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SECTION: B

SUBJECT: Structure Analysis - II

SUBMITTED TO: Engr. Adeed Khan

DATE: 21/8/2020

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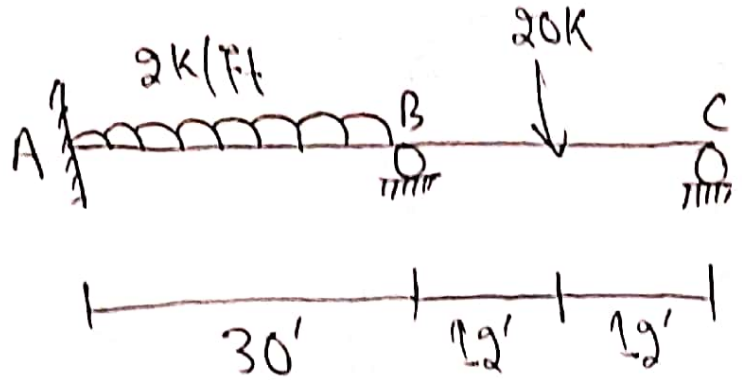
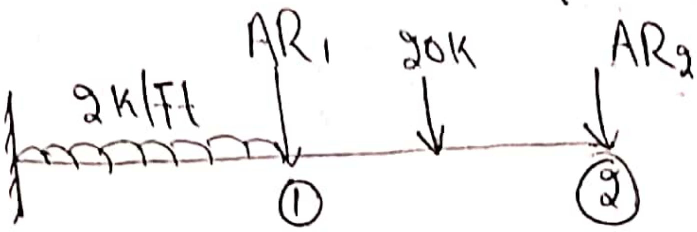
Q1



Sol.

Structural Indeterminancy = 2°

Step-1 Select Redundant Actions



$$\begin{bmatrix} DRS_1 \\ DRS_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \qquad \begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix}$$

$$[DRS] = [DRL] + [F] \times [AR]$$

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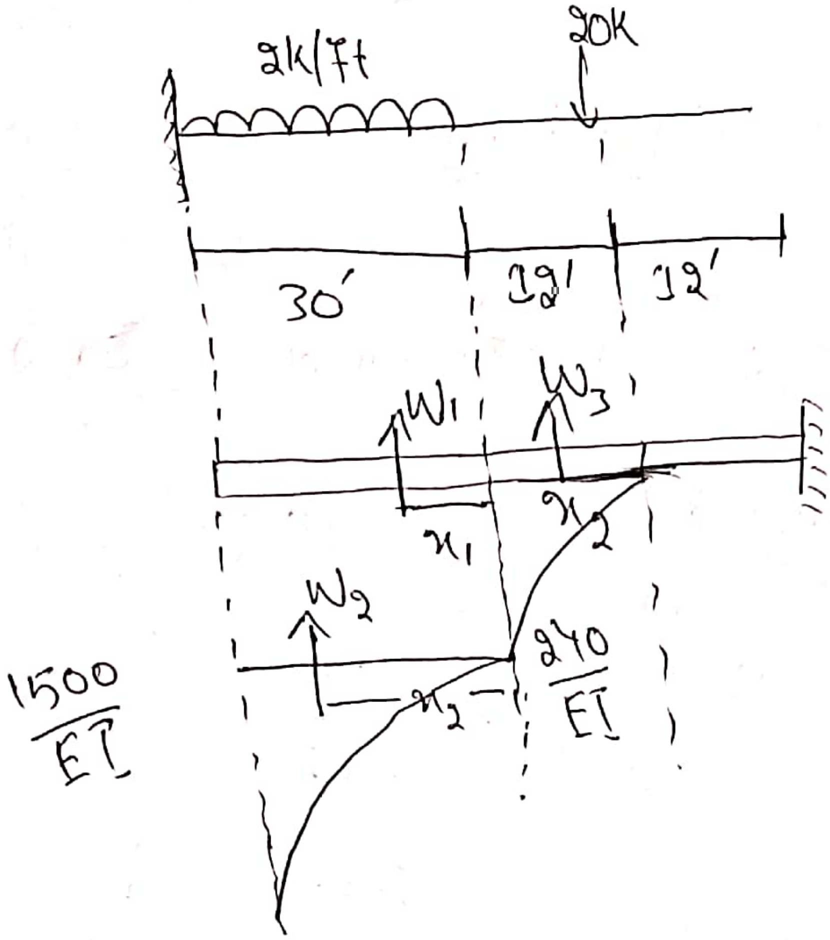
Step: 2 Compute the values of (DRL).



