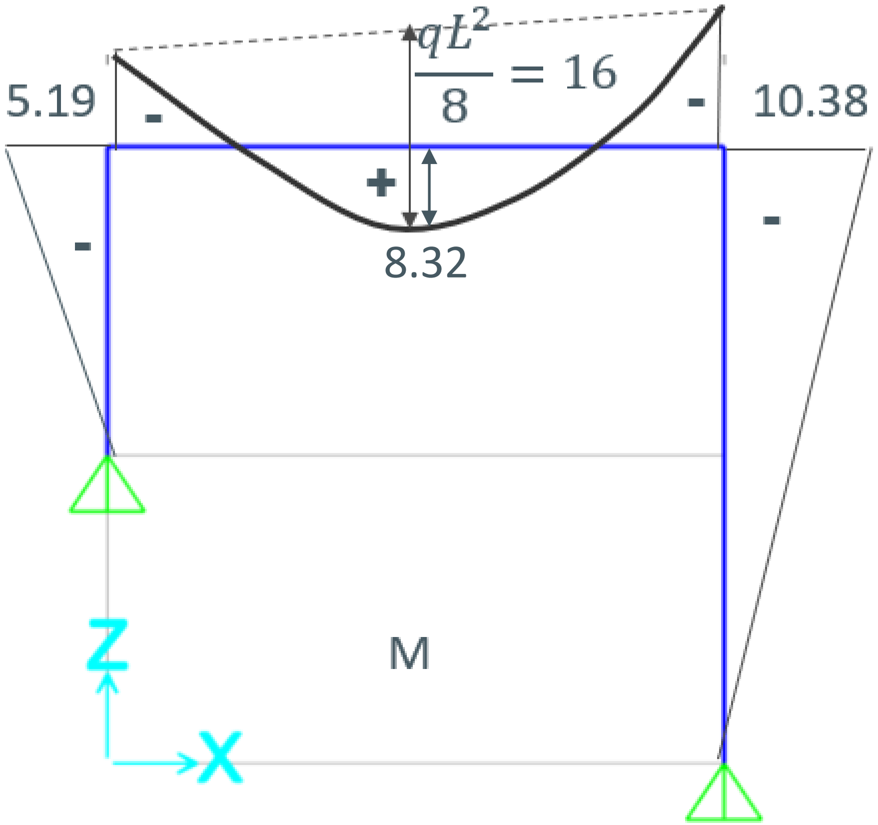
$$EI_c\delta_{11} = \frac{1}{3}4*4*4*[1] + \frac{1}{6}8*(2*4*4+4*8+8*4+2*8*8)*[2] + \frac{1}{3}*8*8*8*[1]$$
$$= 21.33 + 597.33 + 170.66 = 789.32$$

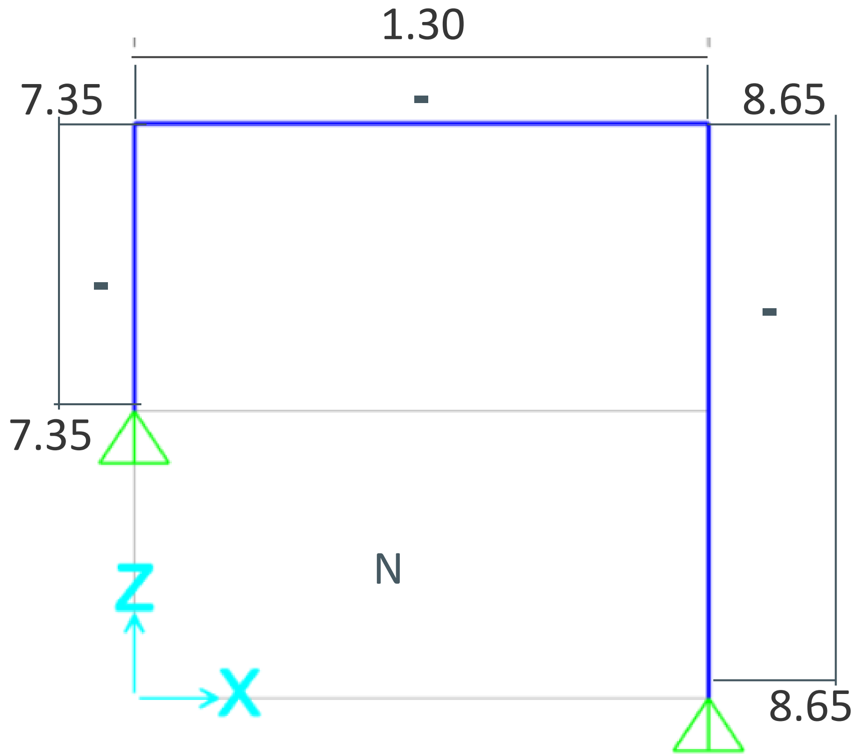
$$EI_c\delta_{10} = \frac{1}{3}*8*(-4-8)*16*[2] = -1024$$

