YAPI STATİĞİ 2

DERS NOTLARI(2-4.2)

Hiperstatik sistemlerde tesir çizgileri

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HİPERSTATİK SİSTEMLERDE TESİR ÇİZGİLERİ

1. Fonksiyonlar metodu
2. Mohr metodu
3. Hiperstatik esas sistem kullanma metodu
4. Ankastre esas sistem metodu

1. Fonksiyonlar metodu

$$\delta_{11}X_1 + \delta_{12}X_2 + \cdots + \delta_{1n}X_n = -\delta_{10}(x)$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$\delta_{n1}X_1 + \delta_{n2}X_2 + \cdots + \delta_{nn}X_n = -\delta_{n0}(x)$$

$$[\delta]\{X\} + \{\delta_0\} = 0$$

$$X_1 = \beta_{11}\delta_{10}(x) + \beta_{12}\delta_{20}(x) + \cdots + \beta_{1n}\delta_{n0}(x)$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$X_n = \beta_{n1}\delta_{10}(x) + \beta_{n2}\delta_{20}(\dot{x}) + \cdots + \beta_{nn}\delta_{n0}(x)$$

YAPILACAK İŞLEMLER

1. İzostatik esas sistem seçilir, bu seçilen, sisteme göre birim yüklemeler yapılarak (sırasıyla X_1=1, X_2=1, …….X_n=1) δ_{ij} ler hesaplanır. Yani [δ] matrisi bulunur. $[\delta] = \begin{bmatrix} \delta_{11}\delta_{12} \ldots\ldots & \delta_{1n} \\ \ldots\ldots\ldots\ldots & \ldots. \\ \delta_{n1}\delta_{n2} \ldots\ldots & \delta_{nn} \end{bmatrix}$

   Bulduğumuz [δ] matrisi birim yüklemelere bağlı olup dış yüklerden bağımsızdır ve sabit sayılardır.
2. Elde edilen δ matrisinin tersi alınarak β matrisi bulunur..

$$[\beta] = \begin{bmatrix} \beta_{11} & \beta_{12}\ldots & \beta_{1n} \\ \ldots\ldots & \ldots\ldots & \ldots\ldots \\ \beta_{n1} & \beta_{n2} \ldots & \beta_{nn} \end{bmatrix}$$

3. 1 kN luk yükün sistem üzerindeki herhangi bir sabit noktadan uzaklığı ‘x’ e bağlı olarak $\delta_{i0}(x)$ ler hesaplanır. Önce sistemde kaç aralık (bölge) olduğu tespit edilir. Sonra 1 kN luk yükün her bölge aralıktaki sabit noktadan uzaklığına ‘x’ denilerek bir M_0 diyagramı çizilir. Daha sonra birim yüklemelerden elde edilen M_1, M_2,……,M_n birim yükleme moment diyagramları, her bölge için elde edilen M_0 diyagramları ile çarpılarak her bölgeye ait olan $\delta_{i0}(x)$, ($\delta_{10}(x)$, $\delta_{20}(x)$, ……., $\delta_{n0}(x)$) değerleri elde edilir.

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4. Her bölge için bulunan $\delta_{i0}(x)$ lerin aynı bölgeye ait olanları aşağıdaki denklemlerde yerine konarak hiperstatik bilinmeyenlerin o bölgeye ait tesir çizgisi ifadesi bulunmuş olur. Dolaysıyla bu işlem her bölge için ayrı ayrı yapılır.

$$X_1 = \beta_{11}\delta_{10}(x) + \beta_{12}\delta_{20}(x) + \cdots + \beta_{1n}\delta_{n0}(x)$$

.....

.....

$$X_n = \beta_{n1}\delta_{10}(x) + \beta_{n2}\delta_{20}(x) + \cdots + \beta_{nn}\delta_{n0}(x)$$

5. Herhangi bir m noktasına ait tesir çizgisini bulmak için bildiğimiz süperpozisyon denklemlerinden faydalanılır.

$$\boldsymbol{M_m = (M_0)_m + (M_1)_m X_1 + (M_2)_m X_2 + \cdots + (M_n)_m X_n}$$

$$\boldsymbol{T_m = (T_0)_m + (T_1)_m X_1 + (T_2)_m X_2 + \cdots + (T_n)_m X_n}$$

$$\boldsymbol{N_m = (N_0)_m + (N_1)_m X_1 + (N_2)_m X_2 + \cdots + (N_n)_m X_n}$$

- M_m, T_m, N_m Hiperstatik sisteme ait m noktasındaki tesir çizgileri

- $(M_0)_m$, $(T_0)_m$, $(N_0)_m$ seçilen İzostatik sistemde m noktasına ait tesir çizgileri

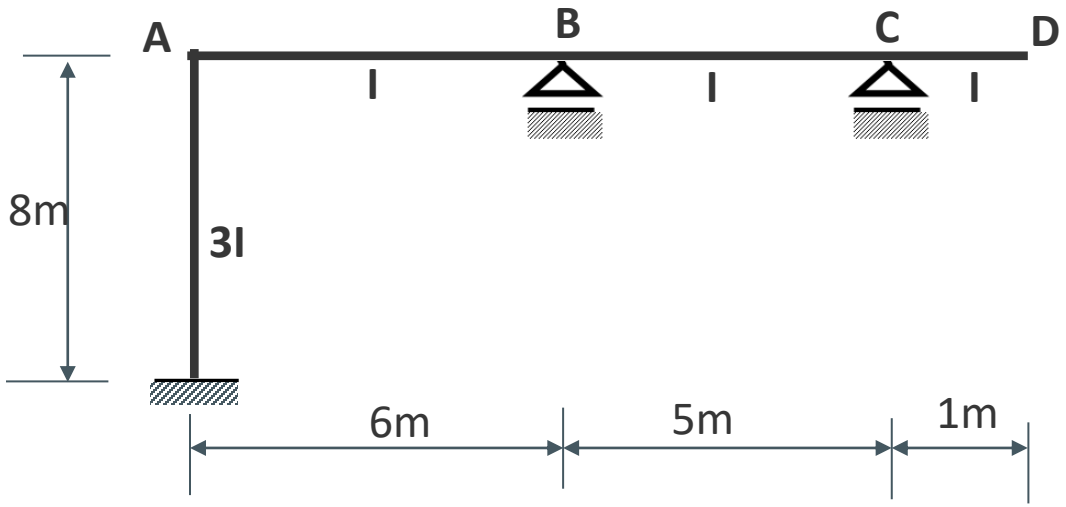
- $(M_1)_m$, $(M_2)_m$ ……. $(M_n)_m$ Seçilen İzostatik esas sistemde sırasıyla yapılan $X_i=1$ (i=1,2 …n) yüklemelerinden m noktasında meydana gelen moment değerleridir.

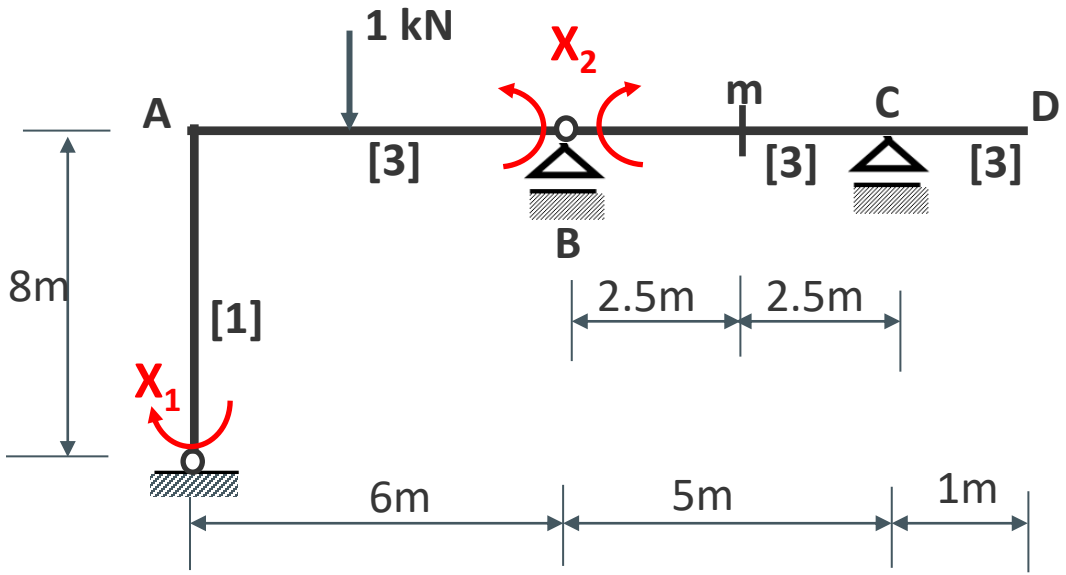
- $(T_1)_m$ $(T_2)_m$ ……., $(T_n)_m$ Seçilen İzostatik esas sistemde sırasıyla yapılan $X_i=1$ (i=1,2 …n) yüklemelerinden m noktasında meydana gelen kesme kuvveti değerleridir.

- $(N_1)_m$ $(N_2)_m$ ……., $(N_n)_m$ Seçilen İzostatik esas sistemde sırasıyla yapılan $X_i=1$ (i=1,2 …n) yüklemelerinden m noktasında meydana gelen normal kuvvet değerleridir

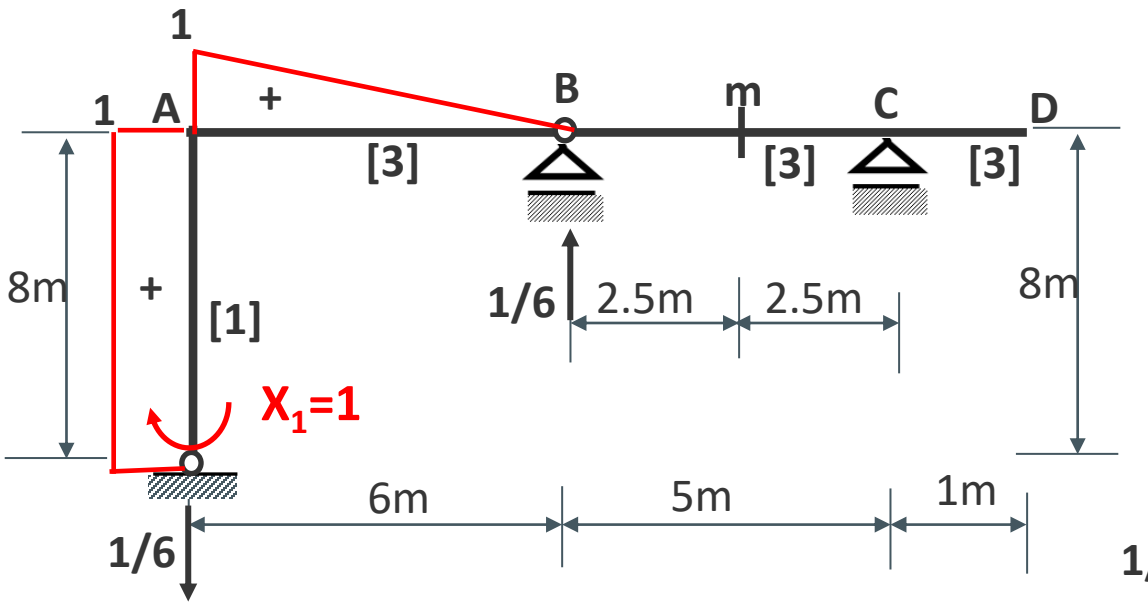
- X_1, X_2, ……X_n hiperstatik bilinmeyenlerin tesir çizgileridir.

UYGULAMA

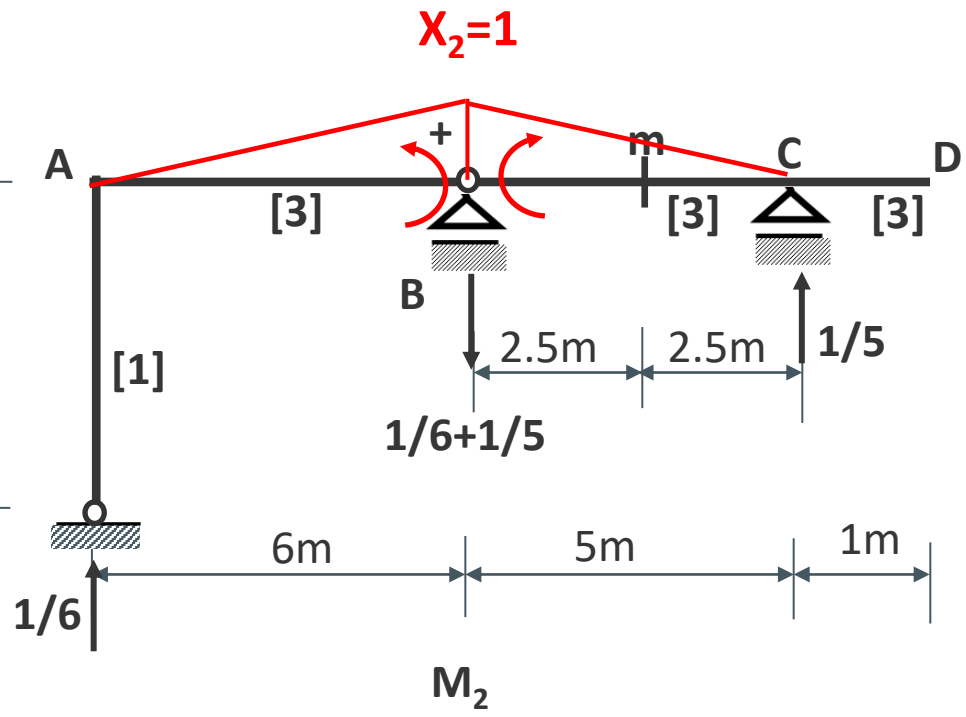




X_1, X_2, M_m, T_m ve N_m tesir çizgilerini çiziniz.



M_1



M_2

$$\delta_{ij} = \int M_i M_j \frac{ds}{EI} \quad EI_c\delta_{ij} = \int M_i M_j \frac{I_c}{I} ds$$

$$EI_c\delta_{11} = 8 * 1 * 1 * [1] + \frac{1}{3} * 6 * 1 * 1 * [3] = 8 + 6 = 14$$

$$EI_c\delta_{22} = \frac{1}{3} * 6 * 1 * 1 * [3] + \frac{1}{3} * 5 * 1 * 1 * [3] = 6 + 5 = 11$$

$$EI_c\delta_{12} = EI_c\delta_{21} = \frac{1}{6} * 6 * 1 * 1 * [3] = 3 \qquad [EI_c\delta] = \begin{bmatrix} 14 & 3 \\ 3 & 11 \end{bmatrix}$$

	k L k	L k	k1 L k2	2. L km
i L i	Lik	$\frac{1}{2}$Lik	$\frac{1}{2}$L(k1 + k2)	$\frac{2}{3}$Likm
L i	$\frac{1}{2}$Lik	$\frac{1}{3}$Lik	$\frac{1}{6}$L(k1 + 2k2)	$\frac{1}{3}$Likm
i L	$\frac{1}{2}$Lik	$\frac{1}{6}$Lik	$\frac{1}{6}$L(2k1 + k2)	$\frac{1}{3}$Likm

$$[\mathbf{EI_c\delta}] = \overbrace{\begin{bmatrix} \mathbf{14} & \mathbf{3} \\ \mathbf{3} & \mathbf{11} \end{bmatrix}}^{\Delta} \quad [\boldsymbol{\beta}] = -[\Delta]^{-1} = -\frac{\mathbf{1}}{\mathbf{EI_c}} \frac{\mathbf{1}}{\mathbf{14 * 11 - 3 * 3}} \begin{bmatrix} \mathbf{11} & \mathbf{-3} \\ \mathbf{-3} & \mathbf{14} \end{bmatrix}$$

$$= \frac{\mathbf{1}}{\mathbf{EI_c}} \begin{bmatrix} \mathbf{-0.0758} & \mathbf{0.02068} \\ \mathbf{0.02068} & \mathbf{-0.09655} \end{bmatrix}$$

