STRUCTURE ANALYSIS 2

MID TERM

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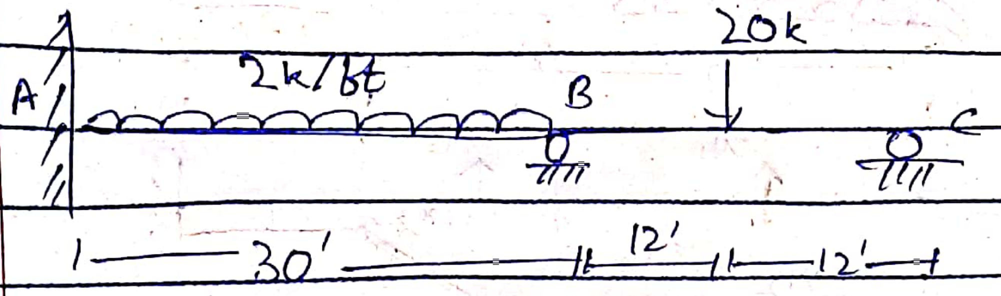
Question #01



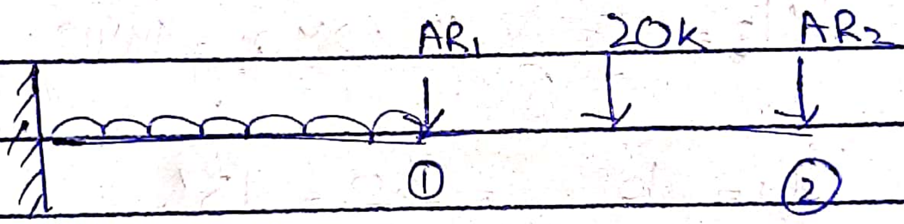
EI = constant

Sol

Structural indeterminacy = 2°

Step #01

Select Redundant Actions

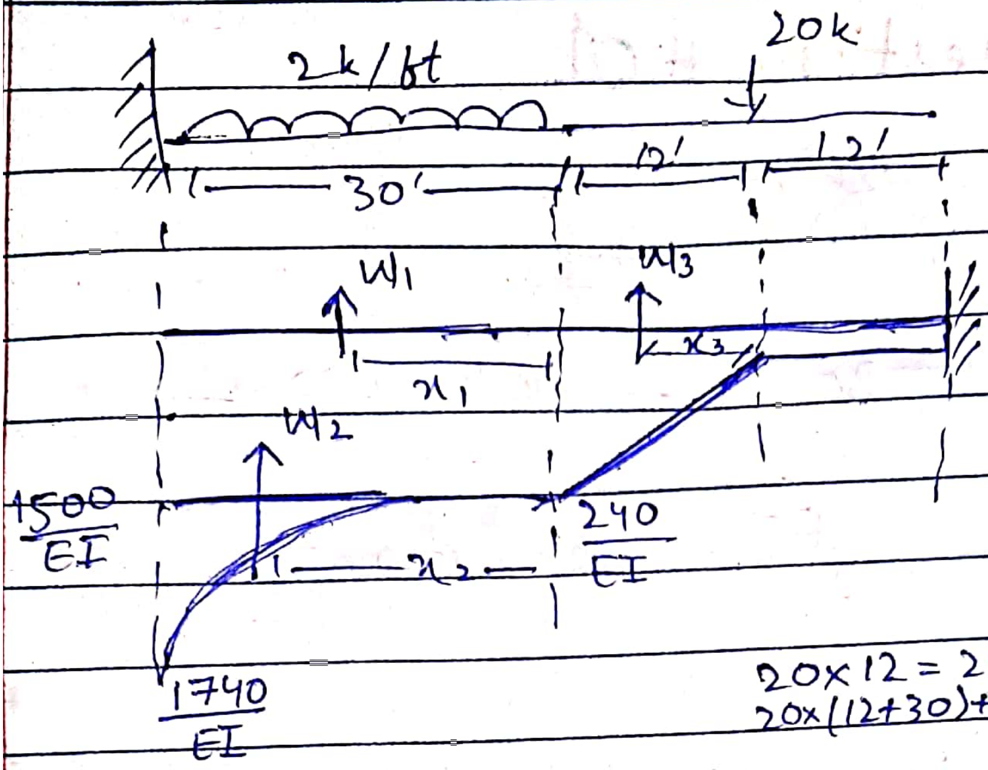


$$\begin{bmatrix} DRS_1 \\ DRS_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad \begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} - \begin{bmatrix} ? \\ ? \end{bmatrix}$$

