CLASS TEST

Sl. : 01_JP_CE_27062026

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STRENGTH OF MATERIALS

CIVIL ENGINEERING

Date of Test : 27/06/2026

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

The stress induced in metal-1 due to restriction = $E_1\alpha_1\Delta T$

So, force required in metal-1 = $E_1\alpha_1\Delta T \times A_1$

Similarly for metal-2, force required = $E_2\alpha_2\Delta T \times A_2$

So, Total force required = $E_1\alpha_1\Delta TA_1 + E_2\alpha_2\Delta TA_2$

$$= (E_1\alpha_1A_1 + E_2\alpha_2A_2)\,\Delta T$$

2. (a)

Elongation due to self weight, $\Delta = \dfrac{\gamma L^2}{2E}$

$$= \frac{\left(89.2\times10^{-6}\right)\times\left(15\times10^{3}\right)^2}{2\times\left(90\times10^{3}\right)} = 0.11 \text{ mm}$$

3. (c)

Poisson's ratio, $\mu = \dfrac{3K-2G}{6K+2G}$

$$= \frac{3\times6.93\times10^4 - 2\times2.65\times10^4}{6\times6.93\times10^4 + 2\times2.65\times10^4} = 0.33$$

4. (c)

Strain energy, $U = \dfrac{1}{2}\times P\times\Delta$

$$= \frac{1}{2}\times P\times\frac{PL^3}{48EI}$$

$\therefore \quad U = \dfrac{P^2L^3}{96EI}$

For $P = 1$; $U = \dfrac{L^3}{96EI}$

5. (b)

If a force acts on a body, then resistance to the deformation is known as stress.

6. (d)

For the given stress condition,

$\sigma_x = +50$ N/mm², $\sigma_y = 0$, $\tau_{xy} = \pm20$ N/mm²

Now, principal stresses,

$$\sigma_{1/2} = \frac{\sigma_x+\sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{50+0}{2} \pm \sqrt{\left(\frac{50-0}{2}\right)^2 + 20^2} = 57, -7 \text{ N/mm}^2$$

So, $\sigma_1 = 57\ \text{N/mm}^2$ (T)

$\sigma_2 = 7\ \text{N/mm}^2$ (C)

7. (a)

Internal hinge in given beam becomes internal roller in conjugate beam.

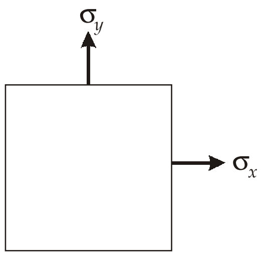
8. (a)

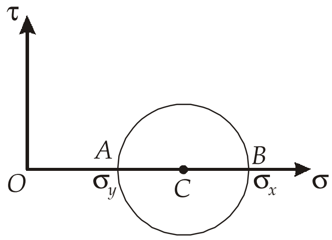
$$\text{Maximum shear stress}, \tau_{max} = \frac{16}{\pi D^3}\sqrt{M^2 + T^2}$$

$$= \left[\frac{16}{\pi(100)^3}\sqrt{(8)^2 + (6)^2}\right] \times 10^6 = \frac{16}{\pi} \times \frac{10 \times 10^6}{10^6} = 50.93\ \text{MPa}$$

9. (a)

Assuming ($\sigma_x > \sigma_y$)



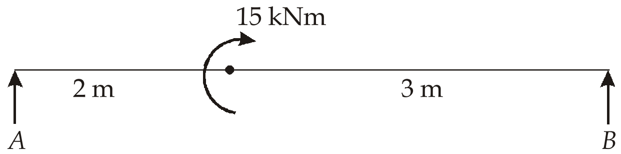


$$AB = \sigma_x - \sigma_y$$

$$AC = \frac{AB}{2} = \frac{\sigma_x - \sigma_y}{2}$$

$$\therefore \quad OC = OA + AC = \sigma_y + \frac{\sigma_x - \sigma_y}{2} = \frac{\sigma_x + \sigma_y}{2}$$

10. (c)



$\Sigma F_y = 0$

$$R_A + R_B = 0$$

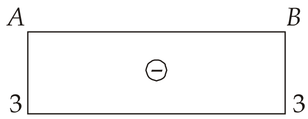
Also, $\Sigma M_A = 0$

$\Rightarrow \quad R_B \times 5 = 15$

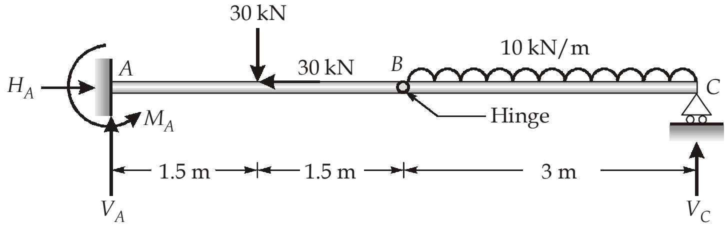
$\Rightarrow \quad R_B = 3\ \text{kN}$

So, $R_A = -3\ \text{kN}$

Now, the SFD for the beam will be as shown below:



11. (c)



$$V_A + V_C = 30 + 30 = 60 \text{ kN} \qquad (\Sigma F_y = 0) \qquad \text{...(i)}$$

$$H_A = 30 \text{ kN} \qquad (\Sigma F_x = 0) \qquad \text{...(ii)}$$

$$M_A + 30 \times 1.5 = 3V_A \qquad (\Sigma M_B = 0, \text{ Left} \rightarrow \text{Right}) \qquad \text{...(iii)}$$

$$3V_C = 10 \times 3 \times 1.5 \qquad (\Sigma M_B = 0, \text{ Right} \rightarrow \text{Left}) \qquad \text{...(iv)}$$

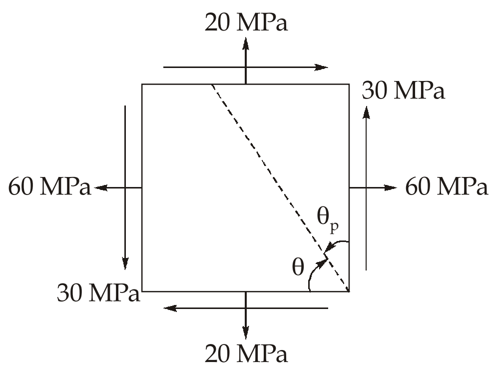
Solving equations (i), (ii), (iii) and (iv)

$$V_C = 15 \text{ kN}, V_A = 45 \text{ kN}, H_A = 30 \text{ kN}$$

$$\therefore \qquad \frac{\text{Reaction at A}}{\text{Reaction at C}} = \frac{\sqrt{45^2 + 30^2}}{15} = 3.6$$

12. (c)

Plane having zero shear stress is called principal planes.



$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

$$\tan 2\theta_p = \frac{2 \times 30}{60 - 20}$$

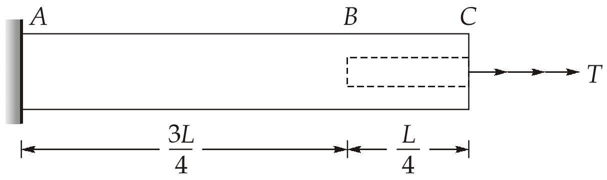
$$\tan 2\theta_p = 1.5$$

$$2\theta_p = \tan^{-1}(1.5)$$

$$\theta_p = 28.15°$$

Required angle from plane B, $\theta = 90° - 28.15° = 61.85°$ (Clockwise)

13. (a)



$$\theta_{AC} = \theta_{AB} + \theta_{BC}$$

$$\theta_C = \frac{T_{AB} \times L_{AB}}{GJ_{AB}} + \frac{T_{BC} \times L_{BC}}{GJ_{BC}} \quad (\because\ \theta_A = 0)$$

$$J_{BC} = \frac{\pi}{32}\left[D^4 - \left(\frac{D}{2}\right)^4\right]$$

$$J_{BC} = \frac{\pi}{32}D^4\left[1 - \frac{1}{16}\right]$$

$$J_{BC} = \frac{15}{16}J_{AB} = \frac{15}{16}J$$

$$\therefore \qquad \theta_C = \frac{T \times \frac{3L}{4}}{GJ} + \frac{T \times \frac{L}{4}}{G \times \frac{15}{16}J}$$

$$= \frac{3}{4}\frac{TL}{GJ} + \frac{4}{15}\frac{TL}{GJ}$$

$$= \frac{45TL + 16TL}{60GJ} = \frac{61}{60}\frac{TL}{GJ}$$

14. (d)

For the given conditions, stress in x and z will be zero as the block in free to expand in x and z directions. Only y-direction will have stress.

On increasing temperature, free elongation

$$= l\alpha\Delta T = 0.1 \times 20 \times 10^{-6} \times 150 \text{ m}$$

$$= 3 \times 10^{-4} \text{ m}$$

$$= 0.3 \text{ mm} > 0.2 \text{ mm}$$

Thus stress induced will be only due to (0.3 - 0.2) = 0.1 mm

$$\text{Stress, } \sigma_{yy} = \left(\frac{\Delta l}{l}\right)E = \frac{0.1}{0.1 \times 10^3} \times E = \frac{70 \times 10^3}{10^3} \text{ N/m}^2 = 70 \text{ MPa} \quad \text{(Compression)}$$

15. (a)

Given, M = 54.0 kNm and T_z = 72.0 kNm

Consider external and internal diameter as D and d (= 0.5 D) respectively,

$$\text{Now, section modulus,} \quad Z = \frac{\pi D^3}{32}\left(1 - \frac{d^4}{D^4}\right) = \frac{\pi D^3}{32}\left(1 - \left(\frac{1}{2}\right)^4\right) = \frac{15\pi D^3}{512}$$

Polar section modulus,

$$Z_p = \frac{\pi D^3}{16}\left(1-\frac{d^4}{D^4}\right) = \frac{15\pi D^3}{256}$$

Maximum shear stress is given by,

$$\tau_{max} = \frac{T}{Z_p} = \left(\frac{256}{15\pi D^3}\right)\times T_e$$

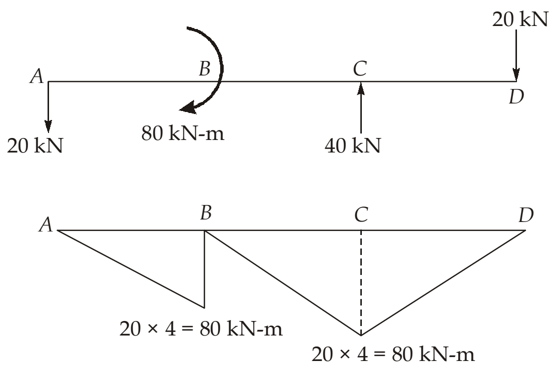
$$T_e = \sqrt{M^2+T^2} = \sqrt{54^2+72^2} = 90 \text{ kNm}$$

Now, $$96 = \left(\frac{256}{15\pi D^3}\right)\times 90\times 10^6 \qquad (\because\ \tau_{permissible} = 96 \text{ MPa})$$

$$D^3 = \frac{256}{15\pi}\times\frac{90\times 10^6}{96} = 5092958$$

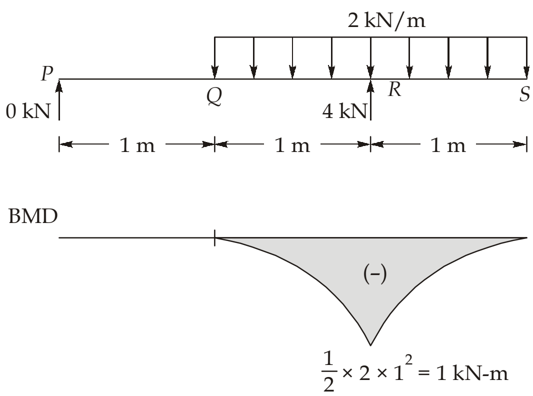
$$D = 172.05 \text{ mm}$$

16. (d)

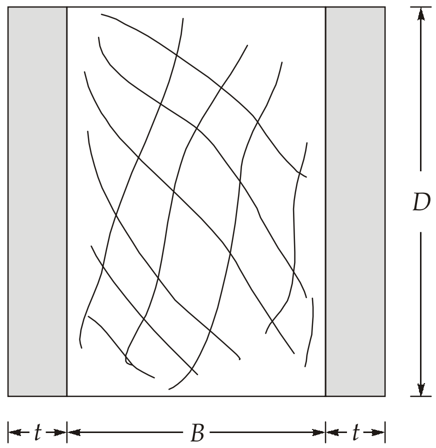


BMD

17. (b)



18. (b)

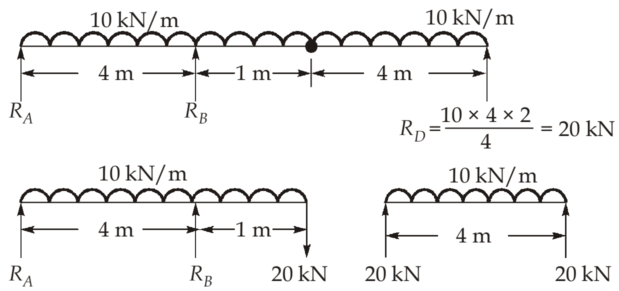


$$\text{MOR} = M_w + M_s$$

$$M = \sigma_w \times \frac{BD^2}{6} + m\sigma_w \times \frac{2tD^2}{6} \quad \left(\because \frac{\sigma_s}{\sigma_w} = \frac{E_s}{E_w} = m\right)$$

$$M = \frac{\sigma D^2}{6}[B + 2mt]$$

19. (c)



Now, $$M_B = -20 \times 1 - 10 \times \frac{1^2}{2} = -25 \text{ kN} - \text{m}$$

$$= 25 \text{ kN-m (Hogging)}$$

20. (a)

Principal strains, $$\varepsilon_{1/2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\phi_{xy}}{2}\right)^2}$$

$$= \left[\frac{800 + 200}{2} \pm \sqrt{\left(\frac{800 - 200}{2}\right)^2 + \left(\frac{-600}{2}\right)^2}\right] \times 10^{-6}$$

$$\varepsilon_1 = 924.264 \times 10^{-6}$$

$$\varepsilon_2 = 75.74 \times 10^{-6}$$

Thus major principal stress is,

$$\sigma_1 = \frac{E}{1-\mu^2}(\varepsilon_1 + \mu\varepsilon_2) = \frac{200\times 10^3}{1-0.3^2}(924.264 + 0.3\times 75.74)\times 10^{-6}$$

$$= 208.13 \text{ MPa}$$

21. (c)

$$\text{Deflection at } B \text{ due to load} = \frac{wl^4}{8EI} = \frac{10\times(3000)^4}{8\times 5\times 10^{11}} = 202.5 \text{ mm}$$

Since gap is 3 mm.

$$\therefore \quad 202.5 - 3 = \frac{Rl^3}{3EI}$$

$$\Rightarrow \quad \frac{(202.5-3)\times 3\times 5\times 10^{11}}{(3000)^3} = R$$

$$\Rightarrow \quad R = 11.083\times 10^3 \text{ N} \simeq 11.08 \text{ kN}$$

22. (a)

As there is a jump at A, there will be an upward load at A.
From A to D, slope of SFD = 0, so no load intensity acts from A to D.
At D, there is the fall so there will be a downward load at D.

$$P_D = -4 - 14 = -18 \text{ kN}$$

So, only option (a) is possible.

23. (d)

In pure bending case,

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

So, $$R = \frac{EI}{M}$$

When same M is applied,

$$\frac{R_1}{R_2} = \frac{(EI)_1}{(EI)_2}$$

$$\Rightarrow \quad \frac{2}{R_2} = \frac{70\times\frac{\pi}{4}\times 2.5^4}{120\times\frac{\pi}{4}\times 2^4}$$

$$\Rightarrow \quad R_2 = 1.404 \text{ m}$$

24. (b)

Axial stress, $$\sigma_a = -\frac{F}{\pi r^2}$$

In radial direction, strain is zero.

So, $$\varepsilon_r = \frac{\sigma_r}{E} - \mu\frac{\sigma_a}{E} - \mu\frac{\sigma_r}{E}$$

$$\Rightarrow \quad 0 = \frac{\sigma_r(1-\mu)}{E} - \mu\frac{\sigma_a}{E}$$

$$\Rightarrow \qquad \sigma_r = -\frac{\mu}{1-\mu}\left(\frac{F}{\pi r^2}\right)$$

Strain in axial direction, $\varepsilon_a = \frac{\sigma_a}{E} - \mu\frac{\sigma_r}{E} - \mu\frac{\sigma_r}{E}$

$$\Rightarrow \qquad \frac{\Delta h}{h} = -\frac{F}{E\pi r^2}\left[1-\frac{2\mu^2}{1-\mu}\right]$$

$$\Rightarrow \qquad \Delta h = -\frac{Fh}{\pi r^2 E}\left[1-\frac{2\mu^2}{1-\mu}\right]$$

25. (a)

We know that for a circular section,

Maximum shear stress, $\tau_{\max} = \frac{4}{3}\tau_{av}$

where, $\tau_{av} = \frac{V}{A} = \frac{6675}{\frac{\pi}{4}\times 50^2} = 3.4\text{ N/mm}^2$

So, $\tau_{\max} = \frac{4}{3}\times 3.4 = 4.53\text{ N/mm}^2$

26. (a)

As it is given that, $\varepsilon = \frac{\sigma}{E} = \frac{y}{R} = 3.0\times 10^{-5}$

So, $\frac{1}{R} = \frac{3.0\times 10^{-5}}{30}\text{ mm}^{-1} = 10^{-6}\text{ mm}^{-1}$

Also, in pure bending, $\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R} = \text{constant}$

For $\sigma_{\max}$, $y_{\max}$ has to be used

So, $\sigma_{\max} = \frac{E}{R}y_{\max} = \frac{200\times 10^3}{R}\times y_{\max}$

$\Rightarrow \qquad \sigma_{\max} = 200 \times 10^3 \times 10^{-6} \times 50\text{ MPa}$

$\Rightarrow \qquad \sigma_{\max} = 10\text{ MPa}$

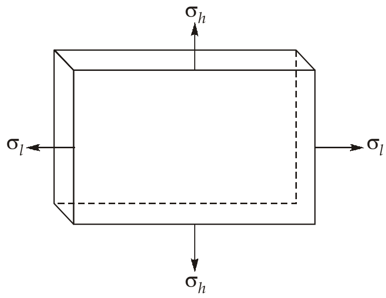
27. (c)

For a closed cylinder (thin), the two stress components induced due to internal pressure are,

$$\sigma_h = \frac{pd}{2t} \qquad \text{(Hoop stress)}$$

$$\sigma_l = \frac{pd}{4t} \qquad \text{(Longitudinal stress)}$$

If we neglect the pressure in radial direction, this becomes a plane stress condition.



For this condition, $$\tau_{max} = \max.\left\{\frac{\sigma_h}{2}, \frac{\sigma_l}{2}, \frac{\sigma_h - \sigma_l}{2}\right\} = \frac{pd}{4t}$$

For safety, $$\tau_{max} \le \frac{\left(f_y/2\right)}{\text{FOS}}$$

$$\Rightarrow \quad \frac{p \times 2 \times 100}{4 \times 5} = \frac{100/2}{2}$$

$$\Rightarrow \quad p = 2.5 \text{ MPa}$$

28. (d)

$$\text{Rankine's crippling load} = \frac{\sigma_{cs} A}{1 + \alpha\left(\frac{l_e}{k}\right)^2}$$

As both ends are hinged

So $$l_e = l = 2.3 \text{ m}$$

$$\therefore \quad P_R = \frac{335 \times 88.75\pi}{1 + \frac{1}{7500}\left[\frac{2.3 \times 10^3}{12.6}\right]^2}$$

$$= 17161.04 \text{ N} = 17.16 \text{ kN}$$

29. (a)

$$\sigma_{P_1/P_2} = \frac{P_1 + P_2}{2} \pm \frac{1}{2}\sqrt{\left(P_1 - P_2\right)^2 + \left(2q\right)^2}$$

Given $\sigma_{P2} = 0$

$$\Rightarrow \quad (P_1 + P_2)^2 = \left(P_1 - P_2\right)^2 + 4q^2$$

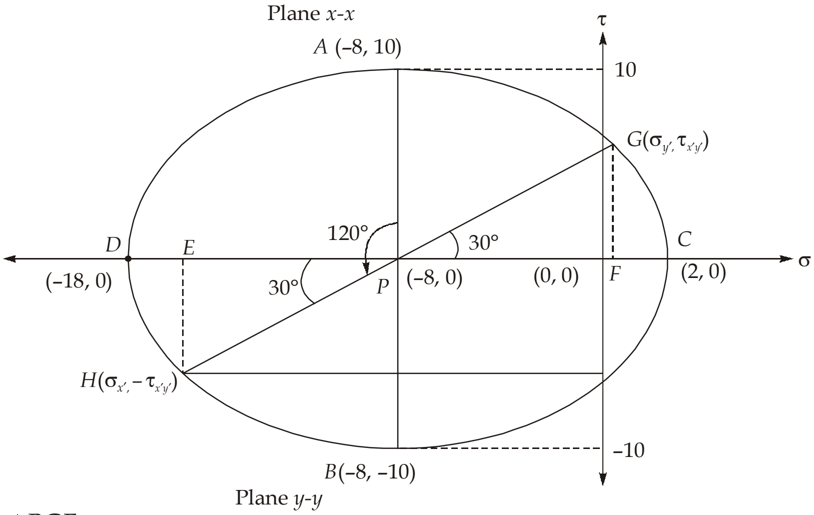
$$\Rightarrow \quad 2P_1P_2 = 4q^2 - 2P_1P_2$$

$$\Rightarrow \quad P_1P_2 = q^2$$

$$\Rightarrow \quad q = \sqrt{P_1P_2}$$

30. **(d)**

Mohr's circle for this stress condition is shown below:



For $\sigma_{y'}$, in ΔPGF

$$\cos 30° = \frac{OF}{OG}$$

$$OF = \frac{\sqrt{3}}{2} \times 10$$

$$OF = 8.66 \text{ MPa}$$

$$\sigma_{y'} = \text{OF} - 8 = 0.66 \text{ MPa}$$

For σ_x', In ΔPEH $\quad PE = 8.66$ MPa

$$\sigma_x' = -8 - 8.66 \text{ MPa} = -16.66 \text{ MPa}$$

For $\tau_{x'y'}$, in ΔPEH,

$$\tan 30° = \frac{\tau_{x'y'}}{8.66}$$

$\Rightarrow$ $\quad \tau_{x'y'} = 5$ MPa

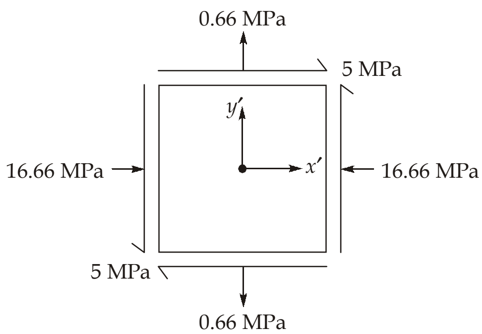
So, at plane x'-x', $\quad \sigma_{y'} = 0.66$ MPa

and $\quad \tau_{x'y'} = 5$ MPa

And at plane y'-y', $\quad \sigma_{x'} = -16.66$ MPa

And $\quad \tau_{x'y'} = -5$ MPa

Hence, option (d) is correct.



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