PRACTICE QUESTIONS

for SSC-JE : CBT-2

Theory of Structures

Civil Engineering

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06 Theory of Structures

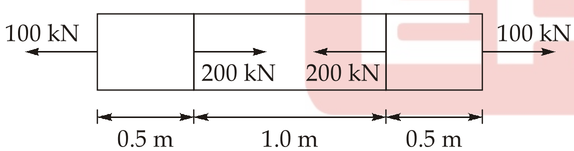
Q.1 The material in which large deformation is possible before the absolute failure or rupture is termed as :

(a) Brittle (b) Elastic
(c) Ductile (d) Plastic

Q.2 The stress at which a material fractures under large number of reversals of stress is called :

(a) Creep
(b) Endurance limit
(c) Ultimate strength
(d) Residual stress

Q.3 A slender bar of 100 mm^2 cross-section is subjected to loading as shown in the figure below. If the modulus of elasticity is taken as 200 GPa, then the elongation produced in the bar will be



(a) 5 mm (b) 10 mm
(c) 1 mm (d) Zero

Q.4 A copper rod of 2 cm diameter is completely encased in a steel tube of inner diameter 2 cm and outer diameter 4 cm. Under an axial load, the stress in the steel tube is 100 N/mm^2. If $E_S = 2E_C$, then the stress in the copper rod is

(a) 50 N/mm^2 (b) 33.33 N/mm^2
(c) 100 N/mm^2 (d) 300 N/mm^2

Q.5 In terms of bulk modulus (K) and modulus of rigidity (G), the Poisson's ratio, can be expressed as

(a) $\dfrac{3K-4G}{4G+6K}$ (b) $\dfrac{3K+4G}{6K-4G}$

(c) $\dfrac{3K-2G}{2G+6K}$ (d) $\dfrac{3K+2G}{6K-2G}$

Q.6 The length, coefficient of thermal expansion and Young's modulus of bar A are twice that for bar B. If the temperature of both bars is increased by same amount while preventing any expansion, then the ratio of stress developed in bar A to that in bar B will be :

(a) 2 (b) 4
(c) 8 (d) 16

Q.7 What does the slope of a bending moment curve as a function of distance represent?

(a) The load applied
(b) The stiffness at that location
(c) The deflection
(d) The shear force at that section

Q.8 If a simply supported beam of 5 m span carries a point load of 100 kN at 2 m from left support, the maximum bending moment on it is

(a) 62.5 kNm (b) 120 kNm
(c) 125 kNm (d) 312.5 kNm

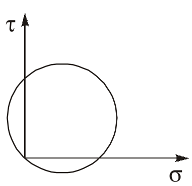
Q.9 A prismatic beam of length L fixed at both ends carries a uniformly distributed load of intensity w per unit length. The distance of point of contraflexure from either end is :

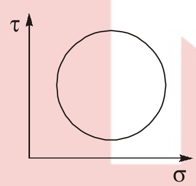
(a) $0.207L$ (b) $0.211L$
(c) $0.277L$ (d) $0.25L$

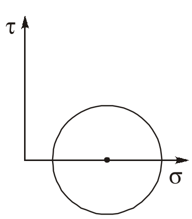
Q.10 If the shear force diagram of a simply supported beam is parabolic, then the load on the beam is
(a) Uniformly distributed load
(b) Concentrated load at mid-span
(c) External moment acting at midspan
(d) Linearly varying distributed load

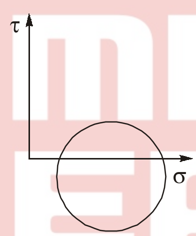
Q.11 If the principal stresses at a point in a stressed body are 150 N/mm^2 (tensile) and 50 N/mm^2 (compressive), then maximum shear stress at this point will be
(a) 100 N/mm^2 (b) 150 N/mm^2
(c) 200 N/mm^2 (d) 250 N/mm^2

Q.12 Which of the following figures may represent Mohr's circle?