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

Step #02

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

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

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

Checked By:.................... Parents:.................... Excellent ☐ Good ☐

$DRL_1 = 675000 + 54000$

$$\boxed{DRL_1 = 729000/EI}$$

$DRL_2 = W_1(x_1+24) + W_2(x_2+24)$
$+ W_3(x_3+12)$
$= 45000(15+24) + 2400(22.5+24)$
$+ 1440(8+12)$
$= 1755000 + 111600 + 28800$

$$\boxed{DRL_2 = 1895400/EI}$$

So,

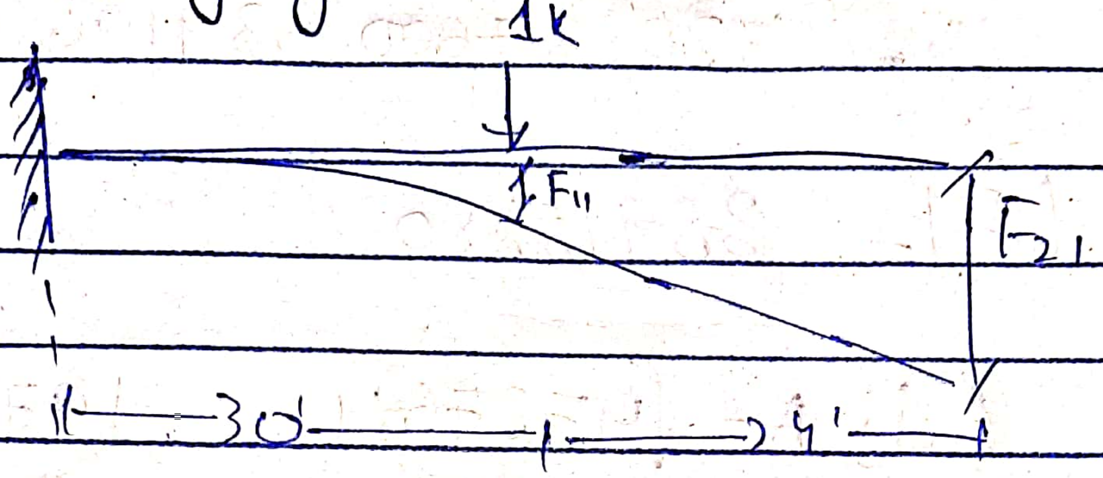
$$DRl = \frac{1}{EI}\begin{bmatrix} 729000 \\ 1895400 \end{bmatrix}$$

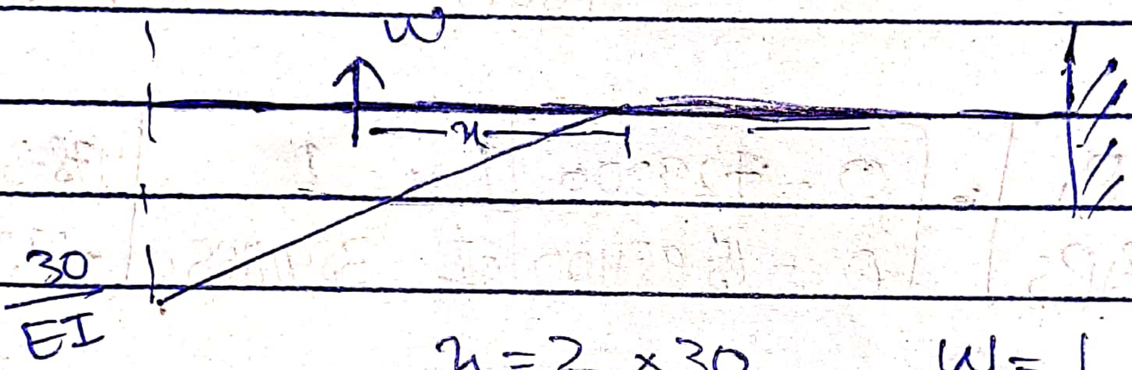
Step#03

Flexibility Matrix

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

a) Applying unit load on AR_1





$$x = \frac{2}{3} \times 30 \qquad w = \frac{1}{2}\left(\frac{30}{EI} \times 30\right)$$

