CLASS TEST

S.No.: 04_CE_JP_06112024

RPSC

Rajasthan Public Service Commission

ASSISTANT ENGINEER EXAMINATION

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STRENGTH OF MATERIAL

CIVIL ENGINEERING

Date of Test : 06/11/2024

ANSWER KEY

1. (d)	11. (c)	21. (d)	31. (c)	41. (a)
2. (d)	12. (d)	22. (d)	32. (b)	42. (c)
3. (c)	13. (c)	23. (c)	33. (d)	43. (a)
4. (b)	14. (d)	24. (c)	34. (b)	44. (a)
5. (c)	15. (d)	25. (d)	35. (d)	45. (a)
6. (d)	16. (b)	26. (d)	36. (b)	46. (c)
7. (c)	17. (c)	27. (d)	37. (d)	47. (b)
8. (c)	18. (a)	28. (a)	38. (a)	48. (a)
9. (d)	19. (a)	29. (a)	39. (c)	49. (a)
10. (a)	20. (c)	30. (c)	40. (b)	50. (d)

Detailed Explanations

2. (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

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

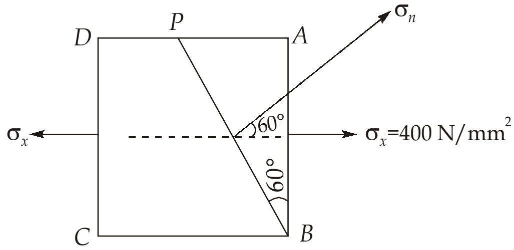
⇒ Slope of bending moment diagram at any section

= Shear force at that section.

3. (c)

Since the bar is free to expand, no stresses will be developed in the bar.

4. (b)



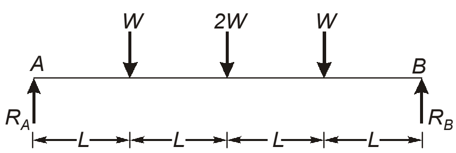
Normal stress on plane PB

$$\sigma_n = \left(\frac{\sigma_x}{2}\right) + \frac{\sigma_x}{2} \cdot \cos(2 \times 60°)$$

$$= \frac{400}{2} + \frac{400}{2} \cdot \cos(120°) = 200 + 200 \times \left(-\frac{1}{2}\right)$$

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

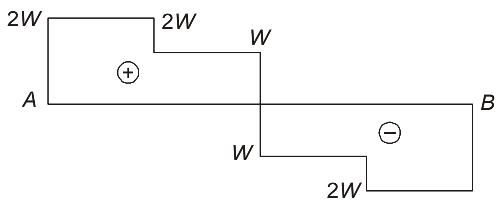
8. (c)



The reactions at the supports A and B respectively are

$$R_A = R_B = \frac{W + 2W + W}{2} = 2W$$

The SF diagram will be



The maximum shear force = 2 W.

9. (d)

In case of circular cross-section

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

$$= \frac{4}{3}\times\frac{V}{A} = \frac{4}{3}\times\frac{10\times10^3}{\frac{\pi}{4}\times(100)^2}$$

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

11. (c)

Principal stresses,

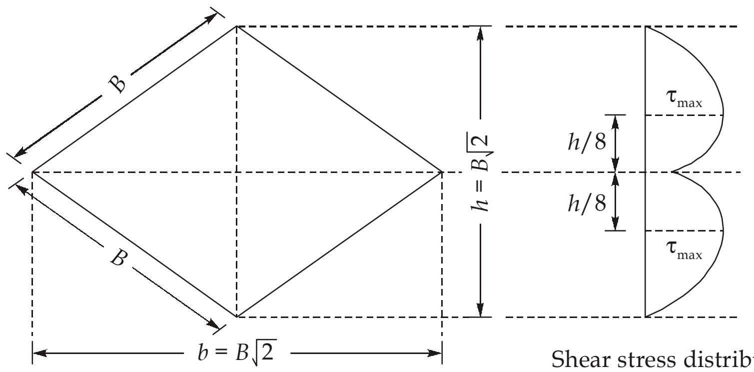
$$\sigma_1/\sigma_2 = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

Since minimum principal stress is zero, therefore

$$\left(\frac{\sigma_x+\sigma_y}{2}\right)^2 = \left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2$$

$$\tau_{xy} = \sqrt{\sigma_x\sigma_y}$$

13. (c)



The shear stress will be maximum at $\frac{h}{8} = \frac{B\sqrt{2}}{8} = \frac{B}{4\sqrt{2}}$ from neutral axis.

