CLASS TEST

S.No. : 04SKCE_OPQ_161024

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SOM

CIVIL ENGINEERING

Date of Test : 16/10/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (b)

Let, the stress developed on each side is σ.

Strain along one side due to σ $= \frac{\sigma}{E}(1-2\mu)$

Strain along one side due to temperature rise $= \alpha T$

As cube is restrained from all sides, therefore, both strains should cancel out each other i.e. algebric sum of both strains should be zero.

$$\Rightarrow \quad \frac{\sigma}{E}(1-2\mu) = \alpha T$$

$$\Rightarrow \quad \sigma = \frac{E\alpha T}{1-2\mu}$$

2. (b)

$$\because \quad \text{Stiffness, } k \propto \frac{1}{\text{Number of coils } (n)}$$

$$\Rightarrow \quad k_1 n_1 = k_2 n_2$$

$$\Rightarrow \quad k_1 \times 25 = k_2 \times 20$$

$$\therefore \quad k_2 = 1.25\, k_1$$

3. (d)

4. (c)

$$\sigma_x = 60 \text{ N/mm}^2$$

$$\sigma_y = -20 \text{ N/mm}^2$$

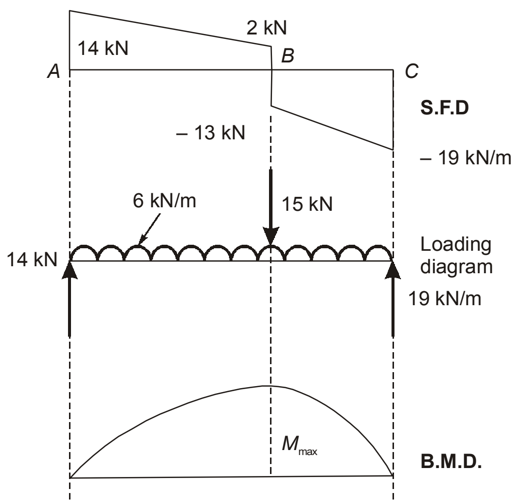
$$\tau = 40 \text{ N/mm}^2$$

$$\text{Normal stress, } \sigma_n = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + \tau \sin 2\theta$$

$$= 60 \cos^2 60° - 20 \sin^2 60° + 40 \sin 120°$$

$$= 34.64 \text{ N/mm}^2$$

5. (d)



$$M_B - M_A = (\text{BM})_B$$

$=$ Area of shear force diagram from A to B since $M_A = 0$, due to simply supported beam.

$$= \frac{1}{2}(14+2)\times 2 = 16\,\text{kN-m}$$

6. (c)

7. (b)

$$\text{Modulus of elasticity, } E = \frac{PL}{A\Delta L}$$

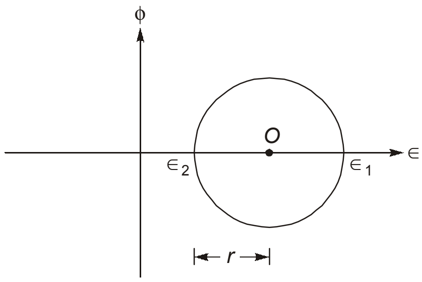
$$\because \quad \frac{\Delta L_1}{\Delta L_2} = \frac{2}{5}$$

$$\therefore \quad \frac{E_1}{E_2} = \frac{5}{2} \qquad \left(\text{as } E \propto \frac{1}{\Delta L}\right)$$

8. (a)

9. (b)

Radius of Mohr's circle for strained body



$$\text{Radius} = \sqrt{\left(\frac{\epsilon_1 - \epsilon_2}{2}\right)^2 + \left(\frac{\phi}{2}\right)^2}$$

$$\text{Centre} = \left(\frac{\epsilon_1 + \epsilon_2}{2}, 0\right)$$

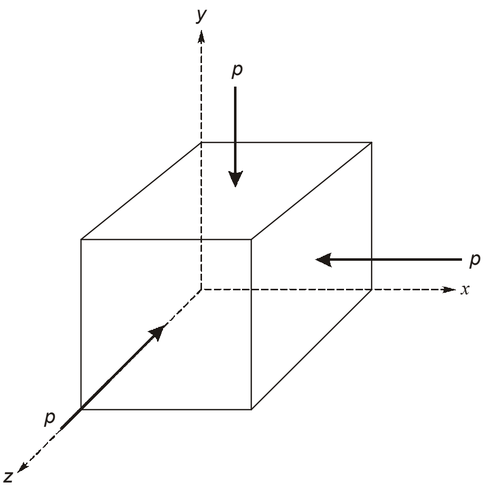
10. (d)

According to maximum shear stress criteria.

