

QUESTION WITH ANSWERS**DEPARTMENT : CIVIL****SEMESTER: IV****SUB.CODE/ NAME: CE 8402 / Strength of Materials -II****UNIT– 2 INDETERMINATE BEAMS****1. Define statically indeterminate beams.**

If the numbers of reaction components are more than the conditions equations, the structure is defined as statically indeterminate beams.

$$E = R - r$$

E = Degree of external redundancy

R = Total number of reaction components

r = Total number of condition equations available.

A continuous beam is a typical example of externally indeterminate structure.

2. State the degree of indeterminacy in propped cantilever.

For a general loading, the total reaction components (R) are equal to $(3+2) = 5$, While the total number of condition equations (r) are equal to 3. The beam is statically indeterminate, externally to second degree. For vertical loading, the beam is statically determinate to single degree.

$$\begin{aligned} E &= R - r \\ &= 5 - 3 = 2 \end{aligned}$$

3. State the degree of indeterminacy in a fixed beam.

For a general system of loading, a fixed beam is statically indeterminate to third degree. For vertical loading, a fixed beam is statically indeterminate to second degree.

$$E = R - r$$

For general system of loading:

$$R = 3 + 3 \text{ and } r = 3$$

$$E = 6 - 3 = 3$$

For vertical loading:

$$R = 2 + 2 \text{ and } r = 2$$

$$E = 4 - 2 = 2$$

4. State the degree of indeterminacy in the given beam.

The beam is statically indeterminate to third degree of general system of loading.

$$R = 3+1+1+1 = 6$$

$$E = R-r$$

$$= 6-3 = 3$$

5. State the degree of indeterminacy in the given beam.

The beam is statically determinate. The total numbers of condition equations are equal to $3+2 = 5$. Since, there is a link at B. The two additional condition equations are at link.

$$E = R-r$$

$$= 2+1+2-5$$

$$= 5-5$$

$$E = 0$$

6. State the methods available for analyzing statically indeterminate structures.

- i. Compatibility method
- ii. Equilibrium method

7. Write the expression fixed end moments and deflection for a fixed beam carrying point load at centre.

$$M_A = M_B = \frac{WL}{8}$$

$$y_{\max} = \frac{WL^3}{192EI}$$

8. Write the expression fixed end moments and deflection for a fixed beam carrying eccentric point load.

$$M_A = \frac{Wab^2}{L^2}$$

$$M_B = \frac{Wa^2b}{L^2}$$

$$y_{\max} = \frac{Wa^3b^3}{3EIL^3} \text{ (under the load)}$$

9. Write the expression fixed end moments for a fixed due to sinking of support.

$$M_A = M_B = \frac{6EI\delta}{L^2}$$

10. State the Theorem of three moments.

(AUC Nov/Dec 2013) (AUC Apr/May 2011)

Theorem of three moments:

It states that "If BC and CD are only two consecutive span of a continuous beam subjected to an external loading, then the moments M_B , M_C and M_D at the supports B, C and D are given by

$$M_B L_1 + 2M_C (L_1 + L_2) = M_D L_2 = \frac{6a_1 \bar{x}_1}{L_1} + \frac{6a_2 \bar{x}_2}{L_2}$$

Where

M_B = Bending Moment at B due to external loading

M_C = Bending Moment at C due to external loading

M_D = Bending Moment at D due to external loading

L_1 = length of span AB

L_2 = length of span BC

a_1 = area of B.M.D due to vertical loads on span BC

a_2 = area of B.M.D due to vertical loads on span CD

\bar{x}_1 = Distance of C.G of the B.M.D due to vertical loads on BC from B

\bar{x}_2 = Distance of C.G of the B.M.D due to vertical loads on CD from D.

- 11. What are the fixed end moments for a fixed beam of length 'L' subjected to a concentrated load 'w' at a distance 'a' from left end?**

(AUC Nov/Dec – 2004)

(AUC Apr/May 2010)

Fixed End Moment:

$$M_A = \frac{Wab^2}{L^2}$$

$$M_B = \frac{Wab^2}{L^2}$$

- 12. Explain the effect of settlement of supports in a continuous beam. (Nov/Dec 2003)**

Due to the settlement of supports in a continuous beam, the bending stresses will alters appreciably. The maximum bending moment in case of continuous beam is less when compare to the simply supported beam.

