Name Jamal Alif

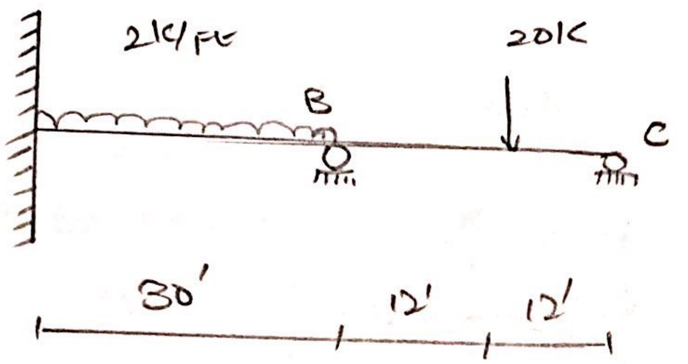
ID 7480

Subject Structural Analysis II

Teacher Engr. Adeed Khan

Summer Mid term Exam.

Q1 Analyze the given beam shown in fig by flexibility method. EI is constant.

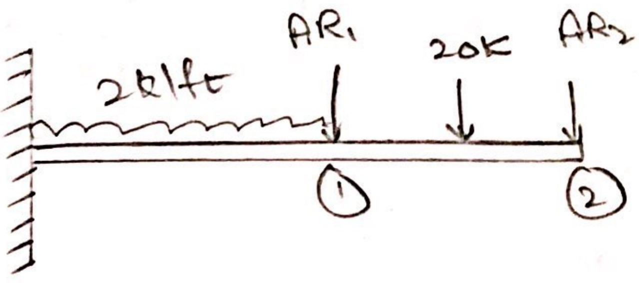


Solution:-

Structural Indeterminacy = 2°

Step # 1

Select Redundant Actions

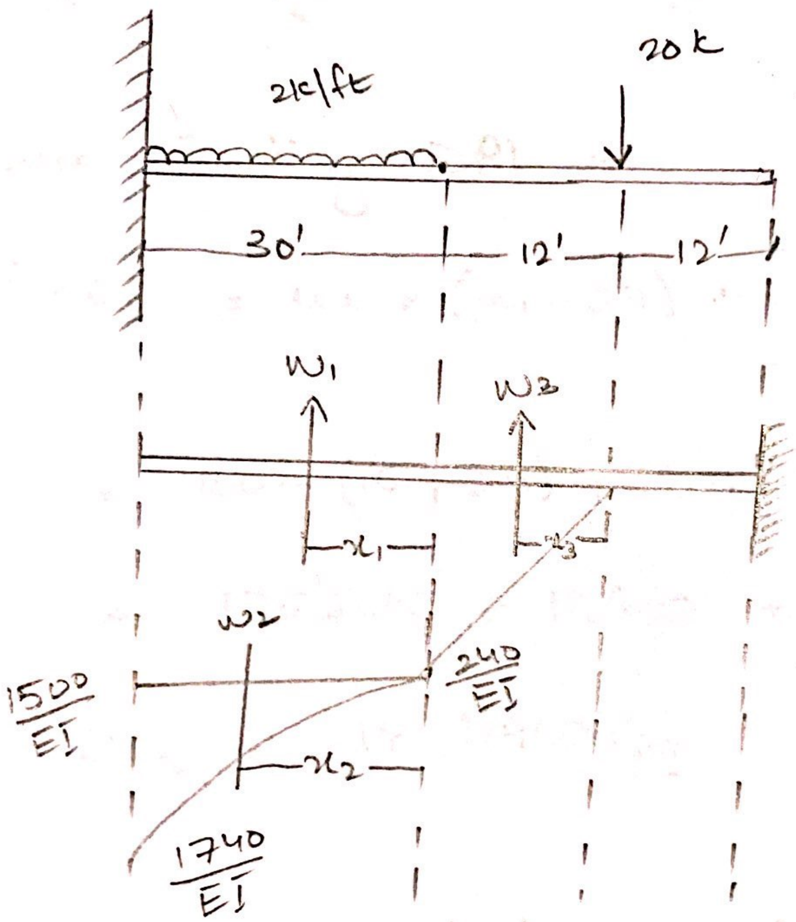


$$\begin{bmatrix} DRS_1 \\ DRC_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} , \quad \begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix}$$