(a)


(b)


(c)


(d)


Q.13 According to the maximum shear stress theory, yield locus is :
(a) a hexagon (b) a circle
(c) a rectangle (d) an ellipse

Q.14 Which of the following theories of failure is most appropriate for a brittle material?
(a) Maximum principal strain theory
(b) Maximum principal stress theory
(c) Maximum shear stress theory
(d) Maximum strain energy theory

Q.15 The _____ at any section in a given beam is equal to _____ at corresponding section in conjugate beam.
(a) Slope, Shear force
(b) Deflection, Shear force
(c) Slope, Bending moment
(d) Slope, Deflection

Q.16 The ratio of deflection at centre of a fixed beam and a simply supported beam under a concentrated load P at the centre of the span is :
(a) 0.2 (b) 0.25
(c) 0.5 (d) 0.75

Q.17 In a cantilever beam of span L and flexural rigidity EI, the total strain energy under a concentrated load P at free end will be :
(a) $\dfrac{P^2L^3}{6EI}$ (b) $\dfrac{P^2L^4}{3EI}$
(c) $\dfrac{P^2L^4}{8EI}$ (d) $\dfrac{P^2L^4}{6EI}$

Q.18 Section modulus for hollow circular section of outer diameter D and inner diameter d is
(a) $\dfrac{\pi}{64D}(D^4 - d^4)$ (b) $\dfrac{\pi}{32D}(D^4 - d^4)$
(c) $\dfrac{\pi}{64D}(D^3 - d^3)$ (d) $\dfrac{\pi}{32D}(D^3 - d^3)$

Q.19 Beam of uniform strength vary in section such that
(a) Bending moment remain constant
(b) Deflection remain constant
(c) Maximum bending stress remain constant
(d) Shear force remain constant

Q.20 A solid circular cross-section cantilever beam of diameter 100 mm carries a shear force of 10 kN at the free end. The maximum shear stress is :
(a) $\dfrac{4}{3\pi}$ MPa (b) $\dfrac{3\pi}{4}$ MPa

(c) $\frac{3\pi}{16}$ MPa (d) $\frac{16}{3\pi}$ MPa

Q.21 A shaft is subjected to a bending moment M and a torque T. The equivalent bending moment 'M_{eq}' on the shaft is given by

(a) $\frac{M+\sqrt{M^2+T^2}}{4}$ (b) $\frac{M^2+\sqrt{M+T}}{2}$

(c) $\frac{M-\sqrt{M^2+T^2}}{2}$ (d) $\frac{M+\sqrt{M^2+T^2}}{2}$

Q.22 The moment of inertia of a semi-circular area of radius R about a centroidal axis parallel to its diameter is

(a) $0.11R^4$ (b) $0.055R^4$

(c) $\frac{\pi R^4}{4}$ (d) $\frac{\pi R^4}{8}$

Q.23 The ratio of the core area of a rectangular section to the area of the rectangular section when used as a short column is :

(a) $\frac{1}{9}$ (b) $\frac{1}{36}$

(c) $\frac{1}{18}$ (d) $\frac{1}{24}$

Q.24 Power is transmitted through a shaft, rotating at 150 rpm. The mean torque on the shaft is 20×10^3 N-m. What magnitude of power (in kW) is transmitted by the shaft?

(a) 50π (b) 120π

(c) 100π (d) 150π

Q.25 Two shafts having same length and material are joined in series and subjected to a torque of 10 kNm. If the ratio of their diameters is 2 : 1, then the ratio of their angle of twist is

(a) 16 : 1 (b) 2 : 1

(c) 1 : 2 (d) 1 : 16

Q.26 Which of the following terms represents the torque corresponding to a twist of one radian in a shaft over its unit length?

(a) Torsional stress (b) Torsional rigidity

(c) Flexural rigidity (d) Torsional stiffness

Q.27 Two closed coiled springs of stiffness K and $2K$ are arranged in series in one case and in parallel in the other case. The ratio of stiffness of springs connected in series to parallel is :

(a) $\frac{1}{3}$ (b) $\frac{1}{9}$

(c) $\frac{2}{3}$ (d) $\frac{2}{9}$

Q.28 The maximum B.M. at a section under rolling UDL shorter than span occurs when the moving load.