$$789.32X_1 - 1024 = 0 \rightarrow X_1 = 1.2973\ t$$

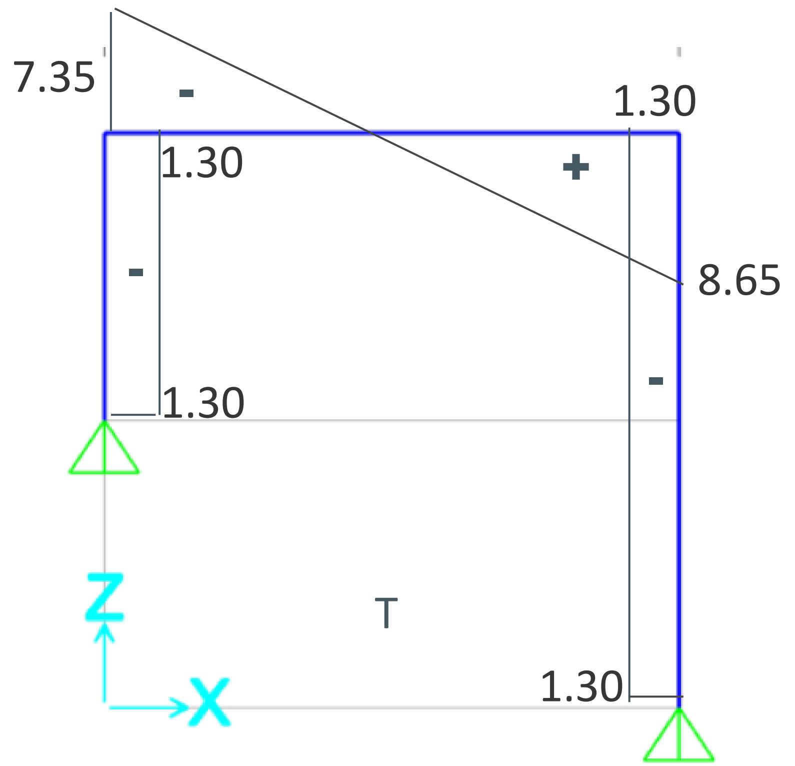
$$M = M_0 + M_1X_1$$

$$M_{(B)} = 0 + (-4)*1.2973 = -5.19\ tm$$
$$M_{(C)} = 0 + (-8)*1.2973 = -10.38\ tm$$