- 13. What are the advantages of Continuous beams over Simply Supported beams?**

- (i) The maximum bending moment in case of a continuous beam is much less than in case of a simply supported beam of same span carrying same loads.
- (ii) In case of a continuous beam, the average B.M is lesser and hence lighter materials of construction can be used it resist the bending moment.

- 14. A fixed beam of length 5m carries a uniformly distributed load of 9 kN/m run over the entire span. If $I = 4.5 \times 10^{-4} \text{ m}^4$ and $E = 1 \times 10^7 \text{ kN/m}^2$, find the fixing moments at the ends and deflection at the centre.**

Solution:

Given:

$$L = 5\text{m}$$

$$W = 9 \text{ kN/m}^2, \quad I = 4.5 \times 10^{-4} \text{ m}^4 \text{ and } E = 1 \times 10^7 \text{ kN/m}^2$$

- (i) The fixed end moment for the beam carrying udl:

$$M_A = M_B = \frac{WL^2}{12}$$

$$= \frac{9 \times (5)^2}{12} = 18.75 \text{ KNm}$$

(ii) The deflection at the centre due to udl:

$$y_c = \frac{WL^4}{384 EI}$$

$$y_c = \frac{9 \times (5)^4}{384 \times 1 \times 10^7 \times 4.5 \times 10^{-4}} = 3.254 \text{ mm}$$

Deflection is in downward direction.

15. A fixed beam AB, 6m long is carrying a point load of 40 kN at its center. The M.O.I of the beam is $78 \times 10^6 \text{ mm}^4$ and value of E for beam material is $2.1 \times 10^5 \text{ N/mm}^2$. Determine (i) Fixed end moments at A and B.

Solution:

Fixed end moments:

$$M_A = M_B = \frac{WL}{8}$$

$$M_A = M_B = \frac{50 \times 6}{8} = 37.5 \text{ kNm}$$

16. A fixed beam AB of length 3m is having M.O.I $= 3 \times 10^6 \text{ mm}^4$ and value of E for beam material is $2 \times 10^5 \text{ N/mm}^2$. The support B sinks down by 3mm. Determine (i) fixed end moments at A and B.

Solution:

Given:

$$L = 3\text{m} = 3000\text{mm}$$

$$I = 3 \times 10^6 \text{ mm}^4$$

$$E = 2 \times 10^5 \text{ N/mm}^2$$

$$\delta = 3\text{mm}$$

$$M_A = M_B = \frac{6EI\delta}{L^2}$$

$$= \frac{6 \times 2 \times 10^5 \times 3 \times 10^6 \times 3}{(3000)^2}$$

$$= 12 \times 10^5 \text{ N mm} = 12 \text{ kN m.}$$

17. A fixed beam AB, 3m long is carrying a point load of 45 kN at a distance of 2m from A. If the flexural rigidity (i.e) EI of the beam is $1 \times 10^4 \text{ kNm}^2$. Determine (i) Deflection under the Load.

Solution:

$$L = 3\text{m}$$

$$W = 45 \text{ Kn}$$

$$EI = 1 \times 10^4 \text{ kNm}^2$$

Deflection under the load:

In fixed beam, deflection under the load due to eccentric load

$$y_c = \frac{Wa^3b^3}{3EIL^3}$$

$$y_c = \frac{45x(2)^3x(1)^3}{3 \times 1 \times 10^4 x(3)^2}$$

$$y_c = 0.000444 \text{ m}$$

$$y_c = 0.444 \text{ mm}$$

The deflection is in downward direction.

18. A fixed beam of 5m span carries a gradually varying load from zero at end A to 10 kN/m at end B. Find the fixing moment and reaction at the fixed ends.

Solution:

Given:

$$L = 5\text{m}$$

$$W = 10 \text{ kN/m}$$

(i) Fixing Moment:

$$M_A = \frac{WL^2}{30} \text{ and } M_B = \frac{WL^2}{20}$$

$$M_A = \frac{10(5)^2}{30} = \frac{250}{30} = 8.33 \text{ kNm}$$

$$M_B = \frac{10(5)^2}{20} = \frac{250}{20} = 12.5 \text{ kNm}$$

(ii) Reaction at support:

$$R_A = \frac{3WL}{20} \text{ and } R_B = \frac{7WL}{20}$$

$$R_A = \frac{3 \times 10 \times 5}{20} = \frac{150}{20} = 7.5 \text{ kN}$$

$$R_B = \frac{7 \times 10 \times 5}{20} = \frac{350}{20} = 17.5 \text{ kN}$$

19. A cantilever beam AB of span 6m is fixed at A and propped at B. The beam carries a udl of 2kN/m over its whole length. Find the reaction at propped end. (May /June2012)