[DRS] = [DRL] + [F] × [AR]

Step 2 :-

Compute the values of [DRL]



$20 \times 12 = 240$

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

$w_1 = 1500 \times 30 = 45000$

$w_2 = \frac{1}{3} \times 30 \times 240 = 2400$

$w_3 = \frac{1}{2} \times 12 \times 240 = 1440$

$x_1 = \frac{b}{2} = \frac{30}{2} = 15'$

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

$x_3 = \frac{2}{3} \times L = \frac{2}{3} \times 12 = 8'$

Now Finding DRL :-

$DRL_2 = w_1 \times (x_1 + 24) + w_2 \times (x_2 + 24) + w_3 \times (x_3 + 12)$

$= 45000(15+24) + 2400(22.5+24) + 1440(8+12)$

$= 1755000 + 111600 + 28800$

$DRL_2 = 1895400/EI$

$DRL_1 = w_1(x_1) + w_2(x_2)$

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

$= 675000 + 54000$

$= 729000$

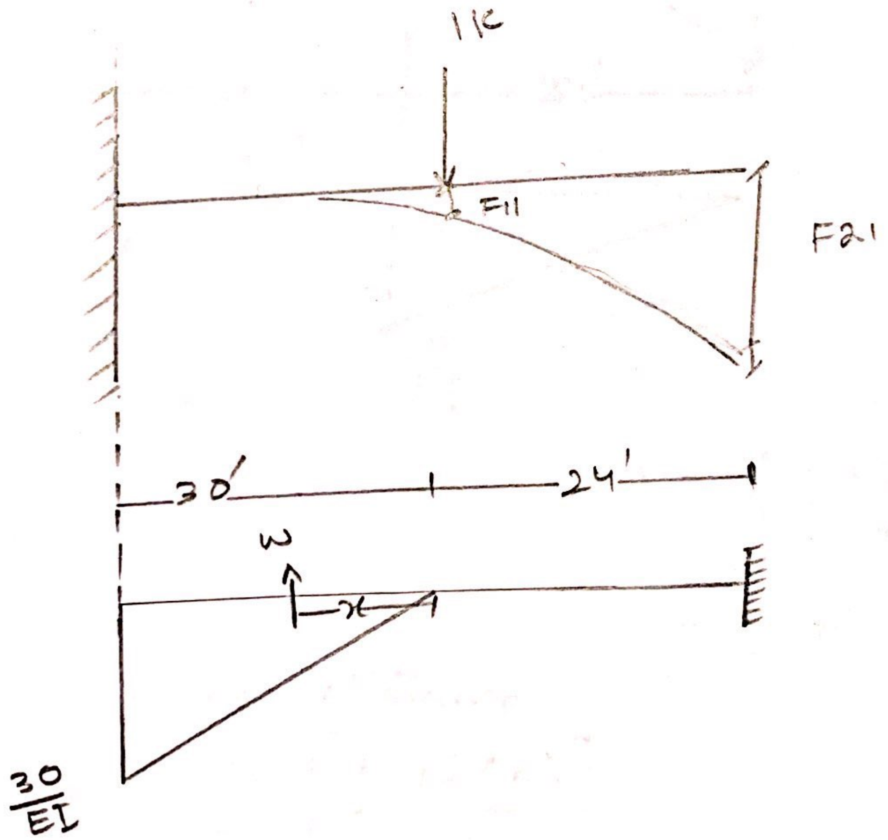
So,

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

Step # 3 Flexibility matrix

$$[F]_{2\times2} = \begin{bmatrix}F_{11} & F_{12} \\ F_{21} & F_{22}\end{bmatrix}$$

