RPSC-AEn

CIVIL ENGINEERING-I

Detailed Solutions

Dated : 04th December 2019

PART - A

Note: Attempt all questions. Answer the following questions in 15 words each . Each question carries 2 marks.

1. Calculate the total cross-sectional area of minimum shear reinforcement in limit state design for reinforced concrete beam of width 350 mm and total depth 700 mm as per IS: 456-2000, if the steel grade is Fe 415 and concrete grade is M35. 10 mm diameter 2 legged stirrups are provided at spacing of 300 mm centre to centre as shear reinforcement.

Ans. mini shear stirrups in beam $\frac{Asv}{bs_v} \geq \frac{0.4}{0.8f_y}$

$$A_{sv} = \frac{0.4bsv}{0.87f_y} = \frac{0.4 \times 350 \times 300}{0.87 \times 415}$$

2. What is pure bending?

Ans. Pure bending refers to flexure of a beam under constant bending moment, which means that the shear force in zero i.e. $\left(V = \frac{dm}{dx} = 0\right)$

3. Define the distribution factor of moment distribution method.

Ans. D.F. of a member is defined as the ratio of stiffness of the member to the sum of stiffness of all members at that joint

4. Calculate the minimum area of tensile reinforcement required in limit state design as per IS: 456-2000 for a reinforced concrete beam having 300 mm width and 450 mm effective depth. The beam is subjected to an all inclusive uniformly distributed load of 20 kN/m. Concrete grade M30 and steel grade Fe 500.

Ans. Ast (mini. tensile r/f) = $\frac{0.85\ bd}{f_y} = \frac{0.85 \times 300 \times 450}{500} = 229.5mm^2$

5. Enlist types of losses of prestress in pretensioning.

Ans. Losses of Prestress in pretensioning

1. Elastic shortening
2. Creep and shrinkage loss due to concrete
3. Relaxation stress in steel

6. Calculate the area of steel base of an isolated grillage foundation of a steel column carrying an axial load of 2000 kN. Self weight of column and foundation is 200 kN and foundation is resting on soil having safe bearing capacity of 110 kN/m²

Ans. Area of steel base plate = $\frac{\text{W.g(column + foundation) + load}}{\text{SBC(Safe Bearing)}}$

7. Define the development length in RCC.

Ans. Development length can be defined as the amount of r/f bar length needed to be embedded or projected into the column to establish the desired bond strength between the concrete and steel in RCC

8. Define the Purlins.

Ans. Purlins are horizontal beam along the length of roof resting on principals and supporting the roof covering material

9. Explain throat thickness and effective length of the fillet weld.

Ans. T.T.:- It is the perpendicular distance from the root to the hypotenuse joining the two ends of the legs.

Effective length of fillet weld :- The area of the weld for which the specified size and the effective throat thickness of the weld exist.

10. Name the main factors/parameters on which pile group efficiency depends.

Ans. 1. Depends on ultimate load capacity of pile group.

2. Depends on ultimate load on single pile

3. Depends on number of piles

11. Define pressure bulb is soil.

Ans. A pressure bulb is a stress contour which connects all point below ground surface at which the vertical pressure for a given loading is the same.

12. Define shear strength of soil and give expression of coulomb equation.

Ans. Shear strength of a soil mass is the maximum internal resistance to applied shearing forces.

Coulomb equation:

$$\tau_f = c + \sigma\tan\phi$$

13. Determine the intensity of passive lateral earth pressure in kN/m² at a depth of 5 m for a cohesionless soil deposit having a unit weight of 18 kN/m³ and angle of internal friction of 30°

Ans. $K_p = 1+\sin\phi/1-\sin\phi = 3$ $(\phi=30°)$

Intensity of passive earth pressure at 5 m , depth for c = 0

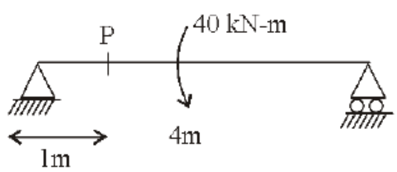
$$\sigma_p = K_p\gamma h = 3\times18\times5 = 270 \text{ kN/m}^2$$

14. Define coefficient of permeability of soil.

Ans. The rate of flow of water under laminar flow condition through a unit cross-sectional area of a porous medium under a unit hydraulic gradient , at standard temperature.

15. Determine the magnitude of bending moment at 1 m from the left end of a simply supported beam AB of effective length 4 m and subjected to an anticlockwise moment of 40 kNm at the centre of beam.

Ans.