For no failure, $\tau_{max} \leq \frac{\sigma_y}{2}$

$$\therefore \quad \frac{\tau_{max}}{\sigma_y} \leq \frac{1}{2}$$

11. (d)



∵ Pressure is a compressive stress

$$\therefore \quad \varepsilon_x = -\frac{200}{200\times 10^3} - \frac{1}{4}\left(\frac{-200}{200\times 10^3}\right) - \frac{1}{4}\left(\frac{-200}{200\times 10^3}\right)$$

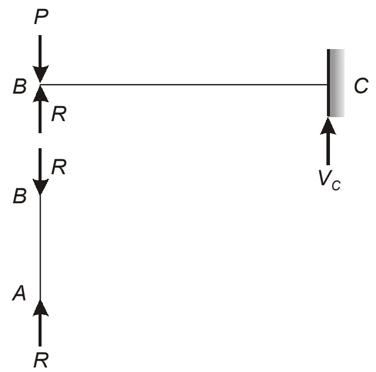
$$= -5\times 10^{-4} \text{ mm/mm}$$

$$\therefore \quad \text{Elongation, } \Delta_x = \varepsilon_x L_x = -5\times 10^{-4}\times 50$$

$$= -0.025 \text{ mm}$$

12. (b)

Let the reaction at support *A* be *R*.



Deflection at *A* in beam *BC* = Compression in column *AB*

$$\frac{(P-R)L^3}{3EI} = \frac{RL}{AE}$$

$$\frac{(P-R)L^2}{3I} = \frac{R}{A}$$

$$\frac{PL^2}{3I} = \frac{R}{A} + \frac{RL^2}{3I}$$

$$\frac{PL^2}{3I} = R\left[\frac{3I + AL^2}{3IA}\right]$$

$$R = \frac{PAL^2}{3I + AL^2} = \frac{P}{1+\left(\frac{3I}{AL^2}\right)}$$

13. (b)

$$\text{Total load on beam, } w = 10 + 20 = 30 \text{ kN/m}$$

$$\text{Maximum shear force, } F = \frac{wL}{2} = \frac{30 \times 8}{2} = 120 \text{ kN}$$

$$\text{Average shear stress, } \tau_{avg} = \frac{F}{A} = \frac{120 \times 10^3}{\frac{1}{2} \times 200 \times 300} = 4 \text{ N/mm}^2$$

$$\text{Maximum shear stress, } \tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2} \times 4 = 6 \text{ N/mm}^2$$

14. (a)

According to maximum strain energy theory,

$$U = \left\{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\mu\left(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1\right)\right\}\frac{1}{2E} = \frac{\sigma_y^2}{2E}$$

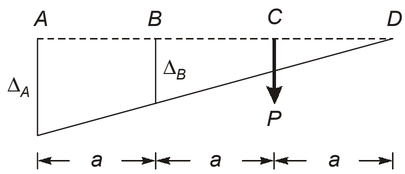
Given $\sigma_1 = \sigma_2 = \sigma_3$

$\therefore$ $U = \left(3\sigma^2 - 6\mu\sigma^2\right) = \sigma_y^2$

$$\sigma^2\left(3 - 6\mu\right) = \sigma_y^2$$

$\Rightarrow$ $\sigma = \dfrac{\sigma_y}{\sqrt{3\left(1 - 2\mu\right)}}$

15. (c)



Moment about D,

$$F_A \times 3a + F_B \times 2a = P \times a$$

$\Rightarrow$ $3F_A + 2F_B = P$

Also, $\dfrac{\Delta_A}{3a} = \dfrac{\Delta_B}{2a}$

$\Rightarrow$ $\Delta_A = 1.5\,\Delta_B$

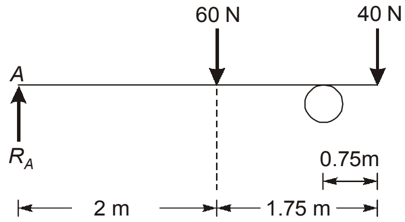
Now, $F = k\Delta$

$\therefore$ $F_A = k_A\Delta_A$

$F_B = k_B\Delta_B$

$\therefore$ $\dfrac{F_A}{F_B} = \dfrac{2k}{k} \times \dfrac{1.5\Delta_B}{\Delta_B} = 3$

16. (b)



Moment about roller is zero.