14. (d)

Proportionality limit shear stress

$$= \frac{300}{2} = 150\text{ N/mm}^2$$

Maximum shear stress

$$= \frac{120-(-30)}{2} = 75\text{N/mm}^2$$

$$\therefore \text{ Factor of safety} = \frac{150}{75} = 2.0$$

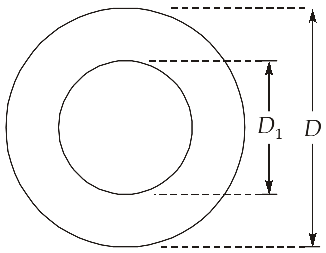
15. (d)

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.

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

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

16. (b)



Let P = Compressive load

$$I = \frac{\pi}{64}(D^4 - D_1^4)$$

$$\text{Stress at outer fibre} = \frac{P}{\frac{\pi}{4}(D^2-D_1^2)} - \frac{Pe\left(\frac{D}{2}\right)}{\frac{\pi}{64}(D^4-D_1^4)} = 0$$

$$\Rightarrow \quad \frac{1}{D^2-D_1^2} - \frac{e\cdot\frac{D}{2}\times 16}{(D^2-D_1^2)(D^2+D_1^2)} = 0$$

$$\Rightarrow \quad e = \frac{D^2+D_1^2}{8D}$$

17. (c)

Strain energy in torsion

$$U = \frac{1}{2}T.\theta \text{ from torsion formula}$$

$$\theta = \frac{TL}{GJ}\ ;\ T = \frac{\tau\cdot J}{r}\ ;\ \theta = \frac{\tau\cdot L}{Gr}$$

$$U = \frac{1}{2}\times\frac{\tau\left(\frac{\pi d^4}{32}\right)}{\left(\frac{d}{2}\right)}\times\frac{\tau\cdot L}{G\cdot\frac{d}{2}}$$

$$\tau = q$$

$$\therefore \quad U = \frac{q^2}{4G}\left(\frac{\pi}{4}\cdot d^2\times L\right)$$

$$\therefore \quad \frac{U}{\text{Volume}} = \frac{q^2}{4G}$$

19. (a)

Shearing strain $= (\epsilon_x - \epsilon_y) \sin 2\theta$

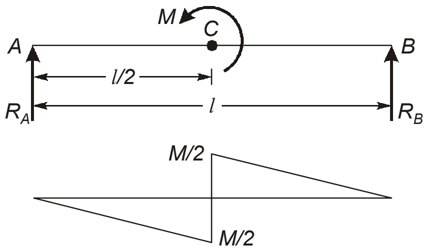
$= (0.003 - 0.002)\sin 60°$

$= \dfrac{\sqrt{3}}{2} \times 10^{-3}$

21. (d)

$R_A \times l = M$

$R_A = \dfrac{M}{l}$



Span AC :

$M_x = \dfrac{M}{l}x$

$M_C = \dfrac{M}{2} - M = -\dfrac{M}{2}$

Span CB :

$M_x = \dfrac{Mx}{l} - M$

$M_B = 0$

24. (c)

$R_A + R_B = 12\,t$

$R_B = \dfrac{5\times2+2\times2\times5+3\times6}{8} = 6\,t$

$R_A = 6\,t$

$\dfrac{R_A}{R_B} = 1$

26. (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, $L_1 = L_2,\ G_1 = G_2$

$\therefore$ $\theta \propto \dfrac{1}{J}$

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

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

27. (d)

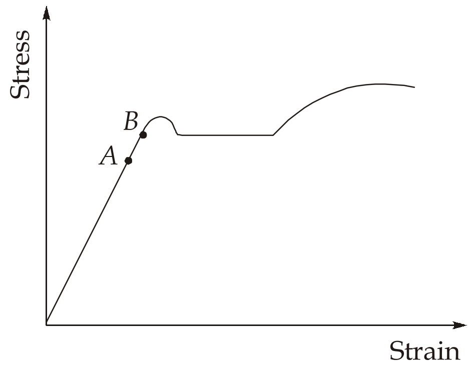
Let the reaction at the prop $= R$

$\therefore$ $\dfrac{5wL^4}{384EI} = \dfrac{RL^3}{48EI}$

$\Rightarrow$ $R = 0.625\,wL$

28. (a)

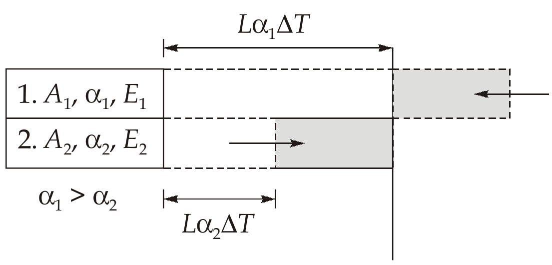
A material is said to be perfectly elastic if it regains, its original shape on removal of load.



A $\rightarrow$ Proportionality limit

B $\rightarrow$ Elastic limit

29. (a)



Hence, in case of composite bar, with temperature increase, bar having larger 'α' will have compression and that having smaller 'α' will have tension.