Solution:

Given:

$$L=6\text{m}, \quad w = 2 \text{ kN/m}$$

Downward deflection at B due to the udl neglecting prop reaction P,

$$y_B = \frac{wl^4}{8EI}$$

Upward deflection at B due to the prop reaction P at B neglecting the udl,

$$y_B = \frac{Pl^3}{3EI}$$

Upward deflection = Downward deflection

$$\frac{Pl^3}{3EI} = \frac{wl^4}{8EI}$$

$$P = 3WL/8 = 3 \times 2 \times 6/8 = 4.5 \text{ Kn}$$

19. Give the procedure for analyzing the continuous beams with fixed ends using three moment equations?

The three moment equations, for the fixed end of the beam, can be modified by imagining a span of length l and moment of inertia, beyond the support the and applying the theorem of three moments as usual.

20. Define Flexural Rigidity of Beams.

The product of young's modulus (E) and moment of inertia (I) is called Flexural Rigidity (EI) of Beams. The unit is N mm².

21. What is a fixed beam?

(AUC Apr/May 2011)

A beam whose both ends are fixed is known as a fixed beam. Fixed beam is also called as built-in or encaster beam. Incase of fixed beam both its ends are rigidly fixed and the slope and deflection at the fixed ends are zero.

23. What are the advantages of fixed beams?

- (i) For the same loading, the maximum deflection of a fixed beam is less than that of a simply supported beam.
- (ii) For the same loading, the fixed beam is subjected to lesser maximum bending moment.
- (iii) The slope at both ends of a fixed beam is zero.
- (iv) The beam is more stable and stronger.

24. What are the disadvantages of a fixed beam?

- (i) Large stresses are set up by temperature changes.
- (ii) Special care has to be taken in aligning supports accurately at the same level.
- (iii) Large stresses are set if a little sinking of one support takes place.
- (iv) Frequent fluctuations in loading render the degree of fixity at the ends very uncertain.

25. Define: Continuous beam.

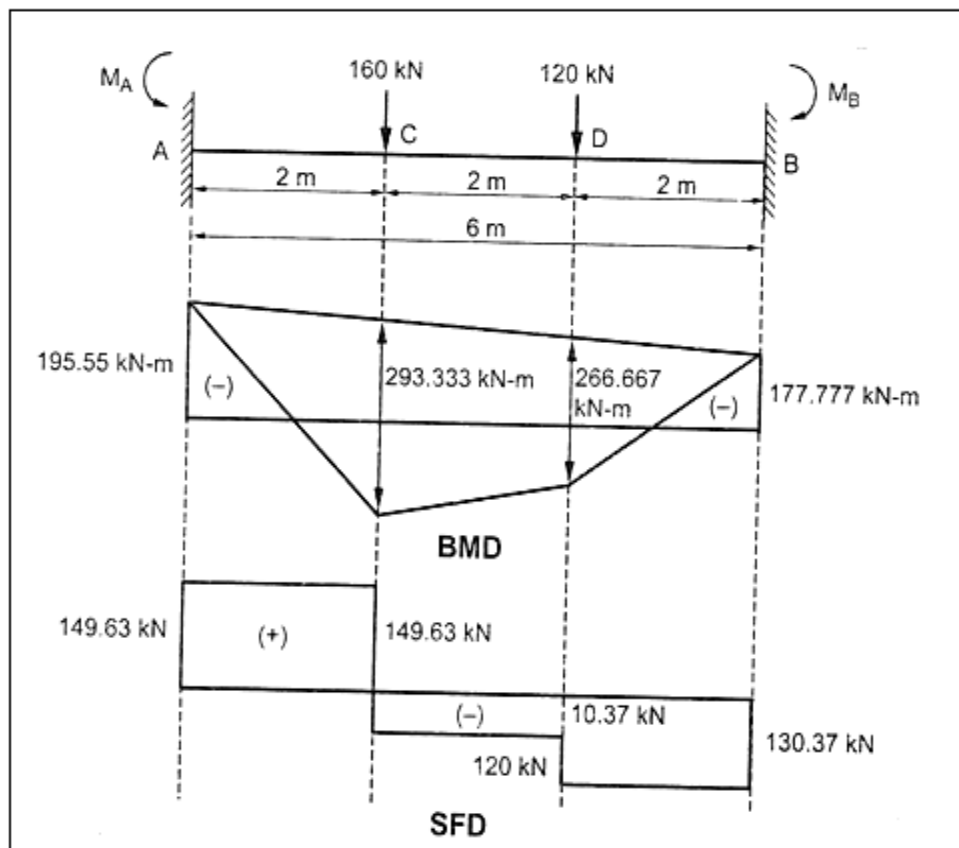
A Continuous beam is one, which is supported on more than two supports. For usual loading on the beam hogging (- ive) moments causing convexity upwards at the supports and sagging (+ ve) moments causing concavity upwards occur at mid span.