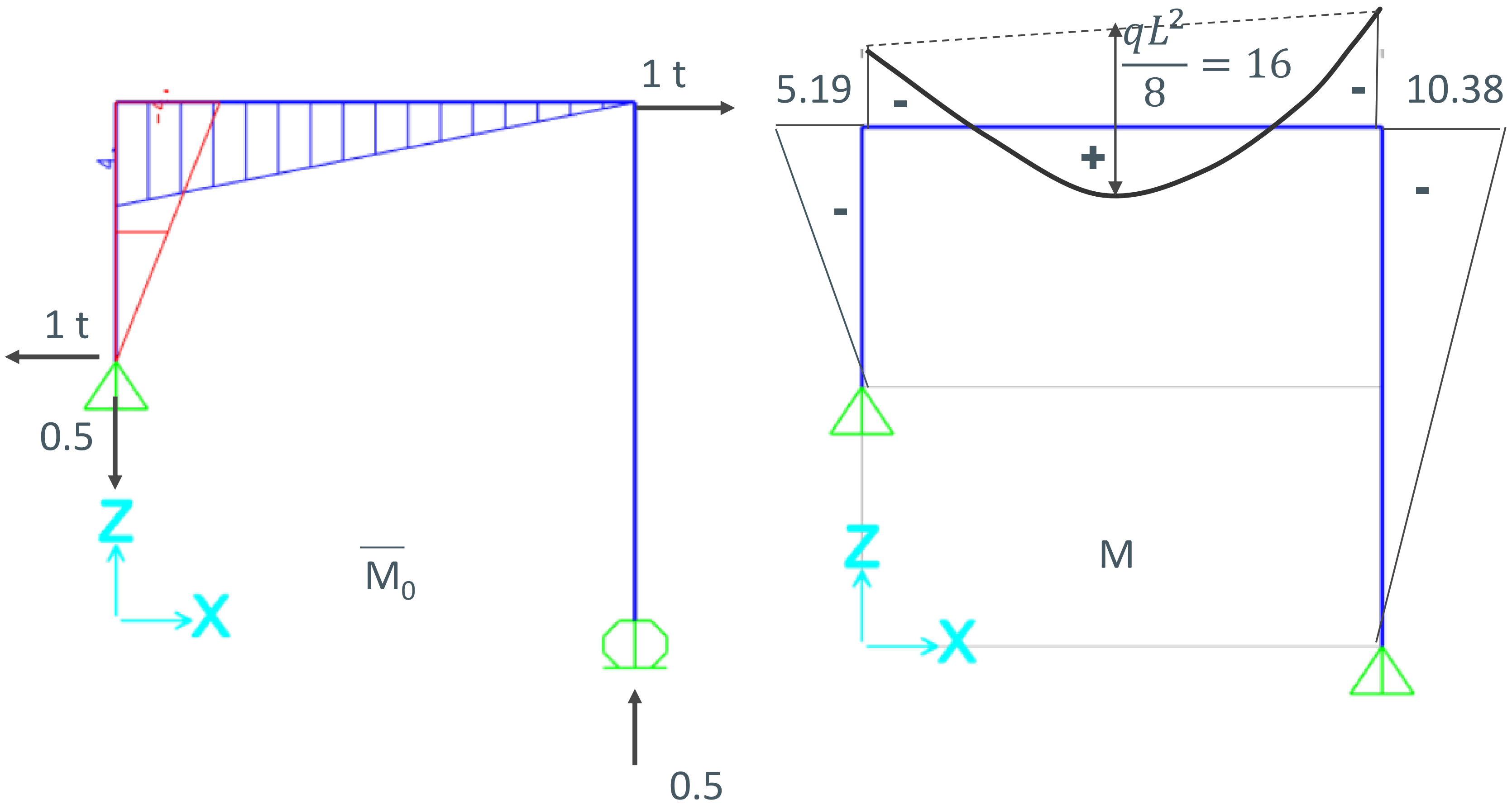


ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	0.00	-5.19	-1.30	1.30	-7.35	
2	5.19	-10.38	7.35	8.65	-1.30	8.32
3	10.38	0.00	1.30	-1.30	-8.65	



ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	0.00	-5.19	-1.30	1.30	-7.35	
2	5.19	-10.38	7.35	8.65	-1.30	8.32
3	10.38	0.00	1.30	-1.30	-8.65	

b) C noktasının yatay deplasmanını (δ_C) hesaplayınız.