$\therefore \quad R_A(3) + 40(0.75) = 60(1)$

$$\Rightarrow \quad R_A = \frac{60 \times 1 - 40 \times 0.75}{3} = 10 \text{ N}$$

17. (a)

$$\text{Strain energy} = \int_0^L \frac{P^2}{2AE} dx$$

$$P = \text{Weight} = \gamma A x$$

$$u = \int_0^L \frac{\gamma^2 A^2 x^2 \cdot dx}{2AE} = \frac{\gamma^2 A^2 L^3}{6AE} = \frac{\gamma^2 A L^3}{6E}$$

18. (b)

$$\tau_{max} = 75 \text{ N/mm}^2$$
$$N = 100 \text{ rpm}$$
$$P = 250 \text{ kW}$$

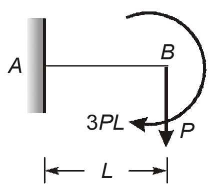
$$T = \frac{60P}{2\pi N} = \frac{60 \times 250}{2\pi \times 100} = 23.87 \text{ kN-m}$$

$$\frac{T}{I_P} = \frac{\tau_{max}}{\left(\frac{D}{2}\right)}$$

$$\Rightarrow \quad \frac{23.87 \times 10^6}{\frac{\pi}{32} D^4} = \frac{75}{\left(\frac{D}{2}\right)}$$

$$\Rightarrow \quad D = 117.468 \text{ mm}$$

19. (d)



$$\text{Deflection at } B = \frac{PL^3}{3EI} + \frac{(3PL)L^2}{2EI}$$

$$\text{Slope at } B = \frac{PL^2}{2EI} + \frac{(3PL)L}{EI}$$

$$\text{Deflection at } C = \text{Deflection at } B + \text{Slope at } B \times L$$

$$= \frac{PL^3}{3EI} + \frac{3PL^3}{2EI} + \left(\frac{PL^2}{2EI} + \frac{3PL^2}{EI}\right) \times L = \frac{16}{3}\frac{PL^3}{EI}$$

20. (a)

Let P be the roller reaction

∴ Upward deflection of beam at A due to 'P'

$$\delta_1 = \frac{Pl}{3EI}$$

Downward deflection of beam at A due to 'w'

$$\delta_2 = \frac{wl^4}{8EI}$$

Now $$\delta_2 - \delta_1 = \Delta$$

$$\Rightarrow \quad \frac{wl^4}{8EI} - \frac{Pl^3}{3EI} = \Delta$$

$$\Rightarrow \quad P = \frac{3}{8}wl - \frac{3EI\Delta}{l^3}$$

21. (b)

Net BM at $P = (F \times 3) - (F \times 2) = F = 300$ N-m

Bending causes compressive stress at P

$$f = \frac{300 \times 10^3}{\left(\frac{30 \times 30^2}{6}\right)} = 66.67 \text{ (MPa) (C)}$$

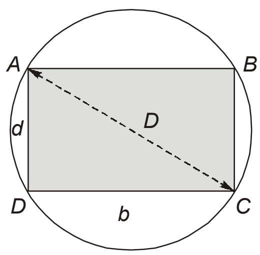
Horizontal force, F = causes axial tensile stress of

$$\sigma = \frac{F}{A} = \frac{300}{30 \times 30} = 0.33 \text{ MPa (T)}$$

At extreme fibre stress shear stress due to bending is zero.

∴ The resultant stress at P is compressive.