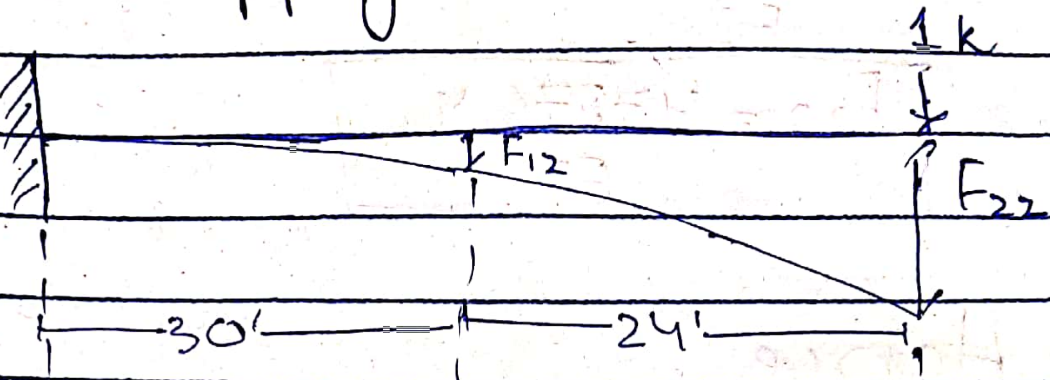
$$x = 20' \qquad w = \frac{450}{EI}$$

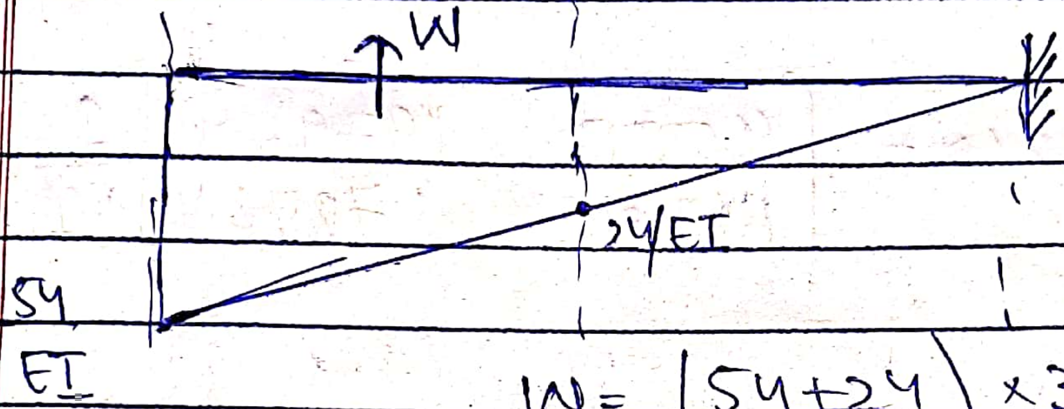
So,

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

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

b) Now apply unit load on AR_2





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

$$= 1170/EI$$

Now the distance

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

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

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

$$\boxed{F_{12} = \frac{19796.4}{EI}}$$

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

$$\boxed{F_{22} = \frac{47876.4}{EI}}$$

Hence

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

Step # 04

Compute the values of AR

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

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

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

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

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

$$|F| = 38918880$$

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

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

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

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

Question # 02

Force Method	Displacement Method
It is also known as flexibility matrix method or compatability method	It is also called as equilibrium method or stiffness matrix method
In force method the unknown are taken as Force or reaction	In displacement method the unknown are take as joint displacements (θ, Δ)
In force method number of reduntants = Ds	In dispacement method number of redundants = Dk
The forces are determined by compatibility equation of displacements	In this method the displacements are determined by equilibrium equation of forces.

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Force Method	Displacement Method
In this method type of indeterminacy is static	In this method type of indeterminacy is kinematic indeterminacy
This method is suitable when $D_s < D_k$	This method is suitable when $D_s > D_k$

Suitable Method For Structure Analysis Of Matrix Approach

- For analysis of structure of matrix approach both the force method or displacement method can be used depends upon situation

→ When the degree of static indeterminacy (Ds) is less than the degree of kinematic indeterminacy (Dk) i.e $Ds < Dk$, then it is suggested to use force method

→ When the degree of static indeterminacy (Ds) is more than kinematic indeterminacy (Dk) i.e $Dk < Ds$ then it is suggeste∂ to use displacement method of analysis.