a) Applying unit load on AR_1



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

$= 20'$

$w = \frac{1}{2}\left(\frac{30}{EI} \times 30\right)$

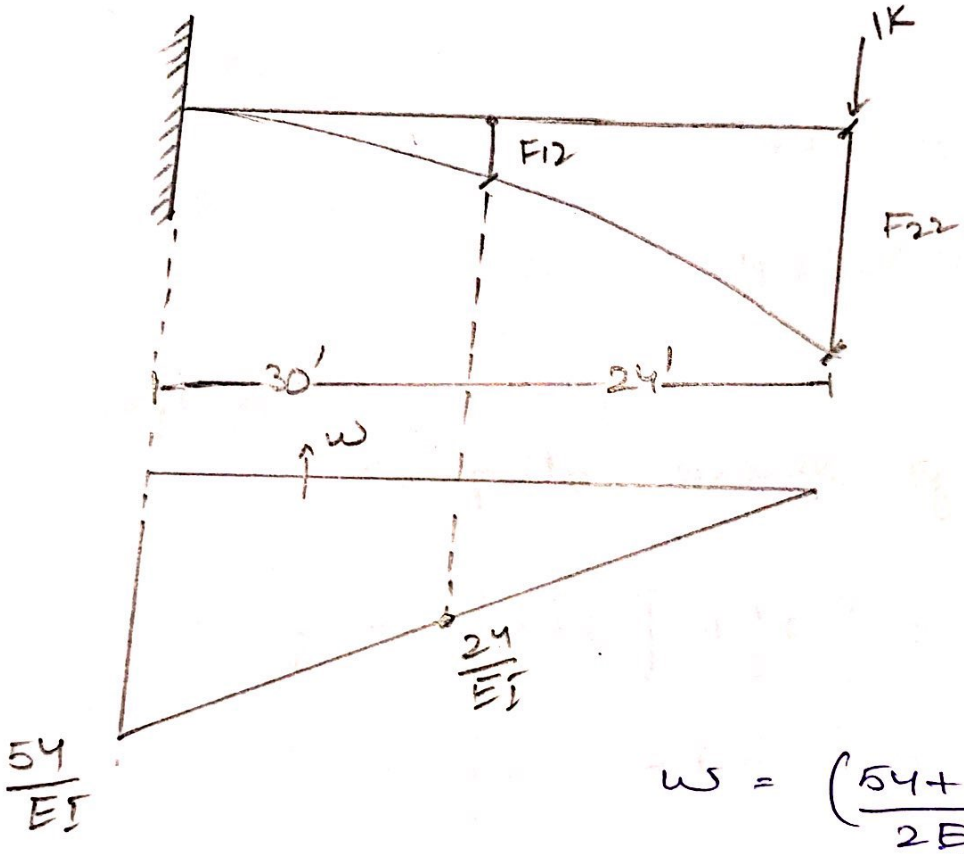
$= \frac{450}{EI}$

So,

$$F_{11} = \frac{450}{EI}(20) = \frac{9000}{EI}$$

$$F_{21} = \frac{450}{EI}(20+24) = \frac{19800}{EI}.$$

Now apply unit load on AR_2.



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

$$= \frac{1170}{EI}.$$

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

$$F_{2\times2} = \begin{bmatrix} 9000 & 19796.4 \\ 19800 & 47876.4 \end{bmatrix} \frac{1}{EI}$$

Step # 4

Compute values of AR

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

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

$$[F]^{-1} = \frac{1}{|F|} \times Adj\,F$$

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

$|F| = (9000 \times 47876.4 - 19796.4 \times 19800)$
$(430887600 - 391968720)$

$\Rightarrow |F| = 3891880$

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

$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} 0 - 729000 \\ 0 - 1879500 \end{bmatrix} \frac{1}{EI} \times \frac{1}{38918880} \begin{bmatrix} 47876.4 & -19796.4 \\ -19800 & 9000 \end{bmatrix}$$