22. (b)



Size of rectangular section ($b \times d$) cutout from circular log of wood

From ΔACD, $$D^2 = b^2 + d^2 \quad \text{...(i)}$$

Section modulus, $$z = \frac{bd^2}{6} = \frac{b(D^2 - b^2)}{6}$$

for the beam to be strongest z should be maximum

$$\frac{dz}{db} = 0$$

$$D^2 - 3b^2 = 0$$

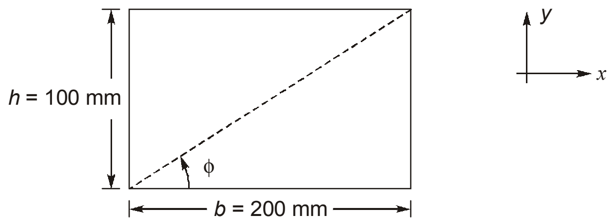
$$b = \frac{D}{\sqrt{3}}$$

From equation (i),
$$D^2 = \frac{D^2}{3} + d^2$$

$$d^2 = D^2 - \frac{D^2}{3} = \frac{2D^2}{3}$$

∴ Size/dimensions will be $(b \times d)$
$$d = \sqrt{2/3}\,D = \left(\frac{D}{\sqrt{3}} \times D\sqrt{\frac{2}{3}}\right)$$

23. (b)



Given,
$$\varepsilon_x = 195 \times 10^{-6}$$
$$\varepsilon_y = -125 \times 10^{-6}$$

$$\tan\phi = \frac{100}{200} = \frac{1}{2}$$

$$\phi = 26.56°$$

$$\varepsilon_{OD} = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos^2 2\phi + \frac{\gamma_{xy}}{2}\sin 2\phi$$

$$= \frac{\left(195\times10^{-6} - 125\times10^{-6}\right)}{2} + \frac{195\times10^{-6} - \left(-125\times10^{-6}\right)}{2}\cos\left(2\times26.56°\right)$$

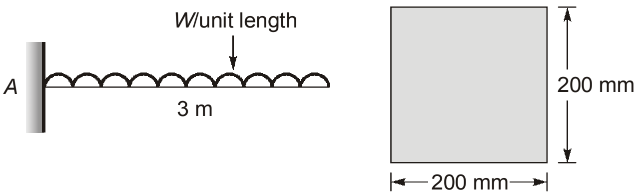
Note : Since the stress are biaxial, so γ_{xy} willl be zero.

$$\varepsilon_{OD} = 1.31 \times 10^{-4}$$

∴ Change in length of diagonal OD

$$\Delta_{OD} = l_{OD} \cdot \varepsilon_{OD} = \left(\sqrt{100^2 + 200^2}\right) \times 1.31 \times 10^{-4} = 0.0293 \text{ mm}$$

24. (b)



$$f_{max} = 5 \text{ N/mm}^2 \qquad \text{Let w in (kN/m)}$$

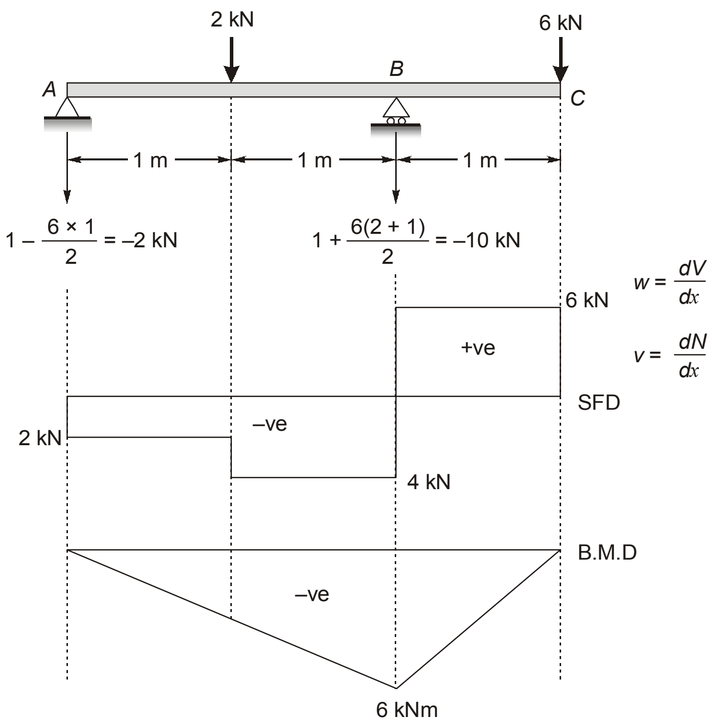
$$\frac{M}{Z} = 5 \text{ N/mm}^2 \qquad (b = d) \text{ for square section}$$

$$\frac{\left(\frac{wL^2}{2}\right)}{Z} = 5 \text{ N/mm}^2 \qquad \text{where, } Z = \frac{bd^2}{6} = \frac{d^3}{6}$$

$$\frac{w \times (3)^2 \times 10^6}{\frac{2 \times 200 \times (200)^2}{6}} = 5$$

$$W = 1.48 \text{ kN/m}$$

25. (a)