$$EI_c\delta_C = \frac{1}{3}4*4*(-5.19)[1] + \frac{1}{6}8*4*(2*(-5.19) - 10.38)[2] + \frac{1}{3}8*4*16*[2] = 92.2133$$

$$EI_c\delta_C = 92.2133 \rightarrow \delta_C = \frac{92.2133}{E2I} = \frac{46.1066}{EI}$$

6DUZLEMI ICERISINDE YUKLU GENEL CERCEVELERIN STATIK HESABI:

SDB88 ÇÖZÜM SONUÇLARI

ELEMAN SAYISI ---------= 3

DEPLASMAN SAYISI ------= 8

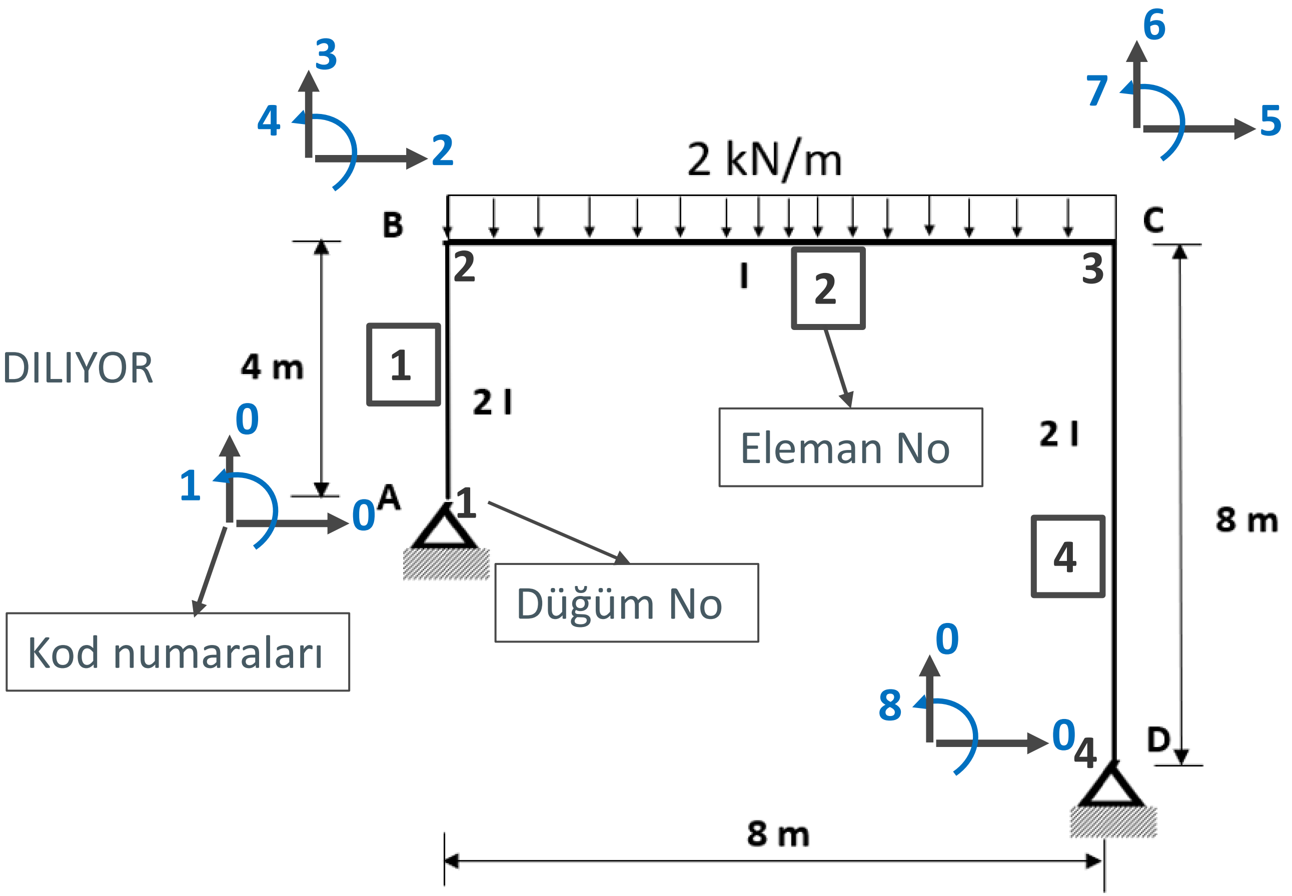
DUGUM SAYISI ----------= 4

ELASTISITE MODULU -----= 1

YUKLEME SAYISI --------= 1

KAYMA DEFORMASYONLARI IHMAL EDILIYOR

DUGUM	X	Y
1	0.00	4.00
