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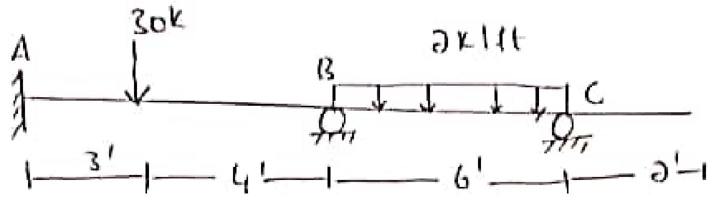
ID # 7707

Subject # Structure 01

Instructor # Engineer Adeel Saib

Dated # 25/09/2020

Q # 1:



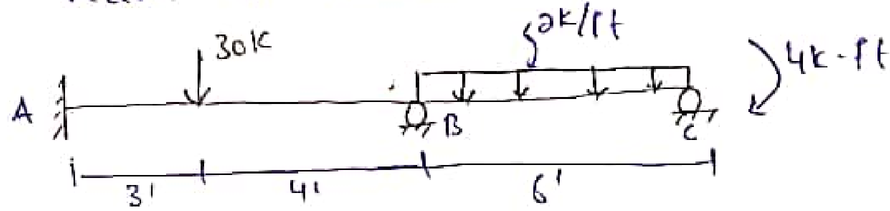
Solution:

Step # 1:

Determination of Kinematic Indeterminacy

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

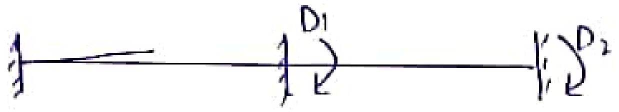
So we have to reduce the extended portion



Now $K.I = 2^{\circ}$ $\qquad \frac{2 \times 2}{1} = 4k.ft$

Step # 2

Determination of unknown joint displacement



$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix}$$

$$\begin{bmatrix} AD_1 \\ AD_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 4 \end{bmatrix}$$

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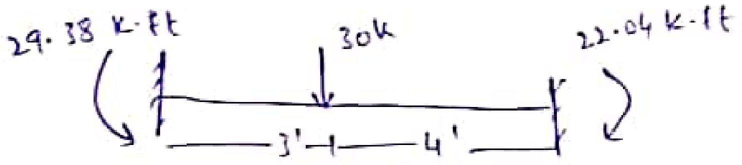
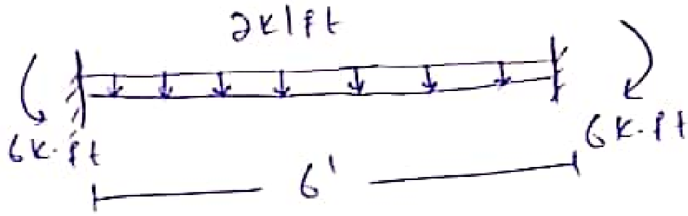
Step # 3

Compute ADL matrix





* for point Load not at mid

* for left end

$$\frac{Pab^2}{L^2} = \frac{30 \times 3 \times (4)^2}{(7)^2} = 29.38 \text{ k-ft}$$

* for right end

$$\frac{Pa^2b}{L^2} = \frac{30 \times (3)^2 \times 4}{(7)^2} = 22.04 \text{ k-ft}$$

* For UDL

$$\frac{wl^2}{12} = \frac{2(6)^2}{12} = 6 \text{ k-ft}$$

$$ADL_1 = 22.04 - 6$$
$$= 16.04 \text{ k-ft}$$

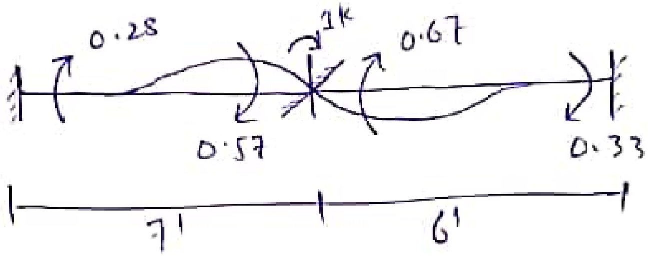
$$ADL_2 = 6 \text{ k-ft}$$

Step # 4

Now compute [S] matrix

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

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



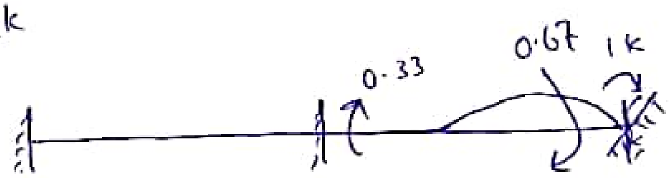
$\frac{4EI}{7} = 0.57$ $\frac{2EI}{7} = 0.28$