26. What is mean by prop? .**(AUC Nov/Dec 2012)**

When a beam or cantilever carries some load , maximum deflection occurs at the free end . the deflection can be reduced by providing vertical support at these points or at any suitable points.

(PART B 16 Marks)

1. A fixed beam AB of length 6m carries point load of 160 kN and 120 kN at a distance of 2m and 4m from the left end A. Find the fixed end moments and the reactions at the supports. Draw B.M and S.F diagrams.
(AUC Apr/May 2008)(AUC Nov/Dec2006)

Solution:**Given:**

$L = 6\text{m}$
 Load at C, $W_C = 160\text{ kN}$
 Load at D, $W_C = 120\text{ kN}$
 Distance AC = 2m
 Distance AD = 4m

First calculate the fixed end moments due to loads at C and D separately and then add up the moments.

Fixed End Moments:

For the load at C, a=2m and b=4m

$$M_{A1} = \frac{W_c ab^2}{L^2}$$

$$M_{A1} = \frac{160 \times 2 \times (4)^2}{(6)^2} = 142.22 \text{ kNm}$$

$$M_{B1} = \frac{W_c a^2 b}{L^2}$$

$$M_{B1} = \frac{160 \times 2^2 \times (4)}{(6)^2} = 71.11 \text{ kNm}$$

For the load at D, a = 4m and b = 2m

$$M_{A2} = \frac{W_D a b^2}{L^2}$$

$$M_{A2} = \frac{120 \times 2^2 \times (4)}{(6)^2} = 53.33 \text{ kNm}$$

$$M_{B2} = \frac{W_D a^2 b}{L^2}$$

$$M_{B2} = \frac{120 \times 2 \times (4)^2}{(6)^2} = 106.66 \text{ kNm}$$

Total fixing moment at A,

$$\begin{aligned} M_A &= M_{A1} + M_{A2} \\ &= 142.22 + 53.33 \\ M_A &= 195.55 \text{ kNm} \end{aligned}$$

Total fixing moment at B,

$$\begin{aligned} M_B &= M_{B1} + M_{B2} \\ &= 71.11 + 106.66 \\ &= 177.77 \text{ kN m} \end{aligned}$$

B.M diagram due to vertical loads:

Consider the beam AB as simply supported. Let R_A^* and R_B^* are the reactions at A and B due to simply supported beam. Taking moments about A, we get

$$R_B^* \times 6 = 160 \times 2 + 120 \times 4$$

$$R_B^* = \frac{800}{6} = 133.33 \text{ kN}$$

$$R_A^* = \text{Total load} - R_B^* = (160 + 120) - 133.33 = 146.67 \text{ kN}$$

$$\text{B.M at A} = 0$$

$$\text{B.M at C} = R_A^* \times 2 = 146.67 \times 2 = 293.34 \text{ kN m}$$

$$\text{B.M at D} = 133.33 \times 2 = 266.66 \text{ kN m}$$

$$\text{B.M at B} = 0$$

S.F Diagram:

Let R_A = Resultant reaction at A due to fixed end moments and vertical loads

R_B = Resultant reaction at B

Equating the clockwise moments and anti-clockwise moments about A,

$$R_B \times 6 + M_A = 160 \times 2 + 120 \times 4 + M_B$$

$$R_B = 130.37 \text{ kN}$$

$$R_A = \text{total load} - R_B = 149.63 \text{ kN}$$

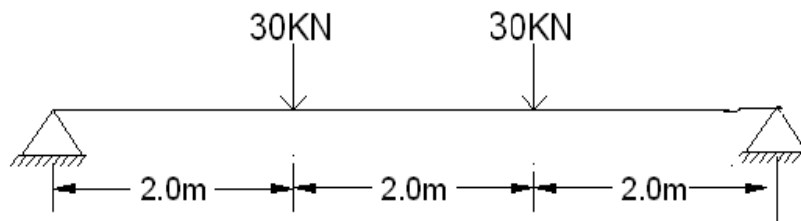
$$\text{S.F at A} = R_A = 149.63 \text{ kN}$$

$$\text{S.F at C} = 149.63 - 160 = -10.37 \text{ kN}$$

$$\text{S.F at D} = -10.37 - 120 = -130.37 \text{ kN}$$

$$\text{S.F at B} = 130.37 \text{ kN}$$

2. A fixed beam AB of length 6m carries two point loads of 30 kN each at a distance of 2m from the both ends. Determine the fixed end moments.

