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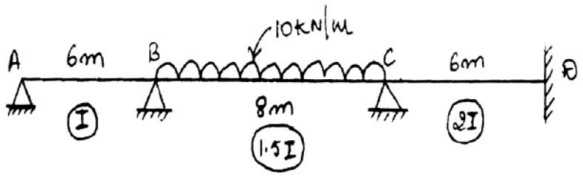
Internal Assessment Test 1 – Nov. 2021

Sub:	Analysis of Indeterminate Structures					Sub Code:	18CV52	Branch:	Civil
Date:	11/11/2021	Duration:	90 min's	Max Marks:		Sem / Sec:	5A		OBE

Answer TWO FULL Questions

1. Analyze the continuous beam shown in fig 1. using the slope deflection method. Sketch BMD and SFD. support B and C settles by 8mm and 5mm respectively, EI= 20000kN/m^2



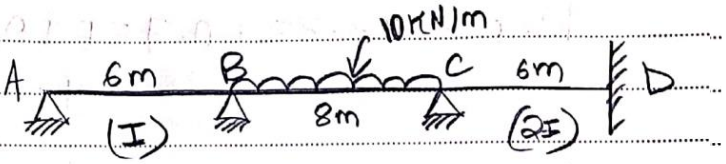
Step 1: Fixed end Moments

$M_{FAB} = 0 KNm$ $\quad M_{FBC} = -53.34\ KNm$

$M_{FBA} = 0\ KNm$ $\quad M_{FCB} = 53.34\ KNm$

$M_{FCD} = 0\ KNm$

$M_{FDC} = 0\ KNm$



Step 2: Slope deflection eqn ; $\delta = 8 \times 10^{-3}$

$$M_{AB} = M_{FAB} + \frac{2EI}{L}\left[2\theta_B + \theta_B - \frac{3\delta}{L}\right]$$

$$= 0 + \frac{2EI}{6}\left[2\theta_A + \theta_B - 3\frac{(8\times10^{-3})}{6}\right]$$

$$M_{AB} = 0.667EI\theta_A + 0.334EI\theta_B - 1.334\times10^{-3}EI \quad \text{— (1)}$$

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left[2\theta_B + \theta_A - \frac{3\delta}{L}\right]$$

$$= 0 + \frac{2EI}{6}\left[2\theta_B + \theta_A - \frac{3(8\times10^{-3})}{6}\right]$$

$$M_{BA} = 0.667EI\theta_B + 0.334EI\theta_A - 1.334\times10^{-3}EI \quad \text{— (2)}$$

for span BC

$$M_{BC} = M_{FBC} + \frac{2EI}{L}\left[2\theta_B + \theta_C - \frac{3\delta}{L}\right]$$

$$= -53.33 + \frac{2E(1.5I)}{8}\left[2\theta_B + \theta_C - 3\frac{(-3\times10^{-3})}{8}\right]$$

$$M_{BC} = -53.33 + 0.75EI\theta_B + 0.375EI\theta_C + 4.21\times10^{-4} \quad \text{— (3)}$$

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$$M_{CB} = M_{FCB} + \frac{2EI}{l}\left[2\theta_C + \theta_B - \frac{3\delta}{l}\right]$$

$$= 53.33 + \frac{2E(1.5I)}{8}\left[2\theta_C + \theta_B - 3\frac{(-3\times10^{-3})}{8}\right]$$

$$M_{CB} = 53.33 + 0.75EI\theta_C + 0.375EI\theta_B + 4.218\times10^{-4} \quad — (4)$$

For span CD

$$M_{CD} = M_{FCD} + \frac{2EI}{l}\left(2\theta_C + \theta_D - \frac{3\delta}{l}\right)$$

$$= 0 + \frac{2E(2I)}{6}\left(2\theta_C + \theta_D^{\,0} - 3\frac{(-5\times10^{-3})}{6}\right)$$

$$M_{CD} = 1.334EI\theta_C + 1.667\times10^{-3}EI \quad — (5)$$

$$M_{DC} = M_{FDC} + \frac{2EI}{l}\left(2\theta_D^{\,0} + \theta_C - \frac{3\delta}{l}\right)$$

$$= 0 + \frac{2E(2I)}{6}\left[\theta_C - 3\frac{(-5\times10^{-3})}{6}\right]$$

$$M_{DC} = 0.667EI\theta_C + 1.667\times10^{-3}EI \quad — (6)$$

Step 3 : Joint Equilibrium Condition

@ Joint 'B', $M_{BA} + M_{BC} = 0$

$$0.667EI\theta_B + 0.334EI\theta_A - 1.334\times10^{-3}EI$$
$$-53.33 + 0.75EI\theta_B + 0.375EI\theta_C$$
$$+ 4.218\times10^{-4}EI = 0$$

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$-71.574 + 0.334\,EI\theta_A + 1.417\,EI\theta_B + 0.375\,EI\theta_C$ — (7)