(a) Just reaches the section

(b) Just leaves the section

(c) Occupies centre of span

(d) So placed that section divided the span and load in the same ratio

Q.29 The theorem of three moments cannot be applied to

(a) Single span fixed beams

(b) Continuous beam with overhangs

(c) Trusses and frames

(d) Continuous beams with sinking supports and rotating joints

Q.30 The final moment at the end A in a beam AB due to rotations θ_A, θ_B and downward settlement (Δ) of support at B is given by

(a) $M_{FAB}+\frac{4EI}{L}\left(\theta_A+2\theta_B-\frac{3\Delta}{L}\right)$

(b) $M_{FAB}+\frac{4EI}{L}\left(2\theta_A+\theta_B-\frac{3\Delta}{L}\right)$

(c) $M_{FAB}+\frac{2EI}{L}\left(2\theta_A+\theta_B-\frac{3\Delta}{L}\right)$

(d) $M_{FAB}+\frac{2EI}{L}\left(\theta_A+2\theta_B-\frac{3\Delta}{L}\right)$

Answer Keys

1.	(c)	2.	(b)	3.	(d)	4.	(a)	5.	(c)	6.	(b)	7.	(d)
8.	(b)	9.	(b)	10.	(d)	11.	(a)	12.	(c)	13.	(a)	14.	(b)
15.	(a)	16.	(b)	17.	(a)	18.	(b)	19.	(c)	20.	(d)	21.	(d)
22.	(a)	23.	(c)	24.	(c)	25.	(d)	26.	(b)	27.	(d)	28.	(d)
29.	(c)	30.	(c)										

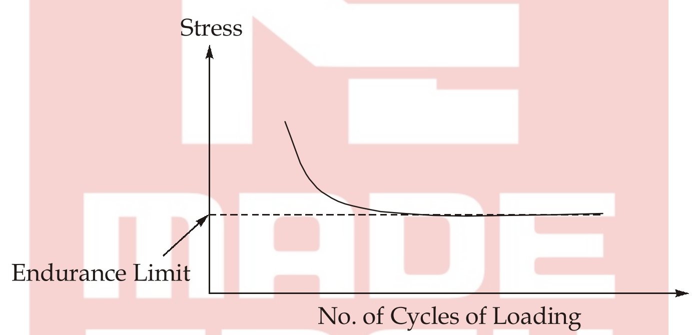
Detailed Solutions

1. (c)

Ductile material shows large deformation before failure whereas in plastic material strain continues to increase without much increase in stress.

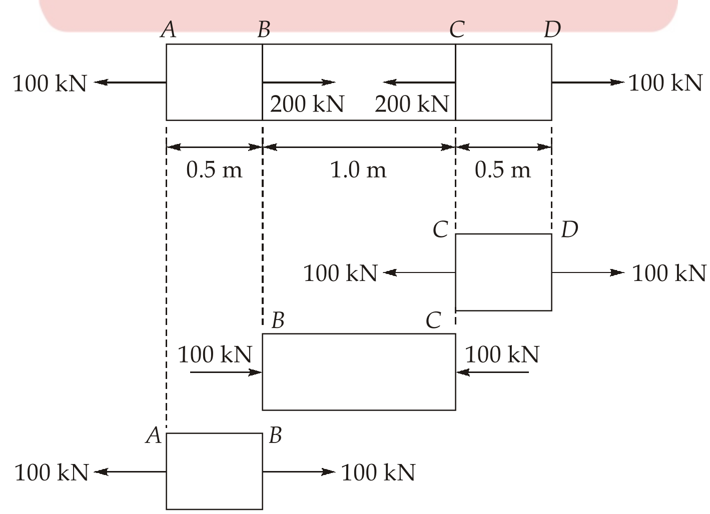
2. (b)

Endurance limit is the stress level below which even large number of stress cycles cannot produce fatigue failure.