31. (c)

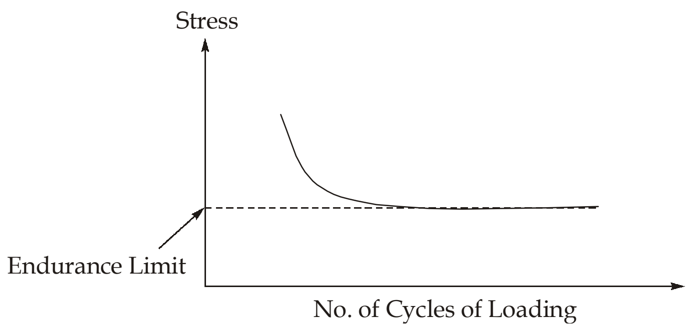
$$\frac{\tau}{R} = \frac{T}{I_P}$$

$$\Rightarrow \quad \frac{\tau}{\left(\frac{D}{2}\right)} = \frac{T}{\left(\frac{\pi D^4}{32}\right)}$$

$$\Rightarrow \quad T = \tau \cdot \left(\frac{\pi D^3}{16}\right)$$

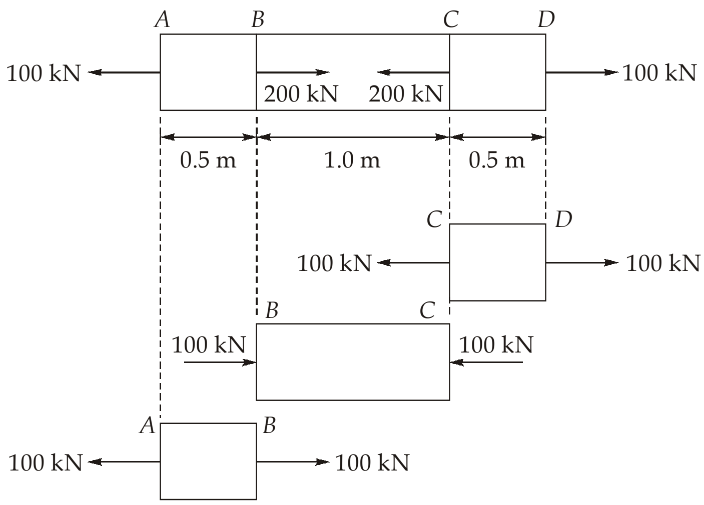
32. (b)

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



33. (d)

FBD of bar :



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

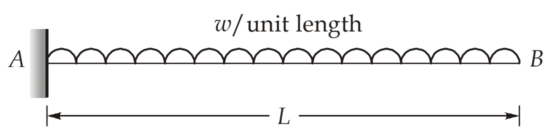
Total elongation :

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

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

$$= 0$$

34. (b)



$$\delta_B = \frac{wL^4}{8EI} ; \theta_B = \frac{wL^3}{6EI}$$

$$\therefore \quad \frac{\delta_B}{\theta_B} = \frac{wL^4}{8EI} \times \frac{6EI}{wL^3}$$

$$= \frac{3L}{4}$$

$$\Rightarrow \quad \frac{15\times10^{-3}}{0.02} = \frac{3}{4}\times L$$

$$L = \frac{60\times10^{-3}}{0.06} = 1 \text{ m}$$

35. (d)

$$\tau = \frac{Tr}{J}$$

For solid shaft: $J = \dfrac{\pi}{32}D^4$

$$r = \frac{D}{2}$$

For hollow shaft:
$$J = \frac{\pi}{32}(D^4 - d^4) = \frac{\pi}{32}\left(D^4 - \frac{D^4}{16}\right) = \frac{\pi}{32} \times \frac{15}{16}D^4$$

$$r = \frac{D}{2}$$

$$\therefore \quad \frac{\tau_H}{\tau_S} = \frac{J_S}{J_H}$$

$$\therefore \quad \frac{\tau_H}{\tau_S} = \frac{\pi/32\, D^4}{\pi/32 \times \frac{15}{16}D^4} = \frac{16}{15}$$

36. (b)

The SFD does not change, while the sudden change in BMD denotes a concentrated moment at the point *C*. The triangular shape of BMD shows concentrated load is applied at free end.

37. (d)

Under hydrostatic loading condition, stresses at a point in all directions are equal and hence no shear stress.

Alternatively,
$$\tau = \frac{\sigma_1 - \sigma_2}{2} = \frac{50 - 50}{2} = 0$$

Thus, Mohr's circle reduces to a point.
Hence shear stress at all orientations is zero.