@ Joint "C", $M_{CB} + M_{CD} = 0$

$53.33 + 0.75\,EI\theta_C + 0.375\,EI\theta_B + 4.218\times10^{-4} +$
$1.334\,EI\theta_C + 1.667\times10^{-3}\,EI = 0$

$95.09 + 2.084\,EI\theta_C + 0.375\,EI\theta_B$ — (8)

@ Joint "D", $M_{DC} = 0$

$0.667\,EI\theta_C + 1.667\times10^{-3}\,EI = 0$

$0.667\,EI\theta_C + 33.34$ — (9)

$\theta_A = \dfrac{167.7}{EI}$ $\theta_B = \dfrac{24.21}{EI}$ $\theta_C = -\dfrac{49.98}{EI}$

Step 4 : Final Moments

$M_{AB} = 93.26$ KN.m
$M_{BA} = 45.47$ KN.m
$M_{BC} = -45.47$ KNm
$M_{CB} = 33.35$ KNm

$M_{CD} = -33.36$ KNm
$M_{DC} = 0$ KNm

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Step 5 : SFD & BMD

$\Sigma F_y = 0$

$V_A + V_B + V_C + V_D = 80\ KN$

$\Sigma M_B = 0$ (LHS)

$V_A \times 6 + 93.266 + 45.47$

$V_A = -23.12\ KN$

$\Sigma M_C = 0$ (RHS)

$-V_D \times 6 - 33.35 = 0$

$V_D = 5.55\ KN$

$\Sigma M_C = 0$ (LHS)

$V_A \times 14 - 10 \times 8 \times 4 + 93.262 + 33.35 + V_B \times 8$

$V_B = 64.632\ KN$

$V_C = 32.935\ KN$

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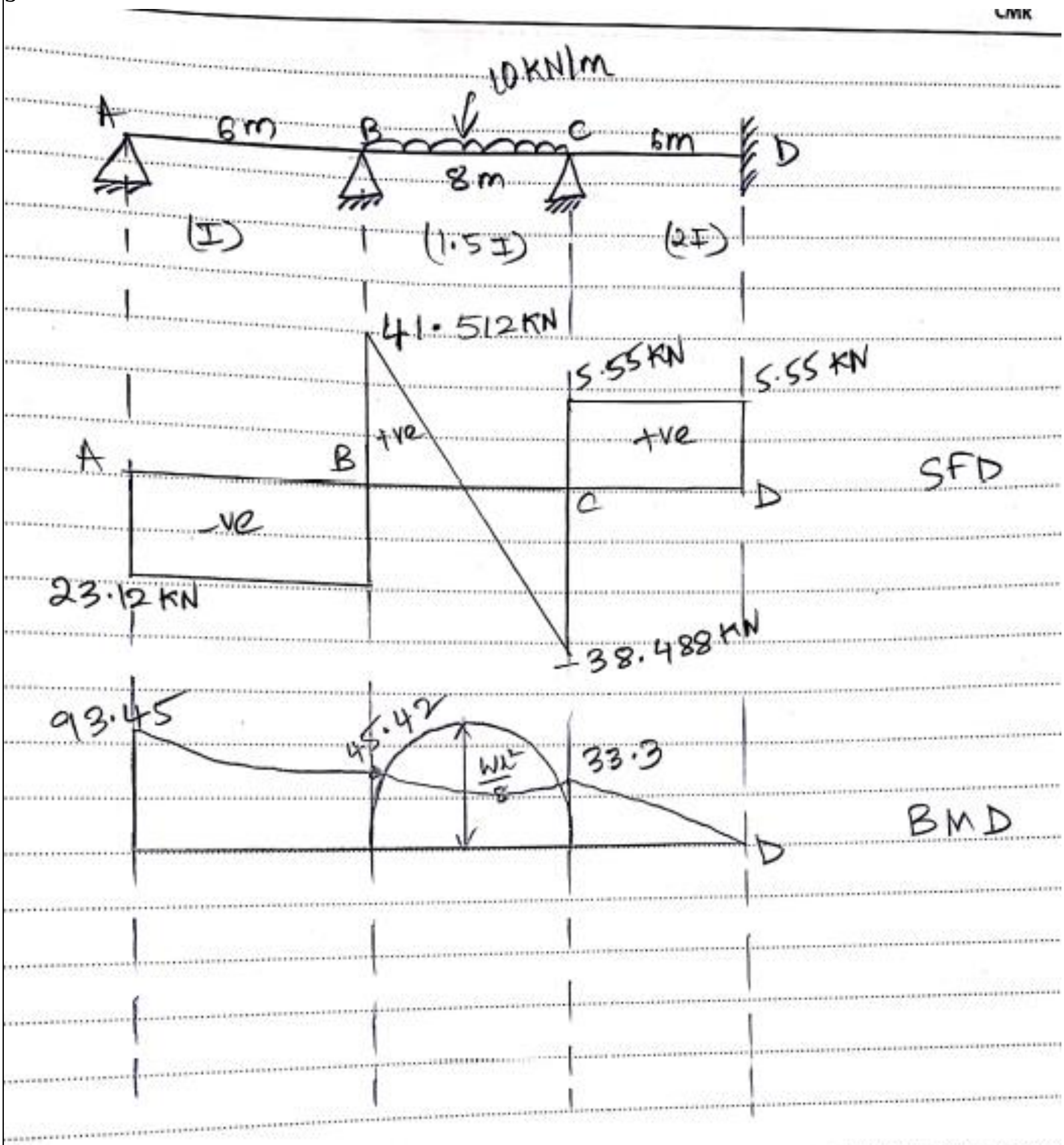
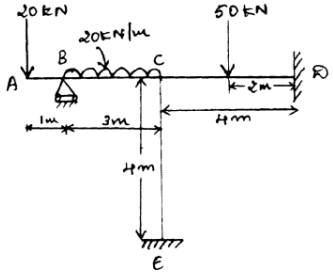