Reaction at R_A

$$4R_A = 40$$

$$R_A = 10$$

B.M.at $P = R_A\times1 = 10$ kN-m

16. What is kinematic indeterminacy?

Ans. If the number of unknown displacement components are greater then the number of compatibility equation than the structure is said to be kinematic indeterminate and and the number of additional equation required for determining all the unknown displacement is called as degree of kinematic indeterminacy.

17. Differentiate between normal stress and shear stress.

Ans.

Normal stress	Shear stress
1. It act perpendicular to cross section	1. It act parallel to cross section
2. It create deformation along the longitudnal axis	2. It create deformation in the plane perpendicular to longitudnal axis

18. Give the values of partial factor of safety for concrete & Steel.

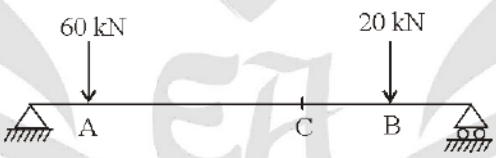
Ans.

Material	Partial factor of safety
Concrete	1.5
Steel	1.15

19. Define the load balancing concept of prestress concrete.

Ans. It the external loads cause a sagging curvature in the beam element, any load which introduces the hogging curvature on to the beam, equal and opposite in nature to that caused by external loads in recognised as load balancing prestressing.

20. For the beam shown in Fig. given below, calculate the load required at C to produce deflection of 10 mm at A and 4 mm at B. The deflection produced at C is 5 mm.



Ans. Solving it by Betti's theroem

$$[P_1\Delta_{1C}+P_2\Delta_{2C}=P_C\Delta_{C12}]$$

$$60\times10+20\times4 = 5P$$

$$P = 136\text{kN}$$

PART - B

Note: *Answer all the following questions in 50 words each. Each question carries 5 marks.*

21. Why do we design a RCC column for minimum eccentricity?

Ans. Every column must be designed for minimum eccentricity to account for constructional defect & material imperfection.

minimum eccentricity formula:-

$$e_{min} = \max\begin{Bmatrix} \dfrac{L_{un\,sup}}{500}+\dfrac{B \text{ or } D}{30} \\ 20 \text{ mm} \end{Bmatrix}$$

22. Briefly discuss two limit states which are considered for the design of steel structures.

Ans. Two limit states for the design are

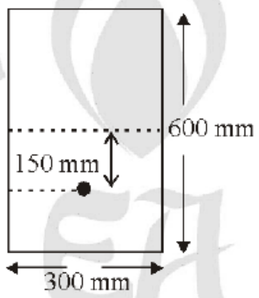
Limit state of strength	Limit state of serviceability
1. It deals with strength of structural members	1. It deals with deflection of strength element to loading
2. Brittle fracture and fracture due to fatigue	2. Vibration , buckling of structure
3. Plastic collapse of structure	3. Corrosion, fire hazard in structure

23. A rectangular prestressed concrete beam (300 mm × 600 mm) is prestressed by 6 Nos. High tensile steel wires of 16 m (dia), effective stress 1,600 MPa located at 1500 mm from the soffit of the beam. Without having any tension in the beam, find the maximum moment that can be applied.

Ans. Condition for zero Tension:-

$$\frac{P}{A}-\frac{My}{I}+\frac{(Pe)y}{I}=0$$

$$\frac{1600\times\frac{\pi}{4}(16)^2}{300\times600}-\frac{M.(300)}{\frac{1}{12}\times300\times(600)^3}+\frac{1600\times6\frac{\pi}{4}(16)^2\times150\times(300)}{\frac{1}{12}\times300\times(600)^3}=0$$



$$10.717-\frac{M}{18\times10^6}+16.07=0$$

$$M = 482.28\text{kN-m}$$

24. A steel plate 160 mm × 10 mm is connected to a gusset plate by fillet weld of size 5 mm at site. If the plate is to resist a factored tensile load of 350 kN. steel grade is Fe 410 and welding is done on all four sides of the plate. calculate the required overlap of plate on gusset plate (overlap rounded off to nearest 10 mm) in limit state design as per IS : 800-2007.

Ans. Design strength of filled weld:-

$$KS\ l_{eff}\frac{f_u}{\gamma_{mw}}\times\frac{1}{\sqrt{3}}$$

$$350\times1000 = 0.7\times5\times l_{eff}\times\frac{410}{1.25}\times\frac{1}{\sqrt{3}}$$

$$l_{eff} = 528.06\ \text{mm}$$

$$l_{eff} = 530\ \text{mm}$$

25. Write a note on five important factors affecting the permeability of soil.

Ans. Factor affecting permeability

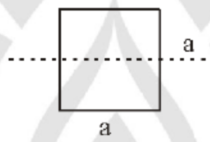
1. Grain size: The permeability varies approximately as square of grain size
2. Properties of pore fluid: permeability is directly proportional to unit weight of pore fluid and inversely proportional to its viscousity
3. Void ratio: Permeability genreally increases for increase in void ratio of soil mass
4. Degree of saturation: permeability of saturated soil is less than that of fully satureated soil
5. Stratification of soil: permeability is high if flow is parallel to the layers while permeability is minimum if flow is in perpendicular direction

26. A beam of square corss section is laid along one of its sides. The beam is then rotated such that one of its diagonal becomes horizontal. What is the percentage in crease or decrease in the moment capacity of the beam if the permissible stress in bending remains constant?