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

$S_{11} = 0.57 + 0.67$

$\boxed{S_{11} = 1.24\ EA}$ $\boxed{S_{21} = 0.33\ EA}$

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



$\frac{4EI}{6} = 0.67$

$\frac{2EI}{6} = 0.33$

$\boxed{S_{12} = 0.33}$

$\boxed{S_{22} = 0.67}$

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

Step # 5

Compute D matrix

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

$$= \frac{1}{\begin{vmatrix} 1.24 & 0.33 \\ 0.33 & 0.67 \end{vmatrix}} \times \text{Adj } A \times \left(\begin{bmatrix} AD_1 \\ AD_2 \end{bmatrix} - \begin{bmatrix} ADL_1 \\ ADL_2 \end{bmatrix} \right)$$

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

$$|S| = 0.7219$$

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

Now

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

$$* \begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \frac{1}{|S|} \times \text{Adj } A \times \begin{bmatrix} -16.04 \\ -2 \end{bmatrix}$$

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \frac{\begin{bmatrix} 0.67 & -0.33 \\ -0.33 & 1.24 \end{bmatrix}}{0.7219} \times \begin{bmatrix} -16.04 \\ -2 \end{bmatrix}$$

$$= \begin{bmatrix} 0.919 & -0.452 \\ -0.452 & 1.70 \end{bmatrix} \times \begin{bmatrix} -16.04 \\ -2 \end{bmatrix}$$

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} -13.83 \\ 3.85 \end{bmatrix}$$

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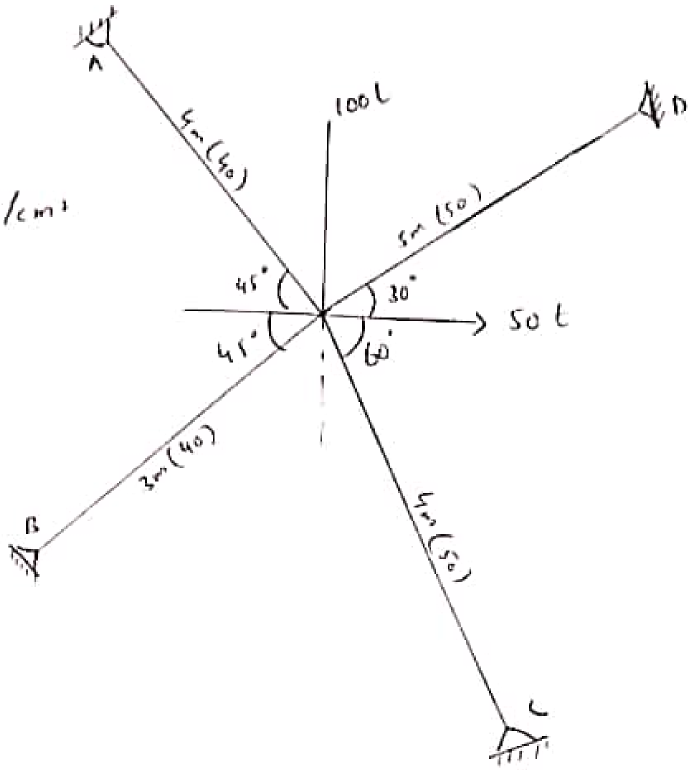
Q # 02 :



Solution :