→ The main advantage of displacement method is it is Primary method used in matrix analysis.

→ Also displacement method is conductire to computer programming, once the analytical model of the structure has been defined no further engineering

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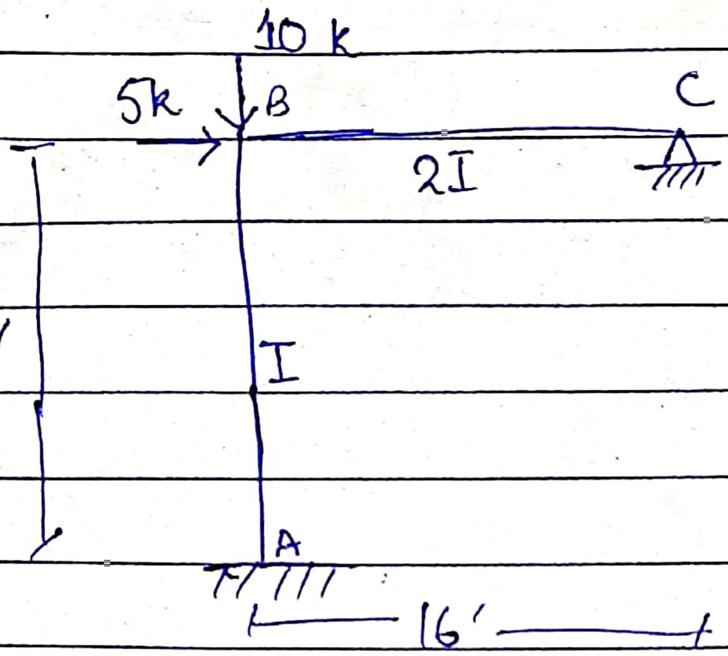
decisions are required in the stiffness method in order to carry out the analysis.
Hence displacement method is suitable for structure analysis of matrix approach.

Question #03



E = constant

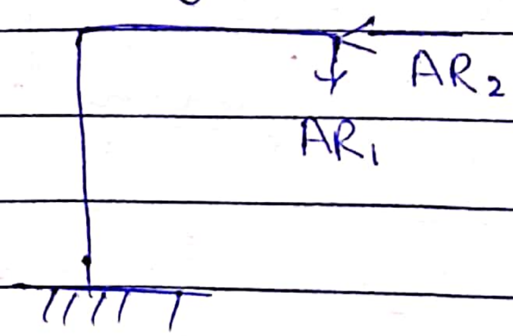
Sol

Total statical indeterminacy

$R - 3 = 5 - 3 = 2°$

Step #01

Identifying Redundant actions



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

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Step # 2

Compute value of [DRL]