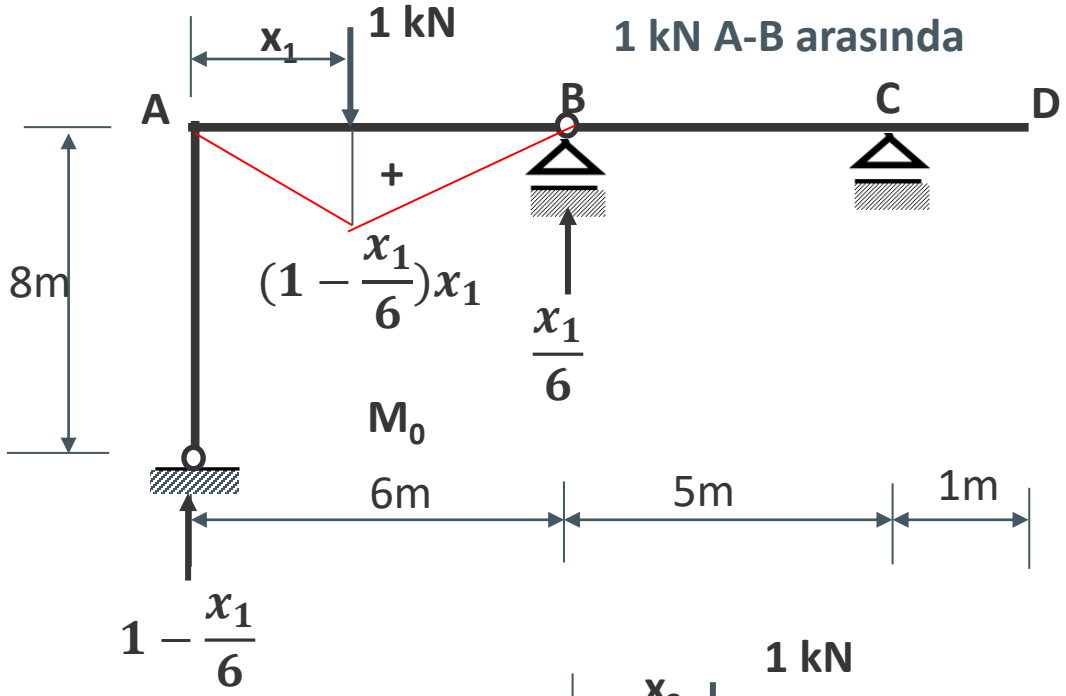
Determinant

$$\Delta \rightarrow \mathbf{EI_c\delta} \quad \boldsymbol{\beta} \rightarrow \frac{\boldsymbol{\beta}}{\mathbf{EI_c}}$$

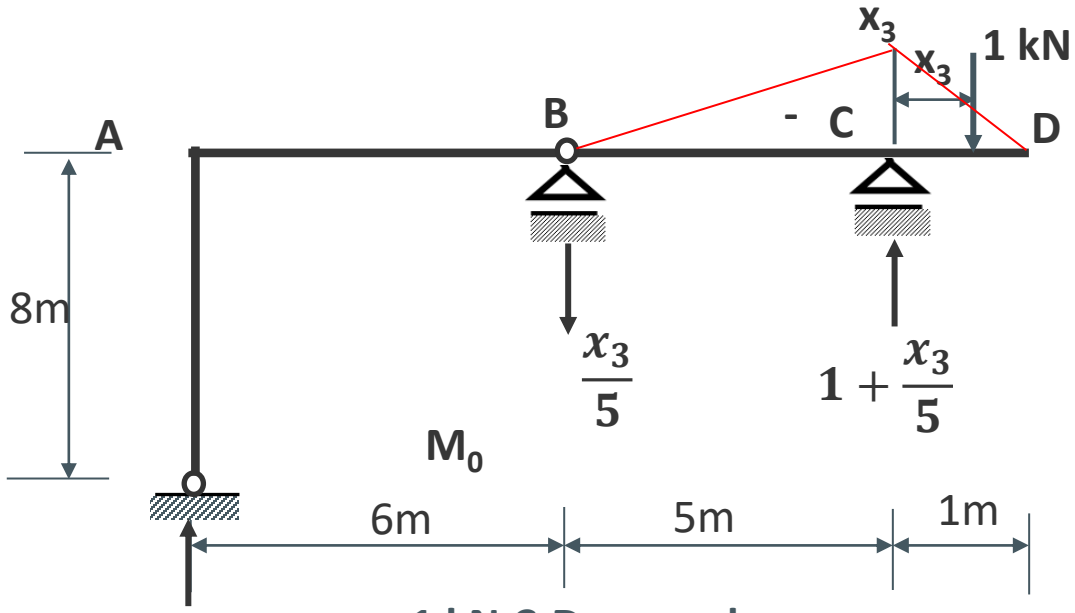
$$[\boldsymbol{\beta}] = \frac{\mathbf{1}}{\mathbf{EI_c}} \begin{bmatrix} \mathbf{-0.0758} & \mathbf{0.02068} \\ \mathbf{0.02068} & \mathbf{-0.09655} \end{bmatrix}$$

$$\boldsymbol{\delta_{11}\beta_{11} + \delta_{12}\beta_{12} = -1 \rightarrow 14 * (-0.0758) + 3 * 0.02068 = -0.99916 \cong -1}$$

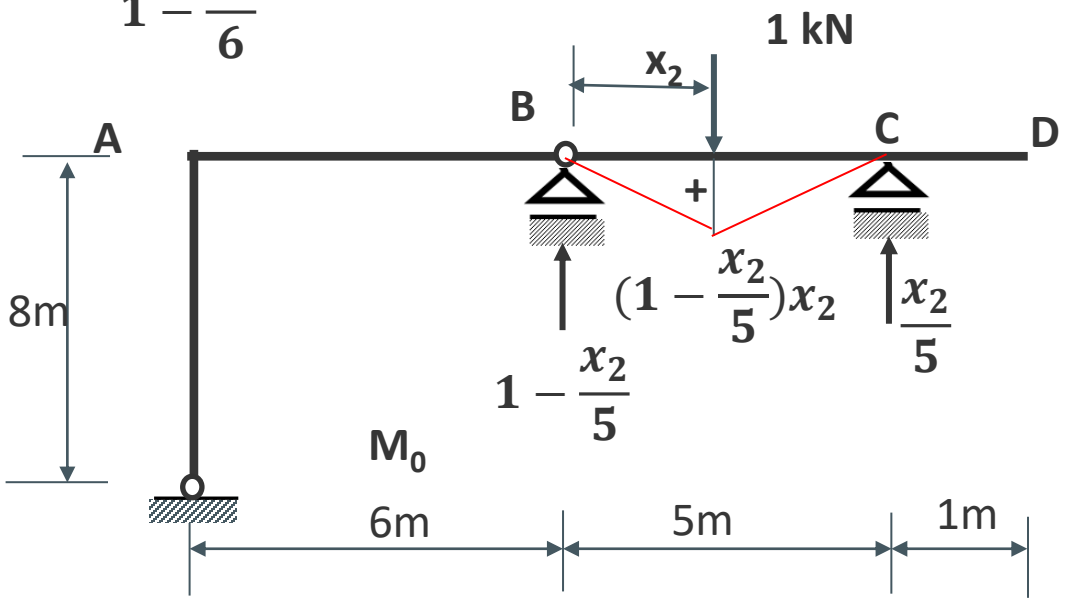
$$\boldsymbol{\delta_{11}\beta_{21} + \delta_{12}\beta_{22} = 0 \rightarrow 14 * (0.02068) + 3 * (-0.09655) \cong 0}$$



1 kN A-B arasında



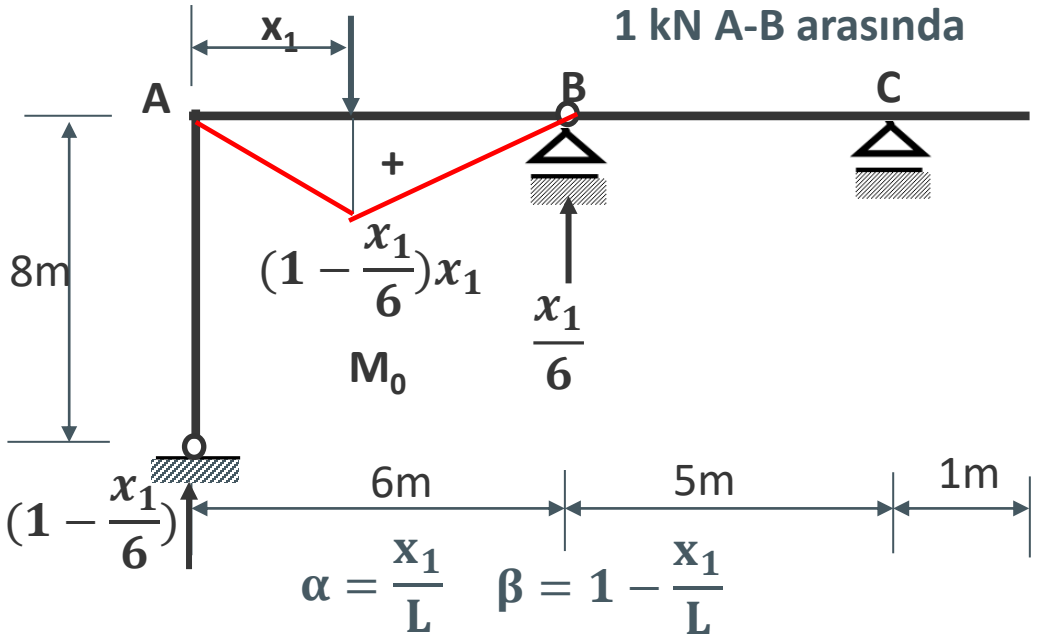
1 kN C-D arasında

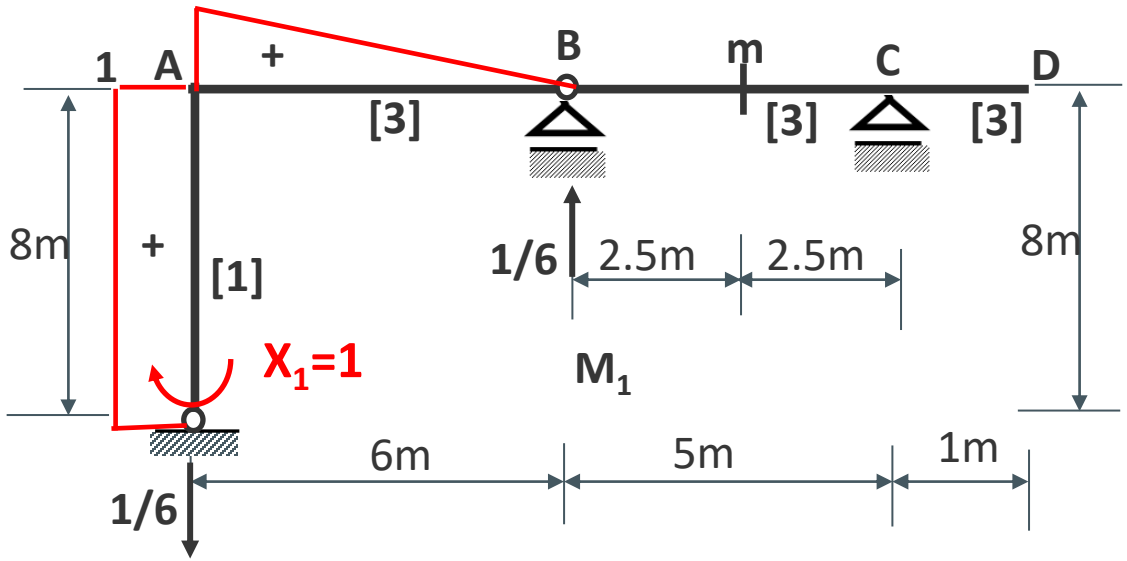


1 kN B-C arasında

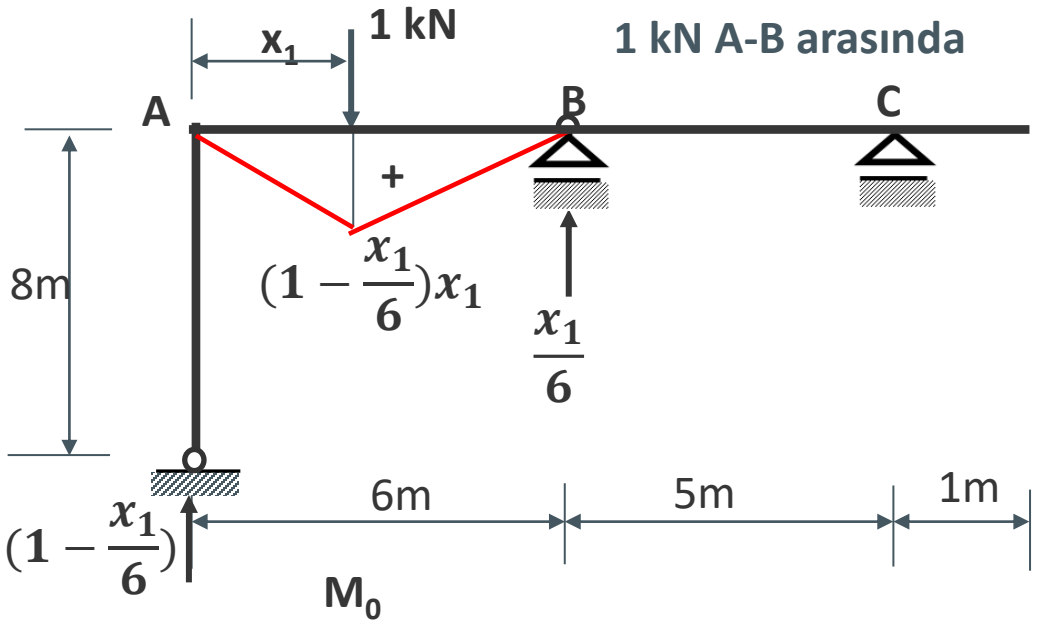
ÇARPIM TABLOSU $\left(\int_0^L M_i M_k ds\right)$

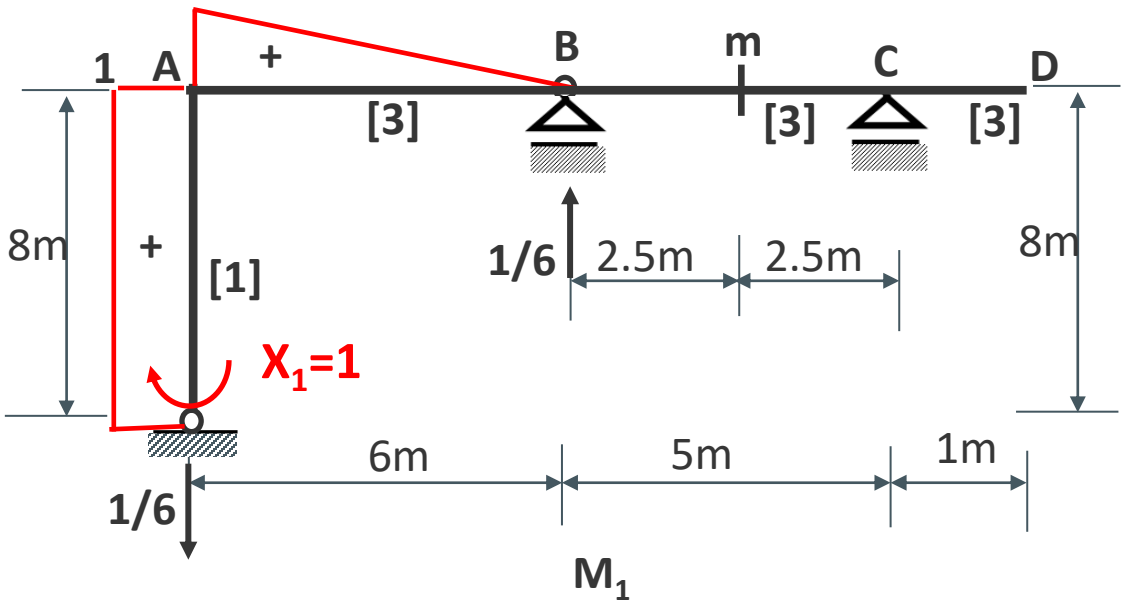
	k — L — k	k — L	k_1 — L — k_2	2.° — k_m — L	2.° — Y — k — L	2.° — Y — k — L	k — αL — βL — L
i — L — i	Lik	$\frac{1}{2}$Lik	$\frac{1}{2}$Li(k_1+k_2)	$\frac{2}{3}$Lik$_m$	$\frac{2}{3}$Lik	$\frac{1}{3}$Lik	$\frac{1}{2}$Lik
i — L	$\frac{1}{2}$Lik	$\frac{1}{3}$Lik	$\frac{1}{6}$Li(k_1+2k_2)	$\frac{1}{3}$Lik$_m$	$\frac{5}{12}$Lik	$\frac{1}{4}$Lik	$\frac{1}{6}$L(1+α)ik
i — L	$\frac{1}{2}$Lik	$\frac{1}{6}$Lik	$\frac{1}{6}$Li($2k_1+k_2$)	$\frac{1}{3}$Lik$_m$	$\frac{1}{4}$Lik	$\frac{1}{12}$Lik	$\frac{1}{6}$L(1+β)ik





$$EI_c\delta_{10}=\frac{1}{6}L(1+\beta)ik=\frac{1}{6}[3]6\left(1+\left(1-\frac{x_1}{6}\right)\right]*1*\left(1-\frac{x_1}{6}\right)x_1=\frac{1}{36}*3*(12-x_1)(6-x_1)x_1$$



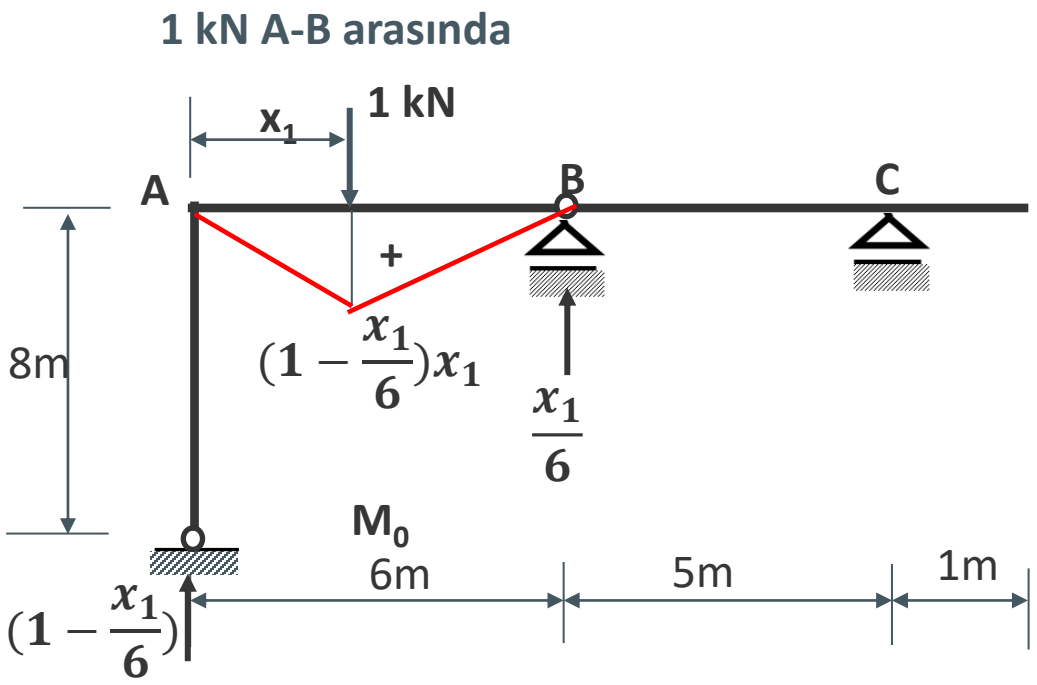


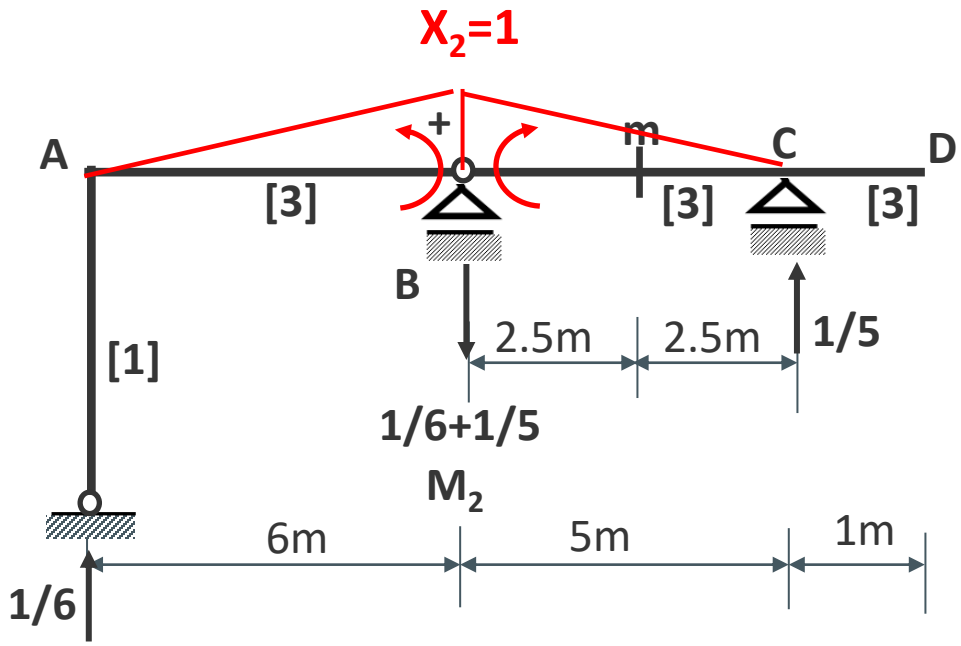
$$EI_c\delta_{10} = \frac{1}{6}L(1+\beta)ik = \frac{1}{6}[3]6\left(1+\left(1-\frac{x_1}{6}\right)\right] * 1 * \left(1-\frac{x_1}{6}\right)x_1 = \frac{1}{36} * 3(12-x_1)(6-x_1)x_1$$

$$\alpha = \frac{x_1}{L} \qquad \beta = 1-\frac{x_1}{L}$$

$$= \frac{1}{6}L(1+\beta)ik$$

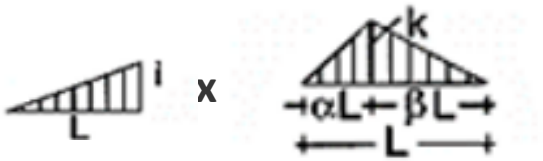
$$EI_c\delta_{10} = \frac{1}{12}(x_1^3 - 18x_1^2 + 72x_1)$$





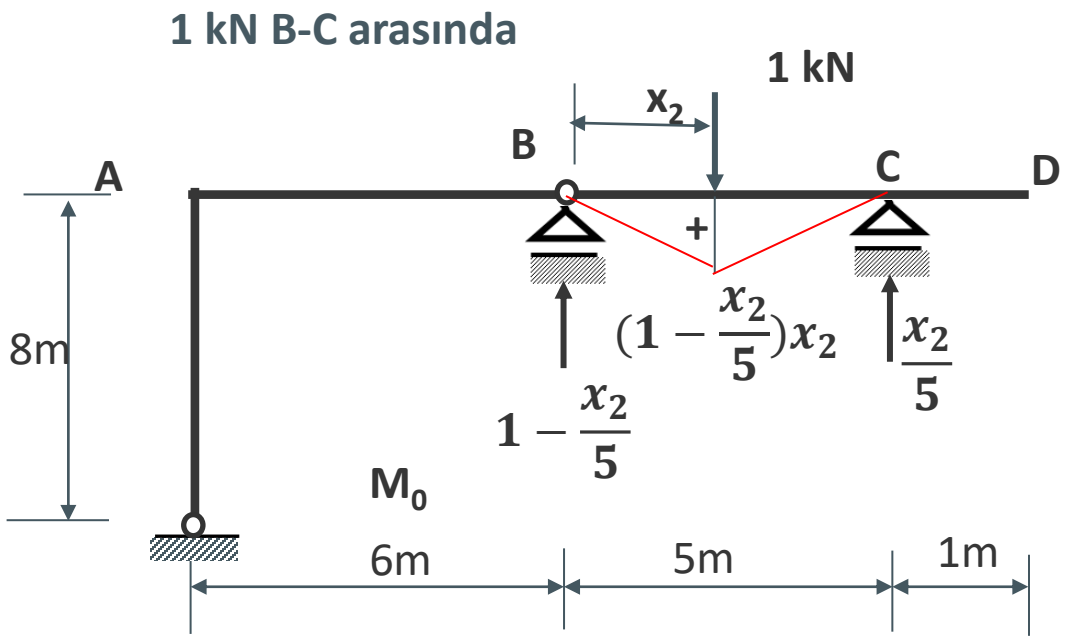
$$EI_c\delta_{20} = \frac{1}{6}L(1+\alpha)ik = \frac{1}{6}[3]6\left(1+\left(\frac{x_1}{6}\right)\right] * 1 * \left(1-\frac{x_1}{6}\right)x_1 = \frac{1}{36} * 3(6+x_1)(6-x_1)x_1$$

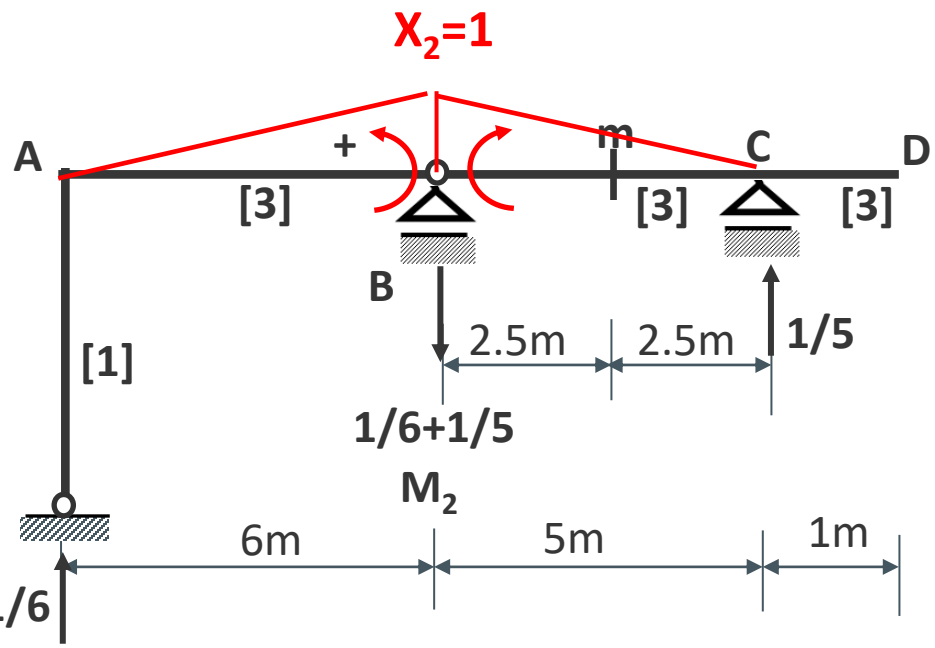
$$\alpha = \frac{x_1}{L}$$



$$= \frac{1}{6}L(1+\alpha)ik$$

$$EI_c\delta_{20} = \frac{1}{12}(36x_1 - x_1^3)$$

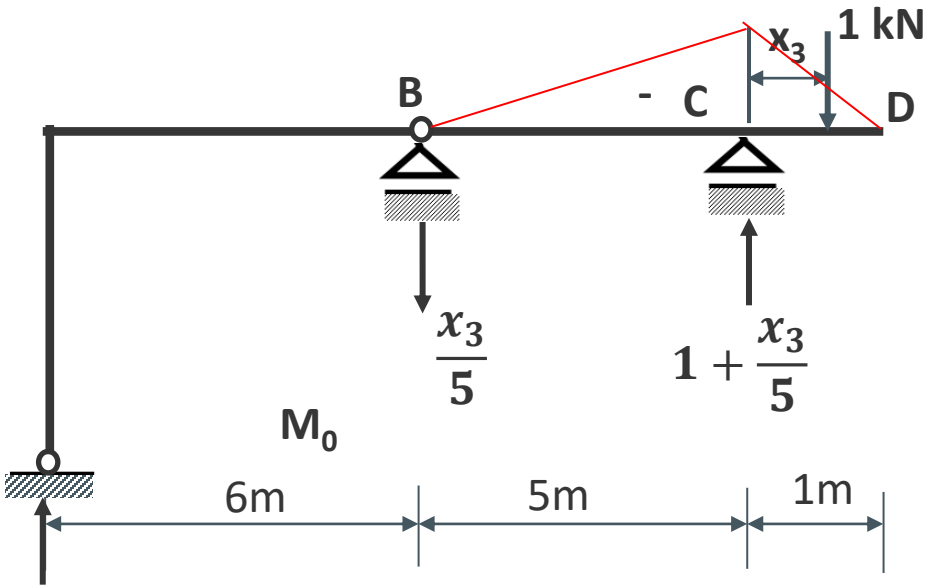


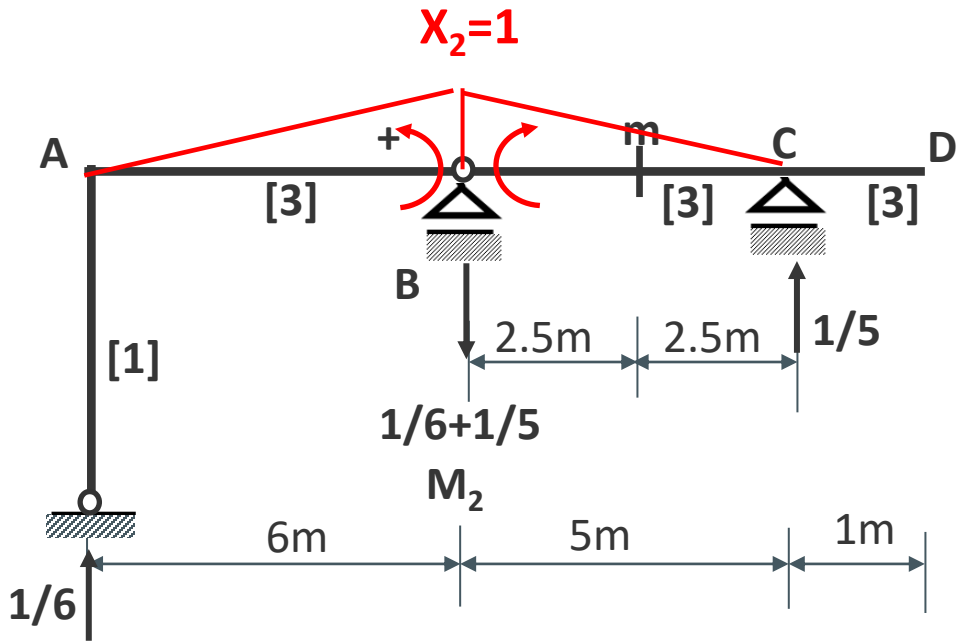


$$EI_c\delta_{20} = \frac{1}{6}L(1+\beta)ik = \frac{1}{6}[3]5\left(1+\left(1-\frac{x_2}{5}\right)\right) * 1 * \left(1-\frac{x_2}{5}\right)x_2 = \frac{1}{6} * 3 * 5\frac{1}{5}\frac{1}{5}(10-x_2)(5-x_2)x_2$$

$$\boxed{EI_c\delta_{20}(x) = \frac{1}{10}(x_2^3 - 15x_2^2 + 50x_2)}$$

1 kN C-D arasında





$$EI_c\delta_{20}(x) = \frac{1}{6} * 5 * (-x_3) * 1 * [3] = -2.5x_3$$

$$\boxed{EI_c\delta_{20}(x) = -2.5x_3}$$

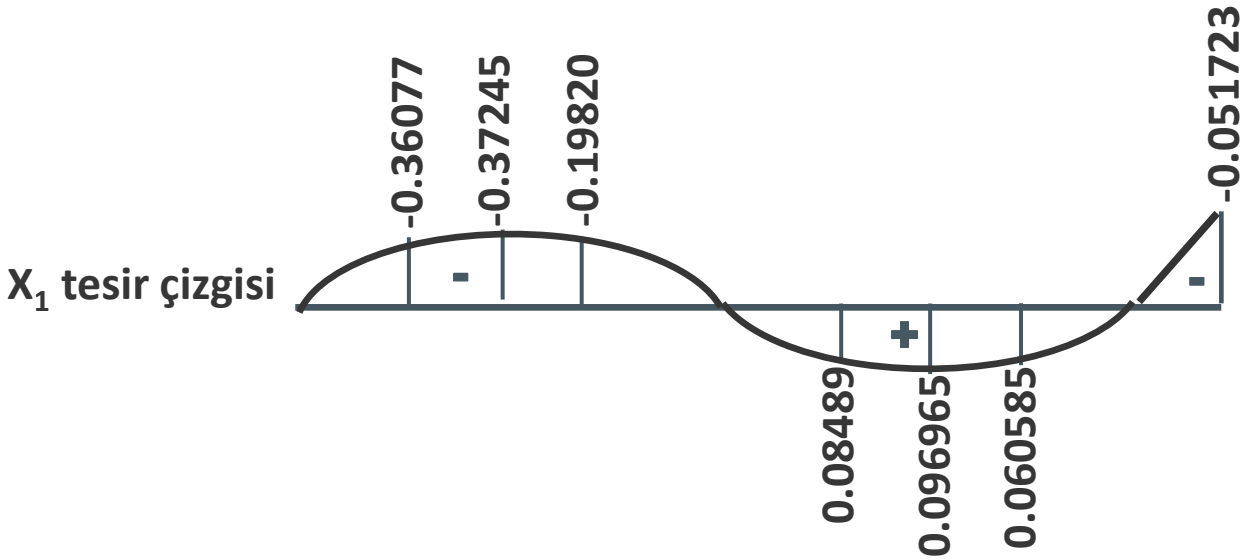
BÖLGE	$EI_c\delta_{10}(x)$	$EI_c\delta_{20}(x)$
A-B	$\frac{1}{12}(x_1^3 - 18x_1^2 + 72x_1)$	$\frac{1}{12}(36x_1 - x_1^3)$
B-C	0	$\frac{1}{10}(x_2^3 - 15x_2^2 + 50x_2)$
C-D	0	$-2.5x_3$

$$\boldsymbol{X_1 = \beta_{11}\delta_{10}(x) + \beta_{12}\delta_{20}(x)}$$

$$\boldsymbol{X_1 = (-0.07586)\beta_{11}(x) + (0.02068)\delta_{20}(x)}$$

1 kN A-B arasında

$$X_1 = -0.008048x_1^3 + 0.113790x_1^2 - 0.39309x_1$$



$x_1 = 0 \rightarrow X_1 = 0$

$x_1 = 1.5 \rightarrow X_1 = -0.36077$

$x_1 = 3 \rightarrow X_1 = -0.372456$

$x_1 = 4.5 \rightarrow X_1 = -0.1980315$

$x_1 = 6 \rightarrow X_1 = -4.68 * 10^{-4} \cong 0$

1 kN B-C arasında

$$X_1 = 0.002069x_2^3 - 0.031034x_2^2 + 0.10344x_2$$

$x_2 = 0 \rightarrow X_1 = 0$

$x_2 = 1.125 \rightarrow X_1 = 0.08003849$

$x_{22} = 2.5 \rightarrow X_1 = 0.09696562$

$x_2 = 3.75 \rightarrow X_1 = 0.0605917$

1 kN C-D arasında

$$X_1 = -0.051723x_3$$

$x_3 = 0 \rightarrow X_1 = 0$

$x_3 = 1 \rightarrow X_1 = -0.051723$

$x_3 = 5 \rightarrow X_1 = 2.5 * 10^{-5} \cong 0$

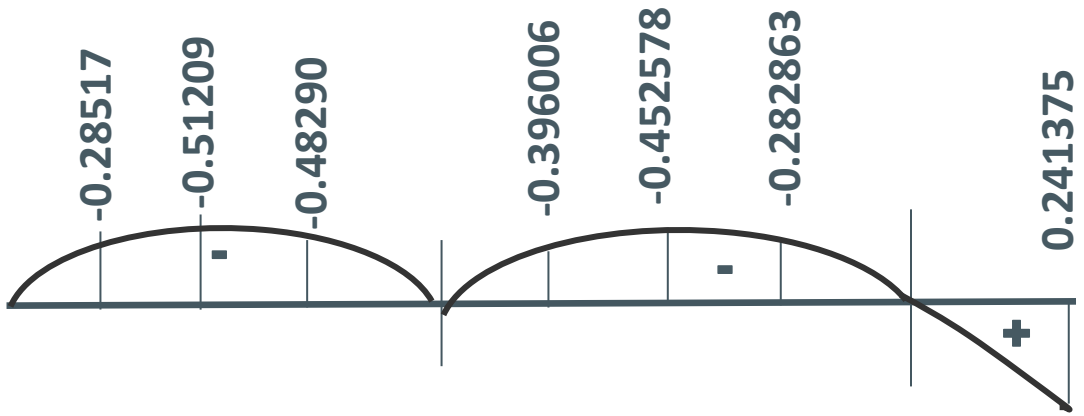
$$X_2 = \beta_{21}\delta_{10}(x) + \beta_{22}\delta_{20}(x) \qquad X_2 = 0.02068\,\delta_{10}(x) + (-0.0965)\delta_{20}(x)$$

1 kN A-B arasında

$$X_2 = 0.02068\,\delta_{10}(x) + (-0.0965)\delta_{20}(x)$$

$$\rightarrow \delta_{10} ve\ \delta_{20}\ yerine\ konursa\ AB\ bölgesi\ tesir\ çizgisi\ fonksiyonu\ elde\ edilir.$$

$$X_2 = 0.00977x_1^3 - 0.03102x_1^2 - 0.165564x_1$$



X_2 tesir çizgisi

1 kN B-C arasında

$$X_2 = -0.009655x_2^3 + 0.144825x_2^2 - 0.48275x_2$$

$$\rightarrow \delta_{10} ve\ \delta_{20}\ yerine\ konursa\ BC\ bölgesi\ tesir\ çizgisi\ fonksiyonu\ elde\ edilir.$$

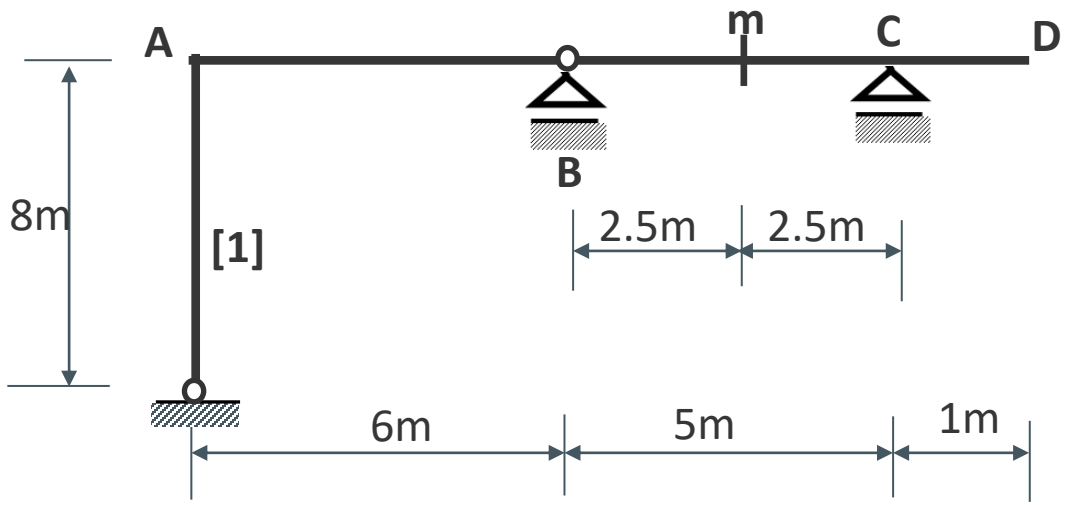
1 kN C-D arasında

$$X_2 = 0.241375x_3$$

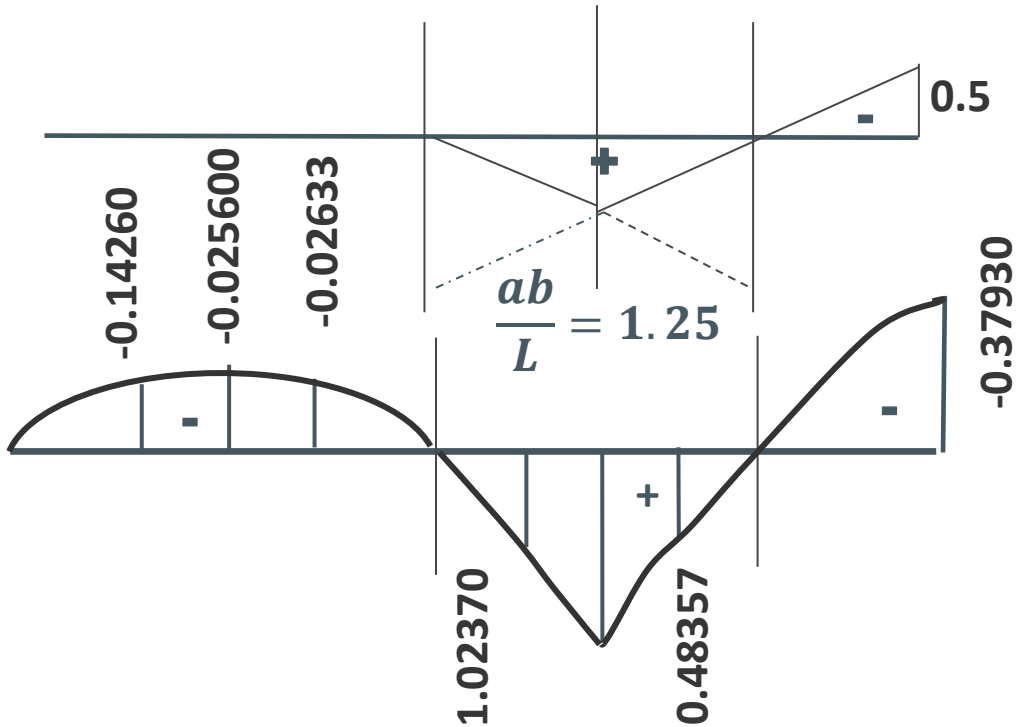
$$M_m = (M_0)_m + (M_1)_m X_1 + (M_2)_m X_2$$

$$M_m = (M_0)_m + 0 * X_1 + 0.5 * X_2$$

$$M_m = (M_0)_m + 0.5 * X_2$$



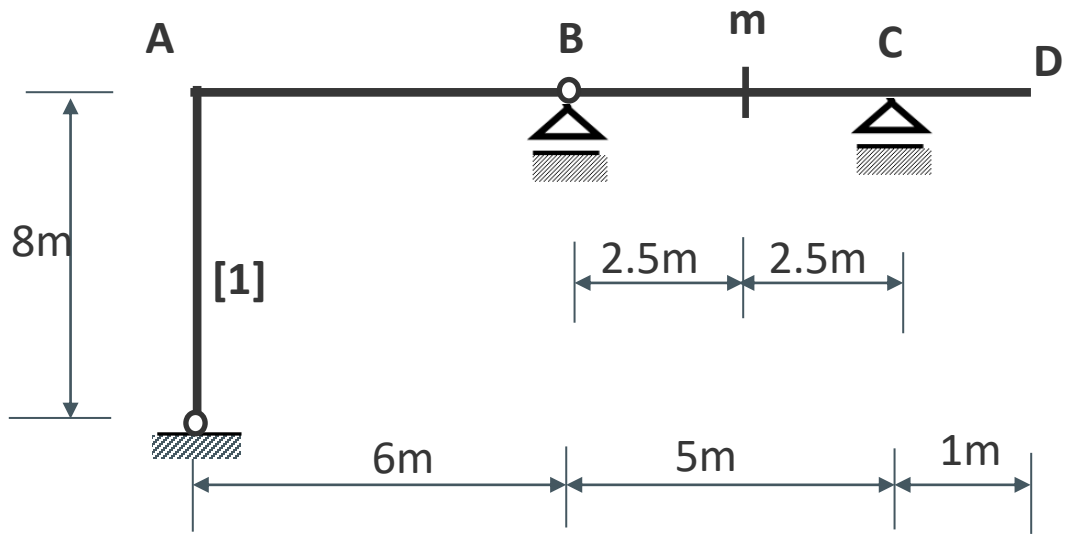
$(M_0)_m$



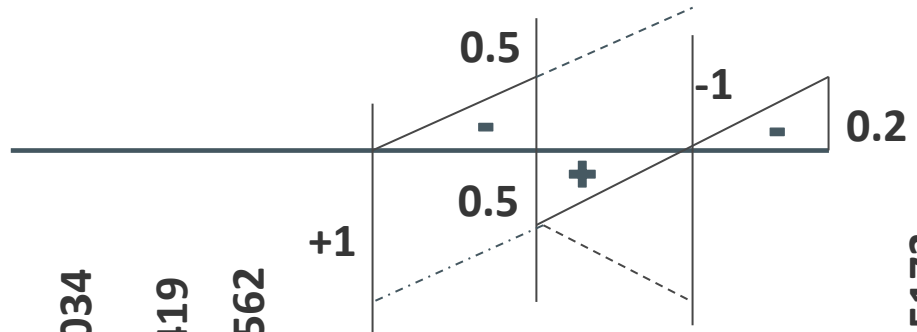
M_m tesir çizgisi

$$T_m = (T_0)_m + (T_1)_m X_1 + (T_2)_m X_2$$

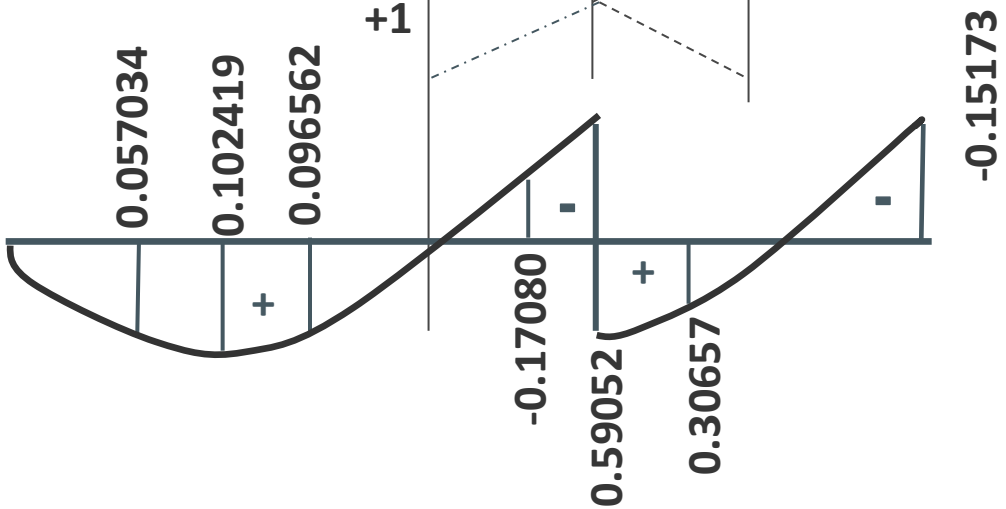
$$T_m = (T_0)_m - 0.20 * X_2$$



$(T_0)_m$



T_m *tesir çizgisi*



N_m=0

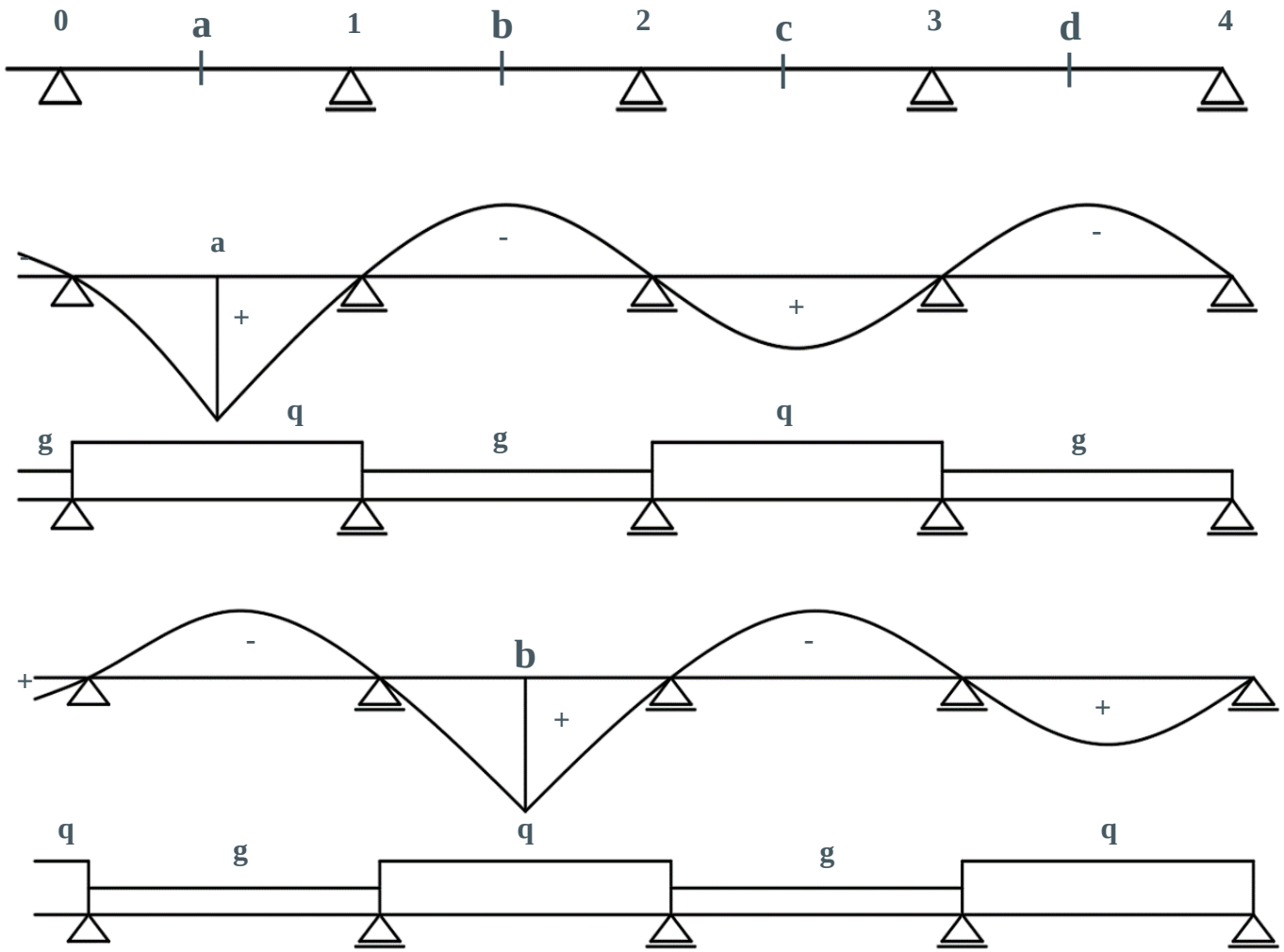
SÜREKLİ KİRİŞLERDE ELVERİŞSİZ YÜKLEMELER

1. Öz ağırlık yükleri (g, G)
2. Hareketli yükler (p, P)
3. Toplam yükler (Öz ağırlık + Hareketli yükler)

$q = g + p$ $\qquad$ $Q = G + P$

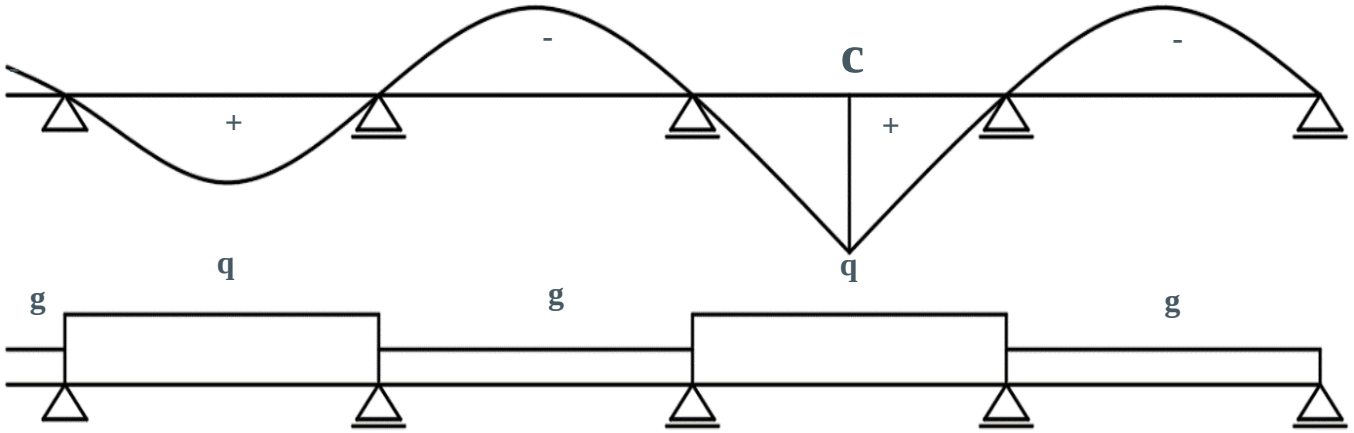
Bir kesite ait maksimum kesit tesirinin elde edilmesi için tesir çizgilerinin pozitif kısımlarının q, Q ile negatif kısımlarının g, G ile yüklenmesi gerekmektedir. Kesit tesirinin minimum değerlerini elde etmek için tesir çizgilerinin negatif kısımların q, Q ile pozitif kısımlarınınsa q, G ile yüklenmesi gerekmektedir.

a) Maksimum açıklık momentleri için elverişsiz yüklemeler

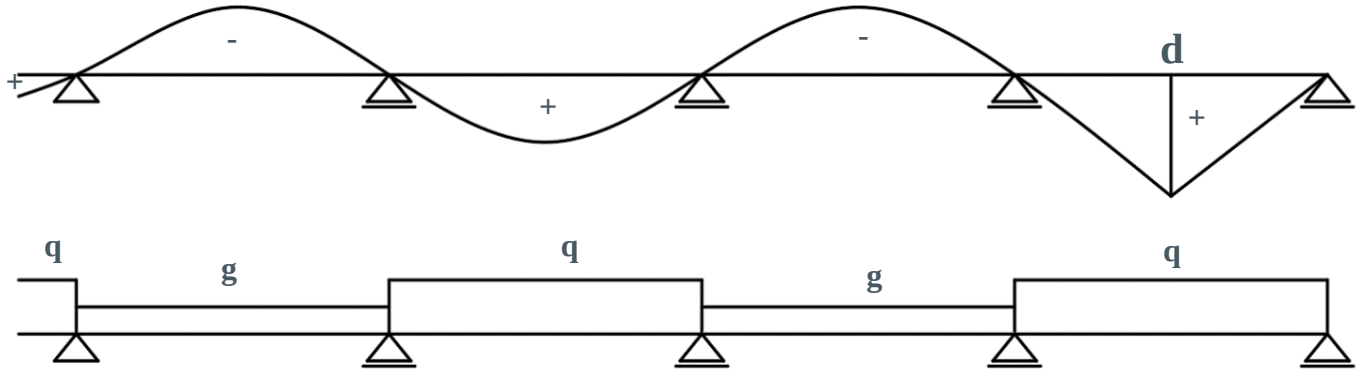


M_a tesir çizgisi

M_b tesir çizgisi

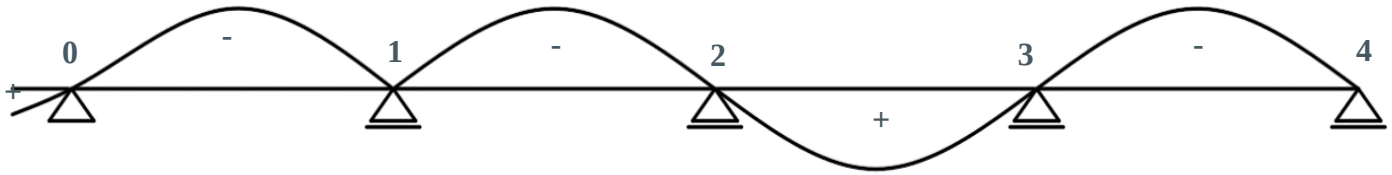


M_c tesir çizgisi

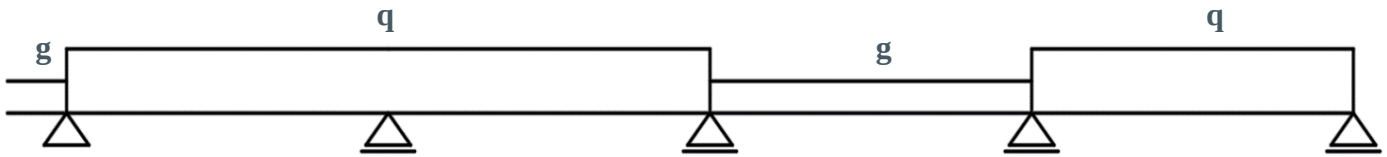


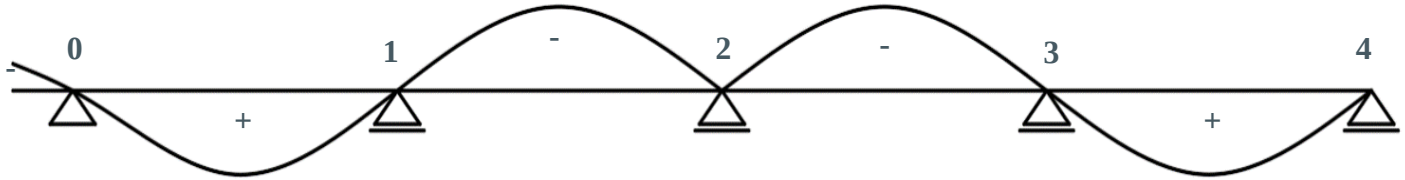
M_d tesir çizgisi

b) Minimum mesnet momentleri için elverişsiz yüklemeler

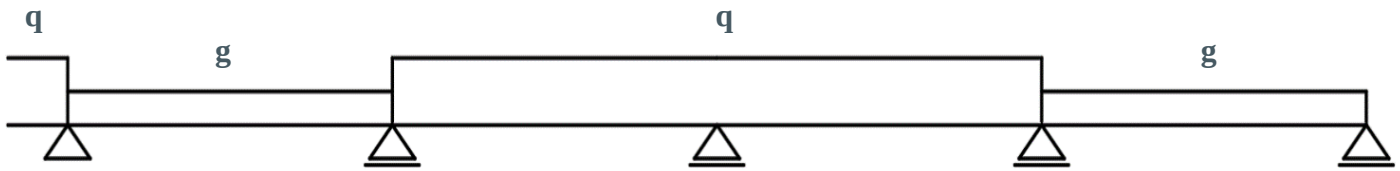


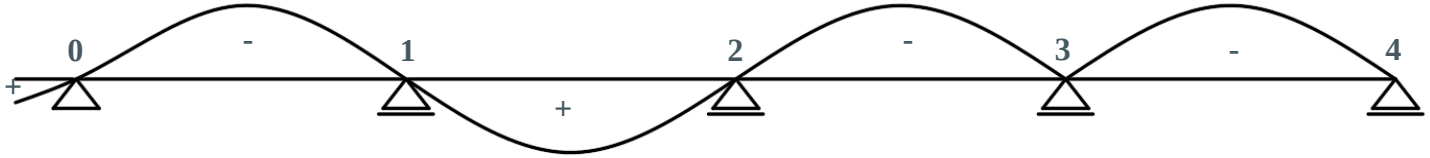
X_1 tesir çizgisi



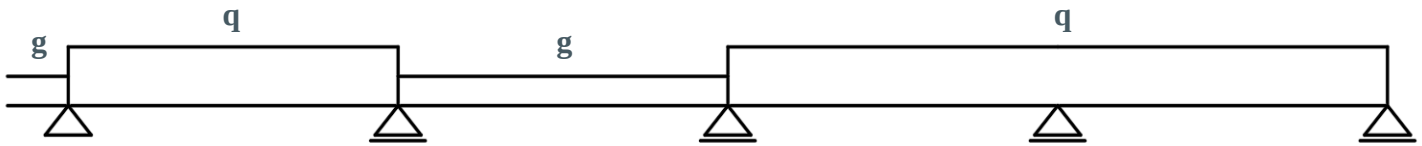


X_2 tesir çizgisi

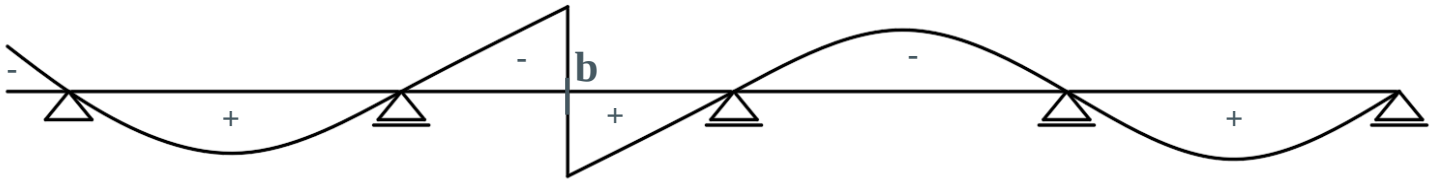




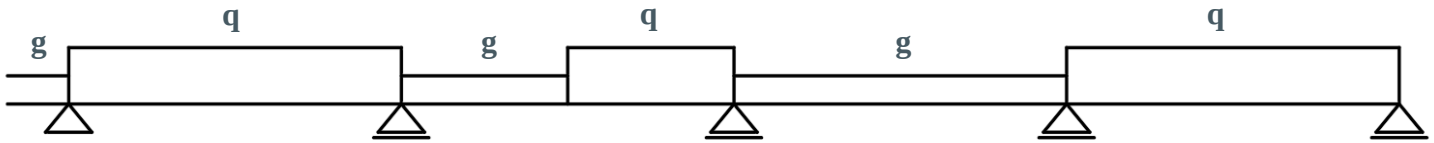
X_3 tesir çizgisi



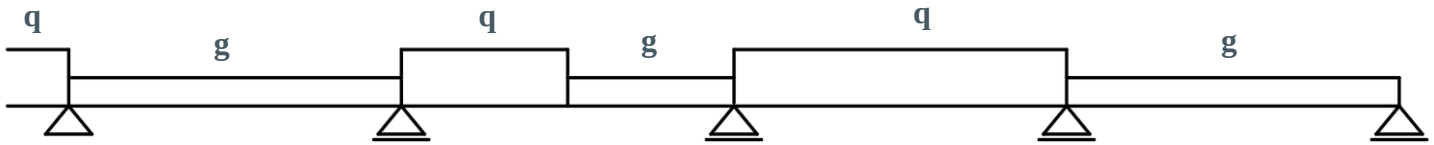
c) Herhangi bir kesitte maksimum ve minimum kesme kuvvetleri için elverişsiz yüklemeler



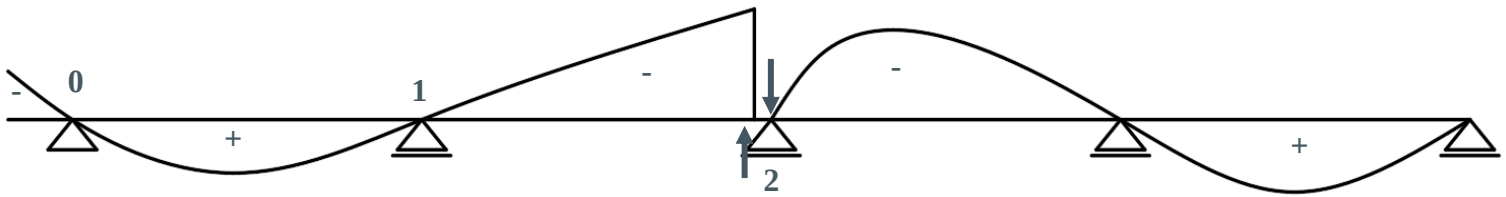
T_b tesir çizgisi



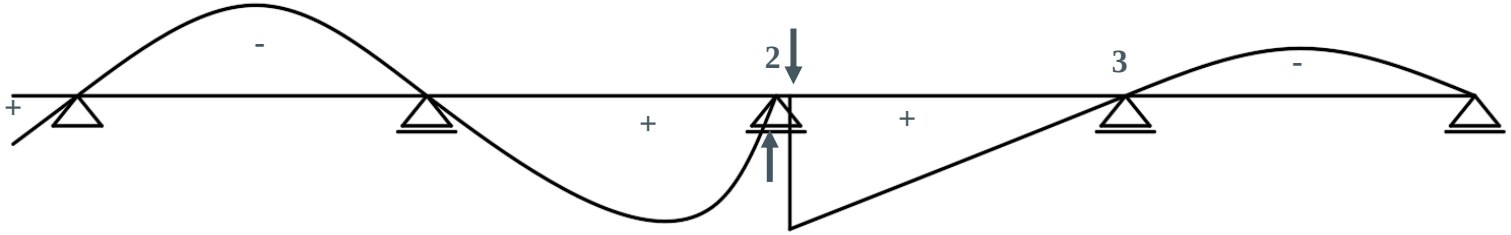
Max. T_b



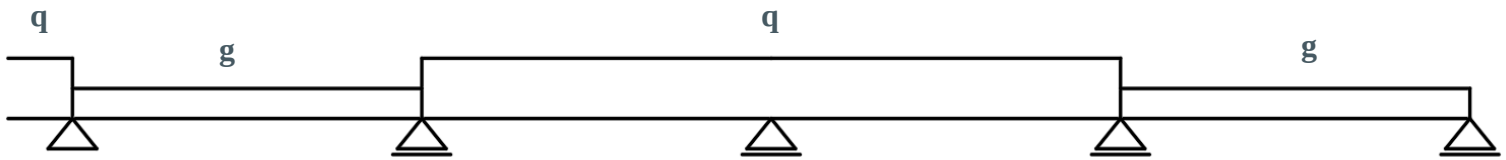
Min. T_b



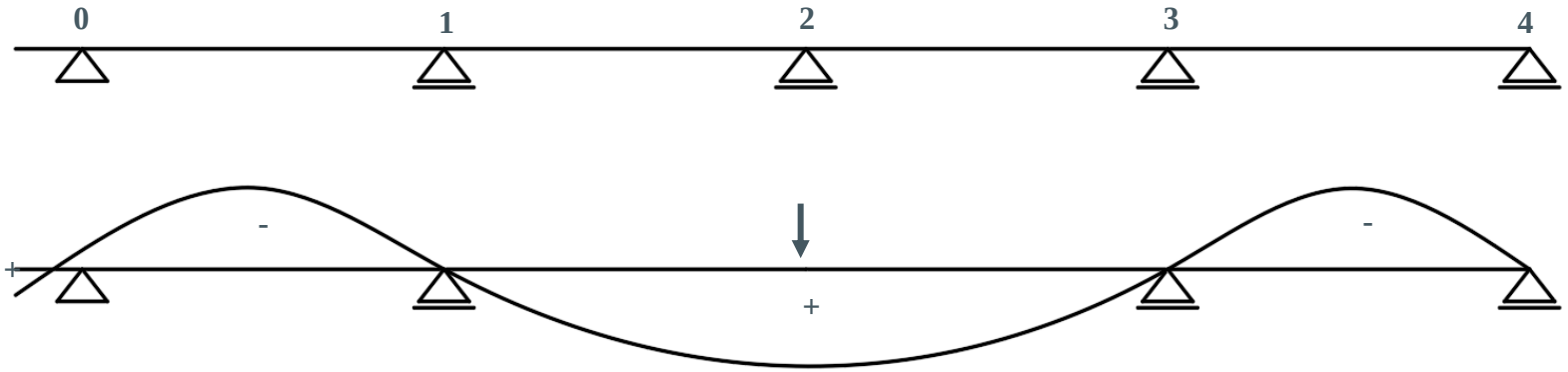
T_{21} tesir çizgisi



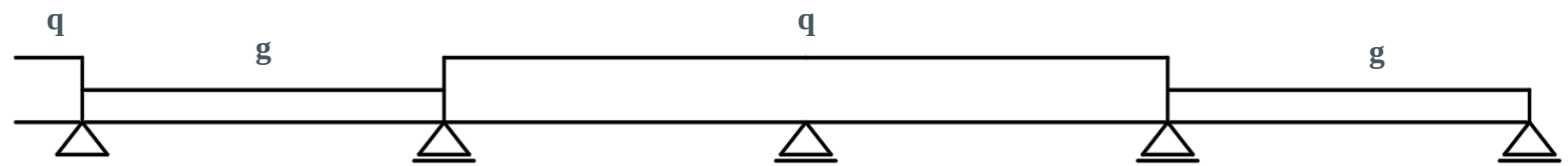
T_{23} tesir çizgisi



Min. T_{21}
Max. T_{23}

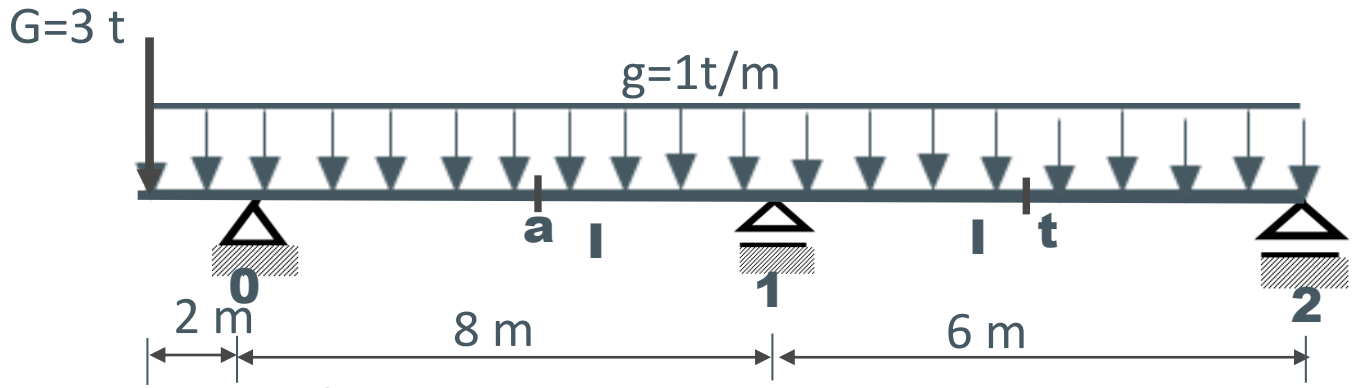


R_2 tesir çizgisi



Max. R_2

UYGULAMA

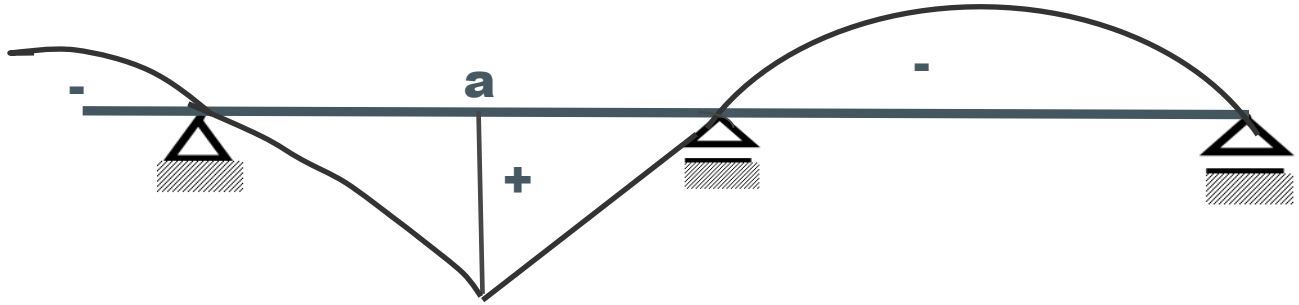


g=1 t/m **G=3 t**

p=1.5 t/m **P=2 t**

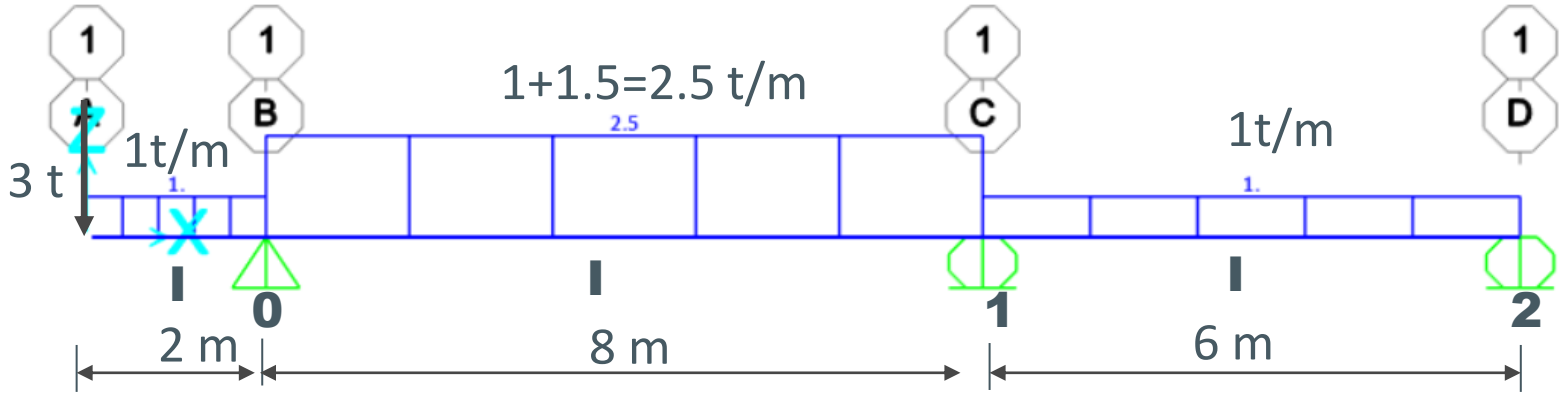
Maksimum M diyagramlarını çiziniz.

1. **01 açıklığında maksimum moment oluşabilmesi için**



M_a **Tesir çizgisi**

Elverişsiz yükleme 1



X_0	X_1	X_2
$\frac{8}{I}$		$\frac{6}{I}$
$\frac{qL^2}{4} = \frac{2.5 * 8^2}{4} = 40$	40	$\frac{qL^2}{4} = 9$ 9
$\frac{8}{I}40 = \frac{320}{I}$	$\frac{320}{I}$	$\frac{6}{I}9 = \frac{54}{I}$ $\frac{54}{I}$

$Konsol\ momenti\ \ X_0 = -3 * 2 - 1 * 2 * \frac{1}{2} = -8tm\ \ Kenar\ mesnet\ momenti\ X_2 = 0$

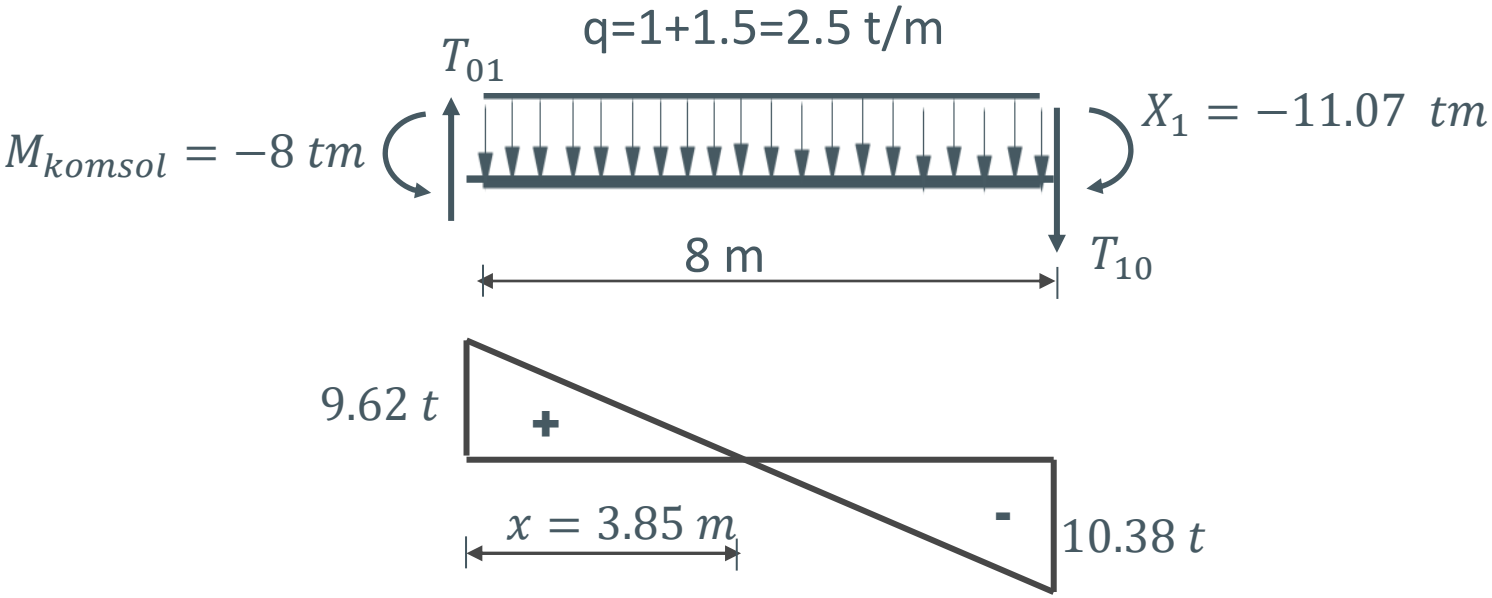
X_0		X_1		X_2
$\frac{8}{I}$		$\frac{6}{I}$		
$\frac{qL^2}{4} = \frac{2.5 * 8^2}{4} = 40$	40	$\frac{qL^2}{4} = 9$	9	
$\frac{8}{I}40 = \frac{320}{I}$	$\frac{320}{I}$	$\frac{6}{I}9 = \frac{54}{I}$	$\frac{54}{I}$	

$$Konsol\ momenti\ \ X_0 = -3 * 2 - 1 * 2 * 2 * \frac{1}{2} = -8\ tm\ \ Kenar\ mesnet\ momenti\ X_2 = 0$$

$$\frac{8}{I}X_0 + 2\left(\frac{8}{I} + \frac{6}{I}\right)X_1 + \frac{6}{I}X_2 + \frac{320}{I} + \frac{54}{I} = 0$$

$$-8 * 8 + 28X_1 + 6 * 0 + 374 = 0$$

$$28X_1 = -374 + 64 = -310 \rightarrow X_1 = -11.07\ tm$$



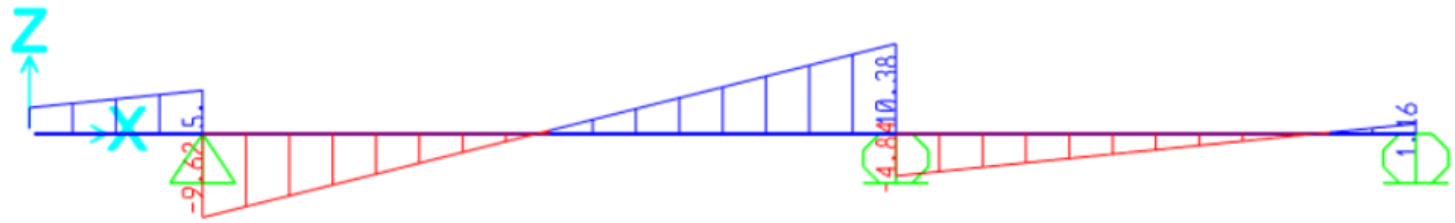
$$\sum M_1 = 0 \ \rightarrow T_{01} = 2.5 * \frac{8}{2} + \frac{8 - 11.07}{8} = 9.62\ t \quad \sum y = 0 \rightarrow 9.62 - 2.5 * 8 - T_{10} = 0 \rightarrow T_{10} = 10.38\ t$$

$$T_x = T_{01} - q * x \rightarrow kesme\ kuvvetinin\ sıfır\ olduğu\ yerde\ maksimum\ moment\ oluşur\ T_x = 0$$

$$x = \frac{T_{01}}{q} = \frac{9.62}{2.5} = 3.85\ m$$

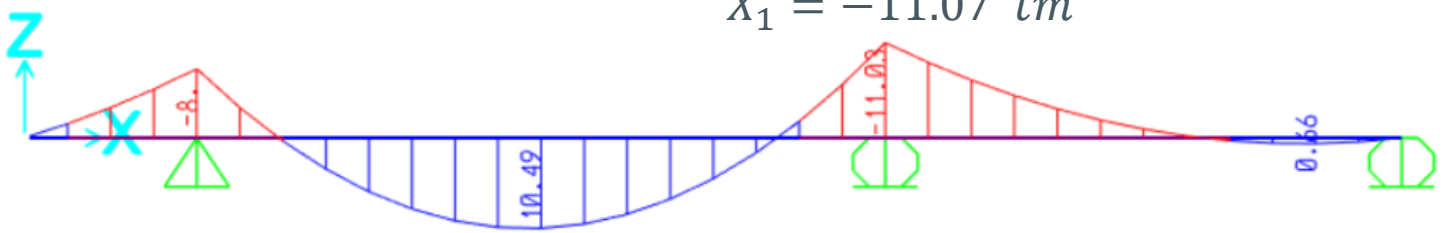
$$M_{max} = \frac{1}{2} 9.62 * 3.85 - 8 = 10.51\ tm$$

Kesme Kuvveti Diyagramı



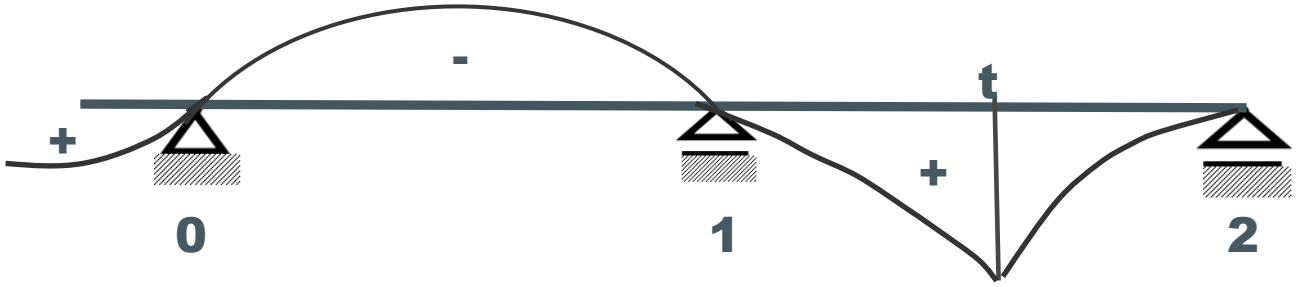
Moment Diyagramı

$$X_1 = -11.07 \ tm$$

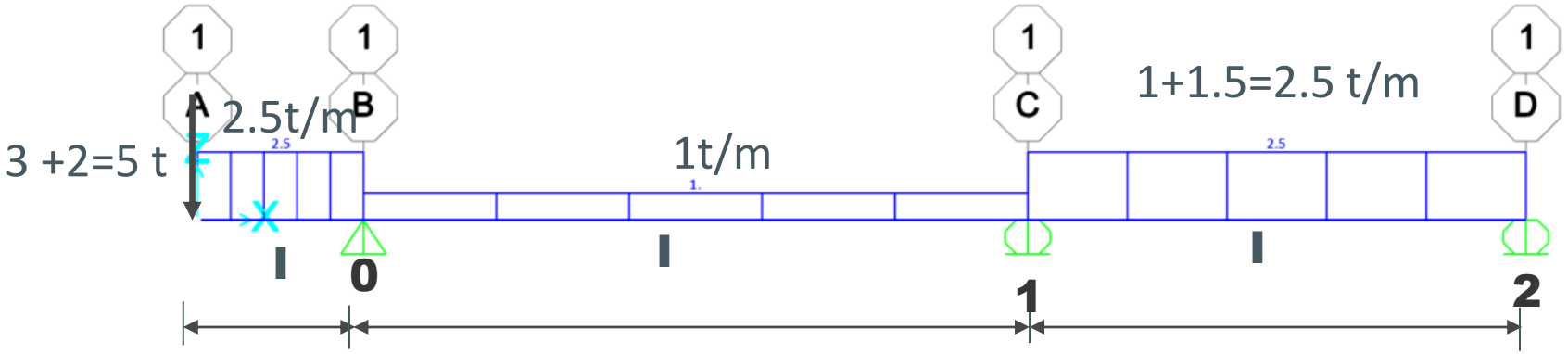


MaxM=10.51

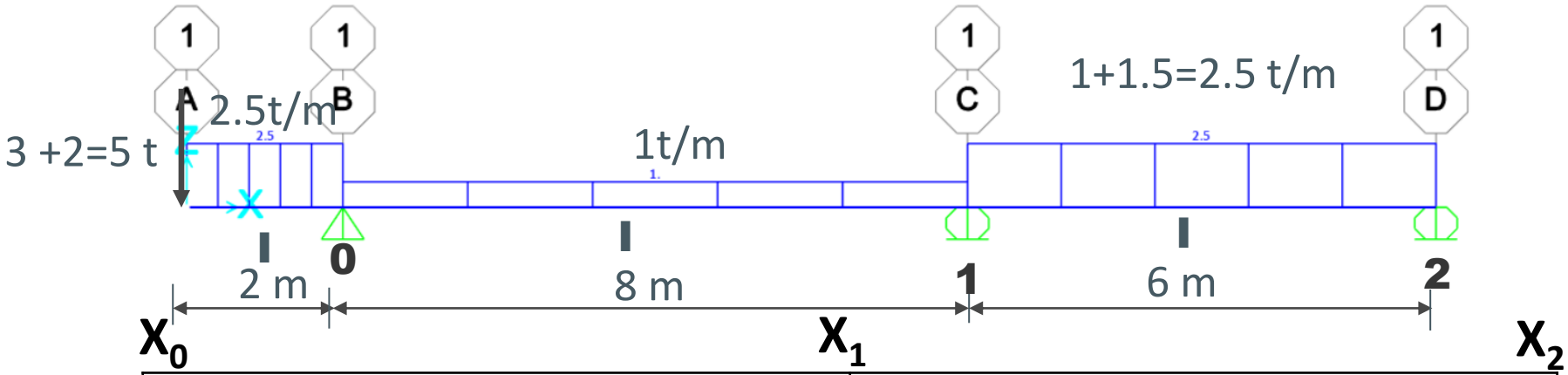
2. (1-2) açıklığında maksimum moment Max. M



M_t **Tesir çizgisi**



Elverişsiz yükleme 2



$\frac{8}{I}$	$\frac{6}{I}$
$\frac{qL^2}{4} = \frac{1*8^2}{4} = 16$ 16	$\frac{qL^2}{4} = 22.5$ 22.5
$\frac{8}{I}16 = \frac{128}{I}$ $\frac{128}{I}$	$\frac{6}{I}22.5 = \frac{135}{I}$ $\frac{135}{I}$

$$Konsol\ momenti\ \ X_0 = -5*2 - 2.5*2*2*\frac{1}{2} = -15tm\ \ Kenar\ mesnet\ momenti\ X_2 = 0$$

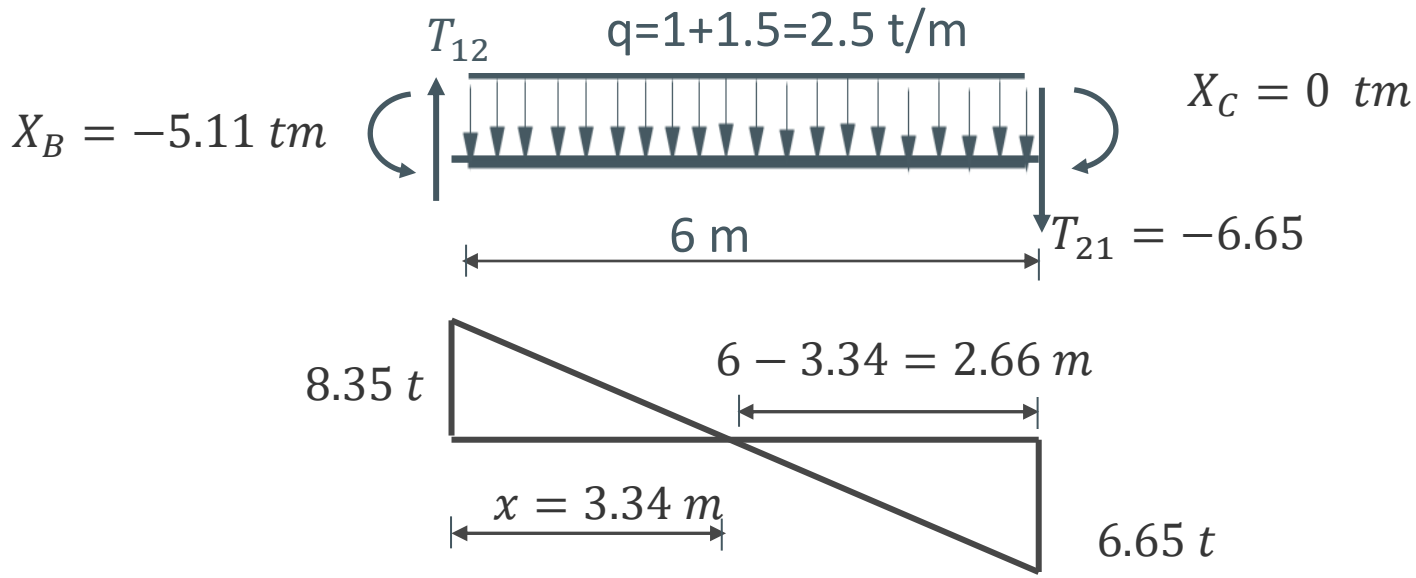
X_0		X_1		X_2
$\frac{8}{I}$		$\frac{6}{I}$		
$\frac{qL^2}{4} = \frac{1 * 8^2}{4} = 16$	16	$\frac{qL^2}{4} = 22.5$	22.5	
$\frac{8}{I}16 = \frac{128}{I}$	$\frac{128}{I}$	$\frac{6}{I}22.5 = \frac{135}{I}$	$\frac{135}{I}$	

$$Konsol\ momenti\ \ X_0 = -5 * 2 - 2.5 * 2 * 2 * \frac{1}{2} = -15tm\ \ Kenar\ mesnet\ momenti\ X_2 = 0$$

$$\frac{8}{I}X_0 + 2\left(\frac{8}{I} + \frac{6}{I}\right)X_1 + \frac{6}{I}X_2 + \frac{128}{I} + \frac{135}{I} = 0$$

$$-15 * 8 + 28X_1 + 6 * 0 + 263 = 0$$

$$28X_1 = -263 + 120 = -143 \rightarrow X_1 = -5.1\ \ tm$$



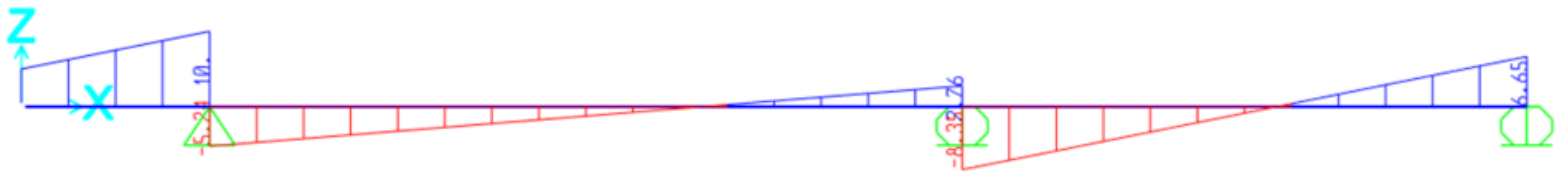
$$\sum M_1 = 0 \rightarrow T_{21} = -2.5 * 6 * \frac{6}{2} + 5.11 = -6.65\ t \quad \sum y = 0 \rightarrow -(-6.65) - 2.5 * 6 + T_{12} = 0 \rightarrow T_{12} = 8.35\ t$$

$$T_x = T_{12} - q * x \rightarrow kesme\ kuvvetinin\ sıfır\ olduğu\ yerde\ maksimum\ moment\ oluşur\ T_x = 0$$

$$x = \frac{T_{12}}{q} = \frac{8.35}{2.5} = 3..34\ m$$

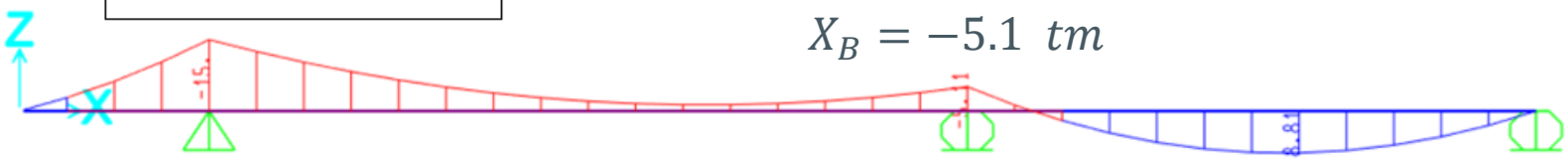
$$M_{max} = \frac{1}{2}8.35 * 3.34 - 5.11 = 8.83\ tm\ veya \quad M_{max} = \frac{1}{2}6.65 * 2.66 + 0 = 8.84\ tm\surd$$

Kesme Kuvveti Diyagramı



Moment Diyagramı

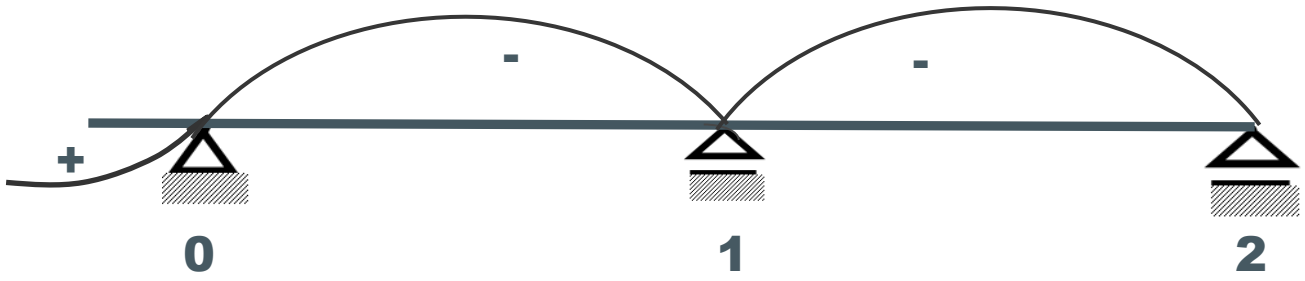
MinM=-15.0



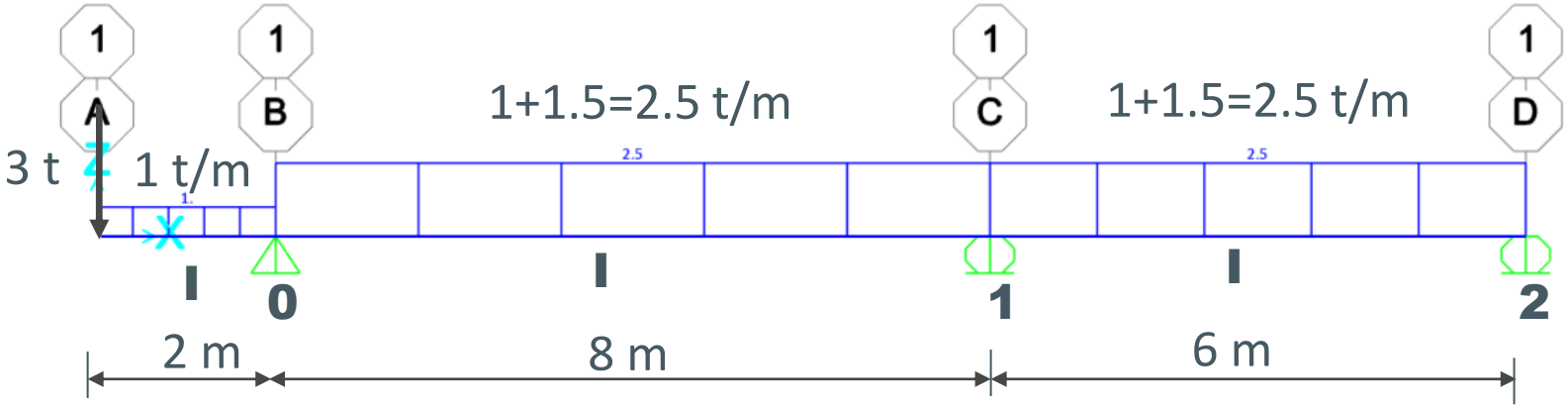
$X_B = -5.1 \ tm$

MaxM=8.84

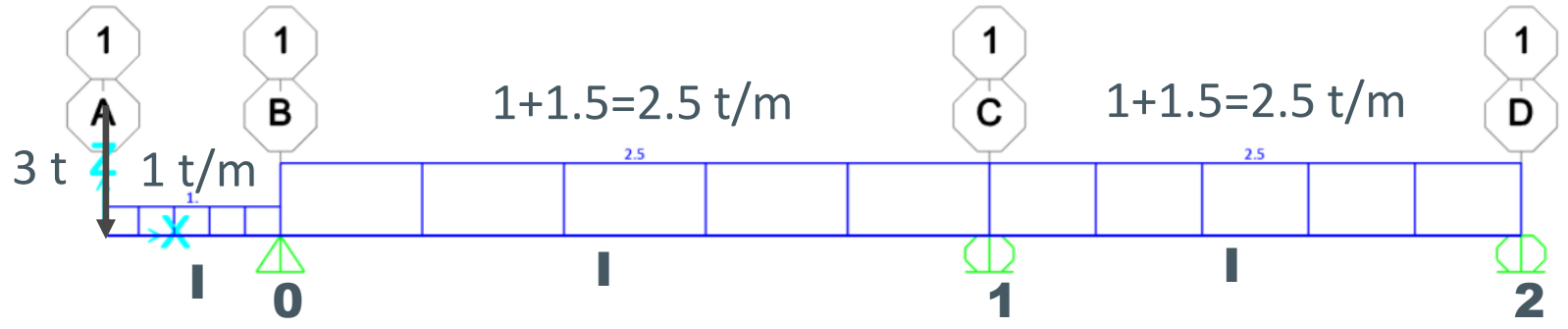
3. 1 mesnedindeki minimum moment Min. M



X_1 **Tesir çizgisi**



Elverişsiz yükleme 3



$\frac{8}{I}$	$\frac{6}{I}$
$\frac{qL^2}{4} = \frac{2.5 * 8^2}{4} = 40$ 40	$\frac{qL^2}{4} = 22.5$ 22.5
$\frac{8}{I}40 = \frac{320}{I}$ $\frac{320}{I}$	$\frac{6}{I}22.5 = \frac{135}{I}$ $\frac{135}{I}$

$Konsol\ momenti\ \ X_0 = -3 * 2 - 1 * 2 * 2 * \frac{1}{2} = -8\ tm\ \ Kenar\ mesnet\ momenti\ X_2 = 0$

X_0		X_1		X_2
$\frac{8}{I}$		$\frac{6}{I}$		
$\frac{qL^2}{4} = \frac{2.5 * 8^2}{4} = 40$	40	$\frac{qL^2}{4} = 22.5$	22.5	
$\frac{8}{I}40 = \frac{320}{I}$	$\frac{320}{I}$	$\frac{6}{I}22.5 = \frac{135}{I}$	$\frac{135}{I}$	

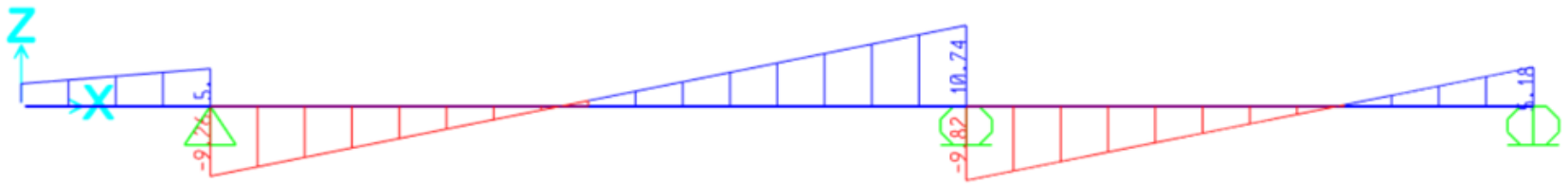
$$Konsol\ momenti\ \ X_0 = -3 * 2 - 1 * 2 * 2 * \frac{1}{2} = -8\ tm\ \ Kenar\ mesnet\ momenti\ X_2 = 0$$

$$\frac{8}{I}X_0 + 2\left(\frac{8}{I} + \frac{6}{I}\right)X_1 + \frac{6}{I}X_2 + \frac{320}{I} + \frac{135}{I} = 0$$

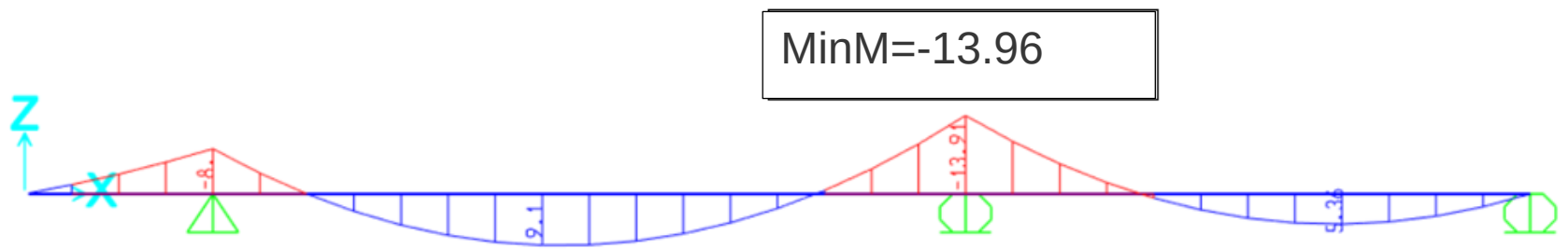
$$-8 * 8 + 28X_1 + 6 * 0 + 455 = 0$$

$$28X_1 = -455 + 64 = -391 \rightarrow X_1 = -13.96\ \ tm$$

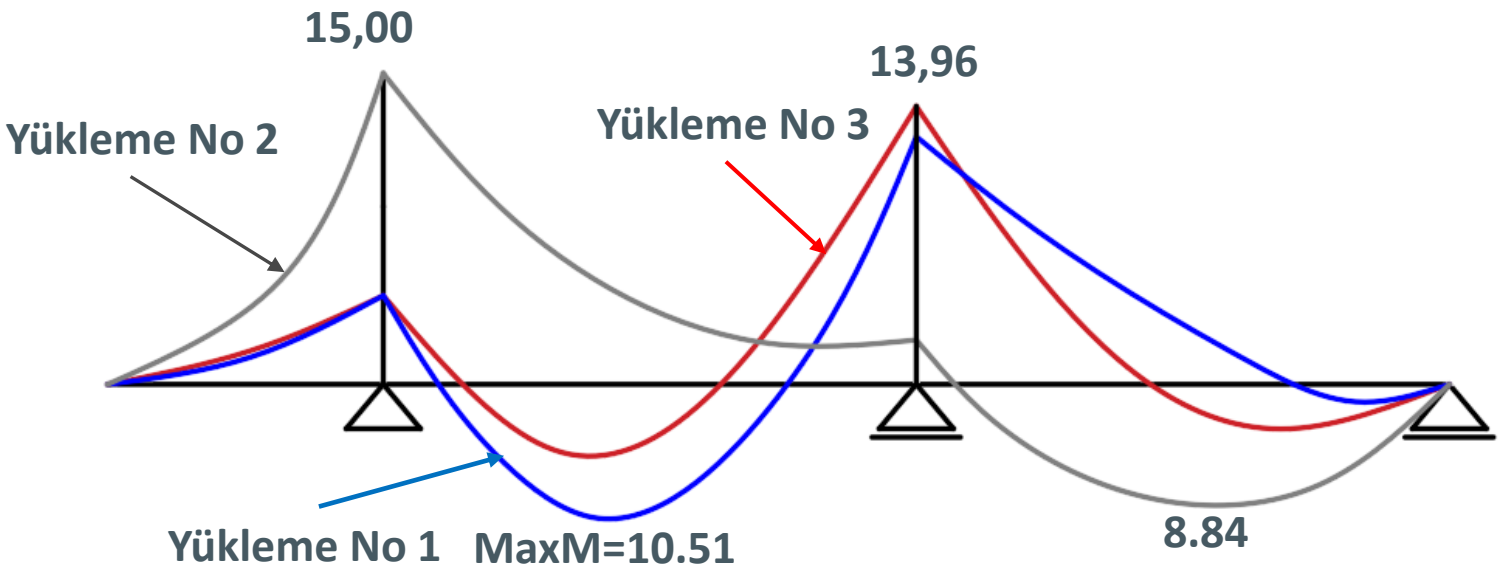
Kesme Kuvveti Diyagramı



Moment Diyagramı

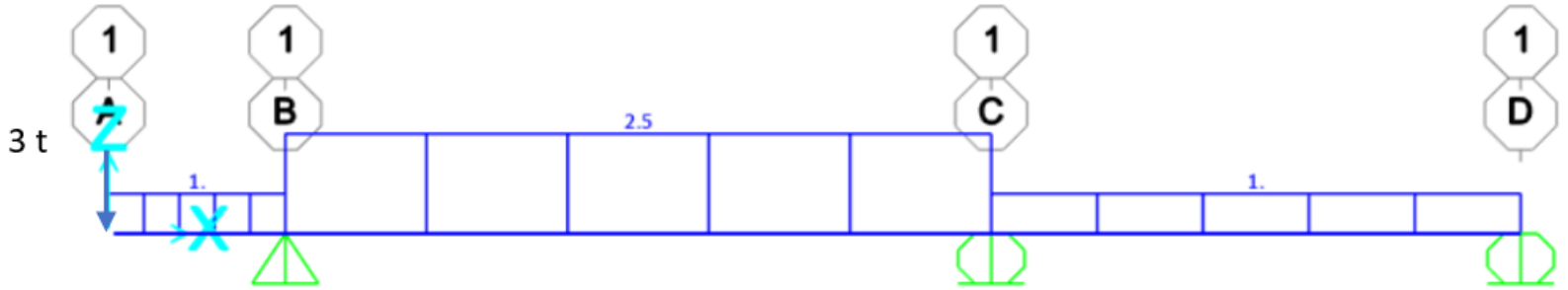


Maksimum Moment Diyagramları (tm)



SAP2000 ÇÖZÜMLERİ

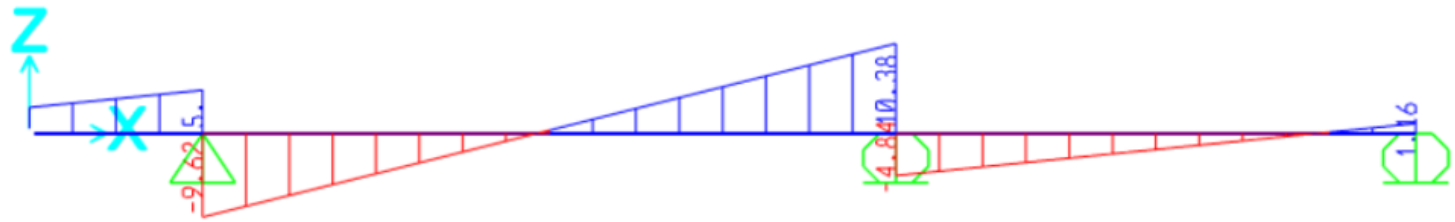
Örnek 3 (Elverişsiz yükleme 1) Sap2000 Çözümü



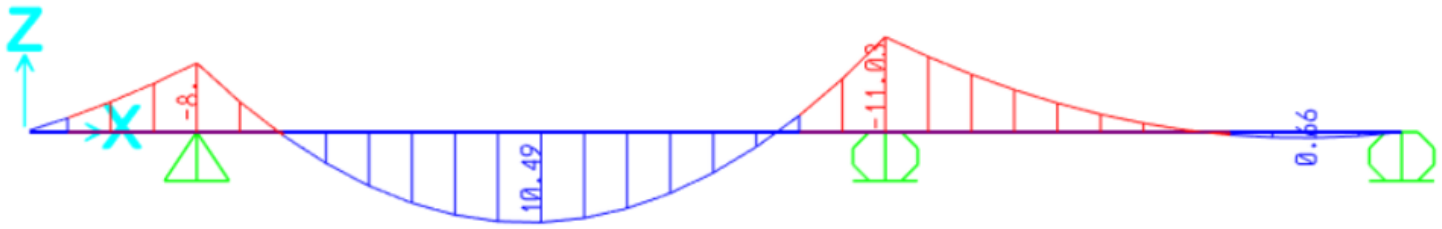
Mesnet Reaksiyonları

SAP2000 ÇÖZÜMLERİ

Kesme Kuvveti Diyagramı



Moment Diyagramı



MaxM=10.49

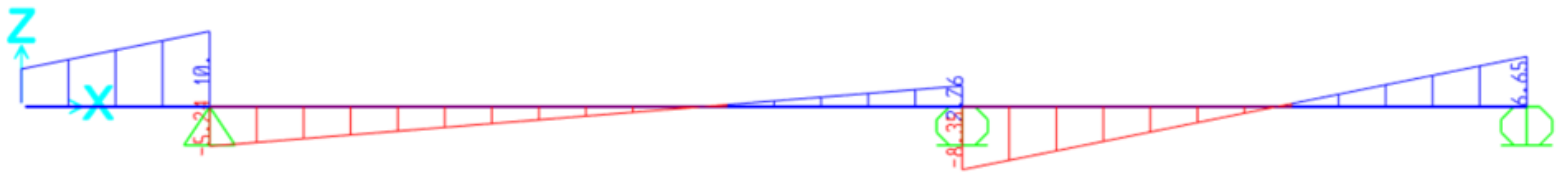
SAP2000 ÇÖZÜMLERİ

(Elverişsiz yükleme 2) Sap2000 Çözümü

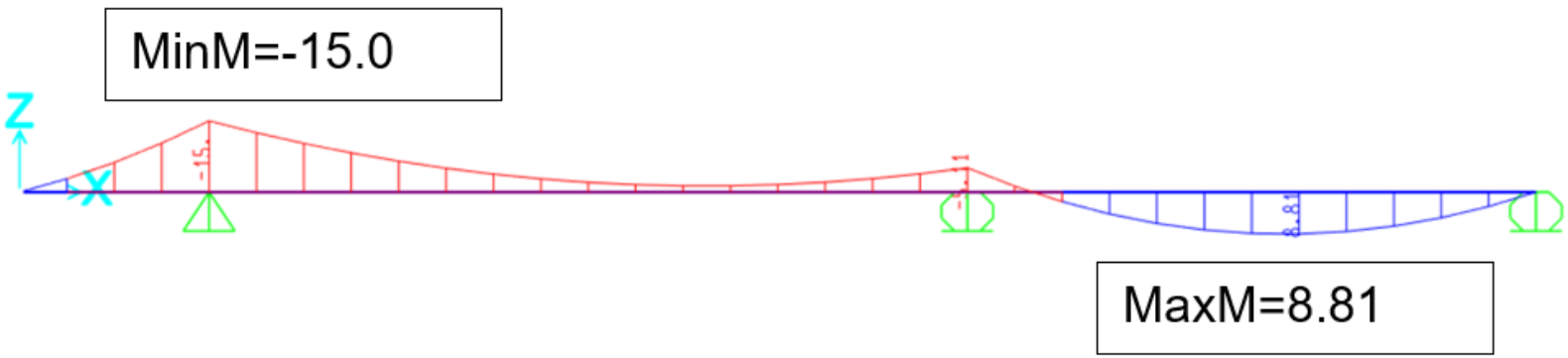
Mesnet Reaksiyonları

SAP2000 ÇÖZÜMLERİ

Kesme Kuvveti Diyagramı



Moment Diyagramı



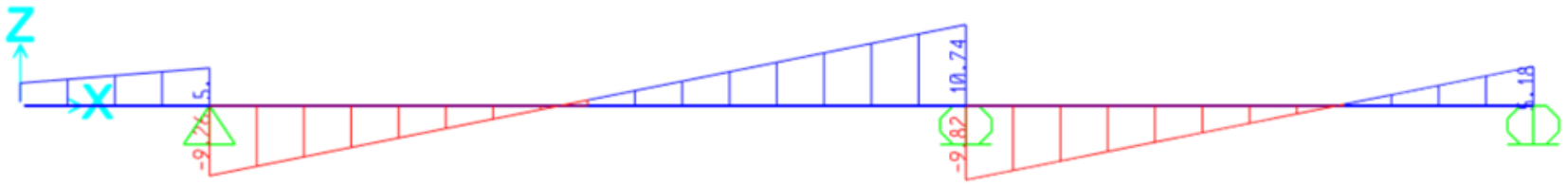
SAP2000 ÇÖZÜMLERİ

(Elverişsiz yükleme 3) Sap2000 Çözümü

Mesnet Reaksiyonları

SAP2000 ÇÖZÜMLERİ

Kesme Kuvveti Diyagramı



Moment Diyagramı