Ans. Moment capacity is directly proportional to section modulus of section (Z)

Let square is of side length = a

Case(1)

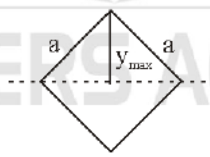


$$Z = \frac{I}{y_{max}}$$

Here $I = \frac{a^4}{12}, y_{max} = \frac{a}{2}$

$$Z = \frac{a^4}{12} \times \frac{2}{a} = \frac{a^3}{6}$$

Case(2)



Here $y_{max} = \frac{a}{\sqrt{2}}, I = \frac{a^4}{12}$

$$Z = \frac{a^4}{12} \times \frac{\sqrt{2}}{a} = \frac{a^3}{6\sqrt{2}}$$

% decrease $= \frac{\frac{a^3}{6} - \frac{a^3}{6\sqrt{2}}}{\frac{a^3}{6}} = \frac{\sqrt{2}-1}{\sqrt{2}} \times 100 = 29.27\%$

27. Write the assumptions on which the Euler's theory of columns is based.

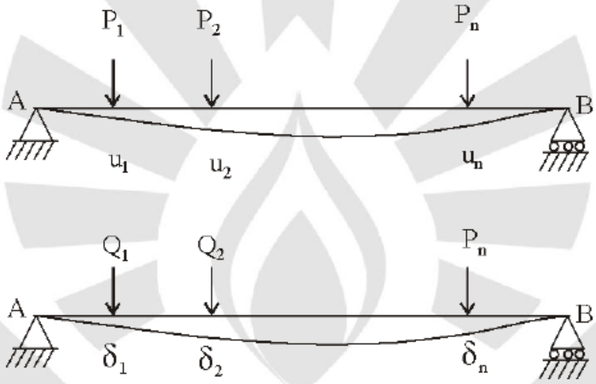
Ans. **Assumption**

1. Perfectly elastic homogenous, and isotropic material,
2. Uniform cros-section of the column throughout its length
3. Perfectly straight column and axial load applied
4. The shortening of the column is neglected due to direct compression
5. The failure of column occurs due to buckling alone

28. State the generalized reciprocal theorem or the Betti's theorem.

Ans. BETTI's Theorem (Reciprocity theorem)

Betti's theroem, discovered by Enrico Betti in 1872 states that for all linear elastic structures subject to two sets of forces Pi and Qi, the work done by the set P though the displacement produced by set Q is equal to the work done by the set Q through displacements produced by set P.

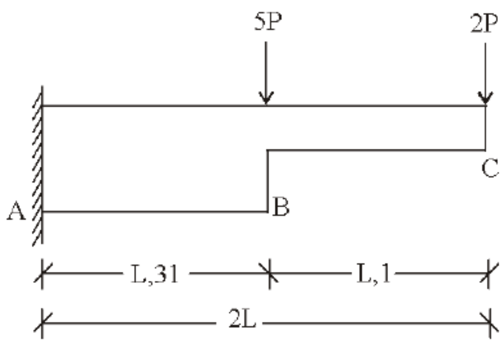


When the first system of forces is P_1, P_2 .... P_n and the second system of forces is given by $Q_1, Q_2, \ldots Q_n$ Let u_1, u_2,.........u_n be the displacements caused by the forces P_1, P_2......P_n only and δ_1 δ_2.....δ_n be the displacements due to system of forces Q_1, Q_2,.....Q_n only acting on the beam as shown in Fig.

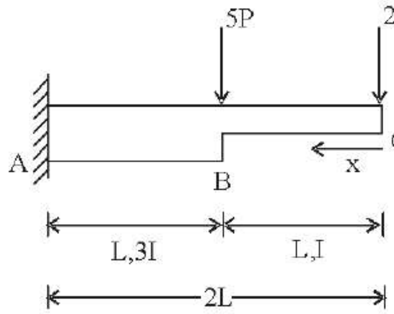
Now the reciprocal theroem may be stated as.

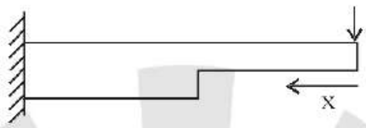
$$P_1\delta_1 = Q_1u_1 \qquad i = 1,2 \ldots\ldots n$$

29. Using unit load method, determine the deflection at the free end of the cantilever beam shown in Fig. given below.



Ans.