**Sloution:**

Given:

Length $L = 6\text{m}$

Point load at C = $W_1 = 30 \text{ kN}$

Point load at D = $W_2 = 30 \text{ kN}$

Fixed end moments:

M_A = Fixing moment due to load at C + Fixing moment due to load at D

$$\begin{aligned} &= \frac{W_1 a_1 b_1^2}{L^2} + \frac{W_2 a_2 b_2^2}{L^2} \\ &= \frac{30 \times 2 \times 4^2}{6^2} + \frac{30 \times 4 \times 2^2}{6^2} = 40 \text{ kN m} \end{aligned}$$

Since the beam is symmetrical, $M_A = M_B = 40 \text{ kNm}$

Integrating, we get

$$EI \frac{dy}{dx} = R_A \frac{x^2}{2} - M_A x - 2 \frac{x^3}{3} + C_1 + \frac{2(x-3)^3}{3} \quad \text{----- (1)}$$

When $x=0$, $\frac{dy}{dx}=0$.

Substituting this value in the above equation up to dotted line,

$$C_1 = 0$$

Therefore equation (1) becomes

$$EI \frac{dy}{dx} = R_A \frac{x^2}{2} - M_A x - 2 \frac{x^3}{3} + \frac{2(x-3)^3}{3}$$

Integrating we get

$$EI y = R_A \frac{x^3}{6} - \frac{M_A x^2}{2} - \frac{2x^4}{12} + C_2 + \frac{2(x-3)^4}{12}$$

When $x = 0$, $y = 0$

By substituting these boundary conditions upto the dotted line,

$$C_2 = 0$$

$$EI y = \frac{R_A x^3}{6} - \frac{M_A x^2}{2} - \frac{x^4}{6} + \frac{1(x-3)^4}{6} \quad \text{----- (ii)}$$

By subs $x=6$ & $y = 0$ in equation (ii)

$$0 = \frac{R_A 6^3}{6} - \frac{M_A 6^2}{2} - \frac{6^4}{6} + \frac{1(6-3)^4}{6}$$

$$= 36R_A - 18M_A - 216 + 13.5$$

$$18R_A - 9M_A = 101.25 \quad \text{----- (iii)}$$

At $x=6$, $\frac{dy}{dx} = 0$ in equation (i)

$$0 = R_A x \frac{6^2}{2} - M_A x 6 - \frac{2}{3} x 6^3 + \frac{2}{3} (6-3)^3$$

$$18R_A - M_A x 6 - 144 + 18 = 0$$

$$18R_A - 6M_A = 126$$

By solving (iii) & (iv)

$$M_A = 8.25 \text{ kNm}$$

By substituting M_A in (iv)

$$126 = 18 R_A - 6 (8.25)$$

$$R_A = 9.75 \text{ kN}$$

$$R_B = \text{Total load} - R_A$$

$$R_B = 2.25 \text{ kN}$$

By equating the clockwise moments and anticlockwise moments about B

$$M_B + R_A \times 6 = M_A + 4 \times 3 \quad (4.5)$$

$$M_B = 3.75 \text{ kNm}$$

Result:

$$M_A = 8.25 \text{ kNm}$$

$$M_B = 3.75 \text{ kNm}$$

$$R_A = 9.75 \text{ kN}$$

$$R_B = 2.25 \text{ kN}$$

3. A cantilever AB of span 6m is fixed at the end and proposal at the end B . it carries a point load of 50kN at mid span . level of the prop is the same as that of the fixed end .

- (i) Determine The Reaction At The Prop.
- (ii) Draw SFD AND BMD.

Solution:

Let P = Reaction at the rigid prop

To find the reaction P at the prop, the downward deflection due to load 50 kN at the point of prop should be equal to the upward deflection due to prop reaction at B.