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

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

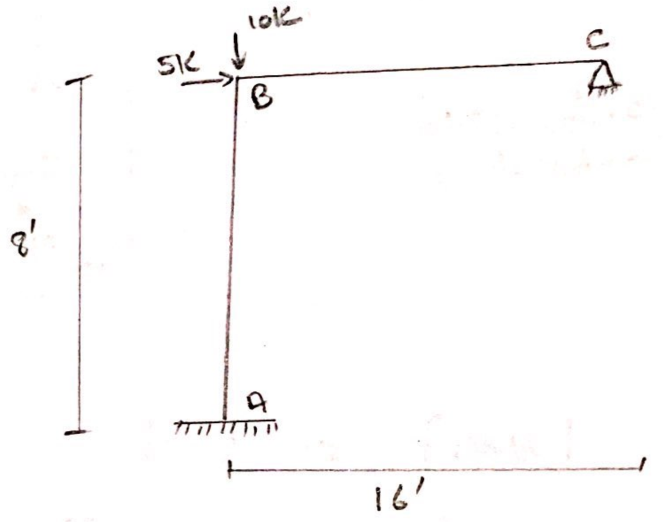
Q2 Differentiate b/w force method and displacement method suggest which is more suitable for structure analysis of matrix approach

	Force Method	Displacement Method
1)	$D_s < D_K$	$D_s > D_K$
2)	Forces are redundant or unknown	Displacement are redundant or unknown
3)	Starts with equilibrium of forces	Starts with compatible deformation
4)	Forces found by compability equations of displacement	Displacement found by equilibrium eqns of forces
5)	No of redundants = D_s	No of reduntants = D_K
6)	Not suitable for computer	Not suitable for Trusses

Stiffness method also known as 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 over flexibility method is that 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.

Globally Displacement based analysis of structure is easy and used more.

Q3 Analyze the rigid-Joint frame shown in Fig by flexibility method. Assume EI is constant for all members