2	0.00	8.00
3	8.00	8.00
4	8.00	0.00



UÇ DEPLASMANLAR

1. -9.811084
2. 46.16172
3. -2.940486E-02
4. -14.99912
5. 46.15134
6. -6.919026E-02
7. 8.068824
8. -12.60779

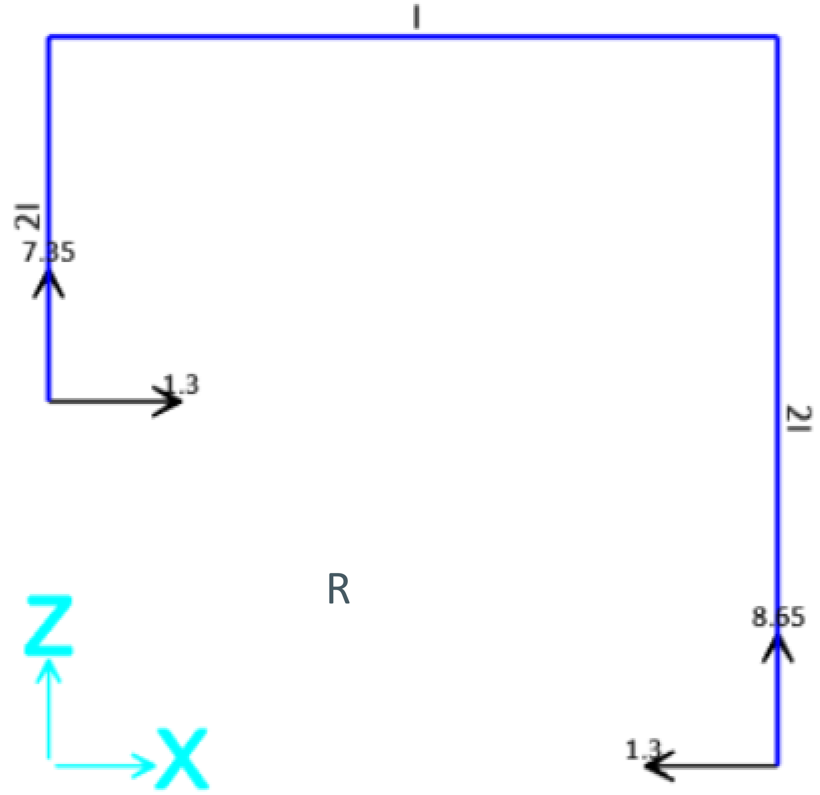
ELEMAN	i	j	BOYU	ALAN	ATALET	K O D	N U M A R A L A R I				
1	1	2	4.00	>>10	2.0000	0	0	1	2	3	4
2	2	3	8.00	>>10	1.0000	2	3	4	5	6	7
3	3	4	8.00	>>10	2.0000	5	6	7	0	0	8

YUKLEME NO = 1

UC KUVVETLERI

ELEMAN	Mij	Mji	Tij	Tji	Nj	ACIKLIK M.
1	0.00	-5.19	-1.30	1.30	-7.35	
2	5.19	-10.38	7.35	8.65	-1.30	8.32
3	10.38	0.00	1.30	-1.30	-8.65	