For A

$$\sin 45 = \frac{P}{H} = \frac{P}{4}$$

$$P = 2.828\,m$$

$$\cos 45 = \frac{b}{H} = \frac{b}{4}$$

$$b = 2.828\,m$$

For B

$$\sin 45 = P/H = P/3$$

$$P = 2.12\,m$$

$$\cos 45 = b/H = b/3$$

$$b = 2.12\,m$$

For C

$$\sin 60 = P/H = P/4$$

$$P = 3.46$$

$\cos 60 = b/H = b/4$

$b = 2$

For D

$\sin 30 = P/5$

$P = 2.5m$

$\cos 30 = b/5$

$b = 4.33\ m$

Now

$EA_{(A)} = 2000 \times 40 = 80,000\ t$

$EA_{(B)} = 2000 \times 40 = 80,000\ t$

$EA_{(C)} = 2000 \times 50 = 100,000\ t$

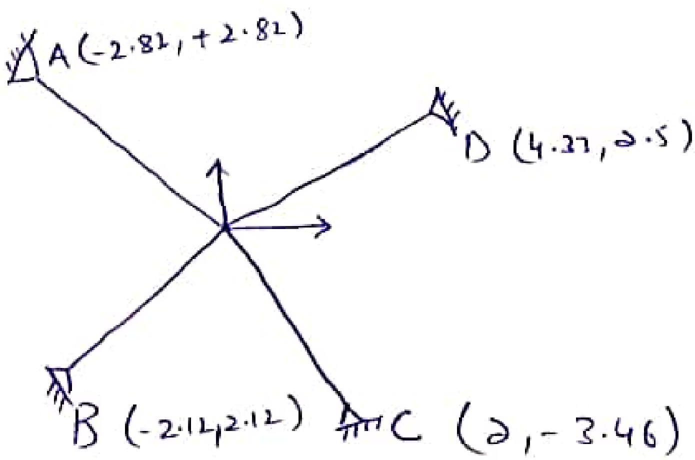
$EA_{(D)} = 2000 \times 50 = 100,000\ t$

Step # 1

$KI = 2j - r = 2(5) - 8$

$K.I = 20$

Step # 2 Select unknown join displacement



$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix} \qquad \begin{bmatrix} AD_1 \\ AD_2 \end{bmatrix} = \begin{bmatrix} 50 \\ -100 \end{bmatrix}$$

Step # 3

$$[AMD]_{4\times 2} \qquad [S]_{2\times 2}$$

(i) $D_1 = 1k \qquad D_2 = 0$

$$AMD = \frac{EA}{L^2}(X_k - X_j)$$

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

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

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

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

Now

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

$$= \frac{80000}{(400)^3}(282)^2 + \frac{80000}{(300)^3} \times (212)^2$$

$$+ \frac{100000}{(500)^3} \times (-433)^2 + \frac{100000}{(400)^3} \times (-200)^2$$

$$S_{11} = 99.405 + 133.107 + 149.991 + 62.5$$

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

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

$$= \frac{80000}{(400)^3}(282)(-282) + \frac{80000}{(300)^3}(-212)(212)$$

$$+ \frac{100000}{(500)^3}(-433)(0-250) + \frac{100000}{(400)^3}(-200)(0+346)$$

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

(ii) $D_1 = 0$ $\quad D_2 = 1k$

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

$$AMD_{12} = \frac{80000}{(400)^2}(-282) = -141$$

$$AMD_{22} = \frac{80000}{(300)^2}(212) = 188.44$$

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

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

Now

$$S_{22} = \sum_{i=1}^{m} \frac{EA}{L^3}(y_k - y_j)^2$$

$$= \frac{80000}{(400)^3}(-283)^2 + \frac{80000}{(300)^3}(212)^2 + \frac{100000}{(500)^3}(-250)^2$$

$$+ \frac{100000}{(400)^3}(346)^2$$

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

Step # 4

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

$$\begin{bmatrix} D_1 \\ D_2 \end{bmatrix} = \begin{bmatrix} 445.03 & 12.237 \\ 12.237 & 469.628 \end{bmatrix}^{-1} \times \begin{bmatrix} 50 \\ -100 \end{bmatrix}$$