39. (c)

$$\text{Strain energy} = \frac{1}{2} \times T \times \theta = \frac{1}{2} \times \frac{\tau J}{r} \times \frac{\tau L}{Cr}$$

$$= \frac{1}{2} \times \frac{\tau^2 \times \pi/32\, D^4 L}{CD^2/4} = \frac{1}{4C}\tau^2 \times \frac{\pi}{4}D^2 \times L$$

$$\text{Strain energy} = \frac{\tau^2}{4C} \times \text{Volume}$$

42. (c)

$$\text{Power} = T \times \omega = T \times \frac{2\pi N}{60} = \frac{1500 \times 2\pi \times 150}{60} = \frac{1500 \times 300\pi}{60} = 7500\pi \text{ W}$$

$$P = 7.5\pi \text{ kW}$$

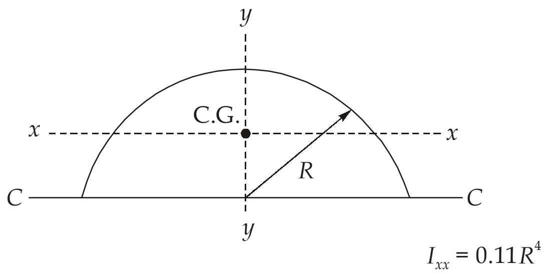
43. (a)

Hoop stress,
$$\sigma_h = \frac{Pd}{2t}$$

Longitudinal stress,
$$\sigma_l = \frac{Pd}{4t}$$

$$\therefore \quad \frac{\sigma_h}{\sigma_l} = \frac{\frac{Pd}{2t}}{\left(\frac{Pd}{4t}\right)} = 2$$

44. (a)



Note: About diametric axis,

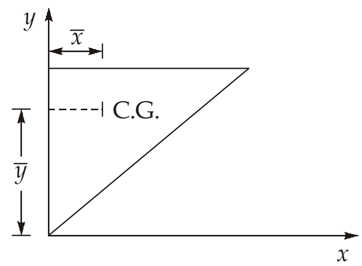
$$I_{CC} = \frac{\pi R^4}{8}$$

45. (a)

For hinged column, $P_{cr} = \frac{\pi^2 EI}{L^2} = 10$ kN

For fixed column, $P_{cr} = \frac{4\pi^2 EI}{L^2} = 4 \times 10 = 40$ kN

46. (c)



$$\bar{x} = \frac{b}{3}$$

$$\bar{y} = \frac{2h}{3}$$

∴ Co-ordinate of centroid $\left[\frac{b}{3}, \frac{2h}{3}\right]$.

47. (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)

48. (a)

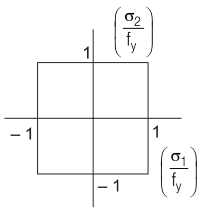
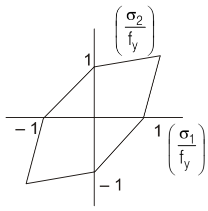
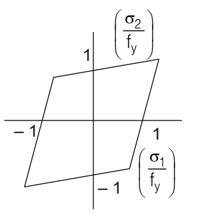
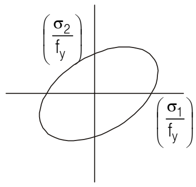
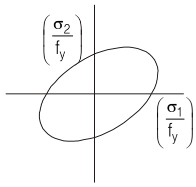
Strain energy stored in a beam due to bending

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

$$M = (Px)$$

$$\therefore \qquad U = \int_0^L \frac{(Px)^2 dx}{2EI} = \frac{P^2}{2EI}\left[\frac{x^3}{3}\right]_0^L = \frac{P^2L^3}{6EI}$$

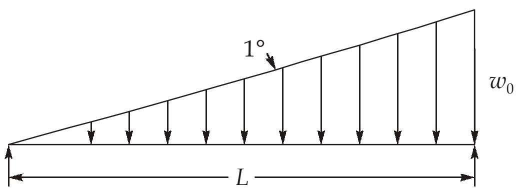
49. (a)

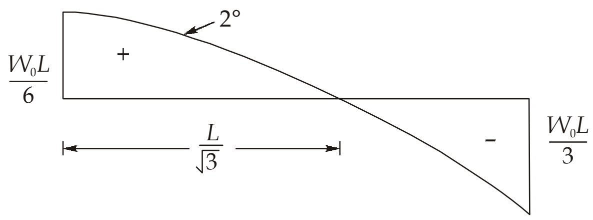
(Theories of failure)	Remarks	(Theories of failure)	Remarks
(i) Maximum principal stress theory	 yield locus – square.	(iii) Maximum shear stress theory/Tresca, guest, coulomb theory	 Yield locus – Hexagon
(ii) Maximum principal strain theory/saint venant theory	 Yield locus – Rhombus	(iv) Maximum stress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

50. (d)

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

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





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