∴ Maximum BM occurs at the right support and its value is 6 kN-m

26. (a)

Loop/Circumferential stress

Given, $\sigma_h = \frac{PD}{2t} = 80 \text{ MPa}$

Circumferential strain, $\varepsilon_h = \frac{PD}{4tE}.(2-\mu) = \frac{80}{2\times2\times10^5}(2-0.28) = 3.44\times10^{-4}$

27. (b)

Direct stress, $\sigma_1 = \frac{P}{b.h}$

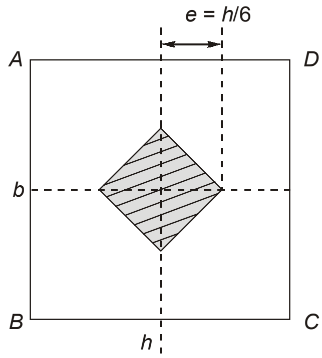
Bending stress, $\sigma_2 = \frac{M}{Z} = \frac{Pe}{(bh^2/6)}$

To avoid tensile stress,

$$\text{Total stress} = -\sigma_1 + \sigma_2 \le 0$$

$$\frac{-P}{bh} + \frac{6Pe}{bh^2} \le 0$$

$$e \le \frac{h}{6}$$



28. (c)

$\sigma = \in E$ and $\sigma = \frac{P}{A}$

$$\frac{P}{A} = \in E$$

$$\in = \frac{P}{AE}$$

$$\text{Poisson's ratio} = \frac{\text{Strain in lateral direction}}{\text{Strain in longitudinal direction}}$$

$$\in_{\text{longitudinal}} = \frac{\in_{\text{lateral}}}{\mu}$$

$$\in_{\text{lateral}} = \frac{\mu P}{AE} = \frac{-0.42\times120\times10^3}{\frac{\pi}{4}\times(0.08)^2\times3\times10^9} = 3.3422 \times 10^{-3}$$

$$\in_{\text{lateral}} = \frac{\delta}{D} = 3.3422 \times 10^{-3}$$

$\therefore$ $\delta = 3.3422 \times 10^{-3} \times 8 = 0.026 \text{ cm} \simeq 0.03 \text{ cm}$

29. (c)

(i) Force on shaded area $= \dfrac{f_{max}}{y_{max}} Ay$

where, A is area of shaded portion, y is distance of centroid of shaded area from NA

$$Ay = 5 \times 5 \times (5 + 2.5) = 187.5 \text{ cm}^3$$

So, $$\text{Force} = \frac{80}{10} \times 187.5 = 1500 \text{ kg}$$

(ii) Moment of this force about the neutral axis

$$M = \frac{f_{max}}{y_{max}} I_o$$

(I_o = Moment of inertia of shaded area about neutral axis)

$$I_o = \frac{5 \times 5^3}{12} + 5 \times 5 \times (7.5)^2 = \frac{4375}{3} \text{ cm}^4$$

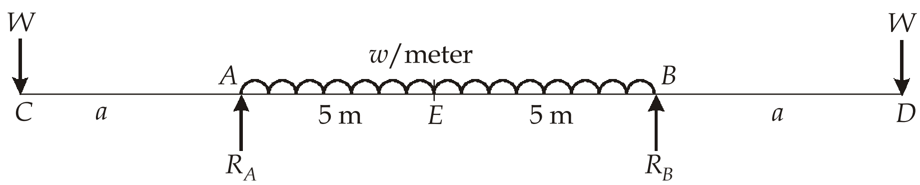
So, $$M = \frac{80}{10} \times \frac{4375}{3} = 11666.67 \text{ kg cm}$$

30. (b)

$$R_A = R_B = \frac{1}{2}(2W + 10w) = W + 5w$$

$$= 15w \qquad (W = 10\,w)$$

Now



$$M_E = R_A \times 5 - W(a + 5) - w \times 5 \times 2.5 = 0$$

$\Rightarrow$ $15w \times 5 - 10w\,(a + 5) - 12.5w = 0$

$\Rightarrow$ $75 - 10a - 50 - 12.5 = 0$

$\Rightarrow$ $12.5 = 10a$

$\Rightarrow$ $a = 1.25 \text{ m}$

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