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

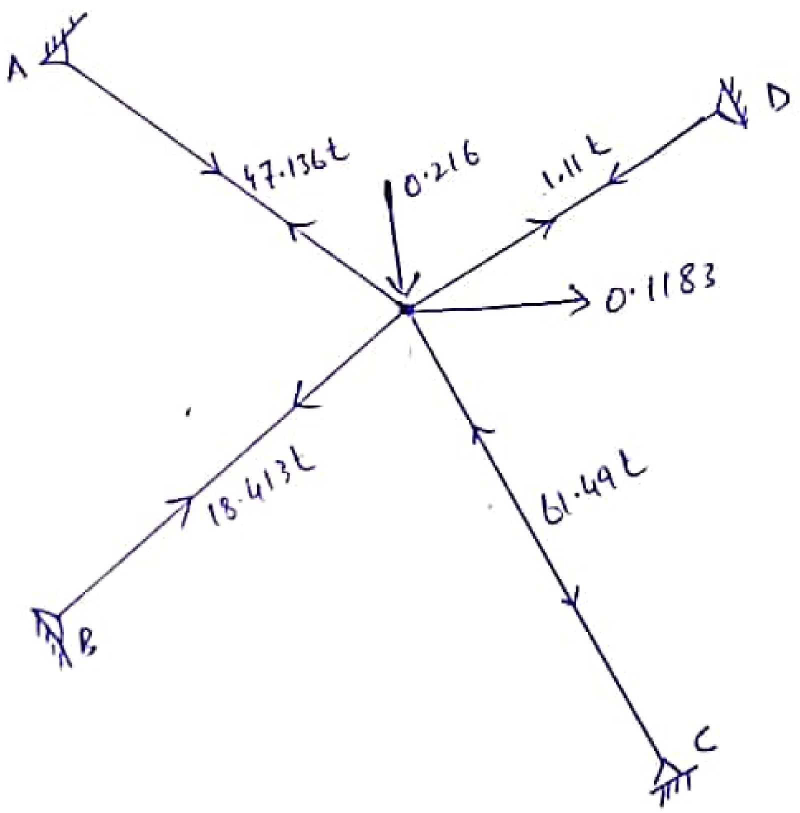
Step # 5

Finding [AM]

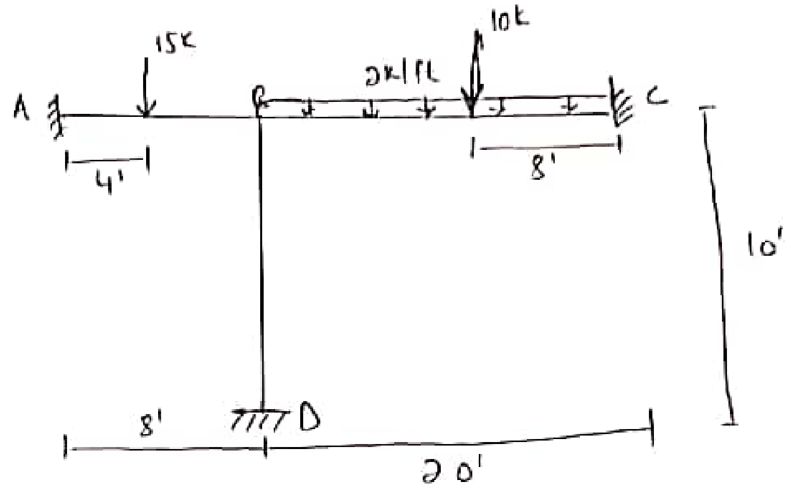
$$\begin{bmatrix} AM_1 \\ AM_2 \\ AM_3 \\ AM_4 \end{bmatrix} = \begin{bmatrix} 141 & -141 \\ 188.44 & 188.44 \\ -173.2 & -100 \\ -125 & 216.25 \end{bmatrix} \times \begin{bmatrix} 0.1183 \\ -0.216 \end{bmatrix}$$

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

$$\begin{bmatrix} AM_1 \\ AM_2 \\ AM_3 \\ AM_4 \end{bmatrix} = \begin{bmatrix} 47.136t \\ -18.413t \\ 1.11t \\ -61.498t \end{bmatrix}$$



Q No 3: Analyze the rigid joint frame by stiffness method. Assume EI is constant.



Sol

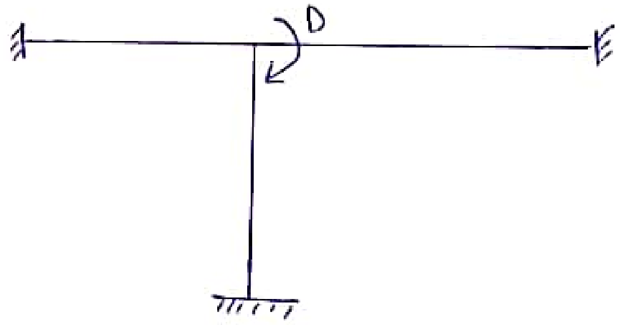
Step # 1:

Determine kinematic indeterminacy

KI = 1°

Step # 2:

Determination of unknown joint displacement

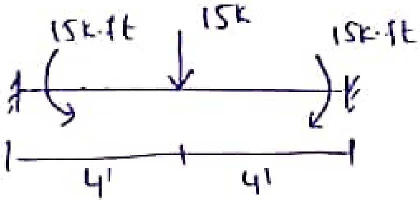


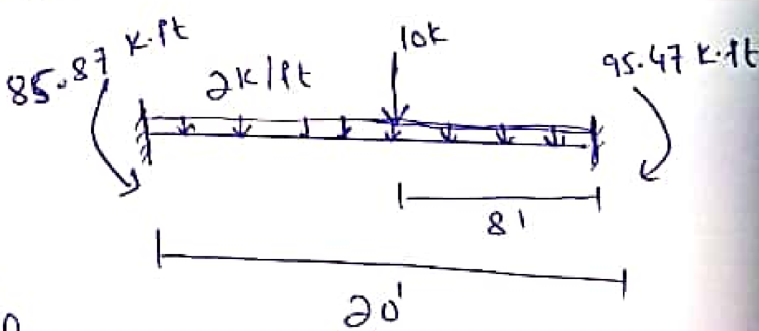
[D] = [?]

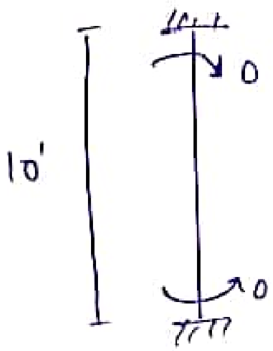
[AD] = [0]

Step # 3

Compute ADL matrix







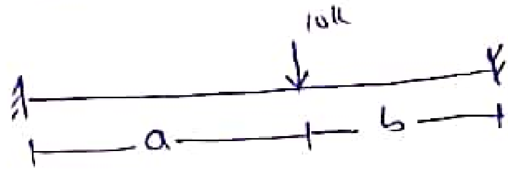
* Point load at centre

$$\frac{PL}{8} = \frac{15 \times 8}{8} = 15 \text{ k.ft}$$

* Uniformly distributed load

$$\frac{wL^2}{12} = \frac{2(20)^2}{12} = 66.67 \text{ K.ft}$$

* Point load not at mid



For left end:

$$\frac{Pab^2}{L^2} = \frac{10(12)(8)^2}{(20)^2} = 19.2 \text{ K.ft}$$

For right end:

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

So total moment at left end:

$$19.2 + 66.87 = 85.87 \text{ K.ft}$$

Similarly at right end:

$$28.8 + 66.67 = 95.47 \text{ K.ft}$$

So

$$[ADL] = -85.87 + 15$$
$$= -70.87 \text{ K.ft}$$

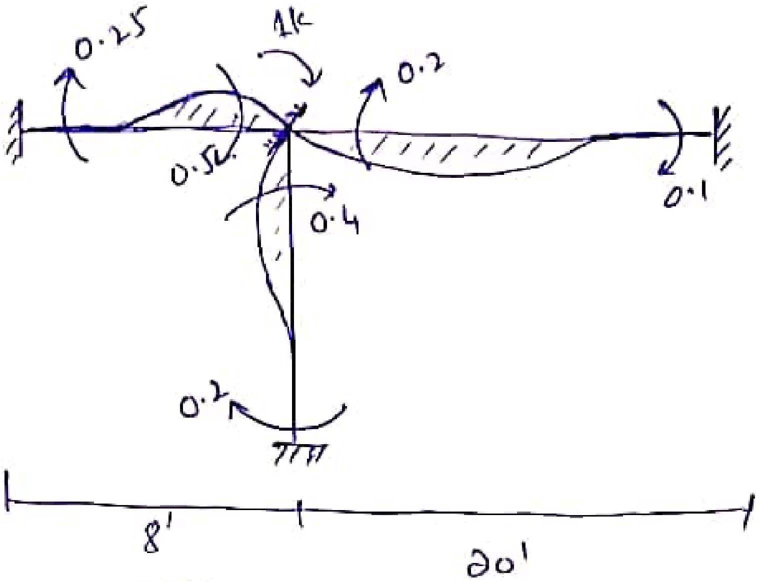
Step # 4:

Determination of [S] matrix

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

Now

D = 1k



* $\frac{4EI}{8} = 0.5$
* $\frac{4EI}{20} = 0.2$
* $\frac{4EI}{10} = 0.4$
* $\frac{2EI}{8} = 0.25$
* $\frac{2EI}{20} = 0.1$
* $\frac{2EI}{10} = 0.2$

$$[S] = (0.5 + 0.2 + 0.4)\,EI$$

$$[S] = 1.1\,EI$$

Step # 5

Compute [D] matrix

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

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

$$[D] = [64.42] \times \frac{1}{EI}$$