Now we know that downward deflection at point B due to load 50 kN.

$$\begin{aligned} \frac{W \left(\frac{l}{2} \right)^3}{3 E I} + \left[\frac{W \left(\frac{l}{2} \right)^2}{2 E I} \times \frac{l}{2} \right] &= \frac{5 W l^3}{48 E I} \\ &= \frac{5 \times 50 \times 6^3}{48 E I} \quad \dots (1) \end{aligned}$$

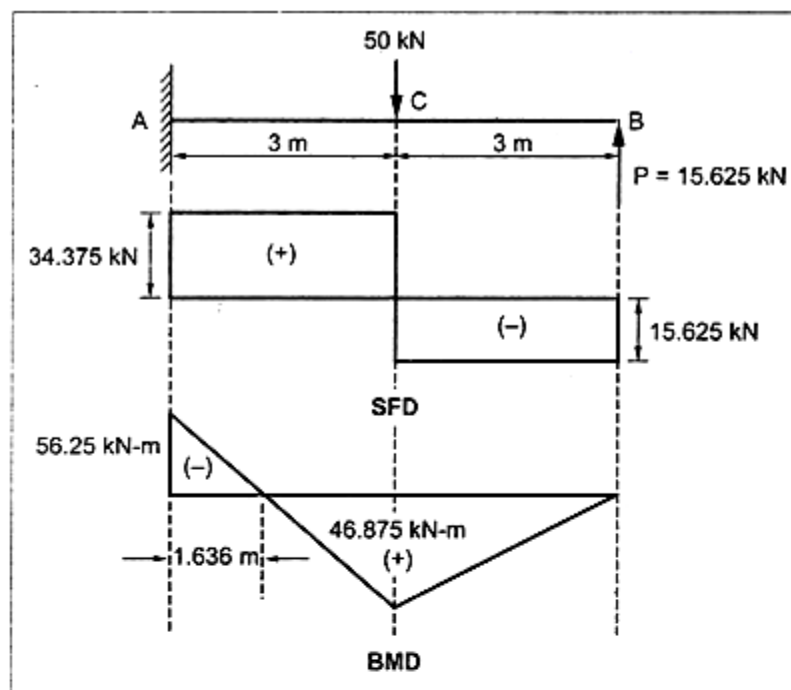


Fig. 2.14.

The upward deflection at the point B due to prop reaction, P alone

$$= \frac{P l^3}{3 E I} = \frac{P \times 6^3}{3 E I} \quad \dots (2)$$

Equating the above two equations,

$$\frac{5 \times 50 \times 6^3}{48 E I} = \frac{P \times 6^3}{3 E I}$$

$$\text{i.e., } 48 P = 3 \times 5 \times 50$$

$$\therefore P = \frac{3 \times 5 \times 50}{48}$$

$$= \frac{250}{16} = 15.625 \text{ kN}$$

(i) **SFD:** SF at B = - 15.625 kN (minus sign due to right upwards)

The S.F. will remain constant between B and C and equal to - 15.625 kN.

$$\therefore \text{SF at C} = - 15.625 + 50 = + 34.315 \text{ kN}$$

The SF will remain + 34.375 kN between C and A.

(ii) **BMD:** B.M. at B = 0

$$\text{B.M. at C} = 15.625 \times 3 = 46.875 \text{ kN-m}$$

$$\begin{aligned} \text{B.M. at A} &= (15.625 \times 6) - (50 \times 3) \\ &= 93.750 - 150 = -56.25 \text{ kN-m} \end{aligned}$$

At the B.M. is changing sign between C and A, there will be a point of contraflexure between C and A. To find its location, equate the B.M. between A and C to zero.

The B.M. at any section between C and A at a distance 'x' from B,

$$15.625x - 50(x - 3) \text{ i.e., } 15.625x - 50x + 150$$

$$\text{Equating zero, } 15.625x - 50x + 150 = 0$$

$$\text{i.e., } -34.375x = -150$$

$$\therefore x = \frac{-150}{-34.375} = 4.364 \text{ m}$$

Point of contraflexure will be at a distance 4.364 m from B and 1.636 m from A.

4. Analysis the propped cantilever beam of the length 10m is subjected to point load of 10KN acting at a 6m from fixed and draw SFD and BMD. (AUC Nov/Dec 2010)

Solution: Let P = Reaction at the rigid prop at B

To find the reaction at prop, the downward deflection due to load 10 kN at the point of prop should be equal to the upward deflection due to prop reaction at B.