For span BC

$$M = -2Px$$

Due to Unit Load

$$M = -x$$

$$(\delta_c)_{BC} = \int_0^L \frac{M.m.dx}{EI} = \int_0^L \frac{(-2Px)(-x)dx}{EI}$$

$$= \int_0^L \frac{2Px^2.dx}{EI} = \left[\frac{2Px^3}{3EI}\right]_0^L = \frac{2PL^3}{3EI}$$

For span BA

$$M = -2Px-5P(x-L)$$

due to Unit load

$$M = -1.x$$

$$(\delta_c)_{BA} = \int_L^{2L} \frac{M.m.dx}{EI} = \int_L^{2L} \frac{[-2Px - 5P(x-L)][-x]}{3EI}.dx$$

$$= \int_L^{2L} \frac{2Px^2}{3EI}.dx + \int_L^{2L} \frac{5Px^2.dx}{3EI} - \int_L^{2L} \frac{5PxL.dx}{3EI}$$

$$= \left[\frac{2Px^3}{9EI}\right]_L^{2L} + \left[\frac{5Px^3}{9EI}\right]_L^{2L} - \left[\frac{5PLx^2}{6EI}\right]_L^{2L}$$

$$= \frac{2P}{9EI}[(2L)^3 - L^3] + \frac{5P}{9EI}[(2L)^3 - L^3] - \frac{5PL[(2L)^2 - (L)^2]}{6EI}$$

$$= \frac{2P}{9EI} \times 7L^3 + \frac{5P}{9EI} \times 7L^3 - \frac{5PL \times 3L^2}{6EI}$$

$$= \frac{14}{9}\frac{PL^3}{EI} + \frac{35PL^3}{9EI} - \frac{15PL^3}{6EI}$$

$$= \left(\frac{28 + 70 - 45}{18}\right)\frac{PL^3}{EI}$$

$$= \frac{53}{18}\frac{PL^3}{EI}$$

$$\delta_c = (\delta_c)_{BC} + (\delta_c)_{BA}$$

$$= \frac{2}{3}\frac{PL^3}{EI} + \frac{53PL^3}{18EI}$$

$$= \left(\frac{12 + 53}{18}\right)\frac{PL^3}{EI} = \frac{65}{18}\frac{PL^3}{EI}$$

30. Explain shear lag effect in beams.

Ans. The non-uniform Transfer of stress across the section caure on-uniform straining of the section due to which the section connot be effectively utilized and faild under the minimum strength across the section instead of average. This whole phenomenon is known as shear-lag effect.

Note→ shear lag can be elimianted by removal of outer leg by providing unequal angle and can increase the length of connection.

31. Determine the percentage loss of prestress due to anchorage slip of 2 mm in a prestressed concrete beam of length 20 m. The beam is post tensioned with a steel cable having an initial stress of 1000 N/mm² and modulus ofelasticity of steel is 2 × 10⁵ N/mm².

Ans. Loss due to anchange slip $= \frac{\Delta}{L} \times E5$

$$= \frac{2}{20 \times 10^5} \times 2 \times 10^5$$

$= 20$ N/mm²

∴ Of loss in prestress $= \frac{20}{1000} \times 100 = 2\%$

32. What is negative skin friction in pile design? Mention two conditions in which negative skin friction will develop.

Ans. Negative skin friction is usually a dounward shear drag acting on a pile on pile group due to downward sinking of surrounding soil relative to the piles.

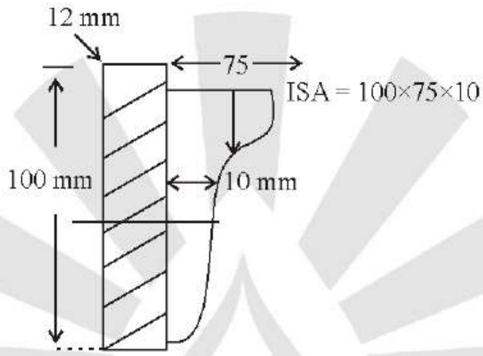
This shear drag movements are expected to occure when a segment of the pile penetrates a compressible soil stratum that can consolidate Eg.1) Palcement of fill on compressible soil lowering of the ground water table

PART - C

Note: Answer the following questions in 100 words each. Each. Each question carries 20 marks.