3. (d)

FBD of bar :



$$G = 200 \text{ GPa} = 200 \times 10^3 \text{ N/mm}^2$$

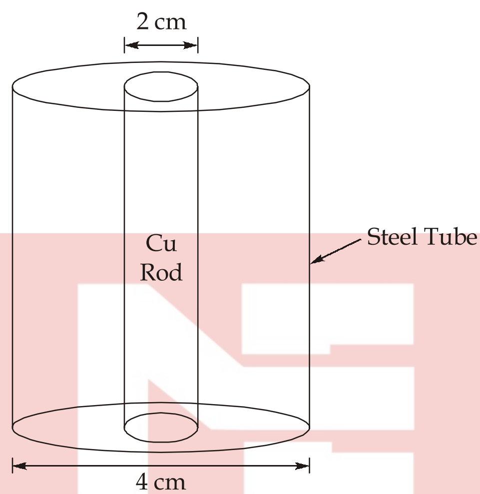
Total elongation :

$$\Delta = \Delta_{AB} + \Delta_{BC} + \Delta_{CD}$$

$$= \frac{100\times10^3\times0.5\times1000}{200\times10^3\times100} - \frac{100\times10^3\times1000}{200\times10^3\times100} + \frac{100\times10^3\times0.5\times1000}{200\times10^3\times100}$$

$$= 0$$

4. (a)



Given :

$$\sigma_s = 100\ \text{N/mm}^2$$

$$E_S = 2E_C$$

Here, the net change in length of the two member will be same since it is composite bars.

$$\Rightarrow \quad \delta_C = \delta_S$$

$$\frac{P_C \cdot L_C}{A_C \cdot E_C} = \frac{P_S \cdot L_S}{A_S \cdot E_S}$$

$$\Rightarrow \quad \frac{\sigma_C}{E_C} = \frac{\sigma_S}{E_S} \qquad (L_S = L_C)$$

$$\sigma_C = \frac{\sigma_S}{2E_C}\times E_C = \frac{\sigma_C}{2} = \frac{100}{2} \qquad (\because E_s = 2E_c)$$

$$= 50\ \text{N/mm}^2$$

5. (c)

We know that

$$E = 2G(1 + \mu) \qquad \text{...(i)}$$

$$E = 3K(1 - 2\mu) \qquad \text{...(ii)}$$

Operating eqn. (i) ÷ (ii)

$$1 = \frac{2}{3}\cdot\frac{G}{K}\cdot\frac{(1+\mu)}{(1-2\mu)}$$

$$3K - 6K\mu = 2G + 2\mu G$$

$$\Rightarrow \quad \mu = \frac{3K - 2G}{2G + 6K}$$

6. (b)

$$\text{Temperature Stress} = E\alpha \cdot \Delta T$$

∴ Ratio of temperature stress of bar A and bar B

$$= \frac{E_A \cdot \alpha_A (\Delta T)_A}{E_B \cdot \alpha_B (\Delta T)_B}$$

$$= \frac{(2E_B) \times (2\alpha_B) \times (\Delta T)_B}{E_B \cdot \alpha_B (\Delta T)_B}$$

$$= 4$$

7. (d)

Relation between bending moment (M), shear force (V) and loading intensity (ω_x).

$$w_x = \frac{dV}{dx}$$

⇒ Intensity of distributed load

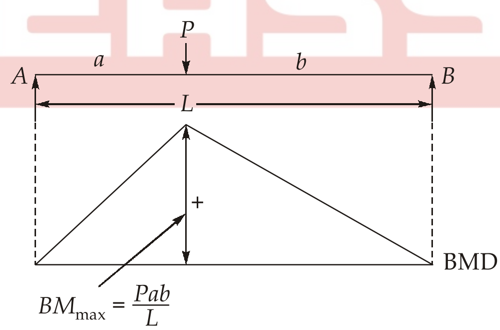
= Slope of shear force diagram

$$V = \frac{dM}{dx}$$

⇒ Slope of bending moment diagram at any section

= Shear force at that section.