$20 \times 12 = 240$

$20 \times (12 + 30) + 2 \times 30 \times 15 = 1740$

$W_1 = 1500 \times 30 = 4500$

$W_2 = \frac{1}{30} \times 30 \times 240 = 2400$

$W_3 = \frac{1}{2} \times 12 \times 240 = 1440$

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$x_1 = b/2 = 30/2 = \underline{15'}$

$x_2 = \frac{3}{n+2} \times L = \frac{3}{2+2} \times 30 = 22.5'$

$x_3 = 2/3 \times L = \frac{2}{\cancel{3}_1} \times \cancel{12}^4 = 8'$

Now finding DRL

$DRL_1 = W_1(x_1) + W_2(x_2)$

$= 45000(15) + 2400(22.5)$

$= 675000 + 54000$

$= 729000$

$DRL_2 = W_1 \times (x_1 + 24) + W_2 \times (x_2 + 24) +$

$W_3 \times (x_3 + 12)$

$= 45000(15+24) + 2400(22.5+24) +$

$\underline{1}440(8+12)$

$= 1755000 + 111600 + 28800$

$DRL_2 = 1895400 / \underline{EI}$

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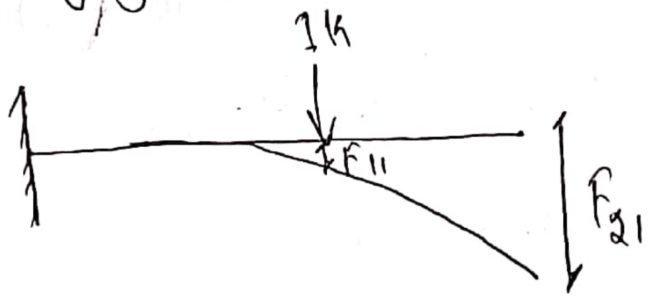
So,

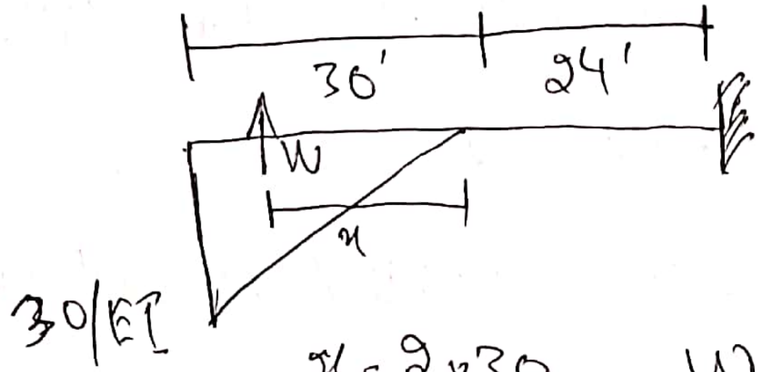
$$DRL = \frac{1}{EI}\begin{bmatrix} 729000 \\ 1895400 \end{bmatrix}$$

step: 3 Flexibility Matrix

$$[F]_{2\times 2} = \begin{bmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{bmatrix}$$