33. A single angle section ISA 100 mm × 75 mm × 10 mm is used as a tie member in a roof truss. Its 100 m leg is connected to a 12 mm thick gusset plate by means of one line of 24 mm diameter bolts of grade 8.8. Determine the ultimate tensile strength of the tension member due to gross section yielding and net section rupture in limit state design as per IS : 800-2007 if steel gade is Fe 410. The shear lag factor can be taken as 0.7.The curvature at edges of the angle can be neglected to calculate area.

Ans.



Ultimate tension strength of tension member

$$\text{mini}\begin{Bmatrix}\text{Gross strength of Members}\\ \text{Net strength of member}\end{Bmatrix}$$

Gross strength of Tension member → $A_g \dfrac{f_y}{\gamma_{mo}}$ $\gamma_{mo} = 1.1$

$$A_g = [100+75-10]\times 10 = 1650 \text{ mm}^2$$
$$f_y = 250 \text{ N/mm}^2$$
$$\gamma_{mo} = 1.1$$

Gross strength $= 1650 \times \dfrac{250}{1.1}$

Gross strength of tension members = 375 kN

(ii)

$$\text{Net strength of } = 0.9\, f_u \frac{A_{nc}}{\gamma_{m_1}} + \beta\, A_{go} \frac{f_y}{\gamma_{m_o}}$$

Tension members

where $f_u = 410\ N/mm^2$

$$A_{nc} = \left(100 - \frac{10}{2} - 26\right) \times 10 = 690\ mm^2$$

$$d_o = d+2 \text{ for dia } (16\text{–}24\ mm)$$
$$= 24+2 = 26\ mm$$

$$\gamma_{m_1} = 1.25$$

$$B = 0.7(\text{Given}) \rightarrow \text{shear-leg factor}$$

$$A_{go} = \left(75 - \frac{10}{2}\right) \times 10 = 700\ mm^2$$

$$\gamma_{mo} = 1.1$$

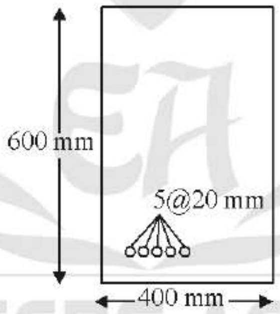
$$= 0.9 \times 410 \times \frac{6.90}{1.25} + 0.7 \times 700 \times \frac{250}{1.1}$$

Net strength of tension members = 315.05kN

Hence Ultimate tenon strength of tensionmebers is 315.05 kN

34. A singly reinforced beam fo width 400 m andeffective depth 600 mm is reinforced with 5 bars of 20 mm diameter as tension reinforcement. There are 8 mm diameter 2 legged stirrups provided @ 200 mm c/c. Concrete grade M 25, Steel grade Fe 415. Calculate the ultimate moment of resistance of the beam for limit state design as per IS : 456-2000.

Ans.



$$b = 400\ mm\ ;\ d = 600\ mm$$

$$Ast = 5 \times \frac{\pi}{4}(20)^2 = 1570.79\ mm^2$$

stirruaps dia = 8 mm 2 legged stirrups @ 200 mm c/c

$$f_{ck} = 25\ N/mm^2$$
$$f_y = 415\ N/mm^2$$

Calculate MOR = ? LAS per IS-456:2000

$$x_{ulim} = 0.48\ d = 0.48 \times 600 = 288\ mm$$

By using compressive force = Tensile force

$$C = T$$

$$0.36\ f_{ck}\ x_u b = 0.87\ f_y\ axt$$

$$x_u = 0.87\ f_y\ axt$$

$$0.36 = f_{ck}\ b$$

$$x_u = \frac{0.87 \times 415 \times 1570.79}{0.36 \times 25 \times 400}$$

$$x_u = 157.53 \text{ mm}$$

$$x_u < x_u \text{ lim}$$

∴ The given section is under reinforced

Now calculate $M_{ulim} = 0.138\ f_{ck}\ bd^2$

$= 0.138 \times 25 \times 400 \times (600)^2$

$= 496.8$ kN-m

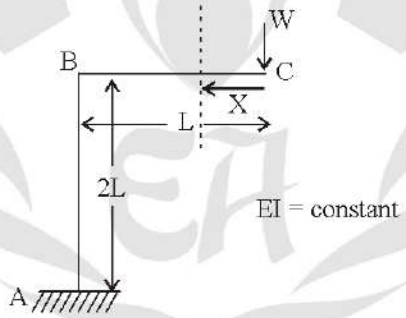
Calculate MOR $= C \times LA$

use $x_u = x_{ulim} = 0.36 \times 25 \times 157.53 \times 400(600 - 0.42 \times 288)$

⇒ $= 302.74$ kN-m

35. Determine by Castigliano's method, the vertical deflection and horizontal deflection at the free end C of a cantilever bend ABC having vertical leg AB of length 2L and horizontal leg BC of length L. End A is bottom end which is fixed support, B is a rigid joint and end C is free. There is a vertically downward load W at the free end C. Flexural rigidity EI is constant throughout.