8. (b)

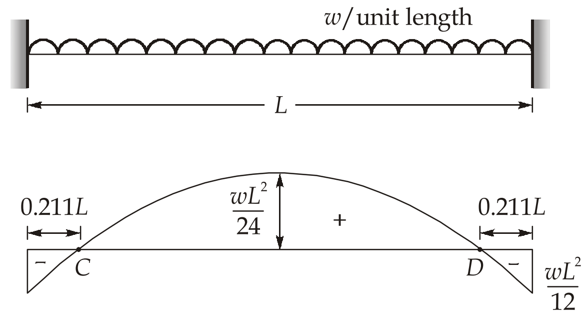


Here, given $P = 100$ kN, $a = 2$ m, $b = 3$ m, $L = 5$ m

$$\therefore \quad BM_{max} = \frac{100 \times 2 \times 3}{5} = 120 \text{ kNm}$$

9. **(b)**

Fixed beam with u.d.l. :



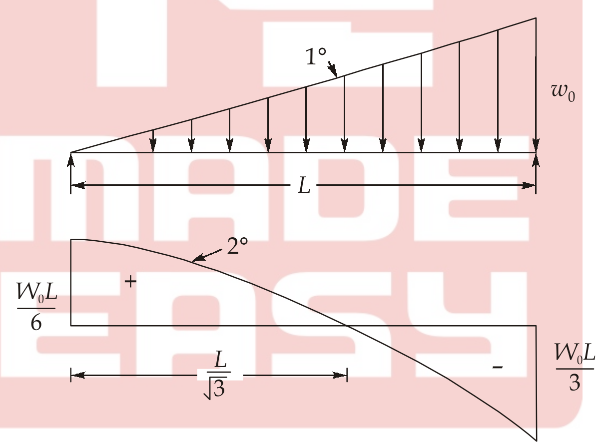
BMD

Hence, points of contraflexure will be at 0.211L from either end.

10. **(d)**

As $$\frac{dv}{dx} = w$$

If SFD is parabolic (2nd degree), then the load on the beam is linearly varying distributed load (1st degree).



11. **(a)**

Maximum shear stress,

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$$

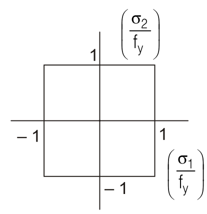
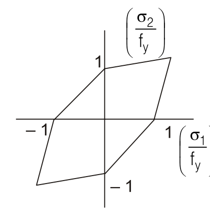
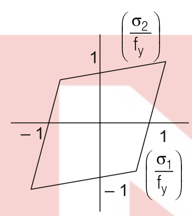
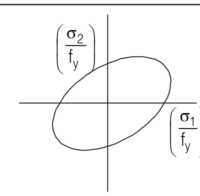
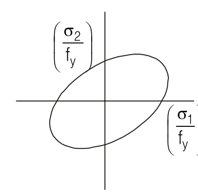
$$= \frac{150 - (-50)}{2} = 100 \text{ N/mm}^2$$

12. **(c)**

Cartesian system with direct/normal stresses along one axis, shearing stress along another axis is called Mohr's circle. Mohr's circle is always symmetrical with respect to normal stress axis.

Note : In case of pure shear, Mohr's circle is symmetrical with respect to both the axes, i.e., normal stress axis and shear stress axis.

13. (a)

(Theories of failure)	Remarks	(Theories of failure)	Remarks
(i) Maximum principal stress theory	 yield locus – square.	(iii) Maximum shear stress theory/Tresca, guest, coulomb theory	 Yield locus – Hexagon
(ii) Maximum principal strain theory/saint venant theory	 Yield locus – Rhombus	(iv) Maximum stress energy theory /Beltrami Haigh theory	 Yield locus – ellipse
		(v) Maximum distortion energy theory (Huber-Hencky-Vonmises theory)	 Yield locus – ellipse

14. (b)

For brittle material, maximum principle stress theory give reasonably good results.

Note : Maximum shear strain energy theory or distortion energy theory is most suitable for ductile materials.

15. (a)

The following theorems are used in conjugate beam method of analysis :

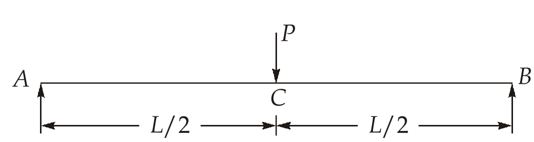
Theorem 1 : The slope at a point in the real beam is numerically equal to shear force at the corresponding point in the conjugate beam.