(a) Applying unit Load on AR_1





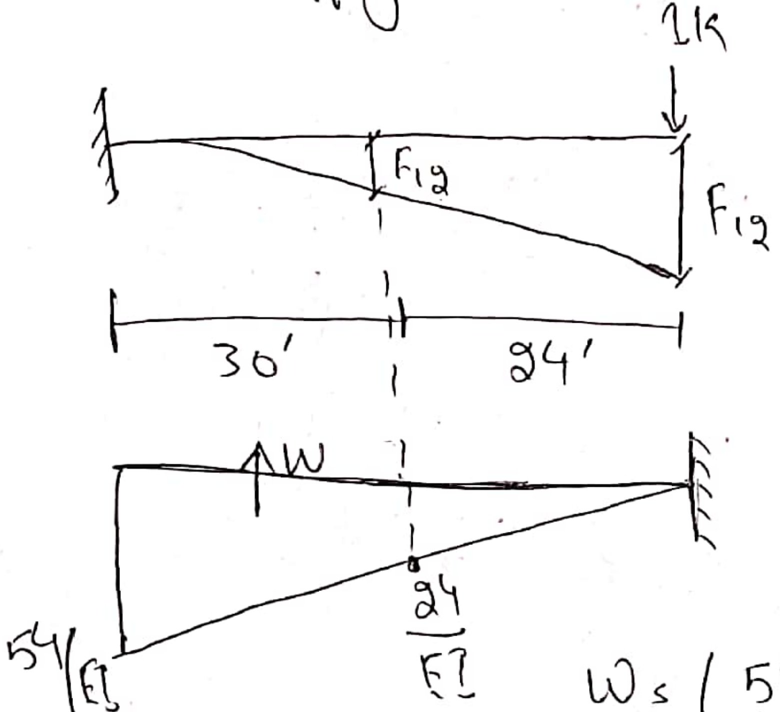
$$x = \frac{2}{3} \times 30$$
$$= 20'$$

$$W = \frac{1}{2}\left(\frac{30}{EI} \times 30\right)$$
$$= 450/EI$$

So, $f_{11} = \frac{450}{EI}(20) = 9000/EI$.

$f_{21} = \frac{450}{EI}(20+24) = 19800/EI$

Now Apply unit Load on AR_2



$W = \left(\frac{54+24}{2EI}\right) \times 30$

$= 1170/EI$

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Now the distance,

$$x = \frac{L}{3}\left[\frac{b+2(a)}{a+b}\right]$$

$$= \frac{30}{3}\left[\frac{24+2(54)}{54+24}\right] = 16.92'$$

$$\Rightarrow F_{12} = \frac{1170}{EI} \times 16.92 = \frac{19796.4}{EI}$$

$$\Rightarrow F_{22} = \frac{1170}{EI} \times (16.92+24) = \frac{47876.4}{EI}$$

Hence

$$F_{2\times 2} = \begin{bmatrix} 9000 & 19796.4 \\ 19800 & 47876.4 \end{bmatrix} \frac{1}{EI}$$

Step: 4 Compute the values of AR

$$[DRS] = [DRL] + [F] \times [AR]$$

$$[AR] = [DRS - DRL] \times [F]^{-1}$$

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$$[F]^{-1} = \frac{1}{F}$$

$$= \frac{1}{\begin{vmatrix} 9000 & 19796.4 \\ 19800 & 47876.4 \end{vmatrix}} \times Adj \begin{bmatrix} 9000 & 19796.4 \\ 19800 & 47876.4 \end{bmatrix}$$

$$|F| = (9000 \times 47876.4 - 19796.4 \times 19800)$$

$$= (430887600 - 391968720)$$

$$\Rightarrow |F| = 38918880$$

$$\Rightarrow Adj\, A = \begin{bmatrix} 47876.4 & -19796.4 \\ -19800 & 9000 \end{bmatrix}$$

$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} 0 - 729000 \\ 0 - 1895400 \end{bmatrix} \frac{1}{EI} \times \frac{1}{38918880} \begin{bmatrix} 47876.4 & -19796.4 \\ -19800 & 9000 \end{bmatrix}$$

$$= \begin{bmatrix} -729000 \\ -1895400 \end{bmatrix} \frac{1}{EI} \frac{\begin{bmatrix} 47876.4 & -19796.4 \\ -19800 & 9000 \end{bmatrix}}{38918880}$$

$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} 66.193 \\ -67.505 \end{bmatrix}$$

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Q2
Sol:

Force Method	Displacement Method
→ $D_s < D_K$	→ $D_s > D_K$
→ Forces are redundant or unknown	→ Displacement are redundant or unknown
→ Starts with equilibrium of forces	→ Starts with compatible deformation
→ Forces found by compatibility equations of displacement	→ Displacement found by equilibrium equations of forces
→ Number of redundants $= D_s$	→ Number of redundants $= D_K$
→ Not suitable for compression	→ Not suitable for trusses.

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=> Displacement Method is suitable for structure anaylsis of matrix approach.
Stiffness Method also called Displacement Method is more suitable for structure analysis matrix approach, as it is a primary method used in matrix analysis. The main advantage of this method flexbility method is that it is conductive to computer programming. Once the analytical model of the structure has been defined, No further engineering decisions are required in the stiffness method in order to carry out the analysis.