Ans.



For vertical deflection at C:-

Span	Moment	Limit
BC	(–Wx)	0toL
BA	–WL	0to 2L

$$U_{BC} = \int \frac{M^2.dx}{2EI} = \int_0^L \frac{(-Wx)^2.dx}{2EI}$$

$$= \int_0^L \frac{W^2x^2.dx}{2EI}$$

$$= \left[\frac{W^2x^3}{6EI}\right]_0^L = \frac{W^2L^3}{6EI}$$

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4.	Technical (CE • EE • ME)	100	100	90 Min.
5.	General Knowledge/Awareness, Reasoning, Numerical Ability and General English	100	100	90 Min.
6.	Technical (CE • EE • ME)	100	100	90 Min.
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8.	Technical (CE • EE • ME)	100	100	90 Min.

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$$U_{BA} = \int \frac{M^2 dy}{2EI} = \int_0^{2L} \frac{(-WL)^2.dy}{2EI}$$

$$\left[\frac{W^2L^2y}{2EI}\right]_0^{2L} = \frac{2W^2L^3}{2EI} = \frac{W^2L^3}{EI}$$

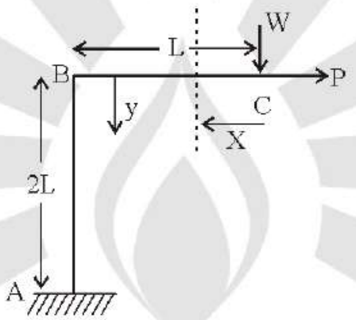
$$U = U_{BC} + U_{BA} = \frac{W^2L^3}{6EI} + \frac{W^2L^3}{EI}$$

$$U = \frac{7}{6}\frac{W^2L^3}{EI}$$

(from castigliano's theorem)

$$(\delta_c)_v \ \frac{\partial V}{\partial W} = \frac{7}{6} \times \frac{2WL^3}{EI} = \frac{7}{3}\frac{WL^3}{EI}$$

For horizontal deflection at C :



Apply a fictious load (P) in the direction in which we have to calculate deflection.

Span	Moment	Limit
BC	(–WX)	0 to L
BA	–WL-Py	0 to 2L

$$U_{BC} = \int \frac{M^2 dx}{2EI} = \int_0^{L} \frac{(-wx)^2.dx}{2EI}$$

$$= \left[\frac{W^2x^3}{6EI}\right]_0^{L} = \frac{W^2L^3}{6EI}$$

$$\frac{\partial U_{BC}}{\partial P} = 0$$

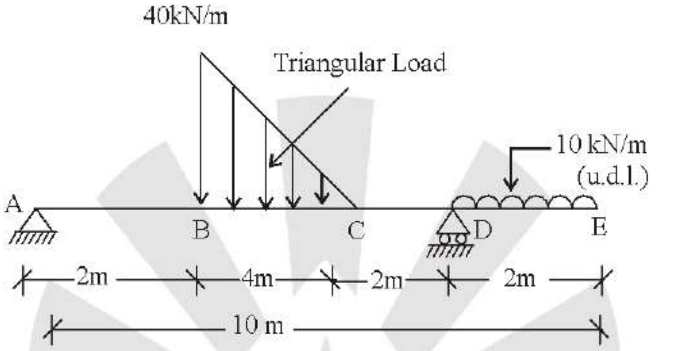
$$U_{BA} = \int \frac{M^2.dx}{2EI} = \int_0^{2L} \frac{[-(WL+Py)]^2.dy}{2EI}$$