SAP2000 ÇÖZÜM SONUÇLARI



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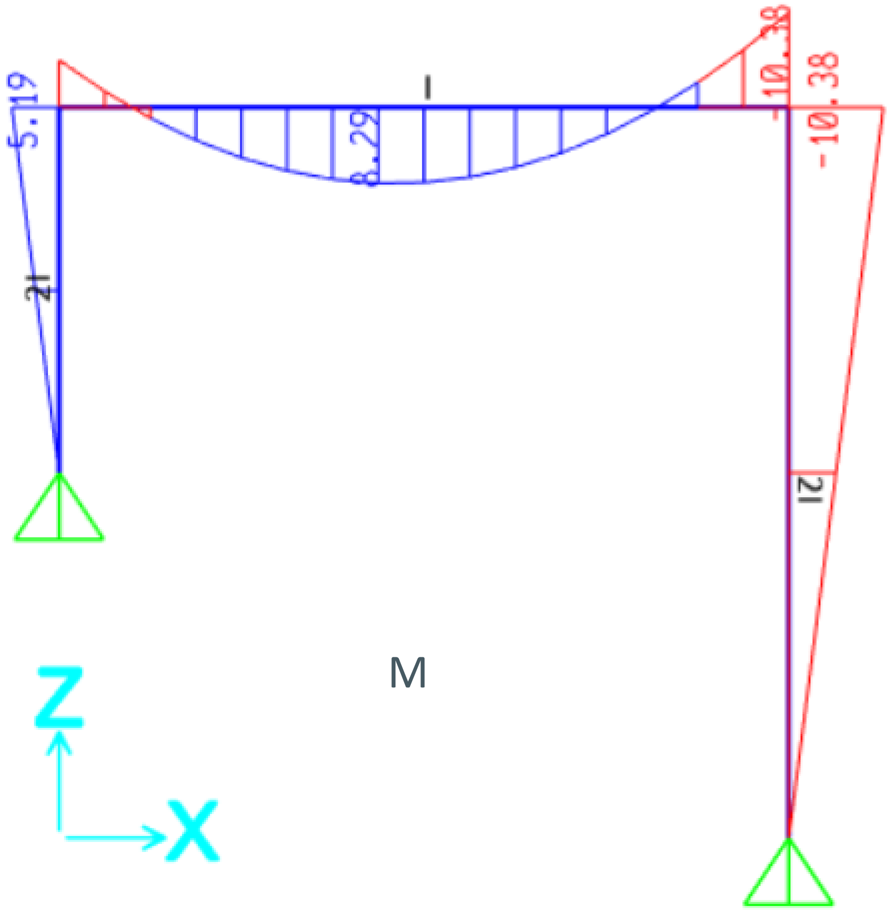