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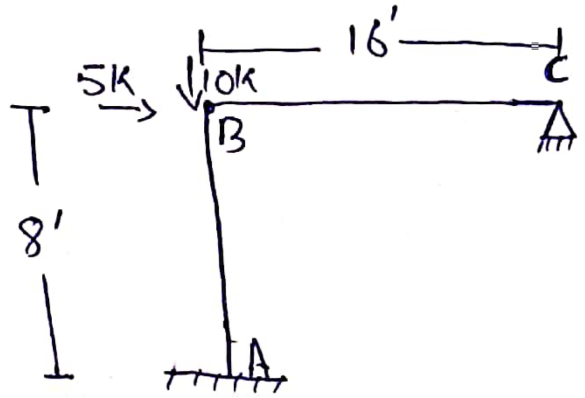
Q3:

Sol:



E = Constant

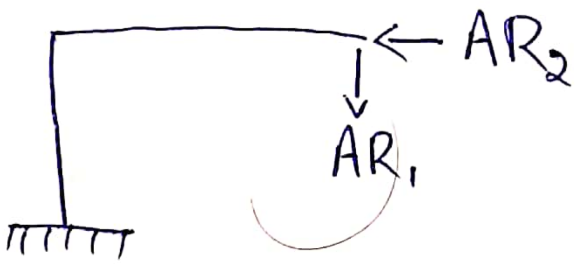
$I_c = I$

$I_B = 2I$

Total statical indeterminacy

$\Rightarrow R-3 = 5-3 = 2°$

Step: 1 Identify Redundant Actions



$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix} \qquad \begin{bmatrix} DRS_1 \\ DRS_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Step 2: Compute value of [DRL]

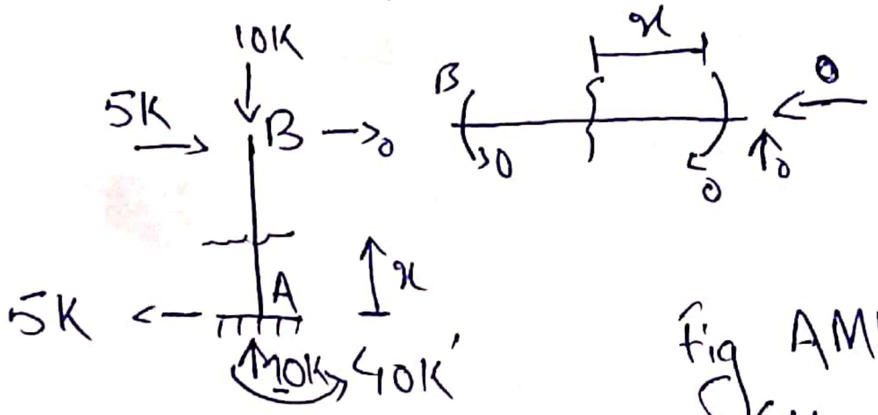


Fig AML value (M-values)

Step 3 [F] or [AMR]

(a)

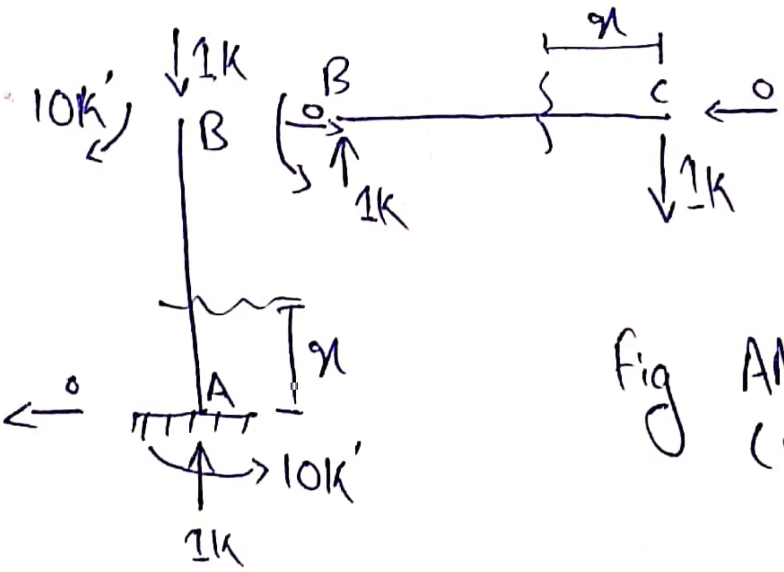


Fig AMR-value (m, values)

(b)