$$= \int_0^{2} \frac{(WL+Py)^2 \ dy}{2EI}$$

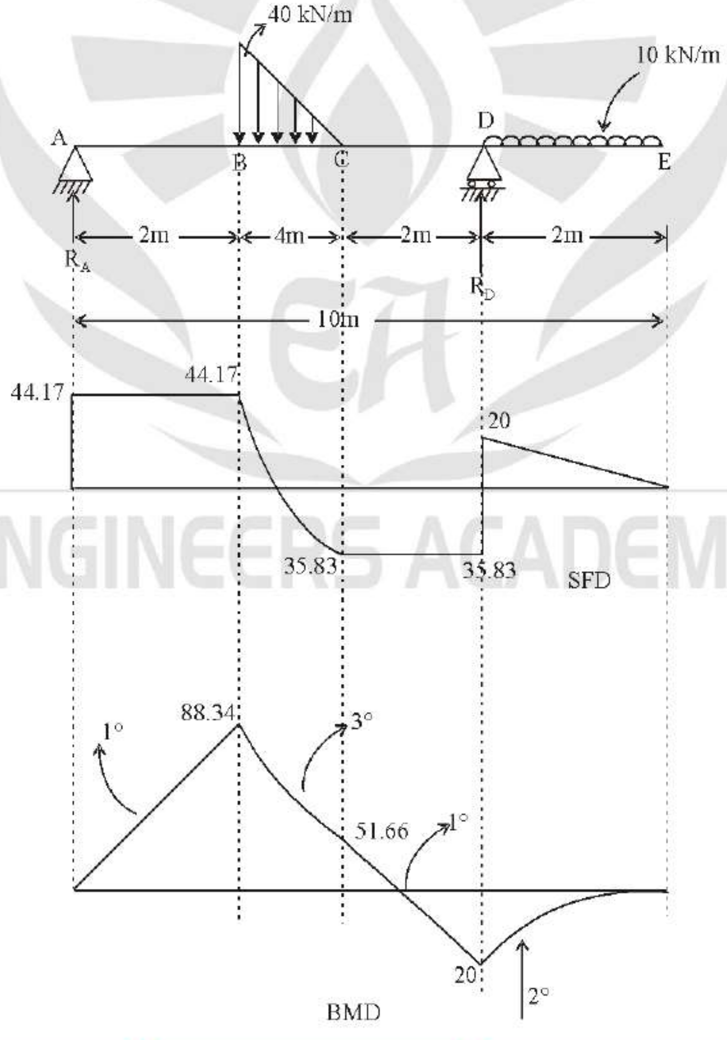
$$\frac{\partial U_{BA}}{\partial P} = \int_0^{2L} \frac{2(WL+Py).y.dy}{2EI}$$

$$(\delta_c)_H = \frac{2WL^3}{EI}\left[\frac{WLy^2}{2EI}\right]_0^{2L} = \frac{WL(2L)^2}{2EI} = \frac{2WL^3}{EI}$$

36. Drw shear force and bending moment diagram for the beam shown in Fig. given below Mention the sign convention adopted.



Ans.



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Ans.

$$R_A + R_D = 10\times2+\frac{1}{2}\times4\times40 = 100 \text{ kN}$$

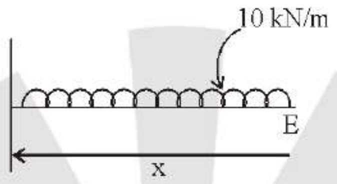
$$\Sigma M_D = 0$$

$$R_A\times8 - \frac{1}{2}\times4\times40\times\left(2+\frac{8}{3}\right)+10\times2\times1 = 0$$

$$R_A = 44.17 \text{ kN}$$

$$R_D = 55.83 \text{ kN}$$

Section between DE



$$M_x = \frac{-10x^2}{2}$$

$$M_x = 5x^2$$

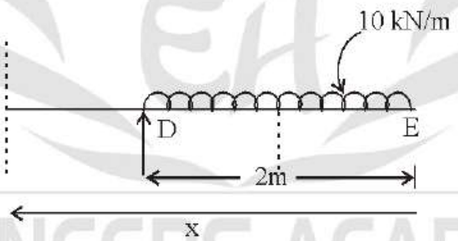
at E, $x = 0$, $M_x = 0$

at D, $x = 2$, $M_x = -5(2)^2 = -20$ kNm

$$SF_x = 10x$$

$SF_E = 0$, $SF_D = 20$ kN ↑|↓ +ve

Section b/w CD



$$M_x = -10\times2\,(x-1)+R_D\,(x-2)$$

$$M_x = -20(x-1)+55.83\,(x-2)$$

$x = 2$, $M_D = -20(1) + 55.83\,(0)$

$= -20$kNm

$x = 4$, $M_C = -20(4-1)+55.83(4-2)$

$= -20\times3+55.83\times2$

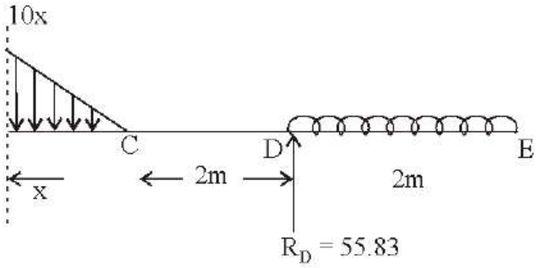
$= 51.66$ kNm

$$SF_x = -R_D + 10x = -55.83+10\times2$$

at $x = 2$, $SF_D = -55.83 + 20 = -35.83$kN

at $x = 4$, $SF_C = -55.83 + 10\times2 = -35.83$ kN

Section in BC



$$M_x = \frac{-1}{2}\times x\times 10x\times\frac{x}{3}+55.83(2+x)-10\times 2(3+x)$$