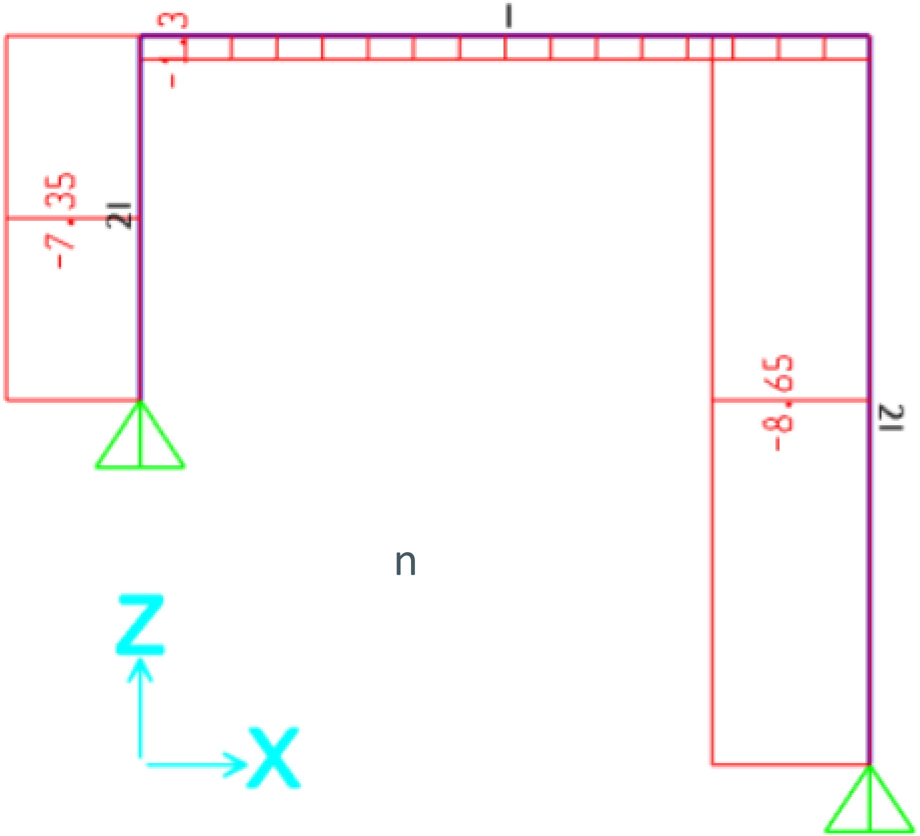
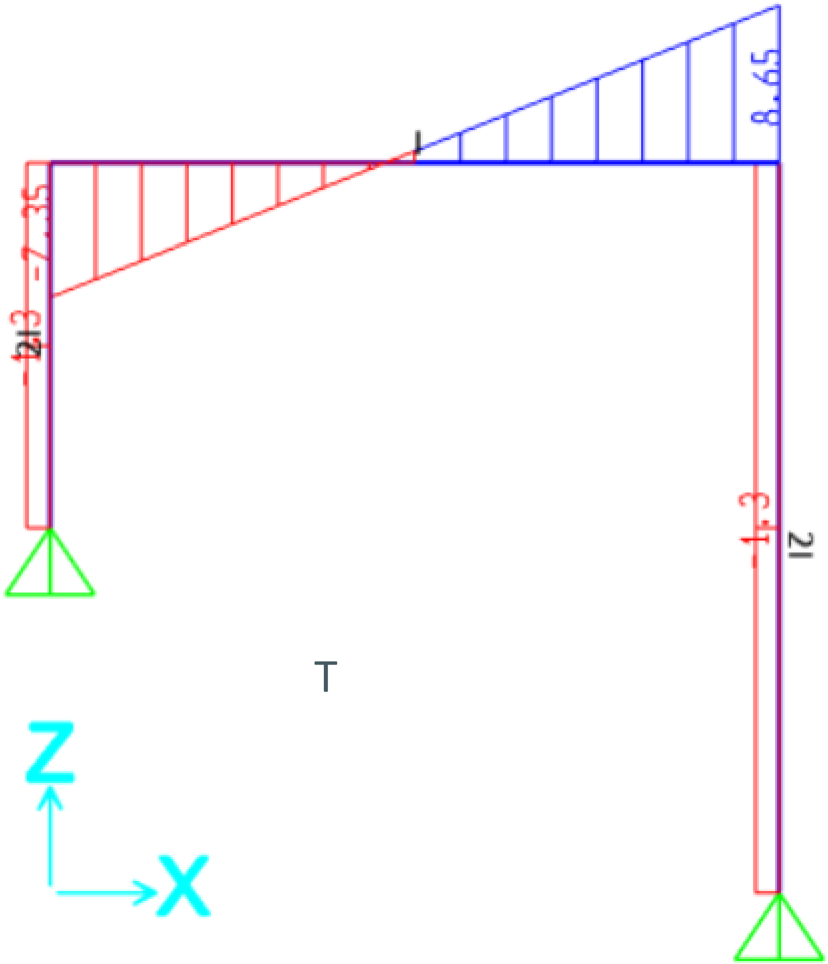