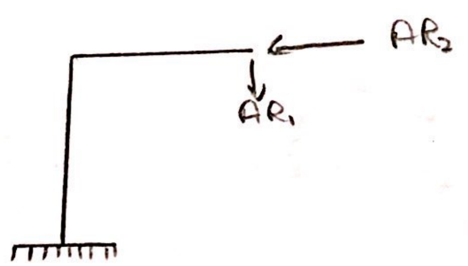
Solution

Total static indeterminacy

$\Rightarrow$ $R - 3 = 5 - 3 = 2^{\circ}$

Step # 1

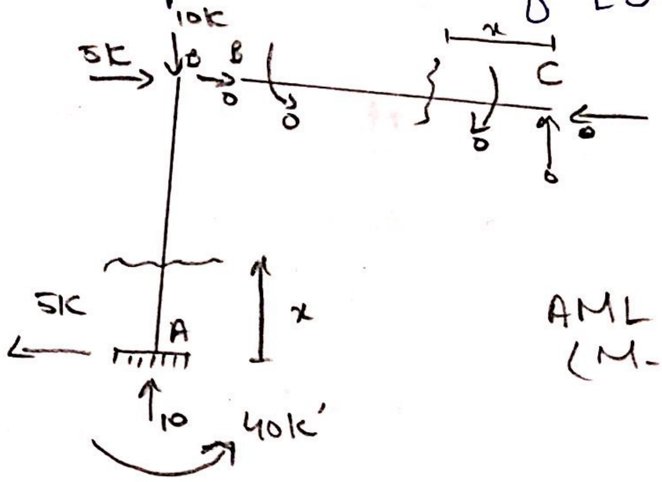
Identify Redundant Actions



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

Step # 2

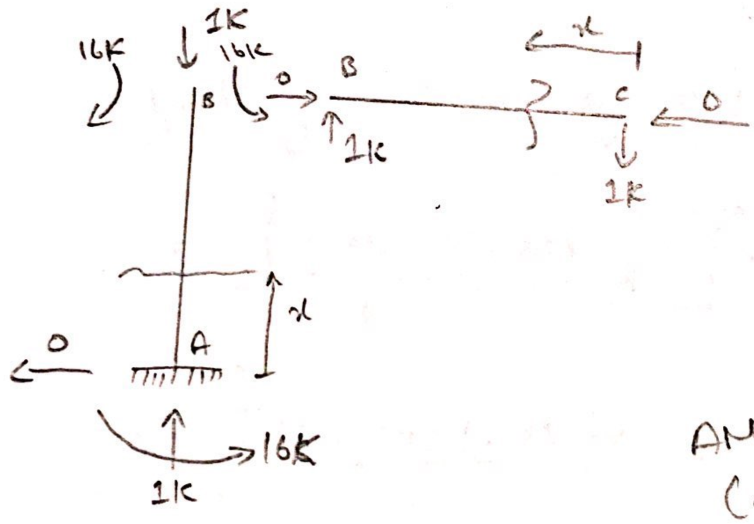
Compute value of [DRL]



AML values
(M-values)

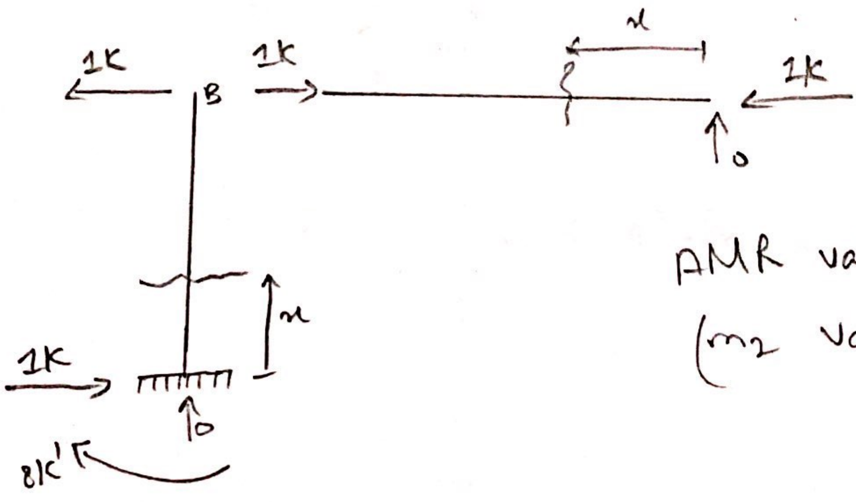
Step # 3 [F] or [AMR]

a



AMR - values
(m_1 values)

b)



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

⇒ For finding values of DRL :-

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

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

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

$$DRL_2 = \int_0^8 \frac{(5x-40)(8-x)\,dx}{EI} + \int_0^{16} \frac{0 \cdot 0}{E(2I)}\,dx$$

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

Now,

Compute Flexibility Matrix :-

$$F_{2\times2} = \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix}$$

$$\Rightarrow \quad F_{11} = \int_0^8 \frac{m_1^2 (AB)}{EI} + \int_0^{16} \frac{m^2 (BC)}{EI}$$

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

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

$$F_{12} = F_{21} = \int_0^8 \frac{m_1(AB) \cdot m_2(AB)}{EI} + \int_0^{16} \frac{m_1(BC) \cdot m_2(BC)}{2EI}$$

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

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

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

$$F_{22} = 170.67$$

As we know

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

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

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

$$= \begin{bmatrix} 2730.67 & -512 \\ -512 & 170.67 \end{bmatrix}^{-1} \times \begin{bmatrix} 0 - 2560 \\ 0 + 853.33 \end{bmatrix}$$

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