Now we know the downward deflection at point B due to load 10 kN

$$\begin{aligned} &= \frac{W a^2}{6 E I} (3l - a) \\ &= \frac{10 \times 6^2}{6 E I} [(3 \times 10) - 6] \\ &= \frac{1440}{E I} \quad \dots (1) \end{aligned}$$

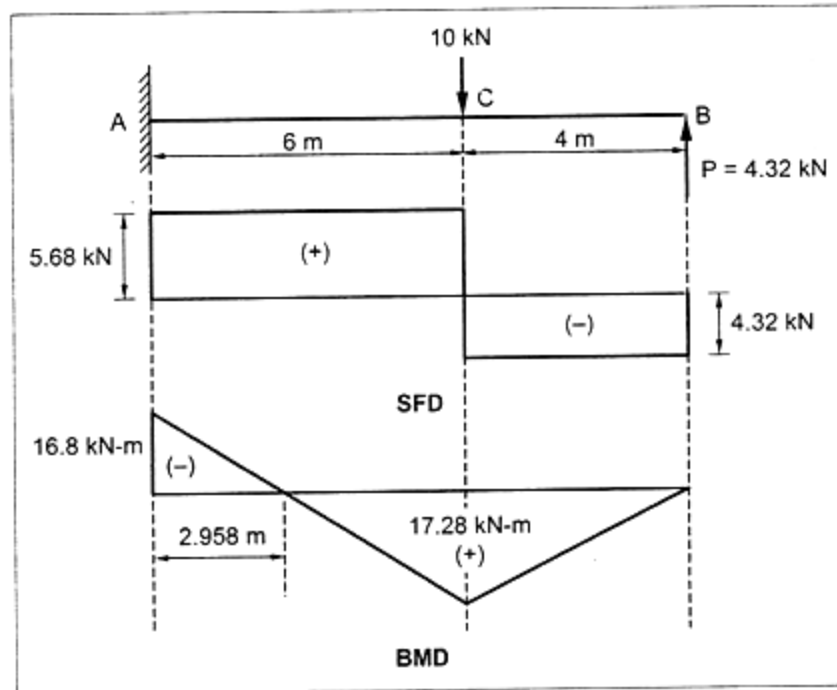


Fig. 2.15.

The upward deflection at the point B due to prop reaction, P alone

$$= \frac{P l^3}{3 E I} = \frac{P \times 10^3}{3 E I} = \frac{1000 P}{3 E I} \quad \dots (2)$$

Equating the above two equations,

$$\frac{1440}{E I} = \frac{1000 P}{3 E I}$$

$$\therefore 1000 P = 3 \times 1440$$

$$= 4320$$

$$\text{i.e., } P = \frac{4320}{1000} = 4.32 \text{ kN}$$

(i) **SFD:** SF at B = - 4.32 kN (minus sign due to right upwards)

The SF will remain constant between B and C and equal to - 4.32 kN.

$$\text{Then SF at C} = 10 - 4.32 = + 5.68 \text{ kN}$$

The SF will remain constant between C and A i.e., + 5.68 kN

(ii) BMD:

$$\text{B.M. at B} = 0$$

$$\text{B.M. at C} = 4.32 \times 4 = 17.28 \text{ kN-m}$$

$$\text{B.M. at A} = (4.32 \times 10) - (10 \times 6) = -16.8 \text{ kN-m}$$

As the B.M is changing sign between C and A, there will be a point of contraflexure. To find its location equate to B.M. between C and A to zero.

The B.M. at any section between C and A at a distance 'x' from B,

$$M_x = 4.32x - 10(x - 4)$$

Equating to zero,

$$4.32x - 10x + 40 = 0$$

$$-5.68x = -40$$

$$\therefore x = \frac{-40}{-5.68} = 7.042 \text{ m}$$

The point of contraflexure is 7.042 m from B and 2.958 from A.

5. A propped cantilever of span 6m having the prop at the is subjected to two concentrated loads of 24 kN and 48kN at one third points respective from left end (fixed support) draw SFD and BMD .
(AUC Nov/Dec 2010)

Solution: Let P = Reaction at the rigid prop at B

To find the reaction at prop, the downward deflection due to point loads of 24 kN and 48 kN at the point at prop should be equal to the upward deflection due to prop reaction at B.