Theorem 2 : The deflection of a point in the real beam is numerically equal to bending moment at the corresponding point in the conjugate beam.

16. (b)

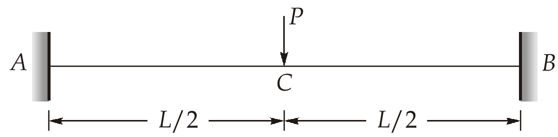
Case 1 :

Simply supported beam :



$$\Delta_C = \frac{PL^3}{48EI}$$

Case 2 :



$$\Delta_C = \frac{1}{4}\left[\frac{PL^3}{48EI}\right]$$

$$\Rightarrow \quad \frac{(\Delta_C)_{Fixed}}{(\Delta_C)_{SSB}} = \frac{1}{4} = 0.25$$

17. (a)

Strain energy stored in a beam due to bending

$$U = \int \frac{M^2 dx}{2EI}$$

$$M = (Px)$$

$$\therefore \quad U = \int_0^L \frac{(Px)^2 dx}{2EI}$$

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

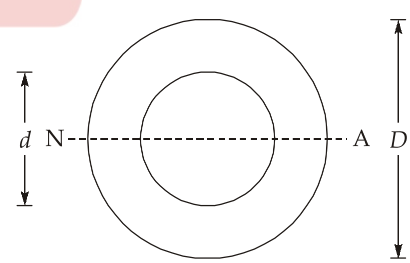
18. (b)

Section modulus, $z = \dfrac{I_{NA}}{y_{\max}}$

For hollow circular section of outer diameter D and inner diameter d

$$I_{NA} = \frac{\pi}{64}\cdot(D^4 - d^4)$$

$$y_{\max} = \frac{D}{2}$$



$$\therefore \quad z = \frac{\frac{\pi}{64}\cdot(D^4 - d^4)}{\frac{D}{2}}$$

$$= \frac{\pi}{32D}\cdot(D^4 - d^4)$$

19. (c)

A beam in which maximum bending stress at all cross-section is same, is called beam of uniform strength.

20. (d)

In case of circular cross-section

$$\tau_{max} = \frac{4}{3}(\tau_{avg})$$

$$= \frac{4}{3} \times \frac{V}{A} = \frac{4}{3} \times \frac{10 \times 10^3}{\frac{\pi}{4} \times (100)^2}$$

$$= \frac{16}{3\pi} \text{ N/mm}^2 = \frac{16}{3\pi} \text{ MPa}$$

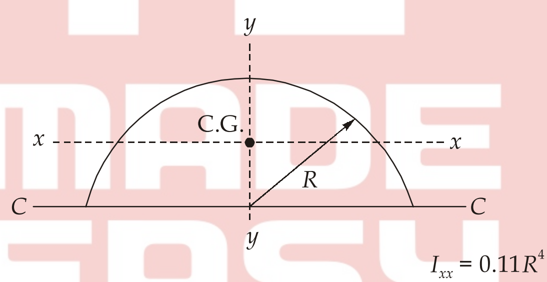
21. (d)

Equivalent moment is that moment which while acting alone produces maximum normal stress equal to the maximum principal stress due to combined action of bending and torsion.

$$\Rightarrow \quad \frac{32M_e}{\pi D^3} = \frac{16}{\pi D^3} \cdot \left(M + \sqrt{M^2 + T^2}\right)$$

$$M_e = \frac{1}{2} \cdot \left(M + \sqrt{M^2 + T^2}\right)$$

22. (a)

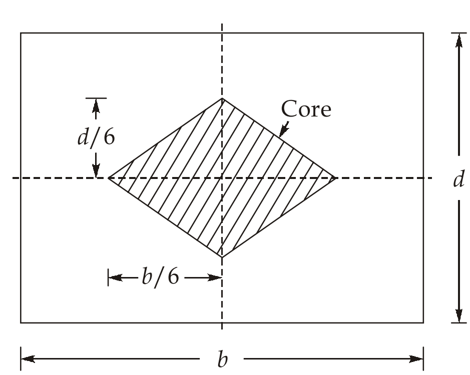


Note: About diametric axis,

$$I_{CC} = \frac{\pi R^4}{8}$$

23. (c)