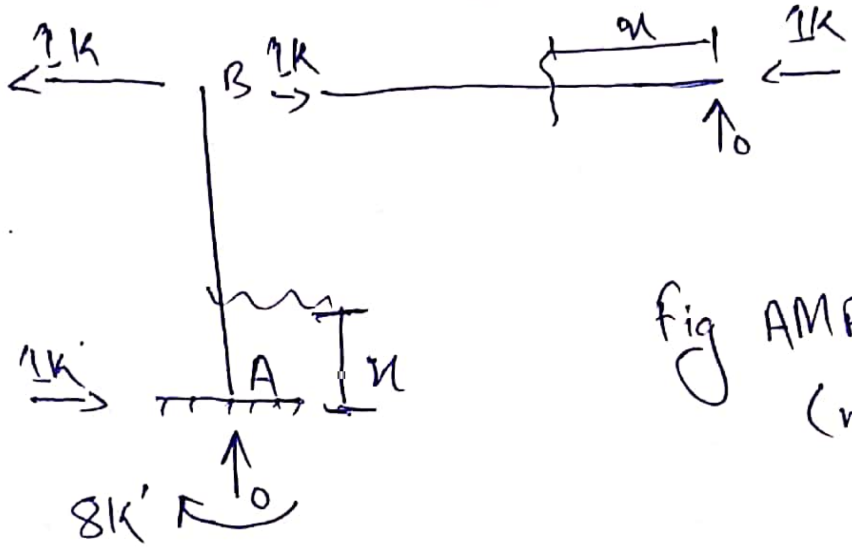


fig AMR values (m_2 values)

Member	AB	BC
Origin	A	C
Limits	0-8	0-16
I	I	$2I$
M	$5x-40$	0
m_1	-16	x
m_2	$8-x$	0

(13)

For Finding values of DRL

$$DRL_1 = \int_0^8 \frac{M_{AB} \cdot M_{1(AB)}}{EI} + \int_0^{16} \frac{M_{BC} \cdot M_{2(BC)}}{EI}$$

$$= \int_0^8 \frac{(5x-40)(-16)}{EI} dx + \int_0^{16} \frac{0.x}{E(2I)} dx$$

$$DRL_1 = \frac{2560}{EI}$$

$$DRL_2 = \int_0^8 \frac{(5x-40)}{EI} dx + \int_0^{16} \frac{0.0}{E(2I)} dx$$

$$DRL_2 = \frac{-853.33}{EI}$$

⇒ Compute Flexibility Matrix

$$F_{2\times 2} \rightarrow 2^{\circ} \begin{bmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{bmatrix}$$

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(14)

$$\Rightarrow \quad F_{11} = \int_0^8 \frac{m_{1(AB)}^2}{EI} + \int_0^{16} \frac{m_{2(BC)}^2}{EI}$$

$$= \int_0^8 \frac{(-16)^2}{EI} dx + \int_0^{16} \frac{x^2}{E(2I)} dx$$

$$\boxed{F_{11} = \frac{2730.67}{EI}}$$

$$F_{12} = F_{21} = \int_0^8 m_1(AB) \cdot m_2(AB) + \int_0^{16} m_1(BC) \cdot m_2(BC)$$

$$= \int_0^8 \frac{(-16)(8-x)}{EI} dx + \int_0^{16} \frac{(x)(0)}{2EI} dx$$

$$\boxed{F_{12} = F_{21} = \frac{-512}{EI}}$$

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$$f_{22} = \int_0^8 (m_2)^2_{AB}\,dx + \int_0^{16} (m_2)^2_{BC}\,dx$$

$$= \int_0^8 \frac{(8-x)^2}{EI}\,dx + \int_0^{16} \frac{0^2}{2EI}\,dx$$

$$\boxed{f_{22} = 170.67}$$

As we know

$$[DRS] = [DRL] + [AR] \times [F]$$

$$\Rightarrow [AR] = \frac{[DRS] - [DRL]}{[F]}$$

$$\Rightarrow [AR] = [F]^{-1} \times [DRS - DRL]$$

$$= \begin{bmatrix} 2730.67 & -512 \\ -512 & 170.67 \end{bmatrix} \times \begin{bmatrix} 0 - 2560 \\ 0 + 853.33 \end{bmatrix}$$

$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} -0.00005 \\ 4.997 \end{bmatrix} = \begin{bmatrix} 0 \\ 5 \end{bmatrix}$$

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