The downward deflection due to point load at B

$$= \frac{W a^2}{6 E I} (3 l - a)$$

\therefore Total deflection at B due to 24 kN and 48 kN

$$\begin{aligned} &= \frac{24 \times 2^2}{6 E I} [(3 \times 6) - 2] + \frac{48 \times 4^2}{6 E I} [(3 \times 6) - 4] \\ &= \frac{256}{E I} + \frac{1792}{E I} = \frac{2048}{E I} \quad \dots (1) \end{aligned}$$

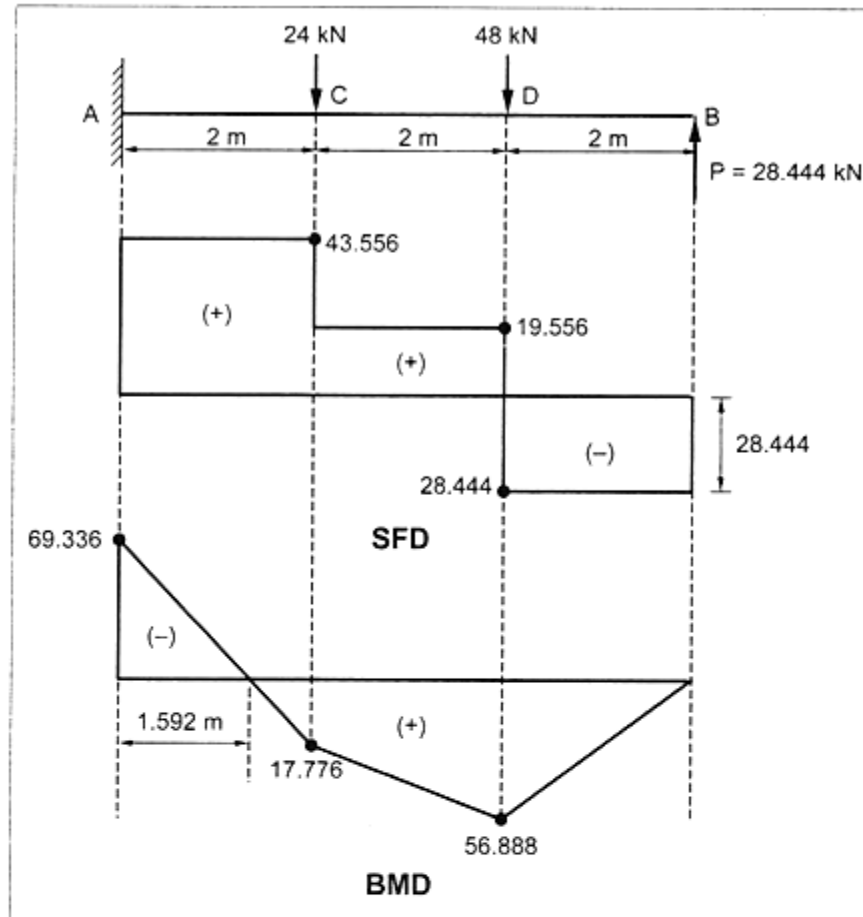


Fig. 2.16.

The upward deflection at the point B due to prop reaction

$$\frac{P l^3}{3 E I} = \frac{P \times 6^3}{3 E I} = \frac{72 P}{E I}$$

Equating the above two equations,

$$\frac{2048}{E I} = \frac{72 P}{E I}$$

$$\therefore P = \frac{2048}{72} = 28.444 \text{ kN}$$

SFD: SF at B = -28.444 kN (minus sign due to right upwards)

The SF will remain constant between B and D.

$$\text{SF at D} = -28.444 + 48.000 = +19.556 \text{ kN}$$

The SF remain constant between D and C. *i.e.*, +19.556 kN

$$\text{SF at C} = +19.556 + 24.000 = 43.556 \text{ kN}$$

The SF remain constant between C and A. *i.e.*, 43.556 kN

BMD: B.M. at B = 0

$$\text{B.M. at D} = 28.444 \times 2 = 56.888 \text{ kN-m}$$

$$\text{B.M. at C} = (28.444 \times 4) - (48 \times 2) = 17.776 \text{ kN-m}$$

$$\text{B.M. at A} = (28.444 \times 6) - (48 \times 4) - (24 \times 2) = -69.336 \text{ kN-m}$$

As the B.M is changing the sign between C and A, there will be a point of contraflexure.

To find its location, equate the BM between C and A to zero. B.M at any section between C and A at a distance x from B,

$$0 = 28.444x - 48(x - 2) - 24(x - 4)$$

$$0 = 28.444x - 48x + 96 - 24x + 96$$

$$-43.556x = -192$$

$$\therefore x = \frac{-192}{-43.556}$$

$$= 4.408 \text{ m}$$

The point of contraflexure is 4.408 m from B and 1.592 m from A.