M



n



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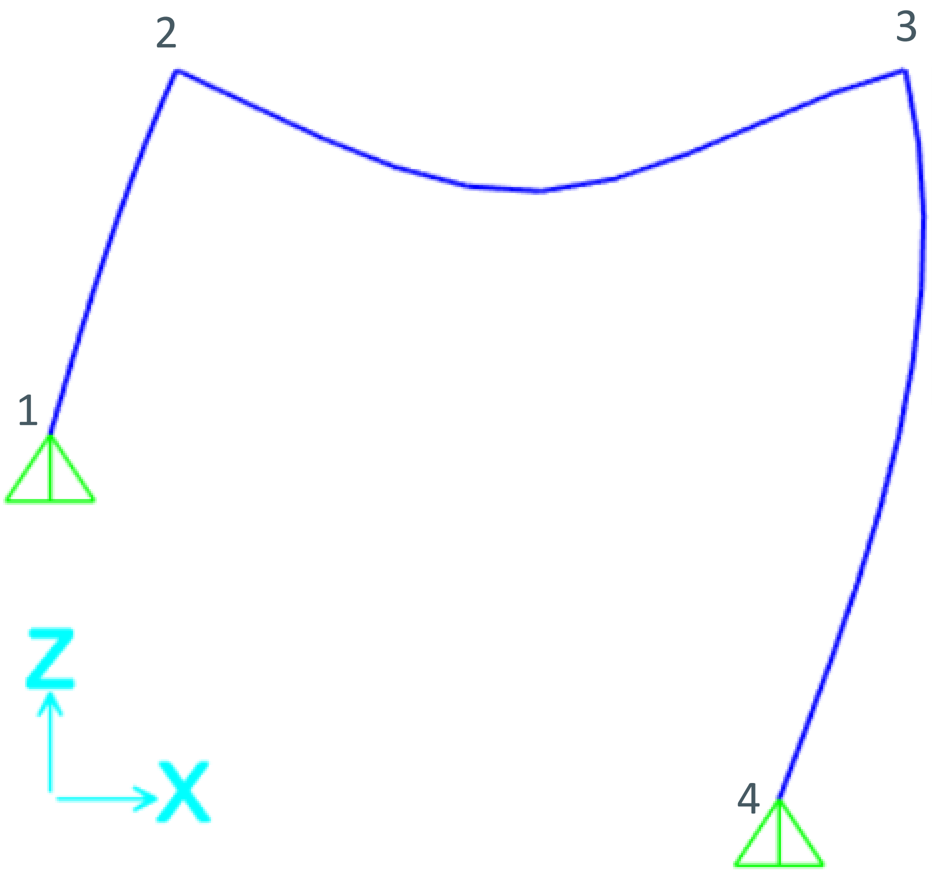
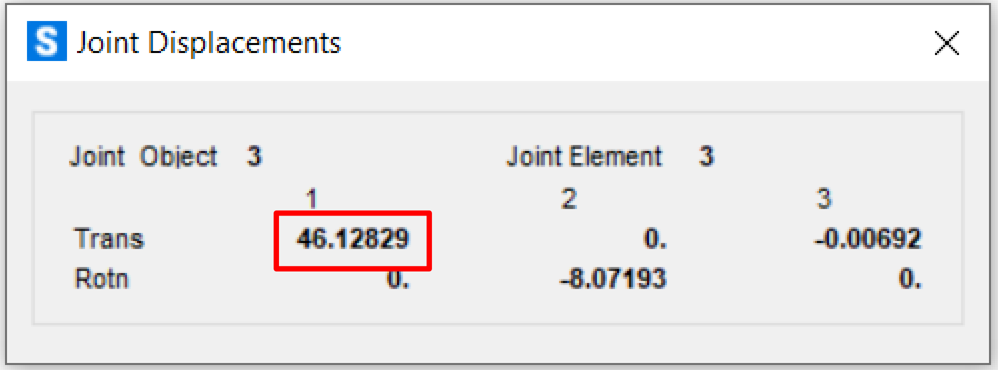

2
3
1
4
Z
X


Joint Displacements
Joint Object 3
Joint Element 3
1
2
3
Trans
46.12829
0.
-0.00692
Rotn
0.
-8.07193
0.