Kern of rectangular section :



$$\text{Core area} = \left[\frac{1}{2}\times\frac{b}{6}\times\frac{d}{6}\right]\times 4 = \frac{bd}{18}$$

Area of rectangular section = bd

$$\therefore \quad \text{Ratio} = \frac{(bd/18)}{bd} = \frac{1}{18}$$

24. (c)

$$P = \frac{2\pi NT}{60} = \frac{2\pi\times 150\times 20}{60} = 100\pi \text{ kW}$$

25. (d)

Shafts are joined in series. So, applied torque will be same on both the shafts ($T_1 = T_2$).

From torsion formula

$$\theta = \frac{TL}{GJ}$$

Also given, $L_1 = L_2,\ G_1 = G_2$

$$\therefore \quad \theta \propto \frac{1}{J}$$

$$\frac{\theta_1}{\theta_2} = \frac{J_2}{J_1} = \left(\frac{d_2}{d_1}\right)^4 \qquad (\because d_1 = 2d_2)$$

$$= \left(\frac{d_2}{2d_2}\right)^4 = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

26. (b)

We know from torsion formula

$$\theta = \frac{TL}{GJ}$$

$$GJ = \frac{TL}{\theta}$$

GJ = torsional rigidity = T (for unit twist of shaft in a unit length)

27. (d)

For springs connected in series

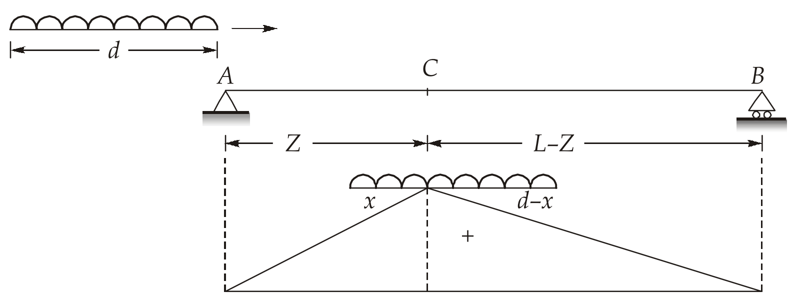
$$K_{eq} = \frac{K_1\cdot K_2}{K_1+K_2} = \frac{K\times 2K}{K+2K} = \frac{2}{3}K$$

For springs connected in parallel

$$K_{eq} = K_1 + K_2 = K + 2K = 3K$$

$$\text{Ratio} = \frac{\frac{2}{3}K}{3K} = \frac{2}{9}$$

28. (d)



ILD for BM at C

For maximum bending moment at section C, the load is so placed that the section divides the load in the same ratio as it divides the span.

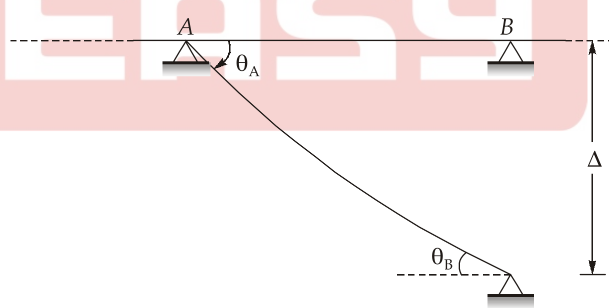
$$\frac{x}{d} = \frac{Z}{L}$$

29. (c)

The equation which relates the moments at the three consecutive support points to the loading on the intermediate spans is referred as theorem of three moments. This theorem was presented by clapeyron for the analysis of continuous beams. It can also be applied to fixed end beams.

30. (c)

Slope deflection equation for span AB :



$$M_{AB} = M_{FAB} + \frac{2EI}{L}\left(2\theta_A + \theta_B - \frac{3\Delta}{L}\right)$$

Similarly,

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left(2\theta_B + \theta_A - \frac{3\Delta}{L}\right)$$

■■■■