2.	Analyze the Portal frame show in fig. using slope deflection method. Draw BMD and SFD 

Step 2: Slope deflection equation

For span BC, $l = 3m$

$$M_{BC} = M_{FBC} + \frac{2EI}{l}\left(2\theta_B + \theta_C - \frac{3\delta}{l}\right)^{0}$$

$$= -15 + \frac{2EI}{3}\left[2\theta_B + \theta_C\right)$$

$$M_{BC} = -15 + 0.667EI\theta_C + 1.33EI\theta_B \quad -(1)$$

$$M_{CB} = M_{FCB} + \frac{2EI}{l}\left(2\theta_C + \theta_B - \frac{3\delta}{l}\right)^{0}$$

$$= 15 + \frac{2EI}{3}\left[2\theta_C + \theta_B\right]$$

$$M_{CB} = 15 + 1.33\theta_C EI + 0.667EI\theta_B \quad -(2)$$

For span CD, $l = 4m$

$$M_{CD} = M_{FCD} + \frac{2EI}{l}\left(2\theta_C + \theta_D - \frac{3\delta}{l}\right)^{0}$$

$$= -25 + \frac{2EI}{4}\left(2\theta_C\right) \qquad [\theta_D = 0]$$

$$M_{CD} = -25 + \theta_C EI \quad -(3)$$

$$M_{DC} = M_{FDC} + \frac{2EI}{l}\left(2\theta_D + \theta_C - \frac{3\delta}{l}\right)^{0}$$

$$= 25 + \frac{2EI}{4}\left(\theta_C\right)$$

$$M_{DC} = 25 + 0.5EI\theta_C \quad -(4)$$

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For span CE, $l = 4m$

$$M_{CE} = M_{FCE} + \frac{2EI}{l}\left(2\theta_C + \theta_E - \frac{3\delta}{l}\right) \qquad [\theta_E = 0]$$

$$M_{CE} = 0 + EI\theta_C \quad -(5)$$

$$M_{EC} = M_{FEC} + \frac{2EI}{l}\left(2\theta_E + \theta_C - \frac{3\delta}{l}\right)$$

$$= 0 + \frac{2EI}{4}(\theta_C)$$

$$M_{EC} = 0.5EI\theta_C \quad -(6)$$

ii) Step 3: Joint Equilibrium Condition

$M_{BA} + M_{BC} = 0$ @ Joint B

$$20 + (-15) + 0.667EI\theta_C + 1.33EI\theta_B = 0$$

$$1.33EI\theta_B + 0.667EI\theta_C = -5 \quad -(7)$$

$M_{CB} + M_{CD} + M_{CE}$ @ Joint C

$$15 + 1.33EI\theta_C + 0.667EI\theta_B - 25 + EI\theta_C + EI\theta_C = 0$$

$$0.667EI\theta_B + 3.33EI\theta_C = 10 \quad -(8)$$

∴ By solving eq (7) & (8), we get

$$\theta_B = \frac{-5.833}{EI}, \quad \theta_C = \frac{4.167}{EI}$$

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Step 4 : Final Moments

Sub θ_B, θ_C in eq ①, ②, ③, ④, ⑤, ⑥

We get, $M_{BC} = -20\,KNm$

$M_{CB} = 16.66\,KNm$

$M_{CD} = -20.80\,KNm$

$M_{DC} = 27.08\,KNm$

$M_{CE} = 4.16\,KNm$

$M_{EC} = 2.08\,KNm$

Step 5 : SFD & BMD

$V_A + V_B + V_C + V_D = 20 + 20 \times 3 + 50$

@ B $\Sigma M_B = 0$

$V_A \times 1 - 20 \times 1 = 0$

$V_A = 20$

ΣM_C @ RHS

$-V_D \times 4 + 50 \times 2 + 27.08 - 20.8$

$V_D = 26.57$

ΣM_C @ LHS

$V_A \times 4 - 20 \times 4 + V_B \times 3 - 20 \times 3 \times 1.5 - 20 + 16.6$

$V_B = 23.33$

$V_C = 60.09$