$$M_x = \frac{-5x^3}{3}+55.83(x+2)-20(x+3)$$

at x = 0, $M_C = 0 + 55.83 \times 2 - 20\times 3$

$= 51.66$ kNm

at x = 4, $M_B = \frac{-5\times 4^3}{3}+55.83\times 6-20\times 7$

$= -106.67 + 334.98 - 140$

$= 88.31$kNm

$$SF_x = \frac{1}{2}\times x\times 10x - 55.83 + 10x2$$

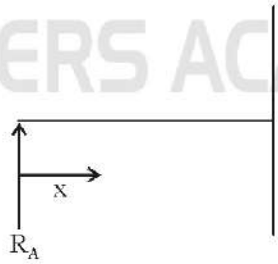
$SF_x = 5x^2+20-55.83$

$x = 0$, $SF_C = -35.83$ kN

$x = 4$ $SF_B = 5(4)^2 + 10\times 2 - 55.83$

$= 44.17$

section AB



$Mx = R_A \times x$

$Mx = 44.17\times x$

$x = 0$, $M_A = 0$

$x = 2$, $M_B = 44.17\times 2 = 88.34$ kNm

$SF_x = R_A = 44.17$ kN

37. A natural soil deposit has specific gravity of 2.48, bulk unit weight of 17.6 kN/m³ and water content of 8%. If the void ratio remains constant, calculate the amount of water required to be added to 10 cubic metre of soil to raise the water content to 18%. What will be the degree of saturation in this condition?

Ans.

$$G = 2.48,\ g = 17.6\ \text{kPa},\ w/c = 8\%$$

Volume of soil = 10m³, water content is raised to = 18%

$$\gamma = \frac{G(1+w)\gamma_w}{1+e} = 17.6$$

$$= \frac{2.48(1.08)9.81}{1+e} = 17.6$$

$$e = 0.49$$

$$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{2.48\times 9.81}{1.49} = 16.32 = \frac{\text{weight of solid}(w_s)}{\text{total volume}}$$

$$w_s = 163.2\ \text{kN}$$

$$\text{wt. of water} = 163.2\times\frac{8}{100} = 13.056\text{kN}$$

$$\text{wt of water for 18\% water content} = 163.2\times\frac{18}{100} = 29.376\text{kN}\ \text{kN}$$

water to be required = 29.376–13.056 = 16.32kN

$$= \frac{16.32}{9.81} = 1.66\text{m}^3$$

$$\text{Saturation(S)} = \frac{wG}{e} = \frac{.18\times 2.48}{0.49} = 0.911$$

38. A reinforced concrete beam of M 20 grade concrete, 300 mm wide and 500 mm deep is required to resist a superimposed moment of 152 kN.m at an intermediate support of a continuous beam. Using mild steel bars, calculate A_{st} at top if 4 Nos. 16 mm dia. bars are required to be continued at bottom from one span to other. Assume effective cover to compression steel as 45 mm and that to tension steel as 50 mm.

Ans.

$$b = 300\ \text{mm}$$

$$d = 450\ \text{mm}$$

$$Mu = 152\ \text{kN-m.}$$

$$\text{factored } Mu = 152\times 1.5 = 228\ \text{kN-m}$$

Cal. limiting moment of resistance

$$Mulim = 0.148 f_{ck} bd^2 = 179.82\ \text{kN-m}$$

BMu > Mu_{lim},so doubly r/f balanced sec^n is design

cal. Reingorcement

$$= 0.414\left(\frac{f_{ck}}{f_y}\right)X_{u\lim}.b$$

$$Ast_1 = Ast_{lim} = 0.414\times\frac{20}{415}\times(0.53\times450)\times250$$

$$= 1189.6mm^2$$

cal. Ast_2

$$MR_2 = BM_u - M_{ulim}$$

$$= 228-179.82 = 48.18\ mm^2$$

$$MR_2 = T_2\times LA_2$$

$$= 0.87\times f_y.\ Ast_2.\ (d-d')$$

$$48.18\times10^6 = 0.87\times250\times Ast_2(450-45)$$

$$Ast_2 = 546.9mm^2$$

Cal. A_{SC}

$$C_2 = T_2$$

$$(f_{sc}-0.45f_{ck})Asc = 0.87f_y\ Ast_2$$

for f_{sc}

$$\frac{d'}{d} = \frac{45}{450} = 0.1$$

$$f_{sc} = 217.5,\ \text{for Fe 250}$$

$$(217.5-0.45\times250)\ A_{sc} = 0.87\times250\times546.9$$

$$A_{sc} = 1132.86mm^2$$

❑❑❑