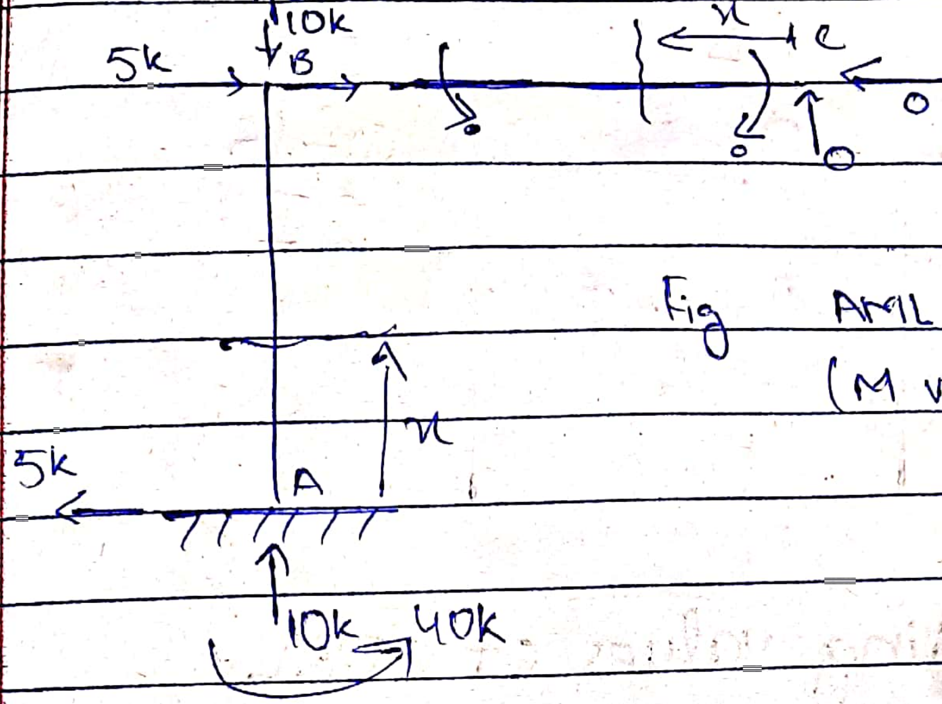

Fig AML value
(M values)

Step # 03 [F] or [AMR]

a)

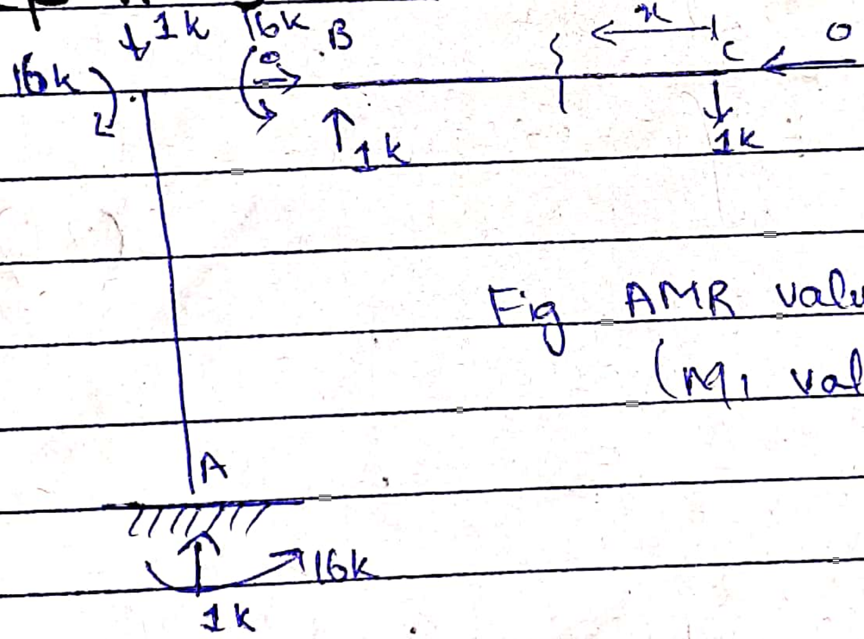

Fig AMR value
(M_1 values)

b)

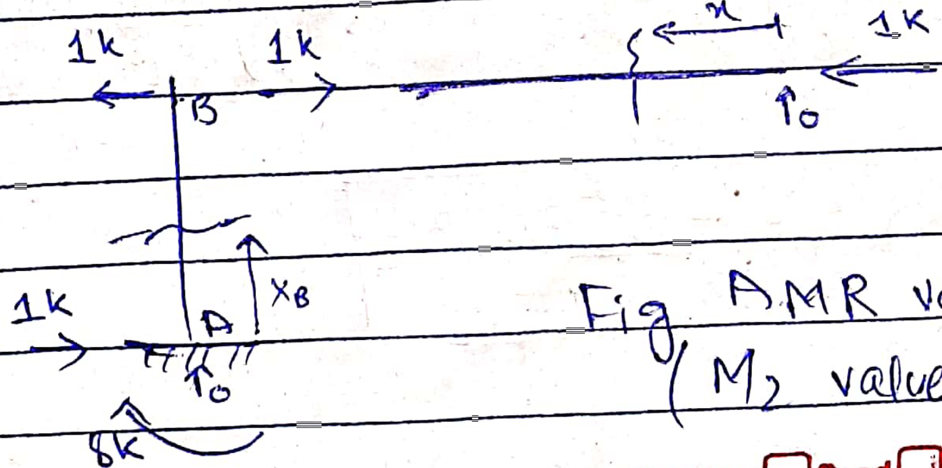

Fig AMR value
(M_2 value)

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

→ Finding values of DRL

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

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

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

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

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

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→ Compute Flexibility Matrix

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

2°

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

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

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

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

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

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

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

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

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

As we know

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

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

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

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

$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} -0.00005 \\ 4.97 \end{bmatrix}$$

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

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