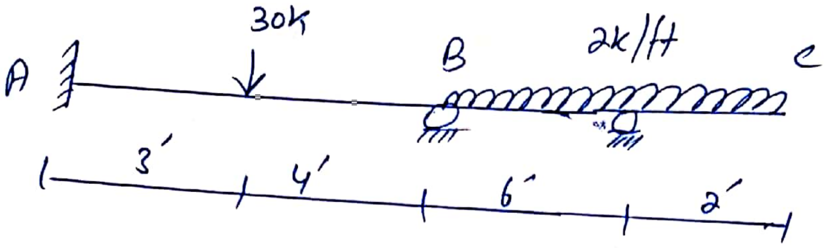
Name	ShohAB malouk
id	7878
Section	A
Subject	Structural Analysis II

Q No 1 Q1 ①

Analyze the beam Shown in fig-1 by Stiffness method Assume EI is constant.



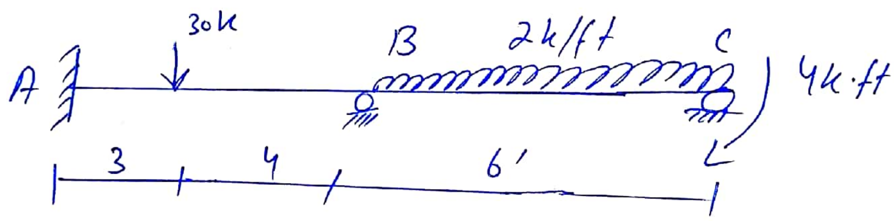
Sol:.

Step # 1

Determining kinematic indetermaniany.

$K \cdot I = 5^{\circ}$

So we have to reduce the extended portion



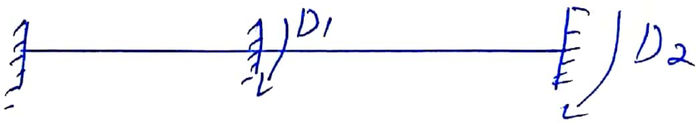
$\Rightarrow \dfrac{2(2)}{1} = 4k \cdot ft.$

Now

$K \cdot I = 2^{\circ}$

Step # 2

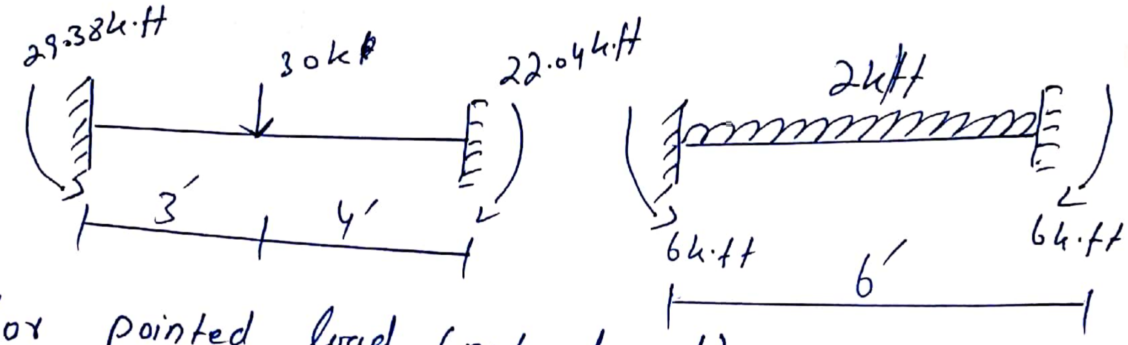
Determine unknown Joint Displacement.



$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix} \quad \begin{bmatrix} AD_1 \\ AD_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 4 \end{bmatrix}$

Step #3 Q1 (2)

Compute [ADL] matrix



=> for pointed load (not at mid)

=> for Left end:-

$$\frac{Pab^2}{L^2} = \frac{(30)(3)^2(4)}{(7)^2} = 22.04\ k\cdot ft$$

=> for UDL

$$\frac{wL^2}{12} \Rightarrow \frac{(2)(6)^2}{12} = 6k\cdot ft$$

$$ADL_1 = +22.04 - 6 = 16.04k\cdot ft$$

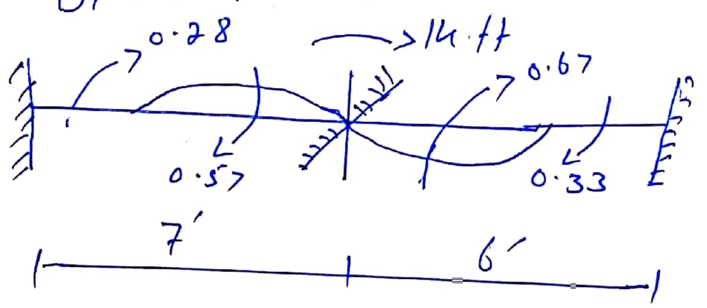
$$ADL_2 = 6k\cdot ft$$

Step #4

compute [S] matrix

$$S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

a) $D_1 = 1k$, $D_2 = 0$



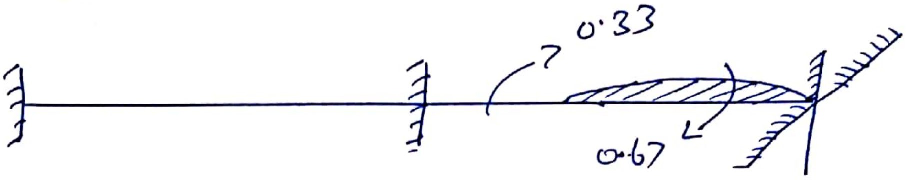
$\frac{4EI}{7} = 0.57$	$\frac{2EI}{6} = 0.33$
$\frac{4EI}{6} = 0.67$	$\frac{2EI}{7} = 0.28$

Q1 (3)

$S_{11} = 0.57 + 0.67$
$= 1.24EA$

$S_{21} = 0.33EA.$

b) $D_1 = 0$ $D_2 = 1k$



$4EI = 0.67$

$2EI = 0.33$

$S_{12} = 0.33$

$S_{22} = 0.67$

$$S = \begin{bmatrix} 1.24 & 0.33 \\ 0.33 & 0.67 \end{bmatrix}$$

Step #5

Compute [D] matrix

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}^{-1} \times \begin{bmatrix} AD_1 \\ AD_2 \end{bmatrix} - \begin{bmatrix} ADL_1 \\ ADL_2 \end{bmatrix}$$

$$\frac{1}{\begin{bmatrix} 1.24 & 0.33 \\ 0.33 & 0.67 \end{bmatrix}} \times Adj\,A \times$$

Q_1 (4)

$$|S| = (1.24 \times 0.67) - (0.33 \times 0.33)$$

$$= 0.8.308 - 0.1089$$

$$|S| = 0.7219$$

$$Adj\ A = \begin{bmatrix} 0.67 & -0.33 \\ -0.33 & 1.24 \end{bmatrix}$$

Now

$$\begin{bmatrix} AD_1 - ADL_1 \\ AD_2 - ADL_2 \end{bmatrix} = \begin{bmatrix} 0 - 16.04 \\ 4 - 6 \end{bmatrix} = \begin{bmatrix} -16.04 \\ -2 \end{bmatrix} E$$

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} 0.67 & -0.33 \\ -0.33 & 1.24 \end{bmatrix} \times \begin{bmatrix} -16.04 \\ -2 \end{bmatrix}$$

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} \begin{bmatrix} -10.08 \\ 2.81 \end{bmatrix}$$

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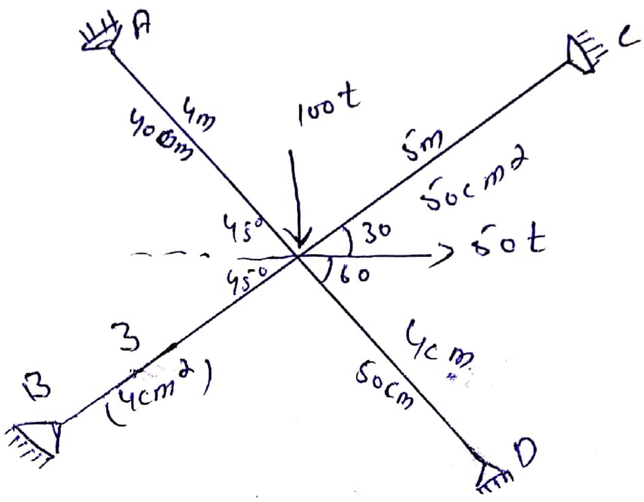
Q2 Q2 ①

Analyze the pin-jointed frame shown by Stiffness method Length of the members in m and cross-sectional area of the member in cm^2 are shown in Fig-3 Take $E = 2000\ t/cm^2$

$E = 2000 t/cm^2$



Sol:- for A:-

$\sin 45° = P/h = P/4$

$\Rightarrow P = 2.828\,m$

$\cos 45° = b/4$

$\Rightarrow b = 2.828\,m$

for B:-

$\sin 45° = P/3$

$\Rightarrow P = 2.12\,m$

$\cos 45° = b/h$

$= b = 2.12\,m$

for C:-

$\sin 30 = P/h = 5$

$\Rightarrow P \Rightarrow 2.5\,m$.

Q2 (2)

$\cos 30° = b/5$

$\Rightarrow b = 4.33m$

Now $EA(A) = 2000 \times 40 = 80,000t$

$EA(B) = 2000 \times 40 = 80000t$

$EA(C) = 2000 \times 50 = 100,000t$

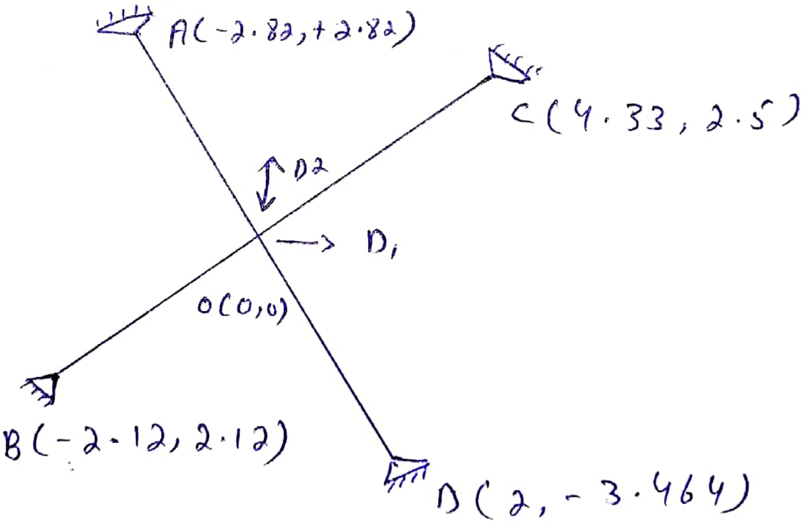
$EA(D) = 2000 \times 50 = 100,000t$.

Step #01 K.I

$K.I = 2j - r$

$= 2(5) - 8 = 2°$

Step #02 Select unknown joint displacement



$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix}, \begin{bmatrix} AD_1 \\ AD_1 \end{bmatrix} = \begin{bmatrix} 50 \\ -100 \end{bmatrix}$$

Step #03 $[\overset{③}{AMP}]_{4\times2}$ & $[S]_{2\times2}$

i) $D_1 = 1$, $D_2 = 0$

$$AMD = \frac{EA}{L^2}(x_c - x_i)$$

$$AMD_{11} = \frac{80000}{(400)^2} \times (0+282) = 141$$

$$AMD_{21} = \frac{80{,}000}{(300)^2} \times (0+212) = 188.44$$

$$AMD_{31} = \frac{100{,}000}{(500)^2} \times (0-433) = 173.2$$

$$AMD_{41} = \frac{100{,}000}{(400)^2} \times (0-200) = -125$$

Now $S_{11} = \sum_{1H}^{m} \frac{EA}{L^3}(x_H - x_j)^2$

$$= \frac{80{,}000}{4} \times (282)^2 + \frac{80{,}000}{(300)^3} \times (212)^2 + \frac{100{,}000}{(500)^3} \times (-433)^2$$

$$+ \frac{100{,}000}{(400)^3} \times (-200)^2$$

$$S_{11} = 99.405 + 133.167 + 149.991 + 82.5$$

$$\boxed{S_{11} = 445.063}$$

$$S_{12} = S_{21} = \sum_{i=1}^{m} \frac{EA}{L^3} \times (x_k - x_j)(y_k - y_j)$$

$$= \frac{80{,}000}{(400)^3} \times (282)(-282) + \frac{80{,}000}{(300)^3} \times (212)(212)$$

$$+ \frac{100{,}000}{(500)^3} \times (-433)(0-250) + \frac{100{,}000}{(400)^3} \times (-200)(0+346)$$

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Q2 ④

$$\boxed{S_{12} = S_{21} = 12.237}$$

ii) $D_1 = 0$, $D_1 = 1k'$

$$AMD = \frac{EA}{L^2}(y_k - y_j)$$

$$AMD_{12} = \frac{80{,}000}{400^2}(-282) = -141$$

$$AMD_{22} = \frac{80{,}000}{300^2}(212) = 188.44$$

$$AMD_{32} = \frac{100{,}000}{500^2}(-250) = -100$$

$$AMD_{42} = \frac{100{,}000}{400^2}(346) = 216.25$$

Now $S_{22} = \sum_{2\times1}^{m} \frac{EA}{L^3}(y_k - y_j)^2$

$$= \frac{80000}{400^3}(-282)^2 + \frac{80{,}000}{300^3}(212)^2 + \frac{100{,}000}{500^3}(-250)^2$$

$$+ \frac{100{,}000}{400^3}(246)^2$$

$$\boxed{S_{22} = 469.628}$$

Step #04 Q2 (5)

$$[D] = [S]^{-2} \times [AD]$$

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} 445.003 & 12.237 \\ 12.237 & 469.628 \end{bmatrix}^{-1} \times \begin{bmatrix} 50 \\ -100 \end{bmatrix}$$

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} 0.1183 \\ -0.216 \end{bmatrix}$$

Step #05 [Am]

$$\begin{bmatrix} Am_1 \\ Am_2 \\ Am_3 \\ Am_4 \end{bmatrix} = \begin{bmatrix} 141 & -141 \\ 188.44 & 188.44 \\ -173.2 & -100 \\ -125 & 216.25 \end{bmatrix} \times \begin{bmatrix} 0.1183 \\ -0.216 \end{bmatrix}$$

$$\begin{bmatrix} 141 \times 0.1183 + (-141) \times (-0.216) \\ 188.44 \times 0.1183 + 188.44 \times (-0.216) \\ -173.2 \times 0.1183 + (-100) \times (-0.216) \\ -125 \times 0.1183 + 216.25 \times (0.216 \end{bmatrix}$$

$$\begin{bmatrix} Am_1 \\ Am_2 \\ Am_3 \\ Am_4 \end{bmatrix} = \begin{bmatrix} 16.68 + 30.46 \\ 22.29 - 40.70 \\ -20.49 + 21.6 \\ -14.79 - 46.71 \end{bmatrix}$$

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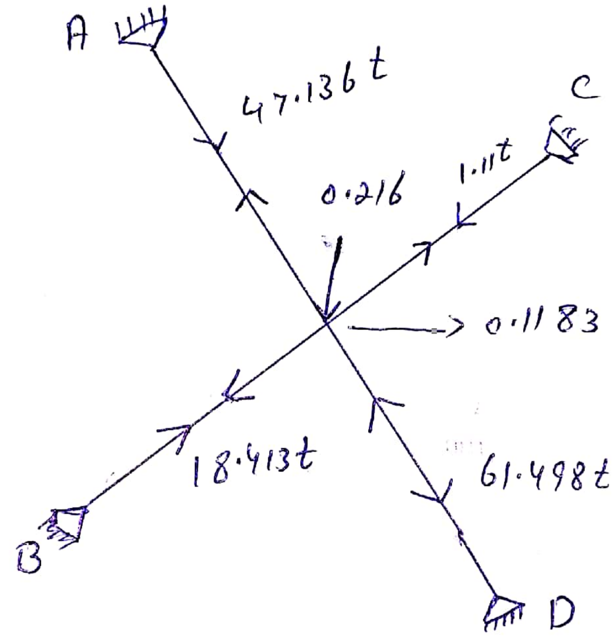
Q2 (6)

$$\begin{bmatrix} A_{m_1} \\ A_{m_2} \\ A_{m_3} \\ A_{m_4} \end{bmatrix} = \begin{bmatrix} 47.136t \\ -18.413t \\ 1.11t \\ -61.498t \end{bmatrix}$$



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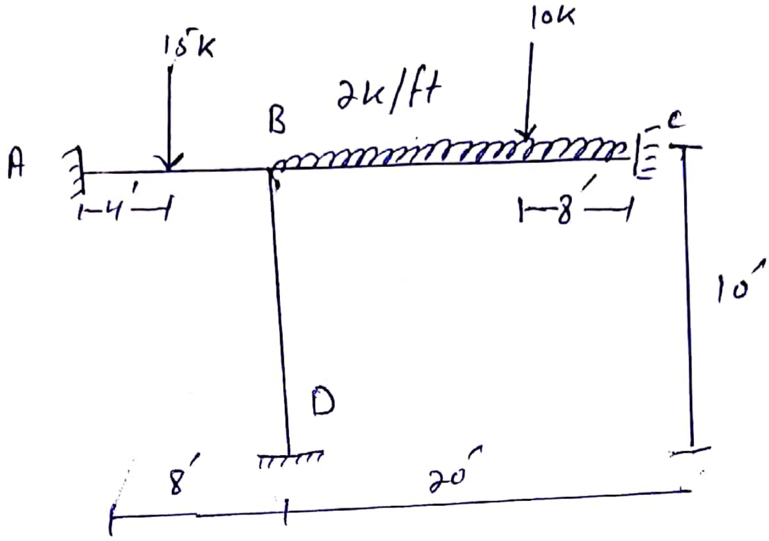
θ_3 ② ...27k·ft

θ_3 ①

QNo 3:- Analyze the rigid-joint frame Shown in Fig 2 by Stiffness method Assume EI is constant.



Sol:-

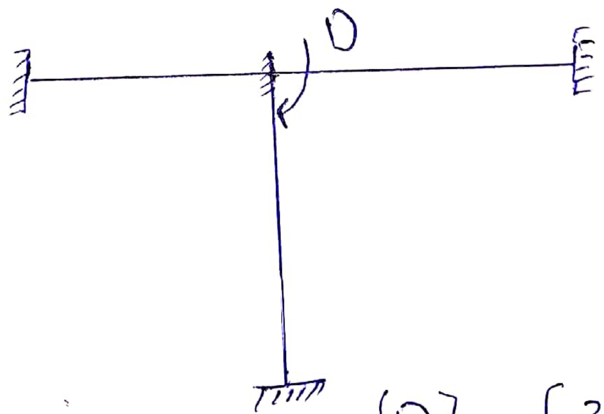
Step #1

Determine kinematic indeterminancy.

$k \cdot I = 1^{\circ}$

Step #2

Determine unknown joint Displacement.



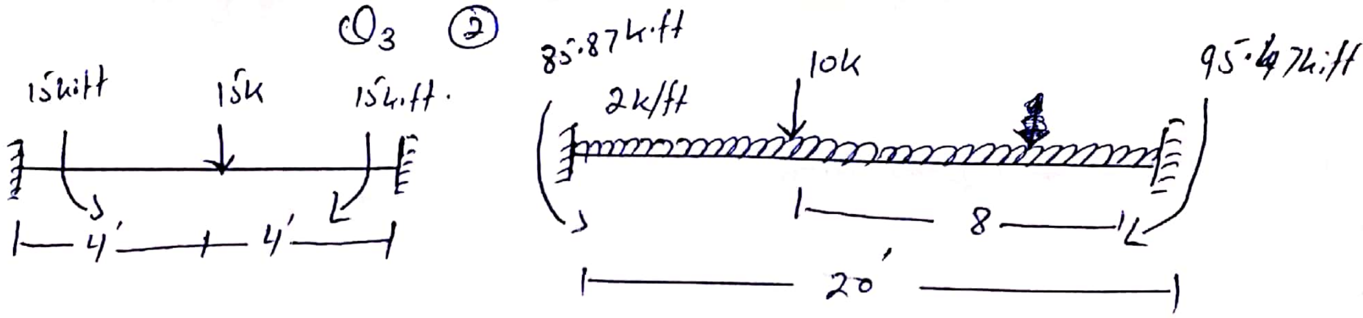
$[D] = [\,?\,]$

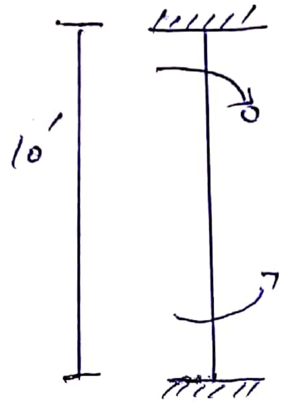
$[AD] = [0]$

Step # 3 :-

Compute [ADL] matrix.

Q3 (2)





=> point load at center :-

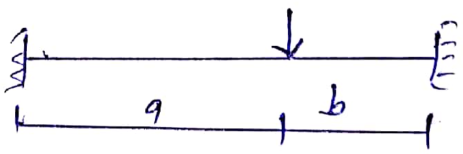
$$\frac{PL}{8} = \frac{(15)(8)}{8} = 15 \text{ kip·ft}$$

=> uniformly Distributed load

$$\frac{WL^2}{12} \Rightarrow \frac{(2)(20)^2}{12} = 66.67 \text{ k·ft.}$$

=> point load (Not at mid)

Suppose.



for left end

$$\frac{Pab^2}{L^2} \Rightarrow \frac{(10)(12)(8)^2}{(20)^2} = 19.2 \text{ k·ft}$$

for Right End

$$\frac{Pa^2b}{L^2} = \frac{(10)(12)^2(8)}{(20)^2} = 28.8 \text{ k·ft}$$

Q3 (8)

So Total moment at Left end

$$19.2 + 66.67 = 85.87k.ft$$

Similarly at right End

$$28.8 + 66.67 = 95.47k.ft$$

So $[AD] = -85.87 + 15 = -70.87k.ft.$

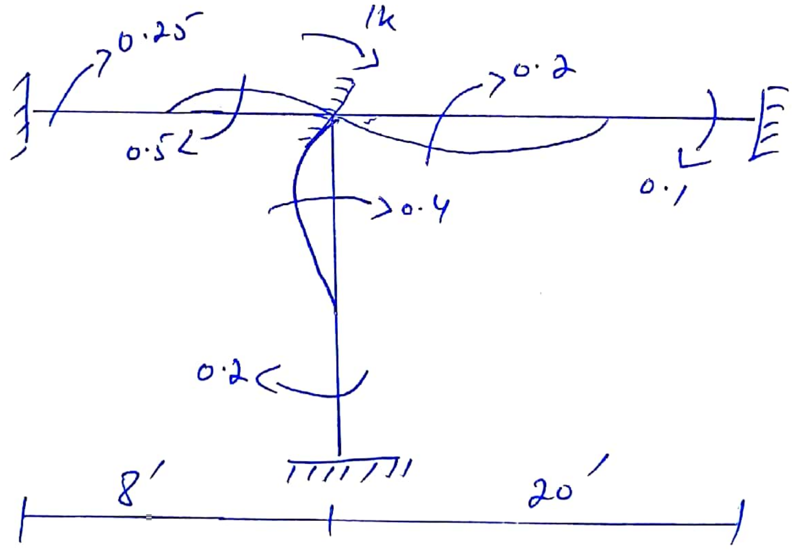
Step#4

Determine [S] matrix

$$[S] = [S_{11}]$$

Now,

$$D = 1K$$



$$\Rightarrow \frac{4EI}{8} = 0.5 \qquad \frac{2EI}{8} = 0.25$$

$$\Rightarrow \frac{4EI}{20} = 0.2 \qquad \frac{2EI}{20} = 0.1$$

$$\Rightarrow \frac{4EI}{10} = 0.4 \qquad \frac{2EI}{10} = 0.2$$

Q3 ④

$[S] = (0.5 + 0.4 + 0.2] EI$

$= 1.1\ EI$

$[S] = 1.1\ EI$

<u>Step #5</u>

Compute (D) matrix

$[D] = [S]^{-1} \times [AD] - [ADL]$

$[D] = \dfrac{1}{1.1} \times [0] - [-70.87]$

$= \dfrac{70.87}{1.1}$

$[D] = [64.42]\ ^